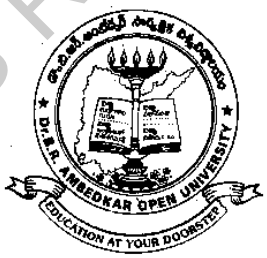
P.G. DIPLOMA IN ENVIRONMENTAL STUDIES

CONTEMPORARY ENVIRONMENTAL ISSUES

Block	1	:	Food & Nutrition
Block	2	:	Forests & Lands
Block	3	:	Fresh Water Supplies in India
Block	4	:	Air Pollution
Block	5	:	Industry in India
Block	6	:	Energy Needs of India



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PREFACE

This book deals with Contemporary Environmental Issues included in the syllabus of PG Diploma in Environmental Studies offered by Dr. B.R. Ambedkar Open University. The topics included in this course generally cover the "core area" of the programme. The syllabus for the sake of convenience is divided into blocks each of which comprises a number of units. Each block generally covers a specific area of the subject. The units are written by the specialists in accordance with a format specially designed as to enable the student to read and understand them without much difficulty. Each unit begins with a statement of its contents followed by objectives. Each unit has at its end summary, model answers for the questions given under Check your Progress. Three assignments are given at the end of the book and the student is expected to submit atleast one assignment to the Coordinator/ Asst. Director/Deputy Director of the concerned study centre.

This book deals with various aspects relating to food and nutrition, forests and lands, fresh water supplies in India, air pollution, Industry in India and energy needs of India. Special emphasis was given for food production and preservation, land management and crop patterns in India, water resources, various pollutants causing air pollution, industrialisation in India, various energy resources etc.

The University hopes that this material will help the student to get acquainted with principal issues of environment. Critical suggestions for improving the text are most welcome and they will be incorporated in the future edition.

CONTENTS

BLOCK - 1
FOOD AND NUTRITION

UNIT - 1 : FOOD PRODUCTION

Contents

1.1. OBJECTIVES

After going through this unit you will be able to:

* recognise various factors responsible for increase in food production,
* understand trends and problems in increasing food production,
* explain the need and availability of alternative food sources,
* discuss about the economics of getting a healthy diet for a common man,
* describe the future plan of action.

1.2. INTRODUCTION

Agriculture has a dominant role in Indian economy contributing nearly 36.86 per cent of the National Income providing employment to about 70 percent of the working population. In crop production it is necessary to maintain continuously high rates of growth in yields as well as output required to achieve supply demand balance to the growing population by 2,000 AD. For this purpose the agriculture policies have to be diversified, available geographical area increased, public distribution system streamlined, and last but not least the production policy should be nutrition oriented.

1.3. FACTORS AFFECTING FOOD PRODUCTION

In a short term contract or annual forecast, it has often been said that the monsoon explains the variations in out-put, so that very little role is left to be played by the policy variables. Among weather variables rainfall and humidity at various stages of crop growth have a significant impact.

The role of chemical fertilizers in increasing food productivity is crucial and hardly needs to be emphasized. Optimal allocation of available fertilizer to the crops and regions is another important factor in food production. Hence increasing the fertilizer output as per demands of farmers is the government's responsibility.

1.4 . FOOD PROBLEMS OF THE DEVELOPING COUNTRIES

The food problems of the developing countries can be studied under 5 different heads. They are (1) population explosion (2) decline in death rate, (3) available geographical area, (4) population and food supply and (5) food production - demand versus supply.

1.4.1 Population Explosion

Increased Growth Rate: The problem of population explosion with its world-wide dimension has been drawing the serious attention of many people. There is concern among scientists for the very survival of the human species if population continues to grow at the present rate of increase. It is calculated that the earth carrying capacity is around 5600 million people. If this conclusion is accepted, then it is clear that the world is not too far from the red alert with its present 5400 million and odd people. In India, the population had sharply increased after the independence. In 1941 the population was around 318.7 million and rate of population growth has increased by 13.31 percent when compared to 1901 population. The increase in population by 1981 census is reported as 683.4 millions (Table-1.1).

Table 1.1. Population of India and the Rate of Growth from 1901 to 1971.

Year	Population in millions	Decade	Rate of Growth
1901	238.4	1901-11	5.75
1941	318.7	1941-51	13.31
1951	361.1	1951-61	21.51
1961	439.2	1961-71	24.57
1971	547.4	1971-81	24.64
1981	683.4	1981-91	--

Source: Census of India 1971; 1981 Census Reports, Registrar General of India, Series I.

1.4.2 Decline in Death Rate

Three factors affect the population balance i.e., birth, death and migration. There is a decline in death rate from 1941-22.4/1000 to 14.8/1000 in 1981. It was this fall in death rate which was the cause for the tremendous growth in the population of India. It is estimated that 14 million are added every year to our population.

Table 1.2. Birth and death rates in India.

Decade	Birth rate per 1000 population	Death rate per 1000 population
1901-11	49.2	42.6
1941-51	39.9	22.4
1951-61	41.7	22.8
1961-71	41.1	18.9
1971-81	36.0	14.8

Population increase, increases the pressure on agricultural production and decreases the per capita availability of both income and food. Hence it is the duty of every citizen irrespective of caste, creed or religion to have a small family norm and at the same time work hard to increase the food production for his nation.

Check Your Progress-1

1. What is the earth carrying capacity of people?

Note: (a) Answer the question in the space provided below.
(b) Compare your answer with the one given at the end of this unit.

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1.4.3. Available Geographical Area

Only 42 per cent or above 140 million hectares are under cultivation. Every hectare supports about 4.6 persons. People who have to make a living on the same land are increasing. Inspite of around 2.7 per cent increase in production, there was only 0.2 per cent increase in per capita production and the level of availability of food for consumption.

The per capita share of land for food grains is about 90 per cent area but its share in total output in terms of value is only 70 per cent. However the non-food grain crops occupy only 10 per cent and contributes 30 per cent in output. This high pressure of grain crops is interpreted to be due to the food habits of Indians (next unit for more details)..

1.4.4. Population and Food Supply

Almost half of the population (consisting of 40 per cent of the population below 14 years and 6 per cent beyond the age of 60 years) are largely non-productive. According to 1971 census only about 126 million are agriculture workers making only 22.8 per cent of the total population who give us our food. According to population trends it is revealed that only 1/3 of the population is working and 2/3 are dependents for obtaining their food. This is yet another factor for the low percapita production.

1.4.5. Food Production - Demand Versus Supply

The importance of a sound agriculture economy was generally overlooked throughout 150 years before the first world war. During this period the ablest of mankind has been mainly involved in exploiting the incredible richness provided by the industrial revolution. However much underfeeding and malnutrition was present in the poorest sections both in industrial and agricultural committees throughout the world, but for a few privileged clear sighted minority there was no realization on the extent and severity of under feeding among the masses at the bottom of the economic scale. The world wars with their interference first with food production, gradually awakened the people of most communities to the importance of the relationship among food, agriculture and population.

During the years 1965-66 the National Food Production declined by 16.7 per cent due to severe drought. There was a pick up in 1973-74, but again a fall of 3.1 per cent in 1974-75. During these adverse periods there also occurred a failure of crops in large parts of Europe and Russia with a resultant global scarcity of food grains. However since 1978 there is a global improvement in food production and the total output in 1980-81 was 1517 million tonnes.

The compound growth rate of production of food grains decelerated from 2.93 per cent during period 1949-50 to 1960-65 to 2.74 per cent during period 1967-68 to 1985-86, that of non-food grains from 3.54 per cent to 2.55 per cent. All crops declined from 3.13 per cent to 2.68 per cent.

According to Swaminathan India is now capable of producing only 105-106 million tonnes of food grains during a year of wide spread drought and unless the base line production capacity is improved there shall always be risk of grain scarcity during a few successive years of poor rains. Though self sufficiency is attained with regard to food grain production protein deficiency still exists because of exclusive cereal diets. However because of the protein and vitamin deficiency which is not found in an exclusive cereal diets. However because of the protein and vitamin deficiency which is not found in an exclusive diet of cereals, malnutrition exists even in those areas which are self sufficient in food grain production.

Check Your Progress - 2 & 3

2. National food production declined in 1965-66 - why?

3. What is the total output of food in 1980-81 at global level?

Note: (a) Answer the questions in the space provided below.
(b) Compare your answers with those given at the end of this unit.

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Table 1.3. Food grain production and population

Period	Population in millions	Food grain production (million tonnes)	Per capita food grain production (Kgs)	Per capita per day availability (gms)
1937-46	310.2	61.4	198	
1947-51	352.1	58.3	166	
1952-57	383.9	66.0	172	
1957-61	424.3	75.5	178	
1962-65	467.2	83.3	178	
1965-66	493.2	72.4	147	
1970-71	550.0	108.4	196	
1980-81	684.0	130.0	190	
1985-86	750.0	150.4	196	
1992-93	840.0	176.5	193.5	323 g

The above table gives an encouraging trend in food grain production though there are a few fluctuations. However the figures for per capita production show a decline during different years compared to 1937-46 (198 kg/capita). In terms of per capita per day availability is

323 g/capita/day which is less than the requirement of 460 g to 500 g per day per capita (ICMR). Thus it is not a happy situation in the rate of 2.15 per cent/annum of increase of food grains while the rate of increase of population is about 2.4 per cent per annum.

The production and supply of other foods (protective foods) the situation is still grim and requires all efforts to improve production, storage and distribution management of agriculture products.

Prices have also increased both in absolute terms and relation to percapita income.

Some major steps are obviously needed including increased production, better storage facilities at the same time cutting down the production cost by helping the farmer through different means.

1.5. TRENDS AND PROBLEMS IN AGRICULTURE FOOD PRODUCTION

One of the objectives of agriculture planning in India is to attain self sufficiency especially in food grain production. Food production has maintained a satisfactory tempo of growth. The success has been more striking in the case of wheat and to some extent rice. Coarse grains, pulses and oil seeds and other possible foods continue to be problem areas of our agriculture. Thanks to the green revolution which increased the production of food grains more than twice since the launch of the programme in 1960's and 70's.

Agriculture production rose gradually since 1950-51, received a severe jolt during 1965-66 and 1966-67, because of the severe drought over vast areas of the country. The upward trend was renewed in 1967-68 between 1969-70 and 1983-84 production of food grains had increased by 60 per cent while production of non food grains increased by 47 per cent. Thus the increase in agricultural production has not been smooth but highly fluctuating (Table.1.4).

Table 1.4. Targets and Achievements in Food-grains (in million tons)

Plan period	Target	Achievement
First Plan (1951-56)	62.6 (1955-56)	66.9 (1955-56)
Second Plan (1961-66)	81.8 (1960-61)	82.00 (1960-61)
Third Plan (1961-66)	101.6 (1965-66)	72.3 (1965-66)
Annual Plans		
1966-67	97.0	74.2
1967-68	100.0	95.1
1968-69	102.0	94.0
Fourth Plan (1969-74)	129.0 (1969-74)	103.6 (1969-74)
Fifth Plan (1974-79)	125.0 (1978-79)	131.9 (1978-79)

Sixth Plan (1980-85)	153.6 (1984-85)	150.0 (1984-85)
Seventh Plan (1985-90)	178.183 (1989-90)	176.2 (1988-89)
Eighth Plan (1991-92)	176.192 (1996-97)	N.A.

1.6. PROGRAMMES AND ACTION OF GOVERNMENT TO IMPROVE PRODUCTION

There are four ways in which the food supply of the world could be increased. There are enormous areas of land which are not used for food production or for rough grazing or shifting cultivation. There are millions of acres of deserts, semideserts, tropical jungles which could be made to produce food. The Isrealis have given the world a striking example of how to make the desert bloom. However the difficulties and expenses of utilizing such lands are very great and the potentially good land is under cultivation. The second way is to improve methods of farming on land already in use. Thirdly it is possible to produce nutrients .... sources of Foods of Synthetic which could be used as foods on large scale by the methods of chemical engineering. A major development has been the production of new high yielding seeds.

Secondly, construction of new dams and use of new irrigation techniques like that of drip irrigation to make cultivation possible even in desert lands, water shed management and the like to improve productivity.

Thirdly, improvement in farming techniques by rotation in cropping pattern, proper and timely use of fertilizers (chemicals, organics, microbial, worm (earth worm culturing) and pesticides and use of modern tools (weeders, thrashers, winnoers).

Fourthly, the food problem is aggravated by losses of food grains before and after harvesting. Estimates of losses vary from 15 to 40 per cent. There is an urgent need to ensure proper storage and handling of food-grains, so that they are not susceptable to loss and spoilage because of rodents, insects and weather conditions.

Check Your Progress-4

4. Name the four ways of increasing food supply.

Note: (a) Answer the question in the space provided below.
(b) Compare your answer with the one given at the end of this unit.

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Attempts have been made and are continuously striving at the Central Food Technological Research Institute (CFTRI), Mysore to develop techniques for the prevention of food losses.

They include fumigation of the storage rooms or godowns (Duro fume-process) pest proofing of gunny bags used for storing grains and the use of non-toxic grain protectants or chemicals toxic for insects, but not for man. Fumigant tablets (minifume) are available for use by the housewives. Low cost indigenous fumigants also have been formulated to disinfect rat burrows and termite colonies.

Methods have also been developed for better preservation of fruits, vegetables, milk, eggs etc. There is a need to develop and evaluate household methods for the storage of these commodities.

Fifthly, education and training programmes like kisan forums, organisation of periodical melas etc. in the newer skills to the farmers. Encouraging farmers and giving incentives/ gifts for those who produce more, use newer farming technologies and the like are some of the programmes to improve production.

1.7. ALTERNATIVE FOOD SOURCES

Miscellaneous Foods: Insects, marine invertebrates and fungi have been made use of as food. Odd and exotoxic foods add variety and pleasure to the necessity of eating. In some communities and certain countries some uncommon foods add pleasure as well as nutrients. For the buntu child for instance reared on little else but maize, grasshoppers (in season) may supply much needed amino acids. The small boy raised on taro raised on a Pacific atoll may improve his calcium intake by catching and eating - the small fish that abound in pools of the coral reef. Similarly in West Africa who depend on Cassava will derive nutritional benefit from catching and eating monkey. Nutritionists who carried diet surveys in under-developed areas must always make note of such sources of nutrients.

New Sources of Foods: Man is no longer limited in his choice of conventional foods and man can not depend only on conventional foods with the growing population. The vast improvements, in food technology provides the possibility of preparing foods from unusual (non-conventional) sources of foods.

a) *Plankton:* The surface water of the sea are inhabited by enormous number of minute microscopic animals - mainly crustacea and coelenterates. Plankton when cooked forms a thin sort of gruel with shrimp-like taste.

b) *Chlorella:* A unicellular green algae forms the scum on the top of many ponds. Like green plants, it grows by using the energy of sun rays for photosynthesis and can make carbohydrates and protein out of the simple elements of carbondioxide, water and inorganic nitrogen. Essential nutrients could be extracted from Chlorella grown under scientifically controlled conditions, perhaps using atomic energy to promote the photosynthesis. Certain types of algae, such as blue green algae is consumed traditionally in Japan and India. Food factories operating on this principle would make man less dependent for his nutritional needs on the vagaries of the climate - and farmers.

c) *Green Leaves/Leaf Protein Concentrates:* These are the most efficient means of making sun light to produce maximum amount of organic matter on a given area of aerable land. Fresh young grass contains good amounts of protein. Traditional cows eat grass and turn it into milk, but cow is not an efficient

machine in this respect. At least 3/4 of the protein is lost for human use. Leafy vegetable cultivation gives maximum yields (20,000 to 40,000 kgs per acre). Leaf protein concentrates (powder form) have been prepared and advocated by CFTRI for incorporating into traditional recipes to improve the protein quality and quantity. They have been experimented successfully in both animals and humans to alleviate protein malnutrition, but the green colour to the food was the unacceptable aspect of this non-conventional food.

d) *Proteins from Petroleum:* French scientists have shown that it is possible to grow yeast using petroleum oils as substrates to provide energy. Attempts have been made all over the world to get proteins from petroleum. These proteins however are reported to contain residual quantities of hydrocarbons which have been made free through technology development.

e) *Mushrooms:* Now a days there is growing interest in the cultivation and use of mushrooms though its consumption was less common in this country especially in South India. They can be valuable addition to food (diet) and can be grown indoors. The most commonly cultivated mushrooms are *Agaricus bisporus* (button mushroom), *Pleurotus sp.* (oyster mushroom) *Volvariella* (paddy straw mushroom) etc.

f) *Synthesis of Nutrients:* Some of the nutrients such as vitamins, amino acids are synthesized commercially for quick use to relieve nutritional deficiencies using micro–organisms such as fungi, bacteria etc.

Check Your Progress-5

5. What are the new sources of food?

Note: (a) Answer the question in the space provided below.
(b) Compare your answer with the one given at the end of this unit.

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1.8. PUBLIC DISTRIBUTION SYSTEM IN INDIA

To protect the interests of the low income consumers and to maintain them in the open market system has failed. The over all stability of the general price level necessitated a central public distribution system (PDS) in India. Government has been recognised the PDS as a permanent feature of the economy for supply and distribution of essential commodities at reasonable prices to the people, particularly the weaker sections of the society. The public distribution system has two fold objectives:

1. To ensure supply of essential commodities to vulnerable sections at a reasonable price.
2. To protect masses from the vagaries of open market mechanism. It intends to–
   a) bring stability in the availability of food grains,

b) to curb the tendencies of certain unscrupulous sections to indulge in profit, during times of shortage and

c) to ensure equity at reasonable prices throughout the country.

The existing PDS operates through a nationwide network of retail outlets called fair price shops. It has been growing steadily. The number of fair price shops have increased substantially and are located at many places and these recently are being maintained by Mahila mandals also.

The procurement task of paddy wheat and other commodities is done by the Central Department of Food, the Food Corporation of India, the State Government and the Co-operatives.

1.9. POLICY FOR DEVELOPMENT OF AGRICULTURE PRODUCTION

In January 1946 government issued a statement on Agriculture and Food Policy in India. The main goal of this was enunciated as: to move the country "away from the menace of famine to a new vigour and prosperity".

'Grow more food' campaign was initiated in 1942. This was later modified as integrated production programme in which besides food grains, cotton and jute also received importance. These were then integrated into 5 year plans. The Community Development and National Extension Service Programme was started into which Agricultural improvements and social development of village life were made the major objectives. Under the new strategy of agricultural developments, in the year 1966-67 on a field scale modernization of agriculture through adoption of scientific inputs and associated improved practices were included.

Similar strategies were adopted in the sphere of animal husbandry (live stock). Initially key village schemes were started and were followed. In the later years under the intensive cattle development projects, cattle and buffaloes, cross bread cattle and improved indigenous cattle and buffaloes were multiplied through artificial insemination. The associated practices of feeding and better health measures were also adopted which resulted in higher milk yields. With regards to poultry, sheep and pigs also modern practices were initiated. Similar modernisation methods and techniques were introduced in feeding, harvesting and marketing.

Mechanisation of boats and development of infrastructural facilities were the two principal means through which total catch in marine foods was sought to be increased.

Agriculture policy is generally aimed at the development of agriculture and increasing the rate of agriculture production per acre and per capita in particular for the people and to the country's welfare and prosperity.

Objectives of Agriculture Policy:

1. For the attainment of a prosperous and egalitarian society - first an adequate supply of goods and services to support a rising standard of living and secondly, sufficient, employment and income opportunities for the masses are to be planned.

2. Secure demand and supply: The problem of Indian economy is not the lack of demand but insufficient supply of agriculture commodities. Hence a rapid rate of growth in agricultural production becomes obligatory and it has to be planned for and to achieve supply demand balance.

3. Secure Social Justice: Widest possible participation of the weaker sections and backward areas in the very process of growth is to be ensured as to reduce disparities in levels of income and consumption.

4. To Generate Maximum Employment: Creation of employment opportunities and rising the efficiency of productions are of crucial importance for the development of agriculture.

5. Diversified Agriculture Activities: Efforts should be made to achieve on integrated development of crop production, Livestock and poultry, fishery and forestry to accelerate the rural economic development. In addition to a diversified base of rural economy supportive marketing and institutional facilities are to be provided. The development of subsidiary occupations like milk production, poultry, sheep and pig rearing and fisheries as well as forest production are of particular importance for enlarging employment and income opportunities of small and marginal farmers and agricultural labourers. This also enlarges the possibilities of export and import substitution.

6. Intensive Use of Land Resources: Agriculture policy should be such as to ensure intensive use of land, create wide spread productive employment and reduce disparity. Efforts should be made that all surplus land be distributed to the landless and marginal farmers.

7. A Faster growth rate in food production to meet the demand for food and raw material as also to create surplus for export and elimination of imports be taken care of. The production policy should be based on modernisation of agriculture in which adoption of technology is the most crucial input. A continuous expansion in production is also necessary for creating surplus for export in raw or processed form of agricultural products.

8. Eradication of Poverty and Distribution Policy: It is not enough to produce more only to eradicate poverty and hunger without proper distribution policy. Food distribution policy should be directed to help the weaker sections through promotional and protective programmes. The present day fair price shops and ration card system are the policies in this direction.

9. Production Policy should be Nutrition Oriented: Production policy should be nutrition oriented to ensure adequacy both in respect of quantity as well as quality. Production programmes should confirm to the needs of different population groups and different regions (socio-cultural habits). The aim of production should be to reduce nutritional deficincies through production of more protective foods like animal and vegetable protein foods (milk, meat, poultry, fish, pulses, oil seeds etc.) and also vegetables and fruits. Particular care should be taken to ameliorate the nutritional deficiencies of the low income group. Most important is to restrict diversion of primary foods to industries for conversion into processed and sophisticated foods which are consumed by the rich people. Only such foods which are in surplus may be processed and preserved so that the interests of the low income group are adequately met.

1.10. SUMMARY

India is largely dependent on agriculture for feeding its millions of people. Population growth in India is alarmingly high and has become an anxiety to the agricultural scientists,

economists and demographers. Efforts are to be made to increase the rate of production by increasing the cultivable land area and intensifying the per acre yields so that a demand supply balance could be achieved. People also should slowly be prepared to change the conventional eating habits and accept novel unconventional food sources. Government should monitor and activise the public distribution systems (PDS) for the welfare of the low income groups.

1.11. CHECK YOUR PROGRESS : MODEL ANSWERS

1. The earth carrying capacity of people is around 5600 million.
2. The national food production declined during the years 1965-66 due to severe drought.
3. The total output of food in 1980-81 at global level is 1517 million tonnes.
4. Increasing the cultivable area, construction of dams, improvement in farming techniques and proper storage and handling of food grains are the four ways of increasing the food supply.
5. Plankton, Chlorella, green leaves/leaf protein concentrates, proteins from petroleum, mushrooms etc., are the new sources of food.

1.12. MODEL EXAMINATION QUESTIONS

I. Answer the following questions in about 30 lines each.

1. Explain the reasons for food problems in developing countries.
2. Discuss about the alternative food sources.
3. Explain the policies and their objectives of Government for the development of agricultural production.

II. Answer the following questions in about 10 lines each.

1. Write briefly about population explosion.
2. What are the trends and problems in agriculture food production.
3. Explain briefly the miscellaneous foods.
4. Write briefly about *Chlorella* as a new source of food.
5. What are the objectives of public distribution system.

Prof. D. Peramma

UNIT - 2: NUTRITION

Contents

2.1. OBJECTIVES

After going through this unit you will be able to:

* define food, nutrition and health,
* listout different functions of food in the body,
* explain the daily requirements of different foods to maintain health,
* describe the effects of food habits on health,
* describe the effects of malnutrition on the health status of man,
* suggest the remedial measures and the role of Government.

2.2. INTRODUCTION

Good nutrition is an indispensable component of healthy life. It is the common denominator for the healthy growth of mind and body. Malnutrition is wide spread in India, based on the studies undertaken by the National Nutrition Monitoring Bureau (NNMB). The major nutritional deficiency diseases identified in India are protein energy malnutrition (PEM), vitamin A deficiency, anaemia and endemic goitre. Lathyrism and endemic fluorosis have also been identified as significant problems in certain parts of the country.

Nutritional deficiencies are not the only problems confronting the growing population, food habits, some traditional beliefs, fads and fallacies in the use of foods contribute to malnutrition.

Adulteration of foods is yet another commonly practiced menace in the society. Adulterants not only deteriorate the quality of foods but also lead to deleterious effects.

Whatever be the causative factors malnutrition lowers one's resistance to disease resulting in higher morbidity, apathy, lethargy and reduction in work capacity.

2.3. FOOD, NUTRITION, HEALTH, AND CLASSIFICATION OF FOODS

Food is defined as, substances that are edible and digested by humans without causing any toxicity/or poisonous to the physiological system.

Nutrition is defined as, the food that is digested, absorbed into the blood stream and perform all the functions or atleast one of the functions like - a) energy yielding, b) body building and repair, and c) protect from disease.

Good health is defined as that state of well being which enables one to carry on an active and productive life. The corner stone of good health is good nutrition - in other words the food we eat makes what we are.

The word nutrition or nutritional status may also be used to describe the bodily conditions or state. One way to judge good nutritional status of an individual is by judging the outword signs listed below:

Body	:	Well developed, correct weight for height and age.
Muscles	:	Well developed and firm.
Skin	:	Smooth, clear and slightly moist.
Hair	:	Smooth and glossy.
Eyes	:	Moist, clear and without dark circles under them.
Facial expression	:	Alert but without strain.
Good Posture	:	Head erect, chest up, shoulders flat, abdomen in.
Attitude	:	Good natured, full of life, buoyant
Sleep	:	Sound
Digestion and Elimination	:	Good
Appetite	:	Good
Appearance	:	Of general well being

To attain these goals of good nutrition one should know the functions of foods in the body, and how these foods are classified according to functions and how much (quantity) we should eat.

The different foods we consume may be broadly classified under three heads. They are:

1. Energy yielding foods (to provide energy)
2. Body building foods (to help in body growth and repair) and
3. Protective foods (to protect from disease)

2.3.1. Energy Yielding Foods

This group includes foods rich in a) carbohydrates and also b) pure fats.

a) Carbohydrates: Carbohydrates are a class of energy yielding substances which include starch, glucose, cane sugar, milk, sugar etc. Grain foods, and roots and tubers are largely composed of starch, a complex carbohydrate. Food ingredients like simple sugars namely cane sugar and glucose are pure carbohydrates. Starch is a complex carbohydrate made up of glucose units. Glucose derived from starch and other sugars present in the diet is the main source of energy (calories) in the body. Carbohydrates derived from cereals form chief source of energy in Indian diets. Starches when enter in a cooked form are completely

digested in the gastrointestinal tract and the released glucose is absorbed and metabolised in the body to yield energy.

b) Pure Fats: Fat is an important component of diet and serves a number of functions in the body. Fat is a concentrated source of energy and it supplies per unit weight more than twice the energy furnished by either protein or carbohydrate.

2.3.2. Body Building Foods

Food rich in proteins are called body building foods Growth and repair are the functions which differentiate the living from the non-living. For body growth and repair of the tissues proteins are required.

Proteins are vital to any living organism. They form the important component of all cells, muscle and other tissues and vital body fluids like blood. Proteins supply the body building material and make good the loss that occurs due to wear and tear. Pulses, meat, fish and egg contain more protein than other foods.

2.3.3. Protective Foods

Foods known to be naturally rich in some nutrients are presumed to be rich in others as well. These are classified into two groups -1) Foods rich in proteins, of high biological value, vitamins and minerals e.g. milk and milk products, fish poultry, meat, and eggs. 2) Foods rich in certain vitamins and minerals only e.g. green leafy vegetables and fruits.

2.4. CHEMICAL COMPOUNDS IN FOODS

Human body is made up of chemical compounds and foods we eat are composed of chemical compounds which are known as nutrients. Six classes of nutrients are supplied from foods - 1) Carbohydrates (starches), 2) Proteins, 3) Fats, 4) Vitamins, 5) Mineral elements, and 6) Water (though not exactly a nutrient).

Nutritional Classification of Foods: 'Nine Food Group Plan': A food guide is useful for promoting good nutrition and better health. The 'Daily Food Guide' was designed to provide a flexible frame work or foundation for making food selections to meet the nutrient needs specified in the Recommended Dietary Allowances. It is intended to be easy to use, easy to remember, and adaptable - to increase the chance that sound nutrition can be achieved by all people. Foods have been divided into groups which are similar in food composition and have the same function in the body.

Table 2.1. Nutritional Classification of Foods - Nine food group plan

Food Group 1	Main Nutrients Contributed 2
I. Energy Yielding Foods:	
Group - 1 Cereals, Rice, wheat, ragi, bajra, jowar, maize etc.	Supplies more than 70% calories, – 50% B-Vitamins, – 80% calcium.
Group - 2 Roots and Tubers	Good source of starch and fair source of vitamin C

1	2
Group - 3	
Sago, sugar and jaggery	Rich sources of carbohydrates
Group - 4	
Oils and fats	Essential Fatty acids, vitamin E and vitamin A
II. Body Building Foods:	
Group - 5	
Milk and milk products, flesh foods	Proteins of moderate nutritive value, vitamins and minerals
Group - 6	
Pulses, nuts and oil seeds	Proteins of moderate nutritive value, B_1, B_2 and F_e
III. Protective Foods:	
Group - 7	
Milk	Proteins, calcium, Vit.A, B_2 and B_{12}
Liver	Proteins, Vit. A, B_2, folic acid, B_{12} and Fe
Eggs	Proteins, Vit. A, B_2, B_{12} and Fe
Group - 8	
Green leafy vegetables	Proteins, Vit. A, Ca, Fe, Folic acid, Vit. B_2, Vit. C
Group - 9	
Fruits and vegetables	Fair to good source of Vit. C.

2.5. BALANCED DIET

Balanced diet is a judicious mix of all essential nutrients - proteins, carbohydrates, fats, minerals, vitamins and water as required by our body. A healthful diet should first of all nutrition related diseases, secondly, it should minimise the risk of diseases associated with our consumption.

An ideal diet cannot be defined. The concept of healthful diet differs from person to person. Infants, young children and adolescents need nutritionally rich diet to meet the demands of their growing bodies and elderly require foods to maintain and tissue repair.

2.6. RECOMMENDED DAILY ALLOWANCES (RDA)

The amounts of different nutrients recommended in dietary standards usually exceeds those found to be needed for metabolic requirements. This extra amount represents a margin of safety to allow for differences between foods with regard to availability of nutrients and between individuals with regard to the efficiency of utilization. Also the requirements differ with age, sex, activity, weight, height special groups like infants, pregnancy, lactation, the age and metabolic disorders.

National and International Organizations such as FAO, WHO, NNMB and ICMR in India are involved in formulating the dietary and nutrient allowances. These are summarized in the tables.

TABLE 2.2. DIETARY AND NUTRIENT ALLOWANCES

Group	Particulars	Net energy Kcal/d	Protein g/d	Fat g/d	Calcium mg/d	Iron mg/d	Vit.A ug/d	Vit.B_1 mg/d	Vit.B_2 mg/d	Vit.C mg/d
Man	Sedentary work	2425						1.2	1.4	
	Moderate work	2875	60	20	400	28	2400	1.4	1.6	40
	Heavy work	3800						1.6	1.9	
Woman	Sedentary work	1875						0.9	1.1	
	Moderate work	2225	50	20	400	30	2400	1.1	1.3	40
	Heavy work	2925						1.2	1.5	
	Pregnant woman	+300	+15	30	1000	38	2400	+0.2	+0.2	40
	Lactation	+550	+25	45	1000	30	3800	+0.3	+0.3	80
Infants	0-6 months	108/kg	2.05/kg	--	500	--	1200	55 ug	65 ug	25
Kg	6-12 months	98	1.65	--	500	--	1200	50 ug	60 ug	25
Children	1-9 years	1240 to 1950	22 to 41	25	400	12-16	1600-2400	0.6 to 1.0	0.6 to 1.2	40
Boys	10-18 years	2190 to 2640	54 to 78	22	600	34-50	2400	1.1 to 1.3	1.3 to 1.6	40
Girls	10-18 years	1970 to 2060	57 to 63	22	600	19-30	2400	1.0	1.2	40

I. Low Cost Balanced Diet (Sedentary Man)

Cereals	460	g
Pulses	40	g
Leafy vegetables	50	g
Other vegetables	60	g
Roots and Tubers	50	g
Fruits (seasonal)	30	g
Milk	150	ml
Oil and fat	40	ml
Sugar and jaggery	30	g

Check Your Progress – 1, 2 & 3

1. Define the terms food & nutrition.
2. What are the functions of food in the body?
3. Give the different nutrients required by the body.

Note: a) Write the answers in the space provided below.
b) Compare your answers with those given at the end of this unit.

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2.7. FOOD HABITS, FOOD FADS AND FALLACIES

Knowledge regarding the food habits of man is provided by many disciplines. The social scientists, anthropologists, sociologists, psychologists and cultural geographers have been concerned with man's culture, social activities and food habits. These include among others, educational and economic level of the community, availability and cost of foods and social and cultural practices. Once the food habits are established, they are handed down from generation to generation. The following aspects are of major concern. 1) Geographic, 2) Religious beliefs, 3) Traditional beliefs, 4) Food fads and cults and 5) Changing food habits.

Geographic: Early man ate whatever food he could get to satisfy his hunger. Soil, climate, water and local agricultural practices determined the types of foods that are green in the locality. Rice is the main food crop in the tropical countries where rain fall is high and water is available for irrigation, while millets are cultivated in areas of low rain fall. Wheat is mainly cultivated in temperate regions.

Religious Beliefs: The various religions of the world had some influence on the food habits. For example, muslims are forbidden from eating pork and Hindus from eating beef.

Traditional Beliefs: Traditional beliefs in food habits are still prevalent with a large majority of the population who are illiterate or ignorant regarding the nutritive value of foods. These beliefs influence profoundly the pattern of food eaten. In South Pacific Islands, it is believed that certain shell fish eaten during pregnancy will cause the child to be born with scales on its head. In India, consumption of papaya fruit by pregnant women is believed to lead to abortion, and consumption of garlic by lactating women will increase milk production. In some parts of India (West Bengal), it was believed that consumption of milk and fish at the same meal will lead to the development of leprosy and leucoderma.

Hot and Cold Foods: Foods are classified as 'hot' and 'cold' by different cultures in many countries. 'Hot' foods are believed to produce more heat in the body and lead to the development of boils. Meat, legumes, eggs, nuts and oil seeds are supposed to be 'hot' foods. 'Cold' foods are supposed to lower the heat production and lead to the development of cold, sore throat etc. Fruits, vegetables and milk are supposed to be cold foods.

Pica: Pica is the habit of eating dirt, clay, chalk, lime stone, plaster, ashes etc. There is a belief that the baby will not be normal if one does not eat clay or starch.

Food Fads and Cults: Exaggerated claims for some foods: Hypocrites wrote of the health value of certain foods. Food fads of various kinds have persisted ever since. 1) According to Indian Ayurvedic system of medicine many foods are reputed to have curative properties of some diseases. For e.g. bitter gourd cure diabetes, 2) Yogurt, wheat germ, brevers yeast and honey have been widely promoted by some food faddists as possessing extraordinary nutritional and medicinal qualities. 3) Fruits and vegetables cultivated using organic manure are believed to possess greater nutritive value than foods grown with inorganic fertilizers. 4) Brown sugar is reputed to possess higher nutritive value than white sugar.

More commonly observed fallacies: 1) Fruits, especially citrus and tomato are too acidic to be handled by the body, 2) garlic cures high B.P., 3) beet builds blood, 4) honey is not fattening, 5) Adults need no milk, 6) Foods cooked in aluminium vessels cause cancer, 7) Cucumbers without salt are poisonous, 8) Fruit juices do not contribute calories to the diet. Most of the above beliefs have no scientific basis.

Cult: For many years, vegetarianism has been practised on religious grounds by Hindus, Buddhists, Zoroastrians, Jains etc. Strict Vegetarians do not even consume milk and hence suffer from Vitamin B_{12} deficiency.

Changing Food Habits: The difference between a food fact and a food fad or a fallacy is that a fact has some scientific basis. A food fad may be compared with a fashion which will soon be replaced by some new belief concerning food. The food fallacy is more ingrained and may owe its beginning to a well publicized food.

Food fads and faulty food habits are the important contributory causes for the wide prevalence of malnutrition among preschool children, expectant and nursing mothers in developing countries. These can be overcome only by education in nutrition.

2.8. MALNUTRITION

Malnutrition describes a state of improper nutrition balance in the body. Malnutrition can be a problem of inappropriate ingestion, digestion, absorption, metabolism, of excretion of nutrients or a combination of several of these factors. Malnutrition can be the result of nutrient excesses as well as deficiencies. Factors such as the amount, and kind of food available, adequacy of housing and sanitation, and the rate of infection, influence the kind of malnutrition and the degree to which it occurs.

When a healthy individual habitually eats in such a way that his nutritional needs are not properly met, the type of malnutrition he develops is primary malnutrition. Primary malnutrition is due to poor food choices or to an inadequate food supply. When malnutrition is the result of faulty body function, secondary malnutrition occurs. Secondary malnutrition may also result as a side effect of certain medications and medical or surgical treatments.

Two other terms used to describe a malnourished individual are undernutrition and overnutrition. Under nutrition applies to an individual who does not ingest an adequate supply of nutrients and overnutrition applies to the individual who eats more food than he needs.

2.8.1. Under Nutrition – Diseases and Remedial Measures

Protein - Energy Malnutrition (PEM): PEM is probably one of the most serious nutritional problems in the world. Often infants and young children in developing nations suffer from a lack of protein and/or calories. PEM occurs characteristically in children under five years. When children are deprived of food and suffer an energy deficit, they degrade their own body protein for energy and thus indirectly suffer a protein deficiency as well as an energy deficiency. The classic energy deficiency disease is marasmus, and the protein deficiency disease is kwashiorkor.

a) Kwashiorkor: The protein deficiency follows soon after weaning. Breast milk provides a child with sufficient protein, but these children are generally weaned to a starchy, protein poor gruel. The gruel does not supply enough aminoacids even to maintain a child's body, much less enough to enable it to grow.

Kwashiorkor typically sets in around the age of two (i) by the time the child is four, his growth is stunted; (ii) hair has lost its colour, (iii) skin is patchy and scaly, (iv) moon face, (v) increase in body weight due to edema, (vi) fatty liver, (vii) diarrhoea and (viii) sickens easily and is weak, fretful and apathetic.

b) Marasmus: The severe malnutritional state resulting from starvation is termed marasmus. Children with marasmus suffer symptoms similar to those of children with the protein - deficiency disease - kwashiorkor, due to the loss of body protein tissue; differences are that kwashiorkor children retain some of their stores of body fat, accumulate fat in their livers and develop edema.

A marasmic child looks like a wizened little old person - just skin and bones. He is often sick, because his resistance to disease is low. All his muscles are wasted, including his heart muscle, and his heart is weak.

Characteristic Symptoms

(i) Growth failure and low body weight.

(ii) Severe wasting of muscle and of subcutaneous fat and

(iii) Dry and atrophic skin.

Most of infants are severely hungry but a few are anorexic.

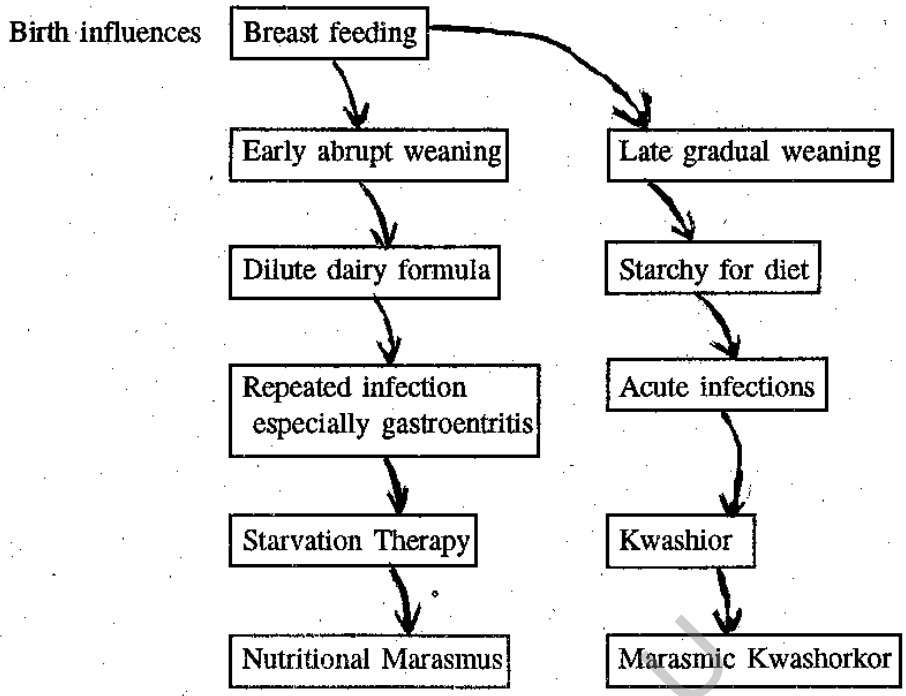

Fig. 2.1. Paths leading from early weaning to nutritional marasmus and protracted breast feeding without supplements to kwashiorkor

Prevention and Treatment

Provide the child with sufficient energy foods and good sources of protein. Milk is excellent but when seriously sick, tolerance to milk will be less and when such a thing happens skimmed milk or casein is to be given. Egg, meat and meat products are good for fast recovery. Alternatively, vegetable protein (pulses, groundnut seed preparations) are also good and are cheap sources of proteins. Many recover well on the RDA for a normal infant of 0-3 months, i.e., 2.3 g/kg/day. But for infants who are seriously ill with indigestive impairment 1 g/kg/day is sufficient to initiate cure though larger amounts are necessary for full recovery.

No age is immune, but in older persons the disease is much less frequent and the clinical manifestations not so obvious and usually less severe, because both protein and calorie requirements are relatively less reduced as age advances.

Vitamin Deficiencies and Prevention

Vitamin A: Vitamin A deficiency continues to be a significant health problem in many developing countries. Vitamin A is essential for the functioning of the mucus membrane which is found in the epithelial tissues of the eye, the tear glands and respiratory gastro–intestinal and urinogenital tracts. In this deficiency mucus secretions decrease or cease. Lack of Vitamin A in the diet is observed on the arms and thighs. As the deficiency is prolonged, the skin becomes 'horny'. This is called Keratinization. Earliest symptoms is the dryness of the conjuctiva. The lack of sufficient amounts of vitamin A in the diet has been related to a condition called nightblindness. Night blindness is the inability of the eyes to

adjust quickly to dark after exposure to bright light, keratomalacia which may result in blindness is found in children with kwashiorkor (diets, deficient in both protein and vitamin A). Follicular keratosis (rough and dryskin) is another condition in vit. A deficiency.

Severe deficiency of vitamin A in humans is often associated with protein energy malnutrition and infection which can modify the immune response. During the years around 1985 considerable debate took place on the extent of vitamin A deficiency, massive doses (2,00,000 IU) of vitamin A supplementation (6 months) on the morbidity and mortality in children.

Most of the children with corneal xerophthalmia also had other conditions such as severe protein energy malnutrition, history of measles, diarrhoea, respiratory illness and a variety of other infections which could also independently contribute to high mortality. Severe vitamin A deficiency involving cornea is reported to be relatively rare where as mild xerophthalmia as evidensed by night blindness, conjuctival xerosis and bitot spots is more widely prevalent. It has been suggested that even mild xerophthalmia may increase the risk of mortality.

Vitamin A deficient children are largely from poorer sections of the families subject to more severe socio-economic and dietary constraints. They are more likely to encounter the multiplicity of threats to survival than those with adequate vitamin A status. Thus the importance of vitamin A in child health programmes is for the prevention of blindness and sufficient reason for strengthening the ongoing vitamin A supplementation programme and in combination with other health care services.

Milder deficiency symptoms can be easily cured and serious deficiency prevented by the regular consumption of leafy vegetables and other carotene rich vegetables and fruits (carrots, yellow pumpkin, papaya, mangoes etc. and animal rich sources for vitamin A - milk, eggs, liver etc.). Children and pregnant women are the special groups for greater attention and prevention of vitamin A deficiency.

Vitamin B (Beri-Beri): Formerly a wide spread disease in orient, caused by eating diets with highly polished (milled) rice. The disease is frequently precipitated by infection, hard physical labour or pregnancy and lactation. The clinical features usually suggests the presence of multiple nutritional disorder, although lack of thiamine produces the predominant clinical changes.

Prolonged deficiency of thiamine or Vitamin B_1 in the diet is one of the main factors leading to the disease beri beri which may manifest in one of the three forms. (1) Dry beri beri - there is loss of appetite, tingling and numbness in the legs and hands and a dropping of the feet. (2) In 'wet beri beri, there is dropsy, palpitation and breathlessness and weakness of heart muscle leading to heart failure and (3) Infantile beri beri. Thiamine therapy produces predominant clinical changes in the condition. With moderate deficiency in the diets the symptoms include loss of appetite, vomiting, constipation, mental depression and vague fears, with more severe deficiency soreness and weakness of the muscle, loss of muscle tone specially in the calf muscle, poor limb coordination, sensitivity to touch etc.

In chronic and sub–acute conditions in infantile beri beri, poor food intake, edema/wasting, excessive urination, puffiness in the face, abdominal pain are formed. Convulsions may also occur.

A high prevalence of beri beri was found in Andhra Pradesh till the 1950 and the age group highly effected are between birth to 12 months (specially between 2-5 months).

Prevention of using highly polished rice, cooking rice by absorption method i.e., non-straining of kanji from rice, using whole grain pulse are found to retain the thiamine content in foods and prevents beri beri.

Vitamin B_2 Deficiency: Some of the clinical symptoms attributed to inadequate intake of this vitamin in the diet are the soreness of tongue (glossitis), cracking at the angles of the mouth (angular stomatitis) redness of the eye and burning sensation in the eyes, scaliness of the skin in the region between the nose and angles of the lips (seborrheic dermatitis). Scrotal dermatitis can also be a result of riboflavin deficiency. Due to this deficiency psychomotor development in children may impaired. Among the several B-complex vitamins, vitamin B_2 deficiency is the most widespread, particularly among children and women in our country. Recent studies indicate that common infections like respiratory infections can accentuate the deficiency of vitamin B_2. Good sources of Vitamin B_2 are milk and milk products, eggs, liver and green leafy vegetables.

Pellagra: People living exclusively on maize diets were found to develop a disease called Pellagra characterised by lesions of the skin (dermatitis), symmetrical butterfly shaped patches on the cheeks are found typically. Diarrhoea and mental changes (dementia) have also been found. It is often called the disease of the 3 D's (Dermatitis, diarrhoea and dementia) and was particularly more prevalent in alcoholics.

Indian studies have shown that in the pathogenesis is of Pellagra in populations subsisting on the millet jowar (which unlike maize) is not deficient in tryptophan, excess of amino acid leucine and deficiency of pyridoxine may play a part. Pellagra is now fortunately on the reduction side.

Whole cereals, pulses, nuts and meat are good sources of nicotinic acid. Groundnut is particularly rich in nicotinic acid. Although poor in nicotinic acid milk is also effective in preventing pellagra because it is rich in tryptophan.

Scurvy: Scurvy is caused by a deficiency of vitamin C (ascorbic acid). There is an impairment of collagen formation and retards wound healing and from fractures. The blood capillaries become fragile and hemorrhages occur. The first symptoms of deficiency to be experienced are weakness, fatigue, loss of appetite, swollen and bleeding gums. The joints become swollen and painful. The skin become dry and rough. Anaemia is generally associated with Vitamin C deficiency.

Scurvy can be prevented by inclusion of fresh fruits and vegetables in the diet. Sprouted grams and cereals contain good amounts of vitamins. Richest sources of Vitamin C are green leafy vegetables and extracts, drumstick, leaf tea, amla, guava, lime, orange juice etc. Vitamin C is heat labile and mild acidification (light tamarind water, lime juice) reduces oxidation losses.

Other Vitamin Deficiency Diseases

Rickets is a disease caused by Vitamin D deficiency. It is found in children characterised by pigeon chest, rosary beads, deformities of the legs etc. The joints become painful and the child is extremely irritable. Severe rickets leads to tetany and death. In women of the child bearing age a deficiency of this vitamin results in a decrease in the mineral content of the bone and the failure of osteoid tissue to calcify satisfactorily. This condition is known as ostematocia. In the deficiency of Vitamin E, blood has a greater tendency to hemolyse and this may result in anaemia and reproductive failure may result in severe deficiencies.

Mineral Deficiency Diseases - Prevention

Anaemia: Anaemia refers to the clinical condition in which there is disturbance (i) in the formation of haemoglobin, eg., iron deficiency, (ii) in the maturation of proerythroblast e.g., vitamin B_{12} of folic acid deficiency, and (iii) depression or destruction of the haemopoietic cells in the red marrow, e.g., effect of toxins or drugs or x-rays on the bone marrow, anaemia may be broadly divided into 3 groups -

i) Anaemia due to nutritional deficiencies, i.e., deficiencies of iron, copper, folic acid or vitamin B_{12}.

ii) Due to loss of blood (haemorrhage) or destruction of RBC (Haemolysis).

iii) Due to depression of the RBC forming tissues of red marrow due to toxins or exposure to x-rays etc.

Anaemia due to iron deficiency is particularly common in reproductive age women and young children. Haemoglobin surveys in different areas reveal that 40 to 90 per cent among women suffer from anaemies and about 10 per cent from severe anaemia (Hb - 8%). About 85 per cent of the anaemies encountered among rural labourers in hot, damp, tropical regions respond to iron therapy. Consequences of iron deficiency anaemia - (1) during fetal life: still birth, abortions, prematurity (2) maternal deaths.

The deleterious effects of iron deficiency are seen earlier than the anaemia stage. The latent iron deficiency is likely to be more wide spread and changes induced in placenta, brain etc. are mostly irreversible. Thus the iron stores have to be built up in pre–conception period and the adolescent stages to prevent health consequences of this nutrient deficiency.

Food sources for preventing iron deficiency anaemia are given below:

Cheap but rich sources: Green leafy vegetables, whole grains and enriched foods some fruits, raisins etc.

Costly but rich sources: Meat particularly liver, egg yolk etc.

Table 2.3. Haemoglobin levels below which anaemia may be said to exist:

Group	Age	Hb g/dl
Children	6 months to 6 years	11
	6 years to 14 years	12
Adults	Men	13
	Women	12
	Pregnant women	11

Goitre: The importance of the trace (micro) mineral iodine in relation to thyroid gland is known very well. The adult body normally contains 20-50 mg of iodine. About 8 mg of this amount is concentrated in the thyroid gland. The thyroid tissue has the property of storing the iodine and releases it slowly in the form of thyroid hormone (thyroxin). During iodine deficiency the release of this hormone diminishes and the whole tempo of the persons life is slowed down. When the iodine level of the blood is low, the cells of the thyroid gland enlarge in an attempt to trap as many particles of iodine as possible. If the gland enlarges until it is visible, it is called a simple goitre.

Clinical Effects of Complications: In great majority of cases of simple goitre there are no clinical manifestations due to hypo or hyper function.

Simple colloid goitre may require surgical treatment either for aesthetic reasons or because of pressure effects on the adjacent structures. The following complications occur on the severity of the deficiency and in endemic regions.

1. *Hypothyroidism:* This condition occurs when the harmones are inadequately produced. This condition produces sluggishness, sleepiness, dry skin, cold intolerance and sometimes constipation.

2. *Cretinism:* Cretins have severe irreversible mental retardation. Other signs including deaf-untism, short stature and retardation of musculoskeletal system.

3. *Reproductive Impairment*: More miscarriages, still births, low birth weight babies.

4. *Infant mortality:* It also lead to high child mortality due to impaired defence against infections.

As against earlier observations the magnitude of this problem in India is as high as 150 million people with the risk for IDD (Iodine Deficiency Disease) and this figure may reach 200 million by the year 2000 AD. It is currently estimated that iodine deficiency causes goitre in 40-50 million Indians. Severe mental retardation in 2.2 million and wider neurological deficits in 6.6 million. Recent studies in India indicate the presence of goitre even in areas outside the sub-Himalayan belt. An ICMR Survey in 14 districts indicate an alarming prevalence of endemic cretinism. Studies in India revealed hitherto inspected serious dimensions of the problem of neonatal chemical hypothyroidism (NCH) and that as high as 13 per cent of neonates in endemic goitre areas are functionally decompensated with respect to thyroid function. In yet another study nearly 15 per cent of school children investigated in endemic goitre area had evidence of neonatal under development. Out of the 200 million people in endemic regions of the country more than 54 million have goitre and one million show different grades of mental and motar handicaps.

More and more pockets of endemic goitre are being reported from different parts of India which include the hilly tracts of Central India, Sub–Vindhya belt of Madhya Pradesh, the Aravali ranges of Rajasthan along Narmada valley in Gujarat and certain big cities in Maharashtra State. The tribal areas of Visakhapatnam district of Andhra Pradesh were also reported to be endemic goitre areas. In the villages of Adilabad it is found that 50 per cent of adults adolescents and school age children had varying degree of goitre.

Iodine is easily met by consuming sea food and vegetables grown in iodine rich soil. Iodine administration is also in the form of iodized salt, iodized bread or iodized oil have all been demonstrated to be effective. Because of the urgency and need Nation wide programme of Iodization of salt has been started and by 2000 AD it is ordered that all common salt should be replaced by iodized salt in the markets.

Check Your Progress - 4, 5 & 6

4. What is meant by marasmus?

5. What are the characteristic symptoms of marasmus?

6. What is the disease of 3 D's?

Note: a) Write the answers in the space provided below.
b) Compare your answers with those given at the end of this unit.

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2.8.2. Over Nutrition, Diseases and Remedial Measures

Obesity: Obesity is a disease of civilization and one of the most common nutritional disorder in west and the well to do. This gives rise to more ill health than all vitamin deficiencies put together. Obesity is a condition in which excessive accumulation of fat in the storage areas of the body takes place.

Aetiology: Obesity can only occur by excessive intakes of food than the physiological needs. The food eating behaviour is controlled by the centres in the hypothalamus in the brain. Very occasionally in man disturbances in feedings are shown to be due to disease affecting the hypothalamus. However the regulation mechanism may also be influenced by a variety of other factors.

Age and Sex: Obesity can occur at any age and in either sex. In children, after puberty it is more common in girls. It is especially liable to occur after pregnancy and at menopause. In men it is most common after the age of 35 years.

Economic Status: Food is a symbol of luxury and with increasing income the food will be available in plenty and more of sweets and fats are consumed in excess.

Eating Habits: Eating habits of obese people are variable. Some eat three large meals a day, while others eat frequently 5 or 6 times a day. In both the groups, excessive food intake is the cause of obesity. Some people develop voracious appetite after evening meal and eat again in the night.

Physical Activity: Obesity is rarely found in those who lead active lives involving hard physical exercise both in occupation and recreation. The farmer who walked behind his plough uses 400 k cal an hour, now rides a tractor and uses 130 k cal an hour. Similarly the housewife who used to wash clothes by hand spends 250 k cal an hour, now uses a washing machine at a fraction of that amount. Now with the coming of television into homes all members in the house have diverted their active recreation to sedentary viewing leading to more people becoming obese. Hence activity may be a most important factor explaining the frequency of what has been described as 'creeping' over weight in modern societies. Although it was once fashionable to do exercise as a means of reducing weight, it is now taken seriously by most of the people for reducing weight along with diet.

Genetic Factors: It is general observation that obesity is seen in some families. Several genes might be responsible for obesity but it is difficult to know the nature of the genetic factors responsible. Also it is difficult to distinguish their influence from those of family customs and eating habits.

Endocrine Factors: Failure of thyroid gland is sometimes blamed. A consistent excess intake of as little as 50 kcal/day can lead to a weight gain of around 2 kg over the course of a year. Fifty calories can be obtained following small amounts of food or drink, about 30 g of lean meat or chicken, one small potato, one fistful of rice, 1/2 teaspoonful of butter, half a glass of milk. A similar situation may occur from a small reduction in physical work when the daily calorie intake remains constant.

Treatment: Treatment to obesity is very difficult to suggest as well as to follow. Also the treatment is slow, gradual and requires a whole hearted involvement. One day fasting may not serve the purpose and may lead to other complications.

The weight reduction regimen is not to loose weight drastically. Not more than 1.2 to 1.4 kg/week should be lost. For this a 1000 to 1200 k.cal/day diet should be planned and followed till the expected weight loss occurs. The calorie reduction needed for shedding the excess weight for achieving normal weight is given in Table 2.4.

Table 2.4. Calorie reduction needed to reduce weight.

Excess weight	Calorie reduction needed for achieving normal weight	
	3 months	6 months
20 kg	800	1600
10 kg	400	800
5 kg	200	400

To summarise the cause of obesity is too much of food intake, too little exercise or both.

Table 2.5. Approximate amounts of different foods providing 100 Cal.

Food Group	As consumed
Fats and oils	2 - 2 1/2 tea spoons
Sugar	5 - 6 tsp
Tea and Coffee	1 - 1 1/4 cup
Milk with sugar, curd	3/4 - 1 cup
Roasted groundnuts	1 1/2 - 2 tsp
Cashewnuts, almonds	1 - 1 1/2 tsp
Biscuits	4 - 6
Rice	1/2 cup
Chapathi	1
Poori	1 1/2 - 2
Liquid dhal	1 cup
sprouted legumes	1/2 cup
Vegetable: Low calorie	1 - 1 1/2 cup
High calorie	1/2 to 3/4 cup
Banana	1
Fried snacks	1/2 serving (30-40 g)
Halwas	One small piece (20-25 g)
Vada	40-50 gm
Idli	1 cup
Dosa/omelette	1
Boiled egg	1 - 1 1/2
Jam	2 tsp

Other Nutritional Deficiency Diseases

Lathyrism: Lathyrism is associated with the excessive consumption of the legume kesaridhal or *Lathyrus sativus*. Much of *Lathyrus* is grown in M.P. (Madhya Pradesh.) In the areas where the legume is consumed exaggerated knee and ankle reflexes in children and outward gait while running are quite common.

The disease starts with weakness of lower limbs. The movement at the ankles and knee joints become painful. With the progress of the disease the foot of the patient becomes completely flexed and the patient is unable to stand or walk. In some cases the onset may be sudden.

A major break through with this disease is the isolation of the toxic factor B-N oxalyl amino alamine. With a good diet even severe cases may respond and milder cases may take longer time for the diseases.

With the National scarcity of pulses, *Lathyrus* seeds are now apparently in high demand especially in Southern states where they are freely used as an adulterant with red gram dhal thus reducing the disease condition in the home land. Hence one has to be careful while purchasing red gram dhal as *Lathyrus* resembles that of red gram dhal.

Fluorosis: Excessive amounts of fluorine (3 to 5 ppm) in the diet or drinking water are toxic and may cause gastro–enterities, nephritis and liver damage. Endemic fluorosis was identified as a disease entity over 50 to 55 years ago. Consumption of moderately high amounts for longer periods result in changes in the teeth and skeleton. With mild fluorosis the teeth become mottled, enamel is lost and become chalky white. This may be followed by brown pigmentation and mottling specially in the incissors of the upper jaw. The condition is generally found after the eruption of permanent teeth.

If people live in endemic fluorosis areas they may develop even skeletal abnormalities. In the early stages a tingling sensation appears allover the body followed by pain and stiffness in the region of the spine. Gradually the bone become stiff and the person loses his ability to send or turn his head. There is a progress in loss of appetite and general wasting occurs.

Osteo–fluorosis has been found in areas of Nalgonda district in Andhra Pradesh where the water contains 11 ppm of the fluoride. Also Punjab is reported to have this disease. Normally fluorosis is expected where the fluorine content of water exceeds 5 to 6 ppm.

Additional quantity of milk/milk powder or calcium and ascorbic acid rich foods in diet protects against this disease. Another important preventional aspect is by defluoridation of water by filtering the suspected water through activated charcoal. Now a number of areas have been identified for fluorosis - Nellore,Visakhapatnam, Nagarjuna area, Anantapur etc. and defluoridation plant for safe drinking water supply have been taken up in these areas.

Check Your Progress - 7

7. What are the common symptoms of Lathyrism?

Note: a) Write the answer in the space provided below.
b) Compare your answer with the one given at the end of this unit.

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2.9. SUMMARY

How healthy we are depends on what we eat. The judicious selection of foods and the quantity of foods consumed keeps you energetic, builds up the body and helps to avoid any infection and disease. Healthy individuals lend a long and productive life.

2.10. CHECK YOUR PROGRESS : MODEL ANSWERS

1. Food is nothing but a substance which is edible and digested by human beings without causing any toxicity to the physiological system. Nutrition is defined as the food that is digested, absorbed into the blood stream and perform all the functions.
2. The functions of food in the body are: (a) energy yielding (b) body building and repair and (c) protection from diseases.
3. Different nutrients required by the body are: (a) Carbohydrates, (b) proteins, (c) fats (d) vitamins, (e) mineral elements and (f) water
4. The severe malnutritional state resulting from starvation is known as marasmus.
5. Growth failure and low body weight, severe wasting of muscle and of subcutaneous fat and dry and atrophic skin are the characteristic symptoms of marasmus.
6. Pellegra is often called as disease of 3 D's (dermatitis, diarrhoea, dementia).
7. Exaggerated knee and ankle reflexes in children outward gait while running are the common symptoms of Lathyrism.

2.11. MODEL EXAMINATION QUESTIONS

I. Answer the following questions in about 30 lines each.

1. How do you classify food? Describe each one of them.
2. What are the aspects that govern the food habits? Explain each one of them.
3. What are the diseases caused by under nutrition? What are the remedial measures?
4. Write briefly about vitamin deficiencies and their prevention.
5. Explain briefly the mineral deficiency diseases and their prevention.
6. What are the diseases caused by over nutrition and suggest remedial measures.

II. Answer the following questions in about 10 lines each.

1. Write briefly about carbohydrates.
2. Write briefly about body building foods and protective foods.
3. Write briefly about protein-energy malnutrition.
4. Write briefly about Kwashiorkor.
5. What is marasmus? Write briefly about it.
6. What are the symptoms of vitamin-A deficiency? How do you prevent it.
7. Explain the deficiency symptoms of Vitamin-B and its control measures.
8. Write briefly about pellagra.
9. Discuss briefly about scurvy.
10. What is anaemia? Explain the three groups of anaemia.
11. Write briefly about Goitre.
12. Discuss briefly about Lathyrism.
13. Write briefly about fluorosis.

Prof. D. Peramma

UNIT - 3 : FOOD SPOILAGE, PREVENTION AND PRESERVATION

Contents

3.1. OBJECTIVES

After going through this unit you will be able to:

* describe the reasons for the spoilage of foods,
* list out and describe the ways of spoilage,
* define food standard and
* describe the methods of storage of both grains and perishable foods.

3.2. INTRODUCTION

Rising population and income are increasing the demand for food at an unprecedented rate. In this country substantial portion of food produce is lost due to spoilage and there is sizeable gap between figures available for production and available for consumption. The losses are much more in the case of vegetables and fruits because they come under perishable foods. The Central Food Technological Institute has developed technologies for grain storage and fruit and vegetable preservation. A knowledge of these methods will go a long way to avoid food wastage and also make the best utilization of available foods in times of non-season.

3.3. FOOD SPOILAGE/POISONING AND PREVENTION

Food poisoning is caused by eating harmful/contaminated food. The most usual symptoms of food poisoning are stomach pain, vomiting and diarrhoea. There can be no evidence of food poisoning though sometimes spoilage can be detected by a change in colour, texture, taste and flavour.

There are three types of food poisoning - (1) Chemical, (2) Biological and (3) Bacterial.

3.3.1. Chemical Poisoning

Chemical food poisoning is caused by the presence of toxic chemicals in food. These substances may be agricultural chemicals which are used intentionally in crop production. The use of weed-killers and insecticides is essential to ensure good yields. However some of these substances may be dangerous if used indiscriminately since they may be toxic if they are consumed in larger quantities.

Poisoning may also be caused by the accumulation of certain metals (lead, mercury, and cadmium etc.) in the body. High levels of mercury and cadmium have been found in fish taken from waters polluted by industrial wastes. Cases of lead poisoning have arisen as a result of drinking water that has passed through lead pipes.

Outbreaks of organic mercury poisoning have occurred in Iraq and Guatemala where farmers who had received grain seeds treated with an organic mercury fungicide and ate the seeds instead of planting them.

Occasionally food poisoning may also be caused by chemicals accidentally added to food during preparation and cooking. However cases of this nature are rare.

3.3.2. Biological Food Poisoning

Biological food poisoning is caused by eating plant foods containing naturally occurring substances which are harmful. Green potato contain a substance called solamine which causes illness or even death if eaten in large quantities. Therefore green potatoes should always be discarded. Foods containing large amounts of oxalic acid also are to be avoided. Kesari dhal which contains the natural toxicant B-N-Oxalyl-Amino-L-Alanine, when consumed in large quantities affects lower limbs and leads to stiff gait. Similarly soyabeans contain trypsin inhibitors and requires some processing before it is consumed as food.

3.3.3. Microbial/Bacterial Food Poisoning and Hygiene

Our knowledge about foods and preservation or storage would be incomplete without some understanding of the role of microorganisms in the production and spoilage of foods.

Microorganisms, invisible to the naked eye are the yeast, mould and bacteria which resemble the plant cells where as protozoans resemble animal cells. Viruses are also classified as microorganisms but they lie at the boarder between living and non-living matter. They multiply like living cells but can only do so in plant and animal tissue which is called the host tissue. In contrast bacteria, yeast and moulds can be grown in sugar solution with some added nutrients.

Conditions for Growth of Microorganisms: Fortunately for humans most organisms are either beneficial or harmless (Non-pathogenic). A few however cause food spoilage and others cause diseases when they enter the human body (pathogenic). They also differ in the products they form during their growth. Some strains produce citric acid, some produce a particular vitamin where as others remove the same from the medium as they require it for its growth. Most microorganisms require air, moisture and an optimum temperature for survival and growth. A temperature of 30 to 40°C is usually favourable for their growth. At high temperatures they die and at low temperatures, as in freezing they remain inactive but become active again when exposed to favourable temperatures. Foods preserved by freezing should therefore be free from initial contamination.

Non-Pathogenic Micro-organisms in Foods: Fermented foods such as curd, bread, idli contain micro–organisms and they are detailed below.

Curd: Preparation of curd is a way of preserving milk. Microorganisms are capable of converting lactose in milk to lactic acid. This brings about chemical, textural and flavour changes in foods. The chief change is the separation and acidification of casein from milk. The sour taste of the curd is due to the production of lactic acid. The environmental temperature is responsible for the too sourish taste of the curd (optimal temperature is 35-40°C for 5 hrs.). The difference in the flavour of the curd is due to the presence of formula yeast which imparts the cheesy flavour. Lactobacillus bulgaris is also used for the preparation of curd or yogurt. The acid forming bacteria prevent the growth of other organisms which spoil milk including those causing amoebic dysentery.

Bread: Leavened bread made from fermented dough are becoming increasingly popular. In most breads fermentation is brought about by yeast. Yeast cells act on the sugar present in the dough and produce alcohol and carbon dioxide. The CO_2 formed helps the dough to rise. When the fermented dough is baked, the alcohol evaporates and the bread gets its typical porous texture. Other micro-organisms such as *Streptococcus lactis* are also used in making certain varieties of breads.

Most plant foods such as cereals and legumes contain micro-organisms. Species of lactic acid bacteria are found in most of them because of which batters prepared from them ferment without the addition of any culture.

The fermentation of idli batter also is associated with an increase in batter volume and acidity because of the production of carbondioxide and lactic acid. These changes enhance the taste and texture of the steamed products and are brought about primarily by *Leuconostock mensenteroids* which is a dominant organism in fermented idli batter. Other fermentation bacteria are *L.delbrockii,* and *L.fermenti.* They bring about increase in vitamins and inorganic phosphate and also a partial break down in proteins and starch. Most of the microorganisms present in fermented batters are found in the food grains used.

Intestinal Microflora: The normal intestine contains many micro-organisms which make their appearance soon after a baby is born. They break down the undigested material to simpler substances and help in the formation of faeces. They also play a role in digestion and in the synthesis of several vitamins particularly B-Vitamin and Vitamin K.

Pathogenic Organisms in Food and Spoilage: Foods become unfit for consumption due to the action of enzymes present in the food itself which bring about undesirable physical (taste, flavour, colour, and texture) and chemical changes. It may also be due to the action of micro-organisms such as yeast, moulds and bacteria or due to infestation with insects and worms. When food comes in contact with cockroaches, rodents or lizards which are present in environment render the food unsuitable for consumption. Foods may also become toxic due to contamination with metals such as lead, copper etc. When food spoilage takes place two distinct processes are involved.

Autolysis (Enzyme Spoilage): The word autolysis means self destruction and is used to describe the cellular breakdown caused by enzymes contained within the food itself. This breakdown starts immediately after slaughter or harvest. Enzymes are chemical constituents in food itself which bring about either favourable or unfavourable changes. The ripening of fruits and cheese and the softening of meat are some examples of favourable changes. The rotting of fruits and vegetables, meat, eggs are due to some unfavourable changes. Enzymes activity is primarily due to, one - exposure to air and two, a favourable temperature and pH. This can be slowed down or arrested by controlling these conditions.

Most of the enzymes are heat labile and hence at high temperatures the enzymes can be destroyed and their action on the food prevented. Exposure to air can be prevented or minimised by bottling as in the case of fruits and vegetables. Keeping the food in opaque/ vacuum containers with air tight lids as in the case of fats, or by coating wax and by external layer of oil as in the case of pickles prevent spoilage. Enzymes are also inactivated by cold freezing and refrigeration to prevent enzyme spoilage.

Microbial Spoilage - Prevention (Pathogenic Microbial and Parasitic Spoilage): Once the cellular structure of the food becomes disorganised the food is vulnerable to be attacked by micro-organisms. Microbial contamination is very difficult to prevent, since the pathogenic organisms are usually derived from food, water, air or through direct physical contact. Hence it is necessary to prevent the spread of these harmful microorganisms through these media.

Factors and Prevention

Personal Hygiene: Pathogenic organisms spread through any part of the person involved with food preparation.

Personal hygiene covers all the rules of hygiene which are the responsibility of the individual and all food handlers should possess an elementary knowledge of why these rules are important. Some of the most important points of personal hygiene are covered here.

Washing Hands: Washing hands should be frequent: (a) Before handling food in the kitchen: This is important since bacteria, particularly *Staphlococcus* may be present on the surface of the skin. (b) Between food-handling operations: This is necessary to prevent cross-contamination of all types of food poisoning bacteria from raw to cooked food. (c) After using the toilet and before leaving the wash-room: This reduces the risk of the transfer of bacteria such as *Salmonella* and *Clostridium perfringens,* from faeces and door handlers to food. (d) In food establishments (hotels and cafeterias): Specially it is necessary to have notices in wash rooms requesting users to wash their hands after using toilet. (e) After smoking, coughing and sneezing and after using a hand kerchief: This reduces the risk of the transfer of Pathogenic microbes to food. Use of soap dispensers, hand creams, antiseptic lotions keep the hands free from bacteria. Paper towels, hot air driers or roller towels, reduce the risk of transfer of harmful bacteria from person to person.

Other personal aspects such as having cuts, boils and septic spots, long harbouring nails, jewellary, ill health (eye, nose and throat infections), typhoid and other *Solmenella* infected people can not be allowed into kitchens.

Pathogenic organisms may also spread from unclean utensils. Hence the utensils used for eating, drinking must also be kept clean through sterilisation or through sundrying of these utensils.

Water: Dysentery and diarrhoea are also caused by micro-organisms which spread through food and water and lodge themselves in intestine. Drinking water can be a potential source for spread of diseases specially in village and slum wells since there is no protected water source. Water can be from river, lake or even from a well (which has no platform around). Under normal circumstances the river or lake waters can be clean by the operation of oxygen cycle but when this is polluted by indiscriminate practices like bathing, cattle and clothes washing, draining sewage water and industrial wastes, purification by the natural ways can no longer be adequate. Where the water source is a lake, people should be prohibited from misusing it at source and should be made to transport it away from the place for other purposes. If it is a well, the inside of the well should be cemented upto to 15-20 ft. deep, so that the polluted water is prevented from seeping into it. Other means of getting clean drinking water is filtering the water through 2-pot system. The upper earthen pot consists of clean sand and charcoal so that clean protected water seaps into the lower pot. This is feasible in a family and more so can be easily provided by the panchayats. Storage of water in copper pots is believed to have an inhibitory effect on the growth of micro-organisms.

In many families drinking water is taken care of but in cooking water people become casual while this is not harmful for foods that are boiled. Only drinking water or boiled and cooled water should be used for preparing butter milk and chutneys and the like.

Soil Contaminants (Intestinal Parasites) : Apart from micro-organisms intestinal parasites such as hook worm, tape worm and round worm also cause great harm by interfering with absorption of food. Vegetables and fruits are often contaminated with these parasites because of their presence in soil. Where modern sanitary facilities are not available. Animals help to spread the infection. Hook worm egg can not hatch and grow outside the animal body. It is important to realise that hook worm and other parasites spread through fruits, vegetables, greens and other foods which lie on contaminated ground. The worms are present in the faeces of affected individuals and when excreted they lay eggs on the soil, if the excreta is not sanitarily disposed off. Thus they spread through soil or water contaminated with faeces containing the parasites. When walking bare foot on contaminated soil, eggs of hook worm enter the blood stream through the skin. They too attach themselves to vegetables etc., but they can not hatch and thrive outside the body of the host (man or animal). Hook worm disease therefore can be entirely prevented by sanitary disposal of faeces and reduced by wearing shoes.

If foods should be consumed free of these eggs and parasites, all vegetables and fruit,should be thoroughly scrubbed and washed with salt water and clean water before cutting. In areas affected with epidemics such as cholera, it is desirable to soak them in weak solution of potassium permanganate or salt. This particularly is important with green chillies, ginger, coriander, salad vegetables and fruits which are consumed as such without cooking.

3.3.4. Food Contamination through Pests and Control Methods

Pests, mice, flies and cockroaches are the most common kitchen pests. Rats and mice often carry *Salmonella* and other pathogens in their intestine and therefore excrete these organisms

in their faeces. In addition they also carry bacteria on their feet and can contaminate open food and working surfaces. Cockroaches breed in warm temperature and on left over foods. They contaminate foods with bacteria from their bodies and excreta but since they are nocturnal their infestation goes unnoticed.

They should be controlled with insecticidal sprays and the best way to avoid is to keep the store and kitchen clean and dry without food left open.

3.3.5. Dairy Management and Hygiene

Milch animals can be carriers of diseases like tuberculosis. The holder of the cow, the hands of milk man and the milking container must be thoroughly cleaned before milking as milk is a very good medium for growth and transmission of microorganisms of diptheria, streptococcal infections, typhoid, paratyphoid, cholera, dysentery and scarlet fever. Hence milk should be transported in chilled condition. Fortunately in our country the practice of boiling milk is a universal want for preservation of milk.

3.3.6. Hotel Industry and Hygiene

Hygiene and sanitation are very important in hotel and catering institutions as spread of pathogenic organisms is fast through personnel connected with preparation of food. Cooks, helpers, servers and every one in hotel/catering institution should be non-carriers of pathogenic microorganisms and they should be trained to observe rules of hygiene. They should wash their hands with disinfectant, trim their nails frequently, use clean washed dress, caps and aprons (cotton sweat absorbable), bathe regularly twice a day and maintain good personal hygiene.

Further they should be free from scratching, sneezing, coughing and smoking during cooking. Most important is that, they should be frequently checked and treated for any intestinal parasites. However food should be subjected to minimum handling after they are cooked. They should be thoroughly trained to use spoons, laddles and scoops to prevent food contamination.

Check Your Progress - 1 & 2

1. What are the three types of food poisoning?
2. What is the role of microorganisms in the intestine?

Note: a) Write the answers in the space provided below.
b) Compare your answers with those given at the end of this unit.

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3.4. FOOD AND PRODUCE PRESERVATION

Most types of produce especially the food stuffs are given some forms of treatment either as part of the final processing before sale and use. In this it is really the initial processing prior to storage that is of most concern.

Produce spoilage or deterioration is usually a combination of an oxidation process together with the contamination by microorganisms and insects. The insects will eat part of the produce and will spoil part by contamination with excrete, saliva and enzymes. In general insect presence will accelerate the process of decay.

The majority of food stores are for grains and flours. At the time of harvest most cereal grains have a moisture content (MC), in the region of 16-20 percent. If the grain is stored at this moisture level it is most certain to be attacked by fungi and insect pests, so it is important that it should be dried before storage. At a moisture content of about 14-15 per cent, grain in storage is not vulnerable for fungi but *Sitophilus* weevils needs 9-10 per cent.

The different methods of food produce preservation commonly in use are given below.

3.4.1. Heat Treatment

Heat treatment is the most important form of food processing. The effect on food itself is very complex, depending both on the food and on the conditions of heating.

Blanching: Blanching consists of heating a vegetable briefly with either water or steam. Before freezing or drying, blanching is carried out to destroy the enzymes which affect colour, flavour, texture and nutritive properties of the product during subsequent processing and storage. Since blanching also destroys the semi-permeable membranes of the cell and expels gas from the material, the tissue often collapses and is easier to pack into cans.

Boiling: Boiling water or steam condensing in a pressure cooker has a high heat transfer capacity and the surface temperature of the food reaches the temperature of the water or steam very quickly. The temperature at the centre of the food depends on its shape, size and heat transfer characteristics. Occasionally there are phase changes with in the food which may affect heat transfer, but these are thought to be small. The temperature of the food never exceeds the boiling temperature of the water. Nutritional losses due to boiling are extremely variable depending inter alia on volume of cooking water, cooking time, state of dispersion of the food, pH and availability of oxygen. Pressure cooking requires less time and water hence losses are significantly lower than with ordinary boiling.

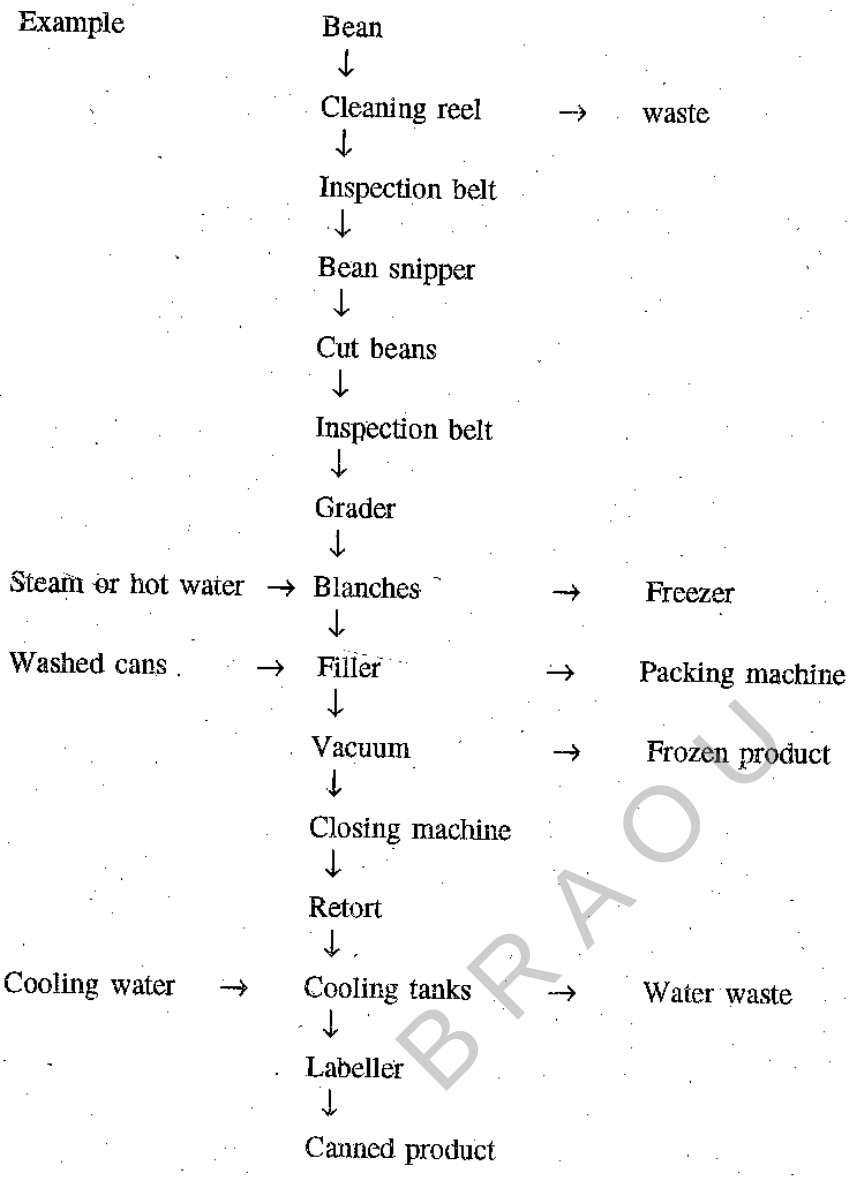
Frying, Deep Frying and Baking: These processes are more complicated than boiling in water because optimum crust properties must be matched by optimum characteristics of the interior of the food. Traditionally frying may take place in an oil bath, by contact frying or in an oven. Characteristically the surface temperature of the food rises to well above the boiling point of water while the temperature at the centre lags behind and only reaches its maximum when cooling has already begun. Chemical changes occur both at the centre and on the surface of the food, but those at the surface are more pronounced. Because of the higher temperature further chemical changes take place but there is also a greater reduction of water and reaction with the heating medium.

Pasteurisation: Pasteurisation consists of rapid heating followed by a rapid cooling process. The object is to destroy micro-organisms, although not all are killed by the treatment and microbial spores generally survive. The time and temperature of the treatment depends to a large extent on the product and its expected shelf life.

Canning: In sterilisation the food is treated to such an extent that neither microbes nor their spores remain viable under optimum conditions of growth. Heating and cooling are maximum stress periods for cans and cooling can set up a vacuum inside the can sucking in contaminated cooling water. Once canned, the product should not be allowed to freeze

or moisture allowed to condense on the outside of the can.

Example



Check Your Progress - 3

3. What is meant by pasturisation?

Note: a) Write the answer in the space provided below.
b) Compare your answer with the one given at the end of this unit.

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3.4.2. Refrigeration

Refrigeration is the removal of heat from a material resulting in either the removal of heat

(cooling) or a change of state (freezing). Some foods are easily damaged by low temperature. Examples are banana, potato, tomato and some citrus fruits. Other foods are relatively unaffected even on relatively prolonged storage. These include some berries, cabbage and spinach etc. Two methods of refrigeration are commonly employed, i.e., chilling at 0-4°C and freezing between -18° and - 35°C. The conditions used depend on the length of time the food is to be stored and on the type of foods. Non-living foods such as meat and dairy products are highly susceptible to deterioration by their own enzyme systems or by micro-organisms. Living foods such as fruits and vegetables which are still metabolically active have the natural resistance of typical living organisms. The former are stored in the frozen state while the latter are sometimes chilled. Indeed, fruits and vegetables often require processing such as blanching before they can be successfully frozen.

If stored too long or at incorrect temperatures or relative humidity the product may suffer. In meat, oxidative rancidity may also occur during cold storage. Nutritionally refrigeration is perhaps the mildest form of preservation. The nutrients which have received most attention are those which are water soluble and easily leached and the ones easily degraded chemically.

3.4.3. Dehydration

The simplest dehydration process and the one very common practice in developing countries is sun drying. More controlled methods are hot air drying, contact drying, drying by radiation and freeze drying. Concentration processes to remove water include evaporation, freeze concentration and membrane processes such as reverse osmosis and ultrafiltration. Nutrient destruction on dehydration is virtually impossible to quantify. It depends on the food, the nutrient and process. Oxygen, pH and trace metals have a great effect on nutrient destruction. There is little loss with freeze drying. Oxidative rancidity can be a problem with all concentration and dehydration processes.

Before drying, food undergoes a variety of treatments. In the case of vegetables this includes washing, grading and blanching (to destroy enzymes). Sodium sulphite is usually added to the blanching water, this improves the colour of the product, aids vitamin C retention and destroys many of the microorganisms. Other foods such as meats may be cooked prior to dehydration.

There are many types of equipment used for dehydrating foods. Some of the more usual methods of drying are - tunnel drying, spray drying, roller drying and freeze drying.

3.4.4. Salting

This has long been one of the traditional methods of food preservation. At higher concentrations it has a pronounced bacteriostatic action and is used to preserve mainly meat and fish.

3.4.5. Addition of Chemical Inhibitors

Many methods of preservation, including many of the traditional methods, depend on the addition of anti–microbial substances to foods. Some of these methods are outlined below.

1. Food Preservatives: A preservative is defined as a substance which can prevent spoilage. Some of the more important preservatives are benzoic acid and sodium benzoate used in an acid medium such as fruit, pickles, soft drinks and fruit juice.

Table 3.1. Examples of permitted preservatives and some of the foods they may be used in.

Preservative	Foods
Sulphurdioxide	- dried fruit, jam, dehydrated vegetables, sausages, beer, lime
Benzoic acid	- soft drinks
Propionic acid	- flour confectionery
Sodium Nitrate Sodium Nitrite	- Jam, bacon, pickled meat

Curing: The curing of meat such as bacon involves using a brine (salt) solution composed of sodium chloride (25%) potassium nitrate (1%) and sodium nitrite (0.1%). The salt content inhibits microbial growth by preventing water absorption by the brine and the meat develops a characteristic colour and flavour. Amla, citrus fruits mangoes and vegetables are preserved by this method.

Some cured products are also smoked by exposing them to smoke from a wood fire. The smoke contains antimicrobial substances which reduce spoilage. It also gives the food a characteristic taste.

3.4.6. Preserving with Sugar

Many fruit products such as jams and crystallised fruits are preserved with sugar. Sugar reduces microbial activity due to its dehydrating effect. The same principle of salt preservation also applies here.

3.4.7. Use of Oil and Spices

Spices such as chillies, and pepper are used in the preparation of pickles. They not only improve flavour of foods but also are believed to create an environment unfavourable for the growth of bacteria.

Similarly when oil is used in pickles a top layer of oil is formed which prevents the microorganisms in the air from coming into contact with the food. Coating fruits (lemons) with thin layer of oil can keep them fresh for a longer time. Dals like green gram, red gram, wheat, rice etc with oil is a common procedure in some states.

3.4.8. Milk Processing

Milk is an excellent nutritive medium for microbes. Milk is easily contaminated and so becomes too sour to drink, unless it is processed. The treatment of milk varies from 65°C for 30 min to 130°C for 3-5 secs. If so treated and packed sterile, the milk will keep for two months.

*1. **Condensed and Evaporated Milk:*** The removal of some water gives a product known as evaporated milk. Sugar may be added to sweeten it giving a total solids content of 75%, 55% being sugar.

*2. **Dried Milk:*** Drying milk reduces its volume, preserves it and makes it into a useful additive to other dried foods. The process was already known as far back as the thirteenth century.

*3. **Reconstituted and Synthetic Cream:*** Reconstituted cream may be prepared by emulsifying unsalted butter with milk or reconstituted milk. Synthetic cream is prepared by using

margarine or another fat instead of butter.

*4. **Whipped Cream:*** This is prepared by whisking cream containing between 36 and 40 per cent fat.

*5. **Butter:*** The cream is separated from the milk, either by gravity or by means of centrifugal separator. The cream is then briefly ripened. The ripened cream is then churned and in the resulting phase inversion butter and butter milk are produced.

*6. **Cheese:*** Cheese is made by microbial fermentation. First, the milk is coagulated by either rennet or a bacterial strates which produces acid from the lactose contained in the milk. The milk may also be coagulated by the direct addition of acid.

3.4.9. Food Additives

Food additives are used as antimicrobial agents, to reduce physical and chemical spoilage and to aid processing.

The increased use of synthetic food additives also poses health problems but these must be seen in proper perspective. Many conventional foods contain toxins.

3.4.10. Flavouring Agents and Enhancers

Spices as well as natural and artificial sweetening agents are important additives of the flavour enhancers, sodium chloride is the most common and the oldest. Other flavour potentiators include ethylmaltol, disodium inosinate and disodium guanylate.

3.4.11. Colouring Agents

Annatto, a yellow colour, is isolated from the seed pulp of the annotto tree, *Bixa orellana.* Turmeric, a yellow dye from the root of *Curcuma longa,* is an East Indian herb, and related to ginger, Cochimeal, a red dye, is obtained from a South American insect, *Coccus cacti.* Some other natural colours include carotene, chlorophyll and caracel.

3.4.12. Stabilisers and Thickeners

These are mainly gums and they are conveniently divided into exudate gums, seed gums, starch and cellulose derivatives. The only gum used in the food industry which is not a carbohydrate and hydrophobic is chicle, used in the manufacture of chewing gum.

3.4.13. Surface Active Agents

These substances include lacithin, some mono and diglycerides of natural fats, sodium or calcium steagoy 1-2-lactylate, propylene glycol monostearate, glycerol lactopalmitale and polyoxyethylene sorbitan mono-oleate.

3.4.14. Antioxidants

Among the antioxidants used in the food industry are Vitamin E and Vitamin C, both of which occur naturally. Among the synthetic antioxidants are butylated hydroxy anisole, butylated hydroxy toluene, propyl, octyl and dodecyl esters of gallic acid.

3.4.15. Chelating Agents

The most important chelating agent in the food industry is EDTA. The pyrrole system chelating metals is very important in nature. Mg is bound in chlorophyll in this way, iron in the haem of blood and copper in copper phalocyamine.

3.4.16. Humefactants

The most important ones added to food such as baked products are glycerol, mannitol, sorbitol and propylene glycol.

3.4.17. Enzymes

Barley malt is still used as a commercial source of amylase. Remnin is used for curdling milk in cheese production. The most common proteolytic enzyme is papain tapping from the unripe fruit of the papaya tree. Enzymes are used for many industrial processes including meat tenderisation, milk fermentation, modification and degradation of starches, fruit juice clarification, alcoholic fermentation etc.

3.4.18. Acids and Alkalies

These are used as preservatives. Acetic, lactic and sorbic acids are widely employed. Sodium bicarbonate is also used in food processing.

3.4.19. Irradiation

Although it has been known for many years that various types of radiation can be used to inhibit microbial growth, radiation as a method of preserving food is still very limited. The main factors limiting its commercial development are, the high cost of the equipment and the development of unpleasent flavours in some foods. Ultra-violet radiation may also be used but its use is limited since it acts only on the outer surface of most foods.

3.4.20. Short-term Preservation

Two methods used for temporary or short-term preservation are chilling and controlled atmosphere storage. These methods can be used when food is transported long distances.

1. Chilling: Temperatures used for chilling vary to a great extent. The temperatures used depends on the nature of the food and the storage atmosphere. For example bananas are stored best at 15°C, whereas meat is stored at 1°C to 2°C.

2. Controlled Atmosphere Storage: This involves controlling of the humidity and composition of the atmosphere and is normally used in conjunction with chilling. Too high a humidity encourages microbial growth while too low humidity results in loss of moisture.

3.5. FOOD STANDARDS

Foods of excellent nutritive value may become unfit for human consumption during storage and handling. Insect infested grains, rancid fats and contaminated milk and sweets are examples.

In any country Food Industry is the major industry with a very large turnover. In our country except among the affluent, 60-80 per cent of the income is spent on food in middle and low income groups. At the same time food supplies (specially pulses, oil, millets, meat and eggs) are not commensurate with population increase. With regard to spices, tea, coffee because of export possibilities and industrialization the home market is poor. When this happens there is a short supply of foods and there is a great temptation for the merchants for either adulteration or sell food of inferior quality. Any food is considered adulterated when its nature and quality are not upto the standards prescribed to consume for that particular item of food.

3.6. FACTORS AFFECTING THE QUALITY OF FOOD

There are various ways by which quality of the food may be affected.

1. Addition of extra meal matter: Addition of water to milk to gain volume, addition of extraneous matter, grains of sand or small white stones to gain weight are some examples.
2. Mixing inferior quality interior: Mixing used tea leaves with fresh tea leaves, mixing infested grains with better quality grains etc.
3. Using prohibited colours, dyes and preservatives: This type of adulteration is found very commonly in a variety of cheap sweets, spices, chilli powder, corriander and turmeric powders.
4. Extraction of valuable ingredients: This is usual with milk vendors who remove fat from milk. This is most times done by middle men and even sometimes by some producers.

The quality may also deteriorate by improper storage conditions. For example, fats get rancid when stored for a longer period specially in tropical climates, and food grains are subjected to insect infestation and rodents.

Hence government has promulgated the prevention of food adulteration act (PFAA) to help consumers to get quality or standard foods from the merchants and caterers. However adulterated foods continue to be sold. Housewives and others concerned with purchase of food must be aware of the qualities expected for different foods.

1. Cereals and Pulses: (1) Loss in weight and volume with insect infestation. (2) Uric acid increase with storage period and insect infestation. (3) Decrease in acceptability. (4) Increase in rancidity due to deterioration of fat in the grain. (5) Deterioration in quality of gluten in wheat and its products. (6) Water steeping and sprouting percentage test.

2. Fats and Oils: It is very easy to mix and adulterate these oils. Mineral oil mixing has also become common but is harmful and toxic. Til oil and coconut oil are mixed with groundnut or cotton seed oil as they are cheap. Hydrogenated oil is mixed with ghee. Mixing vegetable oil with mineral oil dangerous to health. They result in dropsy and paralysis in epidemic proportions. Melting point, refractive index, and perioxide value help in identifying adulteration in oils.

3. Milk: This food is subjected to more adulteration than any other commodity. Milk is usually tested for its 1) specific gravity -1.029 - 1.055 (for fat content and non-fat solids) 2) freezing points 3) protein fat ratio, 4) protein and lactose ratio to know the standard of milk samples. The home life can be detected by 5) taste 6) setting curds, 7) milk becomes yellowish and frothy when mixed with other substances, 8) a simple method of detecting is by heating milk with lime juice to separate the cheese than curdless. With pure milk about 415 g of cheese will be fortified, 9) Yield of butter is also another indication.

4. Sugar, Jaggery and Salt: Should be from insoluble material. Sometimes these are added to an extent of 4-10 per cent.

5. Spices: Turmeric and chillies are coloured with lead and matamil yellow pigments to enhance their colour to look bright and attractive. This may lead to serious liver damage on long term use of such foods. Metamil yellow, sold as kesari colour is commonly used in sweets and beverages though it is prohibited. The presence can be easily detected by its

magenta colour when the food is dropped into hydrochloric acid. Hing (asafoetida) is adulterated with foreign resins.

6. Coffee, Tea/Cocoa: Raw coffee seeds can not be adulterated. Except for mixing low quality seeds with superior quality seed. However when roasted they prove to be mixed with various kinds. Most common being adding of chicory and roasted seed of dates and tamarind. The ash content of pure coffee is less than 4-6 per cent and half of this is water soluble. Chicory has higher insoluble ash. Cocoa is adulterated with finely ground shell sago flour or starch coloured with redoxide or iron is also used. Tests include estimation of moisture, soluble and insoluble ash, alkalicity of ash fat, starch, sugar and nitrogen.

7. Eggs: Shell of fresh eggs have glazed appearance. Fresh eggs sink in water. The chemical changes found in spoilt eggs are lowered content of albumin and increase in alkalicity.

8. Meat: The quality (standard) of meat is determined by its tenderness, juiceness and palatability. To ensure a soft meat supply 1) the animal should be examined before slaughter, 2) adoption of environmental condition to prevent contamination and spoilage, 3) hygienic handling,, transport and distribution under proper conditions.

9. Vegetables: The quality depends on their firmness, freshness, colour, moisture from the stand point of cooking quality. Vegetables must be checked for worm, mould infestation and also spoilage. Vegetables should be thoroughly scrubbed and cleaned with fresh salt water to prevent contaminants.

The practice of adulteration of foods has increased enormously from time to time and hence checking and purchasing the foods of standard quality are not only economical but helps to keep all of us in good sound health.

3.7. PUBLIC EDUCATION

Theoretically the law gives us the right (the consumer) to get the samples analysed by the public analyst, though the procedure is cumbersome and delayed. For a large country like ours there are about 64-70 food analysis laboratories with inadequate staff and equipment. Now-a-days there are consumer protection association and the public should make use of these forms to get quality food. The merchants who try to cheat the consumer should be black listed unless he improves his quality of the products. There is an urgent need that students, teachers, nutritionists, municipal authorities should wake up to totally prevent and punish such shop keepers. Also the public be educated to play an important role in this direction and see that in each town a cell should be set up to detect the adulteration and help the consumer.

3.8. SUMMARY

For good health and to be free from disease,consumption of Nutritional food is a prerequisite. However food is liable to be infected and contaminated by various agents. To prevent the food from spoilage during storage for longer duration, knowledge about how foods get spoilt is important. The consumer should know how to assess the quality of food before purchasing. In view of this consumer education is needed in order to prevent sale of low quality or spoilt foods. This knowledge not only helps the consumer to spend economically but ensures a healthy life.

3.9. CHECK YOUR PROGRESS: MODEL ANSWERS

1. The three types of food poisoning are chemical, biological and bacterial.
2. The microorganisms break down the undigested material to simpler substances and help in the formation of faeces. They also play a role in digestion and synthesis of vitamins particularly Vitamin-B and Vitamin-K.
3. To destroy the microorganisms rapid heating followed by rapid cooling is done. This process is called pasteurisation.

3.10. MODEL EXAMINATION QUESTIONS

I. Answer the following questions in about 30 lines each

1. Write briefly about food spoilage.
2. Write briefly about food poisoning by microorganisms.
3. Discuss briefly about dairy management and hygiene and hotel industry and hygiene.
4. Write briefly about food and produce preservation.
5. Discuss briefly about the factors affecting the quality of food.

II. Answer the following questions in about 10 lines each.

1. Write briefly about chemical poisoning.
2. Discuss briefly about biological food poisoning.
3. What are the conditions required for the growth of microorganisms?
4. Write briefly about dairy management and science.
5. Briefly write about hotel industry and hygiene.
6. Discuss briefly about blanching.
7. Write briefly about Irradiation.
8. Briefly write about public education.

Prof. D. Peramma

BLOCK - 2
FORESTS AND LANDS

UNIT-4 : SHRINKING FORESTS IN INDIA

Contents

4.1. OBJECTIVES

After going through this unit you will be able to:

* describe the necessity of forests in maintaining ecological balance and sustained development,
* list out the various functions and usess of forests,
* discuss on various aspects involved in reversing the process of degradation of land resources.

4.2. INTRODUCTION

Forests are nature's greatest bounty to mankind. The ever increase in population with greater interference of man's activities, the forests are being degraded and depleted to large extent. The gravity of environmental consequences arising from rapid degradation of land resources was felt only in the past decade. The steps were not taken on a large scale in our country to halt the process of degradation. However isolated efforts are being made in different parts of the country to stop the process of deforestation and to reduce the soil loss. People's movements such as Chipko in the Himalayas, the Appiko in Karnataka and the Kerala Sastra

Sahitya Parishat are working to protect the environment from breaking down further.

The country does not have enough land space and the productivity of the land as far as forests are concerned is very low. According to earlier estimates, the area under forests in India is 74.7 million hectares out of a total geographical area of 328.8 million hectares with 22.7% area under forest as against 33.3% enunciated in the National Forest Policy of 1988 to maintain the ecological balance. According to the National Remote Sensing Agency, India had a forest area of 46.35 million hectares in 1981-82 which is far below the central forestry commission estimation in the early 70's (about 75 m.ha). The latest assessment (85-87) of Ministry of Agriculture reveals that the total area under forest in India is about 64 million hectares with 37.8 million hectares under dense forest (crown density above 40%) and 25.7 million hectares under open forest (crown density 10 to 40%) and remaining area under Mangroves and others. The Ministry of Agriculture recent computation reveals that about 20 million hectares of forest lands are in bad shape.

India has 0.11 ha per capita forest area as against the world average of 1.6 ha per capita. The annual productivity of Indian forest is also very low $0.5m^3/ha$ when compared to world average of $2m^3/ha$. This is due to over exploitation, over grazing and over maltreatment of forest areas in the past. In India most of the forests (95%) are owned and managed by the Government in contrast to the management of forests by private sector in the European countries. Although forests occupy about 20% of area, they are reported to contribute only one per cent towards national economy as against 35% from agriculture. Many reasons have been attributed to the low revenue, removal of large amount of forest produce by local population in the form of rights and concession as well as illicit removals being the main reasons . Yet another problem faced by the Indian forestry is the lack of proper investment in reforestation and afforestation programmes (Never exceeded 0.75% of the total plan outlay in the public sector).

4.3. IMPORTANCE OF FORESTS

The word forest is derived from Latin word 'foris' meaning outside the village boundry or away from inhabited land. Generally forests are those areas of uncultivable land occupied by different kinds of trees, shrubs, herbs and grasses.

Ecologically forest is defined as a plant community predominantly of trees and other woody vegetation usually with a closed canopy.

Technically forest is an area set aside for the production of timber and other forest produce or maintained under woody vegetation for certain indirect benefits which it provides e.g., climatic or protecitve (shelter to wild life, birds and other fauna). Legally forests are areas which have been notified by the Government under forest law.

Forestry is defined as theory and practice with regard to creation, conservation and scientific management of forests and continuous utilization of their products. It includes not only management of existing forests but also creation of new forests.

Functions of Forest

Forests cover about 1/4 of the land mass on the earth. However in India they cover only about 1/5 of the area. Forests are one of the most predominant geographic features of this planet. They are world's air conditioners and earth's blankets. They moderate the extremes of local climate. They intercept the precipitation and reduces the impact of rain drops on soil erosion. They also reduce wind velocity and thus reduce the soil loss by wind and water. They regulate stream flow in an area and improve the quality and quantity of water.

Without forests, this world would be an inhospitable place to live in. Forests are the most valuable natural renewable resources of the earth. Forests help the human beings in several ways. These are (a) productive (b) protective (c) ameliorative (d) recreational and (e) developmental.

A. Productive Functions of Forests

1. Wood is the major forest produce which is used for construction of houses, Agricultural implements, bridges, sleepers etc. In India about 12.5 million cubic meters of timber is used for above purposes.

2. Wood is a universal fuel and it is the major source of domestic fuel in India. About 175 million cubic meters of wood is used as fuel in this country.

3. Forest provides raw material to number of industries such as paper and pulp, plywood and other boards, saw mills, furniture making, packing cases, match boxes and toys etc.

4. A large number of non-wood products which are often called as minor forest products (in small quantities) are harvested from forests.

   i. *Fibres and flosses:* Fibres are obtained for making ropes from baste tissues of certain woody plants. Flosses are obtained from semal *(Bombax ceiba)* and kapok *(Ceiba pentandra).*

   ii. *Grasses and bamboos:* Many varieties of grasses are found in the forests. About 20% of 419 million livestock graze in the forests. Among valuable grasses, about 80,000 tonnes of sabazi *(Eulaliopsis binata)* is harvested annually. About 5.5 million tonnes of bamboo is harvested from our forests annually for paper and pulp (25%), rural and agricultural works (25%), housing (10%), and packing and other uses (40%).

   iii. *Essential Oils:* Approximately 1500 tonnes of essential oils are obtained from Indian forests during 1980, which are utilised for making soaps, perfumes, detergents and chemicals. Many species e.g., *Eucalyptus* spp, *Bursera* spp. *Cymbopogan* spp and *Santalum album* etc., produce these oils.

   iv. *Oil seeds:* Many tree species e.g., *Madhuca indica, Pongamia pinnata, Shorea robusta, Azadirachta indica, Vateria indica* etc., produce oil bearing seeds which are commercially important in soap industry. Tribals use these oils for various purposes. There is a potential production of about one million tonnes of oil every year from forest tree seeds.

   v. *Tans and dyes:* The important vegetable tanning materials are the myrobolan nuts and bark of wattles *(Acacia A. decurrens, A . nilotica* and *Cassia auriculata* etc.)

   vi. *Gums and resins:* Gums and resins are exuded by trees as a result of wound or injury to the bark of wood. Gums are collected from several tree species *viz., Sterculia urens, Anogeissus latifolia, Acacia nilotica* etc. Resin is obtained from *Pinus roxburghii.*

   vii. *Drugs, spices and insecticides:* Out of 2000 items of drugs mentioned in Indian Materia and Medica, over 1800 are of vegetable origin. All plant parts e.g., roots, shoots, leaves, fruits, seeds, barks etc., are used for drugs. Important

species which are used as drugs are *Rauvolfia serpentina, Ephedra* spp, *Hemidermus cus, Swertia chirata, Dioscorea* spp, *Podophyllus* spp, *Atropa* spp, *Datura innoxia* etc. Spices like kalijira (seeds of *Carum carvi)* dalchini (bark of *Cinnamomum zeylanicum)* Cardamom (dried capsules of *Ellatteria, Cardommomum,* tejpat (leaves of *Cinnamomum tamala* etc are obtained from forests. Pyrethrum and neem are used as insecticides.

viii. *Tendu leaves and other leaves:* Tendu leaves (bidi leaves) are collected from forests and other waste lands, dried and used for making bidis. Approximately about 90,000 tonnes of tendu leaves (*Diospyros melanoxylon*) are collected annually. Leaves of trees such as *Bauhinia* spp, *Bulea* spp etc are used for making plates, dona etc.

ix. *Edible products:* Fruits, flowers, seeds, tubers etc of several forest species are eaten.

x. *Lac and other products:* Lac is a resinous secretion of lac insects which feed on forest trees particularly on *Butea monosperma.* Similarly silk is obtained from the cocoons of silk worms, which are raised on *Terminalia alata* and *Morus alba* plantations. Honey is also obtained from forests.

xi. *Fodder and grazing:* Forests provide fodder leaves and grazing facility to livestock. Approximately 20 per cent livestock population depends upon forest grazing and leaf fodder supply. The tree species which yield good quality leaves as fodder are *Ailanthus excelsa, Moringa oleifera, Sesbania* spp, *Morus alba, Albizia lebback, Leucaena leucocephala, Pongamia pinnata* etc.

B. Protective and Ameliorative Functions of Forests

The important protective and ameliorative functions of forests are as follows.

i. Forests play significant role in maintaining CO_2 balance in the atmosphere by absorbing for photosynthesis. In the absence of forests, CO_2 released in the atmosphere would result in warming of world's temperature, melting of polar ice caps and increasing sea levels. The CO_2 per cent in the atmosphere has already reached 0.042 per cent against the normal of 0.030 per cent. If this increase continues, there may be many disturbances on the earth, due to increase in temperature which may result in un-imaginable miseries to the mankind.

ii. Forests increase local precipitation by about 5-10 per cent as they act as barrier across the horizontal path of wind and micro-climatic effects. These create conditions favourable for condensation of the clouds, increase in the number of rainy days and help in proper distribution of rainfall.

iii. Forests reduce temperature and evaporation losses and increase the humidity. Temperature in the forests is 3 to 8°C less than adjoining open area.

iv. Forests add large quantity of organic matter through fallen leaves and recycle the plant nutrients.

v. In thick forest with full foliage cover, rain first falls on the leaves of trees and slowly drips and thus reduce the impact of rain drop in splashing the soil aggregates. The run off losses are less due to greater in filtration rate and finally help in considerable reduction in soil loss through water and wind.

vi. Forests check floods and regulate the water flow as they intercept about 20 to 30% of the total rainfall.

vii. Forests serve as store house for genetic diversity of plants, animals, birds etc.

ix. Forests protect from physical, chemical and noise pollution. They also protect us from dust and gaseous pollutants.

x. Forests and trees provide shelter belt and wind break effect which is beneficial to agricultural crops particularly in arid and semi-arid region.

C. Recreation and Educational Functions of the Forest

i. The forests are rich in varieties of trees and shrubs, animals and birds which serve as recreational place by attracting large number of people.

ii. Forests provide large varieties of trees for ecological studies.

iii. Forests provide a natural healing effect for a number of diseases.

D. Developmental Functions of Forests

i. Forests provide employment directly as well as indirectly to large number of people.

ii. Forests and various forest activities help tribals to improve their socio-economic condition through collection, processing and marketing of various forest products and by providing gainful employment.

iii. Government earns a large sum of revenue through forests which can be diverted for other developmental works.

Check Your Progress - 1 & 2

1. Define forest.
2. What is meant by forestry?

Note: a) Write the answers in the space given below.
b) Compare your answers with those given at the end of this unit.

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4.4 FIRE WOOD AND TIMBER PRODUCTION

Silviculture: The term silviculture refers to art and science of cultivating forest crops (trees in community). The Silviculture occupies a position in the forestry similar to that of Agronomy in agriculture. It includes the study of types and life of forest trees and crops, their growth and development, tree and crop morphology, physiology, structure, reproduction, locality factors and their relationship with trees and crops and several other physical and biological laws.

Practice of silviculture includes regeneration of the area, selection of suitable species,

creation and maintenance of forests improving their condition controlling the composition, restocking and understocked areas, improvement of site conditions and time to time operations etc.

Obctives of Silviculture: These include:

1. Control of crop composition and production of species of more economic value.
2. Control of stand density for maximum production.
3. Afforestation of blank and understocked area.
4. Production of quality timber.
5. Control on rotation period depending on the density of crop and size requirement.
6. Facilitate management and use of forest.
7. Creation of man made forests and introduction of exotics.
8. Protection of site and intangible returns.

Forests continue to be an important source of livelihood and means of survival. The human population of India was 361.1 millions in 1951 and it gradually increased to 844 millions in 1991 (Census report) which was 143% increase. The livestock population in India which was 292 millions in 1961 rose to 426 millions in 1985.

The forests and grass lands can support definite number or slightly more number of livestock. It can meet fire wood and timber requirement of certain population only. It is therefore necessary to minimise the population growth on one hand and increase the productivity of forests on another hand.

The Government encourages the individuals to plant and preserve the trees in open spaces near the towns and villages and in waste lands. The persons planting fruit trees on open lands in any village site or on government waste lands had been entitled to the produce of the trees but these concessions have been observed to be misused in the form of land grab. The government also prescribed to confine goat and sheep grazing to the areas where least harm would result to the forests. But this was not properly attended and handled.

When there was not so much pressure of population, the government granted certain previlages in respect of their needs of small timber, firewood, grazing of animals and collection of rab materials etc to local inhabitants as a matter of favour but not as rights. But local inhabitants continued to misuse the concessions without any recoupment and restocking of tree growth by regeneration. They have rendered the vast areas of forests into barren lands. Despite these facts, the politicians and governments are urged from year to year to yield their demands now from reserved forests for earning the sympathy of local inhabitants.

The demand for timber and fire wood and fodder has rapidly out stripped the sustainable yield of forests. The threshold of sustainable yield of forest produce has been crossed long back for fulfilling the needs of fast increasing population. According to estimation of a forest survey in 1987, the demand for fuel wood and industrial timber is around 235 and 27 million cubic meters as against supply of 140 and 12 million cubic meters, respectively. Unless the people owning the land are persuaded and compelled to make alternative arrangements for meeting their timber and fuel requirements, the existance of forests is not going to last long.

The slow process of natural regeneration which depended on for natural restocking of forests

has proved unsuccessful due to intensive biotic influences. The over exploitation, reckless deforestation, shifting cultivation and careless tillage operations have imbalanced the environment. The Cyclones, erratic rainfall, floods and inundation of vast tracts have become regular routine features of adverse climatic conditions year after year. As a result the soil loss amounting to about 1200 crore tonnes worth Rs. 6000 crores of fertile top soil is lost every year. The forests have both receded and depleted fast as the villagers are resorting to more and more use of cow dung for cooking. This inturn has deprived soil nutrients and humans through cow dung leading to decline in soil fertility.

Timber and fire wood for which the forests have been cut are the products of the tree which is only 0.3% of the real cost of living tree. An Indian scientist Prof. T.M.Das's research has indicated that a 50 year old tree weighing 50 tonnes if allowed to survive, can give to the society in terms of production of oxygen, absorption of CO_2, recycling of water, checking soil erosion, sheltering birds and animals and giving leaf protein worth Rs. 15 lakhs which is 100 per cent of its total value. The forests are one of basic natural resources which provide protective umbrella against natural disasters.

India's forests are shrinking by about 1.2 to 1.5 million hectares per year because of their low productivity. These wood lands can yield an annual harvest of not more than 39 million cubic meters as against the projected wood demand of 289 million cubic meters by the turn of century. The present per capita availability of wood works out to be only 0.046 cubic meters in India (both for industrial and fuel wood) compared with industrial wood consumption of 1.86 cubic meters per person in USA which is 40 times higher than India's consumption.

The fuel energy crisis has led the government to open a separate organisation of social forestry to encourage tree planting on field bunds, vacant and marginal lands, community lands, road sides, canal bank and so on. The spread of activities can not be said to have been packed up by majority of agriculturists as demanded by field bunds.

However certain farmers in different parts of India are resorting to plantation of *Eucalyptus, Acacia* and *Casuarina* in their marginal lands, as well as are making use of waste lands. In certain areas hitherto the lands under cultivation of important cash crops are being replaced by the tree species. Higher returns have prompted farmers to take up farm forestry. It is reported that on an average an annual net income through sale of wood works out to be Rs. 2000 to 3000 per hectare from plantation of *Eucalyptus*, Babul and *Casuarina.*

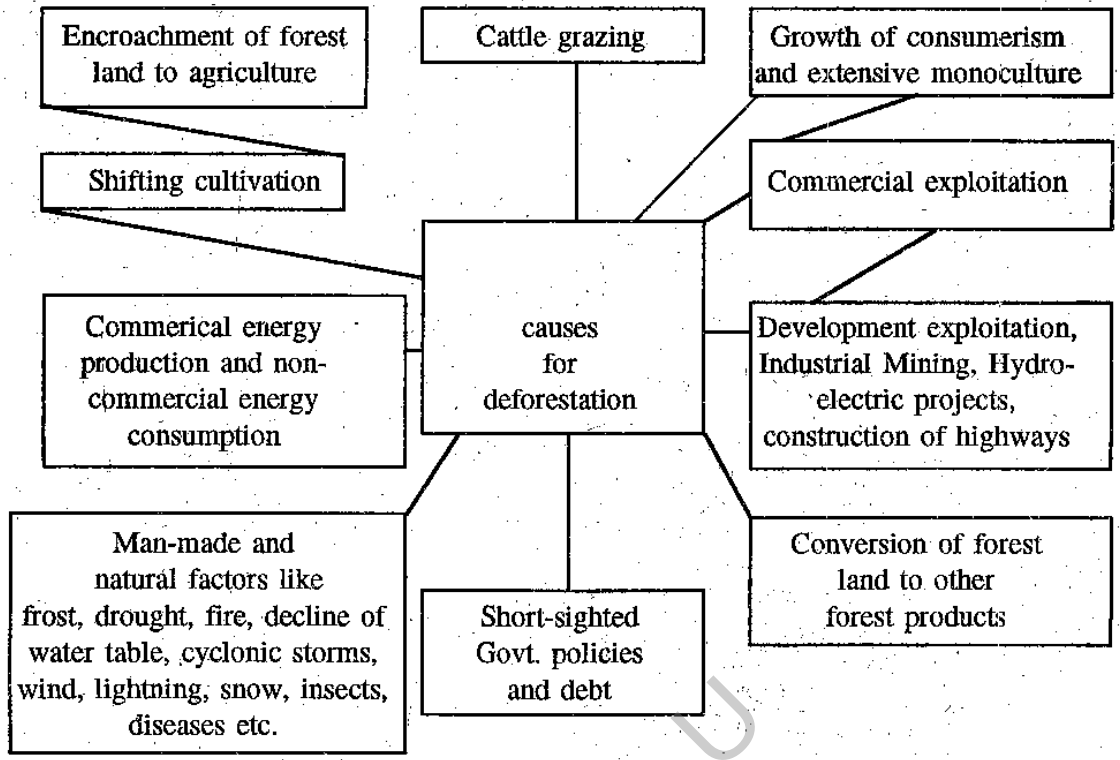
4.5. DEFORESTATION

According to 1993 World Development Report, deforestation is defined as the permanent conversion of forest land to deserts, waste lands, postures, shifting cultivation, agriculture or infrastructure development. The tropical forests which are native for more than 50% of plant species are being reduced by half of their original area and as per estimation of 1990 deforestation claimed 17 million hectares of tropical forest in Asia. The annual deforestation rate in India is 2.7 per cent as against 0.4% in Brazil, Peru and Zaire countries.

4.5.1. Causes for Deforestation

Unless the causes are identified and corrected appropriately, any programme on afforestation or reforestation may not be fruitful.

Some of the causes are:



1. *Encroachment of forest land to agriculture:* Rapid population growth, inequitable land distribution and the increase in area of export oriented crops reduced the land area available for subsistence farming forcing many small farmers to clear forests to grow food crops.

2. *Cattle grazing:* Cattle grazing in the forest land causes damage to both seedlings and older trees. The nation's 12 million hectares of permanent pastures are vastly inadequate to needs of 196 million heads of cattle.

3. *Growth of consumerism and extensive monoculture:* Any attempt to hasten the process by planting monoculture may give higher and immediate yields but at great future cost. In Brazil 18 million hectares has been cleared to meet European and American Coffee demand.

4. *Commercial exploitation and steady demand for timber:* It is one of the most powerful causes for deforestation. According to Smt. Maneka Gandhi the world's tropical forests are being ruined by the demands of developed countries for hard timber and plywood. About 100 million cubic meters of hard wood being consumed in the Western countries from Asian forests (Mostly from Indo-Malayan forests). In 1950 consumption of tropical hard wood by Japan, USA and Europe was 4.2 million cubic meters which increased to 66 million cubic meters.

5. *Shift Cultivation:* Shifting cultivation reduce the forest area but it is mainly confined to North Eastern states of India.

6. *Clearing the forests for rehabitation of the people:* The People affected by submergence of major irrigation dams or for industries or for construction of roads or canals, forest lands are generally selected. For example Sardar Sarovar Project (Gujarat)

envisages an irrigation component of 187 lakh hectares and 1450 MW power but it will submerge about 40,000 ha of forest land and 11,318 hectares of agricultural land. It will also displace 66,675 people, majority of them are tribals who are to be rehabilitated by clearing forest.

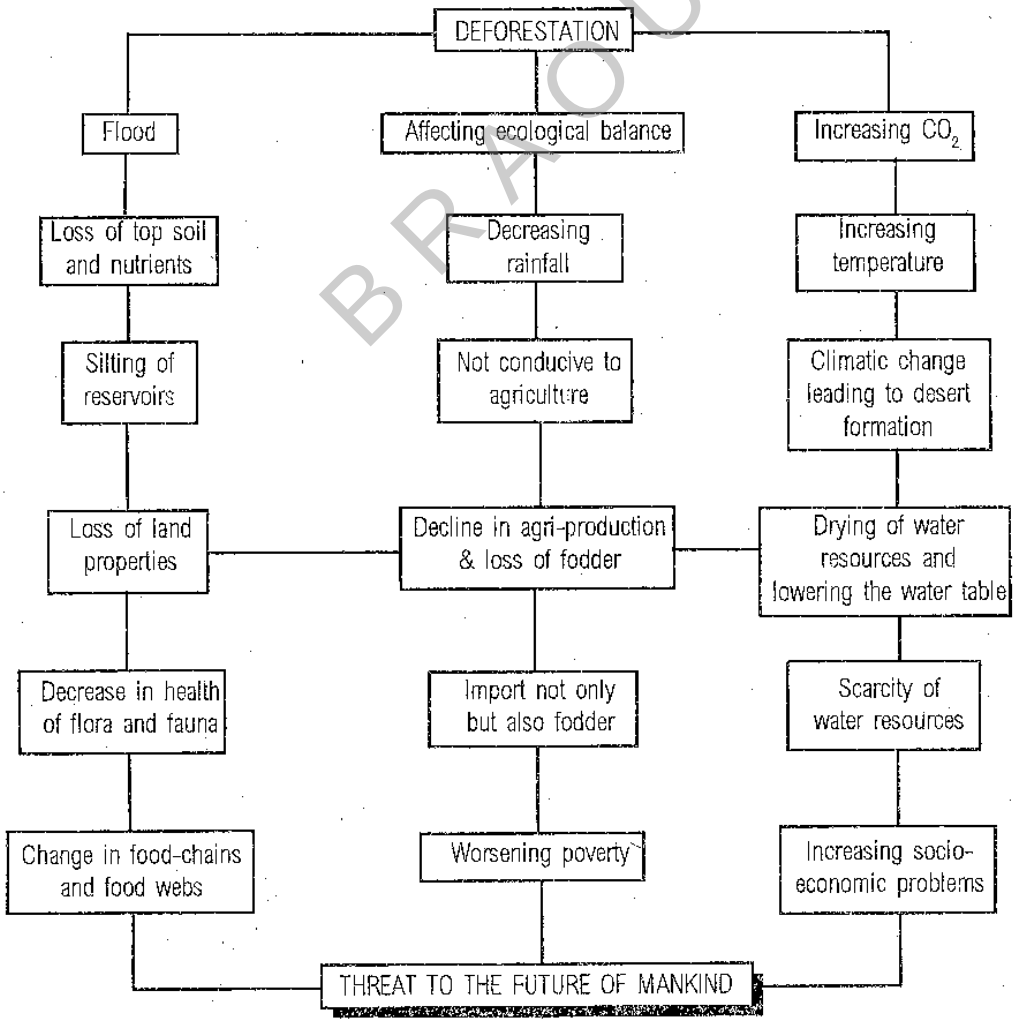
7. *Conversion of forest land into resort complex:* Orissa Government's plan to develop beach complex over more than 900 ha between Puri and Konark by clearing forests raised a storm controversy.

8. *Commercial energy production and non-commercial energy consumption:* Generally mining of coal is done in forest area by felling trees. The coal is used for energy production. Coal combustion produces acid rain which results in the destruction of forests. Deforestation is being done in different parts of the country for meeting the fuel requirement.

9. *Man made and natural factors:* Man is the greatest destructor of the forest in the world. Fire reduces forest area. Natural factors like frost, drought, decline in water table, cyclonic storm, lightning, snow, insects and diseases etc cause forest destruction.

4.5.2. Consequences of Deforestation

The consequences of deforestation are given below.



The wealth of life on earth is vanishing at a faster rate due to deforestation which is a bigger threat to the future of earth as well as man kind. Removal of natural forest cover by felling trees results in accelerated erosion and fertile top soil is washed away during monsoon. Large scale silting of reservoirs and canals, uncertainity and decrease in rainfall, increase in temperature, affecting hydrology and breaking water recharge cycle are some of the effects of heavy deforestation. As there is no human, rain water drains with great speed causing flood.

1. Farming system and food production: After independence the deforestation has taken place at a faster rate. This has led to ecological degradation on one hand and poverty and unemployment on the other as agricultural land and agricultual activity are both directly affected by absence of forest cover. Deforestation has adversely affected the production in sub-Saharan Africa.

2. Floods and drought: The twin problem of drought and floods is getting more and more acute every year because of deforestation. Birla Institute of Scientific Research at Jaipur (BISR) made a scientific study and is of the opinion that deforestation of major mountain ranges of the Himalayas and Western ghats have been the cause of recurring droughts. In Western India, the desert is advancing into Gujarat and Haryana at a rate of almost one kilometer a year. Thus, India has a new phenomenon of man made deserts.

3. Importing wood: The world Bank expects that there will be drop in the number of net tropical wood exporting countries from 33 to 10 over next decade. Nigeria once a major tropical log exporter, saw its timber shipments fall off dramatically after many years of over cutting forests and rapid expansion of slash and burn cultivation. In 1988 the country earned $ 100 million on forest product imports.

4. Fuel wood scarcity and increasing illegal cutting: The increase in the price of fuel wood in urban areas induces some of the poorer people to switch over to cow dung. Even in rural areas the scarcity and higher price would be beyond the reach of rural poor. This will result in illegal collection of wood. In Kurnool district of A.P. villages living within 50 km radius of Kurnool town periodically smuggle fire wood illegally cut from forestry into the town through shuttle trains that run daily. The fuel wood committee report said that with non-commercial sources dwindling in rural areas, fuel wood becomes a major problem soon. In much of West Africa families who used to prepare needs twice a day are now shifting to once a day or once every alternate day.

5. Environmental Refugees: Depletion of forests in developing countries is a complex problem. Unable to support their growing population, they push more and more people to urban areas. This resulted in big slums, pollution and sanitation problems, epidemics such as malaria, cholera and addicting to drugs, crime and violence. In the Nilgiris (Tamilnadu) more and more migrants from the plains are pouring into the hills and most of them have settled down in ecologically sensitive areas. They start cultivating in steep hills which results in soil erosion, water runoff, flash floods, avalanches landslides, resulting in silting up of dams and reservoirs.

6. Global warming affecting habitation of flora and fauna: The role of tropical deforestation in global warming is well known accounting for 20-30 per cent of annual carbon emmission world wide. When there are no trees for absorption of CO_2 automatically CO_2 concentration in the air increases. Added to this felled trees emit more CO_2 as they burn on decay. If respiration exceeds photosynthesis for long period, trees would stop gorwing and ultimately die. The destruction of trees not only make themselves extinct from the area but also other habitats of hundreds of species of birds, insects, reptiles and mammals being

destroyed. Harward biologist Edward O Wilsom estimates that nearly 50,000 invertebrate species per year are condemned to extinction by the destruction of their tropical rain forest.

4.5.3. Deforestation of Himalayan, Eastern and Western Ghats

The continuous onslaught on forest resources and consequent massive environmental degradation call for rational management of forests. The influence of Himalayan forest and mountain regions of North East extend on plain regions extending from Assam to Rajastan. Similarly the Deccan plateu lying between Western and Eastern Ghats is greatly influenced by the extent of forest cover present in the Western and Eastern Ghats.

The rivers rising from Himalayan hills are a major source of the country's prosperity. But in the last 50-60 years the forests of Himalayas have been cut heavily and presently most hills, mountains and valleys are barren. Its effect is being felt in severe floods, heavy soil loss, land slides, drying up of water resources and severe droughts.

In the Eastern ghats, the indiscriminate felling of most valuable sandle wood in the Jawadh and Meltur hills by smuggling gangs with strong political backup has almost made these hills barren. The povertiness of local people made them to rely on the forest wealth for their sustenance without any regard to environmental consequences.

The Western ghats running North-South in the Tamil Nadu is another victim of deforestation. The Nilgiris and Kodaikanal, the two hill resorts are no more healthy. Extensive denudation and faulty agricultural practices have resulted in frequent landslips and severe soil erosion. The pollution of lakes in these places is serious concern. The upper side of Periyar river in Kerala had one time dense forest in the Western ghats. Now the situation has changed with degradation of almost entire forest barring some pockets. The river which had flow of 227 km long being considered life line of the Kerala state has lost much of its importance.

4.5.4. Forest Policy of India

Although the forest management policy in India came into existence since 1864, the condition of forests continue to deteriorate through over exploitation. The first forest policy of 1894 mainly meant to collect revenue from the forests and liberal granting of rights and concessions to local people. There was no interaction to improve the forest management in general. After independence, the Government of India, Ministry of Agriculture enunciated the second forest policy in the year 1952. It recommends that India should aim at maintaining 1/3 of its land area under forests. This policy mainly aims at the conservation of forest and there is no emphasis on production of forests. It is therefore felt to make the existing forests of low productivity to be converted into plantation forestry of high productivity through enunciating the third forest policy in the year 1988. The main objectives of this new national forest policy are:

1. The national goal should be to have 1/3 of the total land area of the country under forest to save fragile ecosystems.
2. The forest should not be looked upon as source of revenue. Forests provide cover to steep slopes, catchment of rivers, lakes and reservoirs. They also check the extension of sand dunes. They should be protected.
3. Massive need based and time bound programme of afforestation and tree planting with a particular emphasis on fuel wood and fodder development on all degraded lands in the country are to be promoted both on forest and non forests as a national imperative.

4. The policy emphatically says that construction of dams, reservoirs, mining and expansion of agriculture should be consistent with the needs for conservation of trees and forests. It categorically states that no mining lease should be granted to any (public or private).

5. The policy specifies that the land laws should be modified wherever necessary so as to facilitate or motivate individuals and Institutes to undertake tree farming or grow fodder trees grasses and legumes on their own lands.

6. The policy favours the restriction on grazing, browsing in forest areas by levying grazing fee to discourage people in forest areas from raising heads of livestock.

7. The policy envisages to put an end to removal of timber by contractors, by replacing with bodies like tribal and labour cooperatives and government corporatives.

8. The new forest policy also invites special care for the needs of wild life conservation.

Check Your Progress - 3 & 4

3. What is meant by silviculture?

4. Define deforestation.

Note: a) Write the answers in the space given below.

b) Compare your answers with those given at the end of this unit.

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4.6. PEOPLE'S MOVEMENTS

Various peoples movements are given below:

4.6.1. Chipko Movement

In mid Himalayan region, the main tributory of Ganga, the Alaknanda and its feeders such as Rishi Ganga, the Patal Ganga, the Garudganga and Mandakini etc., had thick forest cover. In the catchment area of these feeder rivers and Alaknanda, the large scale cutting of trees and rolling them down hill loosened the upper soil which eroded during every rainy season. The deforestation activity over a decade period resulted in a devastating flood in the Alaknanda in July 1970, which caused havoc in the upper catchment area. The silt choked the upper Ganga canal from Haridwar to Pathari for 10 km and affected irrigation in about 3,80,000 hectares for six months besides affecting the functioning of 48 MW Pathari power station. All these greatly affected the agricultural production in this region.

In this region of Uttarakhand, the Dasholi Gram Sarajya Mandal (DGSM), Gopeshwar which was engaged in social work stepped into carry out relief work during 1970 floods. They realised that forest and land and forest and man were intricately linked. The people were educated about it and gradually they geared themselves into a movement. Thus the Chipko Movement was born. A plan of action was drawn by the people of non-violent methods to oppose the cutting of trees by contractors and forest department. It was on April 24, 1973, the people's movement began in the Mandal near Gopeshwar, a brave method of

"hugging the trees to save them from cutting". The forest department and the contractors avoided a confrontation but marked trees for cutting 60km away from Gopeshwar in the Phata-Rampur jungles near Kedarnath. When Chipko workers came to know of this they reached the forest and with the help of local people hugged the trees to save them. The Chipko Movement thus successfully had been launched.

In 1974, the forest department began marking trees for felling in the Peng Murendra jungles in an area of about 430 hectares which was affected by Alaknanda floods of 1970. From this area the Rishi Ganga rising from Rishi glacier flows. The social and political workers and students decided to act against the felling of the trees. The contractors tried to infiltrate into area. But the Mahila Mandal Dal of Rini village challenged them and hugged the trees to save them.

The movement attracted the attention of Uttar Pradesh Government, which appointed a committee headed by the botanist Dr. Virendra Kumar. The Chipko Movement through this committee managed to raise the questions about 10 year plan of forest department and it received global support. The contractors and other agencies who supported the felling of trees earlier became a part of the movement.

After the Chipko Movement was organised and implemented in Gopeshwar, Bheundar (near the valley of flowers), Joshimath and Chancharidhar, the forest officials cancelled the programmes to fell trees. The movement again gathered momentum in 1980 when Dungari Paintoli, a dense oak forest was to be cut to accommodate an orchard.

In 1989, the villagers of Malai-Nauti (near Karna prayag) in Chamoli district - checked the forest departments' move of plantation of pine trees along with oak trees. Pine leaves falling on the ground increased the acidity of the soil which adversely effect the growth of jungles. The needle shaped leaves of pine trees do not retain any rain water. The danger of fire is more in pine forest. In contrast, the oak trees are beneficial to hill farmers. The forests are the sources of fodder, fruits grass and medicinal herbs. Forest officers at an eco-camp organised in DGSM at Nandarain accepted the arguments of villagers and removed some of the pine trees planted as a gesture.

The Chipko Movement began educating the local people about afforestation by organising conservation camps (eco-camps) in areas affected by landslips in mid Himalayas. At these camps, environmental knowledge is imparted and afforestation is done by 'Shramadan' by the people of the area. Voluntary agency workers, youth University students and experts are encouraged to participate. A typical camp begins involving women with local folk songs connected with forest and environmental preservation. Local problems are discussed and solutions devised.

The local people plant trees on barren and unutilised land around villages. There is a festive atmosphere at the camps with active participation and involvement of local people. Stone walls are put up to save planted trees and crops from foraging animals. In 1989 the people of Bacher, Kathura and Tange villages put out a forest fire on a steep hill without caring for their own safety. This movement took the lead in introducing smokeless chullas and gobar gas plants in the area.

The DGSM has successfully attracted the attention of planners on the impact of big dams and hydel project in the Mid-Himalayas. The Vishnu prayag, hydro-electric project was to be put up 15 km upstream of Badrinath temple which was even cleared by the Environment department. The DGSM highlighted that the entire area would be environmentally fragile and the project was rejected after a review though the work had begun on it. Similarly

because of Chipko Movement, soft stone quarrying was stopped and the entire Alaknanda catchment area has been covered with forests. In the catchment area of Bhagirath in Uttarkashi and in Pithoragarh district licences for detergent and chemical units were cancelled.

Thus the Chipko Movement which began with stopping of falling of trees and saving forests, has successfully involved people in greater issues of ecology and environment.

4.6.2. Appiko Movement

The Uttara Karnataka district of Karnataka which forms part of Western Ghats is known as the forest district. Besides being rich in forest wealth the favourable micro-climatic effect of the tropical forest favoured the cultivation of cash crops like black pepper and cardamom. At the time of independence, 82 percent of the district was covered by forests. The forest based industries such as ply wood factory, paper unit were set up. The Government began felling trees for revenue and the forest department converted the prime tropical forest into monoculture teak and Eucalyptus plantations. The development activities led to a drastic drop in the area under forest cover to 20% in 1983-84.

The destruction of forests on such a large scale woke up the local people especially the youth. They were motivated into direct action. A group of youth in Balegadde village represented to the forest officials not to establish teak plantation by clearing the natural forests. But this appeal was ignored. Then the villagers decided to launch the Chipko Movement popularised by environmentalist, Sunderlal Bahuguna in the Himalayas. He was invited and people took an oath to protect the trees by embracing them. This movement came to be known as Appiko in Kannada. In September 1983, when axe-men came for felling to the Kalase forests, people embraced the trees and thus Appiko Movement was launched.

The simple non violent action became popular state wide and the people joined the movement spontaneously in many forest areas of Western Ghats from Coorg to Goa, Padayatras, slide shows and street plays created mass awareness. The Yakshagana, a folk dance was used effectively to convey the message of forest conservation. In Coorg district, people stopped the felling of trees in the Cauvery catchment area for which the government had given felling permits to plywood units. The people camped in the forests for months to save natural wealth. In Dakshina Kannada, the authorities of Subramanya temple resorted to the Appiko Movement to save evergreen forests while in Shimoga district, youth groups stopped felling trees by forest based units. The action groups of this movement with a wide base support of local people constantly watch the status of Western Ghat forests.

The vigorous launching of the movement forced the government of Karnataka to change its forest policy by stopping the felling of natural forests, the policy of raising monoculture plantation of teak was abandoned, allotment of timber to units was stopped and the government itself stopped felling green trees for revenue.

The Appiko Movement has three main objectives. These are:

1. To conserve the remaining meagre tropical forest of Western Ghats.
2. To bring back greenary to areas by natural regeneration and by planting the seedlings raised in the nursery.
3. To make people use forest resources rationally.

The Appiko movement also interacts with action groups in other regions of Western ghats.

In Wynad, Kerala its activists are in touch with local groups to evolve a strategy to save the forests. In Tamilnadu the Appiko is working with the save Eastern Ghat Organisation while in Goa it is helping environmental groups. The impact of successfulness of Appiko Movement has been felt in other countries (Malaysia, Indonesia, Vietnam and Ivory Coast) as wood based units in India started importing timber from these countries.

4.6.3. Kerala Sastra Sahitya Parishad (KSSP)

This is not wholly an environmental Non-government organisation but one of its main activities is environmental education. Some of the activists of this organisation took keen interest in finding out pollution problems in and around the city of Cochin (Kochi) in the early 1970's. The group made preliminary survey on air, water and land pollution and assessed the damage caused and worked towards creating public awareness as a possible means of demanding the arrest of worsening of the environmental status of the Cochin area.

The K.S.S.P. actually involved in the environmental issues in the later part of 1970's. It was invited to study the ecological and other problems in the proposed hydro-electric project in the silent valley in Kuttanand district. The debate on silent valley project was becoming controversial in 1978.

The K.S.S.P. had established its environment and health Brigade and coordinating mass education programmes on environmental issues. At this time, the villagers of the Chaliyar river basin were protesting against the Gwalior Rayons factory at Mavoor which threatened their lives by severe pollution of water and air. The K.S.S.P. got involved in this and soon a team of experts studied the problem and eventually brought into light an economically feasible solution. Simultaneously KSSP strengthened its nonformal education by introducing the famous Kala jaatha using folk art medium, exhibitions, wayside meetings, slideshows and demonstrations.

The campaign to save silent valley turned out to be a public education programme in many respects. All sorts of issues cameup and the campaign grew with various small organisations such as 'Save Silent Valley Societies' "Societies for Environmental Education", "Societies for Environmental Protection", "Nature of Lovers" etc.

KSSP's awareness programmes were designed on multipronged approach. It fought to save forests not for aesthetic or pure ecological value but preserving gene pool with its socio economic implications. It is related to conservation issues to the needs of the future.

According to Mr. Darryl D'Monte, the rallying force of the KSSP, the silent valley is a unique environmental campaign in the entire Third World because it took the issue out of lecture rooms and columns of the press to the people. Many people in Kerala are aware of meaning of ecology, due to silent valley movement. This movement is symbolised with the slogan "Development without destruction". Initially KSSP was associated with state government schemes of social forestry in supplying and distribution of saplings. Subsequently not satisfied with this programme, it also questioned the introduction of *Eucalyptus* and *Acacia* on such a a large scale. The state government had to abandon efforts of planting *Eucalyptus* in new areas. The KSSP learnt that when any construction of dam or clearing of forest is opposed it should be in a position to suggest suitable alternatives.

4.6.4. Narmada Bachao Andolan (NBA)

Under the leadership of Baba Amte, the Narmada Bachao Andolan has put all its efforts to oppose the construction of the Rs. 9,000 crore multi purpose project on the Narmada river. It began as a campaign for rehabilitation for over one lakh oustees of this project spread

across Gujarat, Maharashtra and Madhya Pradesh has crystalised into a movement against large dams. It mainly opposed the government efforts to move and relocate people in the submergence area of particularly Maharashtra and Madhya Pradesh. The movement ideologically questions on the direction of development policy which does not weigh benefits and cost of the project.

To strengthen their point of view Narmada Bachao Andolan activists have lobbied in India and abroad. They gave petition to World Bank which is the main financier of the project and resorted to dramatic action of waiting until flood water drowned them in the village of Manibali in Maharastra. It's do or die tactics were perceived as extreme but its sustained campaign forced the World Bank to suspend further assistance to the project until Independent Review Commission led by Justice Thomas Berger reassessed the project particularly its rehabilitation and relocation plans. The Narmada Bachao Andolan won the Right Livelihood Award popularly known as the alternative Noble Prize in the year 1991.

The second most prominent antidam campaign is against Rs. 3465 crore Tehri hydro-electric project in the Garwhal Himalayas. The project envisages a 260.5 m high earth and rock fill dam across Bhagirathi in a seismically volatile region. The Tehri Bandh Virodhi Samithi a group of local people lead by environmentalist Sri Sunderlal Bahuguna is opposing the implementation of this project.

Check Your Progress-5

What are the main objectives of Appiko Movement?

Note: a) Write the answer in the space provided below.
b) Compare your answer with the one given at the end of this unit.

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4.7. EUCALYPTUS DEBATE

Eucalyptus plantations of different species were being taken up on a large scale during 60's and 70's as a measure of recouping the existing forests as well as on social forests programme on waste lands, common lands, road sides, canal sides, farm bunds and also in agricultural lands. *Eucalyptus* hybrid and *E. tereticornis* were widely planted in areas of average climatic conditions. *E. Citrodora* was planted for extraction of oil. *E. glabulus* was planted at higher elevations of southern and northern hills. *E. grandis* was found suitable for high rainfall area (Kerala) while *E. camaldulensis* was preferred in low rainfall areas. Similarly some other species were grown on specific microsites.

Characteristics of *Eucalyptus* sp.

1. These are quick growing and can be harvested within 7 to 10 years.
2. They are easy to raise and manage.
3. The survival of trees is very good.

4. Establishment is faster.
5. They are not grazed and browsed by livestock.
6. They have good regeneration capacity and can be harvested 2-3 rotations with one time plantation.
7. These plantations are economically viable and commensurate with investment.
8. They are highly adoptable to different soil and climatic conditions.
9. The timber and fuel wood obtained are useful for variety of purposes.

Large scale plantation of *Eucalyptus* has drawn the attention of journalists and environmentalists who started opposing the plantation of *Eucalyptus*. Under these pressures Government of India stopped plantation of these species on forest lands. The controversy whether *Eucalyptus* have long term ecological effects has centered around the following aspects.

1. *Eucalyptus* consumes water copiously and lower the water table.
2. *Eucalyptus* prevents undergrowth and do not check run off water and soil loss.
3. *Eucalyptus* makes the soil acidic and does not enrich it.

The research findings on the above issues are as follows

1. *Eucalyptus* and water consumption

i. The transpiration rate of *Eucalyptus* species vary from 20 to 40 litres/tree/day (FAO 1985). This is not very high and is equal to pines and other borad leaved species. In Nilgiris annual transpiration of *Eucalyptus* corresponds to 347 mm of rainfall. In Isreal evapotranspiration from regenerated *E. camaldulensis* is very small i.e., only 24% of pan evaporation compared with 22% from bare plot and 31% from adjacent natural forest.

The water consumed per unit of biomass produced (litre/g) was low in *E. tereticornis* (0.48) as compared to 0.55 by *Albizia lebbeck* 0.72 by *Acacia auriculaformis*, 0.77 by *Dalbergia sisso* (Chaturvedi 1983, Tiwari and Mathur 1983). *Eucalyptus* has the capacity to adjust the water use by adjusting transpiration rate. When water is available in plenty they go for luxury consumption but when water is in short supply they reduce water uptake considerably (Sharma and Nagi 1984).

When water table is high, say within 2-3 metres of surface, most trees will tend to lower water table to certain extent. *Eucalyptus* root system goes about 3.5 to 4.5 m deep. Water tables located below the capillary fringe area are not likely to be affected by Eucalyptus or any other plants. Rapid development of root system in trees helps in infiltration of rain water and reduce surface and sub surface run-off irrespective of tree species.

ii. *Eucalyptus* are accused for reducing the undergrowth which leads to more run-off and soil loss. but research evidence indicates that *E. camaldulensis* and *E. grandis* plantations supported more undergrowth than *Shorea robusta*. It is believed that certain species of *Eucalyptus* have allelopathic effects which inhibit the germination and growth of other species. However evidence indicates that production of undergrowth is mostly governed by soil fertility, moisture and site factors. In area of high rainfall such as Dehra Dun, with good soil fertility, *Eucalyptus* plantation of different species support as much as undergrowth as natural forest. In dry areas these plantation support a thin undergrowth. There is no evidence to indicate that soil

erosion is more in *Eucalyptus* plantation compared to other plantations or vegetation. Its plantation is more safe in reducing soil loss compared to agriculture.

iii. Trees are important as some of them fix nitrogen and add nutrients through recycling. *Eucalyptus* do not fix nitrogen from the atmosphere. Studies indicate that certain species of *Eucalyptus* add substantial amounts of nutrients through precipitation. The litter production in *Eucalyptus* hybrid plantation varies from 3377 to 6207 kg/ha which is slightly less than teak and sal. There are no evidences to indicate that *Eucalyptus* make the soil acidic.

It is clear that most of the criticism of *Eucalyptus* is not based on scientific facts. However, more investigations are required in different localities to clarify the position on these aspects.

4.8. SOCIAL FORESTRY

According to Jawaharlal Nehru "A growing tree is a living symbol of a progressive nation".

Social forestry was first started in the year 1976 based on the recommendation of National Commission on Agriculture. It is defined as a forestry having social content achieved through the participation of people and intended to meet timber, fuel and fodder grazing requirement of local people. It is agro-forestry taken up by the community on waste lands, community lands, road sides canal sides etc., to meet their needs of timber, fuel and fodder.

Historians have mentioned occurrence of dense forests in Northern India during Alexander's invasion (327 BC). The destruction of forests probably might have started since their main occupation was cattle rearing. By the time of Asoka the destruction of forests was to a considerable extent. He therefore advocated tree plantation along with roads and camping grounds.

The concept of social forestry was enunciated in a comprehensive manner by Mahatma Gandhi, the Father of the Nation. According to him an ideal village be so conditioned that the villagers could procure all their needs and requirements of materials such as bamboos for thatching, fuel wood, grazing, timber for implements and other domestic requirements from with in a radius of 10 km. The credit for coining the term social forestry for the first time goes to Mr. Westoby (1968), who defined it as forestry which aims at producing flow of protection and recreation benefits for the community.

Since the independence, the government of India launched many forestry programmes. The Van Mahotsava, Make India Green Campaign, Save Himalaya Movement and other social forestry programmes are being carried. The central government is also rewarding Van Pandit award at state level and Indira Priyadarshini, Vrikshamitra award at national level in recognition of exceptional contribution in the field of afforestation and wasteland development every year to individuals and non–governmental organisations. The biggest botanical garden in Asia is being set up on the National Highway No. 1 near Karnal in Haryana. The environment and forest department has provided Rs. 30 crore to the state specially for this purpose under the project of "Greening of Haryana".

Inspite of all the efforts made by Government of India only a little success has been achieved in social forestry programmes. The major reason is the lack of active participation by local people as well as lack of full cooperation from persons concerned in these programmes.

4.8.1. Need of Social Forestry

The vast human and cattle population of country needs fuel, wood, fodder and small timber. In India 95% of fuel consumption mainly consists of fuel wood, cow dung and agricultural wastes. The agricultural labourers and farmers are using large quantities (4.58 mt of wet dung annually) of cow dung as a fuel due to shortage of fuel wood, which otherwise can be diverted to increase the food production or "We are burning the food to cook the food". The extensive deforestation resulted in serious soil erosion. About 144 million hectares of land is being affected by erosion, causing removal of 6000 million tons of fertile top soil every year including 5 mt of NPK nutrients. The soil erosion also results in silting up of reservoirs and causes floods. The fast receeding forest cover is causing "Green House Effect" where CO_2 content of atmosphere is being increased which results in increase in earth's temperature by 1-2°C.

It is estimated that about 146 million hectares of wastelands including 30-35 million hectares of degraded forests, 40-45 million hectares of marginal agricultural lands are available in the country. Keeping in view, low per capita availability of land, the waste lands can be put to proper use by effective land use planning.

Therefore the immediate need of the day is creation of new man made forests near the habitations, village waste lands etc., to cater to the needs of rural masses besides conserving the eco-system and restoring the productive capacity of all waste lands. National Commission on Agriculture (1976) therefore recommended that each state should reorganise the forest department into two separate wings (1) To retain charge of traditional production forestry (2) to develop social forestry aimed at the production of fuel wood, fodder and other minor forest products for rural population. Subsequently the World Bank undertook a review of forestry prospects in India in 1978 and identified social forestry programme as an ideal vehicle for economic development in rural areas. In the year 1985, late Prime Minister Shri Rajiv Gandhi set up the National Waste Land Development Board fixing a target of converting 5m. ha of waste land into forests to every year.

4.8.2. Objectives of Social Forestry

1. To develop tree consciousness and love for tree cultivation among the masses.
2. To supply fire wood to the rural areas and to replace use of cow dung.
3. To provide timber for sustaining and creating village level cottage industries based on wood.
4. To supply fodder for livestock.
5. To protect the agricultural fields against wind and soil erosion.
6. To improve the socio-economic level of the village through increased avenues of gainful employment.
7. To raise green belts around industrial locations to contain atmospheric and noise pollution.
8. To help in planting all available land in the urban areas to improve the urban environment.
9. To make vast saline and alkaline lands productive through afforestation.
10. To create recreational amenities.

4.8.3. Components of Social Forestry

The broad base of social forestry was extended to urban forestry and designed for the benefit

of community. The National Commission on Agriculture outlined the scope of social forestry as follows:

1. *Community Forestry:* Practice of forestry on community land in which planting, management, harvesting and marketing of forest products are carried out by rural community members by themselves with the proceeds going to benefit the community rather than individuals.

2. *Farm forestry:* Practice of forestry on farm land in which individual land owners are encouraged by training and incentives to plant the trees along the field boundaries, near wells etc. Raising of shelter belts and wind breaks are also included in farm forestry.

3. *Extension forestry:* Practice of forestry outside farm lands and reserve forests. It includes raising of trees on canal banks, railway lines, road sides, foreshore areas of tanks, reservoirs and on marginal lands not suitable for agriculture.

4. *Recreation and amenity forestry:* Creation and maintenance of trees for recreational purposes and improvement of local amenities.

5. *Rehabilitation forestry:* Creation of forest or raising of trees in degraded forests and degraded lands.

6. *Compensatory plantations:* Supplementing the natural regeneration to conserve the natural forests with the benefits of gene conservation for supplies of medicines and protection.

7. *Agro forestry:* A form of mixed cropping where trees are integrated with agricultural crops on arable lands for sustainable agriculture.

8. Urban Forestry: Growing of trees in urban areas for beauty and climatic amelioration.

4.8.4. Scope of Social Forestry

In India about146 million hectares of waste land is available which can be brought under social forestry programme. The premises of schools, colleges, universities and other institutions, periphery of community ponds, grounds also provide enough area for plantation of trees. Plantation of ornamental trees can be taken up on roadsides and canal banks. Agro-forestry can be introduced in the individual farms for production of food crops besides production of fodder for cattle and wood for fuel and timber.

4.8.5. Selection of Species

In order to ensure success in the social forestry programmes, it is necessary to select suitable species and proper planting techniques. The species selected should possess the following characters.

1. Ability to survive and grow well under difficult social and edaphic conditions.
2. Should be fast growing and in a position to yield useful produce in a shorter duration.
3. Resistance to local hazards including pests, diseases, fires, grazing and browsing.
4. Ease of seed procurement, handling, storage etc., Easy techniques of nursery and regeneration.
5. Should not harbour the pests and diseases of field crops.
6. Should not have adverse effects such as shade or competition with companion crops.
7. Should possess proper root system for soil and water conservation.

A few common examples of such species are *Eucalyptus, Acacia, Dalbergia, Azadirachta, Bambusa, Quercus* etc. An admixture of 75% of quick growing firewood species, 20% of small timber yielding species and 5% of fruit bearing trees is commonly recommended by forest experts.

Social forestry must provide wage employment to certain families in the neighbourhood areas through raising of nursery, planting of trees and protection of trees/ nurseries etc.

4.8.6. Management of Social Forestry

Planning for social forestry activity should be done from the village level so that it is local, need based as well as socio-economic, environment protection and target oriented. The targets should be based on the desire of the people but not on the wish of government. The social forestry programme so far remained unattractive for majority of the villagers. There is a need to assess the requirements of villagers and to identify the local leadership right from the initial stage of planning. The following steps should be taken for effective involvement of people in social forestry.

1. Wide spread education of people through various media for identifying the species and techniques for rapid propagation, demonstration etc., should be taken up.
2. Training of the manpower to be employed, through workshops, seminars, discussions etc, should be held.
3. Seedlings should be raised and extension support should be provided to individuals, institutions, organisations etc.
4. The service of the existing voluntary organisations should be utilised for taking up plantation activities. Involvement of local people will reduce the cost of production.
5. Motivate the farmers to take up tree farming in their holdings.
6. Procurement of common area for social forestry plantations should be taken up by the government and other agencies.

4.8.7. Problems and Constraints

The protection of trees raised under social forestry poses certain problems. The protection of community plantation depends on ownership and sharing of profits by the rural people. The ownership rights are not given to the people in most cases. The uncertainity about legal status of land is a great constraint on taking up forestry development programmes in India. The other constraints are the differences in protection and maintenance of trees, grazing and browsing by cattle and profit sharing etc.

The following suggestions are made for successfully implementing social forestry programme.

1. The involvement of the people by giving proprietory rights at the time of implementation of programme may be the correct step to create interest in the protection and maintenance of forests. The sharing of produce and profits should clearly be spelled out. Forest farming for rural poor (FFRP) has been successful in Orissa, Karnataka and in many other states.
2. Provide financial assistance till the returns from the forestry crops are obtained to reduce financial burden of rural poor.
3. A net work of forest nurseries and extension workers should be created for taking up timely planting of social forestry with suitable tree species.

4. The students in schools and colleges should be involved in making use of premises and other surrounding waste land areas for tree plantation.

5. Demonstration of social forestry benefits on the farms should be organised.

6. A number of non-governmental orgnaisations (NGO's) are playing a crucial role creating awareness for conserving forest resources and adopting new technologies as alternative source of energy. The involvement of these organisations significantly contribute to extension of social forestry to the surrounding villages. These organisations can take up planting and protection of trees in and around government offices, sport bodies, cultural centres, rail tracks, sides of irrigation and drainage canals, road sides etc.

7. Villagers cooperation must be sought in the protection of plantations on government waste lands and other community lands.

8. Grass cutting may be permitted to the villagers in social forests but not grazing.

9. Should be executed taking into consideration the socio-economic needs of the people and land capability of the area.

10. The areas and villages which are having serious shortage of fuel, fodder and small timber should first be selected for social forestry programmes.

11. Tree plantations and revenue from farm forests should be exempted from wealth tax.

12. Prizes and awards for groups and individuals separately can be given in recognition of outstanding work in social forestry programmes.

4.9. ACTION FOR FUTURE

The FAO assessment reveals that tropical forests are being cut much faster than reforestation or afforestation of new areas. In early 1980's in the tropical region about 11.3 million hectares of forests were being cleared annually while only 1.1 million hectares plantation were being established. It is therefore necessary to regulate the felling of trees in the forests restricting to only old trees. The area that is to be brought under forests under various forestry programmes not only compensates the felling of old trees but should account for 8-10% additional area under forests.

The regeneration of stocks of felled trees should properly be protected from trampling and grazing of cattle. They also need to be protected from fire which is a common feature in the forest during summer. The heavy grazing and repeated fires have limited the process of humus formation which is so essential for providing required nutrients for growing trees besides improving the physical condition of the soil. The forest trees are generally deciduous in nature and shed foliage heavily. The shed foliage is one of the primary cause for frequent fires in the forests. It is therefore necessary to make use of fallen leaves as a mulch to check the evaporation losses of soil moisture so that newly germinated or regenerated seedlings get sufficient moisture for longer period. These mulched leaves later get decomposed and serve as a manure for nourishment of young seedlings.

In the existing forests wherever there are gaps and large stretched vacant patches and in adjoining areas of forests, manual reseeding with quick growing tree species like Subabul, Casuarina, and bamboo etc., should be taken up. The former two tree species have profuse foliage with heavy leaf shed. The decomposition of leaves of these species is also quite fast.

The protection of forests from grazing and fire not only result in more humus formation but provide favourable conditions for better growth of newly emerged seedlings. Thus better growth of regenerated seedlings from stocks, and seedlings from indigenous seeds and introduced seeds create a congenial microclimatic environment for further enhancing the natural regeneration of valuable species like teak etc.

The thick and green forests which were seen 30-40 years back in many places nearby villages are no more present. The large scale deforestation resulted into loss of fertile top soil in the forest areas. In all our present five year plans the major thrust is being given only on reforestation and afforestation activities without any budget provision for after care of reforestry and afforestry activities such as watering and manuring. In degraded forests it is necessary that nourishment of young seedlings is made by leaf mulching of fallen leaves and later incorporating near the trunk of trees. In all such slopy degraded forest areas, soil and moisture conservation measures should invariably be taken up to check the further loss of soil and water so that regeneration and recouperation of forests take place properly.

It is being reported that some reserved forests such as Tiger reserve forest on Hyderabad-Srisailam road are being invaded by most undesirable species like *Lantana,* which is bushy in nature without yielding any worthwhile wood neither for fuel nor timber purpose. The growth and spread of such unwanted bushy plants should be checked and these should be replaced with quick growing useful tree species. The common species preferred for planting are Neem, Sisso, Siras, Shivan, Holoptelea, Kachnar etc. There are some other plants like Sawar and Ailanthus which have great potential of colony formation. Subabul is also one of such species besides being multipurpose should find a place in various afforestry programmes.

In the under-developed countries, as seen in previous chapter, the main cause of deforestation is fuel wood requirement. It is felt by environmentalist and others concerned with future prospectives, that a country of our size cannot afford any more cutting of trees from already depleted forests. The gap between demand and supply of fuel wood would be approximately 125 million tons annually by 2000 A.D.

The fuel energy requirement of vast number of rural families has to be tackled mainly by two approaches

(i) To find out alternative fuel resources which can be within the purchasing power of rural people.

(ii) To bring more area under forests utilising waste lands and poor soils through social forestry and other forestry programmes.

I. To meet the acute fuel wood shortage, the following alternative measures are suggested.

1. Educating the rural masses about the ill effects of deforestation on environment, soil loss and other effects.
2. To make use of alternate fuel sources such as Gobar gas plant etc. in rural areas.
3. Installation of improved chullas having heat utilization efficiency of 30 to 40%.
4. Development of gas plants utilising agricultural wastes.
5. Development of suitable solar technology to make use of solar energy for cooking
6. Utilisation of logging wastes.

All these measures partly will reduce the pressure on the demand of fuel wood.

II. 1. The selection of tree species for social forestry should possess fuel efficiency properties such as combustability and caloric value (heating power). The readiness with which it catches the fire and continues to burn is known as "Combustability". The wood of dense structure generally takes long time to burn and gives steady heat than porous wood. The wood containing 8 to 9% moisture is just enough for domestic wood burning for cooking.

2. Under social forestry and afforestation programme, it is being recommended to adopt high density planting using intensive production measures. As the tree growth progresses, the certain number of trees at regular spacing can be cut in phases to meet fuel and other small timber requirements.

3. Tree plantations should be encouraged by individual farmers, on the field bunds and on all border sides of their fields as a farm forestry practice.

4. To popularise agro-forestry and forage forestry and forage horticultural systems particularly in marginal and poor soils to supplement the fuel and fodder requirement of villagers besides field crops and fruit trees.

4.10. SUMMARY

The protective and ameliorative role of forests on various aspects of environment such as maintenance of CO_2 balance, cooling down temperature, increase in precipitation, checking soil erosion and floods, providing organic matter etc., besides supplying fire and timber wood, fodder and various other forest products were emphasised. The demand for fuel and timber wood and cattle grazing by rural people, conversion of forest land into agriculture and other purposes such as rehabilitation, mining, commercial exploitation, shift cultivation are some of the causes of large scale deforestation in our country. The ill effects of deforestation and its threat to the future of mankind were pointed out. The genesis of various people's movements such as Chipko Movement, Appiko Movement, Kerala Sastra Sahitya Parishad Movement and Narmada Bachao Andolan in protecting the trees against felling in forests and their participation in afforestry programmes was discussed. The mass educational approach in environmental issues by these movements was highlighted. The doubts regarding *Eucalyptus* plantation and their long term ecological effects were cleared. The need for social forestry and its various components and their management was considered. The various steps were suggested to overcome the problems and constraints in implementation and maintenance of social forestry. The action for future is suggested in finding alternative fuel energy resources to reduce the stress on the forests and various measures in conversion of waste lands into forest lands.

4.11. CHECK YOUR PROGRESS : MODEL ANSWERS

1. Forest is defined as an area of uncultivable land occupied by different trees, shrubs, herbs and grasses.

2. The theory and practice regarding creation, conservation and scientific management of forests and continuous utilisation of their products is called forestry.

3. Art and science of cultivating forest crops is called silviculture.

4. The permanent conversion of forest land to deserts, waste lands, postures, shifting cultivation, agriculture or infrastructure development is called deforestation.

5. The three main objectives of Appiko Movement are: (1) to conserve the remaining meagre tropical forest of western ghats (2) to bring back greenary to areas by natural regeneration and by planting the seedlings raised in the nursery (3) to make people use forest resources rationally.

4.12. MODEL EXAMINATION QUESTIONS

I. Answer the following questions in about 30 lines each.

1. How are forests important in man's activity?
2. What are the causes of deforestation? What measures do you suggest to tackle the above problem?
3. What is Chipko Movement? How is it started? What are other movements that were started in other parts of the country? Do you think that such movements are necessary to check the deforestation in various parts of our country.
4. What are controversial views with regard to plantation of *Eucalyptus?* Are these views have any scientific basis? Why is *Eucalyptus* plantation became popular?
5. What is social forestry? Why is social forestry necessary for India? What are limitations and how do you overcome them?

II. Answer the following questions in about 10 lines each.

1. What is the role of forests on rainfall occurrence?
2. How are forests useful in protecting the environment and maintaining the ecological balance?
3. Why are forests degraded to greater extent in developing countries compared to developed countries?
4. Briefly describe the forest policy of India.
5. What is Narmada Bachao Andolan?
6. What are the disadvantages of plantation of pine trees?
7. What are the characteristic features one should look into while selecting tree species for plantation under social forestry programme?
8. What alternative fuel sources do you suggest in place of fire wood?
9. Briefly mention different uses of forest products.
10. How do you solve the problem of fuel wood shortage?

Prof. S. Narsa Reddy

UNIT - 5 : LAND MANAGEMENT IN INDIA

Contents

5.1. OBJECTIVES

After going through this unit, you will be able to:

* classify land use system and describe the change in land use pattern over the last 4 decades,
* describe the scope and limitation of extensive and intensive cultivation in relation to food requirement,
* discuss about soil erosion problem and control of wind and water erosion;
* identify of salt affected soils in India and suggest measures for the reclamation and

management of different salt affected soils,

* describe the causes for conversion of cultivable lands into waste lands, types of wastelands, wasteland management of different types of wastelands,
* define infertile and fertile and productive soils,
* describe the method of maintaining soil fertility.

5.2. INTRODUCTION

Land is the basic input for man's existence. Out of total reporting area of 305 million hectares in our country, about 181 million hectares of land is classified as agricultural land (arable land) which comprises of 142 million hectares net sown area, 23.4 million hectares of fallow land, 11.8 million hectares of permanent pastures and 3.7 million hectares under miscellaneous trees. An area of 68 million hectares is under forests. All these lands come under broad category of vegetated lands (249 m.ha).

Nearly 85 per cent of vegetated lands (216 m. ha) are being subjected to one kind of degradation or other and a greater part is due to soil erosion (150 m.ha). The fertility status of Indian soils further points out that 95, 98 and 65 percent of the soils are low to medium in NPK status respectively.

The net cultivated area remained around 140 million hectares from last 25 years which clearly indicates that there is practically no scope for enhancing the food production by extending the area under cultivation. The food grain requirement of growing population has to be met mostly by bridging the gap between the average yields obtained at farmers field and yields achieved at research farm. This is possible through better adaptation of intensive cultivation practices under irrigated conditions as well as adoption of suitable integrated technology under watershed philosophy for rainfed crops.

It is therefore of paramount importance that the present lands are protected from further degradation and restore their fertility status. Hence the immediate attention of planners, rulers, administrators and scientists is called for to halt the process of degradation of our lands through adoption of effective measures in checking soil loss, stopping the process of deforestation, reclamation and management of saline and sodic soils etc. Multidisciplinary and integrated system approach for increasing the yields of dry land crops through better moisture conservation practices and harvesting excess run off in farm ponds for reuse under aberrant rain fall condition as life saving irrigation is being contemplated under watershed programme. The water harvesting technology through farm ponds spread over in number of small watersheds would also help in minimising the flood damage under events of heavy rain.

Development of waste lands at a rate of 3.6 million hectares every year by converting them into forest lands by afforestation and social forestry programmes by National Waste Land Development Board is laudable step in right direction to mitigate the problem of deforestation. The importance of forests in maintaining ecological balance and in preventing land degradation should be realised by present and future generation. Integrated nutrient management of organic and inorganic fertilizers through effective use of organic wastes and other resources are being advocated to sustain the productivity of agricultural lands.

5.3. AGRICULTURAL LAND

The land is the basic requirement for man's existence. It is reported that every person needs 0.4 ha cultivated land to meet his food needs and another 0.8 ha land for all other purposes.

The planet earth provides us a total geographical area of 15.2 billion hectares which measures 3.00 ha per person as on 1989. However in countries like Australia, and Canada the per capita availability of land is 50 ha, in South America and USSR 10 ha, in USA 4 ha, in France 1.2 ha, while it is only 0.41 ha in India. The per capita availability in India based on total geographical area was 0.91 ha in the year 1951. However with the increase in the population, the per capita availability of land decreased to 0.39 ha as on 1991 and it would be further brought down to 0.33 ha by 2000 A.D.

India has a geographical area of 329 million hectares, of which 24 million hectares are inaccessible. The records of land use pattern are available for only 305 million hectares (total reporting area). The land in India is classified into 8 categories and reporting area is taken as a base value (total land area) for computing the percentage of different categories of land.

5.3.1. The Changing Land Use Pattern

The statistical data on land use pattern in India for a period of four decades from 1950-51 to 1990-91 is presented in Table-1. It is seen from the table-1 that the land area put to non-agricultural use increased considerably over the four decades from 9.4 million hectares during 1950-51 to 21.2 million hectares in 1990-91. It is also noticed that the area under barren and uncultivable land decreased by 18.4 million hectares from that of 38.1 million hectares (13.4%) in 1950-51 to 19.7 million hectares (6.5%) in 1990-91. This is mainly due to change in the attitude of the people towards urbanisation where fertile land as well as barren rocky lands are being used for the construction of buildings, roads, recreation parks and play grounds etc. It is further reported that atleast 3,00,000 hectares of prime agricultural land in the world disappear every year under buildings, roads, recreation parks, play-grounds, aerodromes, helipads etc., of modern era (development).

As per the table-5.1, it is inferred that there was a drastic change in land use during the first decade after independence and it was gradual there after. The area under miscellaneous trees decreased to 4.4 million hectares (1.5%) in 1960-61 from that of 19.8 million hectares (7%) in 1950-51 and later the decrease was nominal. There is a substantial increase in the area of forests from that of 40.5 million hectares (14.2%) in 1950-51 to 68.00 million hectares (22.3%) during 1990-91 showing an increase of 60% in the area under forest but 37 million hectares of forest lands are reported to be subjected to suffering varying degrees of soil degradation. The area under thick forests with 40% crown density is approximately 38 million hectares.

There is no much change in the area of total fallow land which was 28.1 million hectare (9.9%) in the year 1950-51 decreased to 23.4 million hectares (7.6%) in 1990-91. The area under current fallow was on the increasing trend from 10.7 million hectares to 18.3 million hectares from 1950-51 till 1987-88. However, about 4.5 million hectares of current fallow land was brought under cultivation as on 1990-91. In recent years with the encouraging trend of remunerative prices for commercial crops, oil seeds and pulses, the agricultural profession could attract the attention of unemployed youth for gainful employment. With the increased irrigation potentials, it is expected that atleast more than 50% of current fallow land of 13.8 m.ha as well as old fallow land of 9.6 m.ha may be put to use either for cultivation of crops or afforestation.

The land available for agricultural purposes as on 1991 is about 181.2 million hectares. This includes 11.8 million ha. of permanent pasture and other agricultural land (3.9%), 3.7 million hectares (1.2%) under miscellaneous trees, 23.4 million hectares (7.6%) of fallow land and 142.2 million hectares (46.6%) of net sown area. There is a net increase of 23.4 million

hectares of cultivated area over 40 years period from that of 118.8 million hectares (41.8%) in the year 1950-51.

Whatever increase in the net cultivated area which was visualised during the first two decades of post-independence, and thereafter it remained more or less the same between 140-142 million hectares. There is a limited scope for horizontal expansion of the land. The possibility of increasing the area under this category lies on the cultivable waste land which is about 15 million hectares. It can be put to use through reclamation and in utilising old and current fallow lands.

The gross cropped area in India is about 185.5 million hectares as on 1990-91 with a crop intensity of 130 per cent. The area sown more than once was 13.1 million hectares constituting 11 per cent of net area sown in the year 1950-51 and it steadily increased to 43.3 million hectares which is 30.5 per cent of net area sown as on 1990-91. Thus increase in the double cropped area over 40 years period was measuring only to the extent of 30.2 million hectares. This increase is mostly due to increase in the net irrigation area from 20.1 million hectares (17.1) in 1950-51 to 47.4 million hectares (33.3%) in 1990-91.

5.3.2. Land Degradation

The arid and semi-arid areas with erratic distribution of rain fall and area of steep slopes with low content of organic matter are more vulnerable to environmental and soil degradation conditions resulting in severe losses to rural community. Land degradation has been defined as "the process whereby land deteriorates through reduction in soil depth or quality as a result of actions of water, wind, gravity and temperature which may be reflected in reduced productivity in current and future periods by its impact on the quality and quantity of vegetation which the land supports (Woods, 1983).

The relentless pressure of an increasing human and cattle population, the diversion of lands in fragile ecosystem for dams and roads, the expansion of irrigation without adequate concern for the treatment of catchment or the dangers of water logging and salinity in the command areas, improper agricultural practices on marginal lands, destruction of forest wealth etc., all have caused a considerable degradation where 185 million hectares of forest land constituting nearly 2/3 of the productive area requires special treatment to restore such land for productive and profitable use.

The major cause of land degradation is soil erosion which is again caused by water (111.3 m. ha) and by wind (38.7 m. ha), followed by other factors such as shifting cultivation (4 m.ha), water logging (8 m.ha), salinity and alkalinity (8 m.ha), river action and other factors (7 m.ha) flood affected areas annually (8.00).

The range lands are under heavy livestock pressure and are becoming largely degraded. The livestock population increased from 292 millions in 1951 to 410 millions in 1982. The environmental degradation is taking place at an accelerated rate of deforestation (0.15 m.ha per year) in the Himalayas, the Shivalik ranges, Aravali, Vindhyachal ranges, Western ghats, Eastern ghats and in Deccan and Chota Nagpur plateau.

The fertility status of soils indicated that 95,98 and 65 per cent soils fall under low to medium category in terms of NPK status, respectively.

The various programmes such as Drought Prone Area Programme, Watershed Development Programme, Soil and Land Resources Mapping, treatment of catchment of the irrigation

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( )^ of the total reporting area.

projects and flood prone areas are being in operation with technological back up by Institutes of ICAR as well as the research projects sponsored by ICAR. The policy making bodies such as waste land development boards, National and State Land Use Boards, Pollution Control Board, Ministry of Environment are collectively engaged in gigantic task of greening the waste lands.

5.4. EXTENSIVE VS INTENSIVE CULTIVATION

5.4.1. Extensive Cultivation

It is a method of raising crops in large areas without irrigation with limited resources of manpower and capital. In this type of farming less care and attention is paid in cultivation of crops and the average yields of crops are usually less ranging between 30-50 per cent of what could be achievable with better inputs of men and material under intensive agriculture.

The extensive cultivation is generally practiced by those farmers who have large boldings such of those farmers who have less zeal and enthusiasm and do not possess managerial skills to make use of available resources effectively also practice extensive cultivation. In this type of cultivation because of less productivity, the growing demand of food grains, oil seeds and fibre crops is met by bringing more area under cultivation. However presently there is a limited scope of bringing more area under cultivation. The present cultivable waste lands of 13.8 million hectares and fallow lands of 23.4 million hectares offer little scope in bringing them under cultivation. Most of these lands are degraded to great extent and have to be reclaimed at great cost. The others are infested with tall perennial grass with long underground creeping root stock spread over in states like Madhya Pradesh, Bihar, Rajasthan covering 10 million hectares. Then there are alkaline and saline lands, water logged and deserted lands. The details regarding reclamation of such lands are given in this chapter in respective of such heads of saline soils and waste land management.

During the first 15 years after independence, a portion of lands hitherto which were under the natural protection of grass cover and forests are turned into plough. Through land reclamation measures, fallow lands were utilised in raising new crops. But at the same time the soil is exposed to greater erosion losses (*). The final result of reckless management of cultivable lands is that they have become less productive.

Lands with low production potential includes arid, semi-arid areas with unrealiable rain fall, steep slopes and poor soils. These lands are more vulnerable for environmental and land degradation. These lands as well as present cultivable waste lands and fallow lands are often better suited for production of fuel and timber wood and fodder as an alternative land use system.

Out of total net cultivable land of 142 million hectares, about 42 million hectares (30%) is irrigated and 100 million hectares is rainfed. The scope of increasing the area under irrigation is limited. The cost of creating irrigation facilities have gone up to about Rs. one lakh or more per hectare. About 70 per cent of rainfed area receives low to medium rainfall ranging from 350 to 1150 mm and remaining 30 per cent area falls into category of high rainfall region with more than 1150 mm of rainfall. Earlier much attention was not paid to dry land crops.

(*) with an average soil loss of 6-10 tonnes/ha/year.

Table - 5.1 Land use pattern in India

	1950-1951		1960-61		1970-71		1980-81		1990-91	
	Area	%	Area	%	Area	%	Area	%	Area	%
Geographical Area					328.73					
Total reporting area	284.3	100	298.5	100	303.8	100	304.2	100	305	100
2. Area under forests	40.5	14.2	54.1	18.1	63.9	21	67.4	22.1	67.99	22.3
3. Area not available for cultivation	47.5	16.7	50.7	17.0	44.6	14.6	39.6	12.9	40.9	13.4
A. Land put to non-agricultural uses	9.4	3.3	14.8	5	16.5	5.4	19.7	6.4		6.9
b. Barren and uncultivable land	38.1	13.4	35.9	12	28.1	9.2	19.9	6.5	19.7	6.5
4. Other uncultivable land excluding fallow lands	49.6	17.4	37.6	12.6	35.1	11.5	33.0	10.7	30.5	10.0
a. Permanent pastures & other grazing lands	6.9	2.3	14.0	4.7	13.3	3.3	12.0	3.9	11.8	3.9
b. Land under miscellaneous tree crops included in net area	19.8	7.0	4.4	1.5	4.3	1.4	3.6	1.2	3.7	1.2
c. Cultivable waste	22.9	8.1	19.2	6.4	17.5	5.8	16.8	5.6	15.0	4.9
5. Fallow land (old and current fallow)	28.1	9.9	22.8	7.7	19.4	6.3	22.0	7.2	23.4	7.6

	1950-1951		1960-61		1970-71		1980-81		1990-91	
	Area	%	Area	%	Area	%	Area	%	Area	%
6. Net area sown	118.8	41.8	133.2	44.6	140.3	46.3	140.0	46.0	142.2	46.6
7. Area sown more than once	13.1	--	19.6	--	25.0	--	32.6	--	43.3	--
8. Gross cropped area	131.9	--	152.8	--	165.8	--	172.6	--	185.5	--
9. Cropping intensity (percent) (gross cropped area x 100)/Net sown area	--	111.1	--	114.7	--	118.2	--	123.3	--	130.4
10.Net irrigated area	20.1	*17.6	24.7	18.5	31.1	22.2	38.7	27.7	47.4	33.3
11.Gross irrigated area	22.6	**17.1	28.0	18.3	38.2	23.0	49.8	28.8	61.8	33.3

* Percent of net area sown
** Percent of gross cropped area

1. Indian Agriculture in brief 24th Edition
2. A.P. Statistical Abstracts 1993 P. No. 464.

The rainfed crops contribute about 40 percent of total food grain production. About 70-100 percent production of important crops like Sorghum, maize, pearl millet, pulses, oil seeds, cotton, mesta and jute comes from rainfed areas. However increase in the production from these dry land crops over last two decades during post-green revolution period is only marginal even in spite of the fact of development of dry land technology by All India coordinated Rice Research Project and ICRISAT and State Agricultural Universities. The technology includes land treatment measures for arresting run off and soil erosion, water harvesting in farm ponds and recycling, selection of suitable crops, inter-cropping combinations and sequence cropping, contingent cropping practices for aberrant weather conditions and alternate land use system for shallow and marginal lands.

In recent years dry land agriculture is increasingly being looked upon as an integrated system than developing merely a crop production technology. For improving the productivity and sustainability of dry land areas, the thrust should be on resource characterisation at microlevel and to develop appropriate cropping system for different agro-climatic regions. Tree crop interface study at micro-level requires further attention in perfecting alternate land use system. Development of dry land agriculture on watershed basis was launched by ICAR in 1983-84 with setting up of 47 model watersheds in each of major agroclimatic zones of India. A National Watershed Development Programme for rainfed agriculture was initiated in 1986 to annually cover 0.232 million hectares. In the 8th plan, the target is to cover an area of 2.8 million hectares in almost all community development blocks having less than 30% of arable area under irrigation. Requisite integrated watershed management plans of about 2594 micro-watersheds identified of size ranging from 500 to 5000 hectares area which will be developed and executed through people's participation.

5.4.2. Intensive Cultivation

It is a method of farming aimed to produce maximum yield per unit area per year where resources are generally not constraints. The available land is put to maximum use with all care and attention from time to time without any limitation of other inputs. It basically involves the higher inputs, adoption of improved technology to exploit the yield potentials of improved varieties and hybrids, better utilisation of human resources so that the land which is limited is put to maximum use. It would provide better support for other complementary enterprises such as dairy, poultry, sericulture etc.

It is seen in the previous chapter, that our net cultivated area has remained around 140 m. ha over the past two decades and there appears to be limited scope for further expansion in the net area for cultivation. In fact the fertile lands are getting diverted for uses other than agriculture like urbanisation, industrial houses, roads, brick making etc. The per capita of net cultivated land which is 0.33 ha in 1950-51 reduced to 0.2 ha in 1980-81 and further brought down to 0.17 ha in 1990-91 and is expected to come down to 0.14 ha by 2000 A.D. Therefore there is a need to produce more area through intensive cultivation to meet the demand of ever growing population.

Irrigation is the major input in intensive agriculture. The use of other inputs such as growing high yielding varieties, optimum fertilizer application, timely control of pests and diseases and adoption of other production technologies which depend on irrigation. It is common feature in intensive agriculture, that the area is sown more than once. The increased food production target can be achieved by enhancing the double and multiple cropped area through better management practices at field level, avoiding conveyance losses with mandatory regulations and better control in supply of irrigation water, more area can be brought under irrigation with existing irrigation facilities. Further new areas can be brought

under double cropping by creating additional irrigation resources duly tapping surface flow of rivers as well as underground water. Another approach of increasing the crop intensity is through improved soil moisture conservation practices.

Higher cropping intensity through multiple cropping results in full utilisation of limited resources of land and water. Multiple cropping requires a high level use of plant nutrients. Higher cropping intensity signifies land augmentation vertically. In general, cropping intensity is inversely related to farm size. The crop intensity is very high in Punjab, Haryana, Himachal Pradesh and very low in Gujarat, Karnataka, Maharashtra, Tamilnadu, Andhra Pradesh, Bihar and Madhya Pradesh.

It is estimated that by 2000 A.D. the population in India may be around one billion and food grain requirement would be 225 million tonnes, 100 million tonnes of vegetable oils, 30 million tonnes of sugar and 17 million bales of cotton. The developing countries like India have to face the twin problems of land scarcity and population pressure which would require to intensify the production on existing cultivated area. In our country 74.5 per cent of population living in rural areas are dependent on agriculture. Intensive agriculture provides more employment opportunities for greater number of people spread over to different seasons. It can also improve the nutritional standards besides providing enough food for people and fodder for cattle. It is one of the ways to improve living standards of 98 million rural families.

Even though the agriculture which accounted for 52.2 per cent national gross product in 1950-51 has come down to 29.4 per cent in 1992-93, still it is an important sector and will continue to be so in the foreseable future.

5.5. TRENDS IN AGRICULTURAL DEVELOPMENT

FAO analysis of growth pattern in crops in 93 developing countries shows that 63 per cent of the growth in production must come from higher yields, 15 percent from higher cropping intensities and 22 per cent from land resources. A comparison between annual growth rate of population (2.3%) and total food grain production (3.6%) over 10 year period from 1981 to 1991 of India suggests that food has kept pace with population growth. However in terms of nutritional adequacy about 30 per cent of its population are still under nourished. The intensive agricultural practices are generally confined to high potential areas. These lands can sustain intensive cropping using existing technologies as long as they are compensated to the extent that has been removed by crops. Usually these areas are either irrigated or blessed with reliable and adequate rainfall. Soil fertility of these lands is commonly high. Existing agricultural technology is capable of raising population carrying capacity of such lands (FAO, 1984).

In Asia 82 per cent of cereals are grown on high potential naturally flooded or irrigated areas. It is not only essential to maintain and increase the staple food production of irrigated land but also necessary that natural resource management be improved in areas contiguous to irrigated river basins.

Indian Agriculture made rapid strides in the production and productivity of major crops changing the agricultural scenario from that of subsistence economy during the pre-green revolution period (1950 to 1964-65) to that of reasonable surplus situation at present. The production of total food grains increased from 50.8 m.t in 1950-51 to 180.0 m.t. in 1992-93; while the productivity enhanced from 522 kg per hectare to 1445 kg per hectare. About

90% of increase in total food grain production came from wheat and rice which was more spectacular during post-green revolution period due to use of high yielding varieties and increased use of fertilizers, pesticides and innovative modern technologies. These crops are mostly grown under irrigated conditions.

The increase of wheat production in India was impressive which was nine fold from 6.4 million tonnes to 55.1 million tonnes and that of rice from 20.6 m.t to 74.3 m.t. during 1950-'51 to 1990-91 (over four decades). The productivity of wheat and rice enhanced from a meagre yield level of 663 and 668 kg/ha in 1950-'51 to 2281 and 1741 kg/ha in 1990-'91 respectively. Further examination of productivity of wheat for pre- and post-green revolution periods, the growth rate per annum was 3.16 per cent during period of 1967-'68 to 1990-'91 as compared to 1.27 per cent per annum during Pre-Green Revolution period.

Though the achievements made so far are commendable, India's annual compound growth rate in the production of food grains during 1980-89 was 2.9 per cent. However, this growth rate appears to be moderate only when compared to growth rates of production in some of the neighbouring countries like China (6.3%) Pakistan (4.4%), Thailand (4.1%) and Indonesia (3.2%).

It is reported that the levels of untapped yield potentials in the developing countries (40-50% for India) even at current levels of inputs could be realised through scientific management of inputs used. It is further emphasised that farmers all over the world can only accept technological input levels as long as they are economical. A cursory look into comparative yield levels of different crops in India with that of world average yield (Tables 5.2, 5.3) reveals that average yield levels of different crops in India are relatively lower than the world averages and far below the potential yields of available high yielding varieties in India. The information further indicates that the productivity of these crops can be doubled by making available the high yielding varieties to the farmers and their full yield potential is realised through appropriate inputs and technology.

5.6. RESOURCE CONSERVATION FOR SUSTAINED AGRICULTURE

Land is the most vital resource for agricultural production. Whatever food grain targets achieved so far is done without concern of sustainability by over mining of our soil resource without adequate replenishments and faulty management practices which created economic and environmental problems. Land resource is getting limited as certain lands are being diverted due to fast industrialisation and urbanization. The lands with low production potential which are generally slopy are being used for growing crops under rainfed conditions. Such soils are subjected to frequent erosion losses getting thinner year after year and if not properly protected, they become unproductive and would fall in the category of waste lands. Further improper management practices in these low potential lands resulted in adverse off-site effects such as silted up reservoirs and reduced soil production.

The high potential lands with intensive agricultural practices under irrigated conditions have neglected drainage problems and also proper water management practices leading to salinity, sodicity or both. The costly and scarce irrigation water resources is being wasted by excessive use. Indiscriminate use of pesticides created a problem in the natural control of insect pests through killing of predators and parasites and thus affecting ecosystem. Now concern being expressed from many quarters whether the growth in agricultural production to feed our ever growing population and land resource base can be maintained in sustainable manner.

Table 5.2. Comparative yield levels in India and world and potential yields of India (kg/ha)

Crop	India's yield	World average yield	Potential of high yielding Indian varieties
Rice	2629	3504	4001 - 5810
Wheat	2274	2591	6000 - 6800
Groundnut	847	1148	2000 - 3000
Rapeseed	900	1371	1500 - 2000
Soya bean	1180	2088	1500 - 2500
Jute	1565	1629	2500 - 3000
Tobacco	1461	1612	2530 - 2865
Potato	16196	14890	23800 -30900

5.7. SOIL EROSION

Soil erosion is one of the gravest human-made disasters; a quiet crisis not widely perceived but gradually unfolding as monstrous phenomenon. Of the various types of degradation, land, soil erosion poses a serious threat to the livelihood and food security of people.

Soil erosion can be defined as removal or loss of surface soil by water and wind. These are known as agents causing erosion. Depending on agents of erosion they are called as water erosion or wind erosion. There are three stages in erosion i.e., detachment, transport and deposition (sedimentation). The force of falling rain drops as well as run-off water or wind on a bare soil first detaches the soil particles from soil aggregates. Then the detached soil particles are transported by flowing water or wind. The rate of erosion depends on intensity of rainfall, slope of the land, soil characteristics, type of vegetation and mode of cultivation.

5.7.1. Water Erosion

Mechanism of erosion: The process of erosion can be conveniently divided into two sub-processes *viz.*, detachment and transport. Detachment needs energy which is mainly supplied by kinetic energy of falling rain drops which break the soil aggregates and splashes the soil particles. The soil aggregates are also broken down due to entry of water from all sides (engulfing). The air inside the aggregates is compressed and pressure increases resulting in bursting of aggregates. The rain water received subsequently mixes the soil particles and muddy water results. The finer particles (clay and silt) block the pores of the soil. The kinetic energy of falling rain drops also compacts the soil. Thus due to sealing and compaction, in-filtration of water is reduced and excess water starts flowing which is known as run off. Along with run off water, soil particles of less than 50 mm in diameter are suspended in water and are transported.

Forms of water erosion: Recognised types of water erosion are sheet erosion, rill erosion, gully erosion, ravines and land slides.

1. *Sheet erosion:* It is the removal of soil all along the field in thin films. It is less conspicuous but could be noticed with moving out of muddy colour run off water from the field. It is the initial stage of soil erosion.

2. *Rill erosion:* When sediment ladden surface flow increases, it starts forming finger size parallel channels and erosion is no longer uniform and erosion is more apparent than sheet erosion. This is the second stage of erosion.

3. *Gully erosion:* When rill erosion is not checked, the rills are further widened and deepened. When channelised run-off from vast sloping land is sufficient in volume and velocity to cut deep and form wide channels of irregular shape and size are known as gullies. These are most spectacular symptoms of erosion and if unchecked creates problems in cultivation.

4. *Ravines:* These are manifestation of a prolonged process of gully erosion. They are deep and wide gullies and their formation indicates very advanced stage of gully erosion. These are typically formed and expanded in deep alluvial soils.

5. *Land slides:* These occur in hill sides when slope exceeds 20 per cent, the soil from top of hill side slip down and some times blocks the traffic in ghat roads.

6. *Stream bank erosion:* Small streams, rivulets, torrents (hill streams) when in excess flow are subjected to stream bank erosion. When streams dry up, vegetation spreads and obstruct flow causing cutting of bank or changing the flow direction. Torrents with flashy flows can carry boulders and uprooted plants which are deposited down-stream causing over flowing and extending stream bank erosion to the neighbouring field. Water erosion cannot be predicted with sufficient accuracy to permit the selection of management alternatives with low erosion potential.

Water erosion control: The main objectives in controlling soil erosion caused by water are

i. to reduce dispersion of soil particles
ii. to put mechanical obstruction in the way of flowing water
iii. to reduce surface runoff.

The objectives can be achieved by:

1. Bringing about improvement in physical condition of soil through proper manuring and cropping with a view to increasing water infiltration and holding capacity.

2. Ensuring good crop growth by adopting the recommended agronomic practices for each crop.

3. Practicing other conservation measures like contour bunding, terracing, contour trenching, contour cultivation, strip cropping, mulching, reclamation of gullies etc.

The problem of soil erosion can be tackled best on a catchment basis rather than on individual plots. The planning should include:

1. All measures like contour bunding, terracing, diversion channels and other agronomic measures like strip cropping, crop rotations etc., on land under cultivation.

2. Structural or vegetative gully stabilization.

3. Structures like the use of spurs, revetments, checkdams, retaining walls etc., to stablise stream banks.

4. Structures for any combined purpose like irrigation and power to control flood

5. Distilling basins to hold back sediment.

6. Erosion control measures on non-agricultural lands including high-ways, railway lines and other wastelands.

5.7.2. Wind Erosion

Wind erosion has the same three phases as water erosion: detachment of soil particles, their movement and their deposition. Control of wind erosion is accomplished by reducing detachment and movement. Detachment of soil can be reduced by compaction, aggregation, wetting, stabilizing with living or dead vegetation, and/or by a chemical means such as the use of organic polymers or asphalt emulsion.

Forms of wind erosion: Clods larger than 1mm in diameter are too large and have too much mass to be readily detached. Aggregates between 0.5mm and 1 mm are too large to be wind borne but can be moved along the soil surface by strong winds. This movement is known as 'Surface creep'. Individual soil grains and aggregated soil between 0.05mm and 0.5mm move by a series of rolls and leaps, known as 'Saltation'. Soil grains and aggregates smaller than 0.05mm in diameter (silt and clay) once detached and suspended in the atmosphere (suspension) are usually kept aloft by air turbulence and may be moved long distance before being deposited.

Control of wind erosion: Principles of wind erosion control are:

1. Reduce wind velocity at ground level
2. Remove sediment from the windstream
3. Reduce the erodibility of the soil.

Practices of wind erosion control includes:

1. Establishing ridges of soil from 5 to 10cm high and at right angles to the direction of the prevailing wind at the time of maximum wind erosion.
2. Planting dense vegetation on the eroding field at right angles to the most erosive winds
3. Establishing a wind break of vegetation or a structure on the windward side of an eroding field.

5.7.3. Extent of Land Degradation Due to Erosion

Soil erosion is a global phenomenon affecting an area of about 1.2 billion hectares with moderate to severe erosion. This represents 11 per cent of earth's vegetated surface. Deforestation, overgrazing, agricultural activities, over exploitation and industrialisation are the main causes of soil degradation. According to World Resource Institute (1990) 29 per cent soil degradation at the global level is caused by deforestation, 35 per cent by over grazing, 28 per cent by agricultural activities, 7 per cent by over exploitation and 1 per cent by industrialisation.

The regions of the world that suffered most due to land degradation in descending order are Asia, Africa, South America, Oceania, North America and Europe. The land degradation is accelerated in countries where population pressure of both human and cattle is high coupled with severe rural poverty, lack of knowledge, ill matched resources and non-sustainable lands. At global level about 20 million hectares of productive range lands, irrigated and rainfed crop lands are rendered permanently useless. FAO estimates that world wide desertification irreversibly claims approximately 6 million hectares each year.

It is seldom realised that a top 20 cm soil produces 97 per cent of the world food production. A loss of 1 mm of top soil amounts 15 tonnes of soil loss per hectare. A loss of one tonne of soil means a loss of 4 kg nitrogen, 1 kg phosphorus, 20 kg potash and 2 kg calcium and considerable amount of soil organic matter. The loss of nutrients is estimated to be equal to be 50 tonnes of FYM/year/ha.

In India it is estimated that about 6000 million tonnes of soil are annually eroded, of which 30 per cent washed into the sea, 9 per cent is deposited in the reservoirs and rest 61 per cent is deposited on the land. The average annual loss of plant nutrients through eroded soil is estimated at between 5.37 and 8.4 million tonnes. The loss of organic matter with 0.5 organic carbon content works out to be 120kg/ha. The average soil loss in India is estimated at 16.35 tonnes/ha/year. Among the world's 16 worst eroding catchments, Indian river catchments of Ganga, Brahmaputra and Kosy occupy second, third and twelth positions, respectively.

It is estimated that 150 million hectares of geographical area of India is subjected to different kinds of erosion; of which 111.3 million hectares area is under water erosion and 38.7 m.ha under wind erosion.

The per capita availability of net cultivated area is decreasing from 0.48 ha in 1950-51 to 0.17 ha in 1990-91 and it would be 0.14 ha in 2000 A.D. and 0.05 ha (500 sq.meters) in 2025. The increasing urbanisation and competition from industry and civic uses etc., is pushing the agriculture to more marginal and fragile environment. The problem of future generation is to produce more food from less land that too of poor quality. The subsistent farmer appears to be concerned more with his fulfilment of present food needs than the welfare of coming generation and threatening un-sustainability of agriculture. The best strategy is to minimise the environmental impact and meet the present and future needs of the country. Sustainability of land resource is necessary and for this the following measures are suggested:

1. Conservation of areas of high bio-diversity and fragile environment through greening and use of soil and water conservation techniques.

2. Optimisation of production from the areas of high potential using eco-friendly and high potential technology.

3. Restoration of productivity of the areas which have been degraded.

Check Your Progress-1 & 2

1. Define soil erosion.
2. What are land slides?

Note: (a) Write the answers in the space provided below.
(b) Compare your answers with those given at the end of this unit.

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5.8. SOIL SALINITY

Salt is the savour of food but at the same time when in excess in soils it kills growing plants.

Soluble salt contamination of soil has caused problems primarily in arid regions of the world where inadequate rainfall means little or no change for the excess salts to be leached from the soil. The effects of salts are apparent in many areas and are becoming increasingly prevalent and serious as water supplies become more limited and are increasingly polluted with soluble salts.

5.8.1. Identification of Salt Affected Soils

There is no much deviation in the criteria used in classification of salt affected soils. The changes proposed are (1) the use of SAR of the soils saturation extract instead of the ESP (2) the proposed lowering of the salt content for saline soils and the (3) units for reporting electrical conductivity.

The change to SAR (Sodium Adsorption Ratio) in place of ESP (Exchangeable Sodium Percentage) has been made partly because of the ease in the estimation of SAR in laboratory compared to that of the ESP. The values of ESP are 15%-30% more than the SAR determination on the soils saturation extract.

5.8.2. Extent of Salt Affected Soils

The salt affected soils are estimated to occupy an area of 7m.ha in different parts of India as shown in the Table-1.

Table 5.3. Geographical distribution of salt affected soils.

	Problem	States in which soils occur	Approx. area (m.ha)
1.	Coastal salt affected soils:		
	a. Coastal salt affected soils of arid region	Gujarat	0.714
	b. Deltaic coastal salt affected soils of the humid regions	West Bengal, Orissa Andhra Pradesh & Tamilnadu	1.394
2.	Salt affected soils of the medium & deep black soil region	Karnataka, Madhya Pradesh, Andhra Pradesh, Maharashtra Rajasthan	1.420
3.	Salt affected soils of the arid and semi-arid region	Gujarat, Rajasthan, Punjab, Haryana, Uttar Pradesh	1.000
4.	Salt affected soil of the Indo-gangetic plains	Uttar Pradesh, Haryana, Bihar, Rajasthan, Madhya Pradesh	2.516
		Total:	7.044

5.8.3. Causes for Salt Accumulation

A combination of factors which are mainly geological, climatic and hydrological in nature usually involved in the formation of saline and alkali soils.

The sources of salts in soil are from the soil itself, ground water, irrigation water, canal and sea. The primary source of salts in soil is from weathering of rocks. During the process of

rock weathering and soil formation, soluble salts are formed. Solute movement with water is the determining factor in the soil salinisation process.

In the humid and per humid regions with adequate rainfall, most of the soluble salts are leached down to some depth below the surface into the ground water. If the rainfall is not adequate, leaching is not adequate to remove the soluble salts.

Soil salinisation is quite common in arid and semi-arid regions having an annual rainfall of less than 550 mm. Encrustation of salts occur on the land surface. Fluctuating depth of ground water table leads to salinity in soil. Soluble salts move upward along with rise in the water-table. The salts are left behind when the water table recedes and accumulates at varying depths below the soil surface. Upward movement of soluble salts already accumulated at some depths of soil also takes place. The higher the depth of water table, the higher is the rate of evaporation. The critical depth of the water table is defined as the depth of the water table above which soil solution along with salts can move upward by capillary action to the surface. This critical depth depends on texture, water retention and water transmission characters of soil in the profile.

In coastal areas, the salinity is due to intrusion of sea water into the main land coupled with the transportation of salt particles from salt affected areas through wind creating salinity in normal soils. Very high summer temperature and low rainfall in these areas similar to arid and semi-arid conditions and occurrence of poor quality ground water results in formation of coastal saline soils. Poor drainage and use of poor quality of irrigation water also results into saline soils.

5.8.4 Effect of Salt Affected Soil on Crop Production

1. Poor soil physical condition restrict the crop production
2. Salinity impede the drainage and results in water logging during monsoon season.
3. High salt concentration results in osmotic pressure affecting water and nutrient by the crops
4. High water table conditions lead to secondary salination affecting soil and health and crop production
5. Sea water intrusion affects the soil and crop growth
6. The nutrient availability in these soils generally lower than normal soils e.g., nitrogen

5.10.5. Reclamation of Saline and Sodic Soils

For economic utilisation of saline and sodic soils, it is desirable that such soils are surveyed and mapped. The potentiality of these soils for agricultural purpose need to be assessed which depends on the water transmission characteristics of soils. The physical, chemical and biological properties of the soil greatly influence their suitability for crop production. The physical characteristics include mechanical impedance (physical barrier), aeration, infiltration capacity, permeability, pore size distribution, bulk density, soil aggregation etc. In the sub soil, clay and kankar pans with different cementation are known to occur which limits drainage, root penetration and cause obstruction in reclamation of these soils.

The chemical properties of saline and alkaline soils need to be estimated in relation to cation exchange capacity nutrient availability at different stages and nutrient imbalance etc. It is being reported that these soils are significantly low in certain plant nutrients and toxically high in other constituents. The nature of organic matter and its content in the soil and microbiological properties of the soils are also important in determining the productive

capacity of these soils. The alkaline condition creates instability in the organic matter content of soil.

The assessment of effectiveness of different methods of reclamation at different stages of reclamation is desirable so that suitable corrections can be affected. The basic principles involved in reclamation of salt affected soils are as follows:

1. **Establishment of drainage:** The effective drainage system should aim at removal of excess water from the field and keep the ground water to permissible depths so that salinity does not increase and effect the crop growth. The Physio-graphic location of the field is important. In providing drainage in the field one may come across any one of the following situations.
   a. Certain fields have adequate natural drainage.
   b. For other fields installation of drainage system such as open ditches or tile drains may be necessary.
   c. There are certain other fields where drainage is impractical or impossible.

2. **Leaching of soluble salts:** The salt content of problematic soils must be lowered at least in place of root zone. In sodic soils (alkaline) most of the replaced sodium must be leached from the root zone. In such soils, the reclamation is not effective without leaching. For leaching out salts use only good quality of low salt content irrigation water.

   The leaching requirement (LR) has been referred as that fraction of water that must be leached through the root zone to control salinity at a specified level. Simply this is the ratio of equivalent depth of drainage water to the depth of applied water and may be expressed as per cent.

3. **Replacement of excess exchangeable sodium:** This process is necessary in saline-sodic and sodic soils. It consists of applications of amendment to supply soluble calcium to neutralise the alkali, replace exchangeable sodium in the soil and flocculate the clay for improving permeability. The amendments include direct application of soluble calcium compound like gypsum which is the cheapest source or an acidifier like sulphur, iron pyrite to dissolve the existing reserves of native insoluble calcium in the soil.

Reclamation of Saline Soils

Saline soils are relatively easy to reclaim for crop production if adequate amount of good quality or low salt content irrigation water is available with adequate surface and sub surface drainage facility.

I. Mechanical method: The mechanical methods are initially employed to improve the physical nature of the soils. It consists of (a) Scraping the surface crust of salt infested soils by manual labour and putting the scraped soil in salt disposal pit (b) Deep chiseling (sub soiling) or deep ploughing may be used on soils with impervious layers to open soil for easy percolation of water. This process may have to be repeated several times and may become expensive sometimes. (c) Application of sand to improve drainage particularly in heavy clay soils would hasten up the reclamation adopted. (d) The process of profile inversion can be adopted to bring less salt content soil to surface.

II. Hydro technical method: Leaching and drainage are the main components of this method. The main thrust in the reclamation of saline soils is to leach most of the salts downward and out of contact of root zone through irrigation water.

The quality of water required to remove salt from the soil depends on following.

1. How deep the salts are to be washed.
2. What percentage of the salts are to be removed and
3. How leaching is done (ponding constantly or intermittent application)

It is generally estimated that ponded water of about 30 cm are required to remove 70-80 percent of salts for each 30 cm depth of soil. Intermittent water additions are more efficient and water required under the method is about 70 per cent of that required with ponding.

Generally saline soils are fine textured and frequently have a high water table or a dense gypsum layer. These conditions reduce the movement of irrigation water downward and make it difficult to leach the salts to the desired depths below the root zone. The magnitude of seepage through irrigation and other sources may augment the ground water recharge. In soils with high water table artificial drainage is necessary to remove excess salts.

III. Biological methods: Addition of organic matter benefits the saline and alkali soils by two ways (a) Improvement in Water infiltration and (b) release of CO_2 during decomposition which has the solubilizing action in soils rich in calcium (calcareous soils). Thus CO_2 released during composition would increase additional soluble calcium content for exchange reaction to replace sodium in the soil exchange complex.

When irrigation water is limited or fields which depend only on rainfall, application of organic mulch on surface will reduce the salinity. Mulch is effective in reducing the evaporation and thus reduce movement of dissolved salts to the surface.

Reclamation of Sodic and Saline-Sodic Soils

In sodic soils, the exchangeable sodium is so great that resulting dispersed soil is almost impervious to water. The sodium must be replaced by another cation and then leached downward beyond root zone and should be moved out of the field through proper drainage. Calcium is often used to replace sodium in sodic soils. Of all calcium compounds, calcium sulphate (gypsum; $CaSO_4$, $2H_2O$) is soluble calcium replaces sodium leaving soluble sodium sulphate in the water which is then leached out.

In calcareous saline-sodic soils, leaching with irrigation water of low salt content (SAR=0.6, pH 7.5) was effective in removing exchangeable sodium without addition of gypsum. Without gypsum, about 50 per cent more water is required to remove sodium through leaching.

5.8.6. Management Practices for Salt Affected Soils

It is not always possible or practical to eliminate all salts from soil but managing of such soil is necessary to minimise salt damage. In sodic soils, some of the exchangeable must be removed before they are put to use along with slightly saline soils. The proper use of irrigation water, correct position of placing the seed choice of salt tolerant crop are some of the management techniques that helps for successful raising of crops in these soils.

1. Water Management: Maintaining a high water content in the soil near to field capacity dilutes salts and lessen their toxic and osmotic effects. With frequent light irrigations to keep high moisture content particularly during salt sensitive germination and seedling stage, plants are able to survive to the normally more tolerant mature stage of growth.

Limited leaching done before sowing or light irrigation by sprinklers after sowing will move salts below the seed and early rooting zone. However soils which develop hard crust should not be irrigated immediately after sowing but irrigation with sprinklers should be given at

the time of emergence to soften the hard crust.

Periodic leaching during off-season where crops are not growing to leach the salts deeper can be practical wherever water is available. In regions with short water supply, the leaching can be done only once every year for several years to achieve good results.

2. Planting position: Salt moves along with water and some will accumulate in the top layer of soil. Laying out the fields into ridges and furrows and sowing of seeds (Planting) at the middle or bottom position of the sides of ridges will help to avoid the damage of germinating seeds from salt concentration. Most of salts move to the top of ridge and accumulate. Careful placement of seed in less salt content position instead of planting at top or near the top ridge will ensure safe germination and growth of young seedlings.

3. Choice of crops: Cultivation of salt tolerant crop is other management practice. Crops can be classified into three groups based on their tolerance to salts.

a. *High salt tolerant crops:* Rice, sugarcane, oats, berseem, lucerne, fenugreek, barley, Indian clover.

b. *Medium salt tolerant crops:* Castor, cotton, mustard, wheat, sorghum, maize, pearl millet.

c. *Low salt tolerant crops:* Pulses, pea, sunhemp, bengal gram, linseed and sesamum.

Varieties of a crop may also differ in their salt tolerance.

5.9. SOIL INFERTILITY

Soil infertility can be defined as inability of the soil or nutrient status of soil which is not in a position to supply required plant nutrients to the growing crops.

It has been estimated that the present level of inherent fertility status of Indian soils can be able to sustain a food grain production of about 100 m.tons. Nearly 40% of the current food grain out put can be attributed to fertilizer applications. In respect of N,P and K 95, 98 and 65% of the Indian soils fall under low to medium category respectively. similarly in respect of micronutrient defficiencies, half of the Indian soils are deficient in Zinc. The other micronutrient deficiencies such as iron, boron and manganese are found to be to lesser extent. Sulphur deficiency is likely to limit crop yields in about 100 districts in the country.

5.10. SOIL FERTILITY

It is the status of the inherent capacity of the soil to supply nutrients to plants in adequate amounts and in suitable proportions.

The productive capacity of the soil is influenced by:

i. The inherent capacity of the soil to supply plant nutrients
ii. The physical condition of the soil
iii. Micro-organisms activity of the soil
iv. Moisture content in the soil
v. Various inhibitory factors present in the soil like acidity, alkalinity etc.
vi. Climatic conditions, incidence of pests and diseases and management practices.

Historically, crop production has been based on the use of plant nutrients already in the soil. Although the addition of plant nutrients is being practiced through application of fertilizers but still many crops in dry lands continue to be grown extracting the most of its nutrients from soil.

Several techniques are commonly employed to assess the fertility status of a soil.

1. Nutrient deficiency symptoms of plants.
2. Biological growth of higher plants is used as a measure of soil fertility.
2. Analysis of tissue from plants growing on the soil.
4. Chemical soil tests.

Out of the above, the first two visual methods of evaluation of soil fertility are useful in that it requires no expensive or elaborate equipment and can be used as a supplement to other diagnestic techniques.

5.10.1. Soil Fertility Losses

The causes for soil infertility losses are given below.

1. Removal of nutrients by crops and weeds: Soils vary greatly in their inherent capacity for how long they can be cropped without yield reduction before a given nutrient must be added. The optimum dose of fertilizer application to supply plant nutrients is influenced by a knowledge of the nutrient supplying status of the soil on which the crop is to be grown.

The knowledge regarding nutrients depletion with targeted yield in different crops is one of the right steps in that direction. The nutrient removal by crop not only vary from crop to crop but also depends on yield levels obtained in the crop. The amount of N P K required to produce one unit of different crops is given in Table-5.7.

Table-5.4. Nutrients required (Kg) to produce one quintal economic produce by different crops

Crops	N	P_2O_5	K_2O
Rice	2.0	11.12	3
Wheat	2.45	0.06	3.28
Barley	2.06	0.78	2.52
Maize	2.63	1.39	3.58
Sorghum	2.24	1.33	3.4
Pearl millet	4.23	2.26	9.08
Finger millet	2.98	1.13	3.9
Chickpea	4.63	0.84	4.96
Groundnut	5.81	1.96	3.01
Mustard	3.28	1.64	4.18
Linseed	1.90	1.2	3.3
Castor	3	1.2	1
Sugarcane	0.16	0.04	0.2
Cotton	4.45	0.83	7.47
Tobacco	1.65	1.93	2.19

Source: Velayutham, M and Reddy, K.C.K. 1987 Regional Agricultural Meeting, IFA, New Delhi.

In intensive cropping when more than one crop is grown during the year, the amount of nutrient removal correspondingly increases. To meet our food grain production target of 225-240 million tonnes by 2000 A.D. an estimate of expected nutrients removal by rainfed crops is given in Table-5.8.

Table-5.5. Production and Nutrient removal (N, P, and K)
(estimates of some rainfed crops by 2000 AD)

Crop	Production (million tonnes)		Nutrient removal (million tonnes)	
	1986-87	2000	1986-87	2000
Sorghum	8.87	20.4	0.44	1
Pearl millet	4.49	15	0.13	0.44
Chickpea	4.46	12.75	0.33	0.94
Pigeonpea	2.32	4.5	0.3	0.44
Groundnut	5.42	13.5	0.95	2.36

Source: Directorate of Economics and Statistics, 1988 and National Commission on Agriculture 1976.

It is being reported by the National Co-ordination committee on efficient use of inputs that weeds take away 30-40% of plant nutrients applied to crops. The yield losses due to competition from weeds in India is annually estimated to be ranging between 18-41 per cent. Thorough land preparation during summer and timely intercultural operations followed by hand weedings are necessary to reduce the nutrient depletion by weeds.

2. Leaching losses: Among the major plant nutrients, nitrogen in nitrate form is highly soluble and therefore is subjected to more leaching losses. The extent of losses depends on the form of nitrogenous fertilizer, soil texture and intensity of irrigation/rainfall. Nitrogen losses are more in light textured soils, hence need to be applied in two to three split doses. Heavy irrigation or high intensity rains results in more leaching losses. Fertilizer nitrogen application should be managed in such a way that it is either utilised by the crop or retained in soil for future use and the methods which can reduce nitrification process also help in minimising the leaching losses.

3. Losses in gaseous forms: Among nutrient elements, only nitrogen is lost in gaseous forms; volatalization as ammonia and denitrification of gaseous form of N (under anaerobic conditions) as in rice fields. The amount of N lost due to volatalization could be upto 30 per cent of applied nitrogen. Drilling of nitrogenous fertilizer reduces the voltalization losses to 5 per cent as compared to 30-40 per cent under broadcast method of fertilizer application.

4. Soil Erosion: No other soil phenomenon is more destructive world wide than soil erosion. It involves losing water and plant nutrients at rates for higher than those occurring through leaching. More tragically, however, it can result in the loss of the entire soil. Further more, the soil that is removed finds its way into streams, rivers and lakes and creates a pollution problem there. Erosion is serious in all climates, since wind as well as water can be the agents of removal. Water erosion carries away the larger amount of soil. The details regarding amount of nutrient losses are discussed under sub-head of soil erosion.

Nutrient Status of Indian Soils

Based on soil analysis reports, soil fertility maps of India show that for phosphate supply, out of 372 districts of India, soils of 42% of the districts are low, 56% medium and 2 per cent high and for 'K' supply, soils in 20 per cent of districts are low, 42% medium and 38

per cent are high. Almost all soils in India are deficient in available nitrogen. Soil samples deficient in micro-nutrients are 46% Zn, 17% boron, 12% Mo, 11% Fe, and 5% copper. Sulphur deficiency is estimated to limit crop yield in about 100 districts in the country.

5.10.2. Maintenance of Soil Fertility

Maintenance of soil fertility should be considered both on short term and long term basis.

Short Term Measures: These include: addition of organic manures green manuring, fertilizers and bio-fertilizers. The organic manures are obtained by composting left over cattle fodder in the cattle shed along with excreta of farm animals and other farm wastes. These are known as Farm Yard Manure (FYM) and compost which are generally bulky in nature and contain less plant nutrients. They supply almost all the ingredients of plant food and application of 5 to 10 tonnes ha^{-1} FYM or compost is generally recommended for all crops. Besides supplying plant nutrients they are much more valued in improving the physical condition of the soil (Soil texture and moisture retentivity). The oil seed cakes, blood meal, bone meal etc., are rich in particular nutrients, the first two in nitrogen and the third in phosphorus and they are referred as concentrated organic manures.

2. Green Manures: Growing a crop purposely and incorporating it in the soil for manuring is called "Green Manuring". Legumes are commonly used as green manure crops, because they fix atmospheric nitrogen and the organic matter produced are distinct additions to the soils.

3. Biofertilizers: These can be more appropriately called as microbial inoculants and defined as biological preparations containing live or latent cells of efficient strains of nitrogen fixing or phosphorus mobilising micro-organisms.

The different kinds of microbes that can be exploited as nitrogen supplies and 'P' mobilizers to crops are: *Rhizobium* legume symbiosis; *Azolla-Anabaena* symbiosis - these are symbiotic nitrogen fixing systems. Free living nitrogen fixing system include free living bacteria like Azotobacter *Beijerinckia, Klebsiella* etc.

4. Fertilizers: The use of chemical fertilizers for increasing the production of crops is a recent development when compared to the use of organic manures. Fertilizers are inorganic substances that contain one or more ingredients of plant food, in large proportion.

The growing need for increasing food grain production can be met only by enhancing the productivity of crops. This calls for significant increase in fertilizer consumption not only in irrigated areas but also in rainfed areas.

Long Term Measures: These include reclamation of the soils by cultural practices and use of amendment and adopting suitable conservation practices.

Apart from the above, the system of growing different crops one after another, by changing the crops grown (crop rotation) and the cultivation of two or more crops as inter crops together would help to maintain the fertility status of the soil.

5.10.3. Balanced Nutrients Use

Sustainability in agriculture is one of the most compelling issues to keep pace in meeting food requirement of growing population. The adequate quantities of fertilizer application is necessary to fully balance the nutrients that were lost from the soil by crop removal and other means. It is necessary to identify the nutrient status of all plant nutrients in soil and develop a balanced programme of fertilizer application. A rough estimate of nutrient

removal show that replenishment of N is satisfactory of P marginal but application of potassic fertilizers is about 5 per cent less than its removal.

Although India ranks as the fourth largest producer and consumer of fertilizer nutrients in the world, the average per hectare consumption is still low (75.2 Kg ha-1). The consumption of fertilizer nutrients in 1950-'51 was 0.6 lakh tonnes with a food grain production of 54.9 million tonnes. These figures significantly increased to 12.6 million tonnes and 180 million tonnes, respectively in 1991-'92. To meet the target of food grain production by 2000 A.D. the fertilizer nutrients requirement is estimated as 20 million tonnes.

The present strategy of integrated nutrient supply through judicious use of locally available organic resources such as Farm Yard Manure, compost, bio-gas slurry, sewage sludge, green manures and bio-fertilizers along with fertilizers is one of the sound management technology for increasing the soil productivity. It is estimated that the total potential of nutrients from livestock, wastes in the country is around 11 million tonnes, much of which is lost when used as fuel. Intensification of agro-forestry systems and popularization of household and community biogas plants will divert a greater part of these organic wastes for manurial purposes.

The availability of crop residues from nine principal crops of India is estimated at about 185 million tonnes with a nutrient content of 3.32 million tonnes which can be recycled for manuring in the form of compost.

Check Your Progress - 3 & 4

3. Define infertility.
4. What is meant by soil fertility?

Note: (a) Write the answers in the space provided below.

(b) Compare your answers with these given at the end of this unit.

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5.11. WASTE LAND MANAGEMENT

Soils are the most precious natural resource of any nation. It takes almost 10,000 years to produce an inch of soil. They are vital to our very existence. But during last 20-30 years, the enhanced demographic pressure and the tendency of over exploitation of natural resources put a heavy pressure on life supporting systems in the country. India has only land area of 2% of World's land area and it has to support 15% of the world's human population and 16% of world's cattle population.

Degradation of land, a man induced phenomenon is a serious problem, the country faces today. The degree of degradation varies with the intensity of human interference. As a result of intense human activity the lands loose their inherent capacity to support crop growth and lie as waste lands. It is therefore imperative that we manage and conserve them to meet the growing demand for food, fodder, fibre and fuel.

The term waste land is being used synonymous to land degradation. According to Dictionary meaning "Waste land" is that which is unfit for use i.e., uncultivable barren (without vegetation). Technical task group report of National Waste Land Development Board defines "Waste land" as the land which is presently lying unutilised except current fallow due to different constraints. Waste lands comprises of (1) Cultivable waste lands: It is capable or has the potential for the development of vegetative cover but not being used due to different constraints of varying degree such as erosion, ravines, water logging, salinity industrial waste lands, shift cultivated lands etc., (2) Uncultivable waste lands: These can not be developed for vegetative cover e.g., barren rocky areas, snow covered areas and sand dunes.

Causes for conversion of cultivable land to waste land

1. Population pressure
2. Mismanagement of soil and rain water
3. Overgrazing pastures
4. Increased demand for fuel wood and other forest problems
5. Building of big dams

5.11.1. Extent of Waste Lands in India

Official source first estimated that the extent of waste lands in India is around 175 million hectares which is 53.2 per cent of total geographical area of the country (329 m.ha).

Area under various types of degradation

Water erosion	= 111.3	m.ha
Wind erosion	= 38.7	m.ha
Salinity and alkalinity	= 7	m.ha
Flooding	= 20	m.ha
Others	= 7	m.ha

Soil and water conservation division of Ministry of Agriculture during 84-85 estimated that an area of 29 million hectares of waste land was treated out of 175 million hectares and the remaining waste land area is about 146 million hectares. As per latest estimation, India has 130 million hectares of degraded state forest lands and 94 million hectares of degraded state forest lands and 94 million hectares of non-forest waste lands (Nair 1994). According to FAO report about 2.1 million hectares is turned into waste lands annually out of which 1.5 million hectares due to deforestation alone.

I. Among the states with extensive degraded lands, Rajasthan ranks first with 37 million hectares followed by Madhya Pradesh (20.7 million hectares), Maharastra (19.8 million hectares), Uttar Pradesh (13.1 million hectares), Gujarat (12.3 million hectares), Andhra Pradesh (12.2. million hectares) and Karnataka (11.4 million hectares).

II. The states where waste lands are more than 5 million hectares but less than 10 million hectares are Orissa and Bihar.

III. The other states of India are having less than 5 million hectares of waste lands.

5.11.2. Types of Waste Lands

Degraded forest lands, agricultural fields affected by soil erosion with gullies and ravines and fields with other specific problem constitute the bulk of waste lands. The waste lands are grouped into 9 categories:

1. Heavily grazed lands infested with uneconomic bushes
2. Gullied and ravinous lands
3. Salt infested saline and alkaline lands
4. Land affected by shift cultivation
5. Shallow hill torrents in sub-mountainous Himalayan region having seasonal and flash flows called "Chos" and other river bed infested areas.
6. Desert lands and sand dunes
7. Road, rail and canal side areas
8. Degraded forest lands
9. Lands affected by water logging

5.11.3. Need for Waste Land Development

National Wasteland Development Board was constituted in 1985 to develop 5 million hectares of waste land every year. Since it was felt, the target is too high that the revised target during 8th five year plan was kept as 18 million hectares with 3.6 million hectares of waste lands to be developed every year. World resource Institute forecasted that by 2000 A.D. most of tropical forests of Western ghats will disappear if the present rate of denundation continues. The hills of west coast of India can not support any vegetation if the top soil is lost.

The major thrust in the development of wasteland is therefore should be on establishment of vegetation. Planting trees (afforestation) is conceived as main technique or instrument for development of wastelands. The following points should be considered before taking up the waste land development programme:

1. Assessing the physical status of waste lands at macro and micro levels.
2. Analysing the factors responsible for formation of wastelands.
3. Assessing relative merits of various reclamation (ameliorative) practices to be adopted in the field.
4. Estimating the economics of waste land development in terms of afforestation, agroforestry, silvi-pasture and agriculture systems.
5. Assessing the availability of resources, inputs and financial requirements.
6. Evolving innovative methods to suit specific site requirement keeping in view the ecological balance, without further degradation of lands and social acceptability.

5.11.4. Waste Land Management

The programme of ameliorative works on degraded and waste lands is difficult to implement largely due to the prevailing socio-economic conditions on the sites and surroundings. Different types of cultivable waste lands require different corrective measures. It is desirable that all measures are less cost effective and should be within reach of local people. The participation of local people will further reduce the cost of maintenance of treated lands. The mass mobilisation of rural population through proper education about waste land resource use and their voluntary participation need to be emphasised. The protection of

planted trees and vegetation from grazing animals is the foremost hurdle which challenges this programme. These should be inbuilt responsibility among local people for resource sustainance and use besides departmental guidance in proper utilization of planted species. The major regeneration is biological correction (Plantation of suitable tree species and grasses and forage legumes).

Severely eroded lands: The gullied and ravinous lands need to be protected first by plugging them at the place of their imitation through suitable mechanical methods. In upper reaches of gullied and ravinous lands and other sloppy lands, suitable soil conservation measures such as contour bunding or live bund with vetifer grass or contour trenching can be adopted to prevent further erosion of gullies and ravines. On the slopping sides of gullies and ravines, soil binding grass can be raised to prevent further spread. The gullies and ravines slowly gets filled over a period of time. Such lands can be put to use for afforestation.

The measures suggested for amelioration of wind erosion are afforestation, plantation of wind breaks and shelter belts like *Prosopis chilensis, Azadirachta indica* etc. Grassland development by growing grasses like *Cenchrus ciliaris* was found effective in arresting and drifting of soil by wind.

The movement of sand dunes towards productive agricultural lands and other establishment is a serious problem which needs immediate attention of the concerned agencies in stabilisation of sand dunes through afforestation.

Salt affected soils: The saline soils occur in arid and semi arid and coastal areas. Irrigation without proper drainage leads to salinisation. The main factors of salinisation are high salt content in the soil profile, saline ground water, high water table and seepage from canals. The reclamation measures include leaching of salts with good quality water and provision of drainage so that salts are kept well below the root zone.

The sodic soils occur in Peninsular semi-arid tract, where soils are injudiciously irrigated. As these soils are saturated with sodium ions capable of alkaline hydrolysis, it is necessary to replace Na with Ca in exchange complex. Gypsum being relatively cheaper and most abundantly available is commonly used as an amendment in the reclamation of sodic soils.

Shift cultivation: Shifting cultivation or Jhuming is practiced in North-Eastern states in three million hectares where dense forests on sloping land is cleared and crops raised without any management. As the yields decrease after some years (3-4 years) new forest is cleared for cultivation, abandoning old area which is subjected to severe soil erosion and the soils become shallow, unstable and degraded.

Acid soils: The acid soils with less than 5.5 pH occur at higher altitudes of western and middle Himalayas, high precipitation region in the eastern Himalayas, eastern and north eastern plains, high rainfall zone in peripheral peninsular and coastal plains. The reclamation of acid soils through use of amendments is necessary. Lime rich industrial wastes such as basic slag, paper mill sludge and cement factory waste can be used as amendment to reduce the cost.

Water logged areas: An area of about 6 million hectares will be water logged during rainy season in the country. Water logging restricts O_2 supply in soil which is essential for respiration of roots and for microbial activity. These soils are subjected to frequent flooding. Providing drainage to remove excess water, lining of canals to prevent seepage in and rise of water table are the remedial measures suggested in these areas. Waterlogged fields can be put to use for fish culture.

In addition to above ameliorative measures, the adaptation of following suggestion would hasten up in converting the waste lands into forest lands.

1. Incentives be given to farmers for growing multipurpose or useful trees around their dwellings, farmsteads, field bunds and other common waste lands.

2. Research on silvi-pastural technology should be identified in different agro-climatic zones so as to evolve site-specific recommendation.

3. Forest department should take up large scale seed multiplication programme of popular tree species, grasses and forages to meet the demand.

4. All waste lands should be brought under productive forestry to meet fuel, forage and timber requirement besides conserving the soil and moisture.

5.12. SUMMARY

1. The changes brought in land use pattern in India decade wise for four decades were analysed. There appears no scope in bringing more area under net cultivation.

2. The increased demand of food production, oil seeds and raw material requirement of industries has to come by increasing the productivity of irrigated and rainfed crops.

3. The adoption of intensive agricultural practices by providing better quality seeds and other inputs in time for irrigated crops and adoption of watershed approach for dry land areas are recommended for improving the crop yields.

4. The extent of damage occurred to agricultural land in India through increased pressure of both human and cattle population in over-exploiting natural resources was brought out and the remedial measures for halting the process of land degradation were discussed.

5. The method of damage due to water and wind and the extent of damage caused by these agents were pointed out. The formulas to estimate the losses due to these factors are given and suitable methods to check these losses are suggested.

6. The extent of presence of saline and sodic soils in different parts of the country are furnished. The effect of these soils on crop production is mentioned; reclamation and management methods are suggested for improving the productivity of these lands.

7. Infertile, fertile and productive lands were defined. The extent of nutrient losses occurring through crop and weed removal, leaching, voltalisation, erosion losses were pointed out and effective remedial measures on short term and long term basis were suggested. The importance of recycling of organic wastes, green manuring, diversion of animal dung from fuel use to manure would improve the chances of integrated nutrient supply through both organic and inorganic sources.

8. The extent of treated and untreated waste lands in India are given. Principles of waste land development and need for development of such lands into forest lands through different, reclamation, amelioratives and corrective measures for different types of waste lands are suggested.

9. All the above measures would ultimately help for sustaining the productivity.

5.13. CHECK YOUR PROGRESS : MODEL ANSWERS

1. The removal or loss of surface soil by water or wind is called soil erosion.
2. When slope exceeds 20%, the soil from top of hill side slip down and blocks the traffic in ghat roads. This is called land slide.
3. Soil infertility can be defined as inability of the soil to supply required plant nutrients to the growing crops.
4. The inherent capacity of the soil to supply nutrients to plants in adequate amounts and in suitable proportions is called soil fertility.

5.14. MODEL EXAMINATION QUESTIONS

I. Answer the following questions in about 30 lines each.

1. What is land degradation? What are the causes for land degradation? What steps are suggested to prevent further degradation and use of these degraded lands?
2. Classify the land based on land use pattern and give the latest area along with percentage under different categories of land.
3. What is intensive cultivation? How could India achieve the present level of food production?
4. What is sustainability in agriculture? How could the food grain targets of India be met for next 30 years?
5. Briefly describe different types of erosion.
6. What are the soil conservation measures you suggest to check the soil loss?
7. What are the causes for salt accumulation and what is their effect on crop production?
8. Discuss the basic principles involved in reclamation of salt affected soils.
9. How do you reclaim salaine soils?
10. What management strategies do you suggest for salt affected soils?
11. Discuss in brief the different types of fertility losses. How do you reduce these losses?
12. What measures do you adopt in making use of different types of wastelands in India?
13. Discuss in brief about management practices for different types of waste lands.

II. Answer the following questions in about 10 lines each.

1. Why is extensive cultivation practiced?
2. Which crops are grown under extensive cultivation?
3. What is the scope of increasing the net area sown in India? What are its limitations?
4. Briefly classify types of erosion. How are these erosions are caused?
5. What criteria should be adopted for making use of salt affected soils?

6. Differentiate between soil fertility and productivity.
7. Mention different techniques used for assessing the fertility status of soil.
8. What strategy do you suggest for effective adoption of integrated nutrient supply?
9. What are the different types of lands that are grouped under waste lands?
10. Write the causes for the conversion of cultivable land into waste land.
11. What is the extent of different types of waste lands?
12. What measures do you suggest in accelerating the process of waste land development?
13. What is the effect of urbanisation on cultivable lands and barren lands?

Prof. S. Narsa Reddy

UNIT-6 : CROP PATTERNS

Contents

6.1. OBJECTIVES

After going through this unit you will be able to

* explain the important features of crop pattern,
* list out the factors determining the crop pattern and describe each one of them,
* define various cropping systems in India,
* list out the types of soils in A.P. and the crops grown in each one of them,
* define hybrids, hybrid vigour, hybridisation, selection, plant introduction and acclimatisation and mutations and
* list out various hybrid varieties in various crops.

6.2. INTRODUCTION

Many crops are grown in India. The net area under these crops is about 45% of the total geographical area. Out of the 143 million hectares, 38 million hectares are sown more than once. As a result of this, the total or gross cropped area is larger at 182 million hectares. The most important features of crop pattern are devotion of large area for food grain crops, increase in the area of cultivation of nonfood grain crops, increase in the area of cultivation of certain crops, slow increase in the area of preponderant crops and emerging imbalance in the cropping patterns. The cropping patterns are always determined by several factors. They are physical, historical, social, economic and government policies.

The cropping systems in India are always determined by climatic factors and they are followed to increase the yield of the food grains and non-food grain crops. The cropping intensification techniques which are usually followed are intercropping, multiple cropping, relay cropping, sequential cropping and crop rotation by using the improved hybrid varieties.

6.3. IMPORTANT FEATURES OF CROP PATTERN

The most important feature in respect of crop pattern that outstands any other is the very large area devoted to food grain crops. The total area presently under food grain crops is about 70% as against 30% under non-food grain crops. In the beginning of the present

century as much as 83% of the cultivated land was under food grains. In 1944-'45 it continued to be around 80%. Since independence, there is a little fall and in 1950-51 it was 74%.

The second important feature is the increase in the cultivated area of non food grain crops. This trend is seen both before and after independence. For example during the first 45 years of this century the land under food grain crops increased by 14% and non-food grain crops by 41%. Even after independence, the trend is similar with an increase of 25% for food grain crops and 50% for non-food grain crops.

The third significant development is the increase in the area of cultivation of certain crops. In the case of food grain crops, the increase has been the largest in respect of wheat. The area of production is almost doubled in its case. Among all the individual crops, the largest increase has been experienced with wheat. Among the non-food grain crops, sugarcane experienced the largest increase.

The fourth feature is the slow increase in area regarding preponderant crops such as rice. Rice is the staple food for majority of Indians. The largest area is under rice cultivation but the growth in area is so small and its share has remained the same (from 23.4% to 23.6%). Same is the case with that of Jowar, the food of the poor and pulses, the source of protein for poor and vegetarians. Among the commercial crops, the largest area is under oil seeds whose growth in area is very slow and it could only retain its previous ranking in the cropping pattern.

The fifth notable feature is the emerging imbalance in the cropping pattern. In otherwords, the crop pattern is changed and it has been drifting away from what is a desirable course. It is evident from two sources of change *viz.*, substitution effect and expansion effect. The substitution effect is nothing but the relative decline in area of some crops through an increase in gross cropped area and the expansion effect is the increase in area under some crops through an increase in gross cropped area. The substitution effect is much more prominent. This is particularly so with regard to some important crops. For example, area under fast growing crops such as wheat and rice has increased continuously in many states at the cost of cereals, millets, pulses and in some places cotton. This is because of the technological changes, increase in the irrigation facilities, increase in governmental support and the changes in relative prices in favour of certain crops. All these factors collectively made wheat and paddy superior in profitability to other crops. This led to the reduction in production of cereals and pulses consumed by the poor which necessitated huge imports.

6.4. FACTORS DETERMINING CROP PATTERN

The factors determining the crop patterns can be studied under several heads *viz.*, physical, historical, social, economic, and government policies.

Physical factors: Natural environmental conditions of a country are the most important physical factors affecting the crop pattern. The physical factors that determine the crop pattern are soil, climate, rain fall etc.

It is a well known fact that certain soils and climate are suitable for particular crops and not suitable for other crops. Due to this only such crops are grown in those areas which suit to the natural conditions. For example the soil and other conditions are suitable to the growth of wheat and coastal districts of Andhra Pradesh are conducive to the growth of rice. Similarly jowar and bajra are grown in places with low rain fall. To some extent modern technology can change the crop pattern by creating the required conditions for any crop but it is a costly affair.

Historical Factors: The crop pattern of a country is given by history. The needs and capacity of population through time have governed the types of crops grown and the lands are earmarked for different crops. The generation after generation will be growing the same crops as they learn the farming techniques of one particular crop from their earlier generations. The small farmer having 1-2 acres of land gives priority for the crops of his daily consumption. The farmers with more land may have a different crop pattern.

Social Factors: Social factors such as density of population, customs, traditions, attitudes towards material things, willingness and capacity for change etc., have played an important role in determining the crop pattern. Before independence, the farmers in India are tradition bound and fatalistic in out look. As a result, the farmers carried on with the crop pattern handed over to them by the earlier generations. After independence, there has been some change in agriculture by taking the advantages of modern inputs, new knowledge and new facilities of agricultural operations.

Economic Factors: The economic factors which determine the crop pattern are the prices, income, size of land holdings, availability of agricultural resources etc. The prices of agricultural products of manufactured goods will have tremendous effect on the types of crops that are grown by the farmers. It also determines the size of land that the farmer devotes for a particular crop. In addition to the level of prices, the changes in prices also affect decisions as to what to grow and on how much of land.

The different prices i.e., sale price of products, purchase price of inputs and consumer goods and the terms of trade between agricultural and non-agricultural goods determine the real income of a farmer. Therefore, the crops that give largest profit will be definitely preferred by the farmers.

Investment for cultivating a particular crop also plays a vital role in determining a crop in the field. Some farmers who cannot invest much for the cultivation will go for crops which needs less investment and others who are economically well equipped will go for crops with much investment and make more profit.

Government Policies: The policies of Government affect crop pattern in a very important way. Policies regarding the priorities given to various crops, exports, taxes, supply of credit, development of backward regions etc. determine the nature of crops and the area under them. The facilities that the government gives for the growth of certain crops and for the development of certain regions determine the crop pattern mostly.

Before independence, neglect on the part of Government, resulted in the continuation of the old crop pattern determined by the old historical factors. However, during second world war, when the "Grow More Food" campaign was launched, some changes in the crop pattern were initiated by the Government. After independence Government policies have played a vital role in changing the crop pattern.

Check Your Progress - 1

Name the factors that determine the crop pattern.

Note: (a) Write the answers in the space provided below.

(b) Compare your answer with the one given at the end of this unit.

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6.5. CROPPING SYSTEMS IN INDIA

To keep pace with the demand of the ever increasing population, the food production has to be increased. There is little likelihood of extending the areas under cultivation. But there is a possibility of raising two or more crops per year through multiple cropping, relay cropping, intercropping systems etc., and by utilising the available resources more efficiently than before.

With the availability of high yielding crop varieties and improved management techniques, the emphasis has been shifted from yield stability of crop mixtures to the achievement of yield advantage, maintenance of soil fertility, increasing of farm income and efficient utilisation of resources through intensive cropping by exploiting the space more effectively. The cropping intensification techniques include intercropping, multiple cropping, relay cropping, sequential cropping and crop rotation.

Intercropping: Growing of two or more crops simultaneously in alternate rows on the same field is called intercropping. In dry land agriculture, to utilise the scarce rainfall efficiently, cropping pattern should be adjusted in accordance with the available resources. In this type of areas, there is no scope for growing a second crop in sequence due to the availability of moisture for a limited period in a year. Under such conditions, the adoption of intercropping system as a whole proved to be more profitable than growing one crop. The use of nutrients and moisture is likely to be all the more complete because different crops in intercropping use the moisture and nutrients from different depths and layers of soil and also there is less run off and leaching.

The advantages of intercropping are: (a) maximum utilisation of resources like sunlight, moisture and nutrients, (b) increase in the production per unit area per unit time, (c) minimisation of risks due to diseases, pests and weeds, (d) building up of soil fertility due to the inclusion of legumes in intercropping (e) distribution of labour peaks due to the maturity of different crops at different times and (9) provision of balanced food for the farmer and his domestic needs.

Multiple Cropping: Growing two or more crops on the same field in a year is called multiple cropping. The main objective of multiple cropping is to intensify cropping with the available resources in a given environment. Success of multiple cropping lies in the choice of crop varieties. Crops should be arranged in such a way that temporary immobilisation of plant nutrients and depletion of nutrients from the same layer of the soil do not occur. Similarly crops which add larger quantities of easily decomposable residues and which benefit the succeeding crop with available nutrients should be included. Legumes are suitable for any cropping system because of their limited demand on resources like water, nutrients and light, their adaptability to varying environmental conditions and their capacity to fix atmospheric nitrogen in their root modules produced by bacteria. Vegetable crops are

also suitable for multiple cropping because of their monetary and nutritional values. Most of the vegetable crops can be raised as seedlings and transplanted for reducing the duration of the crop in the main field.

Relay Cropping: Growing two or more crops simultaneously during the part of the life-cycle of each crop is called relay cropping. The second crop is planted after the first has reached its reproductive stage of growth but before it is ready for harvest is called relay cropping. It is like a relay race in which one crop hands over the land to the next crop in quick succession. It has been practiced in irrigated conditions and occasionally in humid climates as a means of maximising the use of resources like land, water and time. Relay cropping at ICRISAT (International Crops Research Institute for Semi-Arid Tropics), Hyderabad, indicates encouraging potentialities on scope for effective utilisation of soil and water and increased yield.

The advantages of relay cropping are: (a) increase in the efficiency of water and fertilisers, (b) control of growth of weeds, (c) restoration of nitrogen status of the soil by the inclusion of legume crops (d) adding of considerable amount of organic matter to the soil by foliage drop and left over stubbles, (e) efficient use of farm labour and cattle, (f) no need of preparatory cultivation for second crop. But this system is limited to irrigated areas.

Sequential Cropping: Growing two or more crops in sequence on the same field in a farming year is called sequential cropping. The succeeding crop is planted after the preceding crop is harvested. This practice is adopted in assured irrigated conditions and also in sub-humid areas with heavy rainfall. Some of the sequences in assured irrigated conditions are:

a) Paddy - Pulses - Groundnut
b) Green manure - Paddy - Pulses - Fallow
c) Paddy - Groundnut - Paddy

In deciding the crop sequences, it is advisable to select crops with different morphological behaviour i.e., deep and shallow rooting, nutritional requirement of crops etc. Certain basic rules are to be observed in identifying the crops in sequential cropping. They are: (a) Crops having the same pests and diseases should not be grown in sequence, (b) One should be shallow rooted and another with deep roots, (c) restoration of soil fertility by including one legume etc.

The advantages of sequential cropping are (a) better seasonal distribution of labour, (b) less erosion, (c) better weed control, (d) less insect and disease problem, (e) more yield in rotation.

Crop Rotation: Continuous cultivation of crops one after another on the same land is called crop rotation. For the completion of one cycle, one or more years are required. The importance of crop rotation was realised long time ago in view of the need for fertility, maintenance, prevention of the spreading of soil-borne diseases, pests and weeds, control of soil erosion etc. Selection of crops in a given rotation depends on the type of farming i.e., rainfed or irrigated. A well planned crop rotation has several advantages. They are: (a) maintenance of soil fertility, (b) prevention of pests, weeds and soil-borne diseases, (c) control of soil erosion, (d) provision of a balanced programme of work throughout the year etc.

Check Your Progress - 2, 3 & 4

2. Define inter cropping.

3. What is meant by multiple cropping?

4. What is the difference between relay cropping and crop rotation?

Note: (a) Write the answers in the space provided below.

(b) Compare your answers with those given at the end of this unit.

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6.6. TYPES OF SOILS IN A.P. AND CROPS GROWN

The productivity and the type of crops grown always depend on the physical properties of soil such as texture, structure, density, pore space, plasticity and cohesion, soil temperature, soil air and soil water and chemical properties like mineral composition, organic content, and soil pH. Based on these characteristic features soils are classified into different groups. They are coastal sands, deltaic alluvium, red sandy soils, red loamy soils, black soils, laterite soils etc.

Coastal sands: These soils are very deep (180cms to 5 meters). These are coarse textured with sandy subsoils. The water table is close to the surface and ground water is strongly saline. These soils are present all along the eastern coast, in the district of Srikakulam, Visakhapatnam, East and West Godavari, Krishna, Guntur, Prakasam and Nellore districts. Generally nurseries of rice and tobacco are raised and vegetables are also grown in small areas *Casuarina* and cashew plantations can be taken up.

Deltaic Alluvium: These are very deep, over 180 cms. Fertile clay, minerals are varying due to deposition of silts of varying composition. These soils are prevalent in some parts of East and West Godavari, Krishna and Guntur districts. The crops that can be grown are rice, turmeric, sugarcane, banana, chillies, vegetables, maize, cotton and groundnut mostly under irrigation.

Red Sandy Soils: The depth of the soils varies from very shallow to shallow (20-60 cms). These are very low in nitrogen content. These soils are present in tracts of Hyderabad, Medak, Guntur, Prakasam, Nellore and Kurnool districts. The crops grown in this type of soil are jowar, bajra, redgram, castor, groundnut etc. under rainfed conditions and rice under irrigation.

Red Loamy Soils: These are shallow to moderately deep (20-75 cms). They are low in nitrogen and phosphorus. These soils are present in parts of Cuddapah, Ananthapur, Chittoor and Nellore districts. The crops grown in this type of soil are jowar, bajra, Ragi, Korra, pulses, groundnut under rainfed conditions and rice and sugarcane under irrigated conditions.

Black Soils: These soils are medium deep to deep (45-90 cms). These soils are low in nitrogen, very low in phosphorus, and medium in potassium. These soils are prevalent in parts of Adilabad, Nizamabad, Warangal, Khammam, Medak, Hyderabad, Mahabubnagar, Kurnool, Ananthapur, Nellore and Guntur districts. In this type of soil rainfed crops like Jowar, Bajra, Gingelly, Cotton, tobacco, groundnut and irrigated crops like rice and sugarcane are grown.

Black cotton soils are very deep clay soils (90-180 cms). Nitrogen and phosphorus contents are low but potassium content is at medium level. These are prevalent in parts of Cuddapah, Anantapur, Kurnool, Mahabubnagar, Guntur, Prakasam, Krishna, Khammam, Nellore etc. Rainfed crops like Jowar, Maize, pulses, Cotton, tobacco, chillies, wheat and irrigated crops like rice, sugarcane, cotton, chillies etc are grown.

Laterite Soils: These are deep to very deep (90-180 cms) and poor in fertility. They are low in nitrogen, phosphorus and potassium. Considerable area is present in Zaheerabad taluk of Medak and some patches in Kavali taluk of Nellore, certain parts in Visaka and Srikakulam. Crops like potato, turmeric, ginger, tobacco are grown in this type of soil.

6.7. HYBRIDS

Hybrids are nothing but the new crop varieties which are far better than original types in all respects. These are produced by selection, hybridisation, plant introduction and acclimatisation and mutations. The branch of science that deals with hybridisation and production of hybrids of agricultural crops is called plant breeding. The main objective of plant breeding is to produce new crop varieties superior in all aspects as compared to the existing types.

Selection is the oldest breeding method and is the basis for crop improvements. Plant improvement is started with the primitive man changing his mode of life from food gatherer to food producer. He has obtained the first crop from the plants growing in nature but for the next season crop, he had obtained the seeds from the first crop. For this purpose, he might have unconsciously practiced the selection. Even today selection is the most common method of crop improvement. Selection is of two types i.e., Natural selection and artificial selection. Natural selection is a rule in nature and is the result of evolution. According to this, the fittest can survive and rest wipe out. All the local varieties of crops are the result of such a natural selection. Artificial selection is the selection of certain types of plants by the plant breeder from the mixed population for their own advantages.

Hybridisation is applicable to both self and cross pollinated crops. In this, two plants of unlike genetical constitution are crossed together. The plants that are crossed may belong either to two different varieties of the same species (intraspecific hybridisation), or two different species of the same genus (interspecific hybridisation), or two different genera (intergeneric hybridisation). The main purpose of hybridisation is to create variation. No new genes are produced by hybridisation. But variation is created by bringing in new combinations of genes already present in the parental stock. During the course of hybridisation many plants possessing separate combination of different characters are produced. Some, out of them, may be selected possessing all the possible good characters together. By further selection, a variety with as many economic characters as possible may be produced from these plants by hybridisation.

Introducing the plants growing in one locality with better characters into a new locality with different climate is called **Plant Introduction.** The adjustment of crops to the conditions of new locality is known as **Acclimatisation.** The crops may be introduced into a new

locality either from outside the country or from a different region within the country. If the crop is found suitable, it may be utilised as it is after selection or utilised in hybridisation for transferring the desired characters into the local varieties.

Mutations are the sudden changes in the genes present in chromosomes which are heritable. These changes may be due to rearrangement of genes (gene mutation or point mutation), changes in chromosome size and structure (chromosomal mutation), changes in chromosome number (Polyploidy) and changes in the cytoplasmic genes (somatic mutations). These mutations are the basis of selection and production of new crop varieties in plant breeding.

Planting breeders in several countries have been working endlessly to produce high yielding hybrid varieties in several Agricultural crops. In India several Agricultural Research Stations which are under IARI, ICAR, Agricultural Universities, and Institutes like ICRISAT (Hyderabad) are making tremendous efforts for the production of hybrid varieties in several agricultural crops. Some of the important hybrid varieties of important agricultural crops are given below.

Wheat: India is well known for wheat breeding. Several improved varieties have already been evolved and released for cultivation. Some of the important varieties are NI-5439, HD-2189, HD-2278, DWR-39, HD-4502, NI-747-19, CC-464, UP-215, HY-65 etc.

Rice: Rice breeding work in India has yielded more than 500 improved varieties which give 20-50% more yield than local varieties. Some of the varieties which are grown in India are BPT-3301, IET-5854, IET-6314, NLR-9672, NLR-9674, IR-20, IR-50, MTU-6024, MTU-5656, MTU-9416 etc.

Maize: Before 1962, the work was confined to selection, introduction and acclimatisation. But after 1962, many hybrids such as Ganga-101, Ganga-1, Ranzit, Himalayan-123, UL-54, Deccan-101, DHM-103, Rohini, Ganga-5 etc were released.

Jowar: More than 50 improved varieties have been produced by various states. Important among them are : T-4, T-22, M-35-1, CO-20, CSH-1, CSH-5, CSH-6, CSV-2, CSV-3, CSV-4, CSV-5, CSV-6 etc.

Bajra: Most of the bajra breeding work has been done by Punjab, Gujarat, Tamilnadu, IARI and Rajasthan. The Important hybrid varieties are Co-1, Co-2, Co-3, PT-17, PT-248, AKP-1, AKP-2, BJ-104, BK-560, Vijaya Composite, Visakha etc.

Sugarcane: Most of the hybrid varieties of sugarcane are produced at the sugarcane Research Station, Coimbattore. Some of the important hybrid varieties are: CoA-7701, Co-7508, Co-6907, CoA-8201 (early maturing varieties) ; Co-975, CoA-7602, Co-62175, Co-6304 (mid season maturing varieties); Co-22175, Co-719, Co-419 (late maturing varieties).

Cotton: In place of desi cotton, East India company introduced *hirsutum* species of *Gossypium* from America, Egypt, Brazil, Peru etc. Improvement in the varieties was achieved through the breeding programmes of hybridisation and selection. Some of the hybrids recommended are MCU-5, MCU-9, Varalaxmi, Bhagya, Savitri Hybrid, Suguna, DCH-32 etc.

Chillies: Prior to the introduction of chillies in India from its native South America, black pepper was in use. The most important hybrid varieties of chillies are G3, G4, G5, CA-960, CA-1068, X-196, X-197, Jwala etc.

Groundnut: is an important oil yielding plant. The most important high yielding varieties are Kadiri-1, Kadiri-2, Kadiri-3, M-13, TMV-1, TMV-2, J-11, JL-24, POL-1, POL-2 etc.

Sunflower: is another oil yielding plant. The most important hybrid varieties are TNAU SUF-3, TNAU SUF-4, KSF-3, GP-1, APSW-9, APSH-11, PKVSW-1, KBSH-14, MSSW-1,4,5,10,11,12 etc.

Hybrid Vigour: When two homozygous inbreds of genetically unlike constitutions are crossed together, the resulting hybrids obtained from the crossed seeds are usually vigorous, productive, sturdier and taller than either parents. This increased productivity or superiority of the hybrids over parents is called hybrid vigour or heterosis.

Interspecific and Inter generic crosses: Interspecific hybridisation is also called intrageneric hybridisation. Some of the example for this type of cross are (a) pusa red plum (tomato) which is a cross between *Lycopersicon esculentum* and *L. pimpenellifolium* (b) Deviraj (cotton) which is a cross between *Gossypium hirsutum* and *G. arboreum.* Intergeneric hybridisation is a cross between different genera belonging to the same family. In this type of hybridisation new hybrids such as *Raphanobrassica (Raphanus x Brassica), Bromato* (Brinjal and Tomato), *Triticale* (Wheat x Rye) etc. are produced.

Check Your Progress - 5 & 6

5. What is meant by hybridisation?

6. What is the difference between intraspecific and interspecific crosses?

Note: (a) Write the answers in the space provided below.

(b) Compare your answers with those given at the end of this unit.

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6.8. GOVERNMENT POLICIES

The provision of food security to its citizens is an important goal of India. The application of Modern Technology has effectively proved the fallacy of the "Malthusian spectre of Famine" since growth in production of food grains in the world as a whole has by far exceeded the rate of population growth. Enhancing the food grains supply even to the level of minimum requirement still remains the dream in the case of many developing countries. Further, in years when the whether turns unfavourable, the spectre of hunger still looms large for much of the developing world. However the achievement of free India as far as the provision of food security to its citizens is concerned have been quite creditable.

In the late sixtees, India was categorised as a test case by the authors of "Famine 1975". Their analysis had convinced them that India would not be able to increase food grains supplies to match its population growth and they had predicted large scale starvation. But India has been able to record a more rapid growth in the food grain output than its population. It has been able to prevent the occurrence of famine in the country despite domestic production declining sharply in years of drought but has also succeeded in increasing both economic and physical access to food.

It is the total developmental policy for the agricultural sector that has brought about these remarkable changes. Two macro-policy measures have played a major role. They were the agricultural price policy and the policy of public distribution of food grains in conjunction with provisions of scarcity relief.

The national food policy has been steadfast in its pursuit of three goals:

1. To increase food production in the country by ensuring remunerative prices to the farmers by offering to purchase at stipulated minimum prices whatever quantities are offered for sale in the market and thereby encouraging them to increase use of more inputs.
2. To safeguard the interest of the consumers by making available the food grains through the public distribution system throughout the country at a reasonable and uniform price. The idea is to stabilise the open market prices at reasonable prices.
3. To hold adequate stock of food grains as a measure of food security in the country not only to impart inter-seasonal stability but also to meet the emergent situations that could arise due to crop failure, floods etc.

Indian agriculture achieved respectable progress over the last four decades. It achieved an annual growth rate of 3% in the pre-green revolution period and 2.7% in the subseque period. Food grain production increased from 55 million tonnes in 1950-51 to 103 milli tonnes in 1970-73 to 131 million tonnes in 1980-83 to 177 million tonnes in 1991-94.

6.9. SUMMARY

Many food grain and non-food grain crops are grown in India in 45% of the total geographical area and in 9 million hectares the crops are grown more than once. The devotion of very large area for food grain crops is the most important feature of crop pattern. The other important features of crop pattern are increase in the cultivation of non-food grain crops, increase in the area of cultivation of certain crops such as wheat, sugarcane etc., slow increase in area of preponderant crops such as rice & emerging imbalance in the cropping pattern.

Several factors such as physical, historical, social, economic & Govt. policies determine the crop patterns. The important physical factors are nothing but the environmental conditions.

The historical factors such as needs and capacity of population have determined the types of crops grown. Social factors such as density of population, customs, traditions, attitudes towards material things etc. and economic factors like prices, income, size of land holdings, availability of agricultural resources also determine the crop patterns. Some of the Govt. policies such as priorities given to various crops, exports, taxes, supply of credit, development of backward regions determine the nature of crop in an area.

Due to increase in population the food production is to be increased. To increase the food production cropping intensification techniques such as inter-cropping, multiple cropping, relay cropping, sequential cropping & crop rotation are to be followed. Intercropping means growing of 2 or more crops simultaneously in alternate rows on the same field. Growing of 2 or more crops in a year on the same field is called multiple cropping. Relay cropping can be defined as growing of two or more crops simultaneously during the part of the life-cycle of each crop. Growing 2 or more crops in sequence on the same field in a farming year is called sequential cropping and continuous rotation of crops one after another on the same land is called crop rotation.

There are different types of soils in Andhra Pradesh. The productivity and the type of crops grown always depend upon the physical and chemical properties of soils. The types of soils present in A.P. are coastal sands, deltaic alluvium, red sandy soils, red loamy soils, black soils, laterite soils etc.

The important goal of India is the provision of food security to the citizens. The growth in the food grain production has by far exceeded the rate of population growth. The authors of "Famine 1975" said that India would not be able to increase food grains supplies to match its population growth and they had predicted large scale starvation. But India not only increased the food grain production than its population but also prevented the occurrence of famine in the country.

To increase the food production several hybrid varieties of food crops were produced. The hybrids are produced by selection, hybridisation, plant introduction & acclimatisation and mutations. Selection is the oldest breeding method and it is in the selection of certain types of plants by the breeder from the mixed population. Hybridisation is the crossing of two plants for unlike genetical constitution. The plants that are crossed may be two varieties of the same species (intraspecific hybridisation), two different species of the same genus (interspecific), or two different genera (intergeneric). Introducing the plants growing in one locality to another locality with different climate and adjusting it to the new conditions is called introduction and acclimatisation. Sudden genetic changes that occur in plants is called *mutations*. These mutations are the basis for selection and production of new crop varieties in plant breeding.

6.10 CHECK YOUR PROGRESS : MODEL ANSWERS

1. Physical, historical, social, economic factors and Govt. policies are the determining factors of crop patterns.
2. Inter cropping can be defined as the growing of two or more crops simultaneously in alternate rows on the same field.
3. If two or more crops are grown on the same field in a year, it is called multiple cropping.
4. Growing two or more crops simultaneously during the part of the life-cycle of each crop is called relay cropping where as crop rotation is the continuous cultivation of crops one after another on the same land.
5. The crossing of two plants of unlike genetical constitution is called hybridisation.
6. The crossing between 2 different varieties of the same species is called intraspecific cross and the cross between two different species of the same genus is called interspecific cross.

6.11 MODEL EXAMINATION QUESTIONS

I. Answer the following questions in about 30 lines each.

1. Write briefly about the important features of crop patterns.
2. What are the factors that determine the crop pattern? Write briefly about them.
3. What are the different types of soils in A.P.? Write briefly about the crops grown on each one of them.

4. What are the cropping systems followed in India? What are the advantages and disadvantages?

5. Write briefly about hybrids.

II. Answer the following questions in about 10 lines each.

1. Write briefly about the physical factors that affect the crop pattern.
2. How does the economic factors determine the crop patterns?
3. Write briefly about intercropping.
4. Write a brief account on multiple cropping.
5. What is relay cropping? Write briefly about the advantages of it.
6. Write a brief account on black sols and the crops generally grown in this soil.
7. Write briefly about hybridisation.

Dr. M. Ramachandraiah

BLOCK - 3

FRESH WATER SUPPLIES IN INDIA

UNIT –7 : INDIA'S WATER RESOURCES

Contents

7.1 OBJECTIVES

After going through this unit you will be able to:

* describe the distribution of rainfall in India,
* distinguish between ground water and surface water resources,
* describe the pattern of monsoon,
* describe and distinguish between tanks and lakes
* describe the water cycles
* differentiate between drought and floods,
* explain future strategies to be adopted.

7.2. INTRODUCTION

The earth is believed to be in existence since the past 5 billion years. The quantity of water remained constant over the period of the time. The basic source of water is precipitation in the form of rainfall or snowfall, runoff from precipitation drains through streams and rivers or collects in the surface depressions forming tanks or ponds.

Water from streams and rivers is stored in reservoirs or is diverted directly through canal systems for irrigation. Runoff water stored in tanks or ponds is also regulated for irrigation through suitable conveyance systems. A part of the rainfall is stored as ground water.

Rainfall in India varies from place to place and from year to year. The Indian Meteorological department has devised a network of rain gauges for measuring the depth of precipitation over the areas.

7.3. WATER CYCLES

Hydrologic Cycle: The water exists on earth in its three forms *viz.* gaseous, liquid and solid forms and is constantly circulated mainly by Solar and Planetary forces. The sun provides the energy for the evaporation of sea water, the group of numerous arcs which represent the different paths through which the water in nature circulates, is known as the hydrologic cycle. These arcs penetrate into the three parts of the total earth systems *viz.*, 'Atmosphere', 'Hydrosphere' and 'Lithosphere'. The atmosphere is the gaseous envelope above the hydrosphere; hydrosphere is water that cover the surface of earth, and lithosphere is the solid rock below the hydrosphere. The activities of water extend through these three parts of the earth system from an average depth of about one kilometre in the lithosphere to a height of about fifteen kilometres in the atmosphere.

Hydrologic cycle has no beginning or end as the water in nature is continuously kept in cyclic motion. However, for the purpose of description, the cycle may be visualised as beginning with the precipitation from the atmosphere. Precipitation may take place in liquid form as rain and also in solid form as hail, snow, dew, frost etc. While precipitation is taking place, a part of it may evaporate and reach back the atmosphere. Some more precipitation is intercepted by the trees and vegetation and the rest of it only would reach the ground. The intercepted precipitation eventually evaporates into the atmosphere. The precipitation reaching the ground surface is called the throughfall. Considerable portion of the precipitation reaching the ground gets infiltrated into the ground. The throughfall in excess of infiltration would be detained temporarily on the ground before it becomes surface runoff. The precipitation falling directly into the streams is called the channel precipitation and it readily becomes runoff without any delay. And the precipitation ralling on the water bodies like ponds and lakes may be disposed of either as surface runoff to streams if the water bodies overflow or as evaporation or as infiltration. The evaporation would also be taking place from stream surfaces. The infiltrated water may be distributed in different ways. First it supplies moisture to the vegetation and after utilising it for the sustenance of their life, the vegetation sends this moisture into atmosphere through a process known as transpiration. Secondly the infiltrated water may percolate deep and become ground water supply to surface streams known as ground water runoff, or it may become ground water supply to oceans. The ground water runoff is sometimes referred to as the base flow or interflow. The total stream flow which is the sum of surface runoff and ground water runoff ultimately joins the oceans, wherefrom it again evaporates into the atmosphere, thus completing the hydrologic cycle. The entire cycle repeats when the atmospheric moisture precipitates onto the ground after cloud formation. Thus the hydrologic cycle consists of various complicated processes of precipitation, interception, evaporation and transpiration, infiltration, percolation, storage, and runoff.

Check your progress-1

What are the three parts of the earth system?

Note: (a) Write the answer in the space provided below.

(b) Compare your answer with the one given at the end of this unit.

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7.4. RAINFALL DISTRIBUTION IN INDIA AND MONSOON PATTERNS

The major source of water available either for agriculture or for human consumption is obtained from the rainfalls on the earth surface. South-West monsoon, North-East monsoon, cyclonic depression and local storms contribute to rainfall in different degrees in various rainfall regions of the country.

In summer, there is an enormous rise in temperatures, due to which the moisture laden South-West monsoons originate from the vast expanse of the Indian Ocean and enters the Indian Sub-Continent from South-West. The physiographic features of Indian peninsula and the Western Ghats divert these monsoon winds into two branches, one the Arabian sea branch and the other, the Bay of Bengal branch. The Bay of Bengal branch of monsoon winds moves into Assam by June where they strike the Himalayas and precipitates heavily. A Large portion of these monsoon winds are deflected towards the west by the Himalayas advancing the winds upto Delhi, Rajasthan and North-West India. These South-West monsoonic winds increase from June to July and begin to weaken in September, specially in North India.

The Arabian sea branch of the monsoon strikes the Western Ghats and heavily precipitates along the west coast from Kerala to Gujarat between the last week of May to the first week of June. By the first week of July the monsoon is established all over the country. The withdrawal of the monsoon starts in September in North India and there is a rapid decrease of rainfall towards the end of the month. The duration of monsoon activity is minimum in the North-West region of India and maximum in the southern region. The crucial months for agriculture are July and August and the fate of rainfall kharif crop largely depends upon the amount of distribution of rain especially during these months.

Some parts of India receive hot weather rainfall between March to May, which are mainly due to large thunderstorms activity called North-Westers. These rains are of substantial importance in West Bengal for the early spring crop of rice and for tea crop in Assam.

During the North-East monsoon season, the retreating South-West monsoon currents from North-East, which are weak and shallow, are directed towards the peninsula causing occasional showers in the East coast of peninsula.

Precipitation during the cold weather season is due to a low pressure system in the North India called Western disturbance which move from Wet to East. These bring snow to the high ranges in Himalayas and rain to the sub-mountain tracts and adjoining areas. The precipitation decreases from West to East. These are significant as the fate of rainfall rabi crops in the north and the central areas of the country depends upon them.

It is interesting to note that two places, Khagra and Cherrapunji, at almost exactly the same latitude, are among the driest and wettest places, respectively, on the earth. This extreme difference in precipitation of these two places is caused by orographic factors. Along 25^{0}N latitude in northeastern India is located Cherrapunji - a town that holds the world record for the most rainfall in a 12-month period - 1041 (2644cm) in 1860-61. Its long-term average is 430in. (1092cm) per year. The town of Cherrapunji is located on the edge of plateau that provides the first orographic barrier to the moisture-laden winds of a monsoon blowing North out of Bay of Bengal. On the other hand, along the same latitude in Western Desert of Desert of Egypt, the region around Khagra receives virtually no rainfall at all year after year. Its long-term average is probably 1mm (0.04") in a year. Khagra lies in a large depression near the eastern side of the great Sahara Desert, more than 2000 miles (3200 km)

from the Atlantic Ocean and about 500 miles (800 km) South of the Mediterranean Sea. By the time winds from the Ocean reach Khagra, they have lost their moisture on the way and become as dry as the sands they blow across.

Check Your Progress-2

What are the driest and wettest places on the earth.

Note: (a) Write the answer in the space provided below.

(b) Compare your answer with the one given at the end of this unit.

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7.5. GROUND WATER AND SURFACE WATER LEVELS

7.5.1. Ground Water Resources

The ground water is the largest source of fresh water on the planet excluding the polar icecaps and glaciers. The amount of ground water within 800 m from the ground surface is over 30 times the amount in all fresh water lakes and reservoirs, and about 3000 times the amount in stream channels, at any one time. At present nearly one fifth of all water used in the world is obtained from ground water resources. Agriculture is the greatest user of the water accounting to 80% of all consumption. It takes, roughly speaking 1000 tones water to grow one tonne of grain and 2000 tonnes to grow one tonne of rice. Animal husbandry and fisheries require abundant water. Some 15% of World's crop land is irrigated. The present irrigated area in India is 60 million hectares of which about 40% is from ground water.

The average annual ground water recharge from rainfall and seepage from canals and irrigation system is of the order of 67 million hectares/metre of which 40% i.e., 27 million hectares, is extractable economically. The present utilistation of ground water is roughly half of this 13 million hectares/metre, and about 14 million hectares/metre is available for further exploitation and utilisation.

Ground Water Development in India: The excavations at Mohanjodaro have brick-lined dug walls existing as early as 3000 B.C. during the Indus Valley Civilisation. The writings of Vishnu Kautilya (in the region of Chandraguptha Maurya - 300 B.C.) indicate that ground water was being used for irrigation purposes at that time.

Sinking of wells and a variety of water devices were well known from vedic times.

The first Irrigation Commission in 1903 affirmed the importance of irrigation wells. The Well sinking Department of the Government of Nizam at Hyderabad made interesting studies on ground water in Deccan Basaltic Terrains.

In 1934 a project for construction of 1500 community tube wells in Ganga basin was initiated in U.P. The success of this project led to the constitution of a sub-soil water section in the Government of India in 1944 which was converted later into the Central Ground Water Organisation which functioned till 1949. During this period a Central Drilling School at Roorkee was established which trained more than 100 officers of the Central and State Government.

The Exploratory tube Wells Organisation (ETO) was set up during 1954 under Indo-US Technical Co-operation Operational Agreement No. 12, under the Ministry of Agriculture and Concomitantly the Ground Water Exploration Section was set up in the Geological Survey of India.

In October 1970, the ministry of Agriculture upgrades the Exploratory Tube-Wells Organisation into the Central Ground Water Board (CGWB) merging it with the Ground Water Regional Directorates and District Officers of the Geological Survey of India to effectively shoulder the ground water investigation programmes; it started functioning from August 1972. As an apex body at the national level, the Board is concerned with all matters relating to exploration, assessment, development, management and regulations of the country's ground water resources.

Large scale ground water investigation programmes have been taken up since 1967 in Rajasthan, Gujarat and Tamil Nadu with the assistance of the UNDP, the Canadian assisted project in AP, the upper Betwa River Basin Project in MP and UP with UK assistance, Narmada Valley Project in MP, Vedavathi and Tungabhadra River Basin in Karnataka under UK assistance and many such projects.

During the middle and late sixties, the Government of India urged all the State Governments to set up State Level Ground Water Organisations to deal with the problems of ground water surveys and development and utilisation for minor irrigation and eventually they have been set up. State Directorates of Ground Water Board is contemplating special measures for ensuring coordination of work among the various States and between the Centre and States so that overlapping or duplication is avoided.

Since 1970, major programmes with the assistance of UNICEF for provision of drilled wells for rural water supply have been launched in hard rock areas of AP, Karnataka, MP, Maharashtra, Tamil Nadu and Rajasthan. These utilise the air hammer drilling rigs.

In recent years there has been an increasing tendency towards drilling deep wells as well as towards revitalisation of existing open (dug, shallow) wells. Advance in the field of ground water development have made it possible to lift ground water from the depths of 60 to 100 metres. With the extension of electricity in rural areas, there has been a great spurt in the lift irrigation from tube wells and open wells. The Government, Voluntary Agencies, Agricultural Refinance Corporation, Land Development Banks, State Agro Industries Corporation etc., are all coming forward to help the poor and marginal farmers by giving short and long term loans, grants technical advice, and making technical feasibility and economic viability studies, thus accelerating the pace of ground water development and bringing more land under intensive irrigation.

In general the term "groundwater" or "subsurface water" refers to the water that occurs below the surface of the earth. The main source of ground water is infiltration. The infiltrated water after meeting the soil moisture deficiency percolates deeply and joins the ground water reservoirs.

7.5.2. Surface Water Sources

The basic source of water is precipitation in the form of rainfall or snowfall. Runoff form precipitation drains through streams and rivers or collects in surface depressions forming tanks or ponds. Runoff water from streams and rivers is stored in reservoirs or is diverted directly through canal systems for irrigation. Runoff stored in tanks or ponds is also regulated for irrigation through suitable conveyance systems.

River systems of India: The river systems of India can be classified into two groups, *viz.*, the perennial rivers of the Himalayan region and the rivers of peninsular India. The great Himalayan rivers, Indus, Ganga and Brahmaputra, together with their tributaries, are perennial since they are fed by the melting of snow in summer and by rainfall runoff and subsurface flows during the monsoons and other seasons. The rivers are often uncertain and capricious in their behaviour.

The river systems in the central and southern parts of the country are only rain-fed as they originate from mountains which are devoid of snow. These rivers are most stable as they flow through geologicallly stable areas. Rivers from the central plateau flow in all directions contributing to the Ganga in the north, Narmada and Tapi in the west, Damodar and the Mahanadi in the east and the tributaries of Godavari in the south. Most of the southern rivers originate from the Western Ghats which stretch along the entire western coast from north to south. The rivers draining the west slopes carry large volumes of water due to the intensive monsoon rains. The rivers on the east coast are longer but their flows are meagre, their catchment area being in the rainshadow region. Major rivers like Godavari, Krishna, Cauvery and small rivers in the south have formed deltas which are fairy extensive in area and are fit for intensive cultivation with appropriate soil and water management practices.

Water Resources Regions: Water resources regions can be planned on the basis of river basins, which are the natural units. A river basin has a defined water shed boundary and also has relationship with ground water resources in most of the cases. The development of a balanced plan for water resources utilisation requires full knowledge of the quantity, quality and distribution of water resources and also the changing pattern of land use in the entire water shed and its influence on the river flows.

India has been divided into six river basins for the purpose of assessment of the available water resources. They are (i) Indus Basin, (ii) Ganga System (iii) Brahmaputra System (iv) East Coast, (v) West Coast and (vi) Rajputana Region. Table 7.1 presents the location, climatological factors, areal extent and annual runoff the six regions. Table 7.2 presents the statewise distribution of potential and utilization of surface water resources of India.

Table 7.1. Surface water resources of India - Annual Runoff.

R. No.	Important river basins	State in the region	Catchment area m. ha	Average annual precipitation cm.	Total precipitation m. ha.m	Mean temperature ^{0}C	Average annual runoff m.ha-m
1	2	3	4	5	6	7	8
(i)	Ravi Beas Sutlej	Jammu and Kashmir Punjab, and Haryana Himachal Pradesh	35.40	56	19.82	12.6	7.94
(ii)	Ganga Yamuna Chambal Gorga, Gandak Kosi	Uttar Pradesh Bihar Rajasthan Madhya Pradesh West Bengal	97.60	111	108.34	16.8	48.96

1	2	3	4	5	6	7	8
(iii)	Brahmaputra Subansiri Manas Teesta	Assam, Meghalaya Nagaland West Bengal	50.62	122	67.76	8.2	38.08
(iv)	Cauvery Krishna Godavari, Mahanadi Subaranrekha, Damodar	Madhya Pradesh Bihar West Bengal Orissa Andhra Pradesh Maharashtra Karnataka Tamil Nadu	121.03	109	131.92	26.1	41.19
(v)	Tapti, Narmada	Gujarat Maharashtra Karnataka Kerala	49.16	122	59.98	25.5	31.06
(vi)	Mahi, Sabarmati	Rajasthan	16.80	29	4.87	26.2	--
	Total		370.61	--	386.69	--	167.23

Table 7.2. Statewise Distribution of Potential and Utilization of Surface Water Resources of India.

S. No.	State	Ultimate potential m.ha	Utilization of potential till 1973-74 m.ha-m	Percentage utilization of potential %
1	2	3	4	5
1.	Andhra Pradesh	10.98	5.180	52.75
2.	Assam	2.190	0.091	4.15
3.	Bihar	6.800	2.044	30.06
4.	Gujarat	2.85	0.517	--
5.	Haryana	N.A	1.010	--
6.	Himachal Pradesh	--	--	--
7.	Jammu & Kashmir	0.550	0.065	11.82
8.	Karnataka	2.850	0.871	30.56
9.	Kerala	1.535	0.370	24.10

1	2	3	4	5
10.	Madhya Pradesh	7.017	1.030	14.68
11.	Maharashtra	3.399	0.712	20.95
12.	Orissa	3.947	1.673	42.39
13.	Punjab	4.934	2.575	52.19
14.	Rajasthan	3.510	1.129	32.16
15.	Tamil Nadu	2.550	1.590	62.35
16.	Uttar Pradesh	9.429	3.205	33.99
17.	West Bengal	3.840	1.216	31.66
18.	Union Territories	0.110	N.A.	—

N.A. Not Available

7.6. FLOODS AND DROUGHTS

7.6.1. Floods

A flood occurs when a lake, reservoir, or channel is unable to contain the amount of water it receives. It also occurs when an area has inadequate drainage to drain excess precipitation. The result is an inundation of what is usually a dry land. Floods are sometimes caused by the failure of hydraulic structures such as dams, levees and dykes. Natural floods are, however, more common. The problem of flooding is defined by its areal extent, duration, intensity and damage. The projects designed to mitigate flooding and flood damage may be structural (e.g., dams, levees, dykes, diversions, floodwalls, and channels), nonstructural (e.g., flood proofing, floodplain management, and relocation), or a combination of both. The hydrologic input needed to design such projects includes: (1) peak discharge and its frequency of occurrence, (2) duration and volume of flood hydrograph and their probabilities of occurrence, and (3) the arrival of the next flooding.

Floods have been damaging large irrigated areas in the Indo Gangetic Plain, particularly in north Bihar, eastern Uttar Pradesh, Assam, Punjab, Haryana, portions of Rajasthan and also the coastal areas in Orissa, Andhra Pradesh and Tamil Nadu. The damage is acute in the delta areas of Mahanadi, Godavari, Krishna and Cauvery rivers. Floods also cause damage to the areas irrigated by tanks in peninsular India, particularly where these tanks are in series and the breaching of one tank leads to the failure of tanks below.

The best way to control floods is to intercept them with storage reservoirs, so that only moderated floods are allowed to flow through the valley below. Reservoirs constructed merely to detain and moderate floods may not be economically justifiable. However, multi-purpose projects could be planned to provide for flood control also. The works carried out by the Damodar Valley Corporation in the Damodar river basin and the various benefits conferred by them, are the result of such planning where the primary aim was flood control.

7.6.2. Droughts

A drought occurs when there is a shortage of water by comparison with the demand for it. There may not be enough water in lakes, reservoirs, or streams, or precipitation may be deficient. Agricultural, hydrological, and metrological droughts are usually distinguished.

These three types are significantly interrelated, although in extreme, these may be independent of one another. Analogous to flooding, the problem of drought is defined by its areal extent, duration, severity, and the onset of the next drought. From a hydrological perspective, low discharge (defined over a period) and its frequency of occurrence, duration of this low discharge and volume of low flow, as well as their frequencies, and the probability of occurrence of the next drought are useful to design drought-mitigation projects. A similar type of information is needed for rainfall in case of meteorological drought and for soil moisture in case of agricultural drought. Construction of water impoundments, groundwater pumpage, interbasin transfer, water conservation and even augmentation of atmospheric precipitation through cloud seeding are some of the ways to mitigate droughts. However, droughts are known to occur over large areas, even as large as continents, and the effectiveness of mitigation measures is only limited.

The problems posed by drought vary from area to area, depending on the amount of rainfall and its variability, and also the extent to which irrigation has been developed. Assuming that the districts which receive less than 75 cm of rainfall per annum are liable to drought, there are 77 such districts in India, which account for about 34 per cent of the net sown area. Excluding such of these districts as have developed irrigation on the adequate scale, there still remain 50 districts, accounting for one-fourth of the cultivated area in the country, which could be considered as vulnerable to drought. There are in addition, another 22 districts in Maharashtra, Gujarat, Madhya Pradesh, Karnataka, Rajasthan and Uttar Pradesh, accounting for nine per cent of the cultivated area of the country, which get between 75 cm to 85 cm of rain. This rainfall is of doubtfully efficacy and the districts have very little irrigation. They could also, therefore, be considered vulnerable to drought. However, the areas which suffer from chronic drought are only a part of the total area affected by drought. The chronic areas are confined to west Rajasthan, particularly to the districts of Jaisalmer, Barmer, Jodhpur and Bikaner, and Kutch in Gujarat.

The problem of drought has also a socio-economic dimension. There have been glaring disparities in income and living standards between the dry and drought areas on the one hand, and the irrigated and high rainfall areas on the other. Providing irrigation to the maximum extent possible is the major step in relieving the drought affected areas from scarcity conditions. A recent example is that of the Ganga canal in Rajasthan which transformed parts of Ganganagar, one of the intensely arid districts in the State, into a prosperous agricultural tract.

Unfortunately most of the drought affected areas have only limited sources of water which could be harnessed for irrigation. In these areas, transportation of water from other basins are exploitation of ground water to the extent possible, may provide some answer to the problem of drought. The development of suitable techniques to conserve moisture would also be of great value.

Check Your Progress-3 & 4

What are the reasons for the occurence of floods.

What is the meant by drought.

Note: (a) Write the answers in the space provided below.

(b) Compare your answers with the those given at the end of this unit.

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7.7. TANKS AND LAKES

The surface water mainly consists of the water in rivers and lakes. A tank is formed on its upstream of small earthen bunds (earth dam), which is generally less than 12 m height. Tanks are very common through out the country. It provides irrigation facilities to small areas very economically as high investment is not required in the construction of tanks. The tanks also serve the drinking water needs of rural areas (More details are given in Chapter 8).

Lakes may be defined as wide places in rivers. There is a great variation in lake characteristics and geologic condition that resulted in lake formation. The earthen land areas are dotted with hundreds of thousands of lakes. This is essentially true of many small lakes impounded by the river channels. The importance of lakes lie in their ability to store water, allowing the rivers to flow during periods of low precipitation. Lakes also regulate the flow pattern of rivers. Lakes are not common in India, whereas rivers are more common. Lakes of the 3 continents - North America, Africa and Asia - amount approximately 75% of the world's fresh water supplies of lakes of other continents - Europe, South America and Australia amount for about 22.5% of the total. Thus the remaining less than 25% of the total fresh water fills the hundreds of thousands of rivers and smaller lakes found throughout the world.

Asia's largest lake is located in Russia i.e., Lake Baikal, which is supposed to be the deepest lake in the world contains about 21% of the world's fresh water. Lakes are formed in many ways, glaciers by scouring depressions and depositing debris that blocks water drainage. Thousands of lakes present in parts of Northern Asia, Europe and North America are of glacial origin. Some lakes are trapped remnants of prehistoric seas and oceans. Notable among these is the Caspian lake. Craters of extinct volcanoes occasionally are lake sites. Lakes may form in depressions caused by faulting or fracturing of earths surface.

7.8. CASE STUDY OF A TYPICAL DAM (NAGARJUNA SAGAR DAM)

The multipurpose Nagarjuna Sagar Dam is located across Krishna River, near Nandi Konda village in Nalgonda District of Andhra Pradesh. It is named after Buddhist Saint, Acharya Nagarjuna, who lived at the spot about 2000 years ago to fulfill a mission.

This dam irrigates in Guntur, Kurnool, Nalgonda, Kahmmam and Krishna Districts. Its irrigation potential is about 35 lakh acres of land, electrical potential is 1 lakh kilowatt hours of firm power (guaranteed power generation) and 4.6 lakh kilowatt hours of seasonal power.

7.8.1. Salient Features of the Dam

The river gorge is blocked by masonry dam 409' high above the deepest foundation level 4756' long. The full reservoir level is +590 ft above mean sea level (M.S.L.). The most unique feature of this dam is adoption of stone masonry for its construction, deviating from the traditional concrete, the use of stone has resulted in a large saving and had created huge

employment potential for large labour force. Hence, Nagarjuna Sagar Project ranks the first in the man power utilisation among the modern gigantic projects of its own kind in the world. It was designed and executed entirely by Indian Engineers. On the either side of the masonry dam, earth dams have been constructed for length of about 2 miles, the maximum height being 85'. The spillway crest has been installed with 26 radial gates each of size 45'x44'. Other component works of this mighty dam include 8 penstock pipes on the left side, 3 power sluices and a diversion-cum-irrigation tunnel. Two canals offtake on either side of the dam for irrigation. The expenditure on the project was of the order of Rs. 80 crores. The crest level of the dam is +605 ft and the crest level of the spilway is +546 ft. Various details of the dam are given below:

1. Location: Lat=16^0 34' North, Long. 71^0 19' East, 1 mile downstream of Nandikonda village Miryalguda Taluk, Nalgonda District, 90 miles from Hyderabad.

2. States covered: Andhra Pradesh

3. Hydrology

a. Water-shed area at dam site (Sq.miles)	83,087
b. Maximum flood discharge (observed) (cumecs)	11.71 lakhs

4. Reservoir

a. Full Reservoir level	+590'.0
b. Maximum water level (ft.)	+594'.0
c. Gross storage capacity (m.a. ft)	9.37
d. Net (live) storage capacity (m.a.ft)	5.51
e. No. of villages submerged	57
f. Population displaced (families)	4,824

5. Masonry dam

a. Total length (ft)	4756
b. Spillway length (ft)	1545
c. Non-overflow length including power dam (ft)	3211
d. Height of dam (maximum) (ft)	409
e. Base width (maximum) (ft)	320
f. Top width (ft)	28
g. Top level (ft)	+605
h. Top of crest in spillway (ft)	+546
i. Chute sluices 2 no 10'x25' provided in blocks 25 and 51 with sill level elevation (ft)	+450
j. 8 No. of 16' diameter penstocks provided one in each in blocks 16 to 23 with central line at elevation	+450'.0
k. 3 No. power sluices 15' x 38' provided (two in block 71 and one in block T) with still level at elevation	+479'.0
l. Radial Crest Gates 26 No. 45'x44', with crest elevation	+546'.0
m. Thickness of spillway piers	+15'
n. Nine No. sluices 10'x15' are provided for right canal head regulator with still at elevation	+489'.0

6. Quantities at work	
a. Excavation for foundation	+42.07 m cft
b. Volume of masonry and concrete	198 m cft
c. Quantity of cement	About 11 lakh tons
d. Quantity of steel	About 60,000 tons
7. Earth dams	
a. Length of Left Earth Dam	8,400 ft
b. Length of Right Earth Dam	2,800 ft
c. Maximum height above foundation level	85 ft
d. Top width	30 ft
e. Top level	610'
f. Excavation of foundation	9.2 m cft
g. Earthwork for embankment	88 m cft
8. Irrigation-cum-Diversion Tunnel (Horse-shoe in Section)	
a. Length	2,590 ft
b. Diameter	27 ft
9. Power Plant	
a. Left side 8 No. of penstocks 16 ft diameter to develop	3 lakh kw
b. Right side - 3 power sluices of size 15' x 38' to develop	0.6 lakh kw
10. Man-Power	50,000

7.8.2. Organisation

In the earlier years of construction, a Control Board was the overall incharge of the Nagarjuna Sagar Project including technical, financial and administrative aspects. The project was then located in the Andhra Pradesh and the Hyderabad states. After the reorganisation of states, the project came entirely in Andhra Pradesh State. The State Government assumed its full responsibility w.e.f. 1.8.1959. The Control Board becomes an advisory Body to the State Government, whose advice is accepted as a matter of convention.

The programme of construction of dam and canals was so adjusted that partial benefits started accruing even from 1967. The reservoir was able to deliver water to first crop of Krishna delta in time for raising substantial acreage in 2nd crop. Letting out waters in the two canals was inaugurated by Smt. Indira Gandhi, the then Prime Minister of India, on 4.8.1967.

7.8.3. Rehabilitation

The man-made lake of Nagarjuna Sagar fully submerged lands of 52 villages and partially submerged that of 5 villages.

About 4,900 families were displaced and rehabilitated in 24 rehabilitation centres. Good faicilities, liberal compensation and other amenities were provided to those who had to be uprooted.

7.8.4. Nagarjunakonda Excavations

As the Nagarjuna Sagar reservoir was to completely submerge the famous relics of

Nagarjuna Konda, which was the seat of Ikshwaku Kings and one of the principal centers of Mahayana System of Buddhism, the whole area was excavated by the Archaeological Department of the Government of India. The more important of the relics were located in a museum constructed for the purpose, on the top of an adjoining hill. Practically, all the relics had been unearthed and shifted to the museum. Expenditure to the extent of 12 lakh rupees was debited to the Project and the balance was met by the archaeological department.

7.9. FUTURE STRATEGIES

The water potential of India has been studied indepth, after ascertaining the amount of water present, the management of the same should be done, so as to ensure optimal utilisation of water.

The water resources projects should be undertaken as a part of regional development policy, in the context of which they have to be planned as part of it complex, large scale multi objective systems interlinked with energy as well as to meet the various demands of water not only for effective use but also in the context of optimal utility. The operating policies of the project should be decided from time to time based on the availability and the water requirements for irrigation, industrial water supply, drinking water needs, power generation and flood control. The system architecture and configuration has to be determined well in advance so that based upon the demands, after ascertaining the ground water resources, the surface and sub-surface water can be used conjunctively.

The objectives of development of the project should be clubbed with the engineering accept so that maximum benefit is derived from a unit of water. The objectives should be to increase the Duty (irrigating capacity of unit of water) and to bring large areas of barren land into irrigation. To explore the possibilities of storage of flood waters and to adopt drought mitigation measures.

A scientific approach involving systems engineering should be developed for utilising the water. The Warabandi system of distribution of water in the command area of the canals should be adopted to ensure equitable distribution of water irrespective of the reach of the farmer.

7.10. SUMMARY

All the aspects of water including its occurrence, movement and circulation has been studied through the description of the Hydrologic Cycle. The distribution of rainfall in India with reference to the occurrence and the monsoon patterns has been described in detail. A study of droughts and floods, the places of their occurrence has been dealt. A case study of typical project has been given and the strategies for optimal utilisation of water have been discussed.

7.11. CHECK YOUR PROGRESS : MODEL ANSWERS

1. The three parts of the Earths system are atmosphere, hydrosphere and lithosphere.
2. Khagra and Cherrapunji are the driest and wettest places on the Earth respectively.
3. Floods occur when the lakes, reservoirs or channels are unable to contain the amount of water they receive. They also occur when the areas are not having adequate drainage to drain excess precipitation.

4. Drought is nothing but the shortage of water when compared with its demands. During drought, there may not be enough water in lakes, reservoirs or streams and precipitation will also be less.

7.12. MODEL EXAMINATION QUESTIONS

I. Answer the following questions in about 30 lines each.

1. Write briefly about the rainfall distribution in India and the variation of the same with the monsoons.
2. Discuss the importance and availability of surface and groundwater.

II. Answer the following questions in 10 lines each.

1. Describe the water cycles.
2. Distinguish between droughts and floods
3. What strategies do you suggest to improve the utility of water?
4. Differentiate between tanks and lakes.

Prof. K. Megh Raj

UNIT-8 : IRRIGATION

Contents

8.1. OBJECTIVES

After going through this unit you will be able to:

* explain the utility of village tanks,
* description of major, medium and minor irrigation projects,
* list out the problems of water management and
* describe the economic utilisation of available water through scientific management of water resources.

8.2. INTRODUCTION

Irrigation in India has been practiced from pre-historic times. The usage of thousands of small and large tanks for irrigation throughout the country is a common practice. The development of small irrigation works were undertaken during the British rule from 1820 - 1947 and many Irrigation canals were developed including the Nizam Sagar Project in Andhra Pradesh. After independence the five year plans were drawn from 1951 (i.e., 1951-56, 1956-61, 1961-66, 1969-74 and 1974-1979) todate, a total number of 537 schemes were drawn under Major and Medium Irrigation schemes, out of which several projects have been successfully completed. Later during the Sixth Five Year Plan (1980-85) basin-wise planning and several scientific techniques of water distribution were taken up. The assessment and availability of water that is both surface and sub-surface has been discussed. The reasons for difficulty in utilising the created Irrigation potential are being given, so that the necessary scientific management techniques can be used for conservation, distribution and augmentation of water resources.

8.3. VILLAGE TANKS

There is, thus, no technical difference between a 'reservoir' and a 'tank', except that a large-sized tank will be termed as a reservoir. Moreover, a reservoir will generally be formed by dams of any material (such as masonry dam, concrete dam, or earth dam, etc); whereas a tank is generally said to be formed by earth dams only (or strictly speaking by earthen bunds). These earthen bunds, spanning across the streams, are called tank bunds or tank bands.

Most of the existing tanks of South India possess a maximum depth of 4.5 m, while a few are as deep as 7.5 to 9 m, and only a few exceptional ones exceed 11 m in depth. When the depth of the tank exceeds 12 m or so, the tank is generally referred to as a reservoir.

Like all earth dams, tank bunds are generally provided with sluices or outlets for discharging water from the tank for irrigation or other purposes. These tank sluices may be pipes or rectangular or arched openings passing near the base of the bund and through the body of the bund, and carrying the water into the downstream channel below the bund or transporting at distances where required, through pipes or canals. Sometimes, these supply sluices may not be passed through the body of the bund, and may be carried adjacent to it through some hill side at one end of the bund.

Similarly, as in case of all dam reservoir projects, tanks are provided with arrangements for spill away the excess surplus water that may enter into the tank so as to avoid over-topping of the tank bund. These surplus escape arrangements may be in the form of a surplus escape weir, provided in the body or at one end of the tank bund, or some other arrangement like a siphon spillway, may be provided as is done in case of earth dam projects. The surplus escape weir is a masonry weir (compared to an ogee spillway in an earth dam) with its top i.e., crest level at equal to Full Tank Level (F.T.L.). When tank is full upto FTL, and extra water comes in, it is discharged over the surplus escape weir. The length or capacity of this surplus escape weir will be so designed that water level in the tank does never exceed the Maximum Water Level (M.W.L.). The top of the tank bund will be kept at a level, so as to provide a suitable free-board above this M.W.L. Since the surplus escape weir is a masonry weir, it will have to be properly connected to the earthen bund by suitably designed bank connections.

8.4. MAJOR, MEDIUM AND MINOR PROJECTS

Irrigation projects are classified into three categories for administrative convenience, *viz.*,

i. Major projects,

ii. Medium projects, and

iii. Minor projects.

Schemes estimated to cost above Rs. 5 crores are classified as major, those costing above Rs. 25 lakhs (Rs. 30 lakhs in hilly areas) and upto Rs. 5 crores as medium and those costing below Rs. 25 lakhs (Rs. 30 lakhs in hilly areas) as minor.

According to the revised classification in vogue since 1978, projects having a C.C.A. (Cultivable Commanded Area) of more than 10,000 hectares each are classified as major projects, those having C.C.A. between 2,000 hectares and 10,000 as medium schemes and the schemes having C.C.A. of less than 2000 ha each are categorised as minor irrigation schemes.

8.4.1. Major Irrigation Projects

A total of about 80 major irrigation projects have been taken up in India during the planned development programmes i.e., from the year 1951 onwards. Some of the major river valley schemes in India are described in the following paragraphs.

Bhakra-Nangal Project (Punjab): The Bhakra-Nangal project is the biggest multi-purpose river valley scheme and is estimated to have cost Rs. 175.14 crores. It consists of the 226m high dam across the river Sutlej at Bhakra; the 29 m high Nangal Dam; the 64 km long Nangal Hydel Dams; two power houses on the left and right hands of the Bhakra Dam; two power houses on the hydel channel at Ganguwal and Kotla. Besides, these there are about 1,104 km of canals and over 3,360 km of distributors. The project, which has been completed, serves Punjab, Haryana and Rajasthan.

Beas Project: This project, a joint venture of Punjab, Haryana and Rajasthan, consists of two units viz., (i) the Beas-Sutlej Link. and (ii) the Beas Dam at Pong. The former provides for a diversion dam at Pandoh, a combination of tunnels and an open hydel channel, and a power plant with an installed capacity of 660 mw with provision of 330 mw of additional power. It provide irrigation to Punjab and Haryana.

Rajasthan Canal Project: The Rajasthan Canal Project, it is estimated, will cost Rs. 184 crores. To begin with, the 470 km long, Rajasthan Canal will be fed with water from the Ravi and Beas rivers through the Rajasthan feeder which is 215 km long. Later, the flow supplies will be supplemented by stored water from the Beas dam at Pong. The flow supplies will provide irrigation to about 12.64 lakh hectares of parched land in Rajasthan.

Hirakud Dam Project (Orissa): The 4800 m long main Hirakud Dam on the Mahanadi river in Orissa is the world's longest dam. Flanked on both sides by 21 km of dykes, it impounds 810 crore cubic meters of water. The dam and dykes, as well as the power house at the toe of the dam, and the vast network of transmission lines have already been completed. The estimated cost of the project is Rs. 68 crores. The entire irrigation system has been completed and irrigation provided to the entire commanded area of 2.53 lakh hectares.

Damodar Valley Project: This project which benefits the states of West Bengal and Bihar comprises four storage dams completed between 1953 and 1959. They are at Tilaiya, Konar, Maithon and Panchet Hill with hydel power houses of a total capacity of 104 MW attached to all the dams except Konar and three thermal power stations with a total capacity of 957 MW. As a part of the Damodar Valley Project, a 692 m long and 11.58 m high barrage at Damodar in West Bengal was opened in 1955. It is planned to irrigate about 4 lakh hectares of land. Nearly 137 km of the main left bank canal is now navigable. The barrage at Durgapur has canals and distribution nearly 2,494 km long, some of which are navigable.

Tungabhadra Project: The project which benefits the States of Andhra Pradesh and Karnataka, comprises a 2,441 m long and 49.39 m high dam on the Tungabhadra river and a system of canals with power station on either side. The dam was completed in 1956. The reservoir has a water spread of 37,800 hectares. The total irrigation potential created so far is more than 4 lakh hectares and the total installation capacity for power generation is 99 MW.

Kosi Project (Bihar): The Kosi scheme estimated to cost Rs. 64.23 crores, will on completion irrigate 12 lakh hectares in Bihar and Nepal besides affording protection against floods. The project comprises construction of a 1,149 m long barrage with a train cum-road

bridge over the Kosi river. This was completed in 1965. A power-house with four generating units of 5 MW is under construction on the eastern Kosi Canal. Flood embankments affording protection to nearly 20,720 sq.km in Nepal and Bihar, were completed in 1959.

Chambal Project (Madhya Pradesh): The first phase of the project includes, among other works, the Gandhi Sagar Dam, which has a gross storage capacity of about 77,460 lakh cubic meters of water. The Canal System will irrigate 4.44 lakh hectares in Rajasthan and Madhya Pradesh. Besides, 115 MW of power will be generated by five generating sets at the Gandhi Sagar Power station. The dam, the Kotah barrage and the power station have already been commissioned.

Work is nearing completion on the second stage of the project which envisages the construction of the Rana Pratap Sagar Dam and the power house below it. It will provide irrigation facilities to 1.21 lakh hectares of land and generate 90 MWof power.

Work has been undertaken on the third stage of the project which comprises the construction of the Kotah Dam and Power station at its toe. The power house will generate 33 MW of power.

Nagarjuna Sagar Project (Andhra Pradesh): The Nagarjuna Project envisages the construction of a dam on the Krishna River and two canals, on each side. The canals will irrigate 8.3 lakh hectares. The reservoir will have a storage capacity of 808 crore cubic meters and its water spread will be 22,387 hectares. The estimated cost of the project is Rs. 164.9 crores.

Farakka Barrage Project: The principal components of the Farakka Barrage Project which is primarily intended to improve the navigability of the port of Calcutta, are a barrage at Farakka across Ganga, with a rail-cum-road bridge over it, a feeder canal and a cross-regulator across Bhagirathi. Considerable progress has been made in the construction of this difficult project.

8.4.2. Medium Irrigation Projects

More than 450 medium irrigation schemes have been launched in various states of the country during the planned development programme. Of these, about 300 projects have been completed and the remaining are in progress and it is envisaged that these will be completed by the end of the Sixth Five-Year Plan period. Some of the important medium irrigation schemes undertaken or in progress are listed below in the Table.

Sl.No.	State	Project/Scheme	Cost in Lakhs of Rs.	Irrigation Potential in thousands of hectares
1.	2	3	4	5
1.	Andhra Pradesh	i. Musi	409.00	16.92
		ii. Rajolibanda Diversion	383.00	35.61
		iii. Thandava Reservoir	370.00	45.90
2.	Assam	i. Jammun Irrigation	396.00	25.70
		ii. Sukla Irrigation	298.00	32.70

1.	2		3	4	5
3.	Bihar	i.	Kamala Irrigation	148.00	26.31
		ii.	Musakhand Dam	179.29	11.74
		iii.	Sunder Reservoir	192.06	8.50
4.	Gujarat	i.	Bhadar	433.01	17.16
		ii.	Meshwa	314.33	23.90
5.	Haryana	i.	Extension of Irrigation (lift) W.J.C. to Rewari and adjoining areas	130.00	27.82
		ii.	W.J.C. Feeder	339.05	--
		iii.	Irrigation tube wells in W.J.C. tract	104.00	10.15
6.	Jammu & Kashmir	i.	Pratap Canal Remodelling	148.05	8.09
		ii.	Kathwa Canal	75.94	9.05
		iii.	Dudhar Canal	42.50	2.83
		iv.	Kahrbathang Canal	35.13	0.81
7.	Kerala	i.	Peechi	235.00	28.08
		ii.	Pothudi	234.25	8.90
		iii.	Kanchirapuzha	392.84	19.43
		iv.	Parhashsi (Vallapatnam)	476.50	28.33
8.	Madhya Pradesh	i.	Saroda	166.73	7.35
		ii.	Remodelling of Mahanadi Canals	282.69	56.66
		iii.	Dudhwa	333.64	--
		iv.	Removing Shortage in Harsi System	452.44	23.88
		v.	Hardeo Right Bank Canal (R.B.C.)	497.21	47.46
		vi.	Bagh R.B.C.	348.40	47.46
9.	Maharashtra	i.	Gangapur - Stage I	396.00	16.79
			- Stage II	133.60	7.69
		ii.	Manar - Phase I	243.44	10.12
			- Phase II	293.00	16.59
		iii.	Bor - Phase I	358.00	13.56
		iv.	Pus - River	512.81	11.72
10.	Mysore	i.	Tunga - Anicut	302.30	8.70
		ii.	Rajolibunda Diversion	251.00	2.38
		iii.	Hagaribommana - halli	267.00	2.97
11.	Orissa	i.	Darjang	372.35	9.71
		ii.	Salia	294.00	10.83
		iii.	Godehado	197.34	6.47
		iv.	Bahda - Stage I	158.94	9.10
12.	Punjab	i.	Madhopur Beas link	338.00	--
		ii.	Raising and strengthening of banks	114.90	--
		iii.	Extension of non-perenial irrigation to area of U.B.D.C.	272.71	143.71
		iv.	Remodelling of Hairke Headworks	40.27	--

1.	2		3	4	5
13.	Rajasthan	i.	Jawai	249.00	7.69
		ii.	Parabati	135.40	12.14
		iii.	Khari Feeder	118.00	3.24
		iv.	Jakham	233.00	11.65
		v.	Meja Feeder-1	166.30	39.94
14.	Tamilnadu	i.	Amaravathy	334.14	21.65
		ii.	Vaigai Project	330.00	9.24
		iii.	New Kattali High Level Canal	224.58	8.34
		iv.	Pullambadi Canal	205.88	8.95
		v.	Modernising Vaigai Channels	394.00	44.42
15.	Uttar Pradesh	i.	Belan and Tons-Canals	279.24	41.08
		ii.	Sarda Sagar Stage I	472.56	67.75
		iii.	Meja Reservoir	354.70	21.20
		iv.	Nanak Sagar Dam	420.38	53.71
		v.	Baur Reservoir	340.00	18.90
		vi.	Musakhand Dam	315.00	22.29
		vii.	Jamni Dam	372.00	12.48
		viii.	Kosi Irrigation	288.00	19.13
		ix.	Narainpur Pumped Canal	100.00	24.30
16.	West Bengal	i.	Berai Canal	21.78	2.02
		ii.	Karatowa Tamla	46.38	8.80
		iii.	Shahrajore	55.61	4.85
		iv.	Hinglow	97.94	12.44
		v.	Bandhu	42.33	2.02

8.4.3. Minor Irrigation Projects

Minor irrigation works include the construction of wells, tube-wells, small canals and tanks. Such works have been used since time immemorial and they have always formed a substantial part of the total irrigation in the country. The ultimate irrigation potential from minor irrigation has been estimated to be 50 million hectares, out of a total of 107 million hectares i.e., 46.7 per cent. The total cropped area which benefits from minor irrigation so far is of the order of 29.5 million hectares.

Open wells have been constructed in all parts of the country for domestic water supply and for the irrigation of land from the remotest period. An assessment of the total number of open wells in the country is 5 million. About 20,000 state tubewells have been installed in the various states all over India, the largest number being in Uttar Pradesh. There are also a large number of private tubewells in different parts of the country in operation. The number of these private tube-wells is increasing by day and, for the country as a whole, they might soon exceed the number of state tube-well.

Surface minor irrigation works have not yet received adequate technical support in the matter of design. Construction and maintenance. A serious effort will have to be made to correct these defects in the coming plans to make good this deficiency. Minor storage and diversion

schemes are particularly susceptible to loss of potential by siltation and hence suitable co-ordination between the State Soil Conservation Organisations and the authorities responsible for the construction and operation of irrigation of minor irrigation shcemes will be very necessary.

Check Your Progress 1&2

1. How do you classify irrigation projects?
2. Explain on what basis the irrigation projects are classified?

Note: (a) Write the answer in the space provided below.

(b) Compare your answers with those given at the end of this unit.

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8.5. WATER MANAGEMENT AND DISTRIBUTION

The principal ways of water management and distribution can be achieved through integrated and conjunctive use under the following aspects:

1. **State and distribution aspect:** Total amount of rainfall varies generally from place to place and distribution is highly skewed in that 75-90 per cent of total rainfall occur within 3-4 monsoon months. Surface water which is mostly available during the monsoonic months and causes floods, can be used either for recharging the ground water or for diversion to areas where there is a scarcity of water.
2. **Use aspect:** Water is manageable input in respect of time, frequency and depth. The seasonal variations in the availability of surface water can be augmented with ground water and regulated to provide assured means of irrigation. Water use, combination in different seasons should be such as to obtain maximum overall return for a given amount of water supply.
3. **Control aspect:** Integrated and conjunctive use embodies certain advantages to control some of the ill-effects of irrigation.
4. **Time aspect:** Major and medium irrigation projects have long gestation period. Ground water can be utilised in the initial stages of irrigation development before the availability of surface water from the new project. Thus time sequence of application of water for irrigation in the two sources can be adopted.

8.5.1. Objectives of Water Management and Distribution Through Integrated and Conjunctive Use

Apart from the main objective of integrated development of surface and ground water discussed above, some of its secondary objectives are:

1. Reclamation of water logged areas.

2. Control of overdraft of ground water reservoirs.

3. Control of salt water intrusion in coastal acquifers.

4. Combination of saline or brackish water with fresh water in order to dilute the former to such proportion as to bring down the salinity to the tolerable limit of crops.

5. Improvement of dependability of surface water supply, which is generally 75% for such projects. With ground water utilistaion less dependable supply of surface water can be considered through improvement brought to the overall dependability by the use of ground water.

6. Economy in the storage needs of the surface water and consequently in the height of the dam, submergence, etc., which form bulk of the project cost.

7. Flexibility of operation with the utilisation of ground water for the application of correct dosage of water at proper intervals.

8. Early accrual of benefits. Ground water development and utilisation can precede the completion of the dam.

9. Reduction in drainage requirements.

10. Firming up of hydro-power. At the end of monsoon when storage heads are highest and also releases are large for irrigation requirements, lot of secondary power is available. If the releases from the reservoirs during the period (Aug-Oct), when secondary power is available, are kept to minimum and balance irrigation requirements met from ground water through tubewells, the power development aspect during critical (Nov-April) would greatly improve. The secondary power available would be used for working these tubewells.

8.5.2. Problems of Irrigation Water Management

The total irrigation potential created from the major - medium irrigation schems has not been fully utilised. Food grains production per hectare is about 1.7 tonne/ha against average yield of 4.5 tonne/ha from irrigated areas in the countries.

The principal reasons for lag in utilisation of created irrigation potential are summarised as under:

1. Lack of or inadequate field channels: The single most important item to achieve expeditious and efficient utilisation of irrigation potential created is construction of field channels from the outlet of individual fields. While some field to field irrigation may be possible in Kharif season in the absence of field channels, these are a must for raising Rabi and summer crops. Even in Kharif season full impact of fertilizer responsive high yielding varieties cannot be achieved unless field channels are constructed and application of fertilizers and pesticides is employed.

2. Inadequate drainage facilities, seepage, impeded drainage, absence of field drainage channels and waterlogging: Provision of adequate drainage is of vital importance for realising full benefits of irrigation. It is necessary that main drains and the intermediate drains are constructed as a part of the irrigation project.

3. Inadequate preparation of land for irrigated agriculture: For drawing full impact from irrigation works, it is imperative that land shaping and levelling and bidding etc., of the fields are to be done by the cultivators.

4. Warabandi: Inadequate water suply, wasteful use of water, mal-distribution of available water and tail end difficulties for water are responsible for non-utilisation of created irrigation potential. It is therefore imperative that warabandi (turn schedule for water), according to which water is made available to each farmer in the command of an outlet for a specific period in proportion to the size of the holding and according to the turn schedule (prepared in advance) is prepared and enforced for equitable distribution and efficient utilisation of irrigation water; particularly for the farmers at the tail end of the canal. Since the quantity of water, allocated to each irrigator is thus fixed, the warabandi includes the farmer for making more efficient use of water to bring maximum area of his holding under irrigation with allocated amount of water.

5. Crop planning and scheduling of irrigation Crop: pattern and water allowance anticipated under the project are not being realised. It is imperative that full benefits from irrigation works can be derived if crop plans are prepared on a scientific basis keeping in view (i) the availability of water (ii) soil types and (iii) regional agro climatic conditions. Crop varieties which have given equivalent yields with less moisture and of short duration are preferred. Significant contribution in the form of double or multiple cropping can be achieved if the sowing of crops such as paddy, groundnut, archar etc, is advanced, if necessary, by raising the nurseries with the help of ground water.

6. Supplement irrigation: The conjunctive use of surface and ground waters is essential to increase the intensity and stability of irrigtion as also to control water-logging and salination and to reduce requirements of horizontal drainage. As such construction of private tube-wells and dug wells need to be encouraged.

7. Lack of proper coordinating agency or deficiencies in its functioning: The command area development programme is aimed as to remove or minimise the various deficiencies faced in the expeditious and efficient use of irrigation water in the command and achieve full impact of irrigation on increased agricultural production. It needs close cooperation amongst irrigation, agriculture, revenue and cooperative finance departments.

8. Lack of agricultural research, demonstration farms and education, training and extension facilities to farmers: It is desirable that agricultural and engineering universities, IIT's are fully involved in providing training in water management. Efficient agriculture extension in the command areas improving for introducing the right varieties of crops and application of matching inputs as also for popularising some water management practices.

9. Lack of adequate credit, inputs and infra-structure: Infrastructure facilities in the shape of communication systems and marketing in the command areas are essential. Network of roads for movement of agricultural inputs into the areas and surplus agricultural production from the command area to the consuming centres within and outside the command areas is essentially required. Suitable marketing facilities for the agricultural produce have to be made so that the farmers get fair price for their purpose.

10. Neglect of operation and maintenance of irrigation and drainage systems: Modernisation of the old irrigation system which is not able to meet the irrigation requirements of the cropping patterns developed due to excessive transit losses and inadequate of regulating structures is essential by lining the canals, construction of regulatory structures etc., so that the requirements of crop in the peak periods are met and productive agriculture coupled with the use of fertilizers and other inputs become possible.

8.6. SCIENTIFIC MANAGEMENT OF WATER RESOURCES

The considerations for developing water resources in a scientific way (so that economic utilisation of available water and augmentation of supply of water) can be done by tapping new sources of irrigation as mentioned below:

1. **Conservative Water Use:** Water is the most essential and expensive input for irrigation. Water like food has often a cost production but due to lack of cost consciousness, water is often wasted and not properly used. This underlines the necessity for its most economic utilisation through conservation of water use. Since irrigation is the principal water consumer evidently greatest scope for economy in water use is possible in this field. Comparatively new and unconventional method like sprinkler and drip systems of irrigation avoid waste of water through percolation and evaporation and hold great promise of saving water to the extent of 50% compared to surface irrigation methods. Additionally, drip irrigation is more suitable for using poor quality water in sandy loam alluvial soil. In pervious areas where water is in short supply, the use of sprinklers is more advantageous. Conveyance losses in canal system can be reduced by lining the canals. The water thus saved can be used for extension of irrigation facilities to new areas.

2. **Artificial Recharge:** Even after impouding of water in reservoirs with construction of dams, part of flows in wet years, in excess of live storage capacities of reservoirs, spill below the dams. This flow being erratic can only be used by conserving it in ground water reservoirs by artificial recharge for use in dry years. Artificial recharge is an important means of augmenting total yield and tool for management of water supply system. In large irrigated areas there are possibilities of providing underground storage through recharge provided by irrigation supplies as well as natural rainfall. These under ground reservoirs serve as a dependable source of water so as to supplement the waters available in the canals. The quantity of available room to store underground water depends on the volume of porous material between the seasonal high level of water table for a year in which storage operation is conducted and water level which develops an undue effluent seepage.

3. **Command area Development:** Command area development aims to accelerate the process of utilisation of irrigation potential already created in the shortest possible time and to improve the efficiency to serve optimum yield/unit of water, per unit of land, per unit of time. It has not so far been possible for the farmers to maximise advantage from irrigation facilities because of several factors such as non-construction of water courses and field channels, practice of field to field irrigation, non-adoption of roistering. system of irrigation, non-existence of proper drainage system and inadequate infrastructure and inputs. In order to ensure efficient utilisation of irrigation potential created in the command area projects, it is imperative that an integrated development approach is adopted in dealing with those aspects which have led to under-utilisation of irrigation potential.

   Multi-disciplinary approach in this context requires adequate land reforms, including consolidation of land holdings, land drainage, soil survey and regulation intensity and adjustment in cropping patterns depending on the capabilities of the soils worth sustained irrigation, construction of field channels, land levelling and shaping etc.

4. **Increasing Irrigation Efficiency:** Water application efficiency in irrigated areas need to be increased (rather doubled from present 20% to 40%) by land shaping, smoothering land slope and making judicious selection of plot size and slope to a

particular size of stream. With increased irrigation efficiency more area can be irrigated with the same amount of water. Land grading and smoothering the land also results in uniform moisture distribution, simultaneous maturity of crop, ease of tillage operations etc.

5. **Change in Cropping pattern:** Emphasis on high water consuming paddy and wheat need to be shifted to growing cereals requiring less water like maize etc.

6. **Equitable Water Distribution:** Equitable distribution of supplies of water particularly in large commands is of great significance. Farmers assured of equitable and adequate supplies desist from over-irrigation. Volumetric supply of water needs to be encouraged and water rates charged on volumetric basis are to be reduced.

7. **Flood Use:** Farmers generally welcome floods to certain extent as they bring with them high mineral silt. What is desired is control of floods during the early part of monsoon and early drainage of flooded area in time to sow rabi crop. Irrigation water if available during the rabi season and hot weather results in bumper crops in the flooded areas. Storage of flood water in local depressions and tanks, where feasible, for subsequent use for agriculture during the rabi season and fishery need to be encouraged.

8. **Grid of Water System:** Inter-basin transfer of water resource from areas where surplus water available to areas of scracity is one of the promising means for augmentation of water resources. It envisages total utilisation of available water by damming the rivers section by section, channels built skirting the mountains and connected with number of ponds, lakes and reservoirs to bring water to the fields. Thus all rivers, reservoirs, pools and ponds of the valley should be linked so as to form one single system. Through this system the volume of water of the rivers, reservoirs, pools, and ponds is regulated and rivers, when in floods are prevented from causing damage.

9. **Desalination:** India with long coast line of 6400 km has vital scope of devleoping desalination of the sea water for irrigation and public supply. Desalination methods can also be used for conserving brackish ground water in semi-arid and arid parts of Rajasthan, Uttar Pradesh and Gujarat. The constraints in the adoption of this method are high cost and requirement of large amount of electricity power. The advances in nuclear reactor technology have opened vistas for large scale desalination of sea water. Other cheaper methods for desalination are also under active research to bring it within the realm of economic feasibility.

10. **Weather Modification and Weather Harvesting:** Augmentation of water resources by weather modification and weather harvesting are new techniques. Out of over 3.87×10^8 mhm of atmospheric moisture moving in India, only about fraction falls as precipitation. Rain making aims at producing rain from clouds with a moisture content at an adequate level and to form new clouds by encouraging increased evaporation from sea. Nearly all scientific experiments to increase rainfall involve the seeding of clouds with particles in order to cause rian through (i) intensification of the condensation of cloud drops that subsequently collide and coalesce to form larger drops, or (ii) initiation or increase in the growth of ice precipitation particles, or (iii) change of dynamic properties of the clouds themselves. Clouds can be made colloidallly unstable by the addition of dry ice, silver iodide, common salt or other chemical agents, so that a part of the otherwise unavailable water will reach the ground as precipitation. The cloud seeding operation entails using aircraft guided by

ground radar to drop tiny particles of silver iodide in the upper over cooled layers of the clouds. One gram silver iodide make up to a billion minor crystals. Each particle condenses water vapour, like natural ice, and as it grows larger and heavier it enters the warmer layers where it melts and turns into rain. Local rain making can be effective if suitable basic weather conditions exist, the cost of obtaining water from clouds is only a small fraction of the cost of other methods for the same quality of water. Results of some rain making experiments have revealed that it is possible to increase the rain amount by 10 to 20% in situations where rain would otherwise have occured. But legal and jurisdictional problems may arise if the clouds are seeded which are destined to rain in another area.

11. **Water Harvesting:** Water harvesting offers solution to the problem of water for irrigation. Ponds and ditches harvest rain water where it falls rather than allowing it to go to rivers and then pump it back to the field.

12. **Snow Melting:** Augmentation of water resources by melting of glaciers in Himalayan region through artificial means for increasing dry weather flows in rivers in hot weather is under study in India. Induced snow melting can theoretically be accomplished by heating or by using chemicals. Use of chemicals to induce melting is based on the principle that the lowering of the vapour pressure of the solution formed by adding chemical to the snow lowers freezing point of water. The heat used for induced melting may be solar energy absorbed by a coating of materials spread over the snow. The material used for the purpose may be soot, finally powdered coal, industrial slag and finally powdered organic matter.

13. **Evaporation Reduction:** Evaporation which accounts for sizable loss of fresh water particularly in hot, arid and semi-arid regions are generally believed to be the loss on which there is no control. Seepage losses from the canal system can be reduced by lining the canals. Recently attempts are being made to reduce evaporation by controlling the rate at which water escapes from water surface of large lakes and reservoirs by covering the water surface with a thin mono-molecular film. Hexadeconal or cetyl alcohol is found to be an effective file forming agent to reduce evaporation from water surface. It is considered that normal evaporation may possibly be reduced by this method to as much as one-third by saving in actual practice may be much less. Wind velocity will have profound effect in evaporation. A reduction of wind speed by wind breaks is one of the methods used for controlling evaporation.

Limitations

1. Effective application of the methods is a big technical problem for large reservoirs.

2. Effect of the film process of manufactures such as solubility, wind action, method of application and oxidation or degradation by micro-organisms, may sweep off the film and pile it near the shore.

8.6.1. Objectives of Scientific Water Management

Importance of water management has not been given due importance along with water resources development. Water management has much wider concept rather than mere regulation of canal supplies. The principal objectives of water management are briefed as under:

1. Allocation and supply of irrigation water to the irrigators according to their entitlement at the right time for optimum yields of crops with the allocated water.
2. Equitable distribution of canal supplies to irrigators especially at the tail.
3. Achievement of optimum irrigation efficiencies commensurate with agricultural productions. Ensured increased yield for a prolonged period without loss of fertility of land with time due to soil erosion and nutrients, waterlogging, salinity and/or deterioration of soil structure.
4. Economical and efficient operation and maintenance of irrigation system.
5. Realisation of sense of justice and equity among the irrigators by proper implementation of water management rules.

8.6.2. Suggested Ways of Scientific Management

Population of the country in the year 2000 A.D. is likely to be 900 million for which the requirement of food grains will be about double the present production. Accordingly an overall inadequacy of water resources may have to be faced towards the year 2035. It is evident that water, and not land, would be limiting factor in the future economic growth of the country. It is thus imperative that:

1. Economical use of water together with conjunctive use of surface and ground water resources is made. It is estimated that 70% of the world water demand is for irrigation and every effort should be made to conserve water and optimise the irrigation output for every unit of water utilised.
2. Inter-basin transfer of water from surplus river systems to drought prone, semiarid and arid areas to provide life-saving irrigation to about 30 million hectares.
3. Harvesting of rain water through a grid of farm ponds and reservoirs in areas where irrigation facilities do not exist and rainfall is highly irregular in its distribution.
4. Solar desalination of sea water provide drinking water as well as water for irrigation in the rain-shadow regions all along the east and west coasts.
5. Artificial rain making and weather modifications: In India attempts have been made for controlling evaporation and for increasing rainfall artificially. Modification of weather has not yet been attempted but widely possible particularly in the Khasi-Jaynthi hills in Assam.

8.7. WATER BUDGETING

The estimated quantity of water, which remained constant over the period of time is about 1358.72 million cubic kilometers or $1358.72 \times 10^{15} m^3$. This water is not distributed evenly, about 97% ($1,321.26 \times 10^{15}$ cubic meters) is present in the oceans. This saline water spreads over about 361.3×10^6 Sq.km. of the ocean basin areas, with an average depth of about 3.66 km. About 4.17×10^{15} cubic meters of saline (salt) water is buried underground. The total fresh water supply is estimated to be about 33.97×10^{15} cubic meters amounting to about 2.5% which constitutes the total supply of fresh water in the world.

The basic source of water is precipitation in the form of rainfall or snowfall. Runoff from precipitation drains through streams and rivers or collects in the surface depressions forming tanks or ponds.

Water from streams and rivers is stored in reservoirs or is diverted directly through canal

systems for irrigation. Runoff water stored in tanks or ponds is also regulated for irrigation through suitable conveyance systems.

Rainfall in India varies from place to place and from year to year. The Indian Meteorological department has devised a network of rain gauges for measuring the depth of precipitation over the areas. The country's average annual rainfall is about 114cm, which when considered over its geographical area is about 3.92×10^{11} cubic meters, when the snow fall is also considered it may be taken as 4×10^{12} cubic meters. About 7×10^{11} cubic meters is lost into atmosphere. About 1.15×10^{12} cubic meters flow as surface runoff and remaining 2.15×10^{12} cubic meters infiltrates into underground.

8.8. SUMMARY

A tank is analogous to a reservoir but very small in size. The height of the earthen bund rarely exceeds about 12 mts for the formation of a tank. The difference between major, medium and minor irrigation projects based on area now in vogue has been discussed with some examples. The problems associated with water management have been mentioned. The objectives of scientific water management have been discussed. The techniques of water management have been reviewed. The amount of water present in the world has been discussed.

8.9. CHECK YOUR PROGRESS : MODEL ANSWERS

1. The irrigation projects for the sake of administrative convenience are classified into major, medium and minor projects.

2. The basis for the classification of irrigation projects is the cost of the project. The projects costing above 5 crores are classified as major, between 25 lakhs and 5 crores as medium and less than 25 lakhs as minor.

8.10. MODEL EXAMINATION QUESTIONS

I. Answer the following questions in about 30 lines each.

1. What are the principle reasons for lag in utilising the created irrigation potentials?
2. What are the methods of scientific water management which ensure economic utilisation and augmentation of available water?

II. Answer the following questions in about 10 lines each.

1. Describe the water budgeting?
2. Distinguish between Minor and Medium projects. Discuss briefly about them.
3. What scientific methods do you suggest to achieve the objectives of scientific water management.
4. Describe the village tanks.

Prof. K. Megh Raj

UNIT-9 : FISHERIES

Contents

9.1. OBJECTIVES

After going through this unit you will be able to:

* list out different places of occurrence of fishes,
* describe the methods of fish & prawn culture,
* distinguish and differentiate the freshwater, brackish water and marine fisheries and
* describe the advances in aquaculture technologies.

9.2. INTRODUCTION

India has a vast potential of fish and fishery resources located within 2.02 million sq.kms of exclusive economic zone (EEZ), 27,000 kms length of rivers and about 113,000 kms of canals, about 1 million ha in the form of tanks and ponds in addition to about 0.6 million ha of stagnant derelict water spread which can be utilized for capture and culture fisheries development. In addition, about 1 million ha of coastal land awaits utilization through brackishwater farming and a number of protected bays and coves, along the 7,517 km coastline for remunerative mariculture.

Presently, India contributes to about a little over 3% of the world fish catch of about 72-75 million tonnes. By 2,000 AD the world production is expected at 100 million tonnes of which it should be possible for India to contribute to the order of 5 to 6 percent. For the purpose, the target of fish production by the turn of the century is envisaged at 6 million tonnes out of which 2 million tonnes is expected from inland sector. Accordingly there can be a sizeable rise in the contribution from the fishery sector to the Indian national income at the market price from the present 2% to about 5% extending the benefits to about 12-15 lakh active fishermen in the country.

The current quality of export of the order about 93,000 MT valued at Rs. 386 crore (1986-87 rates) is largely due to the harvestable catch and is about 5% of the total marine catch. The scope of enlarging the export quantum to about 3 lakh tonnes valued at Rs. 1,000 crore by 2000 AD could be possible with the enlargement in the culture sector, particularly of shrimp production in brackish water ponds.

In marine sector, the currently harvested quantity of about 1.8 million tonnes (1986-87) of the economically harvestable fish species would be doubled by tapping the estimated resource potential of exclusive economic zone (EEZ) at 4.5 million tonnes through efforts to expand the area of operation in the EEZ and beyond, diversification of fishing activities, processing of unconventional fish and shell fish species for new products and their promotion for marketing both for export and domestic consumption.

Check Your Progress -1

What is the role of fisheries in the economy of India?

Note: (a) Write the answer in the space provided below.

(b) Compare your answer with the one given at the end of this unit.

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9.3. FISH AND FISHERIES

9.3.1. Marine Fisheries

Marine fisheries has a great role to play in increasing food production since fish in one of the sources of getting food. India has very rich fishing grounds to be exploited on commercial basis, not only for meeting its domestic needs but also for increasing the export trade. The exploitation and development of this resource has drawn the serious attention of Government of India after its independence. India can exploit its marine fishery resources up to 2.02 million sq. kms zone which include anchovies, sardines, mackerels, carangids, ribbon fishes, perches, catfishes, elasmobranchs, oceanic tunas, prawns, lobsters and cephalopods.

Marine Capture Fisheries: India declared its exclusive economic zone in the year 1977, thus placing a great responsibility on the country to utilize the zone economically. Various estimates of the potential marine resources varying from 2.3 to 4.47 million tonnes for the EEX have been given based on primary production, exploratory surveys and catch and effort data. Thus, the estimated harvestable fish potential is about three times the yield of 1.5 million tonnes (average for the years 1983-85). The large gap between the actual yield and the potential resource is a matter of great concern. In the present day situation, the exploited resources having a high unit value, require rational exploitation and judicious management. The untapped deep and oceanic resources need to be exploited at the optimum level.

Coastal Fisheries: The coastal fishery resources are exploited by country boats using a variety of gears (nets) ; small mechanised boats using trawl nets, purse seines, gill nets; and boats fitted with outboard and inboard engines both for propulsion and fishing up to a depth of about 50 m.

The major fish landings are contributed by oil sardines, penaeid prawns, Bombay ducks, sciaenids, white baits, lesser sardines, silver bellies, perches, non-penaeid prawns, elasmobranchs, catfishes, ribbon fishes, pomfrets, mackerals, seerfishes, soles, caphalopods

and tunnies in the order of their abundance. In the north-western region, Bombay ducks, penaid prawns, sciaenids and non-penaeid prawns are important. In the south western region oil sardines, white baits, mackerals and penaeid prawns are dominant. In the south eastern region, silver bellies dominate the catches followed by lesser sardines, perches, penaeid prawns and elasmobranchs. In the north eastern region sciaenids, lesser sardines, penaeid prawns, ribbon fishes, catfishes, elasmobranchs and perches contribute to the catches.

Deep Sea Fisheries: Large vessels ranging from 20 to 23 m are operated by the Government agencies and also recently by few private industries. Their contribution to total production is little over 5%. The potential fishery resources in this zone are:

(a) **Pelagic Fisheries:** The potential of the pelagic stock is estimated to be 1.85 million tonnes as against the present yield of about 0.7 million tonnes. Purse seines and midwater trawls are operated for the white baits, mackerals, sardines and tunas, in 20 to 50 m depth. Boat seines and trawl nets would be ideal gear for the capture of ribbons fishes. The carangids are caught with midwater trawls, purse seines and drift gill nets.

(b) **Bottom Fisheries:** The estimated potential of these resource is about 1.1 million tonnes as against the current yield of little over 0.34 million tonnes. Production fish grounds for catfishes have been located along the north-west, south-west and north-east coasts between 20 to 100 m depth. Bottom fish trawls and drift gill nets are used. The perch resources of north-east coast are also significant. Fish trawls, handlines and traps will help in their capture. The silver bellies, sciaenids, elasmobranchs are some of the major groups form and the bottom fishery resource.

(c) **Crustacean Resources:** The potential yield of panaeid prawns is estimated to be 180,000 tonnes against the present yield of over 123,000 tonnes. Non-period prawns are the other important resource consisting of deep water shrimp and lobsters.

(d) **Cephalopod Resources:** As compared to the present catch of 23,000 t, the potential for this resource is estimated to be 180,000 t. It is caught in 0 to 50 m depth areas.

Oceanic Fisheries: This resource has not been exploited on a commercial scale except for some exploratory studies. By far, the most important among the oceanic resources which offers the maximum potential for exploitation is constituted by the oceanic tuna such as yellowfish, skipjack, big-eye, albacore, marlins, and the oceanic sharks. Recent surveys by longline fishing of south-west coast, Andaman sea, west of Maldives and eastern Arabian sea indicated that these areas especially of the west coast of India (120 to 16^{0}N Lat., and 700 to 74^0 E Long.,) , are rich grounds for these fishes yielding catch rates as high as 8.1 to 25 nos per hook. Long lining and purse-seining are expected to yield good results.

Fairly abundant resource of the oceanic squid in the shelf edge and slope of the west coast of India at depths beyond 18 m is also abundantly indicated.

Check Your Progress - 2

Write briefly about marine fisheries.

Note: (a) Write the answer in the space provided below.

(b) Compare your answer with the one given at the end of this unit.

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Mariculture (Sea Farming): Not much information is available with regard to culture of marine organisms except for a few instances by the research organisation in India. But other countries especially in China, Thailand, Japan, Norway, Canada are culturing several varieties of fin fishes in floating net cages set up in the seas on a commercial scale.

Fish Culture: Sea farming of several species of fin fishes is becoming very popular and India is yet to make a beginning in this direction. It is possible to make use of shallow inshore waters along the mainland and sheltered bays in islands.

Crustacean Culture: The current investigations are mostly concentrated on prawns, lobsters and crabs. Prawns are traditionally cultured in the low lying areas adjoining the backwaters and in the brackishwater ponds. Lobsters are cultured in the pen enclosures erected in the inshore waters. Crabs are cultured in the baskets or specially designed cages in the inshore flowing waters. The activity is still at laboratory level and the field technology is yet to be established to exploit our coastal farming potential.

Shell fish Culture: Coastal aquaculture of mussels, oysters, clams and other commercial molluscs is well known. Efforts are made in this direction, specially for pearl oyster farming and pearl culture.

Seaweed Culture: Seaweeds are one of the commercially important marine living and renewable resources of our country. The coastal waters have immense potential for cultivation of seaweeds and seaweed industries producing agar, carrageenin and algin.

Sea Urchin and Sea Cucumber Culture: India's rich resources of sea urchins and sea cucumber are totally untapped for mariculture. They are high priced sea food products with good demand in South-East Asian countries and a source to earn good amount of foreign exchange to our country.

9.3.2. Brackishwater Fisheries

Brackishwater bodies are three types including estuaries, lagoons or lakes and backwaters with connected bays. The brackishwaters are fragile habitats intermittent between the freshwaters and seawater. The animals present in this habitat have euryhaline medium and regulate their body fluids with the changes in the environment. Most of the rivers generally join the sea and meeting place of the river and the sea is called an estuary, where the tide meets the current.

Brackishwater Capture Fishes: The coastline of India has numerous estuaries and a few brackishwater lakes, most of them are in the east coast, the estuary of Ganges is very important, followed by estuaries of Mahanadi, Godavari, Krishna and Cauvery, and the brackishwater lakes like Chilka and Pullicat, whereas on the west coast the estuaries are

limited to Narmada and Tapti and vembanad backwaters. The estuarine species is divided into two types, (i) open estuaries - containing estuaries of rivers and Chilka and Pullicat lakes, and (ii) embanked backishwater one as containing bherries of west Bengal and backwaters of Cochin. Estuarine waters are composed of both freshwater and marine fisheries and some animals like Hilsa, eels and prawns have migrating habits. The general composition of estuarine catches are Hilsa, mullets, Chanos, sciaenids, clupeids, Bombay duck and both penaeid and non penaeid prawns.

Brackishwater Aquaculture: In India we have almost 1.2 million ha of coastal area for brackishwater fish and prawn farming. Because of economic value, most of the area is converted for shrimp farming only. The practices are stated as under.

Prawn (Shrimps) Culture: Shrimp production from captive fisheries from sea has stagnated around 200,000 and further prospects of increasing shrimp production for export is envisaged mainly through shrimp farming. In India we have about 1.2 million ha of coastal area suitable for shrimp farming. Even in this, around 50,000 ha area is under traditional farming in states like Kerala, West Bengal, Karnataka and Goa, with the meagre production of less than 300 kg/ha/yr.

(a) **Traditional Prawn Farming:** In West Bengal prawn is cultivated along with paddy in the rainy season, which is called Bashabada fisheries. While in Kerala, prawn is cultivated after the paddy is harvested. There is no control over the stocking density, because it depends on natural stocking through tidal waters. The production rate in this method ranges from 300 to 500 kg/ha of which good quality prawns *(Penaeus monodon and P.indicus)* constitute only about 20%.

(b) **Extensive Prawn Farming:** This is with an improvement over the traditional system with scientific farm managerial measures. About 18,000 ha is under this system of farming and the production ranges from 500-1500 kg/ha/crop. The ponds are stocked with wild or hatchery produced seed of *P.indicus* and *P.monodon* at the rate of 20,000 to 30,000 tons per ha. Compound feeds have been tried to improve the production.

(c) **Scientific Farming (Semi-intensive/Intensive):** This method is of recent origin and has taken a new dimension with the advent of integrated shrimp farming with components such as semi-intensive shrimp farms, captive hatchery, feed mill and processing plant. This method of prawn farming is practised through selective stocking after preparation of pond by eradication of predators and fertilizer application. High quality prawns, *P.monodon* and *P.indicus,* stocked over 50,000 tons/ha and more, 2,000 kg/ha/crop is harvested (over 40 g size) by adopting feeding and water management. This method of farming is expected to revolutionise within a decade as big corporate sector has entered into the industry with more capital and imported technology including feeds.

Fish Culture: Fish culture in coastal areas is an old established practice in several countries of Asia. The fish culture farms incorporate nurseries, rearing ponds and stocking ponds. It entails selective stocking of compatible species of fish in appropriate densities and application of nursery management and rearing techniques. It involves pond fertilization and feeding so that predictable harvest can be obtained.

In India, brackishwater fish culture development has not taken place but at the same time the valuable coastal land is utilized exclusively for rearing prawns as it fetches more profit because of high export demand. The culture of fish is in the form of traditional method and the fishes along with prawns are harvested. The common fishes harvested are mugil, *Chanos chanos* etc., along with penaeid and non penaeid prawns.

Check Your Progress-3

Write briefly about coastal farming potential of our country.

Note: (a) Write the answer in the space provided below.

(b) Compare your answer with the one given at the end of this unit.

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9.3.3. Freshwater Fisheries

India has a vast potential freshwater fishery resources ranging from cold water hill stream and lake fisheries to rivers, reservoirs, tanks, ponds, swamps, bheels, derelict waters etc., and harbour a wild variety of freshwater fishes. More than 27,000 kms length of rivers, about 113,000 kms of canals, almost 1.75 million ha of identified water spread in the form of reservoirs and about 1 million ha in the form of tanks and ponds and in addition about 0.6 ha stagnant derelict water bodies are available for capture and culture fisheries development. The species structure is also varied from the temperate to tropical fish resources.

The Himalayan rivers have a rich range of fish resources including fast growing major carps, mahseer, catfishes, anadromous hilsa and shrimps, while river basins of peninsular India of a much older geological history have an equally imposing array of endemic ichthyofauna of economic importance. A few species have been introduced into India for ornamental purpose, for public health importance such as food fishes and game fishes.

Fresh Capture Fisheries: Reservoir (Lentic/Lacustrine) Fisheries: Reservoirs are artificial aquatic systems crested by dams built across the rivers. Yet the ecology of reservoirs thus formed radically differs from that of the original river both up and down streams. In general, reservoirs exhibit a high level of initial fertility owing to nutrient leaching from hitherto unflooded substrata, submerged fauna and nutrients washed from catchment areas. This soon faces denudation after reflecting a maximum productivity level and good growth of fishes. The productivity ultimately gets stabilized somewhere near half the magnitude of initial fertility phase getting adjusted to the basic productivity levels of the basin and allochthonus nutrients. The long term fishery management strategy evolved for a reservoir basically revolved around this final biological productivity level. By and large, productivity in reservoirs is influenced by climatic, edaphic, soil quality, drainage and morphometric features. A host of factors thus enable to group the Indian reservoirs broadly into low productive, medium productive and high productive systems for management needs.

The fisheries of Indian reservoirs is constituted by both indigenous and stocked fish populations. Among the former, the Gangetic major crops occupy a prominent place in

North Indian reservoirs both as naturally occurring and stocked species. In addition to these, they also harbour other *Labeo* spp., *Puntius* spp., *Cirrhinus* spp., and catfish species.

In Peninsular reservoirs, the indigenous fishes forming the commercial fishes are *Cirrhinus cirrhosa, C reba, Labeo kontius, L. fimbriatus, Puntius dubius, P. sarana, P. carnaticus, P. kolus, P. dobsoni, P. hexagonolepis, Tor tor, Thynnichthys sandkhol* and *Osteobrama vigorsii.* In addition, Indian major carps are also stocked. Among catfishes, the Indian reservoirs contain *Wallago attu, Aorichthys seenghala, A aor, Silonia, Silondia, Silonia childreni, Pangasius pangasius, Pseudotropius takree* and, various other *Mystus* spp., form commercial fishery.

The reservoirs also harbour a variety of trash fishes, *Ambassis, Esomus danricus, Aspidoparia morar, Amblypharyngodon mola, Puntius spp., Oxygaster bacaila, Laubuca laubuca, Barilius barila, Osteobrama cotio* and *Gudusia chapra.* Though most of these trash fishes form the food of large carnivorous fishes and they compete for the food with the Indian major carps.

Fishing gear in common use are gill nets of entangling type, the typical among them being 'Rangoon net'. Simple long lines, hand lines, traps and shore seines are other common gears. Castnets are also used in shallow areas of reservoirs.

The management policies for stabilising fish population fluctuations and increasing yield generally fall into three categories of fish population and their food supply; and (iii) regulation and control of fisheries. To achieve these objectives it is required to know the changed patterns of fish populations consequent to the formation of reservoir, fish population dynamics, abundance of fish species and their biomass, and maximum yield that the reservoir can sustain.

Stocking of reservoirs with fingerlings of economically important fast growing species to occupy all the diverse niches of the biotype is one of the necessary prerequisites in reservoir fishy management. Lack of such measures would lead to trash fishes present in the riverline icthyofauna to take advantage of the available fast food resources and become dominant. This would also provide opportunity to catfishes and other carnivorous fishes to gain dominance in the reservoir fishery, which have longer food chain.

In contrast to large reservoirs, the small irrigation reservoirs/tanks, constructed or small intermittant water courses, serve to capture the surface run-off for its abstraction during seasonal irrigation demands. Experience has revealed that these water bodies offer immense potential for fish husbandry through extensive aquaculture techniques.

Riverline (Lotic) Fisheries: India has got vast riverline resources falling from the hill streams to the plain Gangetic and Peninsular river systems amounting to have more than 27,000 km length. Added to this with the construction of multipurpose reservoirs an extensive net-work of irrigation canals running to a total 113,000 kms. These sources are designated as flowing water series in which the water body as a whole is continuously in a state of motion in a definite direction. They harbour a wide variety of endemic fauna consisting of coldwater fishes such as some variety of carps including Mahaseer and Gangetic Indian major carps, minor carps, catfishes, *Hilsa*, prawns etc.

Normally the rivers originate in the hills where they have the colder temperatures, and flow through the plain to the sea. Before going to the sea, they may have distributaries, forming deltas. The rivers bring dissolved sand and solid matters during the flow. The fishery of rivers will be different from river to river or vary in the same river in different zones. They

can be broadly classified as (i) Himalayan rivers (Brahmaputra system, Ganges system and Indus system) and (ii) Pennisular rivers or Rivers of Deccan (east coast rivers: Mahanadi, Godavari, Krishna, Pennar, Cauveri, Tungabhadra; west coast rivers: Narmada, Tapti, etc.).

The principal fisheries of Himalayan rivers in the plains are carps: *Labeo rohita, Cirrhinus mrigala, Catla catla, Barbus, Tor; Catfishes: Bagarius, Aorichthys seenghala, A. aor, Wallago attu, Clarias batrachus, Heteropneustes fossils; Murrels; Channa striatus, C. marulius; Clupeids; Hilsa ilisha, Setipinna phasa; Eels; Anguilla bengalensis, spiny eels; Mastacembelus armatus* are approximately in the order of abundance.

The east coast river systems offer, Indian major carps (*L.rohita, C.catla, C.mrigala*) medium carps (*Labeo calbasu; Labeo fimbriatus, Labeo gonius, Labeo bata, Labeo boggut, Labeo kontius* etc.), minor carps (*Puntius sarana, Thynnichthys sandhkhol* etc.), *Channa* sp; *Wallago attu,* major and minor catfishes, *Hilsa*, prawns etc.

The rivers of west coast have fisheries formed by *Hilsa,* carps, mahaseer, murrels, catfishes, perches, prawns etc.

Of late, because of industrialization and high growth of civilization along the banks of rivers brought in pollution and certain stretches of rivers have become uninhabitable for the aquatic life. The river fishery is undergoing many changes and needs conservation and sanctuaries for the protection of endangered species of fishes and prawns.

Cold Water Fisheries: Most of the cold water fisheries is based on exotic fishes transplanted into India during the later half of the 19th century, out of which the trout fishery is significant.

Sport Fisheries: The sport fishery is in the low profile and needs encouragement from sport fishing lovers. The mahaseer fishes are the most prominent ones used in this fishery, mostly in the Himalayan rivers.

Freshwater Aquaculture: Fish is a source of high quality protein which can be produced more cheaply than most other animal proteins for human nutrition. Capture fishery resources are being exploited more or less at maximum sustainable levels and only marginal increase in production is possible through more efficient management of this resource. It is at this juncture that aquaculture gains focus as a means of attaining quantum jump in the production of choice fish. It has tremendous potential for making more fish available, particularly in the rural areas.

Tropical Fish Culture: The carps form the majority of the cultivable fishes all over the world. They are cultured under three systems: (1) Chinese system (2) Indian system and (3) European system. The main cultivated species in India are *Catla catla* (catla), *Labeo rohita* (rohu) and *Cirrhinus mrigala* (mrigala).

Coldwater (Temperature) Fish Culture: The most important fish cultured in cold waters is the trout (*Salmo* spp.,) an exotic species. Trout culture in ponds is also becoming popular.

Freshwater Prawn Culture: Among the increasing number of aquatic animals that have been coming to the force as candidate species for aquaculture, the freshwater prawns are perhaps the most recent. The most notable among these belong to the genus *Macrobrachium, viz., Macrobrachium rosenbergii* and *Macrobrachium malcolmsonii.*

Results of culture experiments in ponds indicated specific size stocking density relationship, the size of the prawn decreasing with increased stocking density (68 g/5700 - 25 kg/ 112,000), although the overall production increased with the latter (284 kg/5700-1929 kg/

112,000) - supplementary feeding resulted in increased production (578 kg/ha) while unfed pond production was very poor (40 kg/ha) under identical conditions.

In polyculture (30,000/ha), mrigal and common carp were found to compete with prawns while the surface and column feeders (catla, roho and silver carp) were compatible (prawns 700 kg/ha). Substratum was also found to influence production. Clayey bottom or bottom infested with weeds produced 124-208 kg/ha while ponds with a silty-sandy bottom produced an excellent crop (700 kg/ha).

Sewage Fed Fish Culture: Sewage waters contribute high productivity as they contain high percentage of nutrients. The sewage fed fish culture is practised in West Bengal. A great potential lies in the utilization of sewage water fed fish culture, particularly in urban areas having great market potential.

9.3.4. Advances in Aquaculture Techniques

Aquacultural Engineering: Aquaculture engineering has to play an important and crucial role for the development of aquaculture in the country. India is having a very rich potential for aquacultural development in inland waters. About 2 million ha of estuarine and brackishwater areas remain largely unexploited. It is to be recognised that modern aquaculture is a major development in the interphase of science, engineering and social sciences particularly economics. One of the major constrains in the growth of aquaculture enterprise is the insufficient inputs of engineering sciences to make aquaculture practice commercially viable.

Pond Construction: According to the use in fish farming, the ponds may be broadly classified into three types (i) the nursery ponds (small size), (ii) rearing ponds (medium size) and (iii) the culture ponds (large size).

(a) **Fish Farm Site**: The success of fish farming depends largely on the selection of suitable site. To construct a good fish farm it is essential to have enough water of desirable quality, heavy impervious soil and suitable type and land of satisfactory topographical characteristics. To assess the site suitability, engineering surveys are required to be conducted thoroughly.

(b) **Design Criteria of Fish Farm:** To construct a fish farm the following design criteria may be considered (i) The spillway requirements: Ponds formed by putting an embankment across a water course require protection by constructing a carefully designed spillway or a combination of spillways. The spillway must pass or convey the excess water from the pond safely to a suitable inlet without overflowing the embankment and damaging the down stream slope of the embankment (ii) The dikes/embankment must be stable. The stability should be checked by drawing a hydraulic gradient/a line of saturation which must pass through the base of the dyke and there should be a clear cover of atleast 0.3 m between the line of saturation and top of the dyke. (iii) The water inlet: All ponds should be provided with a water inlet. A good water inlet should provide required and controllable water supply, and prevent entry of undesirable fish into the ponds. (iv) The pond should be provided with suitable drainage arrangement so that the same can be emptied dry at will. The drainage arrangement for a fish farm can be provided either by constructing suitable drainage channels or by laying drain pipes (v) The layout of the ponds should be prepared as per the land configuration and the contours. The deeper ponds should be positioned on the lower contours, so that lesser earthwork is involved. For economic design the earth available by excavation should as far as practicable, be equal to the earth required in filling or raising the dykes. While preparing the layout due consideration also should be given for easy water supply and drainage arrangement to the ponds.

Fish and Prawn Hatcheries: The hatchery technique depend on the species of fish/prawn to be bred or reared. Technical experts supervision is a must for hatchery design and management. Successful hatcheries are the backbone for the aqua-farming activities and they reduce the dependence on wild seed stocks thus preserving the biodiversity. Enough hatcheries are now under operation with indigenous and foreign technologies to meet the ever increasing demand of fish and prawn seed.

Aeration Systems: Aeration is a crucial process in intensive aqua culture systems to maintain the required levels of dissolved oxygen concentrations in water. Mortality of fishers occur when they are exposed to prolonged period of low dissolved oxygen (less than 3 mg/1). Aeration not only prevents mortality due to oxygen depletion but also reduces stress on the animals by circulation of combined water resulting in destratification, which in turn, helps in better growth. Therefore, in intensive aqua culture systems it is necessary to have artificial aeration or maintenance of dissolved oxygen above 4mg/1 continuously throughout the culture period. Different types of aeration devices such as gravity aerators, paddle wheels, spray type surface aerators, pumps with hydraulic structure, etc. may be used. Of all these types paddle wheel aerators for ponds and diffuser aerators for hatcheries are preferred. Pumps with simple hydraulic structures can be more effectively used under Indian conditions.

Recirculatory Systems: In areas where water is not abundant or when artificial sea water is being used or when the farmer is working with indoor facilities, the recirculatory or closed loop aqua culture systems can be used to achieve satisfactory production rates.

The basic infrastructure consists of (i) rearing/culturing tanks, (ii) adequate aeration systems, (iii) mechanical as well as bio-filtration device, (iv) water pumps, (v) closed-loop pipe line.

Through an efficient biofilter can allow repeated recycling, however about 2 to 10% of water make up would be required per day. The system can be further aerated by pond aeration technique.

Biotechnology Applications: In 1919 Kark Ereky, the Hungarian Agricultural economist coined the new word 'Bio-technology' on the lines of chemical and mechanical technologies to cover the interactions of biology with technology, connoting all productions by means of biological transformation. It also means all the lines of works by which products are produced from raw materials with the aid of living organisms. In view of its wider application, it has become a wider thought area of present day researches.

Genetic Engineering: Genetic engineering or improvement, in broadest definition, includes a wide range of activities and disciplines that are divided for convenience into the following main items.

(i) Selective breeding and genetic analysis of quantitative characters: This section deals with selective breeding carried out by aqua cultural breeders and research workers and with experiments designed to investigate the genetic control of production characters.

(ii) Estimation of genotype X environmental interactions: Better understanding of the role played by genotype X environment interaction would help the aquaculturist to exploit a wider range of environments. More specifically the breeder has to know how organisms selected in the environment would perform under the multitude of environments of commercial aqua culture (iii) Hybridization : The various types and objectives of hybridizing different genetic groups are discussed. The major topics are breeding for heterosis, introgression, establishment of gene pools, distant hybridization and specific subject of hybridization in order to produce sterile or monosex populations.

(iv) Use of genetic markers in breeding programmes and in genetic analysis: Genetic markers in breeding programmes and in supportive genetic research is strongly urged in order to minimise incorrect identification and stock contamination with regard to gynogenesis, polyploidy and mutagenesis.

Present knowledge indicates that relatively simple steps may result in large scale genetic improvement of commercial breeding stocks in aqu.. culture. Most promising of these are cross breeding to benefit from heterosis exploration and testing of new wild genetic stocks, Interspecific hybridization to produce monosex and sterile hybrids, and the properly executed and controlled programmes and selective breeding and gene manipulation through polyploidy.

Other Biotechnological Applications: Utilization of organic wastes of plant and animal origin in fish culture has been a traditional practice in the Asian countries with unintegrated farming providing for all possible channels of recycling wastes into fish production. Biotechnology assimilating the traditional practices and providing modern methods of improving productivity, promises to play a major role in aqua culture. Biological filters are widely used in intensive aqua culture systems with recirculated water, while a host of bacteria are employed in processing organic effluents to be fed into culture ponds. Selective enrichment of biotic communities is attempted in the form of additional periphytic substrates, compost manuring for cladoceran growth or a combination of compost and green manures for the development of oligochaetes.

Biological nitrogen fixation is a priority sector of biotechnology as it accounts for more than 50% of the global nitrogen input. Partial substitution of nitrogenous fertilizers inputs by symbiotic nitrogen fixers is already a common practice in agriculture. Similarly, trials at increasing the nitrogen fixation levels in ponds through biofertilization with green algae (*Anabaena* spp.), minor weeds (*Azolla* spp.) where fixation rates of upto 150 gm/N/ha/year have been recorded. Genetic manipulation of bacteria to improve their nitrogen fixing capacity is a prospective area of research. Photosynthesis improvers, growth promoters and water absorbents have been developed in the form of mixtures of organic compounds, applicable in aqua culture operations.

In recent years, a series of techniques like gynogenesis, androgenesis, sex reversal, male sterile pregnancy etc. are being employed to improve the cultivable traits of fish species. Studies are in the pipe line on micro injection of growth hormone genes into the eggs of economically important fish species. Recognizing its need and potential applications in the field of agriculture and industry, the Govt. of India has set up the National biotechnological Board in 1982 which became the department of biotechnology (DBT) in 1986. The Department formulates and coordinates research activities in biotechnology in several research institutes of the country, many programmers being relevant to aquaculture.

Seed Production Technologies: For taking up any culture operation, seed is a prerequisite and it is either obtained from nature by collection or produced artificially in controlled conditions. Fish seed production is obtained either from natural sources or from artificial reproduction methods.

(a) Natural Collections: Fish or prawn seed is mainly obtained from natural sources mainly from rivers and estuaries. Most of the fishes either breed naturally in flooding rivers during rainy season or in brackishwaters. Eventhough some of species of prawns and fishes breed in open seas, the estuaries act as best nurseries for the young larvae. Thus shrimp seed are collected extensively in mangrove areas.

While the seed of pond breeding fishes is procured easily, that of Indian major carps, which are the main cultivated fishes of the country is collected traditionally from the natural habitats, the rivers, where these fishes breed every year during monsoon. The seed is collected in the form of fertilized eggs, spawn, fry and fingerlings, by specially designed gear (shooting net). The fish seed thus collected, are transported in suitable containers either to the market for sale or to a pond for direct stocking after removal of the unwanted other variety of seed.

Since the breeding season of major Indian carps coincides with that of other fishes (predators, trash fishes) especially the minor carps, riverline spawn almost invariably consists of a mixture of economic and uneconomic species and frequently the economic species is too low to make the riverline collection profitable for fish culture. Collection of riverline spawn in India commences along with the monsoon generally in June and continued in August.

(b) **Artificial methods:** The methods of induced breeding by hypophysation has established itself as a dependable means for obtaining pure fish seed of cultivable and cultivated fishes. This method, in recent years largely supplements the production of required fish seed for stocking purposes. Since the first success in breeding Indian major carps and the Chinese carps in India by hypophysation the technique has been adopted throughout the country for augmenting the production of pure fish seed.

Though, carps attain maturity in combined water they require extraneous stimulations either by hormone injections or by creating environmental stimulation, the former is known as hypophysation and the latter is induced breeding in bundh type of tanks. In the former type, the breeder fishes are injected with pituitary glands collected from other fishes which are preserved in alcohol. The females are injected at the rate of 3 mg gland per kg of fish in first injection followed after 6 hrs by second dose of another 6 mg pituary/kg of fish. At the time of second injection to the female, the two males are given at the rate of 3 mg pituary gland/kg of fish and released both males and females together in a breeding system. The traditional breeding system was a breeding hapa. The fishes respond and the breeding takes place after about 8 hours to the second injection and the eggs are collected and hatched in hapas. This system is now being replaced by adopting Chinese hatcheries where seed is produced on a mass scale. Over the past decade attempts have been made to use in the place of pituary glands, various analogues of LH-RH and the results are encouraging.

Carp breeding in the bundhs (dry or wet) has been found to be the cheapest method with high degree of consistent success. 'Bundh breeding' technique implicates simply a regulated flow of fresh run-off rain water into the small, impoundments where the selected male and female breeders are introduced. The rain water creates stimulation in the brood fish and they start breeding in shallow marginal areas. ~Later the fertilised eggs are collected and hatched separately.

Shrimp Seed Production: Shrimp seed is produced in hatcheries along the sea coast. There are a number of hatcheries have come up for producing seed, especially for *P. monodon*. The breeds are collected from open seas and transported carefully to the hatcheries.

With regard to freshwater prawns, small scale hatcheries have come up in the coastal states of India for producing post larvae. The species is an omnivorous bottom feeder. It grows to maturity within 6 months under pond conditions, their size being around 150 mm (25 g) in females and 175 mm (35 g) in males. Depending upon temperature, the incubation period losts from 15 to 24 days. There are eleven local stages in the larval cycle of the species lasting from 22 to 35 days.

FISH CULTURE TECHNOLOGIES

Composite Fish Culture: Investigations were taken up in India from 1952 onwards to achieve the objective of attaining optimum production of fish per hectare through mixed farming which involves stocking of suitable combination of species in proper ratios, manuring the ponds with organic and inorganic fertilizers and artificial feeding of fish.

In order, to obtain high production per ha of water body, fast growing compatible species of fish of different feeding habits, or different weight classes of the same species are stocked together in the source pond so that all its ecological niches are occupied by fishes. This system of pond management is called mixed fish farming or composite fish culture or polyculture.

The experiments conducted on composite culture call under three broad combinations, (i) culture of Indian major carps alone, (ii) culture of exotic carps alone and (iii) culture of Indian and exotic carps together. A sustained yield of over 4 t/ha/yr was obtained under this system. This technology was further improved and tested under All India Coordinated Research Project at twelve centres located in various parts of the country. Very high yield rates of over 5 t/ha in 6 months, 8 t/ha in 8 months and 10 t/ha in one year were shown possible in different situations. The production levels are likely to be increased still further by judicious combination of species, adequate stocking with yearlings, population manipulations, intense feeding, timely manuring and acrating the pond to ensure high dissolved oxygen concentration.

Following the scientific management, the aqua culturists in Andhra Pradesh have achieved a constant fish production of 7500 kg/year in large ponds (>5ha in area). The highest recorded yield of Indian major carps in pond culture operations in A.P. was 14000 Kg/in 15 months with simple scientific management.

Enclosure Aquaculture: Unconventional aqua farming system in cages, pens and other enclosures installed in open seas or inland waters are amenable for hi-tech production techniques yielding many fold in comparison to conventional aqua culture. Cages are box shaped or circular structures with screens or nets in all sides, either floating, submerged or fixed. Pens, on the other hand, are enclosures, including hose barricading a portion of the water body along with soil and water interface. Among inland fishes the Indian and Chinese carps, air breathing cat fishes, snakeheads have been found to be suitable for cage or pen rearing in lentic or lotic waters. Recently freshwater prawns also have been reared in cages. Marine prawns also have been cultured both in pens and cages and it is yet to be applied on a commercial scale using large cages.

Raceway Fish Culture: The name raceway suggests a very rapid rate of flow, but there it will be defined as any system where there is a perceptible current throughout all the pools or enclosures at all times during normal operation. Though raceways are traditional in intensive trout culture, they are considered a radical departure in the production of other fishes. Culture in raceways is exclusively intensive, i.e., it requires some environmental control, the fishes are stocked in high density, and virtually all the feed is provided from an outside source. The advantages of raceways over standing water are the following.

Production per unit area is many times greater, since polluted water is constantly being replaced by clean water –oxygen depletion never arises.

The raceways may be cement tanks, sunken pools or ready made tanks. Some sort of pond can be built in most places, but a few sites have both suitable topography and an adequate

supply of water for race ways. They may be set up in parallel or in series and both methods have their own advantages and disadvantages.

Recirculatory Fish Cultural Closed Cycle System: As the availability of sufficient water of suitable quality and at the right temperature to run a through-flow system is rare, a closed cycle system need to be employed. The polluted water draining from the tanks is piped into a purification plant for treatment, and after aeration is returned to the fish tanks. A closed warm water system, suitably housed and insulated, saves energy because heat losses are drastically reduced.

Closed systems also reduce water requirements-water availability is an increasingly major limiting factor-because in such systems it is only necessary to replace water lost by evaporation, spillage and spray. Further more the system is not subject to the natural seasonal temperature fluctuations and it precludes problems arising from the progressive pollution often met in natural waters. The system can be employed for the indoor rearing of fish or prawn seed.

Check Your Progress-4

What is the name of the system that can be employed for the rearing of fish or prawn seed?

Note: (a) Write the answer in the space provided below.

(b) Compare your answer with the one given at the end of this unit.

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Integrated Aquaculture: Water is essential for all plants and animals and fish pond could thus be the hub of various farming systems leading to increased production through diversification of activities, additional income and year round occupation. The system of integration as above is met popular in China and now interest is being shown in India to integrate compatible agricultural systems. Among crops, there are pulses, oil seeds, vegetables, horticultural, green fodder, mulberry, mushroom etc can be integrated being land based. Cattle, poultry, ducks, quails, goats and sheep, rabbits and pig are well known animal which would supplement the farmers produce and increase with association with aquaculture. The culture of fish also can be composite or polyspecies culture so as to utilise the various food items available in different layers of the pond system.

Therefore integration of livestock with fish or agri-aquaculture systems provide certain economical point costs. the cattle manure is utilised as a fertiliser for fish production and the pond is a sanitary means of waste disposal of the manure. Additional benefits to integration will be achieved by incorporating irrigated gardens. In recent years fish culture (composite) was integrated with cattle (20 head/ha); with manure collected three nights per week), pigs (20-50 nos/ha), poultry (50-100 kg manure/ha) and ducks (500 ducks/ha).

Ornamental Fish Culture: Ornamental fish culture is considered to be an industry in some of the south Asian countries and it is reported to be the world's largest fishery with annual retail sales (including both ornamental fish and associated equipment) of $ 4 billion in 1971.

Ofcourse, in India it is in the initial stage of development. The interest is in both marine and freshwater side having good export potential. Most of the aquarium fish are imported into India principally from Sri lanka and Singapore.

Paddy-cum-Fish Culture: In areas where paddy fields retain water for 3 to 8 months in a year, paddy-cum-fish culture can provide an additional supply of fish crops. The culture of fish in fields which remain flooded even after the paddy is harvested, might also serve as an off-season occupation for farmers. Depending on intensity of cultural practices involved, fish culture in rice fields can be grouped as:

a) Secondary crop of fish after paddy

b) allowing with paddy during the period of cultivation and

c) a continuous fish culture, transferring the fish to specially prepared ditches or channels during the harvesting period or when fields are drained.

9.4. FISHERIES EDUCATION & RESEARCH

With the attainment of independence of the country, fisheries education, research, training, extension and awareness have received a great fillip.

(a) Education: India is one of the major fish producing nations of the world and after independence it was felt the need for establishing a regular fisheries educational system so as to create a reserve of trained personnel. Soon, the Govt. of India and the State Governments have put in considerable effort to solve the problem and a number of fisheries educational institutions have come up. Now there are many professional and trained personnel are available for holding any positions either in the Government or public sector undertaking or corporate sector.

Research: Considering the importance of fisheries research, the Government of India has started a number of research institutions, one in the fisheries education, inland capture fisheries, freshwater fish culture, cold water fisheries, fish genetics, brackishwater fish culture, marine fisheries, fishery technology, fishery operatives, fishery survey of India etc. There are a number of university departments, fisheries colleges and state departments which are doing research in fisheries for solving regional problems for application in their regions.

Aquaculture is a relatively new science which has in its early stages, been heavily oriented to biological investigations. Production practices have evolved through trial and error, and recent researches have helped in understanding the scientific basis of some of the successful practices. Expansion of aquaculture in the future is expected to be based on transfer of technology, improvement of existing practices, and the development of new technologies.

Directed research at a level appropriate for solving the problems encountered in production programmes has to be carried out to support aquaculture development. Such research has necessarily multidisciplinary and systems oriented. The facilities required for experimental and pilot scale studies make research of this nature.

(b) Training, Extension and Awareness: The training and extension is a part of the laboratory to land program carried out by central, State and university extension wings through field trained personnel. A fifth dimension has been added to the already existing system through non-governmental organisations to create awareness at micro-level, so that the results are percolated to the rural users for better production of aqua products through aquaculture techniques.

9.5. SUMMARY

Fisheries play an important role in the economy of India through supply of nutritional food, by generating employment, raising the social status of the fishermen and earning valuable foreign exchange. The Government of India through the Department of Agriculture and Cooperation is assisting the State governments through various programmes in building the infrastructure facilities for better productivity and exploitation of the fishery resources. Fish production has been increased to 43.65 (lakh tonnes) as recorded during 1992 to 1993 and projected targets for 1994-95 and 47.50 (lakh tonnes). Fish farmers development agencies (FFDA), national programme for fish seed development and a scheme for development of reservoir fisheries in cooperative sector are playing a great role in the development of inland fisheries. Similarly, the development of major and minor fishing harbours including fish landing centres with freezing and processing facilities, mechanising the traditional craft and providing various subsidies to the fishermen are going to play a major thrust in development of marine fisheries. There has been a tremendous increase in export of marine products through prawn culture and deep sea fishing. The exports have gone up from Rs. 597.85 crores during 1988-89 to Rs. 1,767 crores during 1992-93. The target figure for 1993-94 was Rs. 2105 crores. Thus, the marine products have been recognised as a major export item in our global earnings.

Many welfare programmes have been undertaken to improve the socio-economic status of our fishermen who form the backbone of Indian fisheries. The research and development activities undertaken by various fisheries institutes have made significant contribution in the development of fisheries. The overall progress in fisheries after independence is tremendous and there is a bright future in coming years for the students of fisheries.

9.6. CHECK YOUR PROGRESS : MODEL ANSWERS

1. Fisheries play an important role in the economy of India by supplying nutritional food, generating employment, raising the social status of fishermen and earning valuable foreign exchange.
2. Marine fisheries are of great importance in increasing food production, and export trade. India can exploit its marine fishery resources upto 2.02 million sq.kms. zone. It includes the species of sordines, mackerals, carangids, ribbon fishes, perches, catfishes, elasmobranchs, oceanic tunas, prawns, lobsters and cephalopods.
3. Prawns, lobsters and crabs constitute major potential sources in the coastal region. In India we have about 1.2 million ha. of coastal area suitable for shrimp culture. Prawns are traditionally cultured in the low laying areas adjoining the brackish waters and in the brackishwater ponds. Lobsters are cultured in the pen enclosures erected in the on shore waters. Crabs are cultured in the cages in the inshore flowing waters.
4. "Recirculatory fish cultural closed cycle system" can be employed for indoor rearing of fish or prawn seed.

9.7. MODEL EXAMINATION QUESTIONS

1. Answer the following questions in about 30 lines each

1. Write an essay on brackishwater aquaculture.
2. "Marine fisheries have a great role to play in increasing food production" - Discuss.

3. What is the importance of seed production technology. Describe the natural source of seed collection method?
4. Write an essay on fish and prawn hatcheries.

II. Answer the following questions in about 10 lines each.

1. Write a short note on Reverine (lotic) fisheries.
2. What is the design criteria of fish form?
3. Write briefly about Bio-technological applications in aquaculture.
4. Discuss briefly about Ornamental fish culture.
5. Describe the Integrated aquaculture methods.

Prof. Kaza V. Rama Rao

UNIT - 10 : DAMS

Contents

10.1. OBJECTIVES

After going through this unit, you will be able to:

* describe the importance of dam construction,
* list out the benefits accurred due to irrigation,
* describe the process of power generation and explain various terms associated with power generation,
* describe environmental implications due to dam construction in general,
* explain adverse effects due to dam construction and
* determine the impact assessment.

10.2. INTRODUCTION

India is a tropical country with a vast density of climate, topography and vegetation. Rainfall varies considerably in its place of occurrence, as well as in its amount. Crops cannot, therefore, be raised successfully, over the entire land, without ensuring artificial irrigation of fields. Irrigation is the artificial supply to the fields.

More than seventy percent of our population directly depends on agriculture, and the remaining depends indirectly on agriculture. Out of tropical geographical area of about 326.3 million hectares, about 160 million hectares is the cultivable area. In order to save this area from the complete wishes of nature, and to ensure full growth of crops, it is necessary that adequate artificial irrigation facilities are ensured.

Dam may be defined as an obstruction or a barrier constructed across a stream or a river, thus raising the water level on the upstream to ensure the formation of a reservoir.

10.3. IMPORTANCE OF DAMS

The construction of a dam enables the formation of a reservoir. The water available in the reservoir can be used for different purposes like water supply for domestic and industrial, irrigation for food production, flood mitigation to protect property and life, power generation resulting in pollution free source of energy for domestic comfort and industry, silt retention for ensuring improved quality of water, low cost transportation for movement of materials and recreation and beautification for the general improvement of the overall standard of living. The development of water resources, as a result of constructing a dam cannot be quantified as apart from providing the benefits mentioned above shall also provide employment to millions of people by enabling them to involve in the various developmental activities which result due to this development. The reservoirs are also recreational and tourist centres of increasing importance. Some benefits cannot be quantified and are intangible, especially the recreational benefits.

10.4. BENEFITS TO IRRIGATION

Every irrigation project is designed, keeping in view of its economics i.e., the expenditure likely to be incurred and the benefit likely to occur. There is a capital investment on the project and the future maintenance charges. The project estimate is generally sanctioned when the benefit gives at least about 6% interest on the capital outlay. Sometimes, unproductive projects are also sanctioned in view of their general public benefits.

There is hardly any point in emphasizing the importance and advantages of irrigation during the times of acute food shortages and growing population of our country.

Even then some of the advantages of constructing a dam for ensuring irrigation may be summarised as follows:

1. **Increase in Food Production:** Construction of a dam ensuring irrigation helps in increasing crop yields, and hence, to attain self-sufficiency in food.

2. **Optimum Benefits:** Optimum utilisation of water is made possible by irrigation. By optimum utilisation, we generally mean, obtaining maximum crop yield with any amount of water.

3. **Elimination of Mixed Cropping:** In the areas, where irrigation is not ensured, generally mixed cropping is adopted. By mixed cropping we mean, sowing together of two or more crops in the same field. If the weather conditions are not favourable to one of the crops, they may be better suitable for other; and thus the farmer gets atleast some yield. Mixed cropping is thus found necessary and also economical when irrigation facilities are lacking and especially during crash programmes in under developed countries. But if the irrigation is assured, mixed cropping can be eliminated or reduced. Mixed cropping is generally not acceptable because different crops require different types of field preparations and different types of watering and manuring, etc., cannot be made to suit the special needs of either. More over during the time of harvesting, the crops get inter mixed with each other, reducing the purity of each other. But when regular and permanent water supply is assured, a single crop can be sown, depending upon the conditions of the soil and the needs of the country.

4. **General Prosperity:** Revenue returns, are sometimes quite high and helps in allround development of the country and prosperity of entire nation and community.

5. **Generation of Hydro-electric Power:** Cheaper power generation can be obtained on projects, primarily designed for irrigation alone. Canal falls can be used for power generation. Ganga and Sarda Canals, constructed for power and irrigation, are now generating hydro-electric power as a side product, up to about 80,000 kilo-watts.

6. **Domestic Water Supply:** Irrigation helps in augmenting the town water supply, where water is available with a great difficulty. It also provides water for swimming, bathing, cattle drinking etc.

7. **Facilities of Communications:** Irrigation channels are generally provided with embankments and inspection roads. These inspection paths provide a good roadway to the villagers for walking, cycling or sometimes even for motoring.

8. **Inland Navigation:** Sometimes, larger irrigation canals can be used and developed for navigation purposes.

9. **Afforestation:** Trees are generally grown along the banks of channels, which increase the timber wealth of the country and also help in reducing soil erosion.

Disadvantages and Ill-effects of Irrigation

1. Irrigation may contribute in various ways to the problem of pollution. One of these is the seepage into ground water of nitrates, that has been applied to the soil as fertilizer. Sometimes, up to 50% of nitrates applied to the soil, sinks into the underground reservoir. The underground water may thus get polluted, and if consumed by people through wells etc., it is likely to cause diseases such as anaemia. It will ultimately affect the fishing, as the tides carry the polluted water out into the ocean, is still a matter of research.

2. Irrigation may result in colder and damper climate, causing outbreak of diseases like malaria.

3. Over-irrigation may lead to water-logging and may reduce crop yields.

4. Irrigation is complex and expensive in itself, sometimes cheaper water is to be provided at the cost of the government and revenue returns are low.

Check Your Progress - 1

How does irrigation contribute to the problem of pollution?

Note: (a) Write the answer in the space provided below.

(b) Compare your answer with the one given at the end of this unit.

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10.5. POWER GENERATION

The construction of dam raises the water level on the upstream side, thus creating a very high head of water, for generating high velocity flows, possessing enormous kinetic energy,

which can be used for running the turbines. The electricity generated from the energy developed due to the flowing water is called hydro-electric power. The scheme is known as hydel scheme and the power house is known as hydro electric power station. In this scheme certain quantity of water at a certain potential height is essentially made to flow through the turbines. The head causing flow, runs the turbine blades, thus producing electricity from the generator coupled to the turbine.

10.6. ADVERSE EFFECTS DUE TO DAM CONSTRUCTION

Dams are extremely useful. Anyone who lives in Punjab or at Asansol in West Bengal knows how valuable dams are. The farmers of Punjab and people getting electricity from Bhakra sing praises for it. The people of areas benefiting by various dams and other ancillary works on Damodar river are really thankful to those human beings who have miraculously harnessed the Damodar river for them. The prosperity and welfare of millions of people depend directly on these towering handsome dams with which the nation's rivers have been harnessed.

But dams can cause problems too. Dams have drawbacks and disadvantages also. Let us discuss some of the negative features of dams and let us see what can be done to overcome them. There are four major problems, in general, which are posed by such huge constructions. They are:

1. Fish Problem
2. Submergence Problem
3. Failure Problem
4. Bomb Problem

10.6.1. Fish Problem

On large rivers, in later summer season, fish move from downstream to upstream to lay their eggs. These eggs are fertilised by male fishes. The old fish may get exhausted and the new born fish again move downstream. They, after two to three years, return to their ancestral spawning place and may die after getting exhausted, while the newborns move downstream. The cycle goes on for years.

The fish which move to their ancestral spawning place (upstream) are called anadromous fish. Salmon is typical example for such a fish. These are commercially valuable fish, and important industries are dependent on them.

When a dam barrier is constructed on a river, these fish can not move upstream to lay their eggs; because it is impossible for these fish to overtop such a barrier. But surprisingly, even when they find a barrier in their path of advancement towards their ancestral spawning ground, these fish do not return to their down stream dwelling place (i.e., sea). However, they go on fighting against the barrier, trying furiously to overtop it, till they get exhausted and die down. This results in a serious large scale killing of fish, causing great damage to fish industry and economy of the nations.

In the beginning much attention was not paid to this problem; but a little later it was realised, and serious attempts were made to find out the solution to the problem. Sometimes fish were trapped on one side of the dam and passed on to other side by giant steel and plastic nets as external arrangements called Fish Ladder was also devised.

Fish Ladder: Just as river-going vessels can bypass a dam by using a navigation lock, do a series of 'locks' enable the fish to get over the dam. A separate channel is created, consisting of a series of little dams that form a row of pools, rising up over the big dam to reservoir level. The salmon, entering the lowest rung of the ladder at the base of the dam, could leap from pool to pool until they had crested the dam. Then they could continue through the reservoir to the spawning grounds. The new born fish called finger lings could later return to the sea (downstream) in the same fashion via the ladder.

In the beginning the fish ladders worked better in theory than in practice. The fish seemed to prefer to mill ground in splashing water under the spillway, instead of entering the ladder. This difficulty was overcome by careful design that put the fish ladder in the place where it was most likely to attract the fish. Another problem was the slow moving water was stranger to fish and they tended to collect in the lower pools without growing onwards.

Millions were spent in fish-ladder research. Improvement in design made the fish ladder more attractive to the fish, more like the rapids they were accustommed to.

Fish ladders are not always practicable from engineering stand point. In such cases, other steps have to be taken to protect the fish.

Meanwhile, other experiments were going forward to see if fish can successfully induced to spawn in waters other than their own ancestral spawning grounds. In the long run, it may save millions of currency to construct fish hatcheries instead of fish ladders. There are many possible solutions to the problem of anadromous fish, and research is being undertaken in different regions of the world to find out better solution to the problem.

10.6.2. Submergence Problem

Whenever a dam is constructed across a river to store water on the upstream side, a large area gets submerged due to the rise of water levels. The entire area which gets submerged, forming a reservoir, has to be calculated and acquired before the dam is constructed. The owners of the land have to be persuaded, adequately compensated, and well settled somewhere else, before the work can be taken up in hand. Hence it is necessary to investigate the probable damage caused by this submergence.

10.6.3. Failure Problem

We try our best to built dams to last as long as possible. Every person whosoever has worked on a dam hopes that the dam will live as long as the pyramids of Egypt. But many a times, the dams give way under the continued insistent pressure of the water penned up behind them. This failure of the dam may be caused due to bad workmanship or due to faulty design or due to occurrence of unanticipated floods.

Luckily these disasters have been comparatively rare in this country. Dam used to give way easily in olden times. But due to engineering advancement in modern times, their failure has been considerably reduced.

These huge structures are now properly designed keeping in view the various forces which are going to face. Proper and rational design, good supervision and constant vigil and watch during the maintenance period ensures their safety and makes us fairly confident of it. Bhakra Dam on Satlej River in India and Boulder Dam in Colorado River in USA cannot fail in one attempt how furiously these rivers may try to move their foundations. We are fairly confident of this, but sometimes the confidence is rudely and cruelly repaid with tragedies.

Dams may sometimes fail due to excess and unanticipated earthquakes. The Koyna Dam in India was on the verge of failure in 1968 earthquake, thanks to the efforts of the Indian engineers who saved the dam by toiling hard day and night. A very confident dam called Vega de Tera Dam in Spain failed in January 1959. The people were tucked in the town of Rivaldelago. The disaster caused was tremendous. Rivaldeago was flattened. Telephone poles were snapped like matchsticks. Within moments, 123 villages were drowned. Several hundred luckier ones were saved, but were rendered homeless. This was a case where a dam had simply not been built strong enough to bear the full weight of its intended reservoir. Heavy rains wrecked it. Faulty design and bad engineering must be blamed.

Another important dam called the Malpasset Dam, a 200 feet high arch dam on the Reyran River, was completed in 1954. This dam gave way in December 1956, causing 421 persons to die in floods. Investigation revealed that the dam had failed because the foundation rock had shifted along a thin clay seam in the left abutment, making the dam unstable and vulnerable to any serious stress.

We learnt from our mistakes; and several dams of the same type, then under construction in Europe, were resurveyed to find the possibility of such a geological formations. This was very small comfort to the relatives of those who died when Malpasset failed; but atleast, we should learn from our mistakes and there should be no such repetitions.

10.6.4. Bomb Problem

The dams create dangers in wars, especially in modern atomic age. One single atom bomb will cause the failure of Hooever Dam (Boulder Dam) or Bhakra Dam. The resultant failure of such a dam will create havoc and disasters. Not only the flooding waters will cause catastrophes but also it will get contaminated by radioactivity from which there could be no escape.

This is an important point generally stressed by opponents of big dams. But the only answer to this argument is that it would not be advisable to deprive ourselves of the benefits of big dams simply because they are hazards in war time. After all, an atom bomb dropped in Calcutta, Delhi or New York would also cause tremendous damage and catastrophe, but this does not mean that we should not develop big cities.

Atomic war is dangerous to every aspect of living and not only to the construction of dams. We do not refuse riding in automobiles or aeroplanes because of the fear of accidents.

Certain risk has to be accepted if there is to be progress.

So, without denying the very danger that could be caused by Atomic explosions at dams, we must go on building dams. We need them and we devote our energies to the cause of continued peace, so that bombs will never be able to fall. We may also take more precautions and anticraft guns and radars can be established at and in the vicinity of such important works. The use of atomic energy for peaceful purpose and a general feeling of brotherhood is the only possible way to reduce threats.

Check Your Progress-2

What are the four major problems caused due to dams?

Note: (a) Write the answer in the space provided below.

(b) Compare your answer with the one given at the end of this unit.

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10.7. ENVIRONMENT IMPLICATIONS

Engineers in all ages have endeavoured to build dams of aesthetic as well as utilitarian value. Arising no doubt from pride in his structure the engineer has spent money on its architectural treatment and in most instances in re-establishment of the area after construction. In general, dams are not in aesthetic conflict with their surroundings - concrete structures harmonize with rocky mountain gorges earthfill dams with wide valleys of the plains.

What is happening today is not simply the injection of a new factor, the environment, into planning. It is not even the emergence of new sources of opposition to or of new criteria for evaluating development project proposals. It is rather the evolution of a new way of looking at resources and their management, new concepts of planning. Nobody, not even those most energetic in bringing it about, can define this new concept with any precision. It is something we must all work out together.

The engineers should be introduced to at least some of the matters that warrant attention if his dam is to be acceptable to the public.

Effects of Reservoir

Land: Creation of the reservoir will inundate land-frequently good land - and it may cause people to be displaced. Both these factors lead to loss of productivity and personal hardship. Land adjoining the lake may be affected by the permanent raising of the water table; whilst marginal land may also be affected during and following floods; if inadequately drained, such land can quickly become sour and infertile.

When relatively flat areas are inundated, the operation of the reservoir will often expose unsightly mudflats.

Dislodgement of People: In Eastern Anatolia, the Keban dam on the Euphrates entailed the dislodgements of 30,000 people as well as relocation of 300 km of roads and 48 km of railway. Appropriation in this case cost more than the dam and power station but it understood that the whole process acted as a stimulant to the economy of the region. On the other hand, in Ghana the Volta River Project had been developed primarily for electrical energy; it involved the reloading of 80,000 people and although the first filling of the reservoir, it was not solved satisfactorily in the short term. This was evident from the fact that 40 per cent of the farmers abandoned the new land allocated to them by the Government.

Wildlife: The filling of a reservoir may drown many animals as they become standard on temporary islands; on the other hand it may become a sanctuary for water birds. It is a healthy sign, however, that people throughout the world were sufficiently interested to finance the massive 'Operation Noah', a gigantic effort that rescued wildlife as the water rose to inundate 4400 km^2 of land above Kariba Dam, Rhodesia.

That some species of life will be destroyed is almost inevitable but prior studies should resolve whether such species are unique to the reservoir area; only in rare cases would this be so.

Archaeology: An obvious effect of a new reservoir would be the inundation of items of archaeological value. World-wide reaction to such losses emerged prior to the filling of Lake Nasser (High Aswan Dam); an international fund made possible the $50 million removal to higher ground of the temple of Abu Simbel.

Anthropology: In many countries there is also active opposition to the destruction of items of anthropological interest, especially evidence of past cultures, such as the rock paintings and artifacts of the Australian aboriginal.

Beauty: Beauty is of course in the eye of the beholder, and rarely will two people agree on its assessment. Lake Pedder, Tasmania, was a shallow morainlal lake surrounded by barren moorland and mountains, accessible only to hardy bushwalkers or light aircraft but famous for its summer beach. It's inundation into a much larger lake, raised sharp protests. The new lake has covered the bleak moorland country but the beach has been lost. Operation of the new lake is restricted within a range of 1.5 m; it is accessible by a good highway and is rapidly developing as a tourist area.

Silt: It is, however, necessary to consider the effects in the valley below the dam of detention of silt in the reservoir. Normally the silt would enrich the lowlands in times of flood. The complexity of this problem illustrated by reports on the effects of the High Aswan Dam. These have revealed that silt-laden waterflows only during the flood season and more than 88 per cent of the silt is carried into the sea. Thus storage in the reservoir would never deprive land owners of more than 12 per cent -especially as fine suspended matter could still be carried over the spillway. It is estimated that loss to the farmers could be made good with 13,000 tonnes of calcium nitrate fertilizer each year. This can be manufactured with power generated at the dam for Rs. 18,000,000 to 24,000,000 per year which is only one-third of the former costs of dredging and removing silt from canals. There is also concern regarding possible degradation of the river bed downstream from the Aswam dam effects of the Nile delta and the coastline and on the sardine industry by decrease in nutrients.

River Regime: When a river is dammed and the water is diverted to a power station or another valley, there will result a length of dry river bed below the dam. This is aesthetically displeasing. At the same time a river may constitute a national frontier or a property boundary. It has been relied upon as a barrier for animals. In some locations it is convenient to build quite small weirs in the river. A small release from the dam will keep the stream clean, improve the appearance of the river and retain the stock barrier.

Flood Warnings: Alteration of the natural flow in the river can be serious to inhabitants as well as to animals and fishlife. Irregular discharges from a power station can introduce a hazard to life and it is not unusual for a limit to be placed upon the rate at which the river level will be permitted to vary.

Effects of Storage on Water Quality: When a river is dammed the water can be affected in many ways. On the benefit side the reservoir will reduce turbidity, reduce hardness by assimilation of carbon dioxide and subsequent precipitation of calcium carbonate, reduce colour and B.O.D. and average out concentrations of pollutants. However, there are adverse affects such as less mixing and aeration, increase of algae problems and thermal stratification.

Eutrophication: The Organisation for Economic and Cultural Development (OECD) has defined Eutrophication as the enrichment in stagnant and partly stagnant water bodies of materials which have plant nutrient properties. The result is an excessive growth of plantic algae and rooted aquatic vegetation with consequent adverse effects on the quality of the

water. This can be a matter of considerable concern especially wastes that accelerate the process. Weed growth in reservoirs is very definite adverse ecological effect of damming.

Water-Borne Diseases: These are serious in some countries, particularly in large rivers subject to large seasonal floods. This is sufficient to disrupt the life cycle of the mosquito, the larvae are stranded, their food supply is disturbed and they are exposed to predator.

Fish: The free migration of fish in rivers may be important commerically or for sport. If provision must be made for the passage of fish upstream and downstream past the dam then some form of ladder or lift will be required. If a power station is incorporated in the dam then screens will be necessary both at the intake and the outlet from the turbine.

Climatological Change: Although not universally proven, there are claims that the creation of large reservoirs will affect the climate of the district. This could be serious in proximity to centres of population, i.e., if fogs were intensified over an airport, it is a subject for study by meteorologists and in special locations the possibility should not be overlooked.

Construction and the Environment: The whole process of building a dam must affect the environment from the first access track for investigation to the removal of the last equipment from the site. Our objective is to minimize the adverse effects by careful planning. The adverse effects are mentioned below:

1. Access roads and tracks may be extensive. If not properly located and drained they can lead to erosion and consequent turbidity in the river. The excavation of trenches, pits and adits, as well as surface sluicing, should only be carried out with proper specification for environmental protection.

2. River pollution will occur due to:
   waste water from excavations; The construction and removal of cofferdams; wash water from concrete and aggregate plants; oil leakage and waste disposal; sewage and stormwater; hot water effluents; soil erosion during reservoir clearing.

3. Erosion can be limited by prohibiting construction activities outside prescribed limits, by working along contours with proper drainage, by prohibiting heavy machinery where light machinery could do the work, by protecting and revegetating disturbed areas and slopes as soon as possible. Slopes steeper than 1 or 2 should preferably be treated by hydro-mulching, care being taken that the binder used is not toxic. That erosion is a natural phenomenon and should not be overlooked; a comparison should be made between erosion likely to result from floods during construction and that resulting from man's activities.

4. Aesthetic appearance should be preserved by a continuing programme of clean up and protection of natural features. Storage and works areas should be clearly delineated and arrangements made for removal of spilled materials.

5. Fire risks are always considerable around a construction area. Provision should therefore be made for adequate fire-fighting equipment and the training of personnel. Public relations programmes concerning the dangers of fire are essential.

6. Air pollution can be lessened by control of engine emissions and the proper storage of volatile substances. Open burning should be minimized and electric air power used where practicable.

7. Noise pollution can be both a nuisance and a health hazard. Action is necessary to decrease noise at its source, to isolate the source, to insulate and to protect the

individuals. Maximum noise exposure levels should be determined for various areas and action taken with plant manufacturers to ensure that all equipments, including construction vehicles, emits less than 88 dBA at 15 mm distance. Since the noise level of crushing and screening plants usually exceeds 100 such plant should, if possible, be located behind some natural noise screen. If near dormitory areas, where noise level should not exceed 45 dBA, the times quarry blasting should be restricted. Visitor and recreation areas should be located at least 200 m from 80 km/h roads which carry construction traffic.

It is now known that noise-damage to hearing can be cumulative in its effect; attention should therefore be paid to symptoms that may appear amongst the workforce: Abnormal behaviour; Digestive troubles; Imbalance in bodily organs; Heat imbalance; Peripheral circulation.

8. Light spillage from construction areas should be minimized by correct design and location of light sources. Care should be taken on such secondary effects as reflection from roofing, soils and water surfaces. All welding operations should be shielded.

9. Dust can be reduced by surfacing or grassing and the requirement that all bulk handling shall be by closed systems. Haul roads should be regularly cleared of debris and watered as required.

10.8. ENVIRONMENTAL IMPACT STUDIES

In many countries it has now become mandatory for such studies to be prepared before approval for a project will be given. 'To encourage production and enjoing harmony between Man and his environment; to promote efforts which will prevent or eliminate damage to the environment and the biosphere and stimulate the health and welfare of Man; and to unleash the understanding of the ecology systems and natural resources important to the Nation'.

Implementation of such policies will necessitate, a study of alternatives, both for engineering feasibility and cost as well as for impact on the environment. Undoubtedly man has awakened to the importance of his environment, but the pendulum has swung so violently that most legislation has become both confusing and unduly restrictive. An average multi-purpose project will require at least two additional years of the accumulation and assessment of environmental data - with the essential requirement that adequate funds are available sufficiency far advance of approval of the project. Whilst being sympathetic to those who wish to maintain the status quo it should not be overlooked that a changed ecosystem may be just as satisfactory to man.

10.9. PUBLIC PARTICIPATION

The purpose of fostering public participation are to: Achieve a better plan; Increase the probability of implementation; Increase the likelihood that potential beneficiaries will in fact receive the proposed benefits; Ensure that what is done is in the best interests of the community.

10.10. SUMMARY

The uneven distribution of rainfall in both space and time causes uncertainties in provision of water for agriculture. The construction of dams provides irrigation facilities for increased

food production, generation of hydroelectric power, flood control etc. The construction of a dam also causes some adverse effects like the fish problem, submergence of large areas on the down stream, displacing people and causing damage to property. Any failure of dam due to any reason may cause extensive damage. Environmentally the adverse effects caused by the construction like displacement of people, flora and fauna, water logging, erosion of forests etc., have been discussed.

10.11. CHECK YOUR PROGRESS: MODEL ANSWERS

1. The nitrate fertilisers applied to the soil seep into the ground water as nitrates due to irrigation and underground water thus gets polluted and if this water is consumed it causes anaemia.

2. The four major problems posed by the construction of dams are fish problem, submergence problem, failure problem, and bomb problem.

10.12. MODEL EXAMINATION QUESTIONS

I. Answer the following questions in about 30 lines each.

1. Discuss the benefits of irrigation.

2. Discuss the adverse effects due to dam construction.

3. Discuss briefly the environmental implications by dam construction.

II. Answer the following questions in about 10 lines each.

1. What is the importance of constructing a dam?

2. How is Hydro power generated? What are the terms associated with Hydro power? Define any three.

3. Discuss in brief the impact assessment studies.

Prof. K. Megh Raj

BLOCK - 4
AIR POLLUTION

UNIT - 11: QUALITY OF AIR WE BREATHE

Contents

11.1. OBJECTIVES

After going through this unit, you will be able to:

* explain the nature of air we breathe,
* list out the types of air pollutants,
* list out sources of air pollutants along with emissions,
* describe different aspects of Air Pollution in India,
* describe the impact of pollutants on human beings, plants and animals,
* list out measures for the control of Air Pollution.

11.2. INTRODUCTION

Air is a mixture of gases. The air we breathe constitutes Nitrogen (78%), Oxygen (21%), Carbondioxide (0.03%), Hydrogen and other gases. Oxygen is essential for all the living things such as plants, animals, human beings and aerobic microbes. Air is a mobile medium and serves the purposes of a transporting vehicle, in the dispersal of living and non-living particles from one region to the other. It is estimated that an average adult male exchanges about 15 kg of air every day.

Dry air, composition at sea level is given in Table 11.1

Table 11.1. Composition of air at sea level

Gas	Concentration in ppm
Nitrogen	780840
Oxygen	209460
Argon	9340
CO_2	315
Neon	18
Helium	5.2
Methane	1.0
Kryptan	1.1
Nitrous oxides	0.5
Hydrogen	0.5
Xenon	0.08

Air that we breathe in urban areas is highly contaminated due to non-availability of vegetation and rapid industrialization. The main causes of air pollution are combustion of natural gas, petroleum, coal and wood in industries, automobiles, air crafts, railways, thermal plants, agricultural burnings, kitchens and professions like cotton processing, flour mills, mining, welding stone and gem grinding, asbestos etc. Two natural sources of air pollution are valconoes and solar flares. Among many pollutants of air, dust and smoke constitute 10-15% of atmospheric pollution. Dust and smoke particles function as nuclei for condensation of water.

Rapid industrialization without planning, selfish motives of human beings, excessive exploitation of natural resources, destruction of forest wealth, indiscriminate use of fertilizers and pesticides, lack of insight in perspective planning for health and hygiene and many other reasons have lead to the deterioration of air quality. Thus the air we breath has become contaminated and polluted. Vegetation may die and landscape may become non-existent in the years to come. Nevertheless it is necessary to understand that pollution means instability and non-pollution means stability in an ecosystem. Prevention and Control of pollution implies to bring stability in an unstable ecosystem. There must be legislation and strict authority to implement that the industry and people follow the acts and do not cause pollution. Projects like cleaning of the Ganges has brought awareness among common people and fortunately we find a serious concern for environmental protection and control of pollution among administrators, educated youth, villagers, voluntary organizations and common people.

11.3. DEFINITION

In ancient times the people were few and their living style was simple, hence the fresh air of nature has assimilated the pollutant generated out of community needs and was harmless to all living beings and the surrounding environment.

The increased population, rapid urbanisation and industrialization after II World War have created dangerous pockets of air. Air is essential for the survival of man and other living biotic communities. Plants and animals require oxygen that is present in the air. Air is also essential for crop production, cooking food, power generation, driving cars and also in goods manufacturing processes. The used air is fully loaded with smoke, dust, oxides of sulphur, nitrogen and carbon are let out through the chimney stacks into the atmosphere.

Combustion like burning of coal, automobiles, and others need tons of air. In general there are two types of air pollution contamination of Indoor air and deals with the health of inmates of industries such as workers. The second type of air pollution deals with the contamination of outdoor air used by the community. A number of scientists defined air pollution as "the presence of outdoor atmosphere of one or more pollutants like dust in quantities of such characteristics and duration as to be injurious to plant, animal of human populations or to property of which unreasonably interfere with the comfortable enjoyment of life and property". Thus air pollution is the combined effect of solids, gases and liquids that get dispersed and diluted rapidly in the presence of favourable environmental conditions. The pollutants get concentrated in one or other localities and some emissions become concentrated or react with other contaminants and many become harmful pollutants. Air pollutants are health hazard to man. For example inhalation of carbonmonoxide, vapour of toxic metals, oxides of sulphur, nitrogen and carbon cause damage to plants, animals and human beings.

11.4. TYPES OF AIR POLLUTANTS

Air pollutants are grouped by their physical state into solid or liquid form and gaseous nature. Clean air contain minor amounts of compounds considered as pollutants. The increased concentration of carbon monoxide, oxides of sulphur and nitrogen, ozone and other gases cause pollution.

Particulate pollutants are composed of solid or liquid particles. Dust consists of solid particles formed due to mechanical disintegration of matter while smokes are dispersions of fine particles formed during combustion, chemical reaction or condensation processes. Fumes, dust, fog and smog are some of the air pollutants. Suspended particulates range from 10-60 $\mu g/m^3$ in villages, 60-200 $\mu g/m^3$ in towns and over 200 $\mu g/m^3$ in industrial belts. Antimony, arsenic, asbestos, berryllium, cadmium, lead oxides, mercury, silica and sulphuric acid are some of the hazardous materials associated with particulate matter.

Gaseous compounds have a tendency to remain suspended in the air and will not settleout easily and are classified according to physiological behaviour or chemical composition.

Sulphur Compounds: Oxides of sulphur (SO_2, SO_3 and H_2S), result from the combustion of coal and oil, industrial, transport, chemical processing etc. All fossil fuels contain sulphur. Sulphur di-oxide changes to sulphur trioxide and sulphuric acid mist under foggy situations.

Nitrogen Oxides (NO_2): Atmospheric nitrogen combines with oxygen to form nitrogen oxides during combustion at high temperature. Furnace effluent and engine exhausts also possess oxides of nitrogen. Nitric acids and nitrogen dioxides are important from air pollution standpoint. These oxides of nitrogen combine with olefinic hydrocarbons to produce peroxynitrates and ozone.

Photochemical Oxidants: These compounds are produced in urban areas due to chemical combination of reactive hydrocarbons, with nitrogen oxides in the presence of sunlight to form peroxy acetyl nitrate (PAN), aldehydes and others. Hydrocarbons mainly come from gasoline and motor vehicle exhaust, while nitrogen oxides are emitted not only from motor vehicles but also from the stationary combustion sources.

When nitrogen dioxide absorbs energy from the sun and splits into nitric oxide and atomic oxygen atom attaches itself to an oxygen molecule in the air to form ozone. Ozone formed by electrical discharges in the atmosphere does not reach pollutant level unless NO_2 reacts

initially with sun light and then with O_2 and hydrocarbons when O_2 gets stabilized as a secondary pollutant.

Carbon monoxide (CO) : Carbon monoxide, usually a product of incomeplete carbon, combustion, is a poisonous gas. Air pollution produced by motor vehicles can achieve significant proportion in the areas of heavy traffic. Incomplete oxidation during burning of fuel may also result in CO production.

H_2S: Hydrogen sulphide is a toxic and odourous gas used in a number of industrial processes viz., petroleum refining, paper and pulp manufacture and sulphur dye industry.

Chlorine: Chlor-Alkali industry is the major source of chlorine pollutant. Accidents mainly connected with the transportation of liquid chlorine results in the exposure of communities to chlorine gas.

Peroxyacetyl Nitrate(PAN): This is a photochemical or secondary pollutant. In the presence of strong sunlight and poor ventilation, series of reactions between nitrogen oxides and hydrocarbons leads to PAN formation.

Aldehydes: Aldehydes are formed due to incomplete combustion or as a result of interaction of nitrogen dioxide and hydrocarbons under the influence of sunlight. The acrolein and formaldehyde have been detected as pollutants that may be toxic.

Hydrocarbons: The aromatic napthenes, paraffins, olifines and others constitute the hydrocarbons that originate from numerous sources. The most prominent source being unburnt or partially burnt gasoline or petrol These react with other chemicals especially halogen like chlorine, bromine etc resulting in the production of noxious end products.

Inorganic Acids: The most common is sulphurous acid (H_2SO_3) which is produced by the combination of sulphurdioxide and water. It is also produced in small amounts during combustion of coal and petroleum. Oxides by combining with water form acids.

Organic Acids: These are the resultant products of incomplete combustion process. Appreciable quantities are also contributed by industries. These organic acids include acetic, fumaric and tannic acid.

Radioactive Dust and Gases: Radio active, fallout is released high into the atmosphere by nuclear explosions. Nuclear power plants release gaseous and particulate radio-active substances. Krypton, Xenon, Iodine, Cobalt, Manganese and Caesium are released in the form of particles through the chimney.

Check Your Progress -1,2&3

1. Give two examples of oxides of sulphur.
2. When is carbon monoxide produced?
3. What is PAN? When is it produced?

Note: (a) Write the answers in the space provided below.

(b) Compare your answers with those given at the end of this unit.

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11.5. SOURCES OF POLLUTION AND NATURE OF EMISSIONS

There are many varied sources of pollutants.

Combustion operations: The proper burning of fuels, release carbon-dioxide and water vapour. Due to improper combustion of fuels, pollutants like smoke, fly-ash, carbon monoxide, hydrocarbon and organic acids are produced. 80% of air pollution is the outcome of fuel burning in domestic, industrial and transportation activities.

Industrial process operations: During the transformation of different raw materials into finished goods, the specific industries release different types of pollutants. Oil refineries, fertiliser plants, steel mills, paper mills, chemical plants and smelters produce a few common pollutants like particulates, hydrocarbons and gases.

Smelting of ores is done to get metallic elements. Smoke and sulphur gases from coke ovens, dust from blast furnaces and fumes from open heart furnaces are of major importance. The fuming of metallic oxides result in the emission of smoke, dust, carbon monoxide, ash and other gases.

Thermal power plants are also known to emit large amounts of pollutants. Hydrocarbons, oxides of nitrogen, sulphur and carbon get released into atmosphere during petroleum refining. Mining operations for coal, ores etc may result in emitting dust pollutants like H_2S, mercaptans and particulates are emitted while making paper from wood, straw and other cellulosic materials in pulp and paper mills. Fabrication and machinery manufacture, chemical industries, pain manufacture, odour producing industries emit foul odours and chemicals. Table 11.2 shows air pollution sources and nature of emissions.

Principal sources of air pollution are transportation fuel combustion, processing solid waste disposal and others which release million tons of carbon monoxide, sulphur oxides, nitrogen oxides, hydrocarbons and particulates.

Table 11.2. Principal sources of air pollution (in Million Tons/year)

Source	Carbon monoxide	Sulphur oxides	Nitrogen oxides	Hydro-carbons	Particulates	Total
Transportation						
Automobiles	67.3	0.3	7.0	12.7	0.7	88.0
Others	3.9	0.1	1.0	1.1	0.5	6.6
Total	71.2	0.4	8.0	13.8	1.2	94.6
Fuel Combustion						
Power Plants	0.1	14.0	3.5	neg.	2.3	19.9
Industry	0.3	5.5	3.1	0.1	3.0	12.0
Residential	1.3	1.8	0.5	0.6	0.4	4.6
Others	0.2	0.7	0.4	neg.	0.3	1.6
Total	1.9	22.0	7.5	0.7	6.0	38.6
Processing	7.8	7.2	0.2	3.5	5.9	24.6
Solid waste disposal	4.5	0.1	0.7	1.4	1.2	7.9
Miscellaneous	1.2	30.3	16.6	23.6	14.6	172.8
Total	86.6	30.3	16.6	23.6	14.6	172.8

Source: Public Health Service United States

(Table taken from Chemical Week, June 17, 1970)

11.6. ROLE OF BIOLOGICAL COMPONENTS IN AIR POLLUTION

Air also contain minute and microscopic organisms like bacteria, viruses, fungi, protozoan cysts, pollen grains and insect parts. The abundance and increase in their load leads to health hazardous situation. Hey fever, eye irritation, sore throat, farmers lung etc., are some of the resultant products due to biological components of air pollutants. Allergy is the common disease produced by the biological components. Some of the microbes are also known to detoxify the chemicals and other pollutants also by their potent and innate capacities of degradation.

11.7. AIR POLLUTION IN INDIA

Explosion of population and increased industrialization have greater impact on air pollution. For example USA is dumping 135 million tons of pollutants per year into the air. India is letting out one fifth of that lead by using 500 million tons of fossil fuel per year. Motor vehicles in India generate 3-4 times as much pollution as they do in USA due to poor maintenance of vehicles, roads, traffic regulations and adulteration of fuels. It is assumed that by 2000 A.D. there will be 3 million automobiles, 2.5 million buses and lorries and 12 million motorcycles, scooters and auto-rickshaws that cause more dangerous situation by emitting air pollutants.

There are methodical studies on Air Pollution in India. Available data is based on population densities and it indicates that 1.5 million tons of CO_2, 2.0 million tons of SO_2 and 0.8 million tons of NO_2 are discharged annually into the atmosphere. In due course of time some more industries may add load of dangerous pollutants. For example Indian walls contain less than 1% sulphur but more than 30% ash and cause serious health hazards. The burning of cow dung, fire wood and coal cause special problems in villages leading to high incidence of eye problems, lung diseases and diseases of respiratory tract. Major cities like Calcutta, Bombay, Delhi, Kanpur, Ahmedabad, Madras and Visakhapatnam are highly polluted.

11.8. AIR POLLUTION AND HEALTH HAZARDS

11.8.1. Impact on Human Beings

Air pollution is known to aggravate and contribute to respiratory ailments like asthma, bronchitis, pulmonary edema and lung cancer. Respiratory effects are mostly due to interactions of pollutants with the tissues of lung passages, the effects being similar to those caused by exposures in industry.

Ammonia, HCl, sulphuric acid, acetic acid, SO_2, chlorine, ozone, nitrogen-di-oxide are injurious to air passages and lungs.

Chemical asphyxiants namely carbon-monoxide, cyanogen, methane, hydrogen, nitrogen oxides and others react with tissues or blood and prevent oxygen form reaching the tissues. Such chemicals produce intoxication and anaesthesia of nervous system and some gases cause organic injury. Chemicals like vapour mercury, hydrogen sulphide, tetra ethyl lead and others exert a wide variety of toxic actions after absorption in the body. Pollutants also cause injury to eyes, throat and other parts of the body. Gases and aerosols cause objectionable odours. In particular aerosols of biological origin cause higher sensitivity response like asthma, skin rashes etc.

Particulates like antimony from metals and oxides cause irreversible damage to the heart and also to the kidneys. Aresenic causes intestinal problems while asbestos cause asbestosis of the lung besides lung cancer.

Berryllium oxides dust causes berrylosis of the lungs and cancer of the lips and mouth are reported to be due to berryllium oxide contact. Cadmium causes food poisoning and lung damage resulting in breathlessness. Lead oxides are known to cause nervous disorder, burning sensation of the feet; anaemia and bleeding. Elemental mercury may also cause rash and swellings on the skin and blindness. Silicosis in the lungs is due to formation of silicic acid in the body.

Gaseous pollutants like carbon monoxide remove oxygen from blood resulting in headache, brain damage and death. Fluorides cause mottled teeth, bones and weight loss. Hydrocarbons like anthracenes produce cancers, phenols poison central nervous system and prolonged exposure to such chemicals may result in skin diseases. Protoplasmic poisoning is evident due to hydrogen cyanic acid and cyanides. Prolonged exposure to hydrogen sulphide may result in eye irritation, conjunctivitis and visual impairment. Nitrogen oxides irritate nose, eyes and lungs. Oxidant ozone bring out premature aging, increase calcification of bones, reduces body fat and affects vision. Peroxy acetyl nirates (PAN) affect eyes and respiratory system.

Sulphur dioxide causes more damage to the infants, increases heart rate and damages the central nervous system.

Radioactive substances convert water in the body to hydrogen peroxide that oxidises the cells and sometimes death. Tobacco smoke has CO, CO_2, fly ash, mineral dust, NO_2, Nicotine, formaldehyde and others. Tobacco smoke affects central nervous system, bronchitis, irritation of the lungs and cancer.

11.8.2. Effect on Plants

Air pollutants damage plants, and sensitive plants serve as indicators for the degree of the pollutions emitted from industrial sources that discharge chemicals like ozone, oxides of sulphur and nitrogen, fluorides, peroxyacetylnitrates, chlorine, ammonia, smoke, dusts from iron, copper, zinc, lead etc cause adverse effects on plant part. (Table 11.3).

Table 11.3. Effects of Pollutants on Plants.

	Gas	Effect on Plants
1.	Ozone (O_3)	Plant leaf is subject to bleaching, spotting, pigmentation, dwarfing and early abscission
2.	Peroxy acetyl nitrate (PAN)	Lower surfaces of leaves are subjected to glazing, silvering or bronzing
3.	Nitrogen-di-oxide (NO_2)	Lesions occur on intercostal tissue and at leaf margins
4.	Sulphur-di-oxide (SO_2)	Leaf is subjected to bleaching, chlorosis, dwarfing, early abscission and reduced growth
5.	Hydrogen fluoride (HF)	In addition to tip and margin burn, same effects caused as SO_2
6.	Chlorine (Cl_2)	Bleaching, tip and margin burn and leaf abscission
7.	Ethylene (CH_2)	Besides abnormalities in leaf, flowers are affected.

11.8.3. Impact on Animals

Acute injuries to animals are reported around industrial plants and mines. Some details are shown in Table 11.4. The cattle that graze over lands around smelters get poisoned along with inflammation of the respiratory and intestinal tract, kidney damage and destruction of red blood cells.

Check Your Progress - 4

What are the industrial discharges that cause adverse effects to plants?

Note: (a) Write the answer in the space provided below.

(b) Compare your answer with the one given at the end of this unit.

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Table 11.4. Effects of Pollutants on Animals

Pollutants	Sources	Effects
1. Arsenic	Smelters, Coal-burning	Cattle, horses and sheep that graze over polluted lands poisoned; inflammation of respiratory and gastro-intestinal tract, damage to kidney, red blood cells and nervous system-eventual death.
2. Cadmium	Smelters, Pesticide and fertiliser plants	Animals that graze around contaminated soils endangered - decline in milk yield.
3. Chlorine	Accidental spills, industrial uses, leaks during storage and transport	Animals are subject to hazards
4. Fluorine	Aluminium and fertilizer plants	Cattle and sheep subjected to fluorosis, lameness, muscular weakness and eventual death
5. Lead	Combustion of fuels, smelters	Cattle and other animals that graze over polluted lands get nervous with effects on kidney, liver, lungs and pancreas
6. Mercury	Mining and refining, industrial uses, pesticides	Lethal to animals as it is a protoplasmic poison. 0.3 micro-gm/m^3 is harmful-damage to brain.
7. Molybdenum	Steel and other industries	Cattle grazing over vegetation around industries are adversely affected

8.	Selenium	Combustion of fuels refinery waste gases	Animals that eat plants or foods containing selenium are affected
9.	Zinc	Smelters	Animals that breathe air contaminated by Pb, Zn get swollen limbs
10.	Radio-activity	Nuclear industries	Animals that eat plants with Sr-90, I-131 and Ce-137 concentrate them in milk and flesh. Cancer, leukemia and mutation effects.

11.9. CASE STUDIES

Progress and economic viability are essential for any nation. Development of industries is necessary for raising the living standards of people in countries like India. However the location of the industry must be balanced by ecological factors and environmental variables. Urbanisation through industrialisation must not lead to health hazards and on the other side must ensure safety, health and hygiene. Planners, administrators, scientists and industrialists have to realise this fact.

Air pollution due to smoke, dust, SO_2, particulate matter, CO_2 production due to increasing burning of fossil and other organic fuels without a corresponding increase in plant population, formation of carbon monoxide by incomplete combustion of carbon fuels, emission of gaseous fluorides, nitrogen oxides, ozone production by highly energy solar radiations, release of hydrocarbons to the atmosphere, peroxy-actyl nitrates leads to increased rates of diseases such as asthma, bronchitis, lung cancer, skin infection, health disorders, changes in skin colour and others. Such diseases are not uncommon in cities like New York, Bombay, Calcutta, Delhi and other places. There are number of episodes recorded which eventually elaborates the effects of air pollution poisonous fumes from metallurgical industries like copper, lead, zinc and arsenic were also recognized as harmful pollutants. Smoke and fog deaths were reported in 1905 and 1911 in U.K. Since 1943 Los Angeles has been facing the problem for considerable periods when the visibility is reduced by a light blue haze and many people suffered from sore throat, headache, running nose and eyes.

Belgium has experienced heavy fog in December, 1930 due to anticyclonic weather. At the same time the industries located around muse valley have emitted oxides of nitrogen and etc., people become sick with respiratory complaints and few have died and thousands became ill.

In the year 1948 anti-cyclonic weather and atmospheric inversion with no air movement enveloped the north east part of USA and Donora city had emissions from steel and zinc industrial complexes. Thus bad weather and harmful emissions result in the death of elderly people due to cardio-respiratory problems. The pollutants identified are sulphur dioxide including the oxidation products and particulates.

London has experienced air pollution in 1952 due to which 4000 deaths occurred. Smoke level rose by 5 times while SO_2 has increased six times over normal.

Shivaji Rao (1988) has reported that a specific instance that deserves better public attention is the pollution threat to the Taj Mahal. The Taj Mahal got affected heavily by the ill planned 6 million tonne oil refinery at Mathura from the corrosive air pollutants like oxides of sulphur, nitrogen, carbon, chlorides and organic acids. The impact of air pollution of Taj Mahal has been named as stone cancer.

A specific instance of one such toxic chemical industry that caused the worst air pollution disaster in the world is the pesticide plant at Bhopal in December 1984.

The factory was producing Methyl Iso-cyanate CH_3NCO (MIC), an extremely hazardous chemical that is used to manufacture SEVIN (carbaryl), a widely used pesticide. Carbon monoxide, a toxic gas is reacted with chlorine to form another poisonous gas phosgene, which in turn is made to react with methyl amine, an inorganic chemical, to produce methyl iso-cyanate, MIC. It is toxic and highly inflammable due to which many have become blind and suffered with deformities.

There are innumerable cases that have been causing alarming situation and the culprit being air pollution.

11.10. AIR QUALITY STANDARDS

The measurement of air pollutant is done at the discharge outlet point of a chimney stack of a factory. It can also be measured in the surrounding air that people inhale for their living. These measurements are essential for the establishment of "Emission Standards". Animals, human beings and plants are exposed to different concentrations of pollutants for a specified duration of time and the damaging effects are studied. Many countries have established Air quality standards to protect public health and welfare. Air quality standards are mostly based on the meteorological and geographical features. Therefore the air quality criteria are descriptive i.e., they describe the adverse effects on living beings and properties whenever the ambient concentration of pollutant exceeds a specific value for a specific period of exposure. Air quality standard also includes the prescription of pollutant concentration that can not legally be exceeded during a specified time period in a given region. In India the land use pattern and other factors are taken into consideration.

Table 11.5. Ambient air quality standards

Area	Concentration of pollutants (in $\mu g/m^3$)			
	SPM	SO_2	CO_2	NO_x
Industrial and mixed area	500	120	5000	120
Residential and rural area	200	80	2000	50
Sensitive area	100	30	100	30

Sensitive areas cover health resorts, parks, tourist areas, historical monuments and others.

Global effects are also evidenced as pollutants can get dispersed from one continent to the other. Pollution from Europe viz., U.K. to Scandinavia has resulted in acid rains and destruction of forests in Sweden. Industrial pollution of Canada seems to have ruined the lakes in USA. The use of chemical, biological and nuclear bombs in one country causes the pollution in nearby and far off countries.

Increased combustion of fossil fuels and removal of forests have resulted in the increase of carbondioxide. This has greater impact on earth's temperature. Increased Industrialization is causing high levels of particulate pollution of the atmosphere resulting in increased frequency of fogs and low cloud layers. Indiscriminate use of fertilizers, fuels, chlorofluorocarbons etc may reduce the ozone layer by about 25% causing serious damages to plant, animal and human beings.

11.11. REMEDIAL MEASURES

Control of air pollution can be (a) at source (b) in dispersal.

Control at source

The problem of controlling air pollution at source is complex, but can be controlled by using appropriate raw material for industry, site locations for industrial plants and using the most modern technology for efficient reduction of emissions. The injurious emissions can be reduced by absorption, adsorption and condensation. Sulphur dioxide emissions can be controlled by chemical reaction with copper oxide or lime stone.

(a) Absorption: There is a mass transfer between nine soluble gas component and a solvent liquid. HCl, HF and others are removed by dissolving it in acidic water. Sulphur dioxide and Chlorine can be absorbed more readily in alkaline water.

(b) Adsorption: The attractive forces between atoms, molecules and ions which hold a solid together are unsatisfied at the surface of a solid thus available for holding other material such as gases and liquids. With increase in the porosity of a solid its absorptive capacity also increases. Activated carbon, silica gels and diatomaceous earth are some of the important adsorbents. The adsorbents placed in suitable container capture gas or liquid molecules passed through it.

(c) Condensation: Gaseous vapours are usually controlled by condensations and is a suitable measure to combat the emissions of hydrocarbons and organic compounds having reasonably low vapour pressure.

(d) Chemical reaction: Gaseous pollutants are controlled by chemical reaction process. For example SO_2 emission can be controlled by chemical reaction with copper oxide or lime stone, thus SO_2 reacts with them producing either copper sulphate or calcium sulphate.

Settling chambers are known to collect the heavier particles from a gas steam. The particles settleout under gravity action.

Electrical precipitators containing charged plates placed in the air or gas stream settleout particles because of their opposite charge.

Fuel change - using of natural gas instead of coal will avoid sulphur oxide and fly ash emission from power plants. Liquid petroleum gas can be tried instead of petrol for automobiles.

The most important method of controlling pollution is to reduce the actual emission of pollutants.

Control in Dispersal: Air pollution control is possible by control in dispersal. Widening of roads, establishment of green belts in urban and industrial zones will reduce congestion and pollution. It is possible to declare pollution free zones by eliminating polluting vehicular traffic, imposing restrictions on movement of trucks and shifting the hazardous industrial units away from the urban centres. Air monitoring stations must be operated which will give a wa[redacted]ert if contamination of the atmosphere increase to dangerous levels. First alert is due [redacted]owable concentration of pollutants, second alert is given at a level where health menace exists and preliminary stage. Third alert being given at air contamination is at the point at which a dangerous health measure exists.

11.12. SUMMARY

Air pollution is the introduction of any substance or combination of substances into the

atmosphere that cause damage to plants, animals, human beings and material. There are different types of sources and are grouped into solid or liquid form and gaseous nature. These pollutants emanate from industries, refuse and domestic burning, fuel consumption and automobile exhausts. Many of the air pollutants can be controlled by using many devices and techniques. Further selection of site for an industry must be based on not only the production and transport costs but also social cost and ecological factors that influence the pollution potential. The air pollution must be controlled in the best interest of public health, conservation of natural resources and healthy industrial growth. It is essential to provide non-contaminated and non polluted air in the years to come for the growth, progress and sustenance of future generations. Let us not poison our environment, lives and germplasm by the indiscriminate use of chemicals or by emitting large amounts of toxic gases and chemicals in the name of industrialization and by dumping unwanted materials etc into the environment. Proper care must be taken to reduce the population growth as the air we breath is becoming more and more contaminated through air pollution. There are number of episodes and case studies to substantiate the impact of air pollution which sufficiently indicate that air pollution will be a greater threat to human existence until and unless the remedial measures are taken up and implemented in rigid manner.

11.13. CHECK YOUR PROGRESS: MODEL ANSWERS

1. The examples for oxides of sulphur are SO_2 and SO_3.
2. Incomplete oxidation during the burning of any fuel leads to the production of carbon monoxide.
3. The short form of peroxy acetyl nitrate is PAN. When there is strong sunlight and poor ventilation, series of reactions take place between nitrogen oxides and hydrocarbons leading to the formation of PAN.
4. The industrial discharges that cause adverse effects to plants are ozone, oxides of sulphur and nitrogen, fluorides, peroxy acetyl nitrates, chlorine, ammonia, smoke, dusts from iron, copper, zinc, lead etc.

11.14. MODEL EXAMINATION QUESTIONS

I. Answer the following questions in about 30 lines each.

1. Define air pollution and mention types of air pollutants.
2. What are the important health hazards on human beings and plants by air pollutants.
3. Give an account of remedial measures of air pollution.
4. Discuss case studies pertaining to air pollution.

II. Answer the following questions in about 10 lines each.

1. Define air pollution and add a note on its importance.
2. What are the sources and emission of air pollution?
3. What is the role of biological components in air pollution?
4. Discuss the air quality standards.
5. Give an account of air pollution in India.

Prof. C. Manoharachary

UNIT-12: AUTOMOBILE POLLUTION

Contents

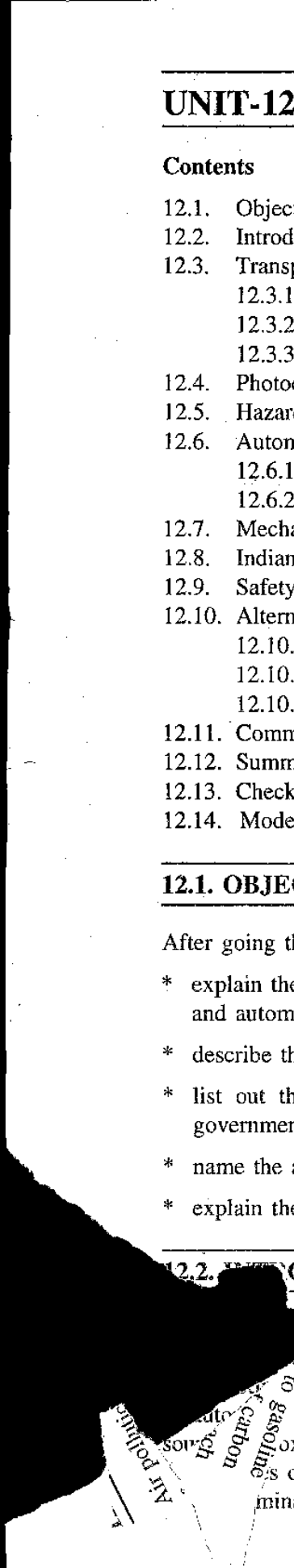
12.1. OBJECTIVES

After going through this unit, you will be able to:

* explain the issues concerning transportation, types of automobiles, automobile exhausts and automobile situation of Hyderabad and some important cities,
* describe the measurement methodology of automobile exhaust,
* list out the hazards of automobile pollution and describe the safety standards and government measures through legislation,
* name the alternative engines and power sources, and
* explain the community action against automobile pollution.

12.2. INTRODUCTION

...v be termed as the presence of one or more pollutants in such quantity and ... which may prove to be injurious to human, plant or animal life or property. ...aust, is contributing as one of the factors to the air pollution and is termed ...aut... pollution. This pollution is posing a serious problem because they are the ...sou... oxides and reductants of C, S and N. Mobile combustion sources include ...s of various types which is now and for the foreseeable future will continue to ...minant source of air pollutants.



The problem will intensify when increasing population puts more motor vehicles into operation. Until knowledge become available, it is suggested that efforts to minimise pollution from automobiles should be made through abatement measures to safeguard the ambient air quality in urban atmosphere.

In large cities, exhaust gases from automobiles lead to inconvenience to the people on the street and thereby cause an air pollution problem. Moreover, automobiles emit gases as well as particulates consisting of both inorganic and organic compounds of high molecular weight which can directly be inhaled and effect the people on the streets and nearby.

In USA out of the 142 million tonnes of pollutants given off to the air every year, motor vehicles account for 86 million tonnes. The automobiles contributed 63% of the total carbon monoxide emissions, 52% of the hydrocarbons and 39% of the oxides of nitrogen.

Check your progress - 1

What is meant by air pollution?

Note: (a) Write the answer in the space provided below.

(b) Compare your answer with the one given at the end of this unit.

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12.3. TRANSPORTATION ISSUES

The three main types of automotive vehicles being used in our country are: (a) passenger cars powered by four stroke gasoline engines, (b) motor cycles, scooters and autorickshaws powered mostly by small two stroke gasoline engines, and (c) large buses and trucks powered mostly by four stroke diesel engines. Emissions from gasoline powered vehicles are generally classified as: (a) Exhaust emissions, (b) Cranck-case emissions and, (c) Evaporative emissions. The amount of pollutants, that an automobile emits depends on a number of factors, including the design and operation (idle, acceleration, etc.). Of the hydrocarbons emitted by a car with no controls, the exhaust gases account for roughly 65%, evaporation from the fuel tank and carburettor for roughly 15% and blowby or cranck-case emission (gases that escape around the piston rings) for about 20%. Carbon [illegible]oxide, nitrogen oxides and lead compounds are emitted almost exclusively in the exh[illegible]

Diesel powered vehicles create relatively minor pollution problems compare[illegible] powered ones. The diesel engine exhausts are only about a tenth of the amount of monoxide exhausted by a gasoline engine, although its hydrocarbon emissions may approa[illegible] those of the gasoline engine. Blowby is negligible in the diesel, since the cylinders contain only air on the compression stroke. Evaporative emissions are also low because the diesel engine uses a closed injection fuel system and because the fuel is less volatile than gasoline.

The major problems of diesel engines are smoke and odour.

12.3.1. Emissions and Efficiencies of Automobiles

(a) **Exhaust Emissions:** The important exhaust emissions from a gasoline engine are, carbon monoxide, unburnt hydrocarbons, nitrogen oxides and particulates containing lead compounds. These emissions vary with the air-fuel ration, spark timings and the engine operating conditions.

Devices and methods to control hydrocarbon emissions fall into three classes (a) devices that modify engine operating conditions such as intake manifold vacuum breakers, carburation mixture improvers, throttle retarders, etc., (b) devices that 'treat' exhaust gases such as after burners, catalytic converters, absorbers and filters, and (c) use of modified or alternate fuels.

(b) **Crank-Case Emission:** Crank-case emissions consist of engine blowbly which leaks past the piston mainly during the compression stroke, and of oil vapours generated into the crank-case. The quality of blowby depends on engine design and operating conditions. Worn out piston rings and cylinder liner may greatly increase blowby. These gases mainly contain hydrocarbons and account nearly for 25% of the total hydrocarbon emissions from a passenger car.

Emissions of hydrocarbons from the crank-case of automobiles can be largely eliminated by the positive crank-case ventilation (PCV) system. These systems recycle crank-case ventilation air and blowby gases to the engine intake instead of venting them to the atmosphere.

(c) **Evaporative Emissions:** An average Indian passenger car would emit about 20 Kg of hydrocarbons through evaporation, annually. For controlling evaporation of fuel vapours in the crank-case or in a charcoal canister, absorbs hydrocarbons for recycling to the engine.

The exhaust gas pollutant comprise of hydrocarbons, carbon monoxide, nitrogen oxides and lead compounds. Evaporative emissions essentially constitute the fuel evaporation from the fuel tank and carburettor and consist of hydrocarbons alone. The chief constituents of crank-case emissions are also hydrocarbons. Thus exhaust emissions contribute 100% to CO, $(NO)_x$ and led compounds. Regarding hydrocarbons, the typical break up is exhaust 55%, evaporative emissions 20% and crank-case emission 25%. The exhaust and crank-case emissions also depend upon engine load conditions.

12.3.2. Automobile Exhausts

Studies conducted by National Environmental Engineering Research Institute (NEERI) have revealed that the level of pollution due to automobile exhaust in Indian cities is reaching ures quite comparable with other major cities of the world. This is so even though, the f vehicles plying even in the Indian metropolitan cities, which have the highest les in this country, is still insignificant as compared to the number in USA, But the inferior maintenance of vehicles in combination with lower cy is making the vehicular exhausts a menace to the city dwellers.

Table 12.1. Constitutents of Automobile Exhaust.

S.No.	Name of the Pollutant
1.	Carbon monoxide
2.	Unburnt hydrocarbons
3.	Oxides of nitrogen
4.	Oxides of sulphur
5.	Partially burnt products like aldehydes, formaldehydes, acrolein, acetaldehyde
6.	Lead compounds
7.	Soot or smoke
8.	Complex products from additives and lubricating oil
9.	Carbon dioxide
10.	Oxygen
11.	Nitrogen
12.	Hydrogen
13.	Water vapours

Table 12.2. Pollutants emitted by petrol and diesel vehicles in India and the World (Prakash et al 1980).

Pollutant	India Metric tons/yr	World Million Metric tons/yr
Carbon monoxide	755	65
Sulphur dioxide	101.6	23
Nitrogen dioxide	73	8
Hydrocarbons	238	15
Hydrogen sulphide	11.6	—
Ammonia	11.6	—
Hydrogen chloride	2.6	—
Particulate	—	12
Other gases and vapour	—	2

The concentration of different pollutants varies with the mode of operation of vehicle whether petrol or diesel driven.

Table 12.3. Concentration of pollutants from petrol driven vehicles.

Mode of operation	Carbon Monoxide (%)	Hydrocarbon (%)	Nitric Oxide (NO) (ppm)	Formal... d...
Idling	3-13	0.1-1.0	15-45	
Accelerating	2-15	0.02-0.0	600-2000	
Normal running	0.5-0	0.02-0	300	
Deaccelerating	2.5-6	0.05-2.6		

12.3.3. Automobile Pollution in Important Cities of India

Hyderabad Scenario: The obnoxious emission from the tailpipes of automobiles has become a serious threat to environment. Air pollution in major urban areas is increasing although urban growth rate nationwide has declined from 1971-80 and 1981-91. One of the main causes of the increase in air pollution is the increase in the number of automobiles. Another reason is the chaotic transport system.

About 5 lakh vehicles are present in Hyderabad.

Two wheelers	4,00,000
Three wheelers	30,000
Cars	45,000
Taxis	2,000
Jeeps	12,000
APSRTC Buses	2,500
Private Buses	1,500
Floating Vehicles/Trucks	8,000

In Hyderabad air pollution is on the increase at a high rate and the main pollutants which are carbon monoxide, hydrocarbons and other gases emitted by vehicles is about 58,000 tonnes every year. It is feared that it may rise upto 82,000 tonnes by 2000 A.D. The vehicular emissions released into the atmosphere by about 5,00,000 vehicles in Hyderabad every day due to incomplete burning of fuel are as follows:

3021	tonnes of carbon monoxide
1729	tonnes of hydrocarbons
82	tonnes of nitrous oxide
17	tonnes of sulphur dioxide
2	tonnes of particulate matter
1	tonne of lead

So the day is not very far off when Hyderabad city will have a black sky.

The pressure of industrialisation, urbanisation and economic growth has induced a phenomenal growth in the road transport sector. Due to the increase in the rapid vehicle fleet the effects damaging the environment are aggravated.

Bombay Situation; Automobile pollution is posing a serious problem, especially in metropolitan areas. It is the major form of pollution in Bombay. Other big cities in India, though they may not be as polluted as Bombay, are not very different. This is because about 25% of the vehicles registered in the country are in Maharashtra and about a third of these are either registered or ply in Bombay only. Though the volume of vehicular traffic in our cities is so high compared to western cities, high concentration of pollution is created due to old age, poor performance and maintenance of most of our vehicles. Narrow roads, poor geometric, frequent traffic jams and congestion aggravate the situation (Shah and Ramprasad, 1979).

Delhi Situation: Automobiles vitiate the atmosphere in Delhi to an alarming extent. In many parts of Delhi, the concentration of poisonous gases like carbon monoxide, sulphur dioxide and nitrogen oxide are three times above the safety limits. An average vehicle emits

2.5 kg of pollutants per day and all the vehicles put together emit a whopping 170 tonnes of hydrocarbons, 80 tonnes of nitrogen oxide and 2 tonnes of sulphur dioxide, not to speak of carbon monoxide and suspended particulate matter. The total number of vehicles registrated in Delhi are 1.075 million.

Surat Situation: Shah Ramprasad (1979) estimated carbon monoxide emission from automobiles in Surat. They have shown that the levels of carbon monoxide in the walled city are comparable to those of other major cities in India. It was observed that maximum carbon dioxide concentration was 350 ppm. The average level of carbon monoxide was about 25 ppm.

Table 12.4. Concentration of Carbon Monoxide and Traffic volume at Surat (between 11.15 to 12.15)

Station	Scooter	Car	Auto	Bus &Truck	CO Content (ppm)
Chowk	290	88	630	1022	20
Bhagal	954	246	2428	178	25
Dehligate	962	252	1946	306	20
Laldarwaja	290	50	506	12	20
Railway bridge	–	–	–	–	30
Guest house	–	–	–	–	35

World Scenario (CO Levels): Carbon monoxide concentration in ambient atmosphere is estimated in selected urban areas of the world. The concentration of carbon monoxide in Calcutta was no less in comparison to that of other cities of the world.

Tabel 12.5. Ambient Carbon Monoxide Concentration in selected Urban areas of the world (Comparative report - NEERI)

City	Maximum time one hour (ppm)
London	58
Chicago	46
Los Angeles	43
Washington	41
New York	27
Calcutta	35

12.4. PHOTOCHEMICAL SMOG

Photochemical smog was first noted in Los Angeles during world war II, but its nature and origin were not understood until the early 1950s. Nitrogen Oxides play an important role in the formation of photochemical smog. Nitrogen dioxide (N_2O) is an efficient absorber of the ultraviolet portions of the solar spectrum which cause the NO_2 molecule to photolyze into

Nitric oxide (NO) and atomic oxygen (O). The atomic oxygen can react with O_2 to form ozone. The ozone in turn can react with NO to form NO_2 and O_2 again, completing the atmospheric nitrogen dioxide phytolytic cycle.

$$NO_2 + \text{UV light} \rightarrow NO + O$$

$$O + O_2 + M \rightarrow O_3 + M \text{ (M = collisional molecule)}$$

$$O_3 + NO \rightarrow NO_2 + O_2$$

The ozone can react with hydrocarbons and other compounds to produce new highly reactive compounds, one of the best known is peroxy acetyl nitrate (PAN). Like ozone, these compounds are highly oxidizing compounds and their major effects are injurious to plants, especially leafy plants and eye irritation to humans.

Table 12.6. Comparison of two types of smog

Characteristics	Los Angles	London
Principal Components	Ozone, organic matter, nitrogen Oxides, Carbon monoxide	Sulphur compounds, particulate matter, carbon monoxide
Type of reactions	Photochemical plus thermal	Thermal
Effect on chemical reagents	Oxidation	Reduction
Time of maximum occurrence	Midday	Early morning
Principal effects	Temporary eye irritation	Bronchial irritation, coughing someties increased deaths among those with respiratory diseases

Check Your Progress - 2 & 3

2. What are the major pollutants of automobile exhaust?
3. What is PAN?

Note: (a) Write the answers in the space provided below

(b) Compare your answers with those given at the end of this unit.

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12.5. HAZARDS OF AUTOMOBILE POLLUTION

Particulates emitted by a variety of sources pose a hazard to the health of animals and plants and also to the longevity of structures and property. Among the gaseous components, oxides of nitrogen are considered to be more hazardous. Even very small quantities of these chemicals cause lachrymation, burning of eyes, nose and other delicate membranes of the body, destroy plant tissue and even attack such resistant materials as rubber nylon and plastics. Nitrated compounds enhance creation of photochemical smog. For this reasons oxides of nitrogen are considered the most dreaded air pollutants in USA.

Carbon monoxide is also hazardous to humans and animals. It reacts and neutralises a part of the haemoglobin in the blood thus reducing respiratory capacity. At a concentration of 100 ppm or more it can cause death with relatively short exposures.

12.6. AUTOMOBILE AIR POLLUTION MEASUREMENTS

12.6.1. Sampling of Auto Mobile Exhaust Emissions

For purpose of analytical chemistry there are two basic principles of sampling air and gases: (1) to obtain a definite vol. of air within a gas collector with a known pressure or temperature. This sample is then taken to laboratory or analysed in the field. (2) to pass a solution or equivalent means where a definite volume of gas is required or desired as the sample to be analysed. There are two possible types of samples that may be taken. These are known as instantaneous (also grab or spot) samples and continuous samples. Instantaneous samples are those taken at a particular time and place within an interval of few seconds to a minute or two and they represent the composition of air or gas at that time and location. These are most often taken in evacuated bottles or gas collectors, although they may be taken with liquid displacement devices. Since the concentration of gases in the exhaust is on the higher magnitude, bag samples or grab samples collection has an advantage. The samples brought to the laboratory may be analysed by Orsat Gas Analyser for CO_2, CO, O_2, CH_4 etc.

In case of continuous samples, the pollutants are absorbed in selective absorbing media and same procedure and methods are to be followed as used for ambient air quality study when the concentrations are low. But for higher concentration analytical methods of stack sampling are to be used. For very low concentration of CO, Carbon monoxide detecting tubes are used. Besides this, gas chromatography, infra-red spectrophotometric methods are also available.

12.6.2. Diesel Smoke Sampling and Evaluation

For this purpose, smoke meter is used. It is a portable, accurate and reliable testing instrument to measure the exhaust smoke of diesel engine. The readings from the evaluating instrument can be easily reproduced. Black diesel smoke results from incomplete oxidation of fuel oil molecules during the combustion process caused by localised lack of air or a localised excess of fuel in the combustion chamber. The engine, fuel or fuel injection system may be to blame for this.

The smoke meter serves as a testing device for exhaust gases to keep diesel smoke within reasonable limit, as far as possible, the least reduction in engine output under all operating conditions. Tests can be made either on a test bench or while the vehicle is in motion on the road.

Description: A sampling pump draw off a certain amount of exhaust gas from the exhaust pipe of the respective engine and then sucks it through a filter disc. The filter paper disc, in turn, darkens during this process and thus gives the measure of the soot contained in the exhaust gases. The evaluating instrument is then used to take a reading of the darkened disc photoclectrically.

12.7. MECHANISM OF AUTOMOBILE POLLUTION FORMATIONS

When the engine is stopped after a run, it is hot and this acts on the petrol in the float chamber. The petrol gets vaporised and passes out through the vent in the float chamber or through the air cleaner.

Fuel evaporating from the tank and carburettor through over flow and venting channels

accounts for 20% of the total hydrocarbon emission from the automobiles. This is higher in summer.

During compression and phases of engine operation, the pressure of the gases inside the cylinder is very high and therefore they leak past the piston-rings into the crank case which is known as 'blowby'. About 85% of this blowby gas is fresh air fuel mixture and the rest comprises of combustion products. When the engine is started from cold, even some of the petrol may leak past the piston in liquid form due to insufficient vaporisation. To reduce the deterioration of lubricant properties and corrosion of metal parts, these blowby are vented into the atmosphere. This crankcase blowby is responsible for approximately 20% of the total hydrocarbons and 25% of the total particulates emitted by the automobile. Particulates in blowby gases consist almost entirely of lubricating oil.

The major components of automobile exhaust are complete oxidation products-carbon dioxides, water and nitrogen that accompanied oxygen in the air supplied. Minor components in the exhaust, but important ones are carbon monoxide, nitrogen oxide, hydrocarbon, particulate and sulphur oxide. Particulates discharged from exhaust consist of carbon particles and lead compounds.

It has been revealed that the fuel pump and silencer are important sources of noise.

Diesel emissions are as important as petrol emissions. Carbon monoxide is the most important pollutant from petrol. However, diesel exhaust contain much higher nitrogen oxide emission which is primarily responsible for photochemical smog. Particulate emission from diesel exhaust is more harmful compared to petrol, largely because of much higher amount of smoke in the former. These particulates contain many toxic and cancer causing compounds and are responsible for many respiratory diseases in polluted areas. Carbon monoxide results from incomplete combustion.

Nitrogen oxides are formed in the engine cylinder whether combustion is complete or not. As the nitrogen and oxygen in the air combine to form nitric oxide, the rate of nitric acid formation increases with temperature and oxygen availability.

Soot emissions in the exhaust result from decomposition of hydrocarbon fuel, nucleation of carbon particles in the flame, growth of soot nuclei, agglomeration of particles and finally soot oxidation.

12.8. INDIAN LEGISLATION FOR AUTOMOBILE POLLUTION CONTROL

The major strategy is the enactment of the Air Act (Prevention and Control of Air Pollution), 1981. This Act lays down in section 16 (1) (h) that the main functions of the central Board shall be to improve the quality of air and to prevent, control or abate air pollution in the country.

Section 17 (1) (g) of this Act lays down that the functions of the State Board shall be to lay down, in consultation with the Central Board and having regards to the standards of the quality of air laid down by the Central Board, standards for emission of air pollutants into the atmosphere from industrial plant and automobiles.

Section 20 of the Act empowers the State Government in consultation with the State Board to give instructions to Transport Authorities.

Under the Motor Vehicles Act, 1939, section 70 gives to the State Government, the power to make rules, inter alia regarding the emissions of smoke, visible vapour, sparks, ashes, grit or oil.

Recommendations and Suggestions: It should be made obligatory for all Motor vehicle manufacturers only such vehicles which do not pollute the atmosphere beyond permissible limits.

Scientists and technologists should device a cheap gadget for fixing on the existing vehicles so that there is no pollution by these vehicles beyond permissible levels.

When this is done, thereafter the provisions of the law should be strictly enforced.

12.9. SAFETY STANDARDS

Motor vehicle emissions may be reduced in several possible ways:

Instituting controls on the gasoline internal combustion engine: This measure has thus far been taken in United States. This method is referred to as positive crankcase ventilation (PCV). In PCV, the gases escaping from the crankcase are recycled back to the engine intake instead of being vented into the atmosphere. In order to reduce CO and hydrocarbon emissions from the exhaust, General Motors, Ford and American Motors originally used as air injection systems in which air was injected into the exhaust near exhaust valves to complete the oxidations into CO_2 and H_2O without the extractions of usable power.

Developing new and cleaner fuels to use with the internal combustion engine like propane, natural gas and alcohol have all been considered.

Developing new types of engines using gasoline or other fuels for example, steam or other pankine cycle engines, stratified charge engines, gas turbines, wankel engines.

Instituting transportation controls to reduce motor vehicle use through educational programs, development of better mass transit systems for intercity and intracity travel, or government control such as gasoline rationing.

Check Your Progress - 4

What is positive crankcase ventilation (PCV) method?

Note: (a) Write the answer in the space provided below.

(b) Compare your answer with the one given at the end of this unit.

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12.10. ALTERNATIVE ENGINE AND POWER SOURCES AND ALTERNATIVE MODES OF TRANSPORT

The various possible power sources for motor vehicles currently in use or under investigation are listed below. The standard internal combustion engine, the diesel engine finds some use, especially on trucks. The other heat engines are very uncommon.

12.10.1. Heat Engines

I. Intermittent combustion, internal combustion engines

1. Motorcycle with gasoline fuel
   a. Standard internal combustion engine.

b. NSU - wankel internal combustion engine.

c. Miscellaneous internal combustion engines (stratified - charged).

2. Diesel cycle with diesel fuel : diesel engine.

II. Continuous combustion engines

1. Brayton cycle with various possible fuels: gas turbine engine.
2. Rankine cycle with various fuels: external combustion engines using steam freon or other working substances.
3. Stirling cycle with diesel fuel: stirling external combustion engine with air as the working substance.

12.10.2. Electrochemical Devices

1. Batteries: Lead-acid, 'nickel-cadmium, nickel-zinc, silver-zinc, zinc-air, sodium-sulphur, lithium-chlorine and so forth.
2. Fuel Cells: Hydrogen-oxygen, hydrogen-air, hydrazinc, methanol and so forth.

12.10.3. Hybrids

Heat engine - battery hybrid engines: gas turbine-battery,

striling-electric hybrid and so forth.

Battery-battery hybrid engines.

Fuel cell-battery hybrid engines.

The wankel engine is simple, operates smoothly, and the lightness of the engine made possible to include pollution control equipment in the engine much more easily than in ordinary engines. But they are not economical from the standpoint of fuel consumption.

Stratified-charge engines are exceptionally promising. These engines have two carburettors, one producing fuel rich mixture and one a fuel lean mixture which are drawn into the main combustion chamber in appropriate fashion. It has low bare engine emissions which makes pollution control easier, and better fuel economy than ordinary engines.

The diesel engine is durable and is economical from the stand-point of fuel consumption. It is suitable for trucks but it accelerates slowly compared to ordinary engines.

Gas turbines produce less pollution than the standard internal combustion engines but they are expensive; stirling engines have high thermal efficiencies, emit few pollutants but they are heavy, bulk and expensive.

Battery systems are generally capable of supplying sufficient power but are energy limited and cannot provide sufficient range. Hybrid power sources characterized by high specific power with one characterized by a high specific energy to obtain an energy source characterized by satisfactory intermediate values. At present hybrids are too expensive to be considered for actual automotive use.

12.11. COMMUNITY ACTION

It is desirable to create public awareness and educate the society with the problems connected with the automobile pollution and by inspiring and motivating for regulating traffic, preserving greenary and proper residential designs as detailed in action plan.

Who is blamed?

1. Society
2. Road Maintenance Agencies
3. Traffic Violators.

Community action depends upon understanding the above problems associated with automobiles.

Road Maintenance Agencies: (1) Laying the roads, (2) Proper identification of routes to be repaired/laid, (3) Negligence on part of these agencies/departments, (4) Allocation of funds.

Traffic Violators: Heavy vehicles: buses, lorries, autos (yellow perils): Auto drivers neglect traffic rules. They cross speed limits, overtake from the left side and enter or come out of small lanes and by-lanes suddenly taking traffic on the main road by surprise.

Light vehicles : Cars, Cabs and Taxis

Cars - Internal music facility - distracts the driver

Sound horns - produce unnerving sounds.

Two wheelers: Scooters, mopeds and cycle rickshaws - rash driving, driving in areas marked for heavy vehicles.

Bullock Carts: Move at a snail's pace bringing the traffic almost to a standstill.

Bad roads can be further classified as follows:

a) Badly laid
b) Neglected
c) Badly maintained.

This can be done by avoiding stop and go traffic, particularly near residential and shopping areas. Highways and main streets should have intersections free entrances and exits, over and under passes, which keeps traffic moving. All heavily travelled roads have elevated ramps or vented underground walkaways.

Traffic needs to be regulated by community involvement to ensure smooth flow by widening roads, restricting certain roads for light vehicles, proper maintenance of roads, appropriate location of signals, synchronisation of signals in close proximity, proper planning of traffic islands etc. A vehicle emits maximum carbon monoxide when it idles and a smooth traffic flow minimises pollutant emissions. In fact, by ensuring smooth traffic flow pollution can be lowered more than by merely controlling carbon monoxide emissions. Besides, there is greater depression and dilution of pollutants when traffic moves fast.

The preservation of green areas with the help of voluntary organisations is one major planning measure by which city planners can influence the climate and air hygiene conditions of urbanised areas. Green areas can filter dust and fly ash from the atmosphere.

Proper residential design should avoid major thorugh roads. No outlet can be planned with natural barriers against over crowding pollution and noise. Automobile parking is clearly the greatest source of pollution and should be separated from residential areas. A parking lot covered with trees would preserve the atmospheric cleanliness and also prevent cars from heating and fuel loss which can be achieved in community involvement.

12.12. SUMMARY

Motor vehicles are responsible for approximately two thirds of the carbon monoxide, one half of the hydrocarbons, and one third of the nitrogen oxide emissions. These emissions are especially noted for their production of photochemical smog in populated urban areas.

Photochemical smog was first noted in Los Angeles. In a series of reactions involving solar ultraviolet radiation, the nitrogen oxides from motor vehicles react with atmospheric oxygen to produce ozone. The ozone can react with hydrocarbons to produce new highly reactive compounds, one of the best known being PAN (peroxy acetyl nitrate). These compounds are highly oxidising compounds and cause eye irritation in humans.

The emissions from uncontrolled vehicles organized from the exhaust, crankcase blow-by, fuel tank and carburettor, hydrocarbons were emitted from all these sources. The exhaust also contains carbon monoxide, nitrogen oxides and other pollutants such as suphur compounds etc.

Pollution control devices were required for safety standards. Crankcase blow-by has been eliminated by positive crankcase ventilation systems. Gasoline vapors from the carburettor and fuel tank are collected and returned to the engine. Exhaust emissions have been controlled by a variety of methods, including engine modifications and catalytic converters.

Several alternatives to the standard four-stroke, spark ignited, reciprocating-piston, internal combustion engine have been studied for possible future use. These include other internal combustion engines (such as the wankel rotary engine, the stratified-charge engine and the diesel engine), external combustion engines (such as Rankine or Stirling cycle engines) and engines using batteries or fuel cells. Each has its advantages and disadvantages. In particular, batteries can provide good power but only short range, whereas fuel cells can provide a long range but little power. The stratified charge engine which combines low pollutant emissions, good fuel economy, and other advantages looks especially promising for the near future.

12.13. CHECK YOUR PROGRESS: MODEL ANSWERS

1. Air pollution may be termed as the presence of one or more pollutants or combinations of these pollutants in such quantity and for such duration which may prove to be injurious to human, plant or animal life or property.
2. The major pollutants of automobile exhaust are carbon monoxide, hydrocarbons and nitrogen oxides.
3. The short form of Peroxy Acetyl Nitrates is called PAN and these compounds are highly oxidizing compounds and cause eye irritation in humans.
4. In PCV method the gases escaping from the crankcase are recycled back to the engine instead of being vented into the atmosphere.

12.14. MODEL EXAMINATION QUESTIONS

I. Answer the following questions in about 30 lines each.

1. What is air pollution? Mention the sources, composition and hazards of automobile pollution.

2. Give an account of safety standards and alternative engines and power sources of automobile pollution. Add a note on community action against automobile pollution.

II. Answer the following questions in about 10 lines each.

1. Write briefly about photochemical smog.
2. What are the sources and composition of automobile exhaust.
3. What are the safety standards for automobile pollution.
4. What are the recommendations and suggestions for automobile pollution control?
5. What are the alternative engines and power sources of automobile pollution.

Prof. S.H. Raza

UNIT-13: METEOROLOGY

Contents

13.1. OBJECTIVES

After going through this unit you will be able to:

* define meteorology,
* describe the meteorological parameters in relation to air pollution,
* describe the consequences of acid rain and suggest the remedial measures,
* suggest the place for the location of industrial plant.

13.2. INTRODUCTION

The branch of Science dealing with the study of earth's atmosphere is meteorology. Atmospheric conditions determine the behaviour of pollutants after they leave the source or sources until they reach receptors, such as people, animals or plants. Let us analyse these questions namely:

What will be the concentration of the pollutants at any distance from the source under certain meteorological conditions and where does the pollution originate? Effect of the pollution on receptor depends on atmospheric conditions. Therefore, knowledge of meteorological and topographical characteristics of a study area is of utmost importance. Transport and diffusion of the pollutants to atmosphere is governed by macro- and micro-meteorological factors. These deal with minute variations in atmospheric conditions, not only confined to an area of a few square kilometers and upto an elevation of 500 to 1000 meters in the atmosphere. They govern the transmission and diffusion of air pollutants.

Even though the total discharge of contaminants into the atmosphere in a given area remains constant from day to day, the degree of air pollution may vary widely because of difference in meteorological conditions. In a specified place the emission of pollutants may be the same but it is the weather that can trigger an air pollution episode.

13.3. METEOROLOGICAL PARAMETERS IN RELATION TO AIR POLLUTION

The important meteorological parameters that influence air pollution are classified into two groups, viz., the primary and the secondary parameters. The primary parameters are wind speed, wind direction and atmosphereic stability. The secondary factors include ambient

temperature, humidity, precipitation, solar radiation, pressure and visibility. The primary factors are responsible for the dispersion and dilution, whereas secondary factors affect the primary parameters, thus altering transmission of air pollutants.

Wind speed, wind direction and atmospheric stability are called primary or basic meteorological parameters as the dispersion and dilution of the pollutants depends mainly on these parameters. Ambient temperature, Humidity, Precipitation, Solar radiation, Pressure, and Visibility are called secondary meteorological parameters as they control the dispersion of the pollutants not directly but through their effect on primary parameters. These parameters may vary as a function of latitude, season and topography. Weather and air pollution have become compliementary to one another in such away that weather affects air pollution and this affects weather in several ways. For example following parameters may be impaired namely visibility, fog and in-coming solar radiation and incidences of smog.

Check Your Progress - 1 & 2

1. What are the primary or basic meteorological parameters?
2. Name the secondary meteorological parameters.

Note: (a) Write the answers in the space provided below.

(b) Compare your answers with those given at the end of this unit.

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13.3.1. Primary Parameters

Wind Speed: This directly determines the rate of dilution and transport of air pollutants. Wind speed effects air pollution through travel time and dilution.

The travel time determines the amount of time the pollution is exposed to the meteorological factors until contact with the receptors.

The wind speed dilutes the pollutants by throwing them in the downwind direction. For example if a continuous source is emitting a certain pollutant at a rate of 5 units/second, and the wind speed is 1 meter/second, then in a meter segment of the downwind plume there will be 5 units of pollutant, since 1 meter of air moves past the source each second.

The dilution of air pollutants released from a source is directly proportional to wind speed. The downwind concentration of air pollutants is inversely proportional to wind speed.

Wind Direction: This directly determines the direction of transport of air pollutants. The direction of travel of the pollutants is determined by wind direction from which the wind is blowing indicating that a north wind will transport pollutants to the south of the source.

Atmosphere Stability & Turbulence: Stability in meteorology, refers to a state of equilibrium and if disturbed, return to its undisturbed state, or changes the equilibrium.

In most simple terms the weather which is not stable may be said to be turbulent. Turbulence may be of two types namely non-thermal and thermal turbulence.

Non-thermal Turbulence: This mainly controls the dispersion and dilution of pollutants in a horizontal plane. This is created by movement of air over earth's surface, and is the induced eddy structure of the atmosphere due to the roughness of the surface over which the

air is passing. Therefore, the existence of trees, shrubs, buildings, and terrain features will cause mechanical turbulence. The mechanical turbulence increases as wind speed increases. These random motions are responsible for the movement and diffusion of pollution path. If the scale of turbulent motion (the size of the eddy) is larger than the size of the pollutant plume in its vicinity, the eddy will move that portion of the plume; if the eddy is smaller than the plume, its effect is to diffuse or spread out the plume.

Convective or Thermal Turbulence: The temperature of the atmosphere varies with height. This controls the dispersion and dilution of pollutants in vertical direction. Thermal turbulence is induced by the stability of the atmosphere. When the earth's surface is heated by the sun's radiation, the lower layer of the atmosphere is heated and the atmosphere becomes unstable. Thermal turbulence becomes greater especially under conditions of light wind. On clear nights with light winds, heat is radiated from the earth's surface resulting in cooling of the ground and air adjacent to it. This results in extreme stability of the atmosphere near the earth's surface. Under these conditions turbulence is at a minimum.

In meteorological terms, the thermal atmospheric unstability or turbulence is defined in terms of difference between the environmental temperature lapse rate and the dry adiabatic temperature lapse rate (1°C per 100m). The stability of the atmosphere affects plume shape and the capability of the atmosphere for dispersing contaminants. As such it serves as an index of atmospheric turbulence.

Dry Adiabatic Lapse Rate & Environmental Lapse Rate: The rate of decrease of temperature with increase in height dt/dz under such ideal conditions (assuming air as ideal gas and assuming adiabatic expansion) is called Dry Adiabatic Lapse Rate and is equal to 1°C per 100 meters (or 5.4°F per thousand feet). Such process never occurs in the atmosphere since, the turbulence tends to destroy the theoretically isolated volume.

The actual variation of temperature in the vertical is called 'Environmental Lapse Rate' (L_E) and it seldom approximates the adiabatic lapse rate L_A in the lowest 100 meters. The effective lapse rate (L) is equal to the adiabatic lapse rate L_A minus the environmental lapse rate L_E.

$$L = L_A - L_E$$

The atmospheric unstability (turbulence) depends upon the value of the effective lapse rate.

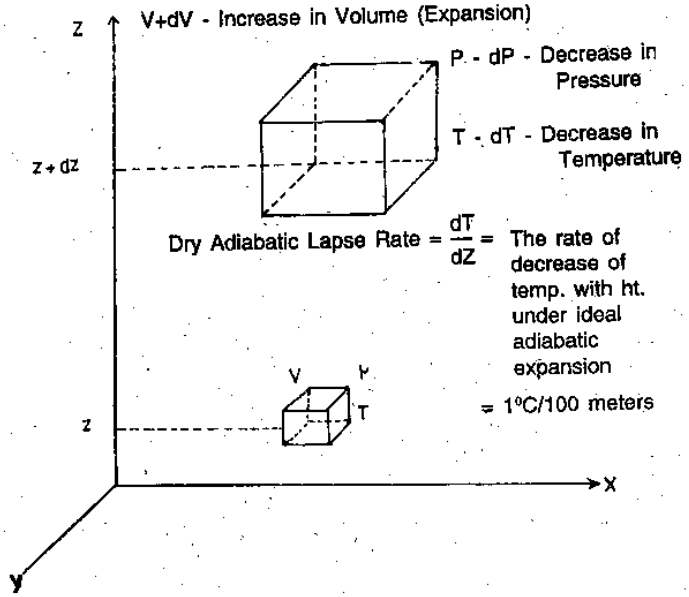

Fig.13.1. Adiabatic lapse rate.

(i) **Superadiabatic:** On days when there is strong solar heating or when cold air is transported over warmer surface, the rate of decrease of temperature with height L_E usually exceeds 1°C/100 meters - the L_A. This is called superadiabatic condition under strong unstable situation. The pollutants released upwards always meet cooler conditions and continue to rise. This is confined to lower 200 meters of the atmosphere.

(ii) **Neutral:** The environmental lapse rate is nearly equal to the dry adiabatic lapse rate implying no tendency for the released pollutants to gain or lose buoyancy.

(iii) **Subadiabatic:** When the environmental lapse rate is negative but less than the - 1°C/100m - the adiabatic lapse rate, it is called sub-adiabatic condition. e.g., over-cast skies, moderate or strong winds. The pollutants released upwards will become cooler than the surrounding and come down to its original position.

(iv) **Isothermal:** When the environmental lapse rate is zero, i.e., temperature variation with height is absent, is called isothermal and is slightly stable as in subadiabatic condition.

(v) **Inversion:** When the temperature increases with height, i.e., when the environmental lapse rate is positive it is called inversion and corresponds to the most stable condition. With very limited dispersion. The inversion gives rise to the ground level pollutants concentration to build up to the hazardous level contributing to air pollution.

Temperature Profile - Variability with Time and Space

The main cause for variation of atmospheric temperature with height is the vast difference between the rates of heating (or cooling) of earth surface and air.

The diurnal variation of the lapse rate is given in Fig. 13.2

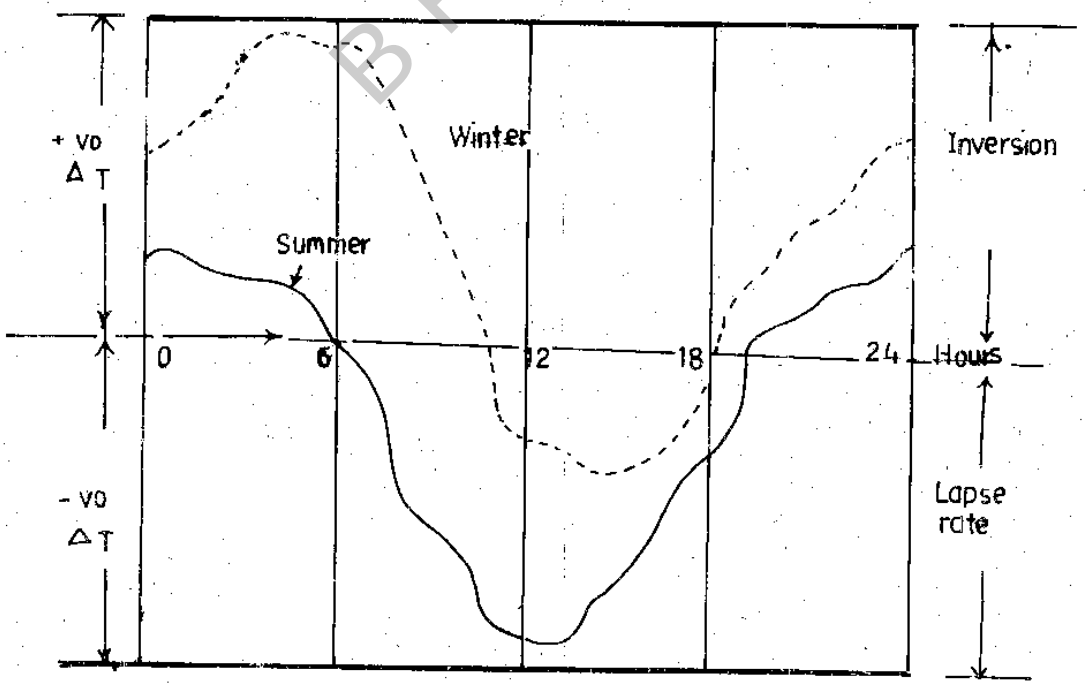

Fig. 13.2. Typical diurnal variation of lapse rate.

Under the normal conditions, in the open country, after the sunrise, the earth's surface starts getting heated because of sun radiations, but the air takes much longer time for heating. Hence, during the day time the temperature of air, closer to earth's surface is warmer than the top air layers, thus there is a decrease in temperature with height, i.e., the lapse rate is observed creating unstable air and good pollutant dispersion. After the sunset, the earth's surface loses heat very rapidly through long wave heat radiations, but the cooling rate of air is very slow, keeping it hot for very long time. Thus, during the night, temperature increases with height, corresponding to stable inversion condition and persists till the sunrise in the next day morning and the whole cycle is repeated. This is seasonal and topography dependent. During the winter when the nights are longer and the sun rays are reaching the earth with low intensity during the day time inversion conditions are more predominantly

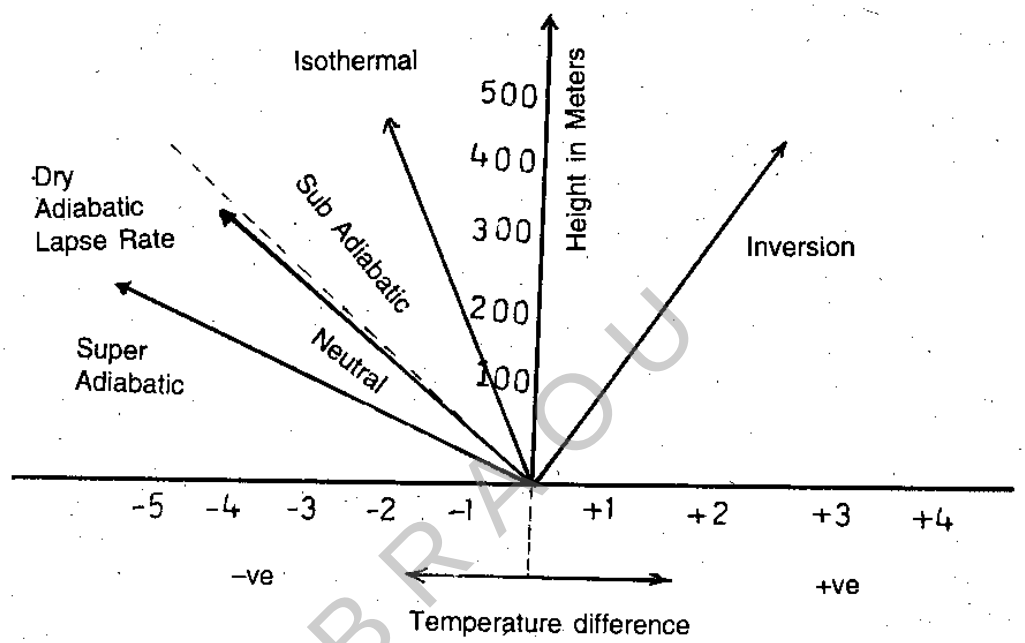

Fig. 13.3. Various Forms of Temperature Profiles.

formed and remain for much longer time than the lapse rate. Similarly, in the valleys, frequent inversions are formed and persist for a very long time.

Mixing Heights: The mean maximum mixing height is the height above the earth surface throughout where relatively vigorous vertical mixing occurs and measured indirectly through temperature profile data and studied in morning and afternoon hours.

The maximum mixing height shows variations during the day, season and topographical features.

Plume Characteristics and Pollutant Concentrations under different Vertical Temperature variations

The manner is which stack effluents diffuse is primarily a function of the stability of the atmosphere.

(1) **Looping:** Looping occurs with a superadiabatic lapse rate. Larger thermal eddies are developed in the unstable air and high concentrations may be brought to the ground for short time intervals. Diffusion is good.

(2) **Coning:** With vertical temperature gradient between dry adiabatic and isothermal,

slight instability occurs with horizontal and vertical mixing forming a cone shaped plume e.g., study of wind nights.

(3) Fanning: If the temperature increase upward, the air is stable and vertical turbulence is suppressed with a little horizontal mixing. Plume concentrations are high but little effluent from elevated sources reaches the ground in this situation e.g., clear skies with light winds during the night.

(4) Lofting: Lofting occurs when there is a superadiabatic layer above a surface inversion with rapid upward diffusion and downward diffusion does not penetrate the inversion and so is dumped out. With these conditions gases will not reach the surface but particles with appreciable settling velocities will drop through the inversion. e.g., Near sunset on a clear evening in open country.

(5) Fumigation: As solar heating increases, the lower layers are heated and a superadiabatic lapse rate occurs through a deeper layer. Thermal turbulence will bring high concentrations to the ground along the full length of the plume. e.g., clear skies and light winds in summer due to increased heating.

(6) Trapping: When an inversion occurs aloft such as a frontal or subsidence inversion a plume released beneath the inversion will be trapped beneath it. Even if the diffusion is good beneath the inversion such as a coning plume, the limit to upward diffusion will increase concentration in the plume and at ground level.

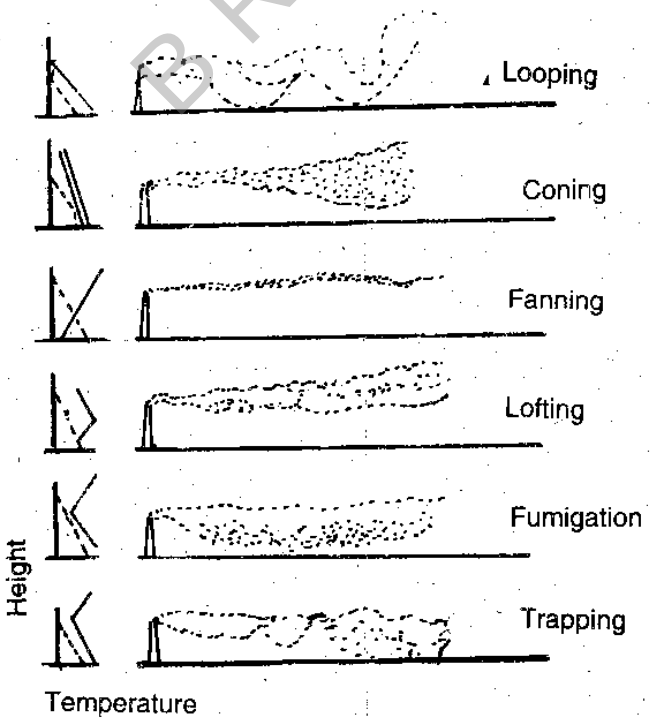

Fig. 13.4. Plume characteristics.

13.3.2. Secondary Parameters

Temperature: The ambient temperature has several effects on air pollution.

Temperature is related through the calculation of 'degree days' to the amount of fuel consumed for heating purpose. Ambient temperature at the pollutant source affects plume rise. Chemical reaction rates in the atmosphere are influenced by ambient temperature.

Precipitation: Precipitation is one of the natural cleaning agents of atmosphere. Precipitation removes pollutants from the atmosphere through (1) Washout and (2) Rainout processes.

Solar Radiation, Humidity & Pressure: Solar radiation and humidity have effect on the type and rate of chemical reactions that occur in the atmosphere.

Pressure: Low and high pressure systems have predictable effects on air pollution potential due to the accompanying atmosphere stability associated with these systems.

Cyclones are characterized by: (1) Uplifting of air, (2) Generally stormy weather, (3) Fast moving system - moderate to high winds.

These factors are conducive to good dispersion and natural removal of contaminants released into the atmosphere.

Anticyclones are characterized by: (1) subsidence of air (subsidence inversion), (2) generally fair weather, (3) slow moving system - light to clam surface winds.

Dispersion Phenomenon: The dispersion of the pollutants is due to the turbulent flow of wind, and is dependent on the atmospheric stability ustiness etc. The turbulent diffusion models for atmospheric pollutants are based on Fick's law of molecular diffusion.

Most of the formulas are derived for simpler cases of constant velocity, steady state and constant diffusion coefficients, though the variation of wind and diffusion coefficient with height is a fact. All point sources models fail, if there is a weak and variable wind. The models are also inadequate for inversion layers.

On the other hand the concentration of pollutants may be determined solving Fick's law numerically considering the wind profile, lapse rate, gustiness, topography, variation of diffusion coefficient or other relevent factors.

Dispersion Models

Mathematical approaches have been made to the dispersion of pollutants in the atmosphere and atmospheric dispersion models have been developed based on Fick's molecular diffusion equation and on statistical theory.

For instantaneous point source, models are based on Fick's molecular diffusion equation and on Gutton statistical concepts.

For continuous point source, the dispersion models are based on, plume behaviuor, eddy diffusion, wind speed, and amount of dilution etc., as continuous emission of pollutants result in a plume which is carried by the wind speed and spreads by the intensity of turbulence eddy.

The other, three well known models are: (1) Pasquill Model, (2) American Society of Mechanical Engineers Model and (3) Mc Elroy Model in the field of atmospheric diffusion.

All of these factors are conductive to good dispersion and natural removal of contaminants released into the atmosphere.

Anticyclones are characterized by:

1. subsidence of air (subsidence inversion)
2. generally fair weather
3. slow moving system - light to claim surface winds.

13.4. ACID RAIN

Rain has traditionally been regarded as the harbinger of growth, productivity and prosperity. Mankind has always acknowledged the useful trouble of rain. The 110,000 cu. km. of rain that fall each year have kept much of the earth's life support system alive. It is the most important source of free fresh water. This source of joy provides a new lease on life by greening the landscape (Varshney, 1983).

However, rain has taken a new threatening complexity. Describing the alarming phenomenon in its State of Environment report, the United Nations Environment Programme (UNSP) notes the way in which rain reacts with sulphur and nitrogen oxides that pollute the air to produce 'acid rain'. It is new climatical phenomenon of lower atmosphere dumps brought to the land through rain and wind.

The term acid rain is not new. It was first coined in Manchester, England over a century ago. What is new is that it is perhaps the most pernicious global problem. Subtle but lethal, it has become a crucial ecological issue, particularly in Europe. It is a modern post industrial form of ruination.

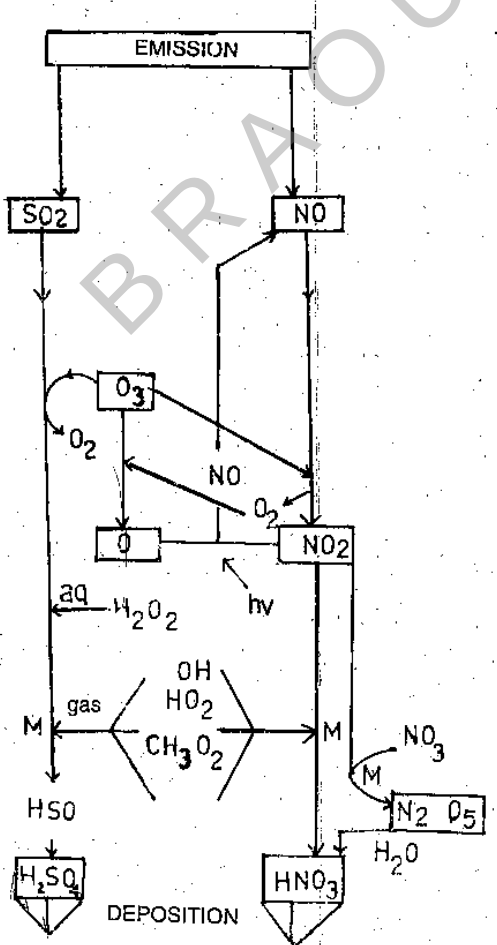

Fig. 13.5. Possible chemical transformation reactions in formation of acid rain.

Soil is affected as acidification due to acid deposition and certain biological processes erodes the fertility. It is suspected to spirit away mineral nutrients within the soil upon which forests depend. It has been seen to damage various kinds of vegetation including croplands and forests. It assaults historic buildings, bridges, dams, industrial equipment, water supply network, power and telecommunication cables and cultural treasures by accelerating erosion. It is known to contaminate drinking water (Malkania and Malkania, 1987). In addition it is known to pose a substantial threat to health by causing skin burns and making holes in cotton clothing.

Acid rain is the term which includes various pollution processes. It is used to describe all precipitation - rain, snow, fog, dew - which is more acidic than normal. It refers to any precipitation which has a pH less than 5.6. The pH of acid rain can be compared with that of common acid and alkaline substances.

Because that pH scale is logarithmic, there is ten-fold increase between numbers. Thus water of pH4 is ten times more acidic than water at pH5 and 100 more at pH6. Acid precipitation generally ranks between 5.6 and 3.5 and in some cases even lower. Because acid rain includes snow, sleet, hail, dew, frost and dry fall, it may be appropriate to call it acid deposition, acid precipitation or 'atmospheric deposition' collectively. The real acid deposition, often turns up days later and hundreds of kilometers away from the source of emission.

The sulphuric acid and nitric acid thus formed remains as vapour under the prevalent high temperatures and begin to condense slowly as the temperature falls. The resulting condensate take the form of aerosol droplets which owing to the presence of unburnt carbon particles, is black, acidic and carbonaceous. This matter is called 'acid-smut' (Agarwal, 1980).

It is believed that oxidation of sulphur dioxide is much slower than that of nitrogen oxides, so that sulphur dioxide may remain airborne for 3 to 4 days, compared with nitrogen oxides which may persist for only half a day. The consequence of this phenomenon is that acid rain derived from sulphur dioxide is transported much farther than nitrogen oxides.

In Europe, the cause of acid rain is largely sulphur oxides followed by nitrogen oxides. Sequeira (1987) recorded trace to slight weighted average free acid levels (pH 5.8 to 4.7) south of 47°N, except in northern Italy. Moderate or high acid contents (pH 4.5 to 4.2) were recorded north of this latitude.

Consequences of Acid Rain: A major consequence of air pollution is acid rain. The pollutants emitted come back along with rain, there by affecting soil, crops, plants etc. Acid precipitation is formed in the atmosphere through conversion of nitrogen oxides and sulphur dioxide. These are transformed into sulphuric and nitric acids through oxidation. Acid rain has a number of hazardous effects on terrestrial ecosystems as:

a) Acidification of soils, altered nutrient supply, increased mobilization of aluminium and other shifts from acid sensitive to acid tolerant species of microbial and soil fauna in the soil, altered rates of decomposition of organics and N_2 fixation.

b) Foliar damage to crops and forests, leaching of nutrients and other substances from leaves, increased or decreased seed germination depending on sensitivity to acidity.

c) Potential indirect effects on forests include acidification of forest soils and alterations in soil chemistry as well as reduced forest productivity, and forest dieback.

Check Your Progress - 3 & 4

3. The term acid rain was first coined in ..... over a century ago.
4. What is the pH of acid rain water.

Note (a) Write the answers in the space provided above and below.

(b) Compare your answers with those given at the end of this unit.

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13.5. REMEDIAL MEASURES

(a) Meteorological elements, though have been damaged due to pollution, still they are the natural means of changing aerial environment. Precipitation and the wind speed and wind direction play a significant role in diluting, transporting and dispersing physically the pollutants that accumulate in a given space and time emphasizing the appropriate role of nature in protecting the environment.

(b) Air pollution is directly linked to dispersion of pollutants and meteorological conditions. Unless these conditions are considered at the time of selection of sites, the problem cannot be mitigated by only handling the pollution at the source. Siting criteria for industrial location has to be made rigorous and no exemption should be permitted.

13.6. LOCATION OF INDUSTRIES AND PRECAUTIONS

Till now the factors considered for locating a new industrial plant were the availability of raw materials, power, water supply, transporting facilities, labour and the market. Now one more critical factor has to be considered by the plant management, i.e., the factor of air pollution control. In fact, the neglect of this aspect of air pollution control in past by many large industries has proved to be a costly error, for today they are facing heavy damage claims, litigation and the necessity of taking control measures after several years of operation.

Factors to be considered for industrial-plant location: While selecting a site from the point of air pollution control, the following should be taken into consideration to avoid costly control measures, improve public relations, and prevent litigation.

1. Existing levels of air contaminants
2. Potential effects on the surrounding area
3. Meteorological factors and climate
4. Topographical features
5. Clean air available
6. Planning and zoning

Existing Levels of Air Contaminants: If the new plant is to be located in an area which is already industrialised, it is a good practice to undertake a pre-operational survey to know the existing levels of contaminants, under prevailing meteorological conditions. This type of survey gives an idea regarding the nature of pollution due to existing industries, i.e., whether the existing level of pollution is high, medium or low. The results of such a survey, with respect to known operational data on the magnitude of contemplated emissions from the new sources, would provide information on the extent to which waste products could be safely discharged into the atmosphere without resulting in too much contamination.

Potential Effects on the Surrounding Area: Another important factor from the point of site selection is to have a knowledge of the specific effects of the major pollutants likely to be discharged into the atmosphere in relation to the population and land use of the area surrounding the site. For example, whether the pollutants will have any effect on the health of the farm animals in that area, is to be considered. A rural and predominantly agricultural area is more affected by fluorides and sulphur dioxide than an urban population. This is because certain pollutants are more toxic and harmful to vegetation but is obnoxious and even dangerous to human life in comparatively low concentrations.

Meteorological Factors and Climate: The prime factors which have to be considered in order to minimise air pollution problems by site selection are the climate and meteorology of the location under consideration. It is important to know the prevailing wind direction, wind speed, and factors favourable for stable atmosphere, i.e., inversion conditions. The dispersive ability of air at each possible site has to be determined.

The ideal site for location of an industry is a level terrain in a region where the average wind speed is of the order of 16 km/h or more and where temperature inversions rarely occur. Also, it is always better, if a populated town or agricultural land is not on the downwind of the proposed site.

Areas where prolonged subsidence inversions occur frequently should be avoided for location of industries if alternate sites are available. Individual valleys where prolonged conditions of stable atmosphere are frequent should be critically examined. Industrialization of these areas must be minimised.

Topographical Features: Air movement is greatly influenced by the topography in the neighbourhood of the site under consideration, like valleys, mountains, etc. In fact, we have to give more attention to air pollution control in valley sites than in level terrain, especially when the average wind velocity is less than 16 kilometers per hour.

Clean Air Available: For example, industries requiring clean air for manufacture are the ones dealing with the manufacture of transistors, electronics, refineries, antibiotics, and vaccines. Also, clean air is required for cooling the reactors of atomic energy plants, since, if polluted air were used, the impurities present would become radioactive and their escape into the atmosphere would create a hazard. In these cases, location of industries in areas of heavy air pollution will add materially to the cost of cleaning the air.

Planning and Zoning: Proper planning and zoning of industrial areas and residential areas can play an important role in the control of air pollution. Residential areas and certain heavy industries should not be located too close to each other. It is always better to have a green belt between industrial areas and residential areas. The concerned municipal authorities should encourage the creation of green belt. If there are any municipal laws and regulations regarding this aspect, they should be strictly enforced.

Recently, scientists have identified a dozen species of trees which have a capacity to absorb industrial pollutants from the air. Many of these trees grow in our country. For example, it has been reported that tamarind and margosa trees are capable of absorbing dust and gas from the atmosphere polluted by cement factories, chemical industries and quarries. This fact has been established by laboratory studies carried out at Ecology Laboratory of Botany Department of Osmania University and jointly by the Toxicological Research Centre and the National Institute of Botanical Research, Lucknow. Therefore, growing suitable trees is an important way of solving the problem of air pollution.

13.7. CITY PLANNING

Today, we are seeing many cities developing in a very haphazard manner. They are now paying the price for the failure to plan for future systematic and homogeneous development. Smoke, dust, fumes, odours and poor zoning practices have spoiled fine residential areas in the heart of the cities have degenerated into slums.

One of the basic principles of country planning is, it must be flexible, continuous and adopted to the local requirements. Residential, commercial and industrial areas must be properly planned. Prime importance must be given for locating sufficient number of public parks and gardens, for they act as lung spaces, especially in the industrial cities. Also, there must be sufficient provision for traffic lanes and parking facilities.

For the proper growth and development of a city, a zoning law is required. And of course, the regulations must be strictly implemented.

Every city or town requires its own zoning ordinance according to the local conditions. As land usage changes, the zoning regulations must be modified to meet new conditions. Satellite towns bordering a city must also be subjected to zoning to provide for orderly growth.

Following are some of the measures that can be taken for air pollution control by planning and zoning:

1. Decentralisation of industry
2. Creation of a green belt between industry and receptor areas
3. Regulations over automobile exhausts
4. Traffic control
5. Creation of smokeless zones in selected areas by limiting industries and residences in those zones to the use of certain specific smokeless fuels.
6. Prohibiting use of volatile fuels.
7. Meteorological means of self purification through 'dilution, dispersion'.

13.8. SUMMARY

Meteorology is the branch of science which deals with the study of earth's atmosphere. Wind speed, wind direction and atmospheric stability are known as primary parameters and ambient temperature, humidity, precipitation, solar radiation, pressure and visibility are secondary parameters which influence the air pollution. Acid rain plays a major role in air pollution.

Rain reacts with sulphur and nitrogen oxides and pollutes the air producing 'Acid Rain'. The pH of the acid rain water will be less than 5.6 and generally between 5.6 and 3.5. It may even be less in some cases. There are a number of hazardous effects on ecosystem by acid rain.

Wind speed, wind direction and precipitation play a significant role in protecting the environment. Selecting a site for industries is also an important factor in environment protection. Following are the important factors to be taken into consideration while selecting a site from the point of air pollution control: (1) Existing levels of air contaminants, (2)

Potential effects on the surrounding area, (3) Meteorological factors and climate, (4) Topographical features, (5) Clean air available and (6) Planning and zoning.

13.9. CHECK YOUR PROGRESS: MODEL ANSWERS

1. The primary or basic meteorological parameters are wind speed, wind direction, and atmospheric stability.
2. Ambient temperature, humidity, precipitation, solar radiation, pressure, and visibility are called secondary meteorological parameters.
3. Manchester, England.
4. The pH of acid rain water is less than 5.6.

13.10. MODEL EXAMINATION QUESTIONS

I. Answer the following questions in about 30 lines each.

1. List out and describe the meteorological factors influencing air pollution.
2. Write in brief about acid rain.
3. Write briefly about the factors that are to be considered for locating the industries.

II. Answer the following questions in about 10 lines each.

1. Explain briefly the meteorological factors influencing air pollution.
2. Describe briefly the adiabatic lapse rate and environmental lapse rate.
3. Discuss briefly the plume characteristics.
4. What is dispersion? Explain briefly.

Prof. S.H. Raza

BLOCK - 5
INDUSTRY IN INDIA

UNIT-14: INDIAN ECONOMY

Contents

14.1. OBJECTIVES

After going through this unit, you will be able to:

* indicate the importance of agriculture in the economy,
* identify the problems faced by agricultural sector,
* explain the industrial policy resolutions,
* analyse the issues of employment,
* describe the migrant labour and
* explain the meaning of development.

14.2. INTRODUCTION

India has an area of 1.2 million square miles which accounts for 2.4% of the total land area of the world. According to the 1991 census, the population of India is 844 million and this is 16% of the world population. The average density of population including desert and arid areas, Lilly and otherwise unpopulated areas is already 689 per square mile. The population of India has been growing at an annual rate of around 2.11 percent per annum between 1981 and 1991 censuses. The growth of the population creates its own demand for diverse social service facilities. Partly as a result of this factor, the average literacy rate was 52.1 percent. Economic development is generally associated with the growth of urbanisation. According

to 1991 census, urban population accounts for 25.1 percent of total population. The occupational pattern of the population can be derived from the census 'count' of the main workers. As per the 1991 census, the work force engaged in the primary sector was 66.8% and the secondary and tertiory sectors account for 33%.

This unit introduces the contribution of Agricultural and Industrial sectors to the GNP, percentage of labour force engaged in these two sectors, progress made by these sectors since independence, governments policies and inter linkage between these two sectors.

14.3. AGRICULTURAL SECTOR

14.3.1. Largest Employment Providing Sector

Labour being a primary factor of production, the size of labour force is of great importance for the level of economic activity in a country. The occupational structure of India reflects clearly the backwardness of the Indian economy. Over the last 80 years, the proportion of working population engaged in the primary sector (agriculture and allied activities) has been steady and not fallen below 67 percent. This is really significant since a large percentage of population dependent on the primary sector is a clear indication of the prevalence of large scale disguised unemployment in agriculture and consequently low per capita labour productivity and prevalence of widespread poverty. In USA and UK only 3 to 4% of working population is engaged in the agricultural sector.

14.3.2. Share of Primary Sector in GDP

In 1950-51 the share of primary sector which includes agriculture, mining forestry and fishery was 55.3 percent. This was on account of practically non-existence of industrial development and infrastructure. However, after the initiation of planning in India, the share of agriculture has persistently declined on account of the development of the secondary and tertiary sectors. From 55.3 percent in Gross Domestic Product (GDP) in 1950-51 the share of primary sector in GDP declined steadily to 44.5% in 1970-71 and further to 31.6% in 1990-91.

However, the mere fact that agriculture still contributes more than 30% of national income shows how important it is for the Indian economy.

The share of primary sector in GDP is often taken as an indicator of economic development. Normally developed economies are less dependent on agriculture as compared to developing countries. For example, only 3% of national income is derived from agriculture in USA and UK. Thus it seems that as the country progresses, the dependence on agriculture declines.

In the developed countries like USA and UK 3 to 4% of the working population is engaged in the agricultural sector and 3 to 4% of national income is derived from the agricultural sector in those countries. Whereas in India 67 percent of working population engaged in the primary sector contributes 31.6 percent of gross domestic product.

Check Your Progress - 1

Comment on the share of primary sector in the GDP

Notes (a) Write the answer in the space provided below.

(b) Compare your answer with the one given at the end of this unit.

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14.3.3. Importance of Agricultural Sector for Industrial Development

In our country, agricultural sector plays an important role in the industrial development. The main source of the raw material supply to the industrial sector is from the agricultural sector. For example, cotton textiles, jute, sugar, vanaspathi, tea, coffee, rubber, coconut etc come from the agricultural sector and all the above items are of basic importance to our economy. In the recent years, the importance of food processing industries is increasingly recognised both in the generation of income and employment. Many of our small scale industries like mice husking, oil crushing, handloom weaving etc depend upon the agricultural sector for their raw materials. These days a lot of agro processing industries are coming up and they get their raw materials from this sector.

All workers engaged in the secondary and tertiary sectors depend for their essential consumption requirements on agriculture. Agricultural sector also provides a market for industrial products.

14.3.4. Role of Agricultural Sector in International Trade

Importance of Indian agriculture arises from the role it plays in India's trade with other countries. For example, agricultural products like tea, coffee, sugar, oil seed, tobacco, spices, cotton textiles, jute etc mainly constitute items of export from India. In recent times fruits and vegetables, prawns, eggs are being exported to the middle east countries. This has great significance for economic development. The increasing exports help the country to pay for the increasing imports of machinery, petroleum, crude, chemicals and other raw materials which are needed for the development of the economy.

14.3.5. Role of Agricultural Sector in Economic Planning

Importance of agriculture in the national economy is indicated by many factors. For example, agriculture is the main support for the transport system in India since railways and roadways secure bulk of their business from the movement of agricultural goods. International trade is mostly confined to agricultural products. Further, good crops imply large purchasing power with the rural masses and that leads to greater demand for the industrial products. There is an universe relationship between agricultural growth and rural poverty. In other words, in those years, when the monsoon is timely and sufficient and crops are good, employment opportunities are abundant, the incidence of poverty is less. Many a time, it is the failure of the agricultural sector that has led to failure of economic planning.

14.3.6. Causes for Low Productivity

Agricultural productivity coverage per hectare is among the lowest in the world. In the recent past, there has been some improvement. It will be useful to analyse the factors responsible for the backwardness of agriculture. It is convenient to group the factors under three headings (i) general factors (ii) institutional factors and (iii) technological factors.

A. General Factors

(i) Over crowding in Agriculture: There are too many people who depend on the agricultural sector for their livelihood. Over crowding and the consequent pressure of population on land are responsible for sub-division and fragmentation of holdings, decline in the per capita area of land, and disguised unemployment.

(ii) Discouraging Rural Atmosphere: In India, the farmers still follow primitive system of cultivation with outdated techniques of production. Only a small percentage of farmers adopt modern techniques of production like hybrid variety of seeds, irrigation, chemical fertilisers etc.

(iii) Inadequate Credit Facilities: Credit is one of the most important aspects in the agricultural sector. The farming community depend to a great extent on money lenders for their input requirements. These money lenders charge very high rates of interest. In the recent times, commercial banks and co-operative banks are catering to the credit requirements of the farming community.

B. Institutional Factors

(i) Size of Holdings: The average size of holdings in India is less than 5 acres. The agricultural holdings are not only small but also fragmented. Since the average agricultural holdings are very small, it is not possible to go for scientific cultivation with improved implements seeds etc. There are many disadvantages of small sized holdings like waste of time, labour and cattle power, difficulty in proper utilization of irrigation facilities, wastage of crops in the absence of fencing etc. One of the reasons for poor agricultural yield is prevalence of small holdings.

(ii) Pattern of Land Tenure: The position of tenants is not satisfactory despite the abolition of the zamindari system. There is no security for the cultivator because he has to pay higher rents for the land he cultivates and he may be turned out of his land at any time the land lord desires. It is difficult to increase agricultural productivity under these circumstances.

C. Technological Factors

(i) Poor Techniques of Production: The old and inefficient methods and techniques of production have been used by the farming community. Only a small percentage of farmers have started adopting improved implements. To increase the fertility and to utilise fallow hands, the use of farm yard manure and chemical fertilisers is very important. In addition, farmers should use high yielding and disease resistant varieties of seeds.

(ii) Limited Irrigation Facilities: Majority of the farmers through out the country have to depend upon rainfall since irrigation facilities are inadequate. Only a small percentage of farmers have and avail the irrigation facility. In the recent years, irrigation facilities are being increasingly made available. Because of irrigation facilities, double cropping, better rotation of crops, fighting plant diseases and pests are looked into. Consequently, land and labour productivity in agriculture is steadily going up.

Check Your Progress - 2

What is meant by inadequate credit facility?

Note (a) Write the answer in the space provided below.

(b) Compare your answer with the one given at the end of this unit.

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14.3.7. Agricultural Policy

Before the mid nineteen sixties, the activities of the government in the food grain economy were limited in scope to the import of grain and its distribution mainly in the urban areas under various forms of motioning. However, with the adoption and promotion of the new agricultural strategy based on the cultivation of high yielding varieties of seeds with the use of modern inputs i.e., fertilisers, pesticides in areas of assured water supply, the government

began to play an important role in the transformation of the agricultural sector. This led to the involvement of the government in various activities such as the development of infrastructural facilities, provision of subsidies of different kinds, supply of inputs and credit and promotion of agronomic resources for the adaptation of crop varieties to Indian conditions. The agricultural price policy was evolved subsequently. It can be seen as an essential part of a larger package of policies designed to promote rapid agricultural growth and to encourage private investment.

14.4. INDIAN INDUSTRY

In 1950, the industrial base of the economy was very small and the industries were beset with many problems such as shortage of raw materials, deficiency of capital underdeveloped infrastructural facilities, bad industrial relations, stagnant economy, transport bottlenecks etc. During the first five year plan the industrial development was confined largely to the consumer goods sector, the important industries being cotton textiles, sugar, salt, soap, leather goods and paper. Industries manufacturing intermediate products like coal, cement steel, power, nonferrous metals, chemicals etc were also established but their production was small as productive capacity was considerably below the requirements.

The first plan was not important from the point of view of industrial development. Since paramount importance was given to the agricultural sector, resources available for industrial development were insufficient. The second plan accorded top priority to programmes of industrialisation. Based on Mahala nobins model, the second plan set out the task of establishing basic and capital goods industries on a large scale so that a strong base for the industrial development could be built in the future. Three steel plants of one million ton ingot capacity each were set up in the public sector at Bhilai, Rourkela and Durgapur besides the expansion and modernisation programmes undertaken in the private sector.

The overall objective of the industrial plan during the third plan was to lay the foundation for further rapid industrialization over the next 15 years. It was considered essential to press forward with the establishment of basic capital and producer goods industries with special emphasis on machine building programmes. This was done so that the growth of the economy in the subsequent plan could become self sustaining. The expansion of the industries was to be done according to the Industrial Policy Resolution of April 1956. Targets of production were fully realised by 1965-66 in the case of following industries namely aluminium, automobiles, electric transformers, cotton textile machinery, machine tools, sugar, jute textiles, power driven pumps, diesel engines and petroleum products. There were substantial short falls in a number of crucial industries (like steel and fertilisers). On the whole, the performance of the Third Five Year Plan cannot be considered satisfactory.

The Fourth Five Year Plan was postponed for full three years because India was in the grip of inflation and depression. A number of factors were responsible for the sluggish growth in the industrial sector during the Fourth Plan period, the more important being (i) sluggishness of demand (ii) shortage of basic raw materials (iii) labour troubles (iv) traffic bottlenecks (v) shortage of coal and power and (vi) low level of capacity utilisation in a number of industries.

The industrial programmes in the Fifth plan were conceived in such a way as to realise the twin objectives of self reliance and growth with social justice. The following pattern of investment and production was envisaged. (i) Rapid growth of the core sector industries, (ii) rapid diversification and growth of export producing industries, (iii) substantial expansion of production of essential consumer goods like cloth, edible oils and vanaspathi, sugar, drugs

and bicycles etc and (iv) restraint on the production of inessential goods.

The target growth rate of industrial production during the Sixth plan was 8 percent and actual growth rate was 5.9 percent. The corresponding figures for the Seventh plan were 8.7 percent and 8.5 percent.

(v) Limiting and controlling foreign investments in domestic industry

(vi) Pursuing self-reliance through import substitution oriented policies of industrial development

(vii) Carving out a central role for the public sector in the process of development.

14.4.1. Industrial Policy

Industrial policy derived from the import substituting strategy was aimed at over coming the resource constraint. This was done through government control of the allocation of scarce resources into priority areas of investment. This control was exercised in two ways. Firstly, crucial areas of investment, namely the basic and capital goods sector largely involved public sector investment. Secondly investment in the private sector was regulated by a system of licensing, permits and controls. Besides the major aim of allocating scarce resources into predesignated areas of priority, industrial policy incorporated objectives which were in keeping with the socialist spirit.

14.4.2. Occupational Structure in Industrial Sector

The process of industrialisation introduced in the middle of the 29th century was limited to plantation and textiles. Heavy investment in manufacturing has made no impact as regards the pattern of occupational distribution since 1951. Considering the overall secondary sector, it looks as if nothing has happened in this sector in terms of employment of workforce. In 1991, 12.7% of the working population was employed in this sector as against 10.7% in 1951. Compared to the position in 1901 when 12.6% work force was engaged in the secondary sector, situation in 1971, 1981, 1991 was 11.2%, 13.5% and 12.7% respectively and they could not be deemed satisfactory.

On the industrial front, the planners made a number of efforts to industrialise the economy specially in the capital goods sector with imported machinery and technical know how. The development of small scale and cottage industries was not given sufficient emphasis/ importance. The plans concentrated on large scale producer goods sector with very little employment generation effects. In addition, there was rapid expansion of luxury durable consumer goods industries, using capital intensive methods, with imported machinery. The highly capital intensive investment structure had very little employment multiplier and thus, produced virtually no effect on the occupational structure.

14.4.3. Share of Secondary Sector in GDP

The secondary sector comprises mining, quarrying, manufacturing industries (factory and non-factory), electricity, gas and water supply and construction. The share of the secondary sector has shown a steady increase from 16.1 percent of GDP in 1950-51 to 28.7 percent in 1990-91. It is pertinent to mention that this sector of Indian economy has grown continuously through out the post independence period. Manufacturing industries and construction are the two major components of the secondary sector. The share of manufacturing in GDP increased from 11.4 percent in 1950-51 to 20.6 percent in 1990-91. Similarly, the share of construction improved from 3.3 percent in 1950-51 to 4.1 percent in 1990-91.

In 1990-91, 12.7 percent of the work force engaged in the secondary sector has a share of 28.7 percent in GDP, where as 67 percent of work force engaged in the primary sector contributes 31.6 percent of GDP.

Check Your Progress - 3 & 4

3. What does the secondary sector comprise?

4. What is the share of the secondary sector in GDP?

Note (a) Write the answers in the space provided below.

(b) Compare your answers with those given at the end of this unit.

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14.5. ISSUES OF EMPLOYMENT

All the Indian five-year plans have stressed a substantial expansion of employment opportunities as a major goal of planning. Operationally, it has been hoped that if employment grows faster than the labour force, all the new entrants into the labour force will be absorbed in gainful employment. Moreover, the backlog of unemployment at the end of the loan period would be smaller than at its start. It is widely believed that these goals have not been achieved.

14.5.1. Crude Worker Population Ratios

The crude worker population ratios are estimated by the four quinquential surveys of the National Sample Survey Organisation (NSSO) i.e., 1972-73; 1977-78; 1983 and 1987-88. The corresponding data from the population censuses are conducted during 1961-91 separately by sex and rural urban residence. The data suggest a reasonable stability since the early 1970's in worker population ratios for rural males was around 54 percent and for rural females between 32-34 percent, for urban males between 49-51 percent and for urban females between 13-15 percent. The worker population ratios for the total population of the country have been stable around 41-41.

14.5.2. Unemployment Rates

Unemployment is measured as percent of the labour force. Underlying rationale is to focus attention on the extent of available labour that is not utilised.

Since early 1970s the NSS has begun to measure unemployment according to three alternative definitions or concepts. The first called the usual status approach, was intended to focus attention on chronic unemployment or the problem of those who remain unemployed for an extended period of time (originally throughout the year but since the late 1970's for major part of the year preceding the date of survey). It is not certain that those classified as 'usually unemployed' really represent the chronically unemployed. In fact, at least in urban areas and among the 'educated' or the matriculates and the higher educated both in rural and urban areas there seems to be a substantial overlap between the usually unemployed and those classified as currently employed or unemployed during the reference week preceding the date of survey.

The latter concept of current unemployment is used internationally and facilitates comparisons across countries. The measurement of unemployment in terms of person days, takes account of unemployment within the reference week.

Estimates of the rate of unemployment according to the weekly status data show the rural unemployment rates to be stable around 4 percent since the early 1960s. The rates of urban unemployment during the 1970's and 1980's have been clearly higher than in 1961-62. But since 1972-73 one observes a certain stability in the rates for males around 6-7 percent and in the rates for females around 9-11 percent.

14.5.3. Employment Problem of Educated

Educational attainment influences the willingness of people to work. In the initial stages, school attendance contributes to a withdrawal of the young children from the work force. Those who complete high school or go to college want to participate in economic activities of a particular type mainly as white collar workers and as regular salaried employees. The education related differences are particularly marked in the case of women.

Since independence, the number of matriculates or secondary school certificate holders and of the higher educated was grown substantially both in rural and urban areas. By January 1, 1988 India has nearly 65 million matriculated or higher educated. Over 24 percent or nearly 16 million were college graduates or higher educated. In urban areas, 7 percent of all men and about 4 percent of all women were graduates. While the rapid growth of high school and college education certainly reflects an achievement, it has also become a major challenge because the work opportunities of the type that they seek have certainly not expanded at the same pace.

14.5.4. Registration of Work Seekers with Employment Exchanges

The NSS data indicate that between 60 to 80 percent of the unemployed matriculates and graduates in both rural and urban areas tend to be on the line register of employment exchanges. The proportion has tended to rise over the years. Along with population growth and a sharp increase in the proportion of matriculates, graduates and higher educated in the population another factor contributing to the rise in the number of persons on the line registers of employment exchanges has been their greater tendency to register. The employment exchange authorities have also relaxed the earlier rule about the periodicity of 'renewal' required to keep a person's name on the live register.

Check Your Progress - 5

Analyse the estimates of the rate of unemployment.

Note (a) Write the answer in the space provided below.

(b) Compare your answer with the one given at the end of this unit.

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14.6. MIGRANT LABOUR

Workers move about systematically seeking and engaging in seasonal temporary employment without becoming residents of the areas in which they work are called migrant labourers. The phenomenon of migrant labour is the result of seasonal and piece rate work that has emerged as a result of a certain type of production technology and the associated organisation of production. Migrant labour is essentially a piece rate wage earner. When he is hired for a certain amount of work, it is the quantum of work which is important and not the hours of work.

Migrant labour is also seasonal labour. Such seasonal work is a feature of the unorganised sector. The operations in certain enterprises like mines, brick links, construction, salt pans, commercial agriculture etc are seasonal. Work in such enterprises starts after the monsoon season and ends prior to the first rain.

There are various patterns that migration can take in terms of time span. Migrant can be permanent, a once for all outward movement. It can be seasonal when the workers move into work for certain short but recurrent periods. It could be circulational when the worker moves with definite periodicity between places.

The strategy of employing migrant labour appears to have been adopted more usually as a strategy to secure better control over the labour process rather than to make up for an absolute shortage of local labour. The hopes that the geographical relocation of the labour from slow growing region through migration would allow permanent and productive employment in the informal sector.

By using the information on the rural and urban character of the birth place and the place of enumeration of the migrants, four migration streams can be identified (i) rural to rural (2) rural to urban (3) urban to urban and (4) urban to rural. The dominant stream of migration was from rural to urban areas in all the four censuses i.e., 1961, 1971, 1981 and 1991. Males clearly out numbered females among rural urban migrants in India as a whole.

Reasons for Migration: The census has extended the scope of migration data by seeking to record reasons for migration. Keeping operational constraints in view, fine broad reasons for migration have been distinguished: (i) employment (ii) education (iii) marriage (iv) family movements and (v) other reasons. The reasons for migration have been elicited only

with reference to movement from the place of last residence to the place of enumeration. The census data confirm that employment was the main reason for migration among males while marriage was the main reason for migration among females.

About 48 percent of rural urban male migrants had moved for employment considerations. About 51 percent of rural-urban females migrants had moved because of marriage. The next important reason for migration among females was that the 'family moved'. About 29 percent of rural urban female migrants had moved for this reason.

Check Your Progress - 6

What are the reasons for migration?

Note (a) Write the answer in the space provided below.

(b) Compare your answer with the one given at the end of this unit.

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14.7. DEVELOPMENT AND ITS MEANING

Development consists of much more than an increase in per capita income. It is desired for many and complex reasons of which the increase in per capita income is merely one. Economic development implies both more output and changes in the technical and institutional arrangements by which it is produced. Development is concerned with the attitudes and abilities of people as influenced by education, access to infrastructure and the nature of institutions. In other words development is concerned with educational stocks and flows, fertility and mortality rates, availability of physical and social infrastructure etc. The concept of development is the pervasiveness of modern economic behaviour and the ability of people to absorb modern technology where education deals with the human aspect, infrastructure deals with the physical aspect and institutions deal with the working of economic institutions especially goods and factor markets.

It is not enough to say that economic development is determined by the supply of resources, available techniques, the organisation of markets, the institutional frame work of economic life and the psychology of the people. The above variables are prominent determinants of development. There are other factors underlying them. The process of development must bring out these underlying factors too. Full interpretation of economic development must consider non-economic factors also. Political sociological and psychological factors have a great deal of relevance in the matter of economic development. The nature of the government, the type of the legal system, the standard of education and health, the attitudes and out look of the people, the role of the family etc have all an intimate bearing on the process of economic development. Another essential element in economic development is that it has to be steady and sustained.

14.8. SUMMARY

The unit tries to explain the importance of agriculture in terms of providing employment to the growing labour force and its share in the gross national product. The role of agricultural sector in international trade and industrial development are discussed. The causes for low productivity like over crowding in agriculture, inadequate credit facilities, size of holdings, pattern of land tenure and some technological factors are discussed.

This unit also analyses the industrial policy resolutions right from 1948. The occupational structure and the share of secondary sector in GDP are presented.

The important issues of employment like participation rates and unemployment rates, problems of the educated unemployed are explained. The types and problems of migrant labour are analysed.

In the last part of the unit, the meaning of development and features of development are dealt with.

14.9. CHECK YOUR PROGRESS : MODEL ANSWERS

1. The share of the primary sector in GDP was 55.3 percent in 1950-51. Gradually, after the initiation of planning in India, it has declined to 44.5 percent in 1970-71 and further to 31.6 percent in 1990-91. In the primary sector, about 67 percent of the labour force is engaged but their contribution to GDP is less than half.

2. In the Indian agriculture, credit is one of the important inputs. The farming community requires credit to buy the inputs like seeds, fertilisers, pesticides, services of labour, water, electricity etc. The commercial and co-operative banks do not cater to the credit requirements of the farmers in time. They have lot of formalities to be completed and they are time consuming. Farmers depend upon money lenders. Hence, credit facilities are inadequate.

3. The secondary sector comprises mining, quarrying, manufacturing industries (factory and non-factory), electricity, gas and water supply and construction.

4. The share of the secondary sector in GDP was 16.1 percent in 1950-51 and it has increased to 28.7 percent in 1990-91. There are two components of the secondary sector namely manufacturing and construction whose GDP has increased. The share of manufacturing in GDP increased from 11.4 percent in 1950-51 to 20.6 percent in 1990-91. Similarly the share of construction improved from 3.3 percent in 1950-51 to 4.1 percent in 1990-91.

5. According to the weekly status concept, the rural unemployment rates were around 4 percent since the early 1960s. The rates of urban unemployment for males were around 6-7 percent and for females were around 9-11 percent. Since 1972-73, there was stability in the unemployment rates of males and females in the urban areas.

6. The reasons for migration have been elicited with reference to movement from the place of last residence to the place of renumeration. There are five reasons for migration. They are (i) employment (ii) education (iii) marriage (iv) family movements and (v) other reasons.

14.10. MODEL EXAMINATION QUESTIONS

I. Answer the following questions in about 30 lines each.

1. Explain the importance of the agricultural sector to the Indian economy.
2. What are the causes for low productivity of the agricultural sector?
3. What are the objectives of the industrial policies?
4. Analyse the importance of the industrial sector to the Indian economy.
5. What are the various issues of employment? Analyse them.

II. Answer the following questions in about 10 lines each.

1. Comment on the share of the primary sector in the GDP.
2. What is the contribution of the agricultural sector in the industrial development of the country?
3. Explain the agricultural policy of India.
4. Describe the occupational structure of the labour force in the industrial sector.
5. What do you mean by migrant labour? Describe them.
6. Analyse different dimensions of the meaning of development.

Dr. S. Sudhakar Reddy

UNIT-15 : TECHNOLOGIES

Contents

15.1. OBJECTIVES

By the end of the unit, you will be able to:

* explain the meaning of technology,
* describe the technology policies,
* analyse different types of pollution and
* explain technology transfer, its methods and constraints

15.2. INTRODUCTION

Technology can be regarded as a factor input or resource. It underlies the process of producing new things with existing resources or using the existing resources in new ways. Technology represents a combination of a given set of factors defined in relation to certain outputs. Technology is regarded as a set of pieces of knowledge, both directly 'practical and theoretical' know how, methods, procedures, experiences of success and failures and also physical devices and equipment.

Technical progress is that technical change which results in an increased output per unit of labour. Technical change in the context of economic development must result in more output for the same resources or the same amount of output for less resources.

The rate of technical progress depends upon a number of factors like educational structure, scientific activity, managerial skills, attitudes to change trade union activity and the rate of investment. Of all the variables, the rate of investment appears to be the most important determinant of the rate of technical progress.

The development strategy starting with the second five year plan and until recently has emphasised import substitution led industrialisation based on capital goods industries with the aim of achieving technological development for self-reliance. The need for special treatment of Science and technology (S&T) is recognised quite early and reflected in the science policy Resolution of 1958. The important aspects of the Indian strategy have been priority investment in capital goods, science and Technology infrastructure, and skill formation for strengthening national technological capability.

Development plans apart, policy instruments (import controls, industrial licensing, regulations on foreign exchange, foreign investments, foreign control and foreign technical collaborations) in principle aim to strengthen the India's technological capacity and to reduce its technological dependence.

15.3. MEANING AND DEFINITION OF TECHNOLOGICAL SELF RELIANCE

Technological self-reliance in the Indian content may be defined as a process of increasing through R & D efforts the nations capacity to acquire and adapt imported technologies. And also to innovate further on that basis so as to increase its internal technological capacity and to reduce its external technological dependence. By and large, the country can said to be more self-reliant in technology if over time its expenditure on technology import reduces relative to its expenditure on R & D and vice versa. The relatively reduced expenditure on technology import implies reduced dependence, and increased expenditure on R & D an improvement in the technological capacity.

We are not presuming here that the pursuit of self-reliance should confine itself to local adaptation of imported technologies and innovations of incremental improvements. Technology import and local adaptation constitute only one input to the firm's capacity to move on the path of self-reliance. There may be areas where technological requirements cannot be met by imports and therefore need to be developed through exclusive indigenous process in an innovative environment. It can be stimulated by import of technology and its local adaptation by domestic R & D. Technical change is very much the outcome of domestic R & D efforts. The knowledge and experience gained from the initial import is used to raise the importing firm's capacity to generate its own subsequent path to technical change. Therefore, the need is to plan collaborations agreements in ways that would ensure effective transfer of basic knowledge and know how for subsequent absorption, adaptation and improvement.

15.4. TECHNOLOGY POLICY STATEMENT

The need to back up the scientific policy Resolution and the attempts at science and technology planning, with a technology policy, has been increasingly felt in recent years. The Government of India brought out a 'Technology Policy Statement' in January, 1983. The main objectives presented in this policy are:

(i) to attain technological competence and self-reliance

(ii) to reduce vulnerability particularly in strategic and critical areas, making the maximum use of indigenous resources

(iii) to use traditional skills and capabilities making them commercially competitive

(iv) to develop technologies which are internationally competitive and have export potential

(v) to reduce demands on energy, especially from non-renewable sources

(vi) to ensure harmony with the environment

The technological policy statement reiterated self-reliance as the basic aim and the development of indigenous technology and efficient absorption and adaptation of imported technology as the strategy. In the policy statement and administrative guidelines in India, technological

self-reliance is seen consistent with the use of a mix of imported and indigenous technologies. The statement also indicated that a mix in which proportion of imported technologies is sought to be reduced over time. The goal of technological self-reliance is sought to be achieved by an 'import-adapt' strategy. This seeks selective import of foreign technology and its subsequent absorption, adaptation and upgradation to suit to domestic resources and conditions by increasing efforts to domestic R & D activities.

The technology import policy that has evolved over the year has the following features. Firstly, it is selective and seeks to provide protection to local technology wherever available local sources in respect of all individual components of technology viz., consultancy know how, skills, capital goods, receive protection from their foreign counterparts. Secondly, it seeks to reduce the direct and indirect costs of technology imports by regulating the royalty rates, other payments, the duration and restrictive clauses. Thirdly, it discourages packaged imports of technology. For instance, technology import through foreign direct investments (foreign financial collaboration) are restricted only to a selected relatively complex technology industries. The imports of designs/drawings/capital goods are relatively easier. Finally, there is emphasis on rapid absorption, indigenisation and updating of the acquired technology.

Check Your Progress - 1

1. What are the features of technology import policy?

Note: (a) Write the answer in the space provided below.

(b) Compare your answer with the one given at the end of this unit.

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15.5. TECHNOLOGY MISSIONS

Modern science and technology are rather young. The large scale growth of science and technology have taken place only in the post independence era. New challenges were taken up. A mission-oriented approach was followed in the case of atomic energy and space, and in agriculture especially in irrigated areas; with the results that the country is proud of. For example, India could continue with its atomic energy programme in spite of the embargoes on various kinds of materials, components and equipments following the peaceful nuclear experiment. It could withstand the U.S. pressures with regard to fullscape safeguards.

The importance of defining Missions - technological and societal - end of delineating the strategy and the tasks against a long term perspective and assigning the responsibility, the necessary resources and powers and the accountability to well selected individuals and terms has been well-exemplified by our atomic energy and space programmes, and by the green revolution and the eradication of small pox.

Five missions have been established in 1986. They were (i) drinking water (ii) oil seeds (iii) vaccination of children (iv) eradication of illiteracy and (v) telecommunications.

15.6. POLLUTION

The history of industrial growth has also been the history of environmental degradation. It implies in effect the passing down of the cost of development to succeeding generations. In recent times, the relentless pressure of population has led to environmental degradation. Man has been changing his environment ever since he shifted from the 'hunting and collecting' mode of life to settled agriculture. The very process of cultivation involved the clearing of forests and the systematic tilling of the soil, the construction of buildings and later the process of irrigation by diverting water from existing channels to the cultivated farms.

We should try to understand the three 'areas' of environmental degradation. The degradation of the environment occurs through the pollution of the air (that we breathe) and of water (on which all life depends), as well as through changes on the earth which may have other harmful effects.

Pollution of the atmosphere is easy to see. Factories belching chemicals and smoke, car exhaust fumes which cannot be seen but which nevertheless pollute the very air we breathe are clear examples of atmospheric pollution. In recent times, diverse sprays (like aerosols) which have become a part of modern urban life may be said to be causing even greater harm than the large factories. Aerosols have the effect of destroying the ozone in the atmosphere surrounding the earth.

Pollution of water is also equally visible from the discharge of effluents from large factories in which chemical process plants are the worst offenders. Leather, paper, heavy chemicals, fertilisers, drugs and pharmaceuticals and a number of other industries have traditionally been discharging their effluents and waste products into nearby rivers. These effluents and waste products kill all fish and other marine life and render the water of these rivers unfit for consumption. Since, the five lakh odd villages in India do not have a piped supply of treated and purified water, they have to depend largely on water drawn from rivers. Because of this, both the human and the cattle population are exposed to the hazard of drinking polluted water. Even where water is drawn for drinking purposes from wells, the seepage of polluted water can make well water unsafe for drinking. This polluted water causes numerous water-borne diseases. The pollution of water in the process of industrialisation is therefore a major problem. The costs are passed on by industry to the entire population.

Both the above forms of environmental degradation have drawn the attention of social reformers and of governments. Many laws have been enacted in different countries to prevent or at least minimize the adverse effects of such environmental pollution.

Apart from the pollution of the air and water, there is a third aspect from the long term point of view, which is increasingly hazardous form of environmental degradation by way of changing the face of the earth. This takes two major forms, though there are other ways of inviting such environmental degradation. These two arise from unplanned mining and quarrying activity; and the felling of trees.

15.7. TECHNOLOGY TRANSFER

One of the important tasks is to raise technological horizon so as to meet the requirements

of development programmes. The gap between the technological requirements implicit in the development programme and the domestic stock of technology is wide to be bridged entirely through indigenous technological growth. Transfer of technology from the developed countries will help to fill this gap more easily and in less time.

The role of transfer of technology is two fold. Firstly, it goes to supplement the domestically available technology. In this way, it thus helps to fill up or atleast narrow down the gap. Secondly, it supplements the domestic capacity to generate new technology. While the first is more important in the short run, the latter is more significant in the long run.

15.7.1. Methods of Technology Transfers

The transfer of technology from one country to another can take place in a number of ways. Some of the most important ways are

i) through the exchange of journals, books and other published information

ii) through the exchange of technical personnel

iii) through foreign investment and the associated transfer of equipment and know how

iv) through technical collaboration programmes - both official and private

v) through import of machinery and equipment

vi) through licensing, patent and know-how agreements.

In actual practice, transfer of technology cannot be effected freely. There are secrecy and property rights in process and product know how. Actually, transfer of technology takes place only if the organisations possessing technical know how are prepared to make a specific effort directed to the recipient. So the profit making organisations are not willing to allow their technology to be made use of elsewhere unless they are compensated financially. Of late, there has grown an international market in licensing and know-how agreements.

15.7.2. Constraints of Technology Transfer

There are several problems associated with the assimilation and adaptation of technology of the developed countries. The more important of these are the following:

i) **Constraints of foreign exchange and managerial skills:** The constraints imposed by the scarcity of foreign exchange and the managerial skills are big hurdles in the technological transformation. India needs to have those technologies which can economise on such scarcities. This in turn would require those technologies to be adopted which can be installed with the available. Supply of human and physical resources and are commensurate with the emerging levels of productive capacity.

ii) **Lack of adequate human resources and social organisations:** In view of capital shortage, the developing countries opt for labour intensive techniques. But the dilution of the capital intensive technologies of the developed countries to the required labour intensive level calls for suitable technological adjustments. This in turn necessitates a certain minimum level of human resources and social organisation. And it is precisely in these things that India lacks. The indigenous engineering and design capabilities are far too inadequate.

iii) **Investment costs and technological conversion costs:** Quite apart from the problem

of choice of a suitable technology, India is faced with the problems of fitting that technology to its environment. In this regard, there are two courses open. It can either duplicate the product designs and production systems with minor adjustments to allow for the differences in the scale of production and relative factor supplies. Alternatively, it may make major adjustments in the product designs and production systems to allow for the difference in the stage of development. In either case, some costs of fitting the imported technology to the native environment are involved. In the first choice, there are investment costs to develop the human resources and production environments. The second alternative involves technological conversion costs to adapt product designs and the production system.

iv) Difficulties of Conversions and Adaptability, of Inappropriate Technology: The technological transformation faces another serious dilemma. A technology appropriate to India's factor endowments calls for economising on its scarce resource (capital) and making more intensive use of its abundant factor (labour). On the other hand, the technological shelf of the advanced countries offers technologies which are the other way round.

Several factors limit the capability to adapt or convert technologies to the existing factor endowments. Firstly, technological conversions so as to make effective use of available resources calls for a high level of human organisation in which India is deficient. Secondly, India lacks essential industrial capabilities and skill to organise, manage, and control production. Thirdly, the requirements in terms of quality and precision impose absolute limits to the technical feasibility of converting a capital intensive technology into a labour intensive one. There are limits to which human skills substitute the machine capabilities. Finally, lack of competition or inefficient planning also restricts adoption of optimal technology.

(v) Protectionist Policies: India is under strong economic and political pressure to establish industries in order to create employment, utilise local resources and save foreign exchange. But the protectionist policies hamper technological transformation, in a number of ways. For instance, under protective umbrella, there is a tendency to start a wide range of industries - right from steel and cement to heavy electrical equipment. This necessarily results in spreading thin the scarce resources like capital and critical technical and managerial skills over a wide range of processing and manufacturing industries. Consequently, the modern technologies cannot be handled and the technological absorptive capacity is all the more strained.

The protectionist policies are a hurdle to technological transformation in another way also. Protection, as is well known, fosters a seller's market. And a seller's market tends to adversely affect the technical standards throughout the economy. It is a breeding place for a built in obsolecene of the technologies. Consequently, the technological lag behind the developed countries tends progressively to increase.

There exists a positive relationship between the rate of investment and the rate of technical progress. A high rate of investment is conductive to the profitability of inventing and developing superior technology. Firstly, it is from the cost side. It is nothing but the expenditure incurred on research and development to invent and develop superior methods of production. Secondly, it is from the benefit side which is nothing but the reductions in the cost of production that are made possible by the use of new equipment incorporating improved technology.

Technical progress calls for heavy investment in education and training, in research and development (R and D) and in plants and equipment that embody the results of R and D.

Additions in the stock of knowledge do not contribute to economic growth. It is only when the new knowledge or the invention is effectively assimilated in the production system that it would contribute to the growth of the economy. In terms of a market economy, it would imply that the commercial exploitation of technical knowledge. With a view to create new markets or to protect the existing ones against competition by effecting reduction in the costs of production of the already existing goods or the introduction of new or more efficient products.

The stock of technological knowledge form the basis of innovations which can be enhanced through R & D efforts. The R and D does not constitute the total innovational process. It is only a part of it. The R and D is just the first stage in the total innovation process. For the technical progress to contribute to economic growth, we need a continuous innovative chain that links scientific research, marketing research, invention, development design, tooling and marketing of the new product.

Innovation and investment are intimately inter-linked. While a potentially profitable innovation stimulates investment, a high level of investment in twin promotes innovation to take advantage of the technological advances.

Whatever be the nature of this relationship, market provides the major impetus to successful innovation. It is basically the pressures from the marketing function due to the need for effecting reduction in costs or evolving improved processes or products necessitate R & D. As such the R and D effort is not a spontaneous operation but has to be a well planned and directed exercise.

Check Your Progress - 2 & 3

2. What is the role of technology transfer?

3. What is the type of relationship between threat of investment and the rate of technical progress?

Note: (a) Write the answers in the space provided below.

(b) Compare your answers with those given at the end of this unit.

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15.8. SUMMARY

This unit explains the meaning of technology, technical progress and technological self-reliance. Technology policy statements are discussed. The meaning of pollution, types of pollution are elaborated.

The meaning of technology transfer methods of technology transfer and constraints of technology transfer are discussed in detail.

15.9. CHECK YOUR PROGRESS : MODEL ANSWERS

1. Firstly, it is selective and seeks to provide protection to local technology wherever available. Secondly, it seeks to reduce the direct and indirect costs of technology imports by regulating the royalty rates, other payments, the duration and restrictive clauses. Thirdly, it discourages packaged imports of technology. Finally, there is emphasis on rapid absorption, indigenisation and updating of the acquired technology.

2. Firstly, it goes to supplement the domestically available technology. In this way, it helps to fill up or atleast narrow down the gap. Secondly, it supplements the domestic capacity to generate new technology. While the former is more important in the short run, the latter is more significant in the long run.

3. There exists a positive relationship between the rate of investment and the rate of technical progress. A high rate of investment is conducive to the profitability of investing and developing superior technology. Firstly, it is from the cost side. It is nothing but the expenditure incurred on research and development to invent and develop superior methods of production. Secondly, it is from the benefit side which is nothing but the reductions in the cost of production.

15.10. MODEL EXAMINATION QUESTIONS

I. Answer the following questions in about 30 lines each.

1. What are the objectives of technology policy statements?
2. Describe the types of pollution that are prevalent in India.
3. In how many ways technology transfers take place? What are they?
4. What are the constraints of technology transfer?

II. Answer the following questions in about 10 lines.

1. What do you mean by technical progress?
2. Describe the features of the import policy.
3. Explain the technology missions.
4. Is foreign exchange a constraint for technology transfer?
5. Analyse the problems in converting and adapting technology.

Dr. S. Sudhakar Reddy

UNIT - 16: INDUSTRIALISATION

Contents

16.1. OBJECTIVES

After going through this unit, you will be able to:

* analyse the meaning of small scale industries,
* describe the role and problems of small scale industries,
* explain the role of large scale industries,
* identify the problems of large scale industries,
* distinguish the small scale industries from large scale industries,
* describe the role of the iron and steel industry and
* describe the importance of cement, chemical and fertiliser industries.

16.2. INTRODUCTION

At the time of independence, India inherited a weak industrial base, underdeveloped infrastructural facilities and a stagnant economy. In addition to this industrial activity had suffered a steep fall due to difficulties in procuring raw materials, transport bottlenecks, backlog of equipment replacement and labour unrest. Hence, the process of industrialisation was accorded top priority right from the First Five Year Plan. In the Second Five Year Plan, the strategy for industrialisation was spelt out clearly. For rapid industrialisation the country must aim at developing basic industries and industries which make machines to make the machines needed for further development. This calls for substantial expansion in iron ore, steel, non-ferrous metals, coal, cement, heavy industries and other industries of basic importance.

Right from the time of independence, the industrial policies were announced from time to time through industrial rolling resolution viz., Industrial Policy (1948), Industrial Policy Resolution (1956), Industrial Policy Statement (1977) and industrial Policy of 1980 and 1990. In the backdrop of these industrial policies, this unit on industrialisation is based.

16.3. SMALL SCALE INDUSTRIES

One of the important features of the Indian economy since independence is the rapid growth of the small scale industry. The small scale industrial sector plays a pivotal role in terms of employment and growth. During the last decade alone, the small scale sector has progressed from the production of simple consumer goods to the manufacture of many sophisticated and precision products like electronics control systems, micro-wave components, electro-medical equipment, T.V. sets etc.

Small scale enterprises were defined as undertakings with a fixed capital investment limit of Rs. 60 lakhs with effect from May, 1990. Those units which will export 30% of their output by the third year of their starting production will have an incentive that their investment limit is further raised to Rs. 75 lakhs.

16.3.1. Role of Small Scale Industries

The second plan emphasised the role of small scale industries on the following four grounds: (1) Generation of employment opportunities (2) An equitable distribution of income (3) Mobilisation of capital and entrepreneurial skills and (4) Regional dispersal of industries. Let us now discuss these arguments in favour of small scale industries in detail.

16.3.2. Employment Generation

The advantage of small scale industries is that they are generally labour intensive and create more employment per unit of capital employed. Since capital is source and labour is abundant in India, the employment argument is the strongest argument that can be *put* forward for the support of small scale industries in India. P.C. Mahalanobis had this to say on the employment potential of small scale industries. "In view of the meagreness of capital resources, there is no possibility in the short run, for creating much employment through the factory industries. Now consider the household or cottage industries. They require very little capital. With any given investment, employment possibilities would be ten or fifteen or twenty times greater in comparison with corresponding factory industries.

16.3.3. Equitable Distribution of Income

The income generated in a large number of small enterprises is dispersed more widely in the community. In other words, the income benefit of small enterprises is derived by large population. Moreover, small enterprises are either proprietary or partnership concerns. Because of these factors, the relations between the workers and the employers are more cordial.

According to Dhar and Lydall, this argument is wrong because workers in small enterprises are unorganised and cannot fight for their rights. Since trade unions do not exist in small enterprises, employers exploit the workers by paying low wages by denying social security schemes etc.

But on the contrary, it is also true that the workers have a choice between a low paid jobs in small scale enterprises or no jobs at all. Since employment opportunities are limited, workers have no choice except to accept a low paid job in small enterprises.

16.3.4. Mobilisation of Capital Entrepreneurial Skills

The small scale enterprises are at a distinct advantage as far as the mobilisation of capital is concerned. They are able to mobilise the savings of people like hoarded wealth, entrepreneurability etc. The small enterprises encourage the growth of a class of small entrepreneurs which introduces a dynamic element in the economy. These enterprises provide congenial atmosphere and environment which encourage a growing net work of feeder and complementary relations among plants and firms. It is this environment which leads to localised innovations and cost saving measures. Given the basic infrastructural facilities and conditions such as supply of power, credit facilities etc., the hidden talents of entrepreneurship can be topped by the growth of small enterprises.

16.3.5. Regional Dispersal of Industries

To benefit from modern industrialisation, the small towns and rural areas attract a large number of rural small enterprises. It may not be feasible to start small enterprises in energy town and village, but it is quite possible to select a group of villages and start small enterprises to cater to the needs of the small area from the local centre.

The regional dispersal of small enterprises helps to top local resources such as raw materials, idle savings, local talents. This process leads to improvement in the standard of living of people in the backward areas. And also dispersal of industries helps to solve the problems of congestion in few industrial towns by enlarging the area of employment.

16.13.6. Problems of Small Scale Industries

The small scale industries face a number of problems such as (i) lack of finance and credit (ii) raw material availability (iii) low technical skill and managerial ability (iv) problems of marketing and (v) industrial estates. It is necessary to develop an overall approach to remove these disadvantages so as to strengthen their competitive position. Let us discuss them in some detail.

Finance and Credit: The scarcity of finance and credit is the main obstacle in the development of small scale enterprises. Their internal resources are so small that they have no surplus to live on during the period of business strain. This leads to instability of their profits. As a result of this, banks do not come forward to give loans/credit. In many cases, such credit is obtained on very high rate of interest and is thus exploitative in character. There is a need for a positive change in the out look and approach of our financial

institutions towards small scale enterprises. Their credit worthiness should not be judged in terms of the value of assets but in terms of the ability of an enterprise to do the job and earn profit. This requires the evolution of a system of integrated credit whereby long term and short term credit is provided adequately at a reasonable rate of interest.

During the recent past i.e., in the 90's the steady increase is seen in the flour of institutional credit to small scale enterprises. Inspite of the vast increase in the credit facilities for small scale industries, most artisans and crafts men particularly belonging to the poorer sections and working in small tours and villages are unable to obtain their credit requirements.

Raw Material Availability: The majority of the small scale industries depend on the local resources for their raw material requirements. However, ever since the modern small scale industries have appeared on the industrial horizon, manufacturing a lot of sophisticated new products, the new material constraint have emerged as a significant constraint on their production efforts. Many small scale industries use imported raw material. Whenever there was a difficulty in obtaining this raw material either on account of the foreign exchange crisis or some other reasons, these small scale enterprises had to suffer a severe set back. In other words, small scale industries get more or less a 'residuary' treatment in raw material distribution and allocation.

Low Technical Skill and Managerial Ability: The development of small scale industries is affected by the present low level of technology and shortage of trained and skilled personnel. If technical service is provided, it will stimulate increased productive efficiency and encourage new product lines in response to the change in attitudes and fashions of the people.

There are at present two facilities for providing technical advice and assistance to small enterprises. Firstly, central small scale industries organisation provides the assistance of its technically qualified staffs services to give advice to small entrepreneurs on the technical problems they are facing. Secondly, technical assistance is given by the common facility workshops in undertaking difficult production operations on behalf of small scale industries. They collect their costs and do not charge interest and depreciation on the machinery employed.

Problems of marketing: One of the main problems faced by the small scale industries is in the field of marketing. These industries often do not possess any marketing organisation and consequently face difficulties in selling of their produce. Secondary, the products of small scale industries are often unstandardised and of variable quality. Often the quality of their products compares unfavourably with the quality of the products of the large scale industries. Therefore, they suffer from a competitive disadvantage vis-a-vis large scale units. There is a clear case for government intervention to eliminate these imperfections by improving information, and bringing producers and dealers into close contact with one another.

Industrial Estates: It is an attempt to provide on rental basis, accommodation and other basic common facilities to groups of small entrepreneurs who would otherwise find it difficult to secure these facilities at a reasonable price. Important factors accounting for less output and low employment performance of many estates include wrong location, unsuitability of sheds and space to the needy, low use of capacity in functioning firms and occupation of faction sheds by government agencies.

Check Your Progress - 1, 2 & 3

1. What are the advantages of regional dispersal of small enterprises?
2. What are the problems in procuring materials for small scale industries?
3. What are the problems faced by the small scale industries with regard to marketing their output.

Note: (a) Write the answers in the space provided below.

(b) Compare your answers with those given at the end of this unit.

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16.4. LARGE SCALE INDUSTRIES

Industrialisation is emphasized because of the close positive link between industrialisation, modernization and economic development. The output of large scale industries can be broadly divided into the following three categories.

(i) Capital goods and equipment like machines, plants etc (ii) Intermediate goods (that are used by other industries as raw material in the production process) and (iii) consumer goods. Most of the capital goods are produced in the large scale sector and these goods provide the backbone of any industrial programmes in a nation. In addition the large scale industries also produce a substantial quantity of intermediate products and consumer goods.

16.4.1. Building up of Infrastructure

In basic economic infrastructure, generally transport, communications, energy sources and basic and capital goods industries are included. The basic heavy industries are iron and steel, heavy engineering, light machinery goods, transport equipment, electrical equipment, chemicals, oil refining and mining. Without their establishment and adequate progress, the conditions for sound economic development cannot be created. On account of this reason, under the Mahalanobis model accepted in the second plan, it was decided to emphasize the development of basic heavy industries for the manufacture of producer goods to strengthen the foundations of economic independence. It was decided to develop the basic heavy industries so that the country becomes self sufficient in the production of steel and other capital goods within a short period of time.

Because of the establishment of large scale industries in the engineering goods sector during the planning period, the country has made rapid studies towards self-sufficiency in the industrial sector. At present, the country produces a large range of electrical, non-electrical machinery, heavy machinery and plant, chemicals and fertilisers, locomotives and railway wagons, electronic goods, machine tools etc.

It is obvious that the production of iron and steel can be done in an efficient way only when it is undertaken on a large scale. For this purpose, some plants were set up in the second plant under the public sector. The setting up of the iron and steel industry increases the demand for various raw materials like coal, pig iron, manganese etc., which are used by this industry. Accordingly, the industries producing them also receive about. In addition, increase in the availability of iron and steel in the market promotes the development of industries like machine tools, heavy engineering, transport, defence industries etc., which use iron and steel as raw material in production.

Goods of basic importance like chemicals, cement, fertilisers etc., are also produced under the large scale sector in India. The chemicals and fertiliser industries have been developed mostly in the planning period.

16.4.2. Import Substitution

In India large scale industries have helped in reducing the demand for a number of imports. The strategy has been to produce heavy engineering goods, machine tools, iron and steel, chemicals and drugs, fertilisers etc., in the country itself on the one hand, and to set up a large number of consumer goods industries on the other hand. In the initial stages of planning, the imports of consumer goods were restricted to enable the economy to import the basic capital goods essential for carrying out the programmes of industrialisation. At present the country has developed the capacity to produce most of these goods at home. Despite technological handicaps, these industries have succeeded remarkably in adjusting their output according to the requirements of domestic demand. This has helped the country in fulfilling its objectives of import substitutions.

16.4.3. Contribution to Export Earnings

Although a substantial part of India's exports is still composed of primary goods and raw materials, yet they have considerably diversified over the years. The products of large scale industries now occupy a significant place in our country's export earnings. At present, many industries like electrical plant and machinery, heavy engineering goods, transport equipment, iron and steel etc., export a part of their production to a number of countries. Engineering goods have merged as the most important export item. The results of large scale industrialisation are also expressed through the increasing volume of exports of chemicals and allied products.

16.4.4. Production of Consumer Goods

A variety of consumer goods are produced by industrial units established in the large scale sector. Because of division of labour, better techniques of production and upto date technology, these industries are in a position to produce consumer goods on a mass scale at prices which common man can afford. The goods produced by the large scale sector are qualitatively superior and more durable.

16.4.5. Generation of Economic Surplus

In India, large scale industries have a significant role from the view of economic development. For regular and steady progress, it is necessary to provide for accumulation of capital or generation of economic surplus on a wide scale. The large scale industries employ capital intensive techniques which generate substantial economic surplus.

16.4.6. Problems of Large Scale Industries

The large scale industries have different problems with regard to their managerial operation, efficient running, labour availability, raw material supply etc. It is not possible to go into these problems separately. However, we highlight below only those problems that are related to the large scale of operations of these industries and which are prevalent in all large scale industries.

Capital Requirements: A large amount of fixed capital is required to set up large scale industries. To obtain necessary capital, the companies are led to float shares and debentures, invite public deposits and take loans from various financial institutions. Since the capital market in India is not developed well, it is frequently not possible for all companies to arrange the huge amount of capital required. It is generally the companies belonging to the large business houses that are in a position to undertake the job. This leads to concentration of economic power and wealth. Arrangement of capital is a problem that public sector industries also have to face. It is because of this fact that there are delays in setting up of new plants and remotivating and modernising old plants.

Choice of Techniques: In large scale industries, the problem of choice of techniques is not as easy as it appears on the surface. Theoretically speaking, large scale industries should opt for the latest techniques of production and latest technology. There are a number of difficulties in carrying out this suggestion in actual practice. The nature and the level of techniques available depends on their availability from abroad and their latest techniques of production. Until the country makes substantial improvement in the field of research and development, our industries will have to remain content with inferior techniques of production.

There is another problem which is faced by the large scale industries. A number of industries, which were set up long ago, have grown old and their machinery became obsolescent. These industries require substantial replacement of machinery. In this respect, they face at least two important problems. Firstly, they are not able to arrange the required capital. Secondly, even if they succeed in arranging capital for rationalisation and modernisation, they face stiff resistance from trade unions which fear retrenchment and unemployment. This has led to a situation where a number of old industries have been declared sick and their utility has declined.

Idle Capacity: Large number of large scale industries suffer from under-utilization of capacity. Since capital goods industries provide the base of industrial development, substantial underutilization of capacity has created problems for many other industries dependent on them. The causes of under-utilization of capacity range from wrong governmental policies to shortage of raw materials and power, managerial incompetence and

industrial unrest etc.

Limited Employment: The large scale industries use capital intensive techniques which have a low employment potential. As a result, employment opportunities fail to increase to a significant extent.

Concentration of Economic Power and Monopolies: In India, the development of large scale industries has led to growth of monopolies and increase in the concentration of economic power. In a capitalist economy, large business houses control substantial economic wealth and power and continuously try to increase their share. This leads to ever increasing concentration of economic power in their hands.

16.4.7. Small Versus Large Scale Industries

Small Scale Industries	Large Scale Industries
1. Small scale industries are labour using and capital saving. They create more employment per unit of capital employed.	1. Large scale industries are capital intensive and labour saving
2. Units are widely scattered	2. Heavy concentration in big cities.
3. The small scale industries are either proprietary or partnership concerns. Because of these factors, the relations between the workers and the employers are more harmonious. There are no trade unions because the workers are unorganised.	3. Workers in the large scale industries are a privileged class organized in militant trade unions. They resist any change that affects their vested interests.
4. Workers are paid low wages and they are denied social security schemes.	4. Workers are paid very high wages and they avail all benefits and social security schemes
5. The income benefit of small scale industries is derived by a large population	5. The large scale industries encourage more concentration of economic power.

For understanding the technical, financial and economic characteristics, we present below the principal notions on the characteristics of small and large industry in a relative terminology. These are:

1. Small scale industries have a higher average cost of production per unit of output than large scale industries.
2. Small scale industries require less capital per worker than large scale industries.
3. Small scale industries generate lower output per worker than large scale industries.
4. Small scale industries have a lower wage per worker than large scale industries.
5. Small scale industries have a lower surplus per worker than large scale industries.

6. Small scale industries generate higher output per unit of capital than large scale industries.

7. Small scale industries generate lower surplus per unit of capital than large scale industries.

The above characteristics can be put briefly and alternatively as follows: Small scale industries have a higher unit cost, less capital intensity, lower output, lower wage and lower surplus per worker, and higher output-capital (i.e, lower capital output) and lower surplus capital ratios than large scale industries.

Check Your Progress - 4 & 5

4. What are the characteristics of small scale industries?
5. What are the characteristics of large scale industries?

Note: (a) Write the answers in the space provided below.

(b) Compare your answers with those given at the end of this unit.

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16.5. IRON AND STEEL INDUSTRY

Steel is used as a basic material in the manufacture of metal products, electrical machinery, transport equipment, textile and other machinery. There are many advantages in the production of steel in India. There are very rich iron ore mines with the highest iron content in India. Moreover, coal and iron are found closeby to each other. By 1990-91, iron and steel industry had integrated plants with an installed capacity of 10 million tonnes of steel ingots. The iron and steel industry accounts for a total investment of Rs. 4,000 crores. The public sector undertakings have a major share in this investment. The iron and steel industry provides direct employment to 2.5 lakh workers. To employ one worker, Rs. 1,20,000 are required. This indicates that, this industry is highly capital intensive industry. Inspite of the above investment, and output, our country imports over Rs. 2000 crores worth of iron and steel every year.

Three steel plants were set up at Rourkela, Bhilai and Durgapur with financial and technical assistance from Germany, USSR and Britain respectively with a capacity of one million tonnes of ingot per year. The Steel Authority of India Limited (SAIL) was created in 1974 and was made responsible for the development of the steel industry and also for major inputs for the industry e.g., cooking coal and iron ore. SAIL coordinates and synchronises development of all major units brought under its control and Hindustan Steel Limited (HSL), Bokaro Steel Limited (BSL); Salem Steel Limited (SSL); Hindustan Steel Works Construction Limited (HSWCL); Bharat Cooking Coal Limited (BCCL); and National Mineral Development Corporation Limited (NMDCL).

16.5.1. The Role of Iron and Steel Industry

The iron and steel industry has made considerable progress from 1.5 million tonnes of crude steel in 1950-51 to over 15 million tonnes in 1992-93.

1. The important feature of the iron and steel industry is the growth of research, design and development within India. Our country is self-reliant and is in a position to set up new steel plants without depending on foreign countries.

2. The public sector is gradually becoming more significant in the production of steel. For instance, in 1950-51, all steel production was in the private sector. By 1992-93, public sector accounted for 85% of the total output.

3. Licences were given to set up mini steel plants which account for 30% of steel production in the country. These mini steel plants produce mild steel as well as alloy steel. In our country, there are 179 mini steel plants with a total capacity of 5.6 million tonnes.

4. India has potential to become a good exporter of steel. Our country has become a leading exporter of iron ores. At present our country exports iron ore worth Rs. 1,000 to Rs. 1,200/- crores per annum.

16.5.2. Problems of Iron and Steel Industry

1. **Under utilisation of capacity:** This industry has been working below full capacity. The under utilisation of capacity is leading to high cost of production and losses. The following factors are responsible for under utilisation of capacity viz., inadequate supply of coal and power and transport bottlenecks, lack of proper maintenance, poor management, specially frequent changes in the top management of public sector steel plants and extensive labour troubles.

2. **Sickness of mini-steel plants:** The mini-steel plants faced the following problems viz., short supply of inputs and a sharp increase in prices of inputs, inadequate power supply, constraint of working capital and poor management.

3. **The problem of administered prices:** The Indian Government had been following a system of administered prices and controlled distribution of steel among consumers. Since there is heavy demand for various items of steel, price control and distribution of steel led to heavy black marketing and acute shortage of steel. Because of this situation, the gainers were private distributors. The main producers were denied the advantage of higher prices and lost heavily.

4. **Inefficiency of public sector units:** The public sector units have been using continuously and heavily due to heavy investment on social overheads, poor labour relations, poor and inefficient top management, underutilisation of capacity etc.

5. **Problem of metallurgical coal:** India's supply of high grade coal for making the smelting of iron is quite low. With the expansion of this industry, the demand for cooking coal has increased.

16.6. CEMENT INDUSTRY

There are 20 large cement units and 140 mini cement plants with a total installed capacity of 68 million tonnes. More than two lakh persons are employed in the industry. The cement industry is well diversified over all the states of India. It requires weight losing materials like limestone or chalk, clay and gypsum. In many parts of the country, limestone is available abundantly.

The problems of cement industry are:

1. **Inadequate production:** The following factors are responsible for the shortfall in production. They are (1) acute power cuts ranging from 20 to 75% in various cement producing states (ii) shortage of coal (iii) inadequate availability of railway wagons (iv) limited availability of furnace oil resulting in partial or complete closure of many units.
2. **Cost escalation and rigid prices:** There has been a rise in the cost of production of cement and this rise was due to government policies like price and freight on coal, power, and wages covered by wage awards. The shortage of railway wagons for the movement of cement has always been a serious problem. The cement industry has been facing acute power problems. In order to solve this problem the cement industry has been setting up diesel generating sets.
3. **Soaring investment costs and declining profits:** Investment costs in the cement industry are growing very rapidly and more than doubled from Rs. 650 to Rs. 680 during the sixth plan to Rs. 1300 to Rs. 1500 per tonne during the seventh plan period.

Check Your Progress - 6

What are the factors responsible for the shortfall in production of cement industry.

Note: (a) Write the answer in the space provided below.

(b) Compare your answer with the one given at the end of this unit.

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16.7. FERTILISER INDUSTRY

The fertilisers have an important role in boosting agricultural output. The soil in India is varied and rich but deficient in nitrogen and phosphorus. These two plant nutrients along

with organic manure influence crop return. The use of larger doses of chemical fertilisers is the only way to increase our food grain production.

The fertiliser industry made rapid progress during the past decade. The production of fertilisers rose from the mere 39,000 tonnes in 1951-52 to 10 million tonnes in 1993-94. The domestic production of fertilisers has been considerable over the years. However, the production of fertilisers is not able to keep pace with the growth in consumption.

There has always been much delay in establishing fertiliser plants. It, sometimes, takes 8 to 9 years to complete a project from the time the letter of intent is issued. This delay causes unnecessary increase in the cost of the project. Secondly, there is the problem of capital for the fertiliser projects. It was estimated that between Rs. 1000 crores and Rs. 1500 crores would be required of which about Rs. 350 crores or more would be foreign exchange component.

16.7.1. Import of Fertilisers

Since the production within the country has been short of continuously increasing demand, the government had to depend upon imports. In 1951-52, the percentage of imports to the domestic production of fertilisers was 133 per cent and it was 90 per cent in 1980-81. Between 1951-52 and 1993-94, imports of fertilisers had increased from 52,000 tonnes to 2.9 million tonnes.

The fertiliser was becoming scarce in the international market, its price was shooting up particularly after the middle of 1973 due to the oil crisis. Heavy pressure of demand, the high cost of feestock of fertiliser factories, high rates of ocean freight have reduced the international supplies of fertilisers to India. India has been spending around Rs. 2,800 crores per annum on import of fertilisers.

16.7.2. Consumption of Fertilisers

The Government has been promoting the consumption of fertilisers through heavy subsidies. Firstly, the consumption of fertilisers in India per hectare was 72 kgs in 1993-94. The corresponding figures for some developed countries were such as South Korea (405 kgs), Netherlands (315 kgs), Japan (380 kgs) etc. Secondly, there has been a steep rise in fertiliser subsidies from Rs. 600 crores in 1979-80 to Rs. 5800 crores in 1992-93. This is a huge drain on resources and most of the time, the bulk of these subsidies goes to the large farmers. Thirdly, the sharp increase in international fertiliser prices has compelled the government to divert to greater use of organic manures.

16.8 CHEMICAL INDUSTRY

Chemicals permeate every sector of industry of household through their products. They have a major role to play in conserving and supplementing natural resources. Chemicals have a potential in important areas like agriculture, clothing, building and construction, transportation etc.

16.8.1. Important Features

Firstly, chemicals present the highest value addition and resource generation. Secondly, chemicals have the highest resource generation in terms of investment. Thirdly, they have a lot of influence on the development of chemical engineering, organic polymers etc. Fourthly, chemicals by themselves are capital intensive. Fifthly, chemical industry gives a big boost to the small scale sector.

16.8.2. Export Performance and Possibilities

The present value of annual production of plastic products is between Rs. 1200 to 1400 crores. Even if 10 per cent of annual production is exported, exports of plastics and related commodities should have been Rs. 120 crores a year. But the actual exports amount to Rs. 80 crores. The basic reason for this year performance is the high cost of production.

16.8.3. Production of Chemicals

The demand for chemicals has touched 1.75 million tonnes by 1989-90; by the end of this century, the demand would exceed 4.23 million tonnes. As was the case with all other major industries, neither the government nor our planners have made adequate preparations to meet this demand. It would be the difficult task to bridge the huge gap between production and demand.

16.9. SUMMARY

In a developing country like India, small scale industries play a very important role. They are labour using and capital saving. They create more employment per unit of capital employed. The units are widely scattered. The workers engaged in small scale industries are paid low wages and denied social security schemes.

The large scale industries are capital intensive and labour saving. These industries are heavily concentrated in big cities and encourage concentration of economic power. The workers engaged in large scale industries are paid very high wages and they enjoy all types of benefits prevailing under social security.

Some large scale industries like the iron and steel industry, cement industry, chemical and fertiliser industry and their performance and problems are discussed.

16.10. CHECK YOUR PROGRESS: MODEL ANSWERS

1. The regional dispersal of small enterprises helps to tap local resources such as raw materials, idle savings and local talents. This process leads to improvement in the standard of living of people in the backward areas. This process also helps to solve the problems of congetion in few industrial towns by enlarging the area of employment.

2. Many small scale industries use imported raw material whenever there was a difficulty in getting this raw material either on account of the foreign exchange crisis, or some other reason, these small scale industries suffer a lot. The small scale industries get more or less a 'residuary' treatment in raw material distribution and allocation.

3. Firstly, these industries often do not possess any marketing organisation and consequently face difficulties in selling of their produce. Secondly, the products of small scale industries are often not standardised. Hence they are of variable quality. Often the quality of their products compares unfavourably with the quality of the products of large scale industries.

4. The characteristics of small scale industries are: (a) They generate higher output per unit of capital. (b) They generate lower output per worker. (c) They have a lower wage per worker. (d) They have a lower surplus per worker. (e) They require less capital per worker.

5. The characteristics of large scale industries are: (a) higher wage per worker.

(b) require more capital per worker. (c) generate more output per worker. (d) generate more surplus per worker. (e) generate less output per unit of capital.

6. The factors responsible for the shortfall in production of cement industry are: (a) Acute power cuts ranging from 20 to 75 per cent in various cement producing states. (b) Shortage of coal. m(c) Inadequate availability of railway wagons. (d) Limited availability of furnace oil.

16.11. MODEL EXAMINATION QUESTIONS

I. Answer the following questions in about 30 lines each.

1. Explain the importance of small scale industries.
2. Describe the role of large scale industries.
3. Compare the features and the characteristics of small scale industries and large scale industries.

II. Answer the following questions in about 10 lines each.

1. Analyse the problems of small scale industries.
2. Describe the problems of large scale industries.
3. What are the principal notions on the characteristics of small scale and large scale industries?
4. Analyse the problems of iron and steel industry.
5. Analyse the problems of cement industry.
6. Describe the role of fertiliser industry.
7. What is the importance of chemical industry?

Dr. S. Sudhakar Reddy

BLOCK - 6
ENERGY NEEDS OF INDIA

UNIT - 17 : ELECTRICITY

Contents

17.1. OBJECTIVES

After going through this unit you will be able to:

* explain the basic principles of electricity generations,
* describe domestic and industrial applications and
* recognise the necessity of conservation of electrical energy and appreciate the need to encourage the renewable sources of energy.

17.2. INTRODUCTION

For the industrial growth of any country adequate attention has to be given by the planners to generation of electricity. Electrical energy is a clean and refined form of energy which can be generated in bulk by the confusion of conventional fuels and can be transmitted economically over long distances. Further it can be adopted easily and efficiently to domestic and industrial applications.

The increase in per capita energy consumption coupled with rising population has put the limited non-replenishable energy resources such as coal, oil and natural gas to great strain. A coordinated world wide action plan is necessary to conserve these fuels to ensure continued energy supply to humanity for a long time.

17.3. METHODS OF ELECTRICITY GENERATION

Thermal (coal, oil and nuclear) and hydro generations are the main conventional sources of electrical energy. Fossil fuels used for thermal generation are fast depleting and this has forced scientists and technologists across the world to look for non conventional and replenishable sources of energy. Some of these are solar wind and tidal sources. The principales involved in the generation of electricty using the above are presented in this section.

17.3.1. Thermal Power Sections

Law of conservation of energy states that energy can neitehr be created nor destroyed. It can only be transformed from one form to another. To convert the given energy to electrical form it usually involves the wages of a primemover. This primemover provides the necessary mechanical energy to the a.c. generator called the alternation which converts it into electrical energy.

Chemical energy is stored in fossil fuels like coal, oil and natural gas. The combusion of these releases heat which in turn produces steam in a boiler at high pressure and temperature. The steam when passed through a steam turbline gives off its internal energy as mechanical energy by driving the turbline which acts as primemover for the alternation. There are a large number of coal fired thermal stations in the country. The major thermal power plants in A.P. are located at Kothagudem, Ramagundam and Vijayawada. There are also many medium and large scale oil fired and diesel power stations in industrial plants as captive generating units to supplement the eleectricity supplied by the state electricity boards.

Nuclear power plants make use of uranium which when bombarded with neutrons causes fission reaction and energy is released in the form of heat. The steam generated is used in a conventional manner to produce electricity.

17.3.2. Hydro-Electric Power Generation

The oldest and cheapest method of power generation is that utilising the potential energy of water impounded in dams and anicuts. The stored water is allowed to flow through a pipe known as penstock which drives a water turbine. Different types of turbines such as pelton, Francis and Kaplan are used. The energy obtained is almost free of running cost. It is also completely pollution free unlike thermal power. However capital cost is high and requires a long gestation period compared to steam plants. The important hydro power plants are located at Srisailam, Nagarjunasagar and upper sileru.

17.3.3. Wind Power Stations

Winds are created by solar heating of atmosphere and earth. These winds possess high kinetic energy, the power being proportional to (velocity)^3. These can generate mechanical energy by turning the blades mounted on a shaft. When coupled to a generator electrical energy is developed. Wind as a power source is plentiful, inexhaustible and non-polluting with negligible running cost. Unfortunately it is non-study and undependable. The potential for wind energy in the country is estimated as 20,000 MW. There are many wind farms existing in the states of Gujarat and Tamilnadu generating power upto 180 MW. A wind form is coming up at Ramagiri in A.P.

17.3.4. Solar Power Plants

Solar energy is free cost, non-exhaustible and pollution free. Two technologies are developed for conversion of solar energy to the electrical form. In the first one conventional steam is developed by usuage of reflectors and is called the solar thermal system. Experimental power plants are situated in USA and France. The other technology is to convert solar energy to the electrical form directly using solar cells. The efficiency of conversion of sunlight to electricity is however very low of the order of 12%. Also the cost of solar cells is very high. The present cost is $5 per watt. Experimental power plants are in operation through out the world including Saudi Arabia.

17.3.5. Geothermal Power Plants

The heat deep inside the earth acts as a source of power. At a depth of 3 to 4 km, heat is sufficient to cause water to boil At a depth of about 15 kms, temperature in the range of 1000°C to 1200°C can be obtained. Surface water when it penetrates the earth's crust turns into steam and comes out of earth through weak spots of crust in the form of hot springs.

The steam produced may be utilised in the conventional way to generate electrical energy. Power stations based on geothermal energy are operating in USA, Italy and Phillipines.

17.3.6. Wave/Tidal Power Generation

Wave power can be converted to mechanical power through turbines. Alternatively the sea water in channels etc during high tides can be blocked and released during low tides. The potential energy is utilised to drive turbogenerators. Ocean temperature gradient may also be used for power generation such plants are known as OTEC (Ocean Temperature Energy Conversional) plants. Tidal power plants are operating in France. Construction of such plants is also progressing in the states of Gujarat and Kerala.

17.4. PRINCIPLES OF DISTRIBUTION

An electric power system consists of three major components: (i) generation, (ii) transmission and (iii) distribution. If long distances separate the generating system with the consumers, then the transmission system is imperative. The generating voltages are stepped upto voltages as high as 220 KV, 400 KV and energy is transmitted through transmission system. At the receiving end they are stepped down to lower levels for the distribution system.

A distribution system has two components (i) Feeder and (ii) Distributor. A feeder in a distribution network is a circuit carrying power from a main station to a secondary substation such that the current loading is the same all along its length. A typical distribution system is shown in Fig. 17.1.

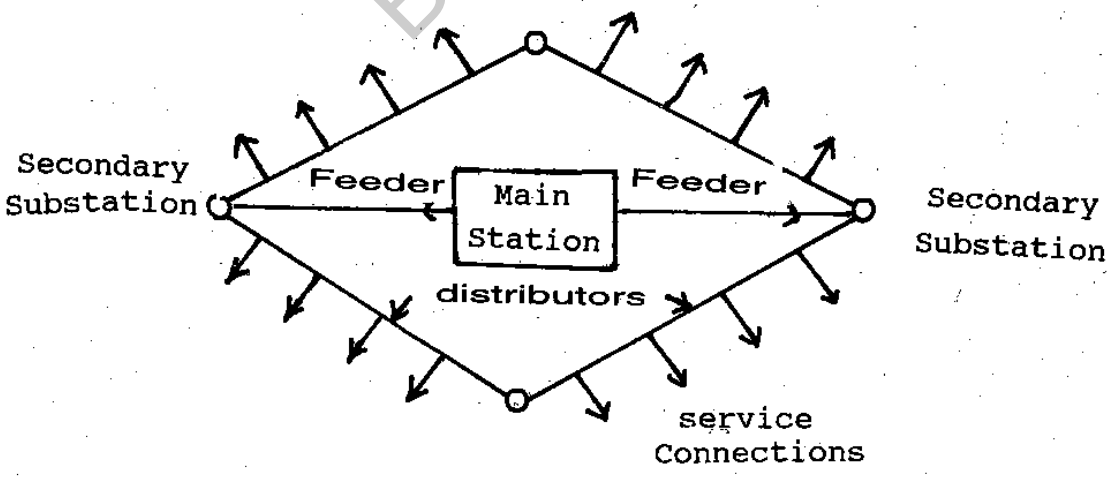

Fig. 17.1 . A typical distribution system.

A distribution has valuable loading along its length due to service connection tapped off at intervals by the individual consumers.

Depending upon the type supply, distribution system can be classified as (i) AC Single phase (ii) 3 phase-3wire and (iii) 3 phase-4 wire. First one is for single phase loads like domestic

supply. The second type is to provide supply for 3 phase loads like induction motor load in a workshop. The third type system can provide supply to both single and three phase loads.

Another classification is based on the type of connections (i) Radial system and (ii) Ring main system. A typical radial distributor is drawn in Fig. 17.2.

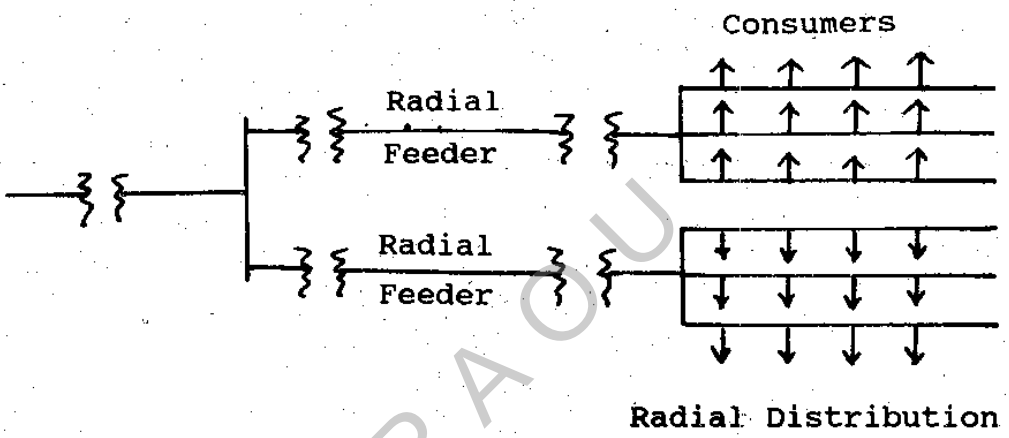

Fig. 17.2. A typical radial distribution.

Radial system is simpler and has low cost. The major dis-advantage is the lack of security of supply. When a fault occurs on any section of the feeder, a number of consumers will be without supply.

The ring main system is frequently used to supply bulk loads where continuity of supply is of considerable importance. A typical ring main feeder and distribution system is shown in Fig. 17.3

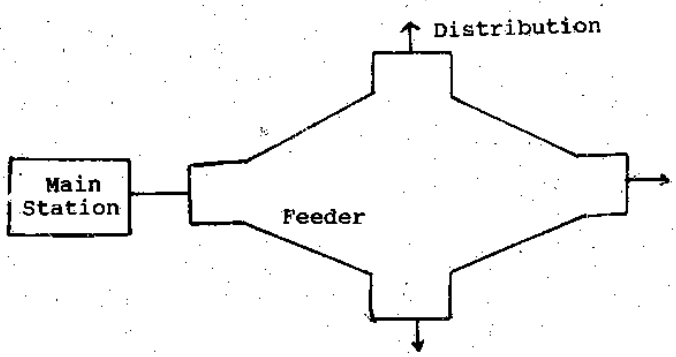

Fig. 17.3. A Typical ring main feeder and distribution system.

Check Your Progress - 1, 2, 3, 4.

1. What is the objective of this unit with regard to electrical energy?
2. State the law of conservation of energy.
3. How is mechanical energy generated by sea waves?
4. What is the disadvantage with a radial system?

Note: (a) Write the answers in the space given below.

(b) Compare your answers with those given at the end of this unit.

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17.5. APPLICATIONS

An electrical motor is a better primemover for driving a mechanical load than hydraulic, steam or diesel engine. This is because an electric motor is easier to control to suit to the requirements of the mechanical load. There are various types of motors working on DC or AC. Among the DC motors, shunt motor and series motor have larger number of applications. Shunt motor runs practically at constant speed for all loads. These are used in pumps, lathes, drills etc. Series motors have decreasing speed charateristic for increasing loads. The motor is suited for loads requiring high starting torque like tramcars, cranes, trally buses etc.

Induction motors constitute the bulk of AC motors. There are two types namely squirrel cage and slip ring motors. Induction motors are more robust and reliable than DC motors and are extensively used in small scale industries, pumpsets and other industrial applications. Slip ring motors are useful in lifts, hoists etc. Single phase induction motors find household applications in the refrigerators, washing machines, air conditioners etc.

Synchronous motors are constant speed motors used in rolling mills, electronic clocks etc.

Electrical energy is also used for industrial and domestic heating. Electrical heating has advantages over the other systems of heating. The main advantage is the cleanliness, absoner of the gases and easy control.

Another application of electrical energy is in wording. This involves joining of metals by fusion process. Electrical welding finds many industrial applications from ship building to bicycle manufacture. An important usage of electricity is in the field of domestic and industrial lighting. Light sources are divided into two classes : incandescent and luminescent sources. An incandescent source is one which emits light because of heating of a tungston filament. In luminescnet source light is emitted due to ionization and excitation of certain elements in a sealed glass tube. Examples are the domestic fluorescent lamps and the industrial mercury vapour lamps. Street lighting is usually provided with fluorescent and sodium vapour lamps.

Electric traction is progressively replacing diesel electric traction because of increasing cost of diesel oil. The electric traction uses either AC single phase systems or three phase

system. Among the various advantages of electric traction in which electric motors are used are the increased acceleration/deceleration, sharing of braking energy etc.

Usage of electricity for transportation has many advantages over other types of transportation. The chief among them are the absence of pollution and higher efficiency. Electric cars are developed with efficient electric drive systems utilizing modern power electronics and high energy batteries. Trolley buses use two overhead conductors and works on 600V DC. For mass transport in urban areas tram ways are staging a come back in European countries.

17.6. GROWTH OF POWER SYSTEMS IN INDIA

India is fairly rich in natural resources like coal and lignite. Some oil and gas reserves have been discovered in Krishna, Godavari basin, but intense exploration is required especially in the off shore locations. India also has immense water power resources of which only a small percentage has been utilized so far. As regards nuclear fuel, India is deficient in uranium but has rich deposists of thorium.

At the time of independence the installed capacity was as low as 1900 MW. During the first five year plan (1951-56) total installed capacity rose to 2300 MW. In the second plan (1956-61) the emphasis was on development of basic and heavy industries and power generation has gone up to 5700 MW. During the third plan (1961-66) the installed capacity has increased to 10170 MW. A significant development during this period was the emergence of an interstate grid system. The country was divided into 5 regions with the installed capacity in 1989 as show in Table 17.1.

Table 17.1. installed capacity in 1989 in 5 regions.

Region	Capacity
Northern Region	20 116 MW
Western Region	21 665 MW
Southern Region	18 493 MW
Eastern Region	11 112 MW
North Eastern Region	2 325 MW

In the fourth five year plan, the country has started producing electricity from nuclear power. These plants are located at Tarapur, Kota, Kalpakkam and Narora. The growth of generating capacity is given in Table 17.2.

Table 17.2. Growth of generating capacity.

Year	Hydro	Nuclear	Thermal	Diesel	Total
1970-71	6,383	420	7,503	398	14,704
1978-79	11,378	890	16,372	-	28,640
1983-84	20,000	1,900	31,500	-	53,400
1990-91	33,000	8,620	50,700	-	92,330
2000-01	60,000	25,000	77,000	-	1,62,000

The energy demand has also been increasing. In 1976-77 it was 90 x 10^9 KWH and the estimated energy requirement in 1995-96 is 500 x 10^9 KWH.

17.7. FUTURE STRATEGIES

Assuming a very modest annual growth of 5%, Indias electrical energy requirement in the year 2000 will be enormously high. A difficult and challenging task of planning and constructing new power stations is imminent to meet this situation. Super power stations have been built in UP,MP, AP, TN and WB. With liberalisation and economic reforms taken up by the Government of India, private entrepreneurs are encouraged to set up power plants in the country based on coal and natural gas. In addition many wind forms are also coming up in several states to harness the wind energy. The power generation by photovoltaic systems using solar energy is likely to catch up in India also. Many pilot plants are already in operation in US, Europe, Saudi Arabia and Japan. With the falling price of silicon solar cells, this method of power generation is likely to play a major role in the 21st century. However the ever increasing gap between demand and energy generation cannot be bridged by adding extra generating stations alone. The country can learn from the experiences of developed countries like UK and USA in implementing energy conservation measures. Studies have shown that substantial electrical energy could be saved by switching over to energy efficient lamps, energy efficient motors and reducing the energy losses in transmission and distribution systems.

Check your progress 5, 6 & 7

5. Mention two domestic applications of induction motors.
6. State the different regions in power grid.
7. What kind of power plant (non-conventional) is operating in Saudi Arabia?

Note: (a) Write the answers in the space provided below.

(b) Compare your answers with those given at the end of this unit.

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17.8. SUMMARY

The energy requirement of developing countries like India are ever increasing. Electricity can be generated by burning coal or oil or natural gas in thermal stations. Nuclear power plants are also thermal stations where heat is generated due to fission of uranium. The potential energy of water stored in dams is converted to electrical energy in hydro power stations. The above methods are classified as conventional methods. Energy in solar radiation, wind and sea waves can also be converted into electrical energy which are given the name non-conventional sources. The applications of electricity are vast and practically there is no field where electrical energy is not used. The generalised electrical energy reaches the consumer through transmission and distribution network. The growth of power systems in the country is unable to match the load demand. Hence there is an urgent need to conserve electrical energy and simultaneously encourage the usage of non conventional energy sources.

17.9. CHECK YOUR PROGRESS : MODEL ANSWERS

1. The objectives of this unit are to recognize the need for electrical energy conservation and usage of non-conventional energy sources.
2. Energy can neither be created nor destroyed.
3. Sea waves turn turbines thereby generating the mechanical energy.
4. When a fault occurs in any section of the feeder large number of consumers would be deprived of power supply.
5. The domestic applications of induction motors are (i) Water pumps (ii) Washing machines.
6. Different regions in the power grid are Northern, Western, Southern, Eastern and North eastern
7. Photovoltaic Power Plant is operating in Saudi Arabia.

17.10. MODEL EXAMINATION QUESTIONS

I. Answer the following questions in about 30 lines each.

1. Non-renewable power plants.
2. Industrial application of electrical energy.

II. Answer the following questions in about 10 lines each.

1. Power Stations in A.P.
2. Radial distribution system
3. Usuage of induction motors
4. Advantages of electrical drive systems
5. Power system growth in the III five year plan

Prof. P. Rajasekharam

UNIT - 18 : PETROL, NATURAL GAS AND KEROSINE

Contents

18.1. OBJECTIVES

After going through this unit, you will be able to

* recognise the importance of fossil fuels as energy sources and
* describe the limitations relating to the use of these fuels as energy sources.

18.2. INTRODUCTION

About 95% of the energy used, the world over is biological in origin. Coal, oil and natural gas are the main sources amongst the conventional natural sources of energy. These are the fossil remains of prehistoric organisms that settled to the bottom of ancient seas and became modified by bacterial action, pressure and temperature effects into oil and gas. Commercial primary energy accounts for 60% of the primary energy supply in India. Among the commercial fuels oil occupies an important position. The share of oil/gas in commercial energy consumption in coal replacement units is going up year by year. Natural gas is emerging as the most attractive substitute for oil. India is on the threshold of major gas development programme. A national gas grid has been concenptualised for effective utilization. The oil and natural gas commission (ONGC) in India is entitled for all the praise for the diligent manner in which it has been tapping whatever oil and gas it has found. However the biggest challenge before the ONGC relates to the production of offshore oil since it calls for greater organizational skills.

18.3. CRUDE OIL

Crude oil or petroleum is made up of mostly hydrocarbon compounds and small quantities of other compounds. Typically deposits of crude oil and natural gas are trapped together deep underground, beneath a cap rock, above a sedimentary rock (shale) and beneath the sea floor. The crude oil exploration started in India in an extensive and systematic way after the setting up of Oil and Natural Gas Commission (ONGC) in 1956. Oil India Limited (OIL) has become the second public sector undertaking engaged in the oil exploration and

production in the country. Oil had been discovered in many parts of India such as Rajasthan, Andamans, Gujarat, Andhra Pradesh and Assam. Off shore explorations have been found very successful in many places. Oil has many advantages that account for its widespread use. It is relatively cheap and can be easily transported. It can also be turned to proper vehicles and it has high net useful energy yield. Oil has also some disadvantages. Supplies may deplete within 50 to 100 years. Its burning may release large quantities of carbondioxide into the atmosphere which may lead to the greenhouse effect. Water pollution from oil spills and contamination of underground water by the brine solution injector into oil wells. The refining operations too have to be streamlined with our updating of technology for maximizing the yield of light and middle fractions in the refining process. The oil discoveries in Andhra Pradesh in the Krishna-Godavari basin during the last few years underline the importance of the Southern Region as a potential oil producer. The offshore discovery located at 25 km southeast of Amalapuram town (A.P.) had given hopes for ONGC to produce 5000 barrels a day which could be easily raised to 40,000 barrels, equivalent to two million tonnes a year. This field is known as 'Ravva' offshore field. The refining operations have to be streamlined with an updating of technology. The formulation of expansion programmes has to be on a perspective basis. It is advantageous to process the imported crude and the indigenous crude with expanded facilities. Thus the challenges before the ONGC are to discover more oil and develop them. There are now about 40 Indian companies both public and private sector offering a variety of offshore equipment and services.

Check Your Progress - 1, 2 & 3

1. What is crude oil?
2. What are the Agencies exploring the oil in India?
3. Where is crude oil obtained in Andhra Pradesh?

Note: (a) Write the answers in the space provided below.

(b) Compare your answers with those given at the end of this unit.

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18.4. POLLUTION PROBLEMS ASSOCIATED WITH CRUDE OIL PRODUCTION

The components of crude oil are mostly hydrocarbons and many are non-biodegradable. Many environmental problems due to oil spills are caused because of the physical properties of oil. It is hydrophobic (water repelling) and is impermeable to oxygen. Therefore the marine organisms die due to asphyxiation (lack of oxygen) in oil spills in oceans. Since oil is a stable chemical, the environmental damage due to oil spills occur even long after the

input to the environment has stopped. The harmful affects of oil on living organisms are physical as well as chemical. The physical effects are caused by oil coatings. Water birds coated with oil lose flight capacity, some marine organisms die of asphyxiation, photosynthetic primary production under water coated with oil is reduced chemical effects are related to the properties of hydrocarbons in it. Many lower animals suffer from anesthesia in oil polluted waters. Aromatic hydrocarbons present in oils, accumulate in tissues of organisms and are concentrated as they move up in the food chain. Benzene inhibits blood cell formation in bone marrow. Polycyclic aromatic hydrocarbons are more dangerous than simple aromatic hydrocarbons. Most oil spills have occurred in the past, within 15 km of the shore and 35 km from the nearest post. But now it is different. Emission of enormous amounts of sulphur dioxide into the atmosphere is a serious problem associated with oil refinery. In addition, the liquid effluent treatment is the most important factor connected with oil refining. The threat to the Taj Mahal through sulphur emissions from oil refinery located in its vicinity has been highlighted by the environmentalists. The adverse effects of the oxides of sulphur on vegetation are noticeable even at very low concentrations. Of particular concern is the acid rain formed from the oxides of sulphur. Apart from oxides of sulphur hydrogen sulphide released in oil refining acts as a dangerous pollutant.

18.5. NATURAL GAS

Natural gas consists of 50% to 90% methane gas and smaller amounts of other gascous hydrocarbon compounds such as propane and butane. Most natural gas made available for use is the one that lies above the deposits of crude oil. But natural gas also occurs by itself in many underground deposits. The propane and butane obtained along with methane in natural gas are generally removed as liquified petroleum gas (LPG). The remaining as, methane, is dried cleaned and pumped into pressurised pipelines for distribution. LPG is stored in pressurised tanks for areas not covered by natural gas pipelines. Natural gas burns hotter and cleaner than any other fossil fuel. It is relatively cheap and can be transported easily over land. Natural gas can displace kerosine, naptha and other petroleum products to a very large extent. Therefore a continuous search is going on for new sources of natural gas. It is estimated that Andhra Pradesh alone will be able to produce three million cubic meters daily. In view of the rich resources for the gas, adequate arrangements are being made for processing the gas and creating a network for transporting raw gas to various centres. Such a network is being available in western India HBJ (Hazira-Bijaipur-Jagdishpur) grid is the first major attempt in this direction. Facilities are being created by laying a 72 km from Narsapur to Kovvur for supply of gas to industries from a common point. It is also very essential to examine methods to convert natural gas into petroleum products such as diesel oil apart from LPG. This will help in the production of petroleum products directly from natural gas. The new role of gas as a substitute for petroleum products has to be recognised and appropriate measures have to be adopted for establishing new reserves of free gas. The constrains arising in setting up LPG extraction plants and the inadequate facilities available for bottling of the gas are mainly responsible for not able to utilise the natural gas to its full capacity as cooking gas. Gas is now being used vastly as an energy source for fertilizer plants. Some of them are National Fertilizers Limited at Bijaipur (M.P.), Indian Farmers' Fertilizer Corporation at Aonla (U.P.) and Indo-Gulf Fertilizers at Jagadishpur (U.P.). Gas is also supplied to gas based power stations for example Kawas in Gujarat, Auraiya in UP and Anta in Rajasthan are receiving the gas for this purpose. More power stations are also earmarked for the supply of the gas. The twenty year conceptual plan given by ONGC in 1985 made the following projection of the annual rates of natural gas production.

ONGC Projections of gas production

Years	Million c.u.m./day
1985-86	13.69
1990-91	46.57
1995-96	76.71
2000-2001	101.36
2004-2005	123.29

Check Your Progress - 4 & 5

4. What are the components of Natural Gas?
5. Name one network available for the transportation of natural gas.

Note: (a) Write the answers in the space provided below.

(b) Compare your answers with those given at the end of this unit.

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18.6. KEROSINE

This is the common man's fuel even till to-day especially in villages. This is obtained from crude oil distillation. The fraction collected between 200-300°C is known as kerosene. This is also a mixture of hydrocarbon containing carbon atoms ranging from 12 to 16. This fraction also contains some sulphur compounds. Kerosene on burning lets off lots of carbondioxide and oxides of sulphur into the atmosphere. Thus among petroleum products, the maximum consumption is that of middle distillates. So any oil refining expansion programme must take into account this fuel of maximization of middle distillates production to meet the kerosene demands of the Nation. In the last one and half decades secondary processing facilities in the form of fluidized catalytic cracking units have been added along with augmentation of refining capacity. About 6 million tonnes of oil are subjected per year to this catalytic cracking process to maximise the production of middle distillates. The refineries at Karnal, Mamgalore and Koyali are using hydro cracker units to maximise the production of kerosene and diesel. This hydrocarbon technology was used for the first time in India at these refineries. However the large scale production and use of kerosene cuts into the use of middle distillates for petrochemical productions. Thus encouraging use of kerosene as a common fuel not only adds to the pollution problems such as green house effect, acid rain etc., but will also affects adversely the petrochemical industry. Hence the Kerosene must be replaced by natural gas or by LPG. Plenty of resources of these two are available in the country but supply system requires to be strengthened and streamlined. When gas is associated with oil as in Assam, Cauvery basin and in some parts of Andhra Pradesh, considerable advance planning is required for avoiding waste of gas as fossil fuel. For example manufacturing capacity of LPG cylinders is very much less than the requirement of the oil industry. Hence it has to be geared up.

18.7. SAFETY AND POLLUTION ASPECTS ASSOCIATED WITH NATURAL GAS

18.7.1. Safety Measures

Fire and explosion risks are given top priority in petroleum refineries and in LPG Bottling plants. More care must be exercised in LPG bottling plants to ensure that all electrical equipment are kept in good condition and all fixtures must be explosion or flame proof. Hot work is to be normally avoided and is carried out only when the plant is shut down and made gas free. Sparks from the nearly passing vehicles can cause a big fire in case of hydrocarbon gas leaks. Therefore spark arrestors are-provided in exhaust of vehicles. In LPG Bottling plants no trucks are allowed without spark arrestors. Hydrocarbon gases mix with air in all proportions but if the proportion is between 1.5 to 95% the mixture becomes highly inflammable. So efforts are made to make sure that these proportions are not reacted. Fire fighting facilities are to be provided adequately for any unexpected outbreak of fire. In the case of LPG Bottling units, effective detection alarm systems for gas leaks are to be provided to ensure that explosive range of gas is not reached at any time.

18.7.2. Pollution

Environmental pollution by the refineries can be due to 1. Waste water, 2. Solid waste, 3. Air pollutants. All refineries employ usually crude oil distillation, cooking catalytic or thermal cracking, and desulphurization. Therefore it is possible to predict the pollutants in waste water. Very often oil is also present in free or emulsified form in waste water. The air pollutants from oil refineries are hydrocarbons, CO, SO_2, SO_3 and NO_x. The general emission in LPG bottling plants are mercaptams (Organic sulphur compounds) and hydron carbons. "The bottling area will have generally sprinkler which acts as water curtain in case of disastrous leak. All the filled cylinders are passed through water baths for detecting leaks.

The effluents produced in different processes in oil refineries can be listed as follows:

	Process	Pollution
(i)	Crude oil distillation	H_2S, NH_3, Phenols
(ii)	Diesel Oil hydrotreating to remove sulphur	NH_4SH, Phenols
(iii)	Calatytic cracking or thermal cracking to produce kerosine	Phenols, Thiophenols, H_2S NH_3, NH_4SH etc.
(iv)	Hydro-cracking	H_2S, NH_3, NH_4SH

18.8. POLLUTION PROBLEMS ASSOCIATED WITH USE OF FOSSIL FUELS

Oil burning releases Carbondioxide gas in large quantities into the atmosphere. This causes green house effect and consequential global warming. The other gaseous products namely sulphur oxides, and nitrogen oxides cause acid rains and photochemical smog.

Natural gas too releases carbondioxide into atmosphere even though in lesser quantities than oil. But transport of natural gas by tankers and on land poses many pollution as well as safety problems.

Most coals and fuel oils contain substantial quantities of sulphur. When these are burned sulphur is released as sulphurdioxide. This is easily oxidised to sulphur trioxides. These oxides can damage material and property. Building materials (limestone, marble etc) and sculptures are decolourised and physically disfigured. The threat to Taj Mahal through these emissions from oil refineries in the vicinity has been emphasised by environmentalists. The vegetation nearly too is damaged very much by oxides of sulphur The acid rain formed from the oxides of sulphur kills the trees by releasing aluminium and potassium, which are toxic to the root systems. Hydrocarbons released into the atmosphere together with the oxides of nitrogen are the precursors of photochemical smog (Smoke-fog). Classical smog is uniquely the result of the inefficient combustion of high sulphur fuels. High levels of sulphur dioxide and particulates in the air, with water droplets in the fog leads to smog formation. Chemical smog is most dangerous during prolonged periods of low temperature and low Clouds. The great killer London Smog of December 1952 lasted for 19 days. About 4000 deaths occurred during this period.

18.9. SUMMARY

1. Crude oil or petroleum is naturally obtained rock oil which contains many hydrocarbons.
2. Crude oil is now being found extensively in India including Andhra Pradesh (Near Amalapuram and Narsapur)
3. Crude oil is always associated with natural gas containing largely methane and small quantities of propane and butane.
4. The middle distillates of crude oil contains kerosene a fossil fuel used by common man.
5. The propane and butane components of natural gas are removed in the liquid form and bottled as fuel gas. This is called LPG
6. Diesel, Kerosene and natural gas are the main products used as fuels.
7. Oil and National Gas Commission (ONGC) and Oil India Limited (OIL) are the two national agencies involved in the exploration, digging and refining of crude oil.
8. Production and bottling of LPG is given top priority since it is the viable alternative to replace kerosene use as fuel
9. Oil drilling, oil refining and transport cause lot of pollution problems. Hence large scale safely and pollution control measures are being followed.
10. Fossil fuels, use pollute atmosphere to a large extent. The most dangerous pollutants being CO_2 and Oxides of Sulphur.

18.10. CHECK YOUR PROGRESS : MODEL ANSWERS

1. Crude oil is nothing but large quantities of hydrocarbon compounds and small quantities of other compounds.

2. Oil and Natural Gas Commission (ONGC) and Oil India Limited (OIL) are engaged in exploring the oil in India.

3. The crude oil is discovered in Andhra Pradesh at Amalapuram town.

4. The natural gas consists of 50-90% methane gas and smaller quantities of other gaseous hydrocarbons such as propane and butane.

5. HBJ (Harira-Bijapur-Jagdishpur) in Western India is the network available for transportation of natural gas.

18.11. MODEL EXAMINATION QUESTIONS

I. Answer the following questions in about 30 lines each.

1. Give a detailed account of formation, drilling and refining of crude oil.
2. What are the hazards associated with the production and use of diesel, natural gas and LPG?
3. What are the pollution effects caused by the use of diesel, kerosene and natural gas as fuels.
4. What are the safety measures and pollution control methods needed in the production and use of fossil fuels?

II. Answer the following questions in about 10 lines each.

1. What is crude oil and how is it obtained?
2. What are the chief components of natural gas?
3. Name the hydrocarbons present in LPG and Kerosene.
4. What are the difficulties encountered in the transportation of Kerosene and natural gas.
5. Use of Kerosene is to be discovered as fuel gas - why?

Prof. S. Brahmaji Rao

UNIT-19 : NUCLEAR POWER IN INDIA

Contents

19.1. OBJECTIVES

After completing this unit, you will be able to:

* explain the importance of atomic power in India, and
* describe the safety measures to be followed in atomic power plants.

19.2. INTRODUCTION

Energy is one of the fundamental quantities needed for life to exist on this planet just as food and water. Energy exists in different interconvertible forms such as thermal energy, chemical energy, electrical energy and material energy. Energy is required in all walks of life, namely in industry, households and transport in the form of oil, gas, coal and electricity. About 95% of the energy used world over is biological in origin. These energy sources of natural origin although present in large quantities, it is estimated that they may not last long to meet human requirements. Therefore a search had been going on since long for alternate sources of energy, especially the renewable sources of energy. Nuclear energy is one of such forms of energy with enormous potentialities. This is also referred to as atomic energy and it is the energy released in nuclear fission or fusion reactions. But the atomic energy or the nuclear energy is not a direct source of energy for consumer use. It is only a means of producing electricity. If one looks at the energy situation on a total basis, in a long term horizon, it is evident that atomic power has to be developed in a big way. The electric power generation is expected to go up to 2,00,000 MWe by the year 2005. Even then the per capital consumption of electricity would be only 60% of the minimum requirement of about 1000 KWh.

19.3. NUCLEAR POWER PLANTS

Nuclear energy has been used for constructive and welfare purposes throughout the world only since 1950. But it has expanded very rapidly achieving an impressive rate of development since then. At present about 17% of the world's electricity is generated through nuclear sources. There is no fundamental difference in the principle underlying a conventional power station and nuclear power station. In both cases energy is used to heat water to produce steam to drive generators of power by means of the turbines. In the case of nuclear power plants, this energy is derived from nuclear or atomic fission (essentially of uranium) in a device called nuclear reactor or atomic reactor.

19.4. TYPES OF POWER REACTORS

Nuclear reactors are classified on the basis of the fuel (the fissionable material), the coolant and the moderator used in the reactor. The coolant and the moderator are required to control the heat generated and the vigour of the fission process respectively. There are basically five types of reactors.

These are

1. Pressurised Water Reactor (PWR)
2. Boiling Water Reactors (BWR)
3. Pressurised Heavy Water Reactors (PHWR)
4. Gas Cooled Reactors (GCR)
5. Liquid metal Cooled Breeder Reactors (LMBR)

The first two types are widely in use amongst the five types. In the pressurised water reactor, the pressure is maintained very high so that water does not boil even at a temperature sufficiently above the normal boiling point. This high temperature water under high pressure leaves the reactor vessel and enters the heat exchanger. The heat exchanger contains a secondary water system. Low pressure is maintained in this circuit and therefore the high temperature water begins to boil and produces steam. This steam moves the turbines to generate electricity. In the boiling water reactor the heat from the fuel rods causes the water to boil producing steam at the top of the reactor vessel. This steam is fed to turbines which generate power.

The two types are schematically shown in the figures 19.1 and 19.2

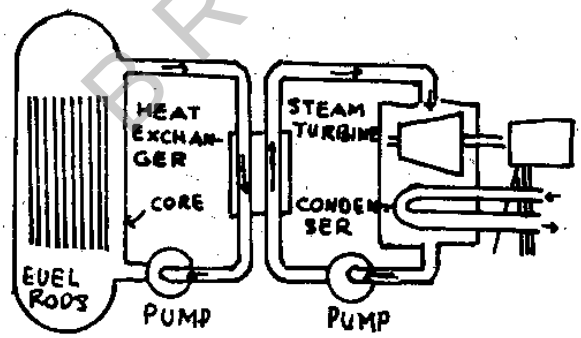

Fig. 19.1. Pressurised Water Reactor.

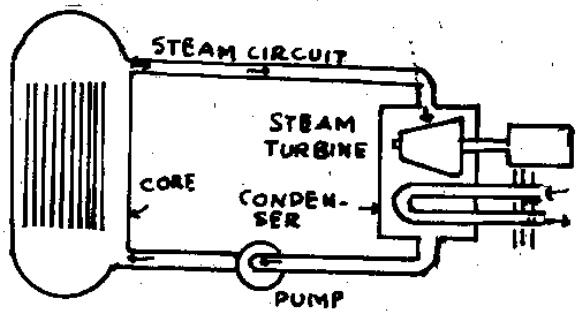

Fig. 19.2. Boiling Water Reactor.

Construction of Atomic Reactor: The fissionable substance generally uranium dioxide in the form of tablets is filed up in the fuel rods. Such rods in large numbers hang in the core of the reactor. The nuclear fission takes place inside the fuel rods and the thermal energy is released. The energy is absorbed by water in the primary circuit and the same is transferred to a secondary circuit through heat exchanger and steam is generated. The steam from the secondary circuit drives the turbines and produces the electric power. The atomic fission reaction is a chain reaction propagated by the neutrons released in the fission process. Therefore control rods are installed in the core besides fuel rods to absorb the neutrons and control the chain reaction. Due to small leakages that take place in the fuel rod, the water in the primary cooling circuit is subjected to mild radioactivity. A safety tank is therefore provided to prevent the spread of this activity. Further to prevent the entry of the radioactive air into the environment, vacuum is created in the safety tank. The contaminated air is removed by suction and fed into filter systems. The radioactive waste water resulting from the decontamination process of the primary cooling water is retained for some time and decontaminated. The components in the reactor may become radioactive in the course of time. The power plants therefore are expected to last for 20 to 40 years.

19.5. NUCLEAR POWER PLANTS IN INDIA

Nuclear power generation in India started in 1969 with the commissioning of the Tarapur Atomic Power Station (TAPS 1&2). It contains two boiling water Reactors of 160 MWe capacity each. During 1972-80, two more Pressurised Heavy Water Reactors (PHWR-1&2) were constructed at Rawatbhata in Rajasthan. All these reactors were constructed with foreign collaboration (US & Canada). The next reactor based on totally indigenous effort became operational in 1983. This was the 235 MWe capacity PHWR at Kalpakkam near Madras (MAPS-1). An identical unit (MAPS-2) at the same location began generating power in 1985.

Table 19.4. Projected Nuclear Power Generation by 1995-2000 in some countries

Country	Reactors number	Expected Capacity (MWe)	Share in Total %
Canada	21	13389	12
France	61	53328	75
Germany	26	23014	25
U.K.	43	13794	20
U.S.	119	107109	20
Russia	124	101612	20
India	32	10090	10

Check Your Progress 1, 2 & 3

1. What would be the expected power generator capacity in India by 2005 AD?
2. How many types of power reactors are there? What are they?
3. Name two nuclear power plants of India.

Note: (a) Write the answers in the space provided below.

(b) Compare your answers with those given at the end of this unit.

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19.6. SAFETY OF NUCLEAR POWER PLANTS

The safety of a nuclear power plant has to be evaluated taking into consideration the entire cycle of operations and processes involved rather than simply the plant itself. Generally in any reactor the fuel rods become deficient in U-235 with a flux of time and hence they have to be partially removed and replaced by new ones. Thus each year about one third of the spent fuel elements in a reactor are removed and stored in large concrete lined pools of water at the plant site for several years. After they have cooled, these are transported to the permanent nuclear waste repository or dump in sealed heavily shielded cash proof casks. During the running of the plants, fission converts some fuel and the metal rods and parts are converted into radioactive materials by neutron bombardment. Large heat, which does not stop even after the reactor is shut down, is produced. So water has to be circulated continuously to cool down the rods and prevent their melting. If the melting is not prevented, large quantities of highly radio active materials will be released into the environment. Therefore a number of safety precautions are necessary and generally these are taken in any commercial reactor plant.

Safety Precautions

1. Thick walls and concrete and steel shields surround the reactor vessel.
2. A steel-reinforced concrete containment building to prevent escape of radioactive materials into the environment in case of any unforeseen accidents.
3. Large filter systems and chemical treatment facilities are provided in this containment building to remove radio active dust from the air.
4. Steam released from damaged reactor vessel is condensed to reduce the pressure build up beyond the capacity of containment building walls.
5. An emergency core-cooling system is installed to flood the core automatically with tons of water within one minute to prevent melting of reactor core.
6. X-ray inspection units are set up to detect flours in the construction periodically.
7. Automatic backup systems to replace safety systems in the event of their failure.

8. Management of radio active wastes is done following the three general principles namely

   (a) Dilute and Disperse
   (b) Delay and decay
   (c) Concentrate and contain

Thus the main aspects about which the safety measures are important are

1) Management and control of large heat generated
2) Management and disposal of radioactive materials formed.

The first principle namely dilute and disperse is applicable for gaseous and low-level liquid effluents. Dilute is done by air or water respectively. The second principle "delay and decay" applies to the wastes which contain short lived nuclides. The third principle "Concentrate and contain" is generally applicable to medium and high level wastes both solid and liquid. The wastes are processed, treated and conditioned before containment.

Check Your Progress 4 & 5

4. What safety measures are required to cool the system after the reactor is sheet down?

5. How do you manage the radioactive wastes?

Note: (a) Write the answers in the space provided below.

(b) Compare your answers with those given at the end of this unit.

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19.7. NUCLEAR ACCIDENTS : SOME CASE STUDIES

A nuclear power plant operating at full power releases negligible amounts of radioactive material into the environment. The amount released from normal plant operations would result in radiation exposures that are far less than those people who receive from medical X-rays and from natural background sources such as cosmic rays and radioactive nuclides on the earth. Thus the real safety of nuclear power arises from adopting a policy that recognises that "Accident prevention is the key to Safety.

There are two nuclear accidents that demand a mention in the context of safety of nuclear power generation.

i) **Three Mile Island (TMI) Disaster :** This occurred on March 28, 1979 in USA near Harrisburg, Pennsylvania. The accident occurred because of a series of mechanical failures and human operator errors not foreseen in safety studies. The installations suffered a damage but there was no radiation hazard posed by this accident either to personnel working at the plant or to people living in the surroundings.

The reactors core became partially uncovered underwent a partial core meltdown. It was realised that unknown amounts of ionizing radiation escaped into the atmosphere. Even though visibly no one is known to have been affected or died as a result of the accident, a debate is going on on the long term health effects on workers and nearby residents.

2. **Chernobyl Disaster:** The accident occurred at the Chernolyl Power Station No.4 in the then USSR on April 26, 1986. One of the four graphite moderated water cooled reactors flew the roof off the reactor building and set the graphite core on fire. The explosion and the resulting fire spewed radioactive materials into the atmosphere. These were carried by winds over parts of former USSR and Eastern and Western Europe as far as 2000 Kilometers from the plant site. It took 10 days for the firefighters to get the intensity of hot graphite fire under control. About 1,35,000 people living within 30 kilometers of the plant were evacuated. These will not be allowed to return to their homes for atleast some years. Five months after some deaths were reported. Many were reported to be suffering from acute radiation sickness. A land area of 2590 square kilometers around the plant was contaminated with radioactive fallout. All the nearby forests had to be cut down and the topsoil removed and boiled. Many people in USSR (former) and Europe may be met with premature deaths in the next 70 years. But one need not be alarmed.

There are major differences between the chernobyl reactor and the Indian pressurised water reactors. The chernobyl reactor was graphite moderated and water cooled. Hot graphite and water make a dangerous combination. Large amounts of hydrogen come out if these two come into contact with each other. No graphite is used in Indian reactors. The Chernobyl plant was housed in an industrial type of building. The situation in India is different since it makes use of the double containment principle. Moreover graduate engineers with adequate training are in charge of the stations at all times in India unlike in Chernobyl. At each nuclear power station there is an environmental survey laboratory (ESL). This establishes the base-line for radioactivity of the natural background and recommends discharge limits for release of effluents for each station. Finally no activity especially industrial power production activity is without some measure of risk. Therefore lessons should be learnt and suitable actions taken to minimise the probability of such accidents and in the unlikely event of something happening, the impact should be contained.

19.8. AGENDA FOR FUTURE ACTIONS

1. 'Quality Assurance' has to be given priority in all the activities such as planning, managing and construction.
2. The industry must strengthen this area with regard to quality system, quality engineering and quality control.
3. Augmentation of the automated systems that ensure reactor safety even under highly improbable abnormal conditions has to be taken up in nuclear installations.
4. Greater reliance has to be placed on operator training, qualification and requalification through use of simulators and review of operating procedures by independent experts.
5. The construction industry has to equip itself with automatic equipment and to adopt modern techniques to reduce the time taken for civil constructions and mechanical creations.
6. People must be informed of the risks and the benefits associated with the use of all energy sources.

7. Efficient functioning of power reactors that are in operation must be ensured.
8. Adherence to schedules and costs of nuclear power generation must be ensured.
9. The requisite R & D back up must be maintained.
10. Much greater importance shall be given for man-machine interface.

19.9. SUMMARY

1. Power demands are increasing day by day and hence nuclear power option must be taken up with open mind.
2. No fundamental difference in the principle underlying a conventional power isolation and nuclear power station.
3. There are five nuclear power reactors. Namely (a) Pressurised Water Reactor (PWR), (b) Boiling Water Reactors (BWR), (c) Pressurised Heavy Water Reactors (PHWR), (d) Gas cooked Reactors (GCR), and (e) Liquid Metal cooled Breeder Reactors (LMBR). The first two are widely used.
4. The nuclear power generation in India began in 1969.
5. Safety measures include, construction of concrete containment building and provision of large filter systems, emergency core cooling systems, X-ray inspection units, automatic backup systems, modern methods of management of radioactive wastes.
6. The major nuclear accidents are Three Mile Island disaster in US and Chernobyl disaster in former USSR.
7. Quality assurance and training and retraining are essential for those engineers involved in the production processes.
8. People must be informed properly of the risks and the benefits associated with atomic power generation.

19.10. CHECK YOUR PROGRESS : MODEL ANSWERS

1. India is expected to produce 2,00,000 MWe by the year 2005 A.D.
2. There are five types of power reactors. They are (1) Pressurised water reactor, (2) Boiling water reactor, (3) Pressurised heavy water reactor, (4) Gas cooled reactor, and (5) Liquid metal cooled breeder reactor.
3. Tarapur Atomic Power Station and Madras atomic power station at Kalpakam, near Madras.
4. Water has to be circulated continuously to cool down the system.
5. The radioactive waters can be managed by following three general principles viz., dilute and disperse, delay and decay and concentrate and contain.

19.11. MODEL EXAMINATION QUESTIONS

I. Answer the following questions in about 30 lines each.

1. Describe with diagrams, the atomic power generation by Pressured Water Reactor or Boiling Water Reactor.

2. Write a detailed account on the safety measures to be adopted in atomic power generation.

3. Mention with details the two disasters that took place in the past.

II. Answer the following questions in about 10 lines each.

1. What is the principle underlying the nuclear power generation?

2. What is a power reactor?

3. What types of reactors are followed in India.

4. How much atomic power is generated every year and what is the expected target by 2005.

5. What are the possible hazards associated with atomic power generations?

6. Name two important safety measures adopted.

7. What are the main disasters that took place in the past?

8. What is the agenda for future safety action.

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UNIT-20 : NONCONVENTIONAL ENERGY SOURCES

Contents

20.1. OBJECTIVES

After going through this unit you will be able to:

* describe the Non-conventional energy sources like solar energy, biogas etc.,
* list out the components of biogas and describe its importance and
* recognise the importance of energy conservation in future.

20.2. INTRODUCTION

For a country to prosper, there is definitely a need of abundant energy. This inturn raises the standard of living and the consumption of energy. Energy resources may categorized as renewable and non-renewable. Renewable energy resources comprise photosynthetic products such as fuelwood and agricultural waste, direct solar conversion, water and wind power and geothermal energy rational utilization of these resources can provide energy indefinitely. But if they are exploited too rapidly some of them may get depleted eventually leading to exhaustion. Non-renewable energy resources include fossil fuels such as coal, oil, natural gas, as well as Nuclear fuels. Energy resources may also be categorised as commercial and non-commercial resources. The former type include fossil fuels, nuclear fuel, geothermal energy, wind and water power. The non-commercial energy resources come from fuel wood, crop residues and animal waste when consumed directly as fuel. The renewable energy is energy obtained from the continuous or repetitive currents of energy occurring in the natural environment. Non-renewable energy is the energy obtained from static stores of energy that remain bound unless released by human interaction.

The Non-conventional Energy Sources cannot replace conventional Energy Sources but can only supplement it. The non-conventional sources of Energy include wind, solar, tidal, geothermal, biogas, wood etc., where as conventional sources are fossil fuels (coal, petroleum etc.) and nuclear. The fossil fuels are costly and non-renewable type of Energy sources. Judicious use of Energy source is more important than harnessing energy sources.

Renewable Energy systems depending on biomass, solar power, wind power, tidal power etc., by their very nature are suited for low intensity, decentralised generation and consumption.

20.3. INDIAN SITUATION AND ROLE OF RESEARCH ORGANISATIONS

As per the survey conducted in the year 1988-89 by the central electricity authority of India,

the energy consumption for different sectors is as given under:

Domestic Sector	—	20%
Commercial Sector	—	7.3%
Agriculture Sector	—	25%
H.T. Industries	—	36%
L.T. Industries	—	8%
Miscellaneous	—	3.7%

The present data may vary slightly now. The per head energy consumption in India is 1/8 of the global average. The Indian Energy scene is characterized by a low per capita resource endowment of fossil fuels. The energy consumption in house holds shows that the share of non-commercial energy is over 80% in rural areas compared to 51% in urban areas.

The energy crisis in our country may be described as a dilemma between the need and availability. It also comprises the increased quantities of energy for development, the need to reduce expenditure on coal, oil and electricity.

India does not have abundant energy resources and is still heavily dependent on traditional sources of energy. Of course, the industrialisation of the country is resulting in changes in the use of traditional energy sources. The availability of coal is diminishing and the coal that is available is generally of poor quality with very heavy ash content. With the establishment of steel plants, the demand for coal went up while production lagged behind. Oil and natural gas reserves in India are still in the process of exploration.

Electricity consumption has been growing at an alarming annual rate of 12%. The efficiency of generation and transmission of Electricity in India is extremely poor.

It is extremely difficult to make an accurate estimate of the domestic consumption of energy, since this involves hundreds of millions of people. Rural energy is one of the predominant energy consumption patterns of India. The Energy crisis in India can be reduced to some extent by the decentralised rural energy systems. Thus rural energy development is a relatively new subject which has gained attention, concentration and momentum recently.

There are various research organisation and institutions in India, which are contributing their mite to solve the energy crisis. The Central Fuel Research Institute (CFRI) is doing research which is aimed at turning coal into petroleum and other synthetic products. Oil and Natural Gas Commission (ONGC) and Oil India Limited (OIL) are engaged in oil exploration. Some of the research organisations in India where an active research in field of Energy and its related topics are being carried out are listed below:

* Department of Non-conventional Energy Sources, ministry of Energy, New Delhi (DNES)
* Solar Energy Society of India, SESI
* Non-conventional Energy Development Corporation of Andhra Pradesh (NEDCAP)
* Dept. of Management Studies, IISc., Bangalore.
* Indian Institute of Tropical Meteorology Field Research Unit, Bangalore.
* Centre for Energy Studies, IIT, Delhi.

* Energy Centre, Dept. of Mech. Engg. IIT, Bombay.
* School of Energy Studies, Jadavapur University, Calcutta.
* Devi Ahilya Vishwavidyalaya, Indore.
* School of Energy , JNT University, Hyderabad.
* Tata Institute of Fundamental Research, TIFR, Bombay.
* Tata Energy Research Institute (TERI).
* National Physical Laboratory, New Delhi.
* Energy Research Centre, Punjab University, Chandigarh.
* Deepak Institute of Solar Energy Research, Jabalpur, M.P.
* Central Arid Zone Research Institute, Jodhpur.
* Sardar Patel Renewable Energy Research Institute (SPRERI) Vallabh Vidyanagar, Gujarat.
* Gujarat Energy Development Agency, Vododara
* Cell for Renewable Energy Dissemination Activities, Karnataka State Council of Science Technology (KSCST) Bangalore.

In addition there are some more research organisations and universities in India which are actively involved in the research works in the field of Non-conventional Energy Sources.

India is blessed with an abundant supply of renewable energy sources such as solar, wind, biomass etc., which are environmentally being. Solar Energy is available throughout the country for almost the entire year. India being a country with numerically dominant rural population, it is imperative that the development of the country as a whole is intimately linked with rural development.

20.4. SOLAR POWER

The sun supplies 20,000 times as much energy as a man consumes from all sources. It is estimated that in India, each square kilometer receives solar energy equal to 7.5×10^6 KWh per day. Solar radiation that is received on earth can be classified as Beam radiation and Diffuse radiation. Beam radiation is also called as direct radiation. It is the radiation intercepted by a surface with negligible direction change and scattering in the atmosphere. The radiation scattered by aerosols, dust and by the Rayleigh mechanism and not possessing unique direction is called diffuse radiation. The global or total radiation is the sum of beam and diffuse radiation. Solar conversion technology involves the conversion of the Sun's radiant energy to heat. This conversion is generally carried out by means of Flat Plate collectors or Solar concentrators. To determine the useful energy delivery the system analysis is to be made. The system comprises the collector and storage. It is essential to evaluate the interaction of the solar system components in response to climate and energy demand. This system analysis is based on well-established engineering knowledge. The Flat plate collectors respond to both beam and diffuse radiation whereas concentrations work on beam radiation only. To say in a simple way, the concentrators will not receive any solar radiation when there is no direct sun (that is on cloudy/rainy days).

Solar Energy, as an energy substitute, can be utilized in the following ways.

* Solar heating
* Solar drying
* Photo-Voltaics
* Solar Stills
* Solar refrigeration

Solar heating involves solar water heating and use in solar cookers to conserve firewood energy. Both require the utilization of Flat Plate Collectors. This requires large areas facing south to locate the collectors. These collectors are glass topped and require clear space without any shade falling on it. They are also to be protected against any vandalism. Water or air is used as working fluid flowing through the tubes which play the role of conversion medium.

Solar cooker does not require fuels like coal, wood, kerosene, cow-dung etc., to cook food. It utilizes the sun's rays to cook food most hygienically and safely, harmless and without any smoke. For starting the cooking, one has to wait till sun rises and comes up and the duration of cooking is long. There are no moving parts and it is more versatile than pressure cooker. Frying is not possible in this method and even the cooking is not possible on monsoon days because of low heat gain. The cost is beyond the reach of average rural household of our country.

Solar water heating does not have any predominant usage in India. There is no necessity of heating of buildings which minimizes the usage of hot water. Hot water at 80^0C can be easily obtained using Flat plate collectors. Higher temperatures can be attained by using Parabolic solar concentrators with evacuated tubes at the focal axis. Since these require more of Engineering knowledge it is not discussed further here.

The seasoning of wood, drying of large quantities of food can be carried out using Solar Dryers. These dryers also works on the same principle of solar energy collection, conversion to thermal energy with or without storage facility.

Solar Photo-Voltaic system consists of modules in which photo-voltaic cells are suitably arranged. These cells may be made up of amorphous or crystalline silicon. The photovoltaic generation of power is caused by radiation separating positive and negative charge carriers in absorbing material. If an electric field is present these charges can produce current for use in an external circuit. Such fields exist permanently at junctions or in homogeneities in materials. The junction devices are usually named photovoltaic cells. The D.C. power generated can be stored in batteries and may be suitably converted to A.C. The P.V. devices are particularly useful for providing electricity for lighting in remote and rural areas but the cost is very high. These devices can also be used to drive pumps to lift water in remote areas.

Basically PV cells convert light (Photo) into electricity (Voltaic). When such a cell is used to convert sun light (Solar energy) into electricity, it is aptly called as Solar Cell.

Brackishwater is one of the major problems in Indian Villages. This can be solved by solar desalination which can be achieved by solar stills.

Solar refrigeration is one of the important applications of solar power. Vapour compression, vapour absorption and steam jet refrigeration may be obtained using solar energy. The

required refrigeration is attained by either producing vapour/steam to run a turbine coupled to compressor of vapour compression refrigerator or produce electricity by means of PV cells to run the motor driven compressor of the system. In vapour absorption system, solar energy supplies the required heat at the generator. The cost of tonne of refrigeration produced is exhorbitant. But this can be successfully used in remote areas which are beyond the reach of power transmission lines.

The line diagrams regarding some of the applications of Solar Energy are mentioned in Figures 20.1, 20.2 & 20.3. Fig. 20.1 illustrates the use of a photo-voltaic module to generate D.C. Power which in turn is converted to A.C. by Inverter and is converted to a motor which drives the compressor of Vapour Compression System of refrigeration.

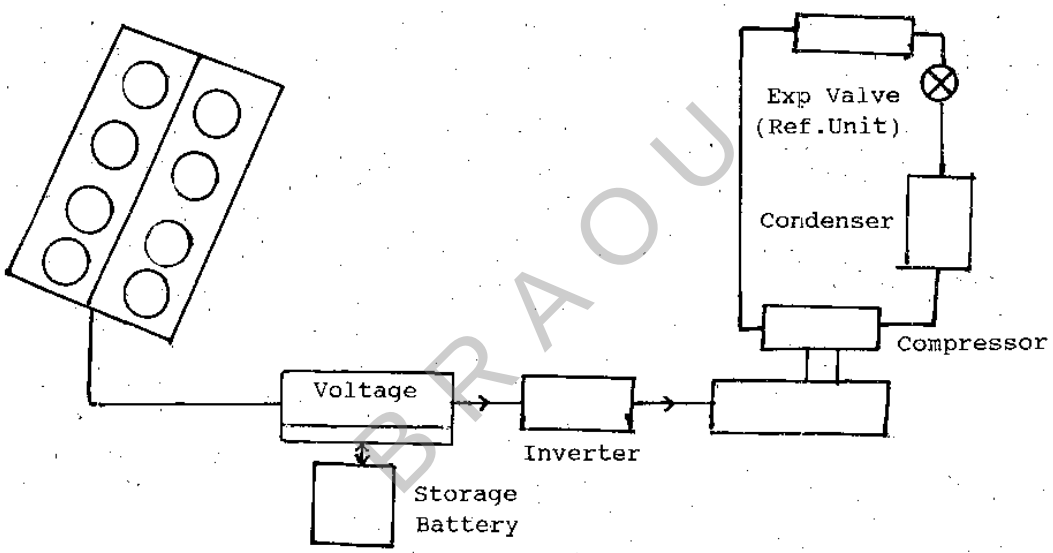

Fig. 20.1. Use of photovoltaic module to generate DC power which in turn converted to AC by inverter

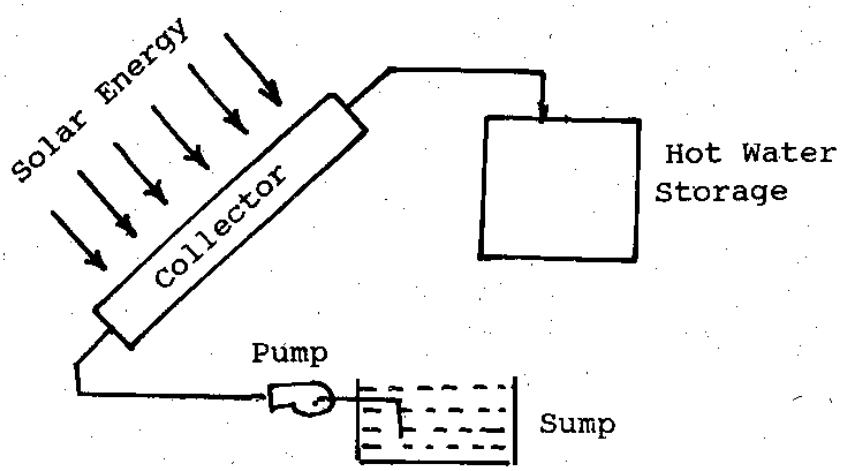

Fig. 20.2. Production of Hot Water

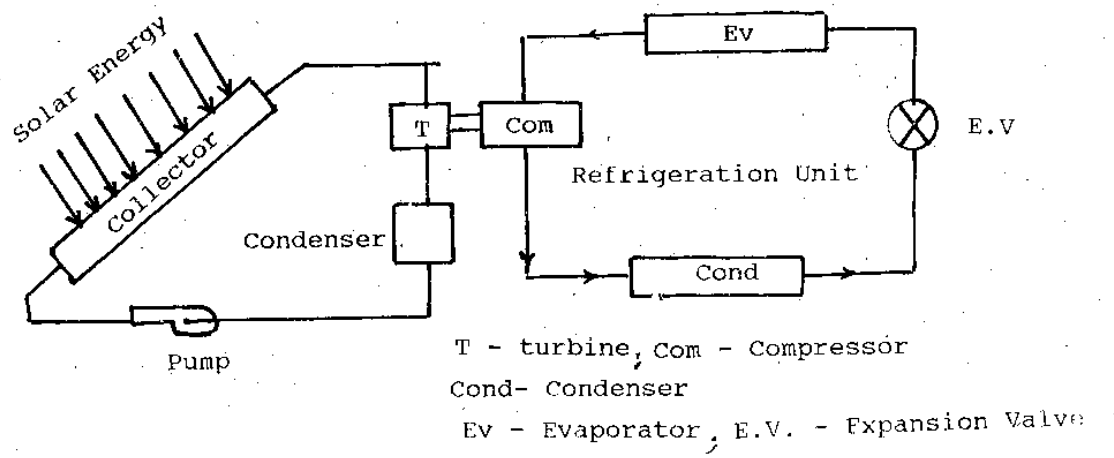

Fig. 20.3. Vapour Compression Refrigeration System

This refrigeration system comprises of a compressor, a condenser an expansion valve and an evaporator. Fig. 20.2 shows how a Flat Plate Collector (FPC) is used to produce hot water which is stored in a hot water storage tank for future use. Fig. 20.3 depicts the working of a vapour compression refrigeration system using FPC. A low boiling liquid is used in the circuit which produces vapour due to the collected heat of FPC. This vapour drives the turbine which is coupled to the compressor of vapour compression system. The condensate is recycled through the FPC by means of a pump. As the temperature attained by FPC is of the order of 70°C-80°C, water cannot be used as working fluid. Turbine needs steam to drive it.

20. 5. BIOGAS

The gas produced using Biomass as fuel is Biogas. Biomass is an inexhaustible storehouse of solar energy, offers the most convenient natural route to meet the growing energy needs, especially, in rural sectors. All organic matter, or biomass, can be used as fuel in one form or other. The Biomass from which energy can be harvested or reclaimed is obtained from different sources like crops, food, manufacturing raw materials, municipal and industrial waste. Wood or dry litter are the forms of vegetable Biomass. Energy from biomass is attractive since its primary source, sunlight, is free. But the collectors that are used in this conversion, namely plants, are inefficient as collectors of solar energy. The energy quantities that are potentially available to plants vary between 2.5 to 8.0 GJ/m^2/yr depending on the latitudes and climates. The energy conversion is due to the process of photosynthesis. To Calculate the amount of energy that can be harvested in plants from a given area, it is essential to have a knowledge of the average energy content of the plant material. Figures 20.4, 20.5 and 20.6 illustrate some of the Biogas plants.

3. What are the essential constituents of solar power system.

Note: (a) Write the answers in the space provided below.

(b) Compare your answers with those given at the end of this unit.

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20.6. SUMMARY

The energy crisis in our country may be described in simple terms as a dilemma between the need, to make available/increased quantities of energy for development and the need to reduce expenditure on coal, oil and electricity. The only solution to this problem is renewable energy sources which make use of the locally available resources. The economic feasibility of any energy from solar or biomass scheme depends ultimately on the cost of competitive conventional fuels. Hence Government of India has introduced many subsidy schemes to encourage the use of Non-conventional Energy Resources. Energy education is to be given top priority and people are to be well educated regarding the energy crisis and the use of non-conventional energy resources.

20.7. CHECK YOUR PROGRESS : MODEL ANSWERS

1. Commercial fuels include fossil fuels, nuclear fuels, geothermal, solar, wind etc. Noncommercial fuels include fuel wood, animal waste.
2. Photosynthesis is the main cause for energy conversion in plants to biomass.
3. The Solar power system consists mainly of collector, storage and distribution system.

20.8. MODEL EXAMINATION QUESTIONS

I. Answer the following questions in about 30 lines each.

1. Discuss the classification of Energy Resources.
2. How do you compare the biomass conversion of plants to that of solar collectors.
3. Discuss the relative merits and demerits of the biomass energy programmes.

II. Answer the following questions in about 10 lines each.

1. Write briefly about solar energy.
2. Write briefly about biogas.
3. What are the advantages of biogas programme?
4. What are the disadvantages of biofuels?

Prof. P. Venkataseshaiah

Dr. B.R. AMBEDKAR OPEN UNIVERSITY

FACULTY OF SCIENCE

P.G. DIPLOMA IN ENVIRONMENTAL STUDIES

Course III : Contemporary Environmental Issues

MODEL EXAMINATION PAPER

Time : 3 Hours **Max. Markx : 100**

SECTION - A

4X15 = 60

Answer any four of the following questions.
Each question carries 15 marks.
Answer the following questions in about 30 lines each.

1. Explain the reasons for food problems in developing countries.
2. Write briefly about food poisoning by microorganisms.
3. Briefly describe different types of soil erosion.
4. Write briefly about the rainfall distribution in India and the variation of the same with monsoon.
5. Write an essay on fish and prawn hatcheries.
6. Define air pollution and mention types of air pollutants.
7. List out and describe the mateorological factors influencing air pollution.
8. Explain the importance of small scale industries.

SECTION - B

5X8 = 40

Answer any five of the following questions.
Each question carries eight marks.
Answer the following questions in about 10 lines each.

9. Write briefly about fluorosis.
10. What is Narmada Bachao Andolan?
11. Write briefly about intercropping.
12. Distinguish between minor and medium projects. Discuss briefly about them.
13. What is the importance of constructing a dam?
14. Write about the safety standards for automobile pollution?
15. What is meant by migrant labour? Describe them.
16. Explain briefly the technology machines.
17. What are the difficulties encountered in the transportation of kerosene and natural gas?
18. What type of nuclear reactors are followed in India?

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Course III : Contemporary Environmental Issues

ASSIGNMENT - 1

Time : 2 Hours

Note:

1. *Do not copy the answer directly from any of the books.*
2. *As far as possible, try to answer the questions independently in your own words.*
3. *If it is necessary to quote from any source, give the correct reference.*
4. *Use your own foolscap pages for writing the assignment.*
5. *Leave sufficient margin for the comments of the evaluator.*
6. *Completion of this assignment normally should not take more than two hours time.*

I. **Answer the following questions in about 30 lines each.**

1. Explain the reasons for food problems in developing countries.
2. Write briefly about food poisoning by microorganisms.
3. Briefly describe different types of soil erosion.

II. **Answer the following questions in about 10 lines each.**

1. Write briefly about fluorosis.
2. What is Narmada Bachao Andolan?
3. Write briefly about intercropping.

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Course III : Contemporary Environmental Issues

ASSIGNMENT - 2

Time : 2 Hours

Note:

1. *Do not copy the answer directly from any of the books.*
2. *As far as possible, try to answer the questions independently in your own words.*
3. *If it is necessary to quote from any source, give the correct reference.*
4. *Use your own foolscap pages for writing the assignment.*
5. *Leave sufficient margin for the comments of the evaluator.*
6. *Completion of this assignment normally should not take more than two hours time.*

I. **Answer the following questions in about 30 lines each.**

1. What are the problems arising due to urbanisation? Write briefly about them.
2. Can the NGOs supplement or replace the welfare programmes of the Government and other Institutions? Elaborate.
3. Write in detail about major chemical accidents and impact assessment.

II. **Answer the following questions in about 10 lines each.**

1. Differentiate between fertility and fecundity.
2. What is Thanrao Struggle?
3. Write briefly about films and publicity.

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Course III : Contemporary Environmental Issues

ASSIGNMENT - 3

Time : 2 Hours

Note:

1. *Do not copy the answer directly from any of the books.*
2. *As far as possible, try to answer the questions independently in your own words.*
3. *If it is necessary to quote from any source, give the correct reference.*
4. *Use your own foolscap pages for writing the assignment.*
5. *Leave sufficient margin for the comments of the evaluator.*
6. *Completion of this assignment normally should not take more than two hours time.*

I. Answer the following questions in about 30 lines each.

1. What are the occupational hazards and diseases? Identify and classify the agents responsible for hazards and diseases. Give suitable examples.
2. Describe the aspects that are normally considered for locating an industry.
3. What are the different causes of famines and floods?

II. Answer the following questions in about 10 lines each.

1. Define earthquake predictions.
2. What are soical and psychological consequences of displacement?
3. How is nuclear waste disposed?