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Indira Gandhi National Open University
School of Interdisciplinary and
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MEVE-003
Agricultural and Allied Sector

AGRICULTURAL POLLUTION

1

Indira Gandhi National Open University
School of Interdisciplinary and
Trans-disciplinary Studies

MEVE-003
Agriculture and Allied Sector

Block

1

AGRICULTURAL POLLUTION

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COURSE INTRODUCTION

Welcome to the Post Graduate Diploma in Environmental and Occupational Health (PGDEOH) of IGNOU. The curriculum prepared for this programme is relevant and significant in the present day scenario. This programme is in consensus with the mission of Environmental and Occupational Health which is to prevent adverse health effects related to chemical and biological contaminants in the Environmental and Occupational exposures through education, research and service.

This core course is entitled "Agriculture and Allied Sector". This course consists of 4 blocks comprising of 17 Units.

Block 1 deals with Agricultural Pollution. Agriculture is the basic economic activity in India and in most of the developing countries. Agrotechnological developments like fertilizer responsive high yielding varieties and hybrids have aided immensely in augmenting our country's agricultural production. The use of pesticides and fertilizers in the agricultural sector has caused serious incidents of pollution and has impacted human health. The block deals with agricultural practices by the use of pesticides, fertilizers, land practices and managing invasive species.

Block 2 deals with the Livestock and Aquaculture Pollution. Livestock is one of the important sources of income, employment, energy/transport and nutrition leading to nutritional and livelihood security to the rural masses. Livestock sector has immense contribution to the food security of the country by providing various highly nutritious products like milk, meat, egg etc. Since time immemorial, livestock rearing is a vital part of Indian agriculture helping in socio-economic development of more than two-thirds of the rural population in India. Livestock rearing is the lifeline for most of the farming community in the country and has both advantages and disadvantages. In the same way aquaculture is also an important sector for the economy of a country. But they also contribute to environmental pollution. These aspects have been detailed in this block.

Block 3 deals with Sustainable Agricultural Management. Pests and weeds are some problems faced in the agriculture sector. Therefore, integrated pest management practices based on sound ecological principles is currently used throughout the world. This block emphasises sustainable practices to achieve safety, durability, and profitability through the adoption of novel and innovative pest management tactics and capitalizing the synergies existing between the methods of pest management. The units also discuss how to overcome the ecological problems resulting from the excessive or indiscriminate use of fertilizers, organic manures and the use of biofertilizers for eco-friendly solutions.

Block 4 deals with Challenges to Agricultural Environmental Health. It discusses about agricultural traceability as the process of gathering information, documenting those gathered information, maintaining it, and applying those information related to all the processes involved in the supply chain in a manner that guarantees to all the consumers and other stakeholders on the origin, location and life history of a product as well as assisting in crises management in the event of a safety and quality breach. The block also discusses food borne diseases resulting from the consumption of either food or water contaminated with viable pathogenic bacterial cells or spores. It also focuses on zoonotic diseases that are a major public health problem. Agriculturists, veterinarians, butchers, laboratory workers, hunters and many more occupational groups are at the higher risk of being affected by these diseases. Finally the block also discusses food loss and wastes and genetically modified organisms.

All these Blocks will provide you with sufficient knowledge about the agricultural sector and practices involved.

BLOCK 1 INTRODUCTION

Block 1 deals with Agricultural Pollution. Agriculture is the basic economic activity in India and many developing nations. Millions of tonnes of chemicals are used in the agriculture sector. The indiscriminate use of pesticides, fertilizers and other chemicals has threatened our land and water. These pollutants have poisoned our environment and have made it unfit for living. The block focuses on these agricultural practices and their impacts on health and environment.

Unit 1 deals with Pesticides. The unit discusses that pesticides are diverse group of chemicals used to contain or manage the pests in the specific crops and specific situations. Chemical pesticide use has helped in saving the crops from pests and increasing agricultural production. At the same time they have impacted the environment and health of humans. The unit details the different classes of pesticides and their applications.

Unit 2 deals with Fertilizers. The unit emphasizes that fertilizer application is one of the most widely accepted practices for increasing crop yield and income of farmers. Fertilizers are essential agricultural input as they replenish the soil, meet the crop requirement, and also they ameliorate the soil and act as soil amendments. At the same time excessive applications can have negative impacts on our environment. The unit gives a detailed account of the classification of fertilizers, its impacts on health and environment.

Unit 3 deals with Land Practices and Pollution. The unit explains that land is a vital resource for producing food and other ecosystem goods and services including conserving biodiversity, regulating hydrological regimes, cycling soil nutrients and storing carbon. It focuses on the land use practices used in the agricultural sector which has resulted in the degradation of land. The unit also explains the soil erosion, sedimentation and desertification processes.

Unit 4 deals with Invasive Species. It discusses that alien species are one of the leading threats to biodiversity. They exert enormous costs on agriculture, forestry, fisheries, and other human enterprises, as well as on human health. The unit discusses in detail on the impacts of invasive alien species on human health, environment and social well being.

UNIT 1 PESTICIDES

Structure

1.0 Introduction

1.1 Objectives

1.2 What is a Pesticide?

1.3 Classification of Pesticides

- 1.3.1 Based on Type of Pest
- 1.3.2 Based on Mode of Entry
- 1.3.3 Based on Mode of Action
- 1.3.4 Based on Chemical Nature

1.4 Pesticide Consumption

1.5 Mode of Action of Insecticides

1.6 Pesticides in Environment

1.7 Pesticides and Human Health

1.8 Insecticidal Poisoning

1.9 Terminal Questions

1.10 Let Us Sum Up

1.11 Key Words

1.12 References and Suggested Further Readings

1.13 Answers to Check Your Progress

1.0 INTRODUCTION

Agriculture is the basic economic activity in India and in most of the developing countries. You can look upon the agricultural activity from the perspective of food sovereignty, economic empowerment of farmers and sustainable environmental management. It is interesting indeed to know that the agrotechnological developments like fertilizer responsive high yielding varieties and hybrids have aided immensely in augmenting our country's agricultural production. However, the crops grown in highly subsidized agro-ecosystem were found to be susceptible to pest outbreaks. In order to manage the crop pest, a diverse group of pesticides with wide ranging pesticidal activity found a prominent place in crop cultivation practices. Albeit, alternative techniques are increasingly developed, the pesticides are no less important in agricultural crop production. You would be surprised to know that our country loses approximately 18 % of the crop yield valued more than Rupees 90,000 crores on account of pest attack every year. The quantum of loss due to pest attack and rising demand for food security places non-negotiable demand for higher food grain production melded with ecological sustainability in food production system. Through this unit, your urge to find answers to intriguing queries like: What the pesticides are? How and on what basis the pesticides are classified?

What would happen to the environment due to injudicious use of pesticides? and such other issues would be quenched with answers and insights.

1.1 OBJECTIVES

After studying this unit, you should be able to:

- define pesticides;
- classify pesticides based on the type of pest, mode of entry, mode of action and chemical nature;
- describe the impacts of pesticides on environment;
- explain insecticidal poisoning.

1.2 WHAT IS A PESTICIDE?

Agricultural chemicals are diverse group of chemicals used to contain or manage the pests in the specific crops and specific situations. They are quite often referred as pesticides, farm chemicals and so on and so forth. So, pesticides can be construed as a group of chemicals that are used to control or manage the pest population well below the economic threshold level. We can categorically state that the use of pesticides for its intended purpose warrants responsible use, handling and management as it has far reaching and irreversible impact on people, and environment. You have read and seen for yourself the abuse of pesticide use resulting in colossal damage of the environment. However, deep study about the pesticides would embark you onto responsible management and rational use of pesticides.

DID YOU KNOW?

The term pesticides include substances that are used as a plant growth regulator, defoliant, desiccant, fruit-thinning agent, etc. The term excludes plant and animal nutrients, food additives, fertilizers and animal drugs.

1.3 CLASSIFICATION OF PESTICIDES

Pesticides are classified into various groups based on the type of the pest against which the compounds are used, their chemical nature, mode of entry and mode of action. A Bird's-eye view of pesticide classification will rekindle your interest on diverse group of pesticides and how it enters and act upon the target organisms.

Think and reflect

How the rational use of pesticides can be achieved in Indian farming condition?

List some of them.

1.3.1 Based on Type of Pest

The pesticides are classified into various types based on the type of pest.

Insecticides: Substances used to prevent, destroy, kill insects (e.g.) endosulfan, malathion

Fungicides: Substances used to prevent, destroy, control plant diseases caused by fungi. (e.g.) Copper oxy chloride

Herbicide: Substances used to prevent, inhibit, or kill the weed plants. (e.g.) 2,4, - D

Rodenticides: Substances that are used to control rats. (e.g.) Zinc phosphide

Nematicides: Substances that prevent, repel, or control nematodes. (e.g.) Ethylene dibromide

Chemosterilants: Substances that sterilize the insect pests.

Molluscicides: Substances that are used to prevent, repel or destroy the snails and slugs. (e.g.) Metaldehyde

Defoliants: Substances that cause the plant leaves to die and fall away.

Desiccants: Substances that drain moisture out of the plants causing them to dry.

Attractants: Substances that attract the insect pests.

Repellents: Substances that repel the insect pest from a treated plant.

Acaricides: Substances that are used to control mites on crops / animals (e.g.) Dicofol

Avicides: Substances that are used to repel the birds (e.g.) Anthraquionone

Bactericide: Substances that are used to control the plant diseases caused by bacteria (e.g.) Streptomycin sulphate.

DID YOU KNOW?

What are the ideal qualities of an insecticide?

1. To Kill the target insect effectively and quickly 2. Be less toxic to natural enemies and beneficial organisms like honey bees, soil microbes, etc. 3. Less hazardous and less toxic during handling of pesticides. 4. Less persistence in the environment 5. Should not engender pest resurgence. 6. Insecticides should possess complex mode of action so as to extend the insecticide resistance development. 7. Should posses a longer shelf life. 8. It should be cost effective and safe to use.

1.3.2 Based on Mode of Entry

Based on the mode of entry of pesticide, the pesticides are classified as follows:

Stomach poison:

The insecticide applied on the leaves and other parts of the plant when ingested into the pest, act in the digestive system of the insect pest and bring about the death of the pest. (e.g.) Malathion, parathion.

Contact Poison :

The pesticide or toxicant causes death of the pest species by means of contact (e.g.) Fenvalerate.

Fumigant:

The pesticide or toxicant enters into the tracheal system (respiratory poison) through spiracles in vapour form. (e.g.) Aluminium phosphide.

Systemic poison:

Pesticides applied on the plant parts or on soil are absorbed by the foliage (or) roots and translocated through vascular system. Such pesticides cause death of insect feeding on plant. (e.g.) Dimethoate.

1.3.3 Based on Mode of Action

Pesticides are broadly classified into physical, protoplasmic, respiratory and nerve poison.

Physical poison:

The pesticide or toxicant will not react chemically but kill the insect either by asphyxiation or desiccation. Mineral oil closes the spiracles and causes asphyxiation. So mineral oil is used for soft bodied insects like aphids. Activated clay exerts a physical effect on wax monolayer and create space so that depletion of moisture in insect cell occurs. Activated clay is used in storage pest management. E.g. Mineral oil, Inert dusts – Ash, silicagel, activated day.

Protoplasmic poison:

The toxicant causes precipitation of protein (e.g.) Arsenicals.

Respiratory poison:

Pesticide or toxicant inactivates respiratory enzymes (e.g.) Hydrogen cyanide.

Nerve poison:

Nerve poisons inhibit impulse conduction (e.g.) Malathion.

Chitin inhibition:

Chitin inhibitors inhibit chitin synthesis (e.g.) Diflubenzuron.

1.3.1 Based on Chemical Nature

Table 1.1: Classification of Pesticides based on their chemical nature

Main Group Insecticides Botanical (plant extracts)	Subgroups	Examples Nicotine, Pyrethrins, Rotenone
Antibiotic		Ivermectin, Spinosad
Inorganic		Aluminium phosphide, Calcium arsenate
Organic	Hydrocarbon Oils	Citrus spray oils, Mosquito Larvicides
	Organochlorines	Heptachlor, chlordane, endosulfan

	Organophosphorous	Dichlorvos, dichrotophos
	Oxadiazine	Indoxacarb
	Oxadiazolone	Metoxadiazone
	Phthalimide	Phosmet
	Pyrethroids	Allethrin, Cypermethrin
	Pyrrole	Chlorfenpyr
	Carbamates	Benthocarb, carbaryl, carbofuran
	Neo-nicotinoids	Imidacloprid, acetamaprid
	Pyrazole	Ethiprole, Fipronil
	Thiourea	Diafenthiuron
	Urea	Flucofuron
Microbial	Bacteria	Bacillus thuringiensis
	Virus	Polyhedral Viruses
Chemo-Sterilants		Diurea
Pheromones (Sex attractants)		Gyplure, Gossplure
Repellents		Dimethyl phthalate
Insect-growth regulators	Juvenoids (juvenile hormone mimics) Chitin Synthesis Inhibitor	Methoprene
	Moulting Inhibitor	Diflubenzuron
	Moulting Hormone	Ecdysone
Fumigants		Carbon disulfide
Acaricides		
Non-fungicidal	Organochlorines	Chlorobenzilate
Fungicidal	Dintro Compounds	Binapacryl
Fungicides		
Inorganic		Bordeaux Mixture
Organic	Dithiocarbamates	Mancozeb
	Phthalimides	Captafol
	Dinitro Compounds	Binapacryl
	Organomercurials	Phenyl mercury acetate
Eradicant fungicides (Chemotherapeutants)	Antibiotics	Blasticidin
	Morpholines	Dodemorph
Nematicides		
Soil Sterilants	Halogenated-hydrocarbons	Chloropicrin
Fumigant nematicides	Halogenated-hydrocarbons	Dichloropropene
Non-Fumigant Nematicides	Organophosphorus Compounds	Fensulfothion
	Carbamates	Aldicarb, Carbofuran

Herbicides		
Organic	Phenolics	Dinoseb Acetate
	Phenoxyacids	CMPP, MCPA, 2,4-D, 2,4,5-T
	Carbamates	Chlorpropham
	Substituted Ureas	Diuron
	Halogenated Aliphatics	Dalapon, TCA
	Triazines	Atrazine
	Diazines	Bromacil
	Bipyridyls	Diquat, Paraquat
	Pyrazolium	Difenzoquat
Desiccants and Defoliants	Quaternary ammonium compounds	Diquat, Paraquat
Plant Growth Regulators		
Growth Promoters	Gibberellic Acid	
Rodenticides		
Fumigants	Aluminium Phosphide	
Anticoagulants	Hydroxy coumarins	Warfarin

Source: ICAR, Handbook of Agriculture, 2013

Check Your Progress 1

Note: a) Write your answer in about 50 words.
b) Check your answers given at the end of this unit.

1) Which agrochemicals come under the ambit of the term pesticides?

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2) What is the purpose of pesticide classification?

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3) On what basis the pesticides are classified?

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1.4 PESTICIDE CONSUMPTION

About 3 million tons of pesticides are applied each year in the world. Roughly, only 2.2 million tons of pesticides are used in developed countries. As regards the quantity of pesticides used in developing countries, it is very low on account of low awareness among farmers, fragmented landholdings, subsistence agriculture, and low level of irrigation. The figure 1.1, 1.2, 1.3 reflects the trend in All-India Area under cultivation, irrigated area, and food grain

production. The increase in food grain production is due to increase in irrigated area, increased use of agricultural inputs and gradual increase in agricultural productivity. The consumption of pesticides in India has increased from 2353 mt in 1955-56 to 57000 metric tons in 2016-17. Through this unit on pesticides, a transaction is embarked to emphasize on the role of agricultural inputs particularly pesticides in modern industrial agricultural production. Nevertheless, the irrational and unsafe pesticide use has resulted in many agri-environmetal issues regarding which we can learn from the forthcoming discussion.

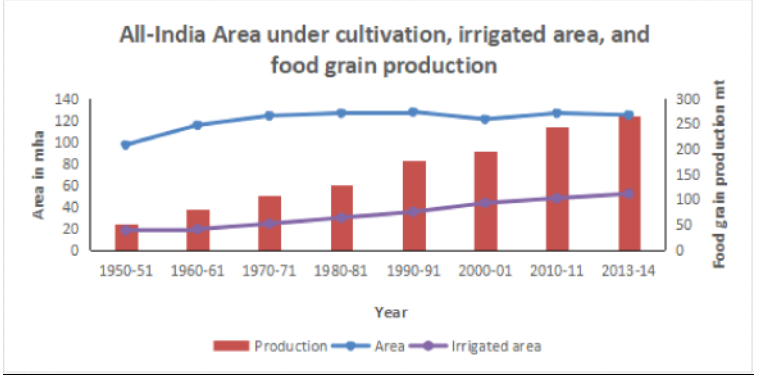


Fig. 1.1: All-India Area under cultivation, irrigated area, and food grain production

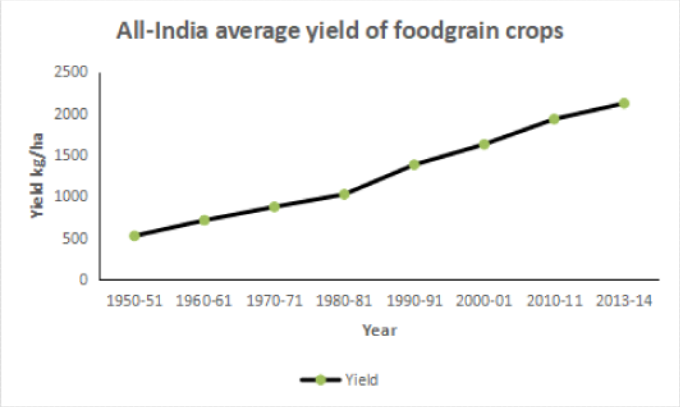


Fig. 1.2: All-India average yield of food grain crops

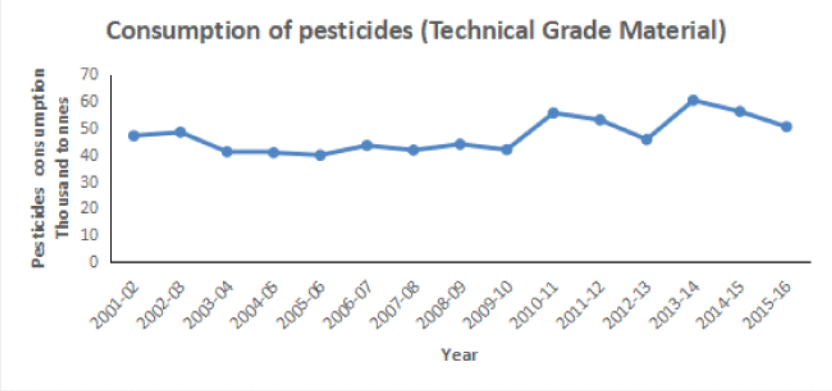


Fig. 1.3: Consumption of pesticides (Technical Grade Material)

Source: Graphical presentation by the author from data accessed from Agricultural Statistics at a glance 2016, GOI.

DID YOU KNOW?

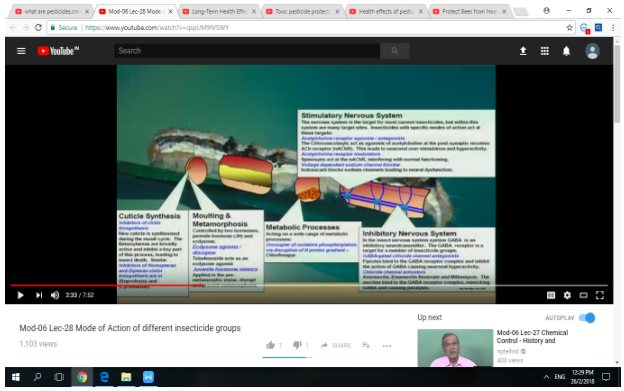
Every pesticide container has a label affixed on it with a leaflet. The leaflet contains information on directions to use, warnings, disposal and storage. The following information must be furnished on the label as required under the Insecticide Act, 1968.

Name of the pesticide (Brand name, Trade name, Common name). 2. Name of the manufacturer and address 3. Kind and name of active ingredient and their percentage 4. Registration number 5. Types of formulation 6. Net content by weight 7. Batch number (assigned by manufacturer) 8. Date of manufacture 9. Expiry date 10. Antidote statement 11. Warning symbols and signal.

1.5 MODE OF ACTION OF INSECTICIDES

Organochlorines and synthetic pyrethroids are axonal poisons. The toxicants act on the nerve axons and interfere with the movement of ions namely sodium and potassium which produces repetitive discharges in the nerves resulting tremors, exhaustion, and death of the insect. Organophosphates and carbamates are synaptic poisons. These compounds inhibit acetylcholine esterase enzyme resulting in the accumulation of acetylcholine which keeps the Sodium-Potassium gate open and the nerve is in the continuous state of excitation.

Watch this video on mode of action of different insecticide groups



https://www.youtube.com/watch?v=qspUM9tV5WY

1.6 PESTICIDES IN ENVIRONMENT

Environment contamination due to pesticides occurs either through pesticide application, pesticide disposal or accidental spillover. Pesticides in the environment (Figure 1.4) are subjected to processes like volatilization, runoff, leaching, absorption and crop removal. Pesticides enter into the atmosphere either by spray drift or volatilization. In fact during agricultural applications of pesticides, a small portion of pesticides reach the target and remaining either fall on soil or carried away by air currents in the form of aerosol or particles. As regards the soil environment, pesticides enter the soil either through soil application or runoff and dumping and accidental spillover. Soil acts as a reservoir of pesticide residues. Pesticides applied on agricultural field reach water body either through surface runoff or sediment transport.

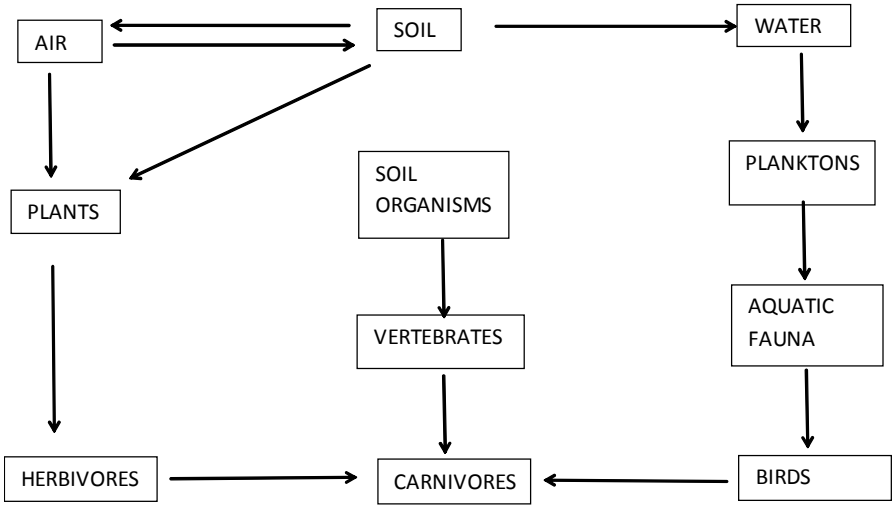


Figure 1.4: Transfer of pesticides in environment

Source: Srivastava and Saxena, 2008

Fate of pesticides in environment

Volatilization: Transfer of pesticides either from plants surface, water or soil to air. Volatilization depends on the vapour pressure of the pesticide compounds. The pesticides may be carried to long distances as particles as they get adsorbed onto the dust particles.

Runoff: Physical transport of pesticides over the ground surface by rainwater.

Leaching: Movement of pesticides downward through the soil by rainwater or by irrigation water.

Absorption: Uptake of pesticides into the plant.

Crop removal: Transfer of pesticides and their breakdown products from the treatment site is called as crop removal.

Adsorption: In the soil environment, the pesticides may get adsorbed to the organic matter, clay minerals and soil particles and remains unavailable to plants.

Degradation: Pesticide degradation can occur either through chemical degradation, photo-degradation or microbial degradation.

Bioaccumulation: In living organisms, the pesticides absorbed by fat issues remains unaffected by degradation processes. They remain in fat tissues for a longer period of time. Bioaccumulation refers to pesticide accumulation in various tissues of a living organism in concentration much higher than the surrounding environment. Bioaccumulation encompasses bioconcentration and biomagnification. Bioconcentration is the direct uptake of a substance by a living organism from the medium through the skin, lungs and gills. Biomagnification occur from the dietary uptake. In case of biomagnification, the pesticide concentration in an organism is higher than found in organisms at lower trophic levels of food chain.

Source: ICAR, Handbook of Agriculture, 2013.

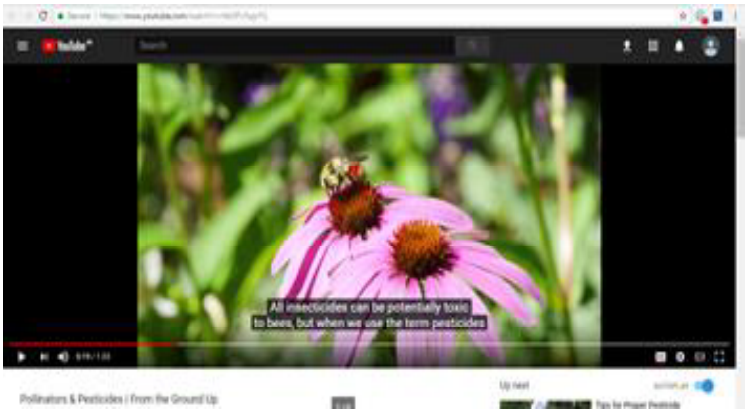
The effectiveness of pesticides as well as the hazards of its harmful residues depends mainly on persistence of pesticides (Table 1.2). For instance, dichlorodiphenyltrichloroethane has a half- life of 3 years in the cultivated soil whereas the organophosphate insecticides persist only for few days. Soil applied herbicides also persist for a short time. Pesticides reaching the soil environment can either be leached deep into the soil or washed away as runoff along with soil sediments. An important parameter that governs the pesticide adsorption to the soil particles is partition coefficient. Partition coefficient refers to the ratio of pesticide concentration in the adsorbed state and the solution phase. Smaller the particle partition coefficient, higher is the concentration of pesticides in the solution. For example, the the partition coefficient of Aldicarb and DDT are 10 and 243,000 respectively. The partition coefficient is influenced by the properties like solubility and melting point of the pesticides. As regards the insecticide residues in India, the most common chemicals are DDT, HCH and dieldrin. Pesticides that are persistent in the soil environment affect the soil biodiversity. The deleterious effect of pesticides on the beneficial soil microorganisms is visible in the form reduced crop productivity and soil deterioration. Pesticides like lindane applied at normal rates found to reduce the number and weight of nodules in the crops like groundnut.

Table 1.2: Pesticides based on persistence in soils

Non-persistent (half-life less than 30 days)	Moderately persistent (half-life between 0 days and 100 days)	Persistent
Aldicarb	Aldrin	Lindane
2,4 - D	Carbofuran	Paraquat
Malathion	Carbaryl	Trifluralin
Captan	Atrazine	Bromacil
Dicamba	Glyphosate	Chlordane
Methyl parathion	Heptachlor	Pichloram

Source: Singh, and Das, 2009

Watch this video to impact of pesticides on pollinators



https://www.youtube.com/watch?v=hlk3PU5qyYQ

Check Your Progress 2

Note: a) Write your answer in about 50 words.
b) Check your answers given at the end of this unit.

1) List examples of pesticides acting as axonal and synaptic poisons?

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2) What is the difference between runoff and leaching?

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3) What is the difference between bioconcentration and biomagnification?

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1.7 PESTICIDES AND HUMAN HEALTH

Modern agriculture aims at large-scale agriculture involving agricultural inputs like agrochemicals, etc. The threats to human sustainability including human health on account of pesticides use for agricultural production are quite grave and force us to dissect the effects of pesticides on environmental and occupational health. Globally about 5 million tons of pesticides per annum are used. You can gauge from the graph that how pesticides use in our country has increased steadily. Pesticides applied on the agricultural field contaminate the environment and affect human health by entering into groundwater aquifers and drinking water through runoff, through ingestion in food produce, through air contamination due to pesticides spray, and through products from animals that have been ingested with pesticides. Pesticides produce both short- term and long-term effects on human health. The effects include elevated cancer risks and disruption of the body's reproductive, immune, endocrine and nervous system (Horrigan et al., 2002).

Pesticides as carcinogens

Quite a number of pesticides have been reported as carcinogens. The pesticide group and their potential carcinogenic effects are presented in the table 1.3.

Table 1.3: Associations between pesticide use and cancer

Pesticide Class	Cancer
Phenoxyacetic acid herbicides	Non-Hodgkin's lymphoma, soft-tissue sarcoma, prostate
Organochlorine insecticides	Leukemia, non-Hodgkin's lymphoma, soft-tissue sarcoma, pancreas, lung, breast
Organophosphate insecticides	Non-Hodgkin's lymphoma, leukemia
Arsenical insecticides	Lung, skin
Triazine herbicides	Ovary

Source: Blair and Zahm, 1995

Pesticides as immune suppressors

Pesticides besides being carcinogens act as immune suppressors. The effects observed in immune-compromised individuals exposed to pesticides include respiratory ailments, gastrointestinal and acute inflammatory kidney infections (Northrop and Connor, 2013).

Pesticides as teratogens

Chemicals that produce teratogenic effects are called as teratogenic agents. Certain pesticides increase the incidence of congenital malformations. Teratogenic effects occur due to the death of certain cells of developing organisms. These effects are pronounced during early differentiation of the immature tissues.

Pesticides as endocrine disruptors

An endocrine disrupting chemicals (EDCs) are defined as an exogenous agent that interferes with the production, release, transport, metabolism, binding, action or elimination of natural hormones in the body responsible for the maintenance of homeostasis and the regulation of development processes (Kavlock et al., 1996; Northrop and Connor, 2013). EDCs act mainly by interfering with natural hormones produced by endocrine glands because of their strong potential to bind to estrogen or androgen receptors. In fact, EDCs can bind to and activate various hormone receptors like Androgen Receptor, Estrogen Receptor, Estrogen Related Receptor, Aryl Hydrocarbon Receptor, Constitutive Androstane Receptor, etc. and subsequently mimic the natural hormone's action (Mnif et al., 2011). Pesticides like atrazine, chlordecone, dicofol, endosulfan, lindane, methoxychlor, and vinclozolin are reported to act as endocrine disruptors. Endocrine disruptors as they act as morphogens increase the susceptibility to cancer and developmental disorders. Endocrine disrupting chemicals are responsible for development and promotion of cancer like prostate cancer, pancreatic cancer, and breast cancer. These chemicals are also increasingly linked to effects like early puberty in humans. These chemicals cause changes in neuroendocrinology, behaviour, thyroid function and metabolism. (Northrop and Connor, 2013).

Watch this video on Long-Term Health Effects of Pesticide Exposure

https://www.youtube.com/watch?v=Vo_LoMNPy5Y

Check Your Progress 3

Note: a) Write your answer in about 50 words.
b) Check your answers given at the end of this unit.

1) What are endocrine disrupting chemicals (EDCs)?

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1.8 INSECTICIDAL POISONING

Globally, pesticides are responsible for an estimated 220, 000 deaths and 26 million cases of acute poisoning annually, mostly in agricultural workers and rural communities. Children are particularly vulnerable to toxic effects of pesticides including acute poisoning, as are the adults with infection, poor nutrition, and substance abuse (Richter, 2002). Insecticidal Poisoning may occur at manufacture level; at operational and consumer level; and Suicidal and homicidal poisoning. Persons engaged in manufacturing insecticides are subjected to insecticidal exposure resulting in chronic poisoning. Poisonings also occur from exposure during mishaps with batch concentrations during manufacture. Symptoms developed due to chronic poisoning are headache, loss of appetite, fatigue, insomnia, loss of weight and memory. It is reported that organophosphates take primacy in causing occupational poisoning. Since the organophosphorus pesticides inhibit cholinesterase enzyme, measurement of cholinesterase level in the blood provide a fair estimate of degree of poisoning. At the operational level, pesticide poisoning normally occurs in hot and humid tropical climatic conditions as the farmers in these conditions do not prefer protective clothing. From the perspective of consumers', it is reported that insecticides like chlorinated hydrocarbons accumulate in the adipose tissues (Srivastava, and Saxena, 2008). Suicidal and homicidal poisoning using pesticides is a major public health issue problem in the developing countries. About 250,000 – 370,000 people die every year due to the intentional pesticide consumption. In the rural households of developing countries, pesticides are normally stored at home for timely use in agricultural fields. This unrestricted access to pesticides is one of the reasons for high rate of suicides in the rural environment. Under such circumstances, the intentional pesticide poisoning can be contained by restricting access to toxic pesticides, educating the farmers, empowering livelihoods, and implementing laws and policies encouraging safer use of pesticides (Dawson et al., 2010).

Table 1.4: Adverse health effects caused by selected classes of pesticides

Chemical/ chemical class	Examples of pesticides	Clinical presentation	Route of exposure
Arsenicals	Arsenic trioxide, CCA, sodium arsenate	Abdominal pain, nausea, vomiting, garlic odour, metallic taste, bloody diarrhoea, headache, dizziness, drowsiness, weakness, lethargy, delirium, shock, kidney insufficiency, neuropathy	O, R, D (rarely)

Borates (insecticide)	Boric acid, borax	Upper airway irritation, abdominal pain, nausea, vomiting, diarrhoea, headache, lethargy, tremor, kidney insufficiency	O, R, D (broken skin)
Carbamates (insecticide)	Carbaryl, thiram, aldicarb, mecarbam	Malaise, weakness, dizziness, sweating, headache, salivation, nausea, vomiting, diarrhoea, abdominal pain, confusion, dyspnea, dermatitis, pulmonary oedema	O, D
Chlorphenoxy compounds (herbicides)	Di/tri-chlorophenoxy-acetic acid, MCPP	Upper airway and mucous membrane irritation, abdominal pain vomiting, diarrhoea, tachycardia, weakness, muscle spasm, coma, acidosis, hypotension, ataxia, hypertonia, seizures, dermal irritation, headache, confusion, acidosis, tachycardia	O, D
Chloralose	Chloralose	Vomiting, vertigo, tremor, myoclonus, fasciculations, confusion, convulsions	O
Calciferol (rodenticide)	Cholecalciferol, ergocalciferol	Fatigue, anorexia, weakness, headache, nausea, polyuria, polydipsia, renal injury, hypercalcemia	O
Copper compounds (fungicide)	Copper acetate, copper oleate	Abdominal pain, vomiting, skin/airway/mucous membrane irritation, renal dysfunction, coma	O, R, D
Coumarins (rodenticide)	Brodifacoum, warfarin, pindone	Echymoses, epistaxis, excessive bleeding, haematuria, prolonged prothrombin time, intracranial bleed, anaemia, fatigue, dyspnea	O, D (possible)
Dipyridil (herbicide)	Paraquat, diquat	Mucous membrane and airway irritation, abdominal pain, diarrhoea, vomiting, gastrointestinal bleeding, pulmonary oedema, dermatitis, renal and hepatic damage, coma, seizures	O, D (via broken skin)
Phosphonates (herbicide)	Roundup, glyphosate	Airway, skin, and mucous membrane irritation, abdominal, pain, nausea, vomiting, shock, dyspnea, respiratory failure	O, R

Mercury, organic (fungicide)	Methyl mercury	Metallic taste, paresthesias, tremor, headache, weakness, delirium, ataxia, visual changes, dermatitis, renal dysfunction	O, R, D
Metal phosphides (rodenticide, fumigant)	Zinc-, aluminium-, magnesium-phosphide	Abdominal pain, diarrhoea, acidosis, shock, jaundice, Abdominal pain, diarrhoea, acidosis, shock, jaundice, paresthesias, ataxia, tremors, coma, pulmonary oedema, tetany, dermal irritation	O, R, D
Organochlorines (insecticide)	Aldrin, dieldrin HCB, endrin, lindane	Cyanosis, excitability, dizziness, headache, Cyanosis, excitability, dizziness, headache, restlessness, tremors, convulsions, coma, paresthesias, nausea, vomiting,confusion,tremor, cardiac arrhythmias, acidosis	O, R, D
Organophosphates (insecticides)	Malathion, parathion, dichlorvos, chlorpyrifos	Headache, dizziness, bradycardia, weakness, anxiety, excessive sweating, fasciculations, vomiting, diarrhoea, abdominal cramps, dyspnea, miosis, paralysis, salivation, tearing, ataxia, pulmonary oedema, confusion, acetylcholine-sterase inhibition	O, D
Pyrethrins, Pyrethroids	Allethrin, cyfluthrin, permethrin	Allergic reactions, anaphylaxis, dermatitis, paresthesias, wheezing, seizures, coma, pulmonary oedema, diarrhoea, abdominal pain	R, D
Strychnine (rodenticide)	Strychnine	Muscle rigidity, opisthotonus, rhabdomyolysis	O
Triazines (herbicide)	Atrazine, prometryn	Mucous membrane, ocular and dermal irritation	O, R, D

Note: Route of exposure key: O,?oral/ingestion; R,?respiratory/ inhalation; D,?dermal or ocular.

Source: Thundiyil, et al., 2008.

1.9 TERMINAL QUESTIONS

1) What is the difference between stomach and contact poison?

2) Explain the adverse health effects caused by insecticidal poisoning

1.10 LET US SUM UP

Agriculture is essential for human existence. Rising food grains demand for feeding growing population had transformed agriculture into industrial agriculture which is driven mainly by the use of industrial inputs like pesticides to manage the crop pests. Indeed, chemical pesticide use had aided in saving the crops from pest and increasing agricultural production. Diverse group of pesticides was synthesized to cater to needs of the farmers growing wide range of crops. We have studied in this unit about the role of pesticides in agricultural production and the agri-environmental issues connected with the pesticides. This can be summarised in the following points:

- Definition of pesticides and diverse group agrochemicals under the umbrella term “pesticides”.
- Classification of pesticides based on type of pest, mode of entry, mode of action, and chemical nature
- Trends in pesticide consumption and agricultural food production in India
- Mode of action of insecticides. Organochlorines, and synthetic pyrethroids are axonal poisons. Organophosphates and carbamates are synaptic poisons.
- Fate of pesticides in environment
- Impact of pesticides on Human Health. Role of pesticides as carcinogens, as immune suppressors, as teratogens, and as endocrine disruptors
- Insecticidal poisoning at manufacturing stage, operational stage, and consumer level.

1.11 KEY WORDS

Pesticides: Pesticides are diverse group of chemicals used to contain or manage the pests in the specific crops and specific situations.

Teratogens: Chemicals that produce teratogenic effects are called as teratogenic agents. Teratogenic effects occur due to the death of certain cells of developing organisms. These effects are noticeable during early differentiation of the immature tissues.

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1.13 ANSWERS TO CHECK YOUR PROGRESS

Your answers should include the following points:

Answers to Check Your Progress 1

1) Pesticides are diverse group of chemicals that are used to contain or manage the pests in the specific crops and specific situations. The term pesticides also include substances that are used as a plant growth regulator, defoliant, desiccant, fruit-thinning agent, etc. The term excludes plant and animal nutrients, food additives, fertilizers and animal drugs.

2) The purpose of pesticide classification is to systematically understand the relation between chemical nature, mode of action and the target organisms. Further, this would help in proper prescription and safe use of pesticides with minimal ecological disturbance.

3) The pesticides are classified on the basis of type of pest; mode of entry; mode of action and based on chemical nature.

Answers to Check Your Progress 2

1) Organochlorines and synthetic pyrethroids are examples of axonal poisons. On the other hand, organophosphates and carbamates are synaptic poisons.

2) Runoff and leaching are considered as important processes involved in pesticide movement in the environment. The runoff refers to the physical transport of pesticides over the ground surface by rainwater. Whereas through leaching, pesticides move downward through the soil by rainwater or by irrigation water.

3) Bioaccumulation encompasses bioconcentration and biomagnification. Bioconcentration is the direct uptake of a substance by a living organism from the medium through the skin, lungs and gills. On the other hand, biomagnification occur from the dietary uptake. In case of biomagnification, the pesticide concentration in an organism is higher than found in organisms at lower trophic levels of food chain.

Answers to Check Your Progress 3

1) An endocrine disrupting chemicals (EDCs) are defined as an exogenous agent that interferes with the production, release, transport, metabolism, binding, action or elimination of natural hormones in the body responsible for the maintenance of homeostasis and the regulation of development processes.

Answers to Terminal Questions

1) Refer to subsection 1.4.2

2) Refer to subsection 1.9

UNIT 2 FERTILIZERS

Structure

2.1 Introduction

2.2 Objectives

2.3 Fertilizers in Indian Agriculture

2.4 Fertility Status of Indian Soils

2.5 Fertilizers and its Use

2.6 Fertilizer Consumption

2.7 Classification of Chemical Fertilizers

2.8 Fertilizer Pollution

- 2.8.1 Nitrate pollution
- 2.8.2 Eutrophication
- 2.8.3 Nitrous Oxide Emission and Global Warming
- 2.8.4 Heavy Metal Pollution

2.9 Let Us Sum Up

2.10 Key Words

2.11 References and Suggested Further Reading

2.12 Answers to Check Your Progress

2.1 INTRODUCTION

The benefits of agriculture have been quite immense. Before the dawn of agriculture, the hunter gatherer way of living supported about 4 million people globally. Nevertheless, modern agriculture now feeds more than 7.2 billion people. Global cereal production has increased from 0.8 billion tonnes (1960) to 2.646 billion tonnes (2017) mainly from the increased yields resulting from greater use of inputs like fertilizer, irrigation water and pesticides, high yielding crop varieties and hybrids. This quantum jump in agricultural production has increased the global per capita food supply. Fertilizer application is one of the most widely accepted practices for increasing crop yield and income of farmers. Fertilizers are essential agricultural input as they replenish the soil, meet the crop requirement, and also they ameliorate the soil and act as soil amendments. Further, the declining soil fertility due to continuous intensive cultivation warrants the use or judicious application of fertilizers to the soil so as to improve the soil physical, chemical and biological properties of soil. Nevertheless, feeding 10 billion people by 2050 is a remarkable task in the back drop of shifts in dietary pattern, pressures on agricultural resources and urges to maintain the environmental integrity. Occupational and public health are also contemplated in the trajectory of sustainable agricultural growth. Fertilizers

being an effective but costly input, information on its correct use is always sought and needed along with best management practices. Through this unit, you would be learning the importance of fertilizer use in agricultural landscape, a close look on the fertilizer consumption, map the fertilizers, and gauge the gravity of impacts due to injudicious use of fertilizers.

2.2 OBJECTIVES

After studying this unit, you should be able to:

- discuss the importance of fertilizer use;
- interpret the trends in fertilizer consumption;
- classify the chemical fertilizers; and
- explain the impacts of fertilizers on the environment.

2.3 FERTILIZERS IN INDIAN AGRICULTURE

Agriculture productivity holds the key to meeting the food security demand of our country. Fertilizers have played a major role in increasing the agriculture productivity in the country particularly in the last few decades and expected to contribute significantly towards the future growth and economy by increased and balanced use of fertilizers. Despite being one of the largest fertilizer producing countries in the world, the fertilizer sector in India still faces formidable challenge. India is relatively comfortable in the production of urea but indigenous production of phosphatic and potasic fertilizer falls short of demand.

Fertilizer use is neither new in this world nor in India. The first commercially made fertilizer, single super phosphate (SSP) was produced about 160 years ago in England. In India, first SSP factory was set up in 1906 at Ranipet in the province of Madras (now in Tamil Nadu). Most of the fertilizers that we are using in the distant past have been mined from the mineral rich rocks or extracted from ore complexes by adopting innovative technologies. Nevertheless, the synthesis of nitrogenous fertilizers is different.

At present, in India about 33 million tonnes of chemical fertilizers are used every year, out of which 26 million tonnes are produced indigenously. There is a well developed network for the distribution and marketing of fertilizers with 2,75,000/- fertilizer sale points (both Government, Co-operative and private) to serve 6,27,000 villages for judicious application of fertilizers. In India, about 50-55% of the fertilizers are used for the cultivation of rice, wheat and sugarcane, 10-15% for cotton 15% for fruits and vegetables, 10% for coarse cereals and 10% for oilseeds and pulses. Although, India is the world's third largest producer and consumer of fertilizers, the average consumption of fertilizer is only 97 kg/ha as against 345 kg/ha in China. Less use of fertilizer in our country is on account of fragmented land holdings, preponderance of marginal and small farmers, etc.

Table 2.1: Type of Fertilizers Produced in India

Type of fertilizers	Grade
Straight Nitrogenous	
Ammonium Sulphate (AS)	20.6% N
Calcium Ammonium Nitrate (CAN)	25% N
Ammonium Chloride	25% N
Urea	46% N
Straight Phosphatic	
Single Super Phosphate (SSP)	16% P_2O_5
Triple Super Phosphate (TSP)	46% P_2O_5
NP/NPK Complex Fertilizers	
Urea Ammonium Phosphate	24 -24 -0
	28 -28 -0
	14 -35 -14
Ammonium Phosphate Sulphate	16 -20 -0
	20 -20 -0
Diammonium Phosphate (DAP)	18 -46 -0
Mono Ammonium Phosphate (MAP)	11 -52 -0
Nitro Phosphate	20 -20 -0
	23 -23 -0
Nitro Phosphate with Potash	15 -15 -15
NP/NPKs	17 -17 -17
	14 -28 -14
	19-19-19
	10-26-28
	12-32-16

Source: Indian fertilizer scenario (2013). Department of Fertilizers, Ministry of Chemicals and Fertilizers, New Delhi.

The fertilizer use efficiency (FUE) has been on the decline mainly due to emergence of deficiency of soil nutrients, due to adoption of intensive cultivation and cropping systems on fragile soils like rice- wheat on sandy soils, etc. We have ignored the soil fertility health largely due to imbalance use of fertilizers or nutrients. Balanced fertilization or nutrient use ensures that plant receive all the essential nutrient elements in adequate amounts and proportion, neither less nor in excess amounts, to meet fully the nutritional requirement of crop(s) or cropping systems on a particular soil to attain optimum or potential crop yield or productivity.

2.4 FERTILITY STATUS OF INDIAN SOILS

Soil is a marvelous gift of nature to mankind. The rise and fall of ancient civilizations were believed to be led by the sustenance or deterioration of the soil quality and health. Therefore the sustainable management of soil holds the key for meeting the basic requirements of food, fodder, feed and fiber and fuel production for burgeoning population. In this era of modernization, and intensive agriculture, soil has been exploited in such a way that it often exceeds its carrying capacity which has resulted in poor soil health which is emblematic of declining soil fertility and productivity across the Indian agricultural landscape. Crop geography is mainly driven by the interaction of biotic and abiotic factors, and more importantly, the soil and microclimate are essential factor deciding the cropping system. Nevertheless, cropping systems and policy framed without due care to the soil environment and soil fertility scenario would lead to condition wherein injudicious use of agricultural inputs mainly fertilizers have resulted in accelerated soil erosion, incidence of macro- and micro-nutrient deficiencies and depletion of soil biodiversity.

Assessment of fertility vis a vis nutrient status of soil has been made by developing or standardizing soil test methods and soil test rating charts. In India, soil testing laboratories (STL) run by the State Government, fertilizer industries, State agriculture Universities and ICAR Institutes assess the nutrient status of the soil and based on this study, soil fertility mapsare published frequently. Nitrogen is low in about 62% and medium in 37% of tested soil. In an analysis of more than 9.6 million soil samples from 363 districts indicated phosphorous is low in about 49% and medium in 47% respectively and potassium is low in about 20 % and medium in 42% respectively in various samples. Analysis of more than 252,000 soil samples of the country showed deficiency of Zn in about 50 % of samples. Once the fertility status of soil is known through soil testing, the fertility status can be maintained through optimum use of fertilizer and organic manure to maintain and restore the soil fertility with increased agricultural productivity.

2.5 FERTILIZERS AND ITS USE

Fertilizers are essential inputs for boosting the output of various crops. Plants require 17 essential nutrient elements for their normal growth and completion of life cycle. On the basis of their relative concentration or amount in plant tissues, these are divided into (i) macronutrients and (ii) micronutrients. The essential nutrient elements are “carbon (C), hydrogen (H), oxygen(O), nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), sulphur (S), iron (Fe), manganese (Mn), zinc (Zn), copper (Cu), boron (B), molybdenum (Mo), chlorine (Cl) and nickel (Ni)”. These are recognized as universally essential nutrient elements, because these meet the essential requirements for diverse groups of organisms, algae, bacteria, fungi and green plants. However, the list of essential nutrients may expand further as evidence of their essential for leguminous plants only.

Soils vary in their capacity to supply different nutrients to different crops. Two soils having the same content of available nutrients may not supply the same amounts of these nutrients even to the same crop. Similarly, the same amount of nutrients added to two soils may not supply their nutrients in the same amount to the same crop. Under a given situation of soil, the system of farming, soil management, fertilizer and manure practices, etc. influence the productivity of soils and crop yield from them. Stability and growth of agricultural production

to a great extent is influenced by the fertilizer industries on the global landscape, their ability to meet the farm demand for agricultural fertilizers, quality inputs, and socio-economic concerns.

Every tonne of fertilizers increased food grains yield by 10-12 tonnes. Fertilizers essentially provide additional N, P and K to crops. Their use in optimal quantities is essential for maintaining the soil fertility. Because of the limited availability of land, their use becomes more important not only for increased yield but also to meet the food requirements of the growing population. A fertilizer can be defined as a "mined or manufactured material containing one or more essential plant nutrients in potentially available forms in commercially valuable amounts". The suitable material can be used as such (rock phosphate) or with some processing (MOP) or products made from raw materials in a factory (urea, DAP,SSP, complexes, etc.). A fertilizer must provide one or more of essential nutrients.

Fertilizers in the broadest sense are products that enable the availability of nutrients to the soil and also improve the physico-chemical properties of soil. It is an established fact that improvement in physical, chemical and biological properties of soil greatly improves the life cycle of plants including growth and development, crop yield, and quality of crop produce.

2.6 FERTILIZER CONSUMPTION

In India, farmers have practiced a cultural system that has ensured stable yields for centuries and maintained a desired level of fertility in soil. Unfortunately due to increase in agricultural production through introduction of high yielding varieties, intensive use of chemical fertilizers and pesticides and intensive tillage practices, this fragile equilibrium got disturbed resulting in unsustainable growth. In the last half of 20th century, North-western India though lying in trans-gangetic plains receiving less rainfall, experienced enormous agricultural growth due to the adoption of high yielding, fertilizer responsive varieties, irrigation facilities and industrious farmers and forthcoming agricultural extension activities. It is estimated that to feed 1.4 billion population by 2025, India needs minimum food-grains production of 300 million tonnes, which would necessitate the use of 30-35 Mt of NPK from fertilizer carriers/synthetic fertilizers and an additional 10 Mt from organic and biofertilizer sources. This perspective throws light on the dire need to augment the production and consumption of crop plant nutrients by 2025 to meet the food demand of burgeoning population.

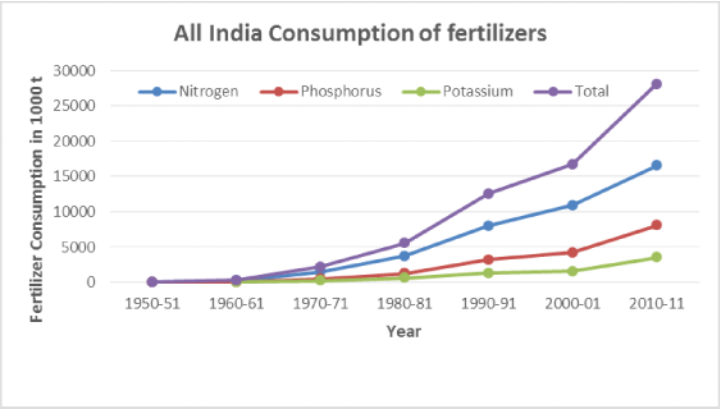

Fig. 2.1: All India Consumption of Fertilizers

Source: Graphical presentation by the author from data accessed from Agricultural Statistics at a glance 2016, GOI.

Chemical fertilizer are and would remain the major and very important component of the integrated nutrient supply system under intensive cropping as these contribute nearly 50 % increased crop yield. The National Academy of agriculture Sciences, India has estimated that for meeting the food needs of India's increased population by 2025, India may have to increase its plant nutrient supply by over 45 million tonnes from the current level of nutrient supply through NPK fertilizer and 4-6 million tonnes through organic manure.

2.7 CLASSIFICATION OF CHEMICAL FERTILIZERS

Based on their chemical composition, fertilizers are classified as:

1) "Mineral fertilizers consist of inorganic or synthetically produced organic compounds.

2) Organic fertilizers are waste products from animal husbandry (stable manure, slurry manure), plant decomposition products (com-post, peat), or products from waste treatment (composted garbage, sewage sludge).

3) Synthetic soil conditioners are products whose main function is to improve the physical properties of soils, for example, friability and water and air transport".

Based on the nutrient content, fertilizers can also be classified as:

1) Straight fertilizers that generally contain only one primary nutrient. For instance, urea (N) or triple superphosphate (P_2O_5).

2) Compound (complex or multi-nutrient) fertilizers contain several primary nutrients and sometimes micronutrients as well.Multi-nutrient or compound fertilizers contain two or more nutrients. The term complex fertilizerrefers to a compound fertilizer formed by mixing ingredients that react chemically. In bulk-blend or blended fertilizers, two or more granular fertilizers of similar size are mixed to form a compound fertilizer.

3) Micronutrient fertilizers contain nutrients required in small quantities by plants, as opposed to macro-nutrients.

Fertilizers can be classified as solid or liquid fertilizers and as soil or foliar fertilizers, the latter being applied exclusively by spraying on an existing plant population.

Check Your Progress 1

Note: a) Write your answer in about 50 words.
b) Check your answers given at the end of this unit.

1) Discuss the importance of fertilizer use in agriculture sector?

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2) Classify the fertilizers on the basis of their chemical composition?

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2.8 FERTILIZER POLLUTION

The agricultural production depends on chemical fertilizer application, as most of our high yielding varieties and hybrids are fertilizer responsive. Though chemical fertilizers increase crop production, their continuous application lead to soil deterioration and degradation. Pollution from fertilizer nutrient occurs when chemical fertilizers are applied at a greater rate than they are fixed by soil particles or they are washed off from soil surface before the plant uptake. The excess nitrogen and phosphorus pollute the surface water through run-off or ground water through leaching. Fertilizers like urea, ammonium sulphate, and ammonium chloride reduce the soil pH. Excess nitrogen in soil leads to soil acidification and soil salinization through nitrification and other nitrogen transformation processes. Acidification of soil will further leads to oil pollution through the mobilization of toxic heavy metals. Overuse of chemical fertilizer has hardened the soil, decreased fertility, strengthened pesticides, polluted air and water, and released greenhouse gases, thereby bringing hazards to human health and environment as well.

The excessive use of fertilizer has resulted in:

- Occurrence of increased concentration of nitrates in the potable water.
- The process of nutrient enrichment through leaching, sediment erosion leads to eutrophication and deterioration of surface water quality.
- The contamination of soils by heavy metal, through fertilizers such as Cd from P fertilizers.

2.8.1 Nitrate Pollution

Nitrogen occurs in many forms in the environment and takes part in many biochemical reactions. The four forms of nitrogen that are of particular significance in environmental technology are organic nitrogen, ammonia nitrogen, nitrite nitrogen, and nitrate nitrogen. The circulation of nitrogen in its various forms through the environment results in nitrogen cycle. Nitrogen, particularly in the nitrate form, is a basic nutrient that is essential to the growth of plants.Nitrogenous fertilizers are carried into streams and rivers through runoff, and further to seas and oceans. They do contaminate groundwater as they seep into soil and reach the aquifers. Excessive nitrate concentrations in surface waters encourage the rapid growth of microscopic plants called algae and excessive growth of algae called algal blooms which degrades water quality.The growth, death and decomposition of algae cause oxygen depletion which prohibits growth of fish or marine life resulting in dead zones. Algal blooms are observed in Baltic Sea, Gulf of Mexico and other nutrient enriched aquatic environments.

Nitrate in ground water also leads to serious health hazards such as methemoglobinemia and formation of other nitrosamine compounds. Nitrate leaching from excessive and imbalanced use of chemical fertilizers result in surface and groundwater contamination. Contamination of surface and groundwater has caused immense social, environmental and political pressure warranting the use of environmental friendly fertilizer which releases nutrient in a very controlled and balanced manner.

2.8.2 Eutrophication

The process of nutrient enrichment and gradual filling in of a lake is a natural process. It is called eutrophication and can be thought of as an inevitable and continual aging of the lake. All lakes go through a natural aging process called eutrophication. Human activity often accelerates this process. Lakes have a natural life cycle. Most lakes start out geologically as deep, cold, clear bodies of water. At this stage, they are called oligotrophic lakes. They usually have sand or rock bottom, very few nutrients, and a scarcity of plant or fish life. Over the years, nutrients slowly accumulate and more organisms enter from inlet streams and the surroundings. Silty sediments begin to form at the bottom as the lake passes through a mesotrophic stage of existence.

The eutrophic stage of a lake's life cycle is characterized by a relatively shallow and warmer body of water, with enough nutrients to support large populations of plants and animals. In a eutrophic lake, there are frequent algal blooms, and at certain times of the year, the water at the bottom may be devoid of dissolved oxygen. Further aging or eutrophication leads to what is called a senescent lake, characterized by thick deposits of organic silts and very high nutrient levels. Senescent lakes are very shallow, with much rooted emergent vegetation growing throughout the lake. Eventually, what was once a lake will become a marsh as natural geological and ecological processes continue.

The natural process of lake eutrophication, from the oligotrophic through the senescent stages, takes many thousands of years. It is an exceedingly slow process. But many people use the term eutrophication synonymously with pollution in reference to lakes. Perhaps, a more accurate characterization of the problem would be the term cultural eutrophication. Cultural eutrophication is the acceleration and hastening of the natural aging process because of human activity in the drainage basin or watershed of a lake.

2.8.3 Nitrous Oxide Emission and Global Warming

Global atmospheric N_2O concentration has increased from the preindustrial level of 270 ppb to 319 ppb in 2005. Nitrous oxide (N_2O), having the "Global Warming Potential" of about 300 is construed as a highly potent greenhouse gas as the atmospheric lifetime of the nitrous oxide is 120 years. Nitrous oxide emissions into the atmosphere are due to use of nitrogenous fertilizers, forest clearing, and combustion. FAO has estimated that by the year 2030, global N_2O emission from fertilizer and manure application will increase by 35-60%.

2.8.4 Heavy Metal Pollution

The main metal contaminants that are found in chemical fertilizer are Cadmium (Cd), Chromium (Cr), Copper (Cu), Cobalt (Co), Molybdenum (Mo), Lead (Pb), Nickel (Ni), Arsenic (As), Mercury (Hg), Selenium (Se), Vanadium (V) and Radionuclide 266 (Ra). These metal contaminants are required by the plant as micronutrient for their growth and development. Heavy metals accumulate in the soil due to repeated applications of fertilizer. They accumulated in the human food chain through biomagnification and causes serious health problem. The health effects associated with the exposures of Cd, lead, arsenic, mercury, etc are well known.

In integrated nutrient management, to sustain the productivity of our soils, organic manures and biofertilizers are recommended as supplements to chemical

fertilizers.The concept of Integrated Nutrient Management is the continuous improvement of soil productivity on long term basis through appropriate use of fertilizers and organic manures and their scientific management for optimum growth, yield and quality of crops and cropping systems in specific agro-ecological situations. The concept gained significance on account of increased demand for agricultural production and scientific findings highlighting the advantages of judicious combination of organic and inorganic fertilizers. The Integrated Nutrient Management helps to restore and sustain the soil fertility and crop productivity. This strategy also checks the nutrient deficiency and soil problems.

The INM strategies focus on the following areas:

1. Reduction of nutrient losses from the applied fertilizers
2. Fertilizer application to synchronise with the crop demand
3. Timing, placement and choice of the fertilizers
4. Controlled release of nutrients
5. Retention and efficient use of the native soil nutrients
6. Research and development of alternative sources of nutrients

The components of INM are the following:

1. Organic manures (Farmyard manure, crop waste, animal waste, industrial waste, sludge, oil cakes, etc.)
2. Bio-fertilizers (Rhizobia, Azospirillum, Azotobacter, Phosphobacteria, etc.)
3. Chemical fertilizers (Urea, Urea super granules, Single Super phosphate, Muriate of potash, micronutrient fertilizers).
4. Green manure and Green leaf manure (*Sesbania rostrata*, *S.aculeata*, *Crotalaria juncea*, Azolla, etc.)

Check Your Progress 2

Note: a) Write your answer in about 50 words.
b) Check your answers given at the end of this unit.

1) What is Eutrophication?

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2) Discuss the importance of Integrated Nutrient management?

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2.9 LET US SUM UP

Since industrial revolutions, humans primarily with the fertilizer use have revolutionized the agriculture food production. Chemical fertilizer has immense potential to increase the agriculture productivity. Globally, we are applying excess fertilizer which ultimately causing pollution to our environment. The atmosphere is polluted by NO_2 and other nitrogen gases causing global warming. Nutrients like nitrogen is also leached from agriculture land and NO_3^- overload in the river, lake, pond, ocean causing a "dead zone" in the water bodies which destroys aquatic life and poses serious threat to environmental health. As we know that current agriculture practices heavily relies on fertilizers, scientist has now engineered nano enable fertilizers which deliver nutrients to crop in a very controlled manner and thereby reducing the pollution and increase in food production.

2.10 KEY WORDS

Fertilizer: Any substance containing one or more recognized plant nutrient(s) which is used for its plant nutrient content and which is designed for use or claimed to have value in promoting plant growth.

Leaching: It refers to the downward movement of free water (percolation) out of the plant root zone. It occurs when the amount of rainfall or irrigation water entering the soil becomes greater than its water-holding capacity.

Soil fertility: Soil fertility is the inherent capacity of the soil to supply nutrients to plants in adequate amounts and suitable proportions.

Soil productivity: Soil productivity is the capacity of the soil to produce crops with specific systems of management.

Macronutrients: Macronutrients are required in large quantities (in g/Kg dry matter) by the plants. The macronutrients are C, H, O, N, P, K, Ca, Mg, and S. N, P and K are called primary nutrients. Ca, Mg, and S are called secondary nutrients.

Micronutrients: Micronutrients are required in small quantities. The micronutrients are Fe, Mn, Zn, Cu, B, Mo, Cl and Ni

2.11 REFERENCES AND SUGGESTED FURTHER READING

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2.12 ANSWERS TO CHECK YOUR PROGRESS

Answers to Check Your Progress 1

1. Your answer should include following points:

- Fertilizers are essential inputs for boosting the output of various crops.
- Plants require 17 essential nutrient elements for their normal growth and completion of life cycle.
- On the basis of their relative concentration or amount in plant tissues, these are divided into (i) macronutrients and (ii) micronutrients.

2. Based on the chemical composition, fertilizers are classified as:

1) Mineral fertilizers consist of inorganic or synthetically produced organic compounds.

2) Organic fertilizers are waste products from animal husbandry (stable manure, slurry manure), plant decomposition products (compost, peat), or products from waste treatment (composted garbage, sewage sludge).

3) Synthetic soil conditioners are products whose main function is to improve the physical properties of soils, for example, friability and water and air transport.

Answers to Check Your Progress 2

Your answer should include following points:

1. The process of nutrient enrichment and gradual filling in of a lake is a natural process. It is called eutrophicationand can be thought of as an inevitable and continual aging of the lake. All lakes go through a natural aging process called eutrophication. Human activity often accelerates this process.

2. Integrated Nutrient Management is the cornerstone of sustainable agriculture. INM focusses on capitalising the positive underpinnings of synthetic chemical fertilizers, organic manures, and biofertilizers and enhancing the activity of soil microbiota so as to improve the health of soil ecosystem.

UNIT 3 LAND PRACTICES AND POLLUTION

Structure

3.0 Introduction

3.1 Objectives

3.2 Overview of Land Degradation

3.3 Soil Erosion

- 3.3.1 Water Erosion
- 3.3.2 Wind Erosion
- 3.3.3 Special Type of Erosion

3.4 Consequences of Soil Erosion

3.5 Causes of Land Degradation

3.6 Agricultural Activities Leading To Land Degradation

3.7 Desertification

3.8 Causes of Desertification

3.9 Desertification and Human Health

3.10 Keywords

3.11 Let Us Sum Up

3.12 References And Suggested Further Readings

3.13 Answers to Check Your Progress

3.0 INTRODUCTION

Soil is the earth's fragile skin that anchors all life on Earth. It is comprised of countless species that create a dynamic and complex ecosystem and is among the most precious resources to humans. Land is an essential building block of civilization. Land is a vital resource for producing food and other ecosystem goods and services including conserving biodiversity, regulating hydrological regimes, cycling soil nutrients and storing carbon, among others. Indeed, the most significant geo resource or natural capital asset is productive and fertile soil. For those communities that rely heavily on land as their main asset, especially the rural poor, human wellbeing and sustainable livelihoods are completely dependent upon and intricately linked to the health and productivity of the land. The development of the agricultural sector has involved progressively more intensive use of land resources for cropping and grazing, and the result is the degradation of land. We know that the land degradation occur principally due to human action, the global introduction and spread of the problem are closely related to spread and growth of human populations and their increasing demands on the natural resource base. Land use practices, which in turn are influenced by technology amongst other factors, are the

primary underlying cause. Half of the topsoil on the planet has been lost in the last 150 years. *The productivity of some lands has declined by 50% due to soil erosion and desertification.* This unit gives an overview of land degradation, soil erosion and desertification and its impact on human health.

3.1 OBJECTIVES

After completing this unit, you will be able to:

- describe land degradation and its major causes;
- explain soil erosion and its effect;
- describe desertification and its causes; and
- identify health hazards due to desertification.

3.2 OVERVIEW OF LAND DEGRADATION

Land degradation is defined as the long term loss of ecosystem function and productivity caused by disturbances from which the land cannot recover. Land degradation occurs slowly and cumulatively and has long lasting impacts on rural people who become increasing vulnerable. The UN Convention to Combat Desertification (CCD,) recognizes land degradation as a global development and environment issue. Desertification is the most severe form of land degradation. The CCD defines desertification as land degradation in arid, semiarid, and dry sub-humid areas resulting from various factors, including climatic variations and human activities. Land degradation is a critical global environmental issue. It directly affects the livelihoods of millions of people, many of them poor and vulnerable especially dry lands, where more than 500 million hectares of land is degraded. This also negatively affects the world's ability to increase the production of food that is necessary to feed the rapidly growing global population. It is therefore necessary to maintain the environmental health and sustainability of production landscapes. Land degradation is a human induced or natural process which negatively affects the land to function effectively within an ecosystem. Land degradation is often linked to sustainability in terms of keeping its productivity. As sustainability and productivity are not easy to define, degradation of land can better be described in terms of non sustainable actions or in terms of loss of resilience. Resilience is defined as the land's ability to recover from a shock, be it climatic or a change in land use.

Land degradation refers to any diminishment of biodiversity and ecosystem functioning that negatively impacts the provisioning of ecosystem services and ultimately impedes poverty eradication and sustainable development. Land degradation is caused by human activities and natural processes and is being exacerbated by the adverse impacts of climate change. In addition to unsustainable agricultural and livestock management practices, other sectoral activities contribute to land degradation ere by reducing socio-ecological resilience and food/ water security. When degradation occurs in arid, semi arid and dry sub humid area where productivity is constrained by water availability, it is called desertification.

In terms of reduced productivity, land degradation deals with changes either in the physical environment, or in crop yields and livestock out puts.

Biophysical indicators of land degradation

i) **Soil Erosion**

- erosion - rate of soil loss (tons/ha/year)
- Soil fertility decline - soil organic matter/topsoil carbon
- Declined Soil nutrient balance
- Occurrence of soil deficiencies, including micronutrients
- Salinization - extent of patches of salinized soil.

ii) **Vegetation degradation**:

- Decline in total plant cover: forests/ woodlands, croplands, grasslands)

iii) **Water resources degradation**:

- Declined water tables;
- Declined river flow regimes.

Land degradation has a number of aspects. They include vegetation, soil erosion, droughts and floods. The idea of ecosystem viability, or health, is useful in bringing some of these aspects together rather than considering them as unrelated, isolated characteristics of the overall problem.

i) Flora and Fauna

Vegetation is often the first element of the biophysical environment to be degraded by human actions, or perhaps it is the most visible. Its decomposition forms humus and releases nutrients into the soil, many of which are then cycled back into the plants. Vegetation importantly provides habitat, shelter and food for larger biota. Loss of native vegetation therefore directly threatens ecosystem processes and the survival of animals and birds. Vegetation degradation often leads to loss of soil fertility, accelerated erosion and reduced water quality (and changed flow regimes), thereby threatening the viability of human communities. Biomass is a common measurement of 'productivity'. Even though the morphology and numbers of plant and animal individuals and communities may appear healthy, they may be suffering stress from insect and fungal attack, depleted or imbalanced soil nutrients, and deteriorating soil- and ground-water or air quality. Ecological processes also need to be included, especially food chains and energy flows again posing difficulties for measurement.

ii) Soil Degradation

Degradation of soil properties can be measured in three groups:

- biological,
- chemical and
- physical/ morphological properties.

The degradation of soil biological properties usually refers to declining soil organic matter (or carbon) and reduced macro and micro soil and litter fauna. Soil organic matter, especially humus, is important for several reasons: it contributes cohesion to the soil, provides nutrients and stores water. Soil and litter fauna are crucial. Their role in bioturbation, which affects soil texture, organic matter and a range of chemical properties, thereby maintaining soil fertility, is fundamental. Declining soil fertility is measured by the loss of soil nutrients, usually the NPK triumvirate (nitrogen, phosphorus and potassium). But trace elements are also essential and are often excluded from standard synthetic fertilizing practices. Synthetic fertilizers also do not contribute to organic matter or to soil physical properties such as soil structure, water holding capacity and cohesion. Elemental imbalances are an important aspect of soil chemical properties in relation to soil degradation.

Some of the most important imbalances worldwide are acidification, sodification and salinization. Most soils become increasingly acid over time as bases are leached out of the system in soil-water or by plant uptake. Some fertilizing practices contribute to the problem. Sodification refers to the accumulation of excess sodium ions in the soil, and is characteristic of many soils in semi-arid environments. It is also influenced by the parent materials. The consequences are mainly a loss of soil structure, enhancing water logging and some erosion processes, and causing difficulties for plant root penetration and loss of oxygen in the root zone. Salinization refers to the hyper concentration in soils (and water) of naturally occurring soluble salts, usually chlorides, sulfates and carbonates, and the accumulation of artificial nutrients associated with fertilizers and pesticides. In the former instance the causes of the salt concentrations are hydrological changes resulting from either irrigation or the replacement of natural vegetation with introduced crops and pastures (secondary, dryland salinization).

Elemental imbalances in soils also result from the addition of toxic elements and compounds. Phosphate fertilizers, for example, include traces of cadmium and uranium, amongst other impurities. In areas such as market gardens (truck farming), where there are high rates of fertilizer applications, cadmium accumulates in soils and in different parts of vegetables, with potentially adverse effects on consumers of the vegetables. Toxic elements and compounds are also added to soils by air pollution, with acid rain and airborne lead being well-known instances. The disposal of toxic wastes in landfills is another, obvious example. It seems that not until adverse health effects are reported in significant numbers of people is any effective action taken to control or redirect this disposal, whilst the construction of residential areas on and around hazardous waste dumps (unknowingly or otherwise) appears to be an increasingly frequent occurrence. Soil physical and morphological properties reflecting degradation include loss of soil structure and compaction. Lateralization is a particular instance. Accelerated erosion by wind and water, and desertification, are other aspects of soil degradation. Data on human induced erosion rates are not difficult to find: the question is the extent to which this has accelerated in comparison with natural (pre-human occupation), geomorphic rates.

In addition to erosion, soil quality is affected by other aspects of agriculture. These impacts include compaction, loss of soil structure, nutrient degradation, and soil salinity. These are very real and at times severe issues. The effects of

soil erosion go beyond the loss of fertile land. It has led to increased pollution and sedimentation in streams and rivers, clogging these waterways and causing declines in fish and other species. And degraded lands are also often less able to hold onto water, which can worsen flooding. Sustainable land use can help to reduce the impacts of agriculture and livestock, preventing soil degradation and erosion and the loss of valuable land to desertification.

Check Your Progress 1

Note: a) Write your answer in about 50 words.
b) Check your answers given at the end of this unit.

1) What do you understand by land degradation?

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2) Give the biophysical indicators of land degradation.

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3.3 SOIL EROSION

Soil is a dynamic natural body on the earth surface and is a repository of essential nutrients required for crop growth and development. It is estimated that the rate of soil formation is about 2.5 cm every 150 years. In other words, the soil is non-renewable within the life span of human beings.

Definition of Soil Erosion:

Soil erosion is defined as the detachment of soil particles, their transportation from one place to another and deposition elsewhere through water, wind, snow, coastal waves and other forces. The factors responsible for detachment of soil particles are impact of rainfall, lack of vegetation, flowing water and wind speed. The transportation of soil practices are aided by runoff water and blowing wind. Soil erosion due to runoff water is noticed more on sloping and denuded lands. The runoff water not only removes the surface soil but also valuable soil nutrients. Removal of soil nutrients by soil erosion depletes the soil fertility and makes the soil unproductive for crop cultivation. Under normal biophysical equilibrium condition, the soil erosion should be balanced with soil formation. Due to the imbalance caused either by human action or natural reason, the soil erosion may be enhanced leading to accelerated soil erosion.

i) Geological or natural Erosion:

Geological erosion occurs due to the action of water, wind, gravity and glaciers. This type of erosion virtually does not pose any serious problem because the loss of soil due to geological erosion is compensated by soil formation.

ii) Accelerated Erosion:

Accelerated erosion occurs when the soil erosion exceeds the normal rate of erosion. This type of erosion occurs when natural equilibrium existing in soil

ecosystem is affected by the biotic interferences in terms of vegetation removal, deforestation, faulty agricultural practices, overgrazing, etc. This accelerated soil erosion is destructive and highly unproductive resulting in degradation of valuable land resources.

3.3.1 Water Erosion

Water erosion is defined as the removal of soil from the land surface by water, including runoff from melted snow and ice. Water erosion is classified into different types:

1. **Splash Erosion:** A falling raindrop due to the kinetic energy it possesses is capable of breaking down the soil aggregates, detach the soil particles and displace the soil particles. This is called splash erosion. This is the first step in water erosion. If the soil is covered with vegetation, the force of raindrop falling on the soil surface is drastically reduced and the soil is conserved.

2. **Sheet Erosion:** A thin layer of soil is removed from large areas uniformly during rainfall and most of the time, the soil loss remains undetected. This is called sheet erosion. The eroding and transporting power of sheet flow is dependent on the depth and velocity of runoff. Sheet erosion occurs because of surface creeping of the soil in uniform layers, suspension of soil particles in runoff water and saltation of soil particles. The soil particles hop or slip over the surface during the downward movement of water. T The sheet erosion results in loss of top soil and soil degradation. The soil becomes shallower and so the crop productivity gradually declines. Sheet erosion can be observed by examining the muddy colour of surface runoff from agricultural fields.

3. **Rill Erosion:** Rill erosion is soil removal by water from small channels formed due to the concentration of surface flow along the slope. These small channels or rills can be controlled by tillage operations and by adopting soil conservation measures. These rills when left unattended may take the shape of gullies. So this type of erosion is considered intermediate between sheet erosion and gully erosion.

4. **Gully Erosion:** The rills or small channels with more than 30 cm depth are called gullies. Gully erosion occurs due to the non-adoption of soil conservation measures and adoption of faulty agricultural practices for a long period of time. Unlike the rill erosion, gully erosion cannot be managed by tillage operations. In fact, the gullies obstruct the operation of heavy machinery and farm implements. The rate of formation of gully erosion depends on the land cover, slope of the land, soil characteristics, drainage area, quality of runoff, etc.

3.3.2 Wind Erosion

Wind erosion occurs in arid and semi-arid areas which are devoid of vegetation and where the wind velocity is high. Wind erosion is mainly due to a strong wind, high solar radiation, and low atmospheric humidity. The strong winds lift the single grained soil particles from the land surface and they are taken to far off place and deposited. In this process, the fertile soil is lost and the agricultural productivity of the soil is reduced drastically. The strong wind detaches the soil particles from the land surface, transport the soil particles to

far off place and deposit the soil particle. The soil particles detached from the land surface are transported by the following three phenomena.

1. **Saltation:** The soil particles detached from land surface due the impact of strong wind move in a series of short bounces along the land surface. The size of the soil particles exhibiting such a phenomenon is small and it varies between 0.1 to 0.5 mm diameters. This kind of soil movement caused by wind is called saltation. Saltation accounts for 50 to 75 % of the total soil movement through wind erosion and it is dependent on the soil type, wind speed and vegetative cover.

2. **Suspension:** Suspension is a type of soil movement wherein the fine soil particles of less than 0.1 mm diameter remain suspended in the air flow. The very fine soil particles are carried to distant locations by this phenomenon. Suspension accounts for about 40% of total soil movement.

3. **Surface Creep:** The soil particles having a diameter varying between 0.5 mm and 1.0 mm are too heavy to move either by saltation or suspension. These heavy soil particles move by creeping over the land surface. The soil creep is initiated by the impact of bouncing soil particles.

3.3.3 Special Types of Erosion

1. **Landslides:** The landslides are common in hilly regions during rainy season. The soil mass gets saturated during heavy rainfall and this acts as a cause for instability in the land mass. The situation aggravates in the absence of vegetation. Afforestation is essential in the hilly region to reduce the disasters like landslides.

2. **Stream bank Erosion:** The quick flowing streams and torrents cause soil erosion by cutting their banks and adjoining fields. This is called stream bank erosion. This occurs due to runoff flowing over the side of the stream banks.

3. **River Bank Erosion:** The Rivers due to the heavy downpour in the catchment areas over flow and erode the river banks. The River bank erosion results in the broadening of the river beds and the river courses also changes.

4. **Coastal Erosion:** In the coastal areas, the strong sea waves driven by wind strike against the seashore and cause soil erosion.

3.4 CONSEQUENCES OF SOIL EROSION

i) **Land degradation:** It is said that many civilization have vanished in the past due to improper management of land. Soil productivity is essential for achieving food and nutritional security. About 45% of total geographical area of our country is degraded, in which more than 65% of the land degradation is due to wind and water erosion.

ii) **Loss in soil productivity and soil degradation:** Soil fertility is one of the components of soil productivity. Due to soil erosion, the top soil which is rich in soil nutrients is lost and this results in loss in soil productivity. Soil degradation is considered as one of the factors responsible for low crop yield in the rainfed area of one country.

iii) **Siltation of reservoirs:** The soil eroded due to different agents like water and wind reaches the reservoirs and due to this siltation, the ecological significance of reservoirs is reduced. Under the multi-purpose river-valley projects, many large reservoirs are constructed in our country. Unfortunately, due to accelerated soil erosion, the reservoirs are silted more than the permissible limit resulting in loss of storage capacity and reduction in hydro-electric power generation. It has been estimated that 5330 million tonnes of soil is lost annually. This is almost four times higher than the permissible soil loss. It has also been estimated that about 29% of the eroded material is permanently lost to sea, 61% is dislocated and 10% of eroded material is deposited in the reservoirs.

iv) **Floods:** Accelerated soil erosion and consequent siltation increases the vulnerability of flood plains to frequent and destructive floods. Due to floods, the rich flood plains lose valuable fertile soil and so agricultural productivity in these regions will be reduced.

Factors affecting Soil Erosion:

The soil erosion is affected by the following factors:

1. Climate
2. Topography
3. Soil Characteristics
4. Land use and Nature of Ground Cover
5. Biotic Interference
6. Conservation Measures

Human-induced soil degradation can be categorized in two ways. . The first category deals with degradation of soil material, and the two major types in this category are water erosion and wind erosion; loss of topsoil through water erosion is the most common type of soil degradation. The second category of soil degradation includes internal soil chemical deterioration (salinization and acidification, soil pollution caused by excessive use of pesticides and manure, and soil pollution due to industrial and human waste accumulation) and soil physical deterioration (compaction, sealing and crusting, and water logging.

3.5 CAUSES OF LAND DEGRADATION

Land degradation, in terms of degradation of soil and water resources, is partially or mainly due to non-appropriate land use. This mismanagement can find its origin in economic and social problems, population pressure, changes in market prices and technical reasons. Global climate changes may contribute to accelerate land degradation processes to a lesser degree than the effects of land use changes.

The direct cause of land degradation is - mismanagement of the land by man. The indirect causes of this mismanagement may be: land tenure regulations, policies related to export import, land politics, drought, poverty, poor advisory and extension services, population pressures. Indirect factors such as governmental policies and poverty usually are the root causes. Combating land

degradation or desertification and developing a sustainable management program depends upon removing both kinds of causes.

Human interventions that have resulted in soil degradation worldwide:

1. Deforestation and the removal of the natural vegetation for fuel wood, agriculture and industry is increasing at an alarming rate and this is causing serious land degradation.
2. Overgrazing of the vegetation is particularly damaging where livestock concentrates around watering points destroying the land within a radius around wells and villages. Stock grazing is the most widespread use of dry lands and is regarded as a major cause of desertification.
3. Mismanagement of agricultural land is being the most important causative factor of human-induced soil degradation. Inappropriate and/or heavy machinery is applied result in uncovered land after cropping which is prone to water and wind erosion.
4. Overexploitation of the vegetative cover for domestic use
5. Bioindustrial activities, Urban Growth, Industrialization and Mining cause soil degradation.
6. Land Shortage, Land Fragmentation and Poor Economy
7. Population Increase

3.6 AGRICULTURAL ACTIVITIES LEADING TO LAND DEGRADATION

Most of the area under cultivation in India has been under cultivation for hundreds of years, and

has reached its state of maximum impoverishment many years ago. The Green Revolution brought about a technological breakthrough, leading to the use of short duration high yielding varieties that helped intensify land use within a year by increasing the area under irrigation and greatly increasing the use of chemicals such as fertilizers and pesticides. This, however, had further consequences, including loss of plant biodiversity and environmental pollution. Widespread land degradation caused by inappropriate agricultural practices has a direct and adverse impact on the food and livelihood security of farmers. Basically, degradation is caused by erosion, which results in the loss of topsoil through the action of water and wind, or water logging, which results in soil salinization. Agricultural activities and practices can cause land degradation in a number of ways depending on land use, crops grown and management practices adopted. Some of the common causes of land degradation by agriculture include cultivation in fragile deserts and marginal sloping lands without any conservation measures, land clearing through clear cutting and deforestation, agricultural depletion of soil nutrients through poor farming practices, overgrazing, excessive irrigation, over drafting (the process of extracting groundwater beyond the safe yield of the aquifer), urban sprawl and commercial development, and land pollution including industrial waste disposal to arable lands.

Agriculture activities leading to land degradation primarily are:

- Low and Imbalanced Fertilization
- Excessive Tillage and Use of Heavy Machinery
- Crop Residue Burning and Inadequate Organic Matter Inputs
- Poor Irrigation and Water Management
- Poor Crop Rotations
- Pesticide Overuse and Soil Pollution

3.7 DESERTIFICATION

Desertification can be considered to be a subset of land degradation, occurring in more arid areas; though land degradation is usually defined as being caused by human actions. The main direct actions are over-clearing, over-grazing and over cultivation. There is a host of more complex direct and underlying causes including the introduction and spread of exotic plants, animals, pests and diseases, fire, economic pressures. Desertification means the transformation of land into desert-like conditions. Some refer to it simply as 'land degradation in drylands', whereas the UN Convention to Combat Desertification defines it as 'land degradation in arid, semi-arid and dry sub-humid areas resulting from various factors, including climatic variations and human activities.

However, Monique Mainguet proposed the following definition: Desertification, is caused by human activities in which the carrying capacity of land is exceeded; it proceeds by exacerbated natural or man-induced mechanisms, and is manifested by intricate steps of vegetation and soil deterioration which result, in an irreversible decrease or destruction of the biological potential of the land and its ability to support population. The causes of desertification are both natural and man-made. Drought, rain patterns, increasing global temperatures and climate change contribute to the drying out of already arid lands, but these areas are also extremely sensitive to human activity. 10-20% of drylands are already severely degraded and some reports trace 70% of soil degradation to human-induced reasons, particularly population growth, agricultural technologies, and unsustainable policies. These factors degrade the land and create feedback effects that result in the loss of biodiversity as well as other negative outcomes that affect us all.

3.8 CAUSES OF DESERTIFICATION

As a result of human activities and decisions such as overgrazing, the relationship between seven key ecological factors vegetation, albedo, temperature, precipitation, soil moisture, wind erosion, and water erosion becomes unbalanced. These mutually reinforcing relationships are especially susceptible to instabilities due to feedback effects, and perturbations like unsustainable cultivation practices are only magnified over time, resulting in essentially irreversible effects. One of the main causes of desertification is unsustainable agricultural practices. This is the case in the Indian drylands of Maharashtra, Karnataka, Rajasthan, and Jhabua. In these areas, agricultural development and plantation expansions often rely on the overexploitation of scarce water resources to prevent crop failure. This mismanagement of water

supply can include irrigation water, ground water, drainage systems, and the inadequate positioning of watering points. In addition, setting controlled fire to land promotes nutrient cycling when done correctly, but when done too frequently, it can permanently reduce the nutrient content of the land. Intensive well and canal irrigation methods and fires are only short term agricultural solutions and unsustainable in the long run. They remove moisture and nutrients from the soil beyond a reparable point and accelerate the conversion of dry environments into decertified ones.

The dangers of unsustainable land cultivation customs are exacerbated by high population growth rates in drylands. This places additional strain on already delicate physical systems as vegetation and natural forest cover earth's natural defense against land degradation are eliminated in an effort to sustain the population. The moisture content in the area decreases and soil becomes more vulnerable to both wind erosion and water erosion, resulting in problems like decreased water quality, increased sediment deposits, flooding, and dust storms. Additionally, the amount of land available for human inhabitance and livestock grazing diminishes. Traditionally, grazing occurs in cycles involving movement and migration when one area becomes overgrazed, animals move to another area, giving the original land a chance to recover. However, the shortage of land causes overgrazing without replenishment and over time, the degradation becomes so severe that it renders the land permanently unproductive. Human activity affects not only soil quality and water supply, but also biodiversity. By decreasing the amount of vegetation and forest area, the habitable area for in sects, animals, and other life forms also diminish. Consequently, desertification can cause permanent species loss, an outcome that will reverberate throughout the world and cause further destabilization.

Check Your Progress 2

Note: a) Write your answer in about 50 words.
b) Check your answers given at the end of this unit.

1) What are the factors affecting soil erosion?

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2) Describe causes of desertification?

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3.9 DESERTIFICATION AND HUMAN HEALTH

The process of desertification presents a serious impact on the well-being and health of the people living in the areas affected by droughts and land degradation on an unprecedented global scale. The worst situations can be found in Africa, which is threatened because the land degradation processes affect about 46 percent of the whole continent and create a health risk to people living in the regions far beyond the affected areas. Asia, on the other hand is the most severely

affected continent in terms of the number of people affected by desertification and drought. Dryland populations are often marginalized and unable to play a role in the decision making processes that affect their well-being, making them even more vulnerable.

In drylands, people depend on ecosystem services for their basic needs, which in turn are dependent on water availability and climate conditions. The extent of the health impact depends on a complex mix of factors involving a population's vulnerability and on pre-existing conditions, including age, gender, disability, genetics, immune status and access to health services. In arid, semi-arid and dry sub-humid areas, desertification and drought are directly linked to food and water shortages, conflicts, mass migration, increased risk of fires and limited access to health care. Furthermore, desertification leads to a decrease in wild plants that provide nutritional supplements for entire communities living in deserts. These changes in biodiversity put at risk traditional medicine which relies on wild plants, and holds an important place in many affected areas where modern medicines are out of reach.

The health impacts of desertification can be divided into

- Malnutrition and famine,
- water borne diseases,
- other infectious diseases,
- respiratory diseases
- burning injuries.

Effects of malnutrition related to desertification and drought include growth and development retardation, major susceptibility to infections, blindness and anemia. In particular desertification can increase fecal- oral diseases and water-wash diseases, which spread from one person to another due to the lack of water for personal hygiene. The drying of water sources increases the use of heavily polluted water, leading to severe epidemics. In affected areas research shows that desertification is linked to declining agricultural productivity and decrease in income levels, leading to severe economic crisis and poverty. Sustainable agricultural innovations are key to restraining harmful impacts on the environment and on the health and livelihoods of populations affected by desertification. Despite the worldwide advancement in modern medicine, many countries suffer under a double burden of diseases that dominate both developed and poorer countries.

3.10 LET US SUM UP

Soil is an essential component of agricultural resources providing ecosystem services like nutrient supply, media for plant growth and habitat for soil organisms. Land degradation negatively affects the world's ability to increase the production of food. The wearing away of the land surface by physical forces such as rainfall, flowing water, wind, ice, temperature change, gravity, or other natural or anthropogenic agents that abrade, detach and remove soil or geological material from one point on the earth's surface to be deposited elsewhere is known as soil erosion. It is therefore necessary to maintain the environmental health and sustainability of production landscapes. Land

degradation is a human induced or natural process which negatively affects the land to function effectively within an ecosystem. Desertification can be considered to be a subset of land degradation, occurring in more arid areas; though land degradation is usually defined as being caused by human actions. The main direct actions are over-clearing, over-grazing and over cultivation. Desertification presents a serious impact on the well-being and health of the people living in the areas affected by droughts and land degradation on an unprecedented global scale.

3.11 KEYWORDS

Desertification : A form of land degradation that occurs in drylands (arid, semi-arid, and dry sub-humid areas).

Drought : Prolonged absence or marked deficiency of precipitation which may contribute to desertification.

Drylands : Conventionally defined in terms of water stress, drylands are areas of land where the mean annual rainfall (including snow, fog, hail, etc.) is lower than the total amount of water evaporated into the atmosphere.

Land : The terrestrial bio-productive system comprised of soil, vegetation, other biota, and the ecological and hydrological processes that operate within the system. In very simple terms: it corresponds to the Earth´s surface and natural resources found there.

Land degradation : This is defined by the United Nations as a reduction or loss of the biologic or economic productivity and complexity of rain-fed cropland, irrigated cropland or range, pasture, forest, and woodland.

Land management : Activities associated with the management of land as a resource from both an environmental and an economic perspective towards sustainable development.

Soil Erosion : The wearing away of the land surface by physical forces such as rainfall, flowing water, wind, ice, temperature change, gravity, or other natural or anthropogenic agents that abrade, detach and remove soil or geological material from one point on the earth's surface to be deposited elsewhere.

3.12 REFERENCES AND SUGGESTED FURTHER READINGS

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3.13 ANSWERS TO CHECK YOUR PROGRESS

Answers to check your progress 1

1. Your answer should include following points:

   Land degradation is defined as the long term loss of ecosystem function and productivity caused by disturbances from which the land cannot recover. Land degradation occurs slowly and cumulatively and has long lasting impacts on rural people who become increasing vulnerable.

2. Your answer should include following points:

   - Biophysical indicators of land degradation
   - Soil Erosion
   - erosion - rate of soil loss (tons/ha/year)
   - Soil fertility decline - soil organic matter/topsoil carbon
   - Declined Soil nutrient balance
   - Occurrence of soil deficiencies, including micronutrients
   - Salinization - extent of patches of salinized soil.

Vegetation degradation:

- Decline in total plant cover: forests/ woodlands, croplands, grasslands)

Water resources degradation:

- Declined water tables;
- Declined river flow regimes.

Answers to check your progress 2

1. Your answer should include following points:

   The soil erosion is affected by the following factors:

   a. Climate

   b. Topography

   c. Soil Characteristics

d. Land use and Nature of Ground Cover

e. Biotic Interference

f. Conservation Measures

2. Your answer should include following points:

a) Human activities such as overgrazing etc.

b) Unsustainable cultivation practices.

c) Mismanagement of water supply.

UNIT 4 INVASIVE SPECIES

Structure

4.0 Introduction

4.1 Objectives

4.2 Definition and Concept of Invasive Species

4.3 Concept of Invasive Species

4.4 Means of Species Introduction

4.5 Common Traits

4.6 Invasion Pathways

- 4.6.1 Successful Establishment of Invasive Species

4.7 Impacts

- 4.7.1 Ecological impacts, Ecosystem, Ecosystem Services and Biodiversity
- 4.7.2 Economic and Social Concern
- 4.7.3 Public Health
- 4.7.4 Livelihood of People
- 4.7.5 Preventing Fishing and Reducing Water Quality

4.8 Impacts on Agriculture

4.9 Reducing the Impact of Invasive Alien Specie: IAS A Global Concern

4.10 Key International Instruments Relevant To IAS

4.11 Let Us Sum Up

4.12 Keywords

4.13 References and Suggested Further Readings

4.14 Answers to Check Your Progress

4.0 INTRODUCTION

Alien species are plants, animals, fungi and microorganisms that have been transported across ecological barriers such as mountain ranges, or oceans as a result of human intervention and have become established in an area outside their natural range. Invasive alien species are one of the leading threats to biodiversity. They exert enormous costs on agriculture, forestry, fisheries, and other human enterprises, as well as on human health. Rapidly accelerating human trade, tourism, transport, and travel over the past century have dramatically enhanced the spread of invasive species, by allowing them to surmount natural geographic barriers.

As far as agricultural sectors are considered it has long been very familiar with invasive alien species. Invaders especially pathogens and insects have almost wiped out entire crops or livestock. This has resulted in threatened livelihoods and national economies. Invasive alien species (may be animal pests, viruses, pathogens and plants) has become one of the most serious threats to the

ecological and economic well-being of almost every habitat and region on the Earth. The unit will discuss cover the invasive alien species and how they are affecting human health, environment and social well being.

4.1 OBJECTIVES

After completing this unit, you will be able to:

- define invasive alien species and pathways for their establishment;
- describe the impact of invasive species to environmental health; and
- discuss key international instruments relevant to IAS.

4.2 DEFINITION AND CONCEPT OF INVASIVE SPECIES

An introduced, alien, exotic, non-indigenous, or non-native species is a species living outside its native distributional range, which has arrived there by human activity, either deliberately or accidentally. Non-native species can have various effects on the local ecosystem. Introduced species that have a negative effect on a local ecosystem are also known as invasive species. Alien that is non-native species have been introduced both accidentally and intentionally. Intentional introductions are mainly for economic, environmental and social considerations. In the forest sector, for example, *Pinus*, *Eucalyptus* and *Acacia* species are important sources of pulp, timber and fuel wood, yet at the same time they have placed tremendous strain on water resources.

Some introduced species are able to boom at the new location. They have the favorable biological properties which allow them to flourish in more numbers quickly. Invasive alien species often outcompete native plant and animal species for food water and space and are usually able to reproduce and spread quickly. Biological invasions by alien (non-native) species are widely recognized as a significant component of human caused global environmental change and the second most important cause of biodiversity decline. Alien species threaten many ecosystems and have serious environmental, economic and health impacts. In particular, they impact adversely upon biodiversity, including decline or elimination of native species through competition, predation, or transmission of pathogens and the disruption of local ecosystems and ecosystem functions.

Box 1

IAS are also commonly referred to as invasives, aliens, exotics or nonindigenous species.

IAS are species, native to one area or region, that have been introduced into an area outside their normal distribution, either by accident or on purpose, and which have colonized or invaded their new home, threatening biological diversity, ecosystems and habitats, and human well-being.

The extent to which introduced species may proliferate and spread is affected by the state of the receiving ecosystem. An alien species may find a vacant niche and spread, or it may compete for one already occupied

by a native species. Some IAS proliferate because they find no natural enemies in their new habitat.

Although some species have invaded habitats on their own, human activity such as exploration, colonization, trade and tourism has dramatically increased the diversity and scale of invasions by alien species.

Sources: CBD 1992, Shrine and others 2000, ESA 1998

Invasive Alien Species (IAS) pose a profound impact on humans as well as on the ecosystems as it can be a cause of heavy economic loss, in terms of reduced crop and livestock production in agriculture ecosystem, reduced native biodiversity in natural ecosystem, costs involved to control their rapid spread and impacts on human health. Thus, these non-native species destroy ecosystems, habitat, or species and are also the second greatest agent of species endangerment and extinction after habitat destruction. Species are being moved around the planet at a rate much greater than we ever expected.

Box 2

In the late 1800s, the small Indian mongoose, which is native from Iran through India to the Malay Peninsula, was introduced to Fiji, Mauritius, Hawaii and the West Indies, to control rats, which had themselves been accidentally introduced and were decimating sugarcane and other crops. Unfortunately, this attempt had catastrophic effects, leading to the extinction of a number of endemic native birds, reptiles and amphibians. The mongoose is a continuing threat to other species, including the rare Japanese Amami rabbit, and it carries rabies, which can spread to other animal populations.

Box 3

The South American water hyacinth, which has large purple and violet flowers, is extremely popular as an ornamental plant for ponds. It is also one of the most voracious and fast-growing aquatic weeds in the world; water hyacinth populations can double in only 12 days. The introduction of water hyacinth around the world for landscaping has led to severe disruption of native aquatic ecosystems. The plant is now found in 50 countries on five continents, where infestations of the weed block waterways and interfere with boat traffic, swimming and fishing. Water hyacinth also prevents sunlight and oxygen from reaching the water column and submerged plants. This shading and crowding of native species has dramatically reduced biodiversity in many aquatic ecosystems.

4.3 MEANS OF SPECIES INTRODUCTION

Invasive plants must first colonize and then persist in their new environment. A small percentage of these may then become abundant and dominant components of the plant community. For example, an annual grass, cheatgrass (*Bromus tectorum*), was accidentally introduced from Asia into grasslands throughout the world, and now occupies many millions of hectares in the environments into which it was introduced. An ornamental plant called the cartwheel flower (*Heracleum mantegazzianium*) escaped its garden environments; it is now known as ‘giant hogweed’ and is a serious problem on three continents. The Monterey pine (*Pinus radiata*), originally from a small area in the western United States, was planted for wood production worldwide.

This tree is now considered a weed in many regions. These examples illustrate the diversity of growth forms that can characterize plant invaders. In India especially NW Himalaya *Ageratum conyzoides* L., *Parthenium hysterophorus* L., *Lantana camara* L. and *Eupatorium adenophorum* Sp. (Syn. *Ageratina adenophora* (Spreng.) R. are major invaders causing huge loss to indigenous species diversity in this part of the world.

Invasive plants have been introduced deliberately as forage, fiber, medicines, or ornamentals; for erosion controls; and for timber plantations. Sources of accidental introductions include ballast in ships, impure crop seeds, adhesion to domesticated animals, and soil surrounding roots of nursery stock. Activities such as agriculture, logging, and grazing further enhance establishment of invasive by creating disturbed sites for colonization. Agriculture also facilitates invasion when pests in agro-ecosystems are exposed to agricultural practices for many generations, resulting in selection for characteristics that make them persistent and noxious.

Introduced species often consume or prey on native ones, overgrow them, infect or vector diseases to them, compete with them, attack them, or hybridize with them. Invaders can change whole ecosystems by altering hydrology, fire regimes, nutrient cycling, and other ecosystem processes. Often the same species that threaten biodiversity also cause grave damage to various natural resource industries. The zebra mussel (*Dreissena polymorpha*), *Lantana camara*, kudzu (*Pueraria lobata*), Brazilian pepper (*Schinus terebinthifolius*), and rats (*Rattus* spp.) are all economic as well as ecological catastrophes. Invasive non-native species are taxonomically diverse, though certain groups (e.g., mammals, plants, and insects) have produced particularly large numbers of damaging invaders.

Thousands of species have been extinguished or are at risk from invasive aliens, especially on islands but also on continents. Many native ecosystems have been irretrievably lost to invasion. Weeds cause agricultural production losses of at least 25% and also degrade catchment areas, near-shore marine systems, and freshwater ecosystems. Chemicals used to manage weeds can further degrade ecosystems. Ballast water carries invasive that clog water pipes, foul propellers, and damage fisheries. Imported pests of livestock and forests reduce yields drastically. Further, environmental destruction, including habitat fragmentation, and global climate change are extending the range of many invaders.

Box 4

Not all non-native species are harmful. In many areas, the great majority of crop plants are introduced, as are many animals used for food. Some productive forest industries and fisheries are based on introduced species. And introductions for biological control of invasive pests have often resulted in huge savings in pesticide use and crop loss. However, many of the worst introduced pests were deliberately introduced. Horticultural varieties and zoological novelties have become invasive and destructive; fishes introduced for human consumption have extirpated many native species, and even biological control introductions have occasionally gone awry. Rhododendrons originated in the Himalayas, and staples of the European diet such as tomatoes, potatoes and maize originated in the Americas. But while many introduced species bring considerable benefits to local economies, others upset the ecological balance and proliferate in ways that are highly destructive to the environment and to economic and human interests.

4.4 COMMON TRAITS

All invasive species, aquatic and terrestrial, tend to share common characteristics that allow them to thrive following their arrival to a new environment. Common traits of invaders include:

- Fast growth
- Rapid reproduction
- High dispersal ability
- Lack of natural predators
- Ability to survive in a wide range of environmental conditions
- Ability to consume a variety of food resources
- Ability to adapt to changing environmental conditions
- Ability to displace native species by utilizing limited resources more efficiently

Check Your Progress 1

Note: a) Write your answer in about 50 words.
b) Check your answers given at the end of this unit.

1) Define Invasive alien species and their means of introduction.

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2) List down the common traits of IAS?

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4.5 INVASION PATHWAYS

There is increasing awareness that the different means by which alien species are introduced from one location to another, play a crucial role in the subsequent likelihood of biological invasion. The variety of pathways identified by the CBD down to a manageable six classifications:

1. Deliberate release – game animals, biocontrol agents or plants used to shape landscapes
2. Escape – from gardens, aquaculture or zoos
3. Contamination – plants, pathogens and pests that are unintentionally transported
4. Stowaway – in ballast water, cargo and airfreight

5. Corridor– (e.g. roads, canals) which highlights the role transport infrastructures play

6. Unaided – the natural spread of an alien species from another region where it is not native.

Table 4.1 Some pathways for the different types of introductions

Intentional Introductions		Unintentional Introductions
Direct Introductions into the Environment	**Introductions into Captivity/ Containment**	
• Agriculture • Forestry • Soil improvements • Horticulture (ornamentals, nursery stock, house plants, etc.) • Conservation • Fishery releases • Hunting and fishing • Release of mammals on islands as food sources • Biological control • Aid trade • Smuggling • Aesthetics • Medicinal · Religious	• Botanical and private gardens • Zoos • Farmed animals • Beekeeping • Aquaculture • Pet trade • Aquarium and horticultural pond trade · Research	• Vessels/aircrafts/ vehicles/trains, etc. • Ballast water • Hull fouling • Sea cargo • Sea containers • Personal baggage/ equipment • Agricultural produce • Seed contaminants • Soil, gravel, sand, etc. • Timber • Packaging material • Dirty equipment, machinery, vehicles - including military • Hitchhikers – including parasites and diseases – associated with aquaculture introductions, cut flowers, and introductions for the nursery trade

Source:http://www.issg.org/pdf/publications/GISP/GISP_TrainingCourseMaterials/Management/ManaginginvasivesModule1.pdf

4.6 INVASION PATHWAYS

Successful establishment of invasive species requires three mail steps:

Introduction

Establishment

Spreading

4.6.1 Introduction

Some non-native species are imported intentionally for economic purposes, but many others arrive unintentionally in shipping containers, under the bark of log imports, infesting fruits carried by tourists, swimming in ballast water exchanged in a harbour, or hidden in soil of imported ornamental plants. Most are harmless or fail to become established, but some proliferate and spread in ways that endanger native species in the invaded ecosystem. They undermine agriculture, threaten public health, or create other unwanted and often irreversible disruptions. The initiation of the process through the introduction of invasives can occur through:

(i) Long distance migrations or movements (e.g. the brown planthopper, Nilaparvata lugens in rice)

(ii) Transportation e.g. Parthenium along with wheat grains in India

(iii) Human activities

(iv) Aquarium plants e.g. water fern, water lettuce

The introduction of alien species to a new location can either be accidental or intentional. Accidental introductions are helped by travel across countries and continents and import of various items such as timber, food grains, fodder etc. Intentional introductions are for a variety of purposes such as agriculture, horticulture, forestry and ornamental. All invasive species possess certain biological attributes which contribute to their success as invaders in a new habitat. For invasive alien plants (IAPs), these attributes include production of a large number of easily dispersible, light weight seeds, fast growth rate and better competitive resource capture and utilization abilities compared to native plants.

4.6.2 Establishment

After initial successful colonization, the next stage of invasion is characterized by of a viable, self sustaining population. The species with the highest intrinsic growth rates were more likely to establish successfully. The species of agricultural weeds with heavier seeds experienced faster germination rates and were better invaders than species with smaller seeds. Competitive ability is another trait that may confer an advantage for invasive species during establishment. Many studies have documented invaders that show a superior ability to exploit local resources when compared with native residents or when compared with non invading introduced species. For example, *Centaurea diffusa*, a noxious invasive weed in North America, has stronger negative effects on biomass production for North American grasses than for grasses from its native Eurasian communities.

4.6.3 Spreading

Spreading of a species into areas away from initial sites of introduction requires that the introduced species also overcome barriers to dispersal within the new region and can cope with the abiotic environment and biota in the general area.

4.7 IMPACTS

There are many examples of significant economic, social and environmental impacts caused by invasive alien species. The impacts of IASs include displacement of native species, change of soil chemical profile, rewarding pollinators better than the native species thereby reducing the reproductive success of local species, changing hydrological regimes, making the new habitat fire prone and limiting the photosynthetic efficiency of the local species by reducing light availability.

IASs **impacts can be economic, environmental or social**

- Economic: financial loss or gain
- Environmental: biodiversity and ecosystem structure and function
- Social: human health, happiness and cultural values

4.7.1 Ecological Impacts, Ecosystem, Ecosystem Services and Biodiversity

The impacts of invasive species are second only to habitat destruction as a cause of global biodiversity loss. In fact, introduced species are a greater threat to native biodiversity than pollution, harvest, and disease combined. AIS impact the habitats they invade by reducing the abundance of native species and altering ecosystem processes. They impact native species through predation, competition for food and space, hybridization, as well as the introduction of harmful pathogens and parasites. AIS may also alter normal functioning of the ecosystem by altering fire regimes, hydrology, nutrient cycling and productivity.

The environmental consequences are considerable ranging from wholesale ecosystem changes and the near extinction of native species, such as the European mink (*Mustela lutreola*), which is threatened by the American mink (*Mustela vison*), to more subtle ecological changes and decreased biodiversity. The Mediterranean Sea has suffered extensive damage from the toxic algae, *Caulerpa taxifolia*. Much of Western Europe has suffered serious environmental and economic damage due to the zebra mussel (*Dreissena polymorpha*), which clogs power plant intakes and competes with native freshwater mussel populations. The Asian topmouth gudgeon (Pseudorasbora parva) has spread rapidly throughout Europe since being introduced into Romanian ponds close to the Danube in the 1960s, with serious consequences for native species due to the parasites it brings. Another potentially serious impact is the possibility of hybridisation with native species, which has occurred for example, between the introduced ruddy duck (*Oxyura jamaicensis*) and the white-headed duck (*Oxyura leucocephala*).

Invasive species may out-compete native species, repressing or excluding them and, therefore, fundamentally change the ecosystem. They may indirectly

transform the structure and species composition of the ecosystem by changing the way in which nutrients are cycled through the ecosystem. Entire ecosystems may be placed at risk through knock-on effects.

Given the critical role biodiversity places in the maintenance of essential ecosystem functions, IAS may cause changes in environmental services, such as flood control and water supply, water assimilation, nutrient recycling, conservation and regeneration of soils. Among other things, both old and newly established IAS contribute to land degradation through soil erosion and the drawing down of water resources, reducing resources available to people and indigenous plants. They may alter the environment in directions that are more favourable for them but less favourable to native species. This could include altering geomorphic processes (soil erosion rates, for instance, or sediment accretion), biogeochemical cycling, hydrological cycles, or fire or light regimes. Goods and services supplied by the ecosystems in which people live also contribute significantly to income generation for instance, different medicinal plant species and many native forest plants have a domestic or pastoral use, with an important role to play as a source of food, drink, construction materials, tools, firewood and medicines.

4.7.2 Economic and Social Concern

Invasive alien species are also a major economic and social concern. The estimated damage and control cost of IAS amounts to billions of dollar each year in Europe. In addition, IAS can negatively affect human health functioning as vectors for diseases or causing allergies and skin damage. The toxic sap of the giant hogweed (*Heracleum mantegazzianum*) for example, contains a substance that causes painful blisters, and the common ragweed (*Ambrosia artemisiifolia*) can trigger attacks of asthma and hay fever.

Aquatic Invasive species are also seen as a threat not only to biodiversity and ecosystem functioning, but also to economic development. They reduce production of fisheries, decrease water availability, block transport routes, choke irrigation canals, foul industrial pipelines, degrade water quality, accelerate filling of lakes and reservoirs, and decrease property values. Through damage to human enterprises, invasive species inflict an enormous economic cost; the cost to manage both aquatic and terrestrial species is estimated at $137 billion per year to the U.S. economy alone. This number is likely an underestimate as it does not consider ecosystem health or the aesthetic value of nature, which can influence tourism and recreational revenue. Estimating the economic impacts associated with AIS are further confounded as monetary values cannot be given to extinction of species or loss biodiversity and ecosystem services.

4.7.3 Public Health

Throughout recorded history, epidemics such as malaria, yellow fever, typhus, and bubonic plague have used introduced organisms as vectors and reservoirs. More recently, West Nile virus was introduced into the United States through an infected bird or mosquito. Waterborne disease agents, such as cholera bacteria (*Vibrio cholerae*), and causative agents of harmful algal blooms are often transported in the ballast water of ships. The effect of invasive species on public health extends beyond the immediate effects of disease and parasites as chemicals used to control invasive species can pollute soil and water. Other AIS, such as invasive mussels, may increase human and wildlife exposure to

organic pollutants such as Polychlorinated biphenyls (PCBs) and Polycyclic aromatic hydrocarbons (PAHs) as these toxins accumulate in there tissues and are passed up the food chain.

Impacts on human health

- For humans, one of the most dangerous effects of invasive alien species is as a carrier of disease. The Asian tiger mosquito has been linked to more than 20 diseases, including yellow fever and chikungunya fever. Climate change projections show that the mosquito will likely extend its range further north in coming years.
- Changing landscapes are another result of invasive alien species. For example, the red palm weevil is destroying large numbers of palms in the Mediterranean region, transforming the green spaces in cities.
- There are also effects on ecosystems which indirectly affect humans. In some cases ecosystems altered by invasive alien species may be less able to provide important 'ecosystem services' which support human activity. For example, the pollination carried out by honeybees may be affected by invasive alien species - the yellow-legged hornet, native to Asia, has been found to devastate beehives in France.
- Other species such as the pervasive zebra mussel can also cause high costs by fouling water filtration plants and water cooling reservoirs of power plants.

4.7.4 Livelihood of People

The livelihoods of large numbers of people depend on natural resources, which provide their primary sources of income and food. Invasive species threaten agricultural systems and crop productivity across the continent often in countries which already suffer from droughts and food insecurity and disrupt ecosystems. Their presence also inhibits the international trade of produce.

4.7.5 Preventing Fishing and Reducing Water Quality

Aquatic weeds such as water hyacinth, *Salvinia molesta* and water *Pistia stratiotes* affect communities that rely on fishing by blocking waterways and diminishing fish stocks. They also reduce water quality; disturb the supply needed for households, agriculture and industry, and present a human health risk by increasing stagnation and harbouring mosquitoes.

4.8 IMPACTS ON AGRICULTURE

Invasive species are a major cause of crop loss and can adversely affect food security. Invasive species present significant threats to global agriculture, although how the magnitude and distribution of the threats vary between countries and regions remains unclear. In agriculture, invasive species is a very broad term that typically applies to any non-indigenous pests, weeds, plants, insects, fungi, bacteria, viruses, and other disease-causing agents that can interrupt the production of livestock, crops, ornamentals, and rangeland. The term applies to pests that have entered and have moved to new locations or have the potential to enter. Damaging invasive species are not just an agricultural problem; they also affect industry, human health, and ecosystems. But not all invasive species are harmful, and some have been deliberately introduced for economic gain. For instance, the vast majority of crops grown

by U.S. farmers today (e.g., rice, corn, wheat, and soybeans) are not indigenous to the U.S., yet they define U.S. agriculture and they have had a large positive economic impact on the nation. In the agricultural context, the impacts from and costs of invasive species can be divided broadly into six categories: crop losses, rangeland value decline, water resource depletion, livestock disease, genetic contamination, and management and eradication costs.

4.8.1 Affecting Agricultural Production

Invasive alien species adversely impact agricultural production. The vast majority of these insect, weed and pathogen invaders have been introduced inadvertently, arriving via commerce in association with produce and grain shipments, living plants and soil, cut flowers, wood products and dry ballast. Invasive diseases and insects attack crops while invasive plants smother them and can significantly reduce the size and viability of arable land. These invasive plants can make field preparation and ploughing difficult, limit the availability of water for crop irrigation, and stop plants from establishing and growing. In regions where cattle herds represent the primary source of family wealth, plants can invade pasture lands, preventing grazing and poisoning livestock.

The costs associated with controlling the encroachment of pests and weeds, for example by chemical spraying or employing labour to clear invaded land, can be huge. Weeding is done by family members on many farms, taking up time they could be spending on other livelihood activities. Some farmers and ranch-owners are forced to abandon their land as it becomes non-viable, resulting in loss of employment for local workers.

4.8.2 Affecting Livestock

Livestock production is affected when invasive weeds colonise prime grazing land. Farmers are driven into marginal areas, use pasture beyond its capacity, or have to take their herds long distances to find fodder. This can lead to conflicts between communities, due to competition for access to resources and fear of the plant spreading.

4.8.3 Affecting Soil Dynamics

Plant invaders have been found to change soil microbial communities and biogeochemical cycling in ways that can feedback to benefit themselves. Nutrient cycling can be altered by invasive plants that fix nitrogen, leach chemicals that inhibit nitrogen fixation by other species, release compounds that alter nutrient availability, including nitrogen and phosphorus, and alter topsoil erosion Some invasive plants can alter the indigenous soil environment by changing soil nutrient pools, for example increasing soil nitrogen (N) availability to plants through N fixation.

Check Your Progress 2

Note: a) Write your answer in about 50 words.
b) Check your answers given at the end of this unit.

1) What are the impacts of IAS on biodiversity and ecosystem services?

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2) How IAS impact agriculture production?

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4.9 REDUCING THE IMPACT OF INVASIVE ALIEN SPECIES: IAS A GLOBAL CONCERN

Because IAS are a global problem, cooperation at international, regional and local levels is required to develop compatible approaches. A number of international conventions, agreements and treaties already deal with IAS issues. For example, the Convention on Biological Diversity - CBD (1992) establishes that Parties should introduce measures to control and eradicate existing harmful alien species, as well as preventing further introductions. In 2002, the CBD adopted specific 'Guiding Principles' (more p.5) to help Parties to prioritize the development of their IAS strategies. The Bern Convention (1979) also requires strict control of the introduction of non-native species. In line with the 'Guiding Principles' adopted by the CBD, prevention, early detection and rapid response are the best means of tackling invasive species. Applying these principles requires increased understanding of the pattern of establishment and spread of invasive alien species. Some habitats are naturally more vulnerable to invasion than others. Plant invasions are most common in nutrient-rich habitats such as coastal and riverine habitats, as well as in man-made environments such as farmland and urban landscapes. By contrast, invasion levels are low in harsh climatic environments and nutrient-poor habitats, including mountains, cliffs, bogs, dry grasslands and coniferous woodlands.

There are four major options (or better, steps) for dealing with alien species:

i) Prevention of introductions

It is the first and most cost-effective option. This lesson has been learned the hard way from several cases of highly destructive and costly invasive organisms such as the zebra mussel in the Great Lakes. Had such species been intercepted at the outset, an enormous loss of native species and/or money could have been prevented. Exclusion methods based on pathways rather than on individual species provide the most efficient way to concentrate efforts at sites where pests are most likely to enter national boundaries and to intercept several potential invaders linked to a single pathway.

ii) Early detection

Early detection of a potential invasive species is often crucial in determining whether eradication of the species is feasible. The possibility of early eradication or at least of effectively containing a new coloniser makes investment in early detection worthwhile. Early detection in the form of surveys may focus on a species of concern or on a specific site. Species-specific surveys are designed, adapted or developed for a specific situation, taking into consideration the ecology of the target species. Site-specific surveys are targeted to detect invaders in the vicinity of high-risk entry points or in high value biodiversity areas.

iii) Eradication

When prevention has failed, eradication is the preferred course of action. Eradication can be a successful and cost-effective solution in response to an early detection of a non-indigenous species. However, a careful analysis of the costs and likelihood of success must be made, and adequate resources mobilised, before eradication is attempted. Successful eradication programmes in the past have been based on:

- mechanical control, e.g. hand-pulling of weeds or handpicking of snails,
- chemical control, e.g. using toxic baits against vertebrates,)
- habitat management, (e.g. grazing and prescribed burning)
- hunting of invasive vertebrates.

iv) Control

The last step in the sequence of management options is the control of an invasive species when eradication is not feasible. The aim of control is to reduce the density and abundance of an invasive organism to keep it below an acceptable threshold. There are numerous specific methods for controlling invasive species. Many of the control methods can be used in eradication programmes, too. Mechanical control is highly specific to the target, but always very labour-intensive. In countries where human labour is costly, the use of physical methods is limited mainly to volunteer groups. Chemical control is often very effective as a short-term solution. The major drawbacks are the high costs, the non-target effects, and the possibility of the pest species evolving resistance. In comparison with other methods, classical biological control, when it is successful, is highly cost-effective, permanent, self-sustaining and ecologically safe because of the high specificity of the agents used. Biological control is particularly appropriate for use in nature reserves and other conservation areas because of its environmentally friendly nature and the increasing instances of prohibition of pesticide use in these areas. Integrated pest management, combining several methods, will often provide the most effective and acceptable control.

4.10 KEY INTERNATIONAL INSTRUMENTS RELEVANT TO IAS

UN Convention on Biological Diversity: The UN Convention on Biological Diversity (CBD) recognizes the importance of IAS and their impacts on biodiversity as a critical global issue. In Article 8(h), it calls on contracting parties to "prevent the introduction of, control or eradicate those alien species which threaten ecosystems, habitats and species." Recent conferences of the parties to the CBD, as well as meetings of its subsidiary body, have focused on how to help parties to the convention to implement Article 8(h).

In addition, voluntary guiding principles have been developed by the CBD that outline recommended approaches to prevention, eradication, and control of IAS and other issues, including international cooperation. The CBD also has recognized IAS as a cross-cutting issue. Of special relevance to plant

protection is the CBD Global Strategy for Plant Conservation adopted in 2002 (Decision VI/9) (CBD 2002). One of the targets (target 10) in this strategy is for "management plans [to be] in place for at least 100 major alien species that threaten plants, plant communities and associated habitats and ecosystems." International Plant Protection Convention. The purpose of the International Plant Protection Convention (IPPC) is to secure common and effective action to pre- vent the spread and introduction of pests of plants and plant products and to promote appropriate measures for their control. The IPPC mandate has always included the protection of native plants

4.10.1 International Programs

i) Global Invasive Species Program.

In 1997, The Scientific Committee on Problems of the Environment, along with partners from the UN Environment Program, World Conservation Union (The World Conservation Union [IUCN]), and CAB International launched the Global Invasive Species Program (GISP),9 a joint international program on invasive species. The GISP completed its first phase of activity in 2000

i) IUCN

IUCN" was founded in 1948 and brought together states, government agencies, and a diverse range of nongovernmental organizations in a unique international partnership. IUCN has been involved with the issue of IAS for over a decade and is one of three founding partners of GISP.

ii) International Plant Protection Convention

The purpose of the International Plant Protection Convention (IPPC) is to secure common and effective action to pre- vent the spread and introduction of pests of plants and plant products and to promote appropriate measures for their control. The IPPC mandate has always included the protection of native plants but in practice, the convention often has been implemented more narrowly to guard against human and economic diseases and pests. However, since 1999, the IPPC has clarified its role regarding IAS that are plant pests. This includes a revision to clarify how environmental impacts are included under the term "economic harm".

4.11 LETS SUM UP

The threat by invasive alien plant species has been increasing with rapid growth of globalization. These species are contributing in reduction of agriculture, livestock and forest productivity, altering soil quality and promoting land degradation and affecting essential ecosystem functions by altering species composition, fire regimes, food web, nutrient cycling and hydrology. They are posing enormous threat to the native species diversity leading to even extinction of rare and endangered species. The overall impact is huge economic and ecological loss. The management and control of IAS present some important challenges for decision-makers. Globally, preventing their introduction is seen as the cornerstone of effective measures for dealing with IAS. This approach is believed to be the most cost-effective and environmentally-sound approach as once an invasive species becomes established, eradication may be impossible and ecological damage.

4.12 KEY WORDS

Alien Species : A species, subspecies, or lower taxon introduced outside its normal past or present distribution; includes any part, gametes, seeds, eggs, or propagules of such species that might survive and subsequently reproduce.

Native Species : A species, subspecies, or lower taxon living within its natural range (past or present), including the area which it can reach and occupy using its own legs, wings, wind/ waterborne or other dispersal systems, even if it is seldom found there.

Biological Diversity : The variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems

Vector : Any living or non-living carrier that transports living organisms intentionally or unintentionally.

Weeds : Plants that grow in sites where they are not wanted and have detectable negative economic or environmental effects.

4.13 REFERENCES AND SUGGESTED FURTHER READINGS

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4.14 ANSWERS TO CHECK YOUR PROGRESS

Answer to Check Your Progress 1

1) Your answer should include following points:

- Species living outside its native distributional range,
- Has arrived there by human activity, either deliberately or accidentally
- Intentional introductions are for a variety of purposes such as agriculture, horticulture, forestry and ornamental.

2. Your answer should include following points:

Common traits of IAS are:

- Fast growth
- Rapid reproduction
- High dispersal ability
- Lack of natural predators
- Ability to survive in a wide range of environmental conditions
- Ability to consume a variety of food resources
- Ability to adapt to changing environmental conditions
- Ability to displace native species by utilizing limited resources more efficiently

Answer to Check Your Progress 2

1. Your answer should include following points:

- IAS impact the habitats they invade by reducing the abundance of native species and altering ecosystem processes.
- They impact native species through predation, competition for food and space, hybridization, as well as the introduction of harmful pathogens and parasites.
- AIS may also alter normal functioning of the ecosystem by altering fire regimes, hydrology, nutrient cycling and productivity.
- Invasive species may out-compete native species, repressing or excluding them and, therefore, fundamentally change the ecosystem

2. Your answer should include following points:

Invasive diseases and insects attack crops while invasive plants smother them and can significantly reduce the size and viability of arable land. These invasive plants can make field preparation and ploughing difficult, limit the availability of water for crop irrigation, and stop plants from establishing and growing. In regions where cattle herds represent the primary source of family wealth, plants can invade pasture lands, preventing.