Course- M.Sc. Botany Part -II Paper- XII
Topic- Pollution - Air & Water Pollution
(Environmental Biology)
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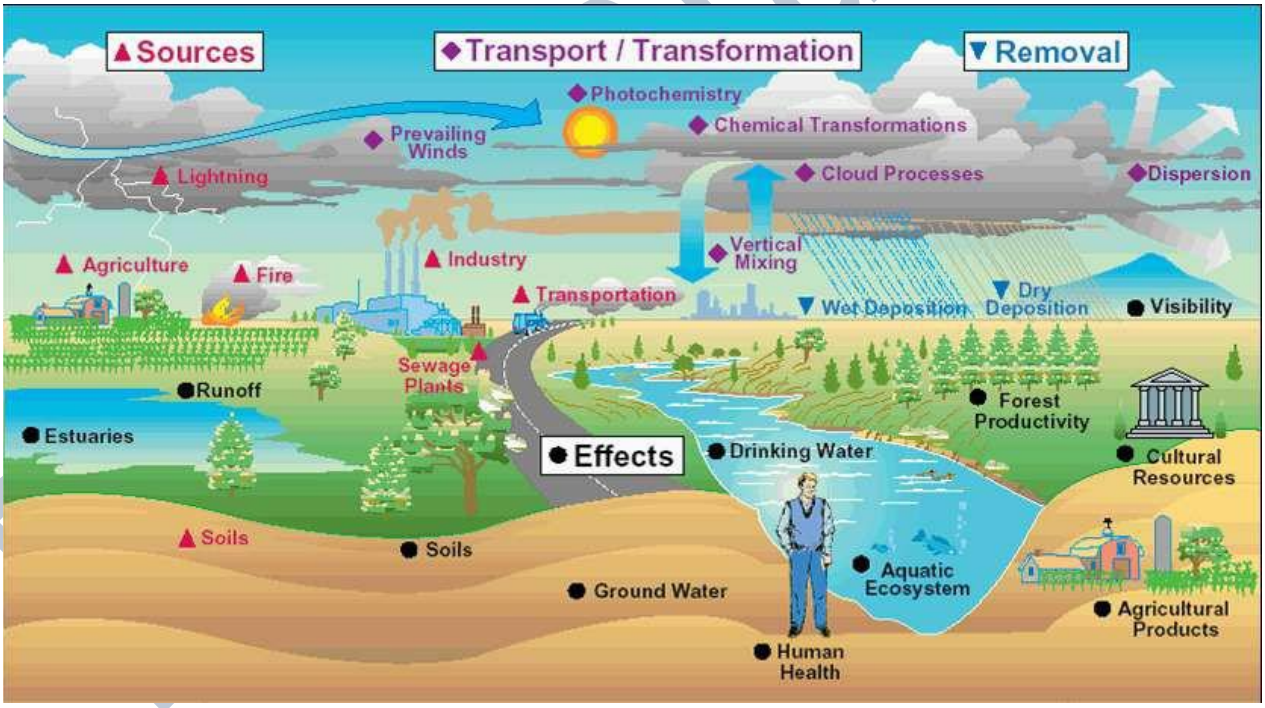
Definition:-

The term Pollution comes from the Latin 'polluere' which means to contaminate. So, pollution is something that contaminates the environment.
When harmful substances contaminate the Environment it is called Pollution.
Pollution refers to the very bad condition of environment in terms of quantity and quality .

Pollution means the presence of substances in the air, water, and land, which has an adverse effects (harmful or poisonous) on living organisms (human-beings, animals, plants, etc.) and on environment OR
"An unwanted change in the environment which involves the physical, biological and chemical changes involving air, water and land which affects the human life in one way or the other".
Pollution has become a serious issue after World War II in developing countries due to unchecked rapid industrialization. Pollution is the root cause of many diseases that kill and disable living organisms.



A Broader View of Pollution

There are Five Major Types of Pollution:-

1. Air Pollution
2. Water Pollution
3. Land Pollution
4. Noise Pollution
5. Radio Active Pollution

1. AIR POLLUTION

Introduction:

Air pollution is a major problem of recent decades, which has a serious toxicological impact on human health and the environment. The sources of pollution vary from small unit of cigarettes and natural sources such as volcanic activities to large volume of emission from motor engines of automobiles and industrial activities. Long-term effects of air pollution on the onset of diseases such as respiratory infections and inflammations, cardiovascular dysfunctions, and cancer is widely accepted; hence, air pollution is linked with millions of death globally each year. A recent study has revealed the association between male infertility and air pollution.

Air pollution has now emerged in developing countries as a result of industrial activities and also increase the quantity of emission sources such as inappropriate vehicles. About 4.3 million people die from household air pollution and 3.7 million from ambient air pollution, most of whom (3.3 and 2.6 million, respectively) live in Asia.

Definition:

Air pollution is contamination of the indoor or outdoor environment by any chemical, physical or biological agent that modifies the natural characteristics of the atmosphere.

Air pollution refers to the release of pollutants into the air that are harmful to human health and the planet as a whole.

The atmosphere is a dynamic system, which steadily absorbs various pollutants from natural and anthropogenic sources.

It is very difficult to get clean air today. Clean air is defined as air flowing in areas sufficiently distant from places of human activities and other abnormal influences.

The World Health Organisation (WHO) defined air pollution as limited to situations in which the outer ambient atmosphere contains materials in concentrations which are harmful to man and his environment.

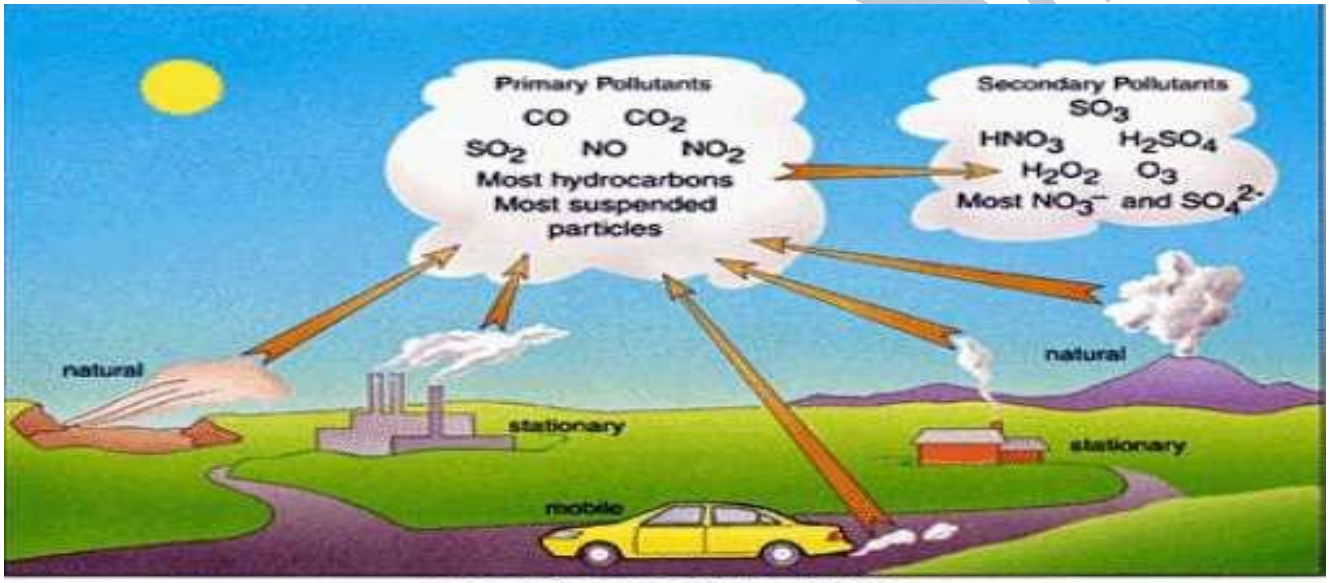
According to U.S. Public Health Service, air pollution may be defined as the presence of contaminants, such as fumes, dust, mist, grease, smoke or vapour in air which may be injurious to living biota.

Major Causes & Sources of Air Pollution:

Air pollutants are substances causing damage to target or receptor. The target may be man, animal, plant, tree, building or material which is affected by pollutants. The air pollutants may be grouped according to the type of source, number and spatial distribution of sources and type of emissions.

A. Natural Sources:

The natural sources of air pollution are volcanic eruptions and gases, forest fires, marsh gases, deflation of sands and dust, pollen grains of flowers, soil debris, cosmic dust, natural, organic, inorganic or vegetative decay, extra terrestrial bodies, smoke, terpenes from forests and comets etc. Green plants through evapotranspiration release huge amount of CO2. Micro-organisms such as algae, fungi, bacteria, yeast, moulds, spores are transported by wind to distant places causing air pollution.



Types and sources of air pollutants

B. Anthropogenic or Man-made Sources:

1. Increase in Population:

The rapid increase in population is one of the most important factors of air pollution. World population had touched 6.3 billion in the year 2010 and it will grow to 22.5 billion by 2100. An increase in population leads to global warming, loss in forest cover and wild life species.

2. Deforestation:

Indiscriminate cutting of plants, trees and forests has disturbed the balance of CO2 and O2 in nature. Forests are also removed to meet the growing demand of population. The world produced 399 million tonnes of paper in 2009 and is losing 23 million hectare of forest cover each year. Developed countries use more than 71% of the world's paper production.

3. Burning of Fossil Fuels:

About 97% of the energy is generated by fossil fuels like coal, oil and natural gas. The major fuel burning sources are automobiles, thermal power plants, heating plants and industrial processes. Burning of fossil fuels produces about 2/3 of SO2 present in air. It is the fourth largest source of air pollution.

4. Rapid Industrialisation:

Next to combustion systems, the major sources of air pollutants are chemical and metallurgical industries.

5. Metallic Contaminants:

Industrial activities discharge toxic metals which are indestructible poisons to living biota. According to International Register of Potentially Toxic Chemicals of United Nations Environment Programme, there exist six million known chemicals in the world today and 30,000 new compounds are added to the list every year. About 70,000 compounds are commonly employed.

6. Agricultural Activities:

Several types of biocides such as pesticides, insecticides, herbicides etc. are used in agricultural practices which have caused soil erosion, ground water pollution and spread of pests resistant to pesticides in air. In global terms India, today has 16% of human population, 15% of farm animal population, 2% of the geographical area, 1% of rainfall, 0.5% of forests and 0.5% of grazing land. A number of biocides such as DDT, BHC, aldrin, chlordane, endosulphan etc. are not easily biodegradable. These are absorbed by plants and create adverse effects on biotic components.

7. Greenhouse Gases:

By trapping the earth's heat in the atmosphere, greenhouse gases lead to warmer temperatures and all the hallmarks of climate change: rising sea levels, more extreme weather, heat-related deaths, and increasing transmission of infectious diseases like Lyme. According to a 2014 EPA study, carbon dioxide was responsible for 81 percent of the country's total greenhouse gas emissions, and methane made up 11 percent. "Carbon dioxide comes from combusting fossil fuels, and methane comes from natural and industrial sources, including the large amounts that are released during oil and gas drilling," Walke says. "We emit far larger amounts of carbon dioxide, but methane is significantly more potent, so it's also very destructive." Another class of greenhouse gases, hydrofluorocarbons (HFCs), are thousands of times more powerful than carbon dioxide in their ability to trap heat. In October 2016, more than 140 countries reached an agreement to reduce the use of these chemicals—which are used in air conditioners and refrigerators—and find greener alternatives over time. David Doniger, senior strategic director of NRDC's Climate and Clean Energy program, writes, "NRDC estimates that the agreed HFC phase-down will avoid the equivalent of more than 80 billion tons of CO2 over the next 35 years."

Control Measures of Air Pollution:

Reduction of Air Pollution at Source:

The most effective method of controlling air pollution is to prevent the formation of the pollutants or minimize their emission at the source itself. In case of industrial pollutants, this can be achieved by undertaking various approaches at an early stage of process, design and development and selecting those methods which have minimum air pollution potential.

These are known as source correction methods. Control of pollutants at the source can be accomplished in various ways through raw material change, operational changes, modification of process equipment and by more effective operation of existing process.

Control of Gaseous Pollutants:

1. NO2 emissions from stationary sources can be reduced by (i) Minimising the residence time at peak temperatures, (ii) Minimising the availability of O2 for reaction with N2. NO2 effluent treatment methods involve scrubbing with slurry or magnesium hydroxide, adsorption, catalytic decomposition and catalytic reduction.

2. SO2 pollution can be controlled by removing SO2 from fuel gases, using low sulphur fuels or scrubbing processes and desulphurization of flue gases.

3. CO emissions from stationary combustion sources can be reduced by proper design, installation, operation and maintenance of combustion equipment.

4. Hydrocarbon emissions can be controlled by using incineration, adsorption, absorption and condensation techniques.

Control of Particulate Emission:

To control particulate emissions, the gravitational settling chambers and cyclone separators do not generally achieve high efficiency for removing small size particles. For most practical application, only fabric filters, electrostatic precipitators and high energy scrubbers are capable of meeting the rigorous air pollution control regulations.

Electrostatic Precipitators for the Control of Particulate Emission:

The electrostatic precipitator is used for controlling particulate emissions at industrial installations ranging from power plants, cement and paper mills to oil refineries. Electrostatic precipitation is a physical process by which particles suspended in gas stream are charged electrically and under the influence of electrical field, are separated from the gas stream.

The precipitation system consists of a positively charged (grounded) collecting surface and a high-voltage discharge electrode wire suspended from an insulator at the top and held in position by a weight at the bottom.

At a very high DC voltage, of the order of 50 kV a corona discharge occurs close to the negative electrode, setting up an electric field between the emitter and the grounded surface. The particle-laden gas enters near the bottom and flows upward. The gas close to the negative electrode is, thus, ionized upon passing through the corona (Fig. 1).

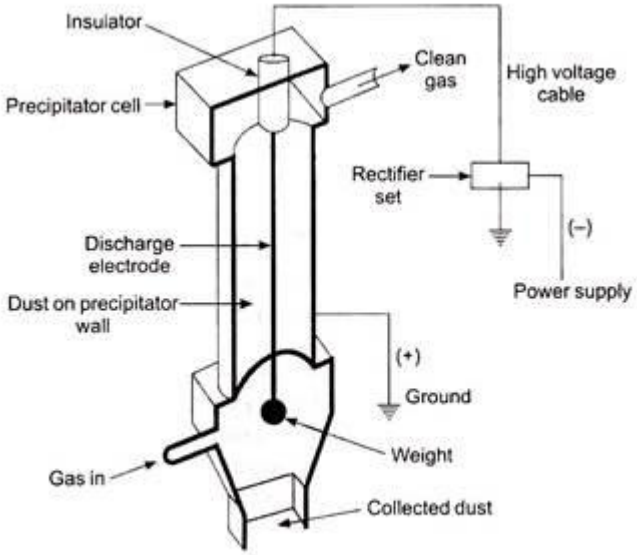


Fig. 1. Schematic diagram of a wire and pipe precipitator.

As the negative ions and electrons migrate towards the grounded surface, they, in turn, charge the passing particles. The electrostatic field then draws the particles to the collector surface where they are deposited. Periodically, the collected particles must be removed from the collecting surface. This is done by rapping or vibrating the collector to dislodge the particles. The dislodged particles drop below the electrical treatment zone and are collected for ultimate disposal.

Effect of Air pollution on Human Health:

Air pollution is considered as the major environmental risk factor in the incidence and progression of some diseases such as asthma, lung cancer, ventricular hypertrophy, Alzheimer's and Parkinson's diseases, psychological complications, autism, retinopathy, fetal growth, and low birth weight. Long and short term exposure to air suspended toxicants has a different toxicological impact on human including respiratory and cardiovascular diseases, neuropsychiatric complications, the eyes irritation, skin diseases, and long-term chronic diseases such as cancer. Several reports have revealed the direct association between exposure to the poor air quality and increasing rate of morbidity and mortality mostly due to cardiovascular and respiratory diseases.

How to Protect Your Health

- "When you see in the newspaper or hear on the weather report that pollution levels are high, it may be useful to limit the time when children go outside or you go for a jog," Walke says. Generally, ozone levels tend to be lower in the morning.

- When you do exercise outside, stay as far as you can from heavily trafficked roads. Then shower and wash your clothes to remove fine particles.

- If the air quality is bad, stay inside with windows closed.

- Wear sunscreen. When ultraviolet radiation comes through the weakened ozone layer, it can cause skin damage and skin cancer.

2. WATER POLLUTION

Introduction

The Contamination of water with undesirable substances which make it unfit for usage is termed water Pollution.

Water is one of the most important commodities required for the survival of any form of life. Today water resources have been the most exploited natural system since man strode the earth. Pollution of water bodies is increasing tremendously due to population explosion, industrial proliferation, urbanisation, increasing living standards and wide spheres of human activities.

Time is, perhaps not too far when pure and clean water, particularly in densely populated and industrialised water scarce areas may be inadequate for maintaining the normal living standards.

Ground water, rivers, seas, lakes, ponds, streams are finding it more and more difficult to escape from pollution. In India, the major 14 rivers receive heavy flux of sewage, industrial effluents, domestic and agricultural wastes. Most of the large rivers of the world are nothing but open sewers fit only to carry urban wastes, poisonous pesticides and industrial toxic effluents etc.

Many of our lakes, including Dal and Nagin of Kashmir have severely polluted with foul odour, silt deposits and get chocked due to excessive algal growths. Now pollution of water bodies has become universal phenomenon in the present day world.

Signs of Water Pollution:

These are bad taste of drinking water, offensive odour from water bodies, unchecked growth of aquatic weeds in water, decrease in number of fish in fresh water, oil and grease floating on water surface. These factors disturb the normal uses of water for public water supply, aquatic organisms, agriculture and industry.

Definitions of Water Pollution:

Water gets polluted when its normal functions and properties are altered. Water pollution actually represents the state of deviation from the quality and purity of water sample.

1. Water pollution shows the addition of foreign substances, either from natural or anthropogenic sources, may be harmful to life because of their toxicity, reduction of normal oxygen level of water, aesthetically unsuitable and spread epidemic diseases.
2. It is the natural or induced change in the quality of water which renders it unsuitable and toxic as regards food, man and animal health, industry, agriculture, fishing or leisure pursuits.
3. Water pollution is the by product of rapid and unplanned industrial progress an over population.
4. Any shift in the naturally dynamic equilibrium existing among environmental segments, i.e., hydrosphere, lithosphere, atmosphere or sediments give rise to the state of water pollution.

Water pollution may be in ground water, surface water, lake water, river or ocean water.

Causes of Water Pollution:-

Water Pollution is Caused by organic and inorganic industrial wastes and affluents discharged into rivers.

Sources of Water Pollution:

Today clean water has become a precious natural resource but its quality is threatened by numerous sources of pollutants which are as follows:

1. Inorganic Pollutants:

This category of water pollutants consists of acids, alkalies, soluble and insoluble salts, metallic complexes, trace elements, organometallic compounds, polyphosphatic detergents from chemical industries, metallurgical processes, coal mines and numerous natural processes causing pollution in water.

2. Toxic Metals:

Toxic metals are added to water from industrial activities, domestic sewage discharges, land run off and fossil fuel burning. Traces of heavy metals such as Hg, Cd, Pb, As, Co, Mn and Cr have been identified deleterious to aquatic ecosystem and human health. In fish mercury is present as $(CH_3)_2Hg$ which is known to concentrate in food chain. Manganese also enters the water system through industrial effluents and dry cell batteries. Selenium content of most drinking water is found as 10 ppb.

3. Organic Pollutants:

Organic pollutants enter into water system through domestic sewage, industrial wastes from paper mills and tanneries, waste from slaughter houses, meat packing plants, plant
nutrients, detergents, biocides etc. The addition of carbohydrates, fatty acids, proteins, aldehydes, polychlorinated biphenyls (PCBs), phenolic compounds and polycyclic aromatic hydrocarbons deteriorate water quality.

4. Sewage and Domestic Wastes:

Sewage is a cloudy dilute aqueous solution containing mineral and organic matter. About 75% of water pollution is caused by sewage, domestic wastes, food processing plants, garden wastes and sewage sludge from cess pools etc. Sewage contains decomposable organic matter and exerts oxygen demand on the receiving waters. Domestic sewage contains trace quantities of toxic metals also. Sewage treatment deposits sludge at the bottom while liquid waste consists of ions such as Ca^{2+}, Mg^{2+}, Na^+, K^+, $CI^–$, $NO_2^–$, SO_4^{2-}, PO_4^{3-}, $HCO_3^–$ etc.

5. Sediments:

The natural process of soil erosion gives rise to sediments in water. Sediments include soil, sand and mineral particles washed into aquatic environment by flood waters. In addition, large deposits of sewage sludge, pulverized coal ash and various industrial solids are disposed off into water.

6. Synthetic Detergents:

Detergents include ingradients like surfactants, builders, additives, stabilizers and soil suspending carboxymethyl cellulose etc. The surfactant is a surface active agent. Alkyl Benzene Sulphonates (ABS) are considered as surfactants. ABS showed remarkable resistance to biodegradation (hard detergents) and has been subsequently replaced by Linear Alkyl Sulphonate (LAS).

LAS undergo rapid biodegradation. Builder is usually a sodium polyphosphate of the type Na5P3O10 or Na4P2O7 acting as a sequestering agent. Both surfactants and builders cause serious pollution in water. Additives consist of anticorrosive sodium silicate, enzymes, perfumes and bleaching agents. Phosphates released into streams act as plant nutrient, thus supporting eutrophic conditions. Currently, celluzyme obtained from hermicola insolents, is added in detergents. The high percentage of sodium tripolyphosphate (STPP) in detergents may be partly replaced by enzymes.

7. Oxygen Demanding Wastes Causing Pollution:

Decrease in dissolved oxygen (DO) level is an indication of pollution due to organic matter, e.g., sewage, industrial wastes from food processing plants, run off from agricultural lands etc. All these materials undergo degradation by microbial activities in presence of DO. It causes deoxygenation process and quick depletion of DO.

Biological Oxygen Demand (BOD):

The degree of microbially mediated oxygen consumption in water is known as BOD. It is a measure of oxygen utilized by micro-organisms during the oxidation of organic material in a five day period. The demand for O2 is directly proportional to the amount of organic waste which has to be broken down. Hence BOD is a direct measure of biodegradable organic matter. Drinking water has a BOD of less than 1 mg/L. When BOD level reaches 5 mg/L, the water is said to be polluted.

8. Plant Nutrients as Pollutant:

Plant nutrients constitute an important limiting factor for plant growth. Nitrogen and phosphorus are the main nutrient species which enter fresh and marine systems changing oligotrophic water to intensely productive eutrophic conditions. According to Wetzel each phosphorus molecule promotes the incorporation of 7 molecules of nitrogen and 40 molecules of carbon in aquatic algae. These nutrients ultimately tend to accumulate in ground water.

Eutrophication:

Eutrophication is a natural process, derived from the Greek word eutrophos meaning well nourished or enriched. This enrichment leads to other slow processes referred to as natural aging of lakes. It is a phenomenon through which a nutrient rich bog in a shallow depression changes to leached bog deficient in nutrients.

Sources of Nutrients:

Eutrophication escalates rapidly, however when abnormally high amounts of nutrients from fertilizers, domestic and industrial wastes, urban drainage, detergents, animal wastes and sediments enter water streams.

9. Thermal Pollutants in Water:

Thermal pollution of water may be defined as the warming up of an aquatic ecosystem to the point where desirable organisms are adversely affected. Chemical industries, electric power plants, atomic energy plants discharge their heated effluents into nearby lakes or rivers.

A coal-fired power plant at 40% efficiency generates 16.7 joule of waste heat for every 41.8 joules of fuel burnt. A single 100 MW power plant may use one half million gallons of cooling water per minute. This process raises the temperature of water by 10°C to 15°C. The heated waters have reduced amount of dissolved oxygen content which results into killing of marine life.

10. Pesticide and Fertilizer Pollutants in Water:

Pesticides like insecticides, fungicides, herbicides, rodenticides and molluscicides enter in water through rain water, spray drift, run off from agricultural fields, domestic sewage, accidental spillage and industrial effluents etc. The annual world production of pesticides (organochlorines, organophosphates, carbamates, chlorophenoxy acids) grew from 6000 million pounds to 24000 million pound. Pesticides hit the aquatic ecosystem and terrestrial organisms ranging from acute toxicity to invisible chronic effects in man, animals and plants.

<u>Control Measures of Water Pollution:</u>

We are now near the stage when water pollution has become a global problem partly because of population explosion and partly due to phenomenal advance in industrialization. In India, 70% of the pollutant load of rivers, lakes and streams is from domestic waste. So obviously it is of no use to apply strict laws only to industries, if municipalities are given free reign to discharge their domestic wastes into water without any treatment.

For Minimiing Water Pollution:

Following methods can be adopted:

1. Stabilisation of the Ecosystem:

The principles involved in this technique include reduction of the waste at source, harvesting and removal of biomass, trapping of the nutrients, fish management and aeration.

2. Using Water Hyacinth to Remove Water Pollutants:

Water hyacinth is extremely efficient in absorbing and concentrating dissolved nutrients from water in which it lives. Introduction of this weed in the lagoon enhances even 1000 times purifying capacity of water.

Experimental studies have shown that in a lagoon of 0.5 hectare having dense growth of hyacinth, with sewage retention time of 15 days, the daily wastes of 1000 people can be effectively treated. Water hyacinth is capable to absorb phenolic compounds commonly found in domestic and industrial sewage. The phenols so absorbed are broken down and can be utilized rapidly.

3. Chemical Methods:

Generally, chemical precipitation, solvent extraction, electro-deposition, ion-exchange, ultra-filtration, and activated carbon adsorption systems are applied to remove heavy metals. All these methods are extremely expensive.

4. Cooling Methods:

In some developed countries, thermal pollution abatement schemes are used to control water pollution. These methods include once-through cooling, cooling ponds, wet cooling towers, evaporative towers and dry cooling towers.

5. Solar Power:

Solar energy is used for purifying the polluted waste water at low cost. Experiments concluded that a combination of sunlight and a catalyst such as titanium dioxide can dissociate chemical toxicants.

6. Removal of Phosphorus by Electrolysis:

In Norway, organic sewage is mixed with 10% of sea water and subjected to electrolysis to remove phosphorus from sewage water. Phosphorus compounds in sewage get precipitated as Ca or Mg phosphate.

During electrolysis, these salts along with sludge and suspended particles adhere to magnesium hydroxide at the negative pole. H_2 gas liberated during electrolysis makes the phosphate and sludge to float on the surface as scum which can be scrapped off from the top layer. Chlorine gas produced at the positive pole can be used for disinfection of the outlet.

7. Removal of Salts by Reverse Osmosis to Purify Water:

Various salts can be removed by reverse osmosis by forcing the waste water through a semipermeable membrane under a pressure exceeding the osmotic pressure. During the process, flow occurs in the reverse direction. The solvent is attracted while the solute is repelled. The method is mostly applied to salinate the brackish water and to purify water from sewage.

8. Removal of Chlorophenols:

Chlorophenols, used as wood preservatives, pollute surface and ground water. Scientists at Tampere University of Technology, Finland used sand, vulcanite mineral, silica based material, called celite R-633 and pumice to clean up

chlorophenol contaminated ground water. The method can remove 99.9% of chlorophenol from ground water at 5°C temperature.

9. Recycling, Renovation, Recharge and Reuse (4R Concept) of Waste Water:

In developed countries the waste water consisting of domestic sewage, industrial effluents, thermal and radioactive pollutants, sullage of municipal waste receives some sort of treatment before it gets mixed into water bodies. For example, urban sewage, sullage etc. may be recycled and reused to generate cheaper fuel, gas and electricity.

NEERI, Nagpur has developed technology for reuse of waste water to provide cheap piped gas and generate electricity by recycling waste water. Recently, one distillery in Gujarat is effective in treating 450,000 litre of water daily and generating energy equivalent to that produced by 10 tonne of coal.

Purification of Water for Municipal Purposes:

The processes used in the purification of water are as follows:

1. Aeration:

The raw water is first aerated by bubbling compressed air. This removes bad odours and CO2 while Fe and Mn salts get precipitated as their hydroxides.

2. Sedimentation:

The water is then allowed to stand in large settling tanks. Some of the heavier impurities present in water agglomerate and settle down by gravity.

3. Coagulation:

The suspended impurities are removed by coagulation using alum, FeCl3, lime or soda ash. The coagulant sodium aluminate removes HCO–3, Cl–,
SO2-4 responsible for temporary and permanent hardness of water. By coagulation, turbidity is reduced to 20 ppm and bacterial load by 5%, thereby bringing about partial clarification of water.

4. Flocculation:

The process of coagulation can be intensified by adding flocculants such as polyacrylamide, starch and activated silica.

5. Filtration:

The partially clarified water is then filtered through sand gravity filter.

6. Disinfection:

The elimination of offensive odour caused by dissolved organic substances in water is done by ozonization, chlorination, aeration, coagulation and ultra violet light treatment.

7. Ozonization:

The water is treated with ozonised oxygen. Ozone sterilizes, bleaches, decolourises and deodourises water. Highly palatable water is sterilised with ozone but the cost involved is very high.

8. Chlorination:

Chlorination is the best and the cheapest method of sterilization of water. For chlorination, chlorine may be used directly in the liquid form or hypochlorates of calcium and sodium, e.g., bleaching powder. It kills viruses and bacteria. The purified water is then supplied by municipalities through pipes for domestic purposes.


Effects of Water Pollution on Human Health:

Discharge of domestic and industrial effluent wastes, leakage from water tanks, marine dumping, radioactive waste and atmospheric deposition are major causes of water pollution. Heavy metals that disposed off and industrial waste can accumulate in lakes and river, proving harmful to humans and animals. Toxins in industrial waste are the major cause of immune suppression, reproductive failure and acute poisoning. Infectious diseases, like cholera, typhoid fever and other diseases gastroenteritis, diarrhea, vomiting, skin and kidney problem are spreading through polluted water. Human health is affected by the direct damage of plants and animal nutrition. Water pollutants are killing sea weeds, mollusks, marine birds, fishes, crustaceans and other sea organisms that serve as food for human. Insecticides like DDT concentration is increasing along the food chain. These insecticides are harmful for humans



Pollution is everywhere..…