5.0

WATER POLLUTION AND TREATMENT

5.0

WATER POLLUTION AND TREATMENT

5.1 What is water pollution ?

The word pollution is derived from the Latin word "**Pollutus**" meaning to soil or defile (foul or dirty). The Oxford Dictionary defines pollution as follows :

The act of polluting or condition of being polluted. uncleanness or impurity caused by contamination. The word pollution implies undesirable quality. From scientific stand point pollution of water can be defined as **"anything causing or introducing objectionable condition in any water course and affecting adversely any use or uses to which the water there of may be put"**. Thus pollution of water is **"the presence of materials in water that interfere unreasonably with one or more beneficial uses of it"**. Pollution involves the introduction of anything which adversely and unreasonably impairs the beneficial use of water eventhough actual health hazard is not involved. **"contamination"** is regarded as the impairment of water quality causing an actual hazard to public health. Pollution of water may also render it offensive to the senses of sight, taste or smell. Coulson and Forbes in their book **"The Law of water"** have given the definition of water pollution as "The addition of something to water which changes its natural qualities so that the ripairian proprietor does not get the natural water of the stream transmitted to him".

The term "Water Pollution" is referred to the addition to water of an excess of material (or heat) that is harmful to human, animals or desirable aquatic life or otherwise causes significant departure from the normal activities of various living communities in or near the bodies of water. The water gets polluted if it has been not of sufficiently high quality to be suitable for the highest uses people wish to make of it at present or in the future.

In reality, the term water pollution refers to any type of aquatic contamination between two extremes: (1) a highly enriched, over productive biotic community, such as a river or lake with nutrients from sewage or fertilizer (Eutrophication) or (2) a body of water poisoned by toxic chemicals which eliminate living organisms or even exclude all forms of life. Felfoldy (1972) precisely define water pollution as "Every impact which changes the quality of our surface and sub-soil waters to such a degree that its suitability either for human consumption or for the support of man's natural life processes will decrease or cease".

Water is considered to be a Universal Solvent, which dissolves anything at least to some extend. Water we get from nature in the form of precipitation is very clean almost as good as distilled water. But during its travel and stay on the earth, many impurities are added to it such as atmospheric gases, particulate matters, and air bacteria before it reaches the land.

During its travel over the surface of the earth it carries with it liquid and solid wastes from domestic, industrial and agricultural uses. Animal and plant debris also meet water and carried through. During it percolation down in the ground, through seepage, leaching and dissolution large number of impurities get their way into ground water.

Even in the most unpolluted geographical areas, rain water is having dissolved CO_2, O_2 and N_2 and may also carry in suspension dust or other particulates picked up from the atmosphere. Surface and well waters generally contain dissolved compounds of metals like Na,Mg,Ca and Fe. The term hard water is used to describe water that contains appreciable amount of such compounds. Even drinking water has been not pure in a chemical sense. Suspended solids have been removed and harmful bacteria destroyed, but many substances still remain in solution. Indeed, absolutely pure water would not be pleasant to drink, because it has been the impurities that impart the characteristic taste by which it is recognised.

In light of the above facts the term pure, when used in a water pollution context, will mean a state of water in which no substance is present insufficient concentration to prevent the water from being used for purposes thought of as normal. Any substance that disallows the normal use of water must be regarded as a water pollutant. Part of the complexity of the water pollution problem arises because the normal uses of water are so varied. Water, suited for some uses and therefore considered to be unpolluted, may have tobe regarded to be polluted when other uses get contemplated.

The most notorious incidence of water pollution in the world is **"Minamata disease"** in Japan. Methyl mercury discharged from a chemical factory into the sea, contaminated the fish eaten by local people at town Minamata. Due to this nearly two thousand people have suffered neurological disorder and about four hundred have died.

Most of the wastes of communities are drained into streams and rivers and ultimately into lakes or oceans. In many cases the waste is dumped into the same bodies of water from which drinking water is withdrawn. The effect of sewage, industrial waste and agricultural drainage of plant and animal life in closed bodies of water is sometimes catastrophic.

5.2 Classification of Water Pollutants

The water pollution could be classified as under :

- Surface water pollution
- Ground water pollution
- Marine water pollution

Impurities in water can be of two types viz. suspended and dissolved. Suspended pollution can further be classified into settleable, floating and colloidal.

The pollutants could further be classified according to their nature as under.

5.2.1 Suspended matter

A common example of suspended matter has been mineral trailings. If the suspended matter has been organic, it would decompose using the dissolved oxygen and would produce noxious gases and odours.

5.2.1.1 Floating materials

Typical floating materials would be oils and greases. they have been making the water unsightly retard equatic plant growth by blocking the sunlight and interfering with the natural reaeration. Destroy the natural vegetation along the banks, are often toxic to fish and other aquatic life. They can also be fire hazards.

5.2.1.2 Colloidal matter

They are finely devided materials. They will not settle easily and will create turbidity. In drinking waters colloidal matter comes in form of clay, ashes, gelatinous material and bacteria. Coagulants are required to remove colloidal material from water.

5.2.1.3 Settleable matter

They are heavy in nature and could settle easily. Typical examples are sand, gravels and stones. They can be removed by simple sedimentation without any coagulant aid.

5.2.2 Dissolved impurities

Typical dissolved substances would be acids, alkalies, heavy metals, and minerals. In general they have been making water undrinkable and destroy aquatic life. For example, Phenol, even in very low concentrations (0.01 mg/l) provide a very objectionable taste and odour. They also can build and concentrate their effects through the normal food chain. The impurities can also be classified as ;

Suspended

- Floating
  e.g.-wood chips, Rags, Charcoal, Leaves, Algae weeds.
- colloidal
  e.g. Ashes, Clay, Silt, Geletinous materials, Bacteria.
- Setteable
  e.g. Sand, Gravels, Stones

Dissolved

- Inorganic Salts
  e.g. Sodium, Calcium, Chloride, Bicarbonate

- Organic Salts

  e.g. Carbohydrates, Tennic Acid
- Gases

  e.g. Mithane, Hydrogen Sulfide, Oxygen

Immiscible Liquids

- Oil & Grease

Again according to nature of impurities, the water pollution can be categorised as shown in **Table - 5.1**

5.3 Source of water pollution

The sources of water pollution can be grouped in two categories as

- Point sources
- Non point sources

The point sources include domestic and industrial waste waters, storm water out falls and any other source with specific entry. The non point sources cannot be exactly pinpointed. They are general land run off and other diffuse contributions. Flow from point sources can be controlled and treated before discharge. Non point sources are difficult to manage. they cause silting and loading of nutrients.

Point and non-point sources of water pollution can be summarised as in **Table - 5.2.**

Prominent sources of water pollution are as under;

5.3.1 Natural sources

- Atmospheric Dissolved Minerals
- Aquatic growths
- Decay of vegetation
- Storm run off

These sources have no relationship with human activity. These sources include the impurities meeting the water course through natural processes. Rain water before it reaches the earth may pick up some impurities from atmosphere like particulate matters, dust and gases as well as other substances of volcanic action. Erosion of land imparts suspended solids where as percolating ground water may get dissolved minerals. Natural entrophication and decomposition of plants and organisms also add substances and chemicals. Urban storm run off can contribute large amount of suspended solids, oxygen demanding substances, bacteria, metals and many other chemicals.

5.3.2 Agricultural Sources :

- Increased erosion

- Animal wastes
- Fertilizers
- Pesticides
- Irrigation return flow

Where land management practices are poor or due to increased cultivation of land, suspended solid will increase in the water. Farm and poultry houses run off may contain animal wastes. Unused fertilizers or washed away pesticides in agricultural use will also find their way ultimately into water courses. The pesticides are non-biodegradable and are hazardous to health. Excess irrigation water flowing through drainage lines may also contain high amount of silt and agricultural chemicals.

5.3.3 Waste waters :

- Domestic wastes (Sewage)
- Industrial waste waters
- Waste waters from boats
- Water treatment by-product

Domestic and Industrial waste waters are important point sources and are viewed as responsible for most of the pollution problems. They will contribute BOD (Oxygen consuming matters), suspended solids, pathogens and other chemicals. Wastes from ships and pleasure boats poses potential health risk. By-products of treatment plants such a sludge discharge from sedimentation tanks and backwashing of filters contain suspended solids, micro organisms, and chemicals (from ion exchange plant).

5.3.4 Impoundments

- Aquatic growth
- Leaching of bottom deposits

Impoundments are the large reservoirs of water such as lakes and dams etc., where no free flowing state will exist. There will be anaerobic biochemical reactions in lower strata which will cause production of odourous compounds. Dissolved oxygen at bottom will get reduce which will reduce the assimilating capacity. Nutrients carried in water will promote aquatic growth which will interfere with the healthy conditions of the system. The chemicals accumulated at bottom in the sediment will leach out in the ground strata impering the ground water quality.

5.3.5 Miscellaneous Sources

- Solid wastes dumps and land fills
- Mines
- Construction activities

Seepage of chemicals and pathogens will take place from the solid waste dumps and land fillings. Operating or abandoned mines will contribute heavy load of acids and metals. Large amount of suspended solids will come from buildings and highway constructions.

5.4 Potential pollutants and their effects

The potential pollutant is one that is having potential for causing water quality problem but not necessarily always doing so. It is damaging for many reasons and hence is highly objectionable. Types of potential pollutants are as under :

5.4.1 Infectious agents (pathogens)

They are responsible for spreading diseases. Bacteria, viruses, algae and parasites are causing water borne diseases such as

- Typhoid fever
- Cholera
- Dysentery
- Infectious hepatitis
- Poliomyelitis
- Gastroenteritis, etc.

5.4.2 Toxic and Radioactive substances

They are very detrimental to health and sometime cause death or adverse physiological effect. Prominent among them are

- Arsenic
- Lead
- Mercury
- Cadmium and other metals
- Pesticides and Radioactive materials

They have chronic effects over long period of accumulation. They also interfere with metabolic, physiological, genetic or reproductive activities. Nitrates are fetal to infants in high amounts and chlorinated organic compounds (THM) are carcinogenic. They will also have biomagnification (food chain) affect.

5.4.3 The oxygen demanding substances

They will cause dissolved oxygen depletion which will result in death of fish and other aquatic organisms. BOD test is a key measure to check such conditions. Maintaining of DO content to adequate level will support fish life, project recreational interest and ensure aesthetic characteristics.

5.4.4 Plant Nutrients

Biological growth requires elements like carbon, hydrogens, nitrogen, phosphorous, sulfur and several others. The addition of plant nutrients to water system will have a number of deleterious effects. It will cause entrophication. They will cause taste and odour problems resulting into reduction in recreational value and will be unaesthetic.

5.4.5 The suspended matters

The suspended matters may increase turbidity and interfere with penetration of light. It may settle down and get accumulated as sludge blanks. Decomposition of such bottom sediments may give foul odours, reduce storage capacity, kill fish by clogging their gills and distroy bottom life.

5.4.6 Heat

Heat is emanated from thermal power plants entry of which to any water body will create problems. It often intensify taste and odour problem in drinking water. Rate of biochemical reaction is accelerated. Solubility of DO is decreased which will reduce DO available in water. Temperature rise will also increase death rate of fish.

5.4.7 Minerals and chemicals

Minerals and chemicals include organic and inorganic chemicals. Many of them have harmful effects to aquatic plants. They have toxic or chronic effects. Some of them may stimulate growth of objectionable organisms. Their interactions may cause taste and odour problem (Phenol + chlorine).

The modern chemistry has multiplied the number of hazardous chemicals. Over 7000 dangerous chemicals are known. Fortunately most of them are limited to the industrial environment. however large public is also subject to stress from toxic effects of such chemicals in water.

Organic toxic agents include compounds of carbon and hydrogen with metallic or non-metallic elements. In this class are found pesticides, solvents, emulsifiers, etc. Inorganic class include compounds of heavy metals if ingested can cause acute and sometimes rapid damage to the body. Iron, copper, zinc and manganese may be a nuisance in water or food but are seldom dangerous.

5.4.8 Oilly Substances

Oil pollution is of two types

- Animal and vegetable oils and fats
- Crude petroleum of mineral oil

The type of oils come from kitchen wastes, floor washings and industries like oil mills and dairies. The other type comes from refineries, petrochemical industries,

off-shore drilling and spillages from oil tankers, ships, etc. It include gasoline, kerosene, benzene, motor oil, etc. The density of oil is less than that of water and because oils are not miscible with water, they tend to float on the surface as a film. This can prevent diffusion of oxygen into the water and promote anaerobic conditions. It also tends to coat cells and tissue thereby causing suffocation. Many of them are toxic also because of their solvent properties.

5.4.9 Laundry Detergents

The detergents are the clearing material use of which is increasing very rapidly. Through waste waters they reach water sources and cause foaming as also interfere with treatment processes of water. Some of their ingredients like TSP increases entrophication problem.

Major parameters of pollution are summarised in **Table-5.3**

5.4.10 Biological parameters

Biological parameters are perhaps of greatest are perhaps of greatest importance from human point of view. All natural waters contain a variety of organisms both plants and animals as the natural flora and fauna. In water receiving sewage, domestic wastes and industrial wastes, a large number of pathogenic organisms may be present. The agents of water borne diseases include viruses, bacteria, protozoa and the helminths. Besides pathogens, unwanted biological growth of algae and fungi are also important. Such growth indicated enrichment of nutrients and entrophication conditions. Such growth hinder with recreation, spoil its aesthetic value and cost more in water treatment.

5.5 Adverse effects of Water Pollution

Domestic and Industrial wastes are discharged into streams, rivers and oceans without treatment creating serious water pollution. These wastes vary widely in composition and contain plant and animal wastes, acids and alkalis, oils and greases, organic and inorganic chemicals, synthetic detergents and radioactive materials, fertilizers and pesticides. Pollution of water is undesirable for the following reasons.

5.5.1 Reduction in oxygen levels

Factors like oil spills, heat, suspended sediments, organic wastes and some inorganic wastes have been found to decrease the available oxygen in a given system. The oxygen level gets reduced due to following reasons.

- Decreasing the photosynthetic rate of the plants
- Decreasing the solubility of oxygen within water
- Interference with the diffusion of atmospheric oxygen at the air-water interface

- Increase in the oxygen consumption of the aerobic bacterial component of the system

5.5.2 Excessive plant Nutrients

The addition of plant nutrients (nitrogen and phosphorous) to marine and fresh water systems will be having a number of deleterious effects. In addition, the decomposition of organic materials will also produce plant nutrients. these materials will cause excessive growth of water weeds which is called eutrophication.

5.5.3 Agents of biological dysfunctions

The agents of biological dysfunction will refer to any contaminant that either directly kills organisms or that interferes with their metabolic or physiological activity or their genetic or reproductive capabilities in such a manner as to threaten the success of a natural population in a given system. In addition, any material that appears to be harmless or to have a negligible effect when ingested, assimilated and or tends to accumulate in the tissues of these or of other organisms as it "Passes up" the food chain to ultimately affect the success of higher consumers would also fall into this category.

The major materials in this category include the various persistent pesticides, heavy metals, PVCs and PCNs, heat and radioactive wastes. these materials have direct effect on metabolic, physiological, genetic or reproductive systems.

5.5.4 Sediments and Erosion

Sediments are having a variety of deleterious effects on water ways. They interfere with photosynthesis by hindering light penetration through the water column. Sediments also clog the gills of fish and blanket the normal bottom sediments, eliminate spawning areas and smoother the eggs of many species of marine and freshwater organisms. When these sediments get carried into water ways by erosional and/or irrigational process, they also carry in the pesticides and add to the pesticide level of these systems. sediments ultimately settle out in water ways, behind dams and interfere with navigation and/or water storage, necessitating frequent dredging of these areas. two other effects have been coastal erosion control and salt-marsh landfill operations. The consequences of pollution on the human race are wide spread and range from a reduction in the recreational value of beaches and water ways, to unaesthetic drinking water to serious health hazards.

5.5.5 Health Effects

Health effects due to water have been elaborately discussed in the chapter on water and health. When water is polluted, the presence to human wastes poses serious threat to the public health. transmission of diseases such as enteric diseases. Vector

diseases, viral diseases and diseases transmitted through eating fish and other aquatic life from polluted waters increases manifold. The chemical pollutants of water, including pesticides and herbicides, are becoming a major hazard to health in industrial areas. Presence of heavy metals and toxic material is becoming very serious health hazard. The health effects of Fluoride and nitrates are discussed separately. Some organic compds present in water as pollutants are known to be cascinogenic or toxic.

5.5.6 Loss of recreational areas

Beaches are closed when the bacteria count is too high or when the water contains toxic substances or gives off a foul odour. Solid wastes or oil spills cause spectacular damage to valuable beach properties. Oxygen level gets depleted due to organic matter causing fish killing. Pollution by heavy metals or toxic chemicals also reduce the recreational value of a fishing lake.

5.5.7 Biological impacts

The biological impacts that result from adding potential pollutants to a stream or lake vary, depending on the life present in the water course, types of materials, amount added, dilution available, temperature, other chemicals in the water and many other factors.

Pollution impacts on aquatic biology may be divided into two broad categories.

- The generation of excessive growths in the water courses
- The elimination or major reduction of some life forms

The first category sometimes results after the addition of large quantities of certain chemicals that can be used by some species to produce objectionable growths. The second category may be that of chemicals that are toxic to some aquatic organisms. Additional of a specific chemical to a stream may sharply reduce or even eliminate, some life forms that are sensitive to it. Depending on the position of affected organisms in the food web. there also may be secondary effects on other species that are not directly impacted by the chemicals in question.

5.5.8 Problems involving detergents

Water pollution problems resulting from the use of detergents involve either the surfactant or the builder. The non-biodegradable detergents pass through sewage treatment plants unchanged and persisted in water for a long period of time. The detergents are not toxic but produce foam. The foam distressed people because it was visible and esthetically unacceptable. Phosphates used in the detergents cause great concern because they are responsible for entrophication process.

5.5.9 Marine Pollution

Coastal waters are also changing due to organic material from sewage out falls. Heavy metals and pesticides residue are found in fish in amounts above those declared by the food and drug Administration to be safe for human consumption. Other species of commercial fish and marine birds are decreasing in number at an alarming rate.

5.5.10 Impacts in India

- 70 percent of the available water in India is polluted according to NEERI, Nagpur
- According to one estimate, twothird of all illnesses in India are water related. 25% of the world's hospital beds are occupied because of unwholesome water
- 73 million workdays are lost every year due to water related diseases. Medical cost for treatment and loss in production accounts for Rs. 600 crores a year.
- Water pollution severely effects aquatic life. Massive fish kills and destruction or lower aquatic life due to industrial pollution. Dead fish means the loss of major source of protein and worse still a livelihood for millions of Indians
- Statistics indicate that the intestinal group of diseases like cholera etc. claim about 5 million lives every year while another 50 million people suffer from these infectious in India.
- Every third person who dies in India is a child below the age of five, a victim of a vicious combination of poverty, malnutrition in sanitary environment and undead drinking water.
- Diarrhoeas attack children in particular, three die every minute about 1.5 million every year. Diarrhoea thus constitute a permanent epidemic in the country.

5.6 Prevention of pollution

The foregoing paras show that a variety of pollutants can have access to sources of water if they are not prevented timely. In these days of shortage of freshwater, prevention of pollution not only protect the health of people but also saves huge costs to be spent for treatment. "Prevention of Pollution pays" has become a popular saying in this context. Some of the salient ways to protect the water sources from pollution are as under.

5.6.1 Segregation

Most of the flows carrying pollutants can be segregated out and diverted from meeting the impounding sources. the flows carrying water with impurities after first rains can be ignored so as to wash away the impurities.

5.6.2 Proper Land Management

Suspended matter entering the sources from agricultural sources can be prevented by better land management.

5.6.3 Control on land run-off

This will impose effective retardation on entrophication. Judicious chemical selection, careful application to crop and improved land management will minimize application to crop and improved land management will minimize transport to contaminants in runoff.

5.6.4 Reuse of Waste Water

Various kinds of wastes like paper, pulp, Municipal & industrial effluents, sewage and thermal power waste-water can be reused/recycled to advantage. For example, urban waste could be recycled to generate cheaper fuel gas and electricity. A new technology of waste recycling and disposal has been introduced by a distillery in Gujarat.

The reuse and recycling would not only save the precious water resource which is becoming scarcer day by day but also reduce the pollutants and also cost of treatment.

5.6.5 Proper treatment of Wastes

Effective treatment of wastes originating from various sources can control they entry of pollutants into the sources thereby reducing the pollution of sources.

5.6.6 Management of solid wastes

Proper management of solid wastes will also prevent entry of many pollutants into the sources. Similarly control over wastes generating from building and road constructions will also effectively control the pollution of such points.

5.6.7 Environmental Protection Regulations

Enforcement of rules for the safe disposal of harmful wastes and preventing exploitation of water could help to a large extent in protecting the quality of water sources.

5.7 Water Treatment

Treatment of water is provided to remove objectionable impurities. Nature does this job in its own way which is known as **self-purification**. But this process of self purification is limited to only mild pollution and is also very slow. We have seen that the pollution of water is sometime so heavy that self purification proves to be inefficient. Hence to provide effective, efficient and fast removal of impurities. Some man made processes are employed. This is accomplished by providing right type of treatment process.

Water treatment is defined as the manipulation of a water source to achieve a water quality that meets specified goals or standards set by the community through its regulatory agencies. Water treatment includes home treatment units, community treatment plants and facilities for industrial water treatment with highly variable on the specific industrial type. The technology exists to remove essentially, all of the dissolved and suspended components of water. Normally however, the extent of treatment applied is determined by the existing characteristics of a potential water supply and limits specified by its designated end use.

Water treatment process selection is a complex task involving the consideration of many factors. The selection of water treatment processes to be used on a given water supply source is dictated by the need to produce acceptable finished water quality at the most attractive over all cost. The choice of a water treatment scheme depends on -

- Water supply source quality
- Desired finished water quality
- Reliability of process equipments
- Operational requirements
- Personnel capacities
- Flexibility in dealing with changing water quality and equipment malfunctions
- Available space for construction of treatment facilities
- Waste disposal constraints
- Chemicals availability
- Capital and operating costs

Water treatment processes can be grouped according to their general function in the water treatment scheme. However, each water source is unique, and process modifications to fit a particular treatment objective must be considered on a case-by-case basis.

5.7.1 Methods of Treatment

There are three basic types of treatment processes.

5.7.1.1 Physical processes

They depend simply on physical properties of the impurities. e.g. Particle size, specific gravity, viscosity etc. Typical examples of this type of process are, screening sedimentation, filtration and gas transfer.

5.7.1.2 Chemical processes

They depend on the chemical properties of an impurity or which utilize the chemical properties of added reagents. Examples are coagulation, precipitation and ion-exchange.

5.7.13 Biological processes

They utilize bio-chemical reactions to remove soluble or colloidal organic impurities. Examples are biological filtration and denitrification.

Depending on its composition a particular water may require one or more of the above processes for satisfactory treatment to a particular standard.

Water quality of water will affect the treatment processes selected as well as the cost of water treatment. Although water quality is variable from source to source, surface waters have many qualities in common. Likewise ground waters have many similar characteristics.

5.7.2 Surface Water Treatment

The surface waters are from streams, rivers, lakes or impounding reservoirs. Streams or rivers have the characteristics of rapid changes in water quality. Heavy rains or spring run off increases turbidity and other constituents. In addition rivers and streams are more susceptible to accidental spills and transport of contaminants. Consequently treatment process selection should consider the occurrence of such events. Lakes and impounding reservoirs may develop stratification resulting in depletion of oxygen at lower depths. Under these reduce conditions, Iron and Manganese can be solubilised. Taste and odour problems may also increase because of release or anoxic and/or anaerobic decay products and hydrogen sulfide. Upper lake levels are susceptible to algal blooms if carbonate, nutrients and temperature conditions are favourable. Algal blooms can cause changes in source water turbidity, alkalinity, taste, odour, pH and other characteristics.

Surface waters being open to sky, are more prone to extraneous pollution. In addition to natural pollution they are subjected to most of the manmade pollution mostly effluents from domestic and industrial sources. However surface waters are low in dissolved salt content but move in microbial pollution. These aspects need careful consideration while selecting the treatment for surface waters.

5.7.3 Ground Water Treatment

Ground water are from the sources below the surface of earth. They are mostly from wells, Galleries and Tube wells. Ground waters are relatively constant in quality from season to season. However ground water supplies may be highly variable in quality from one location to another. Changes in hydrogeological conditions can produce different water quality over a relatively short distance. Ground water quality is usually superior to that of surface water with respect to bacteriological content, turbidity and total organic concentrations. On the other hand, the mineral content (Hardness, Iron, Manganese) of ground water may be more and require

additional treatment. Although a ground water will normally be free from any suspended solid matter, it may contain impurities in solution. It may contain increased nitrate levels from fertilizers, infiltration of refuse sites, salinity from sea water intrusion and toxic substances from industrial wastes. Currently, the quality of groundwater with respect to trace concentrations of organic chemicals such as pesticides, herbicides and solvents is of great concern. The leachate from land fills, burried wastes, deep well injection of industrial wastes. Low cost pit latrine wastes and seepage of on land disposal of wastes as well as sea water intrusion are increasing the concern for ground water treatment.

In some cases ground water can be used without any treatment if it contains sufficient oxygen. A safety chlorination can be applied if required.

Water treatments (Removal of substances) can be broadly classified as shown in **Table 5.4.** Selection of an unit operation will depend on the nature of impurities present. It can be summarised as shown in **Table 5.5.**

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Table - 5.1

Classification of water pollutants

Type	Example
(A) Chemical	
(a.) Organic	Oils, dyes, Synthetic detergents, chlorinated hydrocarbons, Phenols, Carboxylic acids, Carbohydrates, Sugars.
(b.) Inorganic	Acids, Alkalies, Chlorine, metallic salts, nitrates, phosphates sulfates, bicarbonates, hydrogen sulfide, Radioactive isotopes.
(B) Physical	
(a.) Floating matter	Foam, Scum, Wood, leaves
(b.) Suspended matter	Silt, Sand, gravel, metal pieces, cinders, rubber, wood chips, paper, pulp, solid sewage material, animal carcasses.
(c.) Thermal effects	Heat added
(C) Biological	
(a) Pathogenic forms	Bacteria, Protozoa, Fungi, algae, viruses, parasitic worms that produce disease.
(b) Algae	Excess growth caused by excess nutrients, decay uses oxygen.
(c) Aquatic Weeds	Salt cedar plants water Hyacinth

Table - 5.2

Point and Non-point sources of water pollution

Source	Common Pollutant categories
Point Sources	
1. Municipal sewage treatment plants	BOD, Bacteria, Nutrients Ammonia and toxics
2. Industrial facilities	Toxics, BOD
3. Combined sewer over flows	BOD, Bacteria, Nutrients, Turbidity, Total Dissolved Solids, Ammonia, toxics
Non point sources	
1. Agricultural runoff	Nutrients, turbidity, Total Dissolved solids, toxics, bacteria
2. Urban runoff	Turbidity, Bacteria, Nutrients, Total Dissolved solids, Toxics
3. Mining runoff	Turbidity, acids, toxics, total dissolved solids
4. Septic systems	Bacteria, Nutrients
5. Landfills/Spills	Toxics, Miscellaneous Substances

Table 5.3

Major parameters of water pollutions

Parameter	Source	Significance
1. Colour	Humic and fulvic acids, metallic ions, phytoplankton, industrial wastes	• Aesthetic objection • Indicate presence of industrial wastes
2. Taste and odour	Dissolved organic impurities. Decaying aquatic organisms Algae, Industrial wastes	• Aesthetic value • May be toxic • Not suitable for industrial use
3. Turbidity	Clay, silt, organic matter (starch) and micro organisms	• Unfit for domestic and industrial use. Penetration for photo-synthesis reduced
4. Foam	Soaps, detergents and peoteins	• Interfere with treatment and trap pathogens
5. pH	Industrial wastes, mines	• Acidic water cause corrosion. Alkaline water causes taste and hasten scale formation
6. Dissolved oxygen	Organic wastes	• Very important parameter • Low oxygen can kill fish & other aquatic organisms • Give pleasant taste to water
7. BOD (Bio-chemical Oxygen Demand)	Organic wastes particularly domestic and Industrial wastes	• Index of biodegradable organic wastes • Useful for process design & measurement of plant treatment efficiency & operation • For evaluating self purification
8. COD (Chemical Oxygen Demand)	Organic and inorganic wastes	• Very useful where BOD cannot be performed • Rapid determination • Useful for design and treatment evaluation

Table 5·3 contd.....

9. Ammonia	Nitrogenous Organic matters Domestic sewage	• Evidence of organic pollution • Recent pollution by sewage • Toxic at higher concentrations
10. Nitrates	Domestic, Industrial and agricultural wastes	• High amounts indicate pollution • Methamaoglobinemia at high concentrations • Entrophication and growth of algae
11. Phosphorus	Domestic sewage, detergents agricultural and industrial wastes	• Higher amount indicative of pollution • Eutrophication and algae growth
12. Total dissolved solids (TDS)	Natural, domestic and industrial wastes	• Indicates total mineral content • Indicator to decide use of water • Decides potability of water
13. Iron and Manganese	Natural Sources (Rocks and minerals)	• Impart colour and taste, Slime formation
14. Heavy metals	Industrial discharges (Metal plating)	• Toxic even at low concentrations

Table - 5.4

Broad classification of water treatment processes

Class of Impurity	Type of Impurity	Treatment processes
(A) Suspended		
(a) Colloids (Organic and inorganic)	• Inorganic colloids such as clay and oxides of Fe and Mn • Natural organic micromolecules • Industrial wastes from china clay and paper processing • Sewage solids	• Coagulation and Flocculation • Biological treatment for BOD removal • Ultrafiltration
(b) Suspended inorganics	• Natural material mostly sand • Industrial materials from coal washings, mining wastes, lime and other sludges, oxides, dust, fly ash etc.	• Sedimentation • Screening
(c)Suspended Organic	• Plant and animal materials • Industrial and domestic discharges	• Sedimentation/Screening • Biological treatment for BOD
(B) Dissolved		
(a) Inorganic salts	• Leaching of minerals and pickup of atmospheric gases • Fertilizer runoff • Domestic wastes • Industrial discharges especially from metal finishing trade • Salinity from sea water or ground water intrusion • Breakdown products of organic materials	• Oxidation • Precipitation • Ionexchange • Desalination

Table 5·4 contd.....

(b)Dissolved-organic matter	• Natural impurities from decay of vegetable and animal matter • Domestic wastes Decay products, detergents • Industrial discharges Food processing, tanning, paper making, organic chemical industry, oils fats and solvents • Residues of Herbicides and pesticides	• Coagulation and sedimentation • Adsorption • Desorption • Biooxidation

(C) Living matter

(a) Micro-organisms	• Viruses • Bacteria • Fungi • Algae • Protozoa • Iron bacteria • Sulfur bacteria	• Disinfection • Microfiltration • Biological treatment
(b) Larger Life forms	• Worms • Crustaceans • Insect larvae • Lice • Fish etc.	• Screening • Filtration

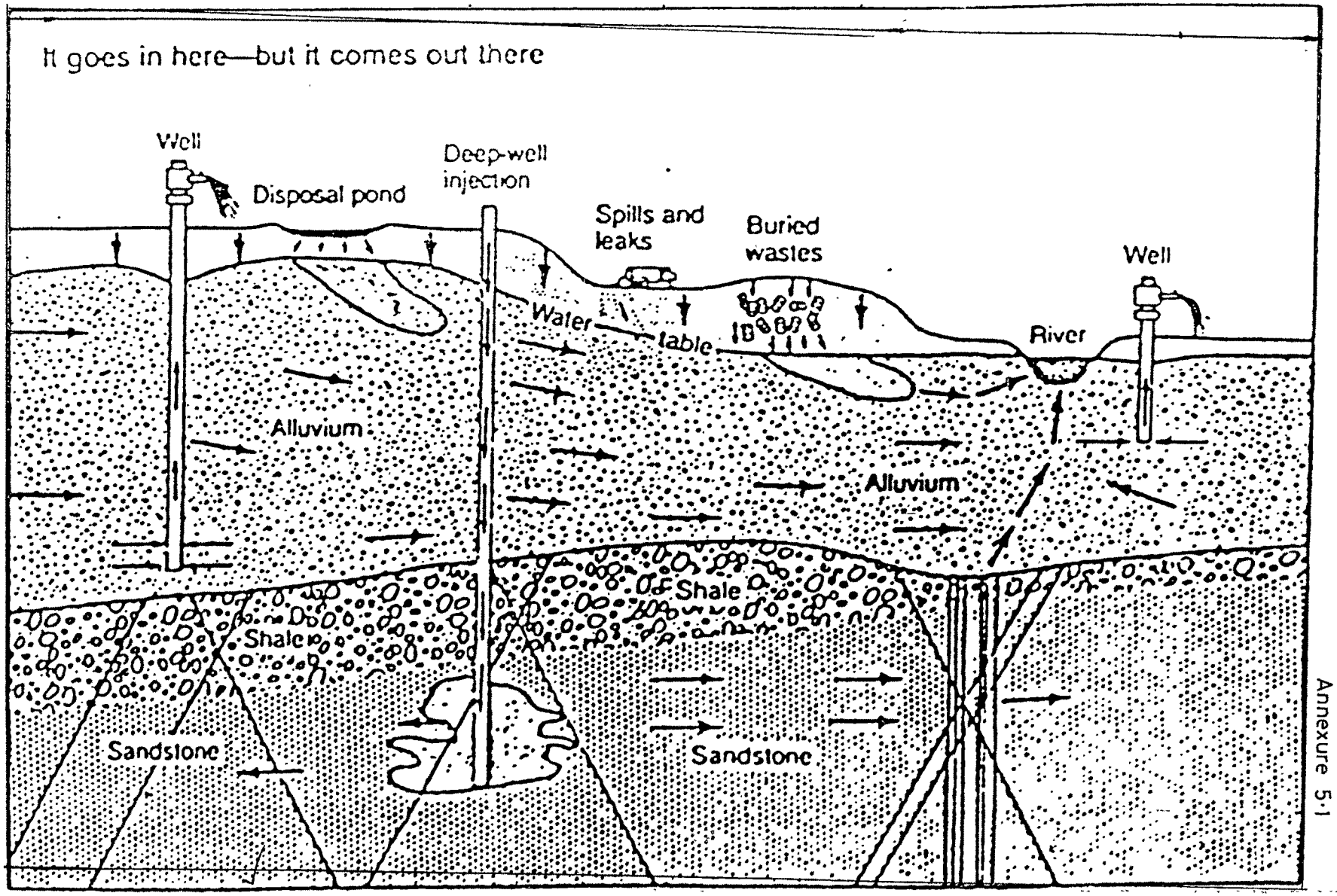
(D) Gases

(a) CO_2, H_2S, CH_4, NH_3	• Biological decay or Industrial discharges	• Aeration (Desorption) • Activated carbon adsorption
(b) CO_2,SO_2,Cl_2	• Cooling towers pick up CO_2 • SO_2,Cl_2 dosed in industrial processes • Algal growth promotes CO_2	• Aeration (Desorption) • Dechlorination • Ion exchange

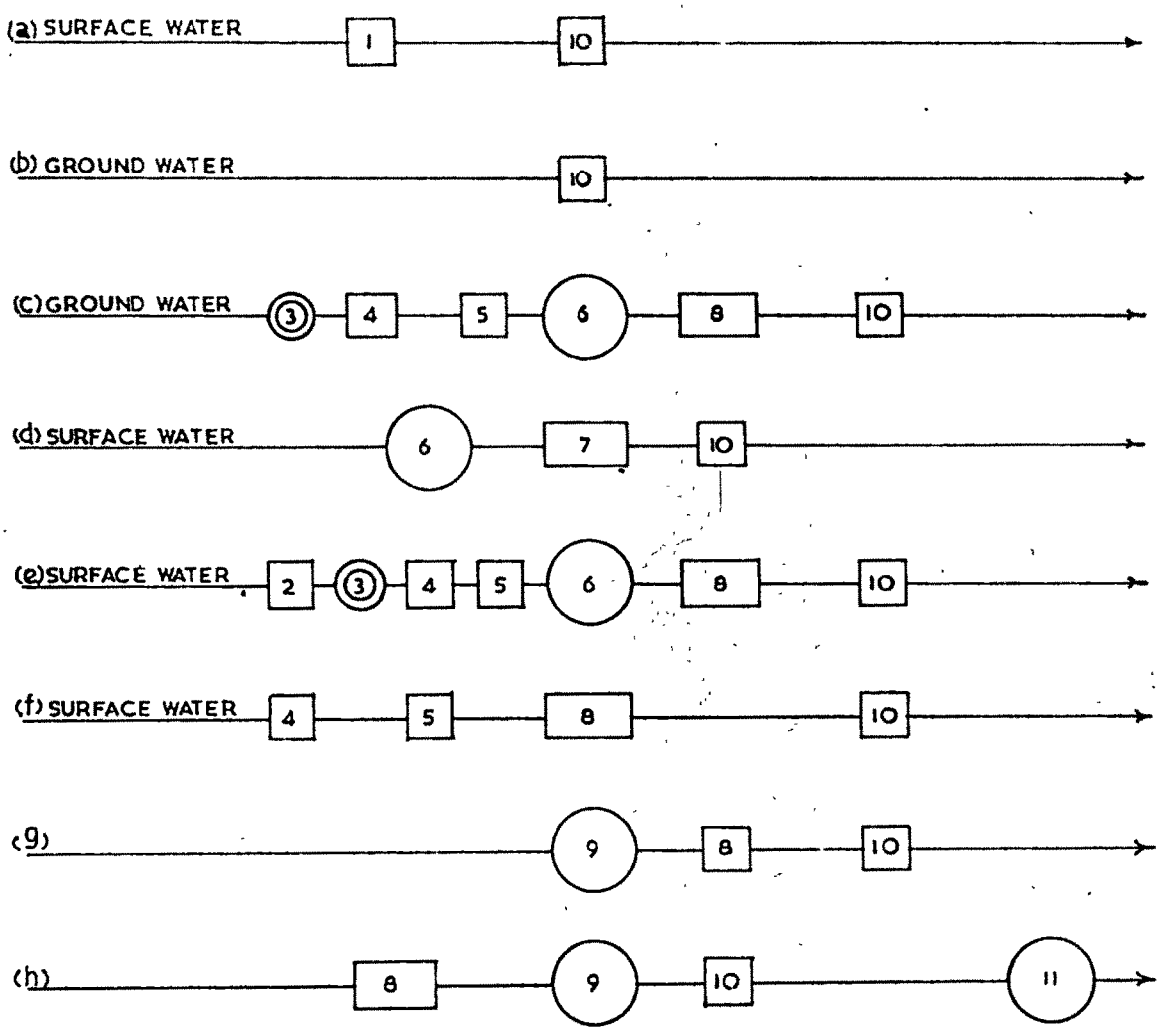
Table - 5.5

Unit operations in water treatment

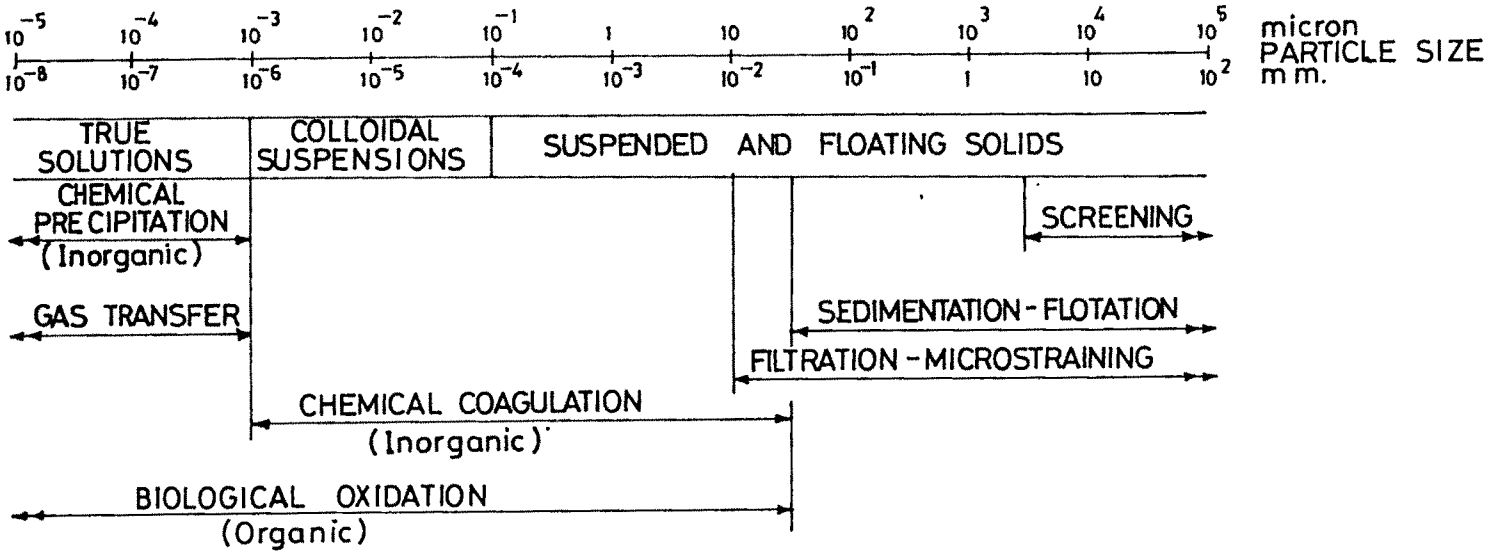
Sr. No.	Type of Unit operation	Nature of impurities removed
1.	Pre-treatment a. Bar screens b.Raw-water storage(7-15 days average water demand) c.Fine screens (6mm spacing)	 • Floating materials of fairly large size particles • Heavy silt and flow variations • Small size floating materials
2.	Sedimentation (3 to 4 hours for plain and 2 to 2.5 hours for co-agulated)	• Settleable suspended solids
3.	Co-agulation and Flocculation	• Finely devided suspended solids and colloids • Organic colours
4.	Filtration	• Suspended and colloidal impurities (Partial removal of bacteria also)
5.	Aeration	• Fe and Mn by oxidation • Expulsion of gases like CO_2, H_2S etc. • Reduction of odour and taste problem
6.	Chlorination (Disinfection)	• Oxidation and removal of Fe, Mn and some other metals • Killing of bacteria and algae • Reduction of colour and slime problem
7.	Softening	• Hardness
8.	Adsorption (Activated Carbon)	• Reduction in odour and colour problem
9.	Demineralization/Desalination	• Dissolved salts (Cations/Anions) Hardness
10.	Defluoridation	• Fluorides
11.	Precipitation	• De and Mn, Silica, heavy metals
12.	Bio-oxidation	• Organic matter (BOD removal)


It goes in here—but it comes out there
Well
Disposal pond
Deep-well injection
Spills and leaks
Buried wastes
Well
Water table
River
Alluvium
Alluvium
Shale
Shale
Sandstone
Sandstone

Annexure 5·2



1. STORAGE
2. CHLORINATION (PRE)
3. AERATION
4. RAPID MIXING
5. FLOCCULATION — SLOW MIXING
6. SEDIMENTATION
7. SLOW SAND FILTRATION
8. RAPID SAND FILTRATION
9. SOFTENING
10. CHLORINATION (POST)
11. DEMINERALISATION



APPLICATIONS OF UNIT PROCESSES