UNIT 4 WATER POLLUTION

Structure

4.1 INTRODUCTION

Water is essential for all living organisms. This is the reason why water is called life and rivers are worshipped as holy mothers. Major important civilizations such as Indus Valley, Sumerian, and Egyptian civilisations developed and flourished on river banks for obvious reasons. The rivers continue to have their use for mankind; and are, as ever, potential sources for water supply and irrigation; and today man has harnessed them for hydel power generation.

At present, looking to the sanitary conditions of most of the rivers in India, they are highly polluted. This is due to the indiscriminate disposal of waste water from cities and industrial zones. The disposal of waste water into the water bodies is basically permitted only after its adequate treatment as per the standards prescribed by the government or the regulatory agency. In many instances, the treatment is either not at all given or is inadequate. The run-off to the rivers also carries lot of pollution from the catchment areas, especially due to the use of agricultural fertilizers and pesticides.

Water is a universal solvent and many natural substances, and modern day pollutants too get dissolved in it. If the volume of the river water is enough, the pollutants get dispersed and eventually diluted. However, if the assimilative capacity of the river water is limited due to the related factors, it gets polluted.

Polluted water is threat to flora and fauna in the river. If the dissolved oxygen level is reduced to less than 4.0 mg/l due to the decomposition of the organic matter, or if the concentration of dissolved solids is high, the fish life cannot sustain in the river.

If the polluted river wastes are to be used as the source of raw water for water supply plants, the cost of treatment of river water is naturally enhanced. The rural population hardly gets reasonably good quality potable water, and is subject to many water borne diseases.

Objectives

At the end of this unit, you should be able to

- know about water pollutants and their origins,
- appreciate the role of water pollution parameters,
- understand Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD), and their determination,
- estimate the quantity of waste water from a given activity of the community,
- explain the effects of water pollution, and
- understand mechanics of the spread of water-borne diseases.

4.2 WATER POLLUTANTS

Pollution is a qualitative term – it describes the situation that may occur while the level of contaminants is such that the intended use of water is impaired. A water body may receive just a small amount of a pollutant and become unfit for drinking; but, the same water might not be considered polluted if it were to be used for agriculture. Physical factors also contribute to pollution – heated water discharged from a power plant can change adversely the temperature of an aquatic environment, especially during the summer time. Moreover, heated water or water containing some contaminant may not pose a problem if it rapidly gets mixed with surface water. Many kinds of contaminants become undesirable especially when in conjunction with other substances, can cause pollution in well mixed water bodies.

The major sources of surface water pollution are : construction activity, municipalities, agriculture, and industries. Rain water, near the coastal regions, may contain particulate and dissolved sea salts; further inland, it may contain organic compounds and acids scrubbed from contaminants that are added to the atmosphere by natural processes and / or by anthropogenic (human) activities.

The items which are responsible for water pollution can be summarised as under :

(1) Oxygen demanding wastes,

(2) Pathogens,

(3) Plant nutrients,

(4) Salts (Inorganic chemicals),

(5) Heavy metals,

(6) Sediments,

(7) Refractory organics (toxic organics),

(8) Volatile organic compounds,

(9) Oil,

(10) Heated water discharge, and

(11) Radioactive substances.

4.2.1 Oxygen Demanding Wastes

Dissolved Oxygen (DO) is one of the important parameters of the water quality. Depending on temperature and salinity of water, the DO level may be around 8-10 mg/l. However, minimum level of 4 mg/l is required for a healthy fish population.

The oxygen demanding wastes are biodegraded organic substances which get oxidized in the water medium that receives them, reducing its amount of DO while they themselves undergoing chemical changes leading to the production of stabilised compounds. All this process (decomposition) obviously leaves fish and other aquatic organisms and wild life with less than needed amount of oxygen in water. Due to depletion in DO level, under extreme conditions, anaerobic situation may prevail. This situation gives obnoxious odour, and reduces the usefulness of water as the source of water supply and recreation.

The biodegraded organic substances are discharged through domestic and industrial waste water. Some inorganic substances and natural organic matter like leaves and animal foul matter going to river waters also exert oxygen demand depleting the DO level.

4.2.2 Pathogens

Communicable diseases are mostly caused by microbes – microscopic organisms including bacteria, protozoa and viruses. However, it is to be understood that most microbes are natural elements of our environment as well as are symbiotic with major life forms; but they never cause disease. And, those organisms that do cause disease are called pathogenic organisms, or simply *pathogens*.

There are various modes of transmission of disease through various life forms (Figure 4.1).

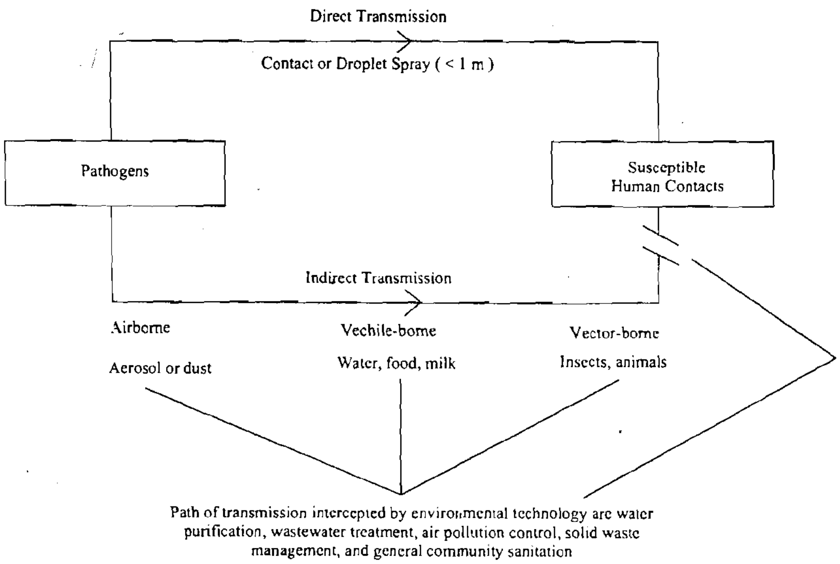

Figure 4.1 : Modes of Disease Transmission

Direct transmission involves an immediate transfer of pathogens from an infected person (*carrier*) to a susceptible contact (i.e., a person having a direct contact with the carrier). The control of this type of transmission does not lie within the scope of environmental technology. However, this technology plays a role in the interception of many of the ways of indirect transmission. It has to be pointed out that airborne transmission should not be confused with the noninfectious public health problems associated with chemical air pollution. *Vectors* of disease include insects, rodents, etc., that are capable of transporting pathogens to susceptible human contacts; while, a *vehicle* of disease transmission can be any nonliving object or substance that gets contaminated with pathogens – forks, spoons, handkerchiefs, soiled clothes, toys, etc.

Water, food, and milk as well are potential vehicles of disease transmission – these constitute the most significant factors with reference to environmental technology and sanitation.

Pathogens are responsible for the water related diseases – epidemics (typhoid and cholera) rage because of pathogen contamination. The World Health Organisation (WHO) estimates project about 80% of human sickness due to sub-standard quality of water – about 10 to 20 million children die each year due to diarrhoeal diseases alone.

4.2.3 Nutrients

Nutrients are chemicals like nitrogen, phosphorous which are essential for growth of living organisms. Nutrients can contribute to water pollution when their concentration is more than the normal amount, and tend to induce a luxuriant growth of aquatic flora and fauna, especially in water bodies. The enrichment of water bodies with nutrients is called *eutrophication*. This leads to algal blooms in the water bodies, reducing their recreational value and usefulness as sources of water supply. We know organic matter imparts colour, odour, turbidity, and taste to water which is desirable.

Nitrogen in water is normally found as nitrate (NO_3) which can be converted to nitrite (NO_2) by the bacteria found in the intestines of infants. Nitrites impure the oxygen carrying capacity of the blood and cause methemoglobinemia (blue babies).

Domestic and industrial waste waters are the major sources of nutrients.

4.2.4 Salts

Along the course of a river many inorganic salts get dissolved in water, being brought by the runoff from the catchment. Domestic as well as industrial waste waters also contribute, especially, to the increase of organic chemicals. The dissolved inorganic chemicals are measured as total dissolved solids (TDS), and is used as a pollution parameter. In drinking water, the preferred TDS level is not more than 500 mg/l. The dissolved salts like calcium, magnesium, iron and anions like sulfates, carbonates, chlorides, etc. are generally present. Cations like calcium and magnesium cause hardness in water, whereas anions like carbonate impart alkalinity; chloride imparts taste and give florid teeth.

Evaporation of fresh water from water bodies, irrigation drainage, effluent mixing are also responsible for increase in TDS concentration.

4.2.5 Heavy Metals

There is no precise definition of heavy metals but metals with specific gravity of 4 to 5 can be classified as heavy metals, and also include toxic metals.

Some of the heavy metals even in small concentration are toxic, and obviously have an adverse impact on human health. The metals which are toxic can be listed as aluminium, arsenic, beryllium, cadmium, chromium, copper, iron, lead, mercury, nickel, zinc, etc. These metals affect kidney, nervous system; and some of these substances are suspected carcinogens.

A wide variety of toxic inorganics (as detailed above) and also organic substances are found in water in very small or even in trace amounts. Some of these substances are from natural sources, but many originate from industrial activities. It is to be stressed that even in trace amounts, they can pose a danger to public health – a toxic substance may act as a poison causing death, or may cause disease that is not noticeable until many years after exposure; substance that are mutagenic cause harmful effects in the offspring of the exposed people.

4.2.6 Refractory Organics

Refractory organics are those substances which resist biodegradation and persist in environment for a long time. Some refractory organics of concern to environmental engineer are pesticides and detergents.

Chlorinated hydrocarbons, such as pesticides, are toxic; and they need to be monitored in public water supplies. The pesticides include insecticides, herbicides, rodenticides and fungicides. The well-known pesticide is DDT (dichloro diphenyl trichloro ethane) widely used to control insects. However due to its adverse impact on human health, its use is banned in USA. DDT gets accumulated in faculty tissues and thus there is biomagnification at successive levels in food chain.

The detergent ABS (Alkybenzine Sulphonate) is highly resistant to biodegradation and responsible for foaming. Foaming creates specific programs in waste water treatment.

4.2.7 Volatile Organic Compounds

Volatile organic compounds are most commonly found in ground water and are discharged from industrial processors using them as solvents. The most toxic organic compounds that are suspected carcinogens are vinyl chloride (chloroethylene), tetrachloroethylene, trichloroethylene, dichloroethylene and carbon tetrachloride.

4.2.8 Heated Water Discharge

The quantity of water required for cooling purposes in power plants (thermal as well as nuclear) exceeds the quantity used for any other purpose, i.e., a very large quantity of water is required for cooling (nuclear power plant may impart sufficient heat to about 40 m^3/s of cooling water to increase its temperature by 10^oC while it passes through the condenser). It is obvious that water carries away waste heat as it passes through the condensers in the plant – steam is converted back to water in the condensers. In general, cooling-water temperature may increase upto 15^oC after it condenses the steam.

Any discharge of warm water into a water body is considered *thermal pollution*, for obvious reasons. Heat (i.e., warmer temperature) decreases the solubility of oxygen (thus, affects the level of dissolved oxygen, DO); and increases the rate of metabolism of fish. These conditions alter the ecological balance obtained in a river or a lake. Valuable game fish, such as trout, cannot servive in water that has a temperature above 25°C, and will not reproduce if the water temperature is more than 14°C. However, coarser fish, like carp or pike, can do well in water as warm as 35°C. Several species of coarse fish do prefer warmer waters, and may congregate near the outfall pipe from the power plant : but the problem crops up if the plant is suddenly shut down for repairs – sudden decrease in temperature kills a significant proportion of this fish.

Thermal pollution can be controlled by allowing the heated water to pass through a cooling pond (or a cooling tower) after it comes out of the condenser. Once the heat is dissipated into the air, water can be either discharged into the river or pumped back to the plant for reuse as cooling water (Figure 4.2).

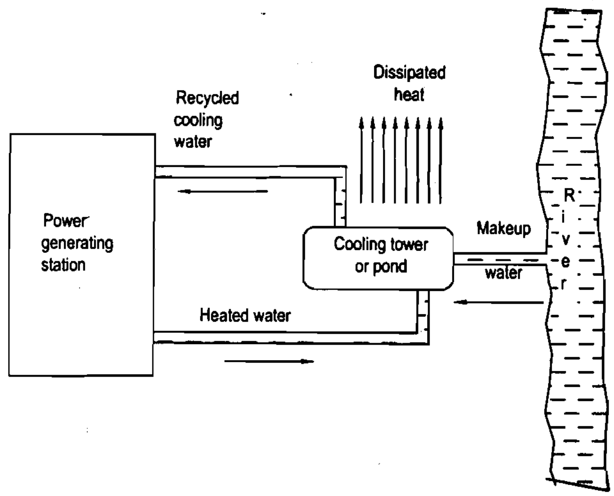

Figure 4.2 : Recirculation of Water to Control Thermal Pollution

In this arrangement there is no discharge of heated water into the river; however, some water will always be withdrawn from the river to make up for evaporative losses. At places where enough space, is not available for the construction of a cooling pond, we can go in for cooling towers. A very common type of such towers is known as natural draft hyperbolic cooling tower.

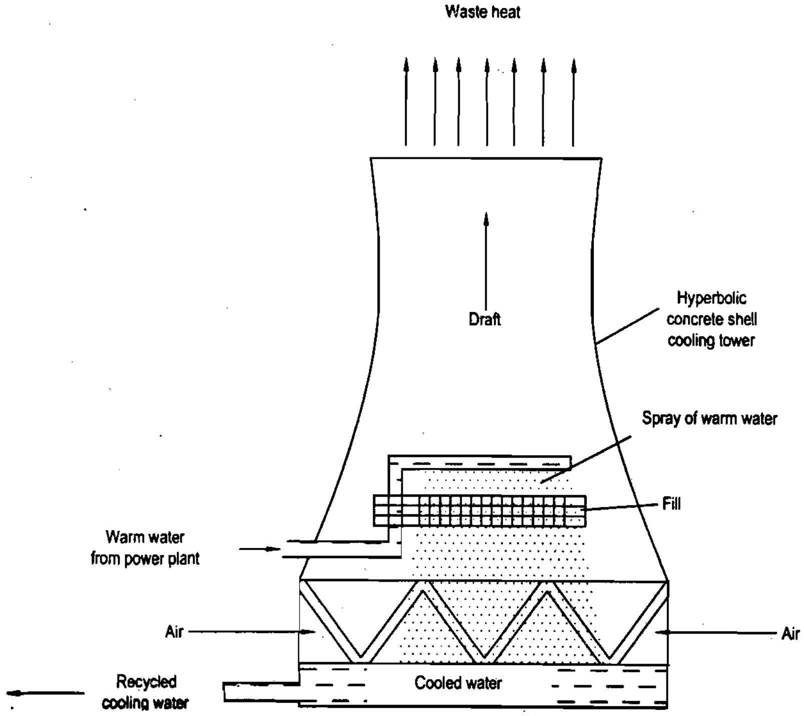

Figure 4.3 : A Schematic Sketch of Natural Draft Cooling Tower

Here, evaporation accounts for most of the heat transfer. They are usually very tall dominating the surrounding landscape.

4.2.9 Radioactive Substances

The emission of subatomic particles from unstable nuclei of certain atoms is referred to as radiation that poses a serious threat of public health. Maximum allowable concentrations of radioactive substances have been set that should not be violated. Potential sources of radioactive pollutants in water comprise wastes from nuclear power plants, industrial wastes, radioactive chemicals used in medical research, and discharges from refining of uranium ores. The unit of radioactivity that is used, vis-a-vis, water quality assessment is *picocurie* per litre (pCi/l), 1 pCi being equivalent to about two atoms disintegrating per minute.

Over and above damaging vital organs or systems of the exposed life forms, the adverse impact get passed on to future generations.

SAQ 1

(a) What do you understand by water pollutants?

(b) List the different types (or groups) of water pollutants. Indicate a primary source of each type.

(c) Write an essay on thermal pollution.

(d) What are the adverse effects of nutrients on the quality of water (lake or river).

4.3 ESTIMATION OF OXYGEN DEMANDING WASTES

The quantity of oxygen demanding waste, i.e., the concentration of total organic pollution is assessed with the help of the following parameters :

(1) Biochemical oxygen demand, BOD

(2) Chemical oxygen demand, COD

(3) Total organic carbon, TOC

(4) Theoretical oxygen demand, ThOD

(5) Total Biological oxygen demand, TbOD

The BOD and COD, however, are very important parameters for the estimation of organic pollution, and are widely used by environmental engineers in professional practice.

4.3.1 Biochemical Oxygen Demand (BOD)

The biochemical oxygen demand measures the amount of oxygen consumed by aerobic microorganisms for complete oxidation (or stabilization) of the organic matter contained in the given sample. Polluted water will continue to absorb oxygen for many months, and so it is not feasible to determine this ultimate oxygen demand. Conventionally, therefore, the oxygen measurement is done at a controlled temperature of 20°C at an interval of 5 days. It is therefore called BOD_5 (or simply BOD) at 20°C. The BOD during 5 days (at 20°C) is taken as the standard demand, and is about 68% of the total demand. A 10 day BOD is about 90% of the total.

The sample for which BOD_5 is to be measured is suitably diluted with dilution water so that nutrients and oxygen are available during the incubation period of five days. If need be the dilution water is seeded with a mixed bacterial culture. The dissolved oxygen (DO) is measured before and after the incubation of the sample.

For an unseeded sample,

$$BOD = \frac{D_1 - D_2}{P} \qquad \ldots (4.1)$$

and for a seeded sample :

$$BOD = \frac{(D_1 - D_2) - (B_1 - B_2)\,(1 - P)}{P} \qquad \ldots (4.2)$$

where, D_1 = DO of diluted sample immediately after dilution mg/l

D_2 = DO of diluted sample after 5 days (120 hours) mg/l

B_1 = DO of seeded control sample before incubation, mg/l

B_2 = DO of seeded control sample after 5 days incubation, mg/l

P = Decimal volumetric fraction of sample used
= Volume of undiluted sample / volume of diluted sample

1/P is known as dilution factor, or dilution ratio. 1% diluted sample means : 1 ml of the raw sample is diluted in order to make a 100 ml test sample; thus, its dilution factor would be 100, because 1 ml has been diluted by 100 times to make 100 ml. Therefore, the multiplying factor, 1/P, would be $1/(1/100) = 100$.

Example 4.1

A 20.0 ml sample of water mixed with dilution water to fill the BOD bottle of 300 ml was found to have an initial DO of 7.0 mg/l; and after 5 days of incubation its DO was 4.5 mg/l. Compute its BOD_5 at 20°C.

Solution

Volume of raw sample = 20 ml

Volume of diluted sample = 300 ml

$$\therefore \text{ Dilution ratio } = \frac{300}{20} = 15$$

$$D_1 = 7.0 \text{ mg/l}$$

$$D_2 = 4.5 \text{ mg/l}$$

$$\therefore BOD = (7 - 4.5) \times 15$$

$$= 2.5 \times 15$$

$$= 37.5 \text{ mg/l}$$

Example 4.2

For a control sample bottle containing seeded dilution water has a drop of 1.5 mg/l in its DO over 5 days incubation of. The BOD bottle (300 ml with 20.0 ml of waste water and the remaining seeded water has a DO drop of 6.8 mg/l. Compute the BOD_5 of the sample.

Solution

$$BOD_5 \text{ (at } 20^\circ \text{ C)} = \frac{(D_1 - D_2) - (B_1 - B_2)(1 - P)}{P}$$

$$= \frac{6.8 - 1.5\left(1 - \frac{20}{300}\right)}{20/300}$$

$$= 81 \text{ mg/l}$$

It is assumed that the oxidation or decomposition of the organic matter follows the first order kinetics and can be expressed by the following differential equation (at a given temperature) :

$$\frac{d L_t}{dt} = -K L_t \qquad \ldots (4.3)$$

where, L_t is the oxygen equivalent of carbonacious oxidable organic matter present in sewage after t days from the start of oxidation (mg / l), and K is a constant signifying rate of oxidation of organic matter – it depends on the nature of organic matter and temperature, it units being $(\text{day})^{-1}$. The minus sign of K indicates that L_t decreases with increase in t.

L_t is known as the ultimate first stage BOD initially present. The first stage BOD is the amount of oxygen required by microorganisms to oxidize carbonaceous fractions of the organic matter. There is an additional demand of oxygen for the oxidation of nitrogenous organic matter which is termed as the second stage demand.

If Y_t is the amount of BOD that has been exerted at time t (i.e., BOD of t days), i.e., it is the total amount of organic matter (expressed as oxygen equivalent) oxidised in t days, then we can write :

$$Y_t = L_o - L_t \quad \ldots (4.4)$$

where, L_o is the organic matter present (expressed as oxygen equivalent) at the start of BOD reaction, and L_t is the organic matter left after t days. It can be shown by the integraion of Eq. (4.3) that :

$$\frac{L_t}{L_o} = e^{-kt} \quad \ldots (4.5)$$

$$\therefore \ Y_t = L_o - L_o\, e^{-kt}$$

$$= L_o\, (1 - e^{-kt}) \quad \ldots (4.6)$$

$$\therefore \ BOD_5 = Y_5 = L_o\, (1 - e^{-k\,5})$$

Figure 4.4 is the graphical representation of Eq. (4.5).

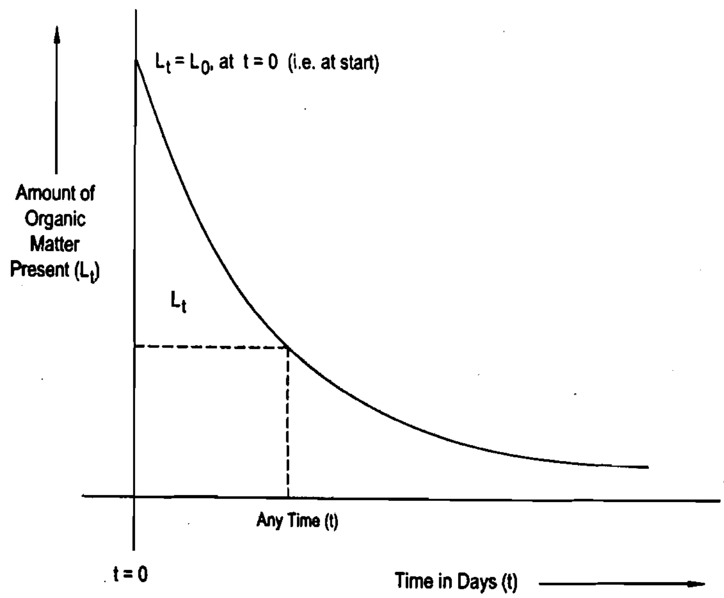

Figure 4.4 : First Stage BOD Curve

These equation can be graphically shown as given in the figure.

Example 4.3

Compute ultimate BOD (first stage), and 20-day BOD for the sample having BOD_5 at 20°C of 100 mg/l. Assume the value of K as 0.23 per day.

Solution

$$Y_5 = L_o\, (1 - e^{-kt})$$

$$\text{or} \quad 100 = L_o\, (1 - e^{-0.23 \times 5})$$

$$\therefore \ L_o = 146.34 \text{ mg / l}$$

$$\text{Hence, } Y_{20} = 146.34\, (1 - e^{-0.23 \times 20})$$

$$= 144.87 \text{ mg / l}$$

It may be pointed out that the ultimate value of BOD exerted at 20 days will almost be identical.

4.3.2 Nitrification

Figure 4.5 shows that the BOD curve flattens out after about 8 days, as it approaches the ultimate BOD. BOD_2 in this Figure denotes the ultimate carbonaceous BOD (also designated as CBOD) because during the first week or so of decomposition, the bacteria act primarily on carbon-containing substances.

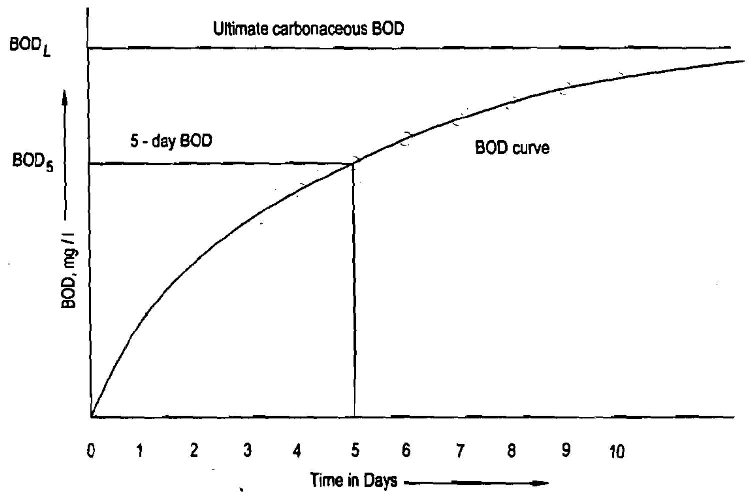

Figure 4.5 : BOD Increases over Time until all the Organic (carbonaceous) Pollutants are Stabilised

However, with the passage of time carbonaceous matter gets consumed; and, then another group of bacteria (nitrifying bacteria) becomes active. This group thrives on the noncarbonaceous ammonia (NH_3), that may be present in waste water, and metabolizes it for energy – this process is known as nitrification, in which NH_3 gets converted into the more stable foms of nitrogen : nitrite (NO_2), nitrate (NO_3). During this process, the nitrifying bacteria consume additional quality of oxygen; thus, there is registered a rise BOD curve after first 8 to 10 days of decomposition (Figure 4.6). The oxygen demand exerted by the nitrogenous matter is called nitrogenous biochemical oxygen demand (NBOD).

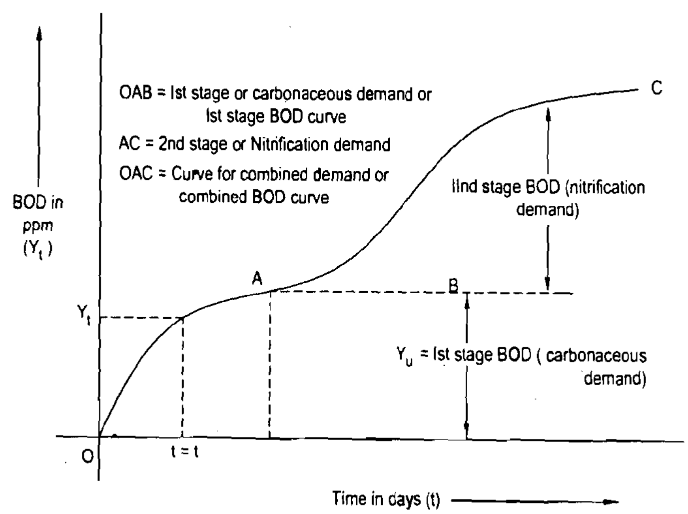

Figure 4.6 : A Typical Complete BOD Curve Showing the Delayed Effect of Nitrification

Nitrification is brought about by two different types of bacteria and is a two-stage process. Ammonia is converted to nitrite by bacteria *nitromonous* and nitrite is converted to nitrate by bacteria *nitrobacter*.

The total nitrification can be expressed by the following chemical equation :

$$NH_3 + 2O_2 \rightarrow NO_3^- + H^+ + H_2O$$

Expressing NH_3 in terms of Nitrogen (N), the nitrogenous oxygen demand will be,

$$\frac{64}{14} = 4.57 \text{ mg of } O_2 \text{ per mg of N}$$

4.3.3 Limitations of BOD Test

Determination of BOD, a very important parameter for assessing the quality of water, has, however, some limitations, such as :

(1) The seed may be necessary to be introduced in the dilution water,

(2) Pretreatment is necessary, vis-a-vis, toxic wastes,

(3) Measures only the biodegradable organic matter,

(4) The test is not valid once the soluble organic matter is used up, and

(5) Testing takes a long time.

4.3.4 Chemical Oxygen Demand (COD)

All forms of organic matter are not biodegradable. Organic matter, such as, phenols, and benzene are nonbiodegradable because they are toxic to microorganisms. We know that the BOD test provides a measure of the biodegradable organic material in water – i.e., those substances that microbes readily use for food. However, nonbiodegradable or slowly biodegradable substances would not be detected by the conventional BOD test.

There is another test – chemical oxygen demand (COD) test – that measures all organics (i.e., including nonbiodegradable substances as well) present in water. Therefore, obviously, that for a given sample of water (or even sewage) the COD value is higher than its BOD value. It is a chemical test using a strong oxidizing agent (potassium dichromate), sulphuric acid, and heat for its completion. Precautionary measures are necessary to eliminate the reflection of oxygen demand exerted by inorganic matter. For, easily biodegradable matter both COD and BOD values may be quite identical. The results of the COD test can be available in just an average of 2 hours (varying from 3 to 4 hours) – a sure advantages over the 5 day period required for the results of standard BOD that to be available.

It may be mentioned that there is, as a rule, no meaningful correlation between BOD and COD values for different waters. Most waste water treatment plants are biological in their mode of operation – so BOD is more representative in this context. However, for some types of wastes, a relationship between COD and BOD could be established.

It is pertinent to the following limitations of COD test :

(1) It does not give the estimation of the organic matter which is biodegradable, and

(2) It does not give the rate at which biodegradation will take place.

4.4 WASTE WATER CHARACTERISTICS

Waste water can broadly be classified into domestic and industrial waste. The characteristics of domestic waste water will differ depending on the raw materials used, and other related factors. However, the characteristics waste water produced from identical industries will be comparable.

The important contaminants (pollutants) found in waste water can, however, be listed as given below :

(1) **Suspended Solids (SS)**

The SS are responsible for sludge deposits in water bodies, and the development of subsequent anaerobic conditions.

(2) **Biodegradable Organic Matter**

This matter, as we know, exerts oxygen demand, and results in the depletion of dissolved oxygen present in the receiving waters.

(3) **Pathogens**

They are responsible for many communicable water related diseases.

(4) **Nutrients**

Nutrients, especially nitrogen and phosphorous are responsible for the eutrophication of water bodies.

(5) **Priority Pollutants**

Some organic and inorganic compounds are suspected calcinogens, mutigens or highly toxic.

(6) **Refractory Organics**

These organics are highly resistant to biodegradation and require specific treatment for their removal. Some of the refractory organics found in waste water include detergents and pesticides.

(7) **Heavy Metals**

Heavy metals enter the waste water from industrial activities and are to be recovered or removed if the waste water is to be reused.

(8) **Dissolved Solids**

The dissolved inorganic salts are added in waste water due to domestic use of water, and are to be removed for possible reuse of waste water.

Typical composition of the domestic waste water is given in Table 4.1.

Table 4.1 : Typical Composition of Domestic Waste Water

Sl. No.	Pollutants	Concentration
1.	Total Solids (mg/l)	900
	Total dissolved solids (TDS) – mg/l	500
	Suspended solids (mg/l)	400
2.	Biochemical oxygen demand (BOD_5 – at 20°C (mg/l)	250
3.	Total Organic Carbon (TOC) – mg/l	180
4.	Chemical oxygen demad (COD) – mg/l	550
5.	Total Nitrogen (N) – mg/l	45
6.	Total Phosphorous (P) – mg/l	10
7.	Chlorides (mg/l)	100
8.	Sulphate (mg/l)	40
9.	Alkalinity – (mg/l)	100
10.	Grease + Oil – mg/l	100

SAQ 2

(a) Mention the parameters used for the estimation of organic pollution in water.

(b) Why COD is always higher than BOD for the same waste water sample?

(c) Distinguish between first-stage BOD and second-stage BOD.

(d) Enlist the major pollutants that could be present in waste water.

4.5 EFFECTS OF WATER POLLUTION

In early days, while population was limited and industrial activity was within limits, the water bodies, like rivers, streams and lakes were in good sanitary condition, and pollution posed no challenges. This was due to the assimilative capacity of the water bodies (the natural purifying processes) taking care of whatever pollution load found its way into them.

The situation now in the present times has changed considerably, and the pollution load has increased due to population explosions and industrialization. The natural assimilative capacity of water bodies now falls short of taking care of the pollution load, and thus gradually the pollution load in water bodies is increasing. Most of the rivers now are polluted to varying degrees. The water pollution has adverse impact on human health and environment. The effects can briefly be listed as under :

(1) Pathogens, toxic substances and other chemicals found in water are responsible for health hazards faced by the modern man. Some diseases are caused by consuming polluted water, while some are due to coming in contact with contaminated water.

(2) The polluted water also adversely affects the flora and fauna in the aquatic system causing ecological disturbance. As a result of DO depletion due to stabilization of organic matter, the fish life is adversely affected and in extreme cases the fish life may not at all sustain itself. Nitrates are responsible for health hazard in infants, whereas flouride causes fluorosis.

Chlorination of water or waste water containing phenolic compounds may give rise to chlorinated biphenyl which are suspected carcinogens.

(3) The polluted water can also damage the property : highly acidic or alkaline waste water can have corrosive effect on the foundation of any structure. Equipment and the pipe systems which pass the polluted water get corroded in due course of time.

(4) The major source of raw water for supply to the community is the river. If the river water is polluted, the cost of treatment for such raw water is enhanced. The cleaning operations for the polluted river are very costly propositions.

4.6 WATER RELATED DISEASES

There are a number of diseases that are caused due to the contaminated water. Some diseases, out of these, as said above, are due to the ingestion (or consumption) of polluted water, whereas others are due to contact with the polluted water. In some instances the pathogens may be spending part of their life cycle in water or in the intermediate host living in river waters. There are also some diseases which are spread due to insects which breed bacteria, and viruses, may spread by protozoa or worms.

The water related diseases are thus classified as under :

(1) **Water-borne Diseases**

These diseases are caused by the consumption of water contaminated by human faeces or urine. Cholera, infectious hepatitis, leptospirsis, typhoid, etc. are typical waterborne diseases.

Other diseases caused by bacteria, viruses, protozoa, and helminthes may also be transmitted by contaminated drinking water.

(2) **Water-washed Diseases**

Water-washed diseases refer to those ailments which are closely related to poor hygiene and inadequate sanitation, and may not prove fatal but reduce one's efficiency. However, the availability of a sufficient quantity of water, in this is taken to be more essential than the quality of water used. Lack of water for washing and bathing contributes to diseases affecting the eyes and skin, and includes infectious conjunctivities, trachoma, bacterial ulcers, scabies, diarrheal diseases, amoebia or bacillary dysentery, and gastroenteritis. It may be pointed out that when enough water is available for maintaining personal hygiene, the incidence of diarrheal diseases seem to decrease, as has the prevalence of enteric pathogens such as *Shigella.*

(3) **Water-based Diseases**

Water-based diseases are caused by pathogens that either spend all (or essential periods) of their lives in water, or depend upon aquatic organisms for the completion of their life cycles.

These diseases, as such, cannot occur by the consumption or contact with contaminated water. Most of such diseases are due to worms which produce eggs and these eggs are discharged alongwith their faeces or urine. In some instances tl infection is caused by the penetration into the skin by these worms and not by consumption. Schistosomiasis, Legionnaires' disease, and Guinea worm disease are water-based ailments.

(4) **Water-related Insect Vector**

Water-related diseases, such as yellow fever, dengue, filariasis, malaria, onchocerciasis, and sleeping sickness, are transmitted by insects that breed in water (mosquitoes), or live near water (flies that transmitted filarial infection, onchocerciasis). All these insects are called *vectors.*

SAQ 3

(a) Briefly discuss the impacts of water pollution.

(b) Explain the classification of water related diseases.

(c) Why are waterborne diseases still a problem in India and developing countries?

4.7 RISK ASSESSMENT

Risk to any life form is a part of everyday human (and sub-human) existence; and it is therefore a crucial factor while taking relevant decisions. Concept of measuring a given risk can best be expressed in terms of probability.

Once the health-related risks are identified, various options have to be evaluated within the framework of risk management process. One important component of risk management is risk communicaiton – i.e., the interactive process of information and opinion exchange among individuals, groups, and intitutions. Risk communication necessarily includes the transfer of information from expert to non expert audiences. Application of risk assessment includes the following functions :

(i) Setting standards for concentrations of toxic chemicals or pathogens in water (and/or food).

(ii) Carrying out analyses of contaminated sources / facilities in order to identify the required remedial action.

(iii) Evaluating conventional as well as innovative technologies with a view to prevent and control the hazard.

(iv) Inducing the articulation of community public health concerns, and developing consistent public health expectations among different localities.

In fact, risk assessment is a continuous process, because water pollution is an inevitable consequence of industrialisation as well as population explosion. In this, context 'pollution in the 21st century' must draw the serious attention of man towards devising simpler, better, quicker, and more reliable ways of risk assessment.

4.8 SUMMARY

Although water is the very elixir of life, but, once having got polluted, it begins gaining the ominous potential to cause ill health, and even death depending upon the severity of contamination. Water pollutants range from organics, pathogens, nonorganic substances, to radioactive matter. Organics are oxygen demanding substances that deplete oxygen from water bodies. Pathogens cause disease while nutrients induce a luxuriant growth of aquatic life and lead to eutrophication that reduces the secreational value, etc. of a water body. Salts, heavy metals, refractory organics, volatile organic compounds, heated water discharge, and radioactive substances also pose health hazards – each of its own way.

Determination of BOD value of water equips us with an important parameter to define the quality of a given water sample with regard to biodegradable matter present therein, while the COD value gives us a measure of both biodegradable and non-biodegradable matter (taken together) present in water.