UNIT 10 OVERVIEW OF PURIFICATION AND PRE-TREATMENT

Structure

10.1 INTRODUCTION

Absolutely pure water is rarely found in nature. Impurities occur in three progressively finer states–suspended, colloidal and dissolved. Different methods of treatment are required for their removal or reduction to acceptable limits.

It has been discussed in earlier units that in many situations, it is necessary to alter the composition of raw water. In most of cases, more than one treatment process is needed to achieve the desired change in quality so that treatment plants usually consist of a chain of processes, which operate in sequence. Each process has a particular area of applicability and it is important that the processes are selected in relation to the nature of the impurities to be removed and the required output quality. It is to be appreciated that most treatment processes do not usually destroy the impurities, which they remove from the liquid phase but simply concentrate them in the form of a sludge or effluent stream. This unit describes the types of impurities, which need to be removed from water and outlines the main forms of treatment, which are available. The unit describes in detail the fundamental principles of the main physical treatment processes.

Objectives

After studying this unit, you should be able to

- list different types of treatment required for raw water,
- sketch process configurations for different kind of pre-treatments,
- describe the acceptable quality of raw water for treatment,
- define pre-treatment and list various treatments that are included in pre-treatment.

10.2 NATURE OF IMPURITIES IN WATER

As already pointed out, pure water does not exist in nature so that all water is contaminated to some degree. It is, thus, possible to consider rain water, surface water, ground water and sea-water as different forms of the same basic material but with varying forms and amounts of impurities. These impurities in water may be classified as :

i) Floating small and large suspended solids e.g. leaves, twigs, micro-organisms etc.

ii) Colloidal Solids–Clay, silt, micro-organisms

iii) Dissolved solids–Salts, hardness and some organics

iv) Dissolved gases–Carbon-dioxide, hydrogen sulphide etc.

Classification of impurities in water may be done as in Figure 10.1.

In a number of situations, it becomes necessary to add substances as part of the treatment process e.g. coagulants for removal of turbidity, oxygen for biological oxidation, chlorine for disinfection.

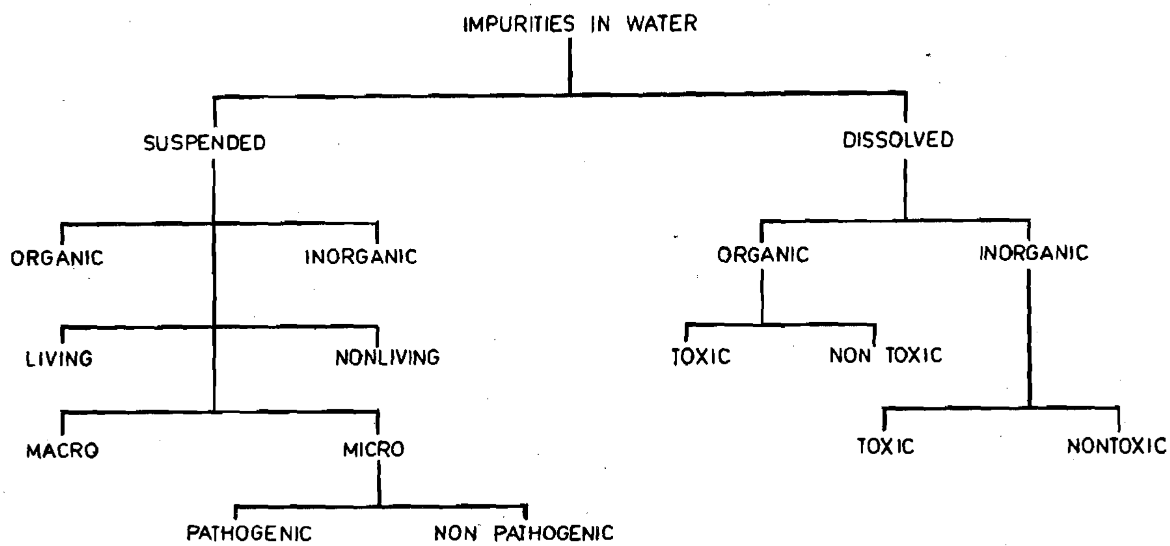

Figure 10.1 : Classification of Impurities in Water

10.3 TYPES OF TREATMENT

Treatment process of water can be divided into three main classes governed by their main principle of operation and the prevailing quality characteristics of the water.

10.3.1 Physical Treatment Processes

Depend mainly on purely physical characteristics of the impurities to be removed. Characteristics such as size, density, viscosity, solubility are of importance in physical treatment operations. The chemical nature of the impurities and whether they are living organisms or inanimate objects are not relevant in physical treatment.

Treatments, which are physical in nature include :

a) Screening and straining

b) Sedimentation

c) Flocculation

d) Filtration

e) Gas Transfer

10.3.2 Chemical Treatment Processes

These processes depend on the chemical properties of the impurities, chemical reagents are added to remove the impurities. They include :

a) Adsorption

b) Coagulation

c) Ion Exchange

d) Precipitation

10.3.3 Biological Treatment

Biological treatment utilises biological activity to stabilise or remove impurities and they are particularly, useful for the removal of organic impurities. Biological processes may be aerobic, anaerobic or facultative and are mostly done to purify waste waters. They include :

a) Dispersed growth system–activated sludge, oxidation ponds.

b) Fixed film systems–biological filter.

In practice, there are several processes, which combine various modes of operation although one may predominate. For example, in the filtration of water through a bed of sand, the processes involved include, physical straining, sedimentation, chemical and molecular attraction reactions, and some biological activity. Adsorption, which is increasingly employed to remove trace of organics from potable water is a process, which involves both physical and chemical activities.

In many cases of water treatment, it is necessary to use several processes in sequence to achieve the desired natural quality. Physical processes like screening and straining often form first stage of the treatment chain and these are frequently followed by further physical or chemical processes for water treatment. Figure 10.2 shows some typical process chains for a number of situations.

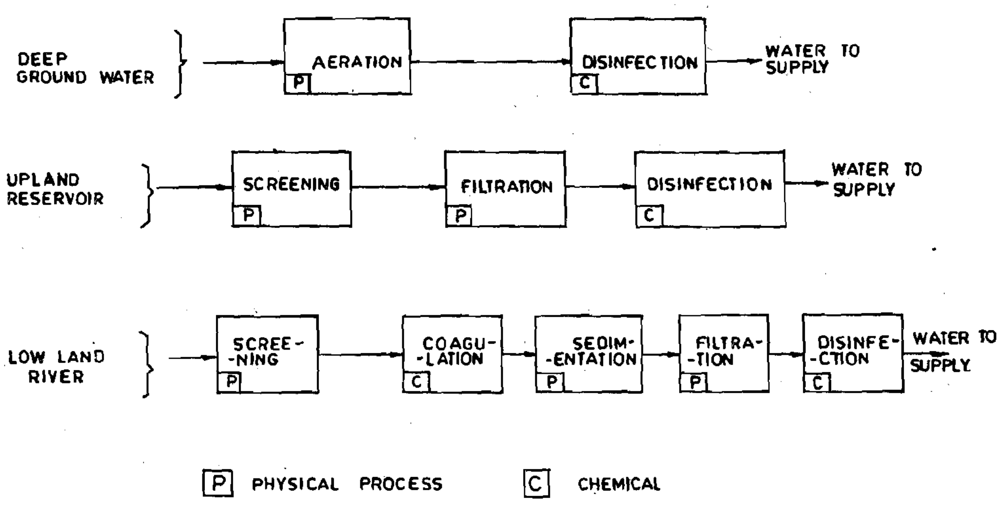

Figure 10.2 : Typical Water Treatment Processes

10.3.4 Process Configuration

Although some processes can be used in a batch mode, most treatment operations take place in a continuous mode, possibly with intermittent pauses for cleaning.

Continuous operation is more cost effective than batch operation, but it requires careful design and control to ensure reliable treatment. Most treatment operations require a finite **residence time** in the unit for the appropriate action to occur and thus, tanks or other reactors must be designed to provide this **retention period.** The hydraulic characteristics of a tank can be determined by injecting a chemical dye or other suitable tracer, into the inlet and then observing its appearance in the output. The flow through curves so obtained as indicated in Figure 10.3 can range between the two extremes of **plug flow** and complete mixing. **Plug flow** is difficult to achieve in practice and most simple tanks exhibit flow through curves, which are a combination of the two extreme patterns. Short circuiting due to density currents and mixing due to hydraulic turbulence produce a peak earlier than would be expected in an ideal plug flow system. The actual **retention time** is thus often significantly less than that calculated by dividing the volume of the tank by the rate of flow through it. This aspect can be important for processes in which time is an important parameter as in sedimentation and disinfection.

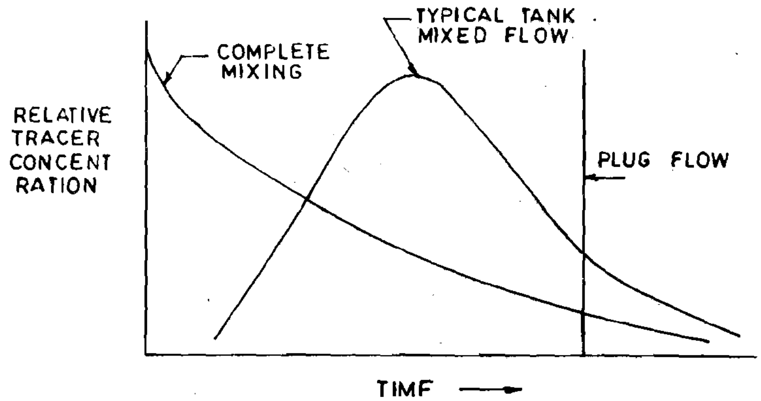

Figure 10.3 : Residence Time Characteristics

SAQ 1

What are the different type of impurities in raw water to be used for drinking purpose? How these impurities are removed?

10.4 PERMISSIBLE QUALITY OF RAW WATER

There is no limit to the degree of turbidity, which might be encountered in rivers in certain parts of the world. Suspended solids to the extent of 70,000 mg/l have been found in certain river of the world.

Table 10.1 shows typical figures observed during floods on some of the rivers. Such values may be expected to occur frequently but do not represent the worst ever recorded. It is to be noted that no basin can continue to work at its full design rate and deliver water with a maximum turbidity never exceeding 25 Jackson Turbidity Units (JTUs) and normally of 2.5 JTUs irrespective of the condition of the raw water. It is sometimes possible to slow down the rate of working and thus, effectively decrease the overflow velocity to give the basin a better chance. No river should be rejected because of a high silt load. It is simply a matter of installing basins big enough or go for pre-treatment.

Table 10.1 : Suspended Solids in Some Rivers

River	Dry Silt by Weight (mg/l)
River Irrawady	10,000
River Nile	5,000
River Hooghly	3,600
River Jamuna	4,000

The presence of harmful bacteria in raw water is more serious than silt. Although any water can be purified, the risk to public health and the cost involved put, practical limits on the pollution considered to be acceptable. The degree of pollution of water is judged from certain items in the chemical and bacteriological analysis. Table 10.2 gives an idea of common standards.

Table 10.2 : Raw Water Quality (Based on ASCE Standards)

	Excellent Source	Good Source	Poor Source	Rejectable Source
Average BOD(5 days) mg/l	0.75 – 1.5	1.5 – 2.5	2.5 – 4	> 4
Max. BOD in any one sample, mg/l	1 – 3	3 – 4	4 – 6	> 6
Average Coliform, most probable number (MPN) per 100 ml	50 – 100	100 – 5000	5000 – 20000	> 20000
Max. Coliform, MPN per 100 ml	< 5 % of samples > 100	< 20 % of samples > 5000	<5% of samples > 20000	–
pH	6 – 8.5	5 – 6 8.5 – 9	3.8 – 5 9 – 10.3	< 3.8 > 10.3
Chlorides, mg/l	< 50	50 – 250	250 – 600	> 600
Fluorides, mg/l	< 1.5	1.5 – 3	> 3	–

Permissible Suspended Solids

For a treatment plant to be fully effective, the following limits should not exceed : Raw water in river-suspended solids concentration can be anything but should preferably be less than 1000 mg/l, if it habitually exceeds 1000 mg/l, a pre-settlement tank will be preferable.

At outlet from pre-settlement tanks–suspended solids less than 1000 mg/l. At outlet from main settling basins–turbidity should be 2-5 JTUs in extreme cases 25 NTUs. At outlet from filters–turbidity < 1 JTU.

SAQ 2

What are acceptable range of impurities which in raw water? What are the different range of these impurities, which will make a source rejectable?

10.5 REQUIRED TREATMENTS

In actual practice a water treatment plant works as shown in Figure 10.4. As discussed earlier, a treatment plant consists of processes–screening, coagulation, flocculation, sedimentation, filtration and sterilization. Although each of them is intended to perform, one main function yet it may, partially, assist with some other. The impurities are removed in order of their sizes–the bigger ones being eliminated first. Since every water does not contain all the impurities, hence all the treatments are not required for every kind of water. The impurities are removed in following orders :

a) Floating objects by screening

b) Algae (if present) by straining

c) Excessive iron, manganese and hardness in solution by precipitation in basins after addition of chemicals.

d) Normal suspended solids by settling

e) Remaining fines and some bacteria by filtration

f) Excessive bacterial pollution by pre-chlorination

g) Final bacteria surviving filtration by chlorination

Settling basins and filters form the basis of all treatment plants and in view of their widespread use, it is to be seen whether they can be omitted in any circumstances. They are to be provided in all cases except the following :

i) A naturally clear ground water, which contains no iron, manganese or hardness in solution needs neither basins not filters.

ii) A reservoir or lake derived water of low colour with a turbidity less than 30 JTU, the final treatment of which is on slow sand filters.

iii) A reservoir or lake water of turbidity never exceeding 26 JTU, the final treatment of which is on rapid sand filters.

iv) Any water with turbidity never exceeding 50 JTU and habitually having turbidity of 5-10 JTU for which multi-layer filters are preferable and basins not required.

v) A clear but hard water being softened by the base-exchange process

vi) A clear water with colour, less than 30 mg/l on the platinum-cobalt scale.

Settling basins should be regarded as highly probable on all river abstraction schemes and all lime softening and iron and manganese removal plants.

Table 10.3 : Details of Treatment Applicable in Different Cases

Item	Coarse Screen	Fine Screen	Microstrainers	Pre-chlorination	Raw Water Storage	Preliminary Settlement	Aeration	Flocculation	Coagulations & Settling	Rapid filtration	Mixed media filtration	Slow sand filters	Post-chlorination	Super-chlorination & dechlorination	Lime/soda softening	Activated Carbon	Special aids	Deslating
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Floating Debris	E	E	O	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Algae	—	—	O	O	—	—	—	—	E	E	—	O	—	—	—	—	—	—

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Turbidity																		
0-5 JTU	—	—	—	—	—	—	—	—	O	O	—	—	E	—	—	—	—	—
5-30 JTU	O	O	—	—	—	—	—	O	E	E	O	O	E	—	—	—	—	—
30-100 JTU	O	O	—	—	—	—	—	O	E	E	O	—	E	—	—	—	O	—
100-750 JTU	O	O	—	—	—	—	—	O	E	E	—	—	E	—	—	—	O	—
750-1000 JTU	O	O	—	—	O	O	—	O	E	E	—	—	E	—	—	—	O	—
>1000 JTU	O	O	—	—	O	E	—	O	E	E	—	—	E	—	—	—	O	—
Colour																		
< 30 Hazen	—	—	—	—	—	—	—	O	O	O	—	—	—	—	—	—	—	—
> 30 Hazen	—	—	—	—	—	—	—	E	E	E	—	—	—	—	—	—	—	—
Taste & Colour	—	—	—	O	—	—	O	—	—	—	—	—	—	—	—	E	—	—
Calcium Carbonate																		
> 200 mg/l	—	—	—	—	—	—	—	—	E	E	—	—	—	—	E	—	—	—
Iron and Manganese																		
< 0.3 mg/l	—	—	—	O	—	—	O	—	—	O	—	—	—	—	—	—	—	—
0.3-1 mg/l	—	—	—	—	—	—	O	—	E	E	—	—	—	—	—	—	—	—
> 1 mg/l	—	—	—	E	—	—	E	—	E	E	—	—	—	—	—	—	O	—
Chlorides																		
0-250 mg/l	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
250-600 mg/l	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	O		
> 600 mg/l	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	E
Coliform Bacteria (MPN per 100 ml)																		
0-20	—	—	—	—	—	—	—	—	—	—	—	—	E	—	—	—	—	—
20-100	—	—	—	—	—	—	—	—	E	E	—	—	E	—	—	—	—	—
100-500	—	—	—	O	—	—	—	—	E	E	—	—	E	—	—	—	—	—
> 500	—	—	—	E	O	O	—	—	E	E	—	—	E	—	—	—	—	—

E = Essential O = Optional

As regards filters, it is accepted that they can be omitted if the turbidity of the water being supplied does not exceed 5 JTU but generally this is not a good practice as most communities require a greater degree of clarification (< 2 JTU). If filters are used, even greater clarity is expected.

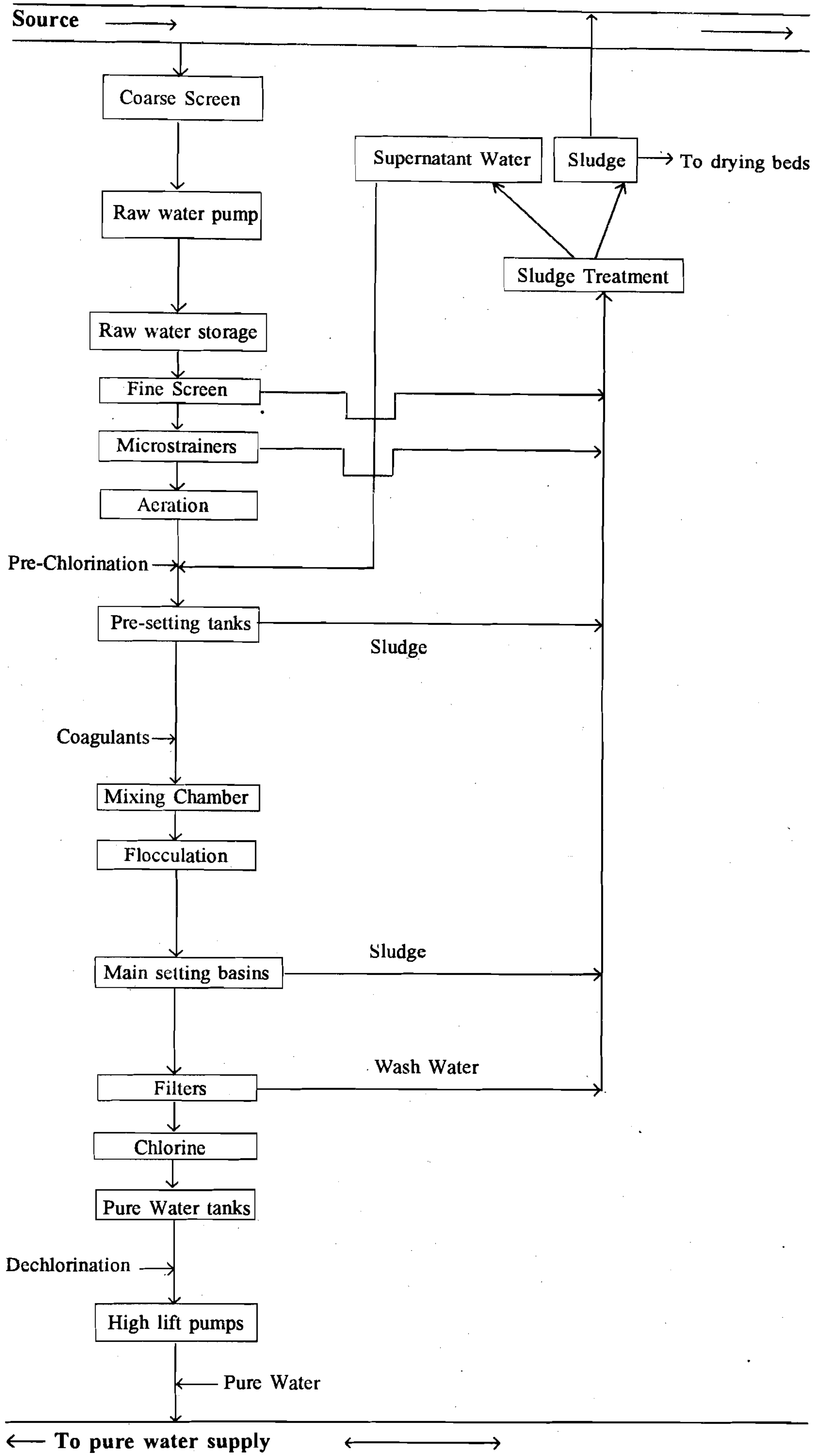

Figure 10.4 : Flow Diagram Showing Different Treatment Stages

Table 10.4 : Functions of Water Treatment Units

Treatment Unit	Function (Removal)
Aeration, use of chemicals	Colour, odour, taste
Chemical methods	Iron, manganese etc.
Coagulation	Suspended matter, a part of colloidal matter and bacterial
Disinfection	Pathogenic bacteria, organic matter and reducing substances
Filtration	Finer and colloidal dissolved matter, bacteria
Screening	Floating matter
Sedimentation	Suspended matter
Softening	Hardness

SAQ 3

a) Match the process with the corresponding impurity removed :

Process	Impurity Removed
i) Screening	a) Larger suspended solids
ii) Aeration	b) Dissolved solids
iii) Filtration	c) Pathogenic microbes
iv) Plain settling	d) Tastes and odour
v) Disinfection	e) Fine suspended solids
vi) Settling plus coagulation	f) Floating suspended solids

b) What are physical and chemical treatments for purification of water for drinking purpose?

10.6 PRE-TREATMENT

Water from river or streams is not pumped directly to the basins. There are some intermediate processes, which collectively are called pre-treatment. They include :

i) Screening

ii) Raw water storage

iii) Pre-chlorination

iv) Aeration

v) Algal control

vi) Preliminary settling

Some of the processes may be required at a particular plant but all are not required at every plant. Each of them perform a particular function, hence, they are provided only when need is there. Otherwise, they can be omitted.

10.6.1 Screens

Intake Screens

Coarse screens are provided at river/stream intakes to prevent floating material of fairly large size entering into the intake. The bars of steel forming screen are normally of about 25 mm dia and are spaced 100 mm apart. The screen is placed at a slight inclination from the vertical to facilitate raking. Sometimes, bars in the form of frames are placed in duplicate so that one of the frames may be lifted for cleaning or repair when required without hampering the process. The bars in the frame are placed such that velocity of water through the screen opening should not exceed 0.5 m/sec.

Fine Screens

Fine screens are normally fitted immediately after the coarse screens. In case of raw water storage is provided, the fine screens are provided at the outlet from the storage reservoir.

The screening is usually undertaken by continuous belt or drum units fitted with a mesh of 4-10 mm. Water jets are used to remove the collected debris. Figure 10.5 shows such an arrangement.

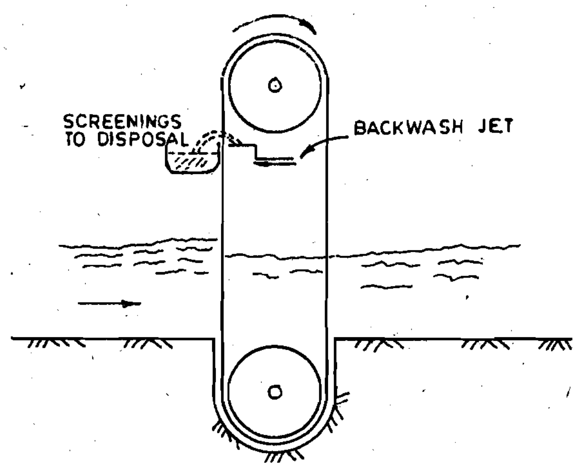

Figure 10.5 : Belt Screen

A development of the drum screen is the screens, which use specially woven stainless steel meshes with aperture sizes of 20-40 mm. These units can provide the physical treatment necessary for a surface water source (Figure 10.6).

Micro-strainer

These are revolving drums of stainless steel wire fabric or other material having very fine mesh. Two of the grades widely in use, are having apertures of 23 microns and 35 microns. Water jets for cleaning the fabric used about 1% of the total quantity of water strained. The loss of head through a micro-strainer varies from 150 to 450 mm and single unit deals with around 45,000 litres/hour to a maximum of 1.35 million litres/hour for a 3 m diameter × 3 m wide drum.

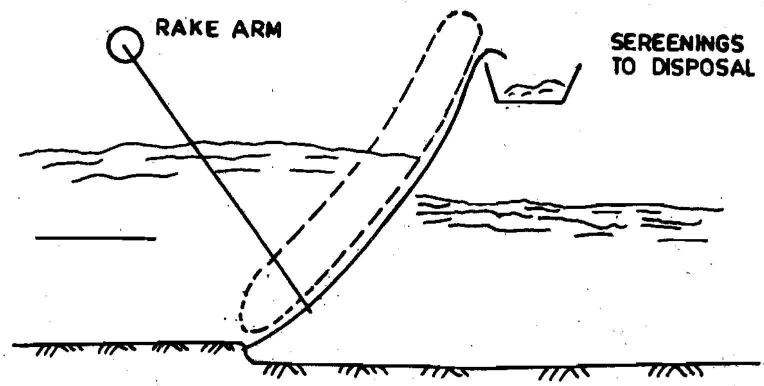

Figure 10.6 : Mechanically Racked Semi-rotary Screen

Micro-strainers are useful for screening stored water, which do not contain a large amount of suspended matter, but contain plankton, algae and other microscopic sized particles. When used in the purification or treatment system, they lighten the load on filters. A micro-straining screen can easily be damaged if more loading is placed upon it. Hence, an alarm system is incorporated to operate when the head across the screen approaches the maximum permissible limit.

The ideal water for a micro-strainer is a lake supply or a large storage reservoir. The ideal position for a micro-strainer is earlier to rapid gravity or slow sand filters whose output is increased by as much as 50%.

10.6.2 Raw Water Storage

This is regarded as a first stage in treatment as it involves a complex combination of physical, chemical and biological changes. Raw water storage has been regarded as an almost essential "first line of defence" against the transmission of water-borne diseases. When water is stored in a reservoir, there is usually a great decrease in the number of bacteria of intestinal origin and the specific organisms of typhoid and other water-borne diseases also disappear. To some extent, this effect is due to sedimentation but the bactericidal action of ultra-violet radiation and of light is of major importance near the surface and there are numerous biotic agencies, which play a major role in reducing the pollution of enteric micro-organisms. But prolonged storage of raw water sometimes causes growth in large numbers of various forms of algae, which increases difficulties in treatment.

In reservoirs, in temperate climates (having a mild temperature without extremes of heat and cold) having depth around 10 m or deep thermal stratification occurs on a seasonal basis. As the water warms up in the spring season, any winter stratification is first overcome and then the water being warmed in the upper part of the reservoir, tends to remain there because of its lower density. Colder water remains in the bottom part of the reservoir. The upper and lower layers are known as epilimnion and hypolimnion respectively. In between these two zones, there lies a zone known as thermocline in which there is steep change in temperature with depth. This thermal stratification is of major importance with reference to water quality and, therefore, in large reservoir, there is usually arrangements for withdrawing water for treatment at several different levels, which is changed as per circumstances.

The maximum water depth may be kept around 15 m whereas vary shallow depth encourages weed growth and should be avoided. The improvement in the raw water quality is noticeable as a result of retention only in the reservoir. Hence, improvement in quality of low grade water is achieved by storage alone. It is recommended that storage provided purely to improve quality should atleast be equivalent to 7-15 days of average water demand. This is sufficient to reduce pathogenic bacteria and river algae. It should also be known that long retention of water encourages development of some organisms. The beneficial effect of storage on water of low quality is shown in Table 10.5.

Table 10.5 : Change in Water Quality Due to Storage

	Raw River Water	Stored Water
Colour (Hazen)	30	5
Turbidity	10	1.5
Chloride as Cl (mg/l)	54	54
Ammonia Cal N (mg/l)	0.3	0.06
Nitrite N (mg/l)	0.1	0.01
Nitrate N (mg/l)	2.0	0.30
BOD (mg/l)	4.5	2.50
Total hardness (mg/l)	430	280
Iron (mg/l)	0.1	—
Presumptive Coli MPN per 100 ml	6500	20
E Coli, MPN per 100 ml	1700	10
Colony Counts (per 1 ml)		
3 days at 20°C	50,000	580
2 days at 37°C	15,000	140

10.6.3 Pre-chlorination

Pre-chlorination refers to the practice of injecting chlorine into the raw water when it is not so turbid but has a high bacteria count. Fairly high dose of chlorine (2-5 mg/l) is used. During the lengthy period spent by water in the settling basins, this oxidizes and precipitates iron and manganese if present in water. Pre-chlorination also kills algae and bacteria, reduces colour and slime formation and asists in settlement. If excessive silt is present in suspension, pre-chlorine is not so effective because silt absorbs chlorine without settling. Hence, in case of heavily turbid water, it is not very effective. In case of clear ground water with high ammonia content, it is effective.

A drawback of using pre-chlorination is that raw water has a high chlorine demand and more quantity of chlorine is absorbed than in later chlorination, to effect the same degree of sterilisation. It is not a substitute for post chlorination. It is most advantageous when extremely polluted clear raw water has to be used.

10.6.4 Aeration

Aeration is the process of providing oxygen from the atmosphere to effect beneficial changes in the raw water. Due to aeration undesirable gases such as carbon dioxide and hydrogen sulphide, is liberated. The absorption and release of gases in water is a slow process hence, water is agitated or a great water area is exposed to the atmosphere. This is done by splashing water over trays to break up the stream into countless droplets or by reversing the effect and blowing air bubbles through water.

Gases are absorbed or liberated from water until equilibrium is reached between the natural content of each gas in the atmosphere and its content in the water. Therefore, if water is lacking in dissolved oxygen, it will pick it up from air and its taste and appearance improves. If it has an excess of carbon dioxide or hydrogen sulphide, it will tend to lose them. Therefore, aeration is a cheap and valuable means of controlling tastes, odours and corrosion but in all cases complete control, may not be achieved. Aeration is found to be necessary, if any of the following conditions are present in a raw water :

i) hydrogen sulphide (causing bad taste and odours)

ii) carbon dioxide (causing corrosive tendencies)

iii) tastes due to algal growth (caused by volatile oil release)

iv) iron and manganese in solution

v) de-aeration.

Hydrogen sulphide is often found in water from the lower depths of an impounding reservoir. Certain volatile substances liberated by algal growths or decomposing organic matter can be released from water by aeration but this is one step in dealing with algal problems.

Types of Aerators

Aeration is effected by specially designed nozzles, which direct thin jets of water against metal plates to produce a fine spray which exposes countless droplets of the water to the atmosphere. Nozzle type aerators are very efficient and are commonly used in the removal of carbon dioxide and iron. The nozzles are 2.5 to 4 cm dia and discharge about 5 to 10 l/sec. To aerate 10,000 m^3/day about 20 nozzles are arranged within an area of 25 m^2. The area where sprays are working is sheltered by louvers set in surrounding wall.

Tray type aerators consist of about five perforated trays increasing in size from top to bottom. The water falls from tray to tray through a total depth of 2-3 m and splashes on through and off the tray 5 to 6 times. The total area of the trays in relation to the flow is generally about 0.1 m^2 per m^3/l. This type of aerator is apt to encourage growth of algae and other life in warmer climates. The method is simple and cheap and more widely used (Figure 10.7)

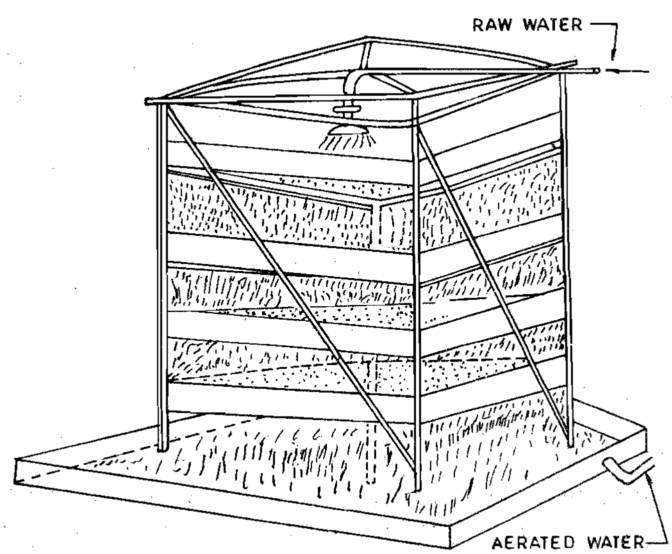

Figure 10.7 : An Aerator

Diffused air aerators consist of tanks in which air is bubbled upwards from diffuser pipe laid on the floor. The air holes in the diffuser pipes are sufficiently fine and are numerous in number to promote a cloud of small bubbles. This type of aerator is efficient because bubbles tend to attain a constant terminal velocity whereas falling droplets tend to accelerate and, therefore, for a given depth the air water contact in a diffused air plant is longer. The amount of air used can also be regulated as per need. Aeration tanks are commonly about 4 m deep and have a retention time of about 15 minutes. The air blower delivers about same amount of air in any given time at a pressure of 0.35 kg/cm^2. For 10,000 m^3/day an air blower of about 5 HP is needed.

Cascade type aerators depend on the turbulence created in a thin stream of water flowing swiftly down an incline and impinging against fixed obstacle. The surface area of liquid exposed is rather limited and there is a loss of efficiency.

Although sprays are most effective but they are expensive whereas trays type are cheap and simple hence, most widely used. Some of the common methods in addition to tray type have been shown in Figure 10.8. Although claims are made of increased efficiency for a variety of aerators, most system fall within the range of 1.5 - 2.5 kg. Oxygen/kWH. Devices, which produce small droplets of air or water have higher efficiency. When using aeration to remove volatile organics from water, packed towers are often employed with the height type of packing and air/water ratios being dependent upon the compound to be removed. For some volatile organic compounds air/water ratio may be 25:1 or higher aid for very soluble substances like ammonia, air/water ratio may need to be 1000:1 or even higher.

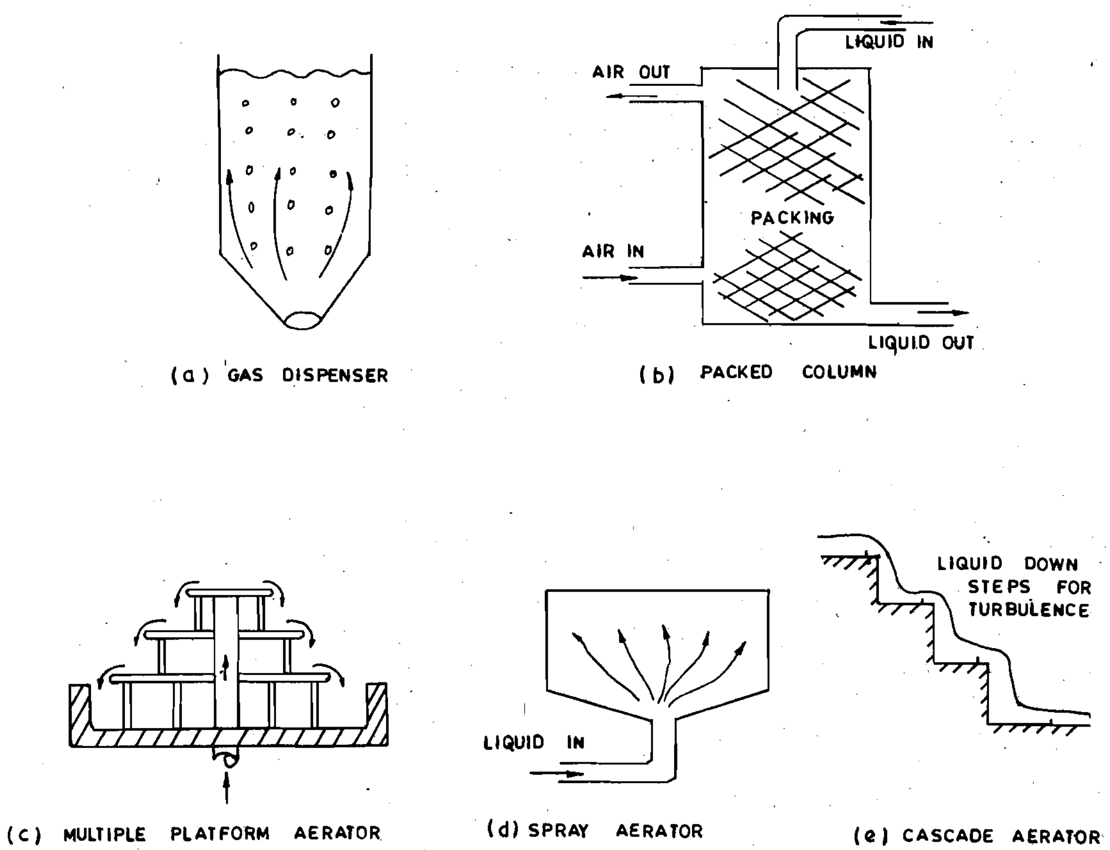

Figure 10.8 : Water Treatment Aeration Devices

Aeration should be used only to a limited extend because excess of absorbed oxygen makes water corrosive and de-aeration may be required. Deaeration is carried out by allowing the water to trickle down through gravel layers in a closed vessel at a pressure of about 1/30th of an atmosphere. Dissolved oxygen is also removed by chemical methods.

10.6.5 Algal Control

As discussed earlier algae are minute organisms classified as plants and proliferate in rivers and reservoirs. The building of an impounding reservoir on an unclear stream encourages their growth, mostly in the upper layers of water. Fairly alkaline water containing more concentration of nitrates and phosphates are prone to algal growth.

Algae tend to float and are not easy to remove by means of settling basins. The best way to kill algae is by pre-chlorination before reaching the basins with a dose of 1 mg/l where organisms are more, a heavier dose of copper sulphate (2 mg/l) or chlorine (3-5 mg/l) may be necessary and again this high dose has to be removed before water is allowed to use. Strainers are widely used to remove algae either in the form of rapid sand filters running without coagulants or as micro-strainers. Micro-strainers are also effective if water is silt free and have been found to reduce the algae problems to the extent of 80% to 90%.

10.6.6 Pre-settlement Basins

They are included in the treatment system to reduce the silt load on basins, which are difficult to clean. The requirement for pre-settlement basins are there where water reaching main settling basins, has suspended solids concentration more than 1000 mg/l by dry weight. Although 3 hours detention period is more than sufficient, pre-settlement basins with 1 hour detention period have been found to be effective.

SAQ 4

What is pre-treatment?

10.7 SUMMARY

In this unit, you have learnt about nature of impurities in raw water. Impurities coming under physical, chemical and biological categories have also been discussed. Flow diagrams show the treatments to be followed in sequences.

Treatments comings under pre-treatment categories also have been highlighted. All types of pre-treatment may not be required for a particular raw water. Depending upon need, a particular pre-treatment may be adopted.

10.8 KEY WORDS

Colloids : Suspended matter in a particular finely divided state. The dividing line between coarse dispersed material and colloids in where the particles are just visible under an ordinary microscope, having diameters of less than about 1 ml. Colloids carry small negative electrical charges, which in relation to their weight are large enough for the particles to repel each other and remain in suspension.

FTU	:	Formazin Turbidity Unit.
JTU	:	Jackson Turbidity Unit
NTU	:	Naphelometric Turbidity Unit
Pollution	:	Pollution (in case of water) means the presence of any foreign substances (organic, inorganic, biological) in water which tend to lower its quality to a point that it becomes a health hazard.
STU	:	Standard Turbidity Unit. The Standard Turbidity Unit is that which is produced by a milligram of finely divided silica in 1 litre of distilled water.
Raw Water	:	Water in its untreated state as it enters the treatment plant (a pre-treatment) plant.

10.9 ANSWERS TO SAQs

SAQ 1

Raw water impurities can be classified in following four categories :

i) Floating small and large suspended solids such as leaves, twigs, micro-organism etc.

ii) Colloidal solids–clay, silt, micro-organisms

iii) Dissolved solids–salts, hardness and some organic materials

iv) Dissolved gases–carbondioxide, hydrogen sulphide etc.

Floating solids are removed by screening colloidal solids by sedimentation and flocculation, dissolved solids by filtration and precipitation and dissolved gases by aeration. Sometimes fine solids are removed during filtration process. Treatments mainly are classified in three main categories–

i) Physical,

ii) Chemical, and

iii) Biological.

SAQ 2

Items	Excellent Source	Rejectable Source
Average BOD(mg/l)	0.75 - 1.5	> 4
Maximum BOD in any one sample (mg/l)	1.3	> 6
Average coliform (MPN per 100 ml)	50 – 100	> 20,000
Maximum coliform (MPN per 100 ml)	< 5% of Sample > 100	—
pH	6 – 8.5	< 3.8 > 10.3
Chlorides, (mg/l)	< 50	< 600
Fluorides (mg/l)	< 1.5	< 4

For more details, refer Table 10.2.

SAQ 3

a)

Process	Impurity Removed
Screening	Floating Solids
Aeration	Taste and Odour
Filtration	Dissolved solids
Plain settling	Larger suspended solids
Disinfection	Pathogenic Microbes
Settling plus coagulation	Fine suspended solids

b) Treatments which are physical in nature include–

i) Screening and straining

ii) Sedimentation

iii) Flocculation

iv) Filtration

v) Gas Transfer such as aeration

Chemical treatment processes include–

i) Absorption

ii) Coagulation

iii) Ion Exchange

iv) Precipitation

SAQ 4

To reduce the load on main purification units such as sedimentation tanks, filter etc. water from river or streams is not pumped directly. There are some intermediate processes, which collectively are called pre-treatment. They include

i) Screening

ii) Raw water storage

iii) Pre-chlorination

iv) Aeration

v) Algae control

vi) Pre-settlement basins

All of them may not be required for each case. Depending upon type of impurities some of them may be required. For example, if raw water storage has been provided, pre-settlement basins only can be provided when silt content is quite high. After filtration chlorination is done for disinfection and after filtration if chlorination is used, chlorine consumption will be less, however, in case of high organic content or biological content sometimes pre-chlorination is resorted to. For more details, refer Section 10.6.