WATER QUALITY AND TREATMENT

The water required for public water supply scheme should be potable or wholesome water i.e. fit for drinking purposes. It is however not essential to have physically or chemically pure water. The presence of some minerals in water is required to give some taste to the water i.e. to make it palatable and they also assist in food assimilation. It will be difficult, time consuming and costly to have complete purification of the water.

WATER QUALITY AND TREATMENT

The impurities in water are to be removed to a certain extent only so that it does not prove harmful to the public health. The term *wholesome* water is used to indicate the water which is not chemically pure, but does not contain anything harmful to the human body i.e. the water in which there are no pathogenic bacteria, no toxic substances and no excessive organic matter. The term *pure* water is a relative term and it has to be interpreted in relation to the use of water.

Water Quality Parameters and Standards

The standards of water quality parameter depend on the purposes of use. These parameters are briefly described as below:

Turbidity: The term turbidity is applied to water containing suspended matter that interferes with the passage of light through the water or in which visual depth is restricted. The turbidity may be caused by a wide variety of suspended materials which range in size from colloidal to coarse dispersions, depending upon the degree of turbulence. Because of the wide variety of materials that cause turbidity in natural waters, it has been necessary to use an arbitrary standard. The standard chosen was 1 mg of SiO_2 in 1 liter distilled water and the silica used must meet certain specifications as to particle size. Now, 1 unit of turbidity = 1 mg SiO_2/L.

Water Quality Parameters and Standards

Total dissolved solids (TDS): Total dissolved solids comprise inorganic salts and small amount of organic matter. The common dissolved mineral salts are claimed to affect the taste, hardness, corrosion and encrustation. Dissolved inorganic substances may exert adverse effects on aquatic animals and plants and may cause irrigation problem. The amount of dissolved solid present in water is an important consideration in its suitability for domestic use. In general, water with a total solids content of less than 500 mg/l is most desirable for such purposes.

Water Quality Parameters and Standards

Depending on the TDS water is often classified as follows:

Excellent	TDS < 300 mg/l
Good	300 – 600 mg/l
Fair	600 – 900 mg/l
Poor	900 – 1200 mg/l
Unacceptable	TDS > 1200 mg/l

Water Quality Parameters and Standards

Colour:

Water become coloured due to addition of various suspended matter in water. Tannins, acid and humates, from the decomposition of lignin, are considered to be the principal colour bodies. Iron is sometimes present as ferric humate and produces a colour of high potency. Colour caused by suspended matter is referred to as apparent colour and is differentiated from colour due to vegetable or organic extracts that are colloidal and which is called true colour. In water analysis it is important to differentiate between “apparent” and “true” colour.

Colour:

Waters containing natural colour are yellow-brownish in appearance. Through experience, it has been found that solution of potassium chloroplatinate ($K_2 Pt Cl_6$) tinted with small amounts of cobalt chloride yield colours that are very much like the natural colours. The colour produced by 1 mg/L of platinum (as $K_2 Pt Cl_6$) is taken as the standard unit of colour.

Water Quality Parameters and Standards

Tastes and odour:

The words taste and odour are often used loosely and interchangeably. Actually there are four tastes: **sour, salt, sweet and bitter** – strictly confined in their perception to the taste buds of the tongue. Odours appear to be without limit in number and are known to change in quality as the concentration of the odourous compounds, or the intensity of their small, is varied.

Water Quality Parameters and Standards

Tastes and odour:

Tastes and odours are associated with (i) decaying organic matter, (ii) living algae and other microorganisms containing essential oils and other odourous compounds, (iii) iron and manganese and other metallic products of corrosion, (iv) industrial wastes, particularly phenolic substances, (v) disinfecting chlorine and its substitute compounds and (vi) biologically nondegradable synthetic organics.

Water Quality Parameters and Standards

Temperature:

The most desirable range of temperatures for a public water supply is between 40 and 50°F. Natural waters are seldom found below 40°F. As the temperature rises above 50°F, the water becomes less palatable and less suited to certain uses. Temperatures above 80 °F are undesirable, and above 90° to 95°F the water is unfit for a public supply.

Water Quality Parameters and Standards

Hydrogen ion concentration, pH:

pH is a term used rather universally to express the intensity of the acid or alkaline condition of a solution. More exactly, it is a way of expressing the hydrogen ion concentration. In the field of water supplies, it is a factor that must be considered in chemical coagulation, disinfection, water softening and corrosion control. In sewage and industrial waste treatment employing biological processes, pH must be controlled within a range favourable to the particular organisms involved.

Water Quality Parameters and Standards

Alkalinity:

The alkalinity of water is a measure of its capacity to neutralize acids. The alkalinity is due primarily to salts of weak acids and strong bases. Such substances act as buffers to resist a drop in pH resulting from acid addition. Alkalinity is thus a measure of the buffer capacity.

Three major classes of minerals cause most of the alkalinity in natural waters: bicarbonate, carbonates and hydroxides. Other salts of weak acids, such as borate, silicates and phosphates may be present in small amounts. A few organic acids, such as humic acid, add to the alkalinity of natural waters. Excessive or insufficient alkalinity interferes with water treatment (coagulation).

Water Quality Parameters and Standards

Specific conductance:

The specific conductance of water is the reciprocal of the resistance in ohms of a column of the water 1 cm long and having cross section of 1 sq.cm at a specific temperature, usually 25°C. It is commonly reported in ohms. The specific conductance is used as a measure of the quality of the water.

Environmental Engineering-1

CE3141

Lecture-8

Week-5, Tuesday

17-05-2022

Water Quality Parameters and Standards

Hardness:

Hardness in water is that characteristic which prevent the lathering of soap. It is caused principally by the solution in water of carbonates, bicarbonates and sulphates of calcium and magnesium, although the chlorides and nitrates of these two elements and sometimes of iron and of aluminum are effective to a lesser degree in causing hardness.

The term hardness is defined as the ability of the water to cause precipitation of insoluble calcium and magnesium salts of higher fatty acids from soap.

Total hardness is expressed in various ways, the standard practice being in parts per million by weight in terms of calcium carbonate.

Water Quality Parameters and Standards

Various ranges of hardness of water

Class	1	2	3	4
Hardness, ppm	0 – 55	56 – 100	101 – 200	201 – 300
Degree of hardness	Soft	Slightly hard	Moderately hard	Very hard

Water Quality Parameters and Standards

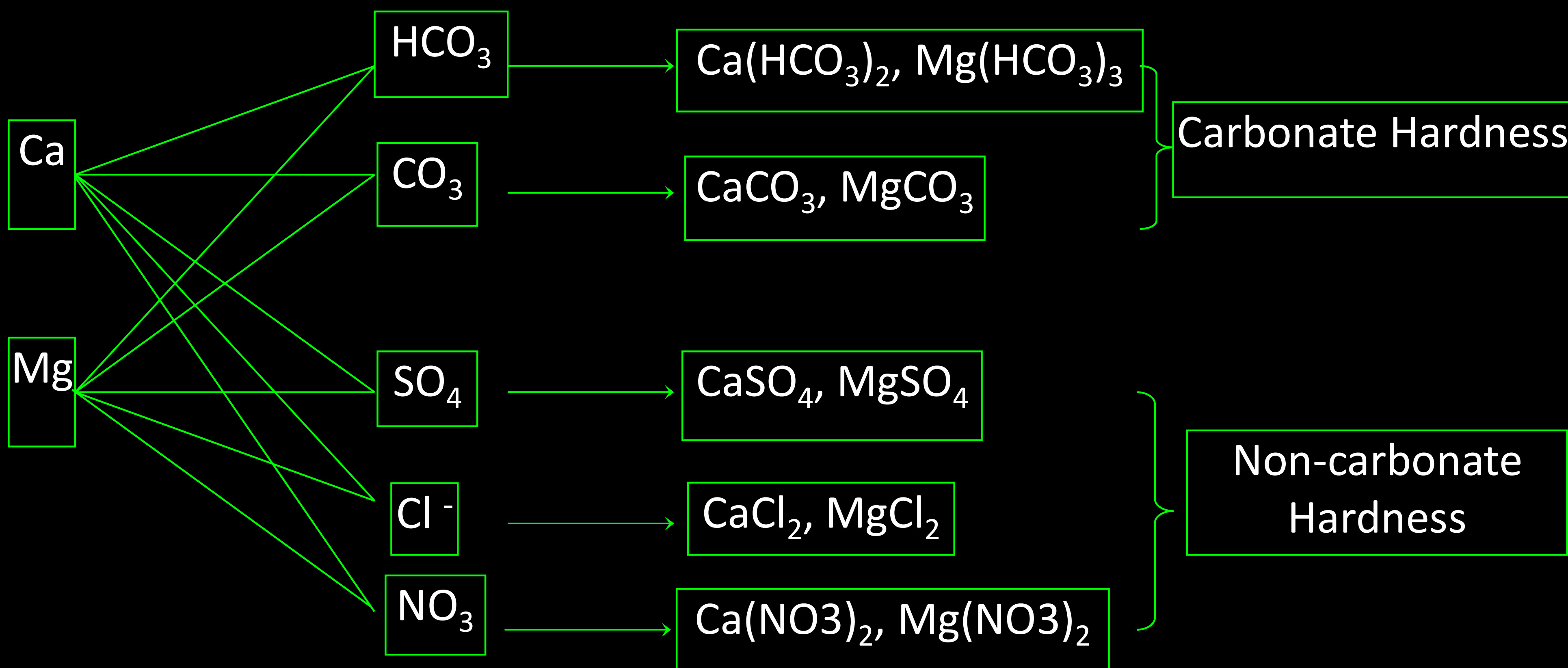
Classification of hardness: Depending on soap destroying power hardness is classified as temporary hardness and permanent hardness.

The temporary hardness is also known as the carbonate hardness and it is mainly due to the presence of carbonate or bicarbonate of calcium and magnesium. It can be removed by boiling or by adding lime to the water.

The permanent hardness is also known as the non-carbonate hardness and it is due to the presence of sulphates, chlorides and nitrates of calcium and magnesium. It cannot be removed by simply boiling the water. It requires special treatment of water softening.

Water Quality Parameters and Standards

The diagram of carbonate hardness and non-carbonate hardness is presented in Figure.



Water Quality Parameters and Standards

Principal bad effect of hardness:

The principal bad effects of hardness are given below:

- Enough consumption of soap.
- Clogs skin, discolours porcelain, stains and shortens fabrics, toughens and discolours vegetables.
- Gives difficulty in textile and paper manufacture, tannery and other industrial processes.
- Forms scales in boilers, resulting in great heat transfer losses and danger of boiler failure.

Water Quality Parameters and Standards

Arsenic: In Bangladesh the presence of arsenic in groundwater was first detected in 1993 at Baroghoria union of Chapai Nawabganj district. The concentration of arsenic in drinking water in excess of permissible limit is toxic to human body. According to the WHO guideline value the desirable maximum concentration of arsenic in drinking water would be 0.01 mg/l. In Bangladesh the maximum acceptable concentration in drinking water is considered to be 0.05 mg/l. Symptoms of arsenic toxicity leading to cancer may occur due to excessive intake of arsenic in the human body over a longer period of time.

Water Quality Parameters and Standards

Drinking water standard

Parameters		Standard (mg/l)	
		USPHS	WHO
Physical quality	Total Dissolve Solid (TDS)	500	500
	Turbidity	10	5
	Color	20	15
	Temperature	50^{o} F	50^{o} F
	Tastes and odor	Water should be completely free from taste and odor	

Water Quality Parameters and Standards

Drinking water standard

Parameters		Standard (mg/l)	
		USPHS	WHO
Chemical quality	Arsenic (As)	0.01	0.01
	Cyanide (Cn)	0.01	0.01
	Lead (Pb)	0.05	0.05
	Barium (Ba)	1.00	1.00
	Selenium (Se)	0.01	0.01
	Cromium (Cr)	0.05	0.05
	Cadmium (Cd)	0.05	0.05
	Silver (Ag)	0.05	0.05

Water Quality Parameters and Standards

Drinking water standard

Parameters		Standard (mg/l)	
		USPHS	WHO
Chemical quality	Detergent (ABS)	0.50	0.50
	Chloride (Cl)	250	200
	Copper (Cu)	1.00	1.00
	Carbon-Chloroform extract (CCE)	0.20	0.20
	Iron (Fe)	0.25	0.25
	Manganese (Mn)	0.05	0.05
	Iron (Fe) + Manganese (Mn)	0.30	0.30
	Nitrate as NO3	45	45
	Phenols	0.001	0.001

Water Quality Parameters and Standards

Drinking water standard

Parameters		Standard (mg/l)	
		USPHS	WHO
Chemical quality	Sulphate (SO_4)	250	250
	Zinc (Zn)	5.00	5.00
	Calcium (Ca)	80.0	75.0
	Magnesium (Mg)	80.0	75.0
	Total hardness	150	100
	Total alkalinity	120	100
	Fluoride (F^-)	0.60	0.50
	pH	7 to 8	7 to 8

Treatment of water

Natural water contains impurities in different forms. The presence of these impurities in excess of acceptable limits make the water unfit for domestic supplies. The main objectives of water treatments are to make water potable i.e. to make water safe to drink, pleasant to taste and suitable for domestic uses.

Groundwater is usually hard but free from pathogenic bacteria and can be supplied for drinking purpose without treatment. Some tubewell water in Bangladesh may contain iron, arsenic and hardness in excess of acceptable levels, and may therefore require specific treatment. Surface water is turbid, colored and contaminated by pathogenic microorganisms and needs extensive treatment involving sedimentation, coagulation with sedimentation, filtration and disinfection.

Treatment of water

The type of treatment required depends on the physical chemical and biological characteristics of water. The most common steps in water treatment are clarification and disinfection.

Clarification involves removal of suspended and colloidal particles including color-producing substances by plain sedimentation, sedimentation with coagulation and filtration to remove visible impurities and make the water attractive to the consumers.

Disinfection means destruction of pathogenic organisms to make the water safe.

Sometimes invisible dissolved minerals and gases present in groundwater are required to be removed by specific treatment processes to make the water potable.

Treatment of water

The common water treatment methods are:

(i) Plain sedimentation,

(ii) Coagulation with sedimentation,

(iii) Filtration and

(iv) Disinfection.

Some of the treatments process/unit operations for removal of specific impurities are (i) aeration, (ii) water softening, (iii) arsenic removal, (iv) iron removal, (v) activated carbon application (vi) fluoridation and defluoridation, (vii) demineralization and (viii) desalinization.

One or a combination of more than one treatment method is employed for water treatment depending on the quality of raw water.

Plain Sedimentation

Principle of particle settling in water

This is a process causing the organic or inorganic particles heavier than water to settle by retaining water in a tank or basin. These particles are held in suspension in natural water mainly by turbulence or current and when the current is retarded, the suspended particles settle at the bottom of the basin.

A particle having specific gravity of more than 1, i.e. heavier than water, tends to move downward in relatively quiescent water by the force of gravity, accelerating until the frictional resistance (drag) of the water equals the gravitational force acting upon the particle. Thereafter the particle travels with a constant vertical velocity called the '*terminal velocity*' or '*settling velocity*' of the particle.

Plain Sedimentation

The settling velocity of the particle depends upon:

- Horizontal flow velocity of water
- Shape and size of the particle
- Specific gravity of the particle
- Viscosity of water
- Density of water
- Temperature of water

Plain Sedimentation

The settling velocity of spherical particles under laminar flow conditions is given by the simplified equation:

$$v_s = \frac{g}{18}(S-1)\frac{d^2}{\gamma}$$

Where, v_s is the settling velocity, g is acceleration due to gravity, S is specific gravity of the particle, d is diameter of the particle and γ is kinematic viscosity of water.

Plain Sedimentation

The above equation is called Stoke's Law. Stoke's Law holds good only for particle size 0.1 cm in diameter and Reynold's number 1 or less. For large particles having diameter greater than 1 cm and Reynold's number above 2000, Newton's Law for frictional resistance or drag applies:

$$v_s = \sqrt{\frac{4g}{3C_D}(S-1)d}$$

Where C_D is the Newton's coefficient of drag.

Plain Sedimentation

The particles in between the above mentioned size or Reynold's numbers are in transition settling. Stoke's Law is valid for computation of settling velocity of discrete particles. Discrete particles are those which do not change size, shape and mass during settling and which do not influence each other by being too close. Particles settling under this conditions is called *discrete settling*.

In case of closely packed particles, the water displaced by the particles may cause additional friction and the settling velocity is reduced. This is termed as *hindered settling*. Hindered settling becomes noticeable when the concentration of suspended solids is greater than 2000 mg/l. This situation of high concentration of suspended solids may happen in river water during high flooding and heavy rainfall.

Sometimes settling particles may adhere to each other and grow in size and thus deviate from the settling characteristics represented by Stoke's Law. This may occur in settling of algae or freshly formed flock by the process of flocculation with coagulant. These particles/flocks and tent to stick together and form new bigger particles which settle at a faster rate. This type of settling is called *flocculent settling*. Discrete, hinder and flocculent settling are shown in Figure.

Plain Sedimentation

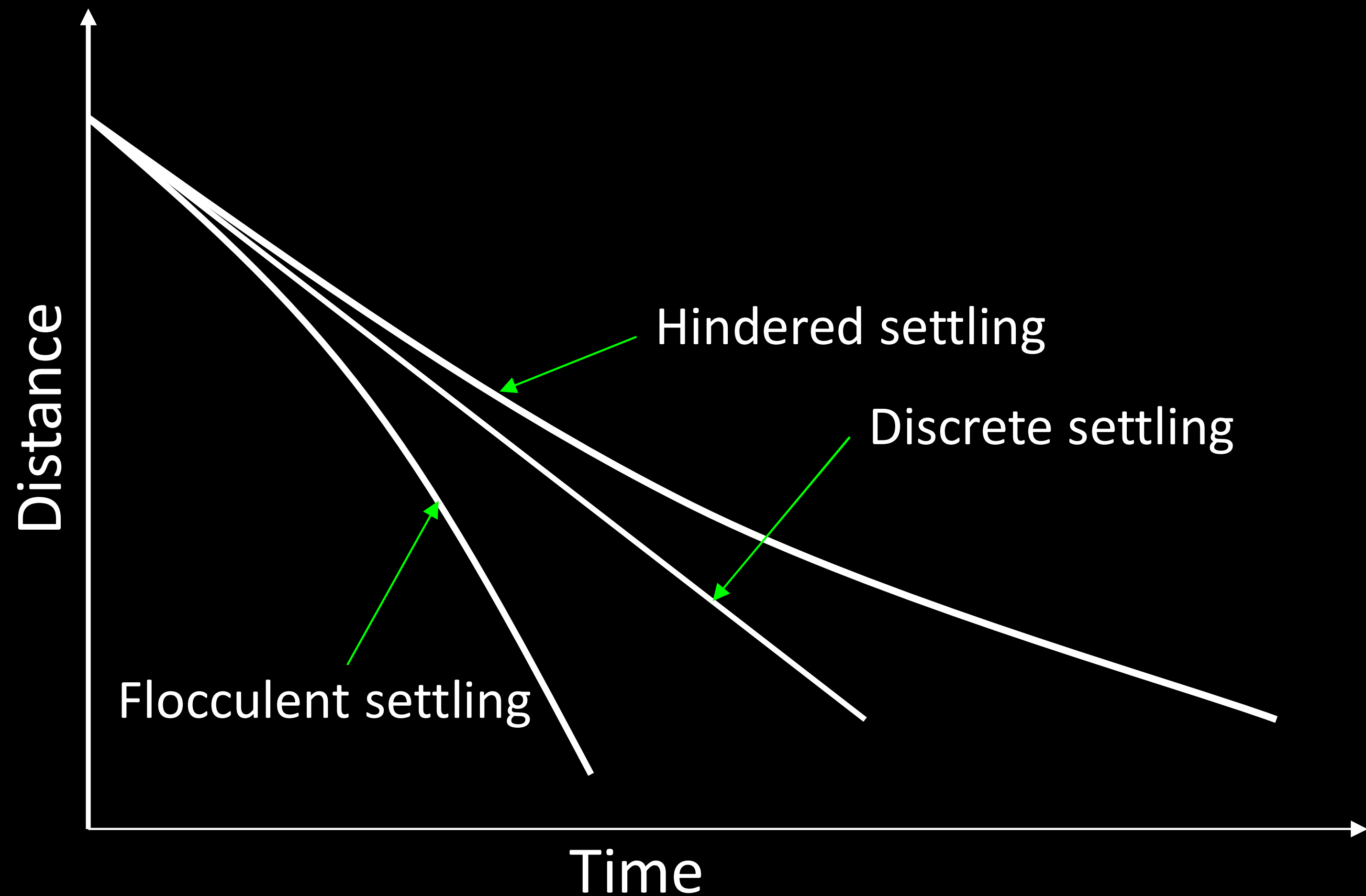


Figure: Settling of different types of particles in water

Plain Sedimentation

Design of sedimentation tanks

A rectangular sedimentation tank can be subdivided into four different areas comprised of an inlet, settling, outlet and sludge accumulation zones. The inlet zone serves to provide even flow distribution over the full cross section, the outlet zone collects the clarified water over the full tank width. Sludge is accumulated at the tank bottom where it is stored and removed periodically.

The efficiency of the settling tank in the removal of suspended particles can be determined using limiting settling velocity v_o of a particle which will just travel the full depth (H) of the tank within the detention time (T). Using the dimensions and notations used in Figure, the following equations can be written: $v_o = H/T$ and $T = V/Q = BLH/Q$

Plain Sedimentation

from these two equations:

$v_o = Q/BL = Q/surface\ area.$

Where, Q = flow rate, B, L and V are width, length and volume of the sedimentation zone of the settling tank.

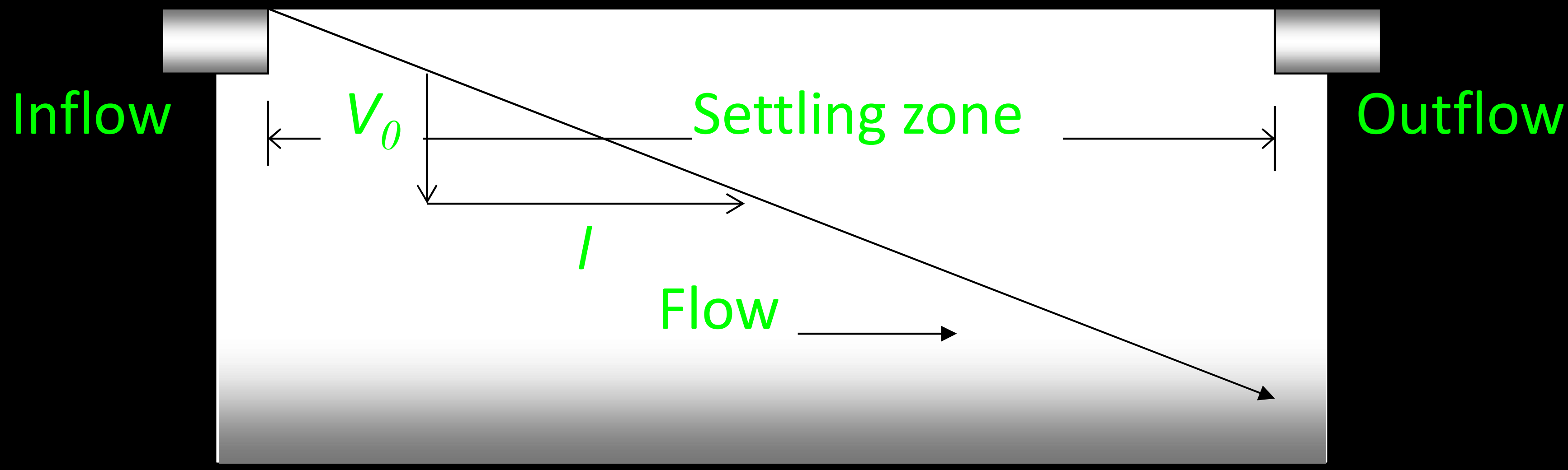


Figure: Rectangular horizontal flow settling tank

Plain Sedimentation

The tank will remove all the particles having settling velocity $v_s > v_o$ and the particles with settling velocity $v_s < v_o$ will be removed in the proportion $v_s : v_o$. The above analysis shows that the settling efficiency depends on the ratio between the influent flow rate Q and the surface area of the tank BL, which is called the "*surface loading*". Hence the efficiency of the settling tank is independent of the depth of the tank.

The higher the surface area the greater is the efficiency.

Plate settlers and tube settlers have been designed to provide a larger surface area and achieve higher efficiency.

Environmental Engineering-1

CE3141

Lecture-9

Week-6, Saturday

21-05-2022

Coagulation and Flocculation

The removal of very fine light colloidal impurities from water is difficult to achieve in practice by the process of plain sedimentation. This can be greatly expedited by the addition to water of certain chemical compound which where thoroughly mixed form wooly masses of flocculent precipitate enmeshing the suspended particles become heavier and finally settle out. These substances are called *coagulants* and their process of action is *coagulation*.

Coagulation and Flocculation

Principle of Coagulation

i. Flock formation: When coagulants are dissolved in water and thoroughly mixed with it, they produce a thick gelatinous precipitate. This precipitate is known as the flock and this flock has got the property of arresting the suspended impurities in water during its downward travel towards the bottom of tank.

ii. Electric charges: The ions of flock are found to possess positive electric charge. Hence they will attract the negatively charged colloidal particles of clay and thus they cause the removal of such particles from water.

Coagulation and Flocculation

Factors Influencing Coagulation

Many factors influence the coagulation of waters. Among them, the following are important:

i. Kind of coagulant

ii. Quantity of coagulant

iii. Characteristics of water (suspended matter, pH and temperature) and

iv. Time of mixing, flocculation and coagulation.

Coagulation and Flocculation

Dosage of Coagulants

This depends upon number of factors such as:

i. Turbidity of water

ii. Colour of water

iii. pH value of water

iv. Time of settlement and

v. Temperature of water

Coagulation and Flocculation

Chemical Reactions

1. $Al_2(SO_4)_3 + 3Ca(HCO_3)_2 = Al_2(OH)_6 + 3CaSO_4 + 6CO_2$

2. $FeSO_4 + Ca(HCO_3)_2 = Fe(HCO_3)_2 + CaSO_4$

$Fe(HCO_3)_2 + 2Ca(OH) = Fe(OH)_2 + 2CaCO_3 + 2H_2O$

$4Fe(OH)_2 + O_2 + H_2O = 2Fe(OH)_3$

Filtration

The process of passing the water through the beds of granular materials is known as the filtration.

The filtered water is potable and palatable and it is free from various undesirable impurities like colour, odour, turbidity, pathogenic bacteria, etc.

During the process of filtration, the following effects occur on water:

i. The suspended and colloidal impurities which are present in water in a finely divided state are removed to great extent.

ii. The chemical characteristics of water are altered.

iii. The number of bacteria present in water is also considerably reduced.

Filtration

The theory of filtration

It can be explained based on the following four actions:

i. Mechanical straining: The suspended particles which are unable to pass through the voids of sand grains are arrested and removed by the action of mechanical straining.

ii. Sedimentation: The voids between the sand grains of filter act more or less like small sedimentation tanks. The particles of impurities, arrested in this voids, adhere to the particles of sand grains mainly for the following two reasons:

a. Due the presence of a gelatinous film or coating developed on sand grains by previously caught bacteria and colloidal matter;

b. Due to the physical attraction between the two particles of matter.

Thus the suspended impurities are removed by filter by the action of sedimentation.

Filtration

iii. Biological metabolism: The growth and life process of the living cells is known as the biological metabolism. When bacteria are caught in the voids of sand grains, a zoological jelly or film is formed around the sand grains. This film contains large colonies of living bacteria. The bacteria feed on the organic impurities contained in water. They convert such impurities into harmless compounds by the complex biological reactions.

iv. Electrolytic changes: When two substances with opposite electric charges are brought into contact with each other, the electric charges are neutralized and in doing so, new chemical substances are formed.

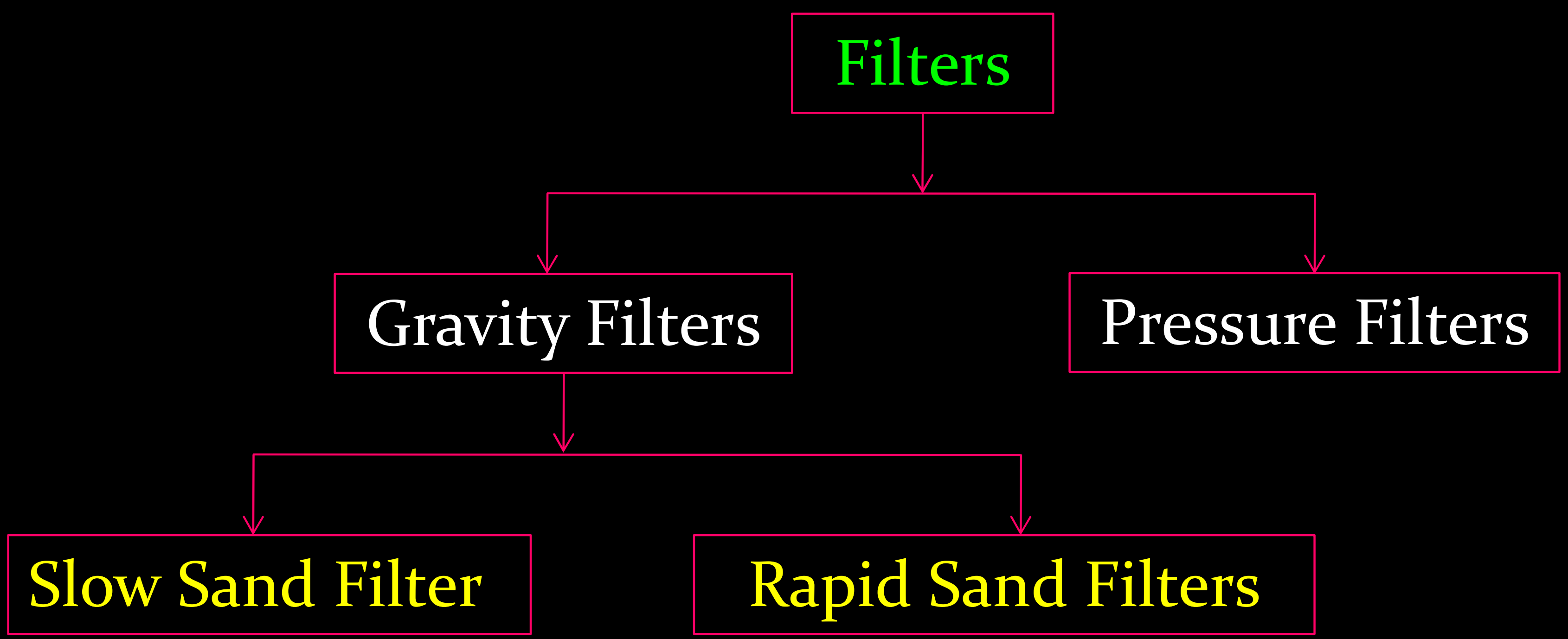
Filtration

Classification of Filters

i. Slow sand filter

ii. Rapid sand filter

iii. Pressure filter



Filtration

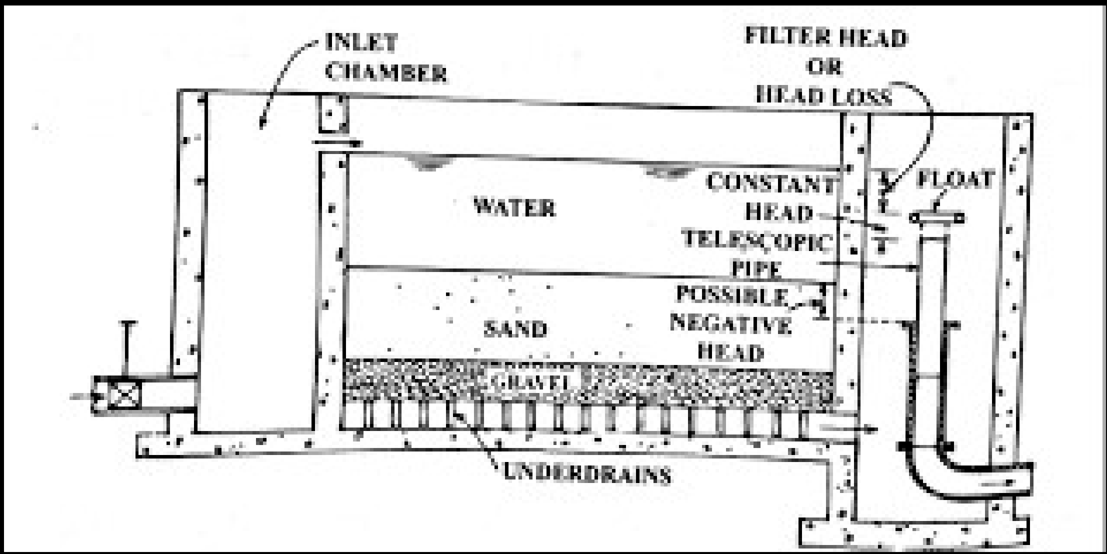
Slow sand filter: A slow sand filter consists of the following parts:

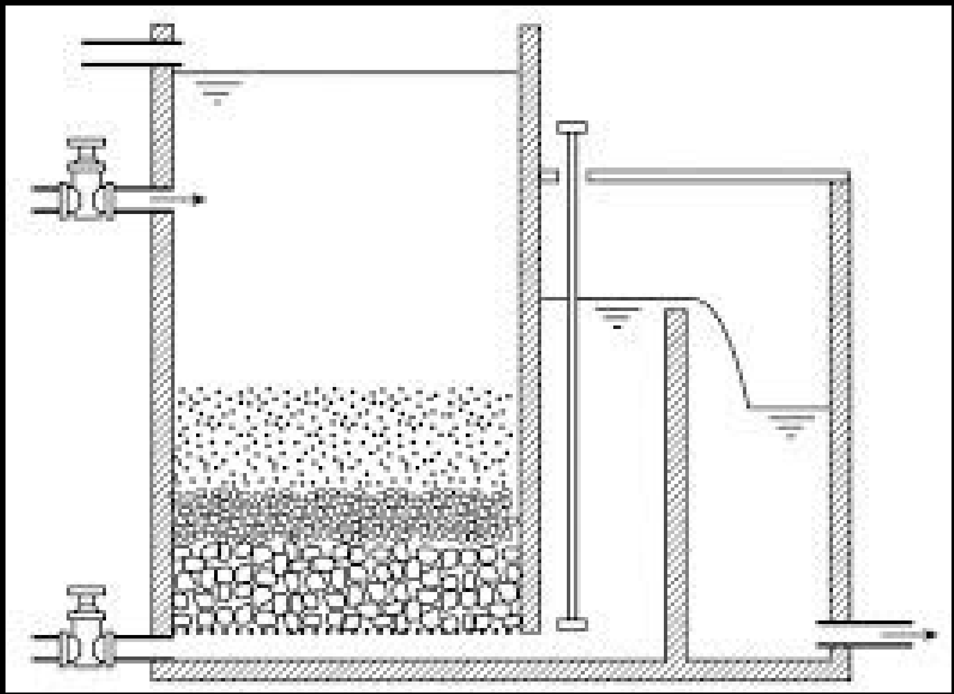
Enclosure tank:

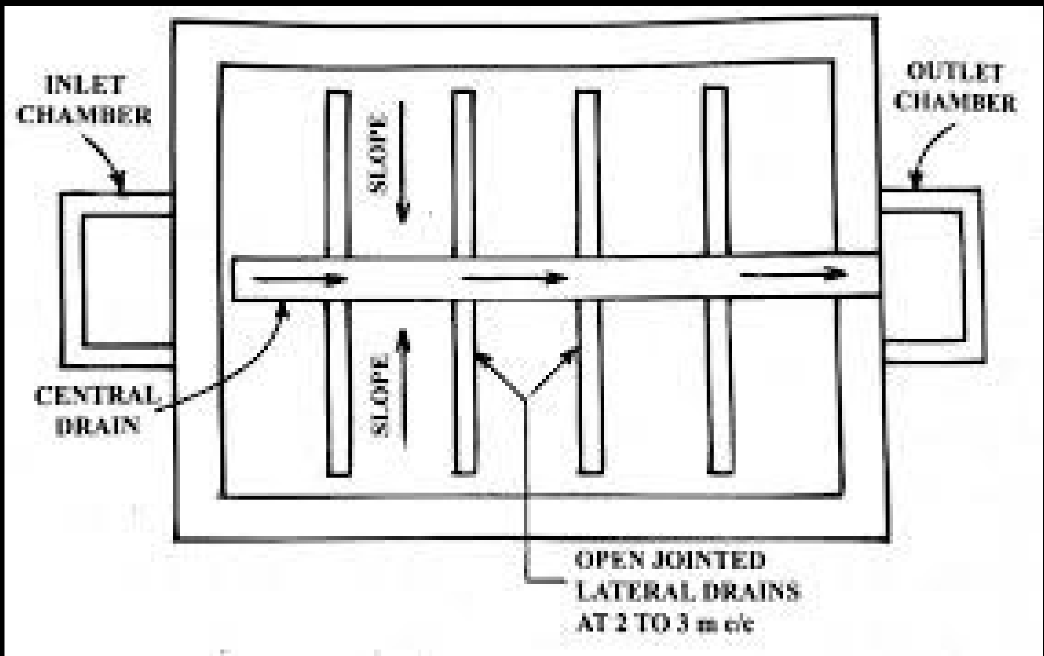
a. Made of brick masonry coated with waterproof material.
b. Bed slope is about 1 in 100 to 1 in 200 toward the central drain.
c. Depth of tank is about 2.5 m to 3.5 m.
d. Surface area vary from 30 m^2 to 2000 m^2 even more.

Filtration

Slow sand filter







Filtration

Slow sand filter: A slow sand filter consists of the following parts:

Under drainage system:

a. Consists of central drain and lateral drains.

b. Spacing of lateral drain is about 2.5 m to 3.5 m

Base material:

The base material is gravel and it is placed on the top of under drainage system.

Its depth varies from 300 mm to 750 mm in a graded layer of 150 mm from bigger size at the bottom to smaller size of gravel at topmost layer.

Filtration

Slow sand filter: A slow sand filter consists of the following parts:

Base material:

Layer	Depth (mm)	Material size (mm)
Topmost	150	3 to 6
Intermediate	150	6 to 20
	150	20 to 40
Lowest	150	40 to 65
Total	600	

Filtration

Slow sand filter: A slow sand filter consists of the following parts:

Filter media of sand:

- Depth of sand layer – 600 to 900 mm
- Effective size – 0.20 mm to 0.30 mm
- Uniformity coefficient – 2 to 3
- The finer the sand, the better will be the efficiency of filter regarding removal of bacteria.
- But in this case, the output from filter is lowered.

Filtration

Slow sand filter: A slow sand filter consists of the following parts:

Appurtenances:

- Vertical air pipe passing through layer of sand. It helps in proper functioning of filtering layers.
- The device for measuring loss of head, for controlling depth of water above sand layer and for maintaining rate of flow.
- In order to maintain a constant discharge through the filter, an adjustable telescopic tube is usually adopted.

Filtration

Rapid sand filter:

Rules for designing under drainage system

- The ratio of length of lateral drain to its diameter should not exceed 20.
- The cross-sectional area of central drain should be about twice the cross-sectional area of lateral drain.
- The total cross-sectional areas of perforations should be about 0.20% of the total filter area.
- The cross-sectional area of a lateral drain should be about 2 to 4 times the total cross-sectional areas of perforations in it.
- The perforations in the lateral drain should be of diameter 6 mm to 12 mm.
- The spacing of perforations in the lateral drain should vary from 75 mm to 200 mm centre to centre.

Filtration

Rapid sand filter:

Base material:

The base material is gravel and it is placed on the top of under drainage system.

The gravel to be used for base material should be cleaned and free from clay, dust, silt and vegetable mater.

The gravel particles should be durable, hard, round and strong.

Its depth varies from 450 mm to 600 mm in a graded layer of 150 mm from bigger size at the bottom to smaller size of gravel at topmost layer.

Filtration

Difference between Slow Sand Filter and Rapid sand filter:

Item	SSF	RSF
Base material of gravel	Varies from 3 to 65 mm in size and 300 to 750 mm in depth.	Varies from 3 to 40 mm in size and 600 to 900 mm in depth.
Coagulation	Not required	Essential
Compactness	Required large area for its installation	Required small area for its installation
Construction	Simple	Complicated as underdrainage system is to be properly designed and constructed.
Cost of operation	Low	High
Economy	High initial cost of both land and material	Cheap and quite economical.
Efficiency	Very efficient in the removal of bacteria but less efficient in the removal of colour and turbidity.	Less efficient in the removal of bacteria but more efficient in the removal of colour and turbidity.
Loss of head	150 mm to 750 mm	3 m to 3.5 m

Filtration

Difference between Slow Sand Filter and Rapid sand filter:

Item	SSF	RSF
Filter material of sand	Effective size varies from 0.2 to 0.3 mm and uniformity coefficient is about 2 to3.	Effective size varies from 0.35 to 0.6 mm and uniformity coefficient is about 1.2 to 1.7.
Flexibility	Not flexible for meeting variation in demand	Quite flexible for reasonable fluctuations in demand.
Period of cleaning	1 to 3 months	2 to 3 days
Method of cleaning	Scraping of top layer of 15 mm to 25 mm thickness. Long and laborious method.	Agitation and back-washing with or without the help of compressed air. Short and speedy method.
Rate of filtration	100 to 200 $L/hr/m^2$ of filter area	3000 to 6000 $L/hr/m^2$ of filter area
Skilled supervision	Not essential	Essential
Suitability	Suitable for small towns/villages where land is cheap.	Suitable for big cities where land is high and demand of water is considerable.

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Lecture-10

Week-6, Tuesday

24-05-2022

Filtration

Pressure filter

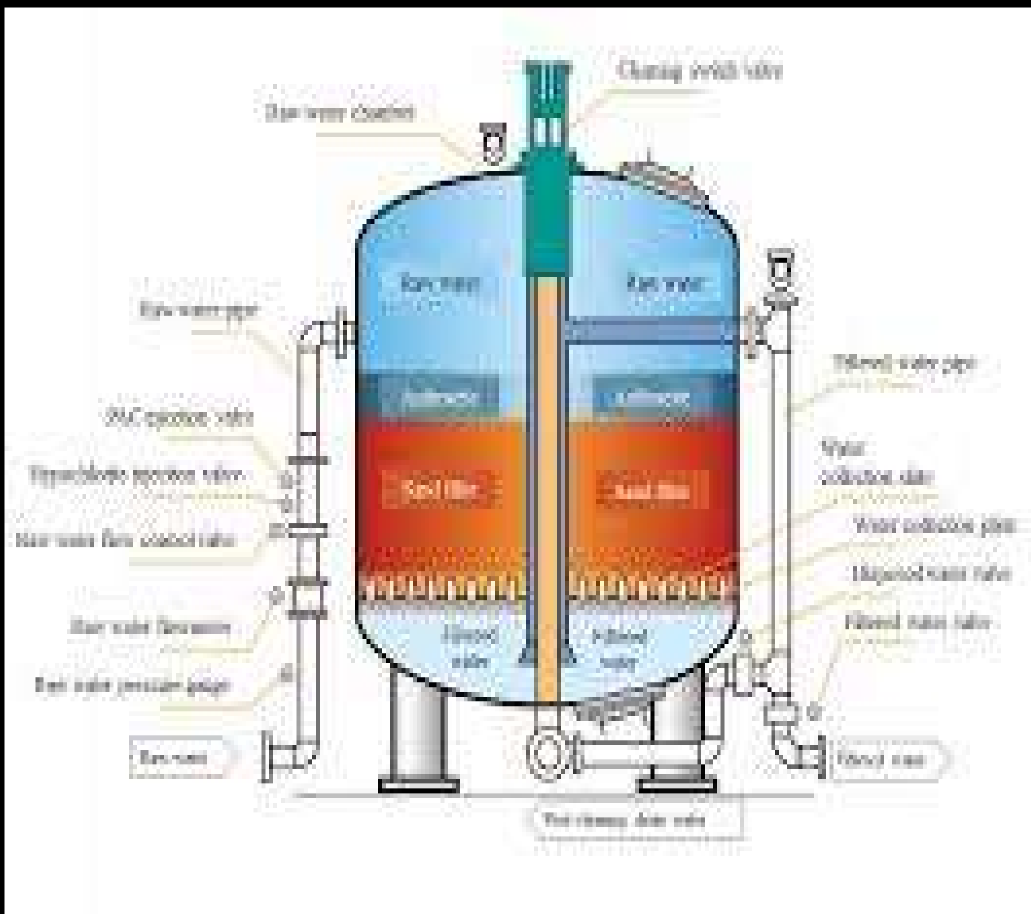
A filter is enclosed in space and the water passes under pressure greater than atmospheric pressure. This pressure can be developed by pumping and it may vary from 0.3 to 0.7 N/mm^2.

Construction: It is closed steel cylinders either horizontal or vertical. The diameter varies from 1.5 to 3.0 m and length or height varies from 3.5 m to 8.0 m. The manholes are provided at top for inspection.

Working: The water mixed with coagulant is directly admitted to the pressure filter. Thus the flocculation takes place inside the filter itself. In normal working condition, all valves are closed except those for raw water and filtered water. Filtered water is collected in storage tank through central drain.

Filtration

Pressure filter



Filtration

Pressure filter

Cleaning: The compressed air may be used to agitate sand grains. The valves for raw water and filtered water are in closed position and those for wash-water and wash-water drain are in open position. The cleaning of pressure filters may be required more frequently.

Rate of filtration: The rate of filtration of pressure filters is high as compared to that of rapid sand filters. It is about 6000 to 15000 litres/hr/m^2 of filter area as compared to that of 3000 to 6000 litres/hr/m^2 of rapid sand filters.

Efficiency: Less efficient than the rapid sand filters in terms of bacterial load, colour and turbidity.

Suitability: Not suitable for public water supply project.

Filtration

Pressure filter

Advantages:

- The unit is compact.
- Modern filter unit does not require manual operation and supervision.
- Flexible in operation because the rate of filtration can be altered by changing the compressed air pressure.
- Dose not require further pumping as the filter water comes out under pressure.
- It is ideal for small estate.
- Require less number of fittings.
- Require small space for installation.
- The sedimentation and coagulation tanks are not required.

Filtration

Pressure filter

Disadvantages:

- It is difficult to keep close watch on the performance.
- It is difficult to repair.
- The overall capacity is small.
- They are costly and hence they cannot be recommended for treating large quantity of water.
- They posses poor efficiency in the removal of bacteria and turbidity.
- They require additional pumps for pumping the water in them.

Disinfection of water

The water should be disinfected before it enters the distribution system. The main purpose of disinfection is to prevent contamination of water during its transit from the treatment plant to the place of its consumption.

Disinfection is the process of destruction of pathogenic bacteria which is harmful for health.

On the other hand, Sterilization is the process of destruction and removal of all harmful or harmless bacteria.

The destruction and removal is brought about in several ways:

i. Physical removal through coagulation, sedimentation and filtration
ii. Natural die-away of the organisms in an unfavorable environment during storage,
iii. Destruction by chemicals

Disinfection of water

The materials or substances which are to be used for disinfection are called the disinfectant and the requirement of a good disinfectant are as follows:

i. Its dose should be such that some residual concentration is obtained to grant protection against contamination in the water during its conveyance and retention.
ii. It should be effective in killing all the harmful pathogenic organisms from the water and make it perfectly safe for use.
iii. It should be harmless, unobjectionable, economical and easily available.
iv. It should be of such a nature that its strength or concentration in the treated water can be quickly determined.
v. It should not require skilled labour and costly equipment for its application.
vi. It should take only reasonable time in killing the harmful pathogenic organisms at normal temperature.

Disinfection of water

Methods of disinfection:

i. Boiling method
ii. Excess Lime treatment
iii. Iodine and bromine treatment
iv. Ozone treatment
v. Potassium permanganate
vi. Silver treatment
vii. Ultra-violet ray treatment

In addition to the above chemicals, certain other chemical agents can also be used as disinfectants and they include alcohols, soaps and synthetic detergents, dyes, hydrogen peroxide, various alkalies and acids, etc.

Disinfection of water

Following factors must be considered in applying the disinfection agents:

i. Concentration and type of chemical agent

ii. Contact time

iii. Intensity and nature of physical agent

iv. Nature of suspending liquid

v. Number and types of organisms

vi. Temperature

Disinfection of water

Chlorination

It is the treatment for disinfection by applying chlorine. It is widely used in large scale because of the following factors:

i. It is easy to apply due to relatively high solubility of about 7000 mg/L.
ii. It is readily available as gas, liquid or powder.
iii. It is very toxic to most of the microorganisms and thus metabolic activities are stopped.
iv. It leaves harmless residue in solution, but it provide protection in the distribution system.
v. It produces desired effects which last for a long time.
vi. The treatment by chlorination is cheap and reliable.

Disinfection of water

Chlorination

When chlorine is added to water , it reacts according to the following equation:

$Cl_2 + H_2O \leftrightarrow HOCl + HCl$

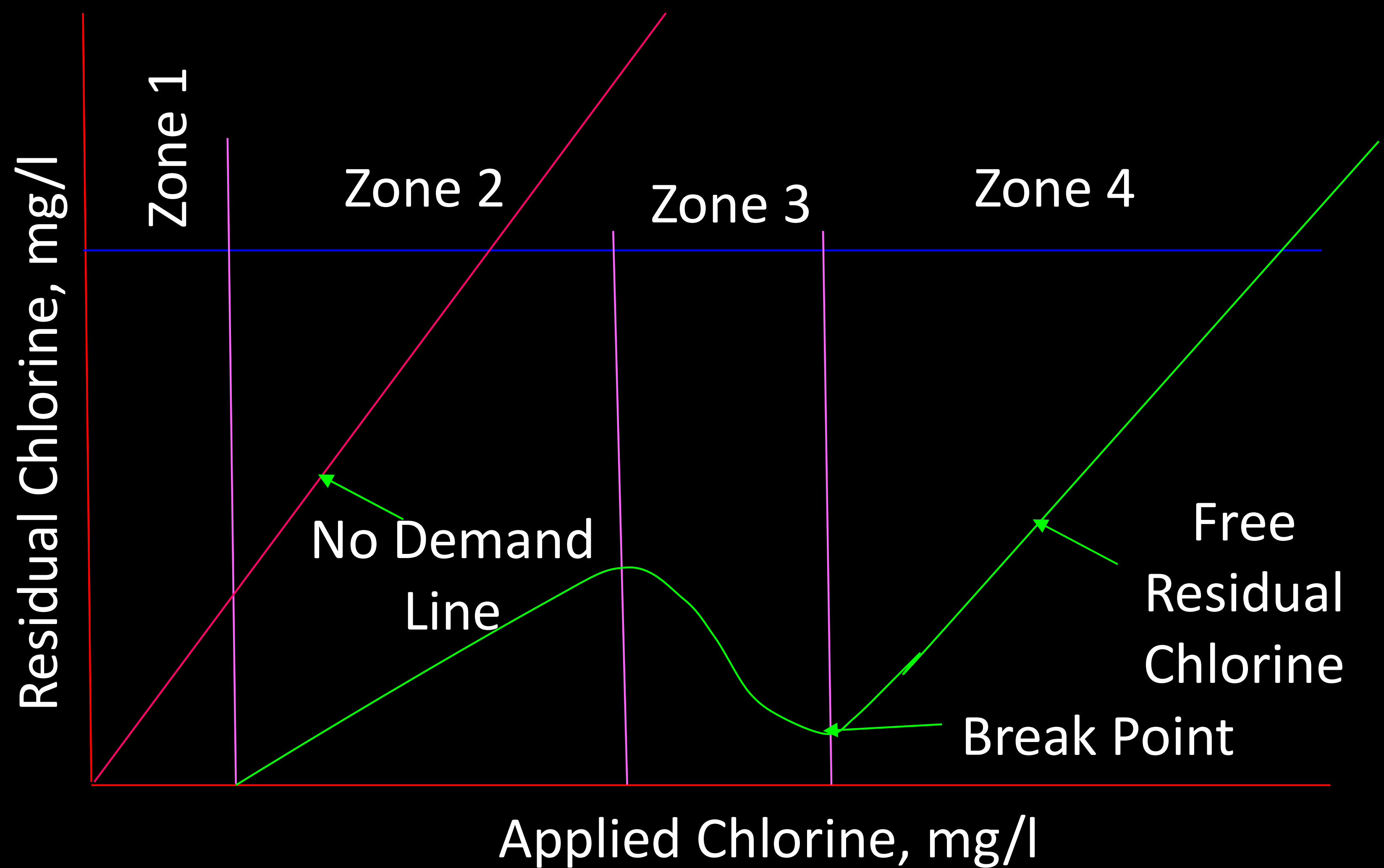
$HOCl \leftrightarrow H^+ + OCl^-$

The hypochlorous acid HOCl dissociates by a reversible equation into hydrogen ions. Both hypochlorous acid HOCl and hypochlorite ions Ocl^- are responsible for the disinfection of water.

The action of chlorine is dependent to the pH value of water.

The disinfection by chlorine is rapid when pH value of water is below 7.00.

Disinfection of water



Disinfection of water

Chlorination

Zone-1: Destruction of chlorine by reducing compounds.

Zone-2: Formation of chloro-organic compounds and chloramines.

Zone-3: Destruction of chloro-organic compounds and chloramines.

Zone-4: Formation of free available chlorine.

The addition of chlorine at the break (or dip) is termed as break point chlorination or free residual chlorination.

Disinfection of water

Application of Chlorine

Post Chlorination: Chlorine is generally applied after all other treatments have been given to the water supply. This may be termed as post chlorination.

Pre-chlorination: It is the application of chlorine before filtration. Pre-chlorination reduces the bacterial load on filters resulting in increase filter runs, and oxidized excessive organic matter thus removing taste and odour.

Double chlorination: It is the application of chlorine at two points in the treatment process. It is essentially pre-chlorination and post chlorination.

Disinfection of water

Application of Chlorine

The advantages of double chlorination are:

i. Decrease load on the filter
ii. Greater removal of bacteria
iii. Greater factor of safety due to maintaining two chlorination
iv. Control of algae and slimy growth in coagulating basins and filters.

Super chlorination: It is the application of chlorine to water of an excess amount of chlorine. The method is effective in destroying high concentration of tastes and odours in water. Bacterial removal is also high.