31/1/18

Treatment of water

Introduction:-

The engineer constructed with the design of water works system has now to see to the problem of treatment of water in order to remove from it all types of impurities & make it conform to the standard of drinking water supply & other use.

The objects to be acheived through treatment of water may be used as:

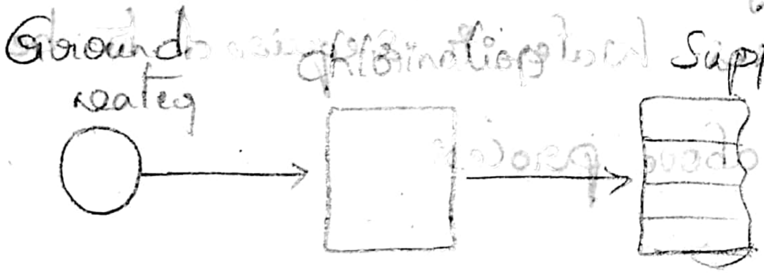
1. Removal of all pathogenic germs contain in untreated water.
2. Freedom of unpleasant taste.
3. Suitability for domestic purpose i.e.; cooking washing & for industrial purpose.
4. Reduction of the corrosion properties of water which affect the carrying capacity and life of the pipe lines.

Unit operations in water treatment:-

The unit operations in water treatment include sedimentation, flocculation, filteration, chlorination, disinfication, Aeration, water softening, rapid mixing etc., The choise of any particular treatment will depend on the raw water and quality of water & the relative cost.

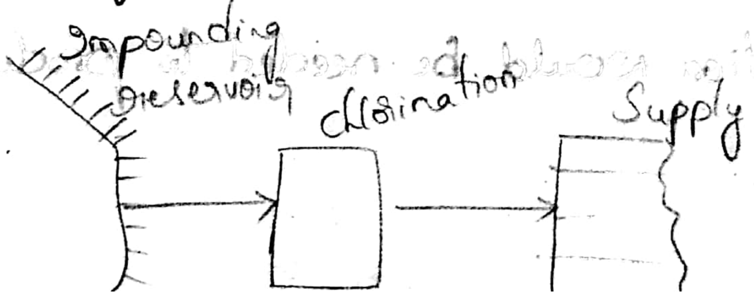
Flow chart of treatment:-

a) Ground water chlorination:



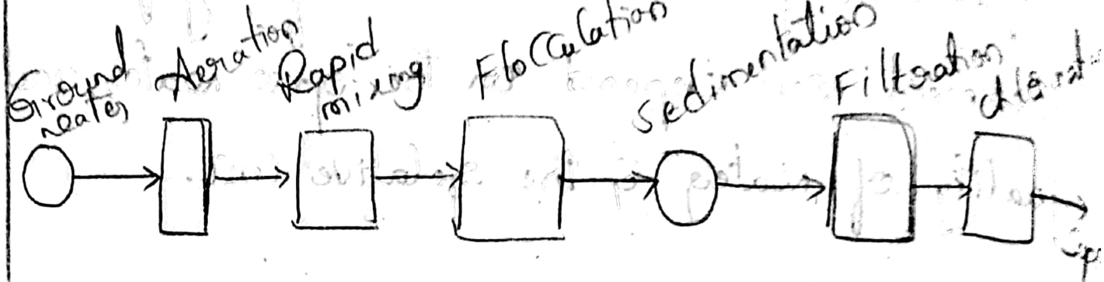
Ground & spring water free from pollution requiring no treatment. Hence it is chlorinate waters before supply

b). Surface water chlorination:



Surface water from upland & mountain streams & from large lakes are unpolluted. However chlorination would be required.

c). For removal of Fe, Mn & dissolved gases:



Ground water free from any pollution but containing iron & manganeese & other dissolved gases. Water is required to be treated by above process (aeration, chemical Precipitation, sedimentation, filtration & ...)

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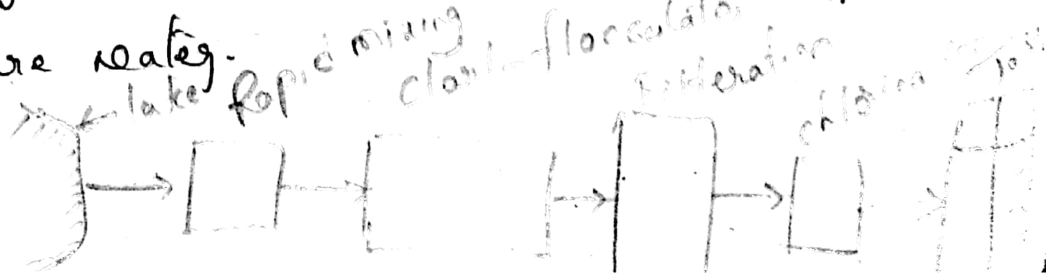
d). Treatment of low turbid water:-

Surface water from lakes & streams some turbid may are not be polluted. Filteration assisted by clarification, flocculation & followed by chlorination would be needed to produce Pure water.



e). Treatment at high turbid water:-

Surface water from turbide streams, generally polluted, some times, very greately. These requires process of sedimention, filteration pre & post chlorination for complete treatment.

f). For Softening of hard water:-

Ground water ~~have~~ containing dissolved salts of calcium & magnesium. These would required softening of hard water following by filteration & chlorination is before supply.

Sedimentation:-

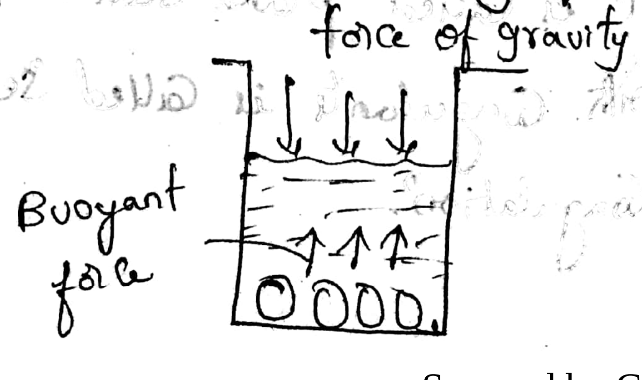
This is the process of causing heavier solid particles in suspension both organic & inorganic to settle by water in basin (or) tank. When the process is carried with out the aid of coagulants it is called "plane sedimentation" & when with coagulants is called "Sedimentation coagulation".

(i) Plane Sedimentation :-

Many of the impurities suspended in water have specific gravity greater than (s) Currents maintain in the water. The suspended matter generally settles to the bottom of the body of water. This is the principle involved in the sedimentation process.

Any discrete particles placed in liquid tends to accelerate until liquid drag reaches equilibrium with the impelling force due to gravity acting on the particle. The particles travel with a constant vertical velocity called the setting velocity.

The impelling force is the net weight of the particles acting downwards due to gravity & the Buoyant force at liquid acting upwards.



Hazen's law,

$$V = \sqrt{\frac{4g(\rho_s - \rho)d}{3C_D \cdot \rho}}$$

Stokes law,

$$V = \frac{g}{18}(s-1)\frac{d^2}{\nu}$$

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V = Settling velocity in cm/sec.

g = Acceleration due to gravity

= 981 cm/sec²

S = sp. gravity of particle

d = diametre of settling particle in cm.

ν = Kinematic viscosity in Centi-stokes

1. In water treatment settling unit water having temperature of 20°C carries solid particles an average of diametre of 0.05 mm & sp. gravity 1.2 using stokes law. Calculate settling velocity of settling particles.

Sol

Given data.

$d = 0.05 mm$

$S = 1.2$

$\nu = 1.01$ [from temperature]

$t = 20°C$

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

$$= \frac{981 \times 10}{18}(1.2-1)\frac{(0.05)^2}{1.01}$$

$$\boxed{V = 0.269 mm/sec}$$

Factors effecting Sedimentation:-

1. Type of Particles:

Settleable suspended particles are of two types. They are discreate & flocculent. The discrete particles which occur in plain sedimentation. The flocculent particles are comm in sedimentation with coagulation

2. Detention Period:

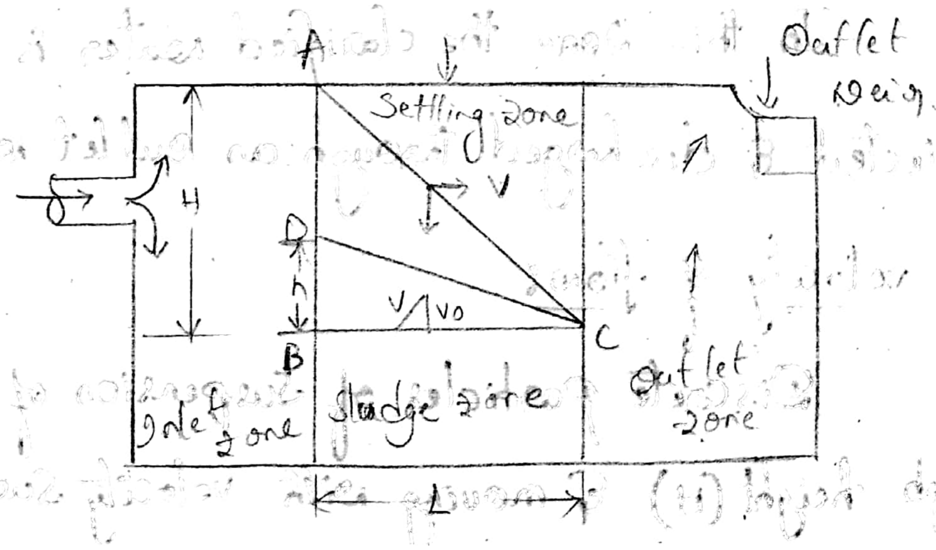
The detention period of a settling

basin is the theoritical time water is detained in it. It is given by the ratio of the volume of the basin to the volumetric rate of flow through the basin. Total removal occurs during the first portion of the period & since water is to be later subjected to further treatment.

3. Flowing through period:

This is the actual time of flow of the avg. time required for a small amount of water to pass through the basin in the given rate of flow. The incoming flow is uniform the percentage ratio of the flowing through period to the detention period is ~~thus~~ therefore a measure of efficiency of distribution of flow to the basin

4. Inlet & outlet arrangements:



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a). The inlet zone:

In this the incoming flow is to be uniformly distributed over the cross section of the tank.

b). Settling zone:

In this zone the flow is to be study: the concentration of each size particle is uniform through out the c/s normal to the flow direction

c). Sludge zone:

In this zone is provided for the collection of sludge below the settling zone. The particles reaching this zone the impurities are removed from the suspension.

d). Outlet zone:

In this zone the clarified water is to be collected & discharged through an outlet weir

e). velocity of flow:

Discrete particles of suspension of high height (H) & moving with velocity such that it reaches the bottom of settling zone before removal. in which vector sum of velocity of flow in the horizontal direction (V) & the settling velocity (v).

The discrete particles at a height (h). The ~~some~~ sum of velocity of flow in the horizontal direction the velocity of flow (V) & settling velocity (v_0)

$$\frac{h}{H} = \frac{v_0 t}{V t}$$

$$\frac{h}{H} = \frac{v_0}{V}$$

$$= \frac{v_0}{(Q/A)}$$

f) - Surface overflow rate:

It may be noted that $V = Q/A$ is the limiting velocity of fall to reach the bottom of the settling zone, that all particles with velocity greater than Q/A will reach the bottom before reaching the outlet for removal.

Let,

$A = 100 m^2$

$Q = 0.5 m^3/sec$

$Q/A = 5 \times 10^{-3} m/sec$

$= 0.5 cm/sec$

This means all particles with settling velocity is 0.5 cm/sec

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(ii) Sedimentation with Coagulation:-

Coagulation:

The removal of very fine and lite impurities from water is difficult to remove the process of sedimentation. This can be addition to water of certain chemical compounds which when mixed form heavy masses of suspended particles, become heavier & finally settled out. These substances are called coagulants and their process of reaction is termed as "Coagulation".

Types of Coagulants:-

The coagulants commonly used as alum,

aluminium Sulphate [$Al_2(SO_4)_3$] : Iron ~~manganese~~ Sulphate [~~Al~~ $FeSO_4$] and lime. Other less Commonly used chemicals are sodium aluminate, ferric Coagulants eg: Ferric chloride, ferric Sulphate, activated silica etc., Besides some natural products such as Nirmali seeds have also used.

The choise of using aluminium or iron is largely decided by their characterisitics and relative suitability in the treatment process. However quality of floc ~~Co~~ formation is better incase of iron Sulphate. The ferric floc is much denser than the alum floc & is more precipitated over by wide pH range.

Chemical reactions :-

1). $Al_2(SO_4)_3 + 3Ca(HCO_3)_2 = \underset{(floc)}{Al_2(OH)_6} + 3CaSO_4 + 6CO_2$

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

The bicarbonate of iron is changed to iron hydroxide by the addition of lime

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

The reaction Continue with the oxidation of the ferrous hydroxide by the oxygen presen water to ferric hydroxide.

(floc)

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

The process may be set to be taking places in two stages.

I stage:

First stage is marked by the neutralization of electric charges. The positively charged Al & Fe ions neutralize the negatively charged particles of turbidity and to form a single mass.

II stage:

If now the water is gently stirred the particles grow bigger in size. The floc becomes heavier & is carried down to be ultimately removed by sedimentation

7/2/18 **Dosage of Coagulants:-**

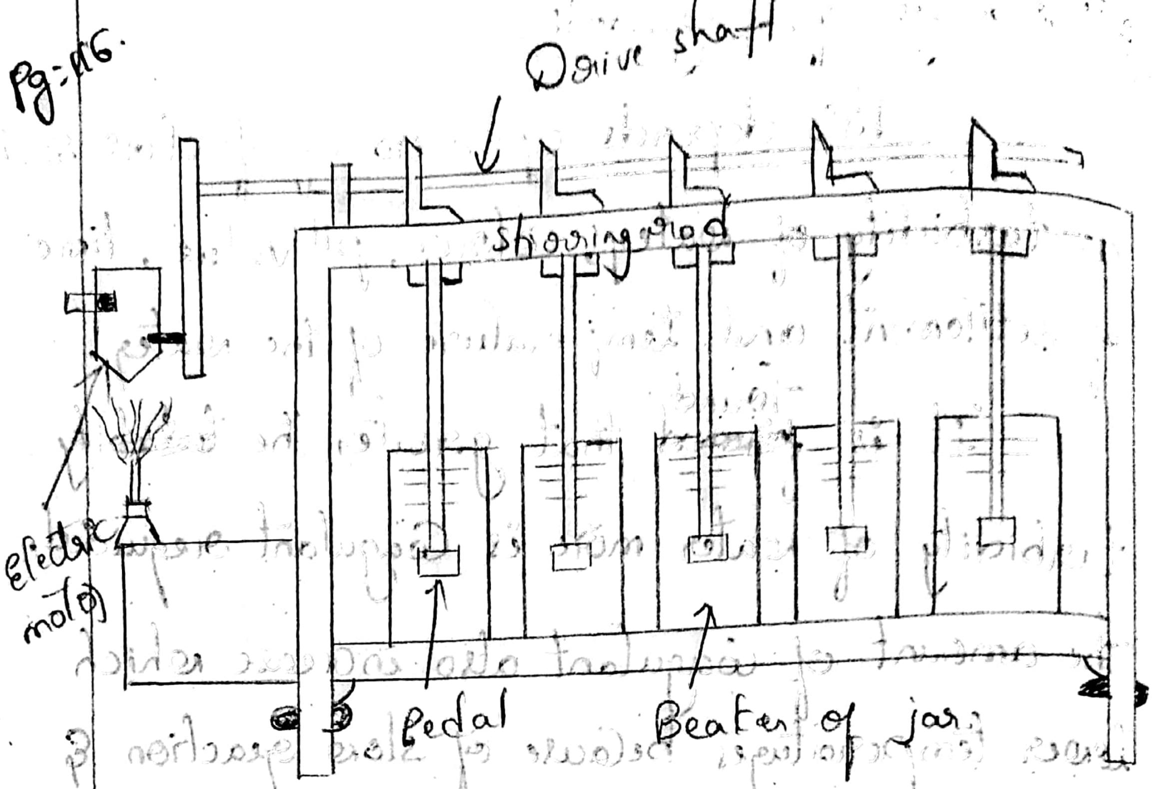
This depends upon no. of factors such as turbidity of water, colour, pH value, time of settlement and temperature of the water.

It is found that greater the turbidity of water more is Coagulant required. The amount of Coagulant also increase which lower temperatures because of slow reaction & floc formation. The Control of pH value is important from the point of view maintaining the character of the flocs.

For the removal of colour, Colour floc is required to be formed first before Subsequent removal through filteration. with most Coloured waters the floc is formed with pH value below 6.5. Alum is quite effective in removing Colour.

The jar test:-

The jar test is the laboratory method to determine the optimum dosage of a particular Coagulant which is required to be added to



The jar test Apparatus

The raw make water for Coagulation and Subsequent. sedimentation in a treatment pla

The jar test Consists of a rotary device having 6 No. vertical stirring rods provided with pedals at lower ends and Called multiple stirrer with stirring water and alum Content placed in 6 No beakers or jars.

The different amount of chemical Solutions are added to each jar Containing the same amount of water sample and the water solution stirred rapidly at first for

3 to 5 min & slowly later for about 30 min. The liquid is finally allowed to stand so that floc may be formed.

The smallest dose of alum that produce a good floc is taken as the optimum dosage for the particular water.

Design procedure :-

1. Velocity of flow assumed uniform through out generally not exceed 30 cm per minute.
2. Detention period 3 to 4 hrs for plain sedimentation & in case of chemically aided sedimentation it is 2 to 2.5 hrs. For vertical flow tank it is taken 1 to 1.5 hrs.
3. Overflow rate for plain sedimentation tank surface loading is 15000 to 30000 $lit/m^2/day$ for horizontal flow & circular sedimentation tank surface loading is taken as 30000 to 40000 $lit/m^2/day$. While for vertical flow sedimentation tank surface loading is 40000 to 50000 $lit/m^2/day$
4. Depth of flow ranges from 3 to 6 m.

5. Weir loading is generally upto 3,00,000 lit/m/day.

9/2/18 6. Rectangular tank channel length should be such as to ~~assure~~ ensure proper flowing through period. A length of 12m, width, length generally not less than 1:4.

7. Circular tank diameter generally not exceeding 60m

2. Cal. the size of a rectangular sedimentation tank to treat 1.8 million litres of raw water per day. Assume particle size 0.03mm, Sp. gravity = 1.8, Kinematic viscosity of water = 20°C as 1.01 Centi stokes. Expected efficiency of particle removal as 75% with tank working under good performance Condition.

Sol Given data

Settling velocity,

1) Stokes law $V = \frac{g}{18}(S-1)\frac{d^2}{\nu}$

$$= \frac{981 \times 10}{18}(1.8-1) \times \frac{(0.03)^2}{1.01}$$

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$V = 0.38\,mm/sec$

2) Reynolds number,

$$R_e = \frac{Vd}{\nu} = \frac{0.38 \times 0.03}{1.01}$$

$R_e = 0.011$ <1

3) theoretical surface over flow rate for ideal settling basin,

$$V = \nu_0 = 0.388\,mm/sec$$

$$= \frac{0.388 \times 24 \times 60 \times 60}{10^3}$$

$$= 33.52\,m/day$$

4) Design surface over flow rate,

$$\frac{h}{H} = 1 - \left[1 + n\left(\frac{v_0}{Q/A}\right)\right]^{1/n}$$

$$\frac{v_0}{(Q/A)} = \frac{1}{n}\left[\left(1 - \frac{h}{H}\right)^{n} - 1\right]$$

[$\because \frac{h}{H} = 0.75$, $n = \frac{1}{4}$]

$$= \frac{1}{1/4}\left[(1 - 0.75)^{1/4} - 1\right]$$

$$= 1.17$$

$$\frac{V_0}{Q/A} = 1.17$$

$$\frac{Q}{A} = \frac{V_0}{1.17}$$

$$\frac{Q}{A} = \frac{33.82}{1.17}$$

$$\therefore \boxed{\frac{Q}{A} = 28.61 \text{ m/day}}$$

for plain sedimentation,

Surface loading = 15000 – 30000 lit/m^2/day.

5. **Design settling tank:**

$$\text{Surface area of tank} = \frac{\text{Design flow}}{\text{design of surface over flow rate}}$$

$$= \frac{1.8 \times 10^3}{28.61}$$

$$= 62.8 \, m^2$$

$B/L = \frac{1}{4}$ [from design procedure]

L = 19
B = 4.75 } Assume

Detention period = 4 hr. [from design Procedure].

Depth of flow = $\frac{1.8 \times 10^3 \times 4}{24 \times 19 \times 4.75}$

= 3.32 m ≃ 4 m

Surface loading = 20000 lit/m²/day

= $\frac{20000}{10^3}$ c.m/day

= 20 m/day

∴ Plane area tank = $\frac{1.8 \times 10^3}{20}$

= 90 m²

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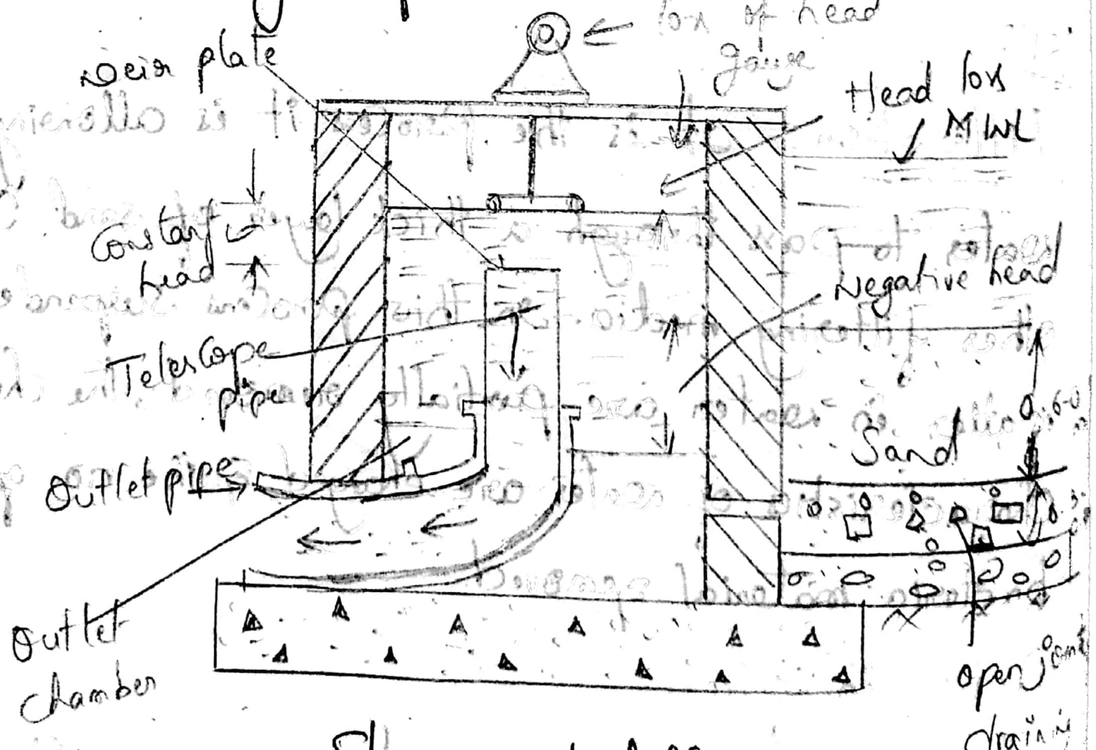
Filteration:- It is the process it is allowing water to pass through a thick layer of sand (or) other filtering media. In this process suspended matter in water are partially removed, the chemical characteristics of water are changed & the no. of bacteria material removed.

Action in filters:-

(i) Mechanical straining: This is responsible for removing such particles of suspended matter as are too large to pass through the sand grains

(ii) Sedimentation & adsorption: The account for the removal of colloids, suspended matter and bacterial particles. The suspended particles smaller than the voids in the filter bed settled upon the sides of the sand grains. The particles adhere to the grains because of the physical attraction b/w the two particles of matter & because of the presence of the gelatinous coating formed on the sand grains by the previously deposited bacteria & colloidal matter.

(iii) Biological metabolism: This is the life process of the living cells. The surface layer get a coated with a zoogleal film in which the bacterial activity



Slow sand filter

are the bacteria & which feed on the organic impurities converting them by a complex biochemical action into simple compounds, resulting in the purification of water.

(iv) Electrostatic action: A certain amount of dissolved & suspended matter in water is ionized

Slow Sand filters :-

Construction: This consist of water tight tank 2.5 - 3.5m in depth having a sand bed 0.6-0.9m thick supported on a bed of gravel 0.3-0.6m thick.

Operation: The raw water is lead gently on the filter bed & percolating downwards passes through the under drains into an outlet chamber. The outlet chamber is provided with a telescopic pipe & an weir plate in order to keep the rate of filtration constant. The loss of head gauge operated with a float arrangement to measure the loss of head.

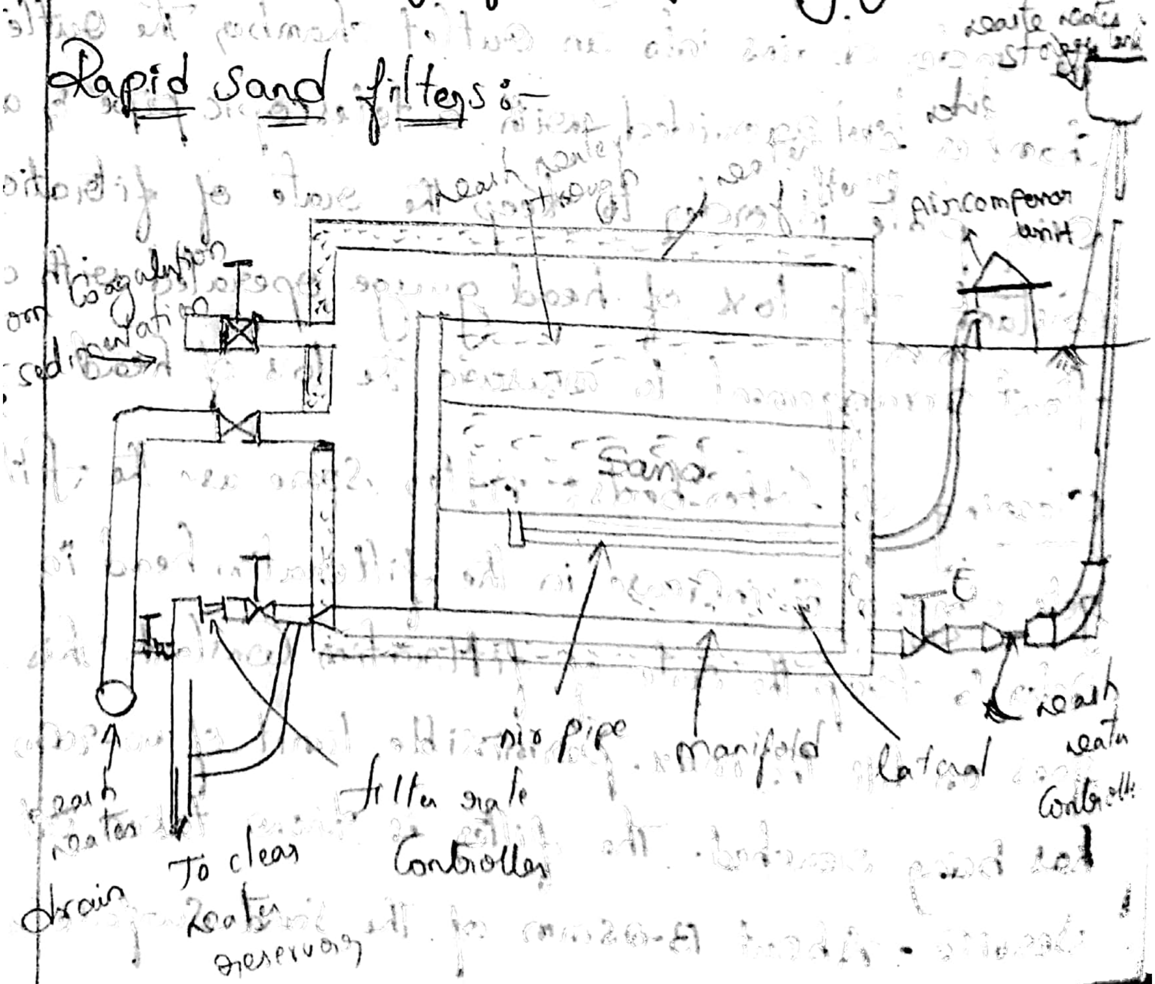
Cleaning of filter beds: After some use the filter gets clogged & increase in the filteration head in order to keep the rate of filtration constant. This goes on till the max. permissible limit of 60-90cm has being reached. The filter is now taken out of service. About 13-25mm of the sand surface is

Carefully scraped off. The filter is then returned into service. The process of scraping of sand surface every time the filter is clogged is repeated till the sand bed has being thinned down to prevent efficient filtering. Cleaning by scraping will normally be required once every 2 to 3 months, provided raw water is of a suitable character.

Characteristics:-

1. Rate of filtration is low 100 lit/hour.
2. The bacterial efficiency is high as much as 98 to 99%.
3. Unsuitability for water having greater turbidity.

Rapid sand filters:-



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UNIT-V

Disinfection

Disinfection of water:-

In previous methods used for the Purification of water that is sedemi Sedimentation, filteration used to remove the bacteria present in water. The treatment of water with chemicals to kill bacteria is termed as disinfection of water. sterilization strictly speaking is the boiling of water before using for the domestic purpose. Boiling kills disease - germs of cholera & typhoid within few minutes.

Methods:-

The methods employed to disinfect water depend upon the disinfecting materials used for the purpose.

Chlorination, ozonization, ultra-voilet ray method, excess lime process & application of silver & bromine methods are the principal methods used for disinfection of water.

Chlorination:-

It is the application to water of small quantities chlorin (or) chlorin compounds. The dose applied is generally less than 1mg/lit & the amount of chlorin is so required to added depends upon the chlorin demand of water

Action:-

chlorin hydrolosis in water to form hypochlorous acid (HOCl) which further reaction to Produce hypochloride ion (OCl). HOCl & OCl together are known as free available chlorine.

$$Cl_2 + H_2O \rightarrow HOCl + H^+ + Cl^-$$

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

$$\frac{H^+ (OCl)^-}{HOCl} = ki$$

where:

ki = Ionization Constant having values of 1.5×10^{-8} moles/lit at 0°C & 2.5×10^{-8} moles/lit at 20°C

If Amonia is also present in water chlorin reacts to as follows.

$$HOCl + NH_3 \rightarrow H_2O + NH_2Cl$$ (Mono chloramine)

$HOCl + NH_2Cl \rightarrow H_2O + NHCl_2$ (Dichloramine)

$HOCl + NH_2Cl_2 \rightarrow H_2O + NCl_3$ (Trichloramine).

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The chlorine in chemical combination with Amonia is called combined available chlorine.

These resulting chlorine compounds in the form of free or combined available chlorine with in the bacterial cell wall forming a toxic chlao compounds This kill the bacteria completely

Calculate the percentage distribution of HOCl in water at 20°C & p^H 8.0

Given data,

temperature = 20°C

at 20°C $k_i = 2.5 \times 10^{-8}$

$p^H = 8.0$

$$\frac{H^+(OCl)^-}{HOCl} = k_i$$

$$\frac{(OCl)^-}{HOCl} = k_i / H^+$$

$$\frac{HOCl}{HOCl + (OCl)^-} \times 100 = 1 \quad [\because \text{formula}]$$

Chlorine,

$$= 0.25 \times \frac{30}{100}$$

$$= 0.075 kg.$$

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Special methods:-

1. Prechlorination: It is the application of chlorine before filteration. prechlorination removes bacteria load on filters result in increased filter run & removing taste & odour.

2. Double chlorination: It is the application of chlorine at two coins in the treatment process. Advantages in this method of chlorination are

a). decrease in the ~~food~~ load on filter.

b). Greater removal of bacteria.

c). Greater factor of safety.

d). Control of algae.

3. Super chlorination: It is the application to water of an excess amount of chlorine. The dose may vary from less than 1mg/lit to 2mg/lit. This method is effective in destroying high concentration of taste & odour in water.

4. **Break Point chlorination:-** It is also termed as free chlorination involves the addition of chlorine so as to oxidized all the organic matters, remove substances and free Amonia in raw water

Ultra-violet rays:-

Ultra-violet rays is an effective method for disinfecting of clear water. Use is made of the invisible light rays beyond the violet of spectrum which are very powerful in killing all types of bacteria. The rays are generated by passing electric current through mercury vapour lamp. The effective penetration of the rays in water is only for a depth of 30cm.

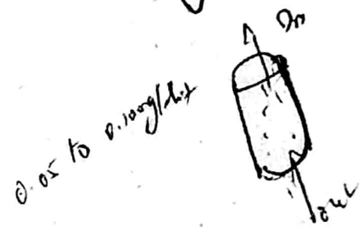
The process has the advantage of no taste, no odour in the water & presenting no danger of over dose. The disadvantage are high cost.

Excess lime:-

Excess lime involves the application of lime for the combined objectives of softening & disinfecting of water. Dose to be given between 10 to 20 mg/l. To remove the excess lime after the process through re carbonation

Silver :-

When immersed in water Silver has been observed the action on bacterial life. Tubes of Silver electrodes contain in hallow Cylinders allowing water to flow from out side to inside. Dosage is 0.05 to 0.10mg/lit. This method however hasn't so far being used on large Scale because of high Cost.



Iodine & Bromine :

These are also process of disinfecting Power. This used in normally Small water Supplies Such as army Camps & Swimming pools. Iodine & bromine are cheaply available. Dosage is about 8 to 10mg/lit. For heavy polluted water it may be doubled

Potassium Permanganate :

Potassium Permanganate is Commonly known is pinky has been used in individual water supply for disinfection. Dosage is 0.5gm/lit. This is effective against Cologa & found to be effective against other diseases germs.

4/2/18

Taste & odour Control :-

Taste & odour in water supplies may be caused due to in the presence in water any of the following

a) Decaying organic matter resulting from algae & other micro-organisms & industrial waste such as phenols.

b). Dissolved gases like H_2S, CO_2. d) Industrial wastes such as phenols

c). Excess amount of chlorine.

Methods for the control of taste & odour.

1. Copper Sulphate treatment :-

It is cheaply used for the control of algae, which is killed within a few days following treatment. Copper Sulphate is applied in a single dose usually less than 3mg/lit. An excess dose result in destroying fish life along with other micro-organisms present in water

2. Ammonia chlorine Process :-

In this process applying amonia with chlorine which result in the formation of chloramines. As a result of these action quantity of chlorine used is reduced. This process is also helpful in removing ~~chlorofinol taste~~ chlorophenol taste i the application of this process amonia is added first mixed with water before chlorine is apply. Ratio of amonia to chlorine is 1:4.

3. Activated Carbon :-

It is the most important method for the Control of taste & odour. Activated Carbon is obtained ~~applying~~ by heating material like saw dust, Paper mill waste. It is activating by passing air or stream for the removal of hydrocarbons. Activated Carbon is very porous & ~~hence~~ has been property of removing many of the dissolved impuriti in water. Dosage varies from 2 to 20 mg/lit.

4. Chlorine dioxide :-

It is produced by injecting a solution of Sodium chloride into a chlorine Solution. It is used for removal of taste & odours Caused by phenols & other algae growth.

Iron & Manganeese removal :-

Iron is present in water either as ferrous biCarbonate or ferrous Sulphate. Iron

& manganeese when present in amount greater than 1.5mg/lit are objectable because of

i) unpleasant taste & odour

ii) Colouring of water

iii) Deposits of iron precipitation in pipes.

Methods for the removal of iron & manganeese are based on Converting the Soluable ferrous & manganeese Compounds to the insoluble ferric & magnetic Compounds.

Aeration is an effective method in precipitating out iron when present as ferrous bicarbonate remove through the process of sedimentation & filteration

Base exchange process in this method the zeolite bed is made of manganeese zeolite. The iron & manganeese of raw water is oxidized to insoluble hydrated oxides & later removed by filteration

26/2/18

Water Softening process :-

There are three general methods used for water softening

1. Lime process:

In this process remove only the Carbonate hardness. The principle involved is to neutralize the CO_2 with milk of lime forming normal Carbonates which are removed by filteration.

$$CO_2 + Ca(OH)_2 = CaCO_3 + H_2O$$

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

$$Mg(HCO_3)_2 + Ca(OH)_2 = CaCO_3 + MgCO_3 + 2H_2O$$

2. Lime & Soda ash process:

Lime has no effect on Sulphates of Calcium & magnesium. Most of the non Carbonate hardness found in natural waters by the use of Soda ash the non-Carbonate hardness Can be removed

$$CaSO_4 + Na_2CO_3 = CaCO_3 + Na_2SO_4$$

$$MgSO_4 + Ca(OH)_2 = Mg(OH)_2 + CaSO_4$$

~~$CaSO_4 + Na_2CO_3 = Ca$~~

3. Base Exchange process:

In this process hard water is passed through a bed of zeolite Sand. zeolites are artificial Products in granular form with Size between

0.5mm to 0.25mm in diameter. The zeolite Softners are very much Similar to the rapid gravity filter with the difference that the zeolite layer is thicker 1.2 to 1.8m.

The zeolite of the base exchange process of water Softening is applied Only to clear water.

Aeration:-

This is the process of bringing water into intimate Contact with air. Aeration is acheive the following objects:

→ Drive out dissolved gases like Carbon dioxide, hydrogen Sulphate & other taste & odour in bodies of water

→ Soluable Compounds present in the ground water.

→ Iron & Manganeese Salt from underground water Sources.

The fundamental process involved in aeration is the exchange of gases between water & atmosphere. For proper aeration the following Points is necessary:

1. To increase the area of water in Contact with

air.

2. Increase the time of contact of water droplets with ~~water~~ air.

Aeration is effective in removing 75% of the odours. Removal of carbon dioxide is also high. The unit operation of aeration is costly.

Reverse Osmosis :-

This involves seperation by passing fresh water through ~~Syth~~ synthetic membranes. (selectively permeable to water out) At high pressure of 10,000 kN/m² fresh water is forced to pass through these membranes which result in the salt being left behind.

27/2/18

Fluoridation:-

It has been found that fluoride concentration 0.7 to 1.2 ppm. In water for the prevention of dental problems in children. However in areas where water is of low fluoride dental problems is high. The process of rising the fluoride content of water is known as fluoridation.

The fluoride compounds that are adopted for fluoridation are sodium chloride, sodium silico fluoride & hydro fluro ~~silicate~~ silicic acid.

Sodium fluoride having 95 to 98% purity is most commonly used. The application of fluorides in water may be either in powder form or in the solution form. It is mostly to apply it in the solution form. Since in the powder form it is toxic & must be shut tight containers.

Defluoridation :-

An excessive concentrations ~~fto~~ fluoride can cause dental fluorosis & bone problems. Hence when the fluoride concentration is more than 1 to 1.5 ppm it should be removed from water. The process of removing the fluoride concentration of water is known as defluoridation.

1. Calcium phosphate: Bone has great affinity for chlorides & can be used in the filter for removal of ~~flurodi~~ fluorides.

2. Bone charcoal: It is essentially tri-calcium phosphate & carbon and has been used successfully for the removal of fluorides

3. Synthetic tri-calcium phosphate: It can be prepared from milk of lime & phospheric acid when the reaction is carefully controlled. This

material has been used in contact filters for removal of fluorides.

4. Fluorex: It is a special mixture of tri-calcium phosphate. It is used as filter medium.

5. Ion exchange: There are a no. of ion exchange materials which can be used for removal of fluorides. Fluorides in water can be removed by successive passage through beds of cation exchange

6. Activated-Carbon: Removal of fluoride from water has also been effected by treatment with activated carbon.

28/2/18

Ultrafilteration:-

It is a system similar in operation to reverse osmosis. ultrafilteration membranes are thin film cast from organic polimer solutions. the film thickness 0.005 to 0.01 inches. ultrafilter membranes may be packed either as a plate device or as a tube device.

This technique is used in conjuction with biological oxidation process such as activated sludge process. From the activated sludge process is passed through ultrafilteration system the filt membranes filter out the biological cells while allowing passage of treated effluent. the process removes suspended solids rather than dissolved solids & small size particles. ultrafilteration removes all the suspended solids 100% of BOD, COD, ~~poc~~ TOC.
