১

[illegible]
L.3 — T-1
> [illegible]
[illegible]
96 [illegible]

Classification of Impurities

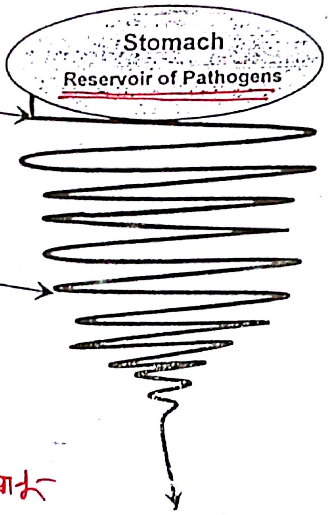
Impurities in water may be classified according to the source of origin and form of presence:

- Type and Origin:
(i) Inorganic and mineral origin (ii) Organic origin (iii) Living impurities (iv) Radioactive impurities.

- Form of Presence:
(a) Suspended (b) Colloidal Suspension (c) Dissolved impurities including Dissolved Gases.

	(i) *Inorganic*	(ii) *Organic*	(iii) *Living*
(a) *In Suspension* : (> 1μ)	Silt, clay	Fats/ oils, leaves, wastes, organic coloring materials	Algae, fungi etc.
(b) *In Colloidal Susp*: (1μ -10^{-3} μ)	Silica, alumina, iron iron oxidized etc.	Decomposable organic matter	Bacteria, viruses etc
(c) *In Solution*: (< 10^{-3} μ)	Many organic matter like organic acid, pesticides etc. remain in solution. Most of the inorganic minerals remain in solution as dissociated cation and anion. Moreover, dissolved gases like O_2, CO_2, H_2S ,NH_3 also common.		

Discharge of Human Faecal Matter



Fairly Constant Environment:
-Moisture content
-Temp 35-37°C

(সবসময় একই থাকে temp.
⇓
Bacteria prefers constant temp.
⇓
But at nature, constant temp. can never be found.
⇓
So Bacteria can't live in nature)
⇓
Bacteria ⇒ Dead organic matter খায়
⇓
Theoretically every half an hour double হয় Bacteria.
⇓
Bacteria বেড়ে diff. symtoms i.e. fever, vomitting, diarrhoea হয়
⇓
Then আবার no. কমে যায় i.e. bacteria বেরিয়ে আসছে।

Intestinal track of man and all warm blooded animal

Coliform Inhabits

⊛ জীবাণু যদি একটি থাকে coliform প্রায় 1 million থাকবে।
⇓
So যদি coliform ই না থাকে তাহলে জীবাণু must থাকবে না।

Healthy Person's Excreta: Faecal Matter + Coliform Organisms (4×10^{10}/day)

Infected Person's Excreta: Faecal Matter + Coliform Organisms + Pathogens

(যে জীবাণু রোগ সৃষ্টি হয়।)

* Water borne disease → highest in the world.

WATER QUALITY STANDARDS

Constituents/ Characteristics		WHO Guide Line Value	Bangladesh Standards,ECR,97
pH	value	6.5-8.5	6.5-8.5
Turbidity	(NTU)	5	10
Color	(TCU)	15	15
Hardness (as $CaCO_3$)		500	200-500
Iron	mg/l	0.3	0.3 – 1.0
Manganese	mg/l	0.4*	0.1
Chloride	mg/l	250	150 - 600
Sulfate	mg/l	250	400
Odor	(TON)	-	-
TDS	mg/l	1000	1000
Fluoride	mg/l	0.6-1.5	1
Nitrate-N	mg/l	50	10
Lead	mg/l	0.01	0.05
Mercury	mg/l	0.001	0.001
Arsenic	mg/l	0.01	0.05
Sodium	mg/l	200	200
T.Coliform	CFU/100ml	0	0
F.Coliform	CFU/100ml	0	0

* Health Risk Guide Line Value

6

Faruk Sir
Sheet-3

MICROBIOLOGICAL QUALITY OF WATER:

(*) In test, We must sterilized our hands by detol, savlon etc ⇒ they are actually Ethyl Alcohol or Spirit

Many **Bacteria** are found in water. Most of them are of no sanitary significance, some are indicator of pollution but are harmless; others, few in numbers, are pathogenic (produce diseases).

smallest ← **Viruses** are parasitic agents smaller in size than *Bacteria*, requiring a particular host cell which serves as a source of raw material for viral reproduction.

Microscopic organisms other than *Bacteria* and *Virus* e.g ***Algae, Fungi, Protozoa,*** (↗ multi cellular) ***Worms* etc.** often have undesirable effects upon water. Some of them produce color, taste, earthy and fishy odors in water.

যেকোন একটির জীবাণু নাই তার মানে নয় যে অন্য কোন জীবাণু নেই।
⇓
So water can never be called safe.

The most common and widespread danger associated with domestic water is contamination, either directly or indirectly, by sewage, by other wastes, or by human or animal excrement. Such contamination of water may introduce a variety of intestinal pathogens. These include:

(i) *Bacteria* causing typhoid fever *Salmonella Typhi*; bacillery (1) dysentery *Shigella*; → cholera *Vibrio Cholerae*, ⇒ কলেরা হয়।

(ii) *Viruses* causing infections hepatitis; poliomyelitis and gastroenteritis,

(iii) *Protozoa* causing amoebic (2) dysentery *E.Histolytica* etc.

Virus - একটির আকারে সাথে আরো অনেক কটির reproduce করে।
So, bacteria ও মারা যায়।

The use of such water may result further cases of infection. Ground waters normally do not contain any *Bacteria* since the effect of filtration, unfavorable environment and time will eliminate most of them. Soils or aquifers having holes cracks or crevices may allow contaminated water to enter wells or springs. Surface waters usually contain many Bacteria.

↳ one cell, one life.

Blue green Algae

Indicator Organism: v.v.i. imp.

faecal test-এর জন্য temp একটু বাড়ানো হয় ⇒ 44.5°c.

non faecal " " " ⇒ temp 35°-37°c

↳ Coliform

- It is impracticable to monitor drinking water for every possible microbia pathogen that might occur with contamination. A more logical approach is the detection of organisms normally present in the faeces of man as indicators of excremental pollution.

  The coliform group (specifically *Escherichia Coli*) normally inhabits the intestinal track of man and other warm blooded animal and is excreted in large number (500 million per gram. In a ratio of 1 typhoid organism to 1 million coliform) with the faeces. It is considered non pathogenic but may cause infections of the genito urinary tract.

  The presence of such organisms indicates the presence of faecal material, and thus that intestinal pathogens could be present. Conversely the absence of faecal commensal organisms indicates that pathogens are probably also absent. Thus the coliform group is of great importance in the microbiological quality analysis of water and includes a number of organisms.

- Some coliform species *Aerobacter Aerogenes* and *Aerobacter Cloaceas* are normally found on plant, soil and as well as in the faeces are termed as "total coliform"(including *Escherichia Coli*) which ferment lactose at 35°c or 37°c with the production of acid, gas and aldehyde within 24 or 48 hours.
- *Escherichia Coli* which is exclusively of faecal origin is known as "*Faecal Coliform*" tolerate and grow at the higher selective temperature range of 44.0 to 44.5°C.

Methods of Analysis:

Two basic methods have been developed for the detection of indicator bacteria in waters-

(1) **Multiple Tube Method (MPN) –**

Different amount of water are added to tubes containing a suitable culture media (lactose broth). After a specified incubation time at a given temperature each tube showing gas formation is regarded as' presumptive positive' and indicates the possible presence of coliforms. From the number of tubes with positive reaction, the most probable number (MPN) of bacteria present in the original water sample can then be statistically determined.

(2) **Membrane Filter Technique (MF) –** Colony Forming Unit (CFU) per 100 mL.

In contrast to the MPN method, the membrane-filter method gives a direct count of the total coliforms and faecal coliforms. The method is based on the filtration of a known volume of water through a membrane filter (pore dia = 0.45μm). The bacteria are retained on the surface of the filter which is incubated with a culture media at a selective temperature for specific period of time. Colonies of coliforms develop on the filter can be counted directly.

⊛ Special filter membrane ⇒ Cellulose

Coliform ⇒ Ferment Lactose (Produse acid & gac)

Bacteria size = 1 μ. ⇒ So filter করলে Bacteria আটকে যাবে

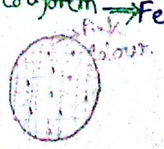
⇓

Pore ছোট দেখে easily যাবে না so vacuum pump use করব।

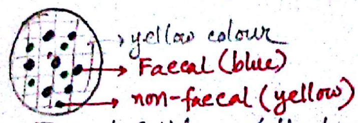
Bacteria ⇐ বোঝা/দেখা যাবে না

So food দিলাম ⇐

Bcteria-এর food is Lactose ⇐



Total coliform



Faecal Coliform. (after keeping specific time 12 hour)

Radioactive Materials and Organic Contaminants in Water Supplies

x পড়ে নিস

Ⓗ Cl_2 is also not permitted to dispose in natural water bodies.

Radioactive Materials- are introduced into the environment from a number of sources; naturally occurring and man-made.

The naturally occurring sources include those substances producedby cosmic rays which may find their way to water courses with rainfall and run off and those present in the rocks and soil.

The man-made radionuclides are those resulting from fall out from nuclear tests, nuclear power production, and medical and other uses of radioactive materials. Various body tissues have different sensitivities to radiation exposure. The detrimental health effects of exposure to radiation are either "Somatic" i.e. those that become manifest in the exposed individual or "Hereditary" i.e., those that affect the individuals descendants.

- The recommended Guide Line Values are 0.1 Bq/litre for gross alpha activity and 1bq/litre for gross beta activity. Bq= becquerel [the SI unit of radionuclide activity]; 1 becquerel is equivalent to 1 spontaneous nuclear transformation per second and corresponds approximately to 27 picocuries.

Organic Contaminants- both naturally occurring & artificial organics (like pesticides) are found in water. The former may be associated with color, taste or odor while the latter in some cases may be toxic or carcinogenic.

- The organic materials in water may be altered by treatment process, which some time make them more dangerous (like trihalomethanes).

Scanned by CamScanner

Ground H_2O ⇒ Fe, Mn, As
Surface H_2O ⇒ turbidity & bacteria
Operation ⇒ chemical process i.e. sedimentation

Imp Q. Draw flow diagram for this water quality.

Suppose, Some H_2O quality parameter দেয়া থাকবে।

* We use Bd standards.

⇓

Suppose, H_2O-এ Fe, Mn, As আছে। যেকোন process ব্যবহার করা যাবে না। এমনভাবে process চিন্তা করবে যেন একটা process একবার করলেই চলে।

⇓

In this case,

WATER QUALITY STANDARDS

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Mercury	mg/l	0.001	0.001
Arsenic	mg/l	0.01	0.05
Sodium	mg/l	200	200
T.Coliform	CFU/100ml	0	0
F.Coliform	CFU/100ml	0	0

* *Health Risk Guide Line Value*

⑧

[illegible]
Shed No = 4
C/ = 3/1

to remove suspended particles from surface H_2O or ground H_2O → no suspended matter.

SEDIMENTATION THEORY

The **vertical settling velocity of a particle in an aqueous system** (Stoke's law),

$$\underset{\text{only settling velocity.}}{V_s} = \frac{g(\rho_p - \rho_w)dp^2}{18\,\mu}$$

dp^2 → only variable. → So diameter of the particles is the main contributor.

Therefore, is a mainly a function of diameter of particles.

The **horizontal velocity of flow,** $\boxed{V_h = \frac{Q}{BH}}$ Therefore, is mainly a function of size (geometry) of sedimentation tank. → B & H ↑ velo. ↓; B & H ↓ " ↑

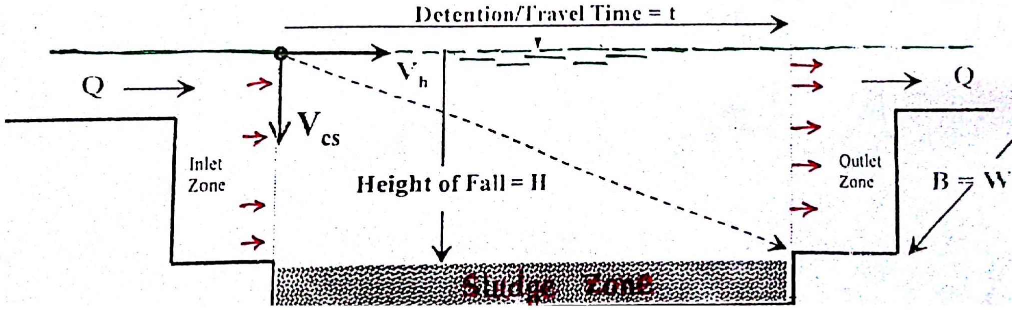
dia of particles fixed so is control করা যায় না। So V_h কমাবো। So we have to increase surface area but it's costly.
⇓
So we have to determine optimum area.

If a particle is to be removed, its settling velocity ① and horizontal velocity ② must be such that their resultant will carry it to the bottom of the basin before the outlet zone is reached, i.e. during the detention time (t) of the water in the tank.

So it may be said that the critical settling velocity must be, $\underset{\text{critical settling velocity}}{V_{cs}} = \frac{H}{t} = \frac{HQ}{V} = \frac{Q}{BL}$

which is numerically equal to the rate of flow (in m^3/day) divided by plan area (in m^2) of the basin, i.e. Surface Over Flow Rate (SOR).

→ $V_{cs} = \frac{Q}{BL}$ ⇒ Q: justify with diagram that
a) removal in a settling tank is a func^n of surface area
b) or is independent of depth.



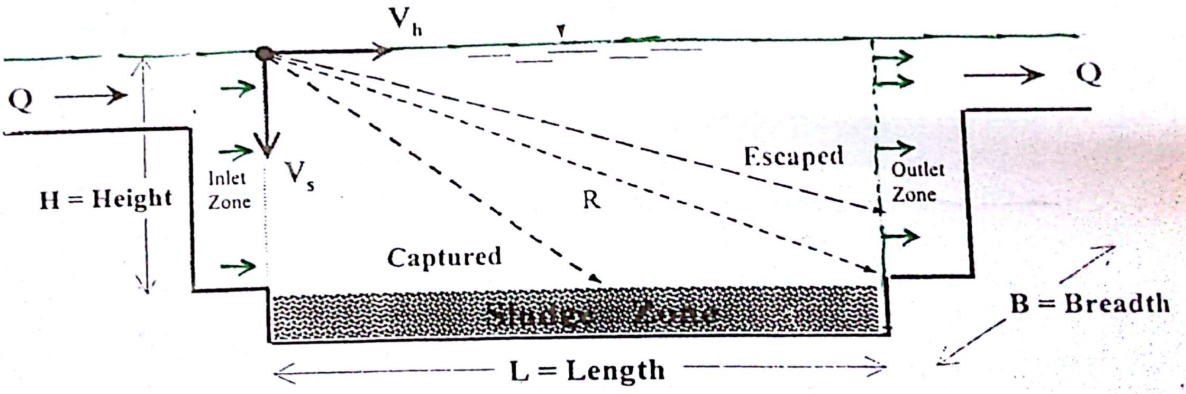
Surface Over flow Rate (SOR) $\frac{Q}{BL}$

Which physically represents the settling velocity of the slowest settling particles that are 100% removed. Those particles which settle at velocities equal to or greater than the surface overflow rate will be entirely removed, while those settle at lower velocities will be removed in direct proportional to the ratio of their settling velocity to Vcs, assuming they are uniformly distributed upon the entering the basin.

Smaller the SOR, greater is the removal of suspended particles i.e. for a given Q, the greater the surface area (BL), the smaller will be SOR, the smaller the particles removed with out the consideration of the depth. Actually, velocity of settling is not so simple, it depends upon a number of factors as mentioned below, however SOR is an important factor. From SOR and detention time, t, plan area and volume are calculated. To increase plan area "Tube Settlers" are employed.

Effect of Surface Over Flow Rate (Increased Surface Area)

(a)

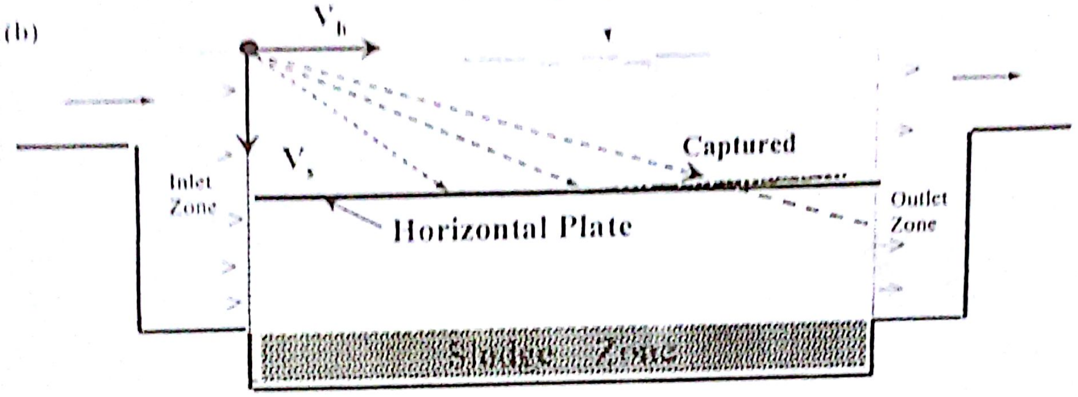


Single Storied Sedimentation Tank

surface area increase করা costly. So this process

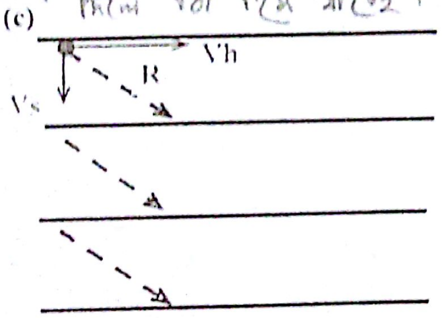
⇓

Imp Q: how parallel inclined plate separator increase the performance of a sedimentation?

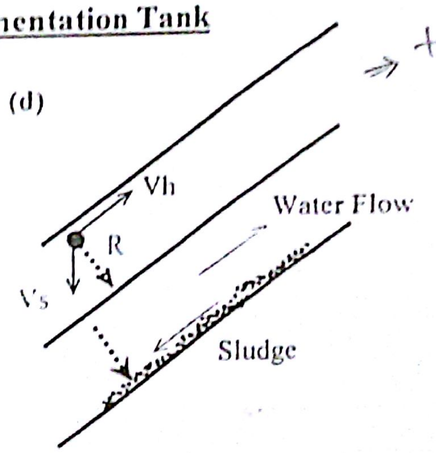


Two Storied Sedimentation Tank

→ parallel plate দিলে vol^m বেড়ে যাবে।



Horizontal Parallel Plates Separator



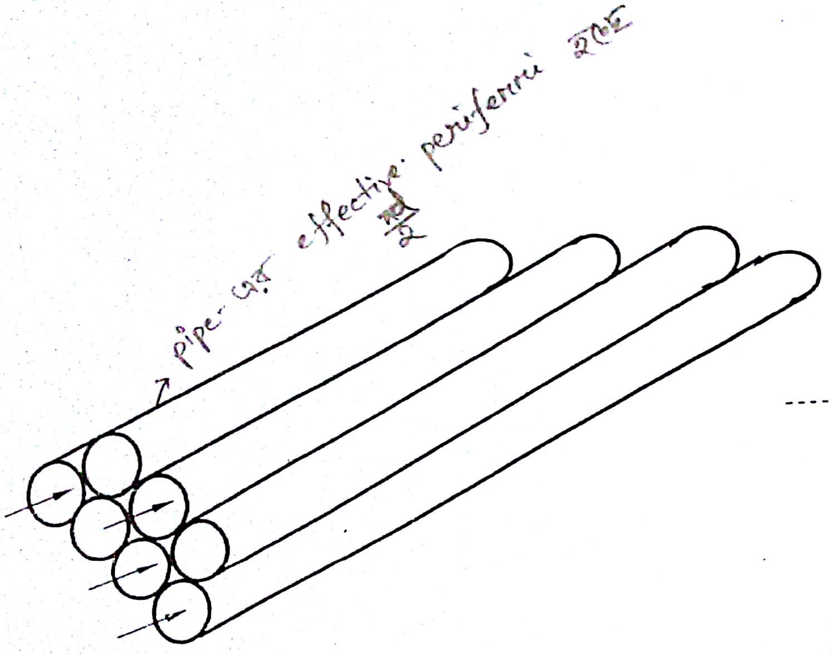
Inclined Parallel Plates Separator

⇒ travel path বেড়ে গেলো। for inclination. So Detention time ও বেড়ে গেলো So V_s's বাড়বে So greater the removal of particles.

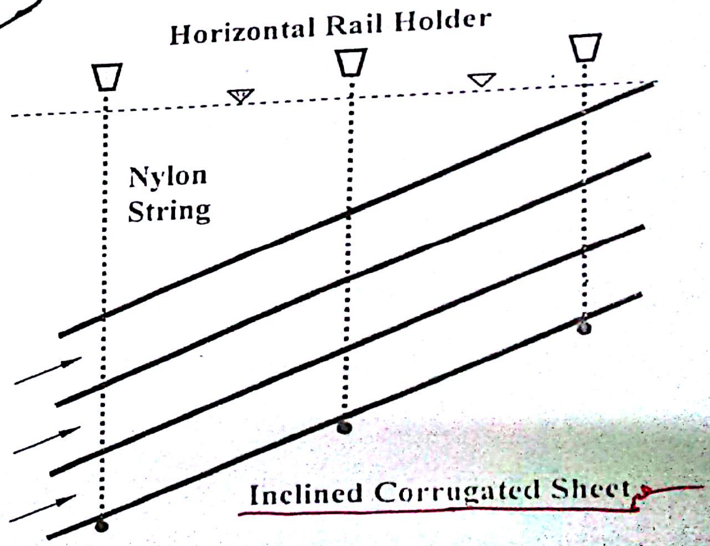
⇓

So increased performance.

Q. How SOR effect the sedimentation process?



PVC Bunch of Pipes
Tube Settler



Inclined Corrugated Sheet

Factors those Influence Plain Sedimentation

- Size, shape and weight of the particles,
- Viscosity and temperature of water,
- Surface over flow rate (SOR = Q/BL i.e. surface area and flow rate).
- Inlet and outlet arrangements,
- Detention period (t = V/Q) and flowing through period (actual time of flow),
- Effective depth of settling basin (3 m – 5 m)

Types of Sedimentation Tank:

1. Rectangular, 2. Circular (Vertical flow & Horizontal flow type)

Design Data: Depth : 3 to 5 meters.

Rectangular Tank- L:W = 4:1 (W = 10 m is common).

Circular tank = (max. 60 m dia). SOR = 450 to 800 litres/hr/m^2

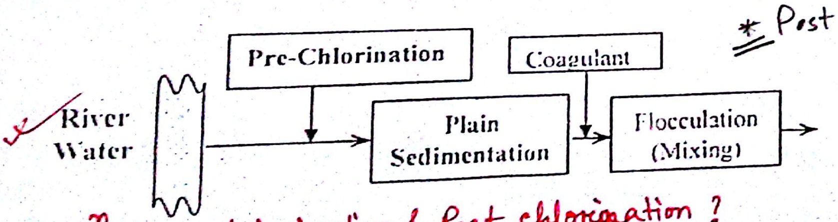
SOR = 900 to 1200 litres/hr/m^2 (Sedimentation with Coagulation-Flocculation).

Detention time, t = 1 to 10 hrs. V_{11} (max) = 15 cm/min.

Pre-Chlorination: - To remove color, odor and other organic matter,

- To control the growth of algae during detention

* Post clorination ⇒ for performing coagulation



#Q. Distinguish bet^n pre-chlorination & Post chlorination ?

Problem-1

বুঝতে হবে Imp

$SOR = \frac{Q}{BL} = 3\,m^3/sec \;/ 10000\,m^2 = 0.3$ mm/sec.

Calculated from Flow rate and settling Tank Geometry (size)

Suspended Particles Size Range [Avg. dia dp in mm]	Avg. settling vel. of suspended Par. (V in mm/sec)*	Wt. fraction of total Par. (in %)
·01	·011	10%
·02	·043	15%
·04	·172	20%
·06	·387	25%
·07	·527	15%
·08	·689	10%
·1	1·080	5%

*Calculated from Stokes law $V_s = [g(\rho_p - \rho_w)\, d_p^2]/18\mu$.

Sheet NO = 5

mainly suspended part

5 μ (for 80%)

colloidal means < 1 μ dp sedimentation

[illegible]

COAGULATION THEORY

Then $V_s = \frac{g(\rho_p - \rho_w) d_p^2}{18\mu}$

A large portion of the suspended particles in water are sufficiently small (< 50 μm) that their removal in a sedimentation tank is impossible at reasonable surface over flow rates and detention time.

The objective of coagulation and subsequent flocculation is to turn the smaller particles of color, turbidity and bacteria into larger flocs (increased effective size) either as precipitates or suspended particles to increase their settling velocity.

Stability of Colloids:

All color particles are -ve charged.

The colloidal particles in natural water are stable because of their surface charge (usually -ve). The stationary charged layer on the surface is surrounded by a bound layer of water in which ions of opposite charge (counter ion, i,e. + ve) drawn from the bulk solution with greater concentration in the vicinity. This arrangement produces a net charge that is strongest at the bound layer and decreases exponentially with distance from the colloid. When two colloids come in close proximity there are two forces acting on them.

(i) Electrostatic Repulsion An electrostatic potential is created by the counter ions surrounding each colloid. As two similarly charged particles approach each other, their diffuse counter-ion atmospheres begin to interfere and cause the particles to be repulsed

(normally same charge = repulsion
But খুব কাছাকাছি নিয়ে আসলে then attract করবে।)

(ii) The Vander Waals' forces of Attraction:

molecular Attraction

The second force, an attractive force called the Vander Waals force, support contact. This force is inversely proportional to the sixth power of the distance between the particles and also decays exponentially with distance. It decreases more rapidly than electrostatic potential, but is a stronger force at close distances.

The sum of the two forces as they relate to one colloid in close proximity to another is repulsive at greater distances and becomes attractive only after passing through a maximum net repulsive force, called the 'energy barrier' at some distance between colloids. Once the force becomes attractive, contact between the particles takes place.

Destabilization of Colloids:

Two theories

(a) Ionic Layer Compression The quantity of ions in the water surrounding a colloid has an effect on the decay function of the electrostatic potential. A high ionic concentration compresses the layers composed predominantly of counter ions toward the surface of the colloid. If this layer is sufficiently compressed, then the Vander Waals force will be predominant across the entire area of influence, so that the net force will be attractive and no energy barriers will exist.

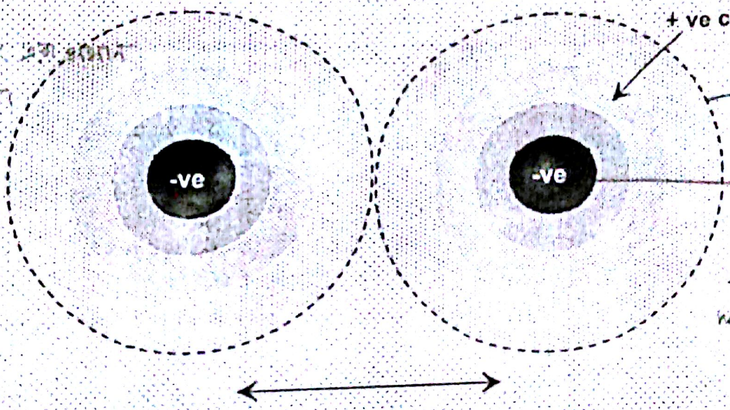
In H_2O there is

-ve Charged Colloidal Particles - Double Layer Electrostatic Repulsion

[Distance between colloidal particles far apart] ① এত dot দ্বারা বোঝায় তত cation আছে।

cation = anion

Suppose -ve charge = 100
⇓
H_2O তে anion & cation থাকে এবং এরা প্রত্যেক
যেমন যে cation কে attract করবে
& only 100 cation কেই
attract করবে।



→ এর পরে cation & anion আবার সমান
⇓
এর পরে আর কোন influence নাই।

→ solid

-ve & +ve will be equal
not in terms of weight
⇓
But in terms of
Miliequivalent
⇓
normally যা হয় miligram/L
সেটাকে equivalent wt দিয়ে ভাগ দিলে
হবে miliequivalent.

*charge balance :

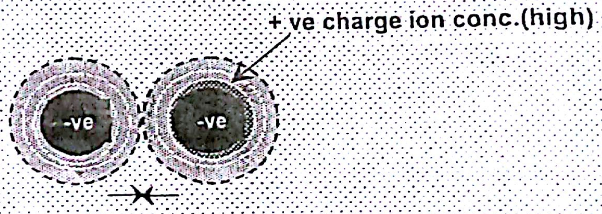
PAC = Poly AL Chloride

④ Colorr → Soluble হলে pass করবে
→ insoluble " pass " না।

-ve Charged Colloidal Particles - Vander-Wall force of Attraction

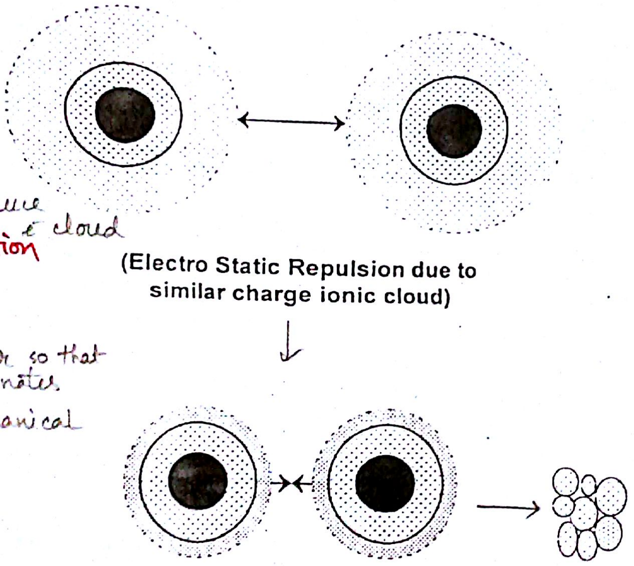
Distance between colloidal particles further reduced due to more electrolyte addition]

⊛ suppose -ve = 100
⇓
So তার লা লাগবে 100 +ve
⇓
But যদি আমি extra +ve add করি then
influence zone compress করবে i.e. ছোট হবে
cz বেশি +ve এর কাছে যাবে
⇓
আরও বেশি add করলে
then attract করবে
start করবে after
optimum ⇒ This attraction is
Vander Walls force ⇒ it dominates



In the short form

+ ve Charged Ionic Cloud 'Double Layer' around – ve Charged Colloidal Particles



(Electro Static Repulsion due to similar charge ionic cloud)

(Vander Waals Force of Attraction)

(Aggregation of Colloidal Particles)

Q. Distinguish betn coagulation & flocculation

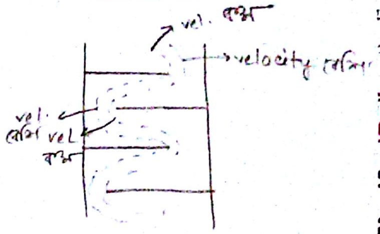
nical process to bring the particle closer so that Van dar walls attraction dominates.
This needs some mechanical process

M Number = G×t

কত জোরে নাড়ছি

কতক্ষণ নাড়াচ্ছি

In lab



⇓

So একই stream line এর particles-এর velocity একবার বেশি & একবার কম হচ্ছে।

⇓

Velocity gradient

⇓

$G = \sqrt{\frac{P}{\mu C}} = sec^{-1}$

viscosity

vol^m

Similarly. ⇒ sea তে chemical থাকে। যখন river water sea তে যায় তখন cloud কমতে থাকে & Van dar Walls attraction হয়। ⇒ turbulance কাজ করে sea এর for stirring & take the ions closer.

According this theory, no é cloud. The -ve ions directly absorbs the +ve ions.

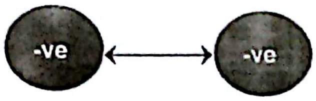
㊟ যদি যতটুকু -ve charge তার বেশি দিলে ওপর part গুলি +ve charged হয়ে যায়।

Neutralization of (-ve) Charged Colloidal Particles upon addition of counter (+ ve) ions and Adsorption

Q. Diff. betⁿ two theories—

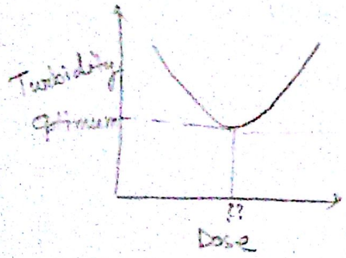
(1) যত ion বেশি cloud বেশি

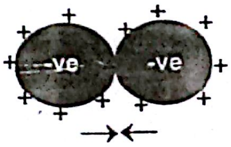
(2) ion বেশি দিলে effect উল্টো হবে।



(-ve Charged Colloidal Particles)

(Electro Static Repulsion due to similar charge of all colloidal particles)





(Vander Waals Force of Attraction due Charge Neutralization and Adsorption)

[Aggregation of Colloidal Particles]

CT syllabus

Types of Sedimentation Tank —

1. Rectangular 2. Circular (Ver. flow & Hori. flow type)

Design Data —

Depth — 3 to 5 m

Rectangular Tank — L : W = 4 : 1 (W = 10 m is common)

Circular " — (max 60 m dia) SOR = 450 to 800 litres/hr/m^2

SOR = 900 to 1200

(sedimentation with coagulation & flocculation)

Prechlorination —

1. To remove color odor & othe organic matter
2. To control the growth of algae during determination.

Sheet NO = 6 5/7/19

Faruq Sir
Sheet - 06
1/7 -> 3/7
[illegible]

THEORY OF FILTRATION

Q. What do you mean by theory of filtration? ⇒ 4 টি process describe করবে।

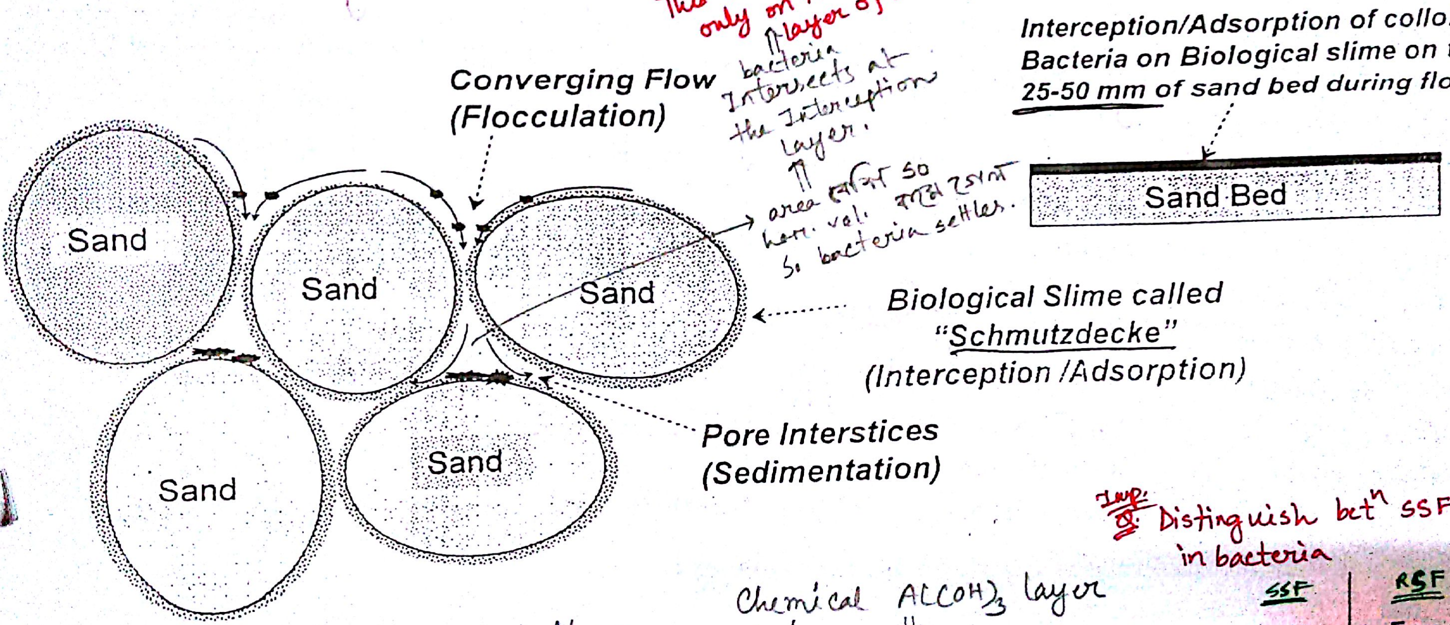
(1) **Mechanical Straining**-the straining action offered by the sand bed removes the particles of suspended matter that are two large to pass through the interstices between the sand grains, which are also reduce in size with time.

(2) Flocculation, Sedimentation and Adsorption- converging flow across the interstices, increases the probability of contact between the small particles to form flocs (Flocculation). The interstices between the sand grains act as a minute sedimentation basin in which the suspended particles, colloids, bacteria settle upon the sides of the sand grains and adhere/sorption because of the presence of gelatinous coating (biological slimes of SSF or coagulant floc layer of RSF) on filter media.

Only Bacteria & Virus can be removed by this process

Theory of Slow Sand Filter Bed Filtration

(Flocculation, Sedimentation, Adsorption & Biological Metabolism)



This removal is only on the upper layer of sand.
⇑
bacteria Intersects at the Interception layer.
⇑
area বাড়িল so hori. vel. কমে যায় so bacteria settles.

Imp. Q. Distinguish bet^n SSF & RSF in bacteria

Biological layer
↓
more active


SSF

Chemical AL(OH)$_3$ layer
⇓
Less active but form quickly


RSF

SSF	RSF
1. forms bio-logica layer	1. Forms chemical layer
2. More active	2. Less active but form quickly

Imp Q. Compare the 3 types of filters

Types of Filter and Characteristic Differences

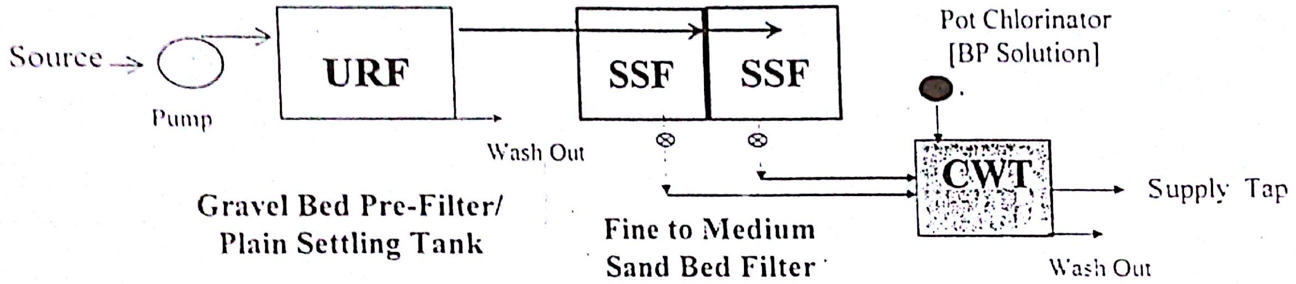
We want to converge to this process

Characteristics	SLOW SAND FILTER	RAPID SAND FILTER	UF ROUGHING FILTER
Suitability :	Turbidity < 50 NTU)	Turbidity > 50 NTU	Turbidity 50-150 NTU
Pre-treatment :	URF/P. Sediment.	Coag., Floc. & Sed.	Not required/DRF
Rate of filtration :	< 0.2 - 0.4 m/h	5 -10 m/h	1 -2 m/h
Ripening :	0.25day -30days	5 -10 minutes	3 -10 days
D_{10} :	0.1-0.3 mm	0.45-0.55mm	5 - 8 mm
U (Coef.) → যত↑	2 -3	1.2 -1.7	1.7 -2.5
Thickness :	1m - 1.4 m (FMS)	0.3 m to >1.0 m (MCS)	0.6 -1.0 m (Gravel)
Under drain:	Slotted pipe grid	Gravel & Perf.Tiles	Perforated RCC slab
Cleaning :	Surface Scraping	Back washing → not physible cz can't be maintain-ed	Flushing drain out → নিচে দিয়ে pressure & gravel coarse থাকায় নিচে জমা হয় so নিচে থেকে valv খুলে দিলে impurities চলে যাবে!
Filter run :	40 - 60 days	1 - 3 days	21 -28 days
Area :	Large in size	Small in size	Moderate in size

UF ROUGHING FILTER → mear coars med

permeability↓ ⇒ cz ছোট বড় বেশি মিশানোর অবকাশ & ছোট সুযোগ হয়ে যায় porce ঢুকে যাবে ⇓ So permeability↓

General Features of the Slow Sand Filtration



URF = Upflow Roughing filter

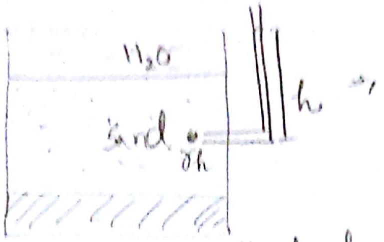


fig: negative head

Operation Difficulties

(1) Negative head and Air binding- When a filter is clean, there is some slight loss of head, which increases as clogging occurs. When the loss of head in top layers becomes greater than the head of water above the sand, the column of water below acts as a draft tube, and a partial vacuum results (negative head) when excessive, allows air to escape from solution in the water and lodge in the sand (air binding).

(2) Mud Accumulation-form a dense mat on the filter surface, which will break & sink to the gravel during back washing. ⇒ head বাড়ে, ও বেশি

(3) Cracking of filter and Jetting-filter grains are pushed away from walls due to pressure difference (less head loss near wall) and shrinkage of bed, which may cause uneven rise of wash water and jetting of water through flow path of least resistance.

FILTRATION → oldest treatment Plant

Sedimentation with or without coagulation, will not ordinarily give clear sparkling and bacteriologically safe water, which requires the use of a filter.

Filtration is a process of water purification in which water from a sedimentation tank is allowed to pass through a bed of filtering media, usually sand and gravel, and the filtrate is collected at the bottom through an underdrainage system.

The filter media are very efficient in retaining finer and colloidal particles of clay and silt. It also aids in removing color, odor, iron and manganese.

Type of Filter

- ~~Sow~~ Slow Sand Filter (SSF)
- ~~Rpid~~ Rapid Sand Filter (RSF)
- Coarse Media Roughing Filter (Horizontal flow / Up flow)

Latin America, Africa, South East Asia

DISINFECTION ⇒ killing of pathogens

Disinfection of water is the killing of disease-causing microorganisms that it may contain, while " Sterilization" is the total destruction and removal of all microorganisms, which is not necessary. The destruction and removal is brought about in several ways-

(a) ***Natural Process***- **Most pathogens are accustomed to live in the temperatures and conditions found in the bodies of humans and animals. They do not survive well outside the body. Storing water for extended periods in open tanks or reservoir prior to treatment can accomplish some destruction of pathogens through sedimentation and natural die-off of the organism. More than 50% of the pathogen in water will die within 2 days and 90% will die by the end of one week.**

(b) ***Conventional Treatment***-**Significant pathogens removal also occurs during the conventional-treatment processes of coagulation, flocculation, sedimentation and filtration. Typical bacterial and viral reduction in coagulation- flocculation processes are 60-70% and addition of a filtration process increases the over all removal to close to 99%.**

(c) ***Coagulation Process (Sweep floc)*** **-During coagulation and flocculation processes bacteria are entrapped in a floc or enmeshed by its 'stick' surface as the flocs settle at the bottom of the settle tank. Removal of *Giardia* in coagulation is closely associated with removal of turbidity (65 - 90%). Removal of hepatitis A virus and rotavirus are typically in excess of 90%.**

(d) ***Softening Process***-**Extreme values of pH, either high during softening process or low, during alum coagulation process can provide good bacterial kills. Precipitation of Mg (at pH value around 11.0) can give coliform reduction of more than 99.9%,**

(e) *Destruction by Chemicals* through Chlorine, Chlorine compounds, Ozone, $KMnO_4$ etc.

Q: What do you mean by tri halomethane?

Chlorination

Cl → toxic gas so, used in rooms with perfect ventilation.

Chlorine is cheap, reliable and present no great difficulty in handling and react with water according to the following equation

$$[1]\ Cl_2 + H_2O \rightarrow HOCL\ \text{(Hypochlorous acid)} + HCL.$$

$$HOCL \rightarrow H^{++}\ OCL^{-}\ \text{(Hypochlorite ions).}$$

→ chlorine react with all organic matter → all all combined Cl

The chlorine existing in water as 1. HOCL, 2. OCL and 3. molecular chlorine (pH< 3.0) are defined as "free available chlorine". HOCL is the better disinfectant and since the relative concentration of the two species is a function of pH (HOCL predominates between 6.0-7.5 and OCL predominates between 7.5-9.0).

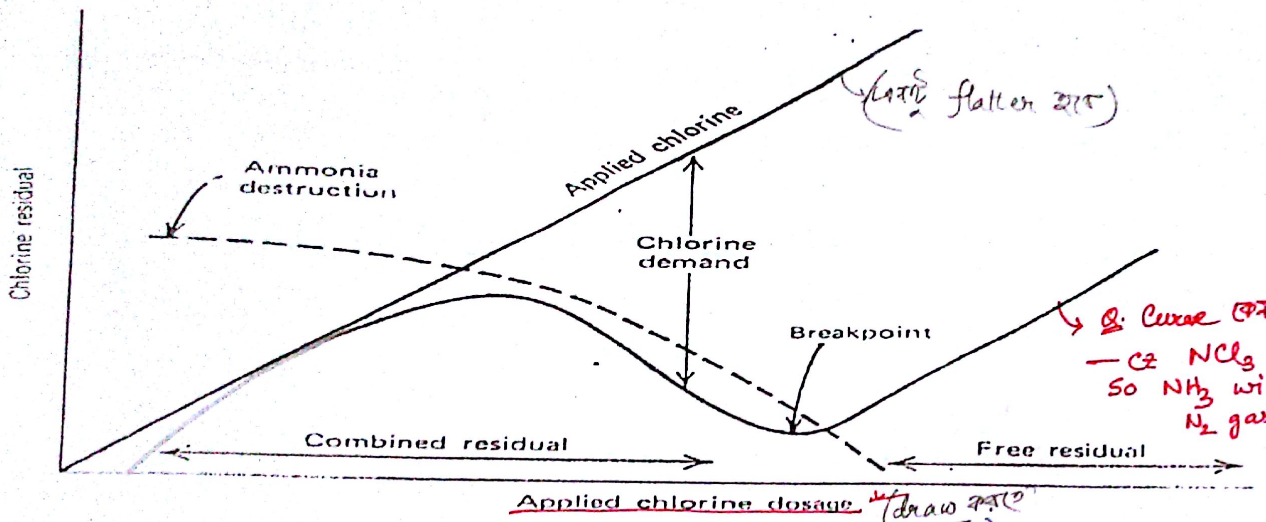
The efficiency of disinfection with chlorine is affected by pH. Hypochlorite, such as calcium hypochlorite [$Ca(OCL)_2$ bleaching powder, 25- 45 % available chlorine] or sodium hypochlorite [(NaOCL)-laundry bleach, 12-15% available chlorine], act in the same fashion.

$$NaOCL \rightarrow Na^{+} + OCL^{-}\ ,\ Ca(OCL)_2 \rightarrow Ca^{++} + 2OCL^{-}\ ,\ OCL^{-} + H^{+} \rightarrow HOCL.$$

Chlorine is very active element and when added to water as free chlorine will combine with organic and inorganic matter and oxidize. Free available chlorine react with ammonia and many organic amines to form chloromines, are less active oxidizing agent than HOCL and their disinfecting efficiency, therefore is considerably reduced.

and produce Chloro Organic Compounds

destruction of chlorine by reducing substances if reducing substances are present.



(ক্রমেই flatter হবে)

Q. Curve কেন নিচে যাচ্ছে?
— cz NCl_3 তৈরী হবে &
so NH_3 will convert into N_2 gas.

(draw করতে হবে।)

The following reactions occur in the formation of chloromines (combined available chlorine).

[2] $NH_3 + HOCL \rightarrow H_2O + NH_2CL$ (Monochloramine, pH > 7.5)

[2] $NH_2CL + HOCL \rightarrow H_2O + NHCL_2$ (Dichloramine, pH = 6.5-5.0)

[3] $NHCL_2 + HOCL \rightarrow H_2O + NCL_3$ (Nitrogen Trichloride pH < 4.4).

Q. What are the advantages of Break Point ~~Condition~~ Chlorination ??
(৭বা)

1. No organic matter
2. No odour
3. No bacteria
4. Cl is available as free.

Theory of Disinfection :-

The use of combined chlorine as a disinfectant has been encouraged by the evidence that Free chlorine contributes to the production of Trihalomethanes (THMs e.g. chloroform) with organic matter and that chloromines being less reactive, are less likely to create these compounds

Reducing Agents and Chlorine Demand- of water is the difference between the amount of Cl added and the amount of chlorine present as a residual either free or combined after reacting with reducing agents (H_2S, Fe^{++}, Mn^{++} and NO_2) during some designated period.

$$H_2S + 4CL_2 + 4H_2O \rightarrow H_2SO_4 + 8HCL$$

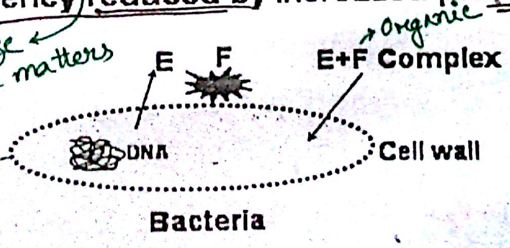
Theory of Disinfection -- Hypothesis

(a) Chlorine (free or combined) react with the cellular (wall) materials and rupture it,

(b) destroys the enzymes (E) of bacterial cells and affect energy yielding process,

(c) and possible that it actually passes through the cell wall to attack intracellular systems. Efficiency reduced by increased pH (8.5) and lower water temperature.

to oxidize organic matters



Bacteria is itself a reactant.

Recommended Minimum Chlorine Residuals for Bacterial Disinfection:

pH	Free Available (10 mins.contact)	Combined Available (60 mins.contact)
6.0 -7.0	0.2 mg/l	1.0 - 1'5 mg/l
8.0	0.4 mg/l	1.8 mg/l

Forms of Chlorination: — Q. Distinguish betⁿ prechlorination & postchlorination.

(i) Pre Chlorination-is the application of chlorine before any other treatment(suction pipe or water entering mixing basin)to oxidize excessive organic matter(algae)and reduce load on filters.

Q. What are the advantages of Chlorination ? — pipe line-এর পানির সাথে থাকে

(ii) Post Chlorination-is the application of chlorine after all other treatment (standard treatment) ∵ cz Ozone যেমন থাকে না pipeline-এ

(iii) Double Chlorination -is the combination of pre and pos-tchlorination, provides greater factor of safety.

(iv) Super Chlorination- excess amount of chlorine(1-2mg/l)is added to destroy taste and odorous in water and it may be followed by dechlorination using reducing agents (sulfur dioxide, sodium thiosulfate) or through aeration.

(v) Break Point Chlorination-the addition of chlorine at the break point (See Fig.).

↳(cz water-এ break point-এ Cl দিতে হবে।)

Q. What are the advantages & disadvantages of chlorination over the other methods of disinfection?

Other Methods of Disinfection-

(i) **Ultra-violet rays**: Involves exposure of a film of water upto 120mm for 15 secs to quartz mercury vapor arc lamps emitting 'UV' radiation at a wave length of 253 nm.

(ii) **Ultrasonic waves**: At frequency (20 to 400 kHz) for 2 sec-60 mins.

(iii) **Metallic ions**: Ag, Cu. $CuSO_4$ ⇒ for killing Algae

(iv) **Heat**

Factors Affecting Disinfection:

The rate of kill is often postulated as a first order reaction,

$N_t = N_o e^{-kt}$ where, N_t = number of organisms remaining at time t.

Temperature, pH, type of organism, type of disinfectant, concentration (C) and contact time (t) play important role. $\boxed{\text{Kill} \infty C \text{ x } t}$

Turbidity producing colloids offer sanctuary to organisms, thus shielding them from the full action of the disinfectant. Particulate matter may absorb the disinfectant.

$$N_t = N_o e^{-kt}$$

Temp, pH, type of organisms & disinfectant,
Contact time (t) and Concentration (C)

$$\text{Kill} \propto Ct$$

● softening by Lime addition benefits to ⇒ {
1. reduce suspended solids i.e. Bacteria & viruses,
2. removal of Fe & Mn
3. co-precipitation of humic & fulvic acid

WATER SOFTENING ✓

Hardness consists principally of Ca & Mg salts. These while not undesirable for a health standpoint, may make the water less suitable for some non potable uses. Benefits of softening to domestic users include reduction in soap use, longer life for water heaters, and less incrustation of pipes.

If the water is softened by addition of lime, additional benefits include removal of Iron and manganese, co-precipitation of humic and fulvic acid, and reduction of suspended solids including bacteria and viruses. Industrial users of municipal water benefit through the lower cost of producing process and boiler waters from softened water. There is evidence that consumption of very soft water may contribute to heart disease and accumulation of certain heavy metal in the liver. * soluble কে first-এ insoluble করতে হবে। Then any process

The two basic methods used for removal of hardness are the
(A) Chemical Precipitation Process and (B) Ion-Exchange Process.

Theory of Softening : least soluble but not completely insoluble ⇒ 30 mg/L as soluble ⇒ In chemical Process যতই hardness কমাই 30 এর নিচে নামবে না ⇓ Precipititive softening Process

The different species of hardness have different solubility limits. The least soluble forms are $CaCO_3$ compared to $Ca(HCO_3)$, $CaCl_2$, $CaSO_4$, $Ca(OH)_2$ and $Mg(OH)_2$ compared to $Mg(HCO_3)$, $MgCl_2$, $MgSO_4$, $MgCO_3$

The objective of chemical softening is to convert all the calcium hardness to $CaCO_3$ & magnesium hardness to $Mg(OH)_2$.

Most difficult water treatment process ⇒ Desalination (Cl^- removal) ⇒ Cl^- is highly soluble.

The addition of chemicals (CO_3^{2-} and /or OH^-) elevates the pH. which shifts the equilibrium of the carbonate acid system in favour of the CO_3^{2-} ion. i.e. it changes the alkalinity from bicarbonate to the carbonate form. This increases the concentration of the CO_3^{2-} ion and shifts the equilibrium to the right.

$$Ca^{2+}_{(aq)} + CO_{3\,(aq)}^{2-} \leftrightarrow CaCO_{3(S)}$$

$$Mg^{2-}_{(aq)} + 2OH^-_{(aq)} \leftrightarrow Mg(OH)_{2(S)}$$

(most easy হচ্ছে হল ($Ca(OH)_2$ use করা।)

Our experiment is in pH ~9.2

In order to precipitate $CaCO_3$, the pH must be raised above 8.3 (optimum 9.0-9.5) to convert bicarbonate (HCO_3) alkalinity to carbonate (CO_3) alkalinity.

If there is not sufficient natural occurring bicarbonate alkalinity (HCO_3^-) for the $CaCO_{3(S)}$ precipitate to form (i.e. there is non-carbonate hardness), we must add CO_3^{2-} source (soda ash Na_2CO_3).

Imp' To precipitate $Mg(OH)_2$, the pH must be raised above ~~10.6~~ 11.0 to convert carbonate alkalinity to hydroxide alkalinity. Sources of OH^- ion are lime [$Ca(OH)_2$] & [NaOH]. However, after magnesium removal decrease opf pH value would be necessary to reduce the pH value below 8.5 through Re-carbonation Process.

⊛ for reducing pH value addition of CO_2 is known as recarbonation

CO_2 add করলে H_2CO_3 হবে so pH value reduce হবে

Complete removal of hardness can not be accomplished by chemical precipitation. 40 mg l of $CaCO_3$ and 10 mg/l of $Mg(OH)_2$ remain in the softened water.

⊛ When alkalinity is lower than hardness, then there will be $CaSO_4$ or $CaCl_2$ ⇒ [illegible] CO_3^{2-} এ precipitate হবে না। So Na_2CO_3 (আলাদা ভাবে) add করব।

alkalinity কম হলে CO_3 Hardness is absent. and pH কম হলে ওখানে HCO_3^- থাকবে So pH বাড়াতে হবে insoluble CO_3^{2-} বানানোর জন্য

Q: When we have to use soda ash?

Q: How pH value & alkalinity effect the softening process?

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Q. Why two stage recarbonation is required?

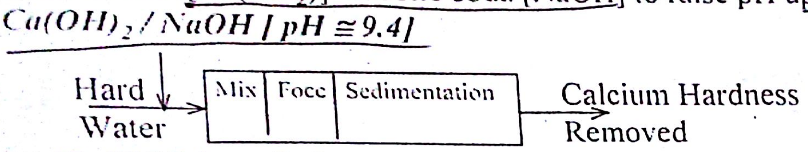
— one stage recarbonation -এ $CaCO_3$ আসবে এর কারণ pH is 8.3. So they will deposit in the pipeline & also clog the filter paper. So we have to use 2 stage as at two stage there is HCO_3^- which is soluble. So problem is solved.

Q. When recarbonation is needed? — only fore Mg^{2+} removal.

Softening Under Different *Environmental Conditions:*

(A) When Alkalinity ≥ Hardness and pH < 8.3 (sufficient bicarbonate hardness is present)

-Addition of lime[$Ca(OH_2)$] /caustic soda [NaOH] to raise pH upto 9.4 will precipitate $CaCO_3$.



$$Ca(HCO_3)_3 + CaO + H_2O \rightarrow \underline{CaCO_{3-}} + H_2O$$
$$Ca(HCO_3)_2 + NaOH \rightarrow \underline{CaCO_3} + Na_2CO_3 + H_2O$$

(B) When Alkalinity < Hardness (noncarbonate hardness,i.e. Cl and SO_4 of Ca. Mg are present)

- Carbonate source like soda ash [Na_2CO_3] should be added to precipitate $CaCO_3$.

$$Ca\begin{matrix}SO_4\\ CL_2\\ NO_3\end{matrix} + Na_2CO_3 \rightarrow \underline{CaCO_3} + Na\begin{matrix}SO_4\\ CL\\ NO_3\end{matrix}$$

(C) Addition of lime $Ca(OH)_2$ or caustic soda NaOH to raise pH > 10.6 will precipitate $\underline{Mg(OH)_2}$.

$$Mg(HCO_3)_2 + CaO + H_2O \rightarrow \underline{CaCO_3} + \underline{Mg(OH)_2} + H_2O$$
$$Mg(HCO_3)_2 + NaOH \rightarrow \underline{Mg(OH)_2} + Na_2CO_3 + H_2O$$

(D) Both lime and soda ash [Na_2CO_3] should be added to raise pH above 10.6 for $Mg(OH)_2$ and $CaCO_3$ precipitate.

$$Mg\begin{matrix}SO_4\\ CL\\ NO_3\end{matrix} + CaO + H_2O \rightarrow Ca\begin{matrix}SO_4\\ CL_2\\ NO_3\end{matrix} + \underline{Mg(OH)_2} \qquad Ca\begin{matrix}SO_4\\ CL_2\\ NO_3\end{matrix} + Na_2CO_3 \rightarrow \underline{CaCO_3} + Na\begin{matrix}SO_4\\ CL\\ NO_3\end{matrix}$$

RECARBONATION:

Complete removal of hardness can not be accomplished by chemical precipitation. Precipitation of the supersaturated solution of $CaCO_3$ will continue slowly, however, resulting in deposits in water lines and storage facilities. It is therefore necessary to 'stabilize' the water by converting the supersaturated $CaCO_3$ back to the soluble form as $Ca(HCO_3)_2$. The most common practice, however, is to make the conversion with CO_2. CO_2 also neutralize excess lime.

$$Ca(OH)_2 + CO_2 \rightarrow CaCO_3$$

$$CaCO_3 + CO_2 \rightarrow Ca(HCO_3)_2$$

$$Mg(OH)_2 + CO_2 \rightarrow Mg(HCO_3)_2$$

This process is generally called **recarbonation.**

IRon Removal

Dissolved Fe and Mn are often found in ground water from wells located in shale, sandst
and alluvial deposits. Mn is an associated problem with Fe in most of the places of Banglad

Dissolution of rocks and minerals

㊉ AEration & Natural Oxidation of Iron.

Fresh/clear H_2O
Fe^{2+} (soluble)
$CO_2 > 100$ mg/L (acidic)
pH < 6.3
DO < 1.0 mg/L

Stored / Turbid H_2O
Fe^{3+} (insoluble)
$CO_2 < 15$ mg/L
pH > 7.3
DO > 3 mg/L

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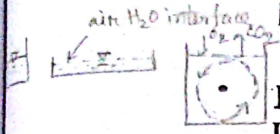
Kinetics of Iron Oxidation, Precipitation & Removal

- **Initial Iron Concentration:**

  The rate of ferrous iron oxidation is of the first order with respect to ferrous iron concentration present and the partial pressure of oxygen.



Renewal of interface

- **pH Value:**

  Reaction rate are strongly pH dependent and there is a second order relationship (100-fold rises with a unit increase in pH), quite slow at pH < 6.5 & very rapid pH > 7.5.

- **Alkalinity:**

  Oxidation reaction is incomplete and very slow for low alkaline water (< 130 mg/l as $CaCO_3$) and very fast at higher alkalinity value.

- **Precipitated Iron Flocs.**

  Aeration is sufficiently rapid only if it is catalyzed by accumulation of oxidation products (Fe_2O_3 and MnO_2) on a porous bed. Previously precipitated iron (Fe_2O_3) serves to catalyze the oxidation of iron.

Moreover, hydrous oxides of metal, e.g. ferric oxide, Fe(III) and manganic oxide, Mn(IV) have high sorption capacities for un-oxide metal ion including Fe^{++} & Mn^{++} ion.

Q. Why direct filtration is not permitted?
— for clogging etc

Effect of Direct Filtration

[Direct Filtration of high Fe content aerated water with high turbid (> 60 NTU) is not recommended by AWWA]

- Clogging of Filter Sand top by ppt Iron particles,
- Frequent backwash → 6% পানির (twice a day)& operation difficulties,
- Wastage of water (30-40%) for back wash and rinsing,
- Less amount of useful water after backwash,
- Changing of Filter Sand after every 3/4 months
- Excess power consumption for backwash

Raw → Aeration → Direct Filtration → Treated

Sol ⇒ Pretreatment before filtration—

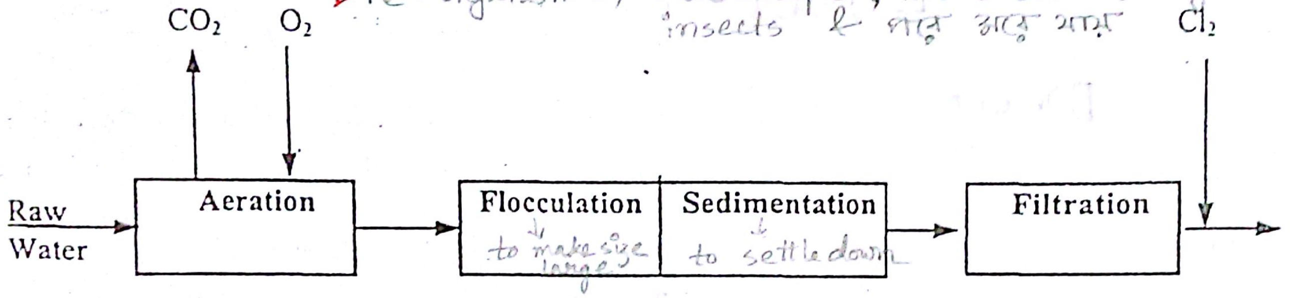
Raw → Aeration → Flocculation → Sedimentation → Filtration → Treated

[Reduces 70-80% suspended particles load on filter sand]

Imp. Q. — What are four diff. Fe removal methods under diff. environmental conditions ?? — Flow dia. আঁকতে হবে & প্রত্যেক step-এর ব্যাখ্যা বলতে হবে।

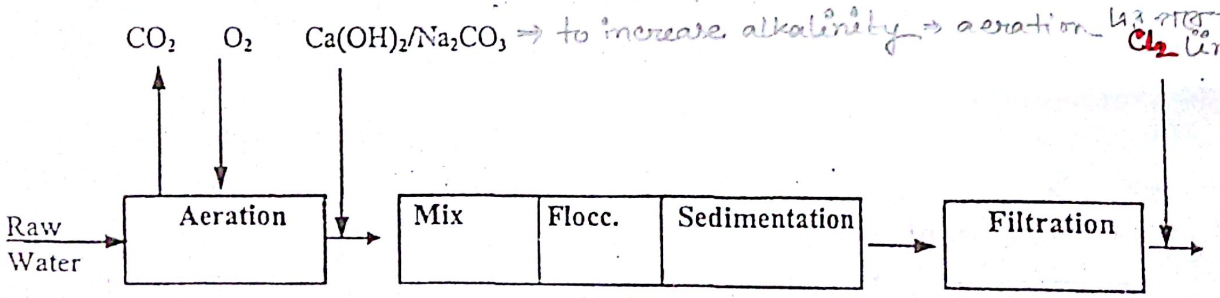
1. Ground waters which contains little or no organic matter with reasonable alkalinity

Fe - organism ⇒ macroscopic, not bacteria, they are insects & গাছে ঝাড়ে থাকে

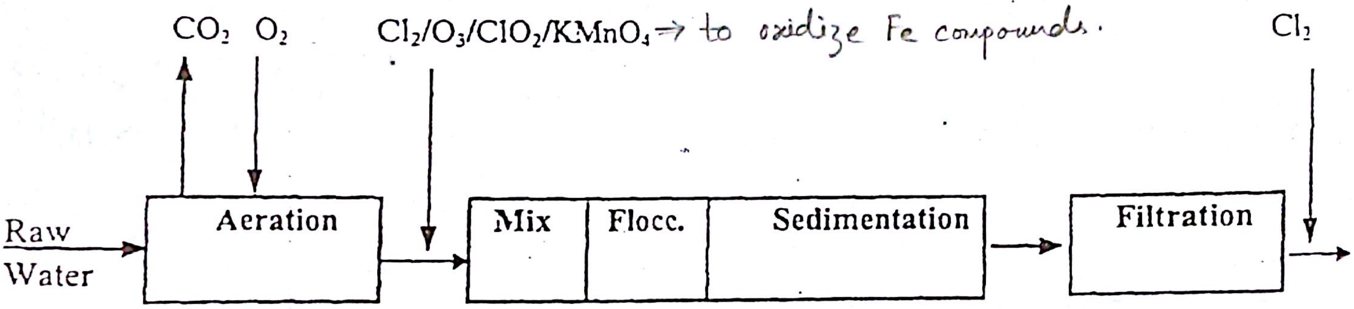


2. Low alkalinity water (<130 mg/L as $CaCO_3$) needs some alkaline chemical additive

$Ca(OH)_2/Na_2CO_3$ ⇒ to increase alkalinity ⇒ aeration এর পরে দিব otherwise Cl_2 lime অনেক বেড়ে যাবে।



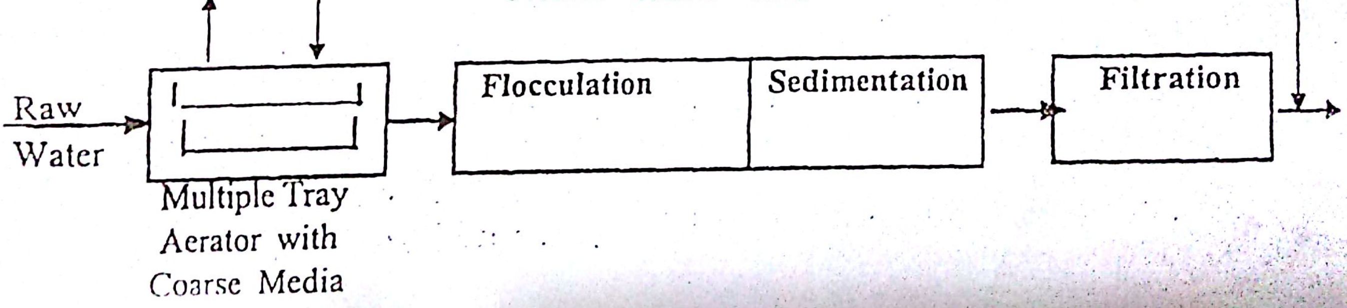
3. In low alkaline or organic content water, the application of strong oxidizing agents such as chlorine, ozone, chlorine dioxide is necessary



4. In low alkaline or organic content water, aeration is sufficiently rapid only if it is catalyzed by accumulation of oxidation products (Fe_2O_3) on a porous bed

this means If we can form a coating on the gravel surface, that coating will act as a catalyst & absorbs Fe.

any metal oxide and hydroxide adsorbs other metal ion.



Kinetics of Manganese Oxidation, Precipitation & Removal

pH Value

- Manganese is much more slowly oxidised through aeration than iron. In fact, the rate is negligible at pH levels below 9.0.
- Chemical oxidation of Mn requires a pH level above 8.5 and 1.0 mg of chlorine can oxidise 1.3 mg of Mn.

1.0 mg Cl → 1.3 mg Mn.

$Mn^{2+} \rightarrow Mn^{4+}$

Catalytic Oxidation & Oxidation Period

- Previously precipitated iron and manganese (Fe_2O_3 & Mn_2O) serves to catalyze the oxidation of manganese, $Mn(II) \longrightarrow Mn(IV)$
- Mn oxidation through chlorine requires 2-4 hours to react completely.

Sorption on Precipitates

- Removal of iron and manganese is generally hastened and made more efficient (swifter) by letting water trickle downward or rise upward through gravel or other relatively coarse heavy materials coated with hydrous oxides of Fe(III) and Mn(IV) precipitates by sorption.
- Both hydrous $Fe(OH)_3$ & MnO_2, tend to sorb Fe^{++} & Mn^{++} ions. $Mn(II) + MnO_{2\,(s)} \longrightarrow Mn(II).MnO_{2\,(s)}$ [This reaction is fast].
- If Fe(II) > Mn(II) rather than Mn(II) alone, removal than becomes predominantly a matter of sorption of Mn^{++} on incipient ppt. of iron

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Q: How Mn & Fe & As removal differs from each other?

Most imp

Difference Among Fe, Mn & As Oxidation

[Iron] Ferrous, Fe (II) *(Soluble)* $\xrightarrow[pH > 7.5]{\text{Aeration-}O_2}$ Ferric Oxide, Fe (III) *(Insoluble precipitate)*

[Manganese] Mn (II) *(Soluble)* $\xrightarrow[pH > 9.0 \,/\, pH > 8.5]{\text{Aeration-}O_2 \,/\, Cl_2}$ Manganic Oxide, Mn (IV) *(Insoluble precipitate)*

for aeration for Cl_2

Arsenite, As (III) *(Soluble & Non-Ionized)* $\xrightarrow[pH = < 7 - > 11.5]{\text{~~Aeration~~-}O_2 \,/\, Cl_2 \,/\, \text{Potash}}$ Arsenate, As (V) *(Soluble & Ionized)* *(-charged ion)*

[Arsenic] *(or)*

Arsenite, As (III) *(Soluble & Non-Ionized)* $\xrightarrow[pH >> 9]{\text{Lime}}$ Arsenite, As (III) *(Soluble & Ionized)* *(-charged ion)*

Q: How oxidation & precipitation of Fe differes from Mn?

1. Fe can be oxidized by aeration at a pH value beyond 7.2 & 7.3
   Mn " not be " below a pH value 9.

2. Mn can be oxidized by Chemicals (Cl, $KMnO_4$) etc at a pH value beyond 8.5
   Fe " " " " " " et at a pH ~~7.2&7.3~~ providing sufficient alkalinity (>130

i. if sufficient Fe can be oxidized, then any metal ion will adsorb including (Mn, As)

Q: How presence of Fe affect Mn oxidation??

ii. Fe কম হলে, Mn, As adsorb করার জন্য sufficient Fe oxide / Hydroxid পাওয়া যা
Then to prevent this, $Al(OH)_3$ (ফিটকিরি) দিলাম। So $Al(OH)_3$ এর সাথে As, Mn adsorb হবে।

Sheet NO = 9

3/I 3F

DESALINATION

$Ca^{2+} = 30$ mg/L, $Mg^{2+} = 10$ mg/L but $Cl^{-} =$

Ocean water has dissolved salts content of about 35,000 mg/l. Many ground water supplies are brackish (dissolved salts 1000 to 3000 mg/l) and too salty for consumption. No simple technique is available and the cost of desalination is still relatively high. Desalination system can be separated into those which employ phase change, like distillation or freezing, and those which separate water and dissolved minerals within the aqueous phase, like ion exchange, electrodialysis and reverse osmosis.

(i) Evaporation/distillation- can be used to distill fresh water from brackish. Problems associated with evaporators include accelerated corrosion and scaling due to the high temperature involved.

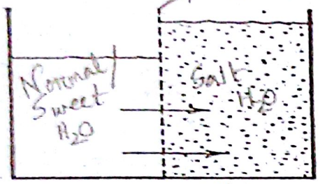
(ii) Solar stills- employ shallow basins covered with glass or plastic upon which the water vaporized by the sun can condense.

(iii) Freezing-In the freezing process the temperature of the sea water is gradually lowered until ice crystals are formed. These are free of salt and can be separated from the brine. ⇒ Salt can not freeze/ form into ice

(iv) Ion exchange-has been applied to desalting by using the hydrogen and hydroxyl-base resins. ⇒ বেশি লবণ হলে use করা যায় না ion exchange.

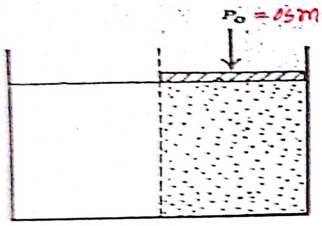
Reverse Osmosis Process

membrane ⇒ H_2O molecules can pass but not the ions.



(a)

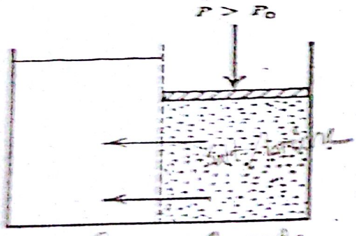
for diffusion there is **Osmosis**



P_o = osmotic pressure
⇓
apply করলে flow of হবে

(b)

Given Pressure



(c)

Reverse Osmosis

Q. How we are going to dispose the brine?

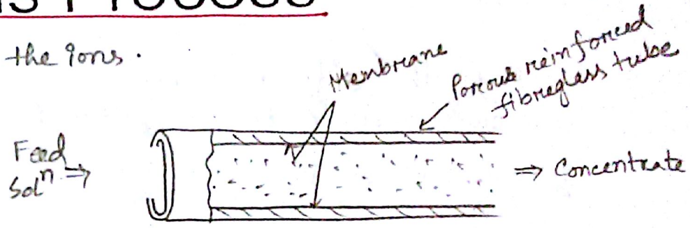
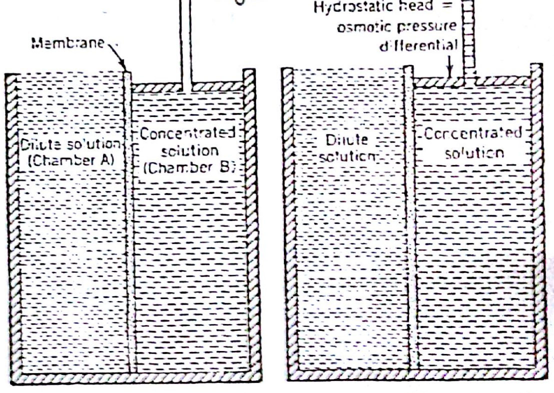


Fig: Membrane Tube



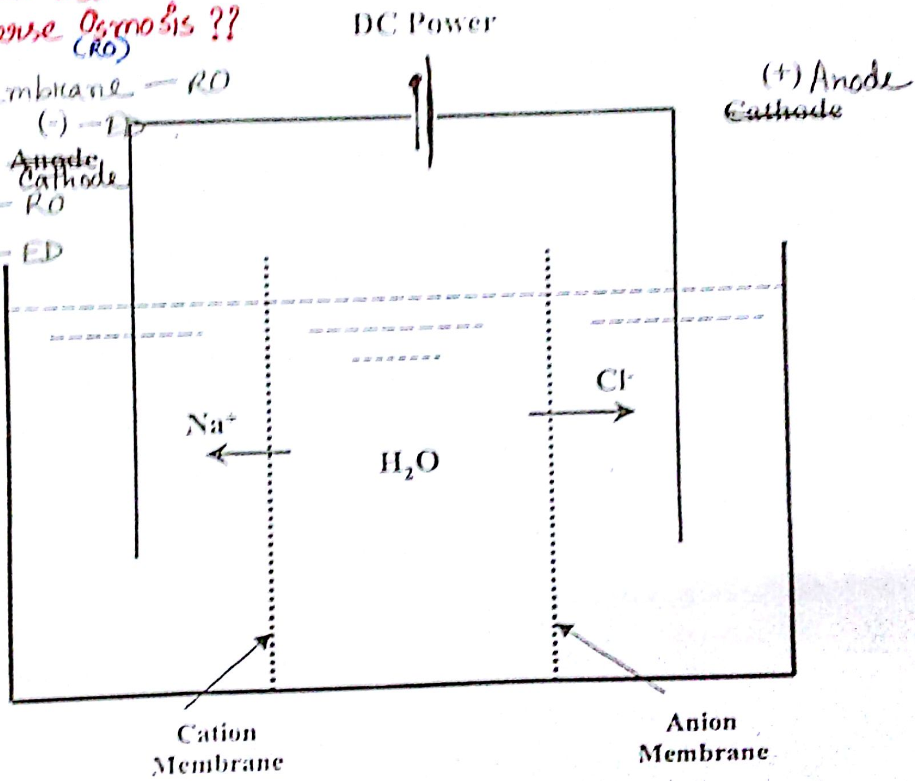
(a) (b)

Electro Dialysis Process

Imp. Q. What is the difference betn Electrodialysis (ED) & Reverse Osmosis (RO) ??

1. molecular selective membrane — RO
   ion " " (-) — ED

2. mechanical process — RO
   Electrochemical " — ED



anode এর পাশে
কেন হয় হে
cation/+ve ion anode-এর
ফিরে আসবে হে
anode -ve charge

resin reacts with H_2SO_4 → SO_4^{2-} [illegible]

→ all minerals are removed by

ION EXCHANGE & DEMINERALIZATION

In this process two different resins are used. Hydrogen-cycle resins exchange hydrogen ion for all the cation present in the water: → So with the H_2 & anion, acids will be produced, this is H-cycle

$$\begin{matrix}Na_2 & (HCO_3)_2\\ Mg,Ca & CL_2\\ Fe & SO_4\end{matrix} + \underset{\text{resin}}{\underline{H_2X}} \rightarrow \begin{matrix}CO_3\\ H_2CL_2\\ SO_4\end{matrix} + \begin{matrix}Na_2\\ Mg,Ca\\ Fe\end{matrix}\ [X]$$

Cation regin → cation replaced by H^+.

this H^+ is regenerated by acids.

Regeneration: $$\begin{matrix}Na_2\\ Mg,Ca\\ Fe\end{matrix}\ X + \underline{H_2SO_4} \rightarrow H_2X + \begin{matrix}Na_2\\ Mg, Ca\\ Fe\end{matrix}\ SO_4$$

This product water contains both carbonic acid and a variety of strong acids, depending on the particular anions in the raw water. Now if this water is passed through anion-exchange resins which will exchange the sulfate, chloride, nitrate, etc. for hydroxyl ion:

$$\begin{matrix}SO_4, SiO_3\\ HCL\\ NO_3, CO_3\end{matrix} + A(OH)_2 \rightarrow H_2O + \begin{matrix}SO_4, SiO_3\\ A\ CL_2\\ NO_3, CO_3\end{matrix}$$

Anion regin → all anions replaced by OH^-.

is regeneralised by alkaline/base.

Regeneration: $$\begin{matrix}SO_4, SiO_3\\ A\ CL_2\\ (NO_3)_2,CO_3\end{matrix} + \underline{2NaOH} \rightarrow A\ (OH)_2 + \begin{matrix}SO_4, SiO_3\\ Na_2CL_2\\ (NO_3)_2,CO_3\end{matrix}$$

The effluent from the two stage process is comparable to distilled water in quality and are used in industrial processes and boilers.

* polisher ⇒ activated carbon.

⊛ চারকোল পোড়ালে AC হয় না।
⇓
cz চারকোল পোড়ায় in presence of O_2.

⊛ AC ⇒ is burned without O_2

⊛ Argillaceous & Carbonaceous material burn করলে ⇒ leaves behind Carbonaceous material.

ACTIVATED CARBON APPLICATION

Refractory organic can be removed from water by adsorption process. Adsorption can be defined as the accumulation of substances at the interface between two phases (liquid and solid surfaces). The adsorbent most commonly used is Activated carbon (AC) ⇒ Carbonaceous materials

Production of Activated Carbon

Activated carbon can be prepared from virtually any organic solid (coal, lignite, wood etc.) by a destructive distillation process which drives off the volatile components of the material, leaving behind a porous carbon skeleton which has a very large surface area per unit volume (500-1500 m^2/g). This skeleton in then 'activated' by steam in an oxygen-depleted atmosphere at temperature ranging from 750°C to 950°C, often with the addition of dehydrating agents such as zinc chloride or phosphoric acid.

due to high temp.

Q. How to distinguish AC or Charcol ??
— Charcol pore কম, smooth surface, weight comparatively heavy, flaky
⇓
AC hugepores, irregular shape, wt extremely light

Theory: Molecules in solution are attracted to, and may be held by a surface in contact with the solution. The forces holding adsorbed molecules to the surface may result from either chemical bonding or Vandar Waals attraction. Adsorption will remove gases, liquids, and solids from solution.

Factors: Adsorption is greatest at low pH, high temperature, the rate of removal increases with increasing concentration but decreases with increasing molecular size, molecular weight and complexity of molecular structure.

Application: Activated carbon is used in water treatment in the form of both 1. powder and 2. granules. **Granular** activated carbon (GAC) has an effective size of the same order of magnitude as filter media (0.1 to 2 mm in dia) while Powder Activated Carbon (PAC) is generally less than 0.075 mm in size. PAC, being finely divided, has an extremely high ratio of surface area to volume. Since, adsorption is a surface phenomenon, this increases its effectiveness, but also make it slow to settle

PAC ⇒ পানিতে মিশিয়ে filter করলে clump / floc হয়ে যায়। So, reactant হিসেবে ব্যবহৃত হয়।
GAC ⇒ surface area কম হলেও " / " হয় না। So reactant " use হয়।

EBCT → Entibate Contact time → with time ↓, cz pore velocity বাড়তে থাকে due to clogging, $t = \frac{V}{Q}$, v↓ and t↓.

Afia (1204008)
Sheet ③

[illegible]

Occurrence of Iron & Manganese

Dissolved iron and manganese are often found in groundwater from wells located in shale, sandstone, and alluvial deposits. Manganese is an associated problem with iron in most of the places of Bangladesh.

Dissolution of rocks and minerals by acidic ground water ($CO_2+H_2O = H_2CO_3$) contribute these minerals.

- Iron exists in soil as Ferrous Oxides,
- Iron Sulfides (pyrite),
- Ferrous Carbonate (siderite) in CO_2 reach water.

Q.(1) How gas transfer betn air water interface can be m ?
— 1. interface বাড়ালে — 3. contact time
— 2. renewal of interface বাড়ালে

AERATION:

Aeration is a process used to remove undesirable gases (CO_2, H_2S, CL_2)or volatile organic materials dissolved in water (degasification) or to add oxygen to water to convert undesirable substances to a more manageable form (oxidation of iron & manganese). Although CO_2 and H_2S gases are only slightly soluble at atmospheric conditions, ground water may contain considerably higher concentrations under pressure commonly found in deep aquifers. These gases are biological waste products from bacterial decomposition of organic matter in the soil or by-product of reduction of sulfur mineral deposits. Aeration of water; supersaturated with these gases serves to speed the release towards equilibrium conditions. Volatile liquids such as humic acid and phenol can be removed from water by aeration at a slower rate.

Theory - liquid-gas contact systems are designed to drive the water-gas mixture toward equilibrium as quickly as possible for degasification purposes and to provide supersaturation of oxygen for oxidation purposes.

These goal may be accomplished by either 1. dispersing the water into air or by 2. dispersing the air into the water. When water is dispersed into the air the interfacial area per volume of water is maximized by minimizing the drop size. This will increase the desorption rate for supersaturated solution or increase the absorption rate for undersaturated solutions.

Ans of Q.(1)

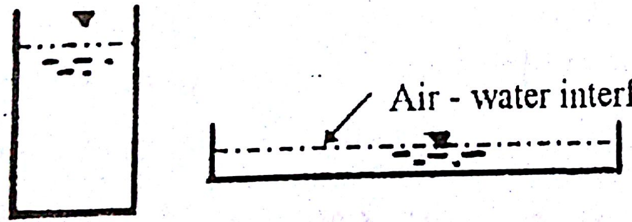
When air is dispersed into the water, both absorption and desorption are enhanced by maximizing the interfacial area by minimizing the size of the air bubble, Exposure time, renewal of interface are important factors.

Objectives of Aeration

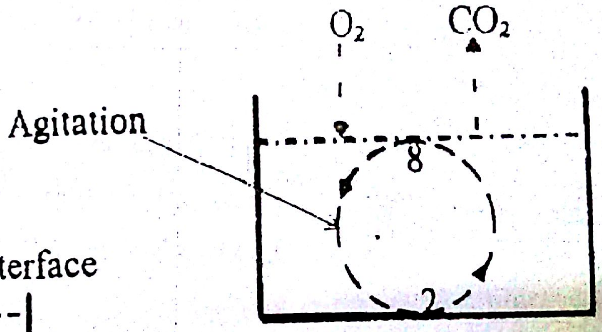
- *Primarily, increase pH value > 7.3 through stripping out CO_2 &*
- *Secondarily, oxidize Fe(II) to Fe(III) iron through adding O_2*
  [1mg/l of O_2 oxidizes 7 mg/l of Iron]

(a) increase air-water interfacial area.

(b) ↑ exposure time



Increase of interfacial Area



Renewal of Interface

Type of As		Arsenite As(III)		Arsenate As(V)
Occurance	⇒	Naturally occurs as undissociated weak acid in pH. of >2 to <9 and remain soluble condition (no surface charge)	⟶	When oxidized with oxidizing agents (BP, Potash) — dissociates into Arsenate ions, although remain in soluble condition (-ve charge on surface)
pH range	⇒	pH > 9.0 dissociate into Arsenite ion (-ve charge on surface)	⟶	pH < 7.0 to pH > 11.5 dissociate into Arsenate ion (-ve charge on surface)

oxidizing agent ⇑

⊛ Arc (III) soluble ⇒ so aeration দিয়ে হবে না, pass করাতে হবে Cl_2, Potash etc দিয়ে। So, dissociate হবে। -ve charge. Then Fe যদি থাকে water-এ, এর +ve charge কে attract করবে। Then precipitate হবে। / যেকোনো +ve charge থাকলেই +ve & -ve attraction হবে & then precipitation.

⇓

co-precipitation & attraction

⊛ এছাড়া যেকোন filtration bed-এ normally +ve ion থাকে বলে -ve As(III) attracted হয়। But Mn হলে attract হয় যদি সে pH ≥ 9.0 হতে হবে। ⇒ 2 processes
- 1. attraction → থাকে যেকোন
- 2. Coprecipitation → ২টা একসাথে precipit

⊛ Aeration → pH ↑, acidity কমলে, Fe oxidized হয়ে যাবে & Mn Adsorp করবে।
So Fe-এর জন্য Cl_2 লাগবে না, লাগবে Mn এর জন্য

Catalytic Contact Oxidation of Metal Ions & Sorption

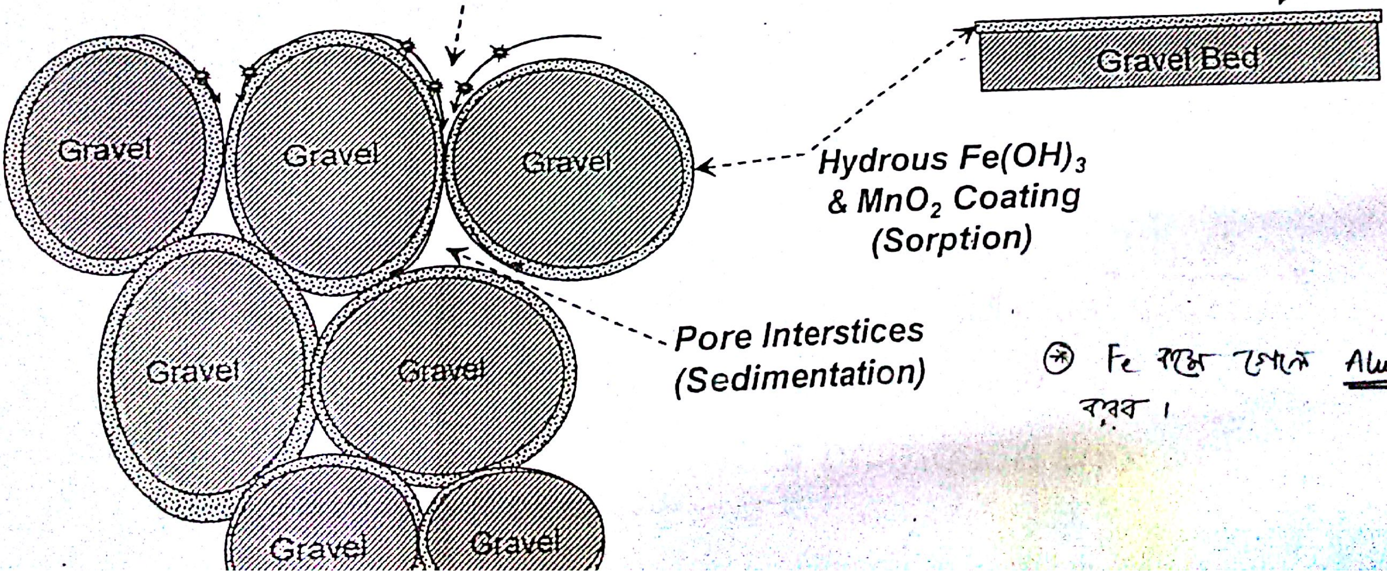
[During Flow through Porous Media]

⇓
কোনো chemical sol^n-এ involve নয়।

Hydrous $Fe(OH)_3$ & MnO_2 coating tends to sorb Fe^{++} & Mn^{++} ions & oxidize Mn(II)

$$Mn(II) + MnO_2(s) \longrightarrow Mn(II).MnO_2(s)$$

$$Mn(II) \longrightarrow Mn(IV)$$



Converging Flow (Flocculation)

Hydrous $Fe(OH)_3$ & MnO_2 Coating (Sorption)

Pore Interstices (Sedimentation)

⊛ Fe কমে গেলে Alum use করব।

⊛ As (III) ⇒ soluble but non-ionized
As (V) ⇒ soluble and ionized.

Occurrence of Arsenic:-

Arsenic Removal —

- In nature, arsenic is generally found only in the trivalent (III) and pentavalent (V)states.
- H_3AsO_3, an un-dissociated weak acid, is predominant in the pH range of 2-9.

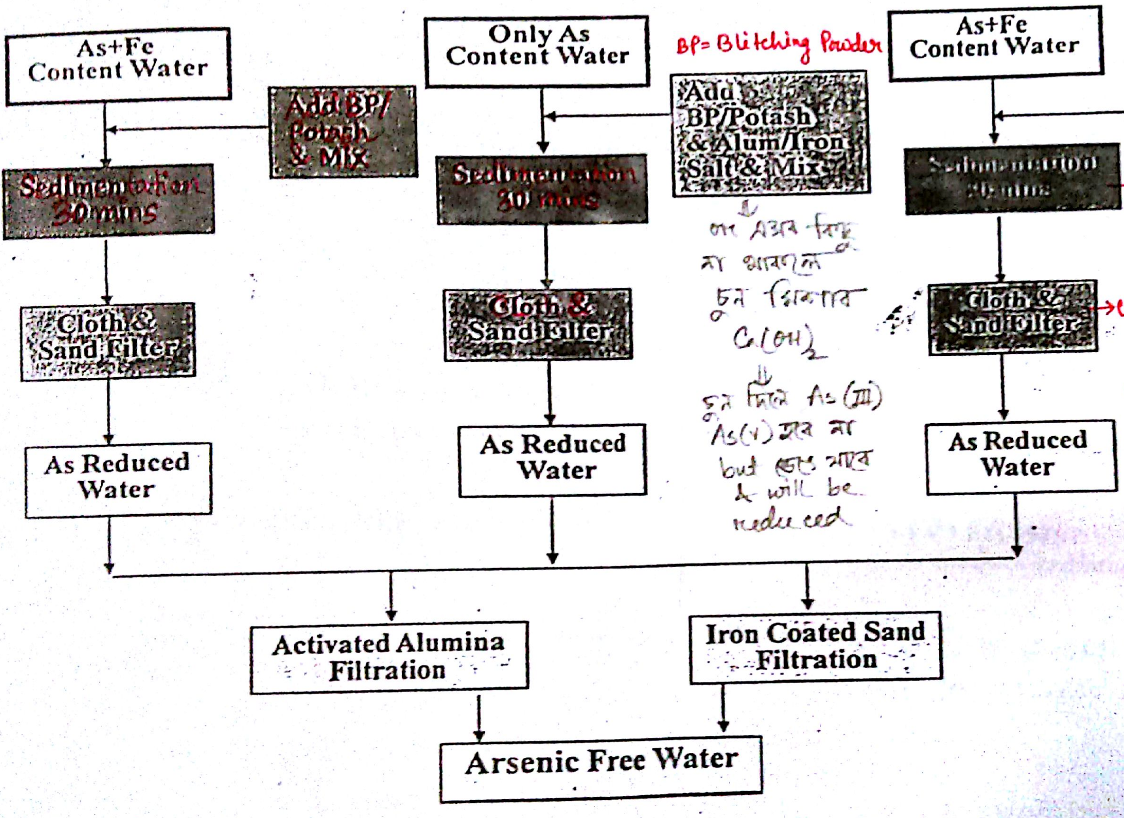
2 forms of As ⇒

- As(III) present in a typical water supply would occur as H_3AsO_3, pH >9.0 → dissociates into Arsenite ion (-ve charge
- As(V) in water occur as a strong acid and dissociates into ions according to the pH value.

Q. what should be added if there is insufficient Fe?

Co-Precipitation, Sedimentation, Filtration & Adsorption

processes of As removal



BP= Blitching Powder

যদি আয়রন বেশি না থাকলে চুন দিতে হবে
$Ca(OH)_2$
⇓
চুন দিলে As(III) As(V) হবে না but কমে যাবে & will be reduced

Add lime [pH >9.0] & Mix

→ Sedimentation 30 mins

→ Cloth & Sand filter

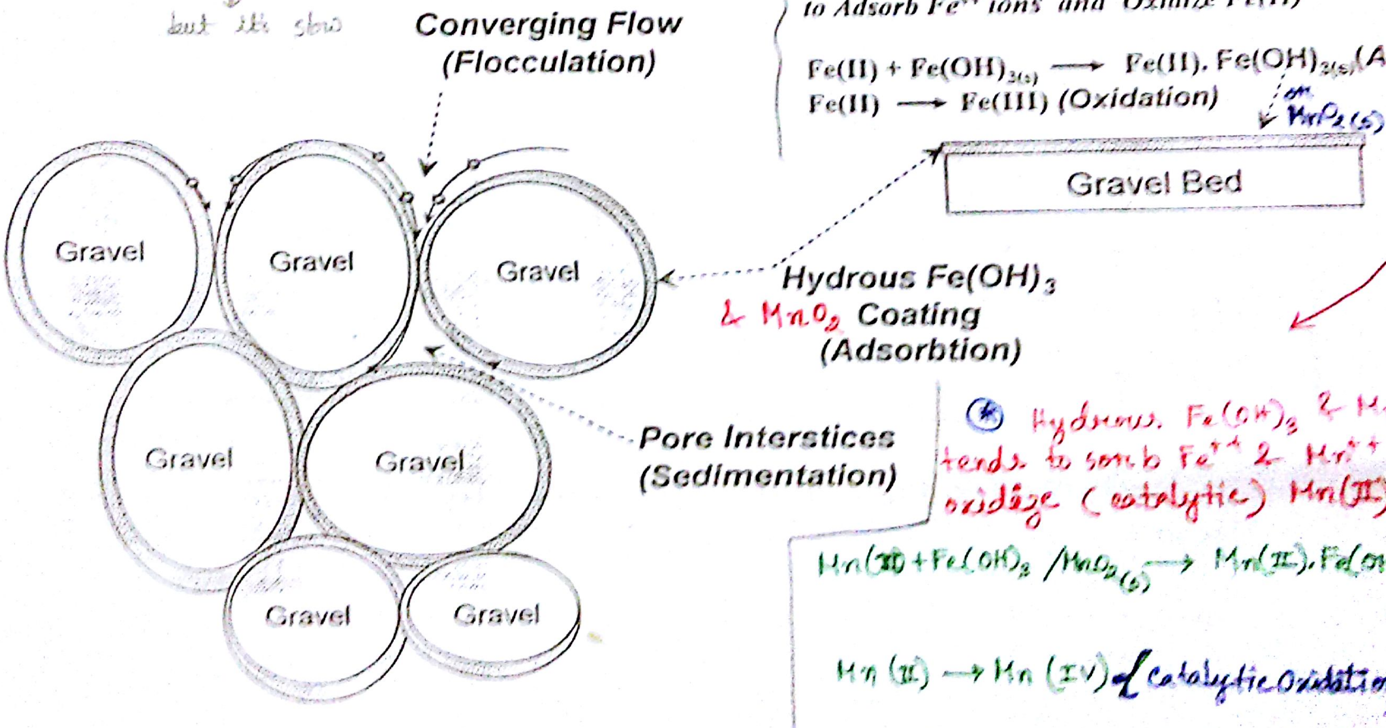
⊛ Cloth filter
⇓
(clogging কম হয়।)

(*) Here 2 processes ⇒ 1. Adsorption (faster process)
2. Oxidation (slower process)

Catalytic Contact Oxidation of Metal Ions & Sorption

[During Flow through Porous Media]

(*) first - 2 adsorb ZB 2+ ion, then oxidation
↓
but its slow



Hydrous Fe(OH)₃ coating on the gravel surface tends to Adsorb Fe⁺⁺ ions and Oxidize Fe(II)

$Fe(II) + Fe(OH)_{3(s)} \longrightarrow Fe(II).Fe(OH)_{3(s)}$ (Adsorb)

$Fe(II) \longrightarrow Fe(III)$ *(Oxidation)*

(*) Hydrous Fe(OH)$_3$ & MnO$_2$ coati tends to sorb Fe^{++} & Mn^{++} ions & oxidize (catalytic) Mn(II)

$Mn(II) + Fe(OH)_3/MnO_{2(s)} \longrightarrow Mn(II).Fe(OH)_3/MnO_{2(s)}$

[Sorptio

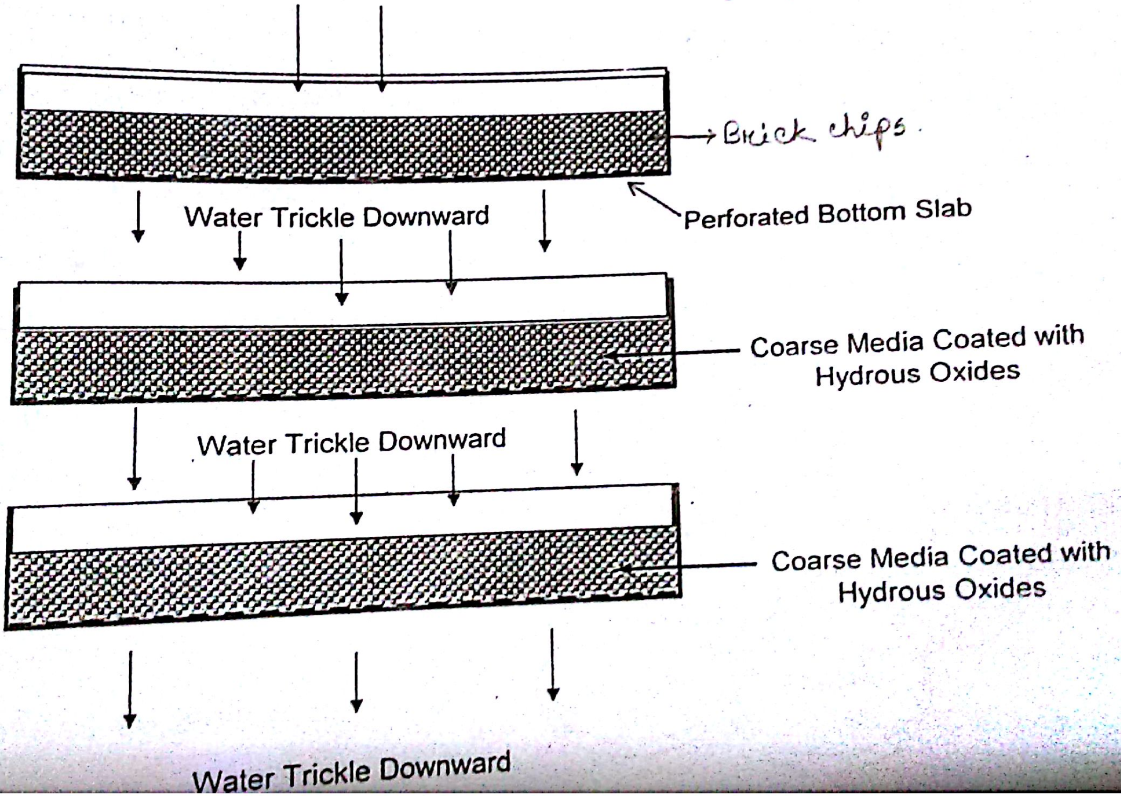
$Mn(II) \longrightarrow Mn(IV)$ {catalytic Oxidation}

Ⓧ due to continuous coating, clogging occurs. So
⇓
[Multiple tray process]

Multiple Tray Aerator with Coarse Media

Ⓗ খাগড়াছড়ি / Hill tracks-এ

Imp. { Ca Hardness = 30 min^m
Mg " = 10 min^m

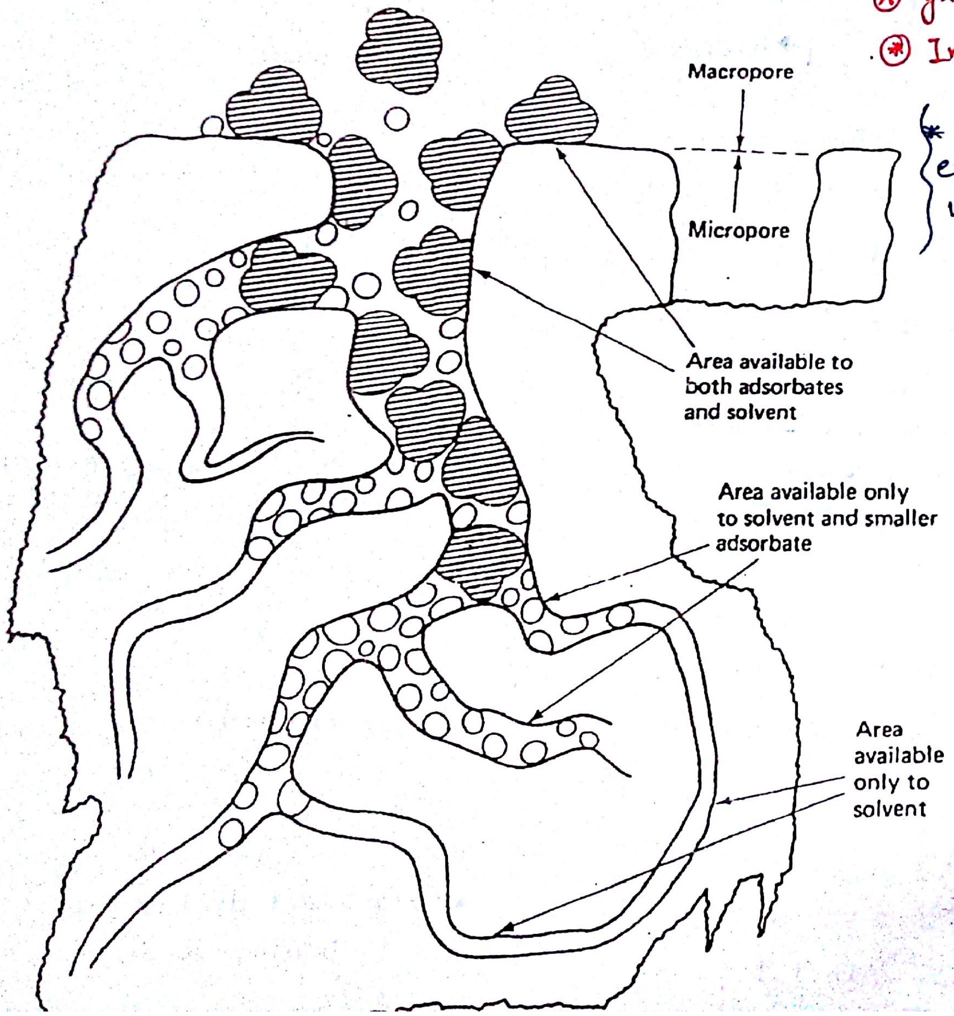


Activated Carbon

⊛ gas mask -এ থাকে

⊛ Industry তে "

* Organic matter থেকে Cl_2 exchange-এর জন্য AC use করা হয়।



Principle of Biological Treatment & Basic Requirements of Life

(✱) highest energy source in our food → Carbohydrate

(a) Mass balance.

Amazon → Produce 1/3 O_2 of the world, biggest rain forest in the world

= { BOD → Biochemical O_2 Determinat
COD → Chemical O_2 " }

	Beteria (Animal / Protista)	Algae (Plant)
• 1. Source of Carbon —	Dead organic matter → Heterotreopic	CO_2 → Autotropic
• 2. " " Energy —	Oxidation of organic matter	Sunlight
• 3. " " Nutrient —	Inorganic salts (N, P etc)	N, P etc → mostly Cl, Fe, Ca etc
• 4. Respiratory oxygen —	DO present in H_2O	Photosynthesis O_2

Aerobic Biological Oxidation of Wastes

Step-1 : $C_xH_yO_zN + \underset{\text{Supply}}{\underline{O_2}} \xrightarrow{\text{Bacteria}} CO_2 + H_2O + NH_3 + \underline{+Energy}$ [Catabolism]

Step-2 : $C_xH_yO_2N + \underline{O_2} + Energy + Salts/Nutrient(N,P) \xrightarrow{\text{Bacteria}} C_5H_7NO_2$ [Anabolism] → আগে ছিল dead but এখনও alive.
(New Bacteria Cell)

Step-3 : $C_5H_7NO_2 + \underline{O_2} \xrightarrow{\text{Bacteria}} CO_2 + H_2O + NH_3 + Energy$ [Autolysis]

Ultimate BOD_u = Total O_2 required (underlined) for the above three steps

Imp. Definition:- Total O_2 required for the oxidation of organic matters by biochemical process.

Imp. Q. Why COD > BOD.
Chemically all O_2 কে trace করা যায়, but biologically organic matter অনেক সব O_2 trace করা যায় না (e.g. synthetic)
∴ BOD < COD

Q. Why BOD is important than COD ?

- Important factors for BOD test —
  1. Dilution ratio → must be optimum
  2. Seeding → Bacteria না থায় / গ্রহণ করে from human fold.
  3. Nutrient ⇒ DAP - Di Ammonium Phosphate (mixed nutrient)
  4. O_2