Water and Wastewater Engineering

Dr. Ligy Philip
Department of Civil Engineering
Indian Institute of Technology, Madras

Water Treatment Systems
Unit Operations
Lecture # 7

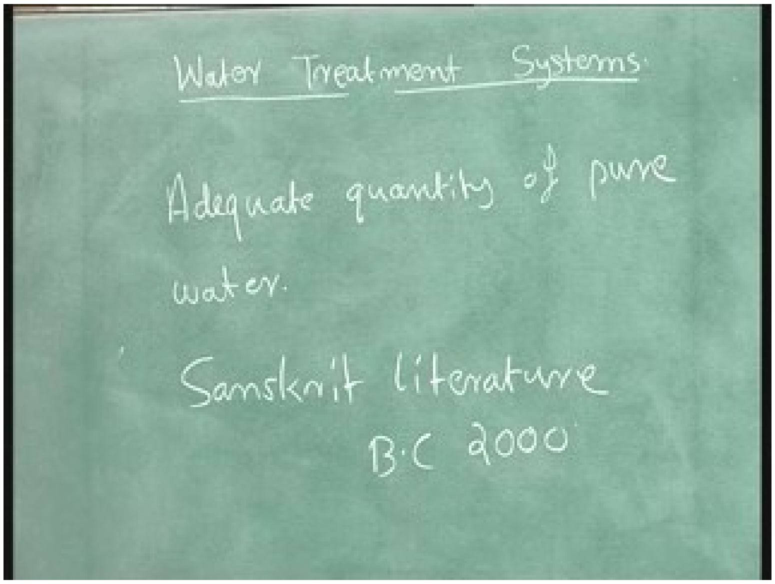
Last class we were discussing about the various water quality parameters. We have seen in detail the physical, chemical and biological parameters of water. We have also discussed the importance of each and every parameter and how to analyze them and what are the instruments used for those for the determination of these parameters. We have also discussed that the physical parameters like color, odor, turbidity etc is important for the appearance of water whereas the bacteriological quality is the most important parameter for water quality especially when it comes to drinking water. If the water is not safe for bacteriological reasons then we cannot supply it.

But coming to chemical parameters for emergency purpose we can even supply water even if it is not meeting the chemical parameters. But for long term supply we have to take care of the chemical parameters according to the standards laid by either Bureau of Indian Standards or Environmental Protection Agency or other recognized standards.

Today we will discuss about the water treatment systems. If the water quality is not meeting the required standards we have to improve the standard so let us see how we can improve the standard. For that we have to give various treatments to the water systems. In the first class we have discussed the major objective or one of the major objectives of environmental engineering which is to supply adequate quantity of pure water. We have also discussed about the various water sources available; we have surface sources, ground water sources, ponds, lakes, ocean etc. But depending upon the quality of water we have to give various types of treatment.

Earlier the water sources especially the surface water sources were very very poor so there was no need of any treatment. But during industrial revolution what happened was many people move towards the water source and because of that the water sources started getting contaminated and the quality was far away from the required quality for various beneficial users.

(Refer Slide Time: 04:08)

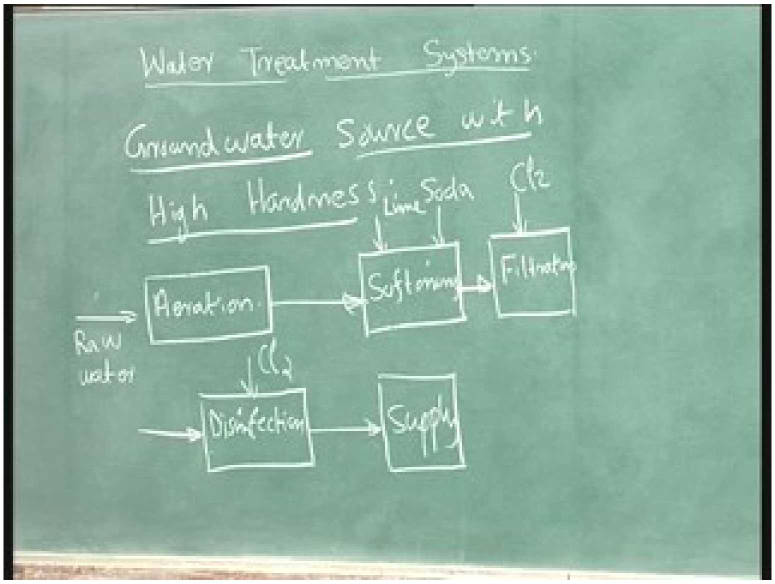


If we scan through the literature even in the Sanskrit literature in B.C. 2000 itself people were aware of water treatment. They have mentioned about the boiling of water and subsequent filtration of water before drinking. Even in all medical books we can see; what is the relationship between clean water and the control of diseases or the contaminated water and incidents of diseases.

In the earlier days or in olden days most of the water treatment systems were for household basis or for individual houses they were having water treatment systems but only in the starting of the first century community based treatment systems started coming up. And if you see in history, again we can see that the European countries were much advanced in terms of water treatment compared to American countries. But the water treatment systems whatever we are seeing today were almost developed in the 19th century.

Now we will see the different engineered water treatment systems available. When we talk about the treatment, as I have already mentioned, we have to decide the treatment units based upon the source of water and the level of contamination.

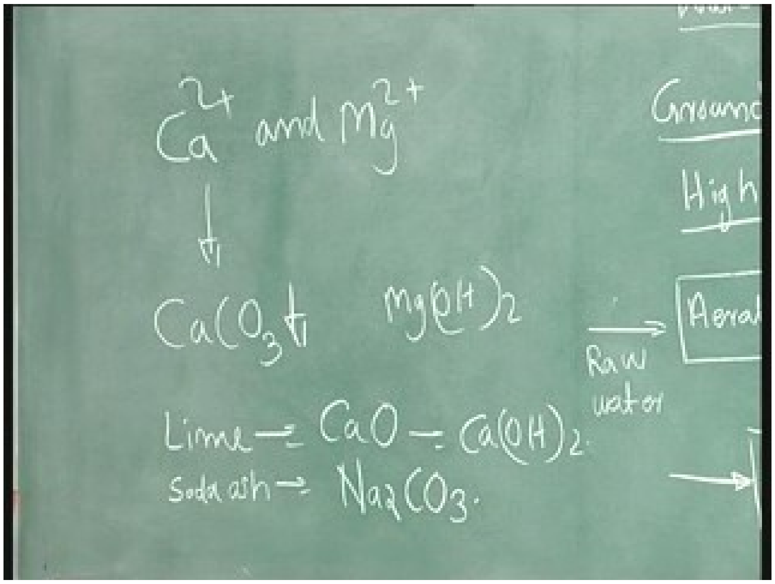
(Refer Slide Time: 06:10)



It is very clear from this picture, if you talk about the ground water source with high hardness what type of a treatment system we have to provide. You are getting the raw water and first you have to go for aeration followed by softening, here (Refer Slide Time: 6:25) we are adding lime as well as soda and after softening we can go for filtration and after filtration you have to go for disinfection then supply. This is the typical treatment system adopted for a ground water source with high hardness.

First what we have to do is we have to take the raw water then aerate it, the aeration process is for removing undesirable gases present in the water as well as to remove metals like manganese, iron etc. Then if hardness is very high we have to remove the hardness because excess hardness is not permitted. So how can we remove the hardness? For that we have to go for softening process.

(Refer Slide Time: 08:05)



Here what we are doing is we are adding lime and soda so if you add lime and soda the hardness is coarse because of divalent cations especially the presence of calcium and magnesium causes hardness which we have discussed in the last class. How can we remove this hardness? We can precipitate out this calcium and magnesium.

Calcium can be precipitated out as calcium carbonate which is highly insoluble and magnesium can be precipitated out as magnesium hydroxide. So, by the addition of this lime (calcium oxide) and soda (soda ash is Na_2CO_3), when it is mixed with water you will be getting calcium hydroxide. So, when we add this lime and soda ash, whatever calcium and magnesium that is present in the system will be getting precipitated as calcium carbonate and magnesium hydroxide. So we can remove the sludge by settling and take the sludge to sludge drying bed and we can even recover the lime if it is required.

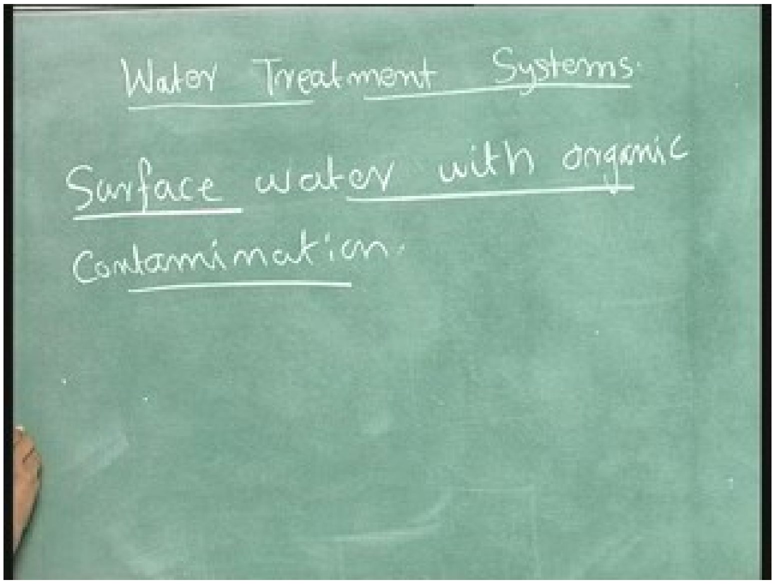
After the softening what we have to do is we have to go for filtration. Here we will be using sand filters (Refer Slide Time: 9:16) so this will be removing the entire leftover flocs of calcium carbonate and magnesium hydroxide. We can even add some chlorine to the filter bed to avoid microbial growth on the filter bed. As the filter bed is exposed to the atmosphere there is a chance of bacterial growth so we can avoid that one by adding chlorine and after this one we can go for disinfection by the addition of chlorine. This is what we are practicing in India.

Instead of chlorine we can go for either ozone or UV radiation and once this treatment is over we can send it to the distribution system. But if the ground water is not having hardness, and for most of the ground water depending upon the locality and the mineralogy of that area the concentration of calcium and magnesium will be varying so in this case we can just take the ground water and if iron and manganese are absent in them then we can straight away go for disinfection and supply. And if the ground water is also contaminated this treatment may not be sufficient so we may have to go for other additional treatments.

So what I want to say is that we cannot generalize the treatment processes or treatment system, it depends upon the type of water that is available and for what purpose it is being treated for. Therefore, these factors decide the treatment system.

For example we will see if instead of ground water we are using highly contaminated surface water then what treatment we have to provide.

(Refer Slide Time: 13:00)

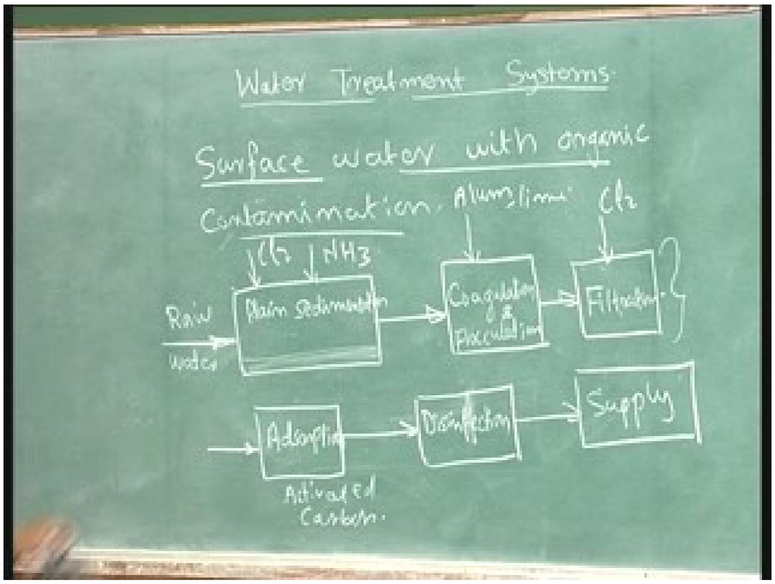


Surface water with organic contamination:

What type of a treatment we can provide for this type of water? again you have raw water and if it is having lot of suspended matter and settleable solids we have to go for plain sedimentation followed by coagulation and flocculation then filtration, adsorption, disinfection then supply and here we can add Cl2 (Refer Slide Time: 13:34). Here the raw water is coming and if it is having lot of settleable solids then we can go for a plain sedimentation tank and here because of gravity the settleable solids will be settling down. And we can add chlorine or other chemicals for oxidizing the organic matter present or preventing any biological action. Sometimes we can even add ammonia to prevent the biological actions.

Once the plain sedimentation is over here we will be getting settleable solids in the plain sedimentation tank and this we can take to the sand beds for drying and after the plain sedimentation here all the settleable solids are removed and it will be left over with colloidal particles as well as dissolved solids. So, if you want to remove the colloidal solids we have to go for coagulation and flocculation. Thus, here we have to add coagulants (Refer Slide Time: 14:37) that means alum and other polymers. So, by the addition of these chemicals alum, lime and other polymers the colloidal particles will get destabilized and we can settle them easily.

(Refer Slide Time: 14:55)



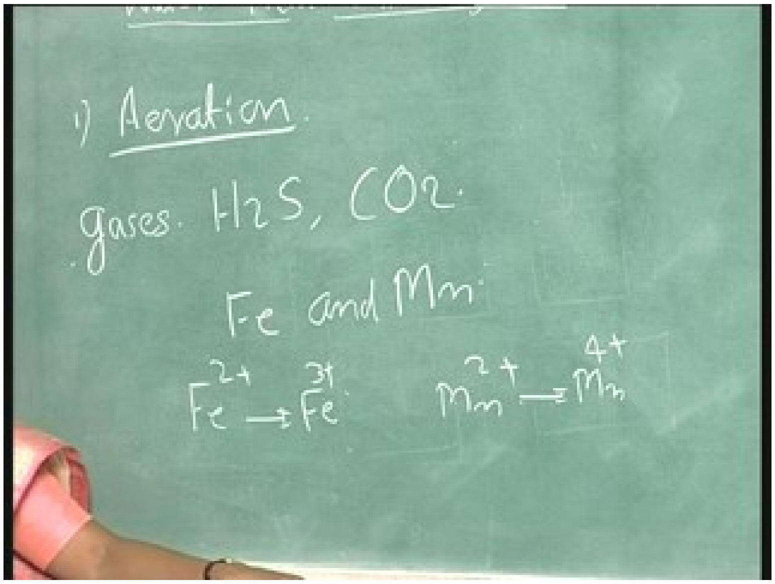
After this coagulation flocculation we will be having a secondary sedimentation tank were all the flocs will be separated. After this coagulation flocculation we have to go for filtration; either slow zone filter or rapid zone filter and here we can add even chlorine to prevent the biological growth.

After filtration we have to go for adsorption. Here we use either activated carbon or other suitable adsorbents to remove the organic content present in the water. once the adsorption is over the water is almost free from the solids dissolved, colloidal as well as suspended solids then we have to go for disinfection to make sure the water is bacterilogically safe and during disinfection we will be providing enough chlorine to take care of all the contaminants present in the water as well as some leftover chlorine which is known as residual chlorine to take care of whatever the contamination is, the minimum contamination in the distribution system and once the disinfection is over we can put the water into the distribution system for supply. Therefore, depending upon the water source we have to decide on the treatment we have to provide.

Now we will see each of these processes in detail; how to design the unit processes. First one is aeration. The purpose of aeration is to remove objectionable gases present in water as well as objectionable materials present in water in presence of oxygen to handleable materials.

For example, the objectionable gases present in water are mainly hydrogen sulphide and carbon dioxide. So gases like H_2S and CO_2 can be removed from water by aeration and objectionable materials like iron and manganese can be removed by aeration. How these gases are entering into water? If it is rain water the amount of hydrogen sulphide and carbon dioxide getting dissolved in water will be very very negligible so we don't have to remove them. But if it is ground water especially when the water is under high pressure the solubility of these gases will be very very high. So, if these gases are present in the water it will be producing undesirable smell so we cannot supply that water so before supply we have to remove the undesirable smell and odor of the water.

(Refer Slide Time: 19:48)

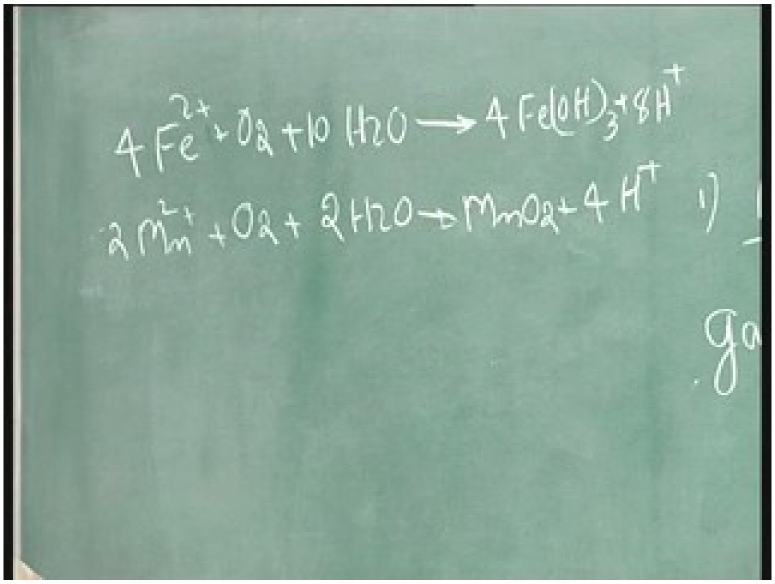


How can we remove the smell or odor? What we have to do is we have to over saturate the water with oxygen. Because of over saturation with oxygen what will happen is these dissolved gases will be getting expelled from water. So that is what is happening in aeration.

You have water which is having hydrogen sulphide or carbon dioxide dissolved in it. What we do is we are proving excess oxygen to that water so what will happen is that water will become over saturated with oxygen so in that process these gases will be coming out. Once these gases are out then the odor of the water will be getting removed. Similarly, how can we remove metals like iron and manganese? In the ground water the availability of oxygen is limited so these metals will be in their reduced form.

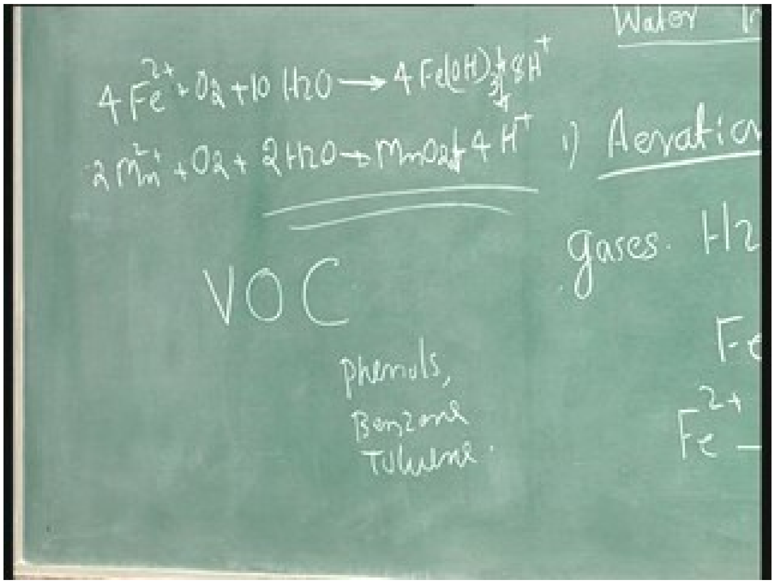
For example, if you take iron Fe Fe will be in the form of Fe to the power 2 plus and Mn also in the form of Mn power 2 plus. So if you can provide excess oxygen then this Fe power 2 plus can get oxidized to Fe power 3 plus and Mn power 2 plus can get oxidized to Mn power 4 plus. So once it is getting oxidized to Fe power 3 plus and Mn power 4 plus then we can easily remove them by precipitation. The chemical reaction we can write like this; 4 Fe power 2 plus plus O_2 plus 10 H_2O gives you 4 Fe $(OH)_3$ plus 8H power plus. Similarly, for manganese we can write like this; 2 Mn power 2 plus plus O_2 plus $2H_2O$ gives MnO_2 plus 4H power plus.

(Refer Slide Time: 20:30)



Here Fe power 2 plus is getting converted to Fe power 3 plus and this Fe power 3 plus is ferric hydroxide which is precipitating out. Similarly, Mn power 2 plus is getting oxidized to Mn power 4 plus and it is precipitating out. Thus, for example, if you take the ground water which is rich in iron and if we expose that one to the atmosphere you can see a brown or a reddish color in the water. What is that? It is this reaction only (Refer Slide Time: 21:12); this reaction is taking place in the water. When you take the ground water it is having low oxygen content but when it is exposed to the atmosphere it is coming in contact with oxygen so Fe power 2 plus is getting oxidized to Fe power 3 plus and this Fe power 3 plus will be precipitating out as ferric hydroxide and those ferric hydroxide flocs here which you see as the reddish material in water.

(Refer Slide Time: 22:38)



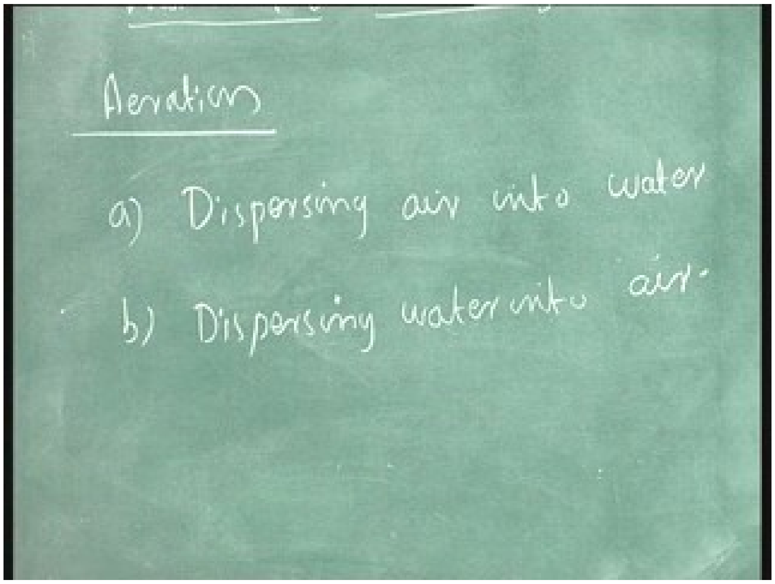
Similarly manganese oxide also can be removed. But manganese oxide precipitation is a very slow process at low pH, means the pH less than 9 the manganese oxide precipitation is low. So if you want to increase the reaction rate what you have to do is you have to increase the pH of the system. This is what is happening in aeration.

In some cases for the removal of VOCS Volatile Organic Compounds like phenols, benzene, tuluvine, zyline etc also this aeration is being used. But we cannot remove them completely using aeration. but if the concentration is very very high then we can go for aeration and bring the concentration down to the handleable level and further we can go for other treatments like adsorption or iron exchange and so on, mainly adsorption because these organic compounds can be removed easily by adsorption process.

In short we can tell that aeration is used for the removal of objectionable gases like hydrogen sulphide, carbon dioxide etc from the water and objectionable materials like Fe Mn power 2 up to handleable materials then sometimes we can use aeration for the removal of Volatile Organic Compounds like phenols, benzenes, tuluvine etc. But in the case of VOCS we cannot remove them completely, we can only reduce the high concentration to a certain level and afterwards we have to go for further treatment.

Now we will discuss how we can achieve this aeration. What are the different ways by which we can provide aeration to water? I am going to discuss aeration in water treatment systems.

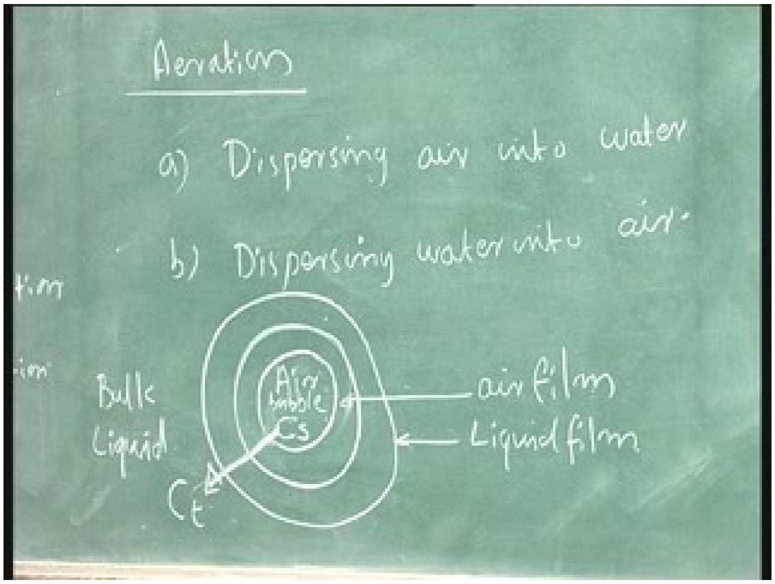
(Refer Slide Time: 24:10)



What is the various process for aeration?

Aeration can be done either dispersing air into water or dispersing water into air we can carry out aeration in both these ways. In the first one we are disposing air into water. We are injecting high pressure air to water which has to be aerated. So it is something like this (Refer Slide Time: 24:46) you have the air bubble, this is your air bubble, this we can call as air film and this is the liquid film and this is the bulk liquid, you are dispersing air into the liquid.

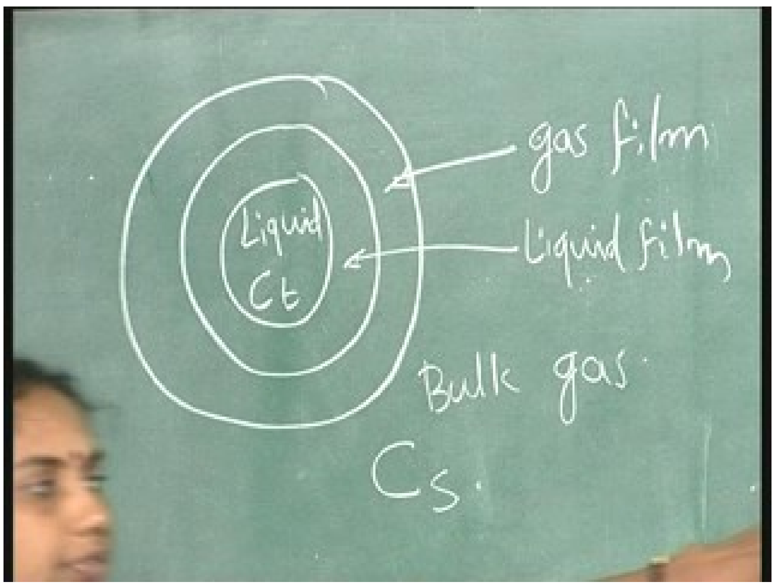
(Refer Slide Time: 27:15)



So air bubble is there in the bulk liquid and this air bubble will be having air film surrounded to that one and after that air film you will be having a liquid film and this is the bulk liquid. So if you assume C_t is the concentration of the pollutant in the bulk liquid and C_s is the concentration of the pollutant in the air bubble so if C_s is less than ct then here the concentration is less compared to the bulk liquid so naturally the concentration gradient will be from the bulk liquid to the air bubble so the pollutant will be moving towards this side and this is known as desorption.

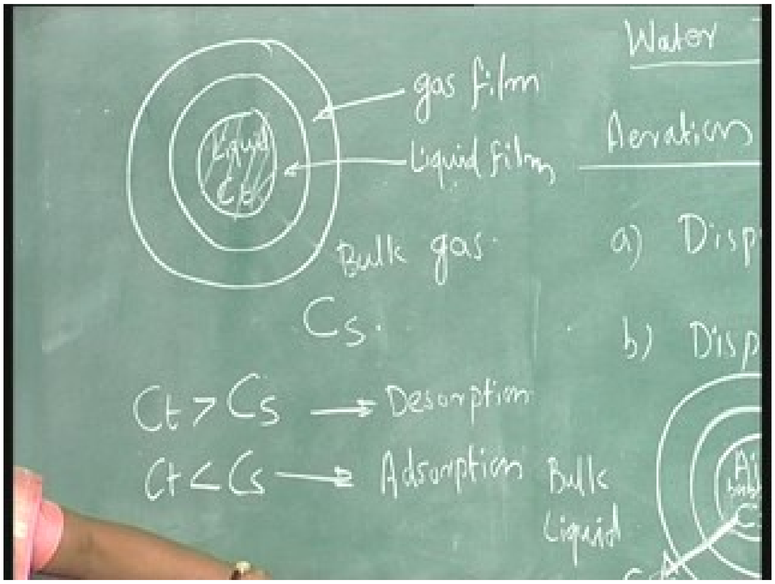
If the case is the other way, if C_s is greater than C_t that means if the dissolved oxygen concentration of the bulk liquid is less than the oxygen concentration of this air bubble then the concentration gradient will be in the opposite direction, it will be like this (Refer Slide Time: 26:53) that means the oxygen will be getting transferred from the air bubble to the bulk liquid. That we can call it as adsorption or the bulk liquid is adsorbing the gas from the air bubble. This is an example of dispersing air into water.

(Refer Slide Time: 27:20)



Therefore, we can see the other case; dispersing water into air, it will be also the same. here we will be having the liquid at the center and this will be the liquid film (Refer Slide Time: 27:33), here the center is liquid so this is liquid film and this is the gas film and this is bulk gas and your concentration here in the liquid is C_t and the bulk gas it is C_s the saturation concentration. This is the example of dispersing water into air that's why the liquid bubble is inside. So if C_t is greater than C_s the concentration of the pollutant in the liquid is more than the concentration of the pollutant in the gas phase so naturally the pollutant will be moving from the liquid to the gas. This is a case of desorption. Similarly, if ct is less than C_s that means here the concentration is less compared to the bulk gas so naturally the gas will be moving towards the liquid so that is an example of adsorption.

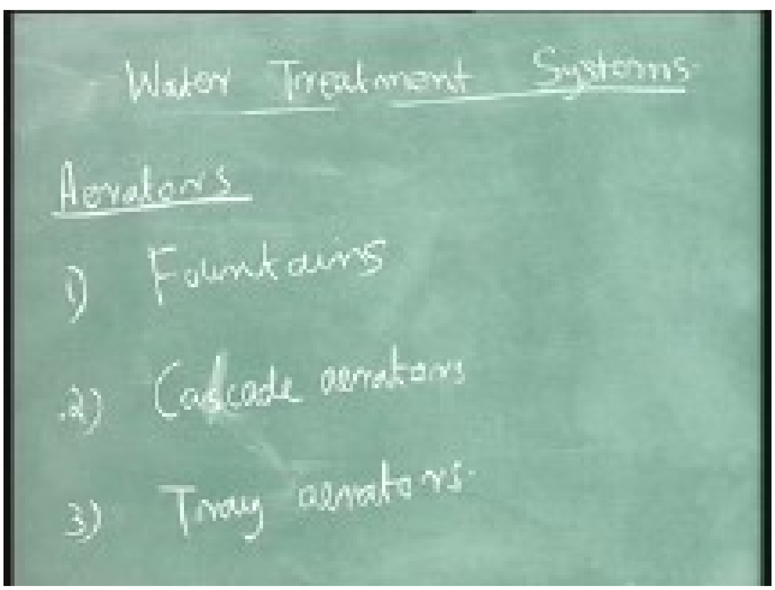
(Refer Slide Time: 29:10)



This is the principle of aeration. In case of water treatment systems in aeration most of the time what we do is dispersing water into air this is what we usually go for. So we will see what are the different systems adopted for the dispersion of water into air.

Aerators: the most commonly used ones are fountains. Second one is cascade aerators and third one is tray aerators.

(Refer Slide Time: 29:37)

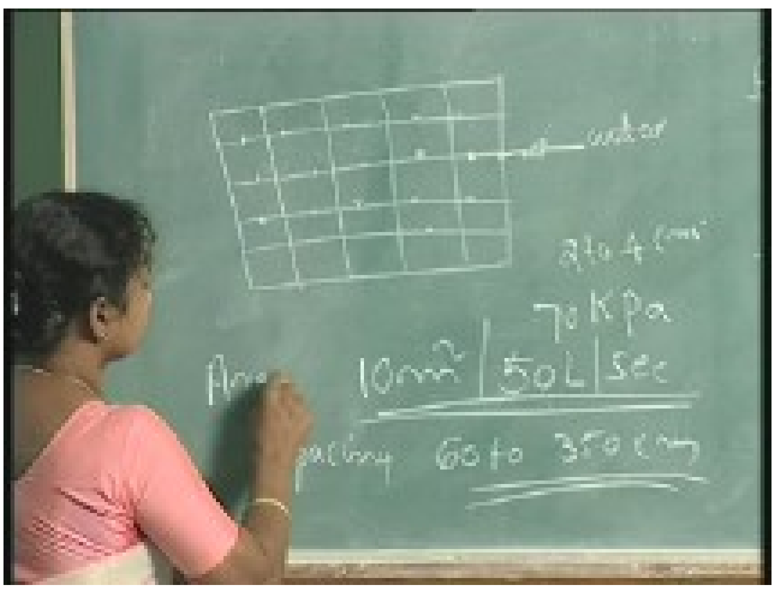


Now we will see how these fountains or cascade aerators or tray aerators are made.

In fountains it is nothing but a grid of pipelines provided above a basin. This grid of pipelines will be having nozzles at various locations and nozzles are provided in such a way that air will be coming out under high pressure in the upward direction so you will be supplying water. The nozzles are provided at different locations and water will be coming out in the upward direction and it will be under high pressure with high velocity. The nozzle size varies from 2 to 4 centimeters and the pressure usually maintained is around 70 kilo Pascal's so it will be coming under high pressure. Around 2 to 4 centimeter diameter nozzles are provided so these nozzles will be injecting water in the upward direction and it will be having very high kinetic energy.

Once the kinetic energy is lost the water will be falling down and it will be collected in the bottom basin. During that time it is coming in contact with the atmosphere and since the contact area is so high lot of gas transfer will be taking place, hence, during that time whatever odorous gas is present in the water will be escaping. Similarly metals like Fe or Mn whatever is in the reduced form will be getting oxidized and subsequently it can be removed.

(Refer Slide Time: 32:42)



This is the cascade system. The area required for this one is in the order of 10 meter square per 50 liters per second. We can design this system very easily. The spacing between the piping vary from 60 centimeters to 350 centimeters depending upon the crowding because when you have the nozzle depending upon how high it is coming up and how much crowding is taking place you can decide the spacing. This is the spacing and this is the area required (Refer Slide Time: 32:40) and this is the pressure required, this is the size of the nozzle. So based upon this one you can design your fountain.

Now we will see what cascade aerators are.
Cascade aerators are just like steps like this (Refer Slide Time: 33:15) so what happens here is the water is lifted to the top of this cascade and is allowed to pass through this one

so water will be falling like this and it is being collected here at the bottom. So, most of the time the height of this step is around 30 centimeter and in most of the cases the cascade aerators will be having ten number of steps.

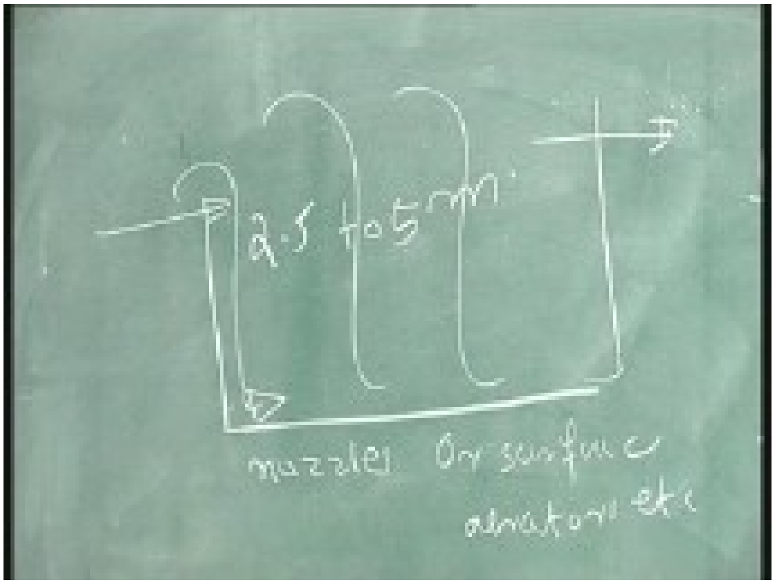
(Refer Slide Time: 34: 48)

Hence we can easily find out what is the head loss here. The head loss is nothing but the total height from here to here where the collection system is. So what will happen is the thin film of water is passing through these steps so the area of contact increases considerably resulting in very very fast gas transfer because the contact area is very high. So the order of gases will be escaping from the system as well as more oxygen is available so the material whichever is in the reduced form will be getting oxidized. These are known as cascade aerators. Here the area requirement is in the order of 4 to 9 meter square per 50 liters per second. This is the area requirement which is almost same as that of the fountain.

Now we will see what tray aerators are.
Tray aerators are something similar to the cascade aerators. The only difference is water is allowed to pass through some solid media and the reactions will be taking place on the solid surface so that more contact will be there and the reactions will be much faster. That is what is happening in tray aerators. Now we have discussed the purpose of an aerator and what are the different types of aerators available and how we can increase the rate of gas transfer. These are the most commonly used aerators (Refer Slide Time: 35:44) in water treatment.

We can even go for the dispersion of gas in the liquid. If we are going for the dispersion of gas in the liquid what we have to do is we have to make some tanks and water will be flowing through the tank and the depth of the tank will be varying from 2.5 to 5m and you can provide aeration using nozzles or surface aerators etc. this type of system is commonly used in wastewater treatment where the oxygen requirement is very very high.

(Refer Slide Time: 36:28)

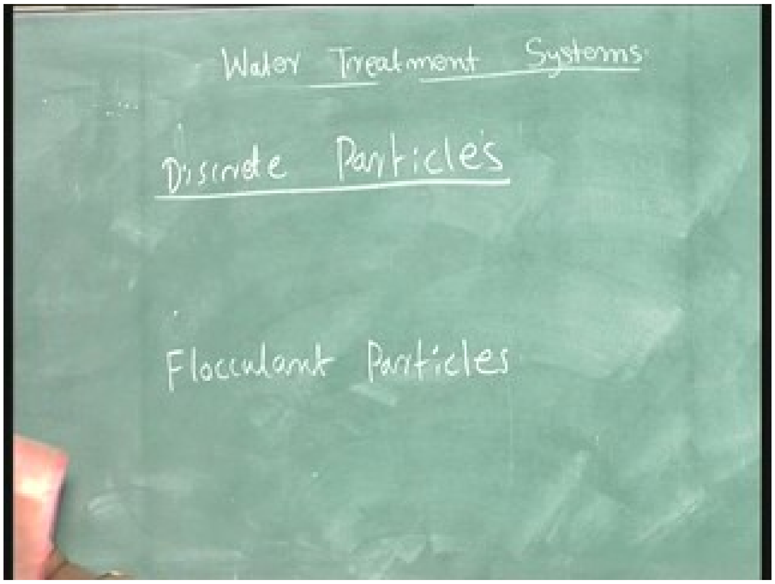


In water treatment we usually go for this fountain cascade aerators and tray aerators.

(Refer Slide Time: 37:36)

Removal of solids: for this one we are using sedimentation or clarification. This is the unit operation we usually used for the removal of solids. These solids are mainly settleable or suspended solids or colloidal solids. So what is happening in sedimentation. because of the gravity force and because of the weight of the particle the particle will be settling down so what we have to do is allow the water to stay quiescent in some settling basin or sedimentation basin and give enough detention time so that the particle will be settling down and we can collect the clear water from the outlet. This settling is depending upon the liquid characteristics as well as the particle characteristics.

(Refer Slide Time: 38:25)



Particles can be divided into basically two categories; one is discrete particles and another one is flocculent particles.

Discrete particles are the ones which do not change in size, shape and specific gravity or the properties with respect to time those are known as discrete particles. That means the particle will be settling as independent particles, it will not be affected by the surrounding particles. But in the case of flocculent particles what is happening is with respect to time the size, shape and the specific gravity of the particles may be changing so naturally the settling velocity will not be a constant. So, in case of discrete particle we can find out the settling velocity using classical mechanics. But in flocculent particle settling we cannot do that one because the particles keep on changing its size, shape and specific gravity so naturally with respect to time the particle size may be increasing, shape may be varying and specific gravity will be varying so it is very very difficult to find out the settling velocity so we have to find out the settling velocity by conducting an experiment.

For example, the flocculent particles if you take, two or three particles like this (Refer Slide Time: 39:47) what will happen is with respect to time these particles will be agglomerating like this, initially two particles and with respect to time two or three particles will be agglomerating, and since the particle size is increasing with respect to time naturally the settling velocity will be increasing and the specific gravity will be varying. Why the specific gravity is varying is because here only one particle was there, here two particles and here three particles are there so the entire one will be acting as a single particle so some water will be getting entrapped in between the particle so naturally the bulk specific gravity of this particle will be varying.

(Refer Slide Time: 40:31)

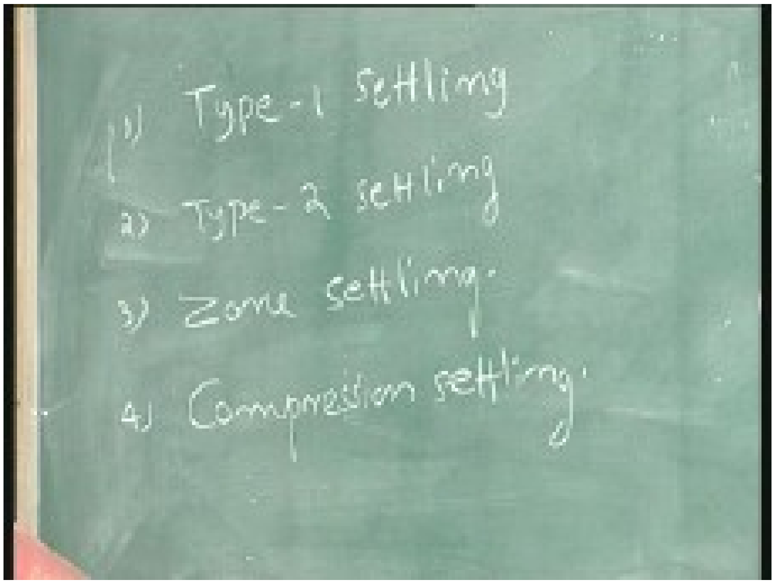
Again when we discuss about the sedimentation we have to talk about dilute suspensions and concentrated suspensions.

In dilute suspensions the concentrations of particles are so low so there is no inter-particle attraction or one particle is not affected by the other particle or each particle will be settling as independent particle. So this concentration of the suspension is also important when we discuss about sedimentation or clarification. In concentrated suspension the concentration of the particles are so high so intra particle forces will be present there so each particle’s settling will be affected by other particles so each particle will not be settling as independent particle but they will be settling as a group of particles. That is what is happening in concentrated suspension.

(Refer Slide Time: 41:44)

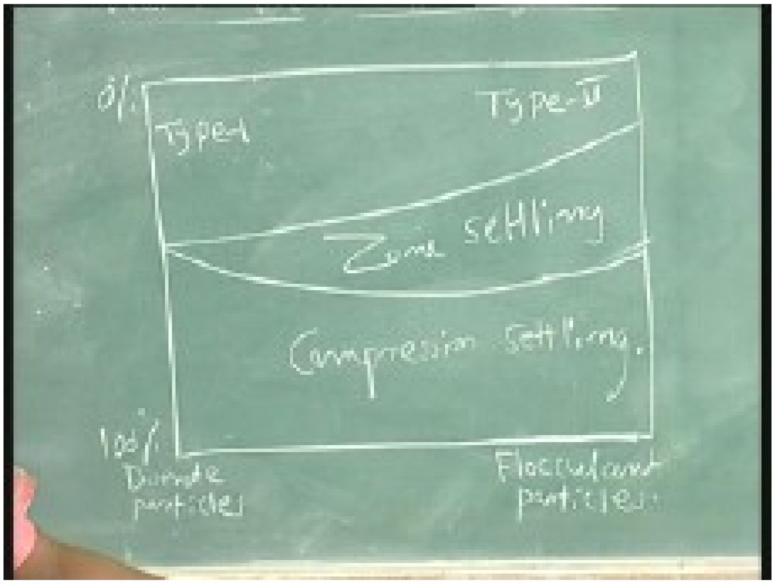
Therefore, based upon the nature of the suspension as well as the nature of the particles we can classify the settling into four categories. One is type one settling and second one is type two settling; third one is type three settling or zone settling and fourth one is compression settling.

(Refer Slide Time: 42:38)



We can represent this one pictorially. It is something like this (Refer Slide Time: 42:55). Here we are representing discrete particles and here flocculent particles and this axis represent the concentration, here it is zero percentage concentration and here hundred percentage concentration so y axis represents the concentration and x axis represent the nature of the particle that means discrete particle to flocculent particle. So we can divide it into different categories so you will be getting something like this (Refer Slide Time: 43:47) this is type one settling and this is type two settling and this portion is type three settling or zone settling and this is compression settling.

(Refer Slide Time: 45:09)



Type one settling means you have dilute suspension and discrete particle. Whenever there is a dilute suspension and discrete particle you will be having type one settling and whenever there is a flocculent particle and dilute suspension then you have type two. So type one and type two is for dilute suspensions but type one is for discrete particle whereas type two is for flocculent particles. But if the flocculent particle concentration is high means relatively high then you will be getting zone settling. If the concentration of discrete particles or flocculent particles is high then you will be getting compression settling.

For example, in type one settling, if you have colloidal particle or sand or silt particle or after a heavy rain if you collect river water and put it in a sedimentation tank and if you watch them settle down the silt particle or the discrete particle will not agglomerate together instead they will be settling as independent particles. This is an example of type one settling.

Type two settling means dilute suspension of flocculent particle. For example, if you take the coagulation flocculation process what we are doing is we are adding alum as the chemical for the destabilization of colloidal particles so what will happen is this alum will be reacting with water to form aluminum hydroxide so you will be getting aluminum hydroxide flocs and the concentration of the flocs will be less so that will be settling as flocculent settling. That is the example for type two settling.

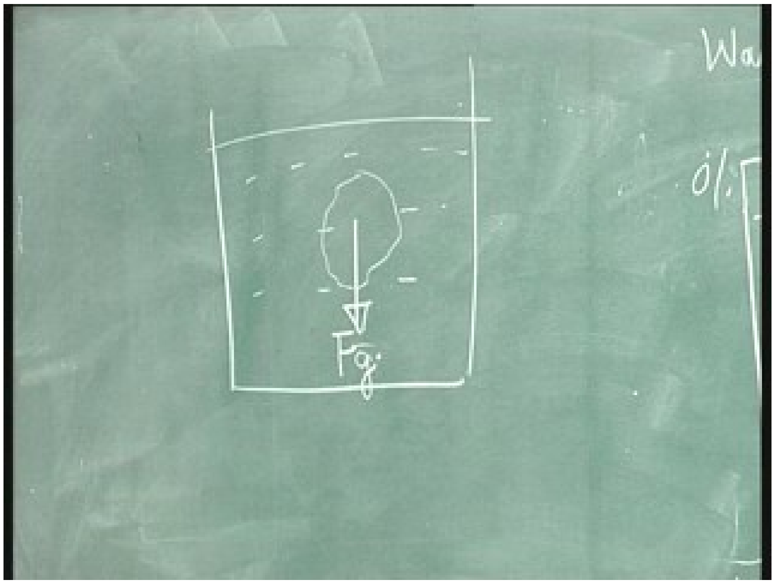
Zone settling does not come under water treatment, this is usually occurring in wastewater treatment systems, for example, activated sludge process. What is happening is you will be having an aeration tank where your wastewater is coming which is containing lot of microorganisms and as we know the wastewater will be having lot of organic material so if you provide enough oxygen the microorganisms will be utilizing the organic matter as their food and they will be oxidizing it to carbon dioxide and water and a part of the organic matter will be getting converted to microorganisms. So, if you leave those microorganisms as such your BOD or COD will not be meeting the effluent discharge standards. So what we have to do is we have to remove the bacterial cells from whatever is coming from the aerated tank so we provide a sedimentation tank. This sedimentation tank is known as secondary sedimentation tank. Therefore, the settling that is occurring in the secondary sedimentation tank of an activated sludge process is the example of zone settling.

Here what is happening is the settling of each particle is affected by the other particle. So during that settling each particle will be having a fixed position because of the repulsive forces so the entire particle will be moving as a group of particle or the settling will be occurring as a zone. You can see a clear zone as something like this and with respect to time what will happen is, the clear zone will be moving down and the suspended particles will be getting concentrated in this portion. Or we can tell that the suspended particles will be moving just like a blanket. That means each particle will be having a fixed position in that entire system so one cannot move independently so everything will be moving as a whole. This is known as zone settling.

(Refer Slide Time: 48:27)

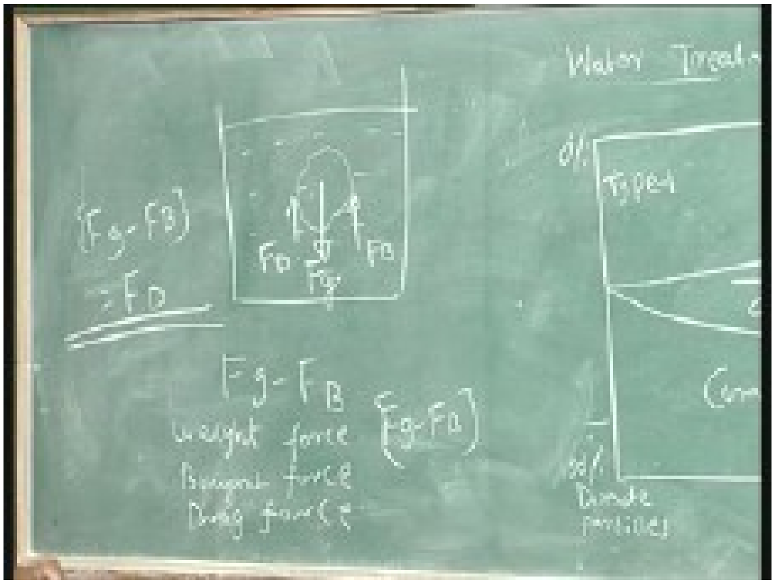
Now, coming to the compression settling, here the concentration of either the discrete particles or the flocculent particles are very very high so one particle will be lying above the other particle. Because of the weight of the particle it will be settling down and whatever water that is present in the system will be getting expelled and it will be reaching a stage after that there will not be any settling possible or any consolidation possible. This is known as compression settling. This compression settling happens wherever we go for sludge thickening. But in most of the cases, as I told earlier, we talk about zone settling and compression settling when we deal with wastewater. So I will be concentrating on the type one and type two settling and how to design these types of sedimentation tanks.

(Refer Slide Time: 49:50)



In type one settling when the particle is in the liquid….. This is your sedimentation tank (Refer Slide Time: 50:02) it is filled with water and your particle is here. So as I told earlier type one settling can be represented by classic mechanics. If you take a particle like this what are the forces acting on that particle? The particle will be having a particular weight so the weight force will be acting on the particle so this will be acting in this direction, this will be f(g) that means because of the gravity the weight of the particle is acting in the downward direction and another force acting on this is the buoyant force, buoyant force will be acting in the opposite direction. So the impelling force that means the impelling force for the movement of this particle is this weight force and the resultant of the weight force and the buoyant force or the impelling force is nothing but Fg minus F_B.

(Refer Slide Time: 51:28)



Another force acting on the body is the drag force F_D so the three different forces acting on the body are the force due to weight force, buoyant force and drag force. Thus, by considering these three forces we can find out the settling velocity of the particle.

What will happen to the particle if it is in the system?
Initially because of this weight force or the buoyant force or the resulting force the body will be moving at a faster rate but the rate will be retarded because of the drag force this F_D acting on the body so the acceleration will be coming down or the rate of change of velocity will be coming down and afterwards the particle will be moving at a constant velocity or the acceleration will become zero.

Hence at that time this Fg minus F_B will be equal to the drag force. By using this equation (Refer Slide Time: 52:33) we can find out what is the settling velocity of this particle. Once you know the settling velocity we can design the sedimentation tank. These things we will discuss in the next class.

Now we will recall everything we discussed in the present class. We were discussing that we have to meet the water quality criteria or standards for each and every beneficial use. But depending upon the source of water, the quality of water will be different. So how can we improve the water quality? We have to go for various treatments. Depending upon the source of water and the quality of water that is available we have to decide which are the treatment systems we have to adopt and these treatment systems are not constant or a fixed one so we have to decide what would be the beneficial use and what are the characteristics of the source water.

We have seen; what are the treatment units we have to provide if it is a ground water source with high hardness. We have also discussed; what are the treatment units we have to provide if it is surface water containing lot of organic matter.

Again we have discussed how to design an aerator and what is the purpose of an aeration unit. Aeration units are usually provided for the removal of odor forming gases like hydrogen sulphide, carbon dioxide etc and for the removal of undesirable materials like manganese, iron to the desired form. That means iron in the Fe 2 form we cannot remove it but if you can oxidize it to Fe power 3 form will be precipitating out easily as ferric hydroxide.

Similarly, manganese can be removed by oxidizing it to manganese oxide MnO_2 and some for volatile organic compounds if the concentration is very high for example phenol, benzene, tuluvine etc if the concentration of the volatile organic compounds present in it is very very high then we can remove them to a certain extent but complete removal is very difficult. So if you want to remove them completely we have to go for some subsequent treatments.

We have also discussed about the different aerators for example fountains, cascade aerators and tray aerators. Sometimes we can even go for nozzles and diffusers etc. It depends upon whether you want to disperse air on water or water on air. We were discussing about the different types of sedimentation, what are the different types of settling. We can classify them depending upon the type of the particles and the type of the suspension. If it is dilute suspension with discrete particles we call it as type one settling and dilute suspension with flocculent particle we can call it as flocculent settling or type two settling. And if the concentration of the particle is relatively high then we get zone settling and if the concentration is very high then the settling is classified as compression settling. In type one settling, we can find out the settling velocity by classical mechanics. We can take the force balance on the particle and we can find out the settling.

We will be discussing this in detail in the coming class.