

Water Quality Management Practices

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Week – 06

Lecture – 30

Types of aeration used in aerobic treatment units & Analysis of Gas Transfer

Hello everyone, welcome to this NPTEL online certification course on Water Quality Management Practices. My name is Gourav, Professor Gourav Dhar Bhowmick from the Department of Agriculture and Food Engineering of Indian Institute of Technology Kharagpur. So, in this particular lecture in lecture module where we are discussing about the fundamentals and principles of biological wastewater treatment. Today I will be focusing majorly on the aeration systems. What are the different types of aeration systems and how we can actually we will get to know about the gas transfer mechanism as well. And we will also solve one numerical to get an idea about how we actually calculate the aeration requirement in any aeration aerobic wastewater treatment systems ok.

So, this will be our concepts that will be covering the type of aeration provided by provided in activator sludge process, the evolution of oxygen transfer coefficient, the factors which affect the oxygen transfer and the application of the different correction factor for real life scenario. To start with we know that there are different types of aeration we normally use in activator sludge process. First one is the diffused air aeration or what happen here we you might have seen that you know when you have this small aquarium in your house. So, there is like small tiny teeny ball like structure from through which actually the air is we normally provide the aeration to the aquarium right the diffused air we supply.

So, that is called the diffused aeration ok. So, diffused air aeration system. So, we are supplying some supplying through some air diffusers majorly made up of ceramics and all tiny teeny you will see this tiny once available for aquarium and the same concept, but when we do it for the industrial scale and a huge larger size we use it in the wastewater treatments in the plants and all majorly in the biological treatment in between the aeration tank itself. So, normally we before supplying it to the actually to the water we pre filter it. So, this pre filtered compressed air we normally blow it through the diffusers with this the aquariums are called the diffusers which we normally install inside the inside the water body and it is normally the tanks which we normally prefer basically long narrow and the rectangular in nature and the air diffusers are normally placed in the bottom of the tank ok.

The air before passing through this diffuser must be passing through the air filter to remove all the dirt particles and all otherwise what will happen because as I have mentioned that those tiny diffusers are having a tiny very tiny pores and all through which the air we like you know blown we blow the air in a diffuse condition. So, the this tiny teeny pores if the air still contain some dirt particles it will somehow clog those pores and it will cause harm to the system. So, that is why it is better always to pass through it through a filter. So, that those dirt particles can be absorbed or the like you know somehow be mechanically filtered out and then the air out of like devoid of all these dirt particles will enter to the system and it will diffuse through this diffuser systems and all ok. So, normally the pressure has to be provided to overcome the depth

of water column and the friction losses to maintain the means of the to maintain the particular air pressure we need we can provide some air compressors and all ok.

So, it is a very commonly available instruments. So, this air diffusers it is normally provided in the aeration tank can be further classified depending on the size of the air bubble they introduce in the aeration system. So, like sometimes we call it micro bubble, nano bubble even recently there is a very famous concept comes into the picture it is in this aeration in the research level I would say like in this aeration systems are called the nano bubble generator. You know that there are the more tiny fraction we can make out of this bubble the more chances of having air transfer I mean like the transfer of air from the from its aerobics I mean like from its air state to the liquid state it is it will be more feasible more possible. The tiniest bubble you can make because the tinier the bubble size is the if say suppose we have a you have suppose like you know 100 square meter of surface area of us just to give you one example.

Say like 100 square millimeter of surface area of one bubble at the same times you have a you have this the 100 like you know this like 10 square millimeter of say like 10 number of bubble ok. So, as because I have already mentioned about the surface area. So, it does not make sense, but if I mean if I talk about in volume say like in case of say in particular size of volume say in one volume of say like you know 1 millimeter cube, 1 10 millimeter cube say like one larger bubble is there and we have a 1 millimeter cubes tiny bubbles of 10 number of 10 number of bubbles are there. There is a chances of them having higher number of surface area the more tinier it is because the surface area will increase for the same volume, but when you reduce the sizes and all. So, the more the surface area more the chances of the exchange of oxygen from air from air to the water state.

So, liquid state. So, this is the this is like the basic concept. So, we try to reduce the bubble size as tiny as possible. Second thing we try to when we reduce the bubble size it will stay in the water column for more amount of time before it actually reaches to the surface and burst out. So, the more amount of time it will it will stay in this water column the more time it will get to diffuse to the air to the water is not it.

So, that is the reason. So, people are trying to make this nanomobile generators and all are now coming to the picture and so, these are actually increasing the air transfer efficiency like anything ok. So, our main target is to maximum amount of oxygen has to be transferred from the air to the water to improve the dissolved oxygen concentration and in its by running it for the minimum amount of time by so, that increasing the aeration efficiencies and all. So, we will discuss about all these things and you will get to know about why aeration is important and how we can actually improve the performance of this aeration systems. In case of diffused air aeration we have a jet diffusers and the jet diffusers what is happening the diffusers give a direct stream of air in the form of jet and this air strike against a small bowl kept into the below the nozzle of the jet and what happen it spatters over the bowl surface and escapes in the form of smaller air bubble and in the wider area of the impact.

And also sometimes what happen the water it actually comes from the atmosphere and it comes in contact with the air and the in the water and this water is actually blown in a very higher rate and this water mix with this air it comes in contact with the in the water body. So, this kind of jet diffusers also nowadays becoming very famous the porous diffusers porous diffusers are majorly it is this tube or like plate like structure made up of grain of crust, quartz, aluminum oxide or carbon fused to form a porous structure or porous plate with resin or

perforated membrane or the plastic tubes. So, normally this is a tile shaped or tubular shaped or dome shaped as you can see in this picture and almost 10 to 20 percent of the area of the aeration is normally covered with this porous lines and all. So, through this porous lines this crust, quartz, aluminum oxide or carbon fused porous structures actually make the very tiny tiny diffused air. So, this diffused air this air has maximum amount of chances to actually you know exchange the oxygen with the water body.

So, that is why the this kind of porous diffusers are more famous and have quite a good efficiency. It normally what we do we normally supply this air through a pipeline on the almost like on the floor couple of centimeter above the floor. And then we depending on the size of the air bubble that we are expecting we can either design it for fine or the medium bubble diffused air retard systems. Normally in common practice this porous dome type of air diffusers are used with a 10 centimeter to 20 centimeter in diameter of this pipes as you can see. And those are economical and initial as well as for maintenance point of view also it is economical.

And the air supply wise we normally supply almost like you know 0.55 to 0.7 kg per square centimeter of pressure we always maintain in order to like you know have a like even whatever the depth it is like it is not whatever the depth it is based on the depth actually this value also alters a bit. But we need to provide this additional pressure to serve like you know somehow overcome the first of all the depth of the water because of the depth of the water it will also like you know provide some additional resistance and the second is the frictional losses. When it goes through the through the pipe or the crevices I mean like through the joints and also through which the air also get some additional frictional losses from the system itself.

So, in order to overcome all these things we need to provide some additional pressure from external pressure from of around 0.55 to 0.7 kg per square centimeter. The quantity of air it can be somewhere between 1.25 to 9.5 meter cube per meter cube of treatment of sewage depending on the BOD of the sewage of the to be treated and the degree of treatment that you are expecting from the system. So, per meter cube of sewage that needs to be treated means per 1000 liter of sewage that you are expecting to treat at a particular moment of time you have to supply somewhere between 1250 to 9500 liter of air into the in the aeration tank in order to you know somehow have a better efficient aerobic treatment systems to be designed and all. And this air transfer capacity of the actuator it is an aerators normally depends on the size of the air bubble as I was mentioning at the beginning only. So, the tinier the size the better the efficiency. The different oxygen transfer capability of aeration device like if you go for fine bubble aeration the oxygen transfer capacity transfer efficiency will be somewhere between 0.7 to 1.4 kg of oxygen per kilowatt of power that you use and multiplied by like kilowatt hour. Then you have the medium bubble aeration 0.6 to 1 kg of oxygen per kilowatt hour of energy that you consume and for coarse bubble diffuse aeration 0.3 to 0.9 kg of oxygen per kilowatt hour.

Next is the mechanical aeration in case of mechanical aeration it normally what it does it normally splashes the water by any means. So, suppose it is in the surface. So, what will happen there is a like you know some kind of paddle will you design. So, this paddle will what it does it will splash the water into the air and then it will come back again just like a fountain ok. The same concept as fountain what we are doing in the fountain the water is splash on the in the air. So, what is happening instead of introducing air into the system you can do the other means also you can splash the water into the air also as the same concept. Our motto is

what to increase the available area of air exchange right. So, if you somehow increase the area by if you just splash the water into the air what will happen it will be it will become it will come in tiny teeny fractions and it will become make some tiny droplets in the air and because of that there is a chances of air water exchange I mean like from the oxygen can actually enter to the water medium and also this is how actually this concept actually comes into the picture. So, it can be done in a various other ways as well. So, in general we try to splash the water into the air that is the one of the basic concept of you know like you know this most of the mechanical additive systems.

It try to averse the stagnation of air water contact surface and enhances the water mass transfer rate in the wastewater and this mechanical addition systems was developed because in diffusion systems only 5 to 8 percent of the total quantity of air compressed would be used for oxygen transfer while the rest is provided for mixing only. So, just imagine the amount of losses that incurs in the diffuser additive system sometimes what happen because when you supply the air in this diffused conditions because of the bubbles there not all the time much more efficient as I was mentioning. So, what happen only 5 to 8 percent of the total quantity of compressed air is actually transferred into the actually get in contact with the water and dissolve into inside the water rest of them are actually used for mixing purposes and all and somehow they escape from the systems by when once it reaches to the surface. However, in case of mechanical aerator we can overcome this kind of issues easily. So, as you can see in this particular picture there is this one impeller there is this this what is happening the driving water is actually running this impellers and impellers actually is throwing the water or making certain agitation on the surface.

The more agitation on the surface the more diffusion will take place it is a we all know about that. The more the agitation on the surface the more the diffusion will take place it is same like they know when you try to you know reduce the temperature of your hot milk or hot chai what you do we keep on agitated the more you agitated the more there will be heat transfer more there will be like diffusion losses. So, diffusion losses come like here in this particular case the this diffusion will I mean like this diffusion will take place in either way not only I mean like from the atmosphere to the water from water to atmosphere as well based on the which particular body is saturated with which particular type of component. It depends on various type of components and all sometimes the water it if it does have some additional amount of substances some kind of gas which are obnoxious and all there if you provide some kind of mixing what will happen those gases will elope from the systems or escape from the water body and it will be good for the water body. The same way the from the atmosphere also the atmospheric oxygen will come in contact with the water and it will dissolve inside the water and which is beneficiary for all the aquatic animal present there.

So, there are natural diffuser systems like the waterfalls and all where naturally the air is getting mixed into the water body and when there it is there is no possibility of such kind then we normally do the manual aeration systems and all ok. This mechanical one or I mean like the diffuser once we design it and anthropogenic activity has to be taken place to introduce the dissolved oxygen inside the system. So, when electric motor starts in general the impeller suck the wastewater from the center and with or without the uptake tube and then it throw it in the form of thin spray over the surface of the wastewater. So, what happens it take it brought in contact with the air hence the oxygen mass transfer happen and it is at a much accelerated rate. Now, let us discuss about it like how actually this gas transfer is happening in like you know in a molecular level.

So, if you I mean like at least in the in a in a very like you know nanoscale how it works. So,

if you see this particular drawing I mean this particular figure. So, this inside one it is showing the gas film and the liquid film in the right side in the left side is the gas film from my side I mean like left side is say like now if I say in reverse from your point of a selling the anyway. So, it is in the left side if you see the turbulent flow where the gaseous phase is showcasing in the right side is the liquid flow. So, from the gaseous phase to the liquid phase in order to like you know somehow oxygen to come in contact with the liquid phase it has to overcome certain barriers.

This distance this is called a tube film theory. So, where the you know the it has to gaseous phase like this particular molecule has to overcome first it will first cross the border between the interface between the gaseous phase to the gas film. Then the air water interface from gas film to the liquid film from liquid film it come to the bulk liquid phase. So, it is this is called the tube film theory generally applied for the analysis of gas mass transfer how a mass transfer is happening gaseous mass transfer is happening in a gas liquid interface. In general it provides some resistances, but somehow if you overcome those resistances and this in order to overcome those resistances you have to provide them with the maximum possible opportunity as possible by means of aeration devices and all.

Normally gaseous which are slightly soluble it encounters the primary resistance of mass transfer from the liquid film as you can see whereas, for highly soluble gaseous it encounter the primary resistance from the gaseous film if you see in the left side the gaseous film. And the gaseous film intermediate solubility it normally enter the significant resistance from both the film gaseous film as well as the liquid film. So, it will it encounter some kind of resistance, but you know to overcome this resistance you have to supply some additional mechanical means sometimes. So, in general the gaseous obviously, it can when it gets solubilized in the liquid phase the rate of gas transfer is proportional to the difference between the saturation concentration and the existing concentration ok. So, whereas, this

$$r_m = K_g A (C_s - C)$$

R_m is the rate of mass transfer is equal to $K_g A$ into C_s minus C .

So, what is this K_g is the coefficient of diffusion of gas and A is the area through which the gas is diffusing over total area. C_s is the saturation concentration of the gas in solution. So, whatever gas you are actually targeting and that you have to make sure and their saturation concentration in that particular water. So, in that particular medium. So, suppose you are talking about the oxygen. So, if you talk about the oxygen because that is our main motto here to talk about the oxygen gas transfer. So, in case of oxygen gas transfer what happen they in 20 degree Celsius at like standard temperature and pressure. So, it normally showcases a saturation concentration of somewhere around 9.07 milligram per liter. So, that 9.07 milligram per liter is actually a very standard number when it comes to the saturation concentration of gas in solution at 20 degree Celsius ok. So, with temperature it may vary like anything ok. We will discuss about it how actually with temperature all these things are varying. So, under the condition of mass transfer in the field R_m equal to V into dc by dt or

$$r_c = \frac{dc}{dt} = K_g \frac{A}{V} (C_s - C)$$

it is the same the R_c is nothing, but the rate of change of concentration represented by dc by dt . So, it can be easily find out by this equation this K_g into A by V into C_s minus C as I was discussing from the last slide also. This $K_g A$ by V is a constant right. So, it can be

replaced by this constant $K_L a$. This $K_L a$ is called the proportionality constant related to the existing exposed conditions and all ok, because this $K_g A$ and V these values are constant. So, from there you can easily find out the $K_L a$ value value ok. So, integrating this equation from between the limits C_0 at t at the initial stage and then C equal to C_t at t times t when it times t and so, in after integration is done as you can see find out this final equation:

$$\frac{C_s - C_t}{C_s - C_0} = e^{-(K_L a).t}$$

This C_s minus C_t and C_s minus C_0 represents the initial final and the initial gas saturation deficits ok. So, you can do it in the other world. So, in case of super saturated solution what will happen the other thing will happen. Super saturated means already the your solution is saturated overly saturated with that particular gas. So, here it will remove from the system. So, in that case the equation will become C_t minus C_s just take the negative sign from the denominator and numerator. So,

$$\frac{C_t - C_s}{C_0 - C_s} = e^{-(K_L a).t}$$

for super saturated condition. There is one like you know thing we have to make sure that the rate of change of oxygen concentration also should consider the R_{micro} . This R_{micro} represents by the rate of oxygen uptake by the microorganisms in that time in that particular time which are present in your system. So, normally it varies from 2 to 7 gram per gram of MLBS per day. So, that also you have to incorporate while doing this kind of calculations that:

$$\frac{dc}{dt} = K_L a (C_s - C) - r_{micro}$$

This R_{micro} because with time there is suppose some oxygen exchange, but there will be some amount of oxygen will which will be consumed by those microorganism present in the system. So, because of that there will be a certain drop. So, in order to incur those drop we have to introduce this particular concept in this equation and all ok. So, this value of

$$K_L a = \frac{r_{micro}}{C_s - C}$$

there also we can find out the $K_L a$ value. The $K_L a$ value is actually depends on different factors to start with first is the temperature. The effect of temperature is similar in case of BOD reaction rate coefficient. If you remember we also did the almost the same way we also calculate the BOD rate transfer coefficient and all remember. So, there what we were doing at 20 degree Celsius $K_L a_T$ can be easily find out by $K_L a_{20}$ degree Celsius into theta to the power $T - 20$. So, this relationship is given by Van't Hoff Arrhenius relationship and there this theta value normally lies between 1.015 to 1.040 which is also known as the temperature coefficient. And this $K_L a_T$ is nothing, but the oxygen mass transfer coefficient at temperature T degree Celsius and T degree Celsius in unit is per hour ok.

It is not degree Celsius per hour it is 20 degree Celsius T degree Celsius unit is per hour ok. $K_L a$ normally the it has a mass transfer coefficient it has a unit of per hour ok. So, it is like at and $K_L a_{20}$ degree is obviously, the oxygen mass transfer coefficient at 20 degree Celsius. There is a effect of mixing intensity in the tank geometry also ok. So, the more you do the mixing the more chances of oxygen transfer happening in the systems the same with the tank geometry also. If you are providing a vortex inside a inside a suppose like a cylindrical

type of reactor provide a vortex and at the right next to it you provide a baffle. What will happen? That vortex will that baffle will actually somehow react with this vortex motion that you create with this aeration units and all and it will make a very nice mixing into the system. But whereas, in the same structure same unit if you install it in a rectangular chamber it will not be effective as effective as in the cylindrical ones. So, based on the tank geometry also your aeration rate and the efficiency of your design will also vary ok. Normally in general if you talk about the when we design any activated sludge process the aeration devices are selected based on the efficiency of oxygen transfer provided by the manufacturer under a standard test condition.

And most cases the aeration devices are rated under the standard test condition with range of operating parameters using a tap water using like tap water is nothing for because like you know it has a very low TDS Total Dissolve Solid. And in the more the because if there is a dissolved solid it will also add some other additional correction factors we will discuss about that. In general if we have those correction factor once you have those real life scenario where the TDS value is obviously, quite high. So, in that case we need to provide one correction factor it is denotes it normally denotes with denotes by alpha it is normally used to estimate the actual KLA for aeration systems under the field conditions. So, this alpha is equal its ratio its ratio between the KLA wastewater by KLA tap water.

So, that means, like you know once the this value you introduce you can easily correct the equation the oxygen transfer oxygen transfer standard oxygen transfer equation for which like you know there is a chances of it influenced by the value of TDS of the amount of suspended solid dissolved solid present into the system ok. So, normally in case of diffused air systems this alpha value ranges from 0.4 to 0.8 and for mechanical aerations it will normally vary from 0.6 to 1. So, what about the wastewater characteristics? Other than that also water oxygen solubility is also depending on the salt particulates the sulfate active substances all these things present in the wastewater because of which also we need to introduce another factor that is called that we call the factor beta factor. So, this beta is actually represented by the saturation concentration of that particular gas at that particular waste in that particular wastewater in field condition and also the saturation concentration of that particular gas at that particular temperature in tap water. So, this correction factor beta this beta normally lies between the value 0.7 to 0.98 for wastewater its lies somewhere between 0.09 and 0.95. So, this alpha and beta once we introduce this to correction factor the equation the oxygen transfer rate equation transfer under field condition changes to this following equation

$$O_f = O_T \frac{(\beta C_s - C_w)}{C_{s20}} \theta^{T-20} (\alpha)$$

So, now once we introduce this factors and all then only we will be able to get the final SOTR value in the stand in a real field conditions ok. So, in let us let us solve an example like you know one solution. So, I mean like it would be easier for you to understand the concepts you know. So, what is what is what we are ask here like you know an activated sludge process is being designed using a diffused air aeration systems ok. So, they have a diffused air aeration systems for a period of peak oxygen demand in the aeration basin following design values are adopted. First is oxygen transfer requirement is 1 kg of oxygen per kg of BOD applied ok. Temperature of the mixed liquor is 17 degree Celsius minimum allowable DO is 1.5 milligram per liter, value of correction factors alpha is given as 0.7 and beta is given as 0.9, oxygen transfer coefficient at 20 degree Celsius is also given 11.5 hour. So, oxygen transfer efficiency is 8 percentage and the pressure in the mid depth of the diffuser is also

given 830 millimeter of mercury. Consider the C_s 830 millimeter of mercury at 70 degree Celsius as 10.56 milligram per liter. So, concentration saturation concentration at 17 degree Celsius is also given. So, you do not have to use the value that is given for KLA 20 also because it is already you already like you know you can easily calculate it like it is given as C_s value is given as 10.56 ok. Now, at C_s at 20 degree Celsius it is given as 9.8 milligram per liter at normal atmospheric concentration ok. Evaluate the rate of oxygen transfer dC/dt and what will be the maximum BOD volumetric loading rate applicable also estimate the volume of air required per kg of BOD applied it is very easy. So, first we have to correct the KLA value for 17 degree Celsius we know the KLA value for 20 degree how much it is 11.5 per hour ok. So, KLA value for 17 degree equal to KLA 20 1.024 multiply to theta remember theta value should be taken as 1.024 to the power $t - 20$ t is here 17. So, if you do it 11.5 multiplied by 1.024 to the power minus 3 the value will come as 10.71 per hour so that means, the KLA value the revised KLA value at 17 degree Celsius is 10.71 per hour. So, now, dC/dt value is equal to α into KLA into β into $C_s - C_t$ ok we all know that. So, from there we can we know the alpha value as a 0.7 KLA value is also known to us how much it is it is we just found out it is 10.71 multiplied by beta value beta value is 0.9 C_s value is also given at 17 degree Celsius as 10.56 milligram per liter the C_t . C_t is what is the final concentration is nothing, but the minimum allowable DO that should be there in the system it is like 1.5 milligram per liter that is also given minimum allowable DO. So, if you replace these values in the equation you will get the 60 milligram per liter per hour that is the dC/dt value that it requires as a rate of oxygen transfer ok. Now, consider the 1 kg of oxygen utilized per kg of BOD applied as it is mentioned which will change if the actual cell production and the ultimate BOD is considered, but we do not we are not considering that.

As of now our in question it is given that 1 kg of oxygen is utilized per kg of BOD applied. Then the maximum applicable volumetric loading rate will be determined by as the maximum applicable BOD loading rate is equal to 60 milligram per liter per hour or you multiplied with 24 you will get 1.44 kg of BOD per meter cube per day. See it is as easy as that because 60 milligram per liter means gram per meter cube into day. So, now, your gram per meter cube you multiplied with 60 from there you will the easily you will get the kg of how much is the kg of BOD per meter cube per day we are talking here.

So, now, once we consider the oxygen transfer rate and the keeping the submerging for the volumetric loading rate of up to 1.3 kg of BOD per meter cube per day. So, it can be recommended with that same value only. The efficiency of this oxygen transfer now it is proportional to the rate of oxygen transfer. So, we can easily find out the at say like oxygen transfer efficiency is 8 percent which is also given in the question.

So, we can easily find out actual field condition what will be the oxygen transfer efficiency nothing but you can multiplied 8 into α into kla_B into $C_s - C_t$ divided by kla_{20} degree Celsius at $C_s - C_t$. So, if you replace this value those we already know the actual oxygen transfer efficiency will come as 4.26 percentage ok. Now if the volume of standard air requirement you know air required at an actual oxygen transfer efficiency of 4.26 percentage per kg of BOD load easily can be calculated as 1 kg of oxygen divided by 0.0426 multiplied by 0.2797 kg per oxygen per meter cube. So, this value this 0.2797 you can easily find out because you know that the air density as 1.216 and the considering the oxygen weight fraction in air is 23 percent. So, you can easily multiply this two you can get the value oxygen content in air around 0.2797 kg of oxygen per meter cube of air that you supply you understand.

So, this much of kg is of oxygen is present per meter cube of air. So, without considering the efficiency and considering the amount of oxygen present in per meter cube of air you can easily find out the total amount of air that it requires for per kg of BOD that it applies. So, the value comes as 83.93 meter cube of air per kg of BOD applies. So, we already we can also able to tell the exact value of air that it requires for per kg of BOD removal and all. So, this is the this is the concept that I would like to like you to understand and I hope you understand if you have any issues please go through this lecture material again.

It is better to actually go through this lecture material again to get your concept completely clear plus I would like to request you to you know go through the literature's available in the online some online platform also. So, that will be very useful for you to get your ideas more clear and try to find out some solutions problems problem statement in this particular field and solve it by yourself ok. There are some so, in conclusion so, we understood we understand about the different diffuse aeration systems for energy efficient and it requires we understand that diffuse aeration systems requires less energy and also it requires lower maintenance and ideal for the smaller setups mechanical aeration systems offers superior mixing for larger facilities or intensive industrial applications like the wastewater treatment. Different factors play a very vital role in predicting the wastewater characteristics due to the variability of the wastewater composition and facilitating the proper design system design aeration system design and efficient operation and efficient effective pollutant removal in this case the organic matter removal from the biological treatment units and all. So, I hope you understand the aeration systems different types of aeration system the concept I cannot go on more in details about the aeration system.

This is the minimum you need to understand in order to design a aeration systems in future I know for your aerobic treatment units that we are going to do some more design in coming weeks. So, it is very important for you to understand this air requirement how you calculate the air requirement when we design aeration systems here only in this lecture we did some basic understanding about we develop some basic understanding about it ok. Please go through this reference book and which will be which is very useful for you to understand and also you can suggest some more from any Google platform. Thank you so much see you in the next week.