

Water Quality Management Practices
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Week – 07
Lecture – 34
Numericals on ASP

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 Agricultural and Food Engineering of Indian Institute of Technology Kharagpur. In this particular module we were talking about the aerobic wastewater treatment systems, we discuss about the activated sludge process in details already. In today's lecture we will be solving some numericals on activated sludge process in order to have some you know in depth you know knowledge or also we so, to get some idea about how to design an activated sludge process system. So, obviously, the content will be only over the numericals on activated sludge process. So, let us start discussing let us start solving one design problem.

Suppose, you are an engineer ok. So, you are asked like you are already wastewater engineer. So, you have experience in you are expert in wastewater treatment system design and all. So, suppose you are asked to design a completely mixed activated sludge process to treat a primary treated wastewater flow of 2000 meter cube per day to meet the total effluent BOD concentration of less than or equal to 30 milligram per liter.

Just try to understand that these are the like whatever the question it will be like you know the design problem it will be it is like almost the same situation that you will face in the real life condition. In the real life condition so, you will be given only the bare minimum informations. So, first of all it is like you have to you have to make sure that your final BOD the effluent BOD should be less than 30 milligram per liter as it is mentioned in this in this particular problem. So, in real life also you may have to deal with this kind of problem only because where the local authority will ask you to reduce the concentration of BOD up to a certain standard. Then only you are allowed to discharge it to the dispose that water your effluent of to the any surface water body or somewhere else ok.

So, the limit is given limit is known to us the effluent water BOD effluent BOD concentration should be less than or equal to 30 milligram per liter. So, in our design we can take 30 milligram per liter if it is working much better obviously, it will reduce further. The flow rate is given through 2000 meter cube per day. Now, the aeration tank is proposed to have a mixed liquor volatile suspended solid concentration of 3500 milligram per liter. So, what is this value is the x you remember the value x.

So, capital X where we discuss about the biomass concentration inside the aeration tank. Then we are given a information about the MCRT mean cell residence time or the sludge retention time right. So, it is given as 10 days perfect so, which is denoted by theta c ok. The influent wastewater to the aeration tank contains average BOD of 320 milligram per liter and TKN of 35 milligram per liter. So, the influent BOD concentration is also known to us ok.

The influent BOD is how much 320 milligram per liter or S_0 value is also given to us that means, the S_0 value is given to us. TKN total gel dull nitrogen total gel dull nitrogen value is also given to us the in for influent wastewater which is 35 milligram per liter ok. Now, there are some like you know this constant values that we need to know and it is given to us like the consider the cell ill coefficient of 0.6 which is denoted by μ and endogenous decay coefficient which is k_d which is equal to 0.06 per day.

Also MLSS to MLSS ratio is also given as 0.8 ok. So, from there you can easily find out the MLSS value inside the aeration tank also because MLSS is given as 3500. So, what will be the MLSS just 3500 divided by 0.8. So, you will get the value of MLSS also inside the aeration tank. Just to give you a brief like you know that this ratios are given. The effluent of secondary sedimentation tank contains about 10 to 15 to 20 milligram per liter of biological solid with two-third biodegradable fraction. So that means, the effluent that coming out of the sedimentation tank does contain some amount of biological solid. Theoretically it should not right.

The theoretically the effluent should not have any biological organic biological at least the biomass it should not be having any biomass at least that is what we assume when we go for when we did the modeling or when we did the mass balance ok. So, but in this case it is given that there are some amount of organic fraction is actually coming out of like you know mass this biomass fraction is coming out of the system by with the with the effluent along with the effluent ok. So, that value is also given that will be very useful to us we will discuss about it. The suspended solid concentration in the return sludge is 1 percentage that is 10 gram per liter right. So, 10000 milligram per liter and BOD 5 to BOD ultimate ratio is also known to us it is like it is given as 0.68 perfect. So, we are given with the information like wastewater flow Q 2000 meter cube per day influent BOD S_0 320 milligram per liter, effluent BOD SE is 30 milligram per liter, influent TKN N_0 is 35 milligram per liter, VSS by SS ratio 0.8, MLVSS is 3500 so that means, MLSS 3500 by 0.8 equal to 4375 milligram per liter inside the aeration tank very good. So, we have good amount of information for us to design our aeration tank design our activator sludge process now ok. So, let us let us let us continue.

First we need to determine the BOD removal efficiency required for the activator sludge process. First we have to estimate the soluble BOD required in the effluent of ASP. Since the effluent contains up to 20 milligram per liter of biosolid as it is given as you can remember the second last line of the numerical that 20 it may contain up to 15 to 20 milligram per liter of biological solid with 67 percentage of biodegradable fraction two-third that means, 67 percentage right. The BOD represented by this solid can be easily estimated by this with this estimation considering that effluent solid concentration is 20 milligram per liter and so the biodegradable solid will be 20 into 0.67. So, total biodegradable solid is 13.4 milligram per liter. Now what is the ultimate BOD for this 13.4 milligram per liter? If you remember we did there and for the endogenous decay coefficient remember for a biological for a biomass in order to let it completely decay by the process of endogenous decay by the when it start consuming its protoplasm what will happen that what is the amount of oxygen that it requires 1.42 times the biomass like you know the 1.42 times the biodegradable solid value. So, in this case also we know the biodegradable solid value total available biodegradable solid in the effluent that is 13.4. If you multiply it with 1.42 that will give you the total oxygen requirement.

So, that is actually kind of represented by the ultimate BOD. It is so 13.4 into 1.42 that is 19 milligram per liter. So, ultimate BOD is 19 milligram per liter.

So, how what will be the BOD 5? 19 milligram per liter BOD 5 by BOD ultimate ratio is given 0.68 in the question. So, BOD 5 will be 19 into 0.68 which is equal to 12.94 say almost 13 milligram per liter.

So, that means, BOD 5 of the solid which left which left the system along with the effluent is 13 milligram per liter ok. So, the soluble BOD soluble effluent BOD how much will be the soluble effluent BOD? We know that total BOD is given as 30 total BOD concentration should be 30 milligram per liter or less. So, out of this total BOD we have the BOD 5 of the solid which represents the biomass which presents which is 13 milligram per liter. So, what will be the soluble effluent BOD soluble effluent BOD means the BOD contributed by contributed because of the dissolved organic fraction present there ok. So, the BOD which is contributed because of this dissolved organic fraction present in the system is 30 total BOD is 30 and the BOD present in the solid is 13, 30 divided by minus 13 equal to 17 milligram per liter.

So, that means, this 17 milligram per liter is the soluble effluent BOD you understand total BOD our target is to reach 30 milligram per liter or less and out of them 17 is anyway 13 is anyway contributed by the organic fraction by the biomass. So, we have to make sure that it does contain, but soluble BOD should not be more than 17 milligram per liter. So, our target is to restrict the soluble effluent BOD of 17. So, that is now our new target is 17 milligram per liter now ok. So, what will be the total soluble BOD removal efficiency inlet wastewater has a soluble BOD of 320 milligram per liter and the outlet we are our target is 17.

So, what will be the total over soluble BOD removal efficiency 320 minus 17 by 320 into 100 it will be 94.69 percent this. So, that much of BOD removal efficiency soluble BOD removal efficiency we are targeting. If you talk about the overall BOD overall BOD removal efficiency will also be because see the initial BOD is contributed entirely because of the organic fraction present the organic matter present there it is not because of the biomass and all. So, there when even while calculating the overall BOD removal efficiency also in the in influent BOD should be calculated as 320 only and the outlet in the effluent the BOD concentration is 30 milligram per liter.

So, 320 minus 30 divided by 320 into 100 it is coming as 90.63 percentage. So, overall BOD removal efficiency are targeted like that is that we are targeting in our design is 90.63 and soluble BOD removal efficiency 94.

69 percentage well understood. Next determination of the aeration tank volume you remember we did the mass balance biomass balance as well as the substrate balance we must substrate mass balance we did it already after doing those mass balancing and all we found out that this the value of V that is the volume of aeration tank with this equation with this particular notations like

$$V = \frac{Y \cdot Q \cdot \theta_c (S_0 - S)}{X(1 + kd \cdot \theta_c)}$$

y into q into theta c into s 0 minus s divided by capital X into I mean bracket 1 plus k d into theta c with this equation you can easily find out the volume of your aeration tank. Now, the yield coefficient is given 0.6 in the equation in the question q is given 2000 meter cube per day now we have the theta c is also given like the mcr t if you remember mcr t is also given to us how much is the mcrt 10 days and S₀ initial substrate concentration how much 320 final

substrate concentration the soluble one 17 divided by x what is the m/l basis concentration inside the aeration tank 3500 multiplied by $1 + k_d$ what is the value of k_d k_d is given as 0.06 the endogenous decay coefficient then we have θ_c which is 10 $mcrt$. If you put all these values in the equation you will get the value of V the volume of your aeration tank which is coming as 649.29 meter cube I would suggest you to do the calculation in your calculator parallelly. So, that it will literally engrave in your brain ok. So, the the stages. So, now, the volume comes out as a 650 meter cube say like 649. So, you can take the 650 meter cube as the volume of your aeration tank.

Now, what will be the HRT the hydraulic retention time for your aeration tank it will be capital V by q we all know that the volume divided by the flow rate the volume is given a 650 and the flow rate is 2000 meter cube per day. So, in order to convert into hour you have to multiply it with 24 then you will get 7.8 hour. So, what is the HRT of your system 7.8 hour which is quite high. So, considering in general our target is somewhere between 4 5 6 something like that 7.8 is quite high, but it is ok. In order to maintain the operation proper operation of your ESP you can go up to you can have this much of little bit higher values as also as well also you can take. Check we you have to check for the m by m ratio if you remember put to microorganisms ratio. So, food means inlet m influent value you know like you know influent flow rate multiplied by the BOD that is the food substrate what is the BOD here 320 milligram per liter and what is the flow rate here 2000 milli 2000 meter cube per day.

So, that is the food 2000 meter cube per day multiplied by 320. What is the microorganism percentage here the volume of your aeration tank which is 650 meter cube we just calculated it then multiplied by the x that is the mix liquor volatile suspended solid concentration which is also given as 3500. So, if you put all this value here you will get the m by m ratio as 0.28 kg of BOD per kg of BSS per day which is well within the limit of 0.2 to 0.6 kg of BOD per kg of BSS per day. So, it can be recommended and hence their design is acceptable. Now, for the volumetric loading for the volumetric loading we only need to calculate the Q the total food that you are supplying divided by the volume of your reactor volume of your aeration tank. So, you will get a Q that is the 2000 multiplied by 320 milligram per liter multiplied by 10 to the power minus 3 in order to convert it to see 320 milligram per liter means gram per meter cube same milligram per liter 10 to the power 3 you multiply with both the numerator and denominator. So, it will become milligram per liter equal to gram per meter cube. Now, gram to kg you have to multiply with 10 to the power minus 3 then it will become in kg only kg per meter cube.

Now, kg per meter cube and meter cube per day from there you can easily it will cancel it out and divided by 650 meter cube of volume of your aeration tank you will get the final volumetric loading rate as 0.985 kg of BOD per meter cube per day which is also well within the range of 0.8 to 2 kg of BOD per meter cube per days hence the design is safe. Estimating the quantity of sludge waste that is another important stuff the Y_{OBS} equal to Y divided by $1 + k_d$ into θ_c we all know this Y value it is given to us 0.6 and divided by $1 + k_d$ value is 0.06 endogenous decay constant multiplied by the θ_c is the $mcrt$ $mcrt$ is also given to us 10. So, Y_{OBS} will become 0.375 milligram per milligram. So, and if now if you calculate the total mass of the volatile waste activated sludge that is produced that can be easily calculated by this equation $p \times$ equal to Y_{OBS} into q_0 into s_0 minus s_0 into 10 to the power minus 3 we already discussed in last lecture. So, from there $p \times$ can be you just replace the value Y_{OBS} is we just you just calculate 0.375 q_0 is given 3 2000 meter cube per day the value of s_0 and s_0 is also known to us. So, the $p \times$ value can be easily calculated as 227.25 kg of BSS per day ok. So, this value is known to us now this much of sludge is being

produced each day in BSS wise if you call now that is see BSS to actual sludge production if you calculate it has to be denoted by suspended solid basis right.

So, then you just simply divided with 0.8 and you will get the value in suspended solid basis like you know 227.25 BSS kg of BSS per day divided by 0.8 you will get 284.06 kg of suspended solid per day. So, whenever you are calculating the sludge quantity and all you make sure that the mass of sludge is always you should always prefer to you know denote it with the means of kg of s s per day ok, suspended solid per day because it is not only the biomass, but also some other constituents can also be present in the sludge.

So, with the concentration of the sludge in the recycle line of SST of say like 10 gram of s s per liter the sludge flow can be easily calculated as 284.06 kg of suspended solid per day divided by 10. So, from there you can easily calculate the 10 gram of s s per liter same kg per meter cube. So, just multiply 10 to the power 3 up and down like a numerator and denominator.

So, gram per liter means kg per meter cube. So, you divide it with this 284.0706 divided by 10 kg per meter cube. So, it will become 28.41 meter cube per day. So, that means, in this that is the sludge flow rate also you can easily calculate with this in this way.

Now, estimating the sludge waste volume that is the Q_w . Q_w is very important for us to understand the how much of the sludge you need to waste from calculating by calculating the mean cell residence time and all from this equation. So, mean cell residence time which is 10 days equal to V into x divided by Q_w into x_r . So, V is known to us 650 meter cube x is also known to us 3500 milligram per liter Q_w we have to find out and x_r is also known to us 10000 multi 10000 milligram per liter multiplied by 0.8 to convert it into V_{ss} ok. 10000 is in it is given in the in it is given in the equation if you see the suspended solid concentration in return sludge is 1 percentage that means, 10000 milligram per liter.

So, if the return sludge suspended solid concentration is a S_S concentration is 10000 what will be the V_{ss} multiplied by 0.8 you will get the V_{ss} concentration in the return sludge which is given as 8000 milligram per liter in the denominator you can see in the instead of x_r you can put. Now, what will be the Q_w value just simply Q_w will be 615 to 3500 divided by 10 into 10000 into 0.8 that is it you will see the value will come as 28.43 meter cube per day. So, that means, the when the wasting is done from the recycle line of SST which is same as the as estimated see this value is almost the same as the calculation we done we have done in the last calculation only the amount of sludge flow 28.41 meter cube per day so, that means, our design is same perfect ok. So, this is the waste that the sludge that is generated and this much of sludge needs to be wasted ok. Now, return sludge ratio we know that the suspended solid concentration in the return sludge is 10000 milligram per liter milligram of suspended solid per liter and return sludge ratio r can be r which is Q_r by Q can be easily obtained by this equation. In general Q_r by r Q_r by Q is equal to you see like you know in general when we calculate it is much more easier x divided by x divided by x_r in minus x with this calculation.

See this x value is known to us 3500 inside the aeration tank x_r is also known to us x_r is how much this 10000 into 0.8 x_r means the return sludge volatile suspended solid concentration minus x . So, x divided by x_r minus x . So, from there you can get the recycle return sludge ratio as 0.78 ok. So, what is the total how we can find out the total return sludge flow Q_r equal to 0.78 into Q , Q value is 2000 so, that means, the return sludge value is 1560 meter cube per day ok. So, now let us discuss about the total oxygen requirement ok. So, total oxygen requirement in kg per day how you will calculate the oxygen based on

this only you have to supply the aerator right. So, how you will calculate the total oxygen requirement total oxygen requirement in kg per day is equal to $Q(S_0 - S) \times 10^{-3}$ to the power minus 3 by $5 \times 1.42 \times Q_w \times r$ ok. So, the kg of oxygen required you can easily replace it with this replace the values that is known to you with in this equation Q is 2000 S_0 is 320 S is 17 multiplied by 10 to the power 3 minus 3 divided by f , f is what the ratio of BOD 5 to BOD ultimate which is 0.68 minus 1.42 into Q_w , Q_w we just found out that it is 128.41 meter cube per day and then the r is also known to us 8000 milligram per liter. So, milligram per liter to gram per meter cube gram per meter cube to kg in order to convert into kg per meter cube you have to multiplied with 10 to the power minus 3.

So, you will get the kg of oxygen required for the organic matter is 568.44 kg of oxygen per day you understand. Now, this is the amount of oxygen that it requires for your organic matter fractions like suppose you are also like in parallel in nitrification is also happening there. So, for the process of nitrification also it needs some amount of oxygen remember we discussed about it. So, if for the process of nitrification what is the amount of nitrogen that it requires? In general for the amount of nitrification that it requires it is it is can be easily stoichiometrically easily done by 1 gram of total gyrdal nitrogen requires 4.57 gram of oxygen for conversion into nitrate. So, for 1 gram of TKN it needs 4.57 gram of oxygen. So, if we know the TKN value which is given to us you can easily find out the what is the total oxygen requirement. So, the oxygen required is 4.57 multiplied by the flow rate which is 2000 meter cube per day multiplied by the TKN value of the inlet wastewater, influent wastewater which is given to us as 35 milligram per liter in the question itself divided by 1000 to make it to the kg and then the final value will come as 319.9 kg of oxygen per day. That means, this much of oxygen is required for nitrification purpose. Now, for organic matter also we need for oxygen requirement we calculated as 568.44. So, 568.44 plus 319.9 total 888.34 kg of oxygen is required per day. Now, in the if you are not supplying the raw oxygen right you are supplying the air by means of diffuse aeration systems or say like surface paddle aerator and all anyway. So, you are supplying the air. So, air does have only 23 percentage of oxygen and also it has a density of density of 1.201 kg per meter cube. So, the what will be the total volume of air that it requires? The total amount of oxygen is 888.34 kg of oxygen per day divided by the density of air 1.201 divided by the percentage of oxygen present in air which is 0.23. So, you will get the total volume of air that it requires is around 3215.94 meter cube per day.

So, that much of volume of air is required for the design ok. So, if suppose the oxygen transfer efficiency is 8 percent I mean like for your aerator for your air compressor system. So, if it is the air transfer efficiency is 8 percent.

So, it is like 3215.94 divided by 0.08. So, total volume that it requires total volume of air that you need to supply is 40199.3 meter cube per day or 27.92 meter cube per minute you just divided with the 24 into 60. With the safety factor of 2 the total air requirement should be around 55.83 meter cube per minute you understand. So, suppose you have a you bought a aerator bought a new aerator diffuse aerator system with the air compressor and all and in the in its manufacturing manufacturer has given in the in the air itself in the aerator itself it is written the box itself it is written that the aerator has a capacity of 20 meter cube of 20 meter cube per minute of aeration. I mean like it can provide a 20 meter cube per minute of air I mean like the air it can supply. If it is 20 meter cube per minute. So, how many aerator you need to employ 3 of them at least.

So, you have to employ 3 of them. So, to supply 60 meter cube per minute of air into your aeration system into your aeration tank you understand. So, from this way we calculate the

amount of aerator that it requires for your aeration system in the activator sludge process ok. So, we can further check for the air volume we know that the air requirement per unit volume is say like 40199 divided by 2000 meter cube per day. So, it is the per unit like you know the flow rate it is like almost 20.09 meter cube of air is required per meter cube of inlet wastewater which is more than the limit of 3.75 to 15 meter cube per day in general ok. So, we somehow it is ok like we it has certain limit, but you somehow it is ok it is because of the demand of the design you may have to like you know sometimes you your values can enhance a bit enhance a bit in then the limit that is given by the scientist and all. So, this air requirement per kg of BOD is 40199.3 divided by total BOD that it removes how much BOD is removing from the system 320 minus 17 into 2000 into 10 to the power minus 3. So, that means, for per kg of BOD removal you have to supply 66.33 meter cube of air which is also greater than the limit of 30 to 55 meter cube per kg of BOD because of the concentration of oxygen required for nitrification.

So, it is completely ok if you have certain ups and downs it is completely ok. So, but you understood right. So, here in this by this way you can completely design your aeration tank, you can design your suspension in the sedation tank your basics considerations can be easily found out. Now, based on the all this design you can choose the size choose the size and the type of your aeration tank and based on that you can I mean aeration tank you just go through with the construction of it ok. So, I hope you understand it is the design the whole this the design of this completely mixed activator sludge process and you can actually replicate the same nicely. And another problem I have also given here the design of conventional activator sludge process to treat the soluble wastewater from bottle washing plant containing a soluble organic waste having a COD of 350 milligram per liter from extensive laboratory studies for untreated wastewater the BOD 5 to COD ratio is also found to be 0.6 and the average flow rate of effluent is 1 million liter per day 1 million liter per day 1 million liter means 1 into 10 to the power 6 liter per day 10 to the power 6 liter means 10 to the power 3 meter cube. So, 10 to the power 3 meter cube per day that is the capacity of that is the amount of influent wastewater that you have you are receiving each day which is to be treated in ASP. So, that the effluent suspended solid and the soluble BOD 5 should be less than 20 milligram per liter. So, final soluble BOD has to be less than 20 milligram per liter and thus effluent a suspended solid concentration should also be less than 20 milligram per liter. Return sludge concentration is 8000 milligram per liter as suspended solid and so 6400 milligram per liter as volatile suspended solid.

So, that means, the 8 percent almost 80 percent is the MLSS inside the aeration tank is 2500 and from there you can easily calculate the MLBSS just multiplied with 0.8. Mean cell residence time is given as 8 days μ is given as 0.5 kg of cell per kg of substrate consumed and k_d is given as 0.06 day. We have to determine the reactor volumes, sludge wasting rate, recirculation ratio, oxygen requirement and hydrogen retention time and also determine the specific substrate utilization rate and F by M ratio it is very easy like we already did all those things. Now, to start with the what should we do first the efficiency 270 minus 20 divided by 270. The how to find out the influence COD is given 450.

So, influence BOD is 450 into 0.6 because BOD to COD ratio is given 0.6 from there you can easily calculate the influence BOD which is 270 effluent BOD should be 20. So, efficiency 270 minus 20 by 270 92.59 percentage volume V is equal to given with this equation

$$V = \frac{Y \cdot Q \cdot \theta_c (S_0 - S)}{X(1 + k_d \cdot \theta_c)}$$

you put all those value you will get the value of your volume of your aeration tank as 337.84 meter cube. Now estimate the quantity of sludge we can we first have to calculate the y OBS. So, in case of y OBS value we can easily find out

$$Y_{obs} = \frac{Y}{1 + kd \cdot \theta_c}$$

y is given as 0.5 k d 0.06 and theta c m c r t is given as 8. So, the value will come 0.338 kg of BSS per kg of BOD removal. Now biomass production = $Y_{obs} \times Q \times (S_0 - S)$

So, that also all the values are known to you Q is 1000 y Q is 1000 1000 meter cube per day remember we calculate 1 million liter per day means 10 to the power 6 liter per day. 10 to the power 6 liter means 10 to the power 3 meter cube. So, 10 to the power 3 meter cube means like 10,000 1000.

So, 1000 meter cube per day multiplied by y OBS is known to you 0.338 multiplied by S 0 minus S by 1000 because to convert into kg S 0 is 270 S is 20 ok, influence BOD effluent BOD very good. So, now we know the biomass production rate 84.5 kg of BSS per day. Now we need to understand the sludge wasting rate ok.

So, we need the quantity of sludge that needs to be wasted. So, from the theta c calculation same it is as easy as that theta c value is 8 you know the V value you know we if you calculated the volume of your reactor aeration tank 337 in last slide and the x value is 200 2500 into 0.8 because 2500 is the m l s s, but you need m l v s s divided by 8 into x r x r is also you calculated that 6000 it is given as 6400 milligram per liter the VSS of your aeration tank. So, Q w becomes 13.197 meter cube per day. What is the wasted sludge here 8000 8000 divided by 1000 into 13.197 that is the sludge wasting rate. So, total value is coming as 105.57 kg of SSS per day. Now estimate recycle ratio

$$Q_R \cdot X_R = (Q + Q_R)X$$

is 2000. The what is the value of it is a x is the value of the m l v s s inside the aeration tank x r is 6400 we just we found out.

So, we it is given. So, this value comes as 0.45. So, that means, the what is the value of Q you just simply calculate the Q r divided by 0.45 you will get the value of I mean like you will get the value of Q r equal to when you calculate multiply the 1000 into 0.45 that means, 450. So, that means, 450 meter cube per day is the Q r value you understand ok. Hydrodetention time the V by Q V is known to us 337 the volume of your aeration tank Q 1000 meter cube per day.

So, what is the retention time 0.338 per day 0.338 day that means, 8.1 hour just 338 multiplied by 24 specific substrate utilization rate S 0 minus S by theta into x if you remember while doing the modeling we did these things. So, S 0 is known to us S is known to us theta is given to us we calculated as 0.338 day multiplied by 2000 is the MLVSS of aeration tank you will.

So, substrate utilization rate is 0.37 kg of BOD utilized by per by per kg of VSS per day. F by M ratio you can easily calculate F by M ratio also the 270 is the food that you are that you are getting divided by see we know the theta right. So, F by M ratio in general means Q into S 0 by V into x. So, if you know the theta just simply divided with 0.338 you know that is that is equal to this equal to the same equation that we would we have done in the last problem. So, 270 is the substrate concentration I mean like the substrate concentration in the influent it is a

like the influent BOD and 0.338 is the hydrodortention time and multiplied by the μ is the MLVSS inside the aeration tank. So, F by M ratio is coming as 0.399 kg of BOD per kg of VSS per day. Now, the F by M ratio into efficiency and this into efficiency the efficiency is how much its efficiency is 92.59 ok. So, multiplied by 92.59 you will get the substrate utilization rate the or the substrate utilization efficiency as 0.37. Oxygen requirement you can easily calculate it $Q(S_0 - S)$ divided by 0.6 because 0.6 is the say like this is the BOD the value of F the BOD 5 to ultimate BOD minus 1.42 into μ , μ is we calculated it biomass production rate 84.5. So, 1.42 into 84.5 and here 1000 into here. So, if you replace this values in the equation you will get the oxygen requirement as 297 96.7 with the say like factor of safety of 2 its 593.3 kg of oxygen per day. So, I hope you understand this different type of the design of activator sludge process and how to do it and it is the one of the you just go through this lecture material again and try to write it down in your notebook all these discussions that we have with step by step manner. I am telling you will be expert in activator sludge process design you can go to any treatment plant and you can just see the activator sludge process you can ask them a certain questions you will see that they all the activator sludge process they design they are going to design a new one they formulate it this way.

So, you can be expert in activator sludge process design if you go through it another 2 3 times and you will be able to understand the whole concept much clearer way ok. So, you can take this book as a reference. Thank you so much.