Water Quality Management Practices

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Lecture - 35

Sequencing Batch Reactor

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. In this final video of module 7, we will be discussing about the Sequencing Batch Reactor. So, it is it is also one of one of a kind of aerobic wastewater treatment system. So, majorly the concepts that I will be covering is the overview of sequencing batch reactor, the equations for SBR design, SBR process phases, applications and case studies, its design factors and some design guidelines. To start with in case of SBR, if I ask if I if I tell you like the process wise, it is a batch process to start with.

It is kind of a batch process and in this batch process in a same reactor only, we are performing all the parameters all the you know performing sequence that we normally do in the any aerobic treatment system or anaerobic treatment system say like activated sludge process or UASB. So, what we are doing we are making it a modular structure, we are using a one single tank for performing all the parameters all the sequences ok. So, that is why it is called the sequencing batch reactor. In this sequencing batch reactor, it is a in this unit operations the primary sedimentation, unit process of like it is it is kind of a primary sedimentation, but it is in this unit process of biological oxidation of organic matter and the settling is done and it is the it is done in the same aeration tank itself.

If you can see this figure, the first one the step one what we are doing we are introducing the waste water into the system into the aeration tank and we start the air or we can switch off the air also we can just wait for to fill in also. After the filling procedure is done of that means, the waste water reaches up to certain height inside the reactor based on its design maximum this maximum height inside the design inside the reactor, then we switch on the aerator switch on the aerator. So, the air will be supplied or may be aerator can be switched on in between in the mean time only. So, the first step is to fill in the reactor, second step is the reaction. So, we wait for certain amount of time based on our design let those aerobic microorganisms consume the organic matter present inside the inside the waste water and it converts into some soluble in some byproducts and its own cell biomass.

So, we will wait for some time this reaction process to take place and while we will supply enough amount of aeration. So, to have the enough amount of aerobic microorganisms present inside the system. Once the design time for this aeration say for this reaction time is finished we stop the aeration, we stop the aeration and we will wait for some time. We wait for some time and what will happen all the biomass all the organic matter which is converted into biomass now they will start settling down ok. So, once they will start settling down.

So, this settling phenomena is happening. So, it takes time time. So, this time is called the settling time or the settle like this is the third step of settlement. Fourth one once we are completely sure that the settling it like you know enough amount of this organic fraction of this biomass fraction is actually settled now we decant it. Decant it means like we let the supernatant part of this settled I mean like this effluent we try to get rid of the effluent from the system and which we which is nothing, but the supernatant part of it.

So, to remove the effluent from the system itself. So, we fill in the waste water and then when the effluent is taking effluent is we are taking out the effluent from the system where there should be certain amount of removal of organic matter from the from the waste water ok. And then and the last step is the idle stage when we you can switch on the air you can switch off the air, but the sludge waste is collected from the bottom and this whole process is done in this 5 step. Feel, reaction, settle, decant and idle ok. Then again you fill the waste water again.

So, in the same reactor we are keep on performing a sequence of reactions that is why it is called sequencing batch reactor and the process is a batch process you fill in wait let the job done in the SBR then again you fill in the new waste water new batch of waste water. So, that is why it is called the sequencing batch reactor. The what is the difference between the activator sludge process and the sequencing batch reactor? Majorly the waste water is treated in the continuous flow region in case of activator sludge process. In case of sequencing batch reactor it we are doing it in a batch process plus the some sequences has been has been maintained in a same reactor same aeration basin or aeration tank. So, that is why it requires a less amount of space it is much more efficient and the more advancement is like you know with this advancement in waste water treatment systems.

We are more focusing on this kind of advance units with time. Each of this SBR it is majorly operated in a staggered cycle of operations to handle the inflow receipt and does not the any given time there will be one SBR under the fill cycle to make sure that you know you have in order to not to stop the you know flow of influent I mean like just try to understand. If you have if you are designing a waste water treatment system for your municipality the water is keep on coming. So, you cannot just ask them to stop use utilizing the waste utilizing the water. So, that waste water will start stop coming into your plant it will keep on coming with a certain rate.

If you have a equalization basin you maintain a certain flow. So, once you maintain the certain flow the waste water will keep on coming. So, how SBR will tackle with this issue? What you can do? You can have multiple SBR you understand. So, you can have say like instead of one SBR you can have like multiple SBR ok. So, what will happen? So, for each time and you can have a diversion system water control structure.

In this water control structure we will let the water flow to one SBR first like wait for the fill time one once its fill time is over it will stop that sluice open the second sluice. So, its second SBR will fill up. Then second one fill time is open second one second sluice will close third sluice will open by the time the fourth sluice or say like fifth sluice is open for the sluice gate is like you know nothing, but the water control structure. So, by the time the fifth one the filling time is over for the first one all the rest of the sequence is also say gate gets over ok. So, what will happen? Just after the fifth one you can again switch on the first one because by that time the first one has done its job and the all the other procedure is finished.

Now, it is ready for fresh intake of wastewater that is that is how you need to design you becoming a wastewater you becoming an expert you have to make sure is client is satisfied with the design that you are provide the proposed them with. So, in this case what will happen? You can have a continuous handling of the wastewater, but in different reactors and this different reactors will perform its own job and so that there will be no delay in the system. There will be no you do not have to provide one reservoir or something in that because, but just you need to provide one water control structure which will take care of the flow of water in each of this SBRs understood. So, then in the treated effluent say like so, total suspended condition solid concentration of less than 10 milligram per liter can be achieved through the use of effective decanter to eliminate the need of separate clarifier as I discussed in the last slide also. The treatment cycle can be adjusted to undergo aerobic anaerobic or anoxic conditions in order to achieve the biological organic matter nutrient removal etcetera including the nitrification denitrification and some phosphorous removal.

That means, this SBR you can supply with aeration and then you can call it aerobic SBR you stop providing aeration you just make provide some mixing condition some you can provide some kind of agitator by means you are mixing the water that is it and you keep the like you know the lead on like you know so that there will be no exchange of air. So, because of that the system will be in anaerobic anoxic condition and so, once it is in anaerobic there are anaerobic SBRs as well there are lot of research going on this anaerobic anoxic SBRs because, it may perform much better in some particular type of waste water. Anyway so, what this can be done you can you can have the flexibility to make it aerobic as well as anaerobic anoxic as well to enhance the nitrification enhance the denitrification and phosphorous removal from the system. The major advantage of SBR over the conventional activity sludge process is a it is a less space requirement is needed due to the modular type of design no separate settling tank is needed low amount of aeration is provided you can provide and automated operation of this SBRs are possible because it is completely upon the time once the time is over you just open just you make it completely automated. So, the water control structure the it will provide the enough amount of inlet waste water after certain moment of time then it will goes to the next and also in that same SBR also after certain moment of time the you can fix the timer which will handle the all the actuators based on the availability.

So, the moment filling time is over filling time is done your actuator will get the signal and it will switch on the aerator by automatically. Then once the aerator performance is done the timer will automatically switch off your aerator and let it settle the biomass then after a while it will open the decanter it will I mean like it will open the it will start the decanting operation or it will let the effluent to come out of the system and then it will let the sludge to come out of this bottom as well. So, automation is possible the shape in general the sludge settling is an integral stage of SBR technology hence the shape of the formed bio aggregates that favor the settling is essential. Sometimes flocculent particles obviously tend to settle less while granular bio aggregates enables the good settling. So, we try to initiate we try to you know appreciate the biogranulation formation there.

So, the better the granulation formations the bio aggregates the better the suspension better the sedimentation process and it will the more faster the sedimentation process it will reduce the time and it in general it reduces the operational complexities in the SBR design. So, which at aids in the formation of granules what we can do if the influent waste water does have some calcium if there are some inorganic cementing fillers extra cellular polymeric substances or EPS as given as demonstrated by the scientist Fleming et al in 2007 paper. So, it is EPS is nothing, but it is a cellular secretion which consisting of a hydrated polymers of protein polysaccharide and DNA whose secretion results from the response to any environmental stress or signals. So, this signals this EPS can actually lead to a formation of biogranules and because of this biogranules if the settleability the settleability capacity or the efficiency is much better in this case and it will settle down very fast and that is what we need. Just after the aeration is done when we let the aeration stop and start settling the system it should settle down as early as possible that will be beneficial for us.

So, we have to maintain a low F by M ratio and high relative shear in to ensure the granulation of sludge as smaller and denser granules are formed. What are the factors which affect the size of the ano this aerobic granular biomass formations first is the reactor configuration the size of the reactor the design of the reactor the structure of the reactor will definitely influence the substrate composition as I was mentioning the presence of calcium if it is there in the influent waste water you do not have to worry about it it will anyway happen if this granulation formation will be much more easier when there is a calcium ah salt in the ah influent waste water. Dissolved oxygen concentration the lesser it is it will involve involve the system involve the lot of issues the solid retention time the lesser the solid retention time the higher the solid retention time it will also influence volume exchange ratio settling time the obviously, the settling time that you provide it is as easy as that because more the settling time the more amount of granulation will occur organic loading rate and the hydrodynamic shear forces that you are providing into the system. So, the better the lesser the shear force I think the better the like the high the higher the relative shear force it will ensure the more smaller and the denser granulation. So, it will also help in leading the forming this aerobic granulation granular biomass and all the more the granular biomass the better the performance of your SBR.

There is this unified equations to choose the appropriate settling rate discharge rate and volume exchange ratio in general the minimum settling velocity should be capital L divided by t_s into t_d minus T d mean square by t_d

$$V_{s,min} = \frac{L}{t_s + \frac{(t_d - t_{d,min})^2}{t_d}}$$

whereas, this L is the length of the outlet port in the SBR tank or the depth of the traversed settling time in t_s and t_d is the discharge time and $t_{d\ min}$ is the minimum discharge time ok. So, substrate mass balance equation also can be done and it can be modified for SBR and considering the it is it operates in batch forces and though the mean considering the mean flow rate I know flow rate q is 0 because it is a batch process the equation will become k s into ln S 0 by S T plus S 0 minus S T plus x into q mu m by y into T whereas, this S is the initial substrate concentration S T is the substrate concentration at type T and other terms bearing the same usual meaning as defined previously in the activated slash process.

$$K_s \ln \frac{S_0}{S_t} + (S_0 - S_t) = X\left(\frac{\mu_m}{Y}\right)t$$

And this equation can be further modified to represent the kinetics of nitrification by replacing the capital S with the capital N that is the total geldal nitrogen and x with x n that is the concentration of nitrifier in the tank and the corresponding monodic coefficients for nitrification represents the mu m n and the y n. So, to account for the effect of dissolved oxygen on the growth of this nitrifying microorganisms that term can be added in the right hand side to obtain the final equation as given in this equation

$$K_s \ln \frac{N_0}{N_t} + (N_0 - N_t) = X\left(\frac{\mu_{mn}}{Y_n}\right)\left(\frac{DO}{K_o + DO}\right)t$$

k s into ln N 0 by N T plus N 0 minus N T equal to x into mu N m by y N m y N into DO by k 0 plus d o into T because the in order to account for the effect of dissolved oxygen in the growth of nitrifying microorganisms and this k 0 it is the half saturation constant for dissolved oxygen in milligram per liter. This equations can be used for designing the SBR using the iterative method by determining the fill and decant volume and the aeration requirement etcetera.

What are the application of SBR technology? Majorly incorporation of polyurethane foam cubes as a suspended media inside the SBR tank with an aim of enhancing the solid retention was an effective strategy adopted for a pilot scale SBR having 1.2 that is 1200 meter liter volume in a in a research done by Sarti et al. 2007. It has also been explored explored for anaerobic an ammonia oxidation or famously known as anammox process and now it is all over world specially in even in IIT Kharagpur also we are also working on it along with our partner in university of Tartu Estonia and this anammox processes and all. So, there is a case study for a period of 500 days demo stated successful development of a deammox process a combination of partial denitrification as anammox for removal of 94 percentage of total nitrogen with initial ammonium nitrate concentration of 64 and 69 milligram per liter respectively.

Extensively used like this SBRs are nowadays extensively used for treatment of landfill leachate poultry industry wastewater for removal of pharmaceutical compounds from wastewater agro industry based wastewater. Even biodiesel recovery from the excess sludge is a sludge generated from SBR is also done for further value addition to the system. What are the different variants of SBR sequencing biofilm batch reactor sequencing granular batch reactor cyclic activator sludge process and intermediate cycle extended aeration type systems and all. So, from the name itself you can understand the more that which variety in which particular which particular like in the sequence is actually more focused on. And like there are hundreds of different applications nowadays specially this anammox one as I was saying it has a it is coming as a very effective one in for treating the nitrogen waste from the system in from the system.

So, efficiency wise in there are recent study which they have found out that the dairy wastewater treatment using SBR can reach to the 90 percent COD removal efficiency 80 percent nitrogen removal efficiency and 67 percent is phosphorus removal efficiency. Low strength municipal wastewater has a 90 percent removal efficiency of COD 95 percent is nitrogen removal. So, overall the what are the advantage no secondary clarifier is needed more often does not require the primary clarifier also. So, and it can be implemented with the when the space is limited in a one single chamber acts like in a works for all the sequences of the operation. Significant potential to reduce the COD with simultaneous removal of nutrients like sodium and nitrogen and the phosphorus.

The size of the SBR tank is dependent on the wastewater characteristic from the site conditions. So, in general that is more of a typical design parameter for most famously used SBRs the continuous flow and intermittent decant and the intermediate flow and intermittent decant type reactor. The F by M ratio it normally lies between 0.05 to 0.08 in case of continuous flow intermediate decant sludge age is 15 to 20 days sludge yield is 0.

75 to 0.85 kg of solid per kg of BOD. Mixed liquor suspended solid concentration of around 3 to 4 gram per liter cycle time 4 to 8 hour in general settling time around less than 0.5 hour preferable. Design depth always 1.5 meter in case of continuous flow in case of intermittent flow 2.5 meter depth is required. Feel in case of design has to be done with the peak flow only and the BOD almost like oxygen process oxygen for BOD removal 1.1 kg of oxygen per kg of BOD and for TKN 4.6 kg of oxygen per kg of total nitrogen removed from the system. So, that is how it is normally designed.

So, let us design one SBR. So, once we design one SBR it will be much easier for us to you know and we will understand the concept much more effectively. Designing a SBR for a sewage treatment plant of select 10 million liter per day capacity with the following ah, influent characteristics as given in the table below you see this 1 2 3 4 5. So, all this 6 parameters are given it is with it is influent characteristics and expected a fluent characteristics from after the SBR operation is done. That means, 250 milligram per liter we are expecting and the BOD level should be go should go down to 20 milligram per liter. The COD 450 to 100, TSS 300 to 30, TKN 50 milligram per liter to 2 milligram per liter ah, total phosphorus 10 milligram per liter to 2 milligram per liter and nitrate it will be obviously, increasing because then ah the ammonia will convert into nitrate.

So, from 0.5 to 10 milligram per liter, but it should not be more than more than that ok. So, also ah we are asked to determine the oxygen requirement the decane pump rate ah, I mean the MLBS's concentration of SBR shall be ah kept like 3500 milligram per liter ah. The effluent characteristic should be meeting the quality norms as stated in the table below and the considered the MLBS's MLBS's ratio to be 0.7. The specific sludge yield can be considered as 0.4 gram of BSS per gram of COD. The diffuse deaeration system installed provide the 3 percent of the oxygen transfer efficiency per meter depth of water column. So, per meter depth of water column this is very important information you need to understand. The understand at condition per meter depth the efficiency ah, is it it change. So, like you know if it is a 3 percent of oxygen transfer per meter, if it is 2 meter depth so, it will be 6 ah, 6 percent efficient. So, consider the pressure at ah, mid depth of diffuser as a 0.830 millimeter of hg. The saturation concentration of ah, oxygen is at 830 millimeter of mercury and water temperature of 17 degree is given as 10.56 milligram per liter. The saturation concentration at 20 degree Celsius ah, with normal atmospheric pressure is given 9.8 milligram per liter.

Ah, oxygen transfer coefficient is 11.5 ah, per hour minimum temperature ah, of wastewater shall be considered as 17 and a DO of 2 milligram per liter is should be targeted in SBR. See ah, the change in pressure here ah, we will ah, avoid that issue. So, we will only consider the change in temperature and based on that how the saturation concentration and the oxygen transfer coefficient will change that also we need to calculate ok. So, for 17 degree as is our the design criteria and 20 degree values is are given ah, 9.8 milligram per liter the saturation concentration.

So, ah, please make sure that you will consider the design at 17 degree Celsius ah, with the with the constant rate ok. Now ah, the flow in the reactor is 10 million liter per day 10 million liter means 10,000 meter cube per day million liter to multiplied by 10 to the power 3 it will become meter cube per day as easy as that ok. Ah, which can be converted into hour which will be very important for us 416.67 meter cube per day please write it down all these things ok.

Assuming the peak flow 1.5 ah, the flow rate will become 625 meter cube per hour 625 meter cube per hour is the peak flow ah, rate and 416.67 is the flow rate in case of in normal average flow. Assuming a fill and adhesion ah, and then fill and adhesion comes together F and A in the in the in the table. Then A means adhesion then settling denotes with S S and then decant time ok. The time is given as 1 hour for fill and adhesion 1 hour it takes to fill the tank ah, 2 hour for the adhesion ah, 0.5 hour that is half an hour for settling and half an hour for decanting ok. So, total time is adjusted ah, with the fill time ah, with the other reactor and this can be adjusted by providing 8 number of basing, basin with operating schedule as given in the following table. So, we are provide we are providing 8 number of basin. So, the reactor the first reactor and the fifth reactor we are filling the first filling at the beginning ok. So, we wait for 1 hour for it to fill first reactor and the reactor 5 R 1 and R 5.

Then R 1 and R 5 goes for ah, 4 hours of ah, 2 hour of adhesion ok. You see the time is given on the on the top in the second second ah, row 0.5, 1, 1.5, 2 this is the time in hour up to 6. So, 6 hour. So, 6 hour what is happening 6 hour we are not stopping the waste water we are keep on ah, in like you know let the in the the waste water make inside the tank every ah, like you know all the time ok. For the first hour R 1 and R 5 comes into the picture, in the second hour R 2 and R 6 you see the fill and adhesion f and f by a. Then ah, in the third hour ah, if R 3 and R 7 and in the fourth hour ah, R 4 and R 8. Then again ah, at the fifth hour again R 1 and R 2 we are filling up the tank because they take they take 5, 4 hour total in total right for their perform for their sequence to be done. So, after 4 hour you can again start ah, filling the tank itself with the waste water of you I mean like the or with the infinite waste water.

So, at a time 2 of the reactor 2 of the reactor basin is actually come ah, like working and you have you design it. So, that 8 number of basins are given in the in a at a particular moment of time you you understand. So, how the operating schedule has been maintained in the SBR 8 number of basins are given at any point of time the waste water is keep on flowing inside any either of either of like any any 2 of this SBRs ok. So, first R 1 R 5 then R 2 R 6 then R 7 R 3 R 7 then R 4 R 8 then it follow like again follows the same schedule ok. Now, the total cycle duration how much 2 hour for filling a 2 hour ah, for ah, the aeration ah, 0.5 hour for decending 0.4 hour 0.5 0.4 hour for ah, the settling and 1 hour for aeration ah, the filling an aeration. So, total 4 hour right the number of cycle per basin is ah, in a per day is 6 24 by 6 4 total 6 6 is the number of cycle. So, total aeration ok. So, but total aeration part day like out of this 4 hour only 3 hour the aeration has to be provided so that means, part day almost 18 hour of aeration we need to provide ok.

So, assuming a m by m ratio of 0.15 the volume of tank volume of basin that it requires is ah, it can be easily calculated by this equation Q is known to us S is known to us 250 milligram per liter the BOD initial ah, BOD is it is given to you 250 milligram per liter ok. So, now, ah, the x value is 3500 milligram per liter. So, the value of ah, how you will calculate the value of ah, V then the V is nothing, but 4762 meter cube. Now, you have 8 number of basin.

So, each basin should have a volume of 595.25 meter cube. So, alternatively what you can do the number of basin that receive the flow at the same times are 2 this is one way of designing the volume required for per basin that is 592.25 meter cube. Another alternatively how we can do at any point of time what is the total number of basin that is receiving the flow 2 basin you remember either in case of R 1 and R 5 is receiving the flow. So, total flow is how much wastewater that is coming to the picture that the field volume how we can calculate the 416 416.67 is what it is the flow rate 10000 milli meter cube per day that means, 416 meter cube 16.67 meter cube of meter cube per hour of water is entering per hour. So, per hour this 416.67 meter cube is divided into 2 basin R 1 and R 5. So, per basin volume should be 208.35 416 divided by 2 208.35 meter cube assuming the volume exchange ratio of 0.3 0.3 and considering that the field volume is equal to the decant volume and based on this the total volume of the reactor required for each basin should be at least 694.5 that is the field volume is only 0.3 percentage of the total volume or the decant volume. So, the field volume should not should that means, the total volume of the basin should be 208.35 divided by 0.3 which is coming as 694.5 meter cube. We have to choose the higher one which one we are going to choose 595 or 694 694 because this is the higher one. So, we have to have the maximum we have to when we are going to design we have to design it based on the maximum possible the the values. So, here the higher volume is 694.5 meter cube. So, we will take this volume. So, total volume of the basin 694.45 into 8 5555.6 meter cube that means, the HRT what is the HRT now 5555 meter cube that is the total volume volume by Q, Q is given as 416.67 Q this flow rate 10000 meter cube per day or 416.67 meter cube per hour. So, the HRT will become 13.33 hour ok. Now, the field volume and the depth calculation peak flow rate you know per hour is 625 meter cube per hour ok. So, the field volume to be accomplished accommodated during the peak flow per basin per basin I mean like you know at any point of time there is like 2 of them are working.

So, 624 divided by 2 total 312.5 meter cube assuming a total depth of 5 meter the decant depth will be 5 into 0.3 that is 1.5 meter ok. So, hence the area to be provided for the basin is 312 meter cube divided by 1.5 total that means, 208.33 or 12 say like 210 meter square. Now, if the length of the basin is like 15 meter the what will be the width width will be 14 meter. So, 15 meter by 14 meter by 5 meter that should be the design of your design of your tank. Considering the specific yield of 0.4 gram of BSS per gram of COD the sludge generated per day can be easily calculated which is 0.4 into S 0 minus S what is the initial COD 450 and final COD that is expected to be 100.

So, 450 minus 100 into 10000 that is into 10000 multiplied by the 10 to the power 3 to convert this gram to kg. So, for 1400 milli kg of kg per day since the to maintain the safety we have to make sure that that in a steady state condition this amount of sludge should be wasted from the SBR per day ok. So, now we need to waste 14000 milli kg of BSS per day in terms of SSS it will be 1400 1400 divided by 0.7 because the ratio is 0.7 total 2000 kg of monotone suspended in total 2000 kg of suspended solid per day ok.

If the SBI of the sludge is say 100 milliliter per gram of SSS after settling then the volume of sludge to be wasted as 2000 we know the SBI sludge volume index which is 100 milliliter per gram of. So, 100 milliliter is the volume of sludge per gram of suspended solid after settling. So, 2000 kg per day multiplied by 100 into 10 to the power minus 3. So, 2200 meter cube per day of sludge has to be wasted everyday ok. Now, for the solid retention time the V into m l v s s divided by sludge wasted into 1000.

So, V is known to us 5555 multiplied by the VSS m l v s s 3500 divided by wasted sludge is 1400 multiplied by in this wasted sludge is in VSS I mean like you have to provide the m a kg of VSS per day multiplied by 1000 you will get the 13.9. So, that is the solid retention time or sludge retention time or m c r t. Air requirement how you going to calculate the air requirement change in BOD from there you can easily calculate change in BOD into flow rate you can get the 2300 kg per day that much of BOD is removed per day multiply say theoretical oxygen requirement is 1.

3 kg per kg of BOD. So, that means, total oxygen requirement 2300 into 1.3 total 2990 kg of BOD kg per day and nitrogen assimilation is 5 gram per kg of BOD removed. So, that means, the bacterial cell mass produce nitrogen assimilation is 2300 kg of BOD multiplied by 5 gram per 1000 right per kg. So, 5 by 1000 that means, 11.5 kg. So, that means, the inlet nitrogen load we know that inlet nitrogen load is 50 TKN value is given or TN value is given TKN value is given 50 milligram per liter and final effluent characteristic should be 2 milligram per liter.

So, that means, inlet nitrogen load is 10000 millimeter cube per day multiplied by 50 by 1000 500 kg and outlet load is 20 kg. So, total nitrogen removed is 500 kg minus 20 kg minus 11.5 kg that is the nitrogen which is assimilated inside the biomass.

So, total removal of nitrogen is 468.5 kg. So, kg of oxygen required per day of nitrification is 468.4 into 4.6 4.6 is you know the amount of oxygen required per kg of biomass right.

So, total oxygen requirement is 2155 for nitrification. So, total oxygen requirement 2990 for organic matter you see in the left side and also for the nitrogen 2155 total 5145.1 kg of oxygen needs to be removed. Now, even if the oxygen transfer efficiency is say 3 percentage per meter depth under any standard condition hence a mean depth of aeration should be 5 plus 3.5 divided by 2 that is it will be always say like 4.2 into 3 12.75 percentage. So, estimating a oxygen transfer efficiency under field condition k l a 20 at 70 degree Celsius you can easily calculate k l a not 20 it should be k l a at 70 degree Celsius you know it should be k l a 20 known to us 11.5 is given in the question multiplied by theta theta is 1.024 to the power T minus 20 T is how much 17 degree minus 20.

So, what will be the k l a at 17 degree Celsius 10.71 per hour. Now, correcting considering the alpha correction factor like alpha 0.7 and beta is 0.9 you can use this equation to for standard oxygen transfer rate in the field condition.

So, this standard oxygen transfer rate 12.75 into alpha is known to us. So, actually this aeration efficiency will become 6.6 6.36 percentage. So, considering the density of air is 1.201 kg per meter cube and kg of oxygen kg per meter cube and weight fraction of oxygen is 23 percentage in air.

So, total air requirement will be 5145 in the last year we find out that 5145 total oxygen requirement and after for nitrification as well as organic matter like total 5145.5 plus divided by 1.201 into 0.23 into 6.36 percentage it will become 292.8 into 0.2 into 2.92 8 ah 6 ah 2.92 864 meter cube per day. As aeration is done 18 hour so, you divided by 18. So, the that means, the 60 16270 meter cube per hour of capacity ah like you have to provide the air requirement ah is needed.

Per basin you will divided with 8 2033.78 meter cube per hour and hence if you provide the 8 number of blower with once pair standby ah with the capacity of 2050 meter cube per hour your job is done. In case of decant rate the designing the decant rate of at ah peak flow volume of water to be decanted is the field volume is not it 625 meter cube time for decanting is 0.5 hour. So, total decant rate will be 12 1250 meter cube per hour as easy as that considering the wire loading rate of 185 meter cube per meter square per day ah by ah day the length of the wire requirement is ah 12 1200 ah since 2 basin is decanting at any point of time.

So, 1250 divided by 185 into 2 so that means, around 3.4 meter so that means, you need a wire of design of at least 4 meter to decant the ah the the your your waste water. So, ah I hope you understand the design ah how you can design a SBR with this basic considerations and all I request you to go through this ah question like this slide again I mean like ah specially this lecture material again to understand the concept more in details ok. So, in conclusion we understand the design of ah sequencing batch reactor and now also we are capable of doing it by own ah we it is it is a very good thing that we understood it is this kind of systems because this is a very this is a very I would say like you know advanced systems and people are nowadays ah trying to do a lot of iterations and trying to make it to the I mean like nowadays you will see like most of the conventional wastewater treatment systems they are replacing their existing aerobic treatment unit or the in the aerobic treatment unit with the SBR because there is a chance of this system to be the future of ah wastewater treatment system. So, I hope you understand this SBR system in details ah in some ah and you can also able to design it by your own. So, these are the references that you can follow ah these papers are very important you can go through this paper it will give you some ah in depth idea about the SBR and its design and its the ah how it works ah I wish to meet you again in the next module. Thank you so much.