

## **Water Quality Management Practices**

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**Lecture - 39**

Lecture - 39: Rotating Biological Contactor and Hanging Sponge Reactor

Hello everyone, welcome to this NPTEL online certification course on Water Quality Management Practices. My name is Gourav, Professor Gourav Dhar Bhowmick. I am from the Department of Agriculture and Food Engineering of Indian Institute of Technology, Kharagpur. In continuation with our discussion on different types of aerobic treatment systems, we discussed about quite a few amount of advanced technologies on that is going on the people are researching on all over the world and people lot of people are already started putting into the real life scale and things are also moving quite fast and like later there are couple of more technologies which are also come into the picture in last couple of decades and in the coming decade those technologies will definitely flourish like anything. So, we are going to discuss with another two of such technologies today, one is rotating biological contactor and the hanging sponge reactor. The concept that we will be covering in this particular lecture material is the rotating biological contactor, their process description factors which affects the performance of RBC, process design, process operation and the hanging sponge reactor its descriptions and the performance of this down down flow hanging sponge reactor in different cases.

To start with rotating biological contactor it is a it is come into the picture in this wastewater treatment scenario for last three decades and this this is nothing, but it is a attached growth hybrid process. So, just if you realize if you see this picture this plain plan view and as well as the elevation view and also the side view of this picture in the right side. In the plan view you can see there are four number of drums which are placed which are rotating on a free plan ok. Influent is influent from the primary sedimentation tank is coming from one side and the effluent is going to the secondary clarified to the second one ok to the from the right side.

Here if you see in the elevation view it is like a tank like structure in this tank there are like four number of series of drums we put in those drums what is happening the drums

are made in such a way with those plates inside a inside this drums like multiple plates or protrusions the different type of media also we can put it inside the drum. So, there are different variations of drums. So, in those drums what is happening because of this excess amount of area that we are providing in between this multiple amount of plate we putting it multiple amount of protrusion base protrusion in a in a single lining base materials also we put it. In a general our target is to increase the surface area ok. So, we increase the you increase the surface area and we will keep it submerged ok.

It is not necessary that it will be submerged it will be completely like you know under the water as well, but it can be partially submerged or fully submerged. So, based on the demand of our you know wastewater or based on our final you know wastewater water effluent characteristics that we want to have and which type of process we want to go ahead with it is an aerobic or anaerobic one. We will discuss about it in details, but to start with it is as you can see from the idea is nothing, but one couple of drum which will be rotating with time and in a very slow rpm and it will just let the aerobic microorganism once it is in the air what will happen those aerobic microorganisms will become will come into contact with the air and it will actually be grow like it can grow healthy in a healthy manner and also it will consume a huge amount of organic matter as easy as that. So, it will in order to increase the aerobicity we are maintaining this submergence ratios and all ok. So, in case of RBC our main target is what to go ahead with the attached growth biological treatment process where this we are providing both biological fixed flume as well as a partial mixing reactor that is well suited for secondary and or the advanced biological treatment.

This is RBC or Rotating Biological Contactor it consists of large disk with 1.123 meter diameter spaced 20 to 30 millimeter apart on a central shaft with a radial or the concentric passages slowly rotating with a rpm of 0.75 to 1.5 revolution per minute only in a tank. During the rotations generally about 40 percent of the media surface area is under the submergence in the wastewater and the 60 percent outside the wastewater.

As you can see from the picture right next to it. The rotation as well as a subsequent exposure to oxygen from atmosphere air atmospheric air it allows the microorganism to oxidize the substrate and multiply to form the thin layer of biofilm over the disk this disk surfaces and all. So, that is how we grow the we normally perform the operation in the rotating biological contactor. So, majorly what is happening here the biological degradation is taking place this large active population on this microorganism which placed in this disk it will cause the biological degradation of organic pollutant. Excess biomass it shears off at a steady rate from the disk the same process as you know you remember we did it for the trickling filter the slogging of phenomena it is the same for here in this case also.

Once it will reach a certain millimeter of thickness it will sloughed off from the surface because of the unavailability of nutrient to the inner biomass. So, they will die and it slowly it will come out of the surface of those disk. So, this is called the slogging of phenomena. This you can easily shear us this biomass can easily shears off the surface and because of that this excess biomass can be collected in the secondary clarifier. It normally we provide some rotation by means of mechanical drive or air motivated rotation also for one side we can provide the aeration or maybe because of the certain wind action also it will move slowly over a period of time, but in general we provide the mechanical aeration only mechanical drive based energy we provide in order to rotate the drums.

What are the main advantages of aerobic RBC? Majorly it has a short hydro retention time thus allowing a very smaller footprint. It has a very high specific surface area thus allowing the more amount of microorganism to grow on the surface of it the more the microorganisms concentration the more better the performance the efficiency of organic matter removal and also the other pollutant removal. High biomass holdup in the reactor that is possible and insensitivity to toxic substances. So, because of its certain structural benefit and on its exposed to air also. So, in some cases what happen it there are research where they found like it is quite withstandable like you know in toxic substances in case of some toxic substance or influence of toxic substance as well as for some basic some bare minimum shock loading as well.

It very less accumulation of the sloughed biofilm and partial mixing because of the very high amount of surface area and make it more durable biofilm to grow on the surface of those plates then the and that is why the amount of sloughed off biomass is quite less and it and as a result there are very less amount of sludge that is being generated compared to the conventional aerobic treatment processes ok. It has a very low energy requirement like you know it only takes like say 1 kilowatt per 1000 population equivalent and operational simplicity is obviously, just have a drum it just keep on rotating you allow some amount of submergence and make have a mechanical drive just you can have a change profit systems or proper gear mechanisms and all that is it as easy as that ok. What are the common factors that affect the efficiency of the RBCs like alkalinity this definitely the alkalinity will definitely affect the wastewater characteristic I mean like the performance of the RBCs because it actually changes the capacity of the microorganism to you know do certain amount of reaction to take to take place. So, to start with if you have a very less amount of alkalinity in the nitrification will not occur because nitrification is the alkalinity demanding process you know. So, likewise the pH nutrient the temperature oxygen biomass population balance that you have to maintain the concentration of the pollutant mass transfer of oxygen and the substrates from the

bulk liquid to the biofilm.

So, how the substrate is actually traversing through the from the bulk liquid to the biofilm will also be a very important factor for the RBCs this kind of a rotating biological contact to perform much better. So, what are the different factors which like you know due to the complexity in the physical and the hydrodynamic characteristics first is the disc rotational speed. The rotational speed will actually you have to optimize in general though by thumb rule we take like say 0.75 to 1.5 revolution per minute, but it depends on the size of the rotational that drama as well.

In your case you can definitely perform optimization technique I can actually check that what which particular revolution per minute you can choose 3 or 4 particular revolution per minute and you can then optimize that which one is actually giving you like certain additional benefit actually give you the exact values I mean like better carbon or organic matter removal as well as the nitrogen removal efficiency. Loading rate obviously, the organic loading rate will obviously, make a quite big difference as well as the hydraulic loading rate. The disc submergence how much of the disc I mean like it is submerged inside the water will actually have a quite important you know implications just like you know if it is completely outside the air. So, what will happen the aerobic microorganisms will I mean like some most of the portions say like 70 percent is outside in the air and 30 percent submergence is there. So, it is it actually influence the aerobic microorganisms to grow very substantially.

However, if you say like there is like only 90 percent submergence only 10 percent in the air. So, there is a chance of having some anoxic environment inside the rotating this disc. So, you have to maintain this disc submergence based on the demand of biological treatment that you are having for your wastewater target wastewater. The media composition how this media is actually composed of you can have the plate you can have other biomedias also stacked in the packed inside the drum. So, there are like based on that you it will vary.

The staging like based on the final effluent demand that you have suppose you have a BOD initial BOD of 100 milligram per liter and your final target is to make it less than 10 milligram per liter. So, based on that suppose in one stage I mean like with one drum you can only get a get an efficiency of select 30 or 40 percent. So, that means, from 100 now it will reduce down to 60 so that means, you need to employ another one. If you employ another one say take another 40 percent is so it will come down to select 36. So, then again you have to employ another one.

So, like this you have to have stage of X-plane stage of drum may drum is placed one

after another. So, this is called the staging to improve the performance of your wastewater treatment and all. Design parameter that regulates the performance of RBC obviously, the organic and hydraulic loading rate, the hydraulic retention time, the rotational speed, the type of media we use the operating temperature, DO level and wastewater and the biofilm characteristics and the sludge recirculation is also something that regulate the performance of RBC ok. What are the effect how the effect of bio hydraulic loading rate is of our concern because we increase the hydraulic loading rate from 34 38 to say 76 liter per day per meter square square meter of square meter it lead to the BOD removal of 80 to 56 percent is ok. So, the more the hydraulic loading rate there is a chance that it will drastically reduce the performance ok.

I mean like it has a there are ample amount of studies where it is done that they actually quite influencing each other influence each other like anything. What are the factors that performance that further affect the performance of RBC in details if we discuss. The DIGS rotational speed, the rotation of media it creates a head difference and leading to a bulk fluid mixing and the convective air and water exchange and that is why the rotor speed of around 0.7 to 2 rpm is are commonly adopted. Loading rate for carbonaceous oxidation ranges from 0.5 to 1 kg of BOD per BOD 5 per meter cube per day and for nitrification it ranges from 0.16 to 0.24 kg of BOD per meter cube per day. The overall soluble BOD loading rate should be should vary from 0.0049 to 0.0146 kg of kg per meter meter square per square meter per day. DIGS submergence the partially submerged DIGS are used for nitrification, completely submerged DIGS are used for denitrification because the completely submerged completely submerged the it is it prevails the anoxic conditions and because of that it helps the denitrification process to occur. However, it can lead to longer start up time because the denitrifying microorganisms it takes longer start up time for it is performance for it to start performing well. About 1 to 4 millimeter thick of thickness of biofilm will develop on the surface of this media or this disk and this DIGS submergence typically impacts the physical properties and the composition and the activity of biofilm growing on the disk ok. It so, the submergence will completely depend on your target that you want to achieve out of or your target waste water that you have.

Media composition the RBC media can be at present like you know it can be disk, it can be mesh plate, it can be saddle cell rings in a packed bed reactor. So, which resembles a partially submerged rotating moving bed biofilm reactor. It looks like I mean like it performs like a moving bed biofilm reactor, but which is in rotation and plus it is in partially submerged. This RBC media commonly has a separate specific surface area of 150 to 250 square meter per cubic meter of volume per for the biofilm growth and which supports the high removal rate at low hydro retention time. Staging staging in compartmentalizing the of the RBC disk to form a series of independent cells the number

of stages it depends on the treatment goals with 2 or 4 stages for removal of organic matter and 6 or more stages for nitrogen removal ok.

We will do this calculations and we will see that how actually the stages are actually important. Enclosure to RBC why this enclosure if you see this picture why it is very important to provide an enclosure to the system because majorly the fiberglass reinforced plastic cover is provided in order to protect the plastic disk from the deterioration due to the ultraviolet light from the sun ray. The protect the process from the low temperature and also the control the buildup of algae in the process because of the sunlight there is a chances of algae which can generate which can actually like you know you can it can produce on the surface of it. So, we do not want the algae to be produced on the surface of this submerged partially submerged RBCs. So, that is why you better be protected from the sunlight.

Also we it protect the equipment from any possible damage. There are different models that we use for designing this RBCs. One of the most famous one is the US EPM model. What are the limitations? Obviously, it does not include the parameters on microbial kinetics and it is also substrate limitations or the changes to influent and the temperature. The equation is given as equation number 1 you see that  $Le$  by  $L_0$  or  $L_0$  equal to exponential of minus  $k_p$  in bracket  $v$  minus  $695 q$  to the power  $0.5$  or bracket close.

$$Le/L_0 = \exp[-K_p(V/695Q)^{0.5}]$$

So, here the capital  $V$  is nothing, but the media volume inside the reactor,  $Q$  is the wastewater design flow excluding the recycle flow MgD this million gallon per day or say like 43.8 liter per second,  $Le$  is the reactor effluent BOD mean milligram per liter  $Le$  and  $L_0$  is the  $L_0$  is the reactor effluent BOD<sub>5</sub> in milligram per liter.  $k_p$  is the performance measurement parameter  $k_p$  here in first model it is the performance measurement parameter. Please remember this  $K_p$  ok.

Its average  $k_p$  value is 0.3 at 20 degree Celsius, but the modified one will also be more useful. This modified US EPM model it actually has the equation of  $Le$  by  $L_0$  equal to exponential of minus  $kt$  into  $Ac$  by  $695$  into  $q$  to the power  $0.5$ .

$$Le/L_0 = \exp[-K_t(Ac/695Q)^{0.5}]$$

Here this instead of  $k_p$  we are introducing a new variable which is  $kt$ .  $kt$  is the treatability function related to the surface area and average  $kt$  value stands comes as normally 0.066 at 20 degree Celsius ok. And  $Ac$  instead of instead of  $v$  the volume media volume we introduce here the  $Ac$  the media surface area. So, we consider that the volume is not the ultimate thing we have to consider the surface area which is more

important when we do the modeling in when we design any RBCs. So, in case of wastewater temperature above 13 degree Celsius this  $k_p$  value is equal to always  $k_p$  20 degree and also  $k_t$  of  $t$  value is also always 20 around almost the same as  $k_t$  at 20 degree Celsius, but if it is below 13 degree Celsius this value will we have to find out this  $k_p$  value by  $k_p$  20 into 1.018 into to the power  $t$  minus 20 this  $t$  is the target temperature ok.

$$(K_p)_T = (K_p)_{20} \text{ and } (K_t)_T = (K_t)_{20}$$

$$(K_p)_T = (K_p)_{20}(1.018)^{T-20}$$

$$(K_t)_T = (K_t)_{20}(1.018)^{T-20}$$

According to the Grady's model the second it is a it is a second order model which is used for estimation of surface area required for RBC.

So, the equation it can be used for prediction of the effluent BOD which is later converted into SI units by Gradiaton in 1999. The paper is also given in the reference section I would suggest you to go through it.

$$Ln = \frac{-1 + \sqrt{1 + (4)(0.00974)\left(\frac{A_s}{Q}\right)S_{n-1}}}{(2)(0.00974)(A_s/Q)} = \frac{-1 + \sqrt{1 + (0.039)\left(\frac{A_s}{Q}\right)S_{n-1}}}{(2)(0.0195)\left(\frac{A_s}{Q}\right)}$$

This equation is very important this  $Ln$  is equal to minus 1 plus this  $Ln$  is not logarithm it is the soluble organic matter concentration in stage ok, in at a particular stage  $n$  in milligram per liter. So, for each stage you can calculate the soluble organic matter concentration easily by this equation ok, that minus 1 plus root over 1 plus 0.39  $A_s$  by  $Q$  into  $S_n$  minus 1 by divided by 2 into 0.0195  $A_s$  by  $Q$ . You remember this equation it will be very useful for you ok. Since the only soluble BOD is used in this model for estimating the effluent BOD after secondary clarifier appropriate BOD 5 to BOD ultimate should be known to us ok. In general the value if you it is not given to you take the value of 0.68 for sewage. For first stage the organic loading rate should be kept equal to or less than 12 to 15 gram of BOD 5 per meter square per day to determine the first stage disk area and the effluent BOD 5 concentration from this equation 5. Another important model is the Clark's model where we can get the get an idea about the removal rate of organic matter in RBCs.

$$\tau_a = \frac{\mu_{max}}{X_a} / Y_a \quad (6)$$

So, how we can calculate this like how we can determine it from the effluent and the effluent conditions and the microbial growth rate it is with the equation given in equation number 6.

$$\tau_a = \left(\frac{K_c}{U_{max}}\right) \cdot \left(\frac{A_s}{QLn}\right) + \left(\frac{1}{\mu_{max}}\right) \quad (7)$$

Also we have this kinkannon and the Stover equations Stover model. So, this model represented the in the equation 7 as you can see it is integrates the substrate removal rate over the disk area of RBC.

And kinetic model it express that in terms of surface area of disk as presented in the equation 8.

$$\frac{Qx(S_0 - S)}{A} = K.S \quad (8)$$

So, this is also quite famously used this kinetic model  $Qx(S_0 - S)$  divided by  $A$  whereas, the  $Q$  is the flow rate like  $S_0$  is the influence substrate concentration  $S$  is the effluent substrate concentration and  $k$  is the reaction rate. So, this wastewater with the variable influent organic matter concentration this kinetic equation can be modified as equation 9 and where  $kS$  by  $S_0$  term will be introduced.

$$\frac{Qx(S_0 - S)}{A} = K.S/S_0$$

So, in case of like you know the maximum BOD removal rate under any given conditions for multiple contactor when we use please use the following equation  $S$  by  $S_0$  is equal to  $1$  by  $1 + k$  into  $A$  by  $Q$  to the power  $n$  ok.

$$S/S_0 = \left( \frac{1}{1 + K \left( \frac{A}{Q} \right)} \right)^n$$

If you have a  $n$  number of contactor. So, in case of process operation what we need to check to be maintained in like you know for proper operation of RBC we have to find out the we have to we have to know the peak organic load load ok. We should design the system in such a way that it should be less than twice the daily average and otherwise improve the pre treatment or expand the plant if it is a organic load is more than 2 ok. It has to be always less than twice the daily average ok. Peak hydraulic load it should not be more than thrice the daily average ok. So, it should be always less than the thrice of the daily average the peak hydraulic load at any point of time otherwise the use the flow equalization before the RBC to maintain the flow rate maintain the hydraulic load.

Desired range of pH should be 6.5 to 8.5 for secondary treatment and for 8 to 8.5 for nitrification ok. Exposure to pH below 5 or above 10 can be sloughed can completely sloughed of the biomass from the disk and it will completely disrupt the complete scenario. Temperature less than 13 degree Celsius will reduce the efficiency of RBCs to try to maintain it somewhere between 20 to 25 degree Celsius which is quite optimum

ok. The advantages of RBCs as I was mentioning for the from the beginning that it is a simplicity of the operation, the adaptability, less land use and a maintenance requirement and high volumetric activity is possible.

The use of RBCs for biological wastewater treatment is to remove the organic matter and ammonia has been well established for the last 3 decades and the process has been adapted for removing other nutrients like you know phosphorus as well. The control of disk immersion will be used for to stimulate the denitrification. Let us do let us do one numerical now. So, it will be easier for us to you know understand the concept of design of RBC. So, we are asked to design a staged RBC treatment system for wastewater with a raw and treated effluent characteristics given in table number 1.

You see in the table number 1, the flow rate is given primary effluent what is the flow rate 4000 meter cube per day ok. BOD ultimate is given as 140 gram per meter cube or milligram per liter ok and treated one is 20 gram per meter cube. BOD 5 is 90 gram per meter cube or and target effluent is only 10 gram per meter cube. TSS target is also given as 20 milligram per liter or 20 gram per meter cube and primary treatment effluent that we are receiving or having 70 gram per meter cube of total suspended solid ok. So, we can easily determine the shaft required for the first stage.

To start with we can have the we can consider a BOD loading of 15 gram per BOD per meter square per day on the first stage. So, what will happen? So, the total BOD load we know 4000 meter cube per day multiplied by 90 milligram per liter 90 gram per meter cube the BOD 5 you will get the total BOD load 90 3,60,000 gram of BOD per day. So, now, this 3,60,000 gram of BOD per day divided by the 15 gram per the loading rate we if you know the BOD loading rate you will easily get the disk area that you require which is coming as 24000 square meter. Now, using the surface area per shaft of say like 9300 square meter per shaft which is quite common. So, total number of shaft that you require 24000 divided by 9300 coming as 2.6 or say like 3 parallel RBCs are required. So, if it is 3 parallel RBCs are required. So, what will be the surface area per shaft 24000 divided by 3 that means, 8000 square meter per shaft that is more than enough you know or you can have the 3000, 9300 only and based on that only you can you can extend the size also like you know which will actually give you additional free board over the BOD loading rate ok, 9300 into 3 also you can do. So, it will be somewhere around 24 and 27,900. So, that much of like you know that much of excess capacity of your like that means, that excess area is actually kind of acting as a free board for your BOD loading rate like to make sure that your BOD will be completely consumed what like completely converted into the target BOD load. So, in general if it is provide select 3 number of trains with 3 stages of each train of this this RBCs what will happen this arrangement will give us a flow rate of around 1333 meter per day

because total flow is 4000.

So, if you divided into 3 different train each train will have a flow rate of 1333.3 meter cube per day. So, how we can calculate the soluble BOD at each stage? Suppose in S stage 1 you know the equation this  $S_1$  is equal to  $\frac{-1 \pm \sqrt{1 + 4 \times 0.00974 \times A \times S_0}}{2 \times 0.00974 \times A \times Q}$ . So, from there if you replace this equation you know the  $A \times S_0$  is given what is the  $S_0$  value 90 milligram per liter or 90 gram per meter cube BOD 5.  $A \times S_0$  is also known to you because  $A \times S_0$  is a 9300 square meter of total area and  $Q$  is 1333.3 meter cube per train ok. So, if you divide it you will get 6.97 day per meter day per meter. So, this value if you in if you replace it in that equation you will get the  $S_1$  value as 29.8 gram per meter cube. So, from 90 it comes down to 29.8 after the first treatment.

So, you need to go for another treatment train. So, similarly if you use this 29.8 in the same again you replace this equation instead of  $S_1$  you find out the  $S_2$  and you instead of  $S_0$  value you put the  $S_1$  value in this equation you will get the final  $S_2$  value as 14.82 and the same way if you repeat it for  $S_3$  you will get the value as 9.1 gram per meter cube which is less than the 10 gram per meter cube. So, that means, your design is satisfying the meat of the regulatory body which is 10 gram per meter cube of BOD as you can see in this table ok.

So, that is that demand is made. Now, what will happen to the organic and the hydraulic loading rate ok. In case of organic loading rate you can easily find out the organic loading rate means what total number of food that is coming per square meter of say like area or surface area of your reactor. So, total food is how much the flow rate multiplied by the BOD if you divided by thing 3 number of train 3 trains are there. So, 3 into 9300 meter square.

So, from there you will get the total organic loading rate as 12.9 of BOD 5 per meter square per day which is within the 10 to 15 meter cube kg gram of BOD per meter cube per day. So, meter square per day. So, it is fine. Then the overall organic loading rate overall organic loading rate also you can find out by the BOD ultimate.

What is the BOD ultimate here? 140. So, 140 if you divide multiply the inflow rate multiplied by BOD ultimate. So, which is like the ultimate BOD of your inlet inflow and waste water. So, 4000 into 140 divided by 3 into 9300. So, which is coming as 21.1 gram of BOD ultimate per meter square per day ok. And hydraulic loading rate per shaft also we can calculate. So, total inflow rate is 4000 meter cube per day divided by 3 into 9300 square meter. So, total is 0.143 meter cube per meter square per day. We can also estimate the volume of each RBC tank how like considering the tank volume

requirement of 0.0049 meter cube per meter square of disk area. So, total 9300 square 300 square meter of disk area that means, for like you know total volume the volume will be 9300 plus 0.0049 that is 45.6 meter cube for each disk.

So, now providing a liquid depth of say 1.5 meter the area required is 45.6 divided by 1.5 equal to 13.38 square meter. So, if you have a rectangular score section of your of your area I mean like you know say like of your tank.

So, you can have a width of say 4 meter and length of 7.6 meter and that is it you have your design ready ok, the tank design you can easily calculate ok. So, next important technology that we are going to discuss about it is the hanging sponge reactor. So, this hanging sponge reactor from the name itself you can understand it is we are using the sponge as a media. The in case of down flow hanging sponge reactor or DHS in short we call it is a modification of trickling filter system equipped with a sponge as a media and it is developed as a very low cost aerobic treatment systems and is used for is used in different effluent treatments plant in worldwide. So, it can be operated without aeration or with a very low aeration requirement as oxygen is naturally getting dissolved in wastewater in this kind of systems.

And this sponge media it supports a large amount of biomass as well as high microbial diversity on the surface and inner section of sponge media. This biomass is retained both inside and outside the sponge media and because of that this nitrification and denitrification both the process can occur in this kind of systems. In general the media may provide aerobic environment near the media surfaces where the nitrification reaction portion occurs and anaerobic or anoxic environment deeper inside the media because of that the denitrification process can also occur in this kind of systems. And also high microbial diversity can be achieved in this ecosystem and with a extremely long food chain and reduces the production of excess sludge because all the parameters all the consume like you know pollutants are been consumed and it converted into some amount of some more other kind of biomass and they can create a chain of ecosystem and which will actually there will be a consumer you know there will be one prey one consumer type of relationship and because of that higher amount of you know the consumption of pollutant is possible with a very less sludge generation. What are the factors that can affect those DHS? The sponge pore size, the pH, loading rate, contact time and the bulk volume of the sponge that you are supplying.

What are the major mode of operations without effluent recirculation and with effluent with recirculation of effluent and anoxic compartment to ensure the denitrification further you know. In one case study done in by Masdar et al 2000 and eventually he is the first one I think he did it this kind of system they designed this kind of system in way

back in 1983. So, in this hanging sponge reactor he has designed and he has showcased that it can reduce the total COD removal of up to 60 percent and total BOD of almost 92 percentage with a TKN total general nitrogen removal of 57 percentage is possible in a with an HRT of as low as 2 hour which is quite high actually considering this very less HRT that is prevailing there ok. The design you can see this this points like a waste water is introduced from this top it is a down flow arrangement there are like this clean sponges are there. The sponges are actually used for you know this bio-media generation from and then it also kind of act as a filter media then from the bottom the effluent is collected.

And it has a certain and in terms of certain slope to collect the sludge as well I mean like the sludge which is which can easily collected from there as well. And it can you can directly collect the sludge as well as waste water to the next secondary clarifier or you can treat it there also like you can have a certain you know height. So, the sludges will be collected from the bottom and the water will be collected using a baffle and from the baffle and then the water fresh water almost the effluent with the devoid of all this organic matter and nutrient can be collected after that. Perfect. So, we understood we get to know about two very interesting technology first is rotating the rotating disk biological contactor as well as the hanging sponge reactor.

And we also understand the how it works the RBC and there we also get to know do one numerical to understand its performance how we can calculate the like you know different parameters design parameters of a rotating disk biological rotating disk biological contactor systems. We also understood a understand about the hanging sponge reactor how it works and its normally successfully used in treating USBF fluids municipal waste water and industrial waste water. And it has a capacity to be a very futuristic system for waste water treatment plant because it reduces the time required this as you can see in the sponge reactor this hanging sponge reactor down to hanging sponge reactor it requires only 2 hour to remove the BOD of up to 92 percentage which is a quite a good success. Still the research is going on in this technologies to you know to be used for addressing the environmental concerns in the water treatment control systems and all. So, these are the references that we can follow and thank you so much I will meet you in the next next video.