Wastewater Treatment and Recycling
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Lecture – 50
Wastewater Treatment Systems: SBR and SBBR

Hello everyone. So this week we have been talking about some of the Wastewater Treatment Systems as a whole. And the last couple of lectures we did talk about the basic conventional systems; how they are assembled how they are unit sequencing is made. And in the last class we did talk about the wet land systems.

So, this particular class we are going to discuss few kind of relatively newer system; when we compare them with the conventional activated such process or that way they are not that new though. So, eventually we are going to talk about sequencing batch reactors which is typically pronounced as SBR. So, SBR and there is another modification to SBR kind of which is SBBR sequencing batch biofilm reactors. So, this is what we are going to discuss in this class.

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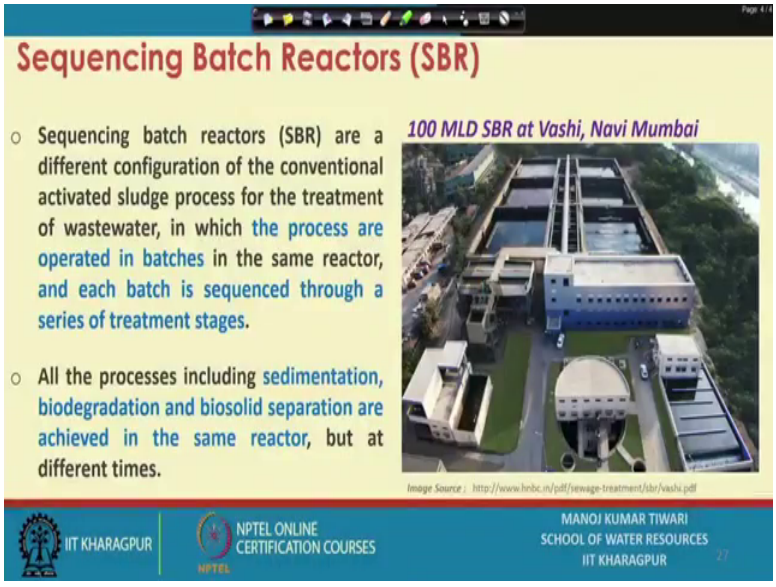

So this sequencing batch reactors or SBR, what typically we call are kind of a different configuration of the conventional activated sludge process. So, what happens in a conventional sludge process, we have the waste water coming in after a primary sedimentation or a primary settling tank. And thereafter it eventually goes to the next

stage which is your aeration tank. So, aeration is provided oxygen is provided in that aeration tank and the kind of your carbonaceous BOD or CBOD degradation takes place over there.

So, deduction in a CBOD is achieved in the aeration tank; where your micro organisms decompose the organic matter. And that is how COD or BOD is reduced and a sludge mass is produced. So, that sludge mass or what we call is mixed liquor so water along with that because it is a suspended growth process. So water long with those sludge mass is taken to secondary sedimentation basin. Secondary settling tank which we typically call.

And from there it is separated and effluent comes out. So, there are different processes of primary settling, then degradation of organic matters, in aerated tank, then the removal of the bio mass in the secondary settling basin. So, these different processes takes place at the different units or different stages; in a conventional activated sludge treatment systems. However, in a SBR which is again works on a similar principal, but in this the processes are operated in a batch mode; so not as in a conventional activated sludge which is usually a kind of continuous process.

Here the processes are operated in a batch. So, one batch of the water will be kind of processed for one step, and then it will be same batch of water is processed for second step, third step, that way. So, it usually done in a batch that is why we, we call it a batch reactor. So, it is done in a batch and then each batch is sequenced through a series of treatment stages ok.

And that is how the name has come sequencing batch reactor because these different batches are sequenced in kind of a series of various treatment stages various removal steps. So, that is how we cal these sequencing batch reactor or it is also refers as sequenced batch reactor. So, all the processes including sedimentation, biodegradation, bio solid separations, are all achieved in the same reactor, but at different stages and at different times.

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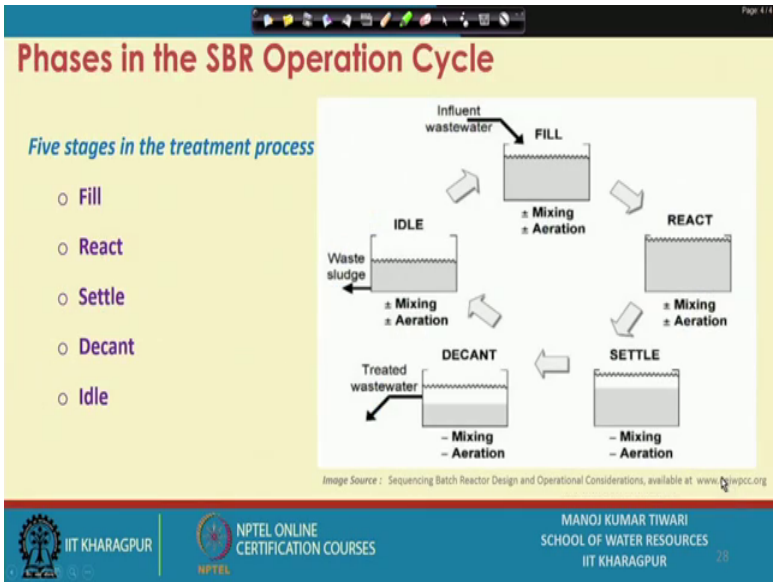

So, what happens there are five different stages in a typical sequencing batch reactor operation cycle ok? So, these stages if we see so these are stages where the first at first filling takes place ok. So, effluent comes in a tank in a batch tank where the first effluent is fixed. Now this filling can be with or without mixing and without aeration. So, they have the different attributes the role of mixing and role of aeration have the different kind of attributes in this filling system so that is typically the first system filling.

Then it goes to the second step which is react ok. So in the second stage where the reaction takes place there also we can kind of ensure what degree of filling or what degree of aeration we want whether we want or not. So, again it is a condition specific so that becomes your typically first stage this becomes your second stage. Then it goes to third step which is settled; so in the third step this settles. Now since, we intend to settle the biomass grown in the system, because these also typically a most usually an aerobic decomposition ok.

Although, an aerobic condition also prevails we will talk about that how it prevails, but then in the third stage. The mixing and aeration both have stopped we do not need mixing we do not need aeration, because we want the biomass to settle. So, if we provide aeration or mixing it is going to create disturbances in the system and the biomass is not eventually going to settle in the system. From there we get to the fourth stage; which is

decant so in decant, what happened that treated waste water is decanted so we will get the treated waste water ok.

In the decant process here also because we want to like the sludge mass to settle what. So, ever the sludge mass was here in this thing to settle, and then we want to decant the effluence or we do not want mixing or aeration in the decant stage as well. And from there after it eventually goes to idle stage which is the next stage of kind of fifth stage of SBR cycle. So, here again the kind of sludge's kept in idle stage we may or may not provide mixing and aeration and then part of the sludge's wastage from here.

And again from idle again it will go to the next stage from this sludge we will get a new batch of the waste water so this is your is going to be a new batch of waste water. So, that is how the operation in a SBR takes place; like the water goes to a fill system, then react, then settle, then decanted. And the sludge mass is kept in a IDLE condition part of sludge is wastage and then the new batch is filled in this tank ok. So, that is how this is kind of a cyclic process this is the entire operation cycle of a typical SBR. Typical sequencing batch reactor system where it the water goes through all these different stages and so is the sludge produced over there.

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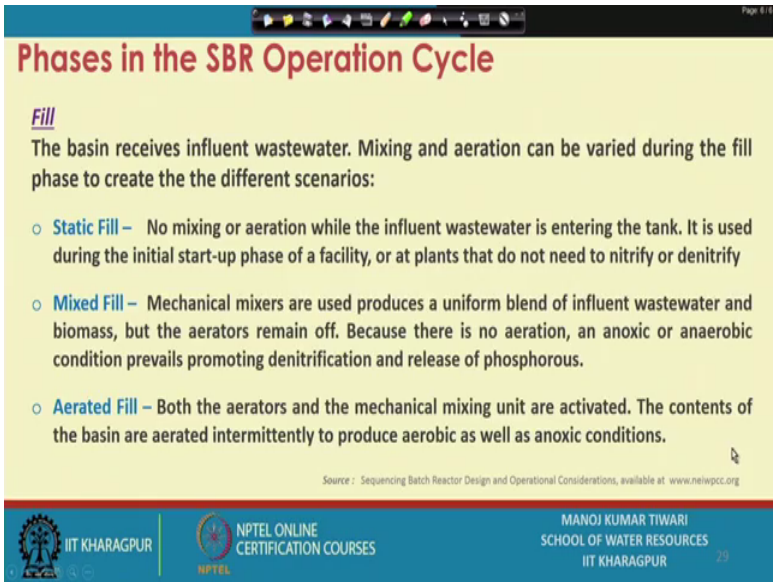

So, if we see these different cycles in the first cycle which is the filling ok. So, in the first cycle there is the fill is just the basin your batch basin will receive the in front waste water ok. So, again as you are saying mixing and aeration can be varied in this filling

cycle ok. We may have a different scenario depending on the extent of mixing and aeration that is being provided in the basin. So, there is a condition static fill in static fill there is no mixing or no aeration ok. So, both mixing or aeration is not allowed ok.

So, we do not have mixing or aeration in the static fill condition. So, what happens that effluent waste water is just entering into the tank? So, this typically is used when we go for a startup of the facility, ok or if we want to operate a plant where we do not need to go for nitrogen removal. So, we do not want the nitrification and denitrification process to takes place; that is not our idea. Then we can go for a static fill without providing any sort of mixing or aeration in the filling tank or in the fill system ok.

This may also be used when like the there is no adequate inflow of the waste water so in that condition also we may go for static fill condition. Then there is another scenario which is mixed fill condition ok. So, under this mixed fill this mechanical mixers are provided and they are operated the idea of these mechanical mixer operating this mechanical mixer is because, we are getting effluent waste water from one end. And then we are kind of having the sludge mass in the system.

So, the idea of this mechanical mixer is to homogeneously distribute this sludge mass within the waste water system. So, it is basically kind of uniformly blend the waste water and the biomass. So, that is what is the basic idea of the mixed fill where, there are mechanical mixers are used, but the aerators remained off we do not go for operating aerators. So, idea here is not to aerate the system just insure the mixing of the biomass uniformly within the domain of the waste water.

So, why we do not need aeration the aeration like is avoided to kind of intentionally produce an anaerobic or anoxic conditions in the system. So, when because waste water usually have very low (Refer Time: 10:40) and if you not providing aeration. So, the (Refer Time: 10:44) remains dissolve oxygen remains very low and the conditions become septic kind off anoxic like anaerobic will prevail. Now what is the point of this anaerobic and anoxic condition is if you recall the discussion in the advanced treatment processes what we had last week.

So, for the removal of the nutrients say; nitrogen and phosphorus, we need the anoxic condition at some stage. The denitrification will only take place when there anoxic condition. And similarly for the removal of kind of phosphorous as well so how are

phosphorous biological removal of phosphorous. We need to provide anoxic conditions so that the phosphate can be released in the system. The phosphorous can be released in the system which later will be accumulated in the aerobic conditions. So, if we intend to remove the nutrients we need to kind off ensure anoxic condition at some stage.

Although, for nitrification denitrification purpose the anoxic condition is better placed if it is done after nitrification; so once the nitrification is done then we go for denitrification, but we have the other system as well where we can first like if there are like existing nitrate or those kind of thing in the system so we just go for the denitrification process in anaerobic system. And later on after nitrification whatever nitrate is done that can actually be recycled also if it is needed. Or we can create anoxic condition in the later stages as well as we will be discussing.

So, what happens that: a basic like kind of in the absence of aeration the anoxic condition or anaerobic condition will prevail. And that will promote denitrification as well as release of the phosphorous in the system so that is the advantage of kind of mixed fill. And then the third type is aerated fill where both aerator and as well as your mechanical mixer units are activated both remains on ok.

So, the content of the basins are aerated intermittently to produce aerobic as well as anoxic conditions. So, both thing actually can be achieved. So, we may keep both on or we may at times keep the aerator off. So, what it will do? It will produce a cycle of aerobic and anaerobic conditions ok. A cycle of anoxic and aerobic conditions and that will kind of trigger the nitrification and denitrification process if you want the removal of the nutrients of the system so that is the fill stage.

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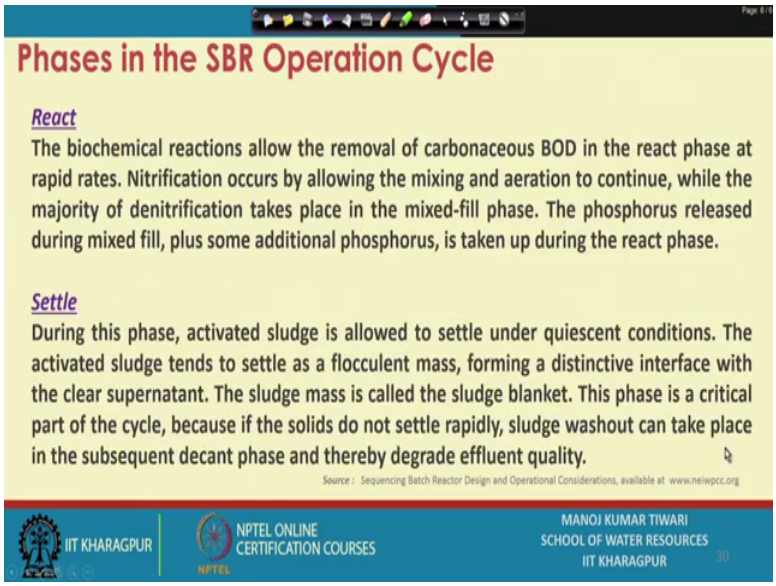

Then we go to the next stage which is react so react stage is the typical stage where these biochemical reactions takes place that is why we call it react. So, those bio chemical reactions which allow the removal of carbonaceous BOD; the major objective of the waste water treatment is the removal of the dissolved organic matter or soluble BOD that way. So, those organic matter which kind of produces this carbonaceous BOD are removed ok.

In the react phase and this removal takes place at a quite rapid phase as appose to the conventional activated sludge process. Now why it reacts rapidly? Because what happens in conventional activated sludge processes those are typically kind of continuous flow system. So, what happens that: we are receiving the effluent continuously in the system and that keeps on diluting the BOD and that is how we get a net BOD in the system. But in batch processes since there is no new inflow so no kind of, no that sort of hydrolic or organic loading rate in between the process no variation in the hydrolic.

And organic loading rate and that is how the bacteria kind of quickly degrades the carbonaceous BOD at restively rapid rates. Nitrification also occurs by kind of allowing the mixed mixing and aeration to continue ok. While the majority of denitrification takes will be happening at the prior stage so we already have kind of a stage where denitrification we said that in the mixed fill particularly or in even in the case of aerated

fill we can switch off and switch on the aerator, so that way producing a cycle of nitrification and denitrification.

So here, because it is a kind of we need to go for the removal of the soluble BOD which is done in aerobic conditions. So, we have to keep kind of aerators on for large period of time and that is how the removal of BOD and nitrification takes place in the system. The phosphorus which has been released during the mixed fill or earlier anaerobic stages ok. So, that will again get accumulated in the cell mass as we discussed in the biological phosphorous removal steps ok.

So, that phosphorous which has been released or if there are some additional phosphorous in the system will be taken up during this react phase. So, that is how it ensures the removal of nutrients as well and removal of the CBOD. So, after react we go next to the settle phase. During this phase the activated sludge is allowed to settle under kind of question conditions ok.

So, the activated sludge here will settle as a flocculent mass and that kind of frames distinctive interface with the clear water supernatant. The sludge is also called as sludge blanket ok. Now this phase is kind of critical part of the cycle because if we are not able to settle the solids properly then it goes to the next stage. And we may see the biomass wash out or sludge washout taking place in the kind of next decant phase which will be following the settle phase.

And thereby kind of the quality of the effluent will be degraded because we will have biomass coming in the effluent water. So, that is why it is kind of very high importance to let this sludge settle properly and we are just able to decant the supernatant in the next phase. We do not allow this sludge to come out to the next phase decant phase and from where if we are decanting the supernatant if we are decanting the water. So, sludge also comes out with that that condition is totally undesirable; we do not want that condition to happen ok.

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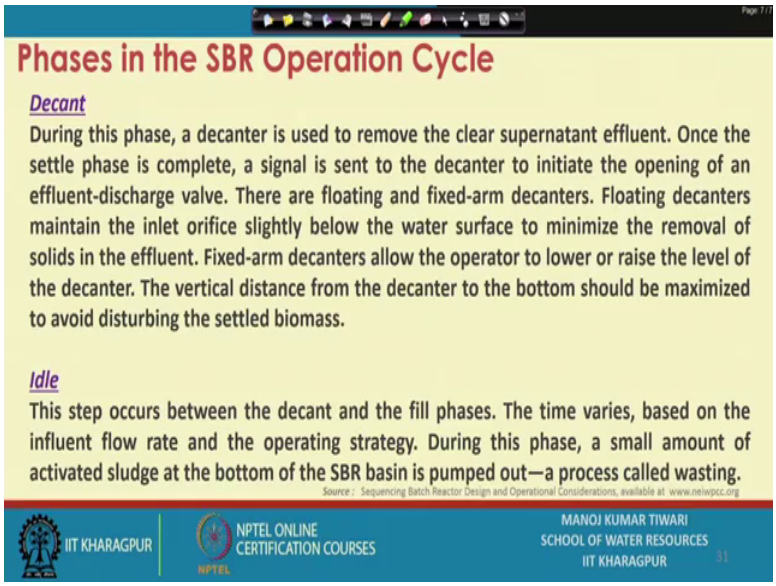

Now, the next cycle is the decant phase. So, during this decant phase a decant is typically used which is kind of set or given the objective of removing the clear supernatant effluent ok. So, the treated waste water is separated from the sludge mass in this decant stage. So, once this settle phase is complete, this is the next step after the second phase; once the settle phase is complete a kind of signal will be sent to the decanter to initiate the opening of the effluent discharge valves.

So, what happens there are different like two different types of decanters typically are used there are a floating arm decanter fixed arm decanter. So, these floating decanters maintain the inlet valves slightly below the water surface because they are floating. So, as your water surface decreases these decanters will basically be able to kind of the level is maintained just below the water surface. So, that the water actually goes through that (Refer Time: 18:43) to the decanter and from there it is taken out ok.

While the fixed arm decanters allow the operator to lower or raise the level of the decanter as a whole it is not floating that way it is just fixed arm, but still we can have the we can change the levels whether little lower or little upper that way. So, it is operator needs to basically change the level of decanter here. Whereas floating it is already on the water surface and the level of decanter is little below the water surface.

So, what so ever is there will actually be a coming collecting in the decanter and through that it will be collected to the final effluent channel. So, another point that one needs to

see because many times this come (Refer Time: 19:30) may also come at the top. So, your decanter should not decant that is come and froth. So, there layers has to be prevented and protected or removed separately and they should not come along with the effluent channel ok.

Another criteria that one needs to see is that the vertical distance between this decanter, and the bottom of the tank should be sufficient enough should be good enough to avoid disturbance in this settled biomass, because in the just earlier phase we have the settle phase where the biomass settles or the sludge settles. Now if we take our decanters to a low level it may create the disturbances in the biomass level. So, that biomass will again come in the re-suspention and it will wash out with the effluent so, it will go through the decant system that we do not want.

So, that is why we want to maximize the distance between the decanter and bottom of the tanks or this sludge level with an idea that minimum disturbances are there to this sludge level and we have to have a sufficient distance maintained always ok, so because otherwise it will kind of will create problem. So, conceptually it is better to the decant volume like because we want eventually like the water which is coming in to the system has to leave the system. So, decant volume over a kind of static period of operation should be same as the inlet volume.

So, the amount of the water which is coming the same amount of water should be leaving the system through this decant system. The last stage is the idle stage so this step occurs between decant and fill phase ok. So, we have water coming in the fill phase and we have taken water out at the decant phase. So, in between we keep an idle phase this kind of time in this idle phase varies on the influent flow rate and the operational strategy as well. And the idea of this phase is that small amount of activated sludge at the bottom of SBR basin is pumped out which is the sludge wasting. So, excess sludge which has been produced will be pumped out and minimum sludge level is maintained.

And your next batch of the water or next batch of the raw sewage raw waste water or raw industrial effluent, whatever we are willing to treat will directly come into the like a tank in a fill stage after this idle stage. So, that is how there are like a that is how we again go back to the cyclic process. So, we after idle keeping this system idle for

sometime we again go to fill in this and that is how our cycle or cyclic process continues further.

So, this is what happens in an SBR operation cycle. So, now, you see the process are essentially same we are getting the removal of c BOD through your typical micro aerobic degradation in the presence of air which we are getting in the conventional activated sludge process as well. We are getting the removal of nutrients through anaerobic aerobic maintenance processes which we may get in a kind of modified activated sludge process for nitrification denitrification either single stage or combined stage and phosphorus removal also if you intend to achieve that.

So, a those process are same in like we have a secondary settling basin, here we are having a kind of a settle phase and then a decant phase. So, that does the job of your secondary settling basin in the same batch in the same reactor ok. And we do not usually need the primary settling tank over there because what. So, ever is coming we are anyway providing a settling basin or settling phase and we are anyway loading water to the existing sludge mass that way.

So, we may even at times primary settling basin is provided though before SBR, but it is not mandatory we can have a SBR direct coming direct operating with the effluent coming after the great removal systems or great chambers. So, that way we can actually remove the requirement of even primary settling, we can remove the requirement of the biomass separation; that way and if all the processes can be done in the same time through this SBR cycle.

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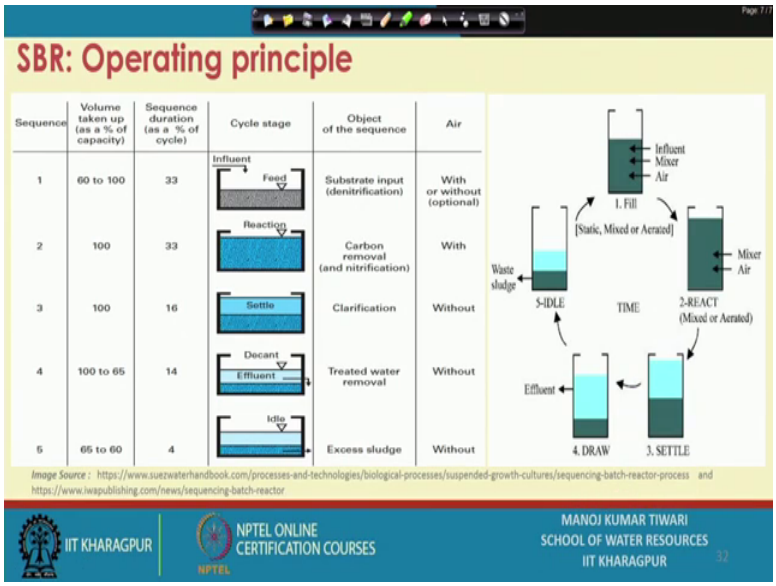

So, if we see the operating principle, o we have various sequences ok. And then that volume taken up as a percentage of the capacity, so the different volumes this sequence durations ok. And these are the cycles influent coming in this fill cycle, then reaction, then settle, then decant, and then idle cycle. The objective here is to (Refer Time: 24:40) input ok.

And denitrification here it is carbon removal, and nitrification in this settle phase it is clarification, in the effluent phase it is treated water removal from this things. And in the idle phase it is excess sludge removal for aeration requirement here it is optional so, with or without it can happen. Here for the removal of (Refer Time: 25:04) BOD we must need aerations. So, that will be needed these off course do not need aeration.

So, that is what is the requirement and principles and that is how the like we may have influent mixer air to fill stage. Then go to the react stage, then go to settle, then draw a decant or whatever we call that. And finally, to the idle stage where waste sludge will be separated effluent will be separated from this stage ok. And effluent inters in this stage so that is how the operation of an SBR typically takes place.

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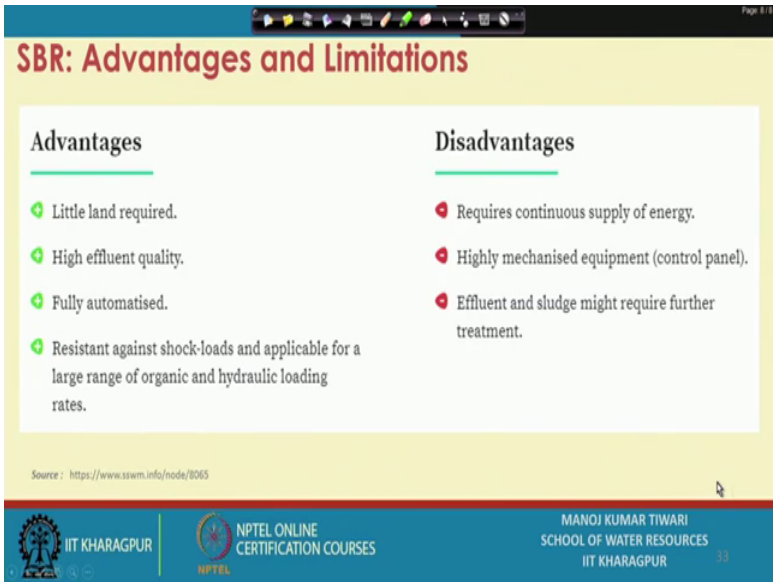

So, this is getting more and more popular SBR's ok. There are quite a few installations across the world, several installations in India as well ok. There are I think there are more than 4- 5 SBR plants running in the Noida itself. There are various SBR systems running in the different cities ok. Just in the first side of this lecture you saw then SBR at Navi Mumbai, Vashi so it is kind of getting more popular. And particularly for the smaller capacities it is far more popular, but for bigger capacities also like that Navi Mumbai is one is 100 million litres per day SBR which is quite big of size.

So, the major advantage there is little land required because we do not need separate to these things as done in a batch processes. So, this is land requirement will be lower there is effluent qualities better. We can have fully atomized SBR plants so everything is controlled with the (Refer Time: 26:46) those kind of things that can be actually even conventional system these days fully atomized though. And then it has the resistance against stock loads and kind of applicable for large range of domestic and hydraulic loading rates.

The disadvantages it requires continuous supply of energy, there is a highly mechanized equipment, the control panel. We have to kind of let the control the wall a control the decanter arms control all those things. So, that way like quite sophisticated system and the effluent and sludge might require further treatment at stages if it needs to be basically reused for say. So, we may need to go for a next stage of treatment for the removal of

dissolved metals or those kind of things which are not removed at this stage so that is what is typical SBR system.

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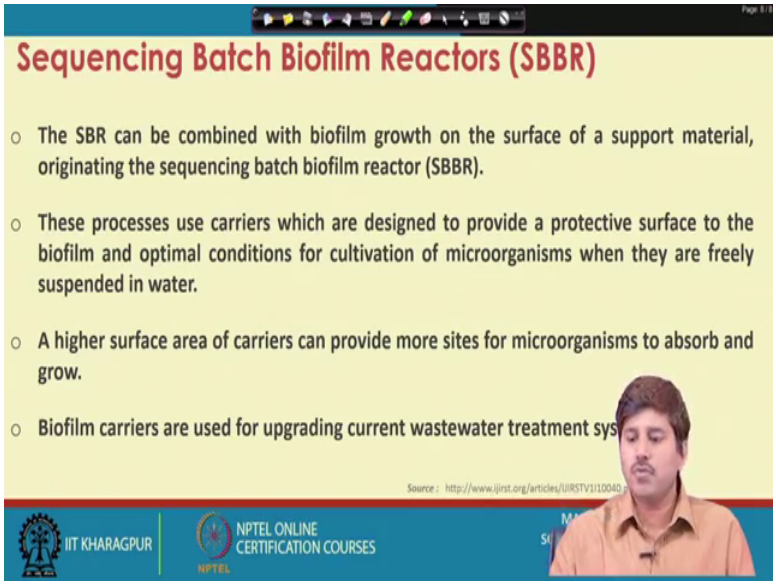

Now, up gradation of this SBR is the sequential batch biofilm reactors which are SBBR ok. So, these SBBR can be like sort of combined system where the SBR and biofilm growth takes place together. So, what happens in SBR we have a suspended growth system right the water is comes in a tank, and then we have make certain radiators. So, growth takes place in a suspended fashion there is no media. So, there is no possibility of biofilm growth ok.

The bacteria remain in the suspension in the SBBR which is the sequential batch bio film reactor. So, what is done here that we provide additional support material or support media which is generally kind of inert media plastic or those kind of thing and let the biofilm grow on this media ok. So, we have a bio film growth in addition to the operation of the SBR. So, from onset from outlook it will look similar like SBR system, but we have additional media put in the reactor which allows the growth of the biofilm on the surface of the media on the surface of the support material.

So, these processes use these carriers these media carriers they are kind of designed to provide a protective surface. So, nonreactive surface where the bio film can grow, and it will give you an optimal condition for this cultivation or micro organisms or for the growth of bio film ok. And these media are then freely suspended in the water ok. So it is

not a like packed bed system completely we just have media put in the water so this media also basically remains in suspension.

So, that way a higher surface area is provided, because these carriers will have the media that that we are providing in the system will have the surface area over which the biofilm can grow or the micro organisms can grow. So, that way there is a higher surface area for the micro organisms there are more sites available for micro organisms to absorb there and get grow. So, these bio film carriers are used to kind of upgrading the current waste water system as well.

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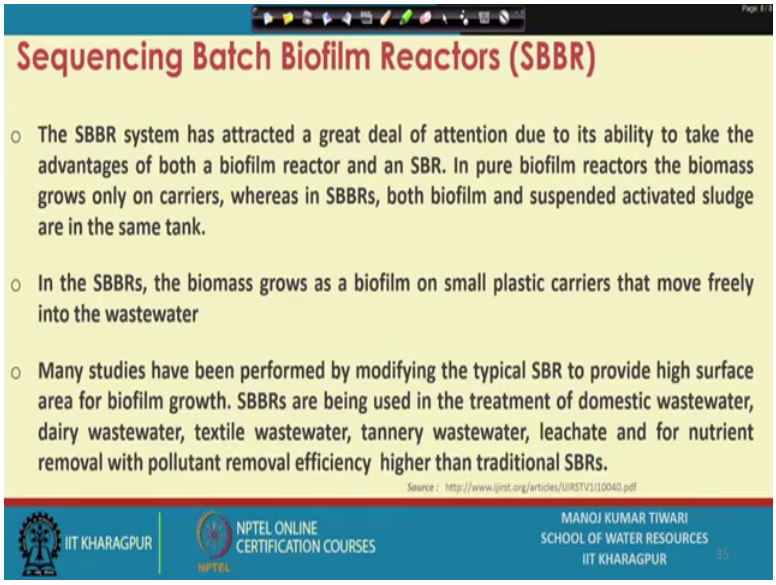

The existing SBR system or those kinds of systems can also be up graded that way. So, if we see the like these SBR's systems have attracted great deal of attention due to it is ability to take the advantages of both biofilm reactor and basically your conventional SBR or traditional SBR. So, traditional SBR is already there in addition we are having growth that too in a suspended system ok. So, that way in like pure biofilm reactors the biomass grows only on carrier where as in SBBR bio film and suspended activated sludge are in the same tank ok.

So, there is bio film there is suspended growth system so that way these SBBR are quite kind of efficient than the conventional or traditional SBR system ok. These carriers freely move in the waste water. So, they also remain in the suspension so in a way that bio film is also actually in the suspension itself. So, there has been several studies

performed by modifying the typical SBR's to provide high surface area for biofilm growth.

And these are kind of getting like these SBBR's are being used for treatment of domestic sewage, daily waste water, textile waste water, tannery waste water, leachate, and even the nutrient removal. And the pollutant removal efficiency are typically observed which are higher than the traditional SBR systems. So, these are the that that is how the your sequential batch bio films reactors operate which is just an extension or a little modification with the additional bio film grown on a suspended plastic carrier or plastic medias in a SBR system.

So, with this we conclude this lecture. And in the next class then we will be talking about the membrane bio reactors and moving bed bio film reactors in the next class. So, see you then.

Thank you.