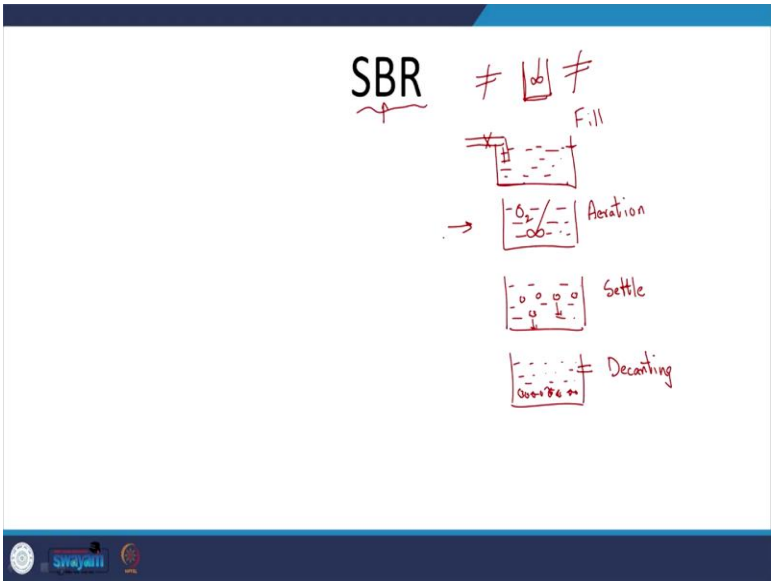
Water and Waste Water Treatment
Prof. Bhanu Prakash
Department of Civil Engineering
Indian Institute of Technology- Roorkee

Lecture -23
Sequencing Batch Reactor

Hello everyone welcome back to the latest lecture session. In the last session we started talking about different variations of activated sludge process. In that context we looked at our briefly discussed sequential batch reactor.

(Refer Slide Time: 00:40)



This is something that is now being widely adopted in India sequential batch. So sequence in sequence we have different batch reactors what's a batch reactor and now a closed system that is continuously mixed or well steered let us say but the key aspect is there is no flow coming in no flow going out so it is a closed system. So why do we say sequential batch so for the in the same tank which we are going to look at now initially they will you know pump in the not pumping fill the tank with wastewater.

So they will keep filling it with wastewater. So once the relevant level has been reached they will stop the flow and then what are they going to start? They are going to start mixing and providing oxygen. So you are going to have aeration. So during this aeration you know the microbes are

going to degrade the relevant waste and their substrate for their own cell synthesis and energy requirements.

After this, they are going to stop the aeration and now what do you have you have flocs. These microbes that we promoted by maintaining the conditions and these flocs will settle down so in this case you have setup you will promote settling. And afterwards after some time you will have all these or most of the flocs settle down with some filamentous microbial or microorganisms. You will have clear water at the top this clear water you will remove. So decanting it is called decanting.

Each process more or less we can say is a batch reactor. So sequential batch reactor so that is something to keep in mind again better efficiency and I think we talked about this earlier let us not go back there. And then obviously lesser area requirements and again looks like especially in India where you are not sure when the power is going to you know be available and not SBR is a better process because you have greater flexibility let us see. Again we are going to look at the IIT Roorkee plant let me directly switch over there.

(Video Start Time: 03:03)

So a brief overview so here we have the sump where all the wastewater is going to be collected by gravity. It goes to the primary treatment here but in this primary treatment we are not looking at sedimentation tanks or such to remove suspended solids. We are only looking at coarse screens and grit removal but again this is I think they are calling it by a trade name. So that is what we have it is not the typical primary treatment.

And after this primary treatment the flow is coming out here. So from sump and obviously this is at the lowest level and why is it at the lowest level in IIT Roorkee. The sewerage network flows by gravity as is the case in most other places by gravity so the end point will be pretty low and then as we discussed you will have pumping or headworks or such. And here we have a submerged pump that is lifting the water up to this particular treatment what do we say unit here.

Here we have the coarse screens and grit removal and from here you are going to have the water going to these sequential batch reactors. We have two sequential batch reactors, reactor one reactor two. And here you see you know some what do we say tanks out here these are the bioselector tanks or bioselectors why are what is it that we are trying to do there? So after this primary treatment again in primary let me not say primary let me only call it preliminary treatment.

You have wastewater that is high strength relatively high strength anyway and we know that you know we want floc forming microbes to be formed but again high F/M is when these floc forming microbes thrive but if I let that stay through the entire system you are going to have pin flocs you are going to have to achieve what do we say both kinds of filamentous some filamentous and floc.

And also you want to prevent the growth of nocardia type of microbes. So we want to create the conditions that lead to the growth of the kind of microbes that we want. So these are called the biosector tanks. So what do we have these tanks with high strength wastewater so you have some sludge or microbes that are put in and they are aerated for some time let us say 15 minutes. And so you have air oxygen so its aeration you know you have aeration and aerobic conditions for most of the time.

And then you have a lot of food for the microbes and you have some microbes because you are putting in microbes too we look at that. So F/M is high in this particular biosector tank. So the kind of microbes that thrive there are going to lead to rapid degradation or the kinetics are going to be faster and the kind of microbes that we want are typically going to thrive there that is what happens in this biosector tanks.

You want the kind of microbes you want to prevail to grow so that is why you are creating high F/M conditions in this tank. You cannot create that or the entire tank because then your effluent quality will be degraded. So you are now having this biosector tanks after that this water which is already in contact with microbes will be released into your sequential batch reactor. So let us go ahead and play this video we have two tanks sequential batch reactors.

And then it goes to this disk filter more or less a kind of what do we say mechanism to remove any further suspended solids, disk filter. And then you have a UV lamp based disinfection system and then it goes to a particular underground what do we say tank out here. And these are the offices where you have the fully automated I believe the SCADA system if I am not wrong to control this process.

These are not manually operated the level of oxygen and such you know which is key is maintained you know via or remotely. So you can see the relevant parameters and such. So the underground tank I guess why do we use that because this water is recycled for the maintenance of IIT Roorkee lawns and such and the remaining water which cannot be used for IIT Roorkee lawns is discharged into the Ganga canal which goes for or which is the source of water for cities downstream of Roorkee.

So that is one aspect and then what happens out here what else do we have so as we mentioned the sludge settles down until now we have not talked about it in detail. But after the sludge settles down again you cannot throw it out onto the road you have a lot of when we say sludge again it sells microbial content cells if I just leave them out there without oxygen or food they are going to die and again septic conditions decaying and such.

So you do not want that you want to be able to treat the sludge but the issue with sludge is even though it is well thickened and has settled down you will still have considerable water content in it. So without removing this water content if you try to degrade it the volume and not just volume yeah again because of the water that is there both volume and the weight will be high. So transportation cost treatment cost and so on will be high.

You want to de-water this sludge or remove as much water as you can from these microbes. So here you are going to have sludge removed and brought out here where you have the dewatering system here. And then we are going to have some what we say stabilization or composting of the relevant sludge that is a different aspect. But I guess that is what we see out here. Again coming

into the sump primary treatment and grit removal and then SBR and the sludge from the SBR goes to this dewatering system.

Now we have the video which we were able to take right so here we have the sump and the dewatering system. Let us just look at what we have here you see the wastewater flowing in at the lower head obviously or lower elevation that is what we saw earlier. And from that particular sump based on the or using the submerged pumps the water is pumped up to this unit where grit removal and what we say removal of plastics and such takes place.

Again this is not the usual one that we see though. So what else we have out here. So now we are looking at after what do we say the preliminary treatment coarse screens and some grit removal what do we have we saw that the water is being pumped up to the bioselector tanks. Bioselector as in we want to have high F/M conditions such that the kind of floc forming microbes that we want to thrive will be predominant later or even now.

So that is what we want to achieve here. So, aeration is not going to be continuous here though for 15 minutes or such high F/M ratio. So that is what we have the water is flowing in to this bioselectors here that is what you see and this is the sludge that is coming into this bioselector tanks you see the sludge out here. And this is the water coming in from the left into the biosector tank and this is the sludge coming in.

This is not the actual I mean the SBR is coming later but this is what these are the bioselector tanks we have. So that the kinds of microbes that you want to thrive, this is the sludge coming in that is how looks sludge with microbes and this is the waste water within that tank. So this is an SBR an overview of the SBR tank and the bioselecter tanks are somewhere out here okay somewhere out here which we cannot see from this angle.

From there the water comes in and here we are seeing the aeration phase again the whole cycle is four hours obviously we cannot look at the whole four hours. So here I guess we have the filling or okay filling was done and we have aeration. So you see the aeration bubbles coming in and

this is the line for providing air and you see the air being pumped in let us see. We look at the kind of diffusers that they are using but the air is being continuously pumped in aeration.

So we are providing the oxygen which is the electron acceptor. So that the microbes which are in the sludge that we added here so that is why it is called return activated sludge. The microbes that are in the sludge that we added earlier are adding will be able to use this oxygen and complete that Redox process let us see. So that is what we have out here. This is a SBR tank again we have tank number one here.

And tank number two is to our hand side which is not visible in this angle let us see. So while aeration might be occurring here decantation would probably be occurring in the other tank. So let us move ahead. So we have aeration just a close up view so you can see the color and again this is due to the MLSS mixer liquor suspended solids which has a lot of microbes in it high microbial concentration.

So just after they stop the aeration you can see the kind of flocs that are being formed so I guess just after we stop aeration or such this is what you see. The shot here that we took was here you see wastewater near a dead zone you can see the color and here you can see the MLSS are microbes and the waste water on the left hand side let us see. So you can see that in a moment or so we will be able to see the relevant flocs also.

Decanter which will come into play later once we are trying to remove this relevant supernatant. This is when we stop the aeration after we stop the aeration or day rather and you see these flocs okay this is a good angle. You can see the flocs you can see this flux all these are flocs and you can see already let us say one centimeter of clear water above. These flocs are settling down by gravity.

Now so it takes some time again one hour one and a half hour or 45 minutes depending on the cycle that they have optimized again you can see the flocs that are being formed in this aeration tank or the SBR system let us see. First fill then aeration which we looked at and now settling down is taking place. See you can see the flocs in a pretty decent manner. So this I guess now

this is the earlier was the close up shot this is the long view when you know the water is settling down not water pardon me the flocs or the sludge are settling down.

Here settling is taking place let us see, let us move ahead. So settling again from the top it does not look like much but obviously when we just stopped aeration and the flocs were at the surface you could see the difference acutely and over time the microbes are going to settle down or the sludge is going to settle down. After we provided enough time for these microbes or the sludge to settle down again type one maybe not type one type two settling probably initially and then type three and four.

What are you going to have you are going to have credibly clear water on the surface and that water is being decanted, decantation. The water at the top is being removed let us see. So that is what you have out here this is decantation. So you can still see gentle or quiescent conditions elsewhere and here you see the water being decanted. Again as I mentioned this is in one tank and the other SBR tank that we have you know probably aeration is taking place or filling is going on decanter 1 and decanter 2 as I mentioned earlier again, a long view.

So here you can see the two SBR units one here where I guess decantation is taking place on the left as you can see you can see aeration is taking place there. Did the two cycles keep going on in different tanks let us see. So that is this is one good shot for us to understand that you know cycles are going on but they are not the same. They go and different times let us see. So here decantation and here aeration, let us move on.

So here I wanted to demonstrate how sludge settles and also we did a minor trial to show what is that what is going to happen if I add electrolyte let us say so that I can utilize the charge and form or promote coagulation and thus flocculation. So but first we are going to look at this particular beaker. This was collected just before aeration was stopped from the aeration tank so here you see water and by the time we set up the shot already you see that the sludge has started to settle down sludge is nothing but the microbes here that are degrading the relevant waste water here.

So you can see the flocs here and relatively clear water at the top this is real time now look at how it settles down. Let I will just stop commenting for some time and we will look at it real time here. Because the height of the settling basin if I make also is only a few centimeters you will have maybe initially type 2 and then type 3 compression settling and type 4 settling, 2, 3 and 4 visible at the same not same time occurring simultaneously I guess.

But you can see within I think 30 seconds you see that the sludge has settled considerable what do we say distance here not distance height here. Again we did not add anything so when we stop aeration and just look at or have settling this is what happens. All the sludge or the microbes because they are now heavy lesser surface area per unit mass relatively heavier what do they do they form flocs and they settle down.

Obviously during that this time I do not want to provide air and mixing or then they will not settle down I want to provide quiescent conditions. So that is what we saw. So in this trial I just for the sake of an experiment or for demonstration I asked the relevant engineer there to add a flocculant or an electrolyte there. So, that; you can see how with the addition of the flocculant or the electrolyte the floc formation changes.

And how they are how they differently settle but again you do not add flocculant typically to sludge but we just looked at the trial because we see this in or we come across flocculation coagulation and flocculation in the sedimentation tank. I guess this is a different angle but soon they will add the flocculant. So I guess it this is from a different angle with a better camera and such but here you can see the sludge blanket hopefully.

Again you could see the time it is again just 30 seconds which I moved up and you can see the sludge blanket again type 2, 3, 4 and maybe now it is at 4 or 3 I guess zone settling and now here they are adding the relevant electrolyte. Let us say or the poly ultralight or the coagulant not flocland part coagulant and you are mixing it. So the charge is being neutralized if any charge if any but again this need not be done we are just doing it for the sake of demonstration.

Charge is being neutralized gentle mixing and all this is real time and then we stop the mixing. This level of mixing is not required but fine we stop the mixing already you see the change in floc size. The flocs are now much bigger and obviously because they are bigger you can see that the flocs settle down remarkably fast or have already settled downwards. So you see that there is a considerable difference in the time required for water to be separated from the flocs.

Especially because the flocs are now bigger and most of the suspended particles too have been captured. So that is something that you see let me now take this forward. So after sequential batch reactor or the last stage was decanting you are going to pump the; what not pump the water out decant the water gently you do not want to disturb the settle sludge or such which being pumped out.

So what do we have we still have some suspended solids as you can see. See even after the sludge has settled out but again this is only 30 seconds typically we give one hour or so and the height are obviously 2 to 3 meters. So you still have some suspended solids but typically it will be much clearer after I let it stay for one hour. So what is going to happen I want to remove these suspended solids further.

So in this case they have a disk filter they have a disk filter. So at that time it was under maintenance. So water comes in and you have these disks out here, let me just switch to the video where we have the disks being shown so here we have a disc filter in my hands. So you see that this acts as a filter sledge, yes. So the suspended particles are going to be trapped in that particular relevant filter.

So let us go back to where we were okay disc filter this is rotating in general so the sediments are going to be trapped and clear water goes through. After that obviously what do we have we want to kill the microbes if any that are harmful to us but in general the pathogen concentration is going to decrease because the pathogens cannot thrive in the system that we had or the kind of microbial community that we have in the SBR system.

But still there will be some pathogens. So you want to what do we say inactivate them by UV or you can add chlorine but chlorine will have its own issues. So I would strongly suggest against chlorinating treated wastewater for the formation of due to the formation of carcinogenic disinfection byproducts let us see. With UV you are going to damage the DNA or RNA of the cell and are the microbe or the pathogen and affect its ability to replicate.

So you have this UV I guess UV here. So it is a flow through system water comes in and goes through when it is not working I guess the bypass but you know you have the UV lamps I think submerged system and the water flows through it. So UV lamp submerged and we also talked about the sludge. The sludge are the settled sludge the microbes what are we going to do with that. We need to also treat that.

So first you want to remove much more water from it so you have this dewatering equipment here and then the poly ultralight is added to the settled sludge not to the whole water. So we saw that poly ultralight what do we say addition there. Let us move on so poly ultra light is added so that the bigger flocs are formed and then you have the sludge going in this is sludge now the settled sludge. And it is going through the dewatering equipment or machine where or what else we have.

This is the sludge that has to be dewatered as you can see it is not the typical wastewater it is sludge and you see that after ultralight the kind of flocs are different but still there is enough water. So it is coming in at the top it is going in like this as you can see it is a filter press filter press system and you can see the water being removed I guess sequentially you see less and less water in the system but let us look at the filter cake.

Here you can see the outlet after dewatering this is you know sludge or the microbes here you can now see the dewatered sludge that is coming out of the filtered press. So obviously now the volume and also because I removed the water the mass is going to be less and it is relatively easy for me to treat or transport and then treat this. So typically anaerobic digestion but because it is a small plant in IIT Roorkee, anaerobic digestion is not really required.

So let me also look at the kind of or show you the kind of diffuser that they are using here. So what do we see out here we see this is the diffuser air comes in through this it is not deep you know it is not entirely you know the air does not go through the entire system. I guess you know the block is somewhere out here and it passes through this diffusion membrane slits of these membranes or diffusers pardon me.

And I think you can see the small holes somewhere here if i hold it you can see the holes and through this the air will come out. Thus, why do we want to do that in the first case obviously because we want to have smaller air bubbles. We talked about actual oxygen transfer efficiency and so on and so forth the whole point is to convert the oxygen in the air such that it changes phase from the gaseous phase to the aqueous phase.

We want dissolved oxygen for the microbes. So obviously lesser the size of the bubble the greater the surface area and then the greater the mass transfer of oxygen. So that is why we have such systems. So I guess that is hopefully visible now. So with that I will end today's session.
(Video End Time: 25:36)

Again at sequential batch reactor the kinetics are better because it will allow me to have a greater average rate of removal of the waste. And as we see you know even with respect to different flows I can vary the relevant levels even without an equalization tanks tank. As you see in this case we had no equalization tank but again because it is a gated community with 15 000 people or so you might not really need it if you size your SBR well.

And we looked at how you know sludge is formed how sludge is not sludge microbes are formed and how the MLSS looks like if I may say so. How the sludge is settling it settled very well but something we looked at and how the water is decanted and how the sludge is also dewatered. So with that I will end today's session thank you for your patients.