Physico-Chemical Processes for Wastewater Treatment

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Lecture - 11

Flow Equalization

Good day everyone and welcome to this new lecture. In the previous lectures we studied regarding the treatment strategies which are adopted for treatment of the water or wastewater which are getting generated in the industry or in our residences and also depending upon whether the water has to be used for drinking purposes or further use for treatment, so, that we can discharge it to some ecosystem.

So, in the previous lecture, we studied in detail, there are various possibilities of using the water treatment plant or different treatment units in combination so, that we can achieve certain targets and what are those targets could be, one of the target is that like getting the water for drinking purpose and then further and that water may be obtained from different sources.

So, there is a possibility that the water that we want to use it for drinking that we are getting from the ground. So, that means, we have a hard groundwater which is coming. Also, there is a possibility in some other places that the groundwater is not available and only raw water is being taken from a stream and that stream may also be very far away only via canal system water is being taken to that place and it has been further be used.

And also, if the surface water is there, so, we have a stream which is very nearby and that water has to be treated. So, this is these two possibilities are there. Similarly, water maybe taken from a lake or reservoir, so there is also possibility of that. So, depending upon the requirement, the water treatment strategies may be different. So, this is illustrated here.

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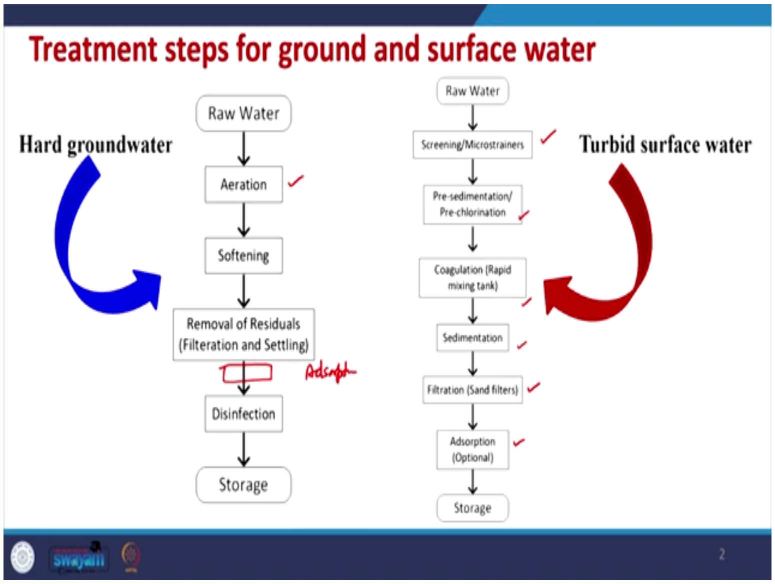

There may be also a possibility that we want to treat the water which is getting discharged from municipal bodies are from the industrial units. So, their treatment strategy will be also different. So, here we are trying to learn regarding the treatment steps for groundwater and surface water. So, we see here for groundwater actually, what we are doing first is that we are aerating the water.

So, this is being done, because there is a possibility that groundwater, if the water is coming from a confined aquifer, it may still contain some amount of gases and if the gases are still not there, it is possible that amount of oxygen and CO_2 which is there, it may be either lower or higher value. So, that aeration is done, so, that remove any toxic gas like H_2S it present. Also, to equilibrate the water with respect to the amount of oxygen and CO_2 present in the water. So, this is possible also sometimes softening may or may not be required depending upon the presence of other ions, calcium magnesium et cetera. So, for that we have to do the softening process.

So, that the hot water is soften further before use and also lot of residuals may be present. So, some other types of impurities may be present in the groundwater. So, those residuals have to be filtered and settled out there is a possibility it is that suppose arsenic is present in the groundwater. So, under that condition arsenic also has to be removed. So, there is a possibility that we may include an adaption step also.

So, anything may be used may not be used. So, depending upon the characteristic of the water, which is being taken for its designated use. Since we are going to use it for drinking. So, that means we have to perform disinfection so that we can remove maximum amount of pathogens before storing it and further distributing it in various residences for use.

So, that is why this strategy is common for water which is being taken from the groundwater. Now, if the water is surface water and it is turbid which is highly possible during rainy season or any other season. So, if suppose rainy season water is there, so, that means, it will contain lot of sediments and those sediments have to be removed.

So, what we do is that we will first screen the water. So, that we remove maximum amount of the suspended material out of that, then some pre-sedimentation and chlorination may be done. So, that we settle out most of the settleable solids and so, that further treatment can be done. Still it will contain a lot of dissolved solids.

So, for removing the dissolved solids and remaining about suspended solids which are not getting settled easily for that what we use that we use coagulation and flocculation methods, so, as to remove all these maximum amount of dissolved solids and settleable solids and since, we are using coagulation as a step we have to perform the sedimentation also. So, as to remove them.

And after that it still it will contain it may contain very small size, pollutants and other materials. So, for that we use the filtration that may be sand filter, we may use the carbon absorption technique also. So, that may or may not be there, there is a possibility that we may have to if chlorination has not been done here, we may require some chlorination or disinfection to be done here before actually distributing storing the water and further distributing the water to various aqueous to various residences for further use.

So, overall takeaway from this slide is the treatment units are same, they may be used sometimes before sometimes after and that will depend upon the amount of water is which is has to be treated, then what are the various quantities and qualities of various pollutants which are present in that water.

So, quantity is very important if load is high that strategy may change quality is also very high suppose the water contains lot of carbonaceous material. So, we may go for anaerobic treatments so, that we can maximise them methane formation if it contains refractive materials are the materials which cannot be bio degraded.

So, we may go for user treatment using the primary treatment coagulation flocculation so, that we can remove the solids beforehand because they are no further uses as such in converting into any valuables and so, any of the unit may be used beforehand may be used after hand it will depend upon the characteristics of the water amount of water and also for the, what is the designated use of the water further on. So, treatment strategies may be different.

Now, what we are going to do is that, we are going to understand each and every unit operation with respect to water treatment in detail. And one of the first and foremost unit operation that we are going to start today it is called flow equalisation and flow equalisation we are going to understand flow equalisation in detail in today's lecture, and then other units will further be understood in detail their design and some of the basic design ideas also will be discussed.

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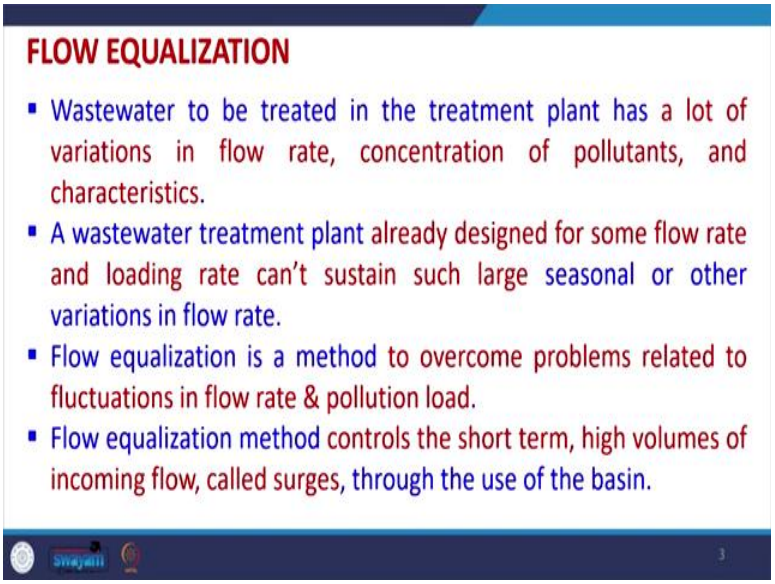

So, we will start with the flow equalisation. So, in many places, the wastewater which has to be treated in the treatment plant, the amount of wastewater generated varies in different season and also the amount or concentration of pollutants present in the water, that also varies along with the flow rate.

So, that means we have variations in the flow rate in the concentration of pollutants and also the characteristics change during various season. So, and remember, we always design a wastewater treatment plant with respect to some flow rate. So, we require some flow rate based upon which that treatment plant is designed. Now, along with the flow rate, the concentration of pollutants in particular, the lumped parameters like BOD and COD are very important.

So, always the treatment plants are designed based upon the flow rate and the pollution load. And now if the that flow rate is not fixed and that pollution load is not fixed, it is very difficult to operate the same plant at optimum condition. So, it becomes very challenging. So, and that challenge can be very well tackled by using a flow equalisation tank or flow equalisation unit. So, a wastewater treatment plant which is already designed for some flow rate or some loading, it will never sustain large seasonal or other variation in the flow rates and then it will not work properly.

It will efficiency will go down the energy consumption values may become very high or they may change totally, and in fact, the plant may not work at all. If these flow rates and the pollution loads are not made, equalised, or they are not homogenised. So, for doing this we use a fluid equalisation basin, it actually overcomes the problems related to fluctuations in both flow rate as well as pollution load.

And it flow equalization controls the short term high volumes of incoming flow, which is like called as surges. So, suppose any wastewater treatment plant is working and suddenly a high flow rate is coming and the pollution load is also high. So, if we start tasking all the water and that pollution load into our system, the system will totally collapse and it may not work properly after the surge which is there that is gone also. So, it is highly possible that overall system may get totally damaged because of this. So, flow equalisation can easily control the surge in the flow rate as well as pollution load that may happen suddenly. So, how does it helps in?

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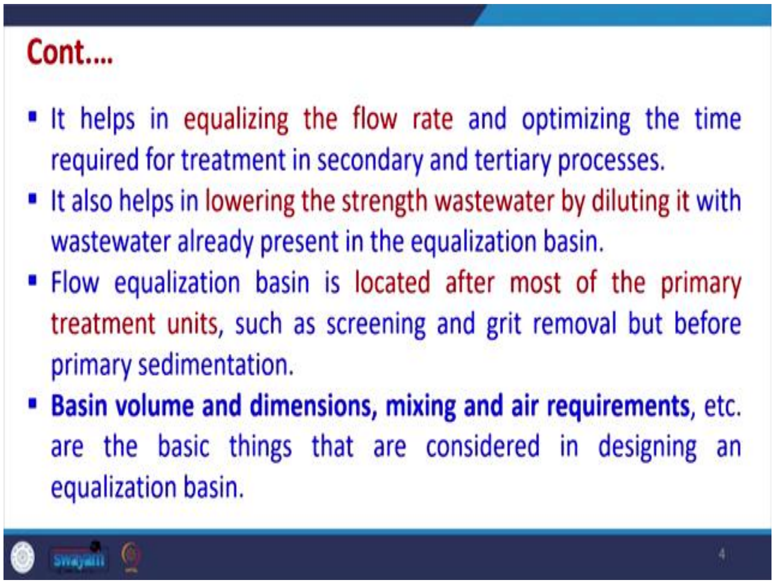

So, it equalises the flow rate and optimising the time required for treatment in the secondary and tertiary treatment. So, since it actually equalises the flow rate and pollution load, so, it works in a manner that all throughout the time period during which the treatment plant is operational the amount of water going into the treatment plant and the pollution load, the amount of pollution load per unit volume, so that remains constant. So, if that remains constant, the secondary and tertiary units will always they can work at optimum condition. So, it really helps in optimising the time required as well as the treatment efficiencies are always high.

So, it also helps in lowering the highest strength water by diluting with the wastewater already present in the equalisation basin. So, in the equalisation basin, what is done is that that any condition if the water amount of water coming is beyond a certain value. So, what is done is that that water is taken from taken away from the main treatment units and it is stored at a place and when actually the flow rate becomes low, then water is taking from that equalisation basin and further combined with the water actually coming at those conditions and further used for treatment.

So, it actually dilutes the highest strength wastewater and thus it saves the secondary treatment unit in particular, because the biological treatment units cannot work properly if the pollution load is too high, because they are designed to a certain conditions of pollution load and flow rate. So, they can work very well.

Flow equalisation basin is located after the primary treatment unit. So, generally it will be located of that the primary treatment unit such as screening and grit removal, but before the primary sedimentation, so it is their, basin volume, what are the various things that we require for designing the flow equalisation?

So, there are few things what should be the basin volume and dimension. What are the different mixing and air requirements if any, because it is possible that aeration unit may be combined with this unit itself. So, it is possible that we may require that what is the air requirement, how much air requirement and how much mixing is there. So, there are certain ways through which we can understand this and this helps in designing the equalisation basin. Not it is not very difficult thing to design. What are the various advantages and disadvantages of while using the flow equalisation basin?

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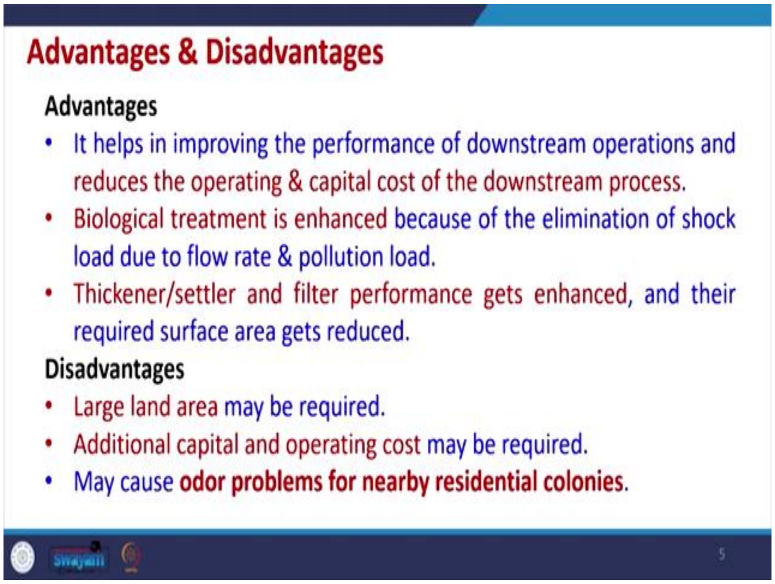

So, there are certainly some advantages those advantages are like, it helps in improving the performance of a downstream secondary and treatment tertiary units. So, it has their performance and it does so, because it reduces homogenises the flow rates as well as the pollution load and thus it reduces the operating and capital cost with respect to downstream processes, otherwise, flow equalisation basin is not there.

So, we have to design the downstream stages with respect to worst condition and that worst condition will be when there is a maximum flow rate or maximum pollution load. So, under that condition the operating and capital costs will be very high in particular the capital cost. So, by using the flow equalisation basin, we are designing the downstream processes at much lower design conditions in terms of and that reduces the capital costs of the downstream processes, also biological treatment is enhanced because it is now not under any shock load due to flow rate or pollution load.

So, that all the biological units are working at the maximum efficiency is possible because of the flow equalisation basin. Now, thickener and settler and other filter performance also get enhanced, and because some amount of settling and other things are possible also in the flow equalization basin.

Now, what are the disadvantages? Certainly, additional land area will may be required, if there is no requirement of flow equalisation basin, we do not require the extra basin. So, that means the land area will not be required, also some additional capital and operating costs for this flow equalisation basin is required.

So, this is additional cost, if it can be avoided, it is there but it has lots of benefit so generally many people use flow equalisation basin and during their design for treatment of any water or wastewater and also the aeration units may be merged with flow equalisation basin, so, it is possible to do that. So, it actually helps overall in the treatment process.

It has one issue that it may cause a lot of odour problems because it is coming before the treatment. So, if any odours compounds et cetera are there in the water, so, that odour will come out. So, it may cause problems to the nearby residential colonies and they may object to this overall treatment plant being created at that place. So, there is a possibility of odour problem because of this.

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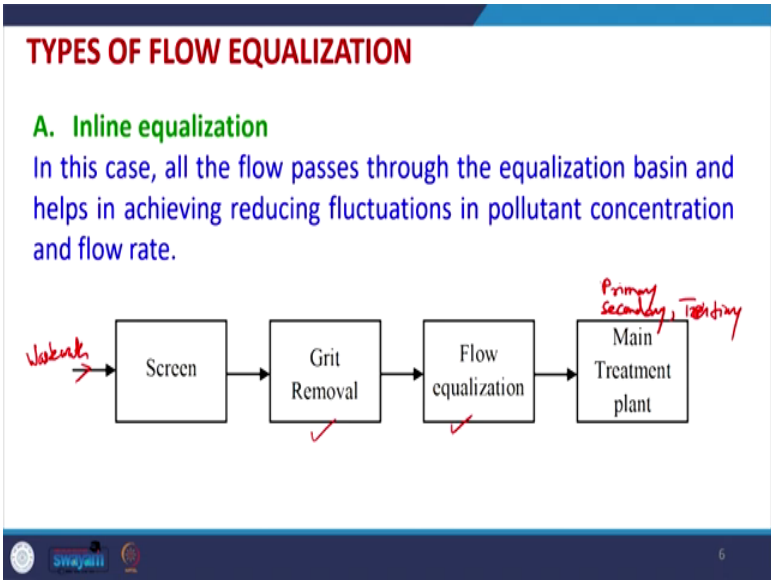

Now, there are two types of flow equalisation systems possible. One is called inline equalisation. So, what does it mean? So, in this case, all the flow passes through the equalisation basin and helps in achieving the reduce the fluctuations in the pollution concentration and flow rate. So here what we see is that suppose there is some wastewater which is getting generated here and wastewater is coming here and so the flow equalisation basin all the water which is coming after grit removal some pre-treatment primary treatment, it will pass through the flow equalisation basin, and from flow equalisation basin it will go to main treatment plant, which may include primary, secondary and tertiary.

So, they it may include everything, but now whole of the water is passing through this equalisation basin and then it is going for further treatment using the primary, secondary and tertiary treatment which is there. So, this already we have discussed in detail. Further we will be discussing, so, this is there,

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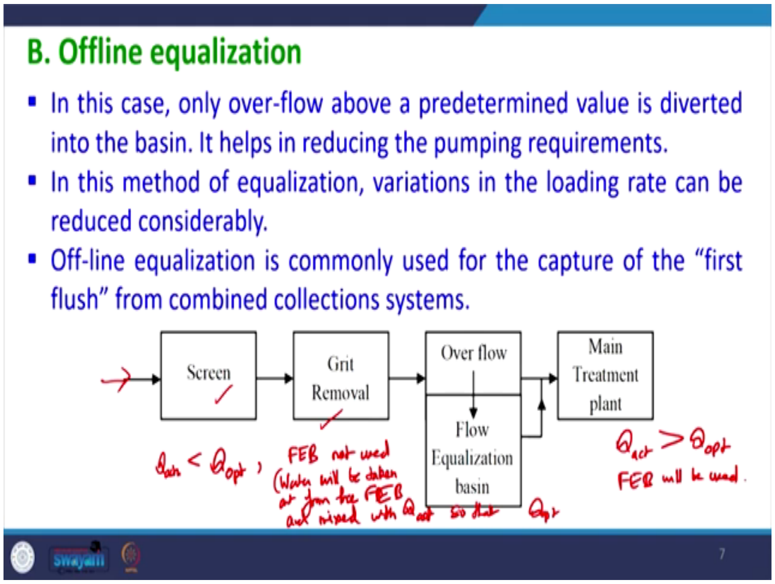

Then there is a second type flow equalisation basin which is called as offline equalisation. So, in this case, what happens that only overflow above a certain predetermined value is diverted into the basin. So, that means here the water which is coming wastewater which is coming it is passing through the screen grit removal.

Now, if the flow rate suppose the optimum design is with respect to some flow rate, and we assumed the flow rate Q optimum, which is based upon which design is there. Now, the Q actual if the Q actual is less than Q optimum, so under that condition, the water will go directly. So, flow equalisation basin, I am just writing as FEB it will not be used not used only in this condition, what is possible is that the water being taken in this case water will be taken out from the basin itself.

So, it is possible that some amount of water is being taken out from the basin and from the basin and it is mixed with the Q so, that we have a and mixed with Q actual so, that we have the this condition is reached. But if Q actually is larger than Q optimum, so, under that condition whatever is the overflow that will go into the flow equalisation basin. So, this is what is meant here. So, only overflow above a predetermined value is diverted into the basin. It helps in reducing the pumping requirement because everything has not to be pumped through the flow equalisation basin.

Now, in this method of equalisation variations in the loading rate can be reduced considerably. Because what is done is that if the key value is under any condition, if Q actual is more than Q optimum, so under that condition, we will be using the FEB so FEB will be used and over workflow rate we will be going into the FEB. So, here FEB will be used. So, this is the flow equalisation basin under that condition.

So, offline equalisation is more commonly used for the capture of the first flush from the combined collection systems et cetera. So, the offline equalisation has more advantages as compared to inline equalisation basin and it is used more commonly as compared to inline. Inline always homogenises everything. So, there is a possibility that it will it has more impact on the treatment units. But here if the variations are too many, we can use the offline equalisation basin only and this way it can work.

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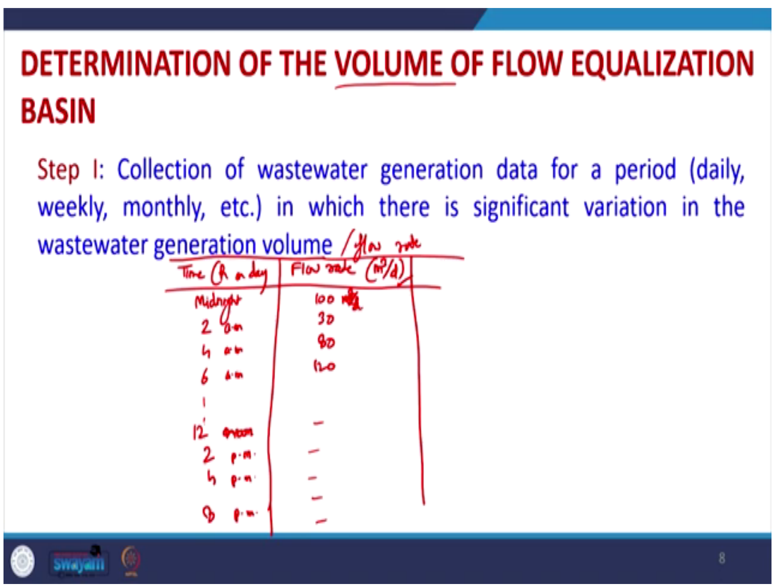

Now, how to find out the volume of the flow equalisation basin? So, this is there and this is what is the major design thing with respect to equalisation basin, that what is the volume that we require, aeration and other things can be more understood when will under understand the aeration basics and also the design aspects of an aeration.

So, from that we can understand regarding the air requirement et cetera. But here the basic purpose is to determine the volume of the flow equalisation basin. So, this the first step is that we have to get lot of data. So, what is the wastewater generation data for a period so that period may be daily, that may be weekly, that may be monthly. In which there is a significant variation in the wastewater generation volume or wastewater generation flow rates.

So, both if variation is significant, then that data is required. If we do not have the data, we cannot go further. So, this type of data is required. So, what is the type of data what we do is that, we measure the time, so in that that time maybe in hours or in days anything so it is possible, and then we try to see that what is the flow rate that how much amount of water is generated in metre cube per day or any other unit on those days.

So, that data is required and in between we can perform some averaging also. So, it is possible that if we suppose start from the midnight, suppose, we are collecting only data with respect to one day, so we start from midnight and we have 100 metre cube per hour of the flow rate. So, per day of the flow rate, which is there.

So, this is being taken, so similarly at after 2 O'clock 2 am, 4 am, 6 am so this way we are collecting like then 12 noon, then we have 2 pm, 4pm all these type of data maybe 8 pm. So, we are collecting all the search data and we are collecting what is the flow rate which is there. So, 100 it may be possible it is 30, it may be 80, then 120. So, these type of data will be there. So, we first we have to collect all these data with respect to flow rate and time and this is the first step.

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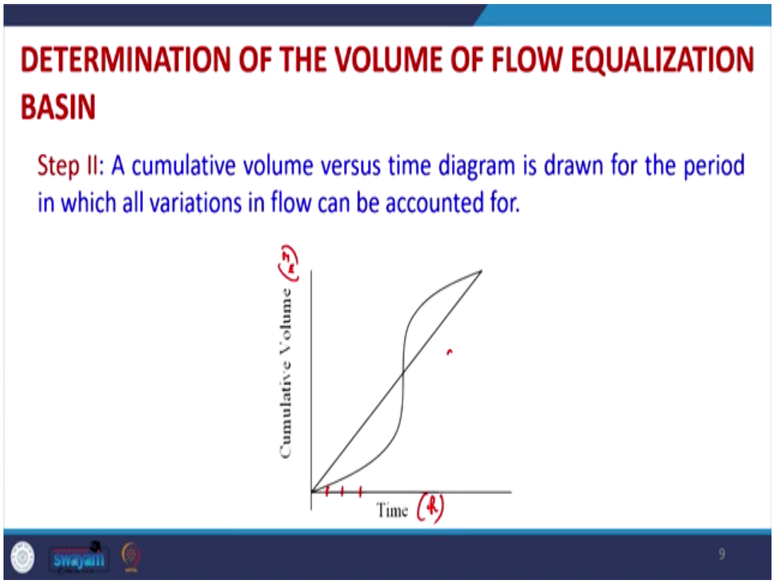

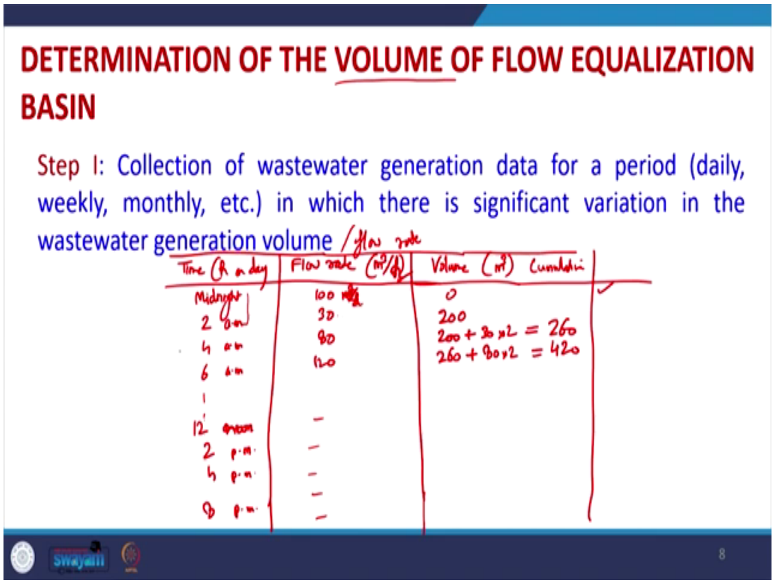

Now, second step is to dry cumulative volume versus time diagram and for the period in which all variations in the flow can be accounted for. So, we have to collect this data in such a manner that we can always account for all the variations in the flow rate. So, this is there and for, so the second step is to draw a cumulative volume versus time data so that means, here we are we have to collect like metre cube, what is the volume of water which has been generated starting from first point and also with respect to time. So, this is like hours. So, we have to collect this data now, if we had to collect this data that means, if the flow rate is like per day or we can keep it for per hour suppose, so, we have 100 and we are 2 hours gap. So, that means, here till here, we will have collected the volume will be like volume in metre cube.

So, we are assuming that okay this is this was 100 metre cube all throughout up till this point, so, 100 metre cube and 2 hours so, that means, here we have collected till this time 200 metre cube. Now, in the next case we have 30 flow rate and 2-hour gap is there so that means 30 into 2 plus 200. So, in that 200 will add the 30 into 2 whatever is the average, so, it will become 260. So, and we will continue doing this. So, for the next case, it will be 2 or the next case it will 260 plus 80 into 2. So, this will be like 160 160 plus this so it will become 420.

So, that means, what we are doing that we are trying to find out the cumulative volume which is there. Now, what we do is that we will draw the volume in cumulative volume, this is cumulative volume. So, this is we can write cumulative volume in place of volume, so cumulative volume versus time. So, this way we can draw 2 hours, 4 hours, 6 hours like this and we can draw a graph like this. So, this is the second step that we have to perform a draw cumulative volume versus time diagram.

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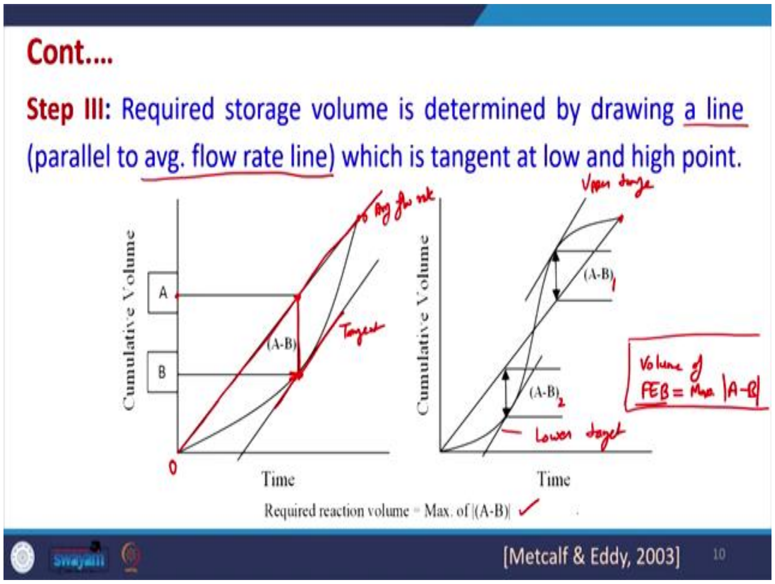

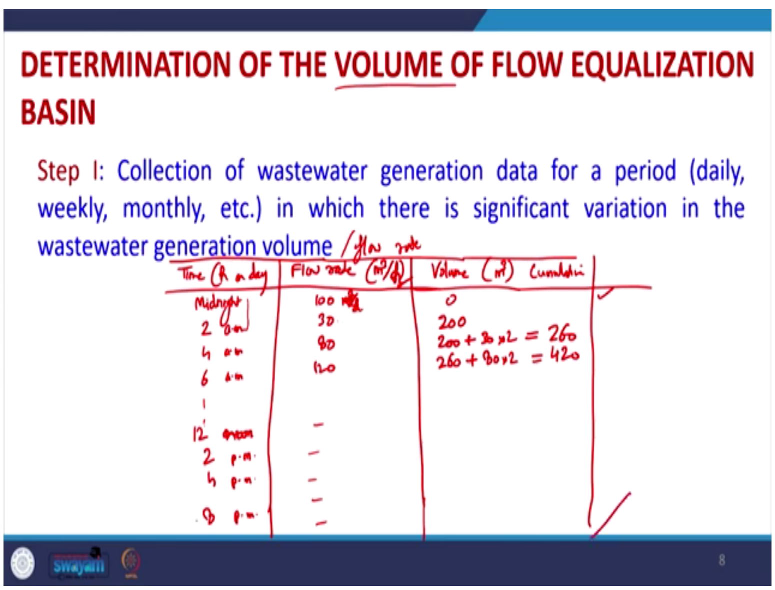

After that what we do is that there is a possibility that this type of curve may be obtained, then there is a possibility that this type of curve curvature may be obtained. So, in this case what we do is that, so, whatever is the average flow rate, so, this is the average flow rate the data which is coming from here, so, starting from 0 and here.

So, if we draw the total value and whatever is the total value if you divide by 24 hour it will give the average flow rate. So, actually this line represents the average flow rate. So, also, we can select any other flow rate also. So, that means, suppose we want to design for any other value. So, that means, we can always draw a line similar to that, so, metre cube per hour so hour will take from here and we can decide for metre cube and we can draw a line like this.

And in the third step what we do is that, in this cumulative volume curve, we draw a line parallel to the average flow rate line. So, in this average flow rate line, maybe this one or any other design flow rate line also and we draw a tangent to this so we draw this tangent line. So, this is a tangent line and in some cases we will be having two tangent line this is upper tangent line and this is the lower tangent line.

So, this possibility is there and the next step is that we have to see the difference between this vertical difference, what is the volume with respect to average flow rate and where this maximum value is coming with respect to this point and this point. So, we draw a tangent, whatever is this point here we draw a line parallel to the y axis. So, this y axis line will be drawn and the value of y axis. So, the volume of Flow Equalisation Basin volume of FEB is equal to the maximum of A minus B we can write like this.

So, absolute value of A minus B. So, here two line. So, there are two possibilities. It may be there. So, A minus B, we can consider 1 and A minus B 2. So, whatever is the maximum of A minus B, that gives the volume of FEB, and which is the design data or the requirement for our purpose. So, through that, these steps, we can find out the volume of the flow equalization basin and it gives the primary idea that how the treatment can be, what should be the volume, dimensions et cetera can be decided based upon the whether we require CSTR type of unit plug flow.

So, that is the different thing. But volume of basin can be obtained from here itself, this is it. So, now we have come to the end of Flow Equalization Basin. We will start with other things in the next unit. We will try to solve one question, maybe actual question and then further, go on understanding other type of treatment unit. So, here you can see, the required reaction volume are the required equalization basin value is maximum of A minus B. So, this is the. So, thank you very much.