Water Quality Management Practices
Dr. Gourav Dhar Bhowmick
Agricultural and Food Engineering Department
Indian Institute of Technology Kharagpur
Week – 05
Lecture – 21

Hello everyone, welcome to this online certification course on Water Quality Management Practices by NPTEL. My name is Gourav, Professor Gourav Dhar Bhowmick from the Department of Agriculture and Food Engineering of Indian Institute of Technology Kharagpur. So, this is a new module that we are going to start today. Here we will continue with the discussion of different other types of primary treatment units and the functionalities of it and we will also solve some numerical on it. So, I would request all of you to actually ready with your note pen and as well as with a calculator because we will be solving a couple of numerical in this subsequent lectures in this module and those lectures needs like you know you need to be ready with the calculator. So, that it will be completely you know engraved in your brain.

So, like how actually the continuous flow actually we can easily maintain ok. So, good so, we will start with the equalization in this particular lecture. So, the content that I will be covering is the equalization, the location, the types of equalization tank, the basin geometry and the construction, the mixing requirement, air mixing I would talk mainly we talk about the air mixing here and the volume requirement for the equalization tank. To start with you know in general what happens in case of treatment units measure of the wastewater treatment plant they normally experience a very great fluctuation on the influent wastewater on the influent sewage because the most of the cases what happens suppose just to give you one example suppose you are running a a municipality treatment plant or sewage treatment plant ok.

So, municipality wastewater treatment plant there the sewage treatment plant what the amount of sewage that it receives in a daily basis it has a certain peaks and certain lows as well isn't it. Just imagine suppose in the morning as you know in the early morning when we normally go for offices and all we use the washroom we use the we normally take shower and all. So, during that time what happens this the amount of sewage that comes into the sewage treatment plant is very high. So, you will see this very high peak in the morning 7 to 9 am then you see gradually it drops down. So, during the noon time it drastically goes down and then again it comes the this the afternoon I mean like the late afternoon or say like early evening session.

So, at that time when we come back from our offices most of the cases in the major big cities. So, this office goers comes back to their home and they start they again use utilize the washrooms and all and because of that there is a again another peak that STPs will receive in a within a hour or two because it takes time for actually the wastewater to actually reach to the sewage treatment plants as well right. So, this again in the if you see afterwards then the midnight time and that flow that flow will reduce down to a maximum low. So, this this most this you know peaks and lows and all. So, that will create a quite a big of a nuisance in the wastewater treatment plant because your wastewater treatment plant it designed a for a certain period of certain flow in general.

You remember we designed for the already we designed the grid chamber we already designed the screens and all. So, anyway so in future also we will be designing more sensitive processes more sensitive unit units. So, majorly the biological treatment units in this biological treatment units they are very sensitive to this flow regimes. So, any shock loading whether it be hydraulic shock or whether it be solid shock it will be creating a problem to the to this biological treatment unit. So, that is why you need to provide you need to design a system which will actually nullify this fluctuation and it will give the constant flow of water to your treatment plant constant flow of sewage to your treatment plant you understand.

So, in order to nullify this fluctuations we normally install a equalization basin or equalization tank. So, that is what we are going to design it and believe me this understanding this equalization basin will give you a very good understanding about various other type of basin requirement as well where I mean like in future suppose you will become a researcher. So, there you need to design some uniform flow like in a in your particular reactor. So, just before that you can install a small scale equalization basin and with the concept that you will be gathering out of after this lecture. So, that concept you can utilize it to actually develop those kind of systems to reduce this fluctuations very good.

So, let us start with the discussion about this equalization basin. So, in general what happened different industry and different commercial wastewater it shows a variation based on the product type the processes and the operational hour that I discussed. In municipal wastewater it can be the generation can be as high as 2.8 times during the peak hours you can realize like if it is like 1 million liter per day capacity it can go up to 2.8 million liter per million liter per day of capacity that I mean like that your design has to be maintained up to 2.

8 though your average flow is 1.1 million liter per day only. So, this fluctuations can actually cause drastic requirement of the land, drastic requirement of the economics I mean like the monetary involvement. So, because of that we need to install this

equalization basins and also this exponential flow increases during the rainy season definitely if it is like the combined sewer you know it that the storm water runoff will come and it will also enter to your sewage treatment line. Then the treatment facilities designed with the constant flow rate which will actually give you additional like you know grips on your treatment capacity and the efficiency.

The holding tank normally used to collect this incoming wastewater to avoid the shock loading and this holding tank what which we call the equalization tank that is the one that we gonna discuss in the in the subsequent slide. So, in general this equalization tank it controls the hydraulic and as well as organic shock loading and it also ensure the higher biological and the physical treatment efficiency. So, that is how it looks like in general the wastewater comes from one side if you see in the left side of your screen. So, from here the wastewater enters through a filter this is baffles is provided then you have the water where the aeration is provided sometimes and also the pH adjustment also can be done by introducing some chemicals. So, and also they have a gravity trap and at the end your water will go up the from other side of the system.

So, in general what we do this from the bottom the heavy solids can be also be collected. So, in general using this systems we can actually reduce the we can actually reduce the I mean like the control the flow in the system. So, we will discuss about it how we control the flow. So, that is how the structurally how it looks like now we will discuss about the slowly like how we will design this basins. Before designing why we need this equalization we already know that this treatment plant I mean like it can it is very much susceptible to this changes in the hydraulic loading rate or the additional solid shocks.

So, that is why we need it. So, and also what are the basic benefit of flow equalization tanks it can control the fluctuation of organic matter as well as maintain the stable pH level that is also very important for us to that is what I was saying in the picture it was you can you remember I saw you I showed you that the pH adjustment can also be done there. And it regulates the concentration of toxic compound in the wastewater as well. It enhances the wastewater treatment capacity by the stable performance of the biological treatment wastewater treatment unit as I was mentioning this is the most sensitive one that can be easily. So, once you ensure that stable flow is there.

So, your biological treatment unit also perform its best way. So, overall your treatment efficiency can be increases can be enhanced. What are the major disadvantages of this equalization tank? Definitely it is it comes with the additional capital cost it requires additional land area in your treatment unit and also the imposes additional operation and maintenance requirements. So, there is a very important factor about where to place the equalization basin. So, I mean like it is a quite a big debate earlier like you know decades back, but now we kind of you know finalize these things where actually we should put the equalization basin.

So, from your understanding if I ask you what is the optimum place to put the equalization basin? Before primary treatment, in between primary and the secondary treatment or in between secondary or tertiary treatment just try to understand. Primary treatment what it does? It normally get reads normally it helps us to get rid of all the inorganic substances or the inorganic high sized particles and as well as some or acetalable organic solids as well in the primary sedimentation tank isn't it. What secondary treatment unit does? Secondary treatment unit its main job is to organ biologically remove the organic matter. Some inorganic matter and some other substances can also be removed, but theoretically in gross its main aspect is the secondary treatment unit is to biologically remove the waste. And tertiary treatment what is the job of tertiary treatment? To do the fine tuning.

So, what is the best place where we can actually place the equalization basin? Definitely in between the primary and the secondary treatment unit. What will happen if you replace it before primary treatment unit? This equalization basin will because of the presence of greed, because of the presence of acetalable inorganic solid, acetalable organic solids it will be very it will be clogged very fast and I mean like it will grow the I mean like in the bottom there will be like huge amount of sludge that may actually slowly develop. So, that will actually nuisance that will actually create the reduce the actual volume and the volume is the major play here in the equalization tank because I will tell you why. So, in general this volume is the major very important parameter here the volume of the equalization tank and based on the volume of the equalization tank only it can regulate the flow fluctuations. So, we do not want the equalization tank to be present before the primary treatment units.

So, after primary treatment units when all the acetalable solids theoretically we it goes away I mean like it we normally consider we already filtered it before that. So, now, your treatment unit is now your waste water is only having theoretically only the dissolved organic solid and some amount of acetalable organic solid. So, this solid can be can go will go to the secondary treatment unit for biological treatment. Just before that if you place it that just the perfect because there your biological treatment is more sensitive one. So, that treatment I mean like because of that if you can control the flow at this at this stage.

So, your biological treatment unit dot will not experience any shock load and it will perform the best. So, ideal location for primary sedimentation tank is in between the primary treatment unit I mean like sorry the sorry the best location for the equalization tank is in between primary sedimentation tank and the biological treatment units in the secondary treatment units ok. You understand? So, this is how actually this is how normally how it looks like. So, if we talk about the basin geometry and the construction normally any kind of material we normally can be used normally concrete steel and earthen construction can be done and we based on the flow and the mass loading that it may experience. But normally we go for earthen buildings because it is quite cheaper.

However, earthen equilation tanks should be should use a synthetic and compacted clay liner to prevent the groundwater contamination because that is very important because you suppose made it with the earthen lining earthen tank, but at the end of the day it started seeping some amount of water. Definitely in the earthen tank there will be a pore sizes they are higher. So, water will definitely seep. So, you have to make sure that there is proper lining in the inner side of the wall. So, that the water will not penetrate water will not seep through the earthen tanks and actually enter to the groundwater level in the bottom.

So, because this water is not treated yet isn't it may have still it may still have some amount of waste polluted that polluted needs to be treated in the subsequent treatment unit secondary and the tertiary. So, before because of that you have to make sure that the lining is properly done. You can also maintain a 1.5 to 2 meter of water depth in the equillation basin to protect the aerator and the other apparatus and the essential for equivalent performance in the longevity. So, please remember this one that we normally maintain at least 1.

5 meter to 2 meter of water depth no matter what. So, the volume that we will design we will discuss. So, after that volume only you have you still have to provide I mean like certain amount of water available on the basin we will discuss about it. And another important thing if it is like a earthen embankment. So, you have to make sure that groundwater level is sufficiently low it is not around the corner.

So, that it will actually prevent the I mean like the somehow the fail the embankment of this earthen tank that you are going to design. So, make sure that groundwater level is sufficiently low. So, mixing requirement. So, in general as you as you remember in the earlier figure and here also in this figure you can see we normally provide certain type either aeration unit like the submerged aerators or say the diffused aerators or sometimes we mechanically agitate by using a proper agitator and fan and blade. So, this agitators are normally what is the reason behind it we normally provide this kind of mixing to prevent the suspended solid to settle on the bottom.

Because we there are still organics I told you some suspended organic solid still it may remain after the primary sedimentation tank also. So, those things can be settled down. So, we have to make sure that it will not settle on the bottom of this equillation basin. So, for that you have to keep on agitating it either by aeration either by mechanical agitations or mixers. So, in general we provide the mechanical mixer like submerged or surface aerator and with the power capacity ranging from 0.

004 to 0.008 you know like 4 to 8 watt per meter cube of basin volume please remember this value. So, normally this is the power capacity that of aerator that we provide 4 to 8 watt per meter cube of basin volume. And the gravity discharge equillation basin normally an automatically controlled flow regulating device is provided. So, to you know control I mean like to control the equalized flow and to monitor the flow. So, in general if you see there are two different type of equillation tank.

If you see this is the first one A raw water screen grid chamber after then you can put the primary sedimentation tank then the equalization basin. And then the pump and with flow meter it will go to the secondary treatment units. This is called the this is the one the in line equalization tank. There is a chance you can even have it offline equalization tank in the scheme B if you see raw water screen grid removal overflow structure and then it comes to the equalization basin and from there we pump the water through and to the other treatment units. So, this is called offline this is not it is not in line this is offline equalization basin.

So, what are the advantages and disadvantages of in line and offline equillation tank? In in line equalization tank it receives all flow primary from the primary treatment. However, in offline it receives only the surplus flow. In in line equalization tank it can maintain the constant concentration and also it operates at continuous flow of wastewater and higher pumping cost may be associated this is the negative for this is the disadvantage of in line equalization tank. However, in offline pumping cost is much lower because it is only only only dealing the surplus flow and also it operates at an intermittent flow pattern and it can also help manage the peak flow much more efficiently ok. So, offline equalization tanks are nowadays preferring over the in line ones.

Now, the most important one how to determine the volume of the equalization tank that can tackle this fluctuation. If you see from this figure ok. So, this is like in the abscissa line x axis we have time in the coordinate or y axis we have cumulative volume in meter cube. With time if you see this is the midnight with midnight you have the certain after say like you know 6 hours this is 12 hours 18 and 24 right. So, after 6 6 o clock see there is a higher surge of water requirement.

So, because of that there is a flow. So, it should follow this line if the same water requirement is same, but no after a while it grows down because this is the cumulative volume try to understand this is the cumulative total volume that is why it is keep on increasing or sometimes it is stable because that means, the water requirement is very low, but still it does not reduce the value. So, obviously, the cumulative value cannot be reduced. So, cumulative volume will be stable at this point because that means, the water requirement is almost 0 at this level. So, around 12 o clock 1 o clock in the in the noon then what is happening then again there is a high surge after say like 8 9 something there is a high surge because what is the office goer people comes and then there is a this peak we can receive ok. So, this peak again it goes again it follows the same pattern.

So, like this it goes. So, this is a standard suppose in this particular graph if we if we want to design equalization basin what will be the best option for you to design what how we can actually design the equalization basin because if you see cumulative volume it from the if you design a draw a cumulative out of mass curve. So, where actually it is maintaining suppose this is the this is the total cumulative flow over time and at the end it reaches this point. So, this is the total cumulative volume after 24 hour. So, this is total volume suppose it is 0 to 100. So, that means, 100 meter see in 100 meter cube in 24 hour.

So, this total how much volume that it actually gathers 100 meter cube per day understand. So, total volume that your wastewater treatment unit is receiving say 100 meter cube per day ok. So, if it is 100 meter cube per day if you have now if you have a equalization basin which is having a constant pump flow constant pump I mean like the one pump is there which actually regulates in a particular standard flow constant flow what it will do this 100 divided by 24. So, 100 divided by 24 that will be that will be the capacity of your pump that you should design that you should actually place in the equalization basin. So, that you have a constant flow in the follow up treatment unit you understand.

So, 100 meter cube per day or 100 by 24 meter cube 100 by 24 around 4 point 4 points 2 or 4 points is something meter cube per hour of capacity. So, that is the capacity of your pump that you need to install in your equalization basin. Now, that is a separate thing now we already know that what should be the constant flow of the I mean like the flow rate of the pump that you need to maintain. Now, next thing is what will be the volume that it can actually mean that your equalization basin should have.

So, that it can somehow nullify this fluctuation. How to do that? The surplus you can get it from the value a cumulative deficit you will get it from the value b. So, if you add this a and b total deficit and total surplus total surplus and total deficit if you add this two you should get the total volume of equalization basin you understand. So, as easy as that. So, just remember that you need to find out the total surplus and you need to find out the total deficit. So, the maximum deficit value you will get after all the value you will put this maximum deficit you need to find out and maximum surplus you add this two you will get the volume of your equalization basin as easy as that.

So, in general normally we design the equalization basin. So, that we can pump the water in a constant rate and we normally find out this vertical distance from the ordinate this cumulative inflow mass curve and from outflow mass curve and inflow mass curve and from there we do this calculation. So, let us do one numerical to make it you know to understand it better. Suppose in this particular numerical at 8 o clock in the morning we have a flow of 28 meter cube. So, then in the next hour it is again 28 then in the next hour it is 87 then in the next hour it is 110 like that for 12 o clock 1 pm 2 pm 7 pm it is 84 then again 8 pm it is 96 then 9 pm it is 80 then you can see the slight increment in the 6 to 6 o clock to 8 o clock then again it goes down goes down at the night 3 o clock it is obviously, it is minimum almost and then slowly goes again goes up at 7 o clock in the next day morning it is again 26 meter cube.

So, please make a table with the left side you make a table and in the left column left most column you write it down in the top the time. The next column you write it down the flow in meter cube and then you keep the rest of the page open. So, I will tell you how to how to do the further how to draw the further columns. So, at least draw the first 2 column on the left most side and write it down the time and the flow please write it down this times and the flow ok. In total now if you add this all this flow 28 plus 28 plus 87 plus 110 if you keep on adding all the flow in a single day of 24 hour of duration.

So, total flow is coming around 1104 meter cube you understand. So, total flow is coming as 1104 meter cube. So, we need to divide this 1104 meter cube divided by 24. So, that you will get the average pumping rate which is coming as around 46 meter cube per hour. Please remember now what is our target? Our target so, that the 46 meter cube per hour of average pumping rate has to be maintained.

In order to maintain this average pumping rate whatever the fluctuation of water is happening we have to make sure that at any course of time this much of water is almost or should remain in the in your equillation basin you understand. So, that is our target ok. So, in order to fulfill this target we need to design the equillation basin how you are going to design it? Let us let us do the next step now. I think you have already written the time and the flow ok. Now, let us make the continue with another 3 column and in this 3 column on the top you write the cumulative pumping then you add the cumulative surplus and then you add the cumulative deficit.

All this things are in meter cube in general in the only then the left hand side if you see the given data time and time is there and also the flow is there in the meter cube ok. So, from there you can easily calculate the cumulative inflow, cumulative pumping, cumulative surplus and cumulative deficit. How we can calculate? Let us start with that. So, first column we put only the timing 8 AM, 9 AM to up to say it goes down like that 12 AM, then 1 PM, then 9 PM, 10 PM, 11, 12 midnight then again 1 AM up to 7 AM next day morning 7 o'clock. Then the flow the meter cube in volumes the flow is given in the question itself.

Now, we keep on adding it. So, first is 28 second one is 28 plus 28 56, 56 plus 87 143, 143 plus 110, 253 plus 96, 349, 349 plus 60, 409. So, this is the cumulative inflow. So, total at the end of the day total inflow is 1104 meter cube in a day ok. So, from there only remember we discuss we how we finalize the cumulative pumping rate total flow divided by suppose we we are not having this fluctuations we should have a like you know constant flow. So, if it is like a constant flow what should be the constant flow? 100 and 100 11 104 divided by 24.

So, which is coming as 46. So, 46 should be the actual I mean theoretically 46 should be the standard cumulative I mean like the standard pumping rate isn't it per hour 46 meter cube per hour. Then only if you have a constant pumping rate of 46 meter cube per hour if you keep on adding 46 into 2 92 46 into 3 138 another 46 184 like that at the end if you see your system will be able to pump out or like this 1104 meter cube of water in a sewage in a day. So, this is the theoretical consideration ok. If you have a 46 meter cube per hour of pumping capacity ok. So, now, this is should be a theoretical consideration and this is the actual scenario that is happening.

So, now, we will find out this this curve ok. How we will find out this curve let us see. What we will do? We will find out the cumulative surplus and cumulative deficit. So, in the beginning we have a inflow of only 28 meter cube per hour, but our system is designed our pumping capacity is 46 meter cube per hour. So, what is the deficit here? Almost 80 46 minus 28 this is deficit whenever pumping is higher it should come in the deficit line whenever the inflow is higher it should come in the surplus line ok.

So, inflow is higher means surplus obviously, inflow is more. So, obviously, it will be more than the pumping rate isn't it and where when the pumping is higher than the inflow that means, you have a surplus you have a deficit your pump is in stress pumping pump is in stress theoretically like I will discuss will it will be much more clearer to you at the end of the numerical. So, cumulative inflow we know, cumulative pumping we know from there we can easily find out the deficit 46 minus 28 as 18 and the same way 92 minus 56 36. Now, 138 143 this is higher that means, inflow is higher so that means, it will come to surplus isn't it very good. So, 143 minus 138 it comes into this category 5 meter cube. Likewise we do it and the end 1048 78 minus 1058 20 meter cube then it will become same obviously, at the end of the day because of our consideration there.

So, now, out of all this cumulative surplus and cumulative deficit what we need to do how we are going to design as easy as that. You just need to take the maximum deficit and maximum surplus. What is the maximum deficit here 18 and 36? 36 what is the maximum surplus here 243, 243 is the maximum surplus and 36 is maximum deficit. You know the best thing is it is very easy that you can just simply add this 36 to this 243 you will get the volume as easy as that. So, what should be the capacity of your equalization basin the total total surplus maximum surplus plus maximum deficit.

Now, you realize that if your reactor basin I mean like the your equalization basin has 279 meter cube of volume active volume plus you add some 20 to 25 percent extra. So, now, it becomes say like around 2 or 335 meter cube of volume. So, what will happen even in the beginning when there is a the less amount of water is coming still you have some amount of water left in your equalization basin right because you add 20 percent extra. Now, you have 20 percent extra and you have the actual volume of 279.

So, total volume of 335. So, what will happen next day suppose in the very early in the morning your experience of flow of 28 meter cube. So, 28 meter cube of water comes into the picture. However, your system is designed for pumping 46 meter cube. So, what will happen you have a deficit of 18. So, this 18 meter cube of deficit will anyway be provided by the excess capacity extra capacity that you have for the for the equalization basin.

So, it will pump the 46 only. Next time also again another 36 deficit 36 meter cube of deficit, but anyway you have enough of water available enough of sewage available in your equalization basin. So, that will also take a bit taken care of by your basin equalization basin only. Now, the inflow will be started it keep on adding keep on adding like you know it will increase time to time, but still your equalization basin is made such a way that it can deal this all this excess flow excess surplus as well as the deficit for a daily manner ok. And at the end you will only receive the final outflow in the biological treatment unit in this next stage of 46 meter cube per hour only.

You do not have to worry about anything else. It will be the constant flow can be maintained. So, that is how we design a equalization basin ok. So, we need to know the total flow from there you can easily find out the cumulative flow I mean like individual flow then cumulative flow. Cumulative flow from there we can easily find out the surplus and deficit ok. If we know the total flow divided by total time we will get the pumping rate and from pumping rate you can easily find out the deficit and surplus.

After you know the deficit and surplus maximum deficit and maximum surplus you add it to find out the equalization basin volume plus 20 to 25 percent extra. So, then you would not believe your final next I mean like the next stage of treatment will be completely will not be experiencing any kind of hydraulic shock ok. So, normally we need to provide 0.004 kilowatt per meter cube of a mechanical mixture.

So, total power requirement will be 4 watt multiplied by 335. So, it will be coming around 1.34 kilowatt of total power that it requires. So, if you have a liquid depth of say like 3 meter.

So, total area that you require is around 111.67 square meter ok. So, you just divide it by 217 by total 335 divided by 3 meter you will get 111.67 meter square square meter. So, this is the total area. So, suppose it is a how to say you made a equalization basin cylindrical in shape. If it is like a cylindrical in shape so, from the area from how will you calculate the diameter obviously, pi d square by 4.

So, from there you can find out the D as 11.9 ok. So, very good. So, now, we know that the total basin total depth on the basin is 3 meter plus we can have some free board on the top. So, total dimension will be 3.5 meter of height, 11.9 meter of diameter of cylinder you need to design for that equalization basin which is having a total volume of 335 meter cube.

You can now this way you can easily design a equalization basin ok. So, I hope you understand how equalization basin works and you can actually design it by yourself and please try to solve this problem by yourself in the notebook again and again after repeating this lecture and I hope you will be able to understand and do the job by yourself ok. Thank you so much we will see you in the next class we will continue with the different other types of primary treatment units. Thank you.