

Water Quality Management Practices
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Week – 06
Lecture – 29

Hello everyone, welcome to this NPTEL online certification course on Water Quality Management Practices. My name is Gourav, Professor Gourav Dhar bhowmick from the Department of Agricultural and Food Engineering of Indian Institute of Technology Kharagpur. So, in this particular lecture module in Fundamentals and the Principles of Biological Waste Water Treatment. In today's lecture I will be discussing about some important nomenclature on aerobic treatment units and whenever we will be designing the aerobic treatment units, what are the other considerations about the primary and the tertiary treatment units that should be chosen. And this particular lecture video is actually majorly focusing on some you know like historical background and we will also go ahead with whatever we have learnt till now, give it a small overview and to you know to make the picture clear for you whenever you will be designing any aerobic treatment units ok. So, this will be the concept that I will be covering the pretreatment chamber, settling tank, aeration tank, activated sludge, recirculation system, sludge holding tanks, decanting systems, disinfection unit and the monitoring and the control system.

So, these are the in general one of the most prominent I would say like you know the part of the any wastewater treatment plant and these are the one that we will going to discuss in this lecture. To start with the pretreatment chamber is nothing, but it is more like a primary setting primary treatment units. So, what are the necessity of primary treatment units? We already know about it, we already understood and we also design those things. So, let us go ahead with it very briefly.

So, first of all our main target in pretreatment chamber is what to remove the larger solid debris from the raw wastewater before it in turn enters to the main treatment process ok. It often employs the mechanical methods such as the screen or filters as we as you remember that we discuss about it in the discussion when we design the screen and all ok. And also it is used to capture some larger particles like leaves, sticks and other debris is from the wastewater. Sometimes also it gets get you help you to get rid of the grit and all present in the in the raw wastewater by using the grit chambers. And by removing this larger solid what happens this actually prevent the clogging and damage of downstream components like the palm pipes in the and also in the aeration tank any problem in the aeration tank.

The removal of this larger solid it obviously, reduces the load on the subsequent treatment systems and make it more efficient and there is a chance of more effective biological treatment in the aeration tank by introducing this properly designed pretreatment unit or I would say like you know the primary treatment unit ok. But regular maintenance is very much necessary essential to for proper functioning and the preventing any potential issues in the overall treatment system. So, these are the steps we have already designed and we already have a very good idea about it that first thing is the screen to get rid of the larger solid particles then you can have the grit chamber and this grit chambers are on majorly to get rid of the grid of grit particles and all then we have the fat oil and grease traps and all this skimming tanks and all the skimming tanks what is it used for its to get rid of the fat oil and grease content from the raw wastewater ok. So, we already know about all the things we had a very good understanding we also know the science behind it the engineering behind it. So, this is the very important prerequisite for a properly functioning aerobic treatment unit ok.

Next is the settling tank after those primary treatment units that I have just discussed its mandatory to have a primary sediment sedimentation tank or the settling tank or we sometimes call it clarifier primary clarifier. This primary clarifier is one of the most crucial component in aerobic treatment units why because it helps separate the solid particles including the activated sludge from the treated water and also it will not let the unnecessary like it will reduces the load in the aerobic treatment unit as well plus there are settling tank that we normally use after the aerobic treatment system also that we call secondary settling tank or the secondary clarifier. The secondary clarifier also has its potential has its own essential you know requisite in the treatment plant what it does it gets rid of it helps us to get rid of all the bio-aerosol biomass that it accumulates in the erosion tank. In this erosion tank you know that the sludge generation is quite high. So, if we do not keep on removing it from the system it will there is a chance it will accumulate on the erosion tank itself and it will disrupt the system it will reduces the food to microorganism ratio and because of that there is a chance of the utter failure of the system.

That is why in the secondary treatment units or the secondary clarifier what happens that once this biomass reach I mean like the wastewater goes there effluent then the because of the certain time that we provide there to settle down those biomass those at the end we it form the sludge on the bottom and from the top the supernatant part we can easily collect it which is clear of almost devoid of this kind of biomass microbial biomass. This biomass because of that we can get the it is easier for us to treat that water if it is if it requires. So, and from the bottom of this from the bottom the where the sludge is getting sedimented you can either discharge it for and to the sludge handling unit or you can return it back a little bit of this sludge to the erosion tank itself which we call the return sludge to make sure that there is a certain level of biomass always active biomass always

present in the activated sludge system. So, that is the reason why we call it activated sludge system ok. So, we will discuss about it why in this kind of erosion tank where why the secondary clarifiers are so important we will even design it in future in the coming lecture we will also design about design it that how we going to design this return sludge what will be the percentage of return sludge that it requires how to formulate this equation and all we will also go through it thoroughly.

We also know that this residual suspended solid it is very important to remove from the system otherwise what will happen it will clog in the systems and it will disrupt the actual performance of the system and also the sludge which is collected from the bottom I mean like majorly we have to make sure that it is disposed properly the sludge handling units are designs properly that is also very important in case of settling tank otherwise what will happen that sludge that will collect in it has a very high amount of water content. So, the volume is quite high. So, you have to somehow use some drying mechanism either by centrifugation or either by solar dry sun drying or either by any other means of drying you have to get rid of the water content unless until the handling will be very difficult or if you suppose you are just simply dumping in the landfill still it will require a huge amount of land and also because of the high water content it will take it will leach through the ground to the groundwater and it will take some heavy metal and all the other obnoxious particles along with it. So, you have to make sure the sludge handling unit is properly designed as well. This is the settling tank in general how it looks like the sedimentation zone in the bottom you have the sludge we will discuss about it in detail in coming lectures.

Then we have the aeration tank in the aeration tank what it happens in general it is a one of the most critical component because in the aeration tank only as in the previous couple of lectures we were discussing that where the microorganism plays the major role by for treating the organic percentage of the pollutant present in the wastewater. So, by treating this organic percentage of the pollutant in the wastewater it actually creates it actually helps that treatment plant like anything because the removal of this organic portion is one of the major nuisance for any most of the wastewater treatment plant and their major target is to get rid of this organic portion of the wastewater only. Because the inorganic portion of the wastewater it may sometimes easier to remove, but the organic part is not because the inorganic portions majorly they are of higher size and all they can be easily removed by using some primary treatment units only. However, there is a chance this inorganic inorganic pollutants are in the form of nitrogen phosphorous and all then it will become little bit difficult then you may have to employ some advance oxidation process or like that kind of a tertiary treatment units. So, that is a completely different game we will discuss about it in coming lectures, but our major target is to remove the organic portion of the wastewater and in order to remove this organic portion of the wastewater which we normally denote by COD chemical oxygen demand or say

like biochemical oxygen demand that can only be removed by I would not say only be removed, but it is the majority of that can be removed by this biological treatment units.

And aerobic treatment units are one of the most efficient one and there what happened we are introducing some aeration externally by means of say like aerator it can be diffused aerator it can be surface aerator like paddle wheel and all anyway by any means we have to provide some dissolved oxygen into the water body into this tank in this water present in the tank. So, what happened because you are introducing the dissolved oxygen continuously to the system the aerobic microorganism the favorable condition will be maintained for those aerobic microorganism to grow into this chamber. So, once they will start growing into this chamber they will definitely need some food. So, that food is also provided because the wastewater is coming into the picture and for us which is a waste for those bacteria it is a resource because for them it is a food. So, they will start consuming those food present in this wastewater in the form of say carbohydrate lipid or protein or whatever it is or its dissociated forms and it will consume it and it will consume it and it will adhere to its anabolize to its cell biomass.

So, once they form the cell biomass that what was the waste now that is now converted into the cell biomass or the energy that it requires for their cellular functionality to perform. So, that pollutant is not converted into biomass or the energy or the gases which will definitely get rid of the system from the top of it from the surface of it. So, this way your pollutant level will go drastically down you will see the COD removal BOD removal efficiency in terms of that we call. So, it will be drastically it can be as low as 80 percent and it can go down as high as 80 percent 90 percent from its initial value because of the pollutant is now converted in this organic matter is converted into biomass or the gaseous substances or the energy. Now, how we can trap this biomass? We trap this biomass by introducing a settling tank after that that is the main goal right.

So, that is how we normally that is how the functionality of this wastewater treatment this aerobic wastewater treatment plant biological treatment plant work like that is how it works. This is a very typical structure where the air compressor from where you supplying the air in the inlet you see the wastewater is introduced the aeration tank the aerobic bacteria will work on it. Then there is this settling tank on this right next to it then settling tank the because of the less turbulence and because of the time that we provide there with the minimal turbulence the sludge will start settling on the bottom. And from the top of it you can see the effluent line from the supernatant we can collect which will definitely be devoid of any kind of organic matter I mean like almost a devoid of any most of the most of the typical organic matter. Activated sludge, activated sludge why we call it activated sludge it is very important for you to understand the concept of activated sludge before we go to designing this activated sludge process.

Try to remember that activated sludge means it is a diverse population of microorganisms including the bacteria and the protozoa which that actively consume and break down the organic pollutant present in the wastewater. That means, those microorganisms which are still active and has the capacity to consume the pollutant present in the wastewater are called the active activated microorganisms. This activated microorganisms represents like in the activate majorly represents in the activated sludge. And this sludge has to be returned time to time that is why that is the main goal of activated sludge process that the sludge that is getting you know sedimented in the sediment sedimentation tank or the secondary clarifier may need to return back to the system in order to maintain a certain biomass concentration inside the system inside the aeration tank. So, in order to maintain this biomass concentration because it is not necessary that it will always be the same I mean like it will all not all it cannot be the same because you are anyway discharging some of this excess wastewater which you thought that it is already done if the treatment is already done now it is it needs to be sedimented on the in the setting secondary sedimentation tank.

After the sedimentation is done there is a chance you will see by that time the activities in that adhesion tank the biomass concentration goes down will definitely go down because the generation time will be may not be enough for this continuous systems to cover the cover the amount of losses of biomass that it occurs. So, in order to incur this losses in order to somehow neutralize this losses you may have to supply the return sludge from the setting a sedimentation tank. Some amount of return sludge has to be keep on applying along with the influent line in the in the this aeration tank. So, that is why it is called it is called the activated sludge in this activated sludge the sludge is quite active and it is it has the capacity to keep on consuming the amount of whatever the amount of organic matter that you are supplying that you are designing for that it is capable of consuming those organic matter ok. In general it is this activated sludge is mixed with the incoming sewage as I was discussing providing an oxygen rich environment for the bacterial activity and also if you realize that return sludge when we put the return sludge those bacteria is already acclimatized to the system.

So, they can be better serve in the system rather than keep on introducing the new inoculum time to time you cannot just do that. So, once your system is ready. So, it is better to keep the effective microorganisms alive. So, that you do not have to face issues like you know keep on regenerating and keep on introducing new elocin inoculum for the re survival of your reactor ok. And activated sludge is also as I mentioned it is place one of the major crucial role in reducing the BOD the biochemical oxygen demand as aerobic bacteria in the sludge metabolize and decompose the organic matter improving the water quality.

After the treatment of this aeration tank that is activated sludge is separated from the treated water in the clarifier and that sludge can be recycled or further processed as

discussed. And it is one of the fundamental component of secondary treatment systems for the removal of suspended solid pathogens as well as nutrient from the sewage before the final discharge or the reuse. Recirculation system as I was mentioning that it is very important for you to understand the recirculation system that it returns a portion of the treated effluent to the aeration tank promoting the growth and the activity of the beneficial aerobic microorganisms. And to maintain the optimal microbial population also to help stabilizing and balancing the treatment process for it to be consistent and reliable all through all. And also this recirculation also minimizes the sludge accumulation by ensuring a steady supply of microbes and preventing the clogging and promoting effective settling in the clarifiers.

Also by reusing the portion of the treated effluent this recirculation system is also contributes to the water conservation and also sustainable use of use of water within the aerobic treatment unit ok. So, there are some there are some advantages of this kind of recirculation systems and all. Then we have the sludge holding tank when whatever the excess sludge that we generate in the aerobic treatment processes we normally puts it to the sludge holding tank. This tank normally facilitate the settling or we call it like you know the secondary treatment secondary sedimentation tank as well. And it periodically remove normally this accumulated sludge from the bottom we periodically removed for further treatment or disposal.

And we also incorporate some dewatering process in this after the sludge holding tank. So, get rid of the water content or the moisture content of the sludge. And as I was mentioning it is very important for us to do a regular monitoring and maintenance of this sludge holding tank because it is very much essential for optimal system performance and in order to compliance with the regulations standard given by your say like you know local governing authority. So, as I was mentioning for India we have central pollution control board, we have national green tribunal. So, they are the people who actually normally like you know take care of the necessary rules and regulations required for your own for Indian context.

So, they have given certain regulations certain standard that needs to be maintained before you even throw it throw any solid waste or liquid waste to its final destination ok. So, those rules has to be maintained. Then there is come there come the decanting system. In this decanting system in aerobic treatment units are designed for separate removal for to separate and remove the new effluent from the settling tank to ensure that treated water is properly discharged. Normally we decant the supernatant water.

It majorly involves the control outlet or wire like structure if you remember we discussed about the wires and all ok. So, that allow the clear water to overflow while leaving the settle sludge behind the clarifier itself. So, proper functioning of this decanting system is very crucial to maintain the effectiveness of the treatment systems

because the water which you need to which you want to clear the waste water all the pollutant you know that it is already converted into biomass. Now, it comes to the sludge handling unit or say like secondary sedimentation tank. There it has to be you have to provide the timing and the design of the tank should be optimal and also you have to design the decanting system in an optimal way.

So, that the properly the biomass will be settled and the water the effluent that will come out of this decanting system or the sludge holding tanks and all will be almost devoid of all these biomasses. So, if you know that if you can ensure that it is devoid of this biomass you can also ensure that there is a good amount of organic matter removal takes place ok. So, this is very important. So, remember that the decanting system or the design of the wire or external control that is the outlet control devices and all it has to be properly designed ok. It would be better nowadays we make it completely automated with sensors and control ensuring control systems for that water level management takes place.

So, whenever the water reaches a certain height all of a sudden it can be siphoned for the first couple of say like centimeter inches or meter based on that the size of the reactor and all. So, it will automate keep on decant very fastly from the system. So, this is how the automation also comes into the picture with time in wastewater treatment scenarios to make the whole system as automated as possible. So, that human we can reduce the human tragedy involved with this kind of treatment systems and all. And the what about the water that we treat the we collected through this decanting systems it should undergo some additional disinfection process before being discharged into the environment.

Because you have to remember that you may incorporate this biological treatment units which are may sufficient to remove some amount of pathogens, but it is always it is very important for you to be very sure because specially when you are treating the sewage treatment sewage's from a municipal treatments municipal areas you have to install one in disinfection unit for sure. Because there is a chance your biological treatment systems may not be able to treat all the pathogen present in your wastewater. So, you have to employ some treatment opportunities treatment systems which reduces this pathogen load ok. And our target is not say like you know to our target is to maintain the pathogen level or the final the amount final micro that microorganisms present in your like you know the unwanted microorganisms present in your effluent should be as low as possible and should adhere to the regulations given by the regulatory bodies ok. Like we normally sometimes go for this mps maintains a most probable number with this test we normally justify that the amount of microorganisms present in our system.

So, this most probable number the MPN in Indian context recently the Supreme Court of India and also National Green Tribunal they also gave a judgment and they come up

with this regulations that it has to be maintained preferably less than 230 like 100, but not more than 230 for sure ok. So, this has to be at least as low as 100 ok, then only it will be considered as the safe to discharge it to the surface water body. So, this is how the decanting system you can see in this how it works this light blue one. Then we have the disinfection unit this disinfection unit majorly designed to eliminate the and deactivate the whatever the remaining pathogens present and also the harmful microorganisms in the treated effluent before you discharge it. There are plenty of treatment systems which involves we will discuss about it in details in couple of modules later when we will be discussing when we will be designing the tertiary treatment units.

So, however, let us go through a let us in order to give you a brief overview. So, that is how it normally we this kind of methods that we normally follow coordination UV treatment, ozonation we sometimes use some kind of photo catalyst and we use the advance oxidation process. It means that this photo catalyst and UV ray. So, inside the UV ray chamber is along with the photo catalyst the wastewater is introduced. So, what happens is photo catalyst it reacts with the water and it actually generates a huge amount of reactive oxygen species which reduces which actually acts on the this organic whatever the pollutant present whatever the pathogens or the microorganisms present and it will disperse the cell and it will actually kill those pathogens and reduces the pathogen load in the system.

Anyway, so, there are different or mechanism of how we can treat the this microorganisms how we can disinfect the wastewater we will discuss about in details, but just for you to understand in a brief that it is very important that you incorporate one disinfection unit at least after the clarified after the secondary treatment is done and in order to meet the regulatory standard ok. And you should contest in monitor the disinfection process it is not that you employ one process and you are completely believing in that you have to keep on checking the results time to time at a certain interval to make sure that your disinfection unit is performing at its best to verify its effectiveness and to adjust to the certain parameters. Sometimes you see in this we add sometimes the ozone a different kind of and also we this ozonation can be done for the disinfection purpose sometimes we add the chlorine and all sometimes we add the advanced oxidation process and also these are the different types of disinfection unit that it that presence. There are some advanced processes are also coming and which will also discuss in coming module. Other than that this monitoring and control system which is very crucial and whenever you will be designing any treatment plant it is better to install a monitor and install a proper sensors and also that you can IoT based devices and all.

So, that you can continuously monitor the crucial parameters like DO level, pH, temperature to make sure your aerobic bacteria is performing at its best ok. Because a certain changes in the DO or pH may completely change the scenario in the aerobic tank

and in a aeration tank and which will have a drastic effect on the system. So, automatic control of different mechanisms like the aeration rate recirculation and other factors like based on the real time data is very essential for maintaining the efficient treatment processes and also now most of the regulatory bodies they are requesting all the ETP and STP plants and all the unit holders I mean like the owner. So, to install this kind of unit so that they will also be 100 percent sure that their reactor is performing at its best ok. And it is obviously, you have to have a monitoring system at the end and the effluent line for sure we can that data has to be supplied to the central pollution control board.

It is becoming mandatory for the grossly polluting industries the GPI which we call it which is targeted which normally which is already mentioned by the government that what are the main this GPI that can be the GPI in the grossly polluting industry. Because they are in a huge scale and if they are not treating their effluent well that can cause a huge harm to the nature to the poll to the surrounding environment. So, those industries are already asked and the name even the municipality corporations are also now requested by the government by the central this governing authority that you have to install the monitoring system at the effluent for of the your plant for sure. And that data has to be that real time data has to be supplied to the Delhi in the in the central pollution control board so that they can also be sure about the performance of your plant. And this data recording is also helpful for analyze the trend and so performance evolution over time for your plant and it will also help them to come with some decisive factors.

So, in general we discussed about in this lecture about different types of different nomenclature related to the aerobic treatment plant design. And it is very important for you to understand it whole the whole picture that from the very beginning the from the starting so say like the pretreatment unit to the sludge hold to the sludge holding unit to the disinfection unit. And this whole scenario this whole treatment plant design this regime when we design this treatment train when we design each and every component is very important and once you understand the whole it is it will be much easier for me to help you with the designing of each and individual units which we are going to do it from the next with the next module onwards ok. So, I hope you understand this whole picture that I want to share with you and these are the references I would suggest you to go through it and thank you so much we will meet you in the next class.