Advanced Aquaculture Technology
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Lecture 36
Overview of Wastewater Treatment Methods

Hello everyone, welcome to the first lecture of module 8 technology of water treatment, my name is Professor Gaurav Dhar Bhowmick; I am from the department of agriculture and food engineering of IIT Kharagpur. So in this particular lecture I will be discussing about the overview of wastewater treatment methods.

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So the concept that I will be covering here the water treatment method different type of wastewater and water treatment method ,elements of plant design and analysis and design, primary treatment units like bar screens, grit chamber, skimming tank and primary

sedimentation tank. So before we start I want to discuss with I want to let you know one very important information first is when we talk about the treatment of water it can be two types,Okay so basically it can be of water treatment or waste water treatment. What is the difference between that; obviously that one is wastewater and is water, but the reason is suppose you have a city you are coming from a municipality or a region so Okay in that municipality region or the city region, city area what happened whatever the wastewater that you are generating day basis that is going through a canal, so some particular conduit system or channel it will go to a particular area and then it is getting treated, after the treatment is done then only it is it get back to the river, surface water bodies. Okay

The waste water treatment is very important, so here the treatment that we are talking about it is a wastewater treatment. What is water treatment in general? When we again take the water from the surface any surface water bodies say river, lakes or something and then we treat the water for the human consumption to make it in a for human or any other purpose irrigation purpose or any other purpose that is called water treatment, simple water treatment.

So we treat the water and then we supply to the municipality area or say for your irrigation channels. So then it is called the water treatment in general Okay, so when we talk about water treatment here we are actually mainly talking about the wastewater treatment in general Okay. Look at here in this particular lecture series, why? Because our concern is first important information that we need to provide here that the water which is used for rearing of aquaculture species is getting polluted very easily; that polluted water has to be treated for further use. Isn't it?

So that is the major concern, the water that is required for our aquatic farm is also important and that is also taken under consideration and we can also somehow relate that water treatment as well that the water which is coming from the surface water we you have to treat it properly, so to supply it to your farm. Okay Then whatever the waste water your farm is generating that has to be treated as well; that treatment can be done before supplying that before throwing that water to surface water bodies or you can use it for again in your farm itself that is called recirculated aquaculture systems.right The wastewater that has been generated from your farm you treat it and then again you use it in your system in your farm. Okay So, all these methods involve certain treatment processes and operations Okay. So why I say this two different terms operations and processes?

I think you already know operations when we talk about it is mostly related to some physical force or physical action Okay, but processes when we discuss the unit processes, unit processes

means it comes with some chemical changes Okay; chemical or biological changes that is the processes when we talk about unit processes and unit operations if some physical force or physical action is being taken place, and by means of this unit operations are unit processes you treat the water or waste water based on your you know which way you were treating it for your farming purpose as well. This treatment method are normally divided into very basic three categories first one that we call primary treatment, then secondary treatment and tertiary treatment. What is primary treatment?

It refers to some physical unit operations which are done for some basic purposes Okay I tell you, I am giving a very gross idea now with the coming lectures coming slides I will give you a more detailed idea about what is it all about. Physical primary treatment What we do in primary treatment, we use some unit operations process to get rid of the higher sized or say like unwanted particles which are having higher than a particular amount, a threshold size and all and mainly they can be plastic, rags, the sample sachet. So these are the very standard thing that we can easily remove using primary treatment unit.

We can remove oil and grease from using the primary treatment unit, we can remove certain type of solids also from the primary treatment unit, the solid of having a particular specific gravity limit that we can easily treat using the primary treatment methods Okay. So primary treatment is a gross process, it is a procedure by which we can get rid of the most of the unwanted particles or the the how to say the stuff that we do not need in our follow-up treatment units and because those things which cannot be treated in follow-up treatment units as well so in order to and also it will reduce the load in follow-up treatment units so primary treatment units that is why we introduce the primary treatment units.

Then there comes the secondary treatment unit; secondary treatment units are mostly they are the chemical or biological unit processes are used. This chemical and biological unit processes they convert the chemical energy present in the waste water to some other form of energy mostly they have converted to their biomass Okay, I mean like mostly the chemical energy that is present into their body is converted into, they consume it and they actually this waste this nutrient actually used to utilize for their improvement of their biomass. What will happen then, why we try to introduce to the biomass, this is a very advanced process I would say like you now. See the nutrient which is present in the waste water or the water in general those nutrients we cannot consume it at all right?, suppose our the drain and the water that is there in the drain or higen or you know this municipality canals those are actually rich source of nutrient but not meant for us we cannot consume it, but there are a lot of different there are protein carbohydrate

lipids present there but not in a way that we can consume right?

So what we do, we use it for the microorganisms who can utilize them; they utilize them they use them as a feed and they can grow by themselves. So once they can grow by themselves they convert into the biomass all these nutrients, what will happen because of that the nutrient load will go down nutrient load means pollutant load will go down from the waste water and also that biomass we can easily harvest that biomass and that is a very rich source of fertilizers, also we can use this we normally call it sludge that can also be used for different purposes and by means of this we can easily segregate the nutrient from the wastewater, you understand the procedure, how it works. Okay Now there comes a tertiary treatment; tertiary treatment is normally referred to as a one or combination of like two or three physical unit operations or chemical or biological unit processes used after the secondary treatment and what is the purpose for it?

First of all to get rid of the material still available after the secondary treatment is done, to get rid of the pathogenic microorganisms because there is a chance of pathogenic microorganisms in the wastewater and all, to get rid of them we can introduce UV, ozone treatment, etc. to get rid of the you know any follow-up contamination, cross contact follow-up contamination in the water body so that is why we sometimes cover it with the chlorine and that residual chlorine that is present in the water can still make the water you know portable or drinkable for larger period of time. So this is just to give you some gross idea about how these different treatment units and treatment process, unit processes and unit operations work and why this is called primary, secondary and tertiary treatment Okay. In general the individual treatment methods normally are classified in physical unit operation, chemical unit processes and biological unit processes.

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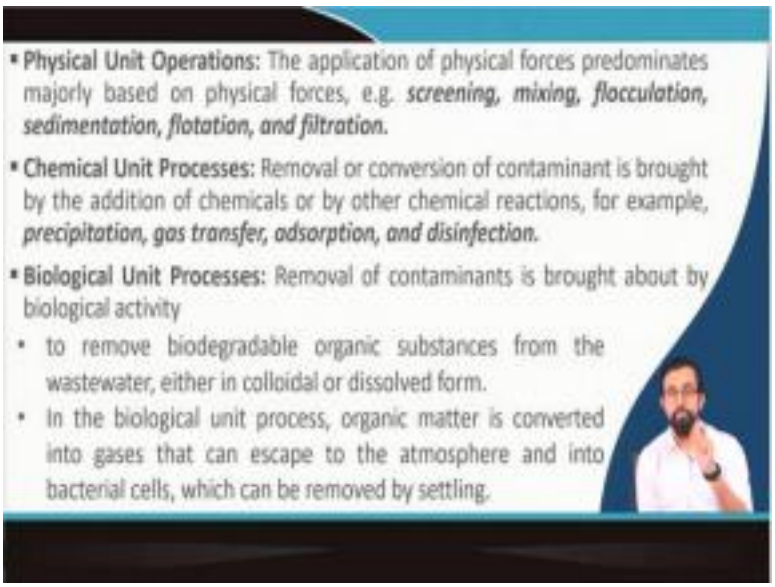

As we already discussed here I am giving you more details about it. Physical unit operation, I told you the application of physical forces predominance and majorly based on the physical forces like in this kind of operations, what kind of operations can be classified under this, can be considered under this physical unit operation? Screening, mixing, flocculation, sedimentation, floatation, filtration Okay, so all this treatment all these operations can be considered as physical unit operation because you are using some physical forces, which you are applying some physical forces to get rid of certain products or certain materials, certain elements from your water body or wastewater body. Okay

Chemical unit processes, normally removal or conversion of contaminant is bought by the addition of chemicals or by other chemical reaction, for example, precipitation, gas transfer, adsorption, disinfection, all this unit processes are considered as chemical unit processes, why? It involves with some addition of chemicals or some chemical reaction is taking place because of that your pollutant load can be minimized or reduced.

Third is a biological unit process, what is biological unit processes? Removal of contaminants is brought about by the biological activity like to remove the biodegradable organic substances from the wastewater either in colloidal and dissolved form, this biodegradable organic substances means, what do I mean by biodegradable, it is degraded by some biological matter, it is possible some biological living being and all right ?. So what they do, they consume that organic substances from the water and they can reduce the pollutant load. In the biological unit process organic matter is converted into gases that can escape into the atmosphere or into the bacterial cell, which can be removed by settling phenomena. Easy enough, organic matter is present so it is converted into either gas or either bacterial cell, if it is in under pump into the gas if it is converted into the gas it can easily escape to the atmosphere and if it is converted to

the bacterial cell that can easily be removed by settling phenomena in a later stage of the treatment unit. Okay

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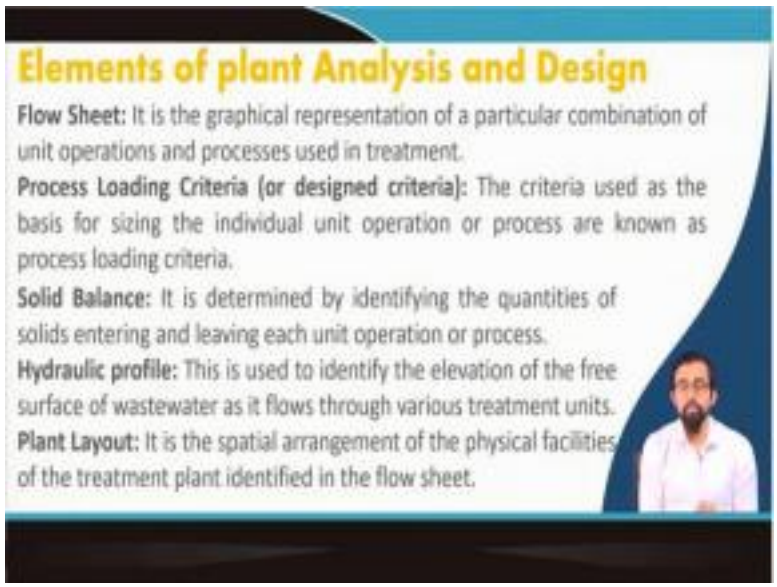

I will give you more details about all these things, but before that you need to understand some elements of our treatment plant analysis and design. When you will be designing a water treatment plant or wastewater treatment plant some very basic elements you need to understand before you go for designing. Flow sheet, it is a graphical representation of the particular combination of unit operation and processes you are going to use in your treatment unit. You need to design that graphical; you need to first decide what are the units you will be used, what are the unit operations or processes you need to use for the treatment of your waste water or water? Based on that you have to represent it in graphically which will be called flow sheet.

Process loading criteria or design criteria is very important. This criterion is used on the basis of sizing the individual unit operation and also known as process loading criteria, why because suppose your waste water has a characteristic of say like 200 milligram per liter of COD Okay. So just say it is a only it is having a 200 milligram per liter of COD on an average, based on that you have to design your system. All of a sudden suppose you think like, no I will design my system no matter what what is the process load is you design it for 100 milligram per liter capacity, what will happen your design will be overloaded with the organic matter concentration right , because COD load is 200 milligram per liter for your inlet wastewater or inlet water. However, your design is optimized for 100 milligram per liter, so it will not work so you have to design your system based on the input load, what is the input load here? The organic matter, the inorganic matter or the pollutant load, whatever whatever the pollutant load it is.

Based on these couple of factors there are all the water quality parameters that I have discussed in earlier lectures, those parameters has to be taken into consideration before designing before going for design and all. So those will be called process loading, based on the process loading you have to design your treatment unitsa and all Okay. Solid balance; you have to determine the amount of solid that is entering to your systems and that will be leaving through your system.

That solid balance you have to determine very cautiously, because based on that only your unit operations will be loaded accordingly Okay. Hydraulic profile; it is used to identify the elevation of the free surface of waste water as it flows through the various treatment units. If you do not know the hydraulic profile suppose you have a primary treatment then secondary treatment and tertiary treatment, so each time you have to do the pumping because it is in different elevation level.

Whereas, you can just do you can just elevate the water a particular reservation in your reservoir and then you put the primary then secondary then tertiary, what will happen it will go through because of gravitational action; you do not have to worry about much of an energy consumption because your energy consumption because of the pumping system will be reduced, so hydraulic profile is very important when you design a plant Okay. Plant layout in general it is a spatial arrangement of the physical facilities of the treatment plant identified in the flow sheet. That plant layout has to be designed properly with each and every component of your facilities that you will be providing.

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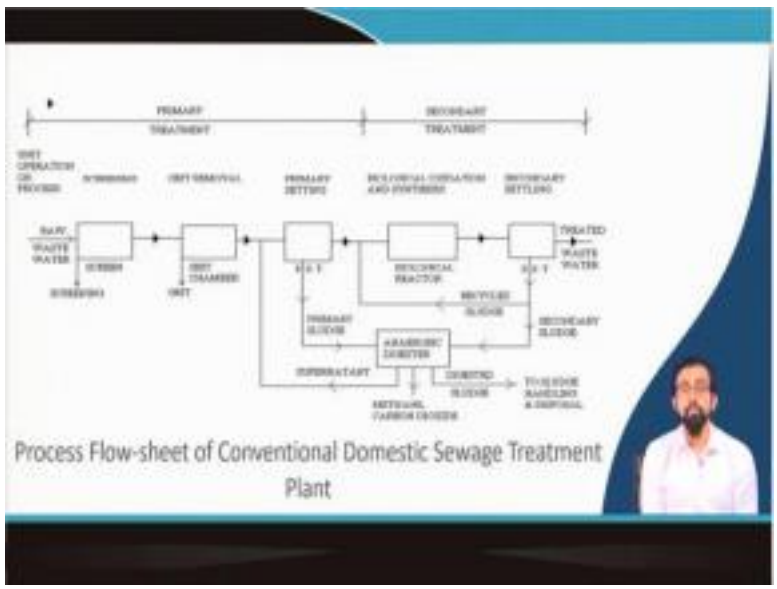

This is the process flow sheet of a conventional domestic sewage treatment plant. Here I will mainly be focusing on sewage treatment plant rather than aquaculture treatment plant in the

beginning, just for you guys to understand the system in general how the treatment is taking place then we will narrow it down to aquaculture in the coming lecture. First we will be discussing the things in general what are the treatment unit operations and unit processes involved in a treatment unit and for different industrial purpose, municipality purpose. Then we will narrow it down to aquaculture purpose Okay, so the first the process flow sheet if you see it is clearly divided into primary treatment and the secondary treatment.

Primary treatment the first thing is you see the raw waste water is coming, the screening is taken place, grit chamber; then primary sedimentation tank or PST then biological reactor which is coming under secondary treatment then secondary settling tank and then it is the treated wastewater is going out. A lot of recycling is happening here, the treated wastewater from the primary sedimentation tank can be supplied to the treated, I mean like the sludge from the primary sedimentation tank or which we call primary sludge can be supplied to the anaerobic digester.

The same way secondary sludge from the secondary sedimentation tank at the last it can also divert it to the anaerobic digester, what they do this anaerobic digester it will use this this sludge coming from the settling tank primary settling or the secondary settling tanks, it will utilize it and it will convert it to the different kind of different bio gases and the final digester sludge can be used for you know fertilizer for fertilizing purposes as a manure if you can add it with your soil you know in your ground in your field.
The supernatant which is again more liquidified liquefied portion that will be going to the PST again Okay; then again the treatment will continue. This whole system every single unit has its own capacity of working Okay, I will be discussing with you in details in the coming slides so just for you to understand how it works first raw waste water is coming, screening is taking place, why we do first why we do screening?

Screening is the major way of getting rid of the particles, unwanted larger size particles, the larger size particles which cannot be treated in a follow-up treatment unit. So we just simply screen it and we can just simply screen the water which is coming out of this the effect from the screen chamber will come to grit chamber; grit chamber is for grit removal sorry grit chamber is normally for the grit removal.

The grits which is having the solids which are having less than 2.65 specific gravity, I will discuss with you in detail in the coming slide. Then PST, sedimentation tank from the name only you can understand, whatever the solids still present in the water can somehow be neutralized, suspended solid specifically that suspended solids can somehow be sedimented if

you wait sufficient amount of time it will sedimented the water from I mean like the solids from the water body and it can be sedimented and that sedimented sludge can be separated out; that is that will be called primary sludge right?.

So whatever the water coming out of primary settling tank it is free of, not completely free of it will have a very reduced amount of suspended solids Okay. Then it will come to the biological reactor because still the dissolved solids are available which is in most of the organic form or inorganic form that organic or inorganic mostly the organic dissolved solid has to be treated in biological reactor.

Biological reactor Then in biological reactor these solid will be converted into biomass what will happen, the water which will be coming out is almost like clean water, but it will have some bacterial biomass and to get rid of the bacterial biomass you have secondary sedimentation tank or SST. In the secondary sedimentation tank if you let it stay there for a certain amount of time, because of the gravitational action all the biomass will get settled in the bottom of the sedimentation tank. So water which will be coming out will be called treated water or treated wastewater which can have a very low amount of organic content or low amount of pollutant load. That is how the treatment is taking place Okay; you understand the procedure now we will go through more in details Okay.

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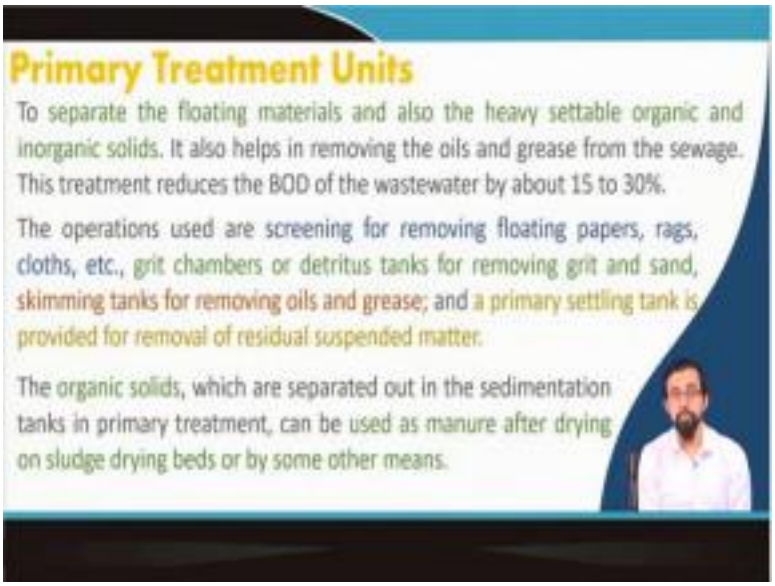

To start with the primary treatment unit like normally we separate the floating materials and also the heavy settelable organic or on inorganic solids. This treatment can reduce the biochemical oxygen load or BOD oxygen demand or the BOD of the waste water by about 15 to 30 percentage Okay. These operations are used for mainly the operations which we use screening I told you first screening to remove the floating paper, rags, clothes, etc. grit chamber or detritus tank for removing the grit and sand particles or larger size suspended solids, skimming tanks for removing the oil and grease and primary settling tanks is provided for removal of residual suspended matter Okay.

The organic solids which are separated out of the sedimentation tank can be used as manure after drying in a sludge drying bed or by some other means. That organic solid is very rich in different organic constituents and because of that it can be used as much enriched manure for irrigation purposes and all.

The first unit operations that we will be discussed about is the bar screen; from this figure itself you can see both the example in the right. The first one is this automatic and the second one is the manual one if you see how it works, it is placed the screens are placed at a certain inclination certain angle and because of this and either by mechanical by the manual one if you see these manual racks or the mechanical racks how they are doing they are cleaning the whatever the debris which are higher in size they are collecting in a certain solid concentrator or manually you can collect it after a certain moment of time.

So you can see mostly the inclination angle and from this is the particular inclination angle that you have to cover it with otherwise there is a high chances of clogging Okay and also there is will be a certain drop just after the screen we normally provide it with a certain drop or certain

elevation just to give the certain hydraulic movement close to velocity to maintain the flow through velocity through the screen. Okay

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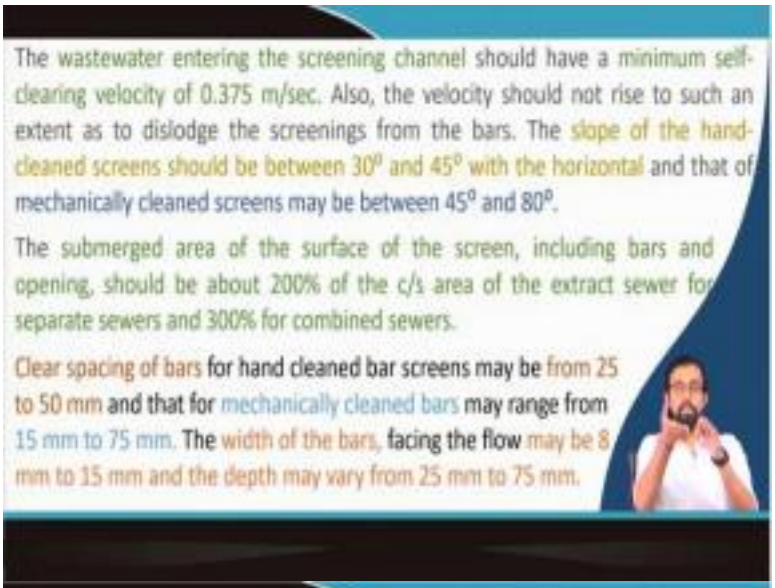

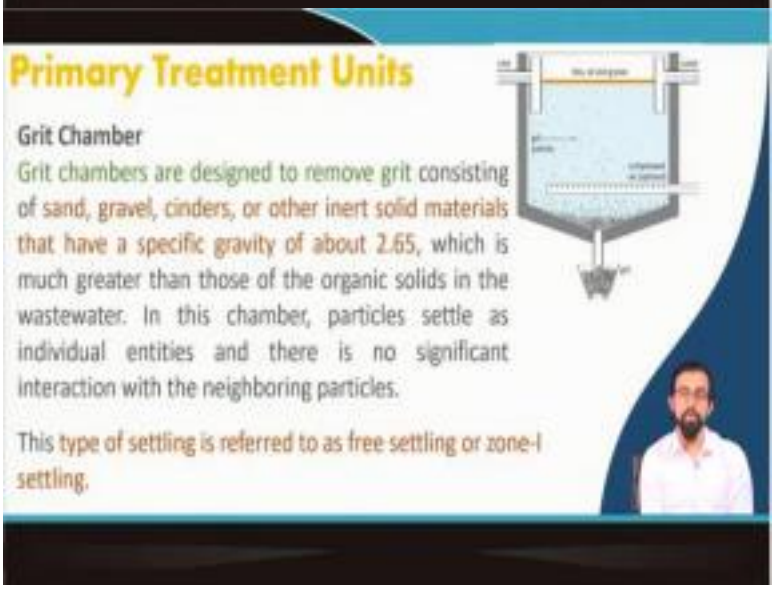

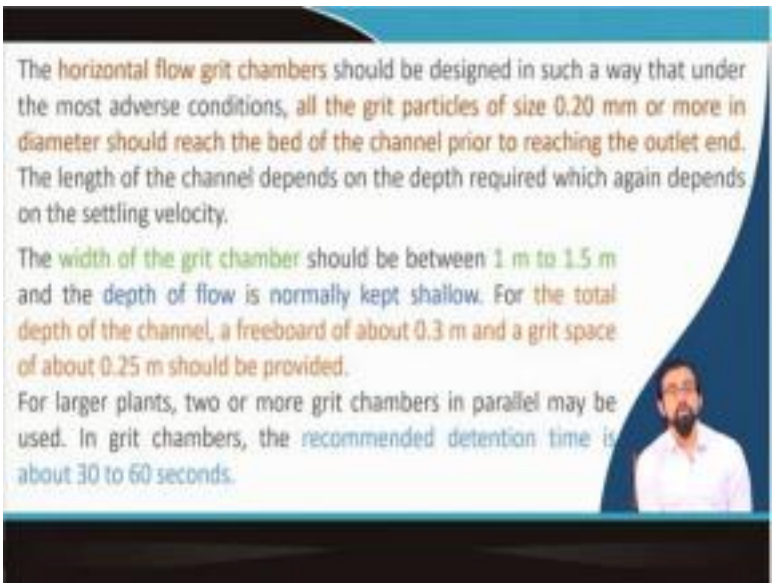

So in general the wastewater which is entering this screening channel should have a minimal minimum self-clearing velocity of 0.375 meter per second, these are very important information that you need to remember and also the velocity should not rise to such an extent that it will dislodge the screening from the bar.

So the minimum self cleaning velocity has to be there but it should not be more than that Okay. The slope of the hand-cleaned screen should be around 30 to 45 degrees with the horizontal but in case of mechanical it can be 45 to 80 degree more inclined Okay. So that it will keep on collecting the racks very easily I mean like the larger particles very easily.

Submerged area of the surface of the screen in general including bar and opening should be around to at least 200 percentage of the cross-sectional area of the extract sewer for separate sewers and 300 percent for the combined sewers. What do I mean by combined sewers, separate sewers? In a sewer line we normally treat, the line which we normally use for treatment of; for transportation of the waste water it can be connected with the rain water harvesting line also rain water harvesting line so the rain water intrusion can also take place which will be called as combined sewers or normally in normal sewers separate sewers where rain water harvesting lines are different and rain water, storm water line is different and the regular waste water line is different, municipality water line is different that is called separate sewers, and for combined saver it should be it means like it is a dual purpose sewer line.

Clear spacing of bar for hand cleaned bar screens may be from 25 to 15 millimeter and that for mechanically cleaned bar it may range from 15 millimeter to 75 millimeter. That means the difference between two spacing between two bars would be this is the range for it. The width of the bar facing the flow may be 8 millimeter to a 15 millimeter and the depth may vary from

the 25 millimeter to 75 millimeter.

Second unit operations that we will be discussing about is the grit chamber; grit chamber is designed to remove the grit which are having a space which is normally the solid materials which have the specific gravity of about 2.65 Okay which is much greater than those of organic solids present in the wastewater. In this chamber particle settles as individual entity and there is no interaction between the neighboring particles, because they are simply different grit particles and they simply settle down as a as an individual entity.

This kind of settling we call it free settling or zone one settling Okay, remember this thing this is called the free settling phenomena or zone settling phenomena Okay. In case of horizontal flow grit chambers in general all the grit particles of size 0.2 millimeter or more in diameter should reach the bed of the channel prior to reaching to the outlet end, because it will flow like this; still the flow is there a certain amount of flow is maintained in the grit chamber. So the grit of particular 0.2 millimeter or more if the diameter it should be designed in such a way that it should reach the bottom of the channel prior to reaching to the outlet end.

Because if the flow is more than a certain threshold limit the grit particles will reach to the outlet end and it will go with the effluent we do not need that we want it to be settled right , so that is why it has to be designed in such a way. The width in general it should be kept between 1 millimeter to 1.5 millimeter, sorry 1 meter to 1.5 meter, depth of flow should be normally kept shallow, and you know the reason right. If it is more than certain limit or if it is like much shallower both are not good it has to be kept shallow, but not very shallow or not very deep. The total depth of the channel a freeboard of around 0.3 meter and a grit space accumulation
zone of around 0.25 meter has to be provided so that after it reaches the 0.25 meter of accumulation grit zone then you have to collect it manually or mechanically based on your design.

For larger plants two or more grit chambers are parallelly used with a recommended detention time of 30 to 60 seconds that means for that detention time is for that particular moment of time any water molecule was present in that particular chamber. What do you mean by bottom molecule, suppose you have a 1 liter size of grit chamber just to give you an example, 1 liter size of grit chamber your inflow velocity is 0.5 liter per hour or say 0.5 liter per minute.

If it is 0.5 liter per minute, so for how long do you think the water will stay here? For two minutes, because if this size is 1 liter the size of this grit chamber is 1 liter and the inflow

velocity is 0.5 liter per minute so that means the water will stay here in the chamber for two minutes Okay. The same way if you want to make it 30 to 60 the inflow velocity should be as same as the grit chamber or slightly more than that.

What does that mean, if the size is 1 liter, the volume of this chamber is 1 liter, your inflow velocity should be 1 liter per second or say like maximum 2 liter per second if it is 2 liter per second the for many for how long the water can stay inside the chamber, for 30 seconds right?. So the volume of this chamber is important you need to know and based on that the flow velocity has to be maintained, you understand the point and this time is required for settling of the grit. So this much time you have to at least provide to systems so that the settling of grit can be taken place.

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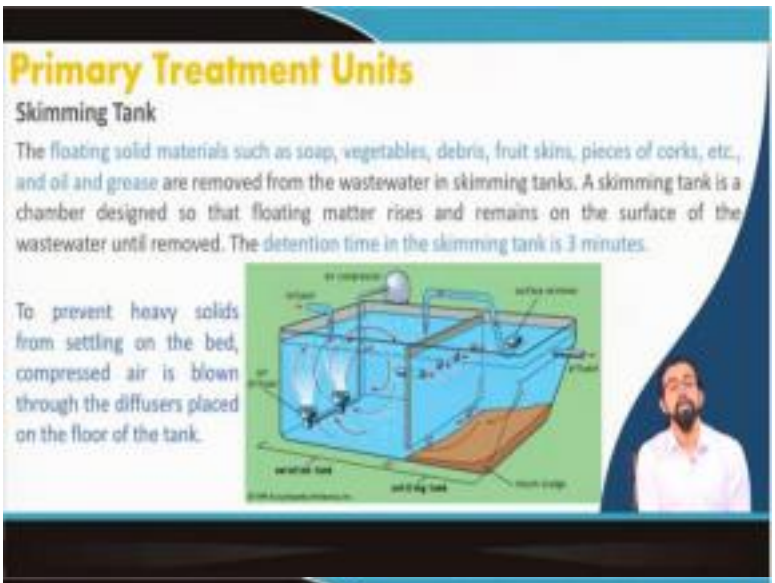
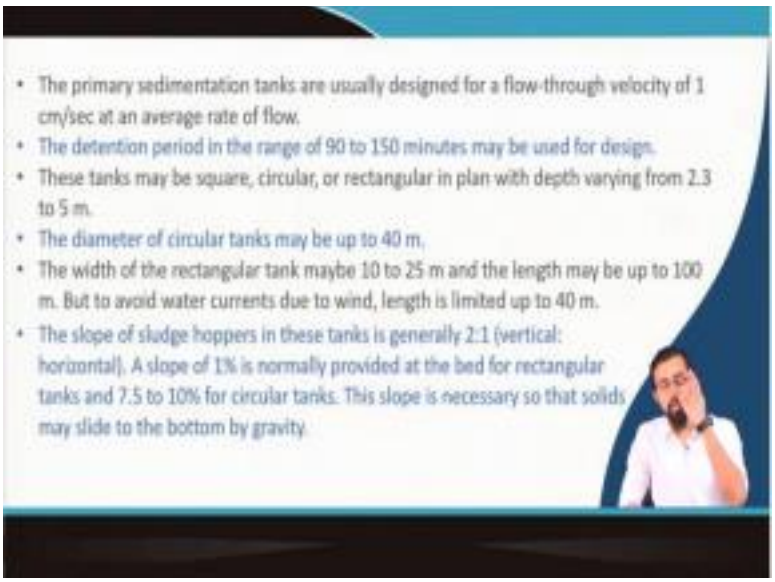




Third is the skimming tank, how skimming tank works? In general the floating solid materials such as soap, vegetables, debris, fruits, beans, pieces of corks, etc and also the specifically the oil and greases in general they can be removed from the waste water using the skimming tank. How the skimming tank works, if you see this picture a skimming tank it is actually a chamber it is designed for which we can use it for floating matter to rise and remain on the surface for a long period. Okay

When it is in the surface for long period by means of providing aeration and also air diffusers, anyway once this floating matters is in the surface for long there is a particular type of management we call skimmer. So this surface skimmers it will skim out this materials, all this floating solid materials, all the oil and grease from its surface that is why we call it skimming tank, you understand.

Skimming tank is used to get rid of the floating solid materials like soap, vegetables, debris which are like you know greasy in nature and also the oil and grease in general so that can be easily collected from the when it will be floating on the surface it can easily collected from the surface Okay. In general to prevent the heavy solids from settling on the bed, compressed air is blown through the diffuser placed on the floor of the tank.

These diffusers will keep on supplying the aeration and all, this aeration not only help preventing the heavy solid settling in the chamber, but also it will help to float all the oil and grease particles in the surface of the water body, I mean like all this floating solid matters in the surface of the water body and then it can be easily collected through the skimmers.

Fourth important thing that we need to know that there are different other units as well Okay I am just giving you a broad perspective of the major primary treatment units, major unit

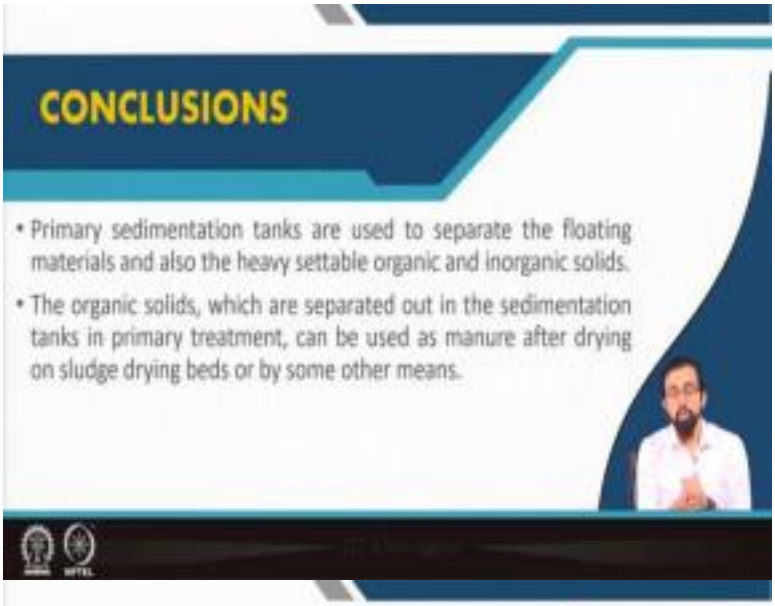
operations that is taking place in the treatment units, any treatment plant and all Okay, water treatment plant or wastewater treatment. Fourth one is the primary sedimentation tank; this is a very important one. Primary sedimentation tank is what it also used as sedimentation from the name only you can understand, what do I mean by the sedimentation tank?

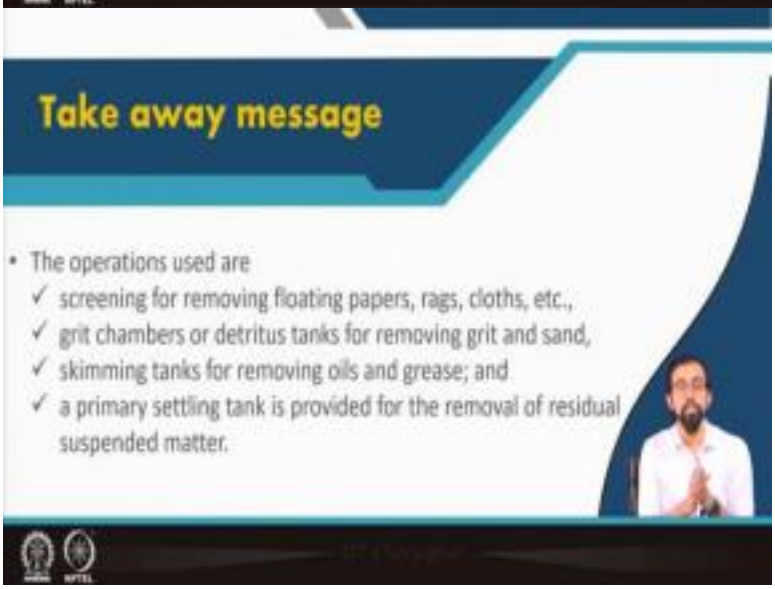
That means the water when it comes to this primary sedimentation tank it has enough time so whatever the suspended solid still present in the waste water can be settled down Okay. Mainly the lightweight organic matter can be easily settled down in the sedimentation tank Okay and objective of this treatment is like sedimentation to remove the readily settelable solids and the floating materials that is to reduce the suspended solid content when they will be used in the biological, they will be come in contact with the biological treatment unit.
Because biological treatment we want to, in order to make it more efficient we have to treat all the suspended solid possibly before it reaches the biological treatment units Okay. Most of the substances are a solid unit that is possible by utilizing the primary treatment unit Okay, primary treatment tank. Their function is to reduce the load on the biological treatments, you can see the size, the influence is coming from the center it is going throughout the circular motion towards I mean like to the circular tank or the you can see the circular tank in the left side is a standard hard design of primary simulation tank water is coming from the center and it will go into the outer side.

Outside they have a weir like structure weir is like this is called the effluent wier, if you see the effluent it is written effluent wier. It is like stair-like structure so water will go and it will overflow through this wier and it will be collected through a collecting unit or collecting main channel and all Okay. Some information is very important in order to know more about the sedimentation tank. Primary sedimentation tank usually designed for a flow through velocity of 1 centimeter per second at an average rate of flow, detention period of around 90 to 150 minutes may be used for design and this tanks may be square, circular, rectangular in plan, but the depth has to be varying between 2.3 to 5 meter.

Diameter of the circular tank may be up to 40 meter Okay based on your load of your system mainly for the municipality purpose it has to be very big because the incoming waste water is very the incoming water is very huge right?. The width of the rectangular tank may be 10 to 25 meter and the length may be up to 100 meter, but to avoid the water currents due to wind, length is limited to 40 meter only we do not go for more than 100 meter of length. The slope of the sludge hopper in this tank is generally 2 : 1. A slope of 1 percent is normally provided at the bed of rectangular tank and 7.5 to 10 percent for circular tank. This slope is necessary so

that the solids may slide to the bottom by gravity and we can easily collect it from a same line. (Refer Slide Time 33:52)





So in conclusion we discuss about the primary sedimentation tank mainly in this lecture, in the coming lecture I will be discussing more about the secondary treatment unit and the tertiary treatment unit Okay and how it is and then we will narrow it down for the aquaculture practices. Primary sedimentation tank are mainly used to separate the floating materials that we know and also the heavy settelable organic and inorganic solid.

The organic solids which are separated out in the sedimentation tank in primary unit can be used as a manure after drying on sludge drying bed or some other means that also we understand from this lecture. So take away message from this lecture mainly the operations used are screening in case of primary treatment unit, screening for removing of floating paper, rags and clothes,

grit chamber or detritus tank for removing grits and sand of around for specific gravity of 2.65 Okay.

Skimming tanks for removing oil and grease particles in general and primary settling tank to provide the removal of residual suspended matter in sedimentation it will be sedimented and could be easily collected Okay. So that is how the primary sedimentation primary unit's treatment units work. Now the water will go to the secondary treatment unit and we will discuss about the secondary treatment and tertiary treatment unit in the coming lecture Okay.

So in the coming lecture we will discuss more in details about all the follow-up treatments units and then we will discuss about how aquaculture or aquaculture food processing treatment plants because aquaculture treatment processing units are also important. So how they are involved with it and how the treatment can be done in this particular case Okay, so thank you so much. See you in the next lecture.