Advanced Aquaculture Technology
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Lecture 37
Overview of Wastewater Treatment Methods (Continued)

Hello everyone, welcome to the second lecture of module 8, technology of water treatment of the subject advanced aquaculture technology. My name is Professor Gaurav Dhar Bhowmick; I am from the department of agriculture and food engineering of IIT Kharagpur.

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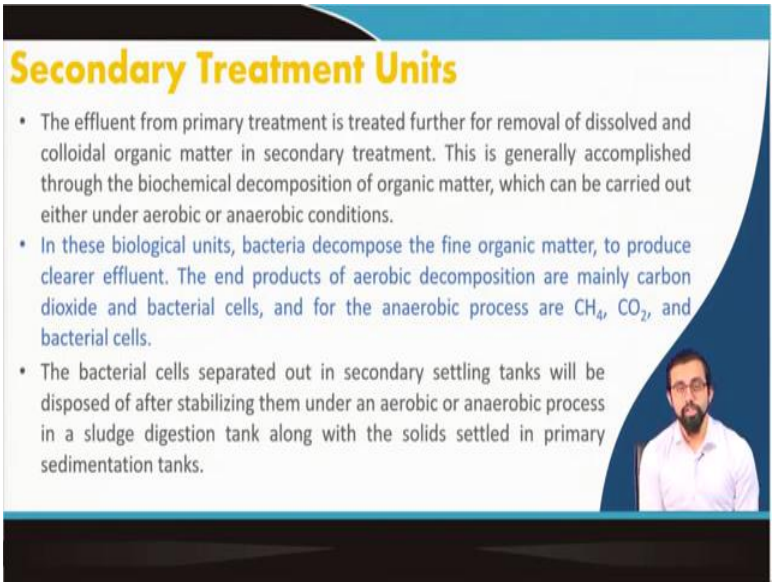

So the concepts that I will be covering in this particular lecture matter are the continuation from the earlier lecture where we have already discussed about the primary treatment unit.

Today we will cover in this particular lecture we will be covering the secondary treatment unit, the trickling filter, activated sludge process, secondary settling tanks, etc and the tertiary treatment units and what are the effluent quality requirement and the standard fish processing wastewater characteristics parameter and the treatment that is normally been used like the conventional treatment technology that we normally use in fish processing unit plus aquaculture's wastewater treatment as well.

So to start with if you remember correctly in last lecture we have covered till primary treatment unit, we already have enough idea about what is wastewater treatment units, what are the different type of wastewater treatment units, unit operations and unit processes, we already have enough idea about what are the type of primary treatment unit that we normally have in our sewage treatment plant or municipality treatment plant or even industrial treatment plants. Okay!

So let us continue with that lecture with that discussion only so now I will be discussing you about the secondary treatment units. In general the effluent from the primary treatment it comes into the secondary treatment units for removal of dissolve and the colloidal organic matter which is still present in the wastewater as it receives Okay. So this is generally accomplished by biochemical decomposition of organic matter which can be carried out under the aerobic or anaerobic condition.

What do I mean by the aerobic and anaerobic condition? Aerobic means the presence of oxygen and anaerobic in absence of oxygen Okay. In this kind of this biological units most of the secondary treatment units are like mostly we follow this biological treatment unit a treatment procedure so that is why this biological unit the different beneficial bacteria or microorganisms to be precise if I say because there are other organisms also which plays the major role here, so they decompose the fine organic matter and produce the clearer effluent Okay that is the overall goal of it.

The end product of this aerobic decomposition are mainly carbon dioxide and bacterial cell when it goes for anaerobic decomposition then the final products is the final products are a methane, carbon dioxide, and bacterial cell. There are some other products also that it develops so we will discuss about it in details with time. Okay

So in general the bacterial cell separate out in secondary settling tanks will be disposed of after stabilizing them under an aerobic or anaerobic process in sludge digestion tank along with the solid settled in the primary sedimentation tanks. This sludge is actually very, how to

say like it is very we normally use as a very like like you know high-end manure or fertilizer for our agriculture purposes and not only that it has a lot of other purposes, a lot of other users as well in biogas plant also we use it sometimes. So anyway, in general the secondary treatment units are working on this phenomena of cleaning simply decomposing the fine organic matter and producing the clearer effluent by means of biochemical oxidation.

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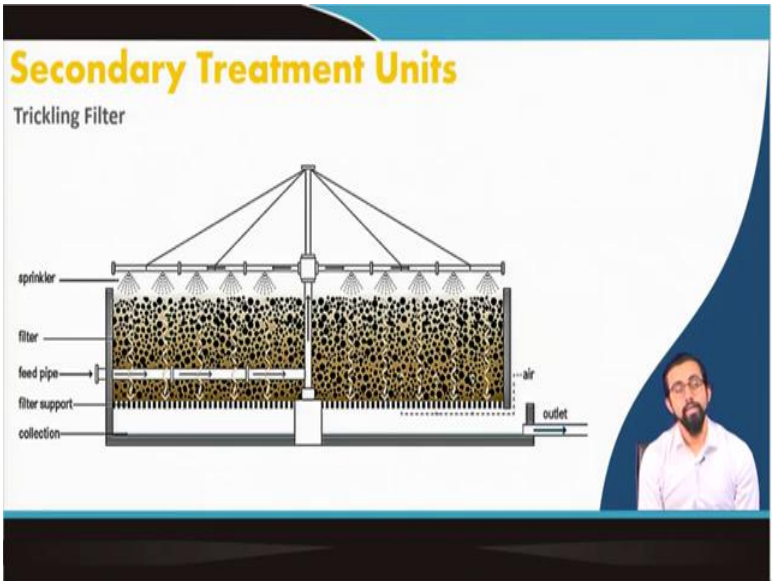

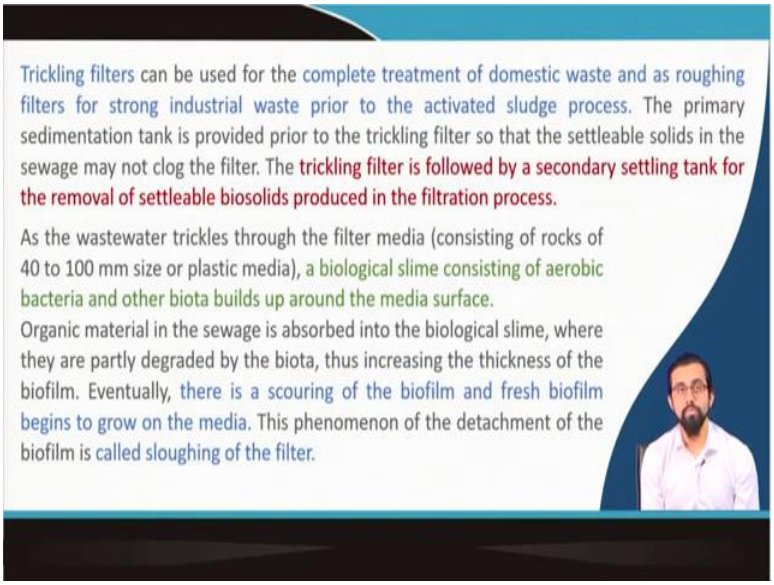

So I will discuss with a couple of treatment units couple of examples of secondary treatment units just to give you a brief idea about how it works Okay. So to start with we will start with the trickling filter; if you see the figure clearly this trickling filters nothing filter media and in the filter media and in the bottom there will filter support and the feed pipe will supply the inlet wastewater the the wastewater influent. Okay

So the wastewater through this in feed pipe it will come to the sprinkler units and it will go like sprinkling action it will come to the surface of the filter media as a sprinkling action Okay, because of the sprinkling action and it is continuously the sprinkler arms are actually rotating over this circular tanks, in general they made in circular in nature. So in this circular time they will keep on rotating and they will sprinkle the wastewater coming from the primary treatment units.

This sprinkled water when it comes in contact with the filter media what will happen, in the filter media with time the beneficial microorganisms start grow. So they start growing on on its surface and this microorganisms they keep on consuming the pollutants from the wastewater and like especially the the colloidal or the dissolved organic matter they consume it and they convert it into their biomass. Okay

So that is as simple as that and then the cleared water will come out from this collecting outlet to the second and to the follow-up treatment units Okay. So that is how it is done, so we normally provided with the aeration also so this aeration units are provided at the bottom so you can provide it with aeration also, and other than that this you may be worry about what happened after a certain point of time when there are very thick biofilm which starts growing on its filter media how to clean it. Okay

So we just need simply backwash it there is a procedure called backwashing, instead of this outlet section will just forcefully fill it with the clean water and by means of that we can backwash some of the particles. So in order to know more in details in general this trickling filters is normally used for complete treatment of domestic water and as a roughing filter for strong industrial waste also can be treated prior to the activated sludge process.

What is activated sludge process I will come in 2-3 slides. Primary sedimentation tank is also provided prior to the trickling filter so that the settleable solids in the sewage may not clog the filter and we already know what is primary sedimentation tank and how it works. So this trickling filter is followed by a secondary sedimentation tank for removal of setteable biosolids produced in this filtration process.

I told you this biological biofilm that it keeps on that it keeps on growing over the surface of this filter media that actually is slogged off, what is logged off, actually what happened with the time this organic material in the sewage it will keep on accumulating as a bacterial slide, it will convert into the bacterial slime where they partly degraded by the biota and increases the thickness of the biofilm with time. Here

ia Eventually what will happen this biofilm will get slogged off and it because of this sloughing action and the fresh biofilm begins to grow in the media this phenomenon of detachment of biofilm is called the sloughing off sloughing of the filter . This sloughing phenomena is actually very much beneficial because what happened, because of the sloughing phenomena you can get the solid biomass which will come into the secondary sedimentation tank now from secondary sedimentation if you provide them enough detention time that will settle down, and the supernatant if you collect it it will be clear wastewater clear like effluent. Okay

This clear effluent it still considers different kind of different pollutants it is always better to check you know with all the water parameters and to check like whether it is completely void of any pollutants or not Okay and then based on that you can go ahead with the tertiary treatment process and in general this trickling filter media they are normally of consisting of a rocks of 42 hundred millimeter size or the plastic media and because of this plastic media or these rocks this biological slimes are keep on formulating as we already discussed and that is the reason why this biofilms are keep on formulating after certain moment of time it will just simply scour up the from the surface of this media and fresh biofilm starts to grow and this process is called the sloughing of of the reactor filter medium.

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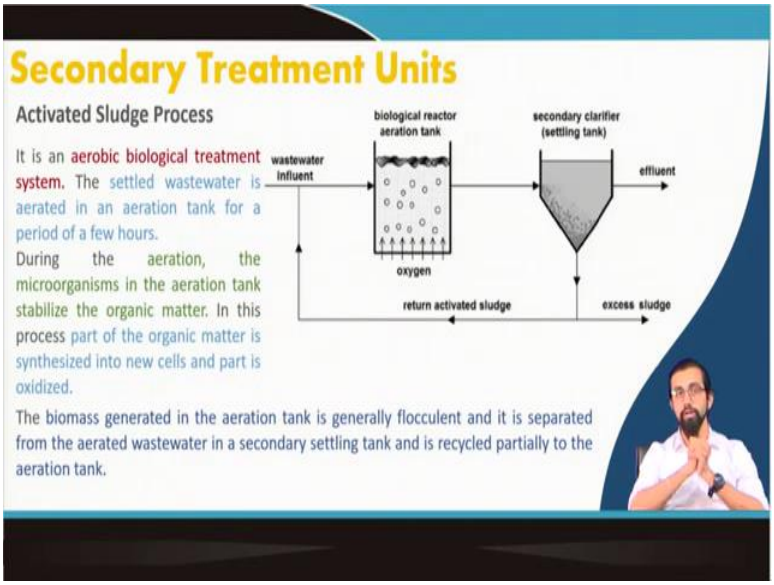

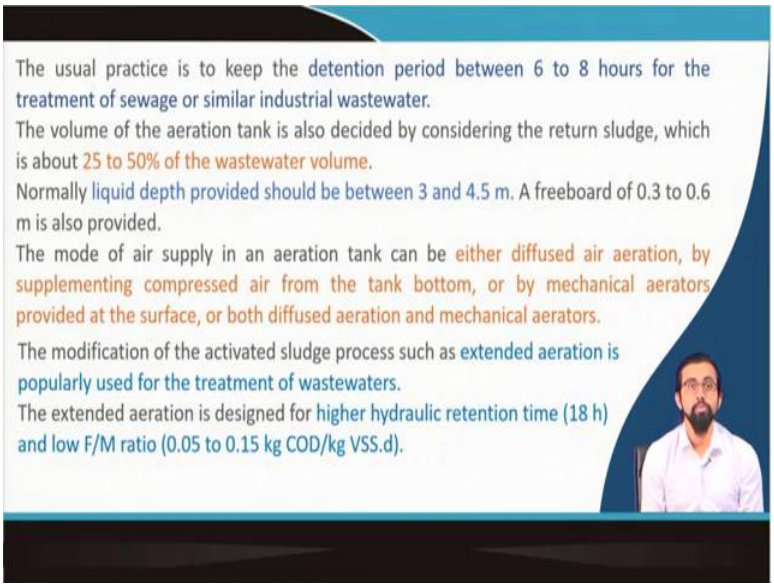

So we have a very basic idea at least some overall understanding about the trickling filter how it works, how any that is the first setting secondary treatment unit that we have learned that it is a biological process and the biofilm it actually keeps on growing and this biological living beings they consume the wastewater and they purify the wastewater in the meantime. Same phenomena happen in case of activated sludge process, ASP or activated sludge process is a very famous one.

I think most of you have seen or if you go to any municipality treatment system and all most of the major municipality treatment systems and industrial treatment systems they use this activated sludge process it is like it is very famous Okay. So this activated sludge process what it happens you supply with the wastewater if you see the figure we supply with the wastewater there is this biological reaction tank or reactor aeration tank or sometimes we normally call it the aeration tank.

In the aeration tank what we are doing we are supplying it with the enough amount of dissolved oxygen or dissloved air, because of the presence of high ample amount of oxygen there is a chances of growing of huge amount of aerobic microorganisms, beneficial microorganisms. What they will do, they will consume the waste pollutants from the wastewater and they are in suspended in nature, see in case of trickling filter that is a attached growth process.

There is two type of biofilm we can get one in attached growth condition, one in suspended condition Okay. So in case of activated sludge process generally the biofilm or the microbiota that the beneficial micro biota that grows inside this aerobic chamber is suspended in nature, they normally it stays in suspension Okay. However, in case of trickling filter it was attached

growth biofilm, they attached to a surface and then they start growing normally but in case of activated sludge process they are in suspended in nature.

So they will keep on suspending on this aerobic basin and they will consume the nutrient and they will utilize it for their biomass production like they will convert it into their healthy biomass and by means of that the pollutant load can be minimized and then it will go to the secondary clarifier or settling tank, what happened to the settling tank almost it also has the almost same procedure or the as you remember in case of primary sedimentation tank also, in case of secondary sedimentation tank also it what happened that all the settleable solid get settled and that can be utilized for the sludge production and all, sludge utilization and all Okay.

In general you remember this part of the organic matter that you are supplying to your aerobic basin is synthesized into new cell Okay and part is oxidized and they convert it to the follow-up products or they convert it to some other gaseous compound and all Okay.

The biomass generated in the eration basin is generally flocculent and separated from the aerated wastewater in the secondary sedimentation tank and then recycle partially to the aeration tank. Why the why we need to recycle it back, you might have been confused, now it is converted to biomass now it is going to secondary clarify, now we just throw it, why to put it back into the activated sludge process again there is a reason behind it.

I would really request you to know some of the important parameter of water quality, so where we discussed about if we remember the solid analysis, different kind of solids like suspended solids, volatile suspended solid, dissolved suspended solids, this volatile suspended solid it is a major concern and volatile suspended solid actually shows us the amount of biomass present in your system. So if you can somehow calculate the VSS of your system or in this particular case we call it mixed liquor volatile suspended solid MLVSS, MLVSS if you want to know more in details just google it and try to understand like what is MLVSS.

I'm just due to the time constant I can only tell you MLVSS is a kinda give you like you know indication of amount of biofilm or amount of biomass present in your system Okay. So this MLVSS has to be in a certain range all the time, you cannot just simply throw it away and at one point of because see wastewater is keep on coming to your system; if you throw certain amount of wastewater and and along with that all the biomass is getting thrown away, what will happen that your aeration basin will have very low MLVSS that means very low

biomass at that particular moment of time. So the treatment will be not sufficient, you have to maintain a certain amount of biomass all the time in your aeration basin, in your activated sludge process that is mandatory, because so that amount of microorganisms can keep on work on your wastewater load that will work on it and then the excess amount of biomass that is getting generated that can be thrown away Okay.

So this is some some important factors that I am discussing with you really should remember those things, if you have any issues any doubt I will be coming for a live session and soon and then there also you can ask or maybe you can simply google it Okay. So this aeration process this is how it works and this activated sludge process majorly we try to keep the detention period of 6 to 8 hour. If you remember the detention period like the amount of time for which the liquid stays in the reactor it should be 6 to 8 hours that means within 6 to 8 hours it is sufficient for your inlet load like the wastewater load to be minimized to a certain limit Okay. Based on the volume of aeration tank, the volume of aeration tank is normally we decided based on the return sludge because it is normally we put it like 25 to 50 percent of wastewater volume is again get back to the aeration basin.

The liquid depth it should be provided 3 to 4.5 meter, a freeboard of 0.3 to 0.6 meter. The mode of air supply either diffused air or by supplementing compressed air from the tank bottom or by mechanical aerator provided at the surface Okay. The modification of the activated sludge process also known as extended aeration is also popularly used in treatment of wastewater. In case of external duration it is designed at very high hydraulic retention time 18 hour with a very low F by M ratio Okay.

It may go as low as 0.05 to 0.15 kg of COD per kg of VSS per day. I hope that you can google it or you can like or maybe I can give you a very basic funda about how, what is F by M ratio. From the name itself you can understand F is food or feed and M is microorganisms, so this is a food to microorganism ratio. How to understand the food, what is the food for microorganisms, organic matter, how to quantify organic matter COD or BOD? So this food is represented by COD microorganisms, how to quantify microorganisms if you remember I just said VSS, volatile suspended solid so VSS is representative of your amount of microorganisms.

So what is food to microorganisms' ratio amount of food that is supplied and amount of microorganisms that is present in your system, this ratio is like food to microorganism ratio. Okay So there are different terms of it there are different conditions of it and the proper

definition and all that I can discuss in details, but due to time constraint I cannot I would really suggest suggest you to go and google it and get learn more about it.

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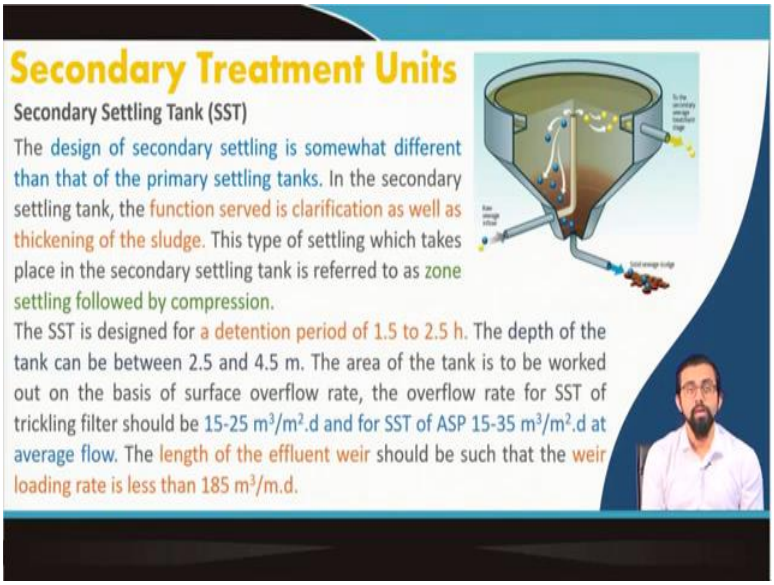

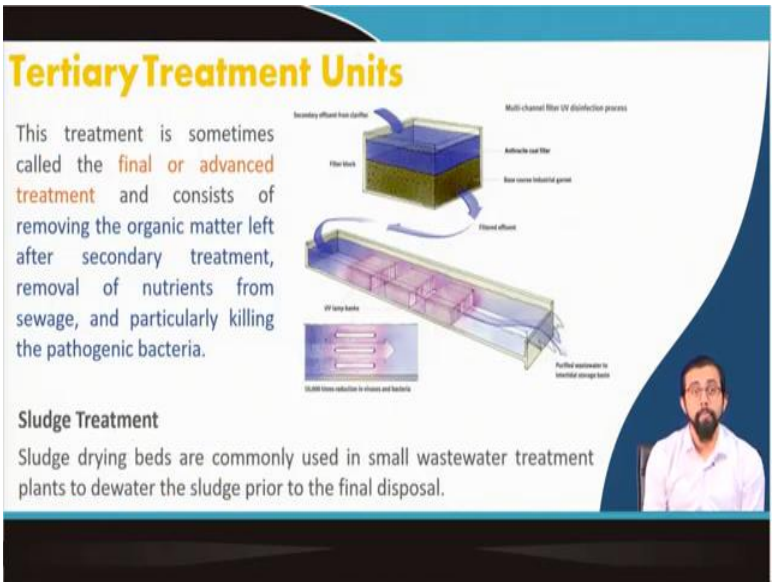

Now there comes the secondary treatment unit, so we only discussed about trickling filter and activated sludge process. These both are aerobic process I only choose this to give you a better understanding of it and with a minimal amount of excess knowledge about more in detail.

So there are other type of treatment units as well USB outflow search blanket reactor, we have different kind of other oxidation ponds is also there, so there are a lot of MBR is there membrane by reactor, moving bed biofilm reactor is there so there are different type of secondary treatment units that I am not discussing in details right now because of time constraint and our motto is not to learn treatment units but to more in the advanced aquaculture practices, but it comes with this knowledge is necessary to understand how we can treat your aquaculture wastewater. Okay

So next we will discuss about the secondary treatment units, majorly the design of secondary treatment settling is somehow different than that of a primary settling tank Okay. In case of secondary treatment unit or secondary settling tank the function served as clarification as well as thickening of the sludge. So our work not only is clarification or the sedimentation but also the thickening of the sludge. The more thicker the sludge and you can be collected in a very precise manner and it can be used for different other purposes and the type of settling that it takes in case of secondary settling tank is referred to as zone settling followed by compression. Okay

In case in SST the detention period is around 1.5 to 2.5 hour, what does that mean that the water will stay there for 1.5 to 2.5 hour, so it will facilitate enough time for sedimentation of

the all your like biomass which is coming from the activated sludge process or UASB or trickling filter or MBR or MBBR, etc.

The depth of the tank can be between 2.5 to 4.5 meter, the area of the tank is to be walked out on the basis of surface overflow rate, the overflow rate for SST this secondary settling tank of tracking filter should be 15 to 25 meter cube per meter square per day, what does that mean, what is surface overflow rate? It means the amount of wastewater which is coming in per square meter of available surface area of your treatment unit per day Okay and SST for activated sludge process is 15 to 35 meter cube per meter square per day at average growth Okay.

Length of the effluent wier should be such that the wier loading rate should be always less than 185 meter cube per meter per day otherwise what will happen it may make certain turbulence into the system and because of that there is the chance of some sludge loss through your effluent wier.

So that is all about the secondary treatment Okay, its not all I am again saying this is just to give you a very brief introduction of these things Okay just to know about secondary treatment unit it will take like 10 hours of lecture at least to give you some basic understanding but as I already mentioned so this is just to give you some overall idea about the systems and the kinetics that is used and later on will with time we will go we will know more in detail and if you are interested you can simply google it and find out the details of the whatever the knowledge you want to hear and gain additionally to this.

Third treatment unit is the tertiary treatment unit, what is a tertiary treatment unit? This treatment is sometimes called as the final or the advanced treatment unit. It consists of majorly the removing the organic matter left after the secondary treatment, removal of nutrients from the sewage and particularly killing the pathogenic bacteria Okay.

Now after these things are done the sludge that is coming out of this system, the sludge drying beds are commonly used for treating this sludge which is coming out from primary sedimentation tank or secondary sedimentation tank or tertiary units it can be treated and it can be well disposed for different other purposes Okay.

So what are the different type of tertiary treatment units that is available you can use the flocculation, chlorine disinfection, tertiary filters, storage pond all these things are examples of different tertiary treatment units. What happens in tertiary treatment units? Ssuppose there

are some amount of solids still somehow feed away from your secondary treatment unit then that solid has to be taken care of right it has to be trapped in the system in the treatment unit that is to be done in tertiary treatment unit.

If some amount of pathogens are still available pathogenic microorganisms just to make sure that there is no pathogenic microorganisms, because it may be used for some anthropogenic activity maybe like you know if it is directly exposed to the human being and all, what will happen in that case if there is pathogenic bacteria are present there it will cause a different type of diseases that is why we use different kind of disinfecting units, UV units, ozonation unit, chlorine disinfection, these are the different examples I am just giving you these examples just to give you a broad idea about how tertiary treatment unit works and why it is provided.

Storage ponds are given, as you know sun is the best disinfectant you put it in the sunlight for the water in a very shallow storage ponds for long amount for long period of time it will treat the water by themselves only like atleast some, at least up to a certain extent Okay. It is not that you will provide it with xenobiotic very high end chemical compounds and all and it will treated, no it has to be treated separately with the proper procedure or scientific way.

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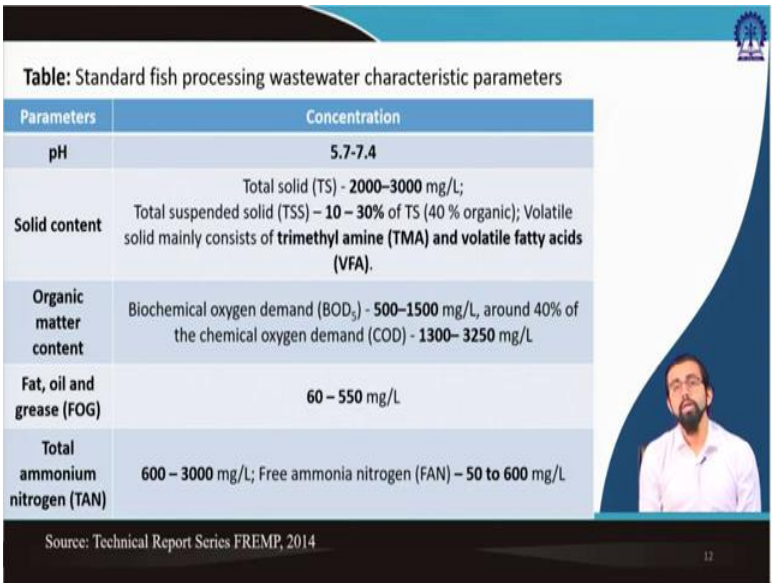

So in general the effluent quality requirement for disposal or treated effluent into the water body or say like you want to reuse for irrigation the effluent standard has to be maintained, effluent standard has to be maintained means the water quality of the effluent has to be properly managed, properly maintained and it has to be well within the limits of limit given by the regulatory body.

In Indian context central pollution control board are the regulatory bodies they are the this is the regulatory body in Indian context, so they say like okay your from this industry so the water that you are disposing from your treatment unit after the industrial purpose is done that has to be well within this limit. The BOD should be this, COD should be this, pH should be this, TSS should be this, the total suspended solid, VSS should be this, and dissolve oxygen should be this. I mean I am just giving you overall example the nitrogen content, nitrite, nitrate, ammonia, phosphorus, chlorine, arsenic and all these things like everything is well prescribed it is given all the details are given in the CPCB website also that you can follow.

So you have to know that these are the limit above of which you may get some legal action, there is a chance of legal actions taken against you if you are not following those regulatory bodies the rules and regulations given by the regulatory bodies and if you do not maintain that effluent standard given by the central pollution control board in Indian context Okay, but there are other regulated bodies as well state state based or private best so that also can be there should be maintained; it is completely based on the place to place Okay.

So after all this let us now discuss about as I mentioned at the very beginning of this model we are discussing a whole treatment system at the beginning, wastewater treatment systems with time will narrow it down to aquaculture or fish processing industries Okay. In case of

fish processing industry or fish processing like like you know different processing wastewater that it comes out from fish crossing industries in general what are the characteristics of this wastewater. It has a pH of around 5.7 to 7.4, solid content TS can be 2000 to 3000 milligram per liter total suspended solids around 10 to 30 percent of TS among the 40 percent organic volatile solid mainly consists of trimethylamine and volatile fatty acid, because these are the excretory products from the fish industries in general.

The biochemical oxygen demand BOD_5 will be like 500 to 1500 it is really high and 40 percent of like chemical oxygen demand which is like different chemicals are 1300, 1500 up to three thousand, five thousand, ten thousand also you can go sometimes depending upon the type of wastewater, type of industry that you are working on. This is highly notorious you cannot just use it, you cannot just throw it into the surface water body it will just completely disrupt the whole ecosystem of your river or your surface water whether it be pond or lake whatever it is.

You have to treat the water the wastewater in a proper manner so that final effluent which is coming out of your treatment plant has to be well added to the regulations given by the regulatory body like CPCB and all Okay. Fat, oil and grease concentration can be as high as 550 milligram per litre, it is pretty, high total ammonium nitrogen 600 to 3000 milligram per liter, free ammonia 50 to 600 milligram per liter and we are talking about in 1 to 10.

Free ammonium nitrogen even like 1 to 10 milligram per liter can be lethal; it is really lethal for the aquatic species. You have to understand this fact, so you know it free ammonium nitrogen is very notorious for any aquatic species Okay. So it has to be minimize, how to do that proper treatment Okay unit proper treatment unit or proper treatment design of your wastewater treatment units.

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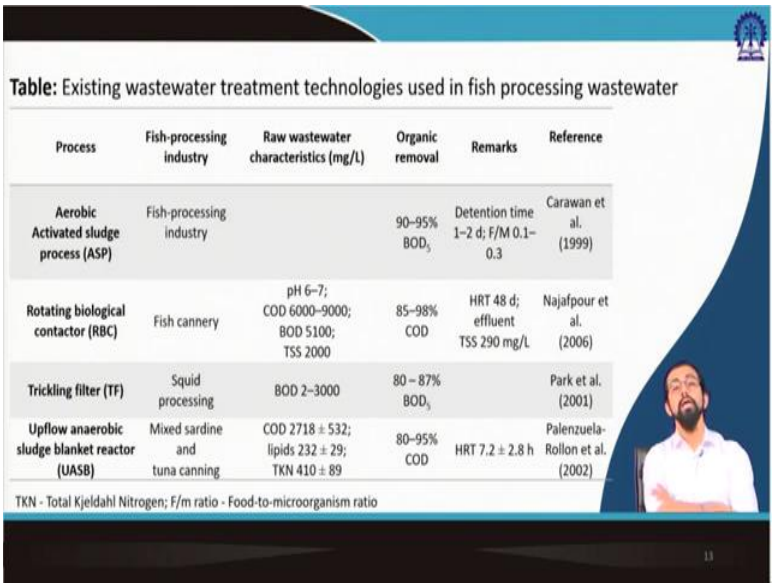
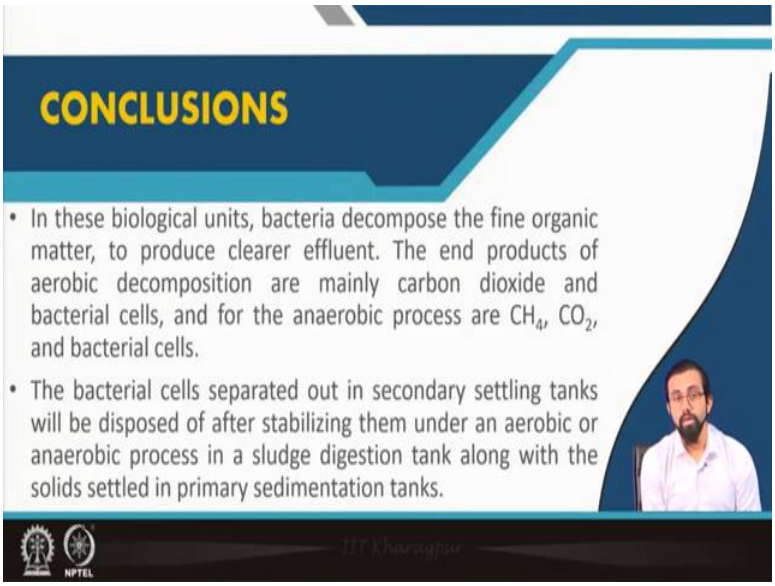


Table: Existing wastewater treatment technologies used in fish processing wastewater

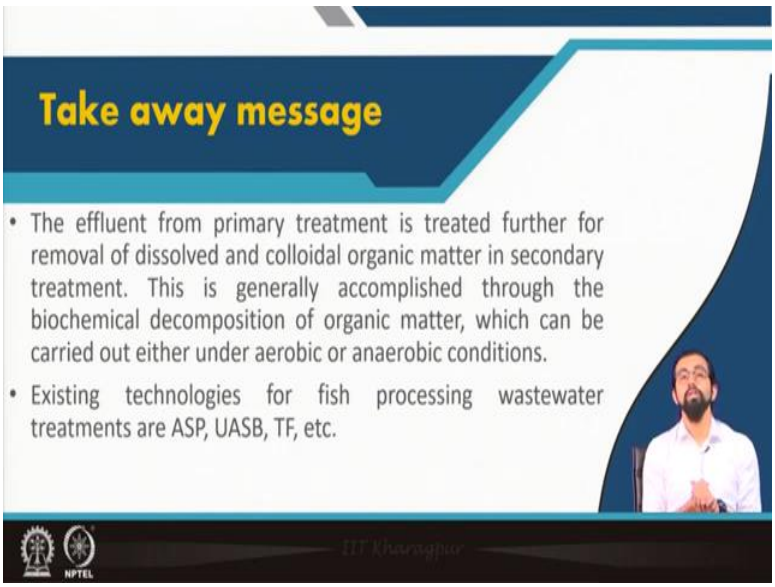
Process	Fish-processing industry	Raw wastewater characteristics (mg/L)	Organic removal	Remarks	Reference
Aerobic Activated sludge process (ASP)	Fish-processing industry		90–95% BOD_5	Detention time 1–2 d; F/M 0.1–0.3	Carawan et al. (1999)
Rotating biological contactor (RBC)	Fish cannery	pH 6–7; COD 6000–9000; BOD 5100; TSS 2000	85–98% COD	HRT 48 d; effluent TSS 290 mg/L	Najafpour et al. (2006)
Trickling filter (TF)	Squid processing	BOD 2–3000	80 – 87% BOD_5		Park et al. (2001)
Upflow anaerobic sludge blanket reactor (UASB)	Mixed sardine and tuna canning	COD 2718 ± 532; lipids 232 ± 29; TKN 410 ± 89	80–95% COD	HRT 7.2 ± 2.8 h	Palenzuela-Rollon et al. (2002)

TKN - Total Kjeldahl Nitrogen; F/m ratio - Food-to-microorganism ratio



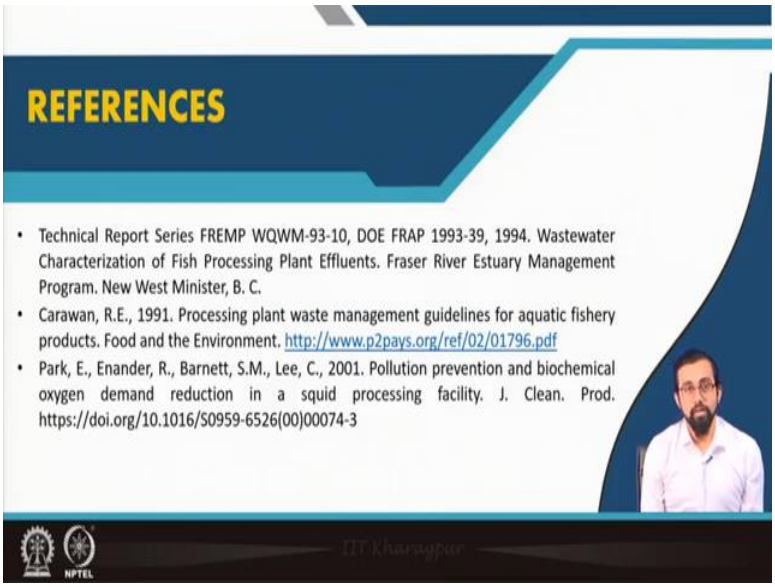
CONCLUSIONS

- In these biological units, bacteria decompose the fine organic matter, to produce clearer effluent. The end products of aerobic decomposition are mainly carbon dioxide and bacterial cells, and for the anaerobic process are CH_4, CO_2, and bacterial cells.
- The bacterial cells separated out in secondary settling tanks will be disposed of after stabilizing them under an aerobic or anaerobic process in a sludge digestion tank along with the solids settled in primary sedimentation tanks.



Take away message

- The effluent from primary treatment is treated further for removal of dissolved and colloidal organic matter in secondary treatment. This is generally accomplished through the biochemical decomposition of organic matter, which can be carried out either under aerobic or anaerobic conditions.
- Existing technologies for fish processing wastewater treatments are ASP, UASB, TF, etc.



There are some existing wastewater treatment technologies that is used in fish processing wastewater like activated sludge process, rotating biological contractor, trickling filter, upflow anaerobics sludge blanket reactor, so this upflow anerobic sludge banket is the anaerobic wastewater treatment units.

So all these statement units are used in fish processing industry and it is studied by different reviewers, different scientists and they found out that the organic removal of around 90 to 95 percent can be achieved in aerobic activated sludge process. Detention time of 1 to 2 days, F by M ratio 0.1 to 0.3, HRT like hydraulic retention time or detention time is the same 48 hour in case of biological order, rotating biological contactor or RBC with the TSS of around 290 milligram per liter.

So all these values are given, this removal efficiencies are given so these are the standard existing wastewater treatment technology that we normally follow however, there are some advantages as we discuss only about the advantages there are lot of disadvantages also with this existing conventional wastewater treatment technology.

First of all it takes a lot of land mass, it has a very high footprint; footprint means land footprint is very high it needs a huge amount of land and it is a huge amount of energy, most of them it cannot give you 100 percent guarantee that the water that is coming out of the system is like foolproof and you can use it at the time itself. So it may require some additional tertiary treatment units and all and all these things are there, so that is why we need to find out some alternate solutions Okay, still scientists are working on it.

In next lecture I will be discussing with you one of this technology which is considered as cutting edge technology for wastewater treatment plus this technology can give us some bioenergy generation as well Okay. So in next lecture I will be discussing more in details about all this about all the treatment units.

In general in conclusion I can say this secondary treatment unit where bacteria normally decompose the final running matter to produce clearer effluent and the end product if it is the aerobic process it is carbon dioxide and bacterial cell and if it is anaerobic process mostly it is methane carbon dioxide and the bacterial cell. The secondary This bacterial cells which is separated out like which is normally generated in biological reactor it comes to the secondary settling tank and then there it will dispose after stabilizing the monitor and aerobic anaerobic process in a sludge digestion tank along with the solid settled in the primary sedimentation tanks and all Okay.

So what is the takeaway message that the affluent from the primary treatment is treated further for the removal of dissolved and organic colloidal organic matter in secondary treatment and this is generally accomplished through the biochemical decomposition of organic matter which can be carried out under either aerobic or anaerobic condition or by mixture of both; there are certain effluents where they use aerobic as well as anaerobic treatment units. Existing technologies for fish processing wastewater treatment are ASP, UASB, trcikling filter, etc Okay.

So we will know more about some advanced technology, advanced wastewater treatment technology in the coming lecture Okay. So these are the references that you can follow for further knowledge. Thank you so much see you in the next lecture.