Wastewater Treatment and Recycling
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Lecture – 38
Introduction to Sludge Management

Hello everyone and welcome to the 8th week of this course Wastewater Treatment and Recycling. We have discussed up till 7 week, the basis of the wastewater generation, then it is quantity characterization, how it is attenuated in the natural systems and then what are the engineering treatment procedures. So, far we have covered the secondary treatment. So, the primary or preliminary treatment which takes cares of majority of the floating material, large suspended solids those part and then the dissolved organics switch are removed in the secondary treatment. And we did discuss in the last couple of weeks one by one, like we first discussed the aerobic secondary treatment processes and then the anaerobic treatment processes.

Now, this week our discussion will be focused on the Sludge Management aspect. So, when we kind of process the wastewater or treat the wastewater; the idea of treating wastewater is removing the pollutants from the wastewater and through the preliminary treatment, we remove the floating materials first through screening and then with the grit chamber we remove the large grit materials, which are which could be present in the wastewater. So, water is free of these things, but where does this screens or the grit which is removed, where does it go? So, that is kind of leaves with water phase and come into the solid phase and it is collected separately and constitutes a type of solid mass.

After grit, we discussed the sedimentation, particularly the primary sedimentation part. So, in a primary sedimentation again the settleable solids not that of grit, grit is removed in the grit chamber, but then there is smaller settleable solids are removed in the primary sedimentation. So, again the water is free of those settleable solids or majority of those settleable solids are removed from the water, but where does that solids go? They again gets collected from the like bottom of the tank as we were discussing collected as a solid mass or solid waste mass, which is coming from the primary sedimentation tank. Then in the secondary treatment, the conventional treatment process which we were discussing is

when we go into the like activated sludge process. So, the organic matter is converted into some of the byproducts which includes some gases and a large portion almost half of the organic matter consumed converts into the biomass which is then removed in the secondary settling tank.

So, the conventional system which mostly rely particularly for the sewage treatment which mostly rely on the aerobic treatment processes again. So, almost half of the organic matter consumed is converted into the biomass and that biomass eventually has to be removed from the water. So, in the secondary, secondary sedimentation or secondary settling tank that biomass is removed part of that is recycled that is a different thing eventually that also comes, but then there is a significant part of the sludge which is wastage. So, that is also being removed the dissolved organic converting into the biomass is being removed from the water in the form of solids again.

So, there is lot of solids that are generated in this process of the wastewater treatment, they are generated from the different stages and then they have the different characteristic also. So, these solids which are generated from the different stages are typically referred as sludge ok. So, that is what is the source of sludge when you are talking about the sludge management. So, sludge essentially consists of these solids which are generated from the different steps of the wastewater treatment processes, ok.

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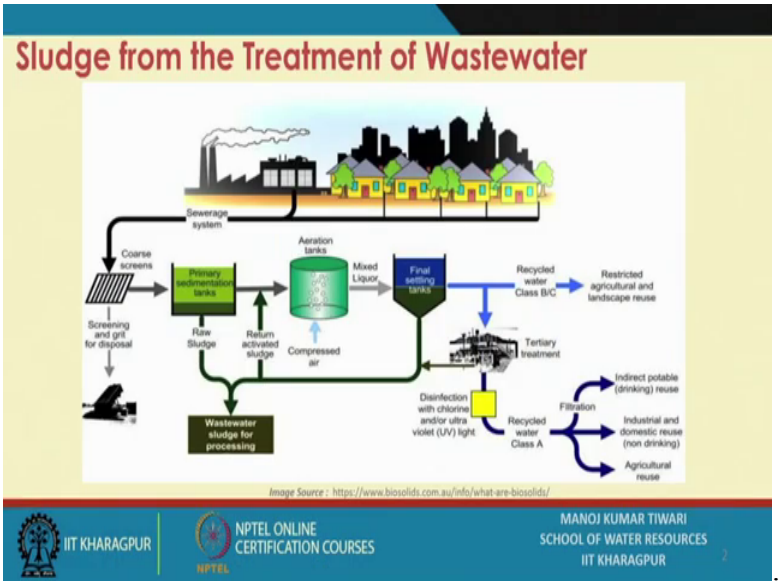

So, if you see the. typical wastewater treatment system what we get here is if you can see there are this primary sedimentation tank that is generating raw sludge, ok. Then there is your radiation tank which is a part of activated sludge process, this again through the secondary settling or final settling tank generate sludge. Part of this could be send again back as a returned sludge, but then rest the wasted sludge component comes here. So, this collectively forms the majority of the wastewater sludge, ok. Apart from this of course, there are screens and there are grit those things.

So, they screen and grit are also collected they are also a form of sludge which actually comes which generated at the wastewater treatment facilities, but the major point of concern is the wastewater sludge which is coming from primary and secondary settling basins, ok. There is possibility of solid mass generation from the tertiary treatment which we have not covered so far, but eventually we will at later stage in the next week. So, when we go for the advanced or tertiary treatment there are again quite a few processes which generate sludge. So, that sludge also can be basically linked to the secondary or primary settling sludge depending on its characteristic and needs to be processed at the wastewater treatment facility.

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So, that way we end up generating sludge from the various different units in the treatment plant. Now what essentially is sludge? The, it is the conventional wastewater treatment plant although quite efficient in removing the organic matters, but at the same

time they generate lot of access sludge, large amount of access sludge in the form of solids, ok. So, these solids which are generated at the different treatment facilities, at the different sites, from the different units. As we were just discussing so, from all those different units a large amount of solids is generated and handling or managing these solids is a big task for any wastewater treatment facility, ok.

The solids are generated from the suspended contaminants that are present in the wastewater as well as the dissolved contaminants which gets converted to the solids in the secondary treatment systems. So, this sewage sludge is typically refers to this residual semi solid material, ok. We are saying solid, but because there is a lot of solid, but in order to carry that solid in order to process that solid, in order to relate that solid flow out of the your treatment reactors, it is actually like the solids are present in a wet condition, ok. So, there is a lot of moisture content in these solids, and that is why it is essentially not a dry solid, but it is kind of a semi solid, with significant amount of moisture content.

So, this is produced as settled byproduct during the sewage treatment, or during the treatment of industrial waste waters and the quantity of this sludge how much it is going to generate eventually depends on the degree of treatment, ok. So, what are the different degree of treatment being provided? Like for say take an example that we discussed in the last couple of weeks. So, in the week before we were talking about the aerobic secondary treatment processes where more than half of the organic matter consumer almost half of the ordinary matter consumed converts to the bio solids. Whereas, the previous week when you were discussing the anaerobic treatment processes, barely less than 5 percent of the organic matter consumed converts to the solid.

So, if you see the generation of solid or how much quantity of the sludge that can be generated will eventually depend on the type of treatment system which is being used, ok. the treatment facility which is being provided and also depends on what degree of treatment is being provided. So, if you are removing let us say 90 percent of organic content or you are just removing 60 percent of organic content, essentially that are things which converts to the solid. And the handling of the sludge may account for as high as 50 percent of the total cost of a sewage treatment facility. So, that actually is a huge cost. Particularly in the conventional activated sludge processes where it can cost as high as

around 50 percent of the total treatment cost that becomes a huge chunk of the money that will be invested, that will be needed for managing the sludge.

And a large portion because if you go for traditional dewatering or drying system. So, large portion of this goes to the transportation and land cost as well because processes are not that difficult processes are relatively simple, but there is a large cost associated in terms of the land cost in terms of the transportation in terms of the handling of these processes ok. So, that is one of the major aspect of the treatment.

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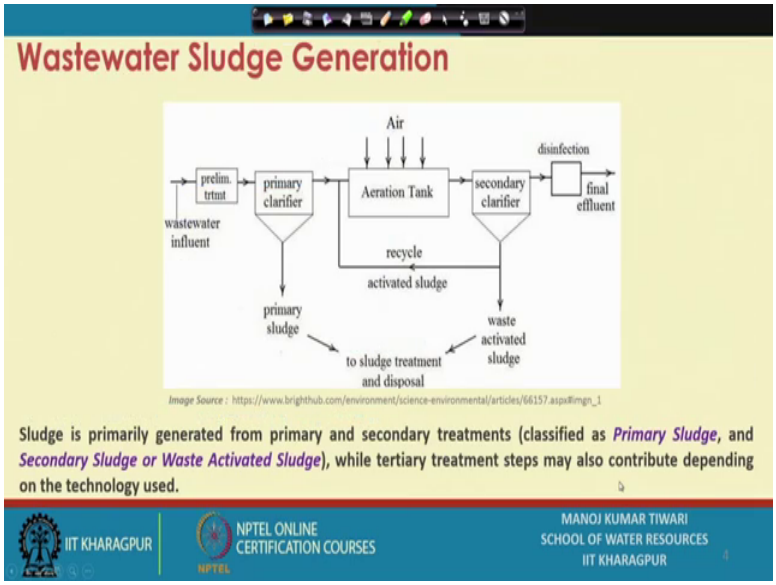

So, if we see the generation of sludge from where the sludge is generated. So, as we were just saying that sludge is generated from all different stages, ok. Sludge is generated from the basic preliminary treatment where the screens and grit chambers, those kind of things generate solid mass it is, but that is a peculiar nature mostly inert nature because grit material is inert, you cannot probe and that does have water content. But, there is not that much of water content either of the very high specific gravity they settle in the solid mass and the grit that you collect and because the particles are larger pore spaces are less. So, there is not much of water content present in there.

Similarly, for this screen when you collect the floating materials and then you take out your bar rack and empty it. So, the amount of screen which is coming into the system or is actually a will not have that much of water content. So, the volume is relatively lower as well as a same from the grit also depending on the how heavy the particle is all those

kind of thing the mass and volume will depend on those things. But they are inert materials and they generally do not need further processing because we cannot make much out of those with those inert materials.

So, what happens they are traditionally then taken to some landfills or those kind of places and dumped in there and when we say that the sewage sludge we are not like although it is generated at sewage treatment facility, but the major focus in the sewage sludge remains to the primary sludge and this secondary sludge. So, sludge is basically primarily generated from this primary clarifier or primary treat, sedimentation tank which is called as primary sludge and then it is generated at, from the secondary clarifier in the conventional wastewater treatment facilities. So, if you are having let us say activated sludge process. So, from secondary clarifier this sludge will be generated and this is called as secondary sludge or also called as waste activated sludge.

So, why waste activated sludge? Because it is the activated microorganisms which are being collected at a sludge as a wastage material; so, that is why this is called waste activated sludge as well or WAS./ And, these collectively are considered as the sewage sludge or wastewater sludge which are kind of further could the processed or could be like handle or management of this needs to be taken care of at any sewage treatment facility. So, while the tertiary treatment steps may also like a contribute some of these sludge depending on the technology as we were discussing in the beginning. Also that if you are going for a tertiary treatment which produces some sort of sludge. So, that sludge can also come and join in here. So, that also becomes a part of the wastewater sludge or sewage sludge which needs to be handled.

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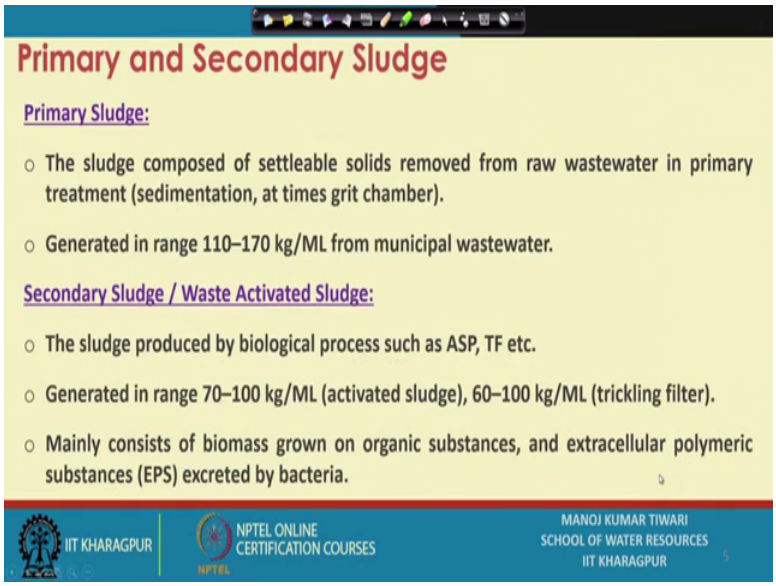

Now if we see the primary and secondary sludge. So, primary sludge typically composed of the settleable solids which are removed from raw wastewater in the primary treatment facilities, ok. So, generally the sedimentation and at times grit chamber is also considered, but the grits are mostly inert material. So, they are not normally processed with the sedimentation sludge or the primary sludge, ok. They can be taken out there is not much of water content anyway. So, they can be disposed off to landfill and those kind of sites as we were just discussing.

The typically primary sludge is generated in the range of 110 to 170 kg per million liters from municipal waste waters, ok. And then we have the secondary sludge which is produced from the biological processes and mostly from the aerobic biological processes because anaerobic biological processes sludge production is very low and daily sludge generation, if we see it is almost very little the sludge is excess sludge is discarded at a much larger intervals as opposed to the frequent like daily disposal or continuous sludge withdrawal which is there in the aerobic systems.

So, the processes such as activated sludge process, trickling filter or various other extended aerobic processes which generate lot amount of large amount of sludge or large amount of these bio solids. So, they are typically considered at secondary sludge or waste activated sludge. The range in which it is generated is 70 to 100 kg per million litre

for the activated sludge processes and almost 60 to 100 kg per million litre for trickling filter processes.

So, that is the typical range of the sludge which is generated per million litre. Now these mainly consist of the biomass which is grown on organic substances because the secondary sludge as we were discussing it is primarily the microorganisms or the cells which has been synthesized in the process of aerobic decomposition. So, the new biomass produced or the new cell synthesized, they come as a sludge, ok.

And apart from that there would be some extracellular polymeric substances which is typically referred as EPS. So, those EPS excreted by the bacteria also settles and they are also termed, they are also a constituents of the secondary sludge. So, that is how we get the primary and secondary sludge. Apart from this primary and secondary sludge which typically we say there are different stages of sludge production, ok.

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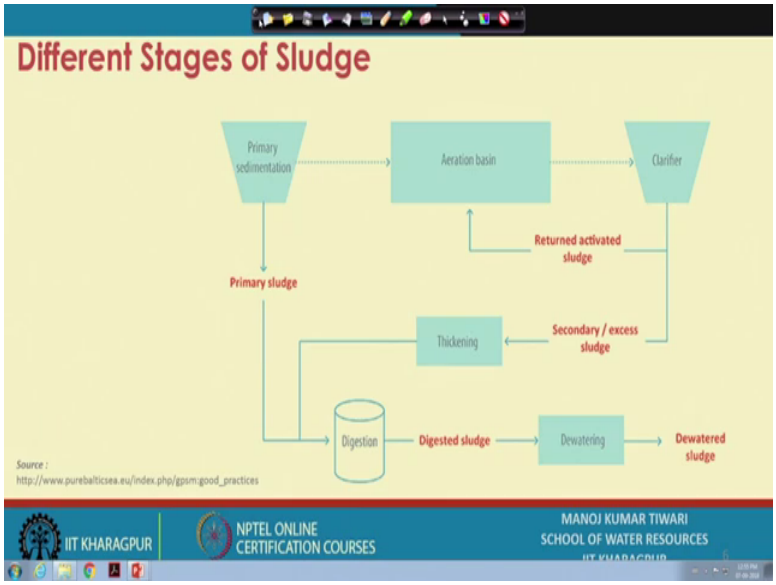

So, these are the different types primary and secondary. So, that is fine, but then there are different stages of the sludge production. So, as we were just discussing we have a primary sludge and then we have a secondary sludge or access sludge or the waste activated sludge what we call. So, these are the 2 sludge that are they are for management, but then we get the different stages of sludge because when we start processing of this sludge so, then like we will get the dewatered sludge, we will get the

digested sludge, we will get somewhere we can call that thickened sludge. So, we will get this thickened sludge as well.

Now, so, these actually are the different stages of sludge apart from the raw sludge coming in from the primary and secondary facilities and could have the different characteristics. They are mostly or primarily different in their water content and of course, the digested sludge will have difference in the characteristic as well, but they are like the first process of thickening or what is ever is there.

So, that is different in the that kind of differs in it is water content the sludge which differs which will have a different water content after the thickening. So, that becomes a different stage of sludge which will probably in the have lesser total volume, but higher solid content the sludge which is coming in here will have lesser solid content and will be in a large volume same for the here.

So, how we basically kind of quantify the sludge or how we figure out the volume of the sludge ok? So, let us say the total solid which are being released out of the either primary or secondary clarifying basin will have certain mass, ok. So, or will have certain volume as well on dry basis, ok? So, for say if you are have you are generating 1 ton of say dry solids ok, if you are generating 1 ton of dry solids.

So, this 1 ton of dry solids may occupy some space depending on its specific gravity depending on it is density ok. So, how much volume this 1 ton occupies right. So, for say because if you have that way 1 ton of water that is going to occupy the one kind of 1 meter cube of the space volume ok, but this if it is say lighter because many of these things are lighter than the water. So, they may occupy certain space depending on their specific gravity.

So, if let us say this occupies this much of space is occupied by the solids dry solids is let us say having this much of the total volume is because of dry solids. Now, this solids does not flow from the clarifier as a dry material they come along with the water. As you are discussing so, there will be lot of water content water content can be expressed as weight by weight percentage or volume by volume percentage or weight by volume percentage also.

So, let us say if you are, if we presenting a water content as volume by volume percent and say that the sludge which is generated is having, 10 percent solids volume by volume so; that means, that the total volume occupied by the solids is, is basically just 10 percent of the total volume ok. So, that way for whatsoever if let us say the total volume occupied by the solids is V, ok. So, V is actually the 10 percent this or say V of the solids volume due to the solids. So, volume of solids is essentially just 10 percent; that means, 0.1 times of the total volume of the sludge.

And from here you will get that the total volume of the sludge will be actually equal to the volume of solids divided by your 0.1. So, that will eventually become 10 times of the volume of solids which is being generated. So, if you are ideally, you are generating V as volume of solids which you want to kind of manage or process or what is ever, but there is large amount of water involved in there and that makes its volume making 10 times higher, ok.

Now, same way if we have let us say the this 10 percent solids again, but not by volume by volume, but by weight by weight. As let us say weight by weight percentage 10. So, in that case if you are having weight by weight as 10 percent so; that means, if there are 1 ton of dry solids, ok. So, if there is 1 ton; that means, a 1000 kgs ok. So, if there is 1000 kg of dry solids so; that means, this total weight of the sludge, ok. So, let us say similar way we will say that weight of this large is actually equal to 0.1 percent weight of the total sludge, if this is weight of solids ok. So, that is going to be 0.1 times weight of the total solids and then from here we can again get that the weight of the total solids is going to be equal to 10 times of weight of the total solids.

Now, weight of total solid is 1 ton so; that means, we are going to get 10 tons of total solids ok, 10 ton of the total weight of the sludge which is being produced, ok. So, that way we will be like we can have an idea of how much this thing is being produced now water and solids may have a specific gravity. So, if you want to determine the volume of this sludge, if you want to determine the if you want to determine the volume of say this total sludge, if you have been given 10 percent weight by weight and you want to determine how much volume is it is going to occupy so; that means, out of this 10 ton, or out of this 10 ton that we have in case of 1 ton. So, 1 ton is actually the solids, ok. So, the 1 ton is weight for solids and 9 ton is weight for water. So, this is your for water and this is for solid.

So, this way you can actually know the volume of water because we know the density of water is 1000 kg per meter cube, ok. So, that way this is going to be 9 meter cube. If you take that by density and when you are having this 1 ton weight of solids. So, depending on the specific gravity, depending on the density of solid, depending on how much volume these solids will occupy.

So, we know the weight of this, if we know the density let us say density of solid is RHO s in say kg per meter cube that way or so, that way we can actually have this is 1 ton. So, the volume if you want to convert this volume into this weight into volume; so, that will be rho we have to multiply actually the, if we multiply the volume with the density we get the mass. So, we have to divide mass with the. So, weight whatever weight we have or mass we have the speed of weight we can use mass though.

So, whatever mass we have if we divide it with the density we will get the volume. So, what is a the weight of this or mass of the solids dry solids. We know and we can actually divide it with the density in order to get the volume and that way we can compute the total volume, ok. So, that will become our total volume and out of that we know that 9 meter cube volume is let us say occupied by the occupied by the water. So, what is going to be the volume occupied by the solids in percentage that also we can determine.

So, that way we can actually like have an idea of the sludge which is being generated from secondary or primary sedimentation tank. So, depending on how much water content is there or how much solid content is there, we can figure it out how much water is there how much solid is there what is the total mass of the water, what is the total volume occupied by the water. So, this, this volume occupied gives us the potential of reducing the volume the mass similarly we can have a potential of reducing the mass, if we kind of reduce the water content and increase the solid content. So, if you are increasing the solid content in the sludge. So, that way the total mass of the sludge or because the water part of the water will leave the system. So, total mass of the sludge will also reduce, total volume occupied by the sludge will also reduce that way.

So, these, the raw sludge is then like can be processed through these different steps releasing to different stages of sludge like thickened sludge as we were discussing, like digested sludge, like dewatered sludge. So, depending on again they, they can have the

different solid content, different organic content also because the digestion of the organic content can also change or the characteristic can also change, which is kind of a treatment process. We will discuss in the subsequent lectures in this week and of course, sort of will occupy the lesser volume and will tend to get the will tend to be in the lesser in the weight as well

So, with this will conclude this particular lecture and in next lecture we will talk about the quantity and various characteristics of the sludge which is generated from the different steps or different units of the wastewater treatment facility.

Thank you.