Wastewater Treatment and Recycling
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Lecture – 39
Wastewater Sludge : Quantity and Characteristics

Hi everyone. So, here we are back again in this 8th week discussing about the Sludge Management part. So, in the previous lecture we had a basic introduction of the Sludge produced in the Wastewater treatment facility. So, from which different units it could be produced ok, and what are the sum of the attributes related to the sludge production what is the primary sludge secondary sludge ok, and what are the different stages in which the sludge remains or sludge is processed throughout the wastewater treatment facilities.

This class we are going to talk about the characteristic of the Sludge ok. So, how the sludge is characterized not the procedure, but the parameters based on which the sludge is characterized and what are the typical characteristic of the sludge coming from the different steps or different unit processes or unit operations from a wastewater treatment facility. And, we will talk about the quantitative aspect of the sludge generation. So, how much sludge can be produced from the different units or those kind of different aspects.

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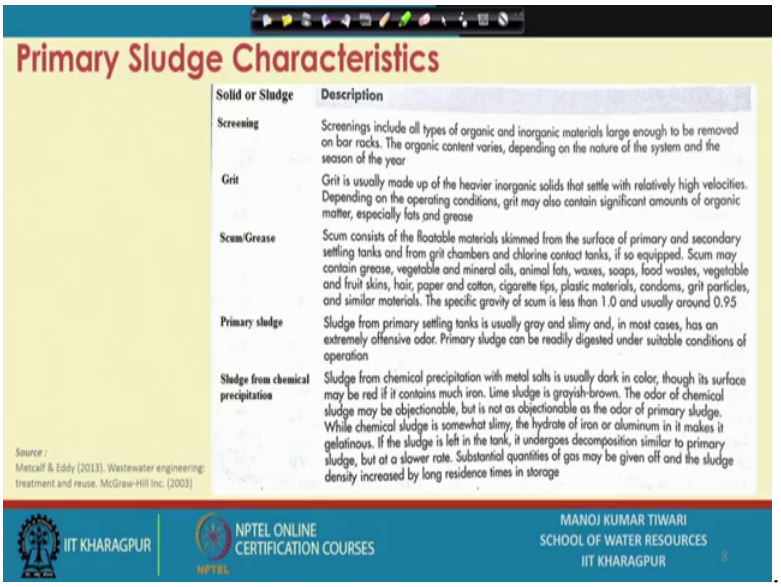

So, to begin with if we see the characteristic of the primary sludge, so, although as we said that the primary sludge basically comes from the your preliminary your primary settling time, but then all the kind of innovate or non biological sludge those kind of thing are also can be included in the primary sludge. So, if we see the based on the source of the sludge, so if it is coming from the Screening so, a screening sludge includes all type of organic inorganic materials which are large enough to be removed from the bar racks that is how they are removed ok.

So, the organic content varies because we never know how what is coming in the floating whether they are leaf, there are clothes, there are wood pieces or there are polythenes or there are say paper those kind of thing there are there could be various nonorganic stuff as well. Ok you are coming let say a iron rod is coming aluminum sheet is floating through that so, some metal those kind of thing. So, it totally depends on the nature of the system and the season of the year also ok.

So, in monsoon we will say lot of things actually go into the drains wastewater drains also. So, they will have much larger portion of the screens coming in which are removed through the screening. So, characteristic can also change from place to place how nice the wastewater system is if you have let us say your sewage system for collecting of the sewage is covered from the top there is no kind of additional or foreign materials entering into the sewer lines. Then you will see lesser of the screens and the characteristic of the screens would typically be whatever is being generated or being flowed from the household scale, but if you have a open drain system. So, there is lot of things wrappers, polythene, various tree leaves all those things actually go into there and that can actually change the composition and quantity of these screens.

The Grit is the second system which kind of generates some sludge. So, grit is usually made of heavier inorganic solids ok, which settle with relatively high velocity and depending on the operating conditions, it may contain significant amount of organic matter also.; But generally it contains it may contain some significant or organic matter, but mostly it contains the inert grit material or those kind of thing ok. It may contain fats and grease also depending on the like the material which is being removed whether it is of that type so, because grease and these things also can actually be removed in the grit chamber. So, they can also come under that set up, but a very little the lot they are since relatively like if there are large clumps of grease and those thing they can probably be

settle, but mostly like majority of the fats or oils and those kind of things are lighter than the water. So, they do not settle in the grit chamber. So, very little composition could be of this, but majority will be inert grit materials.

Then we have Scum removal or Grease removal systems ok. So, in a primary sedimentation in a preliminary treatment when we are discussing so, it is not that common for the sewage treatment facilities, but for many of industrial treatment this things. So, there is if your waste water is containing lot of oil or grease or those kind of thing. So, what happens that grit removes the heavier particle, but these since float on the top. So, there is a scum removal or grease removal unit can also be given which kind of mix it. So, that the things; these things come into the top of the tank and then from there they are removed as scum. So, that is called scum removal or grease removal

So, this consist of basically floatable material which is came from the surface ok, and this we may not always go for a separate unit because this can be done in a primary sedimentation as well ok. So, then again this may contain grease this may contain vegetable oil, mineral oil, animal fats, these waxes soaps. So, whatever is the lighter material which actually floats which does not settle down, but instead of because if it is having a specific gravity which is say lower than the water. So, then instead of settling it down it will flow on the surface. So, all those things which can actually float on the surface of the water they are removed in these scum or grease removal systems ok;which actually can come from primary sedimentation as well. But the difference is let us say if you have a primary sedimentation basin.

So, the sludge primary sludge will be collected from the bottom which is being basically driven by this thing whereas, scum and this thing will be collected from the top. So, in when you allow it for sometime the particles the heavier particles they these sediments or settleable solids they settle down and those lighter particles they may come on to the top. So, the removal could be from both side from top we can remove the scums or grease or floating materials and from bottom we can actually remove the settled materials ok.

So, the primary sludge which is one of the major constituents as we were just discussing; so, this primary sludge again consist of usually kind of like the settable solids ok. So, these solids which coming primary, say usually gray and slimy ok. And in most cases has some offensive odour as well. So, this can be readily digested under suitable conditions

of operation depending on again what kind of this thing may be times like if the primary sludge may contain organic significant amount of organic compound, but there might be possibility if there are very find solids and organic solids which are not removed in the grit chamber even with the higher specific gravity they will also settle in the primary sludge. So, the characteristic can vary again depending on the source, depending on the climate, depending on the reason, depending on the living habitat of the people. So, all these things will eventually govern the characteristic over there.

There could be Sludge coming from the chemical precipitation approaches. So, particularly like though not so, used in the mini trip traditional municipal waste water system, but many of the industrial system it is used. So, if you have let us say a various dissolved heavy metals or those kinds of things or you can basically add one can go for chemical precipitation of those heavy metals by adding lime adjusting ph and those kinds of things. So, there would be lime sludge which will be produced ok, because this chemical precipitation is mostly done by changing alkalinity. So, like this which contains iron metal such as iron and those kind of thing. So, we can add the chemical particularly lime what's in the form, and that allows the various hydrates of iron and aluminum and various other metals to settle.

Now, this material which settles could be gelatinous ok. And particularly with addition of lime or those kind of thing we can actually form gypsum in this thing ok. So, these things also can settle and its quantity again be depending on the those of the chemical which is being added, and the amount of metals which are being precipitated ok. So, what is the TDS of the system there are how many dissolved metals and those kind of thing. So, they can be removed with for the purpose many times these chemical precipitation methods is used in the industrial waste water treatment facilities, and in sewage what happens that for smaller portion. If it is intended to be reused and there are issues related to the kind of characteristic of metal higher metal concentration. So, the treated sewage from the secondary units could be processed for chemical precipitation as advance treatment unit as well at times ok.

For those part of the water which is going under some sort of reuse that is the another type of sludge which is generated.

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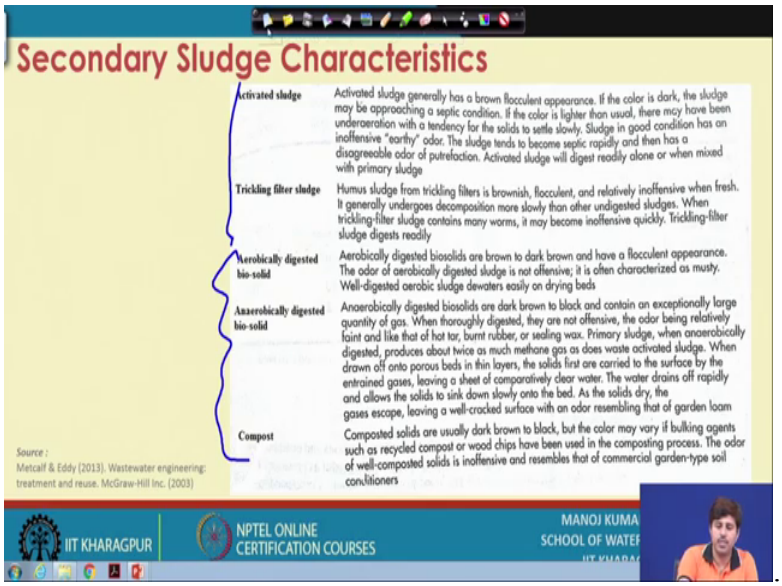

Then if we see the characteristic of the secondary sludge the secondary sludge which is most part comes from the activated sludge process. So, activated sludge process generally has a brown flocculent appearance because the bacteria which gets accumulate they form floccus also. So, that kind of things if the color is dark the sludge may be approaching to a septic conditions so; that means, if the color is turning darker side or blackish there is possibility that there is not enough oxygen available and the sludge is turned out the conditions are turning anoxic and that way sludge is turning septic ok. If the color is lighter than the usual that may have been kind of like under that may have been under radiation with a tendency of the solids to settle slowly.

So, sludge is good cut good condition have a inoffensive earthy odour. So, like the odour which will be coming from the sludge will not be very offensive; will not be like very strong odour or something it will be kind of like the smell of kind of a soil or kind of a earth. So, not much smell comes from the activated sludge that way. The sludge tends to become septic readily and then that us why kind of may have a disagreeable odour for a prettification this activated sludge will digest readily alone when mixed with the primary sludge. So, there is a good possibility of digestion of this activated sludge.

With Trickling Filter Sludge again is kind of brownish flocculent and relatively kind of inoffensive not so offensive smell ok. When fresh it is process is same it is the like in trickling filter or in activated sludge process the material the sludge is produced from the

aerobic decomposition of organic matter. So, kind of characteristic again more or less remains same ok, and this also can be digested readily. The Aerobically digested bio-solids which are the sludge which has been digested once so, as we were saying in the previous class there are different stages of sludge. So, the digested bio-solids are generally brown to dark brown ok. So, the digestion has taken place. We will talk about the digestion process in the later this thing, but like once it is digested it color can have like this way the odour of aerobically digested sludge is also not offensive ok, and its often characterized as musty the well digested aerobic sludge will kind of like the water pretty easily in the drying beds.

Then there are an aerobically digested bio-solids, so when we digest the bio-solids an aerobically which is actually the probably one of the more popular approaches for digestion of the sludge ok. So, this will be kind of in a dark brown or black because it is done in a anaerobic condition, so septic conditions and then there is may contain a large quantity of gas in it ok, An aerobic process are done in a closed system in order to prevent from oxygen and there is a gas production as well as we discussed in the previous class, so previous week. So, there is methane or those kind of biogas generation is there and if it is not taken out well. So, there might be some quantity of gas in present in there and that may lead to some sort of odour as well.

So, when it is properly digested ok, there would not be like much offensive odour ok, but like if it is properly digested; then there might be problem of such odour which his being relatively faint like the odor of hot burnt rubber or this kind of waxes. The primary sludge when an aerobically digested produces about twice as much methane gas as thus the waste activated sludge. Because waste activated sludge the majority of the organic matter has already been decomposed once half of that has already been converted to CO 2 or those kind of thing. So, that way the wa potential for methane production is not that high and in fact, the primary sludge have much higher the methane production potential that way, when drawn off on to the like porous bed of thin layers these solids are first carried out by the surface and then eventually the drying place.

And as the dry solid when the gas escapes, this leads a well crocked surface with an odour resembling that of the garden loam soil. Then there are compost ok, so composted is this sludge can be composted which becomes another layer and composted solids again are dark brown to black ok, but color may vary depending on the kind of bulking

agent and composting process itself. And the odor of the well composted solid is also inoffensive and resembles a basically garden type soil conditioners ok. That is the basic characteristic of the secondary sludge or primarily the secondary sludge is this much though, but then the digested sludge also can be included in there like.

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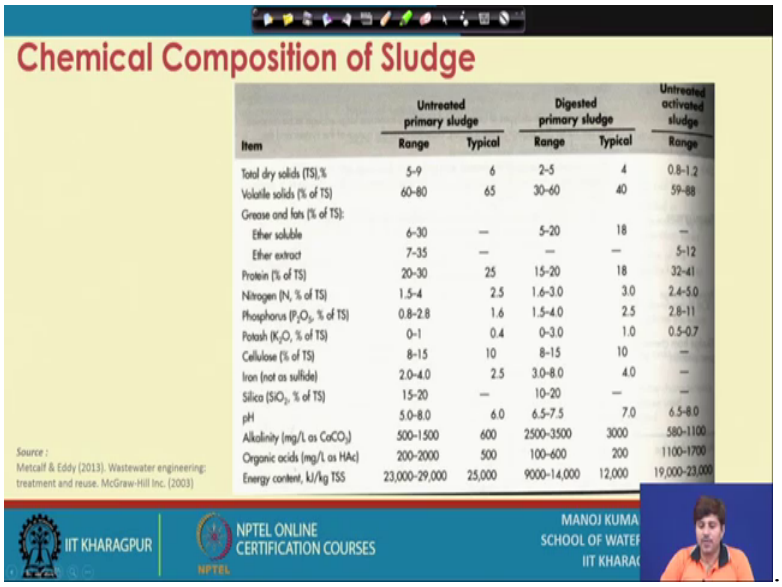

We see the Chemical Composition of Sludge. So, chemical composition of sludge would again be depending on from we are talking about which sludge. So, this is untreated primary sludge will have total solids of the order of 5 to 6 percent the typical value is 6 percent ok, the volatile solids is 65 percent ok, the grease and fat is typically not there very little ok, the proteins is almost 25 percent of the total solids; then nitrogen, phosphorous, potash. So, these are the like nutrients essential nutrients for plant growth or fertilizer in components are there in the untreated primary sludge there could be as high as 10 percent of cellulose around that ok, ranges 8 to 15 there might be little iron then ph is typically from 5 to 8 with an average value typical value of around 6. So, Alkalinity organic acids and kind of energy content in Kilo joule is of the order of 25000 or so ok.

So, that is untreated primary sludge if we see the digested primary sludge. So, after digestion the dry solid may reduce the volatile solid is 14 percent. There might be some soluble fats and those kind of things coming into the system, then protein reduces this these the digestion actually increase the fertilizing component. So, those solids will be

converted to nitrogen phosphorus those kind of things. So, these concentrations increases that way as suppose to be undigested sludge if we see ok, many things more or less remain same though ok, and we will lose on to the alkl there might be like increase in the alkalinity ok, and loose we may lose organic acid front because organic acids are digested that way and the energy content of the sludge will also reduced, because we are reducing the organic mass from the this thing and part of this is keeping as a gas or those kind of things. So, that is why the digested sludge will have lesser energy potential.

This is the activated sludge. So, the dry solids is very little of the order of like 0.8 to 1.2 percent just ok, the volatile solids may be quite high and that way we will have like various the things with proteins and the organic constituents quite high, it is not much of cellulose iron and those kind of thing in there and if we see the pH is around 6.5 to 8, and alkalinity around 580 to 1100 is the range that way. So, these are the kind of chemical compositions of the sludge from primary and secondary systems ok.

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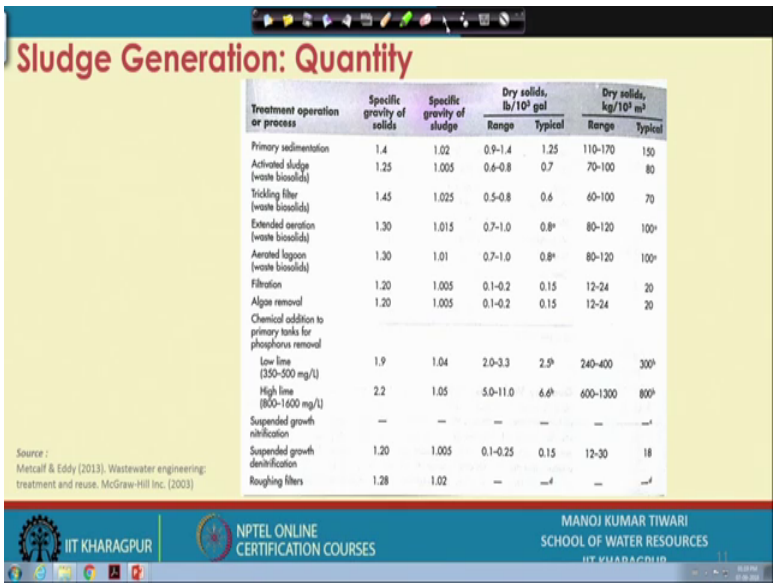

Primary and secondary units which produces sludge; if we look the quantitative aspect of the sludge slow the sludge generation again depending on the different units, we will have the different range of the production of the sludge. So, if we see in kg per 1000 meter cube, so particularly the dry solid. So, the primary sedimentation produces it around 150 the range is 110 to 170, but typically produces 150 kg per 1000 meter cube of the waste water treated that way and the specific gravity is typically 1.8.

The activated sludge which is your waste bio-solids are again of the order of 70 to 100 with an typical value of 80 kg per 1000 meter cube, trickling filter 60 to 100 with an average value of 70 kg per 1000 meter cube then there are extended aeration or this lagoons, so they also produce this sludge in a little higher concentrations because variation figure is extended. So, more solids more dissolved organic converts into the solid and that is why we you know that to have higher efficiency there would be larger sludge production as well. So, typical filtration or algal removal process very little, then we have the processes when we add chemical for the phosphorus removal or those kind of things. So, depending on the line addition depending on the dosage of line we are adding, so if we are adding high line doses although line doses will generate significant amount of sludge.

The sludge is primarily because of chemical addition and not because of the constituents which are already present in the water, because we are adding significant amount of constituents in the water. So, they produce here as a sludge; so, for say if you are adding 500 milligram per litre of the line ok. So, 500 milligram per litre; that means, 0.5 gram per litre or say 0.5 kg per meter cube that way so; that means, for 1000 meter cubes the 500 eventually will come from there itself ok. So, that way the amount of solids generated dy dry solids generated is quite high ok, and then denitrification also produces little sludge because the nitrifying bacteria they produce and they also have to settle and those things. So, little sludge is produced in the process of denitrification as well.

So, this is the kind of quantitative aspect that per unit water treated if it is treated from this different steps or the different processes for how much sludge will be produced that way.

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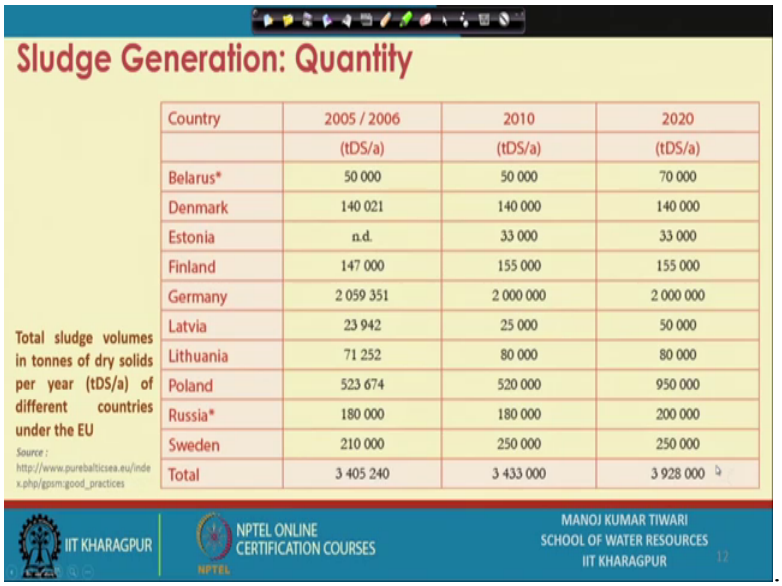

Country	2005 / 2006 (tDS/a)	2010 (tDS/a)	2020 (tDS/a)
Belarus*	50 000	50 000	70 000
Denmark	140 021	140 000	140 000
Estonia	n.d.	33 000	33 000
Finland	147 000	155 000	155 000
Germany	2 059 351	2 000 000	2 000 000
Latvia	23 942	25 000	50 000
Lithuania	71 252	80 000	80 000
Poland	523 674	520 000	950 000
Russia*	180 000	180 000	200 000
Sweden	210 000	250 000	250 000
Total	3 405 240	3 433 000	3 928 000

Now, if we see the Quantity of Sludge Generated in different places we do not have data from all the places available, but like report where the for various countries under the European Union, there is lot of sludge being generated from the waste water treatment facilities ok. So, like you see in the 2010 there is from Belarus it was of the order of 50000 tons of dry solids per year ok, the Germany produces huge amount of sludge ok, that is kind of 2000000 or 2 million tons of dry solids per year ok, your then there are Russia is producing around 180000, Sweden 250000, Poland 520000. So, that way significant amount of sludge is being produced from the different Nations ok.

Japan is facing sludge management problem the collective sludge production from the US, UK and China has a huge production of sludge which is not being managed properly ok, and same with many other nations. So, if we see the total amount of sludge being produced from the like as we are saying the China, US, UK it is actually exceeds over more than 2.5 million mo more than actually 25 or 2.5 million tons per day. That is the order of magnitude at which the sludge is being produced ok. So, that way like the problem is huge of the sludge production

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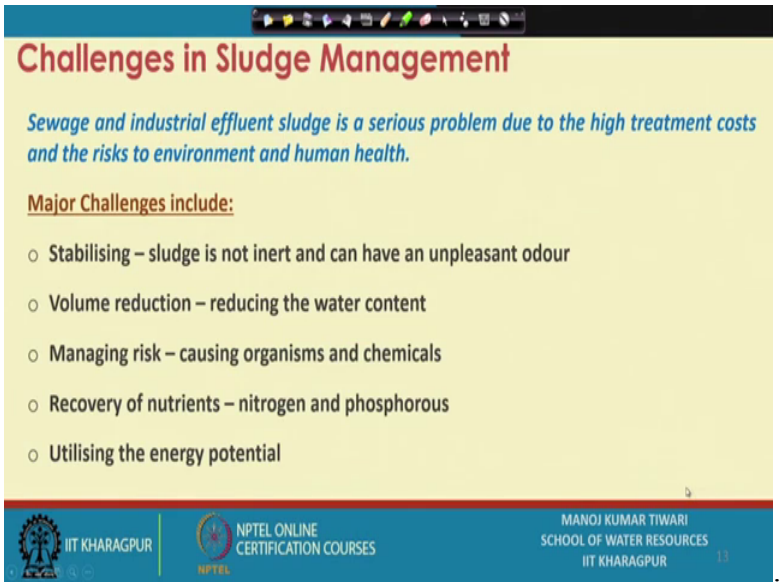

There are various Challenges in the Sludge Management. The Sewage and industrial effluent sludge is becoming a serious problem due to high treatment cost and risk to environmental and human health out of the sludge ok, which is being produced. Further the like if we say the case of India as we discussed in the beginning that almost two-third of the sewage, which is being produced it goes untreated. So; that means, lot of waste water is not being treated at the first place and when you start treating them you will start getting more and more and more sludge. So, what to do with the sludge? How to handle that? It requires a huge cost there is a huge land footprint of the sludge management, then the huge water footprint with the sludge management. There is energy requirement in terms of handling in terms of transportation in terms of the watering processes ok.

So, that way there is a huge cost, huge environmental footprint and huge health risk involved in this if you look at the major challenges. So, few of the major challenges includes the stabilization of sludge ok. So, sludge is not inert and can have unpleasant odour there are lot of organic material present in this and it can turn to septic, it can lead to foul smell, those kind of things and can have various health infects upon contact. So, that is one of the major problems, then we have the volume reduction. Another major challenge because as we were discussing just that the water content of the sludge is let us say for secondary treatment sludge this is as high as 90 percent 99 percent ok.

The solid content is in the range of say 0.8 to 1.2 percent, so roughly you can say on an average value of around 1 percent; so that means, 99 percent is the water and you can imagine the quantity which is being generated ok.

Similarly, from the primary sludge also there is more than 95 percent contained is actually water. So, there is a huge volume of the sludge is generated and for reducing. This volume we have to dewater that sludge we have to take the or dry that sludge we have to take that water out. So, reducing the water content again how effectively can do that if we leave it in the open, there is a large amount of land would be needed and then what is happening to that water untreated water. We will it will probably go to subsurface all those kind of thing. If we process it mechanically through centrifuges or those kind of things; so, then there is a lot of energy aspect energy cost associated with that ok.

Then there is managing risk during due to the organisms various organisms and chemicals. So, there are various risk causing organisms and chemicals could be present in the sludge ok, which kind of can impose health risk then of course, there is recovery of nutrients nitrogen phosphorus. So, as we were just discussing seeing the characteristic of the sludge, the sludge has significant quantity or significant percentage of this fertilizing elements nitrogen, phosphorus, potassium. So, how we can recover those nutrients is it advisable to just like dump or decompose or put this to landfill or do not use that or if there is a means through which we can extract that or we can actually find out use that potential of the like fertilization of the sludge.

So, how we can achieve that that is another major challenge and then utilizing the energy potential. So, the sludge has a lot of energy potential, we just saw that the undigested sludge, indigested sludge they both have significant amount of energy potential. So, how to utilize that energy potential ok, how we can extract the energy out of these systems out of the sludge as a material and then what fruitful application can that energy could be bring in and whether the extraction of energy whether the production of energy from the sludge is sustainable or not ok.

So, there is a lot of debate on that on the energy production from the bio-solids on the energy production from the wastewater sludge. So, if you end up producing energy from the wastewater sludge how much energy you have to supply first because many times, it has been seen that net energy footprint is actually negative. So, you end up supplying

more energy then you are producing energy ok. In order to just managing the solid, so that kind of system cannot be recommended. So, we will have to like figure out that which are the possible approaches through which this potential of energy production can be applied can be extracted or can be utilized in the most sustainable fashion.

So, these are practically the major challenges major issues with the sludge management or sludge handling. So, we will conclude this lecture here and in the next class, then we will start deliberating on to the approaches or methods of Sludge Treatment and Sludge Management and Sludge Handling.

Thank you.