Water Supply Engineering
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Lecture-38
Sludge Management

Hi friends and welcome back so the topic for discussion in this week was disinfection which we have already discussed. We did talk about the basics of disinfection in the first lecture of the week and then we discussed about the chlorination process in a bit detail in the second lecture. And in the last lecture we talked about the alternate disinfection processes which are the ozone and UV.

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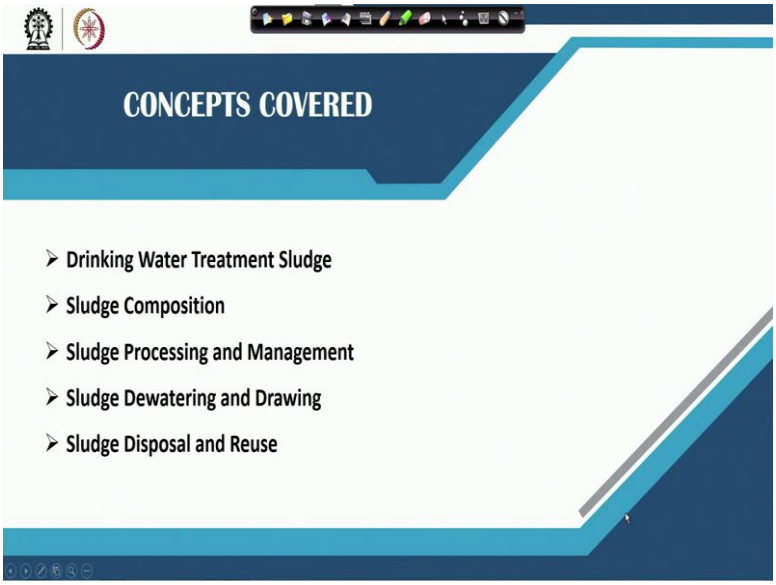

Now we are going to discuss the Sludge Management aspect which is also one of the components of that in fact produces during the water treatment. So, we will be talking about the drinking water treatment sludge what is the typical composition the processing and management of the sludge. Then, the steps that are usually taken like the dewatering and drying and the thickening process. And then, we will be talking about the sludge disposal and reuse.

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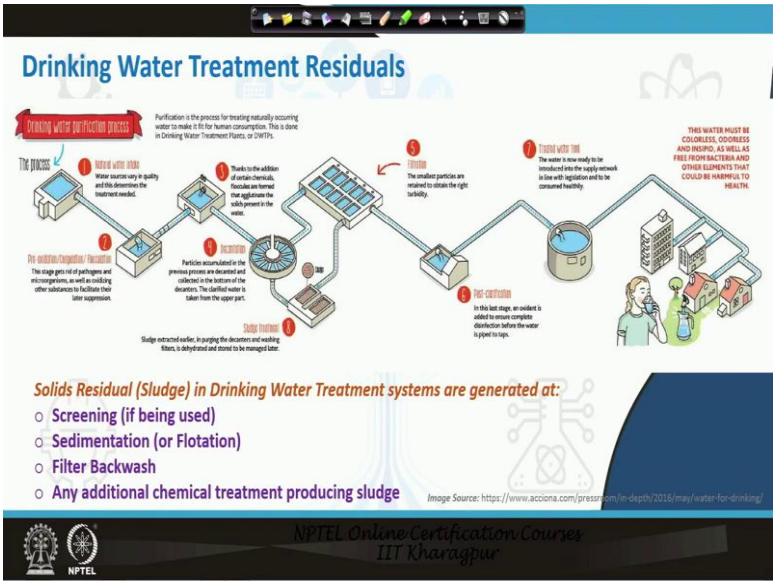

So, to start with, usually the sludge stream which is basically the solid residuals in drinking water treatment systems are generated either at screening, if screening is being used. But as we discussed earlier that screening is very rarely used. So, like most cases we do not have screens coming out at the drinking water treatment plant. And if it does come it will just go to the landfill usually. Then we have the sedimentation or floatation process whatever we are using.

So like the as we discussed that during clarification or sedimentation process, the solids settle at the bottom and then, sludge is collected. So, that is the major component of sludge that produces from the conventional treatment systems. The sludge coming through the sedimentation process and if floatation is being used then it is from the flotation process. We will talk about the flotation briefly in the next class though.

Then, the solids are solid residuals come from the filter backwash as well because the micro flops that get retained during the filtration stage and then when we back was the filter the back was spent or the wash water which is collected contains lot of solids so that wash water might be like settled and whatever residue comes so that is also a component of the sludge. and any additional chemical treatment that produces sludge so like if we are using say softening process or some other processes so they also generate sludge.

So that can also be a component which of the sludge okay. So, practically like if you see a treatment system whether we go for pre oxidation or pre chlorination and then, we add coagulant and we go for flocculation process and then the decantation or the sedimentation

stage produces sludge which come which comes to this sludge treatment stage. And after the filtration also the backwash, the settled mass in the spent water or the wash water also comes to the sludge stage. So, we will be practically talking about this component in this particular class.

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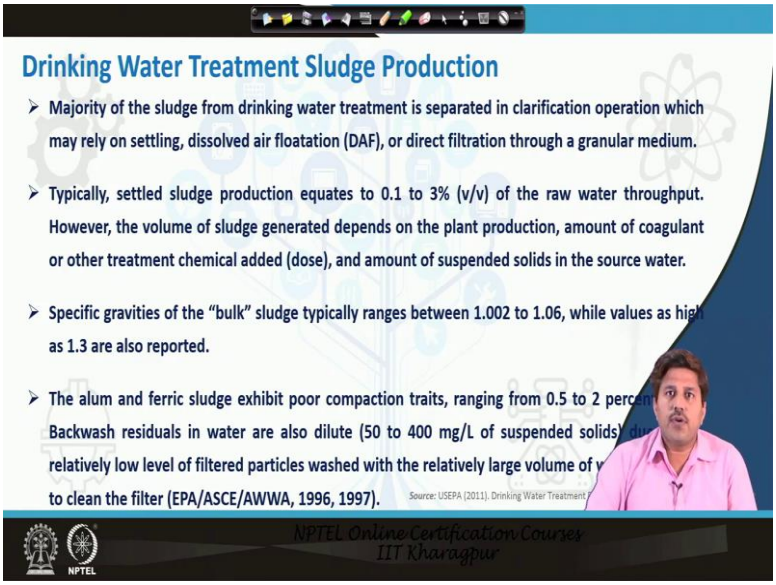

Now the in the drinking water treatment systems, majority of sludge is produced from the clarification operation okay, which rely either on settling or dissolved air flotation. But sometimes the direct filtration through a granular media so then, it will mostly be coming into the backwash of the filter. The average sludge production is approximately 0.1 to 3% volume by volume of the raw water throughput.

So, whatever raw water is fed to a system or a drinking water treatment system almost 0.123 percent of the water comes out as sludge. Now water comes out as sludge means because we are saying because large portion of sludge is in fact water. The solid contained in this are limited okay. So, the volume of the solid generate that will depend on the plant production how much amount is, how much amount of water the plant is handling. Then, amount of coagulant or other treatment chemicals added.

So, like if you are using iron or lime so how much chemical we are adding because all that eventually settles and appears as sludge okay and the amount of suspended solid present in the source water. So, if there are a lot of suspended solids, we are going to get more amount of sludge if there are limited volume of suspended solids, limited concentration of suspended solids so then, relatively less sludge will be produced.

The specific gravity of the bulk sludge that we get is typically reported between 1.0021to 21.06 and the water content is also very high okay. So, the solid content typically are very poor 0.5 to 2 percent solids and rest is predominantly water and that leads the lesser bulk density whereas the density of solids or the specific gravity of solids are higher than 2 okay. In some cases even the like bulk density is also reported as high as 1.3. But that is rare cases.

Generally, it is between 1.002 to 1.06, the backwash residuals are also very dilute because less amount is trapped in the filter. Filter already receives water which is clarified earlier. So, less amount of water less amount of this particulate or the micro flocks are retained on the filter. And when we backwash with a relatively large volume of water of course it's not that large, but in comparison to whatever is trapped so that results in low concentration. So, around 50 to 400 milligram per liter suspended solids come in the backwash water.

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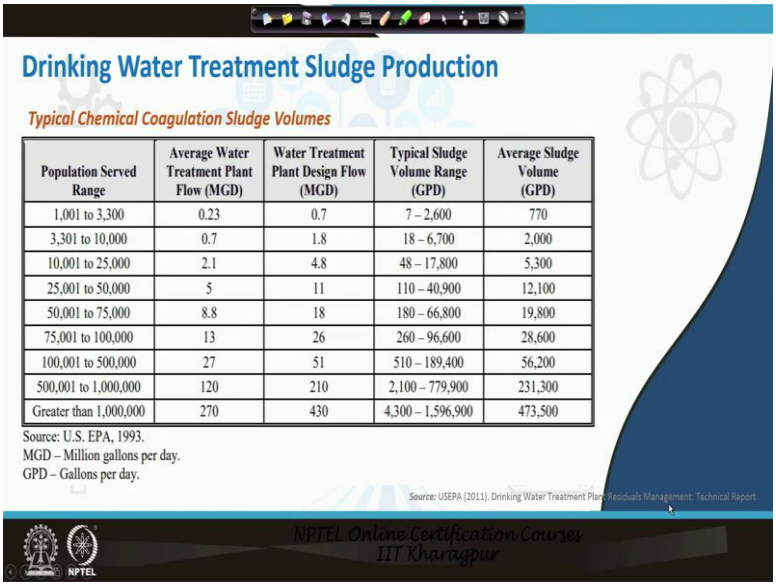

So if we see the typical chemical population sludge volume, that is being produced this is basically from the US EPA. So, depending on the range of the population serves the average plant what flow the water treatment plant design, so water treatment plant is designed say for these flows okay this is in MGD million gallon per liter million gallons per day came. So, typically the average sludge volume in gallons per day is this much. So, as per US EPA we can convert gallons to liter.

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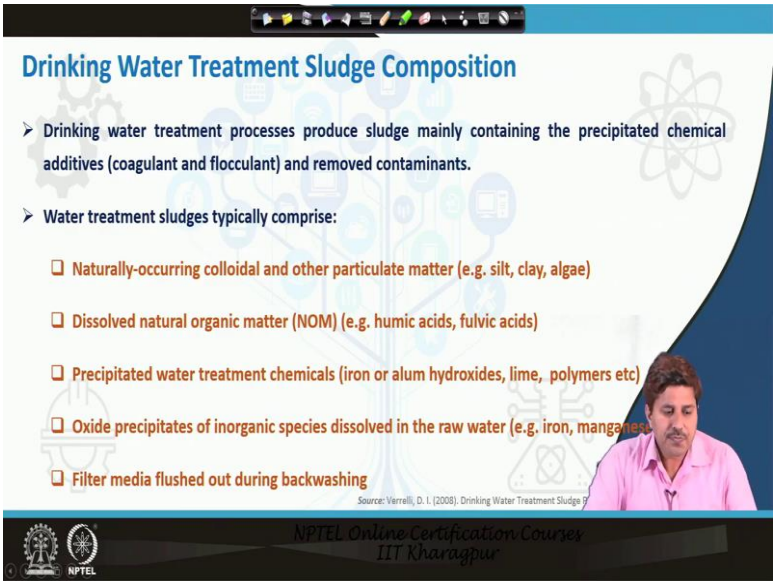

The sludge which is produced the composition varies on several factors okay. It varies on whatever what type of sediments are present in the water, what type of chemicals we are adding okay. And then, because essentially the composition of the sludge and particularly the dry solids present in the sludge or solid fraction of the sludge will depend eventually on what we are adding that is what is going to come okay. So, sludge will be mainly containing the precipitated chemical additives whatever covalent or flocculent we are adding and the removed contaminants.

So, what whatever the nature of the solids present in the water, they will get precipitated or they will get removed through the precipitation process or through the settlement process. So, they come as sludge. So, water treatment sludge typically comprised these naturally occurring colloid and other particulate matter like silt clay, algae. It will be having some dissolve natural organic matter humic acids and fulvic acids.

It will have some precipitated water treatment chemicals so alum or iron hydroxide whatever we are adding. If lime we are adding, some polymers we are adding. So, it will have all these compounds, it may have oxidized precipitates of inorganic species dissolved in the raw water like iron and magnesium precipitates okay. And it may have filter media because sand might also gets, some part of sand might get flushed out during the process of back washing. So it may contain the filter media as well. So, these are the major constituents of this sludge.

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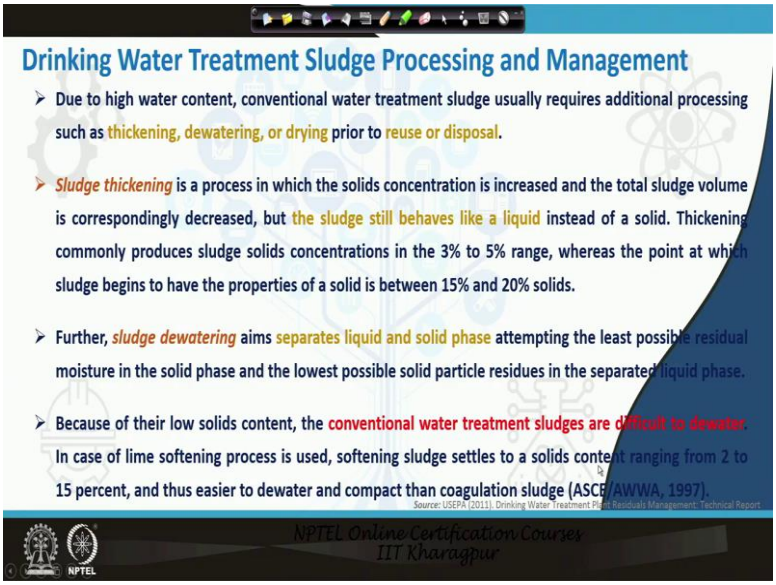

Of course, the concentration depends on the initial characteristic of the water the amount of chemical that are being added so the concentration will vary based on those. But composition wise it is to have those compounds. Now the sludge that is generated is basically processed through thickening dewatering or drying process and drying stages okay. Generally, through thickening and dewatering stages it needs to be dried in fact before it goes to reuse our disposal.

So, why that is essential because as we were just discussing the water content is very low, 0.5 to 2%, solid content is very low 0.5 to 2%. Water content is very high so it is practically liquid. So, that needs to be like if you want to handle that as a solid waste or convert it to a solid material so we need to dewater that. We need to increase the solid content and reduce the water content in the sludge. So, for the for that purpose, we use thickening dewatering or drying processes.

So, sludge thickening is basically the process in which the solid concentrations are increased and this is increased to a range of around 3-5 percent okay solid content so earlier like we just said that it is in the range of 0.5 to 2 now we increased that in the range of 3 to 5 percent range. But this 3 to 5 percent range increase in the solid, reduces the water volume substantially. So, it will be basically decreasing the total sludge volume.

And but sludge will still behave like a liquid because in order to for sludge to behave as a solid, the water the solid content has to be increased by around 15 to 20 percent okay. But it is still in the 3 to 5 percent range so it still behaves like liquid. So, the next step generally

which is followed is the sludge dewatering. We further try to concentrate that and in the dewatering process we aim that liquids and solid phase are separated to the least possible residual moisture in the liquid, in the solid phase and lowest possible solid particles in the liquid phase.

So, we want to like that when we are separating when we are facing out liquid and solid separately so we want minimum solid to go in the liquid channel. And we want mini liquid to come in the solid medium okay. So, the moisture content in the solid we want less and the solid content in the liquid or the drainage which is coming out, we want again that also we want minimum. So, because of their low solid content this conventional water treatment sludge are difficult to dewater.

In case of lime softening process is used this softened lime sludge is in fact better to dewater it has solid content ranging from 2 to 15 percent. So, it is easier to dewater and generally compact then the coagulation sludge.

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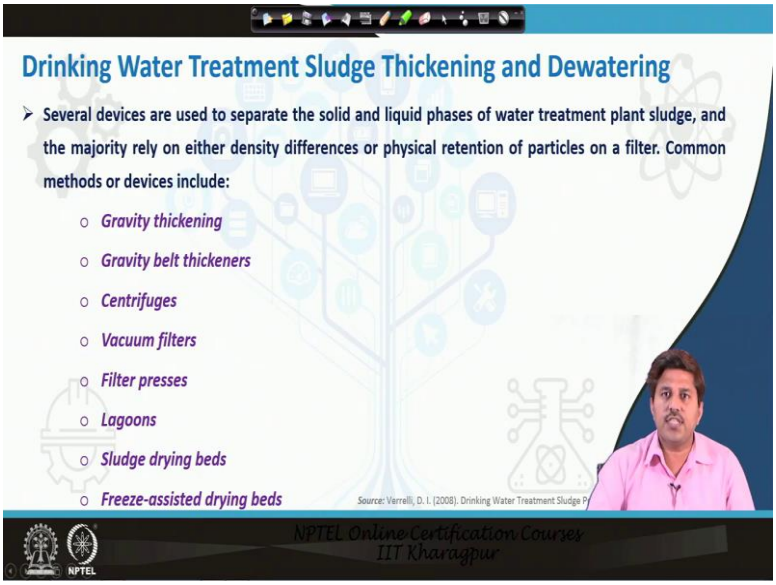

But conventional water treatment which is basically the sludge coming from the coagulation flocculation process, it is rather more difficult to dewater because of the nature of the sludge and the specific gravity is also not that high. So, there are a variety of devices which are used for this purpose for the thickening and dewatering purpose okay. So, we have gravity thickness, gravity belt thickeners, centrifuge vacuum filters, pressure filters then lagoons then sludge drying beds are there okay. So, these are variety there are like, several processes.

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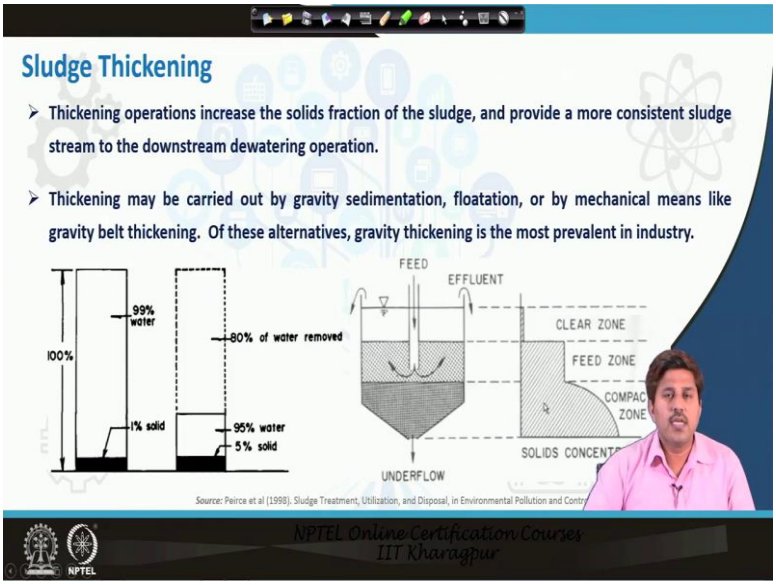

Now, sludge thickening, if you see, so it is basically like, we have either gravity thickening or mechanical means of sludge thickening okay. So, gravity sedimentation is simply like we put this to a gravity system we increase the residence time and that in the top, we will see that it is a clear zone why it it it will actually start settling. In the top will see a clear zone. Then, there would be some feed zone and particularly like, in the bottom it gets compacted during the sludge concentration here is going to be very high here, it is going to be moderate.

And top will be actually relatively like very less solid concentration free from this. so, if let us say we are having starting with 1 percent solid and 999 percent water, if we are able to increase 5 percent solid and 95% water. So, then we are actually bringing the total volume from 100% to here so almost like 80 percent water will be removed and the volume of sludge, instead of this will just remain this okay.

So, 1/5 we are increasing the solid content by 5 times, we will be able to reduce the total volume by 5 times. So, we will just have one fifth of the volume so we start with the thousand litres okay and one percent solid content, if you increase the solid content to 5 percent the total volume your you will be having is just 200 liters as the 800 liters will be washed off.

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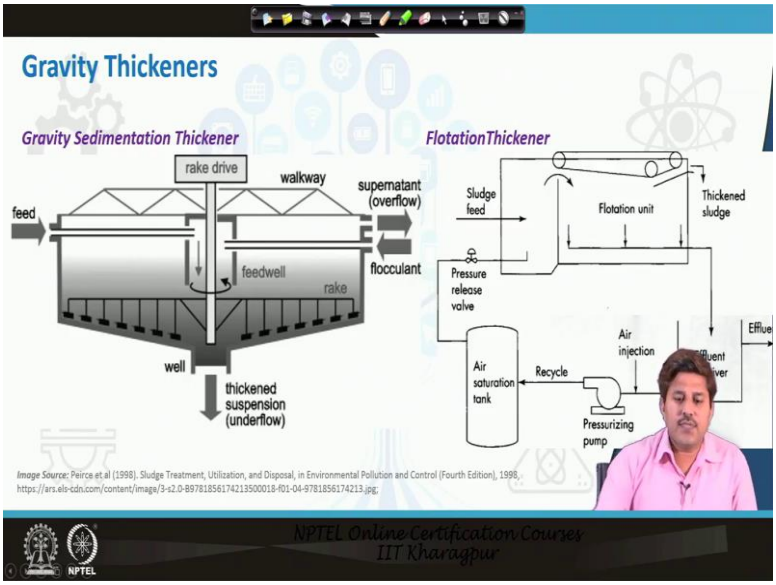

The gravity thickness are as just we were discussing it is a simple like settling basin kind of thing, so, we, we allow the feeds sludge feed to come in and then let that settle and through this crapper, we then, we can collect the thickened suspension or through under flow okay. There are floatation thicknesses which can also be considered as a gravity only because but here instead of settling at the bottom, they float at the top.

So, we like release air through high pressure so that these bubbles are formed and then these bubbles will get stick to the sludge particle and they will make the like entire bubble and sludge complex, will be lighter than the water, the specific gravity will be less because it is attached to the air. And then for that reason it will come at the top and then from the top it can be skimmed off as a thickened sludge okay.

So that is also one of the means it is more popular though in the wastewater treatment systems, water treatment sludge is generally not fed to these kind of thickness.

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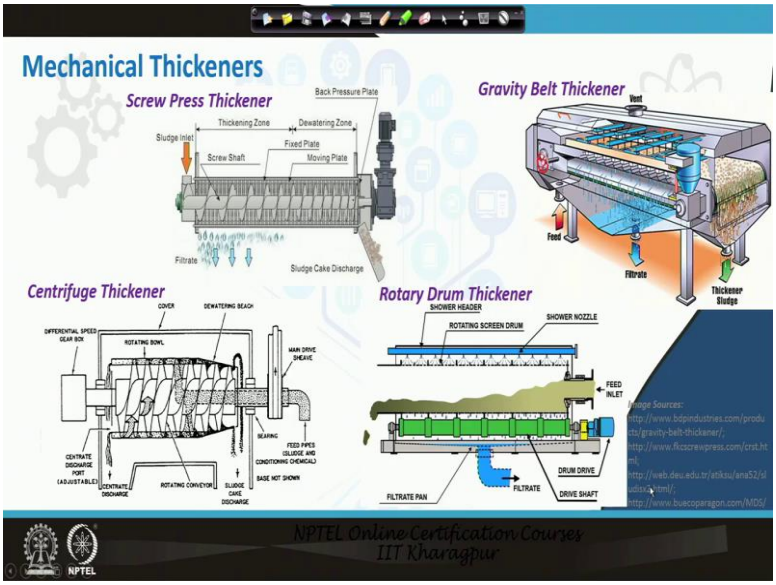

Gravity, gravity thickness are common but the like dissolved air floatation or def kind of thickness, thickness are not that common in the mechanical thickness. Again, we have the gravity belt thickener okay so there is a belt and by the force it is basically pushed through the belt, so that filtrate comes out okay and thickened sludge passes on through the belt and collected here.

So, this belt actually keeps on rotating a and filtrate will be coming at the bottom so will free the sludge here it will go on the belt and then belt is processing it will be pressed okay, so that sludge comes out and. Then, we have compressed thickness again, through a screening system, the the sludge is put into the chamber and then, it is basically through exclude it is pressed and then the solid residuals come out.

Centrifuge thickness is so basically with the help of the centrifugal force the sludge is rotated and the centrifugal force allow the sludge particle to settle the center in the concentrate and then affluent comes as a supernatant. And then Rotary drum thickener again the sludge is put it in a drum and that entire drum is rotated and in the process basically the water drains out and sludge comes. So, these are some of the like mechanical thickness.

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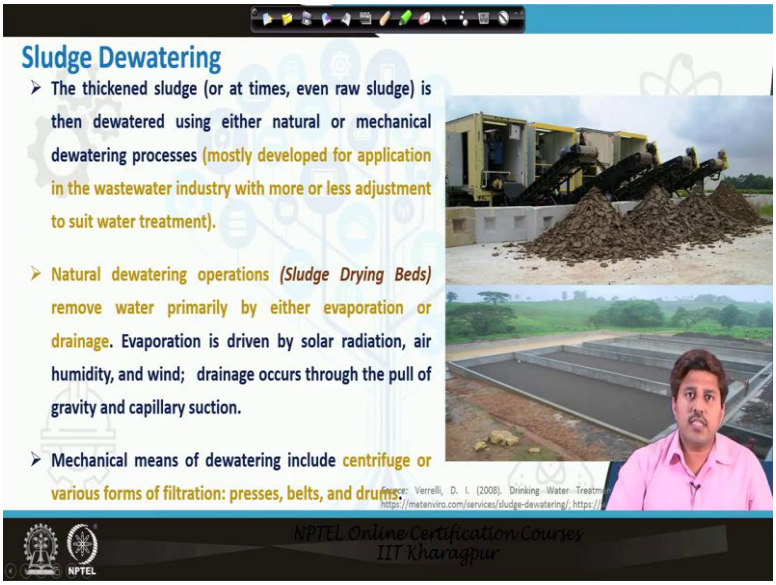

This is not just thickening devices they are used as a dewatering devices as well okay. So, mechanical thickness like, at which stage we are using it, if you are using if you are feeding a very raw sludge it will just thicken to certain percentage. If we are using a more thickened sludge or recycle that again to this thickening process particularly, the mechanical thickening process. So, we are going to get more like elevated solid concentration, so they can be considered as an option for the dewatering as well okay.

Generally, thickened sludge or at times even the raw sludge directly is diverted and it can be diverted either through natural or mechanical dewatering process. So, these dewatering process are also mostly developed for the wastewater industry. But with more or less adjustments they are adopted in the water treatment as well. The natural dewatering operation is typically diverging or drying operation is typically sludge drying beds okay.

So, sludge is laid out on the bed and basically this removes water primarily either by evaporation or by drainage. So, initially what happens that the drainage will take the water out through percolation process and water will evaporate from the top. But there is a limited capacity for water to drain. So, drainage will progressively stop but evaporation still keeps on continuing. So, we can get it dried to whatever level we want.

But again there are certain issues with natural dewatering operations like if bad weather is there if it is a rainfall rain event or something happens then it is going to acquire substantial amount of moisture or water again okay. So, evaporation is driven by the solar radiation air humidity and wind and drainage is basically through the pull of gravity and capillary suction.

So, that leads the like the water through drainage goes down and water through operation goes to the atmosphere.

There are mechanical means of dewatering also again the centrifuge or various forms of the filtration filter process, belt pressures or drums. So, these are used for dewatering purpose.

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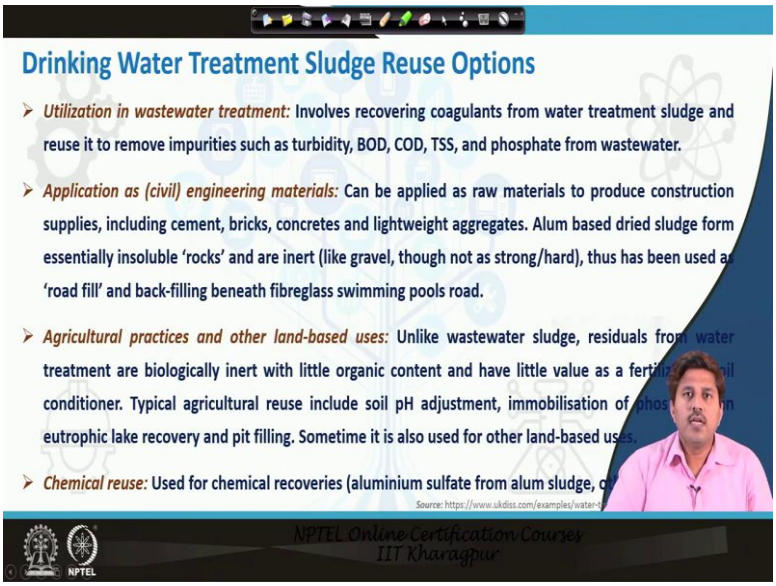

Then, the dewater or dried sludge can be either reused or disposed. Reuse options are there limited but not that frequently used. So, in a reuse terms it can be reused in a wastewater industry. So, research has shown that we can recover the coagulent from the water treatment sludge okay and use that are of basically modified or purified form of a sludge we can use to remove the impurities such as turbidity, BOD, COD, TSS and suspended solids phosphates etcetera from wastewater.

It can be reused for applications as engineering materials and particularly, the civil engineering domain and that is one of the by far like most common or most popular reuse in terms of reuse. In fact so it can be applied as a raw material to produce the construction supplies. So, it can be considered as an ingredient for cement brick or concrete or kind of lightweight aggregates.

The alum based dried sludge essentially forms insoluble rock and are inert like gravel okay. But it is not that hard or that as strong as gravel it is still light okay. So, it has been used for like filling under the road, back filling beneath the fiber glass swimming pool then in during the bridge construction. So, a lot of like for filling material particularly this sludge has been

very common okay. So, that is one of the like most common reuse that these filled these sludge dried sludge is used as a filling material for various civil engineering applications or civil engineering constructions.

Then it can be used for agricultural practices or other land-based uses. Now this part is very critical because sludge use in agriculture is very common. But that is more suited for wastewater sludge because that is mostly organic nature and helps the soil in like it can provide the fertilizers or some other minerals essential minerals to the soil. But unlike wastewater sludge residual from water treatment slits are biologically inert.

We do not have too much of like biological substances or organic substances okay. The organic content is also very little. So, they are very little value as fertilizer or soil conditioner. So, they cannot be typically like used as a soil conditioner or fertilizer is still some people use it okay. For say, pH adjustment immobilization of the phosphorus, in the eutrophic lakes systems and many times pit fillings okay. Sometimes it is also used for other land-based uses okay like levelling, if there are some ground.

And then, even though in the some sports ground also for levelling and these purpose this sludge might be used okay. Then, there are chemical reuse options so which is basically we recover the chemicals from sludge like we can recover aluminium sulphate from alum sludge. And this recovery can be quite good up to extent of around 80 percent we can recover in fact okay. We can recover various metals and salts or ions from the sludge so that is the another like reuse option.

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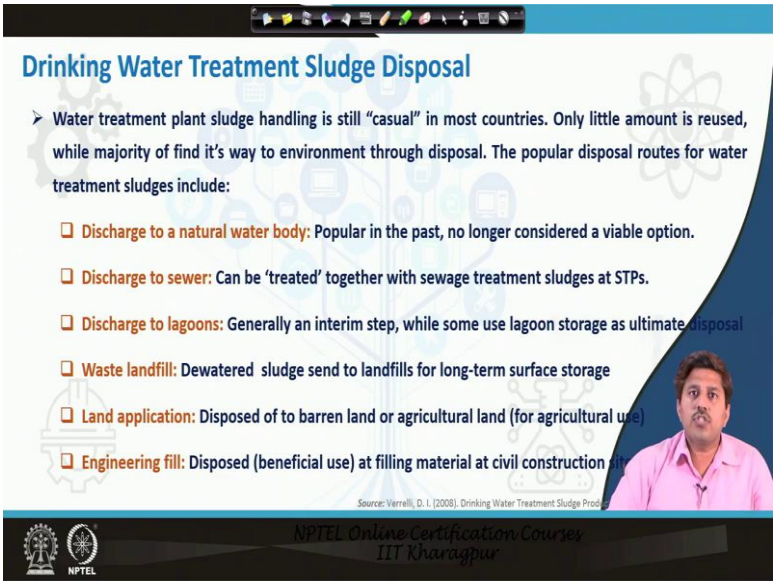

Now if sludge is being reused it is good but otherwise in most cases or most places particularly, in the developing countries the sludge handling is still very casual and only with only little amount is reused. And majority of the sludge find its way to the environment through the disposal systems. The popular disposal routes like the people, the way people dispose the slush includes the discharge to a natural water body.

Now this was popular in the past earlier like majority of the one they like unitary state treatment facilities water treatment plants in the United States they also used to discharge the sludge directly to the natural water bodies like rivers and those systems but environmental regulations has become quite strong now. And this is no longer considered a viable option so we do not consider this as a viable option anymore because it is it will create lot of problem in the river body in which it is disposed of.

The other disposal place is discharging to the sewer line. So, people might put it in the sewer line means the utility water treatment utility at times put it to the sewer line and then it can be treated together with the sewage treatment sludge at the STPs. Here also like many times if it is not discharged directly to the sewer where it is filled in the trucks and bought to the wastewater treatment facility or sewage treatment facility, waste treatment facility and then it is processed along with the sewage sludge.

It can be discharged to simple lagoons or ponds and but that is generally considered as an interim step like people put it in the lagoons and then it get once it gets dry or lagoons gets filled up so they transport it to the other side. But some facilities use lagoons as a storage

system for considering them as a ultimate disposal. So, when there is a no land crisis they can keep on filling these lagoons. Then there are landfill options so it goes to the landfills dewatered sludge is sent to the landfills for long-term surface storage.

It can be dumped into the landfill and then it is stored there for large times again the leaching and those things needs to be studied when it is going to the landfill sites then land application again disposed to the barren land or agricultural land means then you particularly if it is being disposed to agricultural land for some purpose, you can consider that as a reuse option or like beneficial use option.

But otherwise many times it is just disposed to the barren lands so that is a shear disposal option because it does not have any intended use there where it is being applied okay. It is just considered as a like the land is considered as a dump site and the the water or dried sludge is dumped there. Then there are engineering fill okay again it is basically disposed of as a filling material at civil construction sites as just we were discussing. So, engineering fill is essentially a beneficial use although like utility might consider they are dumping this like let us say for a bridge construction or those things lot of filling materials are required.

Now your Road constructions or various other like large civil structures constructions, Dam, Road these things a lot of filling material is required and utility might consider that just they are dumping is but it is actually kind of beneficial use because it is fulfilling the requirement of some filling material. So, that way like these are the disposal options for the sludge. So, we conclude this discussion on the sludge.

This is how the sludge is handled okay and generally the sludge is not given the due attention which it should be given. In most cases like if you see the water treatment schemes they do not even talk much about the sludge processing. But in conventional system the collected sludge is thickened then dewatered or dried by putting through the sludge drying beds and then it is usually disposed off to some landfill site or open dumping, that is what is commonly done with at most places with the solid residues in the, that come from the drinking water treatment facilities.

So, we are concluding this discussion here and now in the next class, we will start talking about the advanced treatment options. So, thank you for joining and see you in the next class.