Biological Process Design for Wastewater Treatment
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Lecture 31
Sludge Management – I

Welcome everyone in this NPTEL online certification course on Biological Process Design for Wastewater Treatment, so today we are going to start an another section within this course and this section is with respect to sludge management, so in the wastewater treatment during various operations which are carried out, lot of sludge or solid waste or biosolids are generated and these bio solids are more generated during the biological process design, so biological processes like activated sludge process, trickling filter and various other operations related to biological processes they generate lot of sludge.

In addition, we have sludge or solid waste which are generated during physico-chemical treatment of wastewater also like during coagulation and flocculation and so during settling we get all these solids and these solids are sludge or bio solids have to be managed properly and this is very important section that we should properly understand the sludge management, what are the different aspects, how they have to be carried out.

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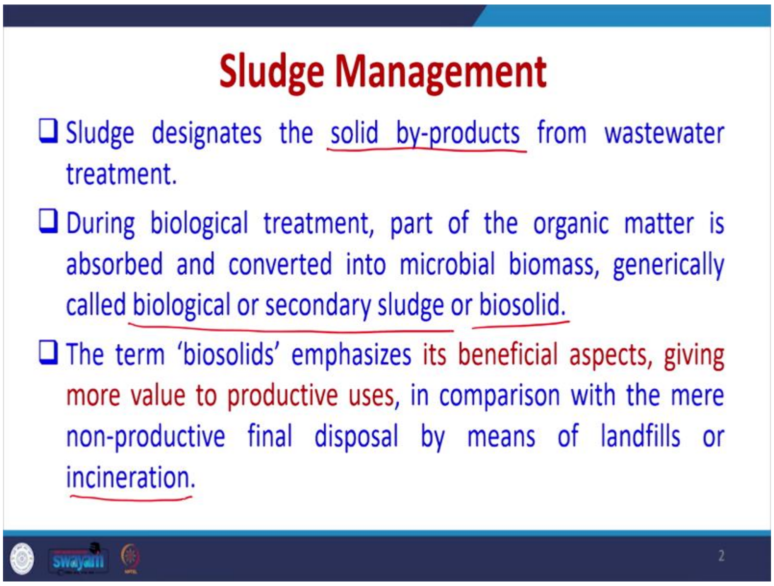

So the sludge designates the solid byproducts from wastewater treatment so the solid by-products which are obtained during the wastewater treatment they are designated as sludge, so what happens is that during biological treatment the organic matter is absorbed by the microbial biomass and then it is further converted into further microbial biomass so that means during biological treatment the organic matter is taken as a nutrient by microbial biomass so they convert that into CO_2 but because they are using them as a nutrient the biomass also grows.

So generally this process is under which the byproduct which is obtained it is called as biological or secondary sludge or biosolid, so when we refer anything as biosolid it emphasizes its beneficial aspects like giving more value to the productive uses, so anything if it is solid then it has lesser productive value as compared to biosolids but generally we have other operations also which may incur more cost also like for other type of solids the only utilization may be that they have to be disposed of in the landfill or they may be incinerated but biosolids may have other uses also.

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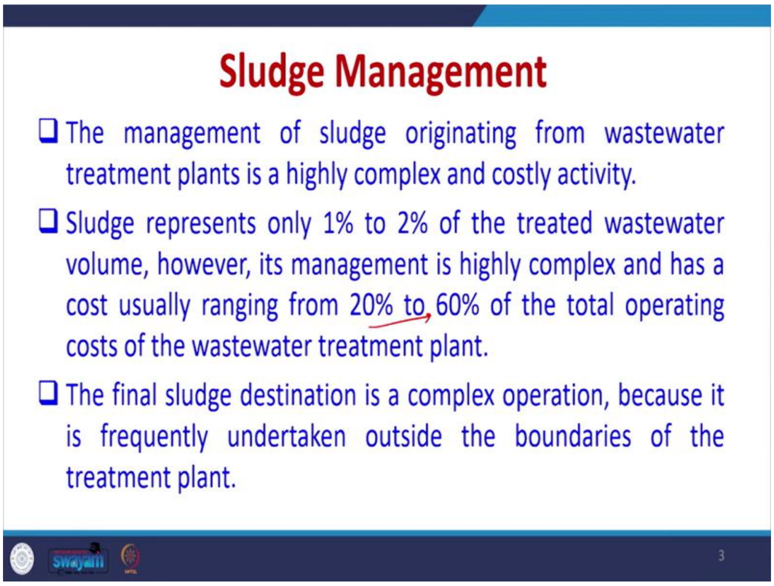

Now the management of sludge originating from wastewater treatment plant is highly complex and costly activity so that is why we have a special section on sludge management through which will be learning all these complex activities and which are costlier also, the sludge represents only 1 to 2 percent of the treated wastewater volume so whatever is the volume it may vary little bit more also but this is the range, however the management if we carried out of this sludge which is highly complex in nature the cost will be around 20 to 60 percent of the total operating cost of the wastewater treatment plant.

So that means the sludge is very important, we have to take care of the sludge very well otherwise the cost may increase from 20 to 60 percent, also the perception of the people who are living outside the wastewater treatment plant that relies on this sludge generated because we have to transport this sludge so how much volume we are generating and how much we are transporting it outside the premises of wastewater treatment plant that also generates lot of perception among the people who are living near the wastewater treatment plant or other places.

So this sludge management is very important though it is highly complex in nature the final sludge destination is also a complex operation because it that sludge management will frequently be undertaken outside the boundary of the treatment plant so we have various issues and challenges which may occur during the sludge management, so we this today onwards we will be having few lectures which will be totally dedicated to sludge management which the sludge which is generated during biological treatment or during physicochemical treatment also.

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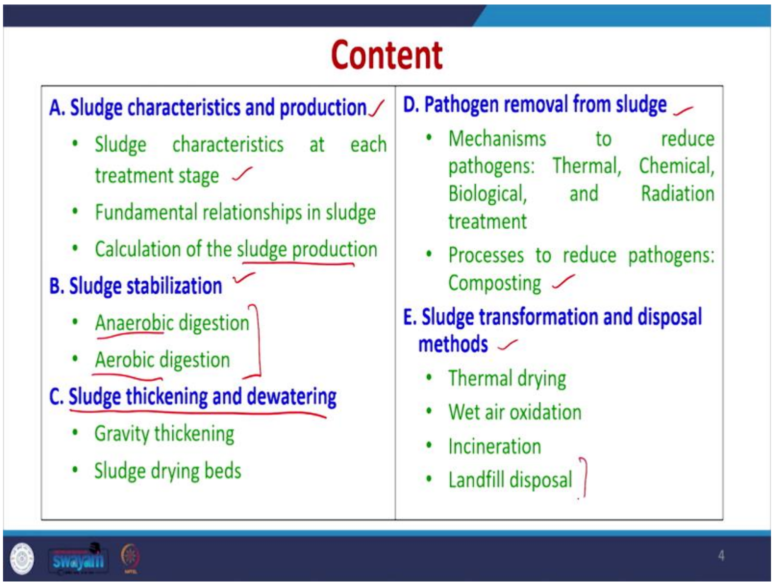

So the content for this section includes that will be concentrating on the sludge characteristics and production so that means we will be studying within that the sludge characteristic at each treatment stage how much it is generated then is there any fundamental relationship in the sludge generation or characteristics so that also will try to perform then we will see that can we perform some calculation, basic calculation with respect to how much sludge we will produce so this helps in beforehand designing the treatment plant as well as the sludge management section.

Then we have during operation what are the steps that have to be taken care for sludge management so this includes sludge stabilization which itself will include both anaerobic and aerobic digestion, so whatever we studied during anaerobic and aerobic biological wastewater treatment processes some of them will be you understood here also so in the sludge management also the concepts are similar to the wastewater treatment.

Now then after sludge stabilization we have sludge thickening and dewatering so we will study regarding the gravity thickening or other methods and then the sludge drying beds also the pathogen which are there in the sludge that is very important so we will have a section related to pathogen removal from the sludge so which is given, so we will try to understand the mechanisms to reduce the pathogens, those mechanisms may include thermal, chemical, biological or radiation treatment so we will have a subsection divided to that.

Then processing to reduce the pathogens that includes composting, finally we will be having section on sludge transformation and disposal methods though the sludge transformation that we will be studying include thermal drying, wet air oxidation, incineration and finally land fill disposure, so now each section will be studying one by one.

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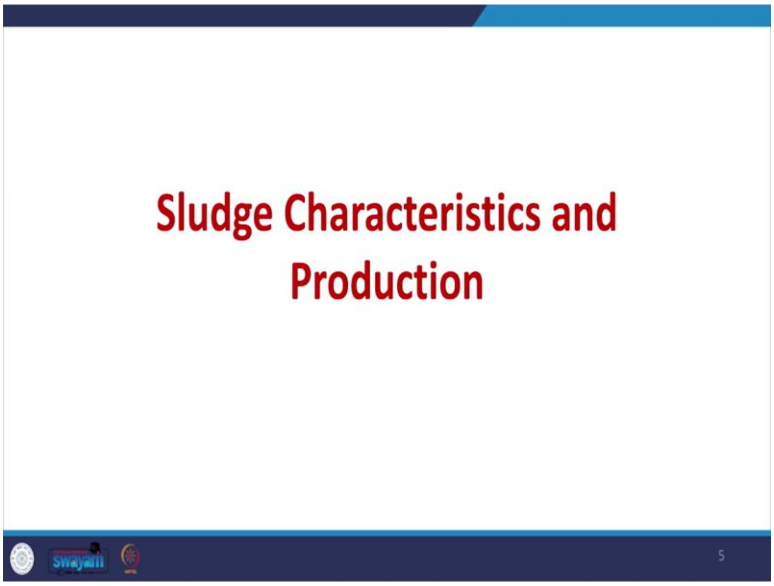

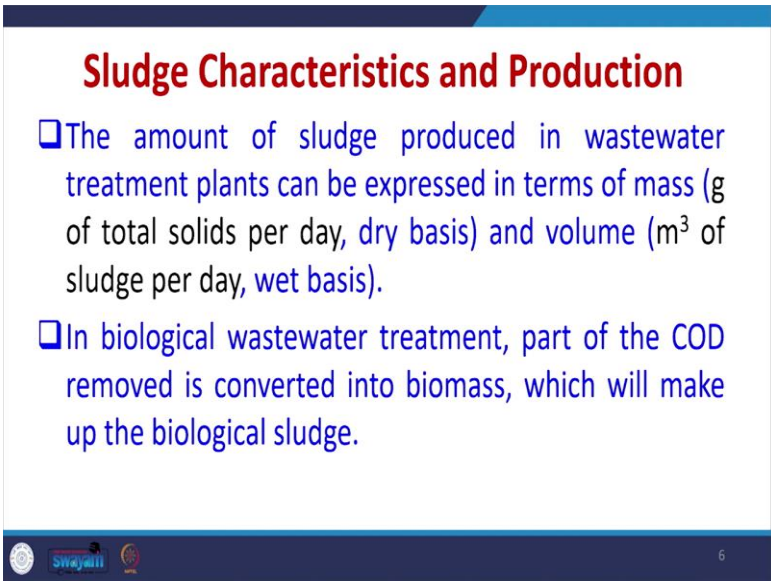

So now we will start the section on sludge characteristics and its production so the sludge characteristics and production, the amount of sludge which is produced in the wastewater treatment plant can be expressed in mass like a gram of total solids produced per day on dry basis also on volume meter cube of sludge produced per day on wet basis, so we can report like this.

In biological wastewater treatment part of the COD which is converted into biomass that makes up the biological sludge, so this is what is we produce during the sludge production. So we have to take care how much is converted into biomass so that will give idea that how much is the production.

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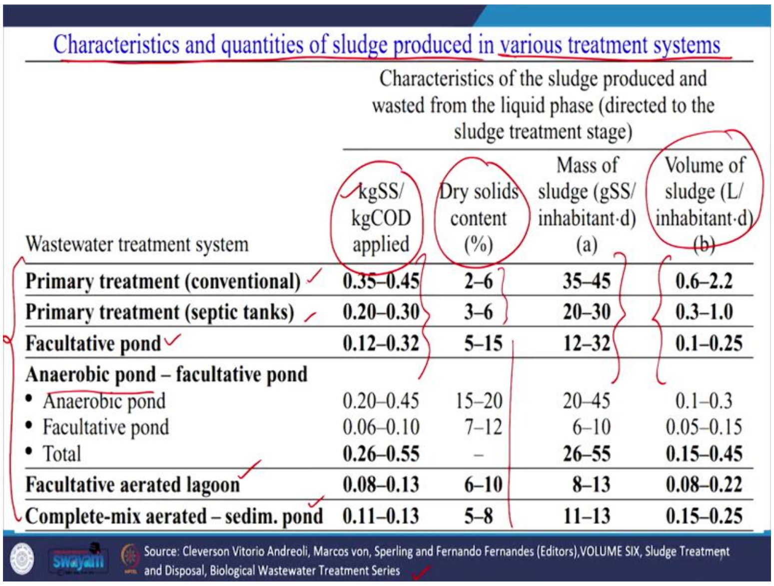

Characteristics and quantities of sludge produced in various treatment systems

Wastewater treatment system	Characteristics of the sludge produced and wasted from the liquid phase (directed to the sludge treatment stage)			
	kgSS/kgCOD applied	Dry solids content (%)	Mass of sludge (gSS/inhabitant·d) (a)	Volume of sludge (L/inhabitant·d) (b)
Primary treatment (conventional)	**0.35–0.45**	**2–6**	**35–45**	**0.6–2.2**
Primary treatment (septic tanks)	**0.20–0.30**	**3–6**	**20–30**	**0.3–1.0**
Facultative pond	**0.12–0.32**	**5–15**	**12–32**	**0.1–0.25**
Anaerobic pond – facultative pond				
• Anaerobic pond	0.20–0.45	15–20	20–45	0.1–0.3
• Facultative pond	0.06–0.10	7–12	6–10	0.05–0.15
• Total	**0.26–0.55**	–	**26–55**	**0.15–0.45**
Facultative aerated lagoon	**0.08–0.13**	**6–10**	**8–13**	**0.08–0.22**
Complete-mix aerated – sedim. pond	**0.11–0.13**	**5–8**	**11–13**	**0.15–0.25**

Now the characteristics and the quantities of sludge which are produced in various treatment systems is given are in this slide, so there are different content also like a wastewater treatment plant you can see here the sections which are listed here so primary treatment if the conventional methods are there then the primary treatment in the septic tanks then if we have facilitative pond which is there so that means both anaerobic and aerobic so then we can there then if only anaerobic pond is there so what is the production then faculty to aerated lagoon and complete mixed aerated sedimentation point also.

So in this table actually there are four columns which are there and they each report four different things, so first thing is how much kg of suspended solid is produced per kg of COD applied so tentatively we can have idea that how much production takes place so based upon that we can tentatively calculate beforehand also so this data has been compiled based upon the various reported and this is from this particular book this volume which is giving this data so then we have dry solids content, so how much is the dry solid content out of the total so that means we have lot of water is getting produced in the solid, so dry solid content is very less.

So we have to see this is very important section because the post processing will depend upon that so how much is the solid content but how much is actually the dry solid content that also we have to see, the mass of sludge also we can tentatively calculate back based upon the how much wastewater is getting generated so tentatively mass of sludge in gram SS per inhabitant which is produced per day, so this calculation gives if you are planning for any community or any city etcetera which we can do.

And then similarly we can go for calculating the volume of sludge in liter per inhabitant per day we can calculate so these are very important data which help in the planning of any wastewater treatment plant and further understanding that how much sludge will be generated if you are going for conventional primary treatment or anything and how we can further take care of the sludge management issues before actually we have installed the plant etcetera so this is there.

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Characteristics and quantities of sludge produced in various treatment systems

Wastewater treatment system	Characteristics of the sludge produced and wasted from the liquid phase (directed to the sludge treatment stage)			
	kgSS/kgCOD applied	Dry solids content (%)	Mass of sludge (gSS/inhabitant·d) (a)	Volume of sludge (L/inhabitant·d) (b)
High-rate trickling filter				
• Primary sludge	0.35–0.45	2–6	35–45	0.6–2.2
• Secondary sludge	0.20–0.30	1–2.5	20–30	0.8–3.0
• Total	**0.55–0.75**	**1.5–4.0**	**55–75**	**1.4–5.2**
Submerged aerated biofilter				
• Primary sludge	0.35–0.45	2–6	35–45	0.6–2.2
• Secondary sludge	0.25–0.35	0.6–1	25–35	2.5–6.0
• Total	**0.60–0.80**	**1–2**	**60–80**	**3.1–8.2**

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Characteristics and quantities of sludge produced in various treatment systems

Wastewater treatment system	Characteristics of the sludge produced and wasted from the liquid phase (directed to the sludge treatment stage)			
	kgSS/kgCOD applied	Dry solids content (%)	Mass of sludge (gSS/inhabitant·d) (a)	Volume of sludge (L/inhabitant·d) (b)
UASB reactor	**0.12–0.18**	**3–6**	**12–18**	**0.2–0.6**
UASB + aerobic post-treatment (c)				
• Anaerobic sludge (UASB)	0.12–0.18	3–4	12–18	0.3–0.6
• Aerobic sludge (post-treatment) (d)	0.08–0.14	3–4	8–14	0.2–0.5
• Total	**0.20–0.32**	**3–4**	**20–32**	**0.5–1.1**

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Similarly, in the further we have the for septic tank and anaerobic filter the data is given if we have septic tank which is the common in a very small residence etcetera then conventional activated sludge so we have primary sludge secondary sludge which is produced and total so we can see that 0.6 to 0.80 kg suspended solid is produced per kg COD which is applied and that the dry content is less and per inhabitant calculations also we can perform.

So, from here onwards we are coming to the system which are at a larger scale so we have like conventional activated sludge then activated slug which is having extended aeration so we can see little bit drop happens with respect to kg SS per kg COD because we have extended aeration so this data help in determining the amount of solid content which is produced per kg.

So similarly for high rate trickling filter then submerged aerated bio filter we have so we have primary sludge, secondary sludge so we can see tentatively if you see the range varies highly from 0.2 to 0.8 tentatively you can see from like somewhere 0.2 0.8 so this is what is coming if you roughly take the data so maximum amount of SS which is produced is roughly 0.8 per kg COD applied.

So, if we want to be on the safer side similarly you can see in the UASB reactor very less amount of suspended solid is produced as compared to in the aerated system then UASB plus aerobic post treatment so here the sum increase happens with respect to amount of total solid which is produced per kg COD applied. So this is there.

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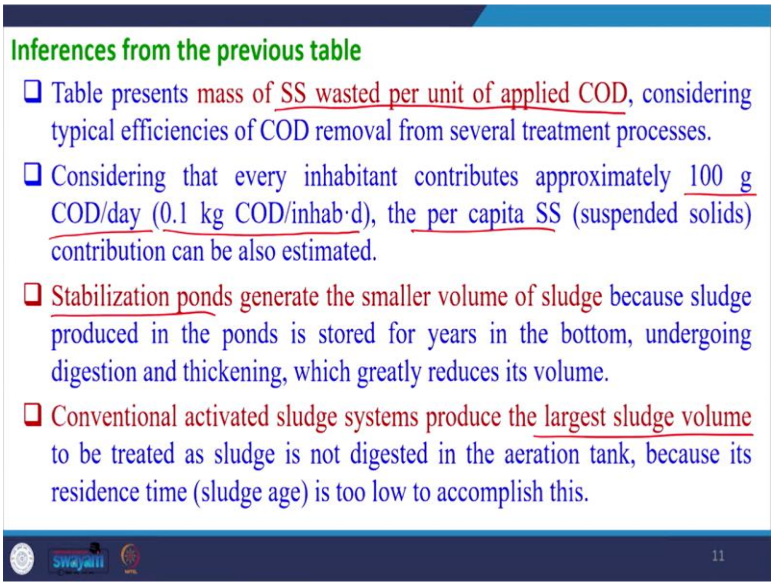

So inferences which can be drawn from the previous table we will try to summarize them, so table presents mass of suspended solid wasted per unit applied COD so considering typical efficiencies of COD removal from several treatment plants so this table gives this and which is the most important data which is reported from that table.

Now, considering that every inhabitant contributes approximately 100 gram COD per day so if we assume that each inhabitant produces 100 gram COD per day that means 0.1 kg COD per inhabitant per day the per capita SS or suspended solid contribution can be calculated and which is given actually in the table.

So this is the data that we can roughly we can calculate now also there are some other conclusions stabilization ponds generate smaller volume of sludge because the sludge produced in the pond is stored for years in the bottom and it undergoes digestion and thickening which generally reduces its volume, so the stabilization ponds produce lesser amount of or lesser volume of sludge.

Conventional activated slot systems produce the largest sludge volume and that has to be handled further so to be treated this sludge is not digested in the aeration tank because its residence time the edge is too low for doing any digestion so that is why we have very large amount of sludge getting produced from conventional activated sludge where the residence time is only in few days only.

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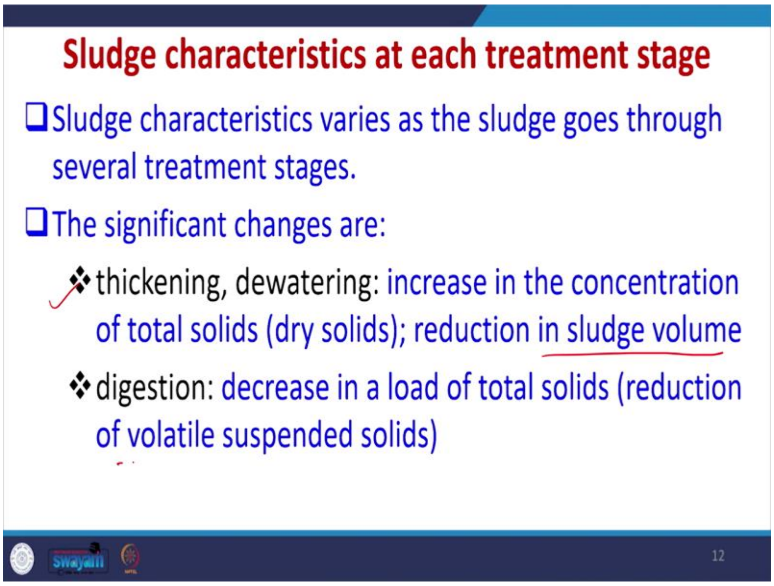

So going further the sludge characteristic at each treatment stage, so the sludge characteristics we can see they vary as the sludge goes through several treatment stages which will be studying further, the significant changes are like during thickening and dewatering increase in the concentration of total solids will happen so the total solid which is there will be increased but there will be reduction in sludge volume, so because we are going for thickening and water is getting removed.

Now if digestion is performed then the decrease in the load of total solids happens so we have the volatile suspended solid VSS fraction of the total SS will be reduced, so this happens during digestion process.

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Table. Sludge characteristics in each stage of the treatment process

Wastewater treatment system	Sludge removed from the liquid phase: Sludge mass (gSS/inhabitant·d)	Sludge removed from the liquid phase: Dry solids conc. (%)	Thickened sludge: Sludge mass (gSS/inhabitant·d)	Thickened sludge: Thickening process	Thickened sludge: Dry solids conc. (%)	Digested sludge: Sludge mass (gSS/inhabitant·d)	Digested sludge: Digestion process	Digested sludge: Dry solids conc. (%)	Dewatered sludge: Sludge mass (gSS/inhabitant·d)	Dewatered sludge: Dewatering process	Dewatered sludge: Dry solids conc. (%)	Per-capita volume (L/inhabitant·d)
Primary treatment (conventional)	35–45	2–6	35–45	Gravity	4–8	25–28	Anaerobic	4–8	25–28 25–28 25–28 25–28	Drying bed Filter press Centrifuge Belt press	35–45 30–40 25–35 25–40	0.05–0.08 0.06–0.09 0.07–0.11 0.06–0.11
Primary treatment (septic tanks)	20–30	3–6	–	–	–	–	–	–	20–30	Drying bed	30–40	0.05–0.10
Facultative pond	20–25	10–20	–	–	–	–	–	–	20–25	Drying bed	30–40	0.05–0.08
Anaerobic pond – facultative pond												
• Anaerobic pond	20–45	15–20	–	–	–	–	–	–	20–45	Drying bed	30–40	0.05–0.14
• Facultative pond	6–10	7–12	–	–	–	–	–	–	6–10	Drying bed	30–40	0.015–0.03
• Total	26–55	–	–	–	–	–	–	–	26–55	Drying bed	30–40	0.06–0.17
Facultative aerated lagoon	8 –13	6–10	–	–	–	–	–	–	8–13	Drying bed	30–40	0.02–0.04
Complete-mix aerat. lagoon – sedim. pond	11–13	5–8	–	–	–	–	–	–	11–13	Drying bed	30–40	0.025–0.04

Source: Cleverson Vitorio Andreoli, Marcos von, Sperling and Fernando Fernandes (Editors),VOLUME SIX, Sludge Treatment and Disposal, Biological Wastewater Treatment Series

Table. (Continued)

Wastewater treatment system	Sludge removed from the liquid phase: Sludge mass (gSS/inhabitant·d)	Sludge removed from the liquid phase: Dry solids conc. (%)	Thickened sludge: Sludge mass (gSS/inhabitant·d)	Thickened sludge: Thickening process	Thickened sludge: Dry solids conc. (%)	Digested sludge: Sludge mass (gSS/inhabitant·d)	Digested sludge: Digestion process	Digested sludge: Dry solids conc. (%)	Dewatered sludge: Sludge mass (gSS/inhabitant·d)	Dewatered sludge: Dewatering process	Dewatered sludge: Dry solids conc. (%)	Per-capita volume (L/inhabitant·d)
Septic tank + anaerobic filter												
• Septic tank	20–30	3–6	–	–	–	–	–	–	20–30	Drying bed	30–40	0.05–0.10
• Anaerobic filter	7–9	0.5–4,0	–	–	–	–	–	–	7–9	Drying bed	30–40	0.02–0.03
• Total	27–39	1.4–5.4	–	–	–	–	–	–	27–39	Drying bed	30–40	0.07–0.13
Conventional activated sludge												
• Primary sludge	35–45	2–6	35–45	Gravity	4–8	25–28	Anaerobic	4–8	–	–	–	–
• Secondary sludge	25–35	0.6–1	25–35	Gravity Flotation Centrifuge	2–3 2–5 3–7	16–22	Aerobic	1,5–4	–	–	–	–
• Mixed sludge	60–80	1–2	60–80	Gravity Centrifuge	3–7 4–8	38–50	Anaerobic	3–6	38–50	Drying bed Filter press Centrifuge Belt press	30–40 25–35 20–30 20–25	0.10–0.17 0.11–0.20 0.13–0.25 0.15–0.25

Table. (Continued)

Wastewater treatment system	Sludge removed from the liquid phase: Sludge mass (gSS/inhabitant·d)	Sludge removed from the liquid phase: Dry solids conc. (%)	Thickened sludge: Sludge mass (gSS/inhabitant·d)	Thickened sludge: Thickening process	Thickened sludge: Dry solids conc. (%)	Digested sludge: Sludge mass (gSS/inhabitant·d)	Digested sludge: Digestion process	Digested sludge: Dry solids conc. (%)	Dewatered sludge: Sludge mass (gSS/inhabitant·d)	Dewatered sludge: Dewatering process	Dewatered sludge: Dry solids conc. (%)	Per-capita volume (L/inhabitant·d)
Activated sludge – extended aeration	40–45	0.8–1.2	40–45	Gravity Flotation Centrifuge	2–3 3–6 3–6	–	–	–	40–45	Drying bed Filter press Centrifuge Belt press	25–35 20–30 15–20 15–20	0.11–0.17 0.13–0.21 0.19–0.29 0.19–0.29
High rate trickling filter												
• Primary sludge	35–45	2–6	35–45	Gravity	4–8	–	–	–	–	–	–	–
• Secondary sludge	20–30	1–2.5	20–30	Gravity	1–3	–	–	–	–	–	–	–
• Mixed sludge	55–75	1.5–4	55–75	Gravity	3–7	38–47	Anaerobic	3–6	38–47	Drying bed Filter press Centrifuge Belt press	30–40 25–35 20–30 20–25	0.09–0.15 0.10–0.18 0.12–0.22 0.14–0.22

Now the sludge characteristics in each stage of the treatment process is defined here though the table is little bigger you can pause the video anytime to further understand, so the wastewater treatment plant we have primary treatment then septic tank, facultative pond, anaerobic pond then facultative aerated lagoon etc., so here the sludge removed from the liquid phase, so sludge mass gram SS per inhabitant per day and its dry solid concentration is given in the first column.

Then if we go for thickened sludge or digested sludge how much the variation taking place now finally the dewatered sludge is obtained so dewatered sludge contains like if the sludge mass is gram SS 35 to 45 then in the range for sludge mass for the after dewatered stage will be around 25 to 28 so the dewatering may be done by any of the process which is given so if drying bed is used, filter press or centrifuge or belt pressed depending upon that and the dry solid concentration, this is important and this has to be done if we want to process the sludge.

So from 2 to 6 percent or maximum you can see for facultative pond it will be 10 to 20 percent then also for anaerobic pond 15 to 20 percent so maximum that drying solid is around 20 percent without any treatment when but when we dewater the sludge the concentration goes up to 40 to 45 percent you can roughly see that it goes up to 40 to 45 percent of the solid that we obtained ultimately contains 40 to 45 percent dried solid, so this is there.

And we can roughly calculate the per capita volume in liter per inhabitant per day, so this is the data which we can take so we will be using this data for a lot of process we have to use it for design of the systems etcetera and further usage also.

The table is further continued for septic tank and anaerobic filter, the conventional activated sludge where the we have primary sludge, secondary sludge, mixed sludge so we can see that after drying we can use any of the process drying bed, filter press, centrifuge, belt pressure any anything is possible but the content the drying solids ultimately increase to 40 percent from whatever is the initial rank solid concentration.

And here like for conventional activated sludge process the thickening can be carried out so thickening can be carried out by a gravity method, flotation method or centrifuge method so when we are doing thickening of the conventional activated sludge process the from 2 percent it will increase to 8 percent then we do the digestion and ultimately dewatered sludge will contain only around 35 to 40 percent the solid content will be there under dry basis.

Similarly we have activated sludge extended aeration process, high rate trickling filter also so we can see for these systems we are performing the thickening also, digestions also so like for mixed sludge from thickening filter we have the thickening which is carried out so the concentration of the dry solid increases from 1.5 to 4 percent to 3 to 7 percent then digestion will be done during digestion it will remain roughly the same but after drying it will increase to 40 percent.

So depending upon the type of drying that we use whether drying bed or filter press or centrifuge or belt press, one thing which is not mentioned here is that depending upon the drying process that we use the residence time or the time it takes for drying is different so that aspect is very important also cost is also different so that will be discussing later on but here idea is being given the how the characteristic of the sludge changes during various stages of its management.

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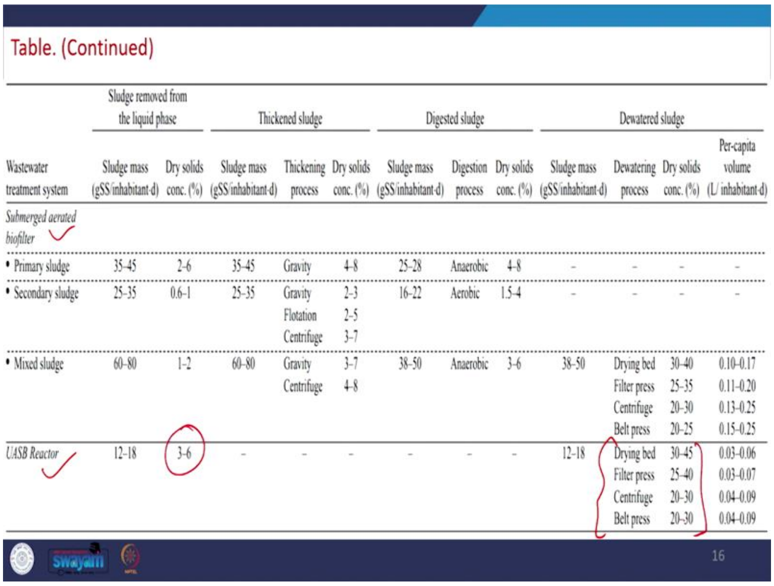
Table. (Continued)

	Sludge removed from the liquid phase		Thickened sludge			Digested sludge			Dewatered sludge			
Wastewater treatment system	Sludge mass (gSS/inhabitant·d)	Dry solids conc. (%)	Sludge mass (gSS/inhabitant·d)	Thickening process	Dry solids conc. (%)	Sludge mass (gSS/inhabitant·d)	Digestion process	Dry solids conc. (%)	Sludge mass (gSS/inhabitant·d)	Dewatering process	Dry solids conc. (%)	Per-capita volume (L/inhabitant·d)
Submerged aerated biofilter												
• Primary sludge	35-45	2-6	35-45	Gravity	4-8	25-28	Anaerobic	4-8	-	-	-	-
• Secondary sludge	25-35	0.6-1	25-35	Gravity Flotation Centrifuge	2-3 2-5 3-7	16-22	Aerobic	1.5-4	-	-	-	-
• Mixed sludge	60-80	1-2	60-80	Gravity Centrifuge	3-7 4-8	38-50	Anaerobic	3-6	38-50	Drying bed Filter press Centrifuge Belt press	30-40 25-35 20-30 20-25	0.10-0.17 0.11-0.20 0.13-0.25 0.15-0.25
UASB Reactor	12-18	3-6	-	-	-	-	-	-	12-18	Drying bed Filter press Centrifuge Belt press	30-45 25-40 20-30 20-30	0.03-0.06 0.03-0.07 0.04-0.09 0.04-0.09

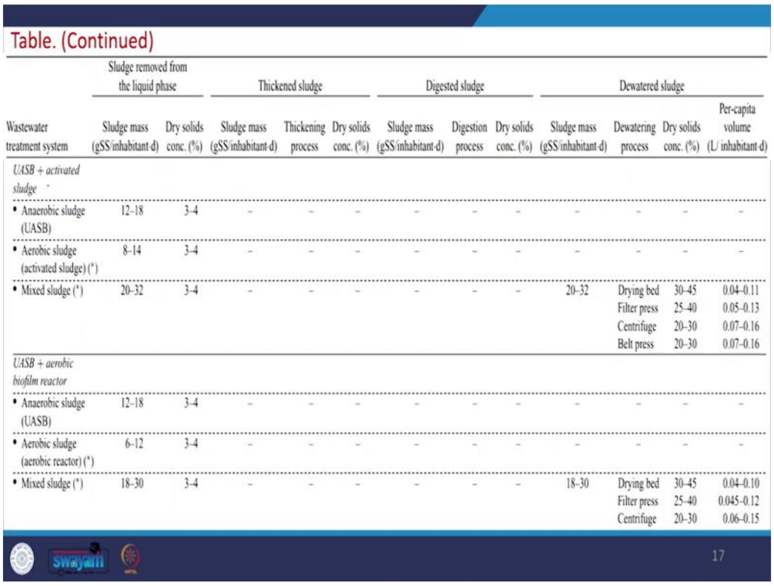

Table. (Continued)

Wastewater treatment system	Sludge removed from the liquid phase: Sludge mass (gSS/inhabitant·d)	Dry solids conc. (%)	Thickened sludge: Sludge mass (gSS/inhabitant·d)	Thickening process	Dry solids conc. (%)	Digested sludge: Sludge mass (gSS/inhabitant·d)	Digestion process	Dry solids conc. (%)	Dewatered sludge: Sludge mass (gSS/inhabitant·d)	Dewatering process	Dry solids conc. (%)	Per-capita volume (L/ inhabitant·d)
UASB + activated sludge												
• Anaerobic sludge (UASB)	12–18	3-4	–	–	–	–	–	–	–	–	–	–
• Aerobic sludge (activated sludge) (*)	8–14	3-4	–	–	–	–	–	–	–	–	–	–
• Mixed sludge (*)	20–32	3-4	–	–	–	–	–	–	20–32	Drying bed Filter press Centrifuge Belt press	30–45 25–40 20–30 20–30	0.04–0.11 0.05–0.13 0.07–0.16 0.07–0.16
UASB + aerobic biofilm reactor												
• Anaerobic sludge (UASB)	12–18	3-4	–	–	–	–	–	–	–	–	–	–
• Aerobic sludge (aerobic reactor) (*)	6–12	3-4	–	–	–	–	–	–	–	–	–	–
• Mixed sludge (*)	18–30	3-4	–	–	–	–	–	–	18–30	Drying bed Filter press Centrifuge	30–45 25–40 20–30	0.04–0.10 0.045–0.12 0.06–0.15

So similarly for submerged aerated biofilter UASB reactor also the same ideas are given here tentatively it will increase from 3 to 6 percent to up to 45 percent, this table now we will trying to wind up so we similarly for UASB plus activated sludge system all the data is given we can use them.

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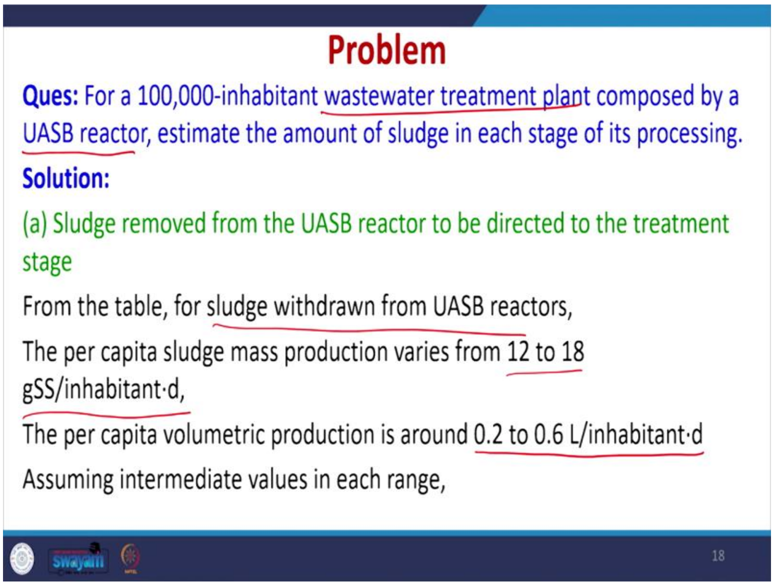

Characteristics and quantities of sludge produced in various treatment systems

Wastewater treatment system	kgSS/ kgCOD applied	Dry solids content (%)	Mass of sludge (gSS/ inhabitant·d) (a)	Volume of sludge (L/ inhabitant·d) (b)
	Characteristics of the sludge produced and wasted from the liquid phase (directed to the sludge treatment stage)			
UASB reactor	**0.12–0.18**	**3–6**	**12–18**	**0.2–0.6**
UASB + aerobic post-treatment (c)				
• Anaerobic sludge (UASB)	0.12–0.18	3–4	12–18	0.3–0.6
• Aerobic sludge (post-treatment) (d)	0.08–0.14	3–4	8–14	0.2–0.5
• Total	**0.20–0.32**	**3–4**	**20–32**	**0.5–1.1**

SS load in sludge: 100,000 inhabitants × 15 g/inhabitant. d

$= 1{,}500{,}000\ gSS/d = 1{,}500\ kgSS/d$

Sludge flow:

100,000 inhabitants

$\times\ 0.4\ L/inhabitant.d = 40{,}000\ L/d = 40\ m^3/d$

(b) Dewatered sludge, to be sent to final disposal

- The surplus sludge removed from UASB reactors is already thickened and digested, requiring only dewatering prior to final disposal as dry sludge.
- Assuming that the dewatering is accomplished in sludge drying beds.

- The table (earlier) shows that the per capita mass production of dewatered sludge remains in the range of 12 to 18 gSS/inhabitant·d, whereas the per capita volumetric production is reduced to the range of 0.03 to 0.06 L/inhabitant·d.

Using average values,

SS load in sludge: 100,000 inhabitants × 15 g/inhabitant. d

$= 1{,}500{,}000\ gSS/d = 1{,}500\ kgSS/d$

Sludge flow: 100,000 inhabitants

$\times\ 0.04\ L/inhabitant.d = 4{,}000\ L/d = 4\ m^3/d$

Assuming a specific weight of 1.05, the total sludge mass (dry solids + water) to go for final disposal is 4 × 1.05 = 4.2 ton/d. 4200 kg/d

$\text{SS load in sludge: } 100{,}000 \text{ inhabitants} \times 15\,\text{g/inhabitant.d}$

$= 1{,}500{,}000\,\text{gSS/d} = 1{,}500\,\text{kgSS/d}$

Sludge flow:

$100{,}000 \text{ inhabitants} \times 0.4\,\text{L/inhabitant.d} = 40{,}000\,\text{L/d} = 40\,\text{m}^3/\text{d}$

$\text{SS load in sludge: } 100{,}000 \text{ inhabitants} \times 15\,\text{g/inhabitant.d}$

$= 1{,}500{,}000\,\text{gSS/d} = 1{,}500\,\text{kgSS/d}$

$\text{Sludge flow: } 100{,}000 \text{ inhabitants} \times 0.04\,\text{L/inhabitant.d} = 4{,}000\,\text{L/d} = 4\,\text{m}^3/\text{d}$

Assuming a specific weight of 1.05, the total sludge mass (dry solids + water) to go for final disposal is 4 × 1.05 = 4.2 ton/d.

Now let us try to solve one problem related to the tables that we have used till now so here the question is given that for a 1 lakh inhabitant wastewater treatment plant so we have 1 lakh inhabitant and for which we are making a wastewater treatment plant which is composed of a UASB reactor so we have a UASB reactor containing treatment plant so estimate the amount of sludge that will be produced in each stage of its processing.

So this is the data that is given, now we can calculate this using the table that we have given earlier so the sludge removed from the UASB reactor is to be directed for the treatment stage so from the table for sludge withdrawn from UASB reactor we can go and we can cross check so sludge withdrawn from the UASB reactor if you go back and cross check it is given that 12 to 18 gram SS is produced per inhabitant per day.

We can cross check this also here for UASB reactor this is you can see 0.12 to 0.18 so this data is taken here so 12 to 18 gram SS is produced sorry, this data is for UASB reactor, this, this data mass of sludge gram SS produced per inhabitant per day so 12 to 18 is produced so this data is taken.

Now the per capita volumetric production is also we can refer to the table and it will be 0.2 to 0.6 liter per inhabitant per day assuming the intermediate value, so in place of 12 to 18 we can take any intermediate value similarly here also so assuming the intermediate value of 15 gram inhabitant per day so amount of the sludge which will be there the SS load in the sludge will be 15 gram per inhabitant per day so roughly 1500 kg of SS will be produced per day and the amount of sludge that will be produced we can roughly take it will be 40 meter cube per day.

So that means we have to handle 40 meter cube of sludge per day which itself will contain around 1500 kg of SS and for this we have to design a wastewater or sludge management strategy and that strategy will be dependent upon other parameters also like we can cross check that what is the solid content actually on dry bases or wet basis so those data also need to be calculated.

Now dewatered sludge that has to be finally sent for final disposal or for further use as it is possible we can go for incineration or anything though the surplus sludge removed from the UASB reactor is already thickened and digested and only dewatering prior to final disposal as a dry sludge is there.

So, assuming that the dewatering is accomplished in a sludge drying bed so if we assume that what type of dewatering process we are going to use, so we can use different types of dewatering techniques as discussed earlier so depending upon the dewatering technique this data will vary but we are assuming the sludge drying beds to be used so table earlier shows that the per capita mass production of dewatered sludge remains in the range of 12 to 18 gram SS per day whereas the per capita volumetric production is in the range of 0.03 to 0.6 liter per inhabitant per day.

So using the average values we can calculate the SS load in the sludge again it will remain the same 1500 kg SS because SS will remain the same it will not go off, we are only dewatering the volume so the volume reduction will happen it will become 4 meter cube per day in place of 40 meter per day so the amount of volume of sludge that has to be handled and that will be sent for disposal or for other in use if possible that will be 4 meter cube per day assuming that now we have to further assume that what is the specific weight of the sludge.

So whether it is how much above the water, so if we are assuming a specific weight to be 1.05 just slightly above water thus total sludge mass, dry solids plus water to be sent for final disposal will be around 4.2, so 4.2 ton per day this is ton, this 1 ton so 4.2 ton per day that means 4200 kg has to be handed which itself will contain around 1500 kg SS per day so this is the rough calculation that can be used further on for performing various calculation. So this is the rough idea that we have obtained.

So today we learned regarding sludge management and we have started the process of understanding that how sludge is generated, what are the different steps, what are the characteristics and how much amount of sludge is produced in each of the production stages so there are different wastewater treatment methods and each treatment method has different amount of sludge which is produced.

Now, this sludge which is produced also has different characteristics, characteristics in terms of how much is the dry solid content and how much is the water content and depending upon other characteristics also whether the digestion has happened during the treatment process itself or not the characteristics will be different.

So, we have to use sludge digestion or not that will depend whether the sludge digestion initially happened during the treatment itself or not and finally we have to dewater the sludge so there are different strategies for dewatering that we will be studying further on. So we will be continuing with respect to discussion on the sludge management in next few lectures also, so thank you very much for today.