Water and Waste Water Treatment
Prof. Bhanu Prakash
Department of Civil Engineering
Indian Institute of Technology - Roorkee

Lecture - 3
Course Outline

Hello, everyone, welcome back to the latest lecture session. In the first couple of classes, I was trying to give you some background about wastewater treatment and why it is necessary, we also looked at prejudices and the role of class. But we are not going to go into that aspect here.

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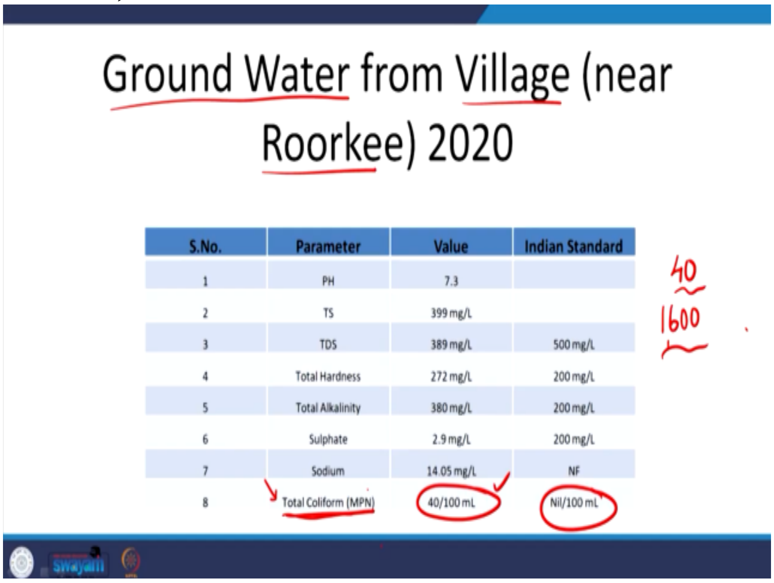

S.No.	Parameter	Value	Indian Standard
1	PH	7.3	
2	TS	399 mg/L	
3	TDS	389 mg/L	500 mg/L
4	Total Hardness	272 mg/L	200 mg/L
5	Total Alkalinity	380 mg/L	200 mg/L
6	Sulphate	2.9 mg/L	200 mg/L
7	Sodium	14.05 mg/L	NF
8	Total Coliform (MPN)	40/100 mL	Nil/100 mL

In the last class or the session, we were looking at groundwater quality report from a village near Roorkee and surprising aspect; in both the samples we had or we came across, coliform total coliform was not nil. But it was for this case, it was at 40, or it is 40 per 100 ml and it was 1600 for the other one, we looked at the case or I provided the information, where I mentioned that the 1600 one was drawn relatively closer to the surface.

And the one that gave the result of 40 per 100 ml was relatively farther from the surface and I mentioned the role of leaking septic tanks. Coliform again, before I go further why coliform? Why not different other indicators? One, it is because it is present in greater numbers in our intestines or the gut coliform is present in the gut of what is it now, warm blooded animals . Here we are talking about humans so I am just talking about me or us here.

Firstly, it is present in great numbers and even after I discharge it or if it comes out through the faeces, it is going to be able to survive others maybe not. We need an indicator organism that can survive can be relatively easily measured, and also is present in relatively greater numbers. That is why people choose coliform, total coliform is an indication of indication of contamination of your relevant water sample by faeces . That is something to keep in mind that can lead to different kinds of diseases, we looked at the mortality rates.

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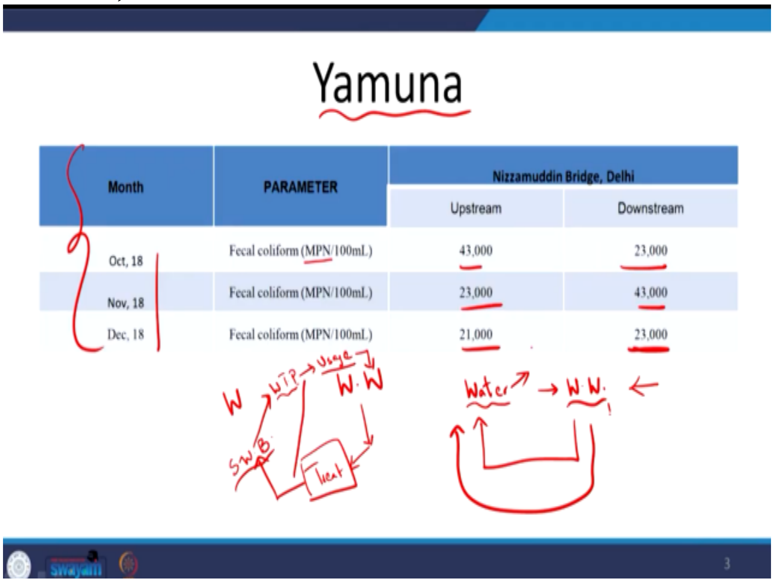

We will now go into that in detail now and in that context, to give you an idea about the situation, or scenario of Yamuna we talked about, or we presented this particular aspect or set of data from 2018 in the winter months. We see that it is pretty poor, or the concentration of the or we see that faecal coliform count is remarkably high MPN here stands for most probable number per 100 ml we will look at the test and the details later.

But again, the point I want to make is Yamuna, more or less is partially treated or untreated sewage, at least downstream of Delhi until Mathura, Agra and even at Atawala. Why is that important? You are going to have contamination of the soil , because it is not just untreated sewage. It is also industrial wastewater coming in and you have what is it now, people living on the banks depend on the water for either agriculture daily usage or such.

And the water from Yamuna goes to Mathura and Agra, and certainly at Atawala too, so though they treat the water, we still have to be relatively careful about these aspects. Otherwise, we are going to end up what do we say causing a pandemic or such or leading to the transmission of disease among a lot of people transmission of pathogens. That is one aspect why we need to look at water and wastewater treatment; both go hand in hand.

As , I am going to use the water and then after I use it, where it becomes wastewater the issue in India is that , we are not treating a lot of this. This is going back and diluting or being diluted by surface water bodies are as more or less polluting the surface water bodies and again, we are ending up using the relevant water and that leads to diseases. Wastewater and water both go hand in hand.

That is something to keep in mind, earlier they just used to what do we say dump it downstream of the city. But with industrialization now we are having to, water and this is wastewater, we now have to be able to treat it first and then send it to dilution in surface water body and then water treatment plant and then our usage .

But the scenario slowly but surely is coming out to , surface water body, I am going to have to discharge it into a river after dilution, then the water treatment plant is going to treat the water and then we are going to use it after usage again, it becomes wastewater . But now the scenario is so dire because of increasing population density and overdrawn groundwater.

The scenario is there existing in South Africa, and some other places in Africa and some places in Europe too. Treated wastewater or the wastewater is treated to such an extent that it is directly sent for usage by the local population usage might not be for drinking, but certainly for toilet flushing. In the future, we are going to be at the stage where the treated wastewater is going to be used for almost all human needs.

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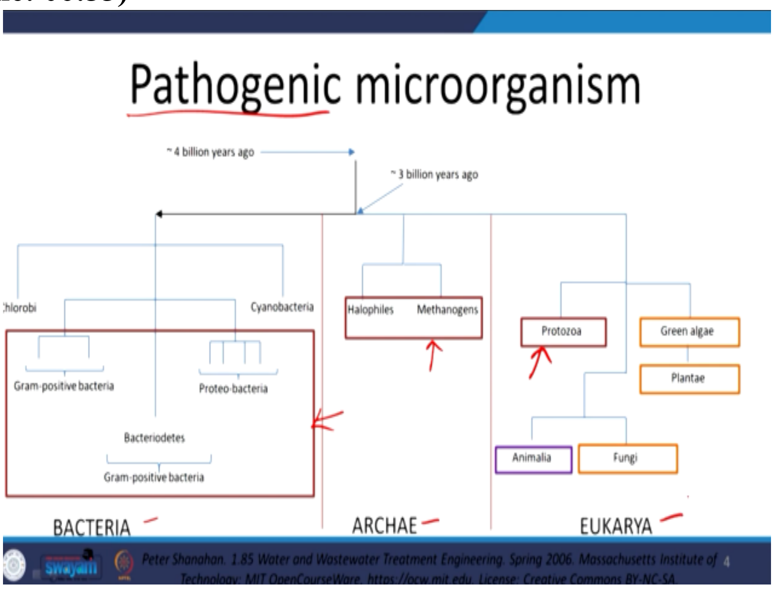

Let us move on here so we were talking about pathogenic microorganisms or pathogens. We will look at this in greater detail later. But the aspects or the microorganisms that we need to be concerned about, I have, highlighted them. We will come back to this bacteria, archaea and eukaryote.

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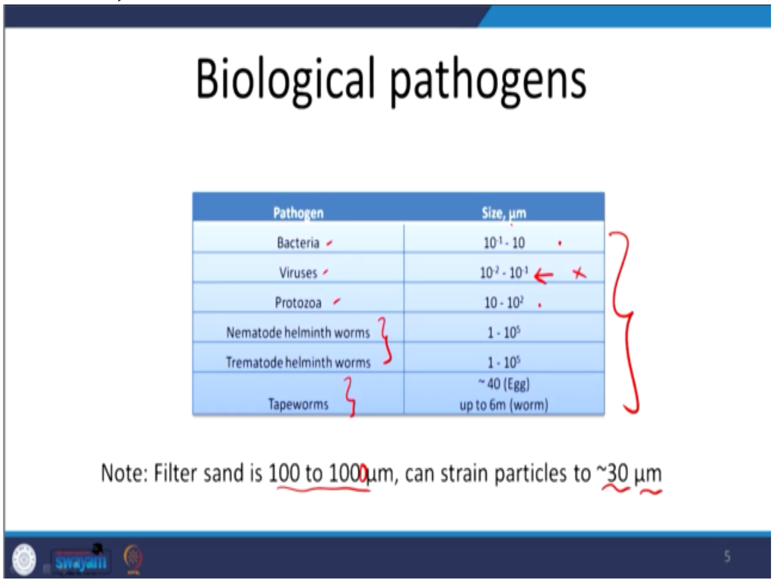

I am concerned about bacteria, viruses, as you can see just RNA that is why the size is remarkably less protozoa, some kinds of worms and the aspect here is that filter sand is 100 to 1000 micrometers, and it can strain and remove particles up to the size of 30 micrometers and or even 20 sometimes. I cannot remove the viruses not all certainly, but protozoa and sometimes we can even get some bacteria though. That is something to keep in mind and here is just the relevant profile, note the size out here it is micrometers.

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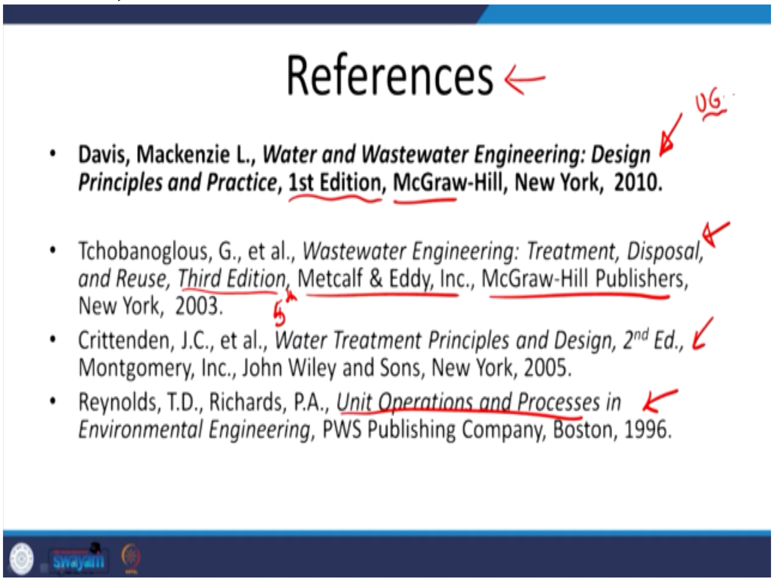

What book is it that you can look at or what are the references that you can consider so, Water and Wastewater Engineering Design Principles and Practice first edition, the second edition or the Indian edition is certainly available by McGraw Hill and it is Davis and Mackenzie. The other one does is again, a relatively more comprehensive source, certainly useful for practitioners, and also for faculty wastewater engineering, treatment, disposal and reuse.

But now instead of the third edition, even the fourth or the fifth editions are outlets, again by Metcalf, and Eddy, McGraw Hill publishers, again, different other sources, this is another good source with respect to unit operations and processes by Reynolds. But in general, this book is more or less good enough for the UG students; that is something to keep in mind.

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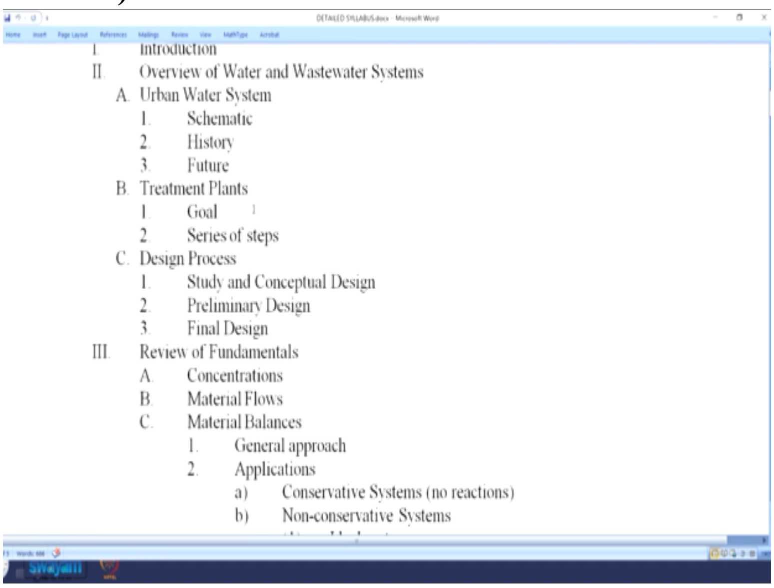

Before we go further, let us look at the course outline to understand what we are going to discuss throughout this particular course. Introduction, we will have a look at some of the we already had looked at the history, we will briefly look at the different kinds of treatment plants only briefly and very generic discussion about the design process required, then before we start getting into wastewater treatment or such, we are going to review the fundamentals.

People might not have the background and the relevant aspects concentration flows or mass balances. We will have to look at those people who do have a background might be relatively rusty in these areas so we will have a look at that, then we will look at mass balances you will have your wastewater treatment plant inlet, influent is coming in and outlet is going out.

You have to design it you have to know what chemicals abit about it, but how much of it to add, what flows what concentration when to add. Those aspects will look at it when we talk about mass balance.

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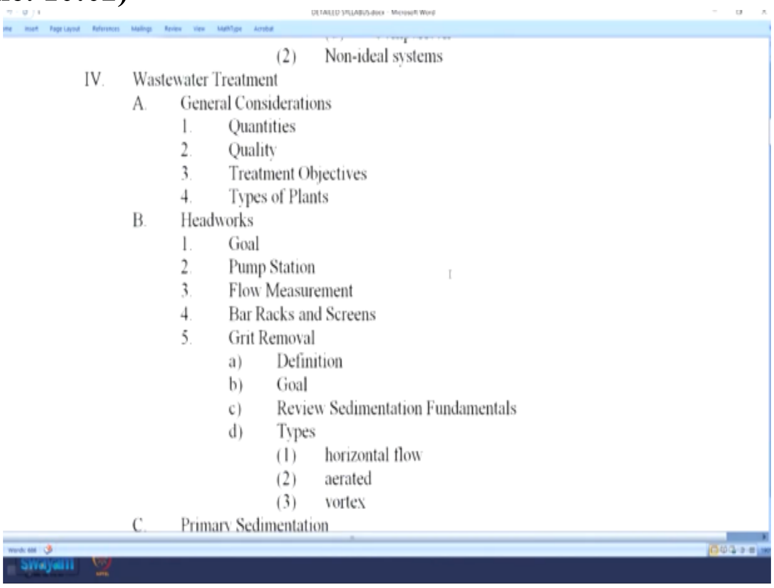

And then we are going to move on to discussing wastewater treatment. Other people typically look at water treatment, but I find wastewater treatment relatively more interesting. We will talk about wastewater treatment initially or first and then move on to water treatment. Wastewater: so head works , you have wastewater coming in people dump all kinds of stuff.

You need to remove the grit, you need to remove the plastic and other bigger screens so that is why bigger particles that can mess up your mechanical instruments. That is why you have bar racks and screens, grid removal, the bigger particles .

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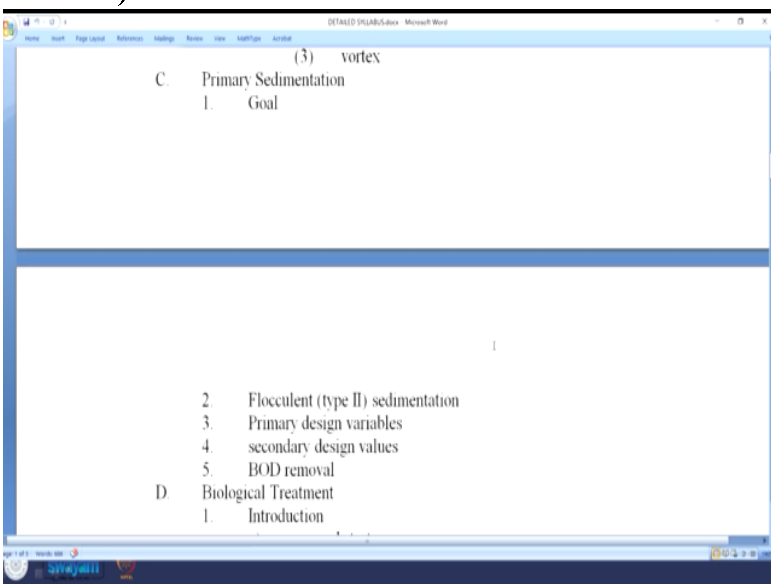

And then you are going to have sedimentation, as an if I add some sand or soil, a glass of water, after some time, I can see that some of it will or you can see some settling, then and there. Or if I come back after, 2 hours or 3 hours, I can see more of it having settled out and only some being dissolved or still suspended out there. How do I remove these particles, by sedimentation, gravity, or you are going to help it settle by letting flocks being formed so, that is one aspect.

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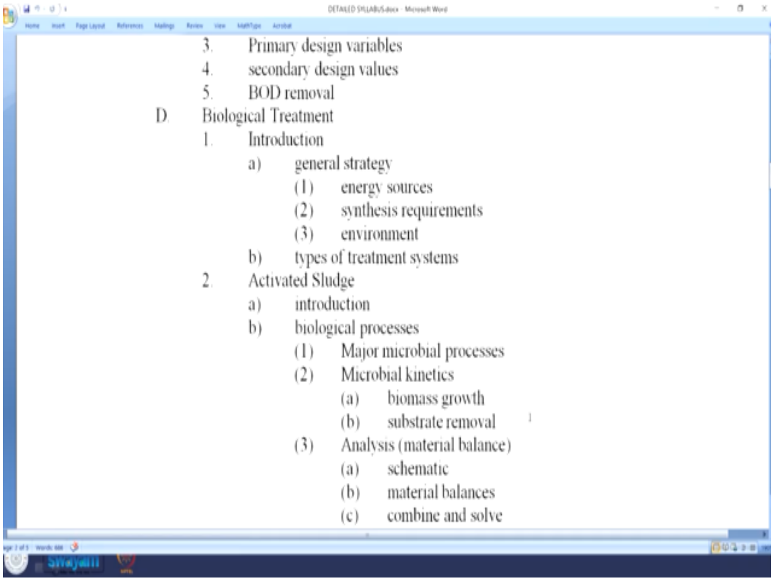

And then biological treatment so after I remove this suspended matter or suspended, particles from your wastewater, I still have some suspended matter, and also some dissolved matter, here, it is organic content think of your urine, your faeces and the kitchen waste. I mean the water here we are talking about the water from your washing utensils, washing your clothes, all this is coming out here, and you need to be able to treat it.

But how are we going to do that though, if I , try to treat it chemically that typically leads to higher costs. But similar to us, the bacteria also need energy they want to thrive. Using that principle, people have been able to develop biological different kinds of biological treatment, the principle there is that the bacteria are going to use oxygen as the electron acceptor.

I am also taking in oxygen as the electron acceptor that is the same reason why I am taking in oxygen here and similarly, aerobic microorganisms or bacteria are going to take in oxygen as the electron acceptor. They are going to use our waste as their food which people also call as substrate, then the relevant redox reaction, you are going to have the energy being used by the bacteria, or they are also going to use it for redox reaction, they are going to use it for self synthesis to and reproduction.

Maybe reproduction is not the right way right word growth. Same case here, I eat food, I take oxygen, I use the energy and some of the waste, I am going to discharge it and that waste is the food for the microbes, say different aspects, we will discuss that in greater detail out here.

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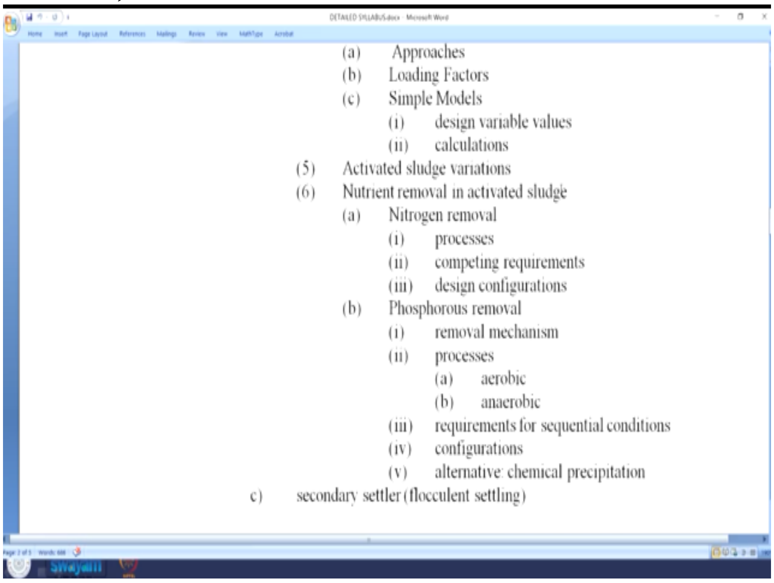

Nutrient removal also, that is what we have here nitrogen and phosphorus is also going to be released from different sources, not just from our urine, and you have to remove it. If not this nitrogen and phosphorus will end up in surface water bodies. If you do not remove these nitrogen and phosphorus, what is going to happen? These nutrients, you are going to have algal growth.

And when you have access in a short period, you will have an algal bloom , once this nutrient inflow is shut down you are going to have death of algae and then you are going to have considerable issues with decay of this algae. Again, dissolved oxygen in your water is going to come down you are going to have fish kills and saturates, also some of the algal blooms are pretty toxic, then you are going to have secondary settling .

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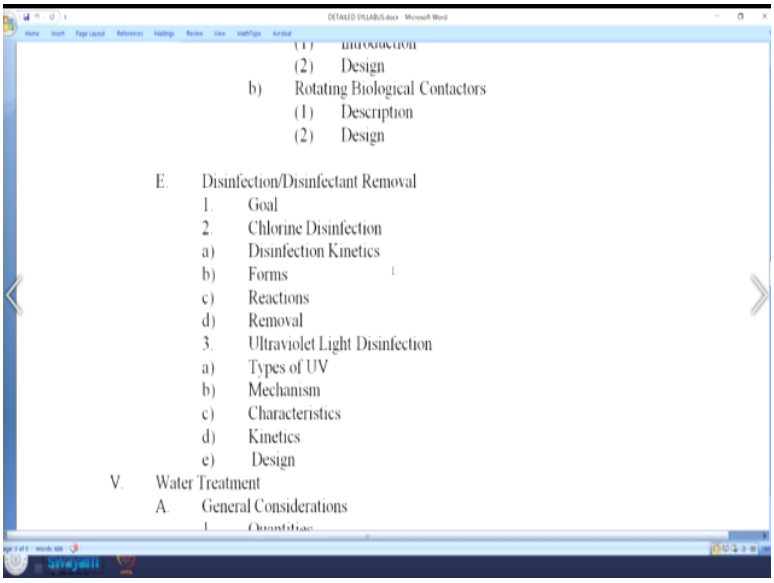

And disinfection we know that we need to take care of the different pathogens in this wastewater, that is why we have disinfection. Once we are done with wastewater, we will move on to water treatment.

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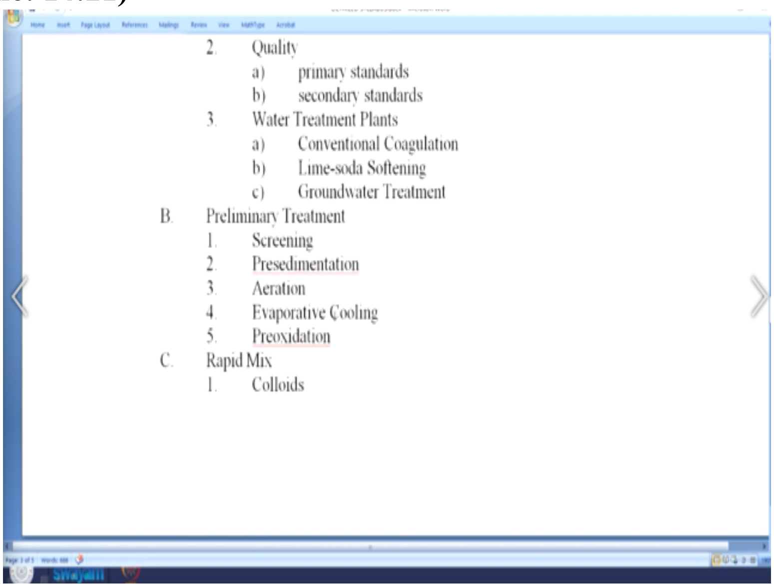

Preliminary treatment first sedimentation as let as just gravity do its job. If not, then we are going to have coagulation and then flocculation coagulation you are going to neutralize the charge on this suspended particles, let them come together and form flocks once they form bigger particles, they will be able to settle down so that is the principle out here flocculation once they form the flocks.

They will settle down you have segmentation and those are that are too small to settle down even after coagulation and flocculation or those which will take too much time. You are going to remove by filtration; sand filtration is one typical way to get that done.

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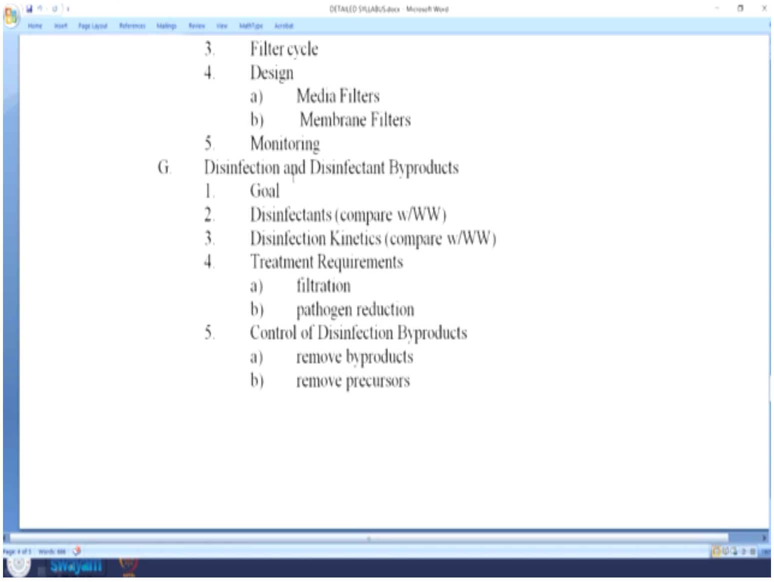

And then disinfection by chlorine or HOCl and the issue is with such disinfectants that is something you are going to look at.

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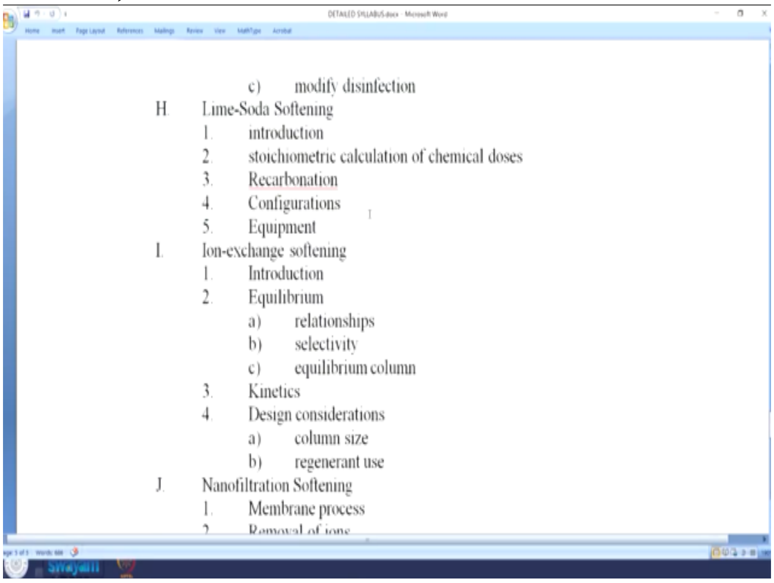

Softening because even if you remember we looked at the data from the village near Roorkee and we saw that the hardness was pretty high. Other than leading to issues with your digestive system, it will typically lead to issues whenever you are trying to wash something because it is going to use up or form a complex if I may say so with your soap. That is one reason why you are going to have to remove your calcium and magnesium or decrease the hardness so lime soda softening.

And then ion exchange people have moved on from typical carbonation and recarbonation relevant aspects for lime soda softening if there are other cations or anions that I want to remove, you are going to have different resins which can absorbed. Here the principle is ion exchange. You are going to have calcium, absorbed by the resin instead of the sodium so ion exchange softening.

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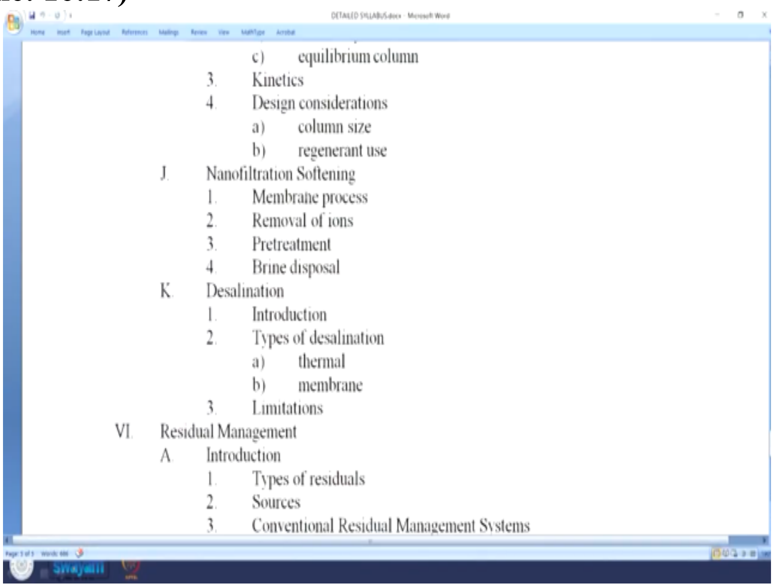

c) equilibrium column
3. Kinetics
4. Design considerations
a) column size
b) regenerant use
J. Nanofiltration Softening
1. Membrane process
2. Removal of ions
3. Pretreatment
4. Brine disposal
K. Desalination
1. Introduction
2. Types of desalination
a) thermal
b) membrane
3. Limitations
VI. Residual Management
A. Introduction
1. Types of residuals
2. Sources
3. Conventional Residual Management Systems

Then filtration desalination we have huge desalination plants near Chennai I think 200 or 100 MLD plants.

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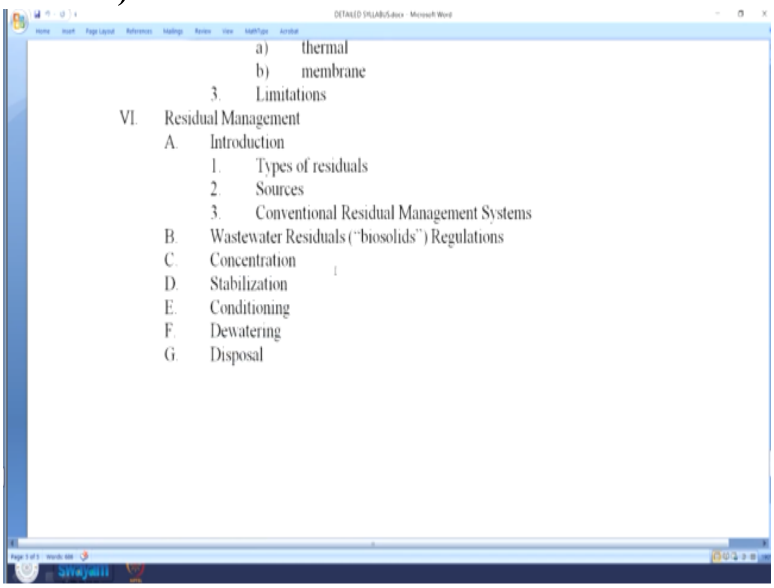

a) thermal
b) membrane
3. Limitations
VI. Residual Management
A. Introduction
1. Types of residuals
2. Sources
3. Conventional Residual Management Systems
B. Wastewater Residuals ("biosolids") Regulations
C. Concentration
D. Stabilization
E. Conditioning
F. Dewatering
G. Disposal

And then residual management we will look at what residue is . General overview we are going to look at material balance to understand how do I analyze these systems for example I want to design it design meaning first I want to know the size or the volume that is required of my either the water or the wastewater treatment plant.

I need to then be able to understand how much is coming in and at what level can I send it out and then how is it being transformed within my particular reactor or treatment plant and then using the principles of material balance or mass balance we will be able to get it done. Then after that we will look at wastewater treatment and then water treatment. Let us go back to our own slides out here. Before I go further, we will just look at this particular wastewater treatment plant that we have here.

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This is the one from IIT Roorkee so you see this sump wastewater will come into the sump we will look at this video in much greater detail later. But for now, we will just look at an overview to get your interest what do we say to capture your interest .

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Here we have our sump out here this is where the sludge is managed but we will look at that typically it comes into the wastewater is coming in how does wastewater come to this sewage treatment plant typically by gravity. Because if you have at upstream lead not upstream of the slope, it is not going to work out you have to have pumping stations and then again costs.

You have a storage network which collects the sewage and comes to the sewage treatment plant and initially in India, the issue is that our sewage collection system is so poor or nonexistent in some cases, but again this is expected we are a developing country. I know it either leaks or there is no sewerage network or the sewerage network is so poor or poorly designed that these what is it sewerage pipes are blocked.

Because you need to have a particular velocity otherwise, they are going to settle there are multiple issues. The reason I mentioned is that we have plants with 250 MLD, 1 MLD I mean MLD is million liters per day, 1 MLD 1.5 crores or so it takes 1.5 crores or cost 1.5 crores to construct a plant of 1 MLD but again it is not linear though.

250 MLD 300 or 350 crores and the issue is that they are only receiving 40 MLD or such why is that because the sewerage network is so poor, the sewage is either leaking in or there is no network or the flow is not going through in the aspect, not aspect that they in the way that they wanted it to happen. Wastewater is going to come in, and then it is going to be pumped up, then you are going to have some equalization tank we will look at that later.

And then here we have the basins here or the tanks here reactors here, where the sewage is being degraded by microbes. The bubbles, that you see here are the air or oxygen or is the air or oxygen that is being pumped into this particular system you I can see that out here. During this process, the microbes are degrading the relevant sewage, after I stopped aeration, so you see the flocks, these are different kinds of, now you can see the flocks more clearly.

And these being heavier will also settle down. You can see them already starting to settle down, I have collected in a beaker and so the supernatant. Once the bacteria, while the bacteria are feeding, you have different kinds of bacteria being formed, you want balance between flock and filamentaeous, you have this flock forming bacteria and right now they are suspended in the water.

When you let them settle, they are going to settle down to the bottom and all the top water which is being collected out here. That is what you see out here is the supernatant, that is relatively clear and that is the treated wastewater. That is something that you see decanting. This is the sample that we are going to look at right now is from the aeration tank, the microbes just spent, a couple of hours, degrading the waste in there.

And now we took the sample from there, we just put it out there for to help you visualize how the flock again, this is bacteria, are going to settle down this is real time I am not fast forwarding it or such. You can see the timeout here it is already starting to settle, settle and given enough time, you will see considerable settling, it is just a matter of seconds here with respect to settling of most of the what do we say, sludge here, this is what I am going to call a sludge.

And this is my supernatant which is relatively clear after some time this is also going to settle down. That is something that you can visualize or see out here. And 30 seconds is what we looked at here or spent out here, we see that it is pretty relatively fast again, that is because this flux now can relatively heavier, and now you see the flock not flock pardon me the supernatant which is relatively clear and treated water. Here for just an experiment, are in different angles so you can see this too.

Then this sludge water you are going to do out here, you have to, dewater it and treat it, if not, you are going to have an issue, we will look at what I am trying to do out here. Here you have the dewatering equipment , otherwise, the volume of this sludge and the weight is going to be high. You want to remove the water so that is why they are adding poly electrolytes to form flocks.

And we can see this sludge coming in sludge that is collected from the bottom you have a filter press out here, the dewatered sludge, as you see is falling down from out here. Yes, this is the dewatered sludge that is composted typically. That is enough for now we will look at this greater I mean not greater in greater detail later on.

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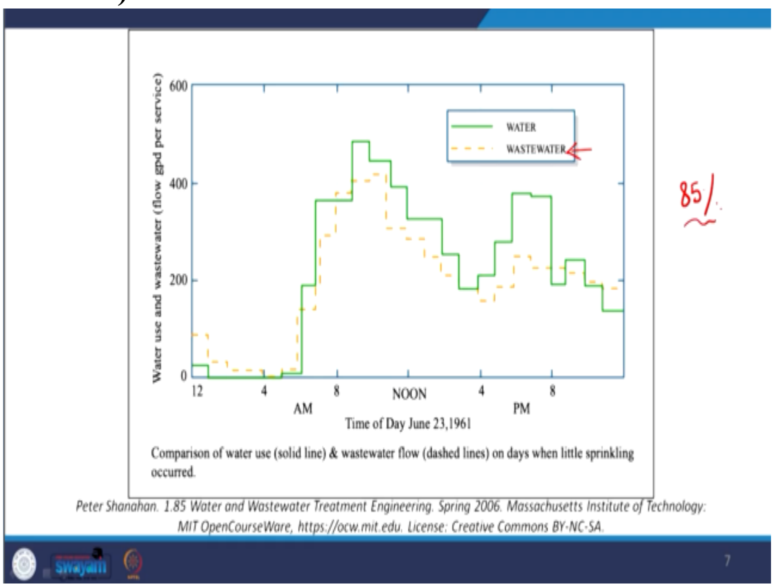

Let us come back to where we were, we look at the references . Coming back to our course out here water and wastewater, as I mentioned are interlinked. A few of the slides or the data which I could not find, I sourced them from the MIT open courseware the link is out here you can search for it in Google and this is the course here . Whenever I mean typically providing the source of the information or the slide that I am taking, if not , we will draw it ourselves .

This is for the US , I could not get the actual one for India, but it will be relatively similar. Here we have water and here we have on the y axis water use and wastewater flow in gallons per day gallon is around 3.7 liters per day. Time of the day, but this is way back in 1961. But our water usage now should be relatively similar if not a way off. You see people start waking up, getting ready for their offices and work.

That is why spike in what is this water usage so and then slowly but surely, again, most of the people are at work or it is only kitchen waste that comes in or wastewater from the kitchens, then in the evening again when people come back you see and bathing , you see that increase again or the spike and then the decrease again and if you look at what we have the relevant wastewater you will see that it matches similar profiles.

Typically, when we are designing for a city or such, we assume that 85% of the water that we are giving to the population will end up as wastewater in our wastewater treatment plant. That is something for you to keep in mind or understand, typical domestic waste water use.

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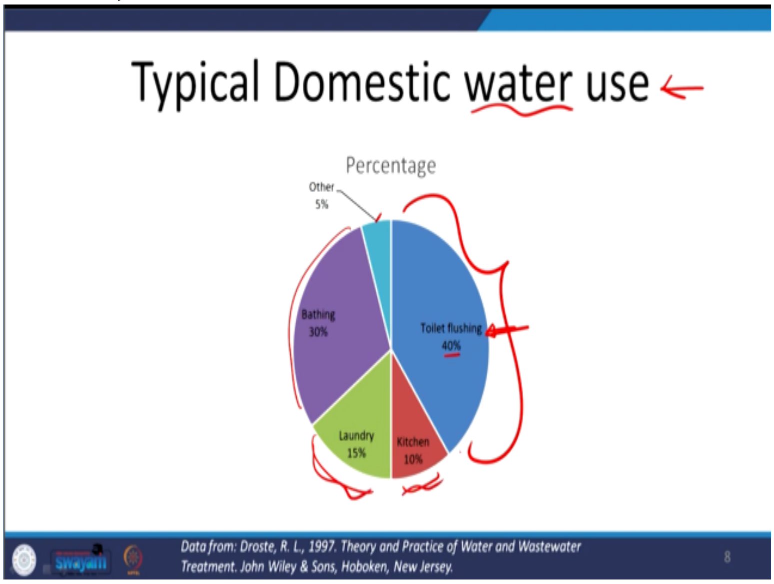

To understand what is it that people typically use it for? Note that again, thus data is from the US I could not get specific data for the Indian scenario, but it is relatively similar, but this is for the middle class, such, and upper middle class. The reason I say so is as you can see, toilet flushing takes up a considerable chunk of the water, now efforts are on to see to it that we decrease this water that we use for flushing the toilet .

That is one aspect that is why Indian style toilets that is the reason why they take up less water, toilet flushing, as you see takes up a considerable chunk, the majority of the water is used for toilet flushing. As I mentioned earlier, some of the treated wastewater is planned to be used for toilet flushing, you see the reason here why so then bathing, and laundry, and kitchen and other uses, including drinking probably is pitiless. Bathing, laundry for washing clothes and kitchen. This is the breakdown out here that is for understanding what we are using the water for.

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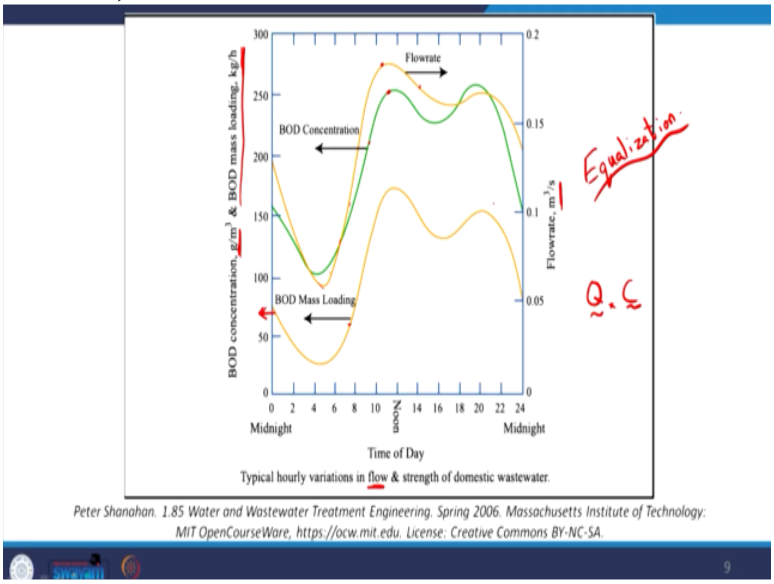

And again, here I have another set of data, oddly variations in flow , for example, in the morning, when I flush the toilet waste, or the human feces , the flow might not be a lot. But the concentration of the organic content, is going to be high. But when I am bathing it, the flow might be high, but the concentration of the organic content in that flow will be less.

We just need to understand that because again, similar to people bacteria too cannot take shock loads, I have started exercising, and I am able to lift only 5 Kgs or, such I cannot jump from a 5 kg squat to 70 kg squat in one go. You want to prevent shock loading so that is the reason why you typically need to understand the flow rate concentration and mass loading. That is why you have something called an equalization tank.

At the beginning of your wastewater treatment plan, you want to equalize the mass that is going to come in contact with your various unit process. We have we have 2 aspects here, concentration here and flow rate, the product will be the BOD mass loading the BOD mass loading is kilograms per hour, concentration, they are using different units g/m^3 flow rate is m^3.

As expected, initially, flow rate is going to be high and it is going to decrease and, in the night, it is going to be relatively low, it is going to go up so, cyclical so same profile, but well to the lesser here during the morning, because bathing and cooking take place around this time. But with respect to the mass loading, again similar profiles, but you see that the concentration here is going to be not concentration, the units are different.

The mass loading is nothing but flow into the concentration. You can look at the units more or less. What do we have out here the mass loading to see follows a similar profiles. How do you capture this and equalize this particular mass of the organics that is coming into your wastewater treatment plant is always an issue, that is why we need to what do we say design our equalization tank well.

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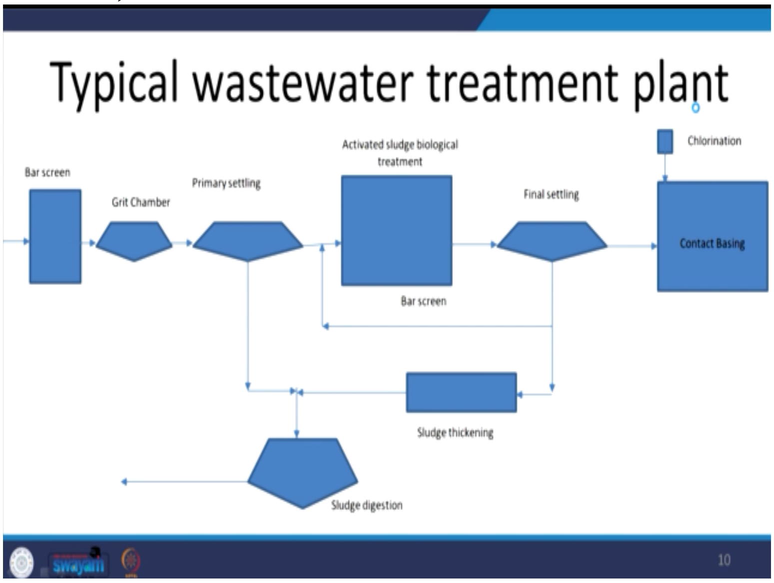

Let us move on so typical wastewater treatment plan. This is what we have before we understand the wastewater treatment plant. What it is that we have but I think I am almost out of time. I do not want to leave this. In the middle? Thanking you for your patience. I will end today's session.