Sustainable Architecture
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Lecture – 29
Water Conservation - IV

Good morning. Welcome back to this lecture where we are discussing about Water Conservation as part of this ongoing online course on Sustainable Architecture. And, I am your instructor, Dr. Avlokita Agrawal, Assistant Professor at Department of Architecture and Planning IIT Roorkee. So, for the past 3 lectures, we have been discussing various concepts and terminologies related to water conservation in sustainable building sustainable architecture.

We have looked at measures which can be implemented at a site level; we have also seen the measures, which can be implemented at a building level itself. So, the strategy is when we started discussing about water conservation started from reduction the aim of reduce. So, reducing the amount of potable water required in a building that was by the means of using low flow fixtures, low flush fixtures, and also by landscaping properly with the help of native trees, efficient irrigation techniques.

So, all these means were used to reduce the amount of water which is required. Next, we looked at how rainwater can be harvested to supplement some of these functions? So, wherever non potable water is used or can be used, rainwater can be used to supplement that need. Thereby further reducing the requirement of potable water and reducing the burden on municipal water supply. In this water conservation only one thing which still needs to be addressed here as part of our discussion is treatment of water.

Now, if we look at the composition of domestic wastewater, we see that approximately 70 percent of the domestic water, which is taken in is released as wastewater that is the minimum amount of water which is sent out as a waste water. The only water which is consumed out of this 100 percent is for drinking, cooking and irrigation landscaping. Rest of the water results it is being used and then it is being released as wastewater.

Now, this is a huge volume, if we are talking about 70 percent of the water which is consumed coming out as a waste water, it is a huge volume. Now, this wastewater is

categorized in two categories; one is a grey water and the other one is a black water. Black water is the sewage, which is coming from toilet us, which contains fecal matter urine.

So, here we are talking only about the waste water, which is coming as part of the from the toilet us, while grey water is all other water, which is probably coming from the kitchens, after the washing of utensils from bathrooms after bathing and laundry washing off home and all those activities, they result in grey water. So, this grey water contains some chemicals, because these detergents and other chemicals might be present there, which are not good for the health of the water and they need to be treated, but even then it is easier to treat them as compared to the black water.

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So, if you look at Indian scenario our cities and towns, they produce huge amounts of waste water daily and there is data available from organizations such as CPCB and others. Unfortunately to treat this wastewater, we do not have enough sewage treatment facilities, in our towns and cities.

And, unfortunately nothing is being done at an individual household level. We are not doing anything practically to treat this wastewater. However, this treatment actually requires removal of the organic matter, organic pollutants and microbial pollutants, chemical pollutants. So, all these pollutants they need to be taken out extracted from the water, grey water or black water to make it, if possible potable or if the need be potable,

if not then treating it to tertiary or secondary standards, where this water can actually be used for non potable purposes like irrigation and others. So, why at all are we talking about recycling?

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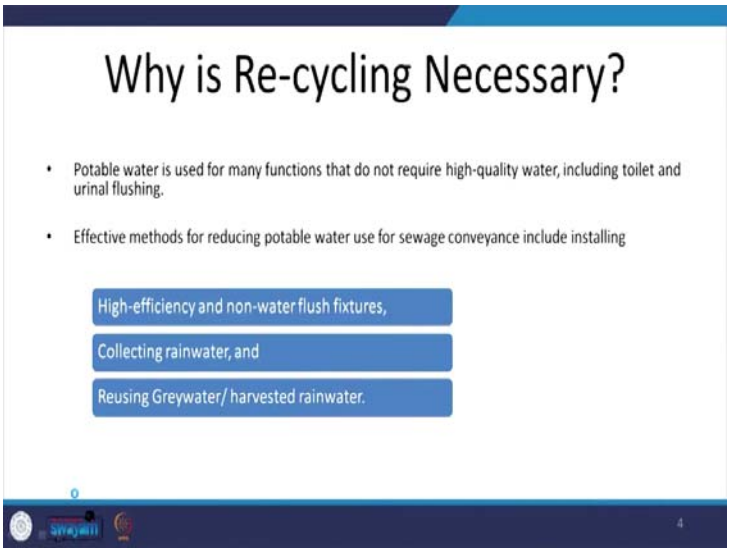

Because, if we treat the 70 percent of water, which is a huge volume, we will we may be actually offsetting the entire need of the potable water. So, it is quite possible it is quite doable and we have already seen that our water resources, underground aquifer, surface aquifers, our rivers, even our glacier for that matter, they are shrinking, they are reducing we have a huge scarcity of water resource available, that is why we are talking about this recycling as the last resort here. Now, once we recycle, once we treat this water recycle it, what all can this treated water be used for.

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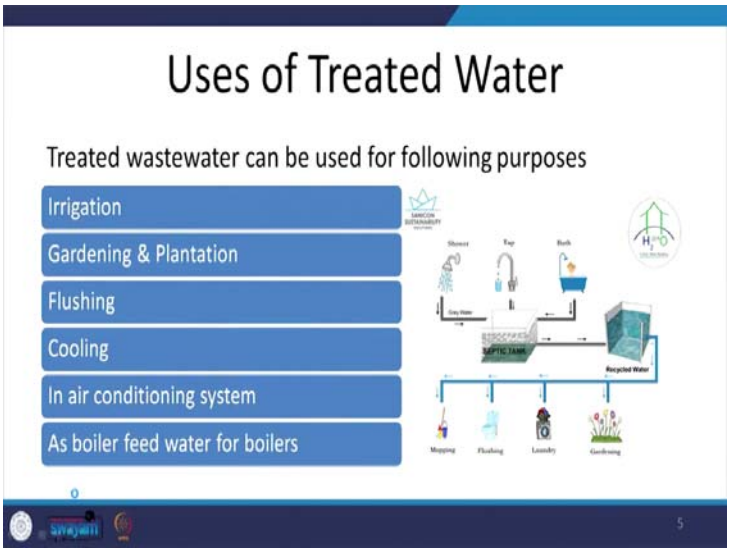

So, this treated water can be used for irrigation, which is absolutely a non potable use, gardening and plantation, we can use it for flushing. We can use it for cooling, which is making up for the water which is required as part of the HVAC system. We can use it in the air conditioning system and also as a desert cooling evaporative cooling. We can also use this as a boiler feed water for boilers. So, there are multiple purposes for which this water can be used, even when it is treated to the tertiary level.

If we treat it to secondary level and primary level of the potable water, it can be used even for drinking and many cities across the world which have huge scarcity of water. For example, Singapore are treating their wastewater to potable quality and feeding it back into the potable water lines supply lines. So, now like let us quickly look at the composition of grey water. So, if we look at the gray water from bathroom.

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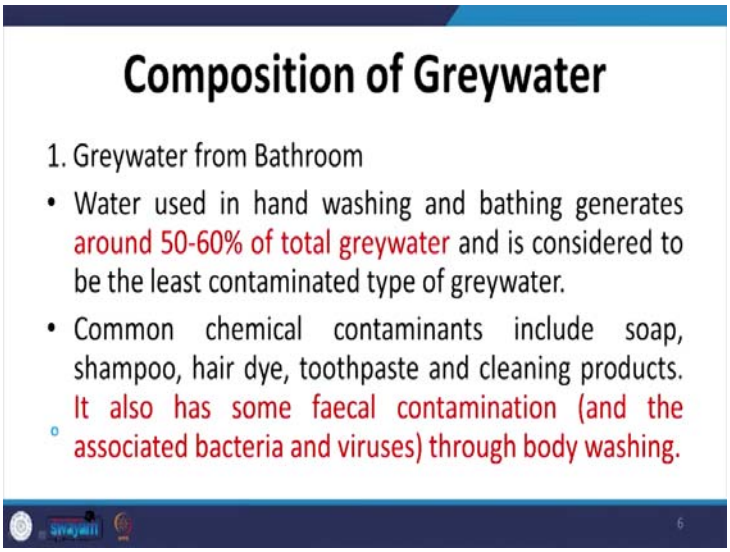

We can see that around 50 to 60 percent of the water, which is used in the bathrooms, is generated in the form of grey water. And, this is the water which is having chemical contaminants, because a lot of detergents, soaps, shampoos, toothpastes, clinic products, they are being fed, they are mixed with this water when it comes out. So, there are chemical contaminants which are present in this type of grey water.

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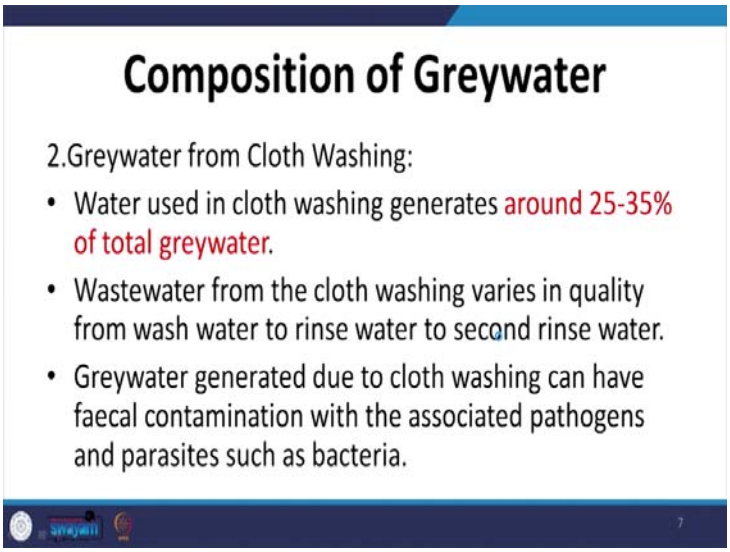

The next is grey water which is coming from washing of clothes again around 25 to 35 percent of the total grey water is being generated from this clothes washing. And, here

also we see that, this particular grey water, which comes from clothes washing, contains a substantial amount of chemical contaminants pollutants, because of the presence of detergents and soaps in them. When we are talking about grey water from kitchen, we see that around 10 percent of the total grey water volume is generated from the kitchens.

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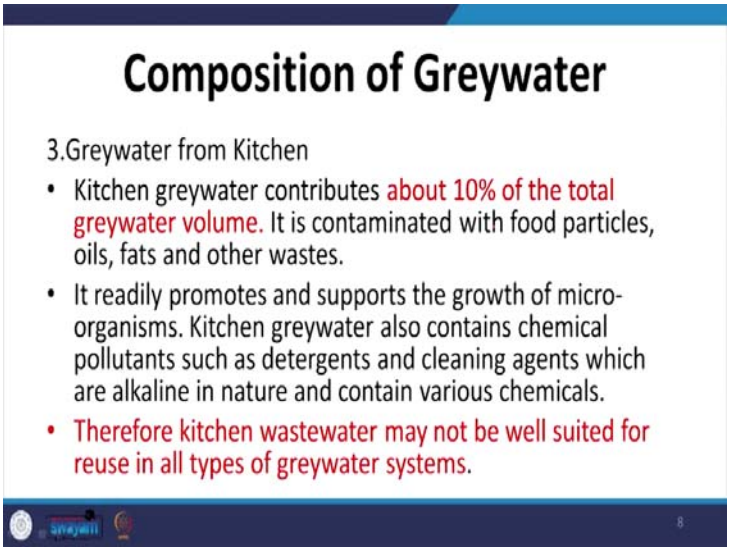

And, this is contaminated with food particle which is organic waste, it also has oils and fats, for which special traps, like grease trap may be required. And, some other wastes, it also has small quantities of chemical pollutants, but largely organic pollutants and oils and fats. So, that is what the composition of kitchen grey water is.

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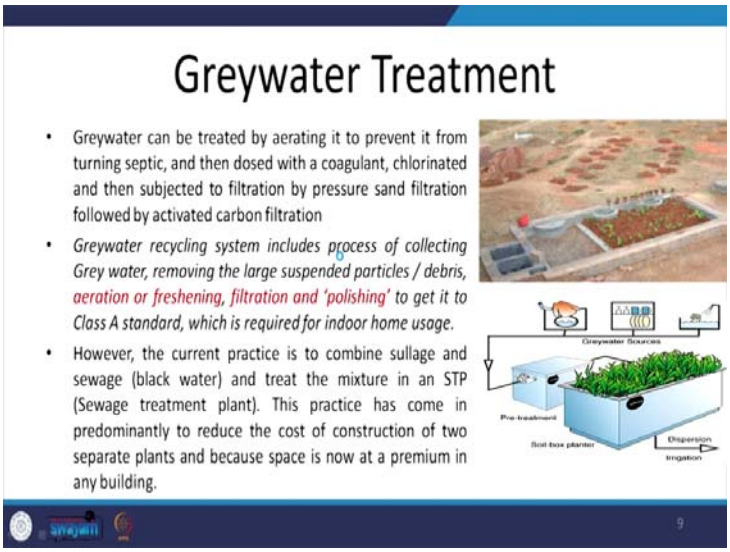

Now, when we are talking about the grey water coming from a household, it is a combination of all these three. If required to optimize the cost one type of the grey water might be left out. For example, grey water coming from cloth washing, which is very heavily polluted with chemical contaminants, it may be left out left out in the sense from treatment. So, we may not treat it depending upon what is the total water requirement, how much of it has to be treated, because all these require different types of treatments filters.

Ideally, we should be treating the entire wastewater, whether it is grey water or black water. Now, to treat this grey water, there are multiple types of mechanisms design strategies, which are available, which are used for treating them. Most commonly the term which is used for these treatment plants is sewage treatment plant.

Now, the sewage as we have distinguished is actually the black water. However, when we are talking about the sewage treatment plant, we may just be treating grey water as part of that, but the entire design, entire strategy is still called as STP, which is the Sewage Treatment Plant.

So, when we are treating the grey water, we are there are two strategies in which it can be treated; one is aerobic and the other one is anaerobic. So, aerobic is where in the presence of oxygen, the pollutants disintegrate in the presence of microbes, various

microbes, which disintegrate these pollutants break it down into smaller, simpler, particles and in this process the water gets cleaned and the waste is segregated.

In the anaerobic one, there is no presence of oxygen the process more or less remains the same there is still presence of microbes, but there it is happening in the absence of oxygen and the process becomes faster and it is more appropriate, for some specific kinds of pollutants and contaminants.

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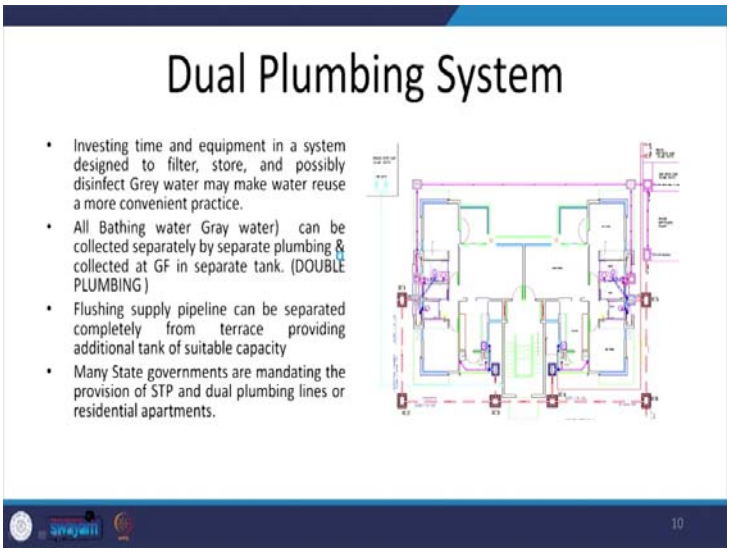

Now, once we have treated the water, we will look at different strategies of these treatment plants in subsequent slides, but once we have treated the water we have to supply it back into the system. So, if we have decided that the building or the site is going to treat all the wastewater. And, the treated wastewater will be used back into the system, right in the initial stages of design and when the project is being conceived dual plumbing system has to be implemented. We have also discussed about dual plumbing system in the previous lectures.

But, what dual plumbing system essentially means is we have two supply lines; one is of potable water, which is going only to the taps and fissures, which supply potable water. For example, the ones which will be used for drinking and bathing, while the others for example, flushing and sinks and wash basins and let for garden taps irrigation, they will be supplied by a separate supply line, which will be supplying the treated water, the

wastewater which has been treated to tertiary or secondary level. So, it will always be two simultaneous supply lines, which is what this dual plumbing system is comprised of.

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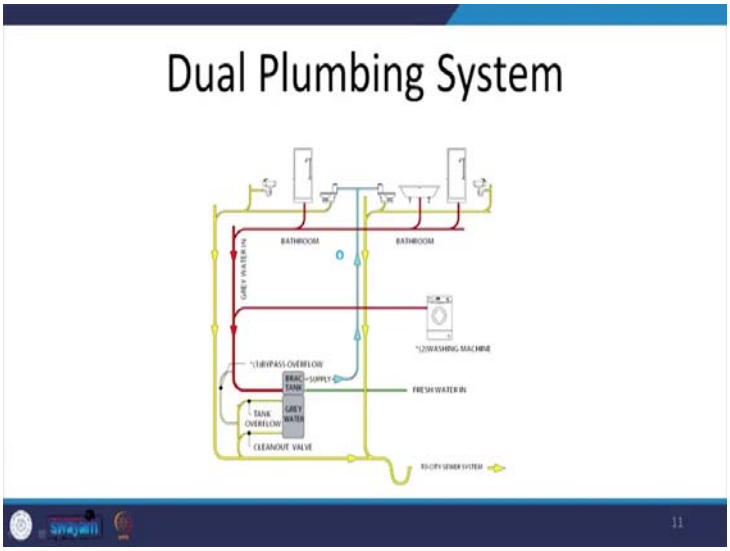

So, this schematic very clearly explains how the dual plumbing line functions. So, we have this wastewater the red one coming from the bathrooms, the flushes things etcetera. So, this is the grey water, which is being taken in it is being treated and the grey water is being supplied back into the flushes. Here, it is only going up to the flushes that is why the extra black water is being sent to the city sewer.

So, black water is not being treated here. Here, very clearly we can see that there is a potable supply, there is a grey water supply not supply, but collection line where it is separately collected taken into the treatment tank and then supplied back. And, then there is a black water which is going to the city sewer, if it is not getting treated.

This is how, now here we can decide that what all systems, what all fixtures will be connected to the treated wastewater line or the potable line. So, right in the beginning this kind of a schematic requires to be prepared. Now, when we are talking about these standards like treated to the tertiary level, or secondary level, or primary level, there are recommended standards which are given by the Central Pollution Control Board CPCB.

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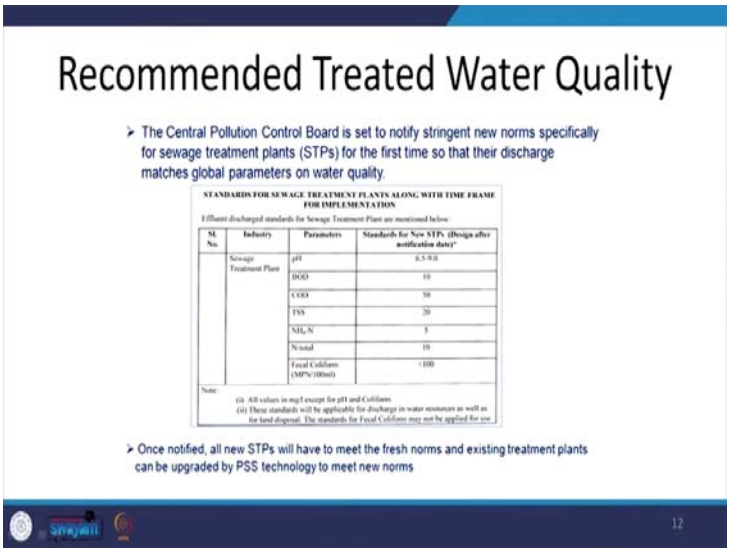

So, CPCB clearly lists down these values of pH, BOD, COD, total suspended solids, NH 4, the total nitrogen compounds and fecal coliform, which is calculated for per 100 ml and in most probable number. So, for each of these CPCB has identified has given these standards. Now, after the treatment of wastewater through the STP, these are the values which have to be maintained, which have to be achieved. Once these values are achieved it implies that water is treated to a tertiary level.

So, these are the tertiary level standards, which have to be maintained while treating the water from the STP. Once, these values are there the water is fits to be used back into this system. Now, we come to the different types of sewage treatment plants which are available. Now, what kind of sewage treatment plant will be good for use, it depends upon the quantity of the sewage which is being received in the sewage treatment plant. So, suppose if we have an individual house, where the sewage generation is very low and it is on a per day basis that the sewage generation will be calculated.

So, if it is very low then smaller and simpler STPS may be used while when we are looking at a large neighborhood or a settlement level, where huge STP has to be prepared, it has to be different technology. Now, each one of these technologies they vary on the area that they require, the space spatial requirement, then the energy, operational energy, which is required in addition to that also the operations and maintenance. How much of maintenance is required?

So, there are some types some strategies for treating the wastewater where no energy is used, but a lot of maintenance is required. So, it is very high on maintenance. So, we have to optimize depending upon the availability of resources at the site. So, based on that any of the STP design strategies could be used; however, in any STP there are three basic steps.

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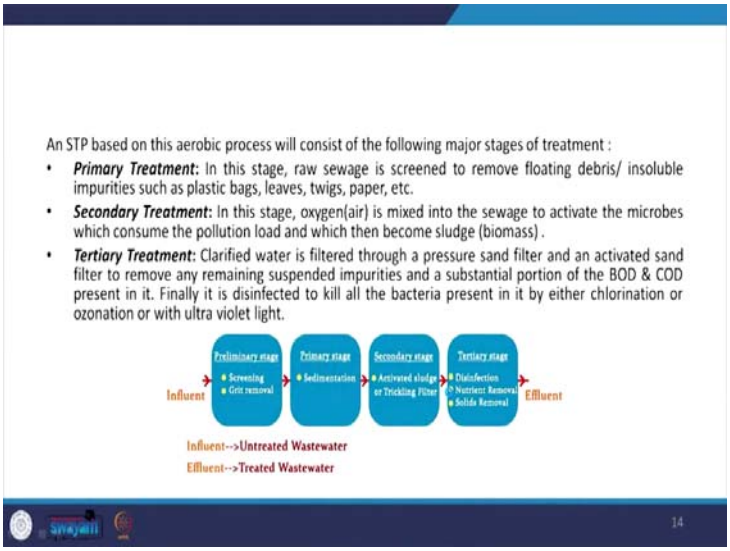

In the first step there is a primary treatment, here the screening is done to remove any floating debris or insoluble impurities such as plastic bags, or leaves, or twigs, or paper. So, this solid floating debris is removed as part of the primary treatment here. Then, we move on to the secondary treatment in this stage of treatment oxygen is mixed.

Here, we are talking about aerobic process, where the sludge the sewage is activated. And, the microbes are activated, which will consume the pollution load and they will disintegrate these pollutants contaminants into simpler molecules, this is the secondary stage. And the third stage is where the clarified water is then filtered through multiple screens, multiple filters with pressure.

And, they are further passed through activated sand filters and there is another layer of purification which is happening, in the presence of microbes. And, once that is done it is further purified to kill all the bacteria which is present by either chlorination or ozonation and after this tertiary treatment the water becomes fit for drinking, it is good potable

water. So, there are different levels of treatments depending upon the purpose for which this treated water will be used, different levels of treatments may be applied, supplied.

So, we may just stop at the secondary treatment level. After, that the water will be good enough to be used for gardening for flushing, while if we want to supply it back to the wash basins and sinks, it may further require treatment cleaning up to a part of the tertiary treatment and to make it potable we have to further treat it through chlorination and ozonation or with the ultraviolet light.

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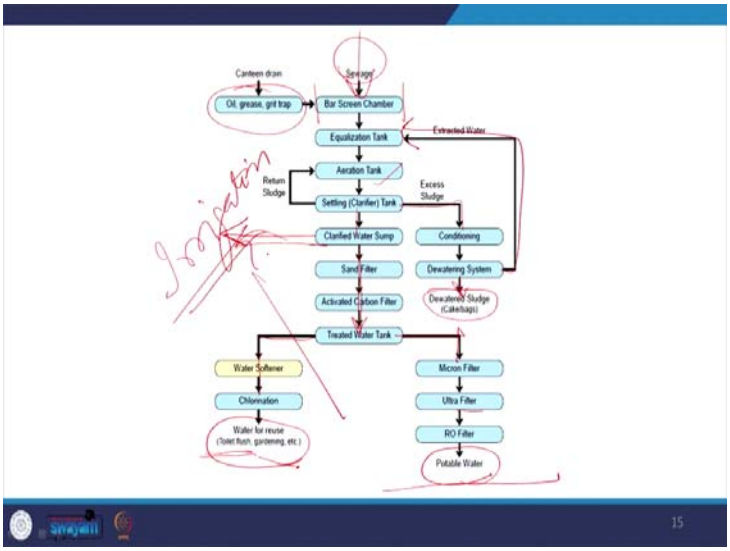

So, depending upon the use these treatments would vary. If we look at this flowchart for all of the wastewater, the flow chart remains the same. However, we may stop it at certain level depending upon the standard the cleaning that is required. All of these will have an oil or a grease trap, where the oil will be separated and after that we will have the bar screen chamber, where the sewage is coming to we will have equalization tanks from, where it will go to aeration tanks where the aerobic process is activated.

And, then we have the clarifier tank. From the clarifier tank the excess sludge is taken into the conditioning and dewatering system, where the dewatered sludge which can be used as the manure. So, it can be converted in the form of cakes, it is extracted, it is taken off and then the extracted water is sent back to the equalization tank. From the clarifier tank it goes to the water sump and then passes through different filters. Now, if we want to take the water out of this clarified water sump, now here we are not talking about the

black water, suppose there is only grey water. This water is good enough for irrigation; we do not need to treat it all the way up.

However, once we take it further through different filters, pass it through water softener, chlorination, this water is good enough to be used for toilet flushes and can go into irrigation gardening as well. However, if we take it further through micron filter, or ultra-filter, RO filter we can get potable water. So, we can get three levels of treatments here depending upon the type of the purpose for which this water is going to be used.

So, we do not need the highest level of treatment, the tertiary level of treatment, for all the waste water, we have to optimize on the resources depending upon our requirement. So, the same process has been shown in the form of a graphics here.

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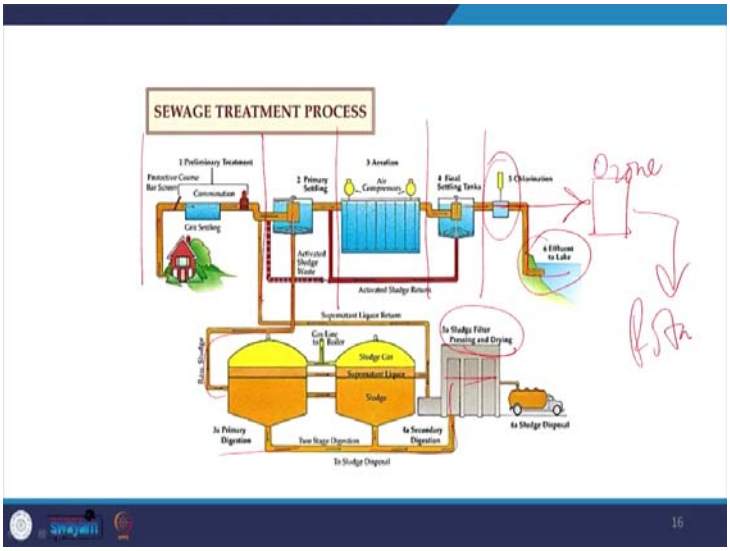

So, the same steps are followed this is the primary treatment, after this the settler tank and then the aerobic process their aeration, and these are the final settling tanks from where the clarified water is taken, and in case chlorination is required effluent is either sent to the tank, or if you want to further treat it we take it to the digestion tanks, where this sludge is removed and the sludge the solid sludge is taken either for disposal or for drying and pressing.

This water which is being sent to surface aquifer may also be further treated, it may further be treated using the ozonation or RO treatment to take out the potable quality of water.

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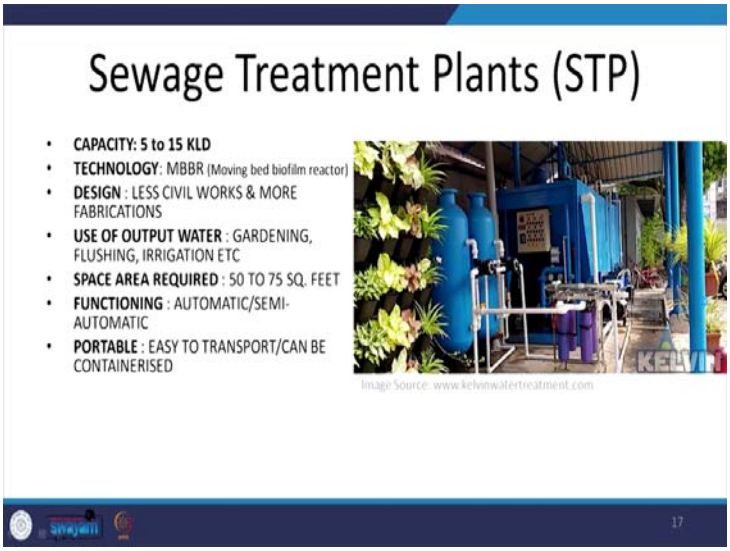

So, it is the same process just shown graphically. I will very quickly talk about the different types of treatment plants, which are good for different capacities of sewage entering. So, when the capacity is very less when the volume is very less say 5 to 15 kilo liter per day, the most appropriate technology is MBBR, it is moving bad biofilm reactor. Now, the advantage for this one is that it requires very less amount of civil work, but it has a lot of fabrication which is required. So, there are many companies, which supply the ready-made fabrication. So, it is a quick process you can very quickly do it.

And, the water which is coming out of this treatment plant is good enough to be used for gardening, flushing, irrigation etcetera. The space requirement is also not very high and it is more or less automatic or semi-automatic in it is functioning. Since, all these components, which we are seeing here are fabricated separately and they are just brought on the site and assembled together, that is why it is easy to transport, easy to install and it is quite portable.

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When the capacity increases to about 30 KLD, again the same MBBR can be used in a different size, and again it requires very less civil work, and the quality of water which is coming out is good enough to be used for gardening, flushing, irrigation etcetera, again easy to be transported and fabricated.

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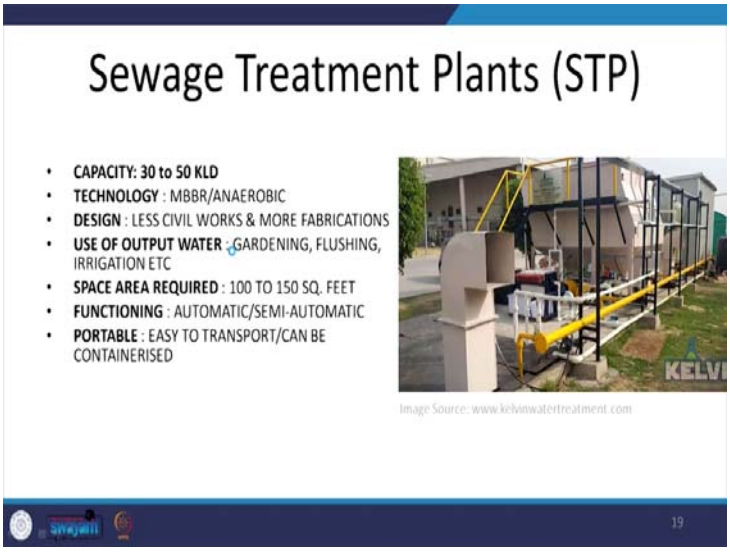

When we increase it further to around 50 KLD, the anaerobic decomposition, the anaerobic type of treatment is advisable for STPs. Now, here again it is requiring less of

civil work and more of fabrications, because this all these technologies have become quite prototyped now.

So, there are companies, which manufacture these smaller parts, smaller components, we just have to bring it on site and they have all these different chambers, the filters, the containers assembled as part of this prototyped product and it just needs to be assembled here. Again the water can be used for gardening, flushing, irrigation etcetera. And, it is automatic semiautomatic just as the MBBR.

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When the capacity increases further to around 200 KLD, the membrane bioreactor system is advisable or even sequencing batch reactors SBRs, they are also advisable. Here, again not much of civil work is required, but again as you can see here, all these prototypes, all these smaller parts, which are fabricated by companies elsewhere, they just have to be brought together assembled and it is just that they require space, which is also not much as compared to the volume of sewage, which is going to be treated on site.

Since, it is again fabricated on site, while the smaller components are brought from the manufacturing plants, it can be easily transported and it can it is quite portable.

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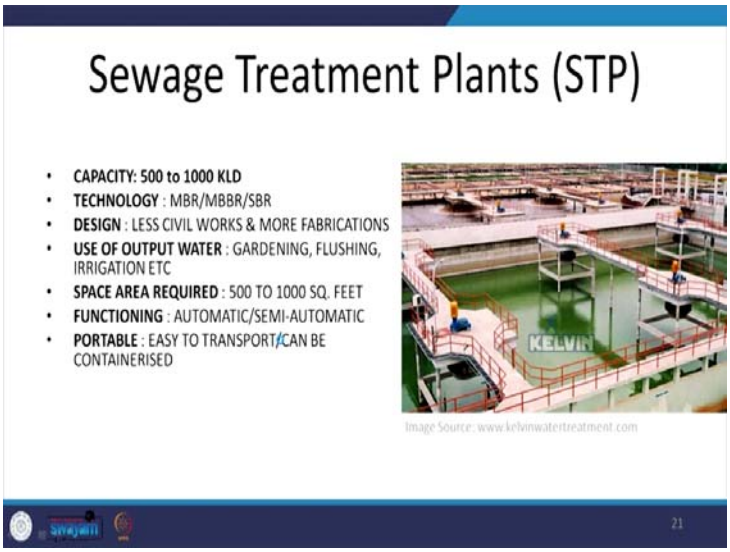

Further, increasing the capacity the type is again the same as the previous one, MBR, SBR, MBBR is a common type of STP, which can be increase in size multiplied in it is volumes. Again, it is requiring less of civil work, but more of fabrication, the water can again be used for gardening, flushing, irrigation etcetera, but it requires relatively more amount of area. So, the space requirement is gradually increasing as the volumes are increasing.

Again it is easy to be transported, but since the size is bigger as we are seeing here the capacity is when they grow. So, the transportation and the portability becomes gradually more difficult.

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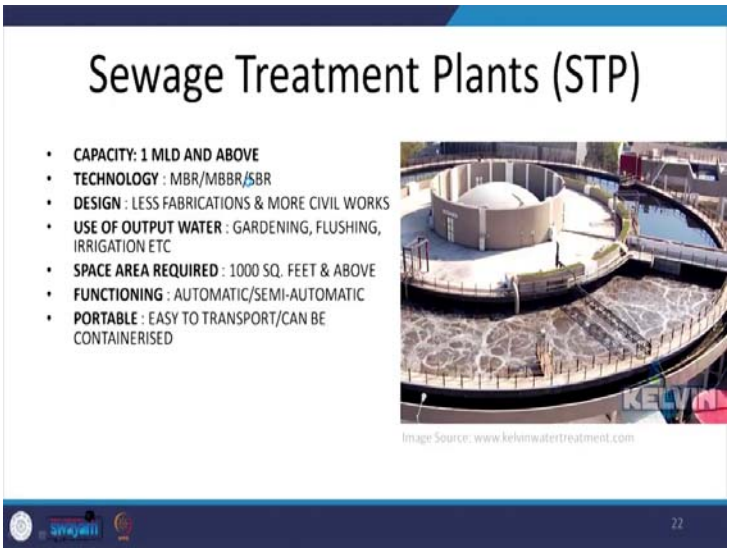

When we are talking about very high capacities again any of these technologies can be used. The next very commonly used and now gradually become very popular treatment system is DEWATS, which is Decentralized Water Treatment System.

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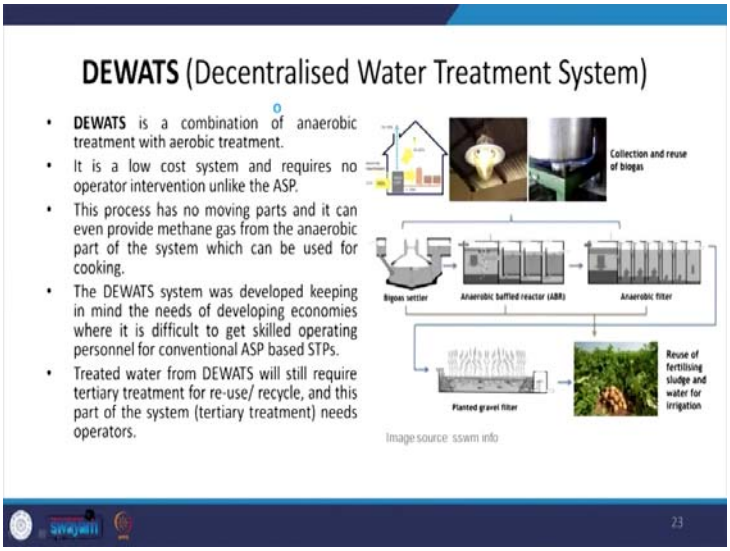

Now, this is a combination of aerobic and anaerobic treatments. Here, the steps are the same starting from the filtration, the primary treatment to secondary treatment. In here what we are doing there are two types of reactors. So, in the first one there is an anaerobic baffled reactor, where no oxygen no air is allowed to enter, pass and from that

it moves on to the aerobic filters, where air is mixed in the chambers and the digestion the decomposition takes place.

And, then the clarified water is passed through the planted gravel filter, the root zone treatment type of mechanism, from where the water is further used for irrigation and the sludge can be used as manure. Now, in this one it is decentralized. So, the it is broken into different parts, it is not in a centralized manner. The advantage of this is that one a centralized management and monitoring of the wastewater treatment system is not required.

Also, it is possible depending upon the waste the type of wastewater, to break down the process and bypass one or the other of the sequence, which is present. Unlike, in all the other previous systems, which we have seen MBRs and MBBR, that the entire process has to be followed through.

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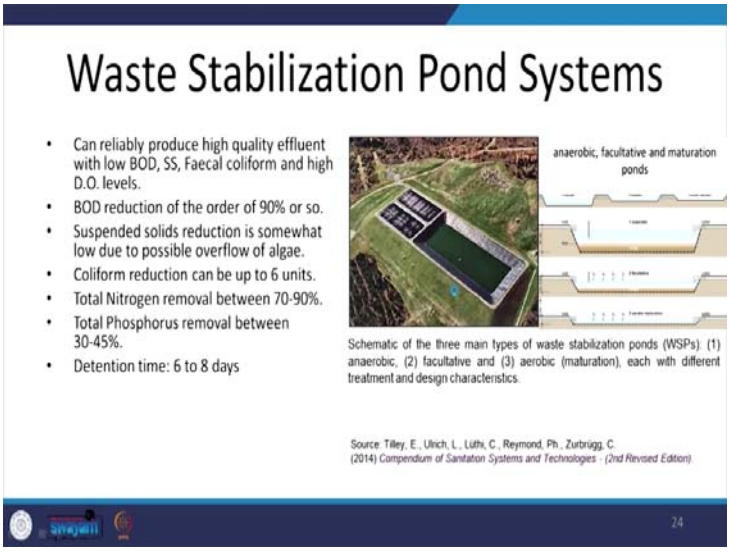

A very traditional system of sewage treatment was called waste stabilization pond systems, unfortunately this is a system which requires huge land to be made available. But, once the land is there, then it hardly requires any energy to continue functioning. The simple principle in this one is of three different ponds; the first one is an anaerobic pond, which is a deeper pond, where the sludge settles in the bottom, and there is no oxygen, which reaches the lower layers and anaerobic decomposition takes place.

After, that there is a pond which is of slightly lesser depth as compared to the first one, where the mixing of oxygen takes place, but the sludge is further allowed to settle in the bottom of the pond. And, once the water has clarified this water which is clarified is taken to the third pond, which is very very shallow, where the entire what volume is mixed with oxygen and with the process of this aerobic maturation, the water is treated and clarified water is further taken out.

It is a highly effective treatment system, but it requires huge amount of land to be made available, that is why majority of our cities are not able to use this waste stabilization ponds system. And, also each pond has to retain the water for around a week. So, 6 to 8 days the water has to stay in these points.

So, the volume which has to be designed which has to be kept in mind is the volume for a week. So, 6 to 8 days of water volume, the pond size has to be large enough to accommodate that much. So, huge area is require that is the limitation of this stabilization pond system. The next one is root zone wastewater treatment.

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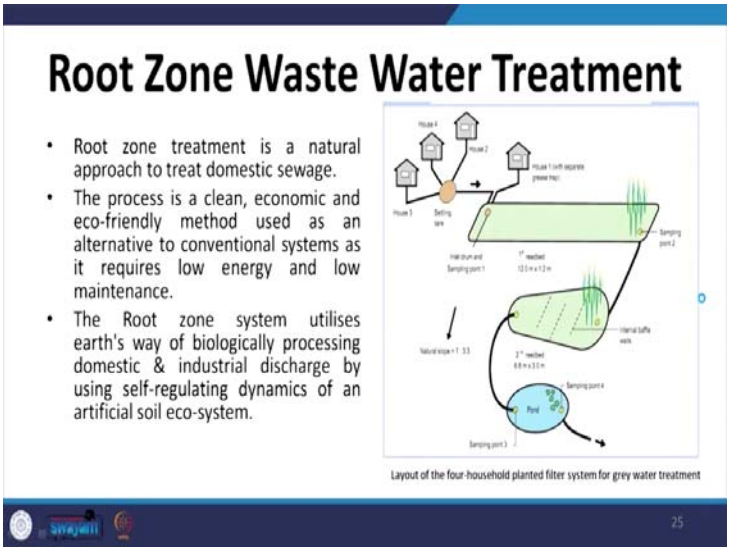

This is very-very effective, but again it requires a lot of area and on top of the land availability, it also requires a lot of maintenance. Now, what happens is the sewage, the grey and black water is collected in a pond. And, this pond is planted towards the end of it with these plants the roots of which actually treat break down the sludge, break down

the solid matter, organic matter, in it once it passes through the first level of treatment the water, the clarified water is then taken in to the second pond.

Now, in the second pond there are baffle walls. So, water is allowed to pass in a particular manner. So, that it takes time and at a very slow rate. In between there are different plants which are planted. So, different types of plants are planted here and they further break down the pollutants contaminants.

And, by the time the water passes through this entire pond through these baffle walls, all the impurities have been dissolved, the sludge has settled down in the first pond itself, whatever was left is further treated and only the clarified water is taken to the clean water pond from where it can further be used for different purposes like gardening, or flushing, or whatever. So, this root zone wastewater treatment is again almost 0 energy treatment strategy and it is also highly effective, but it requires a lot of land area again.

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So, this particular photograph shows the Root Zone Treatment Plant at CII Saurabh G green business Centre Hyderabad. So, these are these ponds where the wastewater is taken in and then passed and then further it goes and gets collected in a pond, which is somewhere here.

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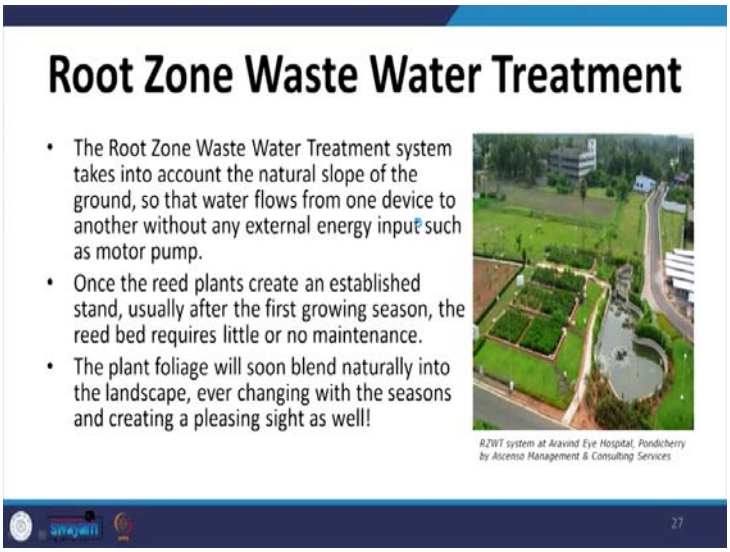

So, the root zone which water treatment is a popular strategy, where available, where availability of land is there. So, if you go to Auroville. So, it is mandatory to treat their own waste for each building for each community. So, root zone wastewater treatment is a very common strategy which is used in almost every second building in Auroville.

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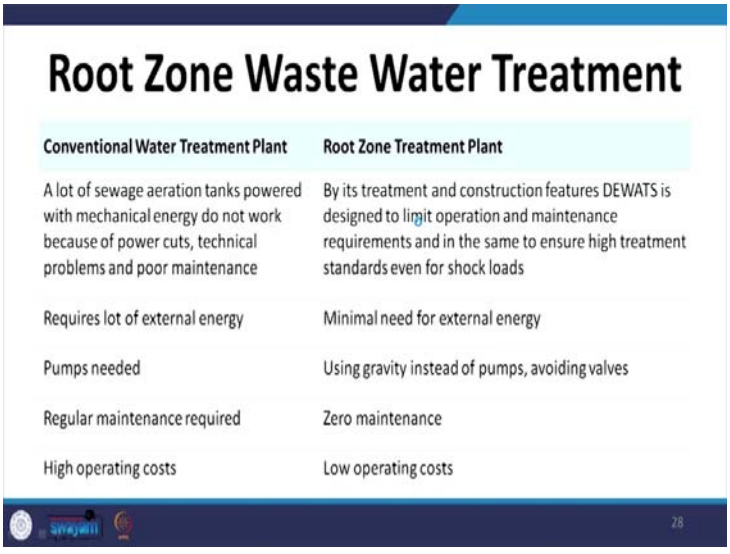

So, if we compare the conventional water treatment plant with it is with the root zone treatment plant, we see that there is minimal need for external energy with root zone treatment plant. And, instead of using pumps it has to be designed, it is usually designed

in such a manner, that with the use of gravity the flow is maintained the rate of flow is maintained, there is very low operating cost, there is zero maintenance if sufficient amount of flow is maintained. So, in case there is not enough sewage generated, then the plants die out they require water and nutrition to grow. So, yes it comes at zero maintenance provided the flow of sewage is maintained in a uniform manner.

So, it cannot be that suddenly there is a rush of flow and sometimes there is very less amount of flow, the flow has to be uniformly maintained. So, when we are selecting the STP for any given project, we have to consider some of the parameters.

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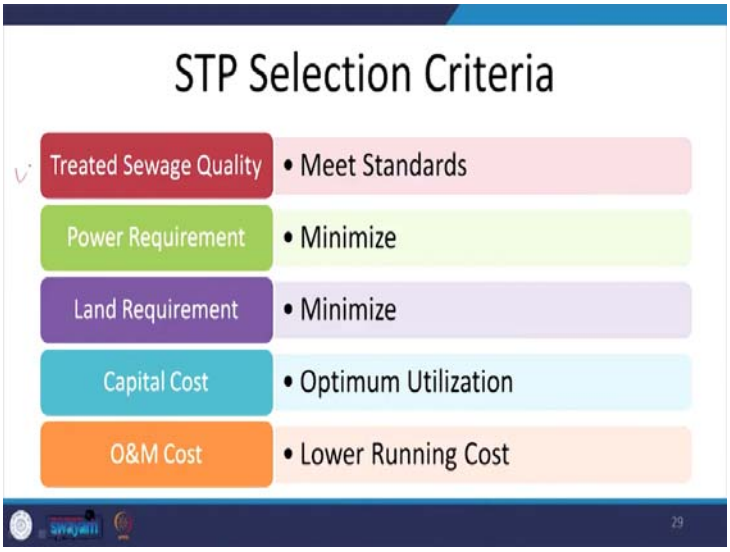

One we have to look at the quality of the treated water, which comes out of the STP. So, it has to meet these standards, we have to minimize the power requirements, we have to minimize the land requirement, in case there is not enough land available.

However, if there is abundance of land, then even the STPs like stabilization ponds and root zone wastewater treatment, they can also be used. We have to optimize the capital cost. So, we should not be treating over in excess to what is required? And, then we have to reduce the operations and maintenance cost. So, on the basis of this we will select the right type of STP and also design it appropriately.

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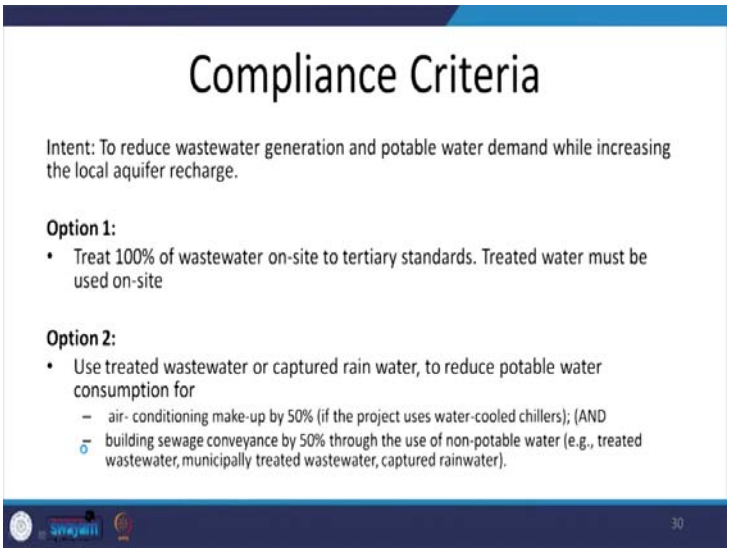

If we look at the green building rating systems and look at the compliance criteria, so we have two options; one treat 100 percent of wastewater on site to tertiary standards we have just seen what the tertiary standards are. So, 100 percent of the wastewater has to be treated on site itself, there is no releasing of wastewater to the municipal sewer. So, the intent is to reduce the burden on municipal sewer systems. And, all this treated water must be used on site itself. So, all this water has to be used, we cannot do that we treat the water and then release the treated water into the sewer system.

No, all this treated water must be used on the site or the second option is we use the treated wastewater or captured rainwater to reduce potable water consumption for air conditioning makeup or building sewage conveyance by 50 percent through the use of non potable water. So, either of the two options can be opted for in most likely cases and a presence of STP on site is almost mandatory to treat the wastewater.

We will look at the calculations and how the optimization of the size of STP has to be done in the following lecture, which will also be the last lecture of this water conservation lecture series as part of this course. So, see you in the next lecture thank you.

Thank you for being with us.