Physico-Chemical Processes for Wastewater Treatment

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Lecture 10
Treatment of Water and Wastewater

Good day everyone and welcome to this course on Physico-Chemical Treatment of Wastewater. So in the previous lectures we studied regarding the various methods which are there for quantifying or qualitatively analyzing different types of wastewaters, and we understood various physico-chemical parameters as well as bacterological and biochemical parameters, which are essential to understand the different other components which are present in the water and how these parameters affect the treatment process, how they affect the toxicity and other parameters which are essential and based upon which we can decide that what type of treatment strategy we are going to adopt.

So, all the previous lectures were based upon those methods, understanding those methods and also trying to know what are the standards, what are the acts and regulations etc with respect to treatment of water and wastewater and also analyzing the various sophisticated instruments, which can be used for understanding the chemical composition and other characteristics of the water, before treatment as well as after treatment. So that we can analyze the efficiency and the mechanism by which the removal is happening inside any treatment plant or treatment unit.

So, from today's lecture onwards we are going to start the understanding the treatment methodologies which are being adopted for treatment of water as well as wastewater. So from today onwards we will try to learn each of the units in detail, some design aspects we will be understanding and then also doing some numericals and other things, so that we can better understand all the mechanism as well as the design aspect of the units. Now why we require water to be treated?

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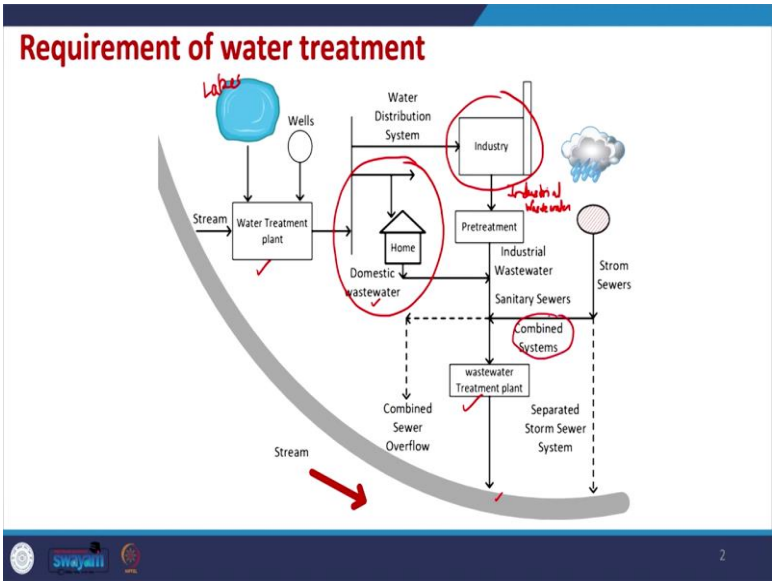

So this is illustrated in this slide itself and so for water is used in our day to day life and in our day to day life what we see is that we use water for drinking, we use water for bathing, as well as for various other needs which are there inside our household. In addition to that we see that water is also used in the industry for various uses and from there the wastewater is discharged. Similarly after uses in our home, lot of water is discharged and that has to be further treated or discharged into any aquatic stream or otherwise.

So there are essentially, if you see most of our cities are located in those areas where water availability is very high and so that is why in the earlier prehistoric ages and after that also most of the well developed cities are always on the banks of some river, so that the water requirement is always met.

So, in any city or any residential colony if you can consider like this, here the water required can be made from two sources. One of the sources is like any of the stream like river which is flowing and also there may be lakes and reservoirs from which the water can be taken, and similarly from wells also water can be taken.

Now if the quality of water which is being taken from the river, lake, reservoir or wells it is not good enough that we can directly use the water, so that water has to be treated. We have water treatment plants, which treat the water from any aqueous system for further use in homes. Similarly, there is lot of water requirement in the industries also, so there may be industrial cluster or an individual industry may be located in any city or outside that city, so for that also water is required.

Now that industry may also take water from lake or reservoir stream or wells it may take ground water certainly via tubewells etc, so that water is further used in the industry and after uses they try to recycle, maximize the use of water, still some amount of water has to be discharged. So we have domestic wastewater which is generated and then there is an industrial wastewater which is generated.

Now both of these wastewaters have different characteristics and they require treatment before they can be discharged into any aquatic stream or used for any other purposes also like agriculture. Now, many industries actually what they do is that they have to treat that waste water up to a certain level the limits of which are prescribed in the MINOS standards and they have to treat the water. Now, they can adopt a certain strategy to treat the water and thereafter they can discharge it to river or to any other system.

So depending upon that the standards are met, we have already studied the standards which have been prescribed by the CPCB or state pollution control boards which monitor all these aspect. Many times what is done is that there is some primary treatment is done by the industries and after that they discharge the water into a wastewater treatment plant and where the treatment is done and thereafter the water is released into the stream again. There may be other systems also for collection of storm water or storm sewers may be there.

Also we have to collect the water from different residences all throughout the city, so there may be a very good collection system may be there and after collecting all the water it may be treated in some Common Effluent Treatment Plant. So these strategies are there, some combined systems may be there where industrial wastewater and domestic wastewater may be treated together. It is also possible that a treatment, separate treatment is there for industries only, because industries have different characteristics with respect to water as compared to domestic wastewater.

So there may be a combined treatment, there may be a separate treatment for each of the wastewater, and after the treatment the waters are discharged to the aquatic streams, other aquatic bodies or they may be used for any other purposes also. So that is why overall we require water treatment before usage and after usage also. Before usage for maybe making it portable for drinking or making it good enough for use in the industry and after treatment so that we can discharge the water in any system or use it for any other application.

Now, there are certain terminologies which are there in the water treatment systems. Those terminologies we should understand and what are the places where water treatment or

wastewater treatment systems are used, we should also differentiate between them. Now water treatment for further use in the domestic cases, we have two types of generally treatment systems.

One is like point of use treatment system where we have in our own residences small treatment units are installed, which contain some of the basic units like adsorption, RO and depending upon UV may be there some filtration systems, so those are point of use treatment system.

Also there is a possibility that community treatment may be there that means we have a bigger plant which actually treats the water which is being taken from a stream also or from the ground water. So ground water is commonly taken in most of the small cities and then it is further some treatment, basic treatment is done in either the water storage tank or before that. So this way we treat, so that may be considered as the community treatment.

Now after usage of the water in our residences, what we discharge is generally termed as municipal wastewater because this is discharged from various municipal bodies and all those water is further collected, we have a severage system for collection of this wastewater and then it is taken to a place where the treatment is done.

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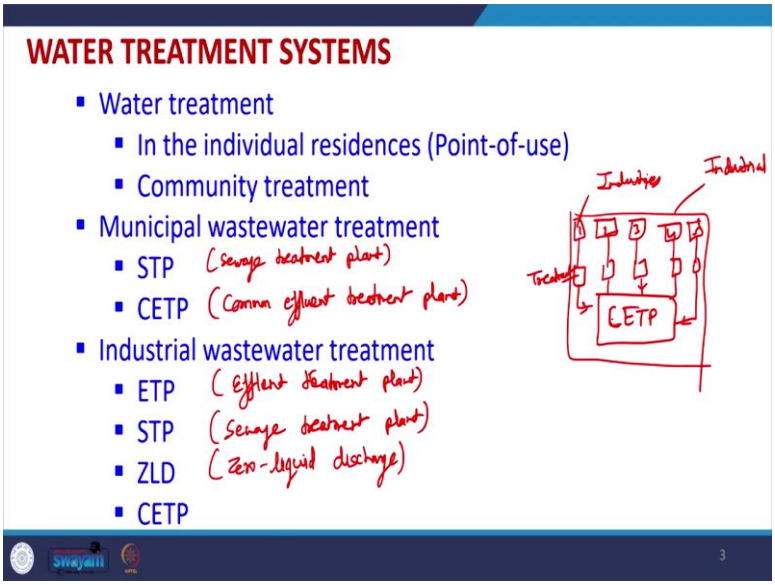

Now there are two terms which are very common one is called STP, so STP is referred to as Sewage Treatment Plant. So these units are there, these units are generally smaller as compared to other types of units like CETP which is called as Common Effluent Treatment Plant.

So sometimes in place of STP we have common effluent plants where the water from industry as well as municipal wastewaters is combined together and they are treated further. So there is a possibility of Common Effluent Treatment Plant also being used for treatment of municipal wastewater, but generally it is lesser common.

Now, there is a another possibility is that since water is being used in the industry, so lot of industrial wastewater which has characteristics much difference than the municipal wastewater may has to be treated. This wastewater treatment plants are named, a number of abbreviations are used commonly during the treatment and those are called like ETP. ETP means affluent treatment plant, so that means generally we are here referring to the waste water which is getting discharged from the industries and it is being treated in a treatment system which will generally be at least three stages.

So Effluent Treatment Plant must be there in any industrial waste industry where some industry wastewater is coming out. Now many a times we may feel that any industry which is not generating any pollutant may require no treatment of waste water. So like any electronic industry suppose it is there, so for electronic industry will consider that in the electronic assembly unit there is no use of water, so that means they are not discharging any industrial wastewater, so there is no treatment required.

Yes, logically it seems so but any electronic industry or in any other industry where the water is not being used but still there are numbers of persons working in that industry, and there they are using the water, they are and further discharging the water in the laboratories also. That means they have lot of urination, all the people are urinating as well and they may be generating some other types of wastewater also and sewage, so that means any industry which is having number of persons working beyond a certain limit they have to install a STP which is like a Sewage Treatment Plant.

So they cannot discharge the water as such still they have to install as Sewage Treatment Plant in those industrial units also where there is as such no generation of industrial wastewater. These units also need to, still need to install the sea waste treatment plant. In fact nowadays there are guidelines that hotels, all those places where there are persons beyond a certain limit at a time then also they have to install a simple basic unit for treatment of water, which is getting generated in that place and then only they can actually do business and run that particular thing for any business etc.

So this is very very essential and this is true for this is true for hotels, restaurants, and many other places also, these treatment plants have to be installed. Then there is a one very common terminology which is called as Zero-Liquid Discharge. So Zero-Liquid Discharge means there are certain guidelines for many industrial units which actually generate wastewaters which are highly toxic and they have lot of pollution load.

So that means the amount of pollution present per meter cube of the water is very very high and for them not only the treatment is very very essential in fact they are told that they cannot discharge any water out of their premises. That means they have to first treat the water, reuse the maximum amount of water and somehow try to see that if any water is still remaining generally they evaporate that water, so they cannot discharge any water out of their premises and that is why this system is called zero liquid discharge, ZLD.

So many times for these industries in place of taking the name ETP, they will take take the name ZLD has been installed. That means they have ETP also and some evaporation type of system where they are operating the water may be generating steam which is further being used in the process but still they have to they cannot discharge any water out of the premises, so this is very essential.

Then there is a Common Effluent Treatment Plant, when we have a cluster of industries are there, so what they do is that suppose this is a big cluster and they have different industrial units which are there and what they do is that they will discharge water, everyone will discharge water after some treatment. What they do is that, because these industrial units may be entirely different from each other with respect to production that means the water which is getting discharged from these units may also be entirely different in terms of characteristics.

That means what they do is that they treat some amount of water in their premises, so this is like suppose this is industries, I am just putting industries, one, two, three, four, five, etc. That means they will be having some primary treatment, some treatment which may not be fully treatment but some treatment may be done and after that whatever water they discharge that that will be taken and treated in a Common Effluent Treatment Plant and so the bigger load is on the Common Effluent Treatment Plant and they are doing some primary treatment after that they are discharging into this Common Effluent Treatment Plant and this may be a industrial cluster may be there, so this is very very common nowadays.

So lot of industrial clusters is being developed by the state government as well as the central government and we have lot many industries. The good thing about this is that the industries

do not have to install all the units they have to only do the primary treatment, so the cost incurred is very less. Certainly they have to give some amount of money to CETP depending upon the characteristics of water they are discharging to CETP and also amount of water.

So it is a mix of both, some weightage may be there and depending upon that monthly they may have to give some amount of money to the CETP and CETP then treats the water discharges or not discharging depending upon the condition further to any aquatic bodies or not. So this is the water treatment systems which are there.

Now we will go further understand the water treatment systems in general. Wastewater treatment and disposal system generally will consist of a number of things. First and foremost point is collecting the water, wastewater. So for municipal wastewater treatment also we have to collect, we have a sewarage system is there for collecting the water. Similarly for industrial cluster also a lot of channels etc are built for collecting the water from different industries and which is further taken to a CETP for treatment. So collecting the wastewater then transporting it to the treatment plant.

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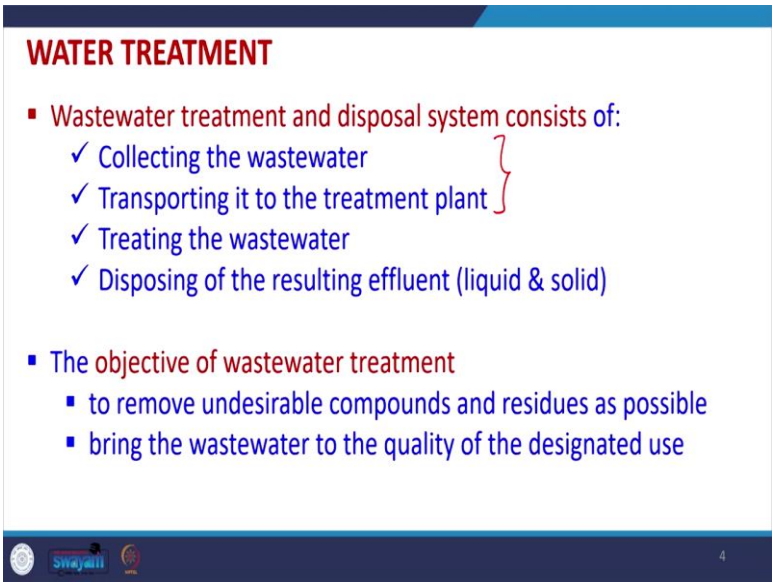

So this is essential, so in the industrial clusters which are made it is the duty of the government to make all these things and similarly for municipal treatment plants also it is essential that municipal bodies install sewerage systems so that the water may be collected and transported to the treatment plant then treating the wastewater or the water in the treatment plant. Then disposing of the resulting effluent liquid, so after treatment there are two types of, one thing is that wastewater certainly the treated effluent will be coming out that has to be discharged also lot of solids etc are generated.

That solid etc also had to be treated and then discharged to the landfill or any other place depending upon the characteristics of the solids, so that also has to be disposed off. Now overall objective of the wastewater treatment is to remove the undesirable compounds are residues as much as possible and to bring the water to the quality of the designated use. So it is possible that we are taking water from river, we will treat to a level, so that we can use it for drinking.

Similarly, if the water is discharged from one is our residences then it has to be treated up to a certain level so that we can further discharge the water to any aquatic stream or reuse it for may be bathing for other purposes, for may be as irrigation water for further use in the agricultural fields etc. So depending upon the designated use the treatment is done further.

For some industries the different designated uses are possible, like for many industries ZLD is compulsory like pulp and paper etc which generate lot of highly toxic effluents and where the pollution load is high they are not allowed to discharge any water. Similarly for some industries since they contain some material which may be good enough for use in the agriculture field, like for sugar industry wastewater which is generated they are allowed to treat to a certain level so that water may, the treated effluent may further be used in the agricultural fields, this is allowed for sugar industry.

This way we understand that the objectives of the water treatment or wastewater treatment units in different places may be entirely different. They depend upon the type of compound being present, how much amount of compound is present, and also what is the designated use or the discharge point after the treatment. Depending upon that the objective may change and also the number of units and type of units within a water or wastewater treatment plant may also change.

Now portable water is never produced at any wastewater treatment plant. It means that if any industrial wastewater is discharged or any municipal wastewater is discharged generally we do not, after treatment we do not use it for portable, for drinking purpose will use it for may be used for other purposes but never use it for drinking purpose.

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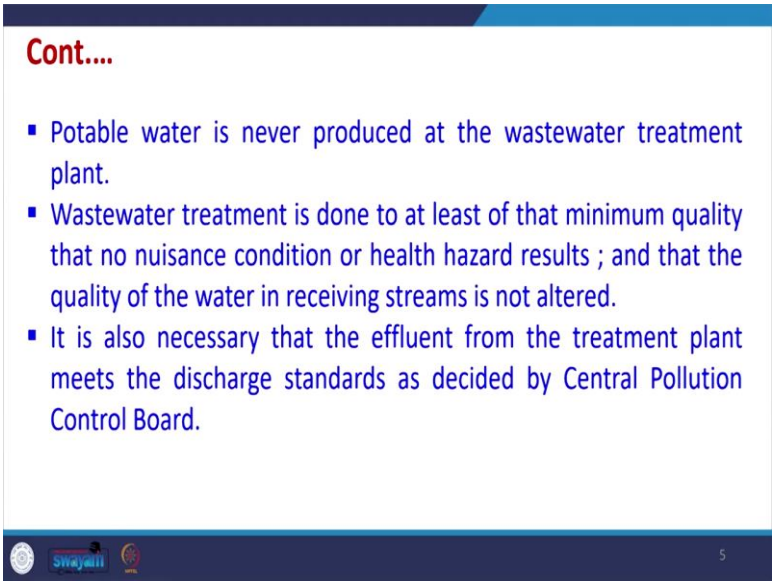

Wastewater treatment is done so that we can make the water good enough that minimum nuisance is called or health hazards are not there when we discharge that water. So quality of, we also see that the quality of receiving stream is not altered because of the discharge of that water into that stream. We have to make a material balance and try to see beforehand. If suppose there is a possibility that industry is there and just besides a river and now that river will be having very high amount of water during rainy season.

It is possible that industry if it discharges effluent to that river, the river quality will not be altered but we will not take that condition where the good thing may prevail, we will take that condition where worst condition is possible. So we will take those wastewater flow conditions in the river it may be in the summer season just before starting of the rainy season. Under that condition amount of water flowing in the stream is very low and under that condition if any discharge happens that will alter the quality of water in the receiving stream.

That is why we will base our analysis on that condition we will not allow that industry to discharge any effluent all throughout the season also, all throughout the year disregarding the variation in the water quality and water quantity in the receiving stream. So we always should look after the worst condition and under that worst condition whatever is the best thing that should be imposed. It is also necessary that effluent from treatment plant meets the discharged standard.

So always we have to see that depending upon the place where the treated effluent is being discharged, the standard should always be meeting the criteria as set by the MINOS standard which have been decided by the central pollution control board, so this is very essential. Now

the water collection system, the first step is the wastewater collection system or water collection system. What do they do? The water collection system actually transports the wastewater from its origin may be industry or different residences where the water is being discharged to its designated destination.

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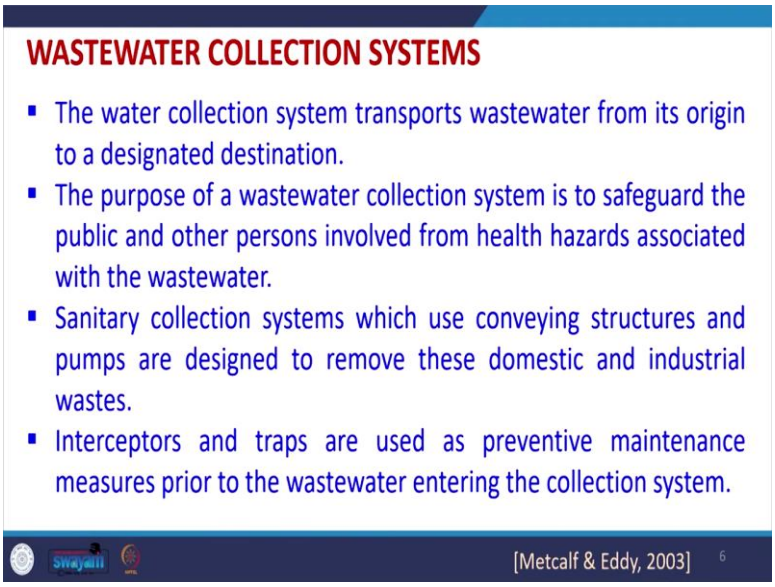

That destination may be Effluent Treatment Plant, a Common Effluent Treatment Plant, a Sewage Treatment Plant, etc. So depending upon that that destination may also vary and we have to transport that water. The purpose of wastewater collection is to safeguard the public and other persons involved from health hazards associated with the wastewater. We do not want water to be discharged from each and every home into the open channels, because it will contain, it will create unhygienic conditions, lot of sanitary issues and other thing may happen this is very important.

So sanitary collection systems which use conveying structures and pumps are designed to take these domestic and industrial wastewaters from their discharge point to the designated positions and in between there are interceptors and traps which are used for preventive maintenance also and to measure anything that nothing is being discharged out of the collection system.

So we always have preventive maintenance and for that we have lot of interceptors and traps which are being used. Wastewater collection system is entirely a different topic which can be discussed in length.

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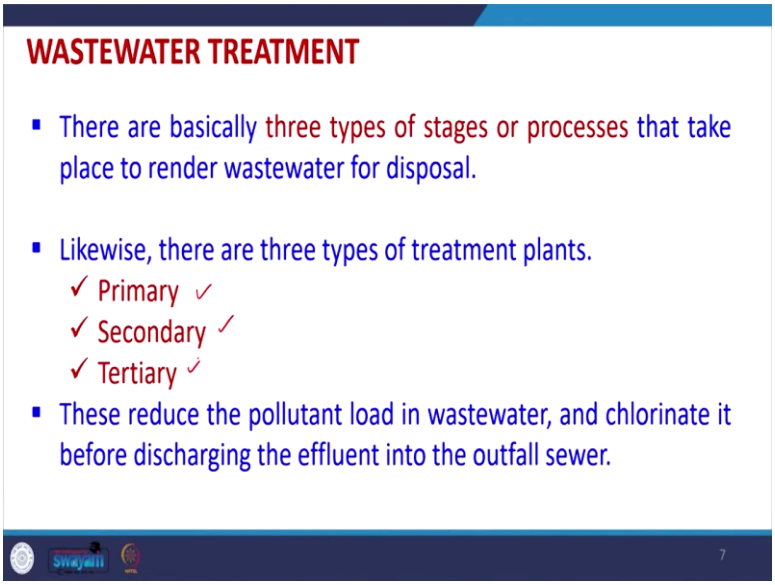

Now further after collecting and transporting it to the treatment plant, so treatment plant where wastewater is further treated. Now there are lots and lots of possibilities of different units and how the water is being treated. That will depend upon the characteristics of water, amount of water being generated, and what is the use. So all the three things decide that which type of units are to be used in the treatment plant. If the water is to be used for drinking purpose the treatment strategy will be different.

Within drinking purpose suppose water is being collected from river, so its characteristics will be different, so treatment strategy will be different. If water is being collected from a lake or reservoir or water is being taken out from the ground then the treatment strategy will be different, though the designated use is same that is for drinking.

Similarly, if the water is coming out after its uses from the industry or from the from the residences then treatment also will be different, but broadly we can classify overall treatment processes as three types of stages or processes that take place whenever we have a water treatment plant or wastewater treatment plant.

It is possible that, and these stages or processes are broadly called as primary treatment secondary treatment and tertiary treatment. There is a pretreatment, also pre-primary treatment also and there is a high possibility that in one of the units depending upon the requirement and from where water is being treated, there may be only primary treatment, there may be place only primary and tertiary treatment only there. There may be place where primary and secondary treatment is only there.

So it depends upon the various factors that how we decide which units have to be used for treatment, but broadly we can classify them as primary, secondary, and tertiary and we are going to learn little bit about primary, secondary, and tertiary treatment in the next few slides and these treatment actually they reduce the pollution load in the wastewater and suppose we have to use the water for drinking, sometimes chlorination has to be done before using it for portable.

Similarly, for effluents also there is a possibility that disinfection or chlorination is done before discharging the effluent into outfall sewere or any other place where it is being discharged. Will try to understand each of the primary, secondary, and tertiary treatment in little bit detail now, so that we can further understand what are these processes and how they are used.

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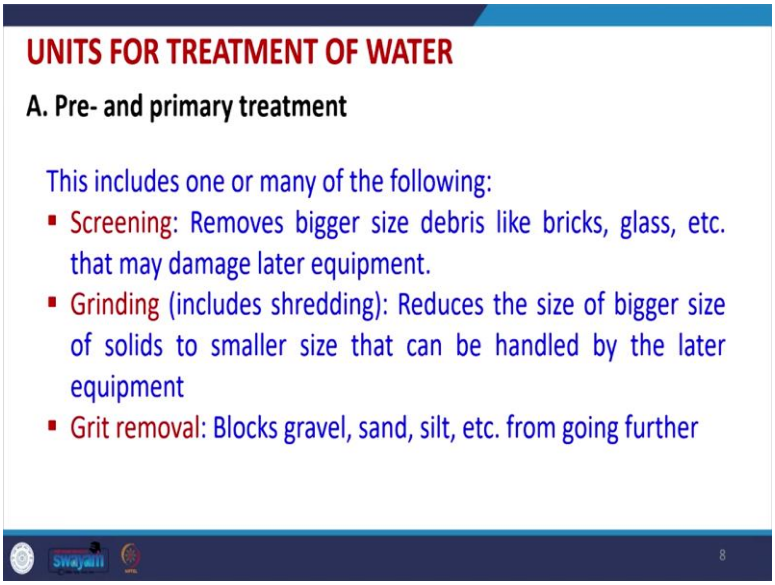

Starting with pre and primary treatment, so they have few objectives, they are broadly used for removing bigger size particles out of the water and also inert materials and other things. Their purpose is to treat the water in a very simple manner and generally physical treatment is more there as compared to other treatment like biological, physical and chemical treatment is generally there in the pre and primary treatment.

So, this may include one or all of the following which are discussed now. Screening is the first step, in the screening what we do is that we remove bigger size debris like bricks, glass, etc and they may damage later equipments. So what we do is that we try to remove all these things during the screening stage. Similarly grinding or shredding in this what we do is that

after removing all the inert materials like bricks, glass, etc. whatever other solids may be present.

They are further threaded into smaller size so that they can be used or they can be handled by later equipments. We do not reduce the already smaller size particle; we only reduce the bigger size particles into smaller particles so that we can remove. It is possible that this unit may not be there, it is also possible.

So depending upon the characteristics of water this unit may or may not be there. Then in the grit removal we block all the gravels, and silt etc, for going further because they have only to be filtered out or removed, there is no further treatment as such, they are not changed into any other form during the treatment.

So it is better to block them or filter them out beforehand, so it is like called as grit removal. Now there is a flow equalization basin which is there in the primary treatment and it helps in equalizing the hydraulic or organic loadings to a certain optimum value for maximizing the efficiency of treatment.

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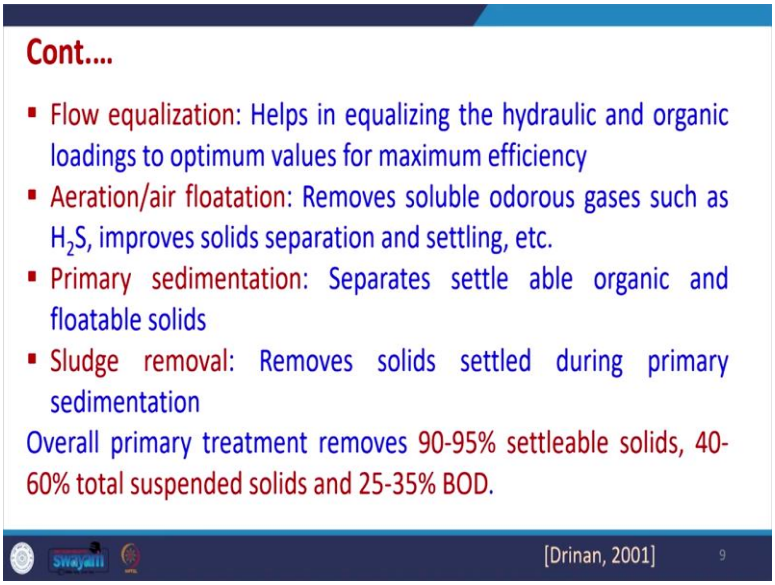

So this flow equilization we will understand, it helps in many ways and actually it equalizes all the hydraulic and organic loadings. That means we can use the treatment plant always at a optimum condition, so it actually maximizes the efficiency. We will discuss each of these things in detail flow equalization, aeration, primary sedimentation, sludge removal everything we will be discussing in detail in three, four slides after the present lecture. So we will be

discussing each of the things in very very detail, solve some problems, etc also for each of the units.

Then we have aeration or air flotation unit, so their purpose is to remove any odorous gases such as H2S, etc present, improve solid separation and settling, also remove like iron and manganese their removal is also possible, so there are multiple uses of aeration and floatation unit. It is also possible that flow equalization and aeration unit may be together. It depends we can use them in together and it is possible that one of the units may not be there.

After that we have primary sedimentation, what we do is that we try to settle out maximum amount of organic and floatable solid or settleable solid during the primary sedimentation. During this process we may use some coagulants, flocullants etc for removal of these and we may use some filtration units as in the grit removal for further removing some of the primary bigger solid, etc. In the sludge removal the settling that happens of the after primary sedimentation we remove the solid, try to settle them out, so that we can further treat them later on and the water after the primary treatment generally it removes 90 to 95 percent of the settleable solids.

So this is the good thing that we can remove lot of settleable solids beforehand in the primary treatment itself then 40 to 60 percent of the suspended solids and 25 to 35 percent of the BOD load. If BOD load is removed getting removed that means certain amount of COD load will also get removed during this overall treatment. So this is called primary treatment, it has some pretreatment units as well. Then comes the secondary treatment, the secondary treatment is generally a biological treatment process.

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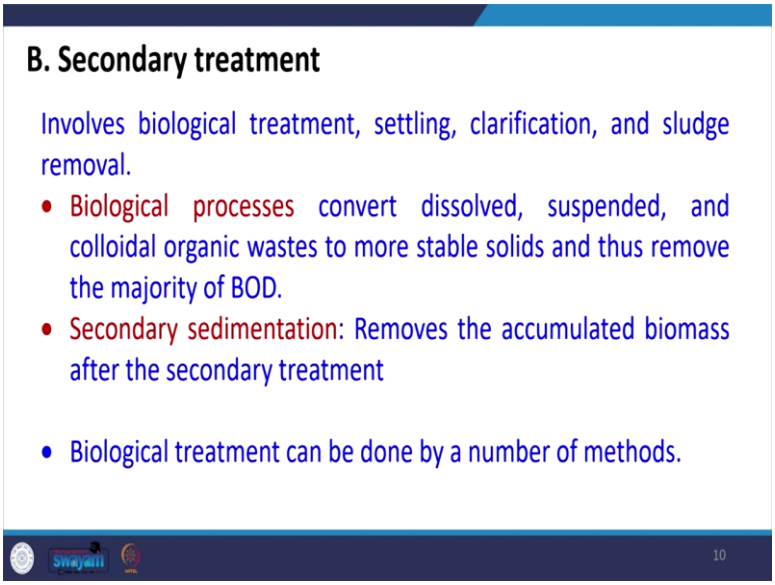

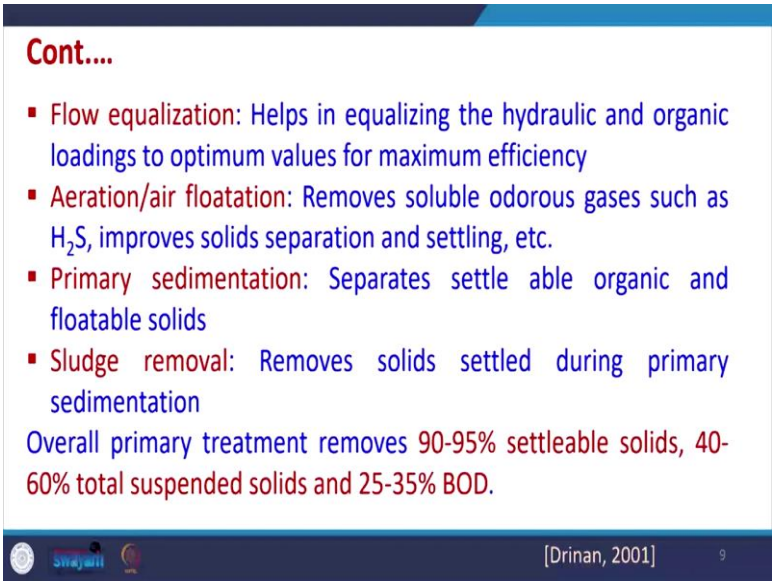

In the biological treatment processes we use microorganisms which actually oxidize or degrade the organic matter present in the water after the one which is obtained from the primary treatment. Still since we are only removing 20 to 35 percent of the BOD so that means rest of the BOD has to be removed here and BOD means that we have to supply oxygen. So all the oxygen is supplied here and microorgans actually use the organics as their food material and they convert it into CO2 and during that process they may require oxygen depending upon whether process is aerobic or not.

In this case in the secondary treatment we have biological treatment, after treatment we settle out the microorganism and then we have clarification unit, certainly sludge is to be discharged, the solid waste which will contain certainly some amount of water as well more

in the form of slurry, thick and slurry and during biological process we convert the organic material the dissolved suspended and colloidal organic waste into more stable solids and during that process lot of oxidation happens so CO2 may get generated.

If the process is anaerobic, so we have lot of gases which may also get generated like methane, hydrogen, etc but majority of the places we have biological treatment in the, secondary treatment is like biological treatment, majority of the places it is aerobic treatment only. Some of the places where the pollution load is very high and the BOD values and COD values are very high; under those conditions we perform anaerobic treatment.

It is done so that to convert the carbon into methane, so methane has lot of calorific value and we can use it for various purposes. Many a times the anaerobic treatment is also possible in the secondary treatment and it is done for those wastewaters, which have very high carbonaceous content and high pollution load.

After biological treatment we have again a secondary sedimentation unit where the biomass or microorganisms which have grown they have to be removed because any of these units perform very well at certain optimum condition and that optimum condition may be with respect to amount of microorganisms present per liter of the water being treated.

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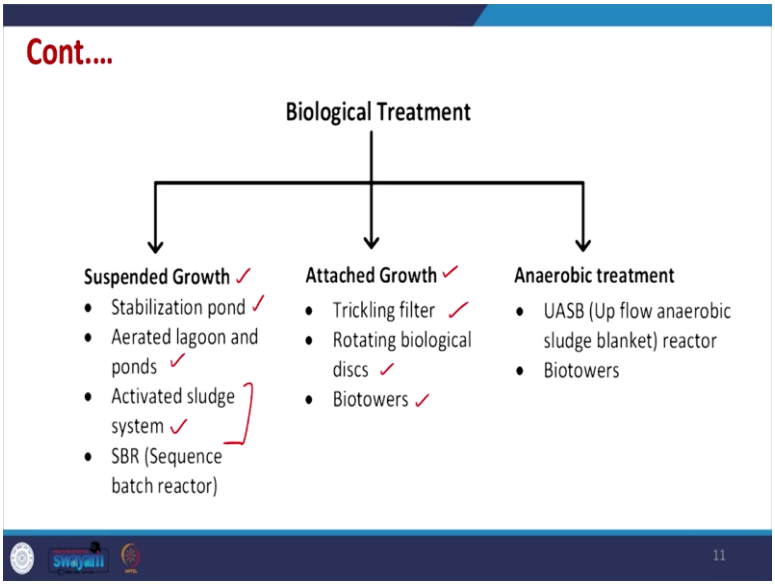

So biological treatment can be done by a number of methods which is described here. So 3 types of units are possible, aerobic, anaerobic this is broad classification then within these classifications we may have suspended growth, we have attached growth also. So in the suspended growth we have stabilization pond, aerated lagoons and ponds, then activated

sludge system which is the most common unit in most of the treatment plant then SBR where sequential batch reactors may be there, so that treatment is also possible.

Attached growth systems involve like trickling filter, rotating biological discs and biotowers. This is also possible and all these are called attached growth system. Then we have anaerobic treatment among which UASB reactor is most common which is called as a flow anaerobic sludge blanket reactor and in addition the biotowers may be also be performing under anaerobic conditions. So we have aerobic, anaerobic treatment and there is a possibility of suspended growth attached growth systems where microorganisms how they are there in the system so depending upon that these suspended and attached growth systems are called as.

So in this particular course we will not be learning much about biological treatment because we have to learn only more about physico-chemical treatment not biological treatment in this course, but you can still study them in detail in other places. Then we have tertiary treatment this may or may not be required depending upon the various end uses this may be there or may not be there and one of the most common things which are listed here these are called tertiary treatment. There are many other techniques which are evolving and this enormous research is being done in this area.

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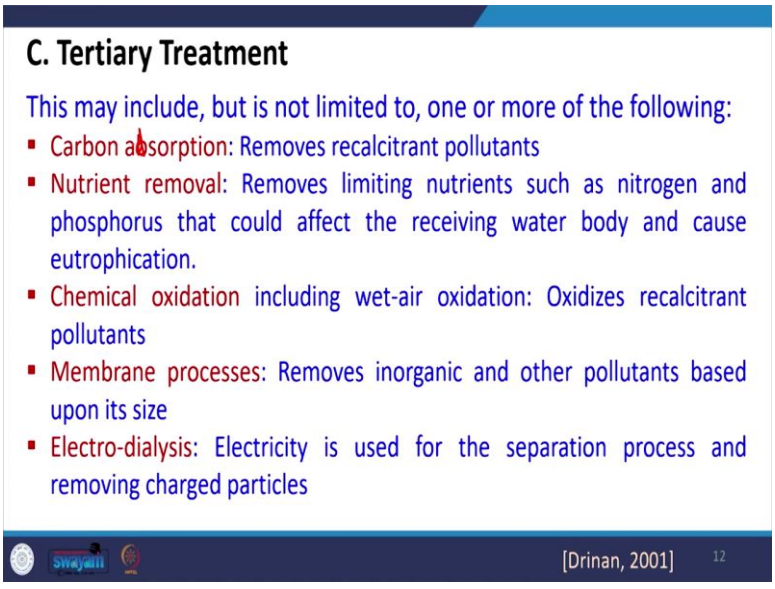

Absorption is one of them, absorption and adsorption so this is more of adsorption. So this is possibility of a treatment adsorbing any recalcitrant pollutant which is has not been removed There is a packed bed and in this packed bed we can remove the the pollutant there itself, so we will be studying in detail the adsorption process. Then we have nutrient removal, so earlier we had discussed that if any nitrogen and phosphorus these elements are present in the

water and they are considered to be the essential elements for growth of any microorganisms or aquatic plants or anything.

So that means if you are discharging any water which contains nitrogen and phosphorus so the receiving body will contain nutrients. If nutrient amount of nutrient in the receiving water body increases it may cause eutrophication, the growth of various water related plants. Slowly and slowly that lake or reservoir may die out because it will be totally covered with the water plant which is not desirable. So that is why it is very essential to remove the nitrogen as phosphorus beforehand.

Similarly, there is a chemical oxidation process; many times it is also referred to as at many places advance oxidation processes. Actually they oxidize any recalcitrant pollutant which is coming still present in the effluent discharge after secondary treatment and this is possible if that chemical compound is highly aromatic in nature. So it will not be broken down easily by microorganisms, it is possible that that compound still be present after the secondary treatment.

Also for many wastewaters, secondary treatment is not possible because they contain so much toxicity that microorganisms cannot survive in those toxic pollutants. That is why we have to perform this chemical oxidation or advanced oxidation and there are many techniques for this we will discuss this in detail.

We have membrane separation processes also which involve like reverse osmosis, ultra filtration, micro filtration, etc and they remove various inorganic and other pollutants based upon their size. So the treatment strategy or membrane system that we use in the Effluent Treatment Plant depends upon the characteristics and type of pollutant being present.

Then similarly electro dialysis technique which can be used for removing charged particles or ions, so now it is becoming more common and lot of research is being done for use of electro dialysis in various applications. There are similarly electrochemical treatment processes also which can be used for treatment of water in details and all these things we are going to discuss in detail and each of them.

We will be discussing the basic mechanism, how they remove the pollutant, some basic idea regarding the design thing, and certainly we will try to have some problems, etc related to all these processes discussed in later sections of this present course. Then RO ion exchange, ion exchange also removes lot of ionic pollutants by exchange processes and which is very

common in particular for removing the calcium and magnesium ions, so this is very very common.

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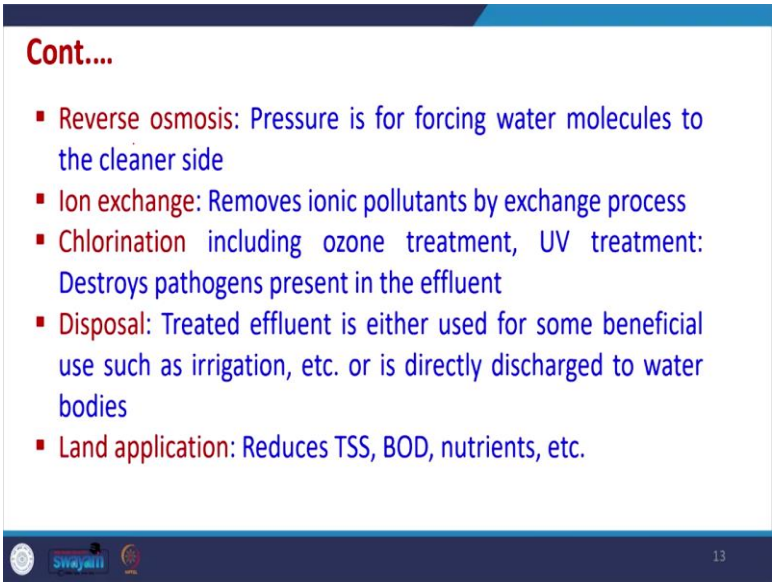

RO is also being used in many industries etc actually they separate out the solids so they have concentrated slurry which is further evaporated in the evaporators and we have a ZLD which is there. RO units what they do is that if any water is coming which is having a certain concentration, so what they do is that they remove very large amount of 80 to 90 percent of the water as clear water and the slurry is further concentrated and that slurry can further be evaporated in the evaporators and we have a ZLD type of system.

After certain treatments, after all these treatment many times what we have to do is that we have to still destroy the pathogens. That pathogens can be destroyed by using chlorination, ozone treatment, UV treatment, etc. So all these are possible for removing or destroying the pathogens in the effluent before discharge.

And then finally we have disposal. The treatment effluent is either used for some beneficial use within the irrigation, etc or it may be directly discharged to the water body or it may be taken to evaporator and further evaporated so that we have a ZLD system and also there may be a land application of the water.

So this is also possible like in the case of sugar industry the land application is possible. We have lot of solids though they do not form the part of biological overall treatment but lot of solids come out and that solids have to be converted or further treatment has to be done for

overall management of the solid. This involves sludge thickening, sludge digestion so we call it as sludge.

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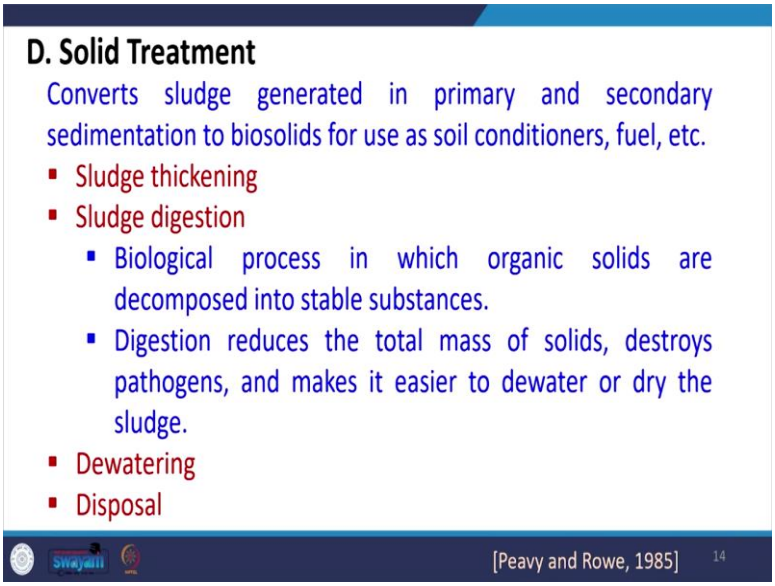

So that sludge has to be thickened then digested, digested means the organic solids are decomposed into stable substances and it may be anaerobic generally and it reduces the total mass of the solids, discharge the pathogens and make it easier to de-water or dry the sludge. So after sludge digestion we have dewatering and further disposal or for further use as a landfill or maybe for getting energy out of that, so there are lots of possibilities of disposal of solids depending upon the characteristics of the solid.

So we will discuss that in detail later on also, this is how the overall treatment works and any of these units may be there may not be there. This will depend upon the amount of water being generated, the characteristics of the water, and also what is the designated use so. With this we end today's lecture. We will continue understanding each of the units in detail in further lectures. Thank you.