Biological Process Design for Wastewater Treatment
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Lecture 17
Treatment of Water and Wastewater – I

Good day everyone, welcome to this NPTEL online certification course on biological process design for wastewater treatment. Today, we are going to start a section, which is the most important section of this course, treatment of water and wastewater. So, today we are going to learn the various steps or unit operations which are performed during the water and wastewater treatment. Now, there are various types of water treatment systems which are used in the industry as well as in the various municipal corporations and other places for water treatment.

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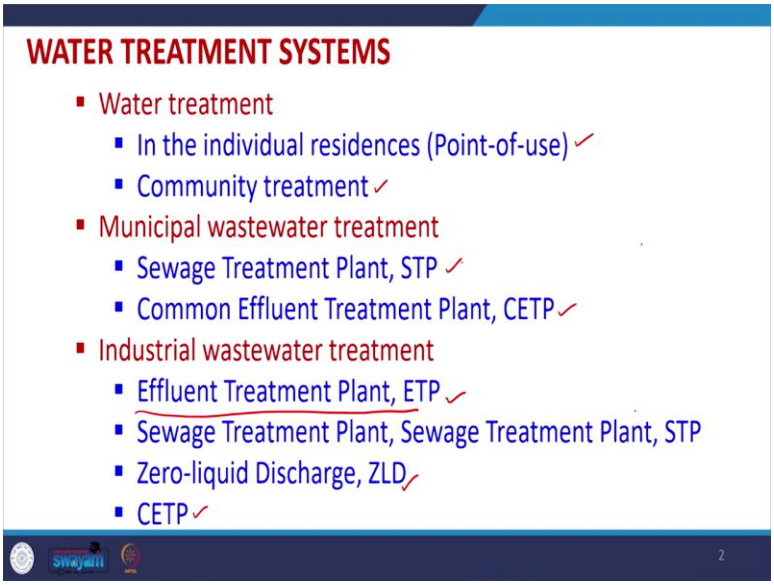

And in general, the overall we can classify all these processes as given in this slide, the water treatment at individual levels in our individual residences is done so that we can get water for drinking. So, we have water treatment is done in the individual residences where point of use is there of the water which is taken out out either from the tap or which itself is coming from the groundwater or it may be supplied from surface water etcetera. But at the individual residences, we are doing some level of water treatment before it is used in our domestic purposes.

Then we have community treatment also, most often the water is taken from some source, it may be river it may be some reservoir, it may be from aquifer or groundwater, and that water is further treated before its uses or it supply to various residences. So that type of treatment will fall into the category of community treatment. Now, once this water is used in our residences, we discharge lot of water and that water is called municipal wastewater. And this municipal wastewater has to be treated before it is discharged into any water bodies or before it is reused recycled etcetera.

So, there are two types of systems which are used. So we have sewage treatment plant where such municipal wastewater is treated. Similarly, we have common effluent treatment plants also where the water from different areas and different sources in terms of wastewater which is generated from different sources it is taken and then treated in the common effluent treatment plant. Similarly, industries also discharge lot of water and that water has to be treated before it is discharged into any of the water bodies if allowed, or most of the water has to be recycled back into the industry itself and it is used further in the process or for irrigation etcetera.

Now, this the effluent which is generated in the industry, when it is treated in a plant, that particular plant is called effluent treatment plant or ETP. Now, many times the industries maybe in such a manner that they do not discharge any water which is highly toxic or otherwise, like suppose any electronic industry is there. So, there will be 1000s of people working in that particular plant. So, process is not discharging any water, but since many people are working, so, that means they are generating water which is like municipal in nature. So, for them, the sewage treatment plant is used within the factory premises itself and that is called STP.

Now, then we have zero liquid discharge, many of the industries they are not allowed to discharge any water out of their premises. So, they have to recycle back use it in the process for generation steam or also for irrigation of various plants etcetera within the plant itself. So, they have 0 they have to do the zero liquid discharge. So that is called ZLD, and also if there are a some special economic zones are there, and there are many industries, so it is possible that all industries may not have individual treatment.

So under that condition, all the industries give the water to a common effluent treatment plant where the treatment of all such effluent generated in various industries is done and this is called

common effluent treatment plant for industry. So, these are the various types of water treatment systems that we can observe in our society.

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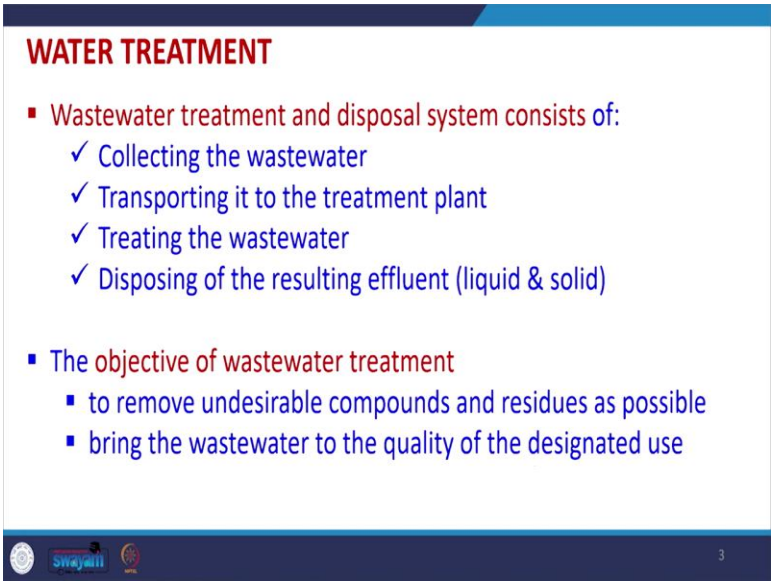

Now, water treatment, the why we do what a treatment. So wastewater treatment and disposal system consists of various steps. So, the first step is the collecting the wastewater itself. So, like we have seen that from our residences, we may discharge water into sewer lines and then the sewer line will go to any bigger it will merge with bigger sewer lines and ultimately it will go to a wastewater treatment plant.

So, collecting the wastewater is the first step. Now, transporting it to the treatment plant is the second step which is done through either sewer lines or various types of pipelines etcetera in the industry. Then the third step is treating the water to its ultimate goal. And ultimately the fourth step is disposing of the resulting effluent which may be because during the treatment we may generate liquid effluent as well as solid waste. So, we have to dispose both liquid and solid.

So, overall the objective of wastewater treatment is to remove the undesirable compounds residues which are present in the water as much as possible bring the wastewater to the quality of designated use and that designated use maybe for irrigation, maybe for industrial reuse or any other designated use, if possible. But, ultimately we have to bring the water to the designated use or to a prescribed level which is determined by the government guidelines.

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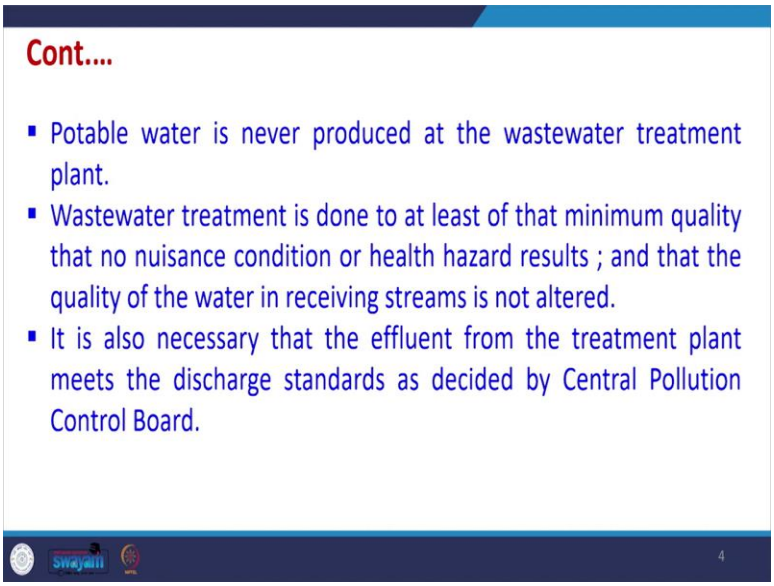

It is essential to remember that we never produce potable water in any of the wastewater treatment plant. So, the water after treatment can never be used for drinking after its treatment in the wastewater treatment plant. Wastewater treatment is done to at least it is essential to remember that we never produce portable water at any wastewater treatment plant, that is the water after treatment in any of the ETPs or STPs can never be used for drinking it will only be used for other applications except drinking.

Wastewater treatment is done to at least of that minimum quality. So that no nuisance conditions or health hazard result and that the quality of water in the receiving stream is not altered, if that wastewater is being after treatment is being allowed to be discharged into any of the river if allowed, it is also necessary that the effluent from the treatment plant meets the discharge standard as prescribed by the central pollution control board.

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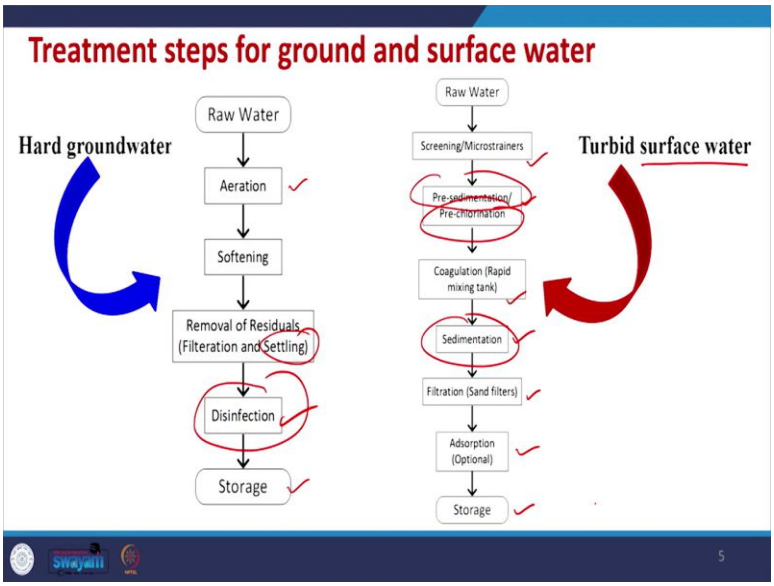

Now, there are various steps are unit operations which are performed for treatment of ground and surface water and this is done to get water for drinking or for other uses. Now, the wastewater treatment have certain steps, but the order in which these steps will be performed are different and they depend upon the characteristic of water which has to be treated.

So, it depending whether the water is hard groundwater or turbid surface water or it is a simple lake water, the treatment may be different depending upon the characteristic and the unit operations may also be different and they may be placed in different order depending upon the characteristics of the water and the designated level up to meet the water has to be treated.

Now taking the case of groundwater. The groundwater is first aerated, aeration is done as to remove any dissolved gases which may be present in the water, then the softening is done. So as to reduce the content and further to take the level of the gases to a certain level which is as per the drinking standards, then the removal of residues is done via filtration and sedimentation. Further, that disinfection may be done using various techniques including use of chlorinated compounds etcetera, or by other methods and further this water is distributed in the society to various residences.

Similarly if the water is taken, from surface water like river then this surface water may contain lots of solids and which will be suspended which will be dissolved. So, the suspended material

can be removed via screening or micro strainers. In the second step we do pre sedimentation, so, as to further remove the suspended materials and also click chlorination may be done so, as to remove the pathogens if present. After that the dissolved solids may be removed via coagulation and flocculation and further sedimentation.

After that the small amount of solid which may further still be present can be removed via using sand filters. Ultimately absorption steps may be involved and we can remove all other types of a toxic elements etcetera is present in the water and ultimately it will be stored and further be distributed. So, we can see there are some common steps like disinfection here and some amount of pre-chlorination here then we have sedimentation which is there in every place we have settling here and we have sedimentation here also here pre sedimentation.

So, the steps may be there but their presence may be different. Similarly, for wastewater treatment which is generated the wastewater which is generated from industry, the steps may be entirely different. So, for wastewater treatment there are 3 types or stages under which that water treatment or wastewater treatment is done before it is discharged.

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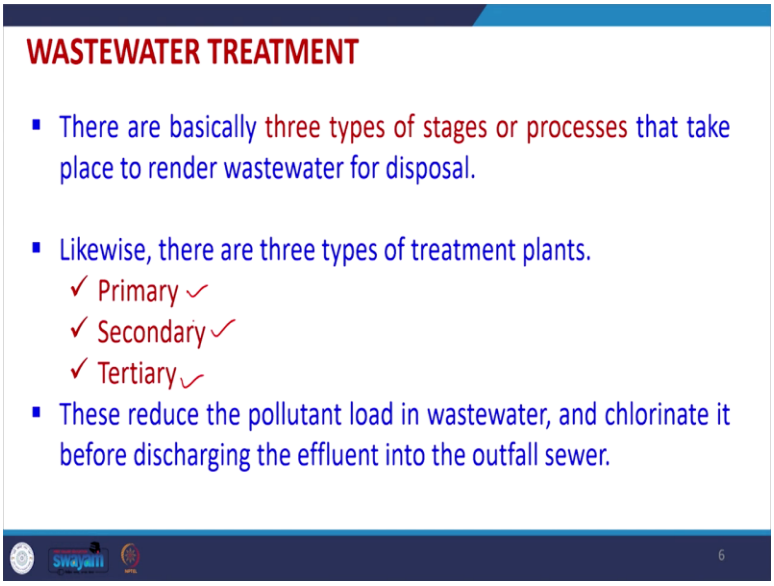

So, there are these 3 types of treatment plant or treatment steps they are called primary treatment, secondary treatment, and tertiary treatment. And after this these steps reduce the pollutant load in

the wastewater and further chlorination may be done if required before discharging the effluent into outfall sewer or maybe for other uses.

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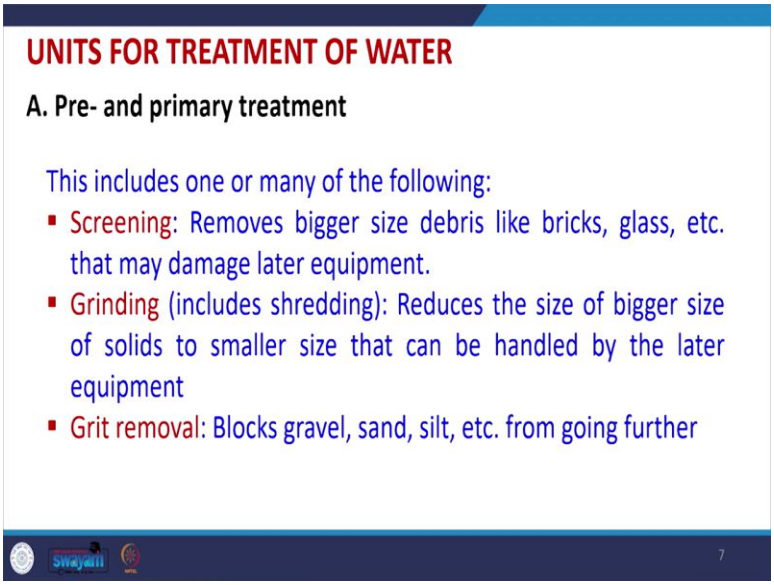

Now, each of these steps the primary secondary and tertiary treatment are being discussed here with. So, primary treatment is this includes many of the steps including screening, grinding, grit removal etcetera. And then in coagulation flocculation etcetera. So, that will be performed later on. So, there are various types of steps which are involved in pre and primary treatment, the major emphasis is to remove the bigger size particles also to remove the suspended materials. And overall during the removal of this overall, the BOD level etcetera will also go down.

So, the first step is screening, so, this screening removes the bigger size debris like bricks, grass, etcetera, that may damage the later equipment. In the second step the grinding including shredding, they reduce the size of bigger size solids to a smaller size that can be handled by the later equipment. Similarly, the grit removal they blocked the gravel, sand, silt etcetera from going further and thus the treatment can be done.

Remember, it is possible that some of the steps may be avoided and some of the steps may not be involved at all or in some other wastewater all these 3 steps may be required. So, it will depend upon the characteristic of water whether we require these steps or not, but they may be used. Now, after this screening steps, the next step is called Flow equalization.

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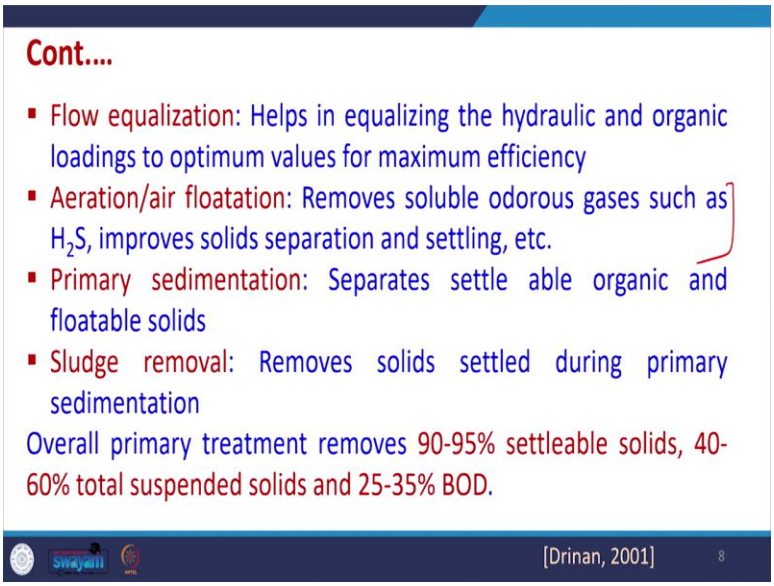

It helps in equalizing the hydraulic and organic loadings to optimum values for maximum efficiency. What does it mean? It means that there are variation in the flow rate depending upon the season and the operation being performed in the industry, like sugar industry that is a seasonal industry, there are variations with respect to season. Similarly, there may be other types of industries where the wastewater generated may vary depending variation maybe with respect to flow rate with respect to composition of the pollutants in the water.

So flow equalization helps in equalizing the overall amount of water or overall volume of water that has to be treated in further treatment units, also this overall it helps in equalizing the hydraulic and organic loadings to a certain optimum value, where the treatment plant will be operated, so that the efficiency is always maximum.

So this is the first step, in the flow equalization basin it, it is possible that aeration may also be done or aeration may be done in a separate step, a flow equalization basin. If the industry there is not much variation with respect to flow rate or composition, it this flow equalization step may be avoided also. Now, the second step is aeration or air flotation. So, aeration or air flotation removes the soluble odorous gases such as H_2S and it also improves the solid separation and settling later on.

So, aeration may be done with the flow equalization basin itself or it may be separate. Now, after this we have primary sedimentation and sludge removal. So, during this step it is desired to settle the organic and floatable solids and it is done via coagulation and flocculation steps, overall large amount of settleable solids and suspended solids are removed.

And after the primary sedimentation where coagulation and flocculation steps are performed, the sludge is ultimately settled and it is further taken out for treatment and the water after obtained after the primary treatment is further taken for secondary treatment, which is generally biological in nature. Overall primary treatment removes 90 to 95 percent of the settleable solids, 40 to 60 percent of the total suspended solids and 25 to 35 percent of the biological biochemical organic demand load.

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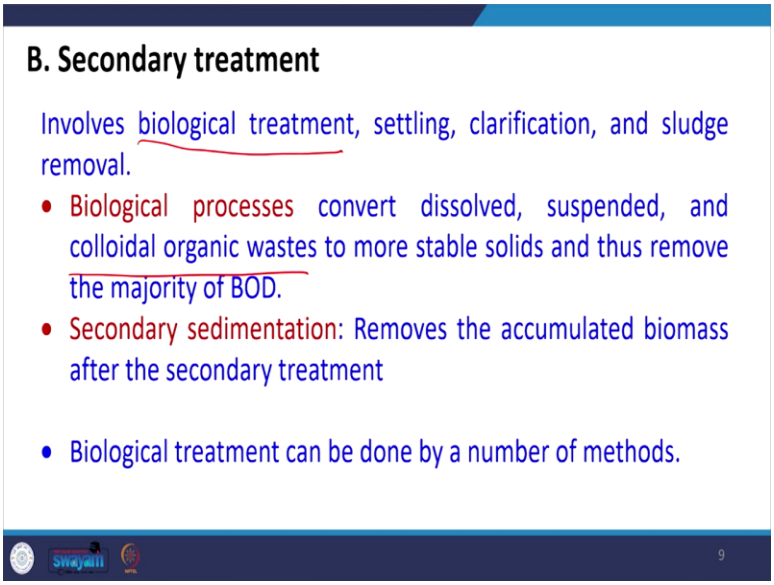

After primary step or primary treatment step, the secondary treatment is done and it involves biological treatment. So, there are certain steps biological treatment, settling clarification and sludge removal. So, there are various types of biological processes which are performed in the secondary treatment. And this is considered to be the most important step during the water and wastewater treatment. And the primary focus of this course is to study the secondary treatment or biological treatment in great detail.

Biological processes, they convert the dissolved suspended and colloidal organic waste present in the water or wastewater to more stable solids and thus remove the majority of BOD, since the micro-organisms are used, so, during this biological process biology, micro-organisms themselves grow and thus they have to be removed also. So, overall the secondary sedimentation is done to remove the accumulated biomass after the secondary treatment, some amount of biomass may be recycled, by depending upon the process, which is being performed in the secondary treatment, or it may be directly be taken for the, further treatment.

Biological treatment can be done by a number of methods and these methods are given here and we will be certainly studying all these methods in greater detail. So, there are two types of possibilities that suspended growth and attached growth and that these growth methods may be aerobic or anaerobic methods.

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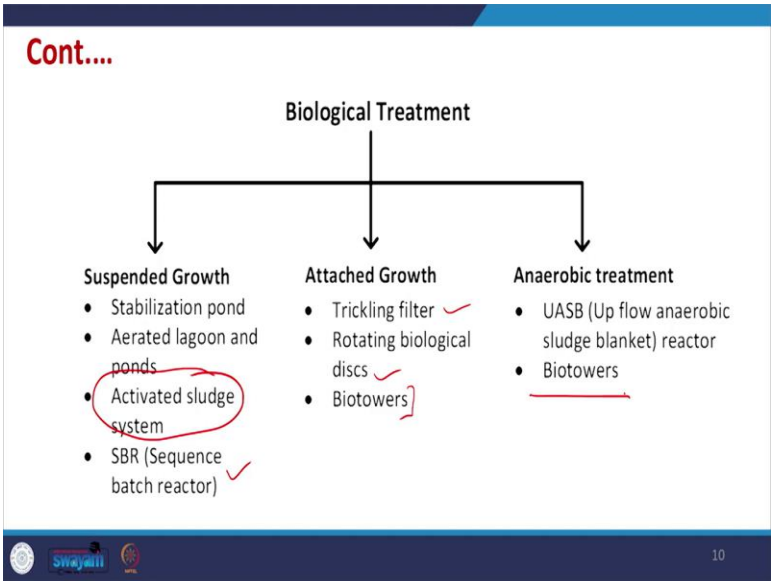

So, in the suspended growth, which are like aerobic methods, we can have a stabilization pond, aerated lagoon and ponds then activated sludge system which is the most common system then SBR the which is called sequential batch reactor and this SBRs are becoming now very common. Then attached growth systems like trickling filter, rotating biological, disc or bio towers may also be used.

Now, these attach growth systems like bio towers may be aerobic and anaerobic both depending upon the configuration. Then we have a specific anaerobic treatment methods which include USB reactor which is like up flow anaerobic sludge blanket reactor and it is very common reactor which is used for anaerobic treatment, we have bio towers also which can be used. Now, after secondary treatment depending upon the water quality or wastewater quality that we get out of that treatment the tertiary treatment may be required may not be required.

And this tertiary treatment has a large number of processes and but these may be used may not be used and some of these tertiary treatment systems are being listed here. So, the most common method which is used in that tertiary treatment is called carbon adsorption. So, these can be other besides carbon they can be other types of methods also or adsorbents which can be used for adsorption.

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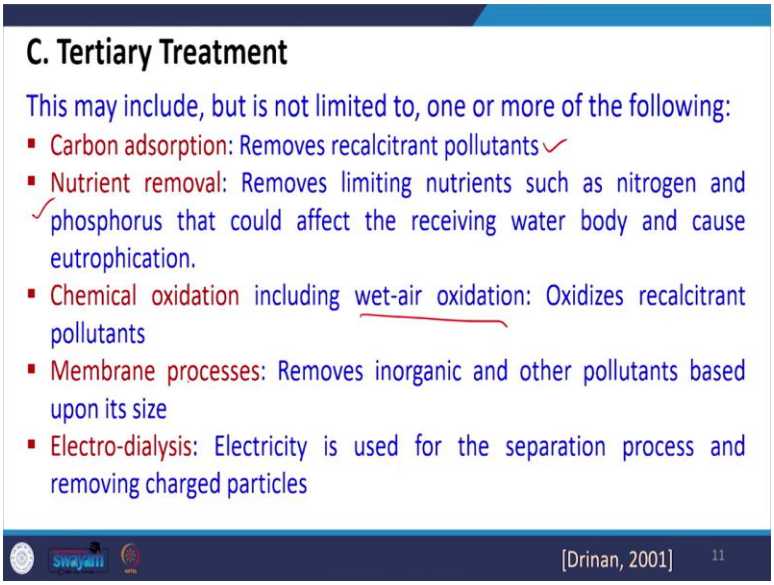

And they removed that recalcitrant pollutants, via the adsorption process. Now or thereafter, we had nutrient removal which may be used and this is required, so, as to remove the nitrogen and phosphorus because if nitrogen and phosphorus are still present in the water, they are nutrient and they will if they are not removed the water body which is receiving the water that will get enough nutrients, so, that eutrophication may happen. So, to avoid eutrophication of the water bodies, it is essential to remove the limiting nutrients, which are nitrogen and phosphorus. So, there could be many biological methods which can be used for nutrient removal.

Then, there are methods which oxidize the chemicals present in the water via various techniques, which may be wet air oxidation or any other methods. So, they oxidize the recalcitrant pollutants which have not been removed by the biological methods. So, there is a possibility that after the secondary treatment, there may be some pollutants which may still be present, because these pollutants are a recalcitrant, they cannot be removed by biological process. So, they have to be oxidized via chemical method, they can be also be separated out via membrane processes.

So, membrane processes they remove not only organic pollutants, they can remove inorganic and other pollutants based upon its size. So, membrane processes may be used and these membrane processes may be ultrafiltration, nanofiltration, pervaporation, etcetera, then a reverse osmosis is one of the most common methods use under membrane processes, then electro dialysis can also be used for separation in the electro dialysis method the electricity is used for the separation and removing the charged particles.

Reverse osmosis falls in the category of membrane separation process, but here we use pressure for forcing water molecules to that cleaner side. So, that the water which is coming into the RO unit actually gets more concentrated overall RO methods have the disadvantage that some amount of water has to be lost and it has to be further we teach it via evaporation method or otherwise, so, as to remove the total amount of water which is generated and this RO is mostly used in those places where ZLD is to be done.

So, when the Zero liquid discharge is implemented RO is used in the RO process the water is treated and if suppose 100 liter of water is treated, so, around 10 to 20, 30 liter of water, which will be discharged and which will be containing high concentration of pollutants, that this water is further treated in multiple effective operator, so, that all the water is evaporated and we have only the inorganic left.

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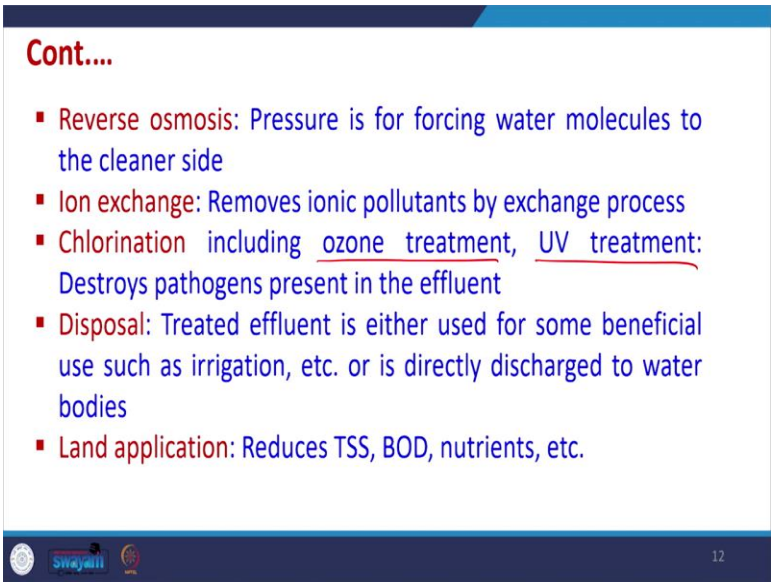

Then we have ion exchange processes, which is very common in the industries if the water has to be treated or reused in the industry. So, we do not want any calcium magnesium etcetera to be present in the water. Otherwise, if that water is is taken for a steam generation, so, there is a possibility of scaling and to avoid scaling we have to remove the calcium and magnesium and to remove calcium magnesium, we use the ion exchange processes. Further chlorination be done via various methods including various types of chlorinated compound and along with that we can perform the disinfection using ozone treatment UV treatment and these disinfection methods destroy the pathogens present in the effluent.

Finally, the water has to be disposed off, that treated effluent is either used for some beneficial use such as irrigation etcetera or is directly discharged to the water bodies. It is also possible that it has to be totally be reused in the process itself. Further, if water is to be used for irrigation, it can be land application may be done and ultimately the total suspended solids BOD nutrient etcetera can be removed via these methods.

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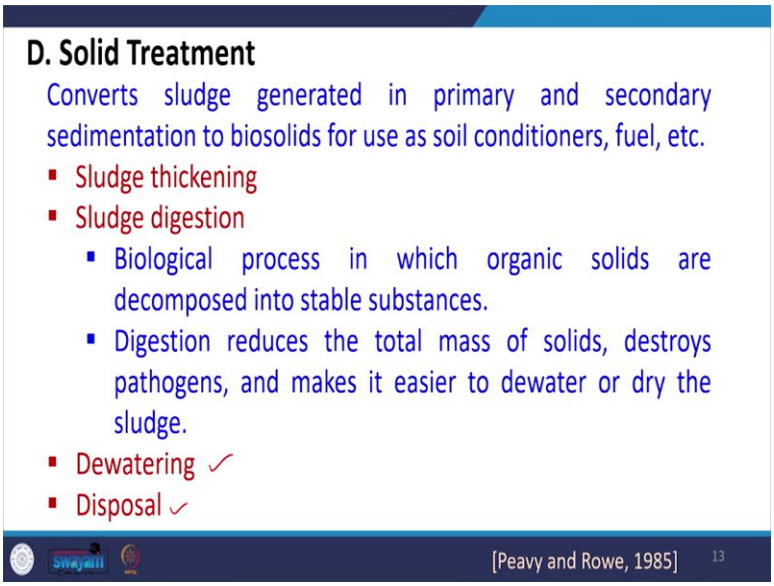

Finally, there are a lot of solids which is generated and during primary treatment we have solid which is getting generated during secondary treatment we have solid which is getting generated. So, these solids which is generated in the primary and secondary treatment can be reused because it contains a lot of organic matter. So, but before it is used, there are various types of steps that have to be performed and this solid is generally referred to as sludge. So, first step is to thicken the sludge, so sludge thickening has to be done.

Further sludge digestion has to be performed and this digestion can be performed via biological processes in which the organic solids are decomposed to stable substances. Digestion reduce the total mass of solids, destroy the pathogens and make it easier to dewater and dry the sludge. The next step is dewatering and ultimately disposal are further application of the solid which is generated in the primary and secondary treatment units.

So, today we have tried to learn the various unit operations which are performed or various steps which are performed during water treatment or during wastewater treatment. During water treatment depending upon the source of the water, whether it is River, Lake reservoir or aquifer, that treatment method may be different and there may be community treatment there may be point of use treatment in our residences, then after that, for wastewater treatment, we have different unit operations which are performed.

Overall it is divided into three steps primary, secondary and tertiary. A primary and secondary are generally performed every where, tertiary treatment may or may not be performed depending upon the characteristic of water and the quality of water that has to be obtained. So, we learn the different primary treatment methods, the secondary treatment methods also after that, there are tertiary treatment methods, where which may be required depending upon the level up to which the water has to be treated and these tertiary treatment methods may or may not be used.

And depending upon the requirement, their uses may be different. So, overall now we have done the biological processes are generally used in the secondary, all the secondary methods are generally biological in nature. Also in the tertiary treatment also some methods are biological in nature, after primary, secondary and tertiary treatment lot of solids are generated and that solids have to be treated further and for their digestion, we use biological methods.

So we have learned that there are many biological methods which are used during water and wastewater treatment, and we will be studying them in greater detail after certain steps. Now in the biological processes, generally, if the aerobic treatment is there, a lot of aeration etcetera may be required. So we will be studying first in detail a little bit of flow equalization and aeration and sedimentation before going for biological treatment in the next few lectures. Thank you very much.