Physico-Chemical Process for Wastewater Treatment
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Lecture 60
Choice of Technology & Summary

Good day everyone and welcome to these last lectures on Physico Chemical Processes for Wastewater Treatment. So, we have come to the last lecture in this online course offered by NPTEL. So, today we will be learning more about the common effluent treatment plant, as well as we will be summarizing the things that we have studied in all these lectures that we have delivered. And we will try to summarize all the things. So, we will start with the in the previous lecture, we understood that common effluent treatment plant is a strategy which has been adopted with respect to wastewater treatment, which is generated in small and medium enterprises.

So, these smaller intermediate prices, depending upon the stern, the cluster industrial cluster, that may be there, it may be heterogeneous, it may be homogeneous, so, they will be discharging some particular water after maybe primary treatment in their premises, and that water will be collected and further taken to CETP for further treatment. Now, what is the treatability of the water and what is the choice of technology with respect to use in the CETP that we will be discussing now.

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So, treatability studies have to be conducted to facilitate in characterizing the physico-chemical and biological nature of the liquid streams which are getting generated after

combining all the different streams from different industrial clusters. So, depending upon the stream wise chemical composition, so, it is possible that we have heterogeneous cluster, we have homogeneous cluster. So, if heterogeneous cluster is there, so, they stream may be entirely varying in chemical composition, but if it is homogeneous cluster so, the competition may be intact or it will not fluctuate that much.

So, depending upon the data which has been provided by the member industries, the CETP promoter or operator has to conduct some treatability studies before and at laboratory scale or plant scale or pilot scale to determine the specific treatment and recycling technologies that have to be adopted in the CETP for minimizing both the capital and operational costs.

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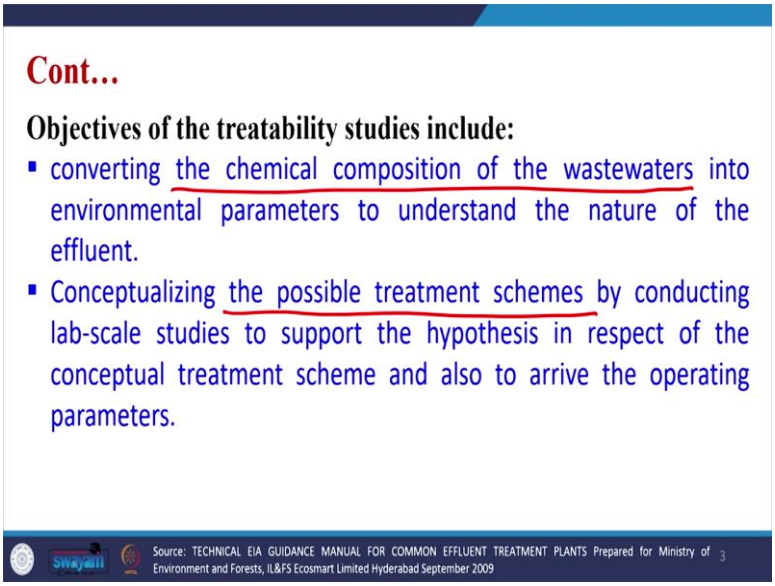

Now, the objective of the treatability study that helps in determining that what is the chemical composition of the wastewater into the environmental parameters. So, we can determine that understand the nature of effluent which is getting generated, how we will treat the water and also it helps in conceptualizing the possible treatment schemes beforehand by conducting the lab scale studies. So, this way the treatability studies are very important and they help in finding out the chemical composition and also the possible treatment schemes.

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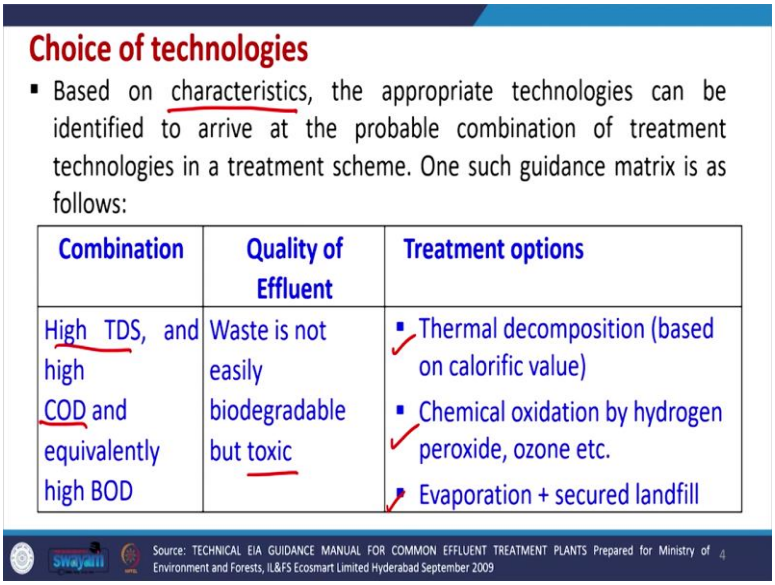

Now, what are the different choice of technologies. So, the choice of technology will depend upon the characteristic of the water the appropriate technologies can be identified to arrive at the probable combination of treatment technologies in a treatment scheme. So, there are different combination which are possible. So, suppose we have high TDS and high COD water and it is equivalently it has high BOD also under that condition that means, the quality of effluent is not easily biodegradable and also it is toxic.

So, what are the treatment options? We can go for thermal decomposition based upon the calorific value, we can go for chemical oxidation by different advanced oxidation processes, we can go for evaporation plus secure landfill. So, these are the different treatment options with respect to this type characteristics of the wastewater.

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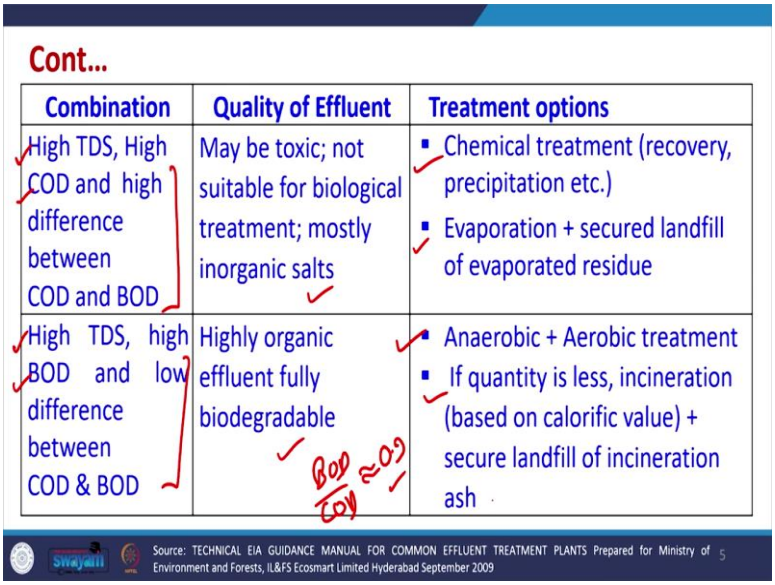

Now, if high TDS high COD but high difference in the COD and BOD. So, it may be toxic, but not suitable for biological treatment and it is containing mainly inorganic salts. So, that means we can go for chemical treatment using recovery and precipitation techniques along with that evaporation and secure landfill method can be used.

Now, similarly, if the wastewater is having high TDS high BOD, but under there is only low difference between COD and BOD that means the COD it is highly biodegradable nature that means the BOD to COD ratio, if it is reaching near to 1 or it is around 0.9 that means, we have very high biodegradable content in the water. That means, it is fully biodegradable and we can go for anaerobic plus aerobic treatment option. If quantity is less, we can go for incineration based upon the calorific value and secure landfill for incineration ash.

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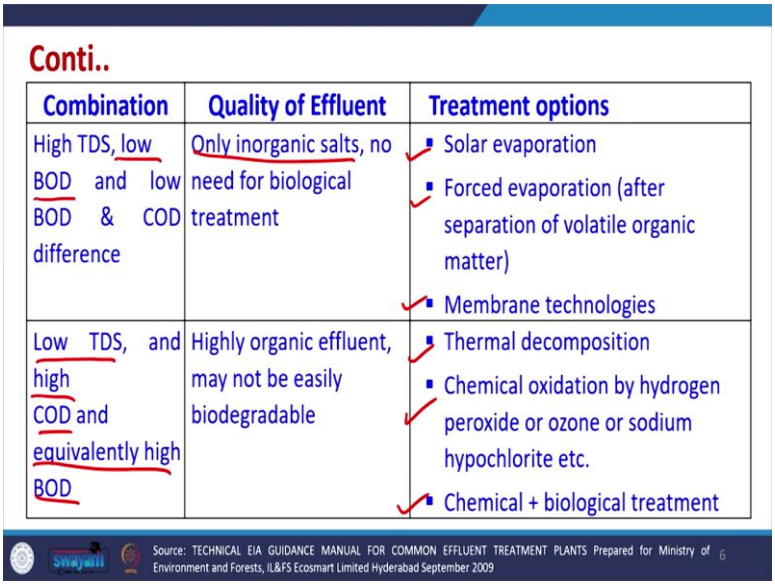

So, these are the strategies similarly, if high TDS, BOD and COD, BOD is low and the difference is also low. So, that means only inorganic salts no need for biological treatment we can go for solar evaporation, forced evaporation or membrane technologies, because the BOD is not there and the difference between BOD and COD is also less only in organics salts are present that means.

Now, if low TDS and high COD and equivalently high BOD, that means it is a highly organic effluent, but may not be easily biodegradable. So, thermal decomposition, chemical oxidation by any of the AOP techniques or combination of chemical and biological treatment may be adopted.

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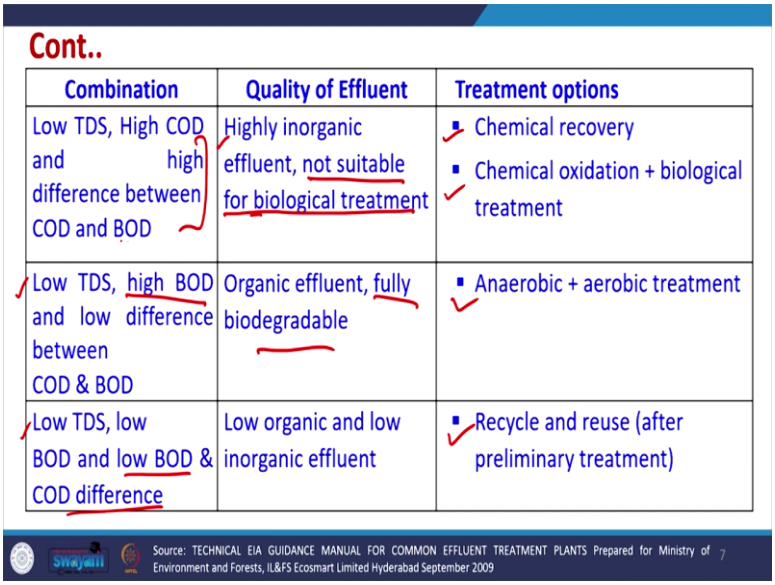

So, these are the general combination which are possible, again low TDS, high COD and high differences that means, there is a lot of difference between COD and BOD. So, that means the BOD value is very less. So, that means it is not suitable for biological treatment. Now, that means it has high inorganic content and we can go for chemical recovery or chemical oxidation plus linked in with amount of biological treatment.

Similarly, if the TDS is low in each of the case TDS is low, high BOD is there and that difference so, that means it is fully biodegradable, we can go for this, if the low BOD and COD we can go for recycle and reuse. So, there are different combinations possible by just looking at the TDS value, COD value and BOD value and the difference in the COD, BOD value are the ratio of BOD to COD. From that we can tentatively adopt the technologies for the treatment. So, that is there.

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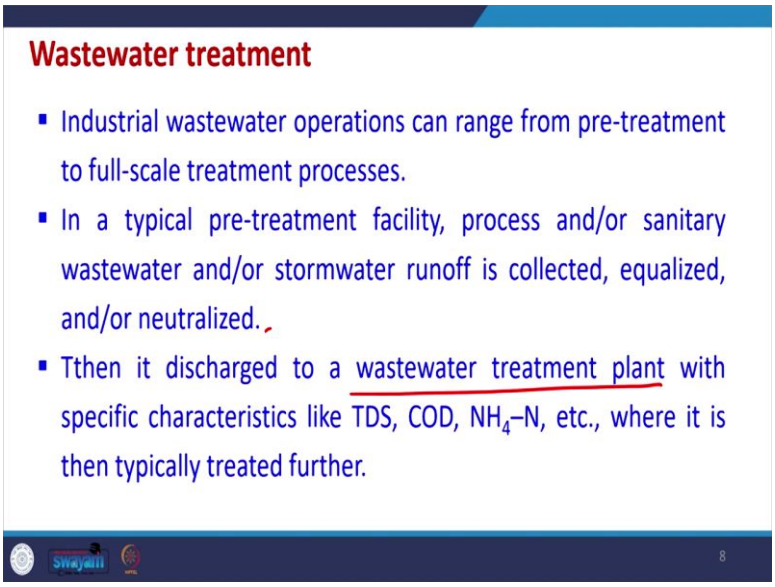

Now, the wastewater treatment, industrial wastewater operations can range from pretreatment to full scale treatment processes. So, we will try to summarize the thing that we have studied in all these lectures and also how they can be adopted for using the CETP. So, both ways we can understand this slide. Now, in a typical pretreatment facility, we have process and sanitary wastewater or it may be storm runoff also it is getting collected. So, it will be equalized and utilized then it will be discharged to a wastewater treatment plant with characteristics such as TDS, COD, ammoniacal nitrogen, where it will be treated further. So, this is done.

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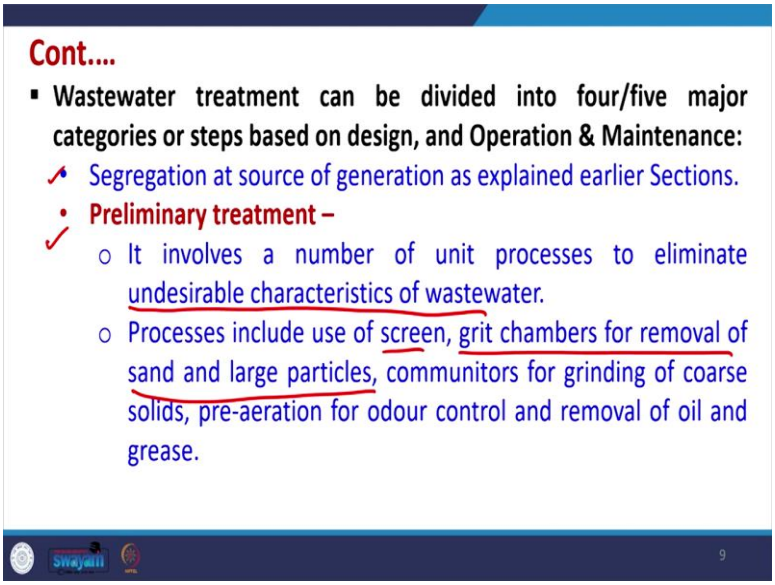

Now, wastewater treatment can be divided into 4 or 5 major categories or steps based upon design operation and maintenance that we have learned. So, we will try to understand this. So, first is preliminary treatment to segregation at source of generation has been earlier explained. So, this is very important and this helps in determining that which strategy has to be followed. Now, after that, there are different options one is preliminary treatment.

So, it involves a number of unit processes to eliminate undesirable characteristics of the wastewater. So, processes may be including the screen, grid chamber for removal of sand, large particles, then some comminutors for grinding the coarse solids, pre-aeration for odour removal and also for removal of oil and grease. So, all these options are there.

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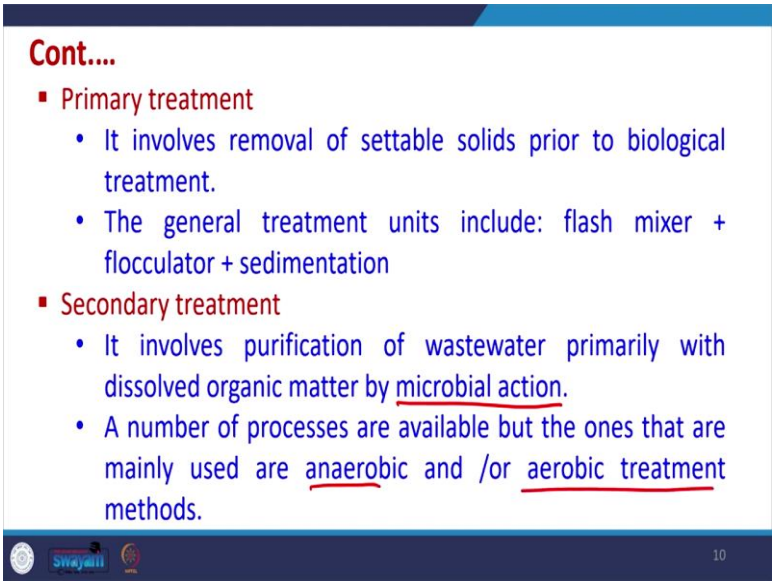

Then some primary treatment involves a strategy involves removal of settable solids prior to biological treatment. And at the general treatment units in this include flash mixture, flocculator sedimentation basin. So, all these coagulation flocculation things that come into the primary treatment, then the secondary treatment that we have not studied much that because that was not within the scope of this course, and this secondary treatment generally involves biological treatment of the wastewater.

So, it involves purification of wastewater primarily with dissolved organic matter by microbial action. So, though we have not studied, but I will be little bit discussing in today's lecture, the number of processes is available, but the ones that are mainly used are anaerobic or aerobic. So, any of the strategy or combination of these strategy may be used for secondary treatment.

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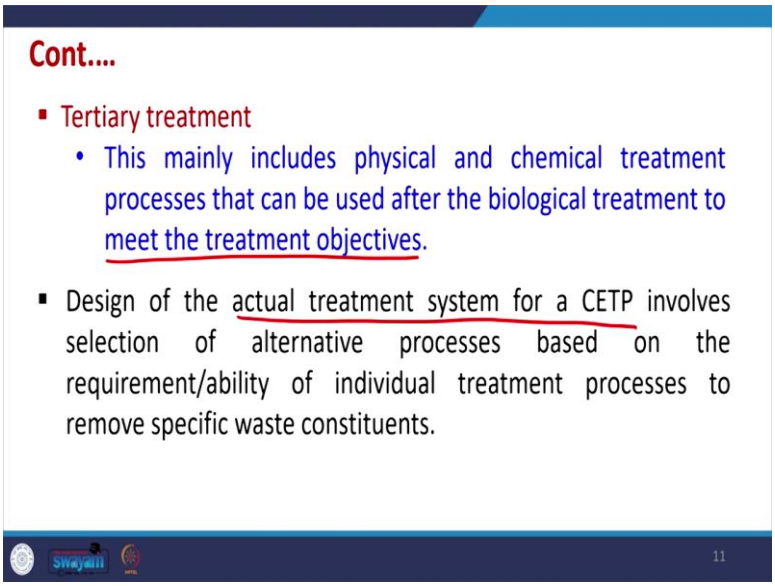

Now, that tertiary treatment that we have studied in detail, this mainly includes physical chemical treatment of a wastewater after the biological treatment and it is done so, as to meet the treatment objectives and to meet the discharges standards. So, design of actual treatment system for CETP may involve selection of alternative processes based upon the requirement of individual treatment processes. So, depending upon the requirement characteristics of the water, amount of water being generated, and the final standard that we have to achieve. So, depending upon that the actual treatment system for a CETP or for any in industry can be designed.

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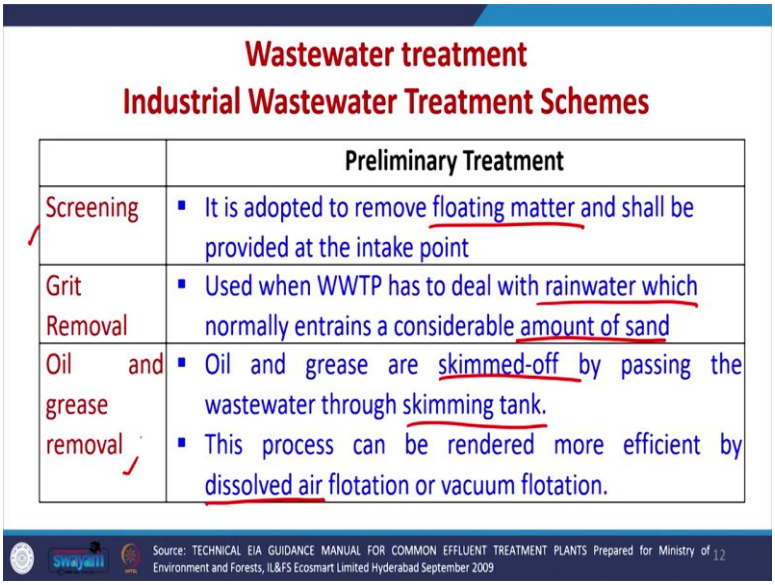

Now, what are the wastewater treatment strategies and how the industrial wastewater treatment schemes what are the different units which are there with respect to preliminary treatment, primary treatment, secondary treatment, tertiary treatment et cetera that we are going to discuss now.

Now, in the pre-preliminary treatment screening is one of the first step so, it is adopted to remove the floating material and it is provided at the intake point after that generally we do the grid removal which is used in the wastewater treatment plant has to deal with the rainwater which may bring lots of sand et cetera.

So, we have to remove the grid then oil and grease removal depending whether the wastewater contains oil and grease or not. So, that has to be installed. So, oil and grease are skimmed off by passing the wastewater through skimming tank. So, that is there and this process can be rendered more efficient by using the dissolved air, dissolved air flotation or vacuum flotation techniques can be combined together for oil and grease removal. So, this is their preliminary treatment.

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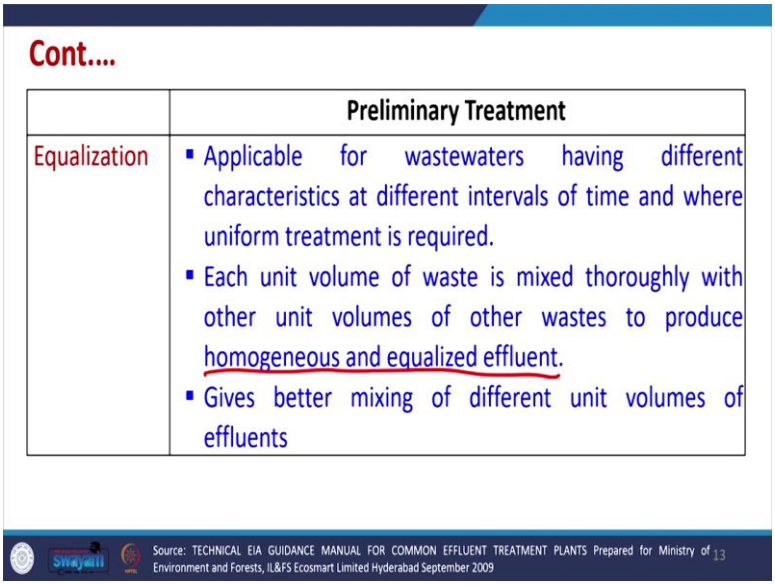

Then we have a equalization basin. So, this is used for wastewater which is having different characteristics at different interval of time and whereas we require a uniform treatment because uniform treatment will give higher treatment efficiency and its untrue equalization basin these fluctuations with respective composition and flow both can be avoided. Each unit volume of waste is mixed thoroughly with the other unit volumes of other ways to produce homogeneous and equalized effluent and that is treated further. So, this is done in the exploitation basin.

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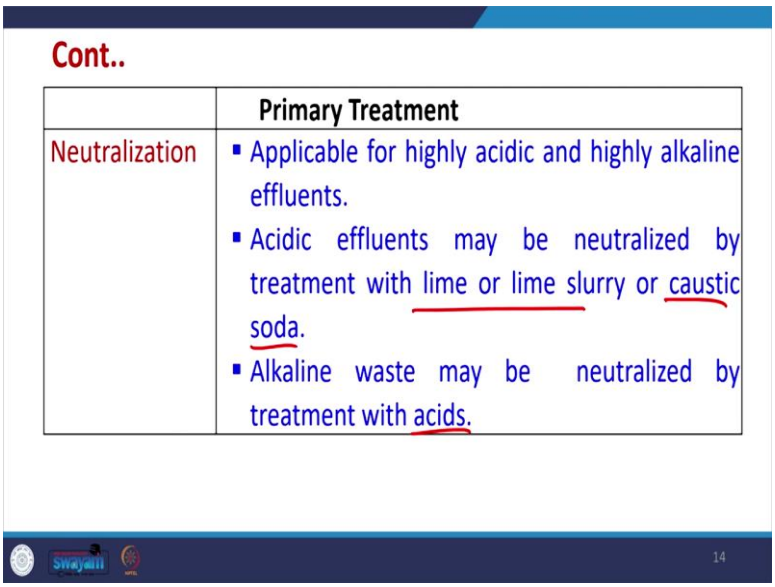

Now, in the primary treatment, some neutralization may be done depending upon whether we have highly acidic or highly alkaline effluent. The acidic effluent can be neutralized by

treatment with lime or lime slurry or caustic soda alkaline waste may be neutralized by treatment with some acids. This is possible. So, neutralization may be the first step in the primary treatment, depending upon the requirement.

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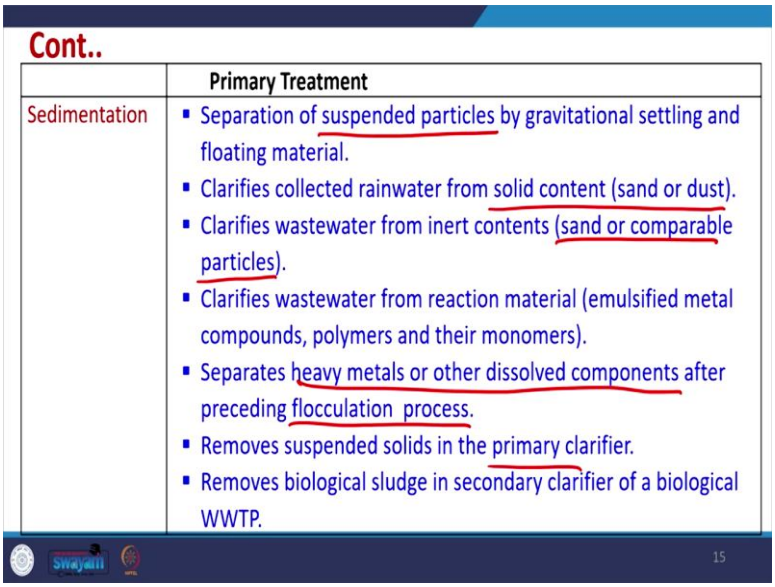

Then the second step is the sedimentation, the separation of suspended particles by gravitational settling or by removing the floating material, then clarifies the sedimentation clarifies the collected drain water from solid content also sand and dust et cetera can be removed also the inert content such as such as various types of inert particle et cetera will get removed from the water.

Also, some of the emulsified metal compounds polymeric material, their monomers et cetera can also be removed using sedimentation basin, it can remove heavy metals and other dissolved content after if you use some flocculation basin et cetera. And it may remove suspended solids also in the primary clarifier. So, we can use sedimentation basin along with the coagulation flow basin units to remove lot of suspended material a little bit of the dissolved material as well. Now, after that it will go into the secondary treatment. Now, secondary treatment is generally biological treatment that we have not studied that much in detail in this lecture. In fact, we this was out of the scope of this course.

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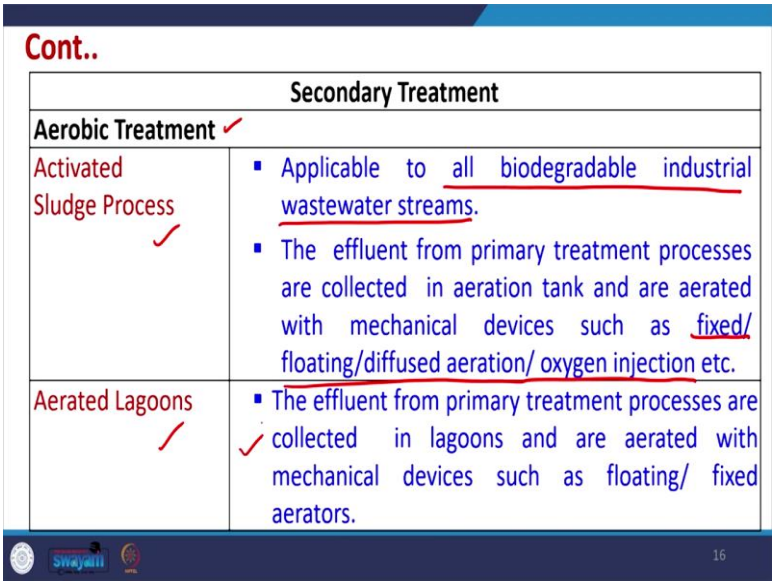

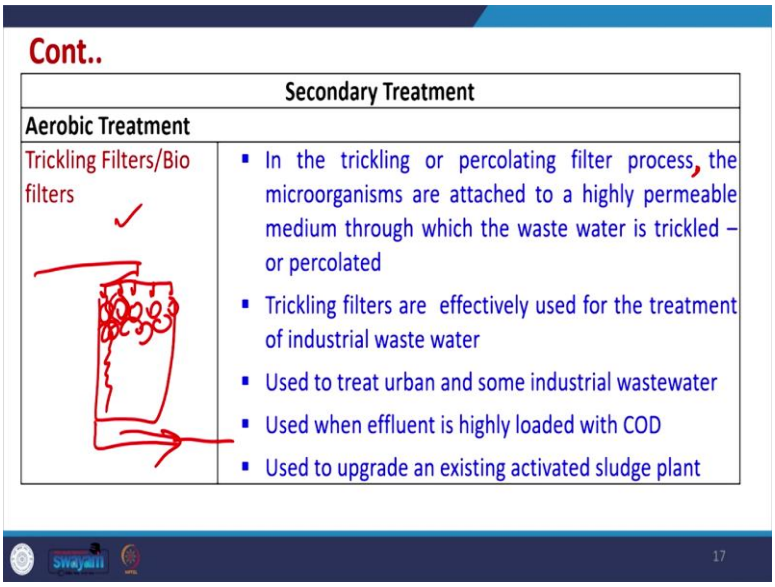

So, what are the still just for the knowledge there are two options one is called aerobic treatment another is called anaerobic treatment. So, within aerobic treatment activity sludge process, aerated lagoons, trickling filters et cetera are common techniques. So, any of these techniques can be used for biological treatment or secondary treatment. So, it is activated sludge processes the most common technique and it is applicable to all biological industrial wastewater streams.

The effluent from primary treatment processes is collected in aeration tanks and are aerated with mechanical devices such as fixed floating, diffused aeration units or oxygen injection units. The concept is similar to aeration that we have studied earlier. Then the aerated along with the activated sludge process or we can go for aerated lagoons also which are simpler. So,

as compared to activated sludge process certainly their efficiency is lower as compared to activated sludge process.

So, here the technology is similar and that can be adopted. Also, trickling filters or bio filters. So, in this case, actually the water is there is a packed bed on which there are packing materials and on these packing materials there are fields of biological fields which are grown. Now, water to be treated is distributed all along this bio tower or trickling filter and then the water trickles through and the treated water is coming out and it is further taken for any other maybe secondary clarification and further treatment. So, this is a trickling filter.

So, in that trickling filter or percolating filter process the micro-organisms are attached to a highly permeable medium through which the wastewater is trickled or percolated and these filters are effectively used for treatment of industrial wastewater. They are used to teach urban and some industrial or they are difficult to teach industrial wastewater is also and they can take a higher COD load as compared to activated sludge process.

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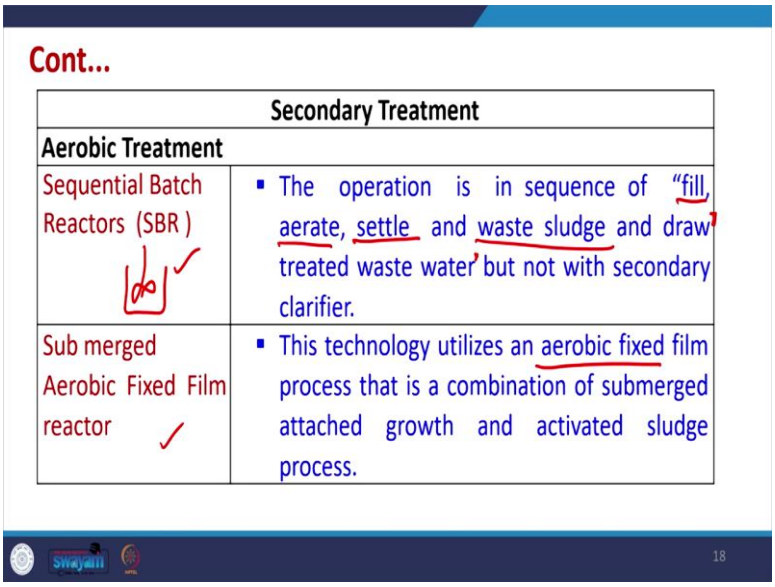

So, this way this trickling filter can be used and they are very common as a secondary treatment unit as for aerobic case, then other options with respect to aerobic treatment are sequential batch reactor, submerged aerobic fixed film reactor in the sequential batch reactor the operations are carried out in sequence they include fill, aerate, settle, waste sludge and draw. So, these are the different operations which are performed in series in a same reactor. So, a reactor is there and all these operations are filling is done then aeration is done after that

the settling happens and then the waste sludge is discharged as well as the treated water wastewater is discharged.

So, all these sections or steps are performed within the same reactor so, we do not have different reactors in series we have different operations in the same reactor in the batch mode. So, that is why it is called sequential batch reactor. So, this is also aerobic mix treatment because we provide air and mixing is also done.

Similarly, submerged aerobic fixed film reactor this technology utilizes aerobic fixed film process that is a combination of submerged attach growth and activated sludge process. So, this is being used nowadays and its efficiency is high as compared to certainly activated sludge process. So, this is also being adopted.

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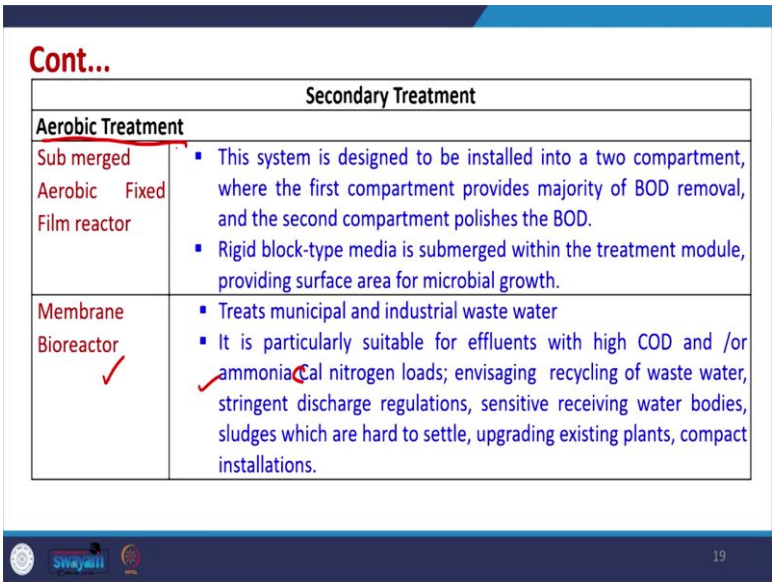

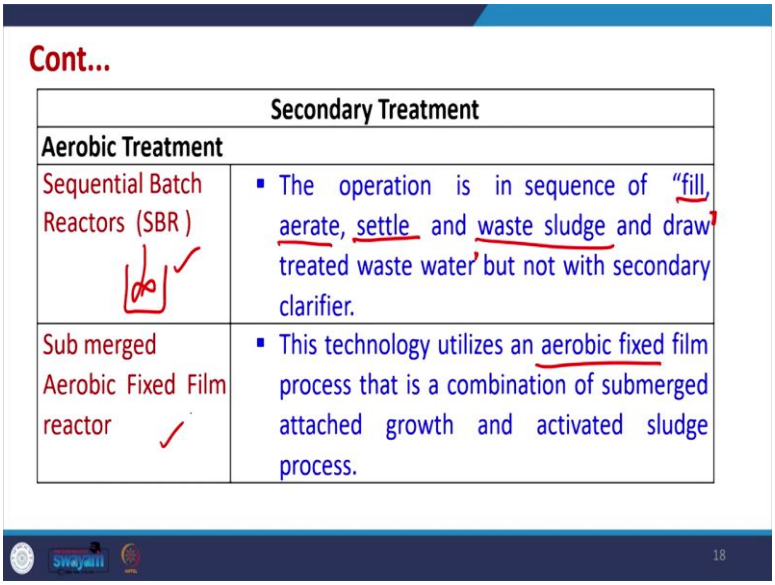

Now, the system is designed to be installed in two compartments where the first compartment provides majority of BOD removal and the second compartment polishes the BOD. So, this this is how it works. Then we have membrane bioreactors also they are being used to treat municipal as well as industrial wastewaters.

It is particularly suitable for effluent with high COD or a high ammoniacal nitrogen loads and they can be used for recycling of wastewater meeting the stringent discharge regulations that may be there. So, membrane reactors, new, technologies like SBR submerged aerobic fixed film reactor and membrane bioreactor, they are becoming more common as an aerobic treatment strategy. So, these are becoming very common.

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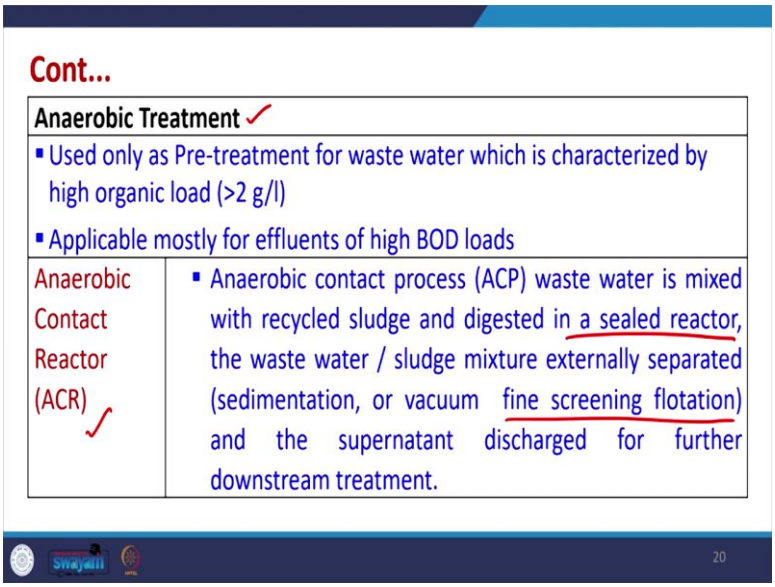

Now, going to anaerobic condition they are used as a pretreatment of wastewater which is characterized to have very high organic load. So, the idea is that if any wastewater is having very high organic load. So, why not use this high organic load to convert that into methane and other types of useful products. So, because of this if any wastewater contains very high organic load, we can go for anaerobic treatment and that can be done in anaerobic contact reactor.

So, in this process the wastewater is mixed with the recycled sludge digested in a sealed reactor and after that the wastewater and sludge are externally separated. So, using sedimentation vacuum fine screening flotation unit et cetera and the supernatant discharged for further downstream treatment.

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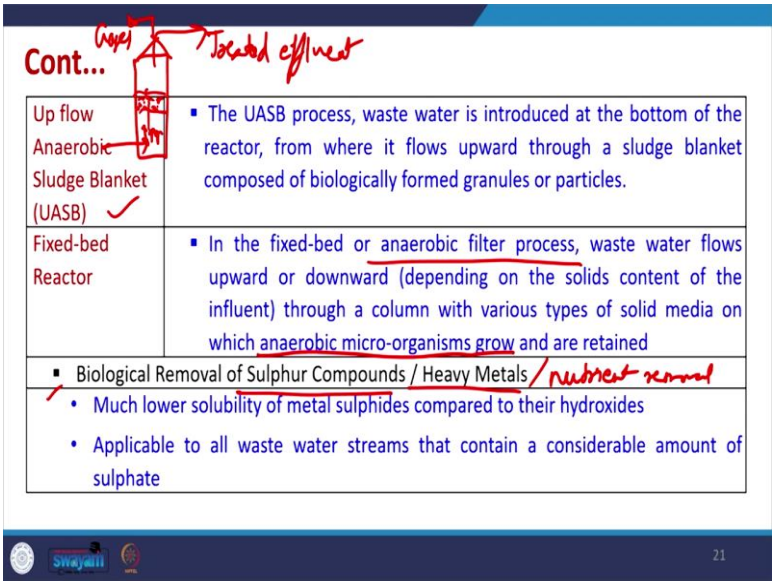

So, we get products like methane other type of gases which may be useful. Now, up flow anaerobic sludge blanket reactor is similar it is very, very common it is commonly called as UASB reactor, in the UASB process wastewater is introduced at the bottom of the reactor from where it flows upwards through a sludge blanket. So, we have a reactor system like this and in this the wastewater flows the inlet and it is just gets distributed and we have a section where a lot of sludge is there an aerobic sludge.

So, while the water passes through this, the aerobic or the organic load gets converted and we have a lot of methane formation. So, we have treated effluent coming out and we have the gases which are coming out which is collected and here we have treated effluent. So, this way this UASB reactor works. So, we can use this UASB reactor for anaerobic treatment.

Similarly, fixed film reactor, fixed bed reactor can be used for anaerobic treatment, it is similar to tickling filter only hear the fixed bed or anaerobic filter process is used wastewater flows either upward or downward depending upon the solid content of the influent through a column with various types of solid media on which anaerobic micro-organisms are grown and while passing through that the anaerobic treatment happens this is there.

Biological treatment can also be used for removal of Sulphur compound heavy metals also for nutrient removal also. So, any of this possibility is there with respect to biological treatment, because nutrient removal is also very important, so as to avoid nutrification and other things. So, this is biological treatment can be used for this purpose as well.

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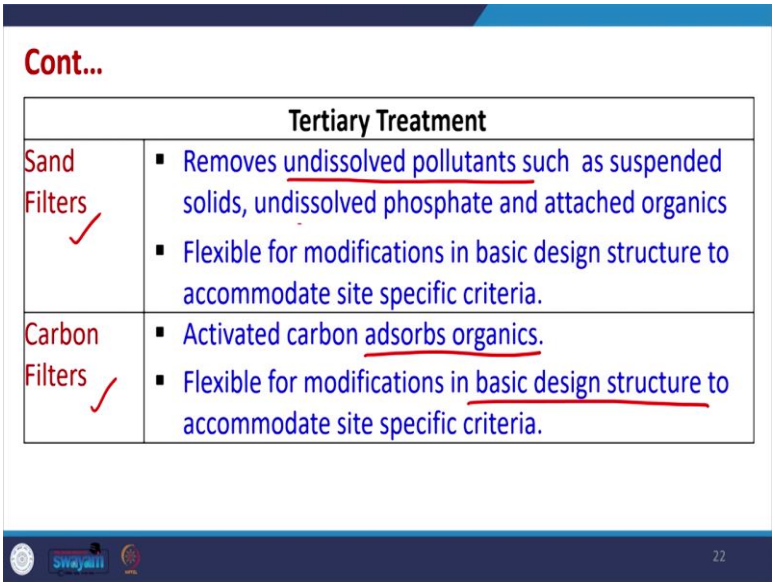

After that, we go for tertiary treatment. So, in that tertiary treatment, we can use sand filters, to remove the undesired pollutants such as suspended solid and dissolved phosphate, et cetera organic, some amount of organic, then the flexible we can have lots of modification in the sand filter, a combination of sand filters are in any of one of them can be used. So, carbon filter activated carbon filter is also common for adsorbing organics present in the water. It is flexible for modification in the basic design structure. Depending upon the requirement, we can design the system we have studied this adoption section in detail.

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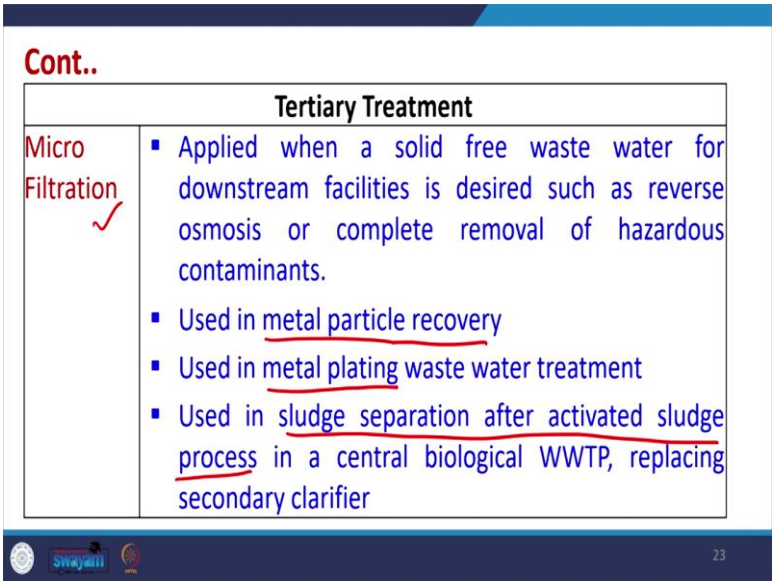

Each of these sections have been studied in detail you can go back and again see the lectures to better understand then we can have micro filtration technique, which is applied when a solid free wastewater for downstream facilities desired such as RO or complete removal of hazardous contaminants. So, in this case we have microfiltration can be used.

So, this is possible to use the microfiltration used, it is used in the metal particle recovery, it is used in the metal plating wastewater electroplating wastewater, it is used in the sludge separation after the activated sludge process has been used. So, there are a number of places where microfiltration can be used.

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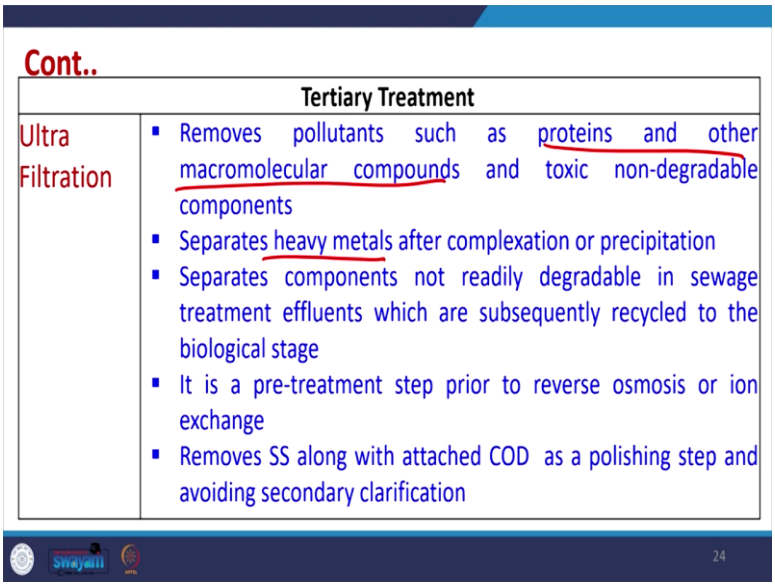

Then ultra-filtration so, all these are membrane-based technologies microfiltration, ultrafiltration, nanofiltration and RO. So, they remove pollutants such as proteins and other micro molecular compounds and toxic non-degradable compounds, they can separate heavy metals also after complexation of precipitation and this ultrafiltration can technique can be used as pre-treatment step also before RO.

So, this we have seen in one of the case studies, this is very common to use ultrafiltration before RO though always will be funding that RO unit will be after the ultrafiltration unit in most of the industries that this method removes the suspended solid along with attached COD and it works as a polishing step as well.

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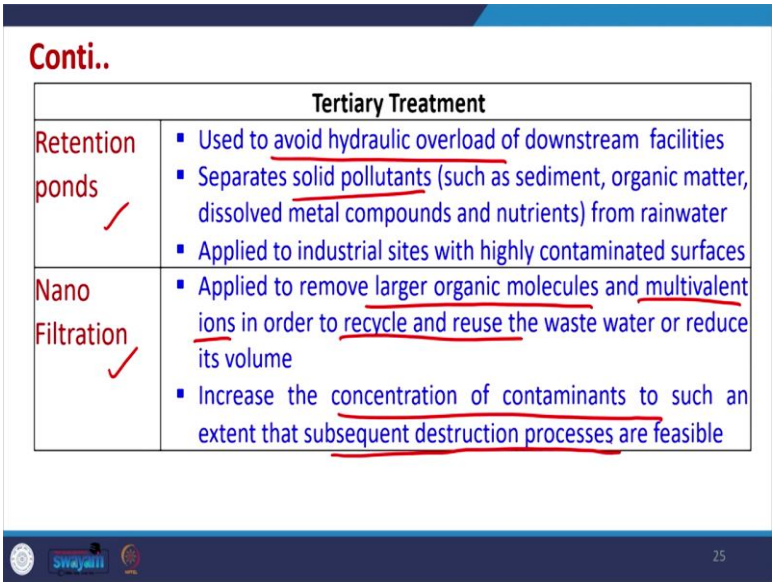

So, then we have tertiary treatment using retention, ponds nanofiltration. So, retention ponds can be used for avoiding hydraulic load one load of downstream facilities if you are going to use other treatment strategies and it can be used for separating solid pollutants from rainwater et cetera. Nanofiltration also removes large organic molecules and multivalent ions also. So, this this way, if we are able to remove this, we can use the recycle reuse the wastewater.

So, this is nanofiltration, ultrafiltration, RO units are very common membrane technologies which are used for concentrating the effluent and after that, we can reuse most of the water and only some amount of water has to be further treated or evaporated or further discharged. So, this is there. So, this increases the concentration of contaminants to such an extent that subsequent destruction processes like thermal treatment et cetera can be used.

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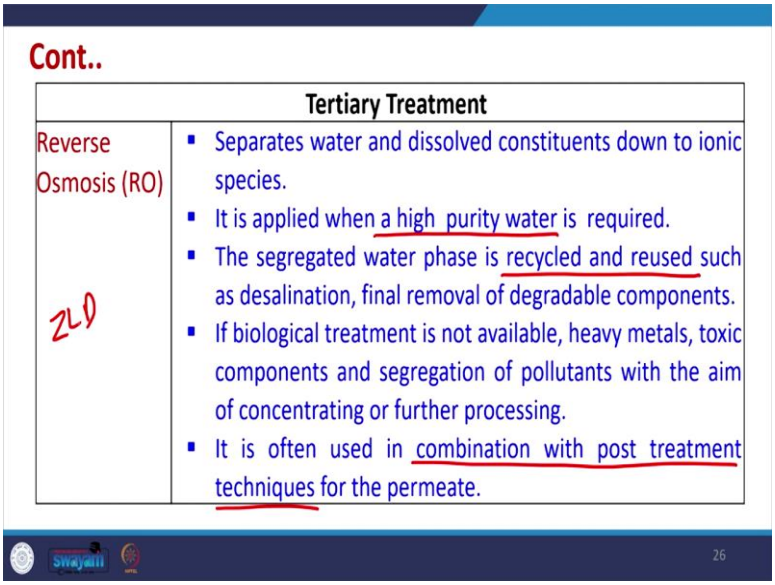

Then similarly RO units also based upon the same idea that they separate water and dissolved constituents down to ionic species, it is applied when a very high purity water is required. So, RO units are very common, the segregated water phases are recycled and reused. So, RO units are always used whenever we have to recycle and reuse the water in particular, suppose we have to use the water in highly pure form.

So, this is very common, and if biological treatment is not available, heavy metal, toxic compounds, segregation of pollutants can be performed with RO units, this is possible it is often used in combination with post treatment techniques. So, this is very, very common strategy nowadays in most of the highly polluting industries, RO units are very common, they are used in all those industries where ZLD has to be there that means all those industries which have been told that they cannot discharge any liquid, ZLD means zero liquid discharge. So, if ZLD has to be implemented, that means that particular industry is most likely it will be using ultrafiltration RO and evaporation multiple effect evaporator. So, this is there.

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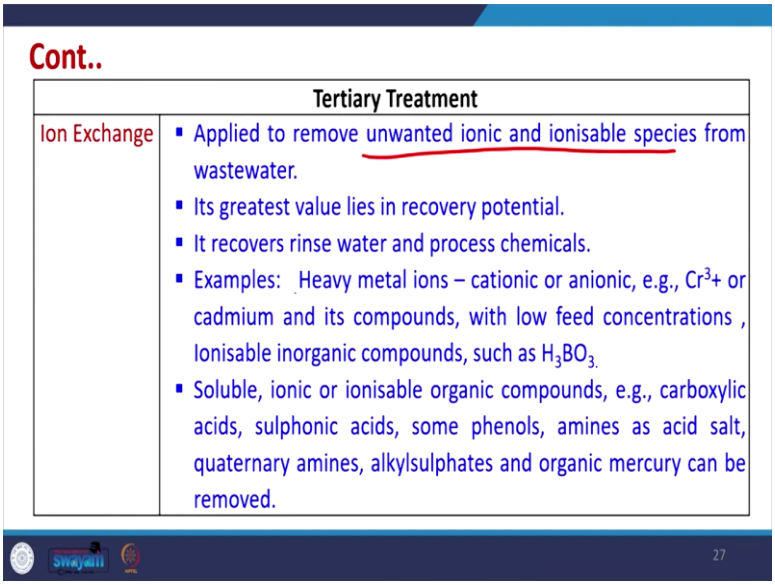

Similarly, ion exchange technique can be used to remove the unwanted Ionic and ionizable species from the wastewater. So, it is very common to remove calcium, magnesium et cetera. It can also be removed to other types of heavy metals et cetera from the wastewater. So, this technique is highly used in particular, suppose, we have to feed the water to the boiler for steam generation. That means, we need to remove the calcium and magnesium for avoiding the scaling in the pipelines as well as for avoiding the scale formation in other units. So, this is an ion technique is very common.

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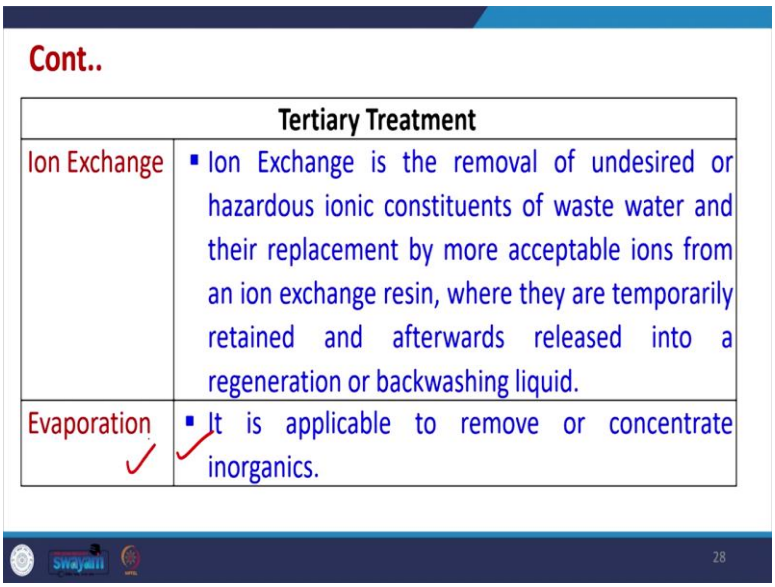

Now, in the last week we can go for removal or destruct most of the organic compounds using the evaporation technique. So, this is how we can use the evaporation technique.

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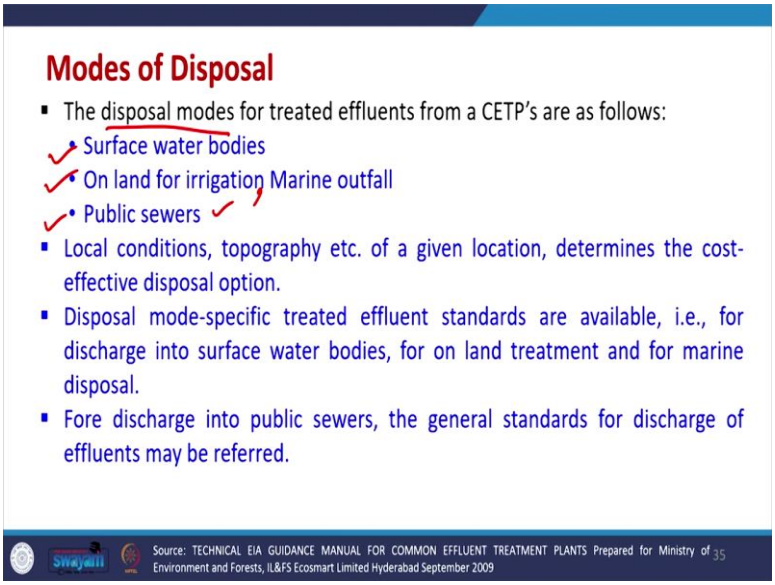

So, we have you understood various technologies which can be used for wastewater treatment. Now, there are different strategies which can be adopted for disposal of the treatment effluents from CETP or from any industrial wastewater treatment unit. Now, the disposal modes could be surface water bodies on land for irrigation or marine outfield or to the public sewers. So, any of these strategies are possible some of the industries are around for using the irrigation like for sugar industry, on land irrigation is allowed marine outfield is also common for industries which are in the coastal belt. So, this is there.

Only few industries are allowed for surface water body discharge, otherwise they have treated the water fully some of the industries are allowed for discharging water if they are only generating sewers like effluent so, they can discharge to the public sewers. So, this is possible. So, local conditions, topographic et cetera of the location of that industry or that locality determines the cost effectiveness of the disposal loss plan.

So, disposal specifically treated effluent standards are always available depending upon the industry. So, there are a specific discharge standard for different types of industries are given and based upon the treatment that they do, they can do that disposal or discharge to any of these places.

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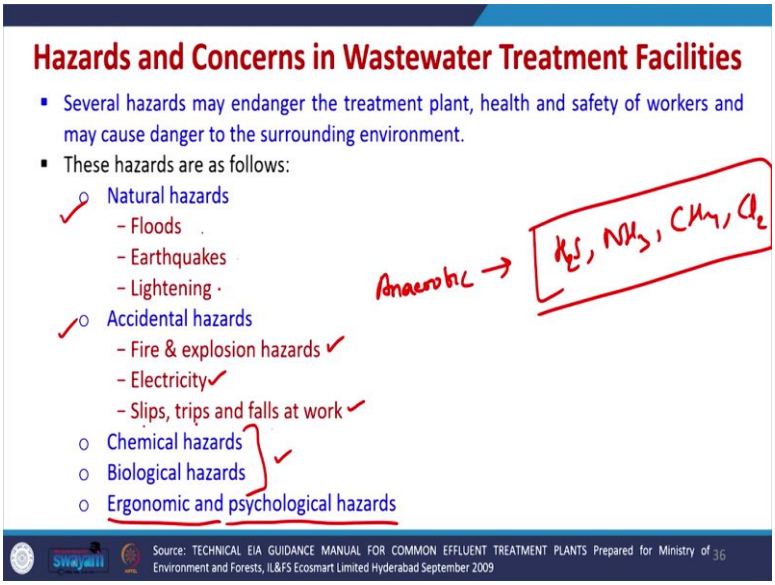

Now, so, any of these possibilities with respect to discharge are there. Now, there are some hazards and concerns in the wastewater treatment facilities. So, that may endanger the people in that treatment plant. So, they have to take care of these hazards. Now, these hazards may be natural hazards floods, earthquakes, lightning, etc.

Then, accidental hazards remember in many places where anaerobic conditions are prevailing. So, under those conditions, we may get H2S we may get ammonia we may get CH4, we may get chlorine also. So, any of these treatment strategies may generate these types of gases and if their concentration is high.

So, under that condition, the fire and explosion hazard may happen. Also, if anybody enters in those sewer lines, those reactors, where these may be presenting higher quantity, then the people may die also. So, we may we many times find in the news that few people died while entering any sewer line. And this is because of the anaerobic condition because of other prevailing conditions, the concentration of these gases et cetera may grow. So, these gases, they cause lots of accidental hazards and that we have to remember.

Similarly, electricity may cause a lot of accidental hazards also slips, trips and falls at work, because these effluent treatment plants may be very, very big in size. So, we have to avoid these things as well. Now, in addition to that, lot of chemical hazards are there because the industrial effluent may contain lots of chemicals which is highly toxic, it may be some of the pH can water maybe having pH condition which we cannot touch also. So, skin problems, other types of chronic problems may happen with time.

So, we have to avoid this chemical biological hazard the all the wastewater may contain some amount of pathogens etc. So, these hazards have to avoided, also ergonomic and psychological hazards may be there in the wastewater treatment facilities, because we are continuously seeing bad quality water and we may feel that odour is continuously coming. So, all these things cause problem and sometime of ergonomic or psychological problems may happen to the persons who are working in these places. So, these hazards and concerns have to be avoided and also the industries which are operating these ETP. They should always take care of these hazards. Now, summarizing what we have learned in this course.

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So, we started this course with some introduction to water pollution and control, what is the necessity what are the different laws and regulations, what are the different standards with respect to discharge, so, all these things we studied in the introduction thereafter, we studied the different types of water quality parameters, this is very, very important section and this section actually gives an idea that what type of treatment strategies have to be adopted. So, this is very important that this section should be well understood.

So, in this section we studied regarding various water quality parameters including the physical, chemical, biological and pathological also though, we did not study pathological that much in detail, because that was not within the scope that much but still all these parameters must be well understood. And after that only we can always better understand that what strategy has to be adopted for treatment of any wastewater.

Now, going further we studied flow equalization, aeration, coagulation and flocculation in detail also we studied settling and sedimentation, settling chamber design in detail. In addition, we studied filtration, filtration system design, also we studied wastewater treatment by adsorption and ion exchange. So, any you can go back and study them again if you have not understood anything.

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Then also we studied the wastewater treatment by membrane-based technologies, including the microfiltration, ultrafiltration, nanofiltration and RO. So, all these technologies we studied thereafter, we studied advanced oxidation processes and these included that like photocatalysis Fenton process, catalytic wastewater treatment, then electrochemical treatment or ozone treatment et cetera. And then the hybrid technologies also including the sono hybrid treatment techniques.

So, we have studied all these techniques and give idea and developed basic understanding that how these technologies work in the last we have studied the case studies with respect to wastewater treatment in various process, chemical and allied industries. And we in particular studied that treatment in the sugar industry, distillery, fertilizer and petroleum refining industry. And in the last lectures, we have been studying that treatment study which have been adopted in the various homogeneous or heterogeneous industrial units, which may be there in one industrial cluster.

So, their water is collected and then it is treated further in the common effluent treatment plant. So, we have studied all these strategies with respect to water and wastewater treatment

in which can be adopted in any industry. And for this we should understand the basic characteristic of the water, amount of water being generated. So, we can use any of these technique, physico-chemical processes for wastewater treatment.

So, with this, we will end this course, all the best to all of you for your future endeavors. If you have any problem, please contact in the forum or you can write to me also and I will try to help you with respect to basic understanding or solving the problems which have been given in the assignments or any other issues. So, thank you very much for joining this course. And hopefully that you may have gained basic understanding of treatment of water or wastewater with respect to physico-chemical processes.

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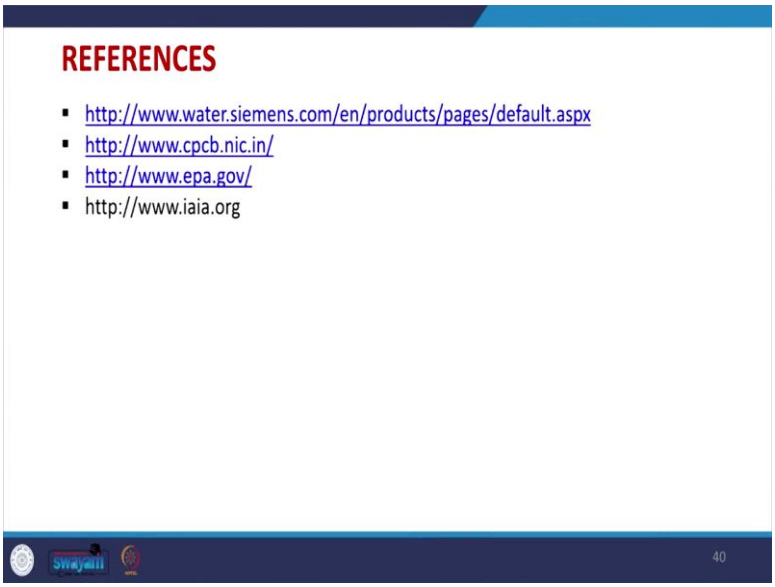

These are the references that we have used in today's lecture. Thank you very much.