Basic Environmental Engineering and Pollution Abatement
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Lecture: 27
Treatment of Domestic and Industrial Wastewater: Schemes

Hello, everyone. Now we will discuss on the topic, treatment of domestic and industrial wastewater schemes. In the previous class, we have discussed on the generation of drinking water from different sources and we have seen that surface water like river, lake and groundwater are used as the source of drinking water.

But, due to the population growth and the creation of more wastewater in domestic and industrial sectors and the lack of proper treatment facilities, the surface water is being contaminated. So, to ensure the quality of the river water or the other surface water, the treatment of the domestic wastewater as well as the industrial wastewater is very-very important. And in this class, we will discuss different schemes which are available for the treatment of such type of waste waters.

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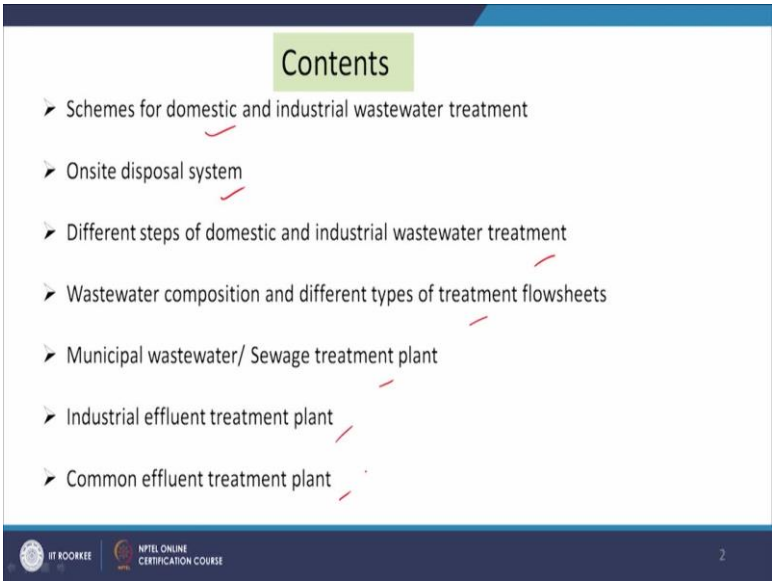

And in this class, we will discuss schemes for domestic and industrial wastewater treatment, then on site disposal system, different steps of domestic and industrial wastewater treatment and wastewater composition and different types of treatment flowsheets, and then municipal wastewater or sewage treatment plant and industrial effluent treatment plant and common effluent treatment plant.

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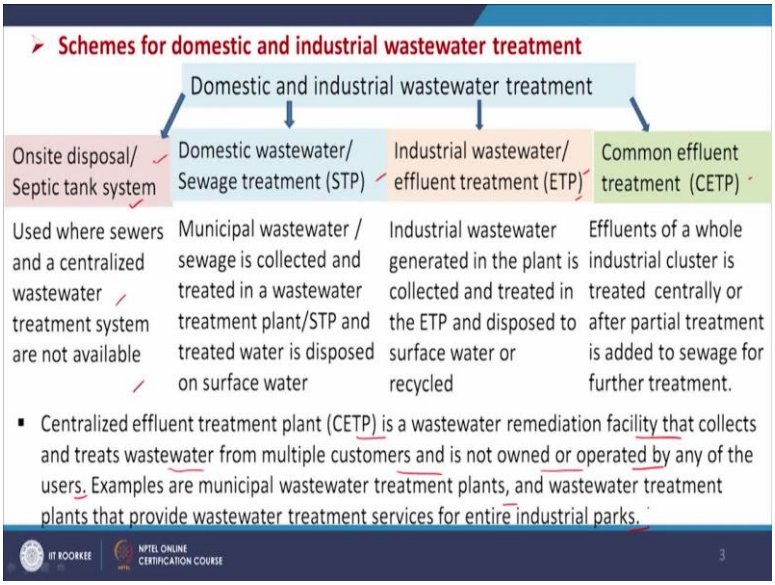

If we see different schemes then, we can see that there are major four type of processes that is on site disposal or septic tank system or domestic wastewater or sewage treatment plant and then industrial wastewater and effluent treatment plant and then common effluent treatment plant. So, in some cases, we will see that the wastewater which is generated in our domestic sector that is not connected with the sewer line. So, we need to develop online disposal system and that is septic tank system.

And this is used where sewers and centralized wastewater treatment systems are not available. And domestic wastewater as you know, which is generated in our domestic sectors are treated in sewage treatment plant. And industrial sector, in industry wastewater is generated from two sources, one is the residential area and other industrial area. So, the water generated in the industrial area is treated in effluent treatment plant and the water generated in the residential area is again treated in their own STP.

But in many industry, neither STP nor ETP is available because of the very small-scale production and lack of infrastructure and financial condition. So, this wastewater generated is directly entered into the sewage stream and then this is treated centrally or sometimes in a cluster different industries generating wastewater are collected in a central facilities and treat it so, that facility is called a common effluent treatment plant. So, effluents of a whole industrial cluster is treated centrally or after a partial treatment is added to sewage for further treatment.

And centralized effluent treatment plant or CETP is a wastewater remediation facility that collects and treats wastewater from multiple customers and is not owned or operated by any of the users. Examples are municipal wastewater treatment plants, and wastewater treatment plants that provide wastewater treatment services for entire industrial parks.

That means there may be two options, either the wastewater generated in industrial sector is commonly collected and treated, there is also CETP or the individual industry is doing some preliminary treatment and releasing the waste water in the sewage streams and then it is treated in the sewage treatment plant, so that way also CETP is possible.

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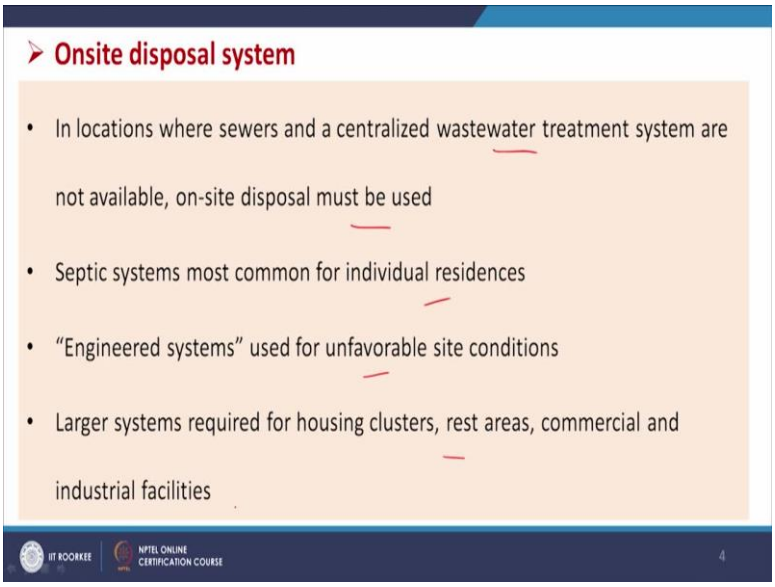

Now, we will discuss on onsite disposal system. So, as you know, that this is applicable in locations where sewers and a centralized wastewater treatment system is not available So, on-site disposal must be used in this case and septic systems most common for individual residences and engineered systems used for unfavorable site conditions and larger systems required for housing clusters, rest areas, commercial and industrial facilities.

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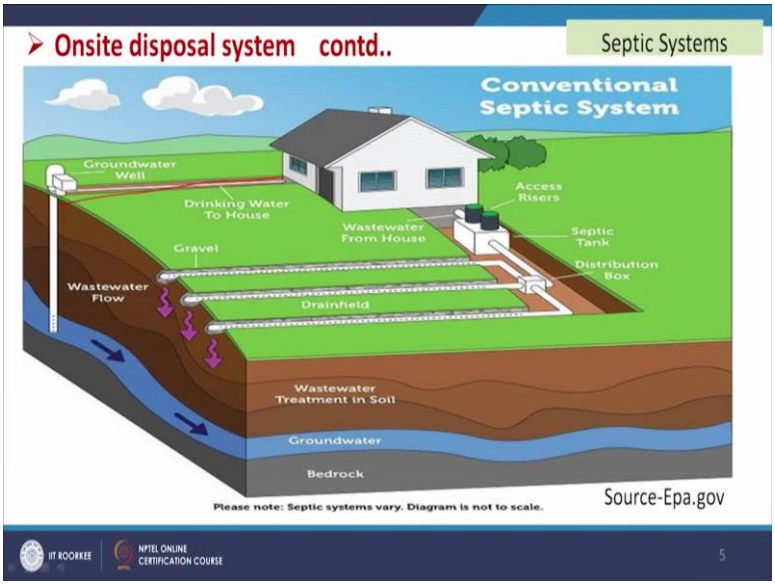

So, this is your septic system, this figure shows us the septic system. So, ground water is taken at our house, then it is used after application, so waste water is generated and it is coming into this collection pit. So, here this is called septic tank and from septic tank, the water is going through the distribution box and then there are some drain field and ultimately the water is going into the soil and through the soil it is being purified that is wastewater treatment in soil and it gets entry into the groundwater as well, in some cases.

So, this is a septic systems. So, the drain field is designed to provide more aeration and so that in case of drain field aerobic degradation will take place and this septic tank anaerobic degradation will take place.

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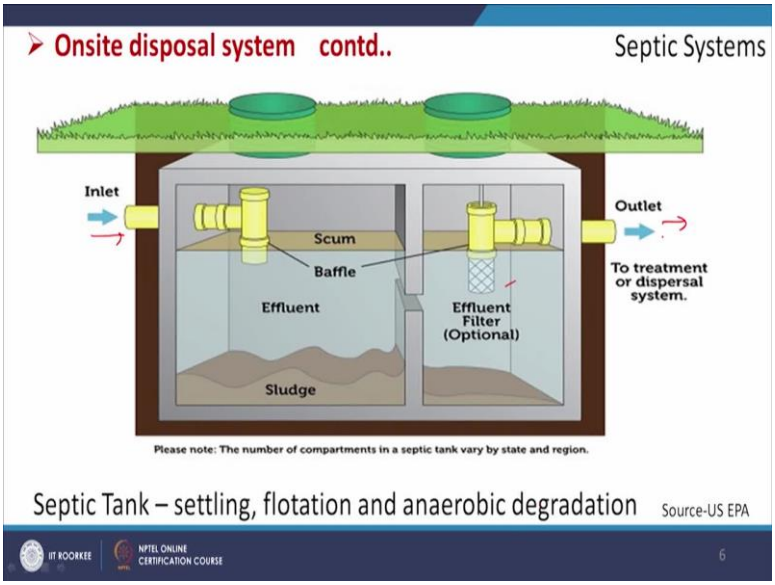

So, now we will see the septic tank, what is happening in this case. Inlet, so waste water is getting entry here. So, there are two chambers basically, in the first chambers, the waste materials, the solids will be settled, so it will give us sludge. And then supernatant liquid, clear liquid will pass to the second one. So, there may be some solid again it may come to the second chamber also, then it will be settled and then there may be some filter effluent treatment, through which the water will pass through.

And this water which is going out, that will be either sent to treatment if sewer line is available or we have to dispose in proper way. And in this case anaerobic condition prevails, so anaerobic degradation takes place and when it is going to the out of it. If sewer line is not available then we will go for that is aerobic degradation in the drain field.

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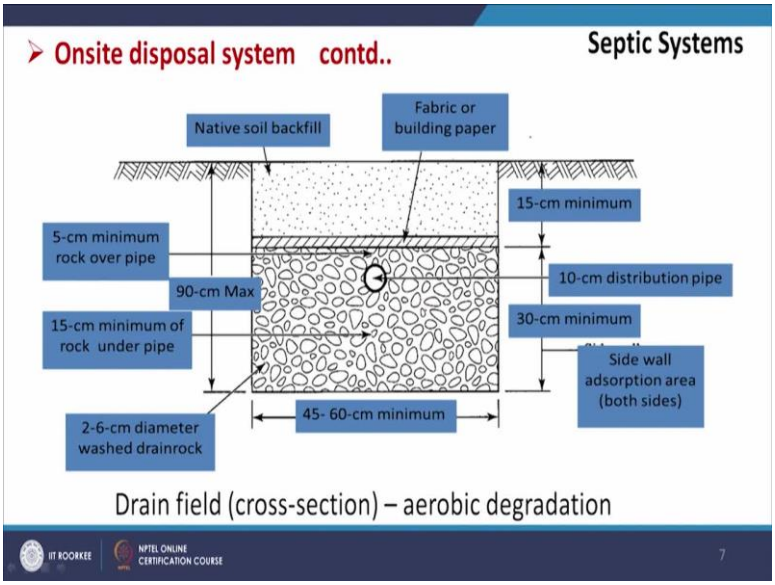

So, drain field in design in such a way that the effective degradations of the organic present in the wastewater can be possible. So, here are some typical dimensions are given basically different rocks and rock cover it is as shown here and specific dimension some soil backfill is also given and the porosity is maintained, so that air circulation can be available.

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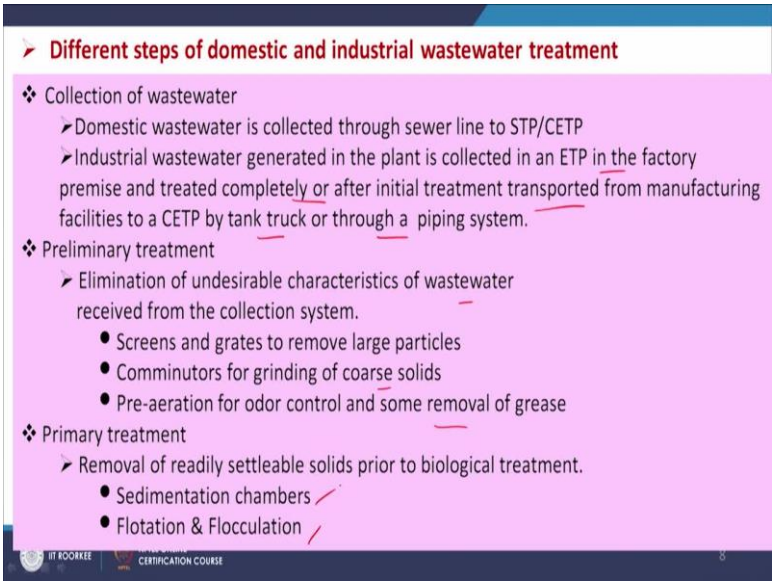

Now, we will discuss different steps of domestic and industrial wastewater treatment. So, the first step is the collection of wastewater. As you have mentioned that from the domestic sector, the collected wastewater from industrial houses, the wastewater is passed through the sewer line and it is collected centrally in the STP, that is sewage treatment plant or it may be CETP where some other the wastewater from other industries after preliminary treatment can also be collected.

And then, industrial wastewater generated in the plant is collected in the ETP in the factory premise and treated completely or after initial treatment transported from manufacturing facilities to a CETP by tank truck or through a piping system, depending upon the volume of the wastewater generated in the individual industry, so this is collection.

Then preliminary treatment, so, eliminations of undesirable characteristics of wastewater received from the collection system, this is the main objective of the preliminary treatment and here screening and grates are there. So, to remove the bigger floating materials from it, so, the screens are used for that, and grates are used for the removal of heavier particles.

And comminutors for grinding of coarse solids and pre-aeration for odor control and some removal of grease, so this is a preliminary treatment. Then primary treatment, our objective is to settle some sort of dissolved solids and other organic compounds etc. So, removal of readily settleable solids prior to biological treatment that is sedimentation chambers, flotation and flocculation.

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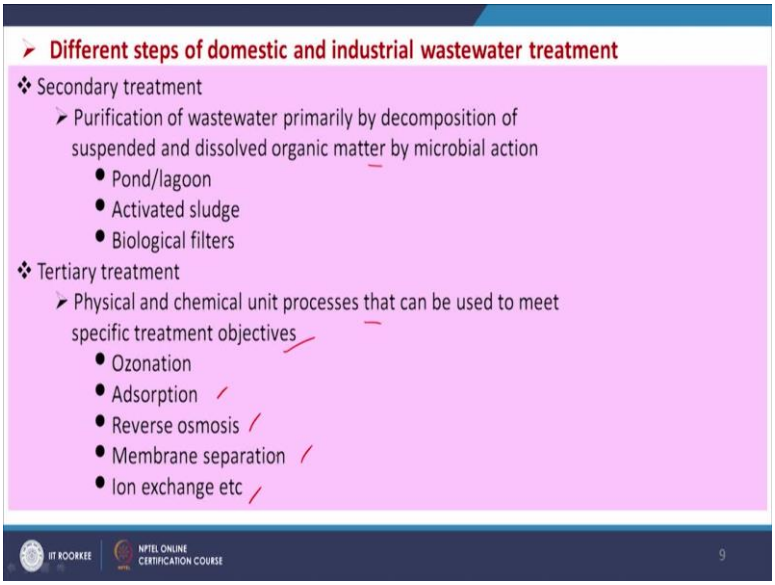

And then, next step is secondary treatment and purification of wastewater primarily by decomposition of suspended and dissolved organic matter by microbial action. So, like pond and lagoon, activated sludge and biological filters, these are very common system used for the secondary treatment.

After secondary treatment, water is passed through the tertiary treatment step. In this case, physical and chemical unit processes that can be used to meet specific treatment objectives like say ozonation, adsorption, reverse osmosis, membrane separation, ion exchange, etcetera. So, here very-very less amount of TDS can also be removed by this method.

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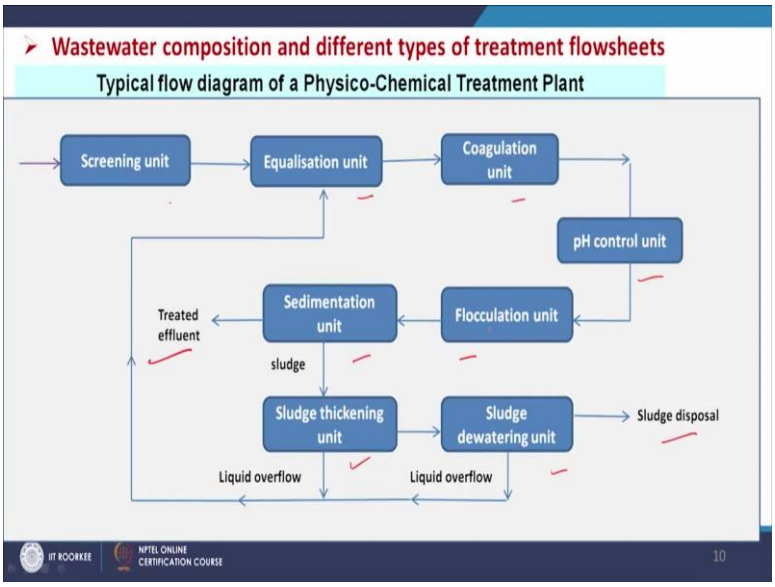

Now, we will discuss wastewater composition and different types of treatment flowsheets. As we are talking about the wastewater generated in domestic sector and industrial sectors so, the composition of this type of wastewater varies widely from industry to industry and from domestic to industrial sector. Somewhere organic content is very high, somewhere organic content is not that high.

So, when organic is not present, in that case secondary treatment may not be necessary. So, in some specific cases, we can use only physico-chemical treatment plant. So, where screening unit, the first unit, then equalization unit, then coagulation unit, and then pH control unit, then flocculation and then sedimentation unit.

Sedimentation will give us treated effluent and sludge will come, sludge will be from the bottom and then sludge will be thickened again and then sludge dewatering unit and sludge disposal and liquid which is coming out that can be again sent to the equalization unit. So, this is very-very simple flow sheet which can be used for the treatment of wastewater where organic content is not available.

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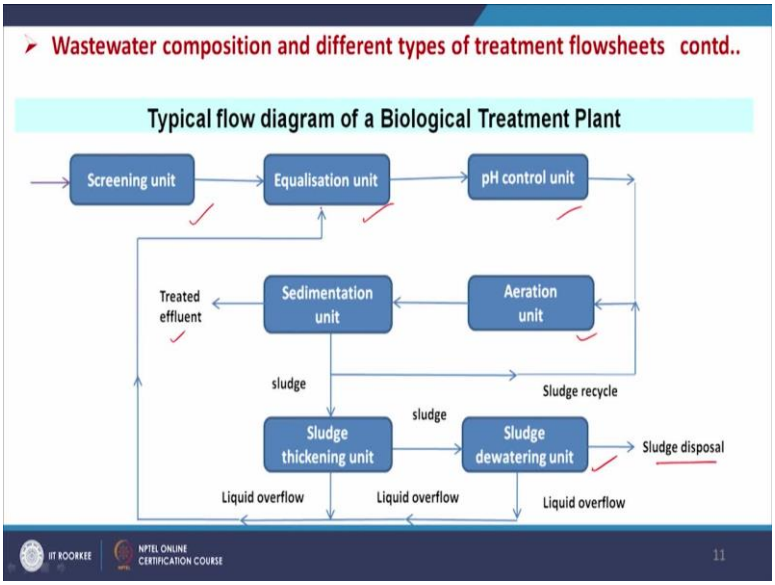

On the other side, if organic is present, but others are not available in excess amount in that case, we can use the biological treatment scheme that is screening unit, equalization unit, pH control, then direct aeration unit. So, like flocculation unit is not available, or coagulation, flocculation is not there. So, directly it is, we are giving some aerations, and microbial addition and then we are going for sedimentation unit.

So, this sedimentation unit will get treated effluent and then sludge will be coming out, sludge will again be thickened and then sludge dewatering will be taking place, so sludge disposal and liquid will be again sent back to the equalization tank. So, this is for biological treatment plant scheme.

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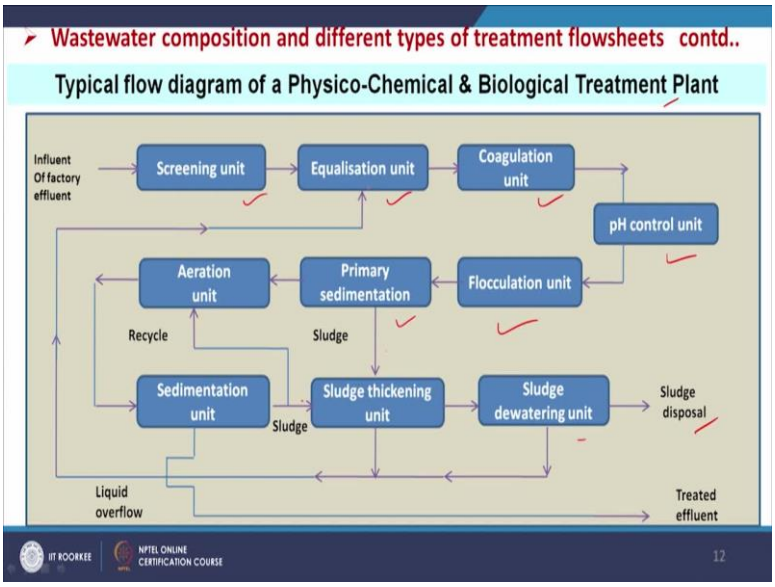

But, in most of the cases, in industrial wastewater and domestic wastewater contains both organic and inorganic contaminants and in that cases a physico-chemical and biological treatment scheme is implemented as shown in this slide. So, here influent or factory effluent is coming, first is cleaning, then equalization, then coagulation, then pH control, then flocculation, then primary sedimentation.

So, we are using primary sedimentation unit and we will be getting the primary sludge then which is going the supernatant here in the aeration unit. So, this secondary treatment starts here. So, secondary treatment, then it is coming here and again it will go to sedimentation unit and we will get secondary clarifier.

And then from this we will be getting treated effluent and sludge, this sludge and this sludge, secondary sludge and primary sludge will be thickened and then sludge dewatering will be there and sludge disposal will be there. And this water which is generated through the thickening of the sludge that will be recycled back to the equalization unit. So, this is the flow sheet, more comprehensive flowsheet and this is mostly used in industrial practices.

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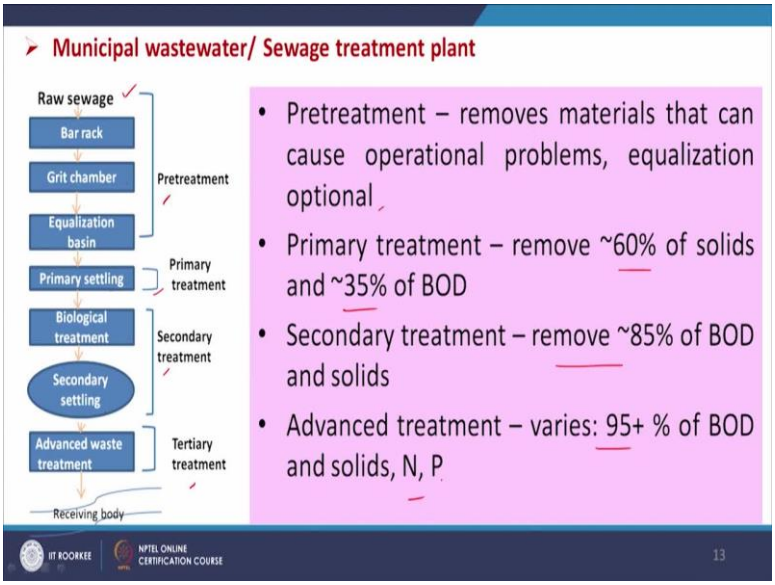

Now, this slide gives us some flow sheet, which discussions we have made that is briefly described here, like we have in case of municipal wastewater, we have raw sewage, so that will first go through bar rack, then grit chamber. So, bar rack for the removal of a larger floating materials and grit chamber is to remove the more high-density materials and then equalization machine is there to make the uniform concentrations of the pollutants in the mixture and to provide some air also in some cases and to remove odor etc.

And then, it is coming to primary settling. So, primary settling will be getting the primary sludge and then again it will go to biological treatment and then aeration unit and microbial addition and then it will go for secondary settling. So, this after the secondary settling, we will get secondary sludge and the supernatant will go for the advanced treatment that is called tertiary treatment. So, this your tertiary treatment, this your secondary treatment, and this is primary and this is pretreatment.

So, ultimately after this treatment, the water will go into the surface water that is receiving maybe river or lake or maybe agricultural land, anywhere it can be. So, we see pretreatment, primary treatment, secondary treatment and advanced treatments or tertiary treatments we can mention here.

So, there are different objectives, pretreatment, removes materials that can cause operational problems, equalization is optional. And primary treatment remove around 60 % of solids and around 35 % of BOD and secondary treatment removes around 85 % of BOD, then advanced

treatment further removes more BOD, that is 95 ± % and also removes the different nutrients like nitrogen phosphorus etc.

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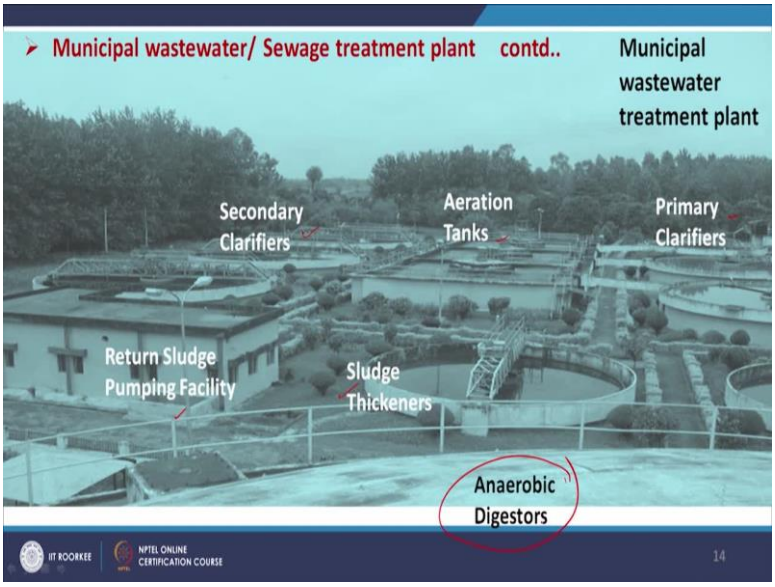

This slide shows us one photograph or a picture of a municipal wastewater treatment plant. So, different units we have like say, primary clarifiers, then aeration tank, then secondary clarifiers, then sludge thickeners, and return sludge, pumping facility and this is anaerobic digesters, this is basically to digest the sludge which is generated in the sewage treatment plant. So, by this anaerobic digestion, biogas can be produced and the wastewater which will be generated through this anaerobic digestion process can further be recycled to this stream in the aeration tank.

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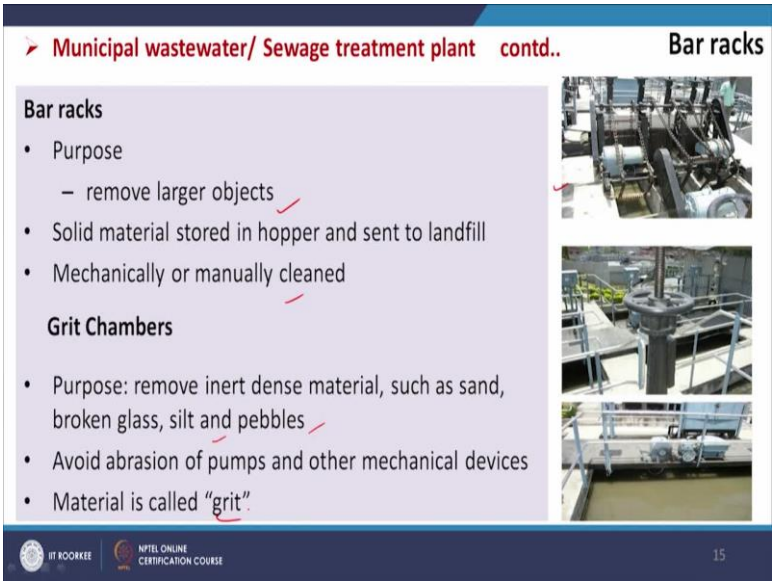

Now, we will see the role of different equipments like say bar racks as shown in this figure. So, these are the bar racks, so the purpose is to remove larger objects, solid material stored in hopper and sent to landfill mechanically or manually cleaned, these type of facilities are used. And then grit chamber, so grit chamber the purpose remove inert dense material such as sand, broken glass, silt and pebbles. Avoid abrasion of pumps and other mechanical devices. This material which is separated in grit chamber is called grit, this is basically a dense material.

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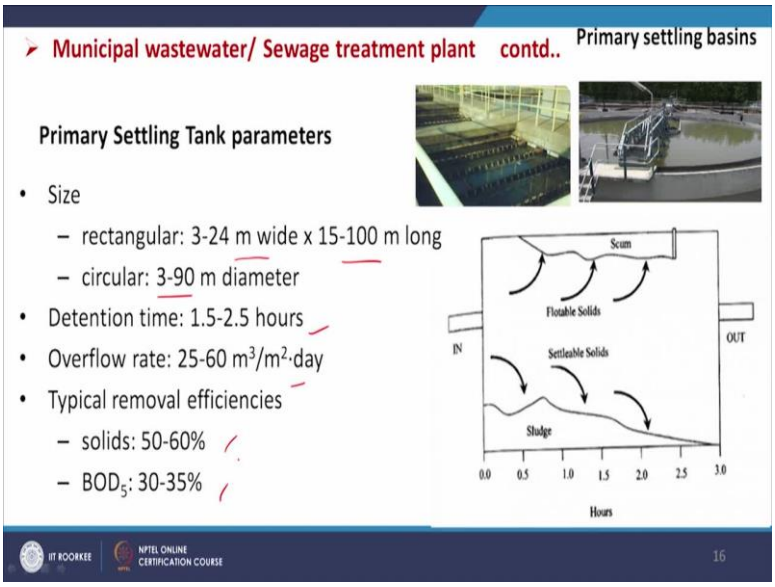

And primary settling basins or primary settling tank parameters the size normally 3 to 24 m wide and 15 to 100 m long, and that may be circular 3 to 90 m diameter, and detention time 1.5 to 2.5 hours, overflow rate 25 to 60 m^3/ m^2-day and typical removal efficiency solid 50 to 60 % and BOD_5, 30 to 35 that is the primary settling basin.

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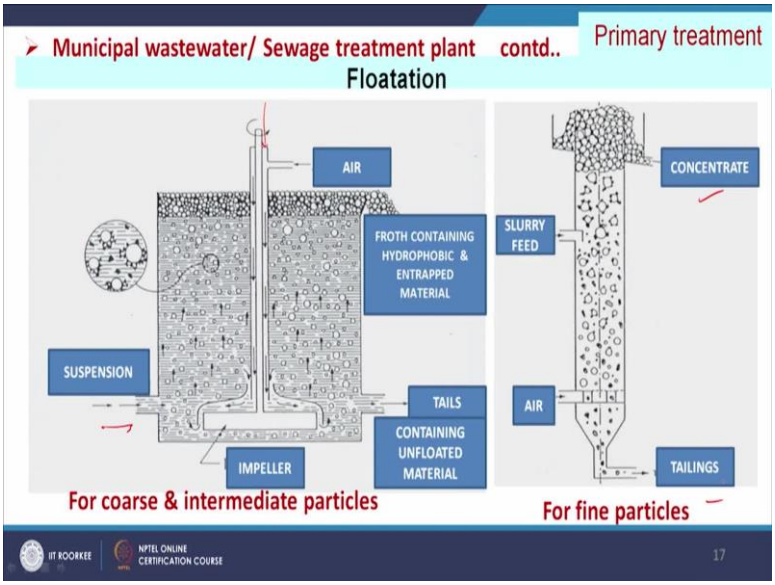

And we will see the flotation unit. So, floatation unit, our objective will be to remove the materials which are less dense so, that by the applications of air so, here we are providing air and here the suspension is coming, so air will be trying to make some layer at the surface of the particles and it will make more hydrophobicity, it will increase the hydrophobicity and it will help to rise the particles.

So, this type of arrangement is meant for coarse and intermediate particle separation and for fine particle separations air is send from the bottom, but slurry feed the middle or the top section. So, then the concentrate comes here and tailings we get here. So, this flotation is also used to separate the particles like say if we have oil materials, so, then its density is lesser than the water. So, that can be separated by using the floatation.

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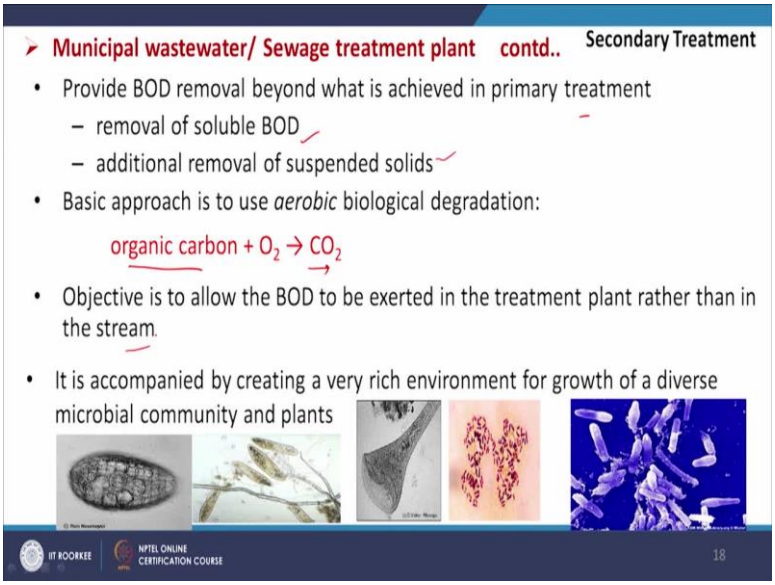

Then we will see the secondary treatment after the primary treatment, then the next step is secondary treatment. And the purpose is to degrade the organic compounds present in the wastewater and it provide BOD removal beyond what is achieved in primary treatment, removal up soluble BOD and additional removal of suspended solids these are the main objective of the secondary treatment. And then, basic approach is organic carbon will be converted to CO_2 and H_2O by the microorganisms in presence of oxygen.

So, organic carbon will be converted to CO_2 in presence of microorganisms with the help of oxygen. So, this is aerobic process, and objective is to allow the BOD to be exerted in a treatment plant rather than in the stream. So, it is expected that the most of the BOD will be eliminated from the wastewater in this step. And it is accompanied by creating a very rich environment for growth of diverse microbial community and plants, even algae can also be used.

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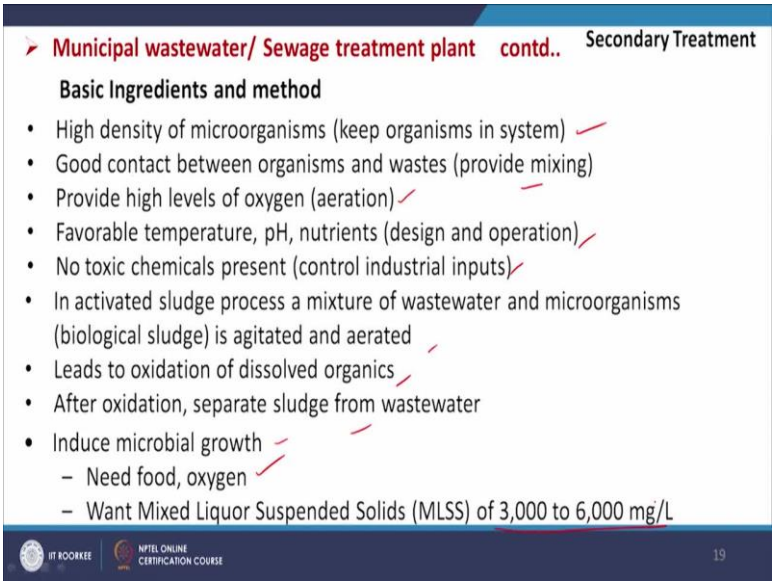

And basic ingredients and method if we think about the secondary treatment, then these are high density of microorganisms. So, we need to give sufficient microorganisms in the system, good contact between organisms and waste. So, we need to provide mixing that means aeration is done, that is why oxygen and mixing both are provided by the aeration, provide high levels of oxygen that we are talking about aeration is done. And favorable temperature, pH, nutrients, the microbes are very sensitive to temperature and pH, so that has to be maintained nicely.

No toxic chemicals present. So, if toxic chemicals present then microbial growth will be hampered. So, biological degradation of organic compounds will also be hampered, so, that is not desirable. In activated sludge process a mixture of wastewater and microorganisms is agitated and aerated, the same reason to provide sufficient oxygen and to get good mixture and good contact between organism and the organic compounds. Leads to oxidation of dissolved organics and after oxidation separate sludge from the wastewater.

So, the sludge can be separated from the wastewater. And we need to induce microbial growth. So, we need food and oxygen. And want mixed liquor suspended solids in the certain range. So, 3000 to 6000 mg/L it is shown but somehow it is 2500 to 4000 mg/L also works well.

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So, we can see here some picture. So, which shows the operations of the secondary treatment that is aeration unit. So, air is sent from the bottom and this type a big tank is used for the aeration purpose and for the biological degradation of the organic compound, it requires sufficient amount of aeration in tank.

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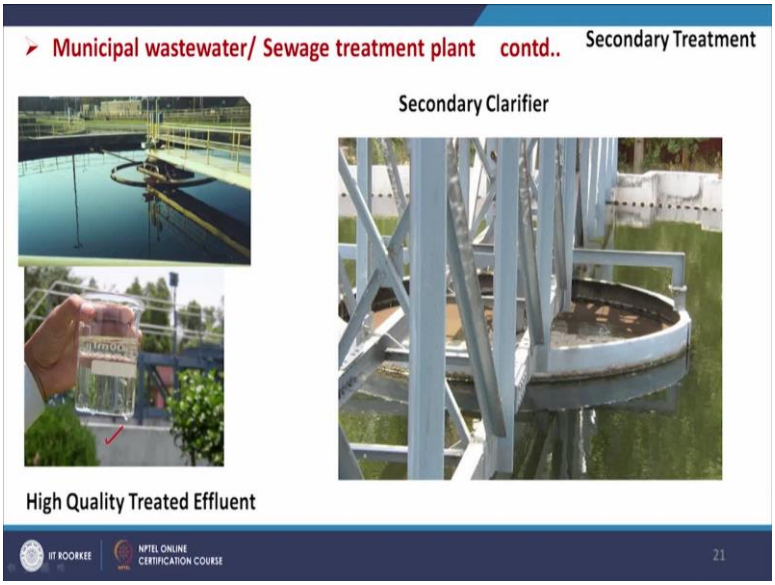

And then that is a aeration tank then it has to be settled. So, that we will be getting the sludge at the bottom and from the top we will get the clear water. So, these are the clarifier and here also clarifier, you see the water is seems to be very clear and this is high quality treated effluent as shown here. So, after secondary treatment, the turbidity of the water reduces significantly and it appears nicely as shown here becomes very clear.

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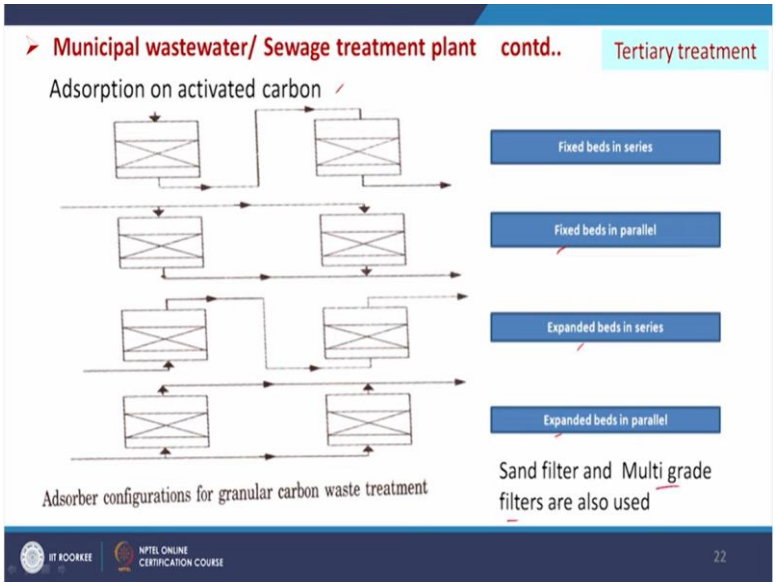

After that it the water is to be sent to the tertiary treatment, tertiary treatment is basically which is used in industry and wastewater treatment plant, domestic wastewater treatment plant that is carbon waste filters and sand waste or multigrade filters are used. So, as shown here adsorption on activated carbon, the very small amount of TDS or BOD which is available after the secondary treatment that can be further fine-tuned or can be removed here and these systems used as a polishing step.

And here, this is fixed beds in series. So, here water is coming from the top, from the bottom it is getting out and again enter the top and so number of units in the series, so fixed beds in series. Now, fixed beds in parallel, in both the units simultaneously water is getting entry and getting out from the bottom. Expanded beds in series, so, this is water is coming from the bottom and from the top it is getting out, again it is entering at the bottom and getting out from the top.

So, just the reverse of fixed bed in series, the expanded beds in series and similarly expanded beds in parallel, which is reverse to that of the fixed beds in parallel. So, these arrangements will give us some advantage and disadvantage as well, when we need more capacity, we can go for parallel arrangement, when we need more purity, we can go for these type of fixed beds in series or expanded beds in series. So, apart from this carbon activated carbon waste material, we can use sand or multigrade filters that means different materials can be used in the filter media.

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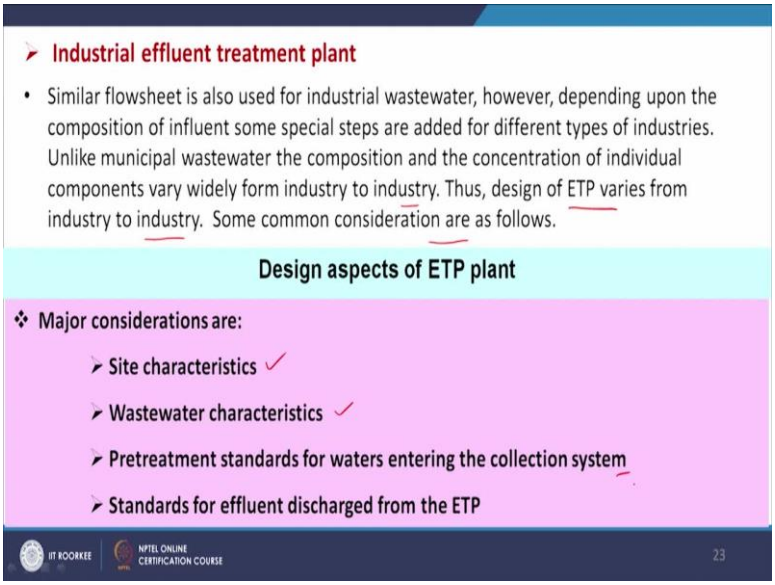

Now, we will see industrial effluent treatment plant. So, industrial effluent treatment plants also works on the similar principle of the sewage treatment plant having all the major steps, but there are the nature of the wastewater are very different from one industry to other industry and from the domestic wastewater also.

So, for the removal of specific pollutants, which are specific to the type of industry, specific arrangement is needed. And in this case, unlike municipal wastewater, the compositions and the concentration of the individual components vary widely from industry to industry. Thus, design of ETP varies from industry to industry. Some common considerations are as follows. So, if we are assigned to suggest some industry for the design or installation of ETP, then we should need to consider some facts.

For example, we have to consider the site characteristics. We need to consider wastewater characteristics, what are the characteristics of the wastewater, where is the site, whether the site is flood prone or not. So, in a particular premise whether it is lowland or not, so that we have to see the sites. And then pretreatment standards for water entering the collection system.

So, what is the pretreatment standards for waters entering the collection system? So, every system has some range or working capacity range we can say, you have to have some idea about that otherwise, if the concentration is very high we need to dilute it. So, standards for effluent discharge from the ETP again after treatment what will be the requirement in terms of the quality of the treated water that also we have to know before planning.

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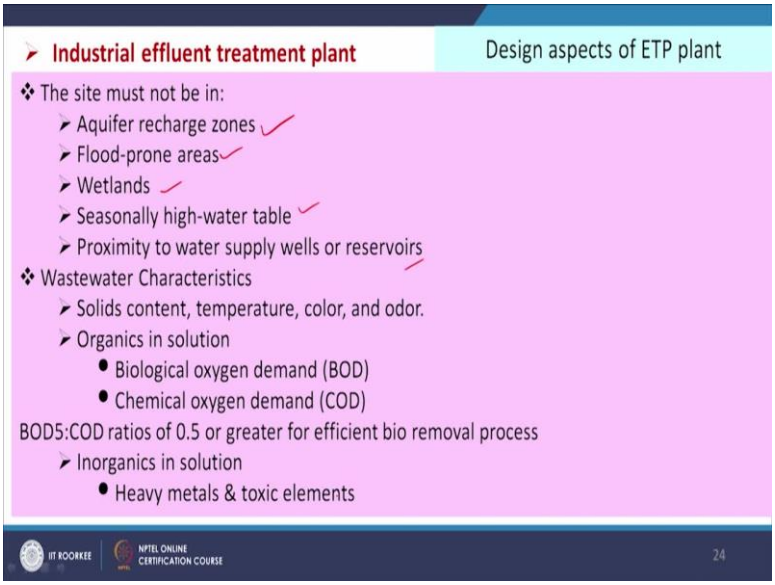

And then, that site must not be in aquifer recharge zones, must not be in flood prone area, it must not be wetlands and seasonally high water table should not be there. Proximity to water supply wells or reservoirs should be avoided and wastewater characteristics like solid content temperature color, odor we should know, organics in solution BOD, COD, what is the BOD, COD content?

What is the ratio of BOD, COD? If BOD, COD ratio is very high like more than 0.5, then it will be very good for the use of secondary treatment, if BOD, COD is less then we may need to add some additional step to increase the BOD, COD ratio. And we can go for bio-removal process after that.

Inorganics in solution, what type of inorganic are present we should know, that is heavy metals and toxic elements if available, we need to install some special step for the removal of those pollutants or we may need to use some specific microorganisms for the accumulations or the degradation of those toxic chemicals.

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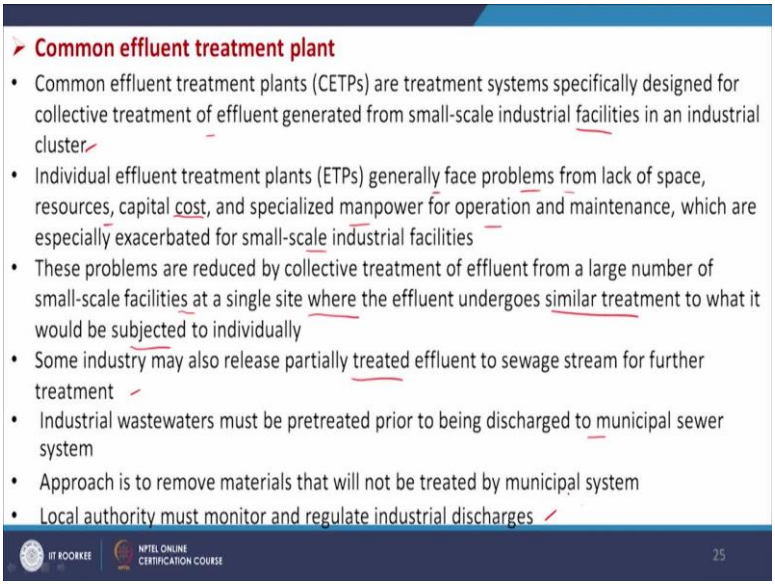

Now, we will see the common effluent treatment plant. So, common effluent treatment plant as you have already mentioned that these plants are treatment systems specifically designed for collective treatment of effluent generated from small scale industrial facilities in an industrial cluster.

Individual effluent treatment plants generally face problems from lack of space, resources, capital cost, and specialized manpower for operations and maintenance which are especially exacerbated for small scale industrial facilities. So, these problems are reduced by collective treatment of effluent from a large number of small-scale facilities at a single site where the effluent undergoes similar treatment to what it would be subjected to individually.

So, some industry may also release partially treated effluent to sewage stream for further treatment and industrial wastewater must be pre-treated prior to being discharged to municipal sewer system. Approach is to remove materials that will not be treated by municipal systems and local authority must monitor and regulate industrial discharges.

So, for the success of CETP, it is very-very essential that the local authority regulates it is very nicely so, there will be some tax impositions etc. So, the industry will make a optimum decision and the municipality will also be able to handle the sewage treatment plant or CETP in a nice way. So, up to this in this class. Thank you very much for your patience.