Wastewater Treatment and Recycling
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Lecture – 43
Tertiary (Advanced) Treatment of Wastewater

Hello friends and welcome to the ninth week of this course Wastewater Treatment and Recycling. So, we have completed so, far eighth week of discussions in which we primarily talked about the basics of the course, then the quantification aspect, the natural attenuation aspect, what is the characteristic, what is the quantity produced of the wastewater, then on terms of processing how we process that wastewater.

So, we did talk about the conventional treatment steps including from the preliminary primary and secondary treatment stages we talked. Last week we had discussions on the sludge management aspects. So, sludge which is generated from the primary and secondary treatment stages. So, how that is processed? So, our conventional treatment systems particularly in India majority of the severe treatment plants and in fact, most of the Industrial treatment Industrial wastewater treatment plants also. So, they go for many of these conventional steps depending on the availability and thereafter the water which is produced out of the secondary treatment units is usually disposed off to some nearby river or those kind of natural water bodies.

That is there again for almost one-third of the wastewater which is generated which receives some kind of treatment because as we discussed during the initial part of the course that majority of the wastewater which is produced almost two third of the wastewater which is produced does not get even the basic treatment does not even get the preliminary and primary or secondary these conventional treatment itself.

So, majority of the wastewater goes untreated, but even though the wastewater which are treated in this treatment facilities; particularly this domestic or municipal wastewater which are treated in the sewer treatment facilities or STPS that we have at present. So, majority of them in fact, are treated up to the conventional secondary stage of the treatment.

So, the process says that we have discussed. So, far are kind of designed and employed where the, we typically go for an activated sludge treatment process and then secondary settling and the effluent from secondary settling is usually disposed off to the natural systems. And the sludge which generate from primary and secondary settling facilities are then dried through some chemical treatment or at times stabilizes and then it goes to the sludge drying bed and eventually then discarded the dried sludge ok.

So, that is what typically happens in field, but that is not sufficient because when we are talking about say the bringing wastewater into circular economy bringing using wastewater as a resource. So, then we as the like this course itself talks about the treatment and recycling aspects.

So, when we intend to recycle the wastewater the effluent which is produced from the secondary treatment units up to secondary treatment units majority of the times they do not have attained a quality which can be like the water does not have attained that quality which can directly we be used for some purpose or which can be recycled ok. So that means, for the purpose of going recycling or for the purpose of reusing that water we have to have put some additional treatment or additional purification mechanism after secondary treatment. So, the purification or the treatment which is provided after secondary treatment is typically called tertiary treatment or we call that advanced treatment as well. So, that is what we are going to discuss this week the various approaches for tertiary or advanced treatment; so, essentially the tertiary treatment or advanced treatment. So, they are typically used as synonyms in wastewater treatment systems.

So, this tertiary treatment is the treatment level beyond secondary. So, that is why it is called tertiary because we had then preliminary then primary secondary and the next level of treatment is usually called tertiary treatment or this tertiary treatment it is a we call as advanced treatment as well.

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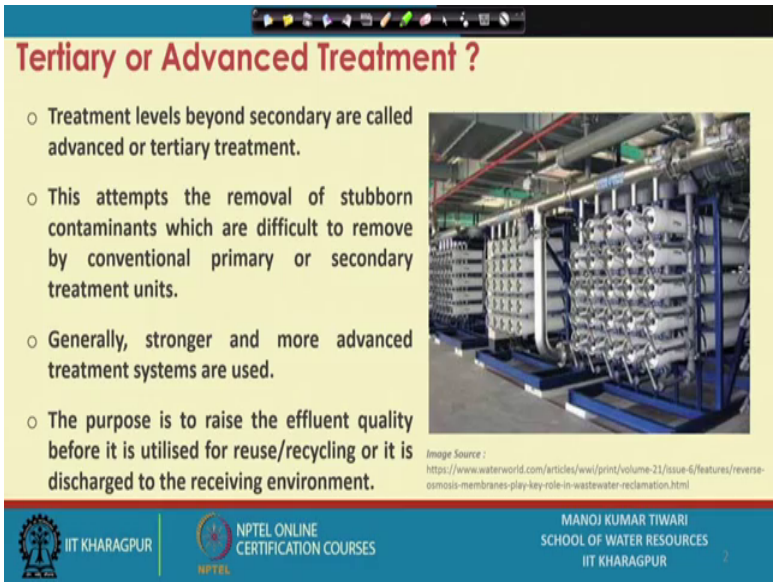

So, what it targets it attempts the removal of various stubborn contaminants which are difficult to remove by the conventional primary or secondary treatment units. It is generally like stronger and more advanced treatment systems are used for this the purpose of this treatment or this level of treatment is mostly like make the water effluent what are suitable for utilizing it for any particular designated reuse or recycling applications ok. Or even if we want to discharge it is to say receiving environment we ensure that at least some problematic elements for discharge purpose we do not need to go water to a let us say the super advanced treatment systems like reverse osmosis or those kind of thing is not needed for the water which is going to be discharged in the environment.

But of course, some tertiary level of treatment at times may require even if the idea is to discharge the water to the receiving environment. So, like what kind of treatment may be required we may our conventional systems works on the removal of soluble organic matters, but nutrients are not removed in most of the conventional treatment systems for removal of nitrogen we need a larger aeration period extended aeration period is needed which typically is not provided. So, removal of nitrogen phosphorus those kind of things are very little up to secondary stage. Even if you want to say discharge or water to a pond or to a lake and we are loading lot of nitrogen and phosphorus. So, it may Eutrophic the lake. So, there like lake system- may turn to Eutrophic and there are lot of algal bloom

and those kind of things can be like can appear as a consequence of the discharge of the sewage after secondary treatment.

So, for even for the discharge purpose if we are having those kinds of things, so, we would like to remove at least the nutrients. If not go to a RO level or not go to the removal of the complete dissolved solids, but at least the nutrients or those kind of things need to be removed which is a kind of advanced stage or tertiary stage treatment.

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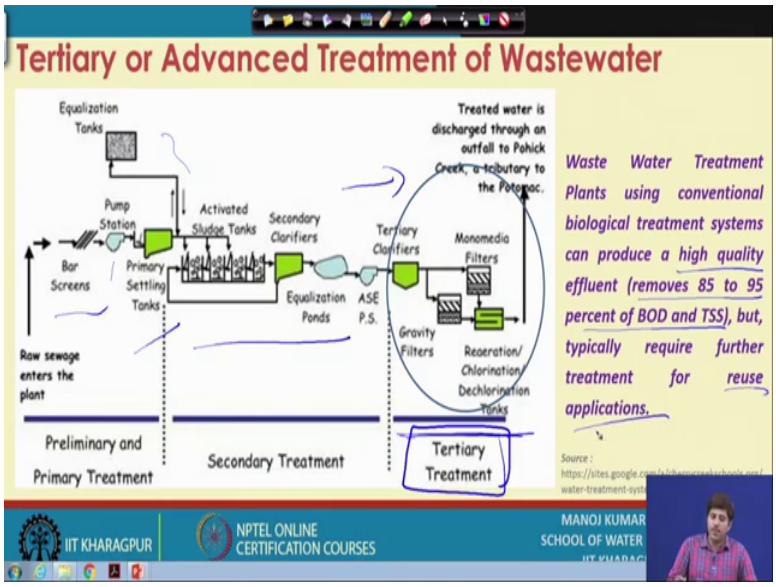

So, that is what is tertiary treatment. Now if we see the traditional wastewater treatment facilities the STP that we get. So, we will have this bar screen then grid removal or equalization tang may have then we have primary settling and activated sludge process. So, from here onwards this point forwards whatsoever treatment procedure is adopted is called tertiary treatment. Ok. So, that is what tertiary treatment is now this wastewater treatment plants using these conventional biological treatment systems can produce a very good quality means up to around 9 85 to 95 percent removal of BOD and suspended solids can be achieved, but typically require further treatment if you want to go for reuse applications because of the stringent water reuse quality which is mentioned by the regulatory authorities.

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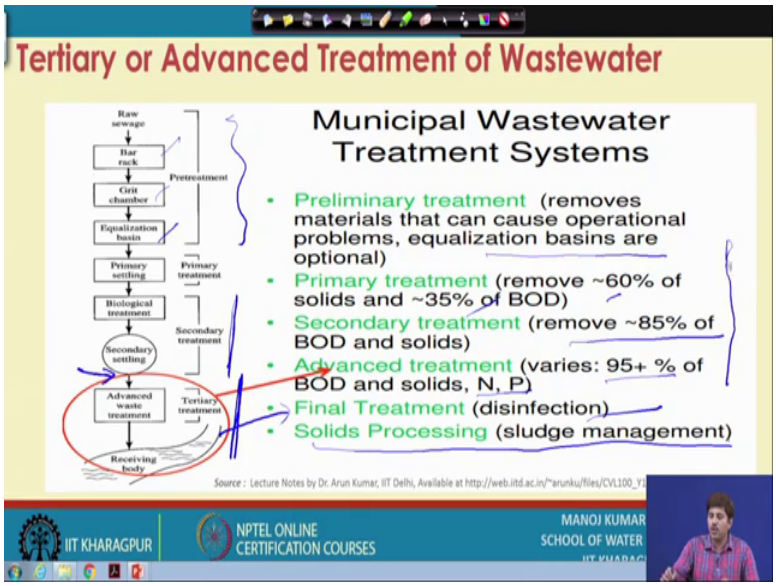

So, those requirements enforce to go for the higher level of treatment; if we see the typical municipal wastewater treatment system. So, the preliminary treatment which removes the materials that can cause operational problem and we may put equalization basin as an optional step if needed. So, your bar racks grit chamber equalization these could basically be your the basic level of treatment, then the primary settling removes almost 60 percent of the solids and 35 percent of the BOD is removed. So, the particulate BOD mores over the BOD which is in the suspended form or the particulate form that will get removed in the primary settling or primary treatment stage ok. So, the overall water you will see that almost 60 percent of the suspended solids and 35 percent of the BOD is removed. Then when we bought this water to the secondary treatment or biological treatment followed by the secondary settling or activated sludge followed by the secondary settling, so, we get the removal of around 85 percent of the BOD and similar order of the similar order of the removal of the solids is also achieved.

So, thereafter we after secondary treatment; that is, when we basically venture into the next level of treatment which is advanced treatment or tertiary treatment. So, this advanced or tertiary level of wastewater treatment the kind of removal varies of the order of 95 percent plus for the BOD and solids and various nutrients as well ok. And then we can go for disinfection many times. In fact, disinfection is also considered as the advanced treatment as a component of advanced treatment that way ok. So, that will be there and then of course, the solid processing which we discussed last week is for the

purpose of sludge management. So, these are the things that take place in a typical municipal wastewater treatment systems and that is how kind of we see the different degree of removal of the different treatment systems.

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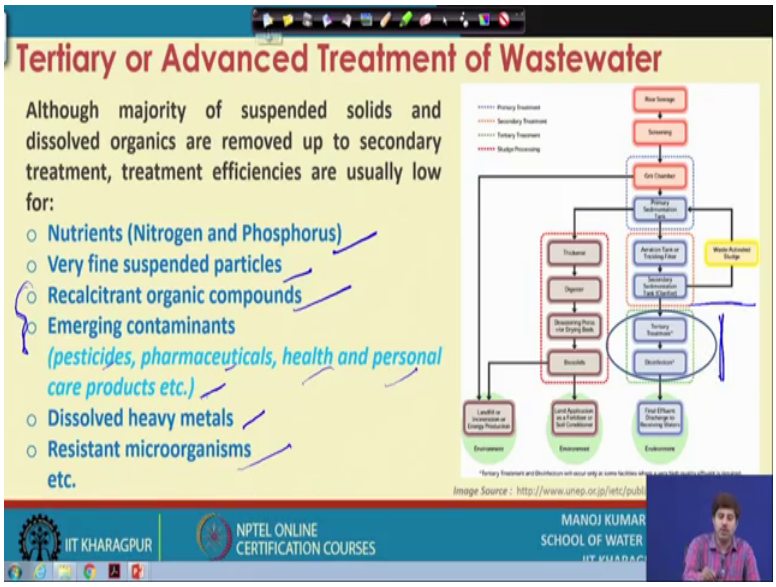

Now,. So, if we see the kind of what is the major things that advanced treatment targets. So, the removal of the suspended solids and dissolved organics are achieved kind of in the secondary treatment process as we have been saying and the however, the treatment efficiencies in the secondary treatment processes are low for nutrients. So, nutrients are typically not removed then very fine suspended particles are typically not removed various recalcitrant organic compounds. So, the compounds which are very difficult to degrade which are recalcitrant or the persistent compounds; so, they also are not removed in the up to secondary treatment systems very low efficiency for removal of these various emerging contaminants. Again many of these emerging contaminants also falls under this category.

So, you can say that way you can club these may be ok. So, various emerging contaminants in the form of let us say pesticides pharmaceuticals coming in the water these days we use lot of household health and personal care products lot of cosmetics those kind of thing are also there in the water and they are very difficult to kind of naturally degree. So, that those kind of thing or those material may still be present in the wastewater coming out of the secondary treatment systems the dissolved heavy metals

and more. So, in the industrial effluents; so, industrial effluents have lot of heavy metals depending on the processes being taken place in the industry.

So, those things will retain still and various resistant micro organisms resistant bacteria or microbial species may also represent in the system. So, these things are not removed up till secondary treatment system and we target the tertiary treatment and disinfection or advanced treatment systems for handling or for removing some of these impurities.

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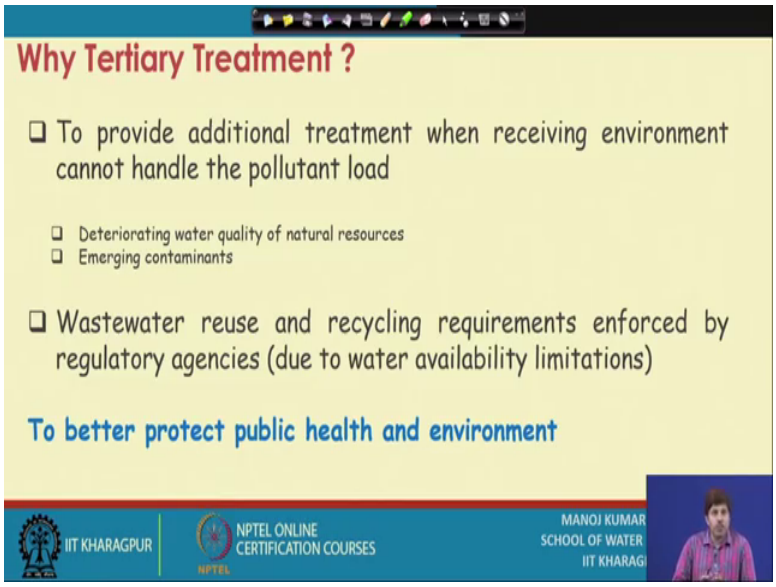

So, why we go for tertiary treatment that is what we have been discussing. So, objective or idea of tertiary treatment idea of going for tertiary treatment is to provide additional treatment additional degree of treatment to various contaminants which are there in the water.

So, that the receiving environment can handle the pollutant load which is being put on them; so, if there are let us say higher degree of nutrients present. So, you are receiving environment may not be able to handle those kind of thing ok.

If you are having emerging contaminants present in the water; again your water body or river or pond or lake will not be able to deal with those recalcitrant various emerging contaminants. So, these are the major issues. So, basically kind of looking at the deteriorating water quality of the natural recourse says various emerging contaminants being discharged into the nature through these means of wastewater or what we call what

we may call as like secondary treated wastewater even or the partially treated wastewater. So, these kind of things create problem in the natural systems our nature is not able to deal with these pollutants. So, it is better to get rid of these pollutants at the wastewater treatment facility itself. And that is why in order to deal with these elements as we were discussing that variety of these things which are not treated well up to the secondary level if you want to remove them if you want to deal with them if you want to treat them we have to go for the advanced level treatment or tertiary level treatment.

So, that is why we should go for tertiary level treatment when we see the disposal prospective when we are talking about the disposal of water into the natural system; so, because our natural system will not be able to deal with these contaminants. So, it is better that we prevent with these contaminants entering into the nature and how can we prevent that we can prevent them by treating them or removing them at the level of the wastewater treatment facility itself. And that is why we should go for the tertiary treatment steps. The other idea is that wastewater reuse and recycling requirements which are enforced by the various regulatory agencies also kind of force the wastewater treatment facilities or the operators to go for the advanced treatment this is not that much in India because as we said that our major water majority of the water is not even getting the basic level of treatment. So, forget about the advanced treatment, but in many western countries or many places that where there is a kind of enforcement that you have to reuse or recycle your wastewater which is nowadays coming in the India also. So, in particularly in the metros were like the multi story apartments are coming in. So, there is regulations or there is far for them.

So, that they if they set up treatment facility in the complex itself and recycle the wastewater. So, those kind of incentives incentivization or those things are coming actually in the field in India as well. So, that is one of the motivation for going for tertiary treatment we can say ok. So, we know that there are water scarcity issues water availability limitations are there or resources are getting depleted the quality of resources is getting depleted we are not getting sufficient water particularly in the dry weather seasons we see that draught here and there every other year couple of years back it was very severe drought in the Maharashtra Lathur or those places Rajasthan faces draught almost every year. So, Maharashtra Rajasthan Andhra those belts particularly are very draught pound. So, because of the issues of the freshwater availability limitations of the

resource says it is kind of quite a motivational thing to use the waste water as a resource. And if we want to use waste water as a resource if you want to go for reuse or recycling of the waste water.

So, there are regulatory enforcements that if you want to say reuse that water for irrigation purpose or for horticultural purpose or for some other industrial purpose. So, we have to treat this water to certain levels and those certain levels can only be achieved by tertiary treatment because our traditional conventional treatment systems up to secondary system may not be able to kind of produce the desired quality of water from the wastewater up to secondary level treatment.

So, that is what another kind of motivation the reuse and recycling for purpose. So, these are the two major motivations which kinds of forces to go for a tertiary level treatment the whole idea is to bet kind of protect the public health and environment in a much better way. So, if we see the specific objectives of the tertiary treatment ok.

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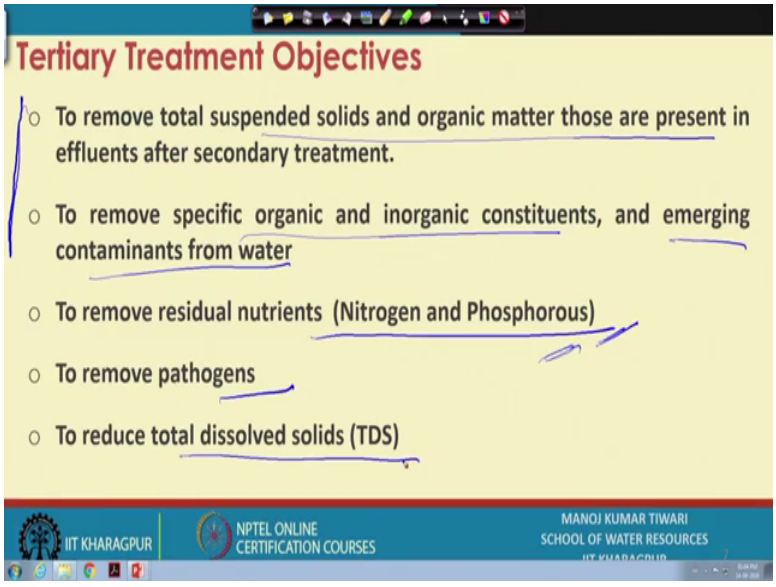

So, the specific objective is the removal of those things which are not removed till secondary level right.

So, that is what the objective of treatment anyway. So, the objective of treatment is the purification of the water or kind of removal of the contaminants from the water. So, those contaminants which has been removed till secondary stage are fine, but whatsoever

contaminant still persisting the contaminants which has still not been removed for them we need to go for a tertiary level treatment.

So, the removal of suspended solids and organic matters those that are still present in the effluent after secondary level treatment they should be removed. So, that is one of the objective of tertiary treatment then the removal of specific organic and inorganic constituents whatsoever are they are present in the water and the emerging contaminant which are which are present in the water.

So, removing those from water those various organic specific organic or inorganic constituents and emerging contaminants present in the water they needs to be removed through tertiary treatment. So, that is one of the objectives the removal of residual nutrients nitrogen and phosphorus particularly is again one of the objective of tertiary treatment which is more; so, ever for the disposal purpose ok.

These are more. So, for the reused purpose, but this is for disposal purpose if we want to reuse our wastewater for agricultural purpose we may not bother too much about the nutrient removal, but if you want to dispose that to a water body and particularly the static water body which is quite prone to eutrophication.

So, these things can actually destroy the ecology of the body through this algal bloom or eutrophication to remove the pathogens. So, that is another objective and to reduce the total dissolved solids. So, the TDS which is maybe they are in significantly high concentration should also be removed through the tertiary treatment. So, that becomes one of the other objectives of tertiary treatment systems.

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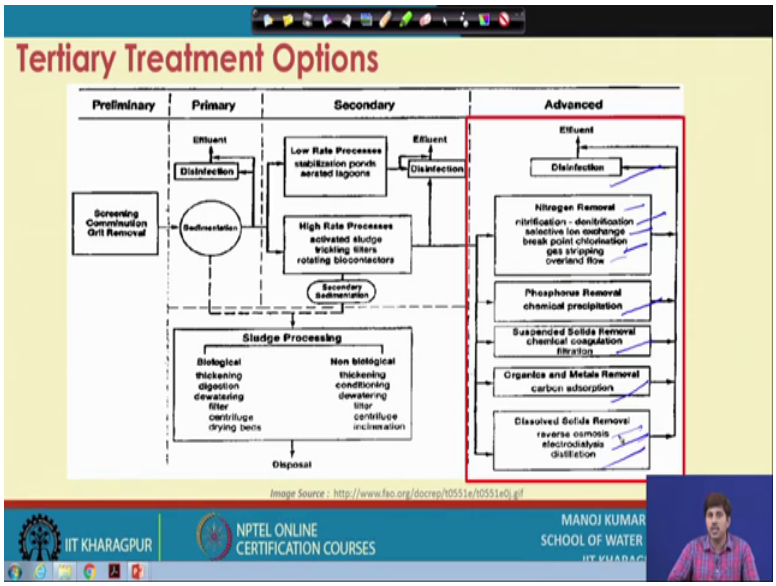

It so, if we see the various treatment options for advanced or tertiary treatments. So, again there are kind of variety of processes there is disinfection for the removal of microorganisms the nitrogen removal could be achieved by nitrification denitrification or selective ion exchange or kind of chlorination gas stripping.

So, all these are approaches for nitrogen removal phosphorus removal is usually done for chemical precipitation there are biological phosphorus removal methods also exist though and can be used then there is suspended solids or the fine suspended solids. So, they can be removed through chemical coagulation or filtration processes there are organic and metals they can be removed by the adsorption process or adsorption on the activated carbon and the dissolved salts various dissolved salts which are present in the water they can be removed through reverse osmosis electro dialysis or distillation processes. So, that way there are like these are different processes there are we can see from other sources also.

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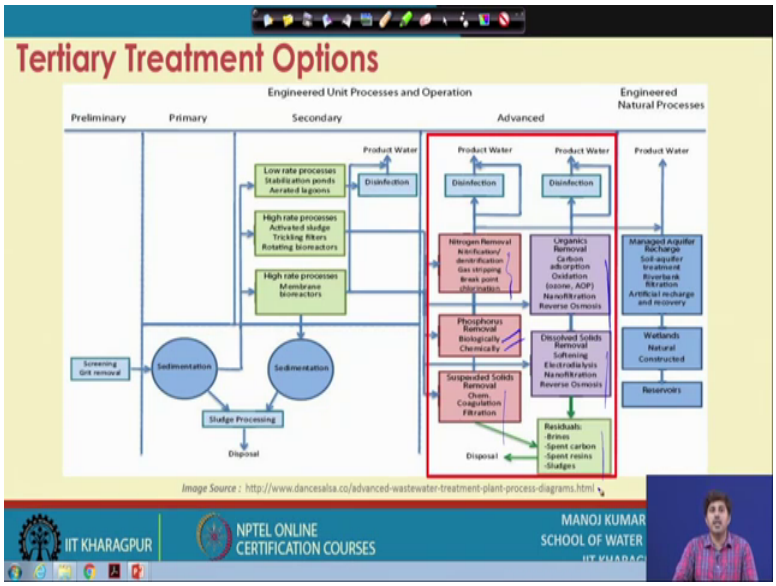

So, many such process will be there for nitrogen removal again nitrification denitrification gas stripping those things phosphorus removal can be biologically chemically suspended solids dissolved solids organic matter removal residual removal.

So, that way, there are varieties of processes which can be used for the treatment of the wastewater coming out of the secondary level as the advanced treatment unit.

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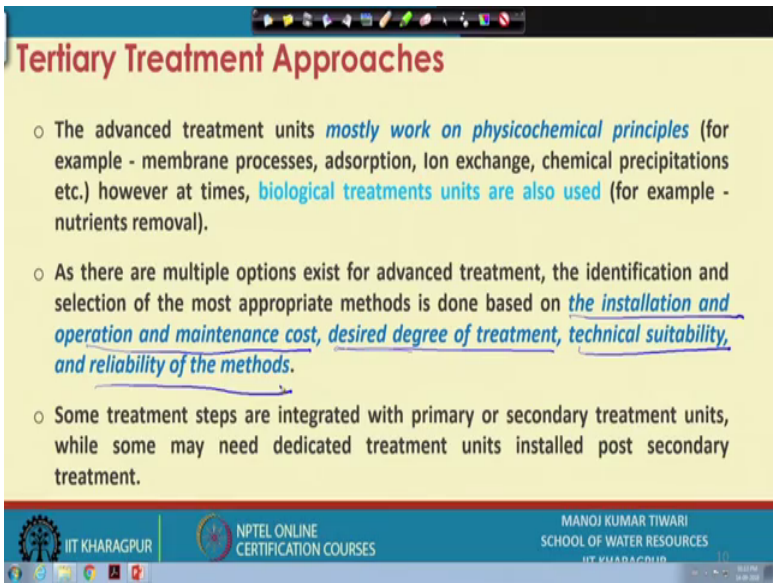

So, if we see the tertiary treatment approaches what are the various approaches for tertiary treatment? So, as we say just saw that there are actually several methods exist for

the treatment of some of the pollutant ok. If you just can have a overlook again. So, like for say nitrogen removal we can go for nitrification denitrification we can go for gas stripping. Similarly for organic removal we can go for adsorption we can go for oxidation advanced oxidation processes through ozone or something we can go for nanofiltration reverse osmosis. So, dissolve again through softening electro dialysis nanofiltration reverse osmosis. So, particular type of contaminant or a particular kind of form of contaminant can be removed through different options ok. So, we have like in case of biological treatment also we discussed that for the removal of dissolved organic we can go for say activated sludge process we can go for trickling filter we can go for rotating biological contractor we can go for anaerobic processes and there are few more as well which we will discuss in the next week when we go for the kind of integrated treatment schemes which are used these days.

So, that way there are variety of processes for the removal of specific type or kind of contaminant and same is seen in the advanced treatment process as well for say for removal of dissolved salts whether we go for electro dialysis we go for reverse osmosis we go for distillation process for the removal of various organics we go for dissolved organics or recalcitrant organic compounds we go for adsorption we go for again nanofiltration we go for reverse osmosis. So, there are options available for treatment of different type of contaminants. Now how do we decide which approach is to be adopted how do we take a call ok. So, the advanced treatment units mostly work on majority of these advanced treatment units if we see mostly work on the basic physicochemical principles and processes ok. For example, membrane filtration training and kind of letting the water pass through the filter under pressure. So, primarily physicochemical processes the adsorption is a physicochemical processes an exchange again specific type of adsorption can chemical adsorption or a physicochemical process that way we have chemical precipitations.

So, majority of that process are of physicochemical nature, but at times we go for biological treatment units also and for example, nutrient removal. So, for nitrogen removal like nitrification and denitrification or for phosphorus removal the biological phosphorus removal are there. So, there are approaches of the kind of biological there are approaches which work on a biological principles as well. So, they also can be used, but

predominantly its physicochemical of kind of treatment options the majority of unit or majority of options we have are of the physicochemical nature for advanced treatment.

So, as there are kind of multiple options exist as we were just seeing that for one specific type of contaminant removal we can have multiple options for advanced treatment as well. So, the idea like one needs to basically able one be one should be able to identify the most appropriate method one should be able to distinguish and select the most appropriate method based on several criteria's and what could be those criteria's those criteria's could include the installation and operation and maintenance cost.

So, that becomes the first criteria because once you are going for say selection of a method. So, you have to see your pocket as well what is your budget of course, RO gives you the best water quality right, but does your budget permit it because it is a quite cost intensive process there is a high installation cost there is a high operation and maintenance cost. So, does like the cost permit does your budget permit that for going for RO system or that advanced system. So, the installation and operation and maintenance cost would be a criteria then desired degree of treatment would be another criteria. So, like do as we were saying that RO can actually provide the best water quality in terms of the treated effluent, but do we need that kind of water quality if you are planning to use that water for irrigation purpose. So, what is the point of processing that water to a RO system what is the point of removing all the dissolved solids and those kind of thing what harm it is going to do to your kind of agricultural system or soil anyway ok.

So, that is why one has to basically make a call on what is the desired degree of treatment if you are if you want to say use water for agricultural purpose or irrigation purpose why do we need to go for nitrification denitrification process? Ok if little nitrogen little nitrate and for like phosphorous compounds are added to this while with along with the irrigation water that is. In fact, good because that will reduce your fertilizer requirements we anyway add lot of nitrogen and phosphorous in the form of fertilizer to agricultural soils.

So, there is absolutely no need for kind of complete removal of nitrogen and phosphorous if we are going to go for the say your agricultural reuse options or irrigation purpose ok. So, depending on the target reuse option where we want to reuse it or what is

the application if you want to dispose water you have to go for removal of certain kind of things you may not need to like for complete removal of say various organic compounds or complete removal of all the kind of dissolved metals for disposal water if you want to reuse that water say for industry. So, you have to ensure its kind of like properly desalinated water because that can cause lot of problems if you are using in the boiler or. So, scale formation those kinds of issues will come.

So, in order to avoid that or you know like in order to see what are the my final requirement what degree of treatment I need. So, that will be one of the governing aspect for selection of the treatment approach then of course, there are other things like how technically suitable the method is what is the reliability of the method it may be very good method, but not reliable because it again depends on the various environmental and climatic conditions as well you choose a method which may not work at lower temperature and install in a place at where the temperature often remains very low. So, may not get a good degree of removal. So, how scientifically reliable the system is or how scientifically viable the system is. So, that also needs to be checked for when we go for kind of finalizing the approach for the tertiary treatment steps.

Some treatment steps out of these tertiary treatment are actually done as a separate or done as an independent unit post secondary treatment systems whereas, quite a few tersely treatment steps not quite a few tertiary treatment steps are actually integrated with either primary or secondary treatment levels. So, for say if you want to go for nitrogen removal through nitrification denitrification; so, there is option that you can have post secondary treatment a nitrous like a different nitrification system, but it can be integrated to the like your existing conventional activated sludge process ok. So, then we can kind of have single stage nitrification where the removal of CB O D or the carbonaceous BOD and NBOD or nitrogenous BOD are both done together ok.

So, the nitrogen removal also takes place in the same tank. So, we can integrate that to these thing or same way through like adding some chemical doses before primary sedimentation or those kind of places we can remove some of the finer solids or those kind of thing as well.

So, there are processes which can be integrated with the primary or secondary treatment steps as well although they are tertiary level they are not usually employed in the

conventional treatment system. So, that is why we call them a tertiary level treatment, but then there are quite a few processes like if you want to go for any of these advanced treatment systems which works on majority of these like say adsorbent column and ion exchange removal ion exchanger system or some say membrane filtration units. So, then we have to go for with the affluent of the secondary treatment and have installed a dedicated unit for this kind of tertiary treatment stuff ok. So, that is how we kind of that is that is the kind of approach we basically adopt for the treatment of wastewater coming out of the secondary treatment system.

And we will conclude this lecture here and in the upcoming lectures of this week then we will discuss these different treatment options the removal of these different treatment impurities like these nitrification denitrification ion exchange adsorption various membrane processes in the subsequent week.

So, thank you for joining and see you in the next class.