Wastewater Treatment and Recycling
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Lecture - 61
Course Summary

Hello friends and; so, we have discussed in the last 60 lectures about the different aspects of this course Waste water Treatment and Recycling and since we have concluded with our major discussions. So, I thought of kind of providing a review or a summary of the entire discussions that we have over last 12 weeks.

So, this is divided into two lectures which is in the first one; we will discuss the summary of the discussions from week 1 to week 6; whereas, the letter 6 weeks discussions will be done in the next lecture.

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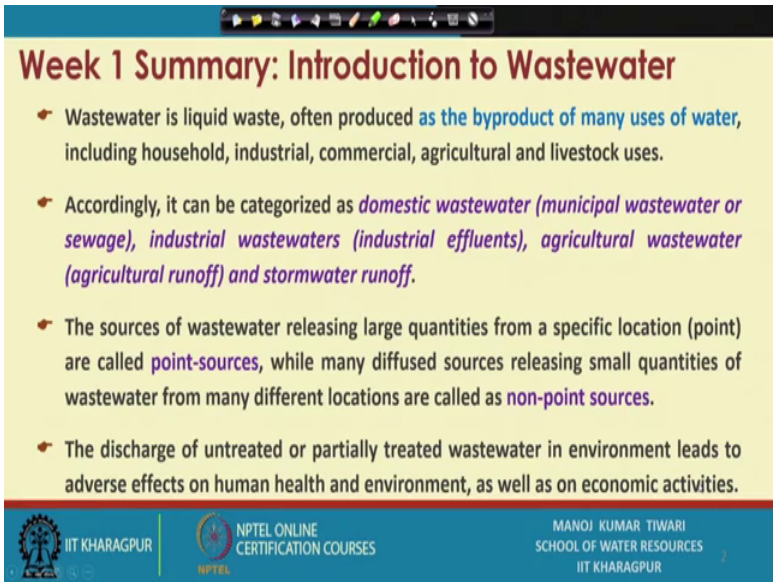

So, to begin with we started this course with our discussions to the basic introduction to the wastewater. So, wastewater is actually a liquid waste which is often produced as a byproduct of many uses of water which could include household, industrial, commercial, agricultural and livestock uses; accordingly we categorized wastewater. So, the wastewater can be categorized as domestic wastewater, which is also known as municipal wastewater or often people just call it sewage or there is industrial wastewater, which is also known as industrial effluents, then agricultural waste water or agricultural

runoff we call that or stormwater runoff. So, the source of the waste water releasing large quantities of waste from a specific location is termed as point source.

So the point source is something where basically a large quantity of waste is discharged at just one particular identifiable point. Whereas, if there are many diffused sources for say the example of agricultural runoff or urban runoff; where the wastewater the entire volume of the wastewater is not concentrated at just one single point, but has many different channels, many different pathways to get introduced in the nature. So, those kind of sources are called non point sources.

So, the kind of like municipal sewage or industrial affluent they are usually discharged from a specific point. So, they are the examples of point sources where as we discussed that agricultural runoff, urban runoff those are the prominent sources for nonpoint pollution in the wastewater in the water. Then discharge of the untreated or parsley treated sewage into environment will lead to various adverse effect, which could be on the you affect on the human health, effect of than the environment.

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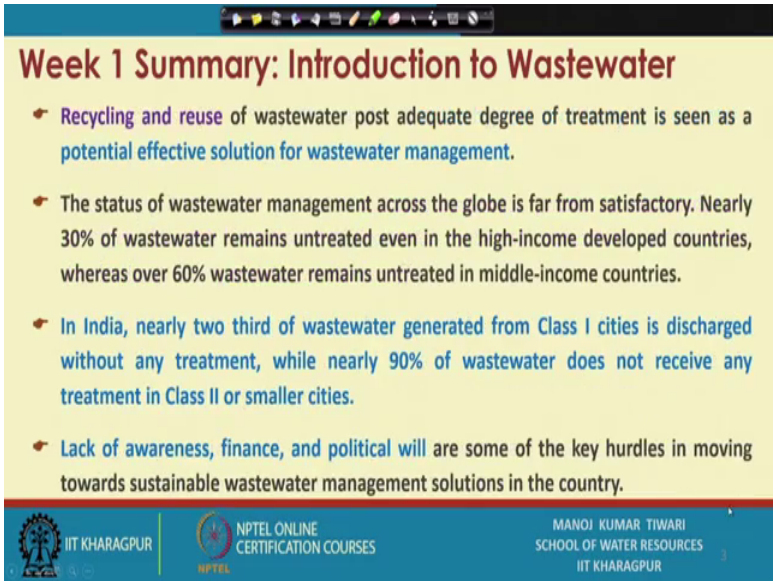

As well as there are basically the economic activities also get suffered because if the water is polluted; obviously, the kind of economic development taking place in that area or in that region will not be of that quality, which can take place in a reason fed with the clear or clean water in it is kind of rivers or streams or channels.

So, we also talked about the basics of recycling and reuse as one of the potential solution. So, the recycling and reuse of wastewater post adequate degree of treatment is perceived as kind of effective treat; effective solution for wastewater management. We discussed the status of wastewater management which is if we see the global status.

So, nearly 30 percent of wastewater remains untreated even in the high income developed countries; whereas, over 60 percent wastewater remains untreated in middle income. We discussed that in fact, the lower middle income this number is over 70 percent whereas, upper middle income this number is over 60 percent and in the underdeveloped countries it is actually close to 90 percent.

So, we did we discussed about these status of wastewater generation and treatment that we get in the Indian cities. So, class I cities here almost two third of water goes untreated just around one third of water gets some sort of treatment; that is also may not be completely adequate because often it is just primary or secondary level treatment is provided.

Whereas, in the lower cities class II or smaller cities more than 90 percent of the wastewater does not receive any treatment, there is lack of awareness, lack of financial resources, lack of political wills which are kind of the major challenges kind of key hurdles in moving towards the sustainable wastewater management solutions in our country.

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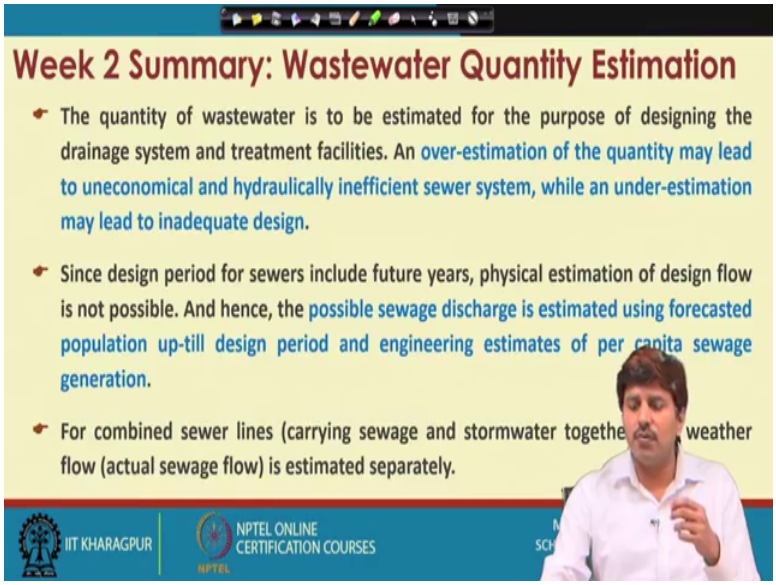

In the week 2 we had discussions over the quantity estimation of the wastewater. So, the quantity of the waste water that we estimate is essential for the purpose of designing the subsequent facilities, designing the drainage system, designing the treatment and planning reuse if you want to do some reuse application. If we overestimate the quantity, it is going to be kind of uneconomical and hydraulically inefficient sewer system; if we underestimate we are going to again go up with the inadequate design.

So, those are the issues with under estimation and over estimation; since the period of sewers are or whatever wastewater management facilities we come up with it is either treatment systems or sewerage systems; we usually design it for some future years. And because we are trying to like have a design period which covers say next 30 to 40 years or so, so that that and for that futuristic time; it is very difficult to get the correct estimate of the sewage that will be generated during that period.

So, there are kind of engineering estimates are done for the per capita sewage generation which is usually based on the per capita water consumption and then what is going to be the population in during that time. So, if your design period is say 30 years; so what is going to be the population at the end of 30 years that requires some sort of population forecasting.

So, based on those population forecasting method we can first predict the population and then we can actually have a robust engineering estimate of the per capita sewage generation. And if you multiply that population with per capita sewage generation we get an idea of the amount of sewer generated. If we are planning to go for combined sewer lines; it is important that we estimate dry weather flow also which is the actual sewage flow; whereas the total flow in combined sewer lines will have stormwater as well as the wastewater or sewage both.

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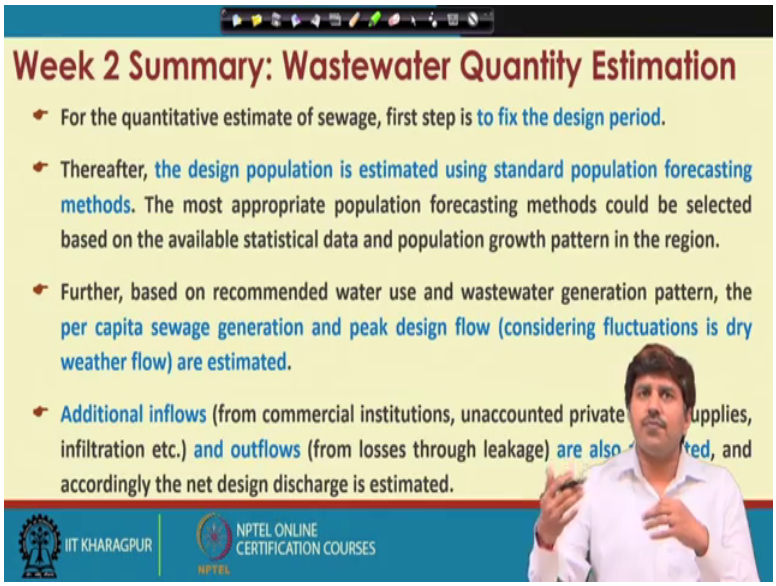

So, for the purpose of wastewater quantity estimation as we discussed we need to first fix the design period, thereafter we need to get the design population estimates using the standard population forecasting methods.

We did discuss various methods involving arithmetic increase method, geometric increase method, incremental increase method, ratio method, master plan method ah; so, various graphical methods. So, those methods are there are several methods and the best method or the most appropriate population forecasting methods could be selected based on the what kind of data; we have at hand. What kind of the population growth pattern have been in the past in that region or whether the city is being developed under some sort of master plan or joining systems.

So, that will give us an idea that which method to adopt; further based on the recommendations of water use and wastewater generation patterns, we can get the per capita sewage generation. And then we have to estimate the peak flows as well because there are fluctuations in this dry weather flow or in this wastewater generation. The fluctuation could be diurnal, fluctuation could be seasonal or could be annual fluctuation; so, accordingly we get kind of various peak factors; so, which ranges from 2 to 3 for the purpose of designing the sewer systems.

Then there is possibility of additional inflows or outflows. So, inflows could come from the commercial institution, could come from the unaccounted private water supplies, it

could come from the infiltration happening bringing water within the sewer line systems or there is a possibility of certain outflows also in the form of losses through leakage and those kind of thing.

So, they also need to be estimated, they also need to be accounted and then accordingly we get the net quantity of the sewage; which is available for handling or which could be available for handling in a during the design period.

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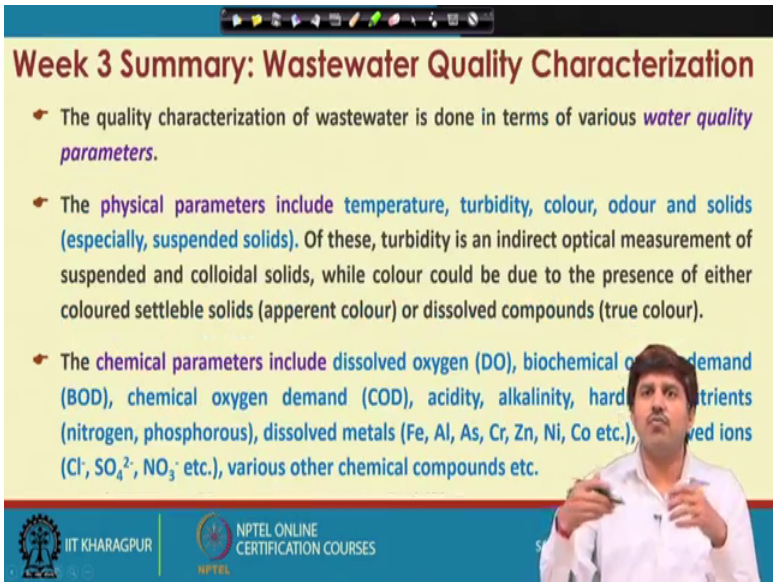

So, then in the next week third week of the course we discussed about the wastewater quality characterization. So, the quality characterization of wastewater is usually done in terms of water quality parameters.

There are physical parameters that include temperature, turbidity, colour, order and solids especially the suspended solids part of these parameters turbidity is actually a indirect optical measurement of the suspended and colloidal solids; whereas colour could be either apparent or true colour apparent colour is caused by the settleble solids which can be removed if we just allow water in a static condition so that those colour causing substances get settle.

Or it could be true colour which is due to the dissolved compounds which cannot be removed without proper processing ok; just settling cannot remove the true colour. We also discussed the various chemical parameters that include the dissolve oxygen,

biochemical oxygen demand, chemical oxygen demand, acidity, alkalinity, hardness, nutrients then various dissolved matters, dissolve ions and certain other chemical compounds. So, all those actually are the contaminant of chemical nature.

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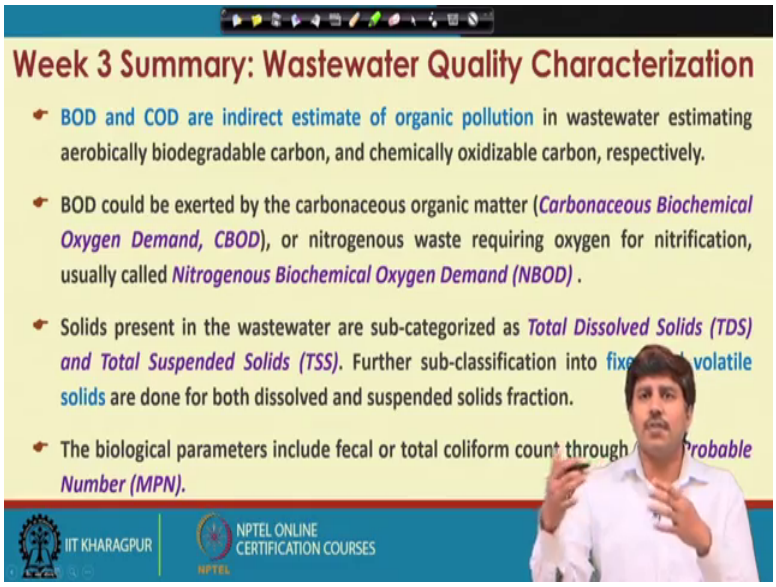

And kind of BOD DO COD are the various parameters chemical parameters which are used for assigning or estimating the quality characteristic of the water or waste waters.

So, of these BOD and COD are some of them like more often used terms and they are in direct estimate of the organic pollution in the wastewater; where BOD estimates the aerobically biodegradable carbon; whereas, COD estimates the chemically oxidizable carbon. So, that is how because everything which is biodegradable often chemically cannot also be oxidized for measurement of COD; we use a dichromate which is a strong oxidant and can almost oxidized all the organic carbon present there in the water.

So, that is how COD is often; COD is in fact, always greater than the BOD values because BOD is just estimation of biodegradable organic carbon whereas, COD whether it is biodegradable or non biodegradable it is for both. So, the BOD could be exerted by the carbonaceous organic matter ok which is the carbonaceous biochemical oxygen demand or we call it CBOD or by the nitrogenous waste requiring oxygen for nitrification which is usually called NBOD or nitrogenous biochemical oxygen demand.

Then there could be various solids present in the waste water. So, we discussed that the total solids present in the wastewater are referred as total solids tears; then we can sub classify them into various ways. So, these sub categories include like if we filter that water; so, we the filtrate we get will be containing the dissolved part of the solids.

So, we can call that as total dissolved solids and the retained mass on the filter is actually the suspended part of the solids; so we call that as total suspended solids. Then if we expose it further into the furnace at 550 degree Celsius for 20 to 30 minutes. So, the solids that escape the system we call them as a volatile solids whereas, the solids that still retain we call them fixed solids.

So, that way we have the total volatile solids, fixed volatile solids, total dissolved solids, total suspended solids. And we can evenly like the dissolved solids can also further sub classified into the fixed and suspended part. Similarly the suspect fixed and volatile part; similarly the suspended solids can be classified again into the fixed and volatile part.

So, we can have volatile suspended solids, volatile dissolved solids; similar wave fixed suspended solids and fixed dissolved solids, then the biological characteristics which includes the total coliform or fecal coliform count; that is usually estimated to MPN which is most probable number.

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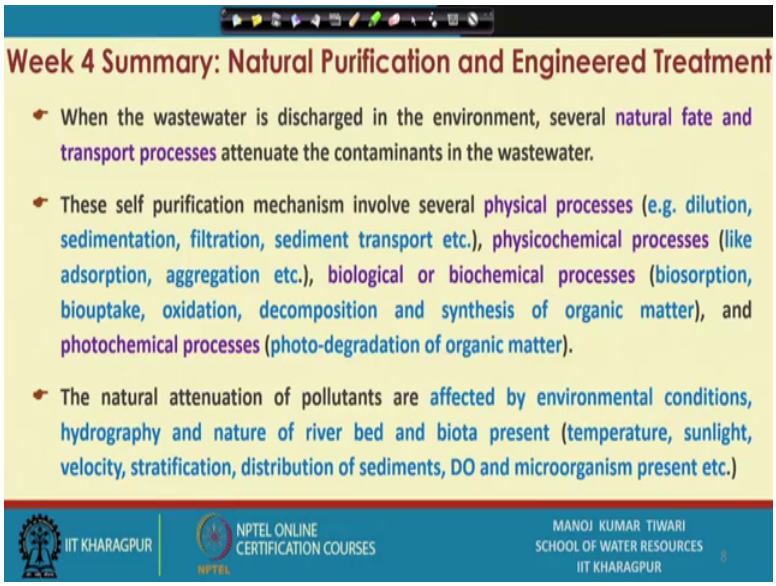

So, those were the discussion centred around the quality characteristic of the wastewater. Then in the fourth week we had started discussing the natural attenuation processes; so, the natural purification systems and the basic concept of engineer treatment also we started discussing in this week itself.

So, in the fourth week ah; we discussed that when the wastewater is discharged in the environment what happens to the various contaminants present in the wastewater ok. So, how the different natural fate and transport processes attenuate these contaminants present in the wastewater. This leads to the cell purification of the water when it is particularly disposed of in these streams.

So these self purification mechanisms involved several physical processes like dilution, sedimentation, filtration or sediment transport; various physicochemical processes like adsorption, aggregation etcetera; various biological or biochemical processes. So, biosorption, biouptake, oxidation, decomposition and synthesis of various organic matters and to some extent particularly the exposed water systems the photochemical processes like photo degradation of organic matter may also have some contribution.

So, this natural attenuation of pollutants are affected by the environmental conditions; then hydrography and nature of the river bed and biota presents. So, what is the temperature, sunlight, the velocity of the water in the river, the stratification; so, because DO varies based on the stratification. Then distribution of the sediments what kind of sediments are there, what is the absorption ability of those sediments, the dissolved oxygen that is what is of very prime importance for natural attenuation on our self purification of the self purification ability of the rivers.

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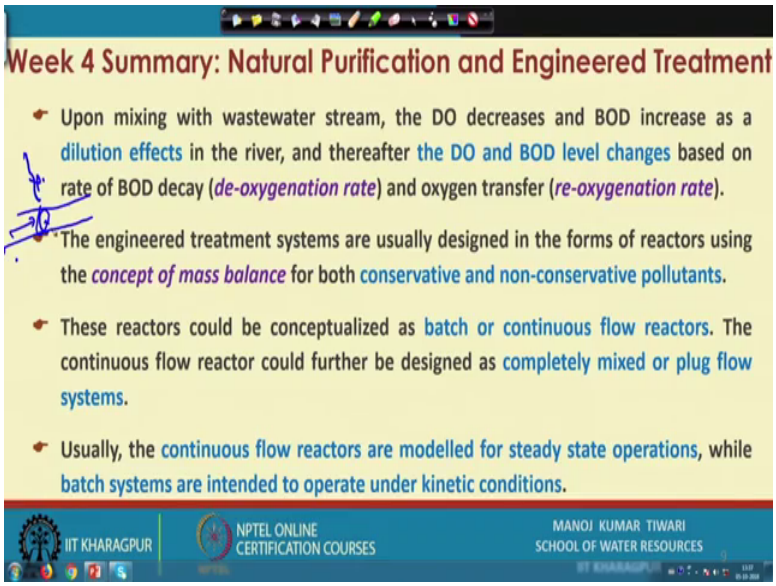

Then what are the kind of microorganisms present? These are the factors that will eventually govern to what scale or to what extent these pollutants are dealt with in the nature. So, when the wastewater is mixed in the stream the DO decreases and BOD increases as a dilution effect, because the wastewater is likely to have low DO and high BOD.

So, when we mixed a low DO say low DO profile this is having a high BOD and low DO and this is our natural river which is coming with high DO and low BOD. So, when the mixing happens this BOD of the river water will decrease because it is getting a higher BOD stream in the form of wastewater. Whereas, the DO of the stream or DO of the river will decrease because it is getting mixed with a water stream or wastewater stream; which is having very low dissolved oxygen.

So, that results in the dilution effect at first and from that point forwards; the DO and BOD level will change based on the rate of the BOD decay because BOD will get decreasing and the oxygen transfer also takes place. So, the BOD is kind of from the point of mixing or it is growing to decrease slowly usually it is first order decay. Whereas, the dissolved oxygen level are more complicated because as the organic matter is decreasing; so, there is a constant decrease in the BOD profile. But in the case of dissolved oxygen the dissolved oxygen is consumed in the action of the BOD decay.

So, while microorganisms are degrading organic matter they will consume dissolved oxygen. Then there is some dissolved oxygen is consumed in the respiration process; so, that makes the oxygen level decrease, but at the same time the re oxygenation takes place. So, at oxygen transfer from atmosphere through the air water interface also takes place; so, that leads to the increase in the oxygen.

So, as a result oxygen there is two processes; one which is decreasing the oxygen, another which is increasing the oxygen and the combination of these two eventually governs the dissolved oxygen profile. So, initially dissolved oxygen will decrease; so we go into the kind of from clean zone the water goes to the decomposition zone; then the oxygen levels will get to minimum.

So, it is the water or the river will reach to the septic zone there not much of dissolved oxygen is present in there. Then from that point forwards it again goes back to the like eventually slowly and steadily recovers and then moves again back to the clean zone. So, we discussed all those aspects; then the from for engineering treatment perspectives, the basic concept, which is utilized for designing the engineering engineered wastewater systems are the concept of mass balance. So, we discussed how the concept of mass balance could be applied to various reactor configurations and various kind of solute or pollutant natures.

So, we discussed the concept of mass balance uses for both conservative and non conservative pollutant. Then the reactors that could be conceptualized as batch or continuous flow reactors, the continuous flow reactors could be designed as a completely mixed plug flow completely mixed systems or plug flow systems. So, we have these different kind; we discussed these different kind of configurations, usually the continuous flow reactors are model and as kind of steady state operation; whereas, the batch systems are intended to usually operate in the kinetic conditions.

So, the steady and non steady state model for the completely mixed system, plug flow system or with the conservative pollutant or non conservative pollutant, in a batch or continuously mixed system all those cases were discussed during the week 4.

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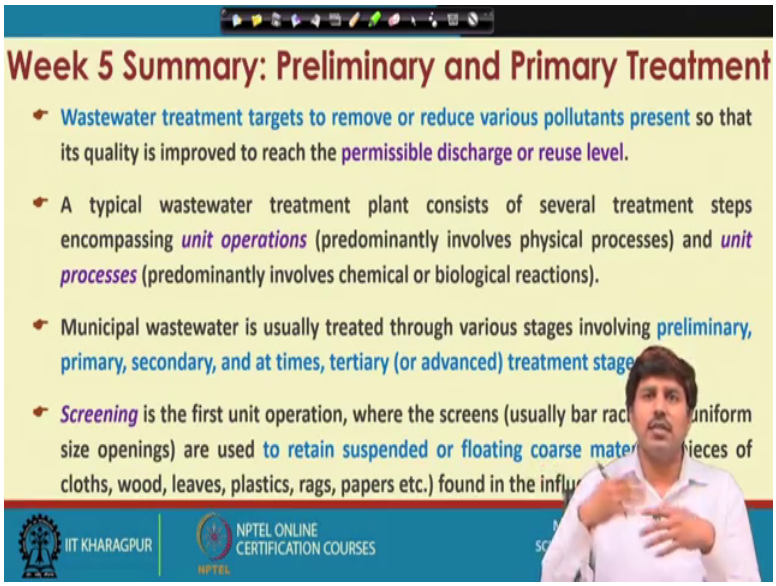

Then the week 5 we started discussing about the various treatment units. So, the week 5; we basically discussed the preliminary and primary treatment of the wastewater. So, the waste water treatment first thing is why we treat wastewater? The wastewater treatment objective or target is to remove or reduce the various pollutant present so, that the quantity of; so that the quality of the wastewater is improved to reach the permissible discharge or reuse level ok.

So, a typical wastewater treatment plant consists of various steps which includes unit operation unit operation that predominantly involves the physical processes and unit processes which predominantly involves the chemical or biological processes. So, the municipal wastewater is usually treated through various stages; even industrial wastewater; so, preliminary primary, secondary and at times tertiary or advanced treatment stages is also provided. The screening is usually the first unit operation under the category of preliminary treatment ah; many few people combine preliminary and primary as just primary.

So, that time we can say the screening as a primary, but usually it is a preliminary treatment because that is the first stage of treatment; where the screens which are usually bar racks there are other type of configurations available which were discussed in the week 5; while discussing the screen screening process. So, this bar, bar racks of uniform size openings are used to detain the suspended or floating coarse material and which

could include pieces of clothes, wood, leave, plastics, rag, papers those kind of things which are found in the influent water ok.

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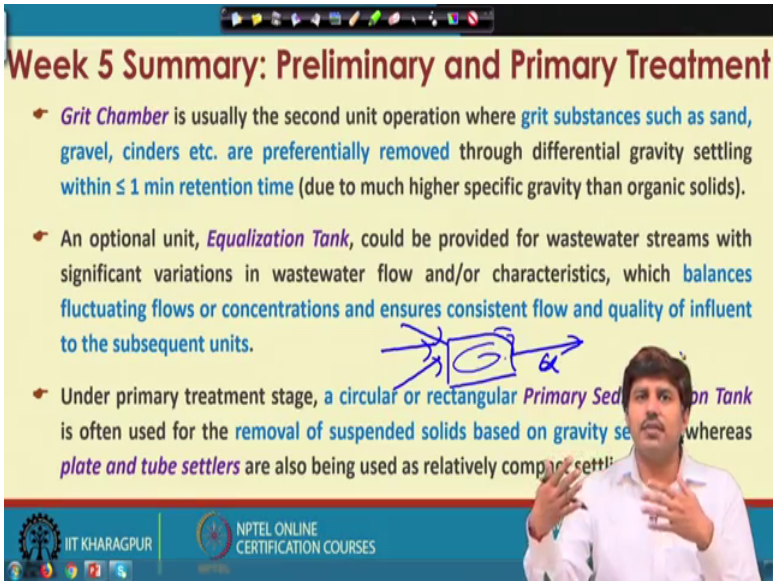

Then the grit chamber is the subsequent unit which is usually the second unit operation ah; grit substances such as sand gravel cinders etcetera are preferentially removed through the differential gravity settling. So, in the grit chamber we give the retention time very low or less than or equal to a minute or so. And in that time itself the particles the grit particles settle quickly because they have much higher specific gravity than the organic solids which are usually settled in the primary sedimentation.

So, these grit particles that way if we see the specific gravity is close to 2.65 and that is how because their specific gravity is much higher than the water. So, they quickly settle within a minute, we can get the removal of these grid particles through the differential settling; whereas, other fine suspended particles or organic suspended materials still remains in the suspension itself. Then equalization tank in the form of an optional unit could be used.

So, it is not necessary to always use equalization tank, but if we are having the wastewater streams which are having significant degree of variations in the wastewater flow or the wastewater characteristics; then we can go for the equalization tank which kind of balances the fluctuating flow on concentrations and ensures the consistent flow and quality of influent to the subsequent units. So, that is what is equalization tank is

used for; it is a fairly simple tank where the waste water inflow comes we can have actually multiple channels.

So, if that way let us say this is a tank we are having 2, 3 different streams of wastewater coming in and we will retain it for some time 6 to 8 are sometimes even 12 hours it is retained in here. Then the waste gets homogenized and from here its pumped the homogenized quality of waste is pumped at a constant discharge for all subsequent unit.

So, depending on the need we can go for equalization tanks; similarly depending on the need we can go for skimming tank also, if there are oil and grease those kind of things are coming in there. So, we can have a skimming tank for the removal of these things or many a times what is done that; those oil and grease kind of things could actually be also removed during the primary sedimentation itself.

So, post this we go into the primary stage; primary treatment stage where a primary settling tank is often used. This is either rectangular or circular in the safe and the removal of this is basically aims for the removal of suspended solid based on the gravity settling. So, we provide different degree of retention time; if it is like there are different type of settling, chemical added settling or just plain settling. So, normally as a primary sedimentation tank; we do not add any chemical.

So, it is just a plain settling in this plane settling what is done or in the primary settling or plane settling; so, we let the water enter into a settling basin. There are there are 4 different zones in a typical basin; so, water enters in an inlet zone then settling zone the settling process takes place the settled water comes as a sludge which is collected from the bottom. And then the water goes to the outlet zone from where it is through wier or through specific outlet mechanism this water is taken from this primary sedimentation basin.

So, that way the suspended particles are removed here and it gets settled in this which is collected as a sludge which is typically called as primary sludge. So that is what happened in the primary settling there are some other configuration in the form of plate or tube settlers are also being used as a relatively compact settling devices, but their uses are restricted to some few industrial scale treatment or those kind of thing because of the possibility of clogging or greater maintenance requirements.

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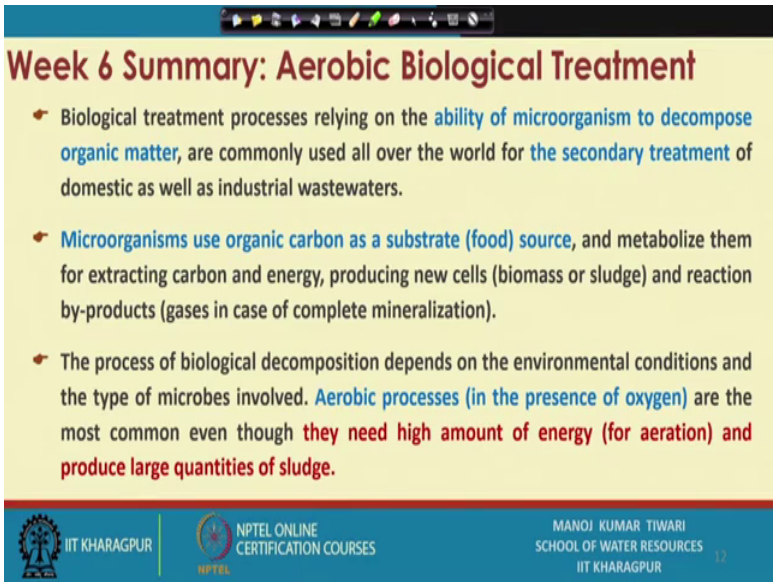

So, the 6th week discussions was where we started discussing about the biological treatment systems. And the first thing that we discussed is about the basic concept of the biological treatment. So, biological treatment processes relatively kind of are there for removal of biochemical oxygen demand or BOD, which is the biodegradable organic carbon.

So, that is what the major aim for this bio biological treatment processes and they essentially relay on the ability of microorganisms to decompose the organic matter ok. And they are commonly used all over the world in the form of secondary treatment of domestic; as well as industrial waste waters. So, why this organic matter is decomposed? Because microorganisms use this as a substrate which is food source for them and then the process they metabolite them for extracting carbon and energy; in the process they produce new cells and reaction by products ok.

So, generally the gases are produced in aerobic system the methane and carbon dioxide and in aerobic system primarily carbon dioxide. The process of biological decomposition depends on various environmental conditions and the type of microorganisms involved. So, like the aerobic processes which are in the presence of oxygen are most common, but they need high amount of energy particularly for the aeration purpose and produce large quantities of sludge as well.

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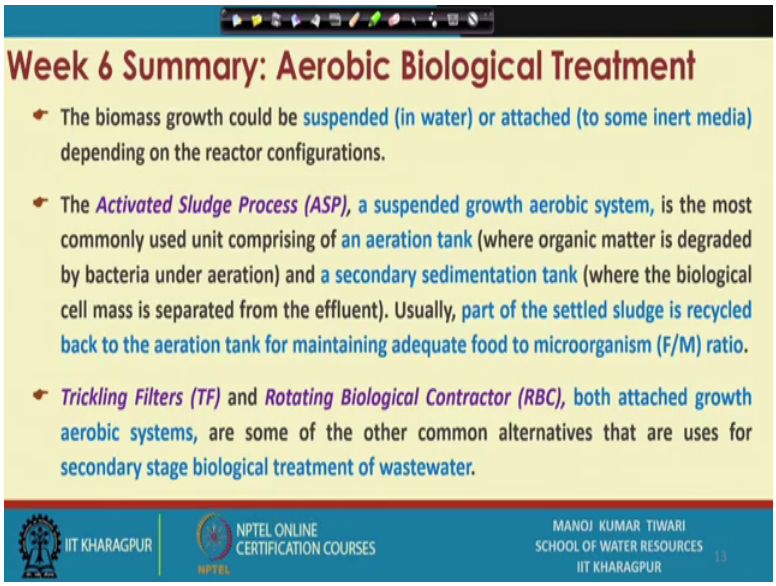

The biomass growth could be suspended or attached; so, the suspended growth are where the microorganisms remains in suspension within the water; whereas, in attached growth system they grow on the surface of some media. So, there is some inert media it is provided and on the surface of these media the biomass grows slowly and as a result form the bio film ok.

So, the retention is better in the attached growth system because once they are attached to a media said; they do not easily gets wash out whereas, in the suspended when the water is taken out the microorganisms suspended in that will also come with that. So, the biomass retention is poor in the suspended systems as opposed to the one which is in the attached growth systems.

So, among the biological treatment units in the week 6; we had discussions over the aerobic systems. The activated sludge process is the most popular and most common system which is actually a suspended growth aerobic system, which is used for the secondary stage treatment of the wastewater. It essentially comprises of an aeration tank, where the organic matter is degraded by the bacteria under aeration.

So, the aeration is the mechanical aerators or diffused aerators are used to ensure the oxygen supply. And the bacteria in this aerobic environment utilizes oxygen and decompose the organic matter to the lower buy and buy products and could actually form some gases also in the CO 2, but it also produces lot of biomass in the process.

So, particularly the aerobic system; so are almost like 40 percent 40 to 50 percent of the organic carbon which is used or which is decomposed off is used for converting into the biomass. So, lot of biomass is generated and when the water is taken from the areas aeration unit; it is since it is a suspended growth system. So, the microorganisms remains in suspension and when the water is taken from the aeration unit the microorganisms also move along and they come into the secondary sedimentation tank, which is where the biological cell mass is separated from the effluent.

So, what happens in the secondary sedimentation tank? We do not assume any further degradation, but what happens that these biomass or particles or these bacteria gets settled in the secondary sedimentation tank and water is the effluent is taken out this. The settled biomass part of this is wasted and part of this is again recycled back into the aeration system for maintaining adequate food to microorganism ratio in the system.

So, that is the activated sludge process which is the most popular system then there are units like trickling filter or rotating biological contactor both are the aerobic attached growth system ok. So, they are aerobic system; they work in a presence of oxygen, but they are attached growth systems in trickling filter we have basin on which water is trickled.

And there is a media on which the bio film grows and then water is passed through that media and the treatment happens; whereas in rotating biological contactor we have a kind of rotating discs, which are almost 40 percent is submerged in the water and 60 percent exposed and then keeps on rotating; so the microorganisms are at one time exposed to the substrate in the water medium and then goes back into the air so, that way the air supply is ensured. So, these are some of the other common alternatives for the secondary stage biological treatment of wastewater. So, these are the discussions that we had in the 6th week.

So, we will take a break here and end this lecture at this point. In the next lecture, next summary lecture we are going to discuss the summary of the content that we discussed from week 7 to week 12. So, see you there.

Thank you.