Applied Environmental Microbiology
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Lecture - 36
Wastewater Microbiology I

Dear students in today's lecture and hence for we will be talking about other applied environmental problems, which use which apply them molecular biology and macro biology understanding to treat environmental contamination and environmental problems. And today we are going to start with wastewater. Now there is lot of focus at currently in India on sanitation, through the Swachh Bharat Abhiyan and making show that we get we eliminate open defecation. But the question arises we get rid of open defecation people can are required for defecate in toilets public or private toilets, but what happens to the faecal matter and the urine after the person has defecated.

The where does it go where is it dumped of how is it treated and that job is done by wastewater treatment plants we call them wastewater, because we do not have dry toilets we use wet toilets. So, we use water for flushing for cleaning and the water contained in faecal matter in its surface is quite substantial. So, when this wastewater we call it wastewater very politely.

So, this wastewater typically in developed countries is collected through a wastewater collection system, it goes to a centralize facility or de centralize facility which then treats this wastewater employees microbes to get rid of organics in the wastewater, and treats it to a degree that it can be now safely released in the aquatic systems. However, in a country like India the major problem is that first of all we do not have a good and reliable wastewater collection system and secondly, many parts of the country still do not have functional wastewater treatment plants.

For example, why do not you do this go ahead and find out this week if your town your city your village has a wastewater treatment facility or not. And if it does go ahead try to make a visit to it and if you are unable to make a visit to it look up the information of how much MLD the plant is or not, and one of the questions in your homework this week would be about your local wastewater treatment plant. In case you do not have a

local wastewater treatment plant for example, I live in Roorkee and unfortunately in Roorkee right.

Now, we do not have a wastewater treatment plant. So, basically all are faecal matter first droughts an aerobically inner septic tanks and then is disposed to aquatic systems and causes much damage to our environment, and also to our public health because microbes love to greed in that rich decomposing faecal matter and many of them and many of them can be pathogens and; obviously, we have flies and other vectors that in carry diseases from the (Refer Time: 02:54) faecal matter and expose humans and other living beings to the diseases.

So, if you live in a city or a town or place like myself, which does not have a wastewater treatment plant, then your job in this week's homework would be to find out the nearest wastewater treatment plant to your place and its so, happens that I have a map of wastewater treatment plants that are at least on paper functional in India.

So, I will be able to know where you are and what is the closest wastewater treatment plant for you so, but it is your job to find out and then to find out how much MLD million litres of per day of wastewater does it receive, and does it treat and at times you know do your wastewater treatment plant might have a unique approach to cleaning waste for example, many of the plants in India ASP based what is ASP activated sludge process? We will be talking about it today and in the next lecture, but many um wastewater treatment plant at least the recent one, that are built through public private partnership are SBR base which is sequence say sequence batch reactor base.

So, we will be talking about that very briefly. So, you also need to find out what kind of wastewater treatment plant it is and how much MLD of wastewater receive everyday now dear students coming back to the wastewater scenario in our country because our wastewater collection system is non-existent in large parts of the country, even if you are using a toilet to defecate where does the toilet go and how do we treat it will determine the impact on public health.

So, there is some criticism right now among scientist about the current approach of the government to focus more on stopping the open defecation bringing people into the toilets instead, without focusing on what do we do with the waste that will be generated and collected in the toilets. So, today I want to talk about wastewater I mean very briefly

talk about the history of wastewater treatment plant then compare what is happening abroad in different countries and what is happening in India. And if not in this lecture then definitely in the other lecture I want to present few slides to you about giving a comparison of how different countries take care of the human waste.

So, let us get started with wastewater treatment water and wastewater microbiology.

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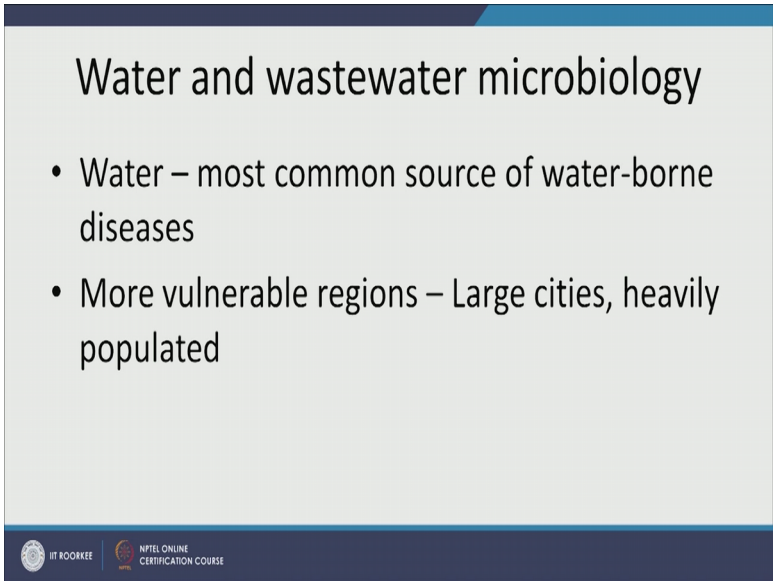

Water is the most common source of water borne diseases obviously, but not only that water borne diseases make the major chunk of infectious diseases across the country. So, it very important for us to take good care of water the other thing is water is essential for life we cannot survive without water and here is a beauty. The more populated the region is the more dense its water demand is more concentrated its water demand is, and also the more dense its wastewater generation would be.

So, if I have a sparsely dense sparsely populated place, then the wastewater generated per kilometres square would be much lower and thus the burden, it will cast on public health would be lower versus in congested cities with a lot of people living vertically stand over each other, there we generate lot of waste per kilometre square, and that makes the large cities and heavily populated regions and heavily populated countries such as India very well (Refer Time: 06:15) to water borne outbreaks.

Now, one example I would like to give, whenever a mass population is mobilized after the water briefly earlier whenever mass population is mobilized they re setup refugee camps where the refugees can stay and survive, until we find a solution of how to either rehabilitate them back to the home town home place or to rehabilitate them in new lands.

So, in this intern period when they are staying in the refugee camps, the population density is very high the wastewater treatment infrastructure is nonexistence. So, even though let us say a it is arriving and giving them clean water, but nobody is taking care of the wastewater and as a result refugee camps are very very susceptible to water borne illnesses.

So, whether we look at Haiti after the major earthquake that really devastated the island, when the refugee camps were setup and people lost their wastewater collection system what resulted was a very sad cholera outbreak; another example would be the, what on Yemen. So, in Yemen there we have the one of (Refer Time: 07:22) one of the largest refugee population in the world that history has ever seen.

Now these people were living in refugee camps to some degree have access to the inverter, because people are really trying hard to get this minimum essentials to them; However, there is no infrastructure in place to take care of the wastewater treatment plant and thus the Yemen is not only seeing a refugee crisis, but is also seen the worst cholera outbreak as we as I talk right now.

So, these examples that happen when there was a natural disaster or manmade disaster like war and refugee camps were setup. But what we have in our Indian cities is not very far or from a refugee camp. We have lot of people packed together they probably have access to clean water because the government takes (Refer Time: 08:10) to ensure that it can supply water to you and with the water is treated to a certain degree; that you will not fall sick given the general immunity of our country men and women and those who cannot those who do not use municipal supplied water they have access to aqua guard, filters or bottled water to keep them safe.

However, every individual no matter whether you drink water from bottled water from a water fountain, from municipal supplied water or from a well that you trust and let us say it reliable well no matter where you drink water from the all generate waste and many a

times water borne illnesses they do not they are a simtomic, they do not show symptoms in us.

So, as a result I might be how doing diseases that do not know about it or maybe even I know about it, but there is nothing I can do except defecate in the place that I am supposed to defecate in my defecated matter will then makes with the communities defecated matter let us see we are using toilets. So, the toilets will become the focus point focal point for the defecated defecal matter of the entire community.

When that happens we have lot of biomass in place and the biomass is the perfect food that the pathogens are used to at least the water want pathogens and the gut micro biotise is used to, and this is the place where microbes can multiply readily. And if we have poor management and these defecal matter either infiltrating to a drinking water system or the infiltrating to a ground water system or contaminated surface water system or just lie outside open exposed as pools of defecal matter then they become a source of diseases.

So, again to coming back to the point heavily populated areas are more vulnerable for outbreak such a water borne diseases, because lot more faecal matter is generated and if you do not have adequate wastewater infrastructure wastewater collection and treatment infrastructure, then we are likely to have serious diseases.

Now the question that might arise well in India, we are heavily populated and as I mentioned earlier we do not have good wastewater collection system, we do not have good savage treatment system for example, Roorkee does not have a single wastewater treatment plant. So, lakhs of people living in Roorkee their waste is just contaminating the environment and we defecate every day it is not the amount of waste we generate as a community is in enormous.

So, the question arises why is Roorkee not seeing (Refer Time: 10:39) why are people not dying out of water borne diseases and there was a simple answer to that is well nor not all water borne diseases are as infectious as choleras, choleras highly infectious it requires very little infectious dose to infect healthy individual and the other thing is the cholera microbe survives (Refer Time: 11:01) in the environment.

So, even if they are few cholera microbes that have been defecated by human being, and water source has been contaminated or food source has been contaminated or just the

faecal matter is lying in a (Refer Time: 11:13) picks up the cholera it can. In fact, many people very fast. And the other thing is that the cholera kills really fast because the diarrhoea is really severe that is cost by which is cost by cholera.

So, coming back to the question why in India do we not alarmed about the water borne outbreaks ok. The 2 explanations were this many people will tell you that we Indians have developed certain level of immunary, which is partly correct partly not the other thing is unfortunately we the people who are more susceptible to getting water borne illnesses, such as the middle class lower middle class and the really a social economically under privileged class of people in India, take it as a part of life getting water borne illnesses.

Getting diarrhoea is part of life getting jaundice is part of life, getting typhoid is part of life. We do not question in a public health illnesses do not are not very particular about collecting the data and making it public and saying these regions in the country are endemic to ameba histolytica diarrhoea, these regions have an outbreak of typhoid these there is something about our culture our current culture that we take it for granted we do not question it we suffer silently and (Refer Time: 12:29) with the other thing, but that is a different lecture completely.

So, India is sitting on a major outbreak of multiple water borne illnesses and there is another thing I want to ask. So, another part of your homework is to do a small family and neighbourhood survey, and find out in the list of water borne diseases is given to you in the question, find out what water borne diseases had affected your neighbours your family your friends in past one year.

So, all you need to do is against every disease you just put a tally mark and then count how many what kind of diseases have been your family and your friends and neighbours have been affected in last one year and how many times. For example, the place where I come from entamoeba histolytica is endemic. So, people get that amoebic dysentery very often and it is not I if I say that I yes I did get amoebic dysentery in last one, year it is an inaccurate presentation because I might have got the dysentery 20 times last year.

So, in that case I would want you to draw 20 write withdraw one tally and then write 20 next to it. So, we know that the one person got the amoebic dysentery last year 20 times. So, both information are important how many people got what diseases they got and how

many times were they infected all right let us move on I have already talked about recent outbreaks of cholera. So, now, let us move on about half of the world population faces scarcity of water.

So, forget about having water that is not safe half of the population still does not have enough water to drink and to live. And if you I hope you realize the importance of drinking water hopefully most of us are most of us have access to drinking water, but many in our own country maybe some of us who are attending this class do not have access to clean drinking water. 2.4 billion; people like access to adequate sanitation this was in 2006 the figures have improved.

But they nearly still the same nearly 2 billion people across world do not have access to adequate sanitation.

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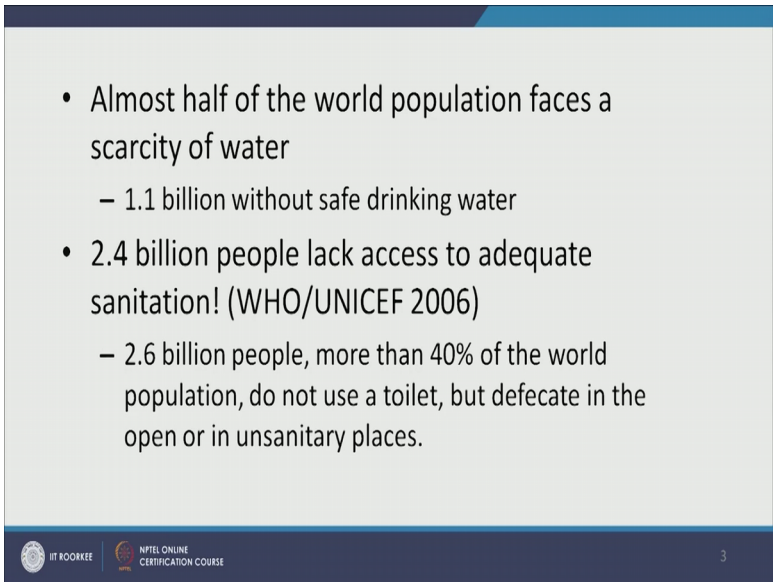

And where do you think this 2 billion people are most of this 2 billion people are in India. Most of the this 2 billion people who do not have sanitation are in India and that is the reason why the country is pushing away from open defecation and encouraging people to use toilets. Instead now here is a problem when people do not have good sanitation system.

We promote water borne diseases earlier our focus was on drinking water and making sure people have good quality, and save water to drink because if the water is

contaminated and you drink and you fall sick and that is quite quick this sickness will come quite quickly. Now if you do not have adequate wastewater treatment plant you are contaminating a water sources and your food more frequently.

So, you are more susceptible to fall in sick anywhere. So, we have to do we have to wage our efforts, we have to put efforts in tackling both the water treatment and wastewater treatment. Now how does wastewater treatment work? And because this is applied in moment microbiology class, let us see how and why is; microbiology very important for wastewater treatment. So, in wastewater treatment we have usually have multiple steps we start with this wastewater correction process.

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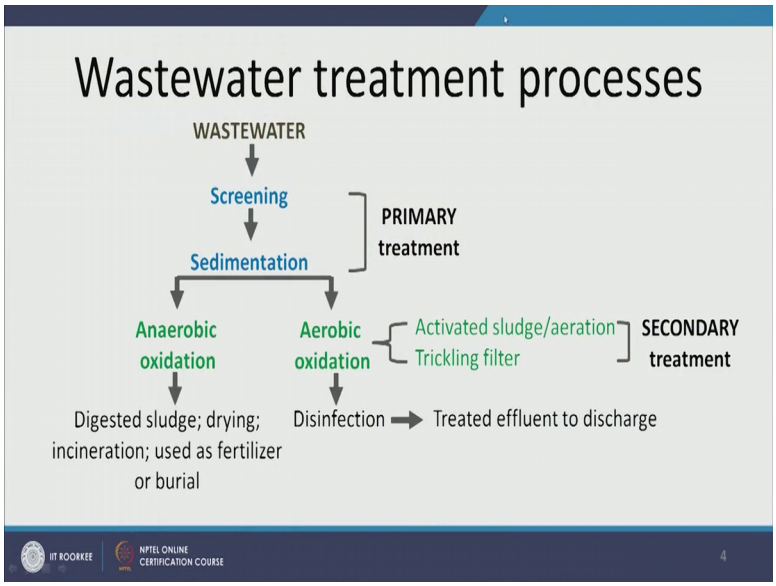

So, the wastewater is collected from different parts of the city or the area or the region that comes under the waste purview of the wastewater treatment plant and then it is taken to the wastewater treatment plant. Now one thing I wanna mention in most developed countries that I am familiar with usually there is a pipe system like how we had drinking water distribution system there is a wastewater collection system, that that is also laid at the time of constructing a city planning a city.

In India we have that to in many cities and many regions, but I have noticed that in India many a times we have tankers they come and they collect the waste from septic tanks or wastewater collections tanks and then they carry it to the wastewater treatment plant.

So, instead of many a times instead of having pipes that are laid under the town under the city, which carry the wastewater to the wastewater treatment plant, we actually have tankers that come that fill the waste and then they carry it. So, this is a quite unique feature that I have noticed in our country and I think it is fun any ways.

So, the wastewater gets eventually either whether it comes from tankers or from pipes its get collected into wastewater treatment plant, this is the first step that wastewater undergoes is screening. So, we get rid of the big particles maybe surprised the amount the kind of waste we see in a wastewater treatment plants, in many parts of the world we have note we have found parts of car; in wastewater treatment plant we have found dead bodies of animals and even human beings people have an routinely we find agricultural produce.

So, we have the kitchen waste coming in wastewater treatment plant, these things really mess up the functioning of wastewater treatment plant. Because if they pass through the screening stage let us say a lemon passes through the screening stage or in India we have many of us have an habit of eating [FL] which comes in aluminium foils. So, this aluminium pouches.

Now these are we have use shampoos that cover aluminium and plastic pouches or sashes. Now these the aluminium is really bad for wastewater treatment plant because it easily passes through the scream because these sashes are usually requite small or thin, they pass through the scream and ones, they have passed they have they have seen stay cause severe abrasion of rest of the wastewater treatment system.

So, one of the request that I have that from all the students please spread awareness about this and inform people not to throw waste into their pots. If you are using a toilet do not throw household waste inside your toilet you should have another land field waste tree or solid waste management system for that, this is only for wastewater this is only for human waste and not for aluminium foils, shampoo sashes and definitely not for agriculture produce automobile parts and dead bodies.

Any way after screening we have the next step called sedimentation; in sedimentation now that we have screamed the wastewater of the big parts, now the great and the big part we allow the remaining great sand and other inner particles and even un instable unstable particles to settle in the sedimentation tank.

Now, this is very important because in sedimentation tank just because of gravity, some 50 percent of biologically unstable material and particulate matter is removed. So, ones the sedimentation is happened the supernatant goes for further treatment and this is aerobic oxidation, which is aerobic oxidation if you remember from microbiology microbes are consuming oxygen and they are oxidizing the electron donor.

So, microbes will take the oxygen, we supply them lot of oxygen and then they consume the wastewater they consume the faecal matter and all other organics that are present in the wastewater. The settled solids in the sedimentation tank, they go for anaerobic oxidation. So, this is in absence of air, but there is oxidation we will talk about it, but for now know that screening and sedimentation are called primary treatment because together they are very physical processes this is this sieving, this is basically mechanical sieving and sedimentation is sedimentation vary mechanical process we are not using chemicals yet we are not using biological process yet to clean the wastewater. In aerobic oxidation an aerobic oxidation we use microbial processes.

So, in aerobic oxidation the two methods broadly one is where we have microbes planktonic in the waste water. So, they float freely in the wastewater they interact intimately with the waste and then they degrade it and they irritant heavily such system is called activated sludge system. So, sludge is the biomass and the waste material together, trickling filter systems are different there here we have stationary bio-films. So, microbes are stationary and the water trickles to them.

So, here we have its much like the if you remember from acid main drainage, we talked about reactive barrier on one side we have contaminated water and as it passes through the reactive barrier the microbes reduces sulphide and then we get clean water out of the barrier. Similarly in trickling filter we have a trickling filter, wastewater drops from the top and as the water trickles down, it goes interacts with microbes and the trickling filter which degrade the organics and then we get literally very clean water below the trickling filter.

So, these are the two ways and two methods in aerobic oxidation and the differences that in activated sludge process, the microbes are mobile and they are mixed with the wastewater in trickling filter they are stationary and they are attached to the filter. Now this part is called secondary treatment because it utilizes micro bio chemical processes

for cleaning water. Now the supernatant went for aerobic oxidation, the sedimented portion the certain portion goes for anaerobic oxidation. Now this happens at three different temperatures. So, we have warm, hot and hotter and mostly mesophilic and thermophilic conditions are where we do anaerobic oxidation and the point is that we digest the sludge. So, the sludge that was collected from the bottom of sedimentation tank is digested and then it is dried or de watered.

So, we can do de watering through different techniques, we can centrifuge it we can press it, we can sundry it, we can blow in whatever way different drying techniques and ones we have dried we have reduced the volume of the sludge, and now this can be incinerated or used as fertilizer or could be buried under the land.

Now ones we have treated the water coming back here, ones we have treated the supernatant and to petty good degree the turbidity reaches usually reaches the it should reach yours regulated regulatory values your BOD should go to regulatory values, your chemicals that can degraded aerobically by microbes, they should go to regulatory values and even the n p n which is a way of measuring microbial population, that should also go to regulatory values in the next step is disinfection.

So, we add chlorine or other disinfectants and we get rid of the microbes. So, it is quite possible that through screening sedimentation and even aerobic oxidation, some pathogens have survived and we do not want these pathogens going and going out in the environment and being exposing to animals and human beings. So, we undergo disinfection process, then this is the treated effluent is discharge to the water body. So, this is basically wastewater treatment process for you.

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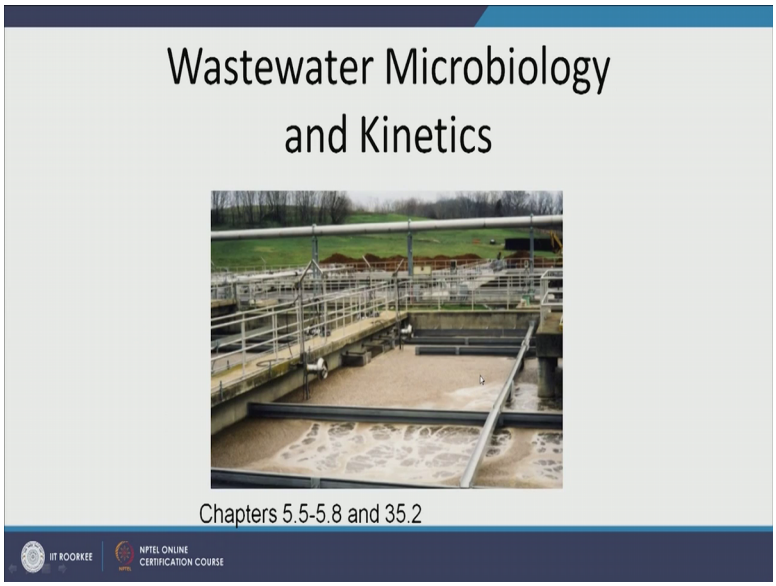

Now, let us look at some pictures and let us look at the kinetics of the wastewater and about how the microbial processes worked.

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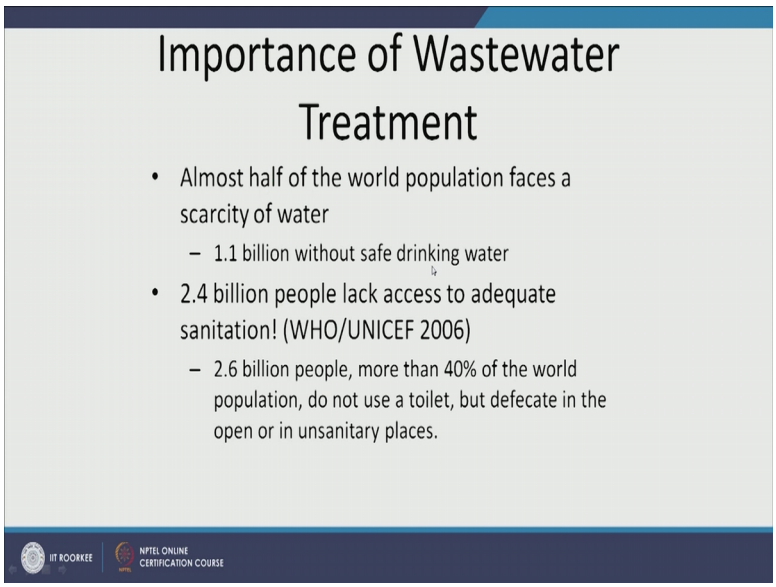

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So, and this is very important because this is in line with a UN millennium a development goal, we were hoping that by 2015 we will have safe drinking water access and access to adequate sanitation, but India is yet to meet its target ok.

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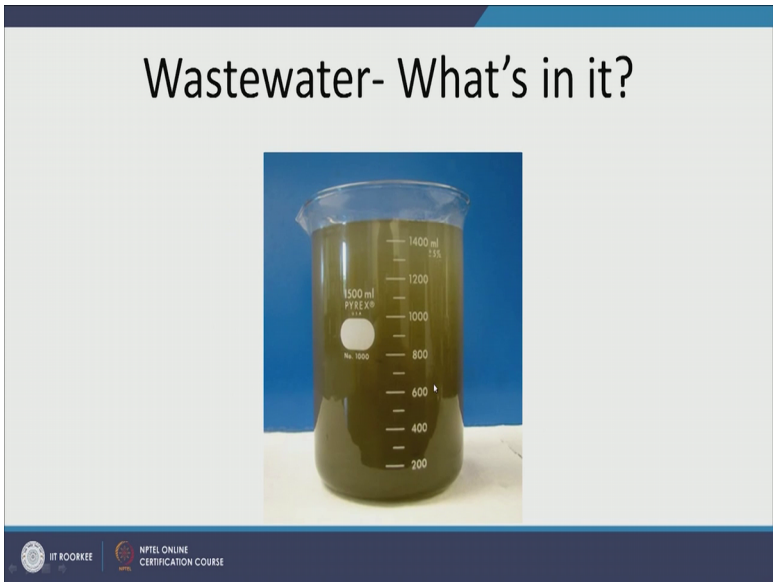

So, first of all if this is the wastewater, we need to find out what is there in wastewater.

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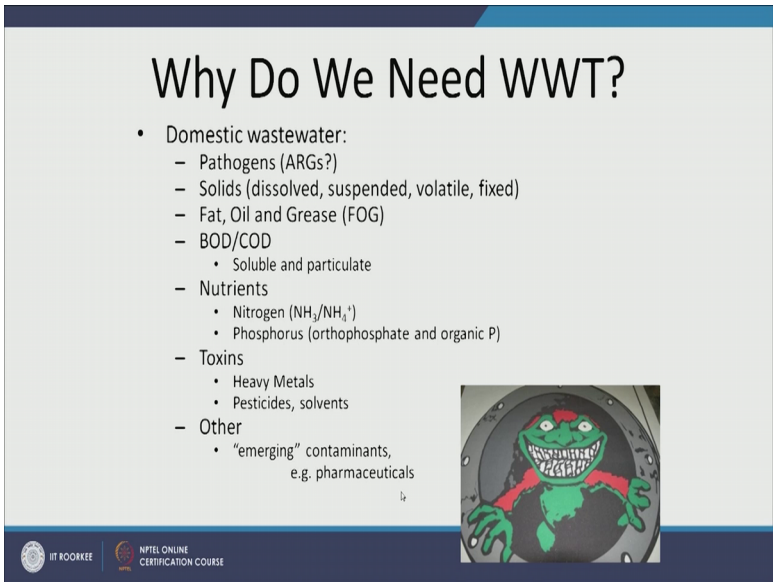

So, you would know that in wastewater, domestic wastewater we have pathogens.

So, because they are coming from a faecal matter, we have microbes that live in a gut and these microbes some of them might be pathogenic. But they might not be in enough dose to infect us or we maybe we have very good immune system and we are not simtomic we do not throw the symptoms, but most likely it is going to have lot of microbes and some pathogens.

Also it will have solids, some solids will be dissolved some would be suspended, some would be volatile and some would be fixed. It might have fat oil and grease they together called as fog now why would fat oil and grease come into domestic wastewater if it is just human faecal matter. Because it is not just human faecal matter many a times grease is also disposed in the wastewater treatment plant for example, in many homes across the world even the kitchen wastewater is combine with the sewage and it goes to together it goes to wastewater in that case we might have lot of fat oil and grease.

Now, BOD and COD I have talked about BOD before and COD I do not think I have talked, but. So, it is a good idea to go over them again, now BOD and COD BOD stands for biochemical oxygen demand COD is chemical oxygen demand ok. It is very hard for us to measure how much bio degradable organics are present in the water and how much organics are present in the water that can be degraded chemically. So, the way we find out about how much organics are present in water and how much of it can be degraded

biologically is by exposing the wastewater to microbes and then allowing them to degrade it. And as microbes degrade it they consume dissolved oxygen and dissolved oxygen goes down. So, the principle behind measuring waste by allowing microbes to eat the waste is that the more the waste is present the more oxygen will be depleted in 5 days 3 days or any given time period by microbes.

So, by looking at how much the oxygen is falling, we get an idea of how much waste was present. If lot of waste was present then almost all oxygen would be consumed (Refer Time: 25:53) little waste was present little or in bio degradable organics were present, then microbes will not need to consume lot of dissolved oxygen. So, basically what we do is we take wastewater we dilute it enough. So, that we do not always get no oxygen left or less than 2 milligram of per litre oxygen left and then we allow microbes to eat it we add microbes allow them to eat the wastewater and then we notice how much BOD has dropped and then we extrapolate and find out how much BOD was present.

So, that is BOD. BOD biochemical oxygen demand by looking at the oxygen demanded by biology by biological agents that is microbes to consume a waste will give me an idea of how much waste was present. Now COD is chemical oxygen demand bio microbes are not the only ways to degrade the waste or we can also use certain chemicals to completely oxidize the waste right into even mineralization. So, this is chemical oxygen demand we use a very strong oxidizing agent such as k 2 c r 2 o 7 and then very well standard using a very well standardized protocol we oxidize all the way carbonyl, carbonaceous material that can oxidized.

So, we know that because COD is chemical oxidation, the part of the organics or carbon based materials that microbes could not degrade in time, because let us say its toxic or because its recalcitrant does not like to bio degrade or it microbes do not eat it anyway all these would be included in COD along with bio degradable fraction. So, BOD is always less than COD or equal to COD ok. Now BOD and COD are usually soluble or particulate matter and then in domestic wastewater we have also nutrients.

So, urine is very rich in nitrogen's; nitrogen is important, it also might have phosphorous it will have phosphorus in orthophosphate or organic phosphorus, and we need to remove nitrogen and phosphorus also and I hope I have mentioned about this in one of the previous lectures. If not here is a brief review for you that nitrogen and phosphorus are

very important to remove from a wastewater because if we have access of nitrogen and phosphorous going out from the (Refer Time: 28:00) effluent into the environment and it let us a goes to a surface water body it is going to promote algal bloom and if algal bloom happens then lake dies lake Eutrophication happens and we do not want that. So, there is a particular ratio of nitrogen to phosphorous and that ratio should be respected.

So, we want to reduce nitrogen and phosphorous, our recently propose (Refer Time: 28:19) guidelines require us to reduce nitrogen phosphorous a lot. And then wastewater might have toxins like heavy metals pesticides and solvents same question again how will heavy metal pesticides and solvents find their way into wastewater, well many of us have a habit of dumping our waste pesticide waste solvent into toilets and that is how it ends up there the other reason is many a times in our kitchen.

We deal with chemicals that have xenobiotics in them that have solvents in them that have heavy metals on them even our vegetables and fruits that tent to have lot of pesticides residues on them or others gets washed and it goes to the wastewater. Now this is very important part because the microbes they want to outcompete pathogens remember pathogens want a host millennium host cholera wants to infect human being, it does not want to infect another bacteria.

So, other bacteria want to outcompete cholera ,ah in a wastewater treatment plant because there are no human (Refer Time: 29:16) or there are less human (Refer Time: 29:17) obviously, we want to degrade solids microbes to degrade solids to degrade fog to degrade BOD COD to get rid of nutrients, but the toxins will they will effect ; however, the microbes degrade these solids fog BOD COD and nutrients because the heavy metals pesticides solvents and other contaminants such as pharmaceuticals many of which are antimicrobial. So, they actually kill the microbes, which get rid of all the waste they will affect the functioning of wastewater treatment plant and does not require lot of pharmaceuticals to kill microbes.

So, if let us say a wastewater treatment plant now is begins to receive wastewater from a pharma industry, then that will have lot of antimicrobials. And it might actually kill the plant there is an incident that my advisor doctor (Refer Time: 30:14) with us she was in Colorado state university there was there was local wastewater treatment plant which died like it just stopped working and they wanted to know what happened and then they

found out that that wastewater treatment plant was exposed to very high levels of mercury, and then they trace (Refer Time: 30:28) that mercury was coming from when I if I remember it correctly it was coming from an small factory plant right next to her laboratory and that was the reason why the wastewater treatment plant died. So, if you put a really bad toxin in your toilet it might kill a local wastewater treatment plant we do not kill it, but you kill the microbes that are doing your job.

So, please be very careful about what you are putting in your toilet, this is very very important for public health and environmental health. Dear students this is all for today in the next lecture we will talk more about how wastewater treatment works and what is wastewater treatment biology, what are different organisms that participate in wastewater treatment that are very activated and who and what do they do eat. Because there are some microbes like protozoa that eat bacteria there are some microbes that exclusively eat BOD COD. So, we will talk about these things in the next lecture that is all for today.

Thank you.