Course on Industrial Biotechnology
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Lecture 55
Module 11
Aerobic Effluent Treatment Process

Welcome back to my course Industrial Biotechnology I think in the last lecture I tried to cover this biofertilizer I told you biofertilizer is a very widely used throughout the world in India also we use and this is a great concern now-a-days when we because we tried to use the inorganic fertilizer as less as possible and this is to be replaced by the organic fertilizer because not only it give the some kind of value to the soil but also increase the fertility of the soil to a great extent, particularly humus it produce that that improve the water retention property of the soil which is very much required for the plant growth because plant usually take the their nutrient through the process of diffusion through their roots.

So that for that it requires water. So if soil the water retention property then we shall have to use more water in the soil and that pose not additional expenditure. So organic fertilizer maintain the fertility of the soil to a great extent and so this I tried to cover in the last lecture now today and subsequent lecture we try to cover the waste water treatment process because up till now we mostly concentrated on this different production processes that how different chemicals like oxy chemicals like you have citric acid, we have lactic acid or you know alcohol we have that different single cell protein like spirulina.

We also talk about the Baker's yeast fermentation process and also we talk about the fodder yeast. So also we discuss about that different antibiotic fermentation process, now because I told you in the last class that there was a survey long before by the central pollution control board that they tried to find out what are the industry that pose the environmental pollution problem and they identified that mostly the chemical and biochemical industry that poses lot of problem to the environment because when water containing organic matter it discharge into the water courses the bacteria present in water course that go and multiply.

As for example suppose any industry that generate the water and dispose in the reverse rime, river contains lot of bacteria. They utilise that organic material for their growth and metabolism when they use the growth and metabolism they produce a lot of metabolites and also mostly the aerobic organism they grow and they utilise the dissolved oxygen I told you aerobic organism they use the dissolved oxygen present in the that water.

So dissolved oxygen concentration in the water drastically reduce that will affect the plant and animals, growth of plant and animals will be drastically affected and not only that due to the presence of some toxic metabolites that it is injurious for the human health. So it is a great concern by the all countries so they put some kind of rules and regulation to control the kind of waste water disposed by the different industry.

And for to treat this waste water two process is mainly process biochemical or chemical process they mostly use and it has been observed that 70 per cent waste water treatment process are controlled by biological means.

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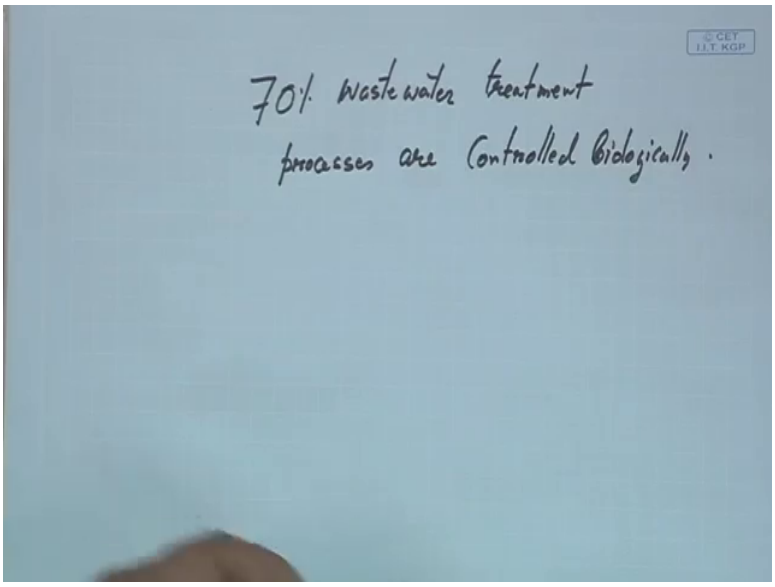

So I want to find out 70 per cent waste water, so 70 per cent waste water treatment processes are controlled by the biologically that means biological process plays lion share in the waste water treatment process and if you look at waste water treatment process two process two different type of process largely in operation one is called aerobic waste water treatment process and there is the anaerobic waste water treatment process. So I shall first I shall concentrate on aerobic waste water treatment process then latter I shall discuss about the anaerobic waste water treatment process. Now this aerobic waste water treatment process is easy to most of the industry they have this process also lot of industry they also use the anaerobic waste water treatment process.

But aerobic waste treatment process is mostly in operation in case of waste water content very low amount of organic matter and but if the organic matter containing the waste water is more we usually go for anaerobic waste water treatment process. Now here at this juncture I

want to point out that initially because whoever whatever the industry suppose I am a entrepreneur I am going to have a industry, so I shall have to show in my plan that how I am going to take care the waste water or industrial effluent that is generating by that particular industry.

And it has been assumed that 10 per cent of the total expenditure that we have in the industry that goes for the waste water treatment process. The early days mostly we have the aerobic treatment processes and aerobic treatment process basically what we convert we convert the soluble organics present in the in the waste water that is converted to the insoluble organics because the cell mass that is the that is the insoluble mass, so soluble organics that when cell grow and multiply it produce carbon-di-oxide and cell mass carbon-di-oxide will go out and cell mass remain in the system.

The problem is that that after the process is over cell mass 50 per cent carbon I shall show you the carbon and carbon and energy analysis of the aerobic and anaerobic treatment process and we find that that 50 per cent of carbon is restored remain in the system in the form of cell mass. So again cell mass is a biodegradable mass that is again we have the disposable problem. So this has the this has the issues that we shall have to address how so later on this anaerobic treatment processes are come in practise and it has been found this is successfully utilised this organic material both in the form of solid and liquid and they convert to methane and carbon-di-oxide.

When we produce methane and carbon-di-oxide methane has some heating value so it can be used as a fuel so we get lot of revenue out of that, so initially early days when we use the mostly the activated sludge process we do not have much of revenue on this process but as due to the application of the anaerobic waste water treatment process we have some revenue I can give a typical example that distillery industry they produce as the distillery effluent when they passes through the anaerobic digestion process they observe the 50 per cent energy that is required for the distillation plan can be recovered from the anaerobic digestion plant in the form of methane.

So let me tell you that this aerobic today I shall concentrate on aerobic waste water treatment processes largely in practice in the industry.

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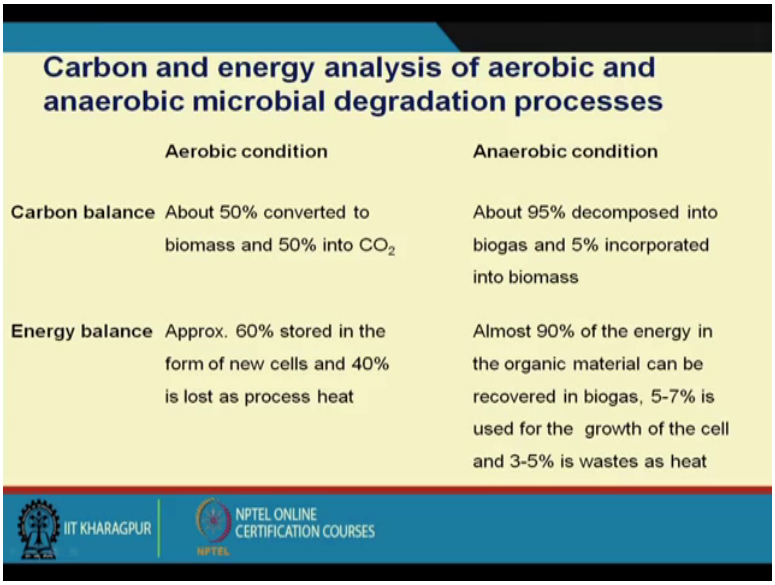

Now if you see the carbon and energy analysis of aerobic and anaerobic microbial degradation process is like this that that 50 per cent carbon is converted to biomass just now I pointed out and 50 per cent carbon goes in the form of carbon-di-oxide. So carbon-di-oxide is a gas it will go out of the system now if you look at the anaerobic process 95 per cent decomposed into the biogas and 5 per cent incorporated into biomass.

So you know that whatever is removed in case of anaerobic treatment process suppose that organic removal is 80 per cent that means more less 80 per cent or very close to that is removed from the system because nothing remain in the system, but when we talk about the aerobic process 50 per cent that remain in the cell mass again we have to treat this biomass so that you know stabilization of the organic matter can take place.

Now if you look at the energy balance 60 per cent store in the form of new cells that is the aerobic process I told you rate of growth of the organism is very fast in case of aerobic say conditions aerobic organism as compared to anaerobic organism and 40 per cent is lost as a process heat, plus that you know I told you that aerobic process we require we shall have to supply the dissolved oxygen in the fermentation media so you have to spend lot of money for that.

You have to spend in the form of pump you have to spargers you have to use to increase the dissolved oxygen concentration in the liquid. So the additional energy expenditure is involved here and if you look at the anaerobic process it does not require any kind of (()) (11:3) it is 90 per cent almost 90 per cent energy from the organic material can be recovered

in the form of biogas and 5 to 7 per cent is used for the growth of cells, 3 to 5 per cent waste as heat. So it is a clear cut picture that how anaerobic system is find dominates as over the aerobic process only the advantage of the aerobic process is the reaction is faster but though it is slow but it is quite useful because you know we get lot of avenue out of that revenue out of that, okay.

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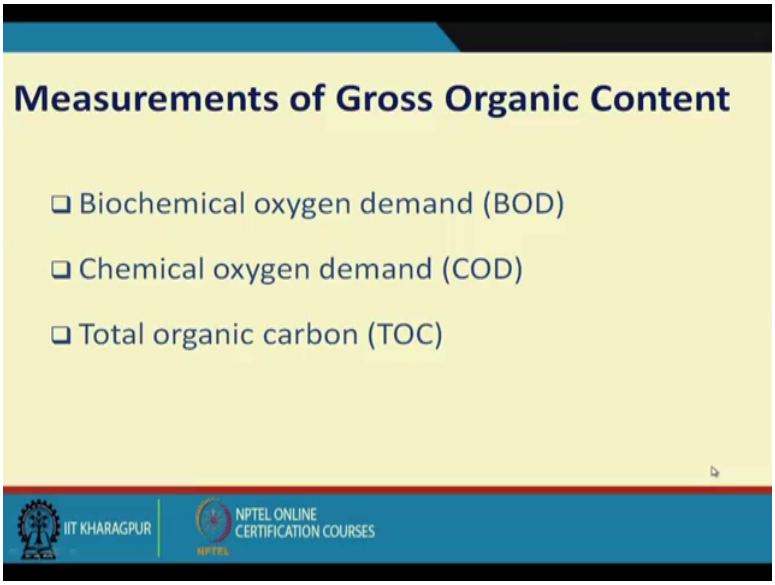

Now first that you know that how you measure the quality of the waste water that is discharged by the industry. Three different parameters plays very important role one is biochemical oxygen demand what you call BOD another is chemical oxygen demand we call COD and total organic carbon what you call TOC. So these three parameters plays very important role in this waste water treatment process.

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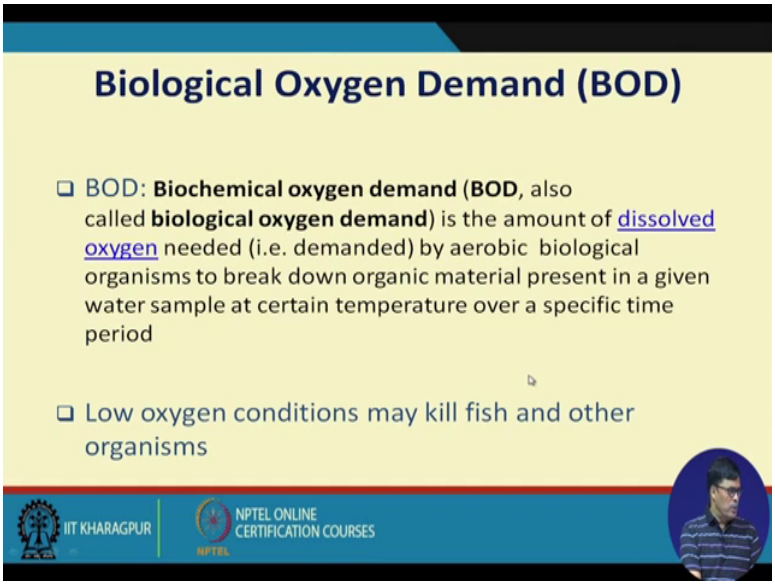

Now let me tell you something on BOD. BOD basically it is a biochemical oxygen demand also it is sometimes it cause biological oxygen demand is the amount of dissolved oxygen needed by the aerobic biological organism to break down the organic material present in a given water sample in certain temperature over a specific time.

They utilise the organic matter for their growth and metabolism that BOD during utilisation of organic matter they consume that dissolved oxygen present in the waste water.

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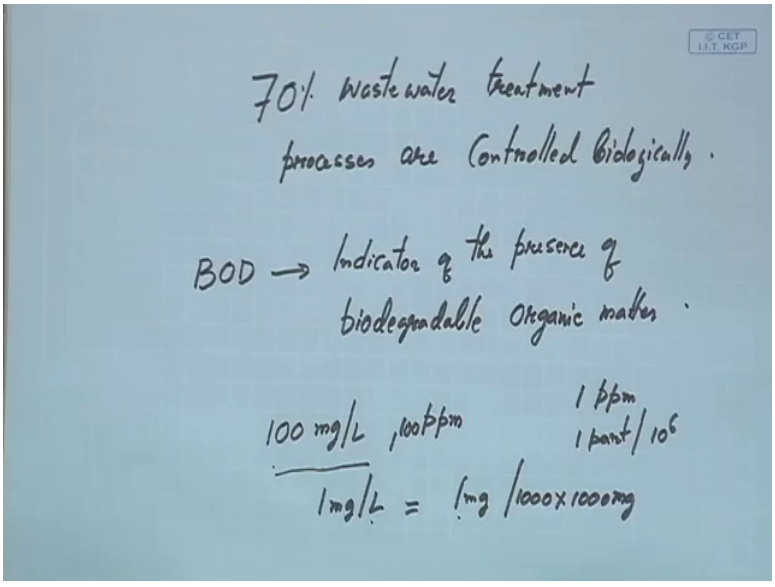

So basically the BOD I want to tell that BOD basically though it is biochemical oxygen demand it is the indicator. So BOD is the biochemical oxygen demand but it is a indicator of

the presence of biodegradable organic matter because suppose as for example suppose if I say BOD is 100 milligram per litre, because sometimes it is expressed milligram per litre or ppm, the ppm means parts per million.

Parts per million and milligram per litre they are same, because how it is same? If you say parts per million means suppose if you have 1 ppm, if you write 1 ppm that means 1parts part 10 6, am I right? now if you here if you look at that 1 milligram per litre means what 1 milligram per 1000 gram into 1000 milligram and we know we know that because the density of water is 1 gram per millilitre so we can we can have substitute this. So you see that 1 per million you know the that is exactly I want to tell that 100 milligram per litre is same is equal to 100 ppm.

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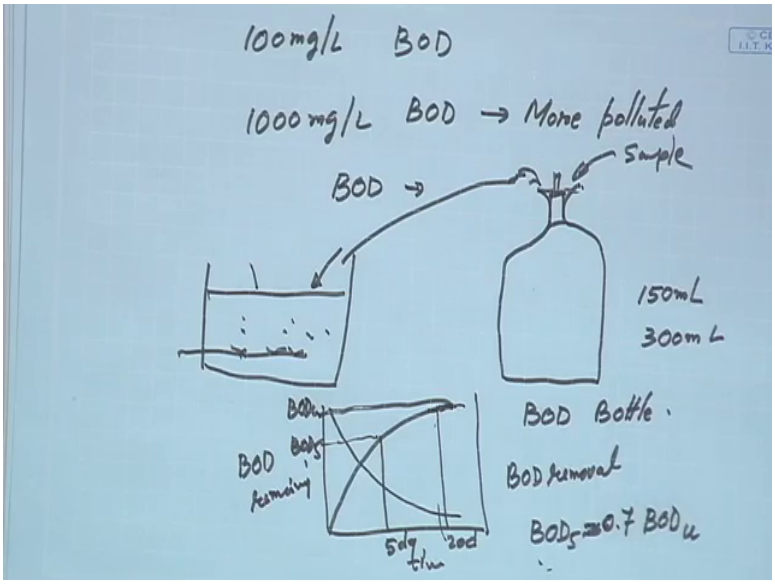

So this is how we express that means if suppose a waste water contains waste 1 waste water contains 100 milligram per litre BOD and another waste water is 1000 milligram per litre BOD so this is the indicator this is more polluted, more because if we discharge this waste water in the atmosphere then lot of bacteria can grow in the water and it will affect the water quality to a great extent.

So this is indicator of the biodegradable organic matter present in the system and another thing I want to point out that BOD usually we reported BOD estimation usually done by this by using BOD bottle and BOD bottle is specially prepared like this, it is a wide mouth bottle is a specially this is called BOD bottle the name of the bottle is BOD bottle.

The typical feature of this bottle is that it is a wide mouth and we have groundnut joint and here we have a cock so this every bottle it has either 150 millilitre capacity or it has 300 millilitre capacity. So this is how this bottle looks so what you do that we take we usually prepared the sample that biological sample we have we take the minimum medium minimum medium is contains the minerals and here we put 1 pinch of glucose and put some culture from the sewage water and we aerated it we aerated it for one night.

So what will happen your organism will grow here and this organism will acts as a dilutant here and then we add the sample here, here we use the sample here we have we use this culture here and then we incubate this is incubate zero hours 1 day, 2 days, 3 day, 4 day like this we can incubate and we take out the bottle 1 day, 2 day, 3 day and 4 day and try to find out what is the dissolved oxygen concentration present in the water because the as the time passes on the bacteria will grow and multiply and it utilized the dissolved oxygen and then naturally the dissolved oxygen concentration will be keep on decreasing with respect to time.

So that we measure and from that we determine the BOD value. Now what you call what you we can we can write that BOD remaining BOD remaining means how much BOD remain in the water because you started with some BOD initial BOD is there and this is the time, so if you plot it is like this is like this and if you another if you plot BOD removal how much BOD is removed the plot is like this.

Now why I want to show you this this you know that here is called 5 days and here when it attains the plateau this is 20 days, now usually that when this is this is BOD is a parameters and suppose you are you are determining the characteristics of the waste water and if you take 20 days for finding out the BOD values that it is very very time consuming. So we find that (())(19:08) is mostly reported the reason is that about 70 per cent of the organic matter biodegradable organic matter will be utilised and on 5 days.

So if you if you have total BOD suppose this is BOD5 this is BOD5 and this is BODu, BODu means ultimate BOD maximum BOD we have, so we can write that BOD5 is usually equal to approximately that is usually equal to 0.7 into BODu. So if you want to ultimate BOD if you want to find out this when it is the 20 days you just multiply by the factor with the ultimate or you know you divide this 0.7 you will get the ultimate BOD but BOD5 parameter is mostly used by the industry to characterize the waste water.

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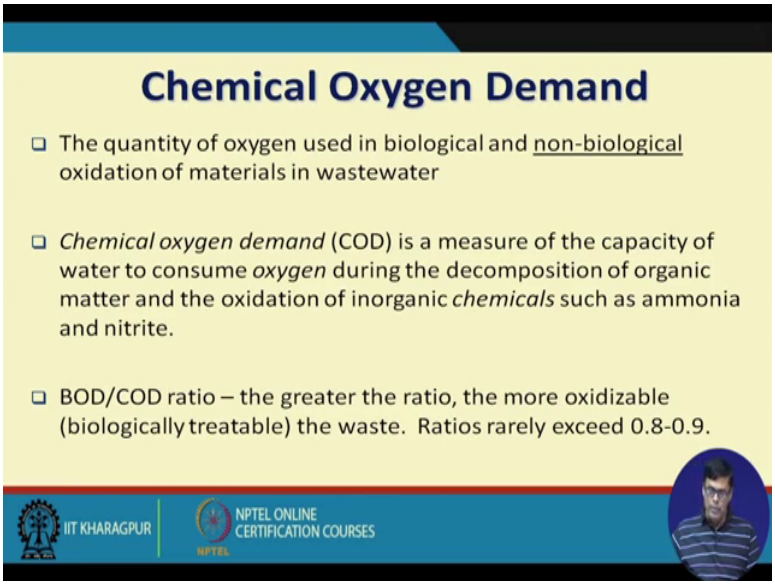

Now here very interesting thing is there I shall come back here after COD explaining the COD there is another parameter called chemical oxygen demand.

Now chemical oxygen demand is the oxygen required from the chemicals for the oxidation of the different material reducing material present in your sample as for example, we know potassium dichromate is a strong oxidizing agent. So in acidic conditions that if you heat it we take this and we reflux it reflux it for you know 2 hours then whatever reduce material present in your sample all material will be oxidized because it may be organic it may be inorganic.

Organic material mostly comprises carbohydrate may be protein, may be liquid like this will be oxidised totally oxidised to carbon-di-oxide and water and nitrogen would be nitrogen oxide, phosphorous will be phosphorous oxide different oxide metal will convert to metal oxide but inorganic material reduce inorganic material also get oxidised as per example ammonia. Ammonia present there ammonia also it is reduced from that also oxidised so COD it does not indicate the biodegradable organic matter but indicate the total oxidizable matter present in the sample that is a indicator that how much total oxdizable matter present in the sample.

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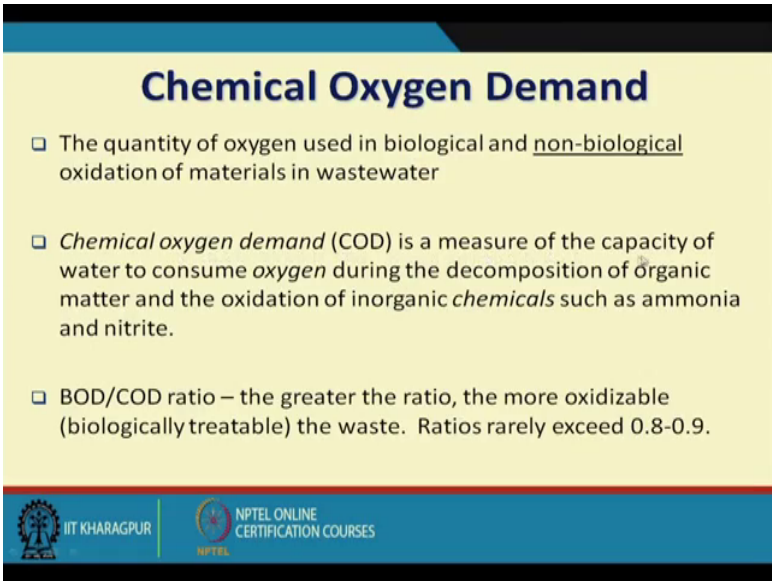

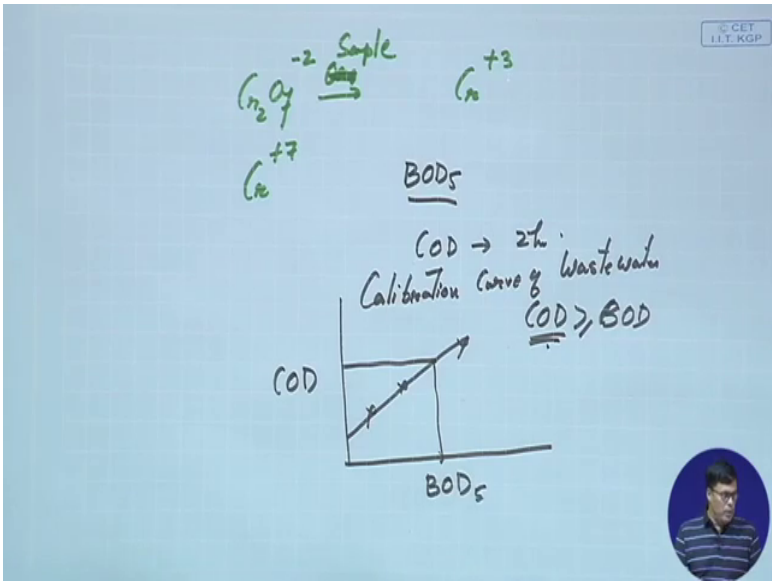

So it is like this chemical oxygen demand is a measured of the capacity of water to consume oxygen during the decomposition of organic matter the oxidation of the inorganic chemical such as ammonia nitrite. So we know that you know that potassium dichromate that Cr2 O7 this is the, so this is when in presence of the organic in presence of your sample that you know it reduce to this is Cr Cr plus 7 so this will be converted to Cr plus 3, so this will be oxidised to reduce, so when it reduce that means your sample will be get oxidised.

This is how we determine this and we find the BOD, COD ratio is 0.8 to 0.7. Now here I want to tell you very interesting thing that BOD value we require 5 days, am I right? I just now I told you for estimation BOD value you have to wait 5 days to get the value of BOD but you know that COD value is required only 2 hours by 2 hours you can find out because what

you do you boil your sample with potassium dichromate solution acidify potassium dichromate solution in presence of some inorganic catalysts so there oxidised all the materials.

And then whatever potassium dichromate remain un-oxidised that you can determine with the help of kind of titration technique by sulphate solution with ferroin as the indicator, you can easily find out that how much that potassium and how much potassium dichromate has been consumed that from that we can calculate and find out how much COD. So this requires COD requires only for 2 hours time or 2 hours maybe 2 hour 15 minutes or like this so what every industry they do they do the correlation between COD and BOD value.

So if you have the calibration of any kind of waste water usually the COD calibration more or less you can say it varies from waste water to waste water but particular one waste water that correlation remains more or less same. So always we consider that you know that BOD value will be COD value always should be little bit higher or equal to say BOD value because why higher because it contains not only the organic matter but also contains some kind of inorganic matter also and organic all organic matter may not be biodegradable also I can give the example of leavening material, leavening type of material that cannot be oxidised very easily.

So that is why the COD value always will be high, so if you plot this then we will get the plot like this that you know that means any sample you find out a COD value and corresponding that BOD value you can find out. So this is the called calibration curve for waste water. For any industry this more or less remains same for a particular effluent for a particular effluent this correlation more or less same still they do time to time see the variation of that. So if you have this value COD value directly give you the value of BOD5. This here if you have a correlation like you can you can easily you can find out this like this.

Now here it has been mentioned the BOD, COD ratio greater ratio is more oxidizable matter biological material is present in the waste. The BOD, COD ratio is high that means more biodegradable organic matter present the ratio rarely exceed the 0.8 to 0.9 because it usually lies in between 0.8 to 0.9.

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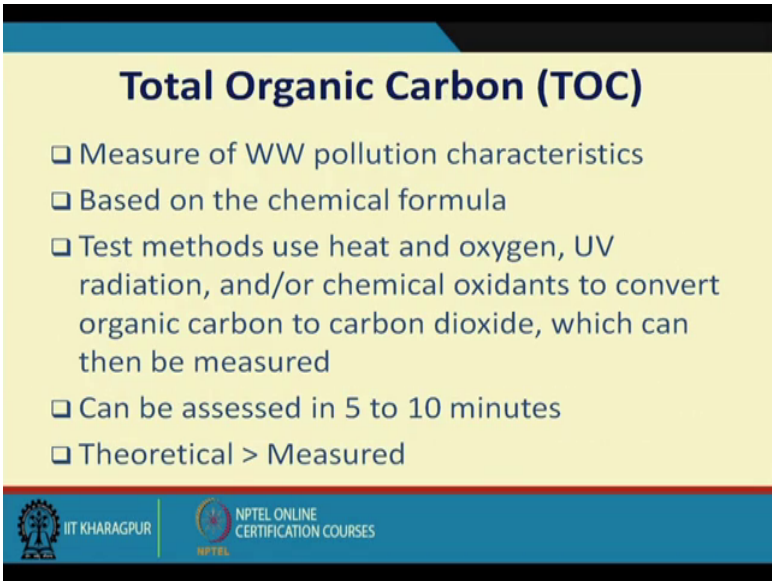

Now next is total organic total organic carbon total organic carbon measure is the waste water pollution characteristics based on the chemical formulae that total the test method use heat and oxygen, ultraviolet radiation and chemical oxygen to convert the organic matter to carbon-di-oxide which can then be measured and can measured within 5 to 10 minutes theoretically carbon because what let me explain that because carbon when you burn it produce carbon-di-oxide. And if we measured how much carbon-di-oxide is produced that from that calculation we can easily find out how much carbon present in the organic sample there is a very simple technique that we can use for the determination how much carbon present in the sample.

And you know that we have seen COD and carbon content has little correlation with each other the correlation more or less remains same.

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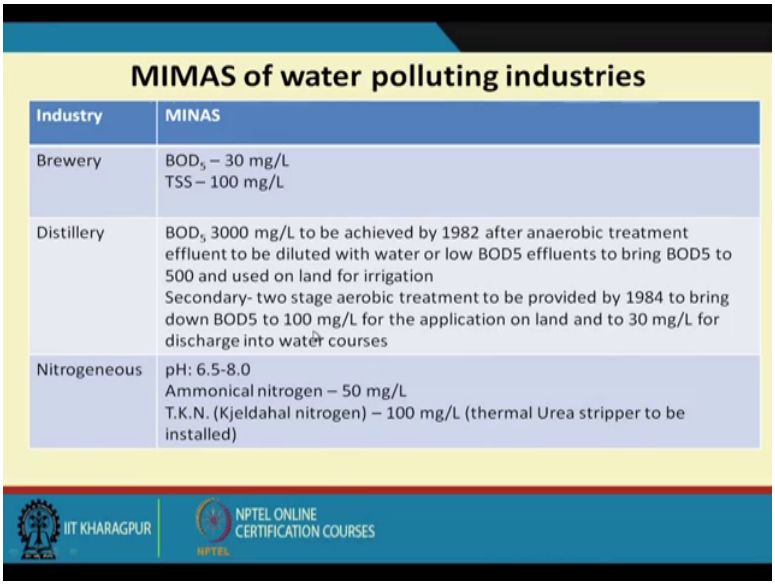

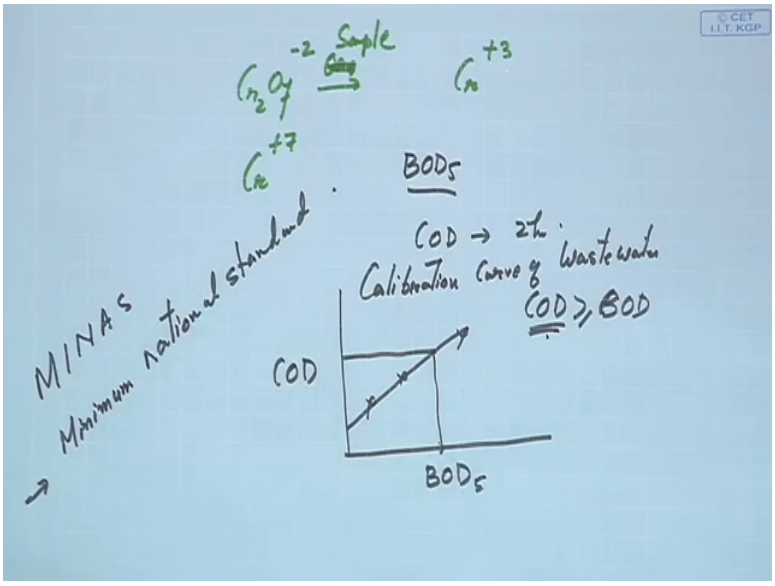

Now this that you know MINAS MINAS is the minimum national standard because I told you in the last lecture that we have central pollution control board that is located in New Delhi and central pollution board they have regional offices in different states of our country and that monitor the waste water disposal or you know the quality of the waste water discharged by the different industries.

Now different industry they have they disposal standard this is MINAS called MINAS means minimum national standard MINAS is called minimum national standard, so that you know disposal standard for different type of industry will be different now here I have given the typical example in the brewery industry I discuss the brewery process you know that BOD5 should be 30 milligram per litre and total suspended solids is 100 milligram per litre.

Distillery industry they have very high BOD and COD value and they have they finally they should bring out the BOD value to because they might be having BOD as high as 30,000 milligram per litre that should be reduced to 100 milligram per litre if they apply on the land but 30 milligram per litre for discharge in the waste water very difficult to achieve but until unless they achieve that other otherwise our water stream will be affected, if we talk about the fertilizer industry that ammonium nitrogen that is discharge in the water should be 50 should be within 50 gram per litre, should be less than that and Kjeldahal nitrogen will be 100 milligram per litre.

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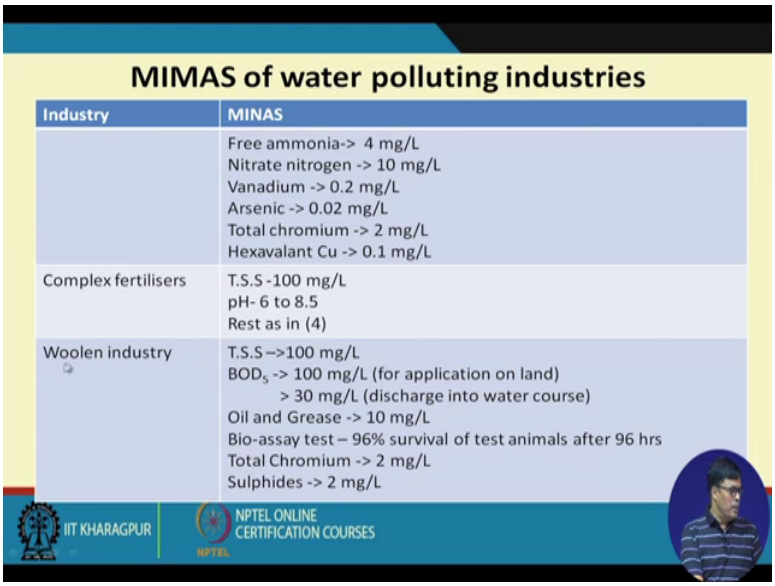

We have complex fertilizer woollen industry we have different disposal standard that has been given here and synthetic fibre, semi-synthetic fibre and sugar industry total suspended solid 100 milligram per litre BOD5 is 100 milligram land application and 30 milligram per litre for discharge into the water course.

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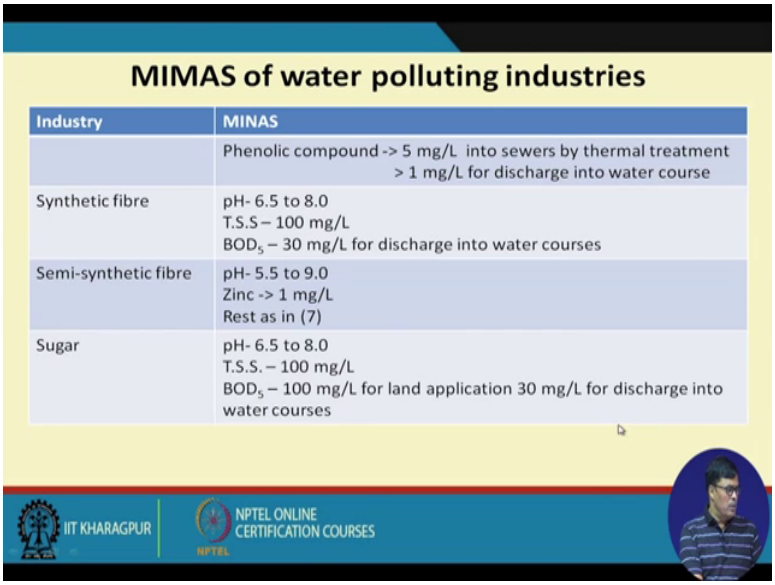

Now another here I want to tell very interesting thing the water quality for the drinking and bathing because quality more or less same I if you look at the WHO World Health Organisation standard the pH should be of the drinking water should be 6.9 total dissolved solid it should be less than 1500 milligram per litre, iron should be 50 milligram per litre, nitrate should be less than 45 milligram per litre.

Chloride should be less than 1.5 milligram, BOD value you can see here it should be 6 milligram per litre, COD is 100 milligram per 10 milligram per litre and phenolic substance 0.002 milligram per litre. Cyanide is 0.2 milligram per litre.

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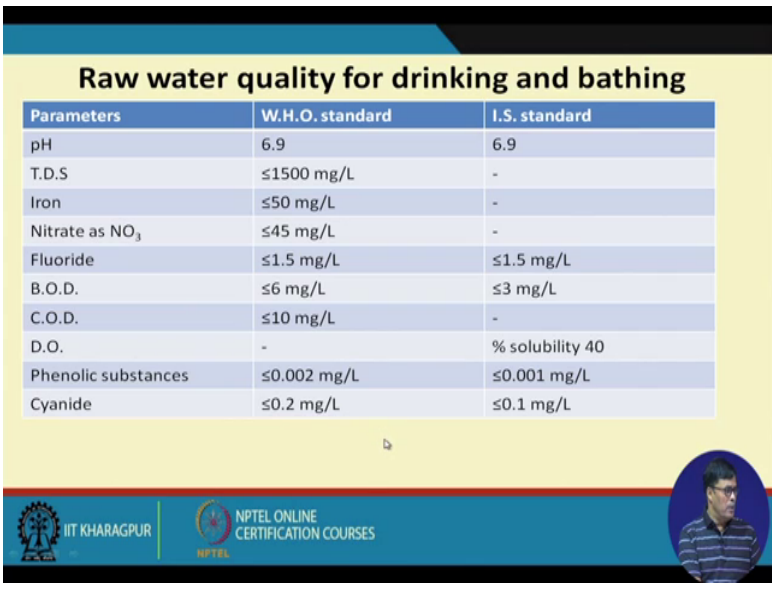

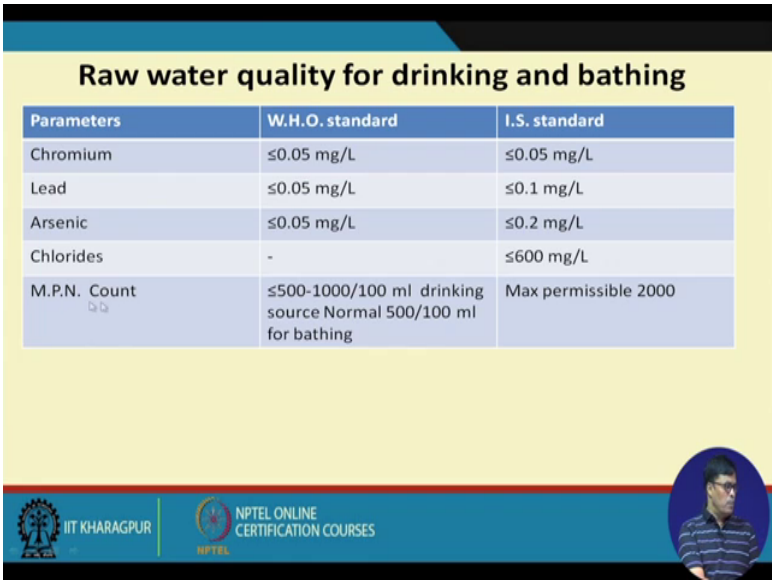

Now that chromium and other minerals they have also they here one interesting parameter I want to tell you most probable number, this most probable number indicate whether your your water stream is contaminated with pathogenic organism because if the water drinking water comes in contact with the sanitary system then we know all the sanitary system everyday every human beings they discharge the millions of e. coli form of bacteria and lot of pathogens present in our the sanitary system.

So if your water drinking water source is coming in contact with this sanitary system then coli form of bacteria concentration will keep on increasing and that indicate the presence of pathogenic organism present in the water sample that is undesirable and that we determine by one important statistical count called most probable number. So this is this is some preliminary information I want to give on the aerobic treatment process in the next presentation I shall discuss the process in details, Thank you.