Water Quality Management Practices

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Week – 02
Lecture – 09

Hello everyone, welcome all of you to this NPTEL online certification course on Water Quality Management Practices. My name is Gourav, Professor Gourav Dhar bhowmick from the Department of Agricultural and Food Engineering of Indian Institute of Technology Kharagpur, India. So, in this ah particular lecture video ah continuing to the discussions that we are having in last ah lecture also about BOD, COD and the TOC. I will be discussing about the modeling of BOD and its relation with COD and the TOC. The concept notes that I will be covering particularly in this material are the BOD model, the factors affecting the BOD reaction rate constant. How to interpret the results and then some numerical also will be solved which is very important and essential for understanding the BOD, COD and this BOD concept.

To start with the BOD model we know that in general the oxygen consumption rate in ah for any aerobic oxidation ah that is happening the inside the BOD testing when we do that. So, what we are what is happening there the aerobic decomposition of organic matter right. During this aerobic decomposition of organic matter the the biodegradable organic matter we this oxygen consumption rate it normally directly linked with the remaining biodegradable organic matter present in the BOD bottle ok. So, what does that mean? That means, the DLT by DT this LT is representing the amount of first order BOD remaining in your wastewater at any time T is equal to is almost is equal to minus K into LT.

What is this K? K is the first order BOD reaction rate constant and LT as I was mentioning is the ah the BOD remaining in wastewater at any time T ok. So, if you integrate this equation right now that this DLT by DT equal to minus K into LT this first order equation if you now ah integrate it from 0 time 0 to T ok. So, if you integrate it in the left hand side if you see DLT divided by LT equal to minus K into DT ok the LT can be goes in the left side on the bottom in a denominator right. So, it is nothing, but the integration of 1 by LT into DLT equal to minus K into DT I mean like integration of minus ah integration of minus K integration of DT is not it. So, if you integrate it 0 to T you will what what number you will get in the left hand side you will get log of LT 1 by LT if you integrate it is a logarithm of LT is not it.

So, logarithm of LT 0 to T is equal to minus K into T because minus K into T again plus K into 0. So, if that part will be eliminated. So, minus K into T. So, now, log of LT 0 to T that means, log of LT minus log of L0. Is not it? So, log of LT minus L0 means log of LT by L0 also we can say is not it.

So, if you remember this logarithmic ah ah functions and all. So, log of LT by L0 is equal to minus K into T. So, that means, LT by L0 can be easily find out is equal to minus is equal to e to the power minus KT or 10 to the power minus KT based on what is the base of your logarithm. If your logarithmic functions base is 10 it will be 10 to the power minus KT if it is e it is e to the power minus KT. This is a very important equation you should write it down LT is equal to L0 into e to the power minus KT or LT equal to L0 into 10 to the power minus KT ok.

You understand how this equation comes? So, if you rearrange this solve this equations we get this 2 or 3 this equation that is I was just mentioning about. Now, what is this L0? L0 means it is it is the first is the like you know the ultimate BOD. That means, the maximum oxygen that remains that is that is remaining that is remaining in the ah in your system that is the first I mean like the I would say like the first ah point I mean that that at the point when the time is 0. With time what is happening the oxygen will this BOD will reduce with time ok. This BOD will reduce then oxygen will cost like will start consuming the maximum amount of oxygen, but however, we cannot reach to that ultimate BOD point.

We can reach to an as in plot, but it is it will become an as in plot, but it will we cannot find out the exact value of ultimate BOD or L0 ok. So, it is very hard for us to find out, but this L0 value is theoretically we can easily find out and that actually is a very important phenomena in important number I would say for calculate for the whole calculation of this BOD model you understand. So, this L0 is what L0 is ultimate BOD of your system ok. So, ultimate BOD is known to us now we that is which can be easily ah in the synonymous way we can say L0 and if you see this equation in the left hand side the y axis or the coordinate axis is giving us an idea about the oxygen consumptions and the BOD remaining. Oxygen consumption is actually you can easily find out by the ah the the the the dotted graph and the BOD remaining you can easily get it by the smooth graph ok.

You can see the smooth line from like the from the the the smooth line ah you can easily get the BOD remaining and also we can ah synonymously call it LT. The x axis or the abscissa will give you the value the the the the the it will showcase the time in days. So, with time we have a ultimate BOD you see the dotted line on the top and then you see the BOD at the beginning with time what is happening? BOD is reducing right with time

the BOD will reduce and with time this oxygen that is BOD T that is we can easily find out also that can also be derived with this dotted line which is the oxygen exerted value. So, this variation in the DO this figure actually showcase us the variation on DO profile and the BOD with the duration of incubation in the BOD test. If you go further we will get the maximum we will there is a chance we will get to we actually find out the maximum amount of final I mean like there is a chance we may reach to the almost near to the ultimate BOD instead of 5 days if you say like go for 20 days 30 days.

In general in 20 days theoretically we should reach almost 90 percentage of 85 to 90 percent of ultimate BOD. However, you will be surprised to know in 5 days we can actually reach up to 60 67 to 70 percentage of actual ultimate BOD, but still we consider it as a standard why because that is the that is the that is the limitations the protocols are says that we cannot go beyond that we can go beyond that then we have to standardize because whole world has to follow a certain protocol to maintain a certain you know level of ah you know accuracy in your result and also the trans ah transparency in your result. So, that is why the BOD 5 is actually chosen. BOD 5 if you see it is only it will give around 67 to 70 percentage of ultimate BOD still there are some BOD ah you know the actual BOD is quite less the I mean like quite ah higher than the BOD that you are actually finding out after 5 days of operation ok. So, anyway so, from this equation from here you can see the LT value we can find it out any time say even L 5 also we can find it L 5 is equal to L 0 into e to the power minus 5 minus 5 into k you understand instead of t we will put the 5 the L 5 the L 5 will show what this if you see the 5 line when it reaches up to this ah smooth line that that value is actually the L 5 this L 5 is equal to L 0 into e to the power minus k into 5 or 5 you understand.

So, this is how the BOD remaining can be calculated ok. So, this is the graph it is very important for you to understand this graph it is ah I would request all of you to actually go through it one ah couple of times. So, to understand the whole functionality ok. In general the relation between the BOD reaction rate constant the k with base e in case of natural log and base k with base 10 ah for log with a to the base 10 can be given by the equation 4. Normally k with the base 10 ah to the base 10 is equal to k to the base e ah divided by 2.303 that is the relation between this 2 when you are when your k value is given for base 10 and e is not given you can easily calculate by multiplying it with 2.3 you can easily get the k base e or if it is k base 10 is ah not given k base e divided by 2.303 you will get the k base 10 ok. The amount of BOD that has been exerted or the amount of oxygen that is being consumed with at any point of time ah is given by the equation 5 this BOD t is nothing, but the L0 total BOD minus the the BOD that is exerted this you can see this is the if you see from this model this BOD t is what we are talking about here is equal to L0 minus L t L0 minus L t what is L0 here L0 is the ultimate BOD and L t is what L t is also L0 multiplied by e to the power minus k t. So, if

you take the L0 common it will become 1 minus e to the power minus k t you understand BOD t is equal to L0 minus L t.

Now L t is also from the equation 3 you can say equal to L0 multiplied by e to the power ah minus k t or 10 to the power minus k t. So, now, you common ah take the L0 common it will become L0 in bracket 1 minus e to the power minus k t or 10 to the power minus k t you understand you have understand right. So, this is the equation 5 what it depends. Now therefore, the 5 day BOD we can easily calculate the BOD 5 is equal to L0 minus L t or L0 ah minus ah 1 minus e to the power minus 5 k. For polluted water and the waste water at 20 degree Celsius this k base e is typically 0. 23 per day and for same condition k base 10 is typically obviously, divided by 2.303 it will become 0.10 ah 10 per day. For this values can widely varied based on the organic matter constituents and the biodegradability of the nature of your waste water ranging from 0.

05 to 0.3 per day for ah k base 10 and for ah k base e it can be 0.23 to 0.7. Ultimate BOD is the maximum BOD ah waste water can exert and its challenging to pin point the exact time to achieve L0 as I was mentioning because theoretically it requires infinite incubation time. Because just imagine it is not only about the organic matter that is present in the waste water now because that organic matter easily being consumed by the microorganisms.

However during that procedures they will also grow by themselves and they will also die. When they will die that will that will also add to the organic matter present in your waste water isn't it? That is also an organic matter their biomass this biomass is also adding to the organic matter present in your waste water. So now, again the new fraction new biomass that is creating it is actually consuming the older biomass I mean like this fraction you can narrow it down, but this will keep on growing in the system unless until the whole system will be converted into some gaseous product say carbon dioxide and all then that will be released. However in general this process actually takes infinite amount of time ok. Practically L0 is considered to be achieved when the BOD curve becomes nearly horizontal ok.

Then the BOD model the time to reach L0 it depending upon the it depends upon the waste water characteristics, the organic matter compositions, the biodegradability nature of your waste water, it is incubation temperature, the higher temperature led to the faster faster attainment of L0 then the lower temperature. Obviously, because some additional amount of microorganisms will be active because in this higher range of mesophilic temperature because normally we have the cyclophilic, mesophilic and thermophilic, but higher range of mesophilic almost on the sandwich layer between the mesophilic and thermophilic that the the microbial activity goes very high is not it. L0 in general

represents the concentration of biodegradable organic matter based on the total oxygen needed for its oxidation and however, this L0 does not reveal the rate at which oxygen will deplete at the receiving water that depends on both L0 as well as the BOD rate constant or the value k in per day ok. However this BOD reaction rate constant or the value k it depends on following different parameters. First the nature of organic matter present in a waste water, second thing the ability of microorganisms in the system to utilize that waste is not it because it is not that you have a certain amount of organic matter, but there are some type of microorganisms which you have introduced they do not eat those they are not they they do not like those kind of food.

So, for them now it is becoming a quite a verdict for us that we introduce synoculum, but there is no depletion in the DO because they were not they are not accustomed they are not unless until slowly those type of microorganisms will start growing they will not eat this food is not it. So, it is like that. So, ability of microorganisms in the systems to utilize this waste and the temperature. How they are related we will be discussing in details. First the nature of waste different organic compound in the water have varying the degradation rate.

Obviously, if you take sugar it is very easy to degrade. Now, if you take say like any kind of phenyl say it is very hard to degrade. Simple compounds like sugar and starch degrade rapidly resulting in a high BOD rate constant. However, complex compound like cellulose or say like human hair as I was saying it degrades more slowly and may not degrade at all in short term test. So, your result though these are the organic matter, but it will not give you the value in case of BOD test you will not get that organic matter concentration actual organic matter the value that will get BOD is erroneous or say like it is not inclusive of the all the biodegradable organic matter because it may take time.

The biodegradable rate will like you know the time is different that is differ to like you know with the type of nature of the waste. For sewage in general the BOD rate constant depends on the proportion of ah different organic compounds and raw sewage has normally higher BOD rate constant ah while treated sewage has a lower BOD ah rate constant because due to the removal of easily biodegradable matter what does that mean? Just always remember higher BOD rate constant means the system has a more amount of or more fraction of easily degradable organic matter ok. So, then only the BOD rate constant will be higher in this case initially when the raw sewage is introduced to your plant to suppose one the treatment plant that raw sewage has more more fraction of biodegradable organic matter that is why the rate constant was much higher with time when the treatment is done those biodegradable compound is already treated already consumed. That means, the fraction is now much less the biodegradable organic fraction is much less. So, that is the reason the organic ah the the the the value of k the reaction rate constant will also reduce ok.

The treated sewage in general contains higher proportion of less biodegradable organic matter and what is the reason because that I was saying k its lower BOD rate constant. Next factor is the ability of microorganisms or the organisms to utilize that waste as I was saying they have certain limitation in oxidizing the specific organic compounds. In natural environment the microbiota capable of degrading the particular organic matter which is thriving there. In case of BOD test in the laboratory it may lack those specialized microorganisms and which will result in a lower value of BOD. However, in actual case may be it much it is much higher.

BOD test also should use the acclimated microbial seed culture what does that mean? ah Suppose ah you have a you want to understand the BOD value or the the suppose the efficiency of a treatment unit where it is treating say ah some high some higher rate like say like phenol it is treating the phenol. When it is treating the phenol and when you have a you want to understand that where whether your treatment plant is working fine or not you need to understand the efficiency right say like BOD removal efficiency we need to understand just to give you an example. So, in this case suppose the phenol degrading microorganisms are not available readily in the inoculum that you are supplying. What will happen? Those inoculum those bacteria is not associated with they do not normally associated with the phenol degradation. What they will do? It will take time for the acclimatization period we call it acclimatization period or it will try to acclimatize to the system to the to the surrounding then only it will slowly grow some that specific microorganisms which loves those phenol loves those particular type of chemical.

Then they will start proliferating very fast they will start growing very fast because for them their natural food is available. However, this period for which actually it needs this acclimatization period what we call this period will actually say like 3 to 4 days in general just to give you example. So, what will happen? Your actual beauty test is 5 days and for 3 to 4 days it will take all the microorganisms to will actually make themselves adjust to the type of ah food that they have. So, actual result that will get BOD 5 will not give you the not give you the not not not at all give you the exact value isn't it? It will give you something like say 1 day of BOD whereas, you are considering for 5 days of BOD because your microorganism they will start acting on those ah chemicals acting on the waste water for the they only get 1 day to do that. So, this is the thing that we that is why before even supplying the ah the seed that inoculum you need to acclimatize it.

Once you know the waste water you have the waste water in a separate unit and you try to start growing you add the inoculum there in a small bucket and you keep on you provide aeration there and make them grow slowly with time you will see some amount of sludge on the bottom it will grow or they in a suspended condition. You take the sample from there take the seed from there that means, you know that that

microorganisms those microorganisms that is present in that ah environment where that culture bucket from where you actually collecting the sludge or the inoculum it definitely will have those microorganisms they can they are responsible for treating that particular type of waste you understand. So, acclimatized microbial seed is needed to match the natural conditions. So, now, it will start acting on those ah BOD model from the day 1 you understand. Now, acclimatized seed structure provide more accurate estimate of oxygen requirement then though those random inoculation ok.

So, this is very important. So, this is this is very important to understand when you ah when you are be doing the BOD test in your laboratory. Another very important ah factor is the temperature. Most of the biochemical ah reactions that take place in nature also it definitely varies with the temperature it is depending on the temperatures likewise the BOD. BOD test is also temperature dependent. Microorganisms started their activity will started increasing with higher temperature up to a point and then it starts decreasing.

In general BOD test is conducted at a standard temperature of 20 degree Celsius for 5 days and Indian context sometimes we use 27 degree Celsius for 3 days that is also standard that is also you can follow. Adjusting this BOD rate constant to the actual water temperature is very necessary and this adjustment can be done with the relationship like ah with the rate constant if you see the k T is equal to k 20 theta to the power T minus 20. What is this theta? Theta theta is nothing, but the temperature coefficient ok. Please remember theta is the temperature coefficient which is generally 1.056, but 1.046 for temperature above 20 degree Celsius. The rate increases more when temperature goes from 0 to 10 to 20 compared to 20 to 30 ok. Because from 10 to 20 it is becoming more favorable for the microorganisms then the comp 20 to 30 ok. So, in general so, this adjustment factor has to be remembered you please note it down k T is equal to k 20 theta to the power T minus 20. So, that means, if k 20 is known to you the T value is known to you what is the temperature for which we are talking about you can easily find out with this equation what is the value of k T ok.

And this theta is always either 1.056 or 0.1.047 it will be given to you in general this is either of these values. Interpretation of BOD test results. So, I will be discussing about the numericals couple of numericals at the end of this presentation I mean like the discussion. However, before that we need to interpret the BOD test right we do the BOD test that the result has to be interpreted correctly. In while interpreting this BOD test results we need to consider couple of factor.

First of all as I was discussing whether the seed is already acclimated or not. If it is not acclimated then we need to reduce we need to somehow eliminate that lag time or that acclimatization time from the actual BOD value. So, that instead of 5 days you may have to take the BOD for 6 days or 7 days considering that the your microorganisms needs to adapted to the new type of BOD. So, you have to take the BOD for 3 to 4 days according

to the literature you understand. So, acclimatized seed is very necessary it is better to provide them provide them.

Reaction rate constant we have to determine the first order BOD reaction rate constant separately for raw and the treated wastewater. They differ with higher values for raw wastewater and the lower values for the treated wastewater. Acidic wastewater we have to neutralize the acidic wastewater sample before the BOD test what will happen? Definitely it will affect the microorganisms that you are introducing is not it. So, that we need to added to.

Suspended organic matter that is very challenging. If your wastewater has a suspended organic matter it will be really interpret really really really interacting with your BOD test like anything. Because what will happen the this suspended organic matter it will take time for the hydrolysis procedure to occur. After the hydrolysis only it will be before oxidation this hydrolysis procedure take some time then only this oxidation process will occur this hydrolysis procedure takes this lag time take some lag time. So, it is always better that the particle size you have to know and obviously, the suspended organic matter presence in your system should be as low as possible.

If it is the suspended organic matter is less. So, now, the that means, it is already oxidized now that matter that solution is easy for you to do the BOD estimation and all ok. Particle size affect for settleable solid more than 100 micron in size the rate constant in general it is around a 0.08 per day with the base e and for colloidal organic matter it is 0.1 to 1 micron in size it is about 0.22 per day with the base e and for dissolved organic matter it can reach up to 0.

39 per day with the base e ok. So, particle size with the change in particle you can see the BOD rate constant will also vary like anything. Now, another very important ah another very important ah criteria here is the nitrification in the BOD test. If you realize whenever we are talking about this BOD test COD test and all we are majorly focusing on the carbonation of the carbonaceous organic matter. Majorly especially in case of BOD test we are talking about the carbonaceous organic matter. We do not consider the nitrogenous ah ah nitrogenous organic matter nitrogenous organic matter is what they are also a type they are also contributing to the system the presence of organic matter present in their in your wastewater.

However, we do not normally consider because there are certain issues with that. First of all this nitrogen majorly say like present in say like ammonia or nitrate or nitrate form it those nitrifiers like nitrosomolus nitrobacter and all they are very slow growing. It takes time for them to grow in an ah artificial environment. Once they will grow so, after then they will start consuming the nitrogen present in the system and they will also

consume some amount of oxygen because this is a aerobic decomposition it is a aerobic ah process this process is called nitrification.

This nitrification process is a aerobic process. So, all this process will also convert the ammonia to nitrate and nitrite ok. So, majorly at the end it will convert into nitrate and this nitrate can be further converted into nitrogen gas in denitrification process that is separate issue. However, this process ammonia to nitrite to nitrite to nitrate is actually oxygen consuming. So, this oxygen when it is oxygen consuming that means, this degradation process will also add up to the BOD.

However, in 5 days it does not affect much. It started at started appearing to this started appearing this nitrifiers after 7, 8, 9, 10 days depending upon the type of waste and all type of nitrogen waste. In general the hydrolysis of nit proteins in the wastewater it generates this kind of non carbonaceous matter this ammonia and all. Though this nitrogen tied in the organic matter from microbial activity organic compound it can be easily converted into ammonia and this ammonia under aerobic decomposition anaerobic aerobic conditions it converted into 2 step nitrification process into nitrate right. And the organic matter with nitrogen ah in wastewater it requires oxygen not only for standard oxidation, but also for the nitrification process because of that this is the this becomes the actual BOD consumption graph. If you see the oxygen which is consumed after 6 or 7 day there is a jump sudden jump because there are more amount of oxygen is being started consuming ah by the nitrifying organisms nitrifiers present in your systems.

Because of that the actual BOD will see this is the ultimate carbonaceous BOD ultimate BOD graph there the actual BOD will say more than that because of the nitrogen present in your system you understand. So, this is the nitrification when it starts occurring because of that the this is also another reason when why we have the BOD value around 5 or maximum ah like 3 or maximum 5 days ok. So, this nitrification will start generally typically occurs during 6 to 10 days it is reflecting the slow growth of the nitrifying bacteria and standard 5 day BOD test in chosen to focus on the carbonaceous oxygen demand only excluding the nitrification. And as as was as I was mentioning this 5 day duration was historically linked to the Thames river flow from origin to the sea reflecting the concerns about the protecting the river water quality. So, when we talk about the ah relation between the BOD and the COD, COD value is normally proportional to BOD only for soluble organic matter in dissolved form.

If your waste water is complex if your waste water has certain type of suspended organic matter then there is it is very hard to find out the correlation between BOD and COD. For readily ah biodegradable waste water like dairy effluent BOD can be estimated as 0.92 times the COD value it is the BOD ultimate. At the COD is faster determination of BOD, but it does not provide the information about the nature of organic matter that is also something very important. So, if you realize if you can

somehow correlate the COD and BOD for your waste water it is much easier for you.

Suppose you have a industry you cannot do the BOD in very frequently because it is very hard in it is like 3 to 5 days right, but you can easily do the COD. So, you do the COD and once you know and and also do the BOD at the very beginning couple of days you do it and you know that this ratio because normally the waste water that you have in your system will definitely will be the same. So, once we have the ratio when you fix that ratio that BOD to COD ratio once you know that from now onwards you better to you better for you if you only do the COD. So, if you only do the COD still you can actually from that correlation you can say the BOD value approximately say like 0.8 percent 80 percentage of your COD, 75 percentage of your COD say 70 percent of your COD ok understand.

So, this is one of the best possible way that you can that normally being suggested by the scientist and the researchers. So, however, this COD to BOD correlations are different as I was saying if your waste water is complex in nature and also if it has some suspended organic matter present in your system ok. And once COD value is known and it is much more easier because for the routine treatment plant as I was saying and this BOD to COD ratio from this graph is also very important it gives you a standard ah you know representation of the sewage ah and their BOD ultimate to COD ratio you see like 0.87 and ultimate BOD to ah say like BOD 5 ratio 0.68 as I was saying that it is around ah 68 percentage of the actual BOD that we actually get ah after 5 days of BOD.

And if you consider the BOD 5 to COD it will be definitely you know 0.68 will further ah reduce to ah 0.59 ok. So, this is this is how you actually you can actually find out the this correlations are very important ah for your waste water if you know this correlations once you know that after that any one any one of the parameter will give you the value of the rest of the rest of the two. Let us do one numerical ah please write it down in your ah notebook it will be easier for you to remember afterwards the BOD of a sewage incubated for 3 days at 27 degree Celsius has been found to be 180 milligram per liter what will be the 5 day 20 degree Celsius BOD considering the k value is 0.

12 with base 10 at 20 degree Celsius and theta is 1.047 it is a very easy the BOD of 27 degree is given 180 milligram per liter k 20 value is also given 0.12 with the base 10 per day. And now k 27 easily find out from that equation if k 27 equal to k 20 into theta to the power t minus 20 what is theta here 1.047 it is given what is the theta t here 27 degree Celsius. So, from that equation you can easily find out the the rate constant at 27 degree Celsius which is 0.

166 per day. So, once you know this point 0.166 per day now BOD total is given how much it is ah 180 milligram per liter ah is equal to L 0 multiplied by 1 minus 10 to the

power minus k t remember this is 10 because base 10 is given the the the rate constant ok. So, this k value is we already find found out it is 0.166 and t is what the 3 days ok. So, from from that value you can easily find out the L 0 the ultimate BOD which is 263.8 now 3 days ah 20 degree Celsius value we know it 180 from there we can easily find we easily found out the ultimate BOD which is 263.

8 milligram per liter. Now from there you can easily now calculate the BOD 5 ah at ah 20 degree Celsius right for that also we can easily do that BOD 5 at 20 degree Celsius equal to L 0 1 minus 10 to the power minus k t L 0 we know just found out we found out it is 263.8 multiplied by 1 minus 10 to the power minus k value is 0.

12 into t t is 5. So, which is 197.5 or say like 190 milligram per liter. So, that means, the 5 day BOD in at incubation temperature 20 degree Celsius for that waste water will be 190 milligram per liter is not it resembling you understand. So, after 3 day it was 180 milligram per liter after 5 day it will definitely be higher 190 milligram per liter 5 day the BOD level will further decrease is not the further I mean like utilized. So, it will be 198 milligram per liter ok. I hope you understand this numerical and if you understand please ah take a picture or snapshot of this ah exercise and you try to do it by yourself it is very easy and once you try to do it by yourself it will give you some confidence additional confidence then how actually it will be done ah it should be done in the real life exercises and all ok . So, in conclusion we understand about the the relationship between the BOD and the time ah that can be represented by a curve and BOD exerted decreasing and the BOD remaining increasing over time.

We understand the and the control we understand the factors which are majorly controlling the importance of reliable BOD testing and waste water treatment. We understand the factors like temperature pH and the inhibitory substances that can affect the reaction rate. We also understand the actual waste water treatment in anaerobic process that can achieve a high removal efficiency of more than 90 percent BOD and this removal high removal efficiency is achieved normally 5 to 6 hours of retention time in a biological reactor and this their relation their correlation with the COD and all CODs and all. So, we also understand about the relationship between the BOD COD and ultimate BOD and BOD 5 and all and the modeling is also done. So, I hope this lecture material will give a very strong base about how ah the numerical has to be followed how I mean like you should ah go ahead with the understanding about the BOD concept for any waste water treatment systems or any waste water ah sample ok.

I hope you understand the concept and if you have any doubt feel free to contact me ah this is the some of the references. I hope you understand ah basic knowledge and the understand the overall understanding the numerical that can be done in the real lab

scenario for BOD COD and TOC. So, we will meet you on the next class. Thank you so much.