**Wastewater Treatment and Recycling**
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**Lecture – 15**
**Waste water characteristics: Practice Problems**

Hello friends. So, this week or discussion was more or less focused on to the wastewater characteristics and their different parameters that are used to define the wastewater characteristics, we did discuss all the major parameters almost and then of course, there are endless there are many more other parameters and new parameters are being added on. So, these parameters are typically used to quantify the quality of water, how is the water quality in terms of these different parameters, what is the value of BOD, what is the value of DO, what is the value of COD for say and based on these parameters, we can designate particular water; whether it is fit for a suitable use or fit for disposal or not.

So, there are let us say guidelines and standards available for discharge water quality for say, if you are if you want to discharge a water to a or treated sewage to or treated industrial waste to a river what are the allowed parameters for that water. So, like what is the permissible limit for BOD? BOD is say for say should not exceed 10 or should not exceed 30 milligram per litre. Similarly what should be the minimum dissolved oxygen in that water what should be the minium mini what should be the maximum solid concentrations in that water maximum concentration or level of different metals in that water.

So, that way the overall quality of a water or in our case waste water is checked and then we designate that water whether it is suitable for discharge, suitable for reuse or needs further treatment; what are the parameters that are exceeding the standards. So, accordingly we fix on the type of treatment also for say if your suspended solids are very high so, if you are putting and trying to give a biological treatment that is probably not going to work. So for the suspended solids what are the suitable treatment or organic matter is very high; so, what kind of treatment should be provided; all these are decided based on the quality of the water or wastewater.

There are discharge standards available from the different agencies different norms, even the bureau of Indian standards as designated discharge standard for sewage discharge;

similarly the different type of as we discussed earlier also. So, the different types of waste water or the wastewater received from different sources are likely to have different characteristics, different characteristic means the different values of these parameters. So, for say wastewater domestic waste water which is coming in may have a BOD ranging from say 80 or 100 to 300 400 or 500 ok. However, a waste coming from a let us say; distillery will have very high values of BOD could be in a few thousands or even at times even in lakhs.

So, that way we can have very particular values of BOD and COD depending on the source of the waste. We will share some of the some of the typical characteristic of waste received from a few industries, waste received from the municipal sewage in the lecture materials along the course. However, for this particular class we I want to utilise this time for solving some of the practice problems. So, based on the discussions that we had in the week; so far in the previous 4 classes, in this week, we will take a few practice problems and will try to solve it here. To begin with the question is the question that you are saying is basically a glycine undergoes a reaction in the presence of oxygen.

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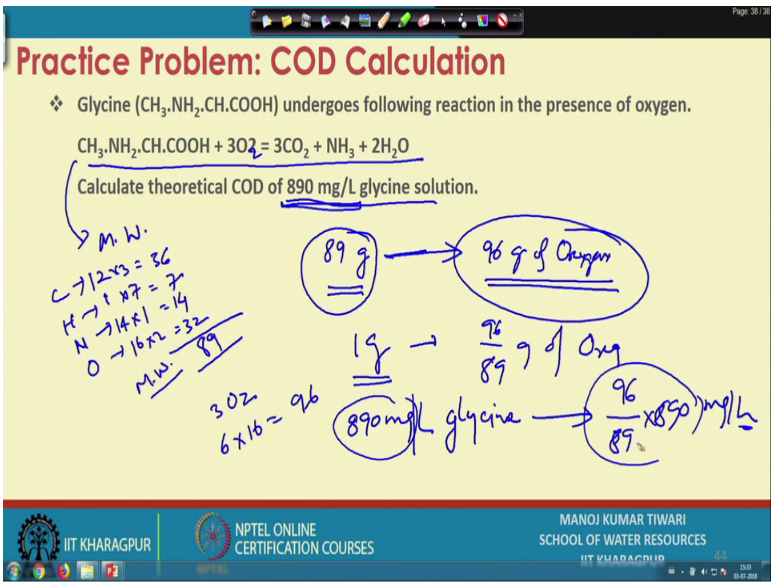


So, this is the reaction which is taking place this should be O 2 so, we need to calculate the theoretical COD of 890 milligram per litre of the solution. So, remember we discussed; how theoretical COD can be estimated. So, if the primarily compounds are having carbon hydrogen and oxygen, we can estimate the required amount of oxygen directly we discuss that during the class for different other organic matters like this has a nitrogen and all that. So, it will not fit directly to that formula, but anyway we have been provided a equation and we can use that equation for determination of theoretical COD. So, how we can use this determination?

Now, if we see let us say the compound that we have what is the molecular weight of this compound now you can quickly see, there is a 1, 2, 3; 3 carbon. So, 12 into 3 that makes it 36, there is 3 plus 2; 5 plus 1; 6 plus 1; 7. So, there is 7 hydrogen; that makes it 7. So, this is for carbon this is for hydrogen there is 1 nitrogen. So, 14 into 1 that makes it 14 and there are 2 oxygen molecules. So, 16 into 2 that makes it 32 1, 2, 2; 4 plus 7, right so, if we add these numbers, what we get is 4 plus 2; 6 plus 6; 12 plus 7; 19 and 1; 1, 2 and 3; 3, 6 plus 2; 8; 89.

So, the molecular weight of this compound is 89 total molecular weight and so, this if you see the stoichiometry of this reaction; this 89 gram or what is ever you need, you can take it is basically molecular weight. So, the 89 gram is reacting with 3 moles of oxygen it is reacting with 3 O 2 3 O 2 means 6 into 16. So, that makes it 96; right. So, this 89 gram of your glycine is reacting with 96 gram of oxygen, 89 gram of glycine will demand 96 gram of oxygen for its oxidation purpose that is why, now we can see that one gram would need; obviously, 96 by 89 gram of oxygen ok. Now, what is the strength of the solution in water? The strength is 890 milligram per litre, right. So, 1 gram will need 89 by 90; 96 by 89 gram of oxygen or 1 milligram; similarly would need 96 by 89 milligram of oxygen.

So, the one that we have 89 890 milligram per litre of your solution would need how much 96 by 89 for unit and into 890 similarly milligram per litre. So, this is mass by mass, we can similarly say this much milligram would need this much milligram forget about litre yet, but this much milligram is available in one litre. So, practically 1 litre of solution containing this much of containing 890 milligram of glycine will the same one litre of solution will exert a demand of oxygen for 96 by 89 into 890. So, this gets cancelled and this comes total as 960 milligram per litre. So, this becomes the theoretical COD of the sample. So, that is how we can actually calculate the theoretical COD ok, this was an example for calculating theoretical COD.

Similarly, we can if such reactions are given to us or if we know the compound and we can sort of set up a stoichiometric reaction with the oxygen. So, theoretically we can compute how much oxygen demand would be there or how much oxygen is required to react with that particular organic matter or that particular compound for which we want to estimate the theoretical COD. So, that is how this concept can be used.

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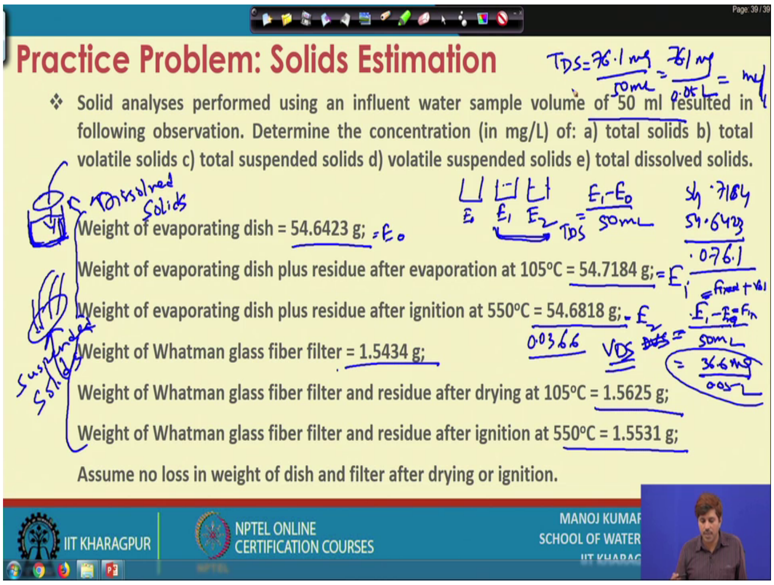


The next problem that we are going to take is on the solids estimation. So, we discuss the different type of solids also during one of the classes this week. So, this is a question which says that the we need to perform the solid analysis using a influent sample volume of 50 milligram; sorry 50 m l and that has resulted in these observations which observations for are given here.

We had the blank weight of an evaporating dish as 54.6423 grams and the weight of evaporating dish plus residue after evaporation. So, once we add these residues filtered reduced because a residue will come after the filtration. So, dish plus or water residues after evaporation at this and weight of evaporating dish plus residue after ignition is this the weight of Whatman glass fibre filter paper is also given and the weight of glass fibre filter paper and residues after drying at 150 and weight of glass fibre filter paper after ignition at 5 50.

So, these 6 different weights are given to us this evaporating dish this is actually like it is not is specifically mentioned in the question. However, this evaporating dish will eventually contain the residue that it is containing is once we filter the water. So, the filtrate that is coming that is coming into the evaporating dish and the when we are filtering the water. So, the amount that which is getting trap on the filter paper will come on the glass fibre filter paper. So, this 3 belongs to this group which is primarily containing suspended solids while the first 3 belongs to the evaporating dish which primarily contains the dissolved solids.

Now, then how we can analyse or how we can determine these different parameters. So, for this purpose or actually this one of the other things that it is not specially mentioned in the question though generally it should be provided that whether it is the filtered dish thing are coming or the total water can also be taken. So, in that case, this will be the first 3 set will belong to the total solids never mind we are considering that lets it is the filtrate part. So, this 3 are for the dissolved part and this 3 are the for the suspended part.

Now if we see the dissolved part first alright. So, the weight of evaporating dish is the blank weight is given to us and then once it is the filtered now the blank weight is let us say the E 0 of the evaporating dish then after getting water in this and evaporating it at 104 degree Celsius. This is let us say E 1 and the after it is ignition let us say, this is E 2. So, the difference of E 1 minus E 0 is the one which is the total part which is there because the water has evaporated and all the solids had retain in there. So, this way, we can see the difference in here. So, this is a practically 0.7184 54 and this is 54.6423. So, if we subtract this is one this is 6 and 11; minus 4 7.

So, 0.0741 is the difference. So, this difference is practically coming from 50 m l of sample, we divide it with the volume. So, this gives us the total dissolved solids which are in the dissolved. So, that way our TDS becomes 0.7; 0.0761 grams or we can consider that at in a milligram also let us say. So, that will become 76.1 milligram. So, this becomes our TDS becomes 76.1 milligram in 50 m l or say 76.1 milligram in 0.05 litres and then we can divide this number by 0.05 and get the total dissolved solids in milligram per litre.

How we are going to determine the from the same number we can actually determine the difference between E 1 and E 2. So, instead of that will give us the part which has evaporated the difference between E 1 and E 2 because E 1 has the both as well as volatile part while E 2 has only fixed part. So, if we differentiate between E 1 and E 2 or if we take the E 1 minus E 0 divided by 50 m l; sorry E 1 E 1 minus E 2 ok, E 1 minus E 2 divided by 50 m l. So, E 1 essentially contains the fixed part plus volatile part while E 2 contains only the fixed part volatile as escaped. So, fixed plus volatile minus fixed what will be there is volatile. So, this is going to be the total means it we are talking about the dissolved solids here. So, it is going to be the dissolved volatile solids or volatile dissolved solids you can express VDS.

So, the VDS will be E 1 minus E 2 by 50 m l. So, the difference of these 2, Now you can see that 14 minus 8 become 6 and then this become 7 minus 1; 6 and 11 minus 8; 3. So, 0.0366; so, this number becomes that way or we can say 36.6 milligram divided by 0.005 litre; so, you dissolve this and you get the volatile dissolved solids and if one it is fixed dissolved solids. So, the difference of TDS and VDS will give us the fixed dissolved solid ok. Now, similar calculation can be made for here also. So, for the filter one let us let us say.

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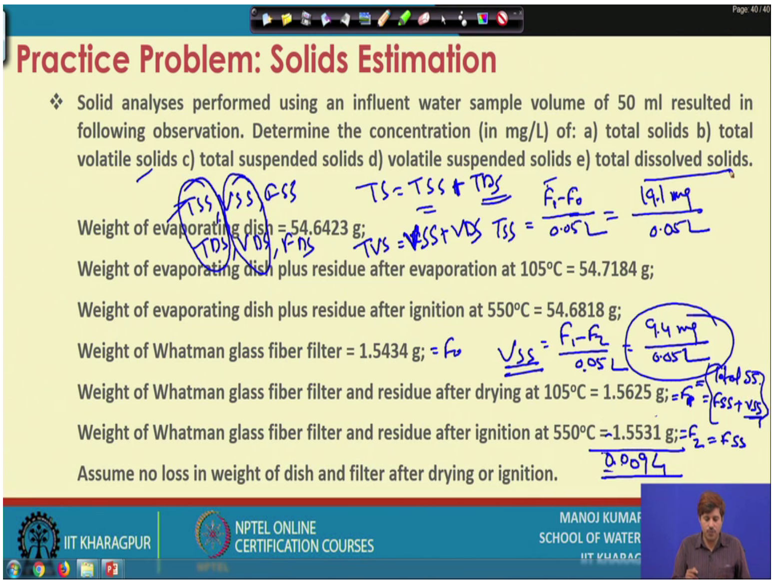


This weight is F 0 sorry the weight of blank filter is F 0 this is F 1 and this is F 2. So, the difference between F 1 and F 0 which is coming from 0.05 litre will be. So, this F 0 is the blank filter paper while this is the suspended solids. So, it is actually the total suspended solids which is coming on the filter paper total suspended solids or we can say, it is a combination of fixed suspended solids plus volatile suspended solids, right.

So, this is with the total suspended solids this is blank. So, what you will get is TSS from here we can we can take the difference out from here. So, this is 1.5434, if we subtract this what we get is 1 and 12 minus 3; 9 and then 5 minus 4 is 1. So, this is what we get.

So, F 1 minus F 0 will be actually 19.1 milligrams in milligram because this is in gram. So, milligram divided by 0.05 litres. So, we divide this and we get in milligram per litre that is our T; that is our TSS. Similarly we can estimate the because what F 2 is F 2 the volatile part has escaped upon putting in furnace and what is F 2 is left with FSS only. So, if we take the difference between F 1 and F 2 that will give us the volatile suspended solids ok. So, the difference between these 2, if we want to determine now so that will be instead of this, if we take the difference between these so, what we get is 4; 12 minus 3 is 9 and 0 and 0. So, 0.0094 or we can say 9.4 milligram divided by 0.05 litre. So, that will give us the volatile suspended solids.

Similarly, we can estimate the fixed suspended solids by subtracting these 2. So, we got that way the what we got so far is a volatile suspended solids; total suspended solids, fixed suspended solids, total dissolved solids, volatile dissolved solids and fixed dissolved solids, what else is needed the total solids, if we add these 2 total suspended solids and total dissolved solids, we are going to get total solids. So, total solids is total suspended solids plus total dissolved solids. So, whatever are the numbers, we can add them and get the total solids that way total volatile solids we have estimated.

So, now total volatile solids if you want to estimate. So, the total volatile solids similarly will be fixed sorry dissolved volatile solids and suspended volatile solids. So, volatile suspended solids plus volatile dissolved solids. Now, we have estimated these 2 also. So, we can add and get the total volatile solids total suspended solids, we have already estimated volatile suspended solids are also estimated and total dissolved solids are also estimated. So, that we can estimate the different species of the solids for the purpose and that is how we can sort of do these calculations.

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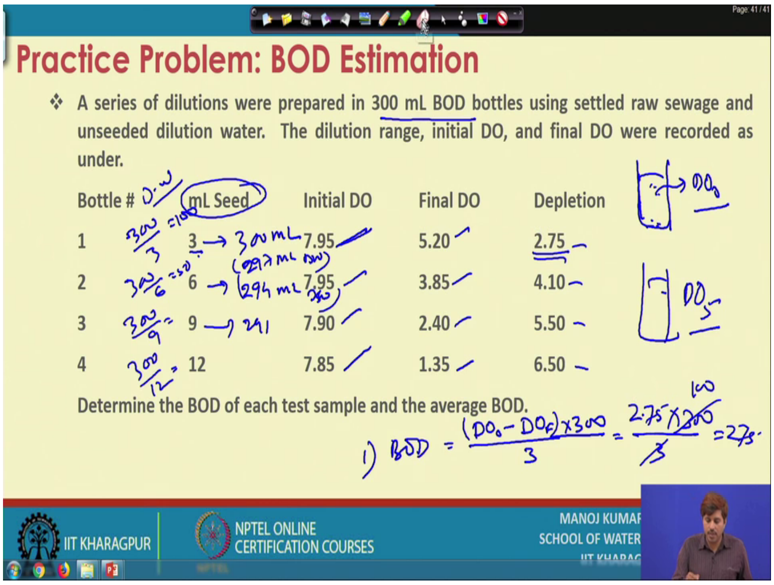


So, then there is another practice problem on the BOD estimation a simple problem. So, this says that the series of dilutions were prepared in 300 m l BOD bottle. So, the volume of the bottle is 300 m l now if you see the dilutions. So, there is 3 m l seed; the volume of seed in this experiment means that how much was the sample. So, 3 m l sample, but the bottle was of 300 m l. So, rest is filled with the dilution so; that means, this 3 m l seed was made up to 300 m l with by adding 297 m l of dilution water or rather aerated dilution water which is used typical in this case.

Similarly, this is 6. So, for this, we 294 m l would dilution water would be added this is 9; so, 291. So, all will be made up to sort of 300 m l. Now, if we see the dilution factor. So, here the dilution factor becomes how much time it is diluted, it is diluted to 300 from 3. Similarly, this was diluted to 300 from 6. So, dilution factor of 50 dilution factor of hundred this was diluted to 300 from 9. So, dilution factor of accordingly, we can calculate 33.33 and this was diluted 300 from 12. So, this was the dilution factor for the different samples.

We have been given initial dissolved oxygen in the bottle for BOD purpose, if we if you recall the discussions that we have we will have a initial dissolved oxygen means once we set up a sample. So, there is let us say seed and bacteria. So, we monitor the dissolved oxygen at initial level and then after few days. So, if let us say its 5 day test for say typical BOD. So, what is the dilution after 5 day or final dissolved oxygen. So, initial dissolved oxygen's are given for each bottle and final dissolved oxygen's are also given for each bottle we can compute what was the depletion the difference between initial and final and then we can determine the BOD of each of these test sample.

So, how BOD will be determined there is initial DO. So, say DO 0 minus DO on that particular day in this case it is final DO. So, let us write DO F divided by the how much times, it has been diluted that way. So, the actual sample volume is 3. So, this has this is coming from 3 and this has been diluted to 3. So, this will actually be the sort of for let us say; case one or bottle 1. So, BOD is going to be this one; now if we say the difference in initial DO and final DO is 2.75. So, 2.75 into 300 divided by 3 so that makes it 275 so that way, we can estimate the BOD values for the different all these different samples which are given to us.

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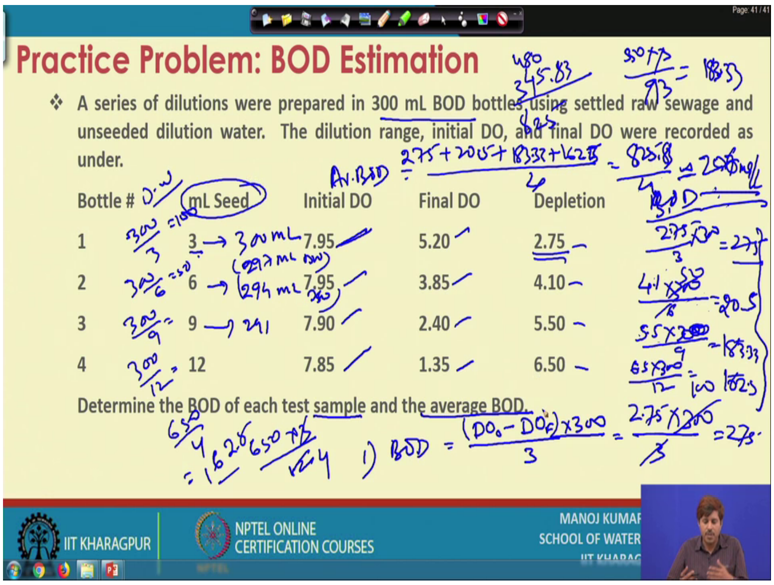


So, now let us see the BOD of the samples. So, here it becomes 2.75 divided by 3 into 300 which is 275 in the second case it becomes 4.1 into 300; 300 is there volume and this is 6 ok. So, this becomes 50 or 41 into 5; so, 5 ones are 5 and 5 4; 20 205; similarly, here it is 5.5 into 300 divided by 9 and this becomes 6.5 into 300 divided by 12; this is 300.

So, that way, we can estimate the values BOD values for these different dilutions and then determine the BOD of each test samples. So, that will be the BOD of each test sample and then of course, we can take the average BOD. So, summation of this divided by therefore, samples. So, total sum of this divided by 4. So, like this become 2 seventy 5 this become 2 0 5 if you try to solve this. So, this becomes 5 50 into 3 divided by 9. So, 550 by 3; 3 ones are 3 25 8, 10 and 3; 9.33; so, this becomes 183.33 and for the last one which is this becomes 650 into by 12; 4. So, 650 by 4 4 ones are 425; 624 and 10; so, 2.51, 62.5; and if you want to take the average of these; so, 275 plus 275 plus 205; not 0.205 plus 183.33 plus 162.5 and this divided by 4 is the average BOD.

So, this will be 480 plus 60 to 85; 5, 345.83; so, this total will be 825.83, roughly divided by 4; if you divide this by 4. So, this becomes 200 around 207 or 6. So, approximately 206 or 7 milligram per litre would be the average BOD of this sample for which this values are given. So, that is how the BOD can be estimated. So, these were a few examples that we saw how the DO estimation is again simple based on the titimetric precision or these days just we monitor the DO by the probes as our discussed during the class MPN is a bacteriological processes.

So, that is depending on the counting how many tubes are positive how many tubes are negative and then values estimated based on this, but from the other major parameters this how BOD can be estimated or COD can be chemically estimated or calculated one example we have seen from this will be happy to share or discuss few more questions in the as in the form of lecturer materials or so, and will happy to have further discussions in the forum on this.

So, with this, we and this week's discussion here and we will start discussing about the next topics; how the when the waste comes into the nature how nature takes it some self neutralization processes and all that in the next week.

Thank you.