Water Quality Management Practices

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Week-02

Lecture - 07

Measurement of DO & Solids in wastewater (TSS/VSS/TDS), Turbidity

Hello everyone, welcome to this NPTEL online certification course on Water Quality Management Practices. My name is Gaurav, Professor Gourav Dhar Bhowmick. I am from the Department of Agriculture and Food Engineering of Indian Institute of Technology Kharagpur. In this module that I am discussing right now is the quality estimation of major pollutants in the water and the wastewater. So, in this particular lecture I will be focusing on the measurement of dissolved oxygen and the solids present in the wastewater majorly the total suspended solid, volatile suspended solid, fixed solids, total dissolved solids all these things. I hope lot of you actually heard about all these terms isn't it.

So, today during this lecture I will be discussing you what does it all about ok, what does it actually mean and like how they can be quantified and what are the significance of this in terms of treatment plant design and all ok. So, these are the different type of different concepts that I will be covering the measurement of solids present in the wastewater, determination of total solid, total dissolved solid, total suspended solid, fixed and the volatile suspended solid or the volatile solids, settleable solids sludge volume index and also we will be determining the dissolved oxygen. We will understand that what are the process by which we can actually determine the dissolved oxygen ok. First the solid, whenever we talk about the solid present in the water.

So, you can you know that solid present in the water in a different phases right I mean like in a in a in a based on the phases at which actually solid is present we can quantify it either it is a solution, either it is a say colloidal solutions, either it is a true solutions, either it is a suspended solution is not it. So, in case of suspended solutions or it is can solve like colloidal solution it can select two solutions when the water the when the solid is dissolved in the in the in the solvent I mean like in the water based on that we can actually quantify different type of solid present in the water also in the wastewater also. How just let us let us start from the beginning. You have a water in which you know

either the solids are present in a soluble form or say like in a suspended form ok. Once it is in the suspended form or an or say like it is in a dissolved or soluble form how we can quantify that what is the what is the number of solid, what are the amount of solid present in a unit volume of water that is our concern right.

How we can actually find out the solid concentration in the wastewater? It is very crucial for physical as well as the biological wastewater treatment processes. You remember the biological treatment it case it we call it unit process and the physical it is a unit operations remember. So, we in order to understand the whether this the wastewater that is having a sufficient quality to be treated biologically or not it can only be understood if we know the solid concentration characteristics of that or the solid concentration profile of the wastewater or the influent that is coming into the picture. It also helps us to access the compliance with the wastewater effluent standards said by the regulatory bodies. What are the key definitions that we will be discussing? First is the total solid from the name itself you understand whatever the like type of solid whether it is suspended or it is a dissolved solid if we can under if we can finalize if I can somehow get that value that what is the total amount of dissolved as well as suspended solid present in the system it will be considered as total solid.

You can understand it is very easy actually. You take say like 10 ml of sample what is a 20 ml of sample in a crucible in a porcelain type of structure basin like in a small crucibles it is called in this crucible you take 10 or 20 ml of sample wastewater sample and then you put it in the oven. You put it in the oven for say like 100 degree Celsius 103 to 105 degree Celsius for say like overnight 24 hour ok. For 24 hour keep it in the say like in the basin what will happen the water will evaporate you will only get the sample whatever will be left if you if you somehow if you substrate that value I mean like with the actual the with the only crucible crucible weight you will get the value of total solid present in a this 10 ml of 15 20 ml of wastewater. Then you can easily get an idea about the what is the milligram per liter of concentration I will be discussing in the coming slides.

So, this is called the total solid. In this total solid it is further divided into total suspended solid and the total dissolved solid the TDS is not it. So, this TSS and TDS is also very important for us to know how we can quantify how we can actually analyze it we will also discuss about that. Before that let us discuss about the what is fixed solid and the volatile solid. Fixed solids are the one which is even if you go for ignition process it will still retain it is called the fixed solid.

So, what will happen if in case of ignition what type of solid will vaporize definitely the biomass. So, this biomass whatever is vaporized we call it that so, that portion of the

solid is called volatile solid. The volatile solid is signifies the amount of biomass present in your reactor ok. Volatile suspended solid specifically signifies this particular measure. Volatiles what I am saying again I am repeating volatile suspended solid it signifies it actually kind of symbolizes the presence of biomass the amount of biomass present in your system ok.

And then there comes a fixed solids ok. Then there comes a settleable solid. Settleable solid is nothing, but the solids that can be settle out suspensions after a certain period of time. So, when we talk about the solids present in the wastewater what are the effects of solid on the water quality? First of all it induces an unfavorable physiological reactions in the consumer for that reasons a limit of 500 milligram of dissolved solid per liter is desirable for drinking water based on the Bureau of Indian Standard. However, for world world health organization WHO has a different standard they have a standard of 300 milligram per liter of TDS or the total dissolved solid ok.

So, please remember that this this also varies with country to country a bit. So, in general in Indian context Indian BIS context they actually there according to this regulatory body the total TDS should be around 500 milligram per liter. However, in case of WHO its 300 milligram per liter. Also, highly mineralized water is actually not healthy and also it is not suitable and many industrial application also this high concentration of suspended solid may be aesthetically unsatisfactory for different purposes. And also for us also for bathing and recreation purposes also we do not normally like the water which is turbinated in nature which normally has a suspended solid.

Do you like it? No, no one likes it right. So, the there is the there is the reason why we actually want to get rid of and also it has a drastic effect on our health as well ok. So, in general what are the factors which affect the measurement of solid? First of all the temperature of drying. After the volatile is I am say like it the temperature of drying means like you know if you dry it say like 100 degree Celsius and at the same time you dry it at 550 degree Celsius the the the type of solid that you will get as a result will change. Is it not? Because volatile all the volatile solid will actually volatilize.

So, you cannot you the solid concentration the final value that you will get it may actually differ from the actual suspended solid or actual dissolved solid that you are trying to calculate. So, temperature of drying is very important. Time of drying. So, if you are rapidly drying it can cause some incomplete evaporation or loss of volatile component because of that you may actually lose the actual volatile suspended concentration and you may actually get a end up having a erroneous result. Composition of the sample.

Special purpose analysis procedure is needed for in case of chlorine oil etcetera which is if it is present along with the solids. Defending characteristics it affects the separation and the analysis procedure and also the type of solid it if it is a lot of dissolved solid is there a lot of suspended solid is there that also will affect the measurement procedure. So, as I was discussing like how we can actually find out determine the total solid. You take the sample you take the crucible weigh it in the weighing machine you know note it down say like it is capital A then you filter that sample you do not have to even filter that sample you simply just you know put it in that crucible you take 10 or 50 ml in that crucible only and then you put it inside the oven and heat it at 103 to 105 degree Celsius for say 24 hour. After then you let it cool down a little bit then you put it inside the desiccator.

Why to put it in the desiccator? To further absorb the if any other water molecules or water vapors are present there then you weigh that final take the final weight say like which is capital B. So, from this capital B minus capital A only from you can get the total solid present in your sample of that volume say 10 ml 50 ml whatever you took it. So, as I was discussing is the same we when we go ahead with the sample preparation from the for the total solid concentration we normally dried at 103 to 105 degree Celsius and we try to well mix the waste water before doing it and also we calculate the total solid with the subtracting those 2 values that I have just mentioned. We have to have some concentrations for highly mineralized water because it requires the prolonged drying and proper desiccation and rapid weighing is necessary because if these materials are hygroscopic in nature. If there are oil and grease is there then you have to disperse the visible floating oil and grease with a blender before analysis.

So, that it is competitive blended with the sample. After then you measure the total solid and majorly we choose the sample volume somewhere between the 2.5 to 200 milligram try to weigh in between and then we final weight minus initial weight multiplied by 1000 divided by sample volume will easily get the value in milligram per liter which is the total solid concentration of your sample ok. Then there come the total suspended solid. So, out of this total solid some portion are suspended in nature some portion are dissolved in in suspension some of them are in dissolved condition right.

So, how to get the suspended solid? Total suspended solid we can easily employ a pre weighted glass fiber filter paper should be 22 to 25 125 mm in diameter and preferably less than 2 micron in size the pore size should be 2 micron in nature. Then we exclude the large floating particles or non homogeneous agglomerates in the waste water unless essential for this accuracy and also thoroughly wash the filter and we have to be very cautious that the prolonged filtration time we can like you know which will clog the

system. So, what how it is normally done we what is the procedure? You have a filtration unit ok. So, you have a filtration assembly in that there is in the bottom you have a certain you have a say one beaker. So, or flux in the then we have this filtration assembly then you have the reservoir.

In the reservoir what you do you say like 20 ml of sample you will put and the the the collecting chamber or the filtration assembly is connected with the vacuum pump in that vacuum pump it will create a suction pressure. So, because of the suction pressure what will happen through this filter the when you put the water will water will completely try to pass through this filter. However, the suspended solid cannot pass through this filter this glass filter glass fiber filter. So, it will retain on the glass fiber filter paper only the water with the dissolved solid it will pass through it and it will fall into the beaker in the bottom ok. So, now, if we know the weight of this glass fiber initially we do the weight of this glass fiber and then after then once we know the weight of this glass fiber we add this glass fiber in a crucible.

So, now, we take the set take the weight of glass fiber along with the crucible initial weight of the glass fiber and initial weight of the crucible ok. Then we say the value of the value is A. Now, what we will do we will take the crucible the glass fiber along with the solid after the experiment is done then we also put it in the crucible and then put it in the say like 103 to 105 degree Celsius in a oven for overnight. What will happen it will it you will be you have to make sure that there are no water or any water molecule present in the this glass fibers in the in the in the pores of this glass fibers and glass fiber membrane around. Once this water will be completely vaporized what you will be left with you will be left with the solid suspended solid plus the glass fiber membrane plus the crucible.

So, if you know this is say like this is you weight and this value comes at B as B. So, this B minus A you will get the total suspended solid you understand. So, you can easily understand the total suspended solids in 20 milli 20 milliliter of volume when you the amount of waste water that you put or select 10 milliliter of volume. So, you can easily find out that what is the amount of suspended solid in that 20 ml or say 20 ml or say 10 ml of waste water that you use as a sample volume. From there you can easily calculate what is the total suspended solid concentration of your sample you understand.

This is the procedure you see in this picture the water see the filtration assembly how it look like there is a clip like structure it actually kind of you know sandwiched to the reservoir as well as the I mean like the beaker collecting beaker. Here you can see the glass fiber filters are placed on that filtration assembly and when you put the water along with the suspended solid it will actually somehow suspended on like you know somehow

collected filtered on the top of this filtration membrane grass fiber filter and this dissolved solid will pass through it. So, if we evaporate and dry the filter paper we can get the total suspended solid if we evaporate and dried that filtrate on the bottom of this beaker say like 20 ml of sample if you take it from the bottom I mean like from the filtrate then you put it in the crucible again that crucible way also you know. So, you put 10 ml 20 ml of it say 10 ml of it and then you put it in the oven again for 103 to 105 degree Celsius you leave it for another 24 hour then all the water vapor water will vaporize then what will be left with that is the total dissolved solid. So, that value minus if you substrate it with the actual value of the crucible from there you will get the you will get the value of total dissolved solid and also if you can find out the total suspended solids if you can substrate it with the total solid that also will give you the total dissolved solid.

So, this is the procedure that I have just mentioned the for total dissolved solid in the when you can dry in the total dissolved solid you can have you waited to dry it and up to as high as 180 degree Celsius to make sure there are no other water molecules and others it is absorbed even on the dissolved solids dissolved solid particles and from there you can easily get the value. How you can get the value for fixed and the volatile solid? Once you take the total solid remember in the very beginning we discussed about the total solid then we discussed about the total dissolved solid and the total suspended solid all these cases in all these cases whenever you are done with your experiment when you are done with your total solid determination or total sol suspended solid determination or total dissolved solid determination you take the sample and put it in a muffle furnace muffle furnace for 550 degree plus minus 50 for couple of minutes say 15 20 minutes. So, you when you put it in the muffle furnace 15 20 minutes say like for half an hour what will happen? All the volatile substances volatile organic substances that is present the solid that is present will volatize will be volatilized right. So, you will end up having the fixed solid the final sample that will get it will also give you the fixed total solid if you are taking the sample just after doing the total solid you will get fixed suspended solid if you are taking the sample just after doing the total suspended solid if you are you will take you will get the fixed dissolved solid if you just take the sample just after doing the total dissolved solid ok. So, for all these cases you will get the different fixed solid value.

So, if you substrate this fixed solid ah substrate this actual value with the fixed solid fixed solid value or fixed suspended solid value or say fixed dissolved solid value you will get the volatile solid value or volatile suspended solid value or volatile dissolved solid value in all these three cases ok. This volatile suspended solid is resembling or is kind of a very significant ah in terms of in case of wastewater treatment scenario because it gives us the the the value of biomass the amount of biomass present in your treatment

unit present in your biological treatment unit or biological wastewater treatment plant ok you understand. So, this is how we can understand the fixed solid or the volatile solid present in your ah sample I mean like ah wastewater sample and all. We before make sure that ah all these experiments has to be repeated at least 2 to 3 times ah until and unless the like you know suppose you have the sample just to give you one example suppose you do the total solid you take this initial sample of the crucible say like capital A then you do the get the capital B after half after say like overnight put it in the muffle point I mean like ah air oven ok hot air oven say 102 to 105 degree Celsius after then you will get the value B you now you what you will do you just B minus A you will get the total solid right. However, it is better to to scientifically correct way of doing it ah you keep it again in the ah ah hot air oven for couple of hour you take the sample out.

So, now, the new sample new way it will be say like B 1 if B 1 and B is not significantly different in value then only you will consider that value as the final one. If then B 1 is little bit lesser than the B that means, still there are some water molecule present and still ah it needs to be evaporized needs to be evaporated is not it. So, this then you have to wait till B 1 then after B 1 also you do it again B 2 if B 2 and B 1 if those values are same that means, your experiment has reached to the excrement. So, now, you can take that value as a now you can substrate that with the A and you will get the total solid value you understand. So, this is the same for all the other cases total suspended solid or total dissolved solid all the cases ok.

And make sure that once you take out of this hot sample you put it in the desiccator for like you know as much as possible. So, that actually it will come down to the room temperature then only you will take the value because if it is not in the room temperature then also there is a chance it will give you error value ok. How we can ah determine the settleable solids? We there are two methods first is the gravimetric method and the second one is the volumetric method. What is the gravimetric method? Firstly, what we do we ah determine the total suspended solid in a well mixed sample then we will put it in the glass vessel say like 9 centimeter in diameter and 1 liter is in volume. We simply put it in the glass vessel and let it quiescent for like say 1 hour and then say after we quiescent for 1 hour we siphon 250 ml ah from the center without disturbing the settled of the floating solid on the like the settled solid in the bottom or say like floating solid.

We will try to take as slowly as like you know quietly as possible 250 ml of the water from the top or say almost of the middle ok. Now we determine the total suspended solid of that supernatant liquor. So, this supernatants thus total suspended solids concentration of this supernatant liquor that we take out this 250 ml from this ah glass vessel is represent the non settleable solids. What is the difference between the difference between this ah total suspended solid and this non settleable solid will give us the value

for settleable solids you understand it is quite easy. So, this is how we do it in a gravimetric measurement.

There is a volumetric measurement method also we have this ah M of cones. This M of cones are made in such a way that it has this like you know different marking at different volume ok. With a uniformly mixed sample if you simply put it there and if you keep it ah allow it to ah settleables ah solid to settle for say like 45 minutes and after you gently stare it a little bit and then you allow it for another 15 minutes. So, after 1 hour you record the volume in milliliter per liter. So, that milliliter per liter value that you can easily see the like you know a point at which till which the solid will settle.

So, you take that value that that volume is the actually showcasing you the settleable solid volume ok. So, this is the volumetric method of determination of settleable solids. So, there are this gravimetric measurement methods and the there is this volumetric measurement method for understanding for ah I would say like you know estimating the settleable solids. Then there comes a sludge volume index. The sludge volume index it is the measures of the volume occupied by 1 gram of sludge after 30 minutes of settling ok.

It is as easy as that it is normally it is used to access the settling characteristics of the activated sludge and other biological suspensions. And we can easily calculate this SVI in milliliter per gram of suspended solid by using the settled sludge volume in milliliter per liter divided by the suspended solid in milligram per liter multiplied by 1000 ok. Now, another important ah characteristics of water is the dissolved oxygen. We need to understand the dissolved oxygen present in the ah water. It is very important because ah the presence of dissolved oxygen only give us a indication that whether that ah water I mean like this suitable for aerobic decomposition aerobic decomposition of organic matter or not or anaerobic decomposition of ah organic matter or not.

If it is ah less ah like even we can manipulate it. We can simply add some aerator by which you can introduce some dissolved oxygen into the water body. So, it will be suitable for aerobic treatment units ok. So, in general ah if you see the solubility of atmospheric oxygen in fresh water which is 14.6 milligram per liter at 0 degree Celsius at saturation and ah at 7.

0 milligram per liter at 35 degree Celsius under normal atmospheric pressure and ah temperature, but in general say like in ah in if you say legacy standard or standard ah temperature and pressure which is say like 20 degree Celsius and and say like a normal atmospheric pressure 180 more pressure the this solubility of oxygen or the dissolved oxygen present in the air it is saturation concentration of dissolved oxygen is 9.2 milligram almost 9.

17 milligram. Please remember this value 9.0 9.17 or 9.07 or 9.1 milligram ah per liter ah is one of the its standard at 20 degree Celsius at 1 atmospheric pressure. It is a standard saturation concentration of oxygen present in the dissolved form inside the in the water ok. How we can determine this dissolved oxygen? There are different procedures. So, normally DO can easily oxidize the divalent manganese manganese and it is the precipitation as brown hydrated oxide can after adding the sodium hydroxide and the potassium iodide can be easily ah identifiable and its acidification is reverses manganese into the divalent state and liberating the iodine from the K I and its much easier by one we titrate it against the ah sodium thiosulfate and its using the starch as a as an indicator.

What are the interference sources ferrous ion, ferric ion, nitride, microbial mass or high suspended solid concentration can be interfering this equation. So, we have to be cautious about that. What are the type of solutions that we need ah in order to prepare? First manganese sulfate 480 gram of tetrahedral manganese sulfate in 1000 ml, alkali iodide azyte reagents, stock sodium thiosulfate at 0.1 normal and standard sodium thiosulfate at 0.025 normal and also standardized against the dichromate solution for precision in each set of titration.

Procedure first we fill the 300 ml of BOD bottle with waste water or the water sample we add 2 ml of manganese sulfate, then ah we followed by 2 ml of this ah the sodium hydroside K I and N 3 solution. Then we lower the pipette tip below the liquid level and stopper immediately and ah invert the bottle 2 3 times and allow the precipitate to settle. We then we add the 2 ml of concentrated ah sulfuric acid and mix ah the precipitate a little bit and it dissolves and so, until it dissolves and it take around 200 ml in the conical flux and titrate against the ah sodium thiosulfate using the starch as an indicator and each ml of this 0.025 normal ah sodium thiosulfate it represents 0.

2 milligram of oxygen. Thus DO present in the sample can be easily estimated using the following equation

$$D.O\ in\ mg/L = \frac{0.2\ x\ 1000\ x\ mL\ of\ Thiosulphate}{200}$$

Ring class modification ah in this or also the ah Asterberg ah Azide modification we call it the reagent when we sodium hydroxide plus ah potassium ah iodide and the sodium Na Na 3 Na Na N 3 ah used to eliminate the interference from the nitrate and the higher concentration of ferric ion. So, in this case we add 0.7 ml of concentrated H 2 SO 4 immediately after the sample collection then we add 1 ml of 0.

63 KMnO 4 to this BOD bottle and in large ferric ion concentration we add 1 ml of ah 40 percent ah Kf solutions ah potassium fluoride solution as well. To remove the excess KMnO 4 with potassium ah KMnO 4 we use the potassium oxalate to neutralize without causing any negative air. There are other ah DO determination processes as well for activated sludge mix liquor we ah prepare the ah different reagents sample with the sulphamic acid ah ah copper sulphate in the 500 ml of distilled water and 25 ml of acetic acid. We pre treat it with the complex sulphur compounds and treat it the alkyl hydrochloride solution to convert the ah polytheanates to sulphate and the free sulphur free sulphur. It destroys the excess a excess hydrochloride with ah potassium iodate and also sodium sulphate it is quite accurate, but it is little bit challenging ah test I would say.

One of the best way nowadays what we have ah for dissolved oxygen analysis is the DO probe. We simply go for this ah DO probes which which we can properly calibrate before measuring per manufacture as per the manufacturer instruction and we insert the probe into the water sampling and avoid the water bubble entrapment in near the sensor. So, it will give you error erroneous result and then in the DO meter in the digital disk you can easily see the ah the actual DO value in couple of seconds which is one of the most fine easiest one actually. So, in conclusion we discuss about the different type of solid present in the waste water and how we can quantify it, how we can do the estimation of different kind of ah solids. We also discuss about the dissolved oxygen present in the water and how we can estimate the dissolved oxygen present in the water.

Various methods and modification ah we discussed to address the specific challenges for accurate determination of this ah pollutants or this characteristics behavior of water or waste water. The results of ah solid having the high oil and grease may be questionable because of the difficulty of drying the constant weight in a practical time. Some special purpose analysis may demand ah deviation from the stated procedures to include an unusual constituents with the measured solid and various DO measurement procedures will was also discussed ok. I hope ah we are also discussed and I hope you it is useful to you and you actually got to know that how the TDS whenever you talk about you might have your ah aqua garden all these things in your home. So, you might confuse sometimes get confused like what is this TDS and whenever they come the aqua garden people they check and they call you ok.

So, this is the TDS of your water. So, this is what it means ok and this is how it should be calculated in a laboratory method and normally nowadays the probes are also there by which you can ah calculate the TDS value in situ basis ok. These are some of the references that you can ah follow. I hope you get to know ah about this total solid concern how to calculate the solid ah present in the waste water and also the dissolved

oxygen present in the waste water. In the coming lecture we will be ah discussing about the biology biochemical oxygen demand chemical oxygen demand etcetera and their interactions in the waste water. So, till then thank you so much.