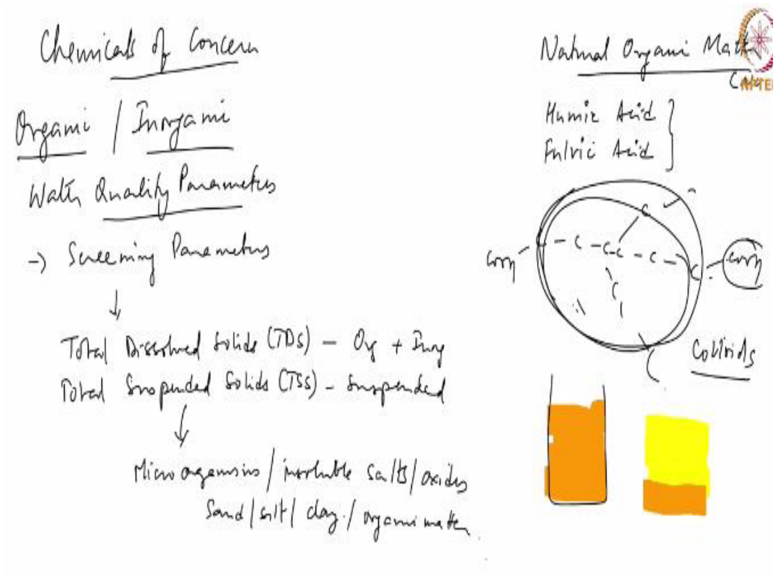
Environmental Quality: Monitoring and Assessment
Prof. Ravi Krishna
Department of Chemical Engineering
Indian Institute of Technology – Madras

Lecture – 4
Water Quality Parameters

(Refer Slide Time: 00:23)



So, yesterday's to summarize yesterday's class. We were looking at the classification of pollutants what we call as chemicals of concern and we were looking at water parameters, we looked at organic, inorganic and so on. We also tried to classify the the parameters for water quality and we came up with a few things which are screening, the first level of screening parameters, so it’s just visual in nature. So, you can just look at it and decide whether something is there or not, okay.

For further analysis, we will again because we are looking at organic and inorganic, we have to characterize how much of it is organic and how much of it is inorganic. So, we will further classify this as TDS and Total Suspended Solids or TSS, will come back to this in a in a bit how to measure this and all that when we are doing the methods section. So, the total dissolved solids include both organic plus inorganic that’s the definition, this is only suspended, okay.

So, the suspended, the total suspended solids also include microorganisms and then any minerals, sand, silt, clay, any of those things we have insoluble, salts and other compounds.

They include sand or oxides, this is insoluble oxides, can also be organic matter, microorganisms. Microorganisms are part of organic matter, but we treat them separately because organic matter, the nature of organic matter, so what we call as natural organic matter, we call it as NOM, lot of people call.

This is essentially non-living material, it is material that is already decomposed and it is sitting there, it's got a it has a very strong carbon background. So, if you look at organic matter organic matters, many of the organic matter, different types of organic matter depending on where it is generated from, you know different locations have different kinds of biological life, that decays it will create an organic matter of that nature, which is why you do not see that petroleum deposits different parts of the world are not same composition, they have different compositions because it depends on each location.

So, similar to that, if you go and take soil in Chennai and go and do it in Hyderabad or in Delhi or in some places, it is going to be very different, in the middle of a forest, in a dry region. So, typically, the organic matter, there are some even though it is very, very broad, people have tried to characterize it into a few known standards and one such chemical compound, it's a model compound which represents organic matter, okay and it is not limited to this.

So, these are the kind of these are two commonly used organic carbon substitutes, so I mean they they are there as part of the organic matter if you take some in some place, but suppose, I want to test what is the effect of organic carbon on something, this is I need a model, yeah so, this is that kind of compound to give us some idea when we want to study the effect of organic carbon, organic carbon is the matter is very important, we will discuss that shortly.

So, the humic acid and the organic matter, the general structure is like this. It has a C-C-C-C this thing backbone, but then at the end, if you see that there is an acid written there, which means that there is a COOH group somewhere, okay. You can have multiple COOH group, singles COOH group, it can be branched. Yeah, so the backbone is essentially organic, but the end groups are polar. So, this is very similar in structure to another compound that you have you are all familiar using, that are the surfactants. We have surfactants also have the same kind of structure, they have a backbone, which is carbon, but they have end group that is polar.

So it's an nonpolar backbone and end group which is polar, so this this central group likes to, it has a greater affinity towards organic compounds and the larger end groups here are have an affinity, more affinity towards polar groups, which are polar, either water or the other mineral compounds that are there, okay. So, natural organic matter when the size you can have it when the size becomes very big, this chain becomes like, it is also possible that matter exists as a solid particle as it does not dissolve in water very well, it stays as a an aggregate.

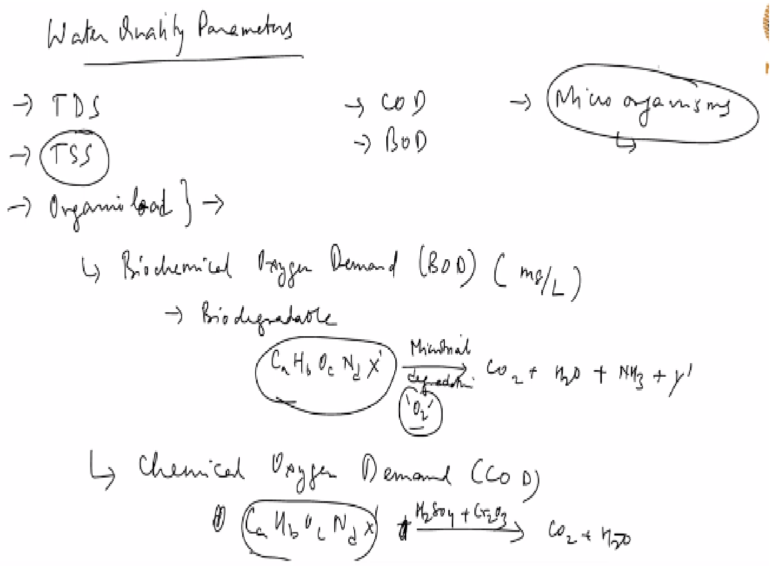
So, you will find it suspended in water. So, whenever you take water from a lake or sediment or a lake or a river or even soil, just take soil and put it into water, shake it, stir it, it become all turbid. Then you wait for it to settle down, after a long period of time, you will see that the, when you start with a when you start with a very dark, I do not know if I if I can show it here. When you start with a very dark this thing and then after a period of time, it will all settle down and this very dark thing will go down.

So, you will get a very dark region in the bottom, but in the top you will get a very light solution and suspension. So, you will get a very pale yellowish, which will not go away very easily. Now, this the organic matters here are usually colloidal in nature. Colloids, colloids are particles which are below a certain size. So, there is a definition of colloids in some places, you will see it as 0.45 micron, somewhere it is just 0.2 micron. So there are different definitions to it, that is not important.

What is important is colloids are many of the colloids are charged, they have a charge, they don't like to settle down, they are moving around, sometimes they will aggregate, they will different conditions they will aggregate and all that. So, they are there freely moving. So, a lot of organic carbon can be considered as colloids, ok and they are very much a part of the soil sediment system and therefore because they are part of soil sediment, they are also part of the water that is attached to the soil and sediment so, okay. So, keep this in mind.

So, the the solid phase also includes organic matter so and the organic matter plays a very important role in the fate and transport of chemicals okay.

(Refer Slide Time: 08:50)



So we look at water quality parameters that are commonly. So, one is TDS, Total Dissolved Solids, which we have already discussed. The other one is Total Suspended Solids, yeah. Now, in the TDS, it's not enough for you to say that it's not we discussed yesterday that there is a lot of inorganic material. TDS is dominated by the inorganic compounds. So, so you can measure it, but you also need to know what is the amount of organic load in the in the water.

One of the main things that happens in organic load is the one that people are worried a lot about, in terms of when we look at ah when we look at the water quality because the water quality issue, historically started with with public health engineering, sanitation engineering, where you know you have sewage coming out of households, and the management of sewage in larger settlement of cities became a problem. And therefore, you know the the water that comes out and it is contaminated with pathogens or microorganisms, which are one of the things that people, even then the that fecal coliforms which are one part of the microorganism group, we will come back to that in detail. So, this this is all naturally recycling kind of systems, so we wait for long enough time, they degrade and they go away, and so there is a there is also organic load there. There is an organic load, all organic matter coming from this thing mostly are organic.

So, they will degrade over a period of time and that was the assumption, okay. It is only later that when we have little more of industrialization and more city formation of cities, we have a bigger problem, this is very recent, what we are talking about in terms of other compounds coming into the water streams became more severe, we have industries which can pollute and then they have organic load that's coming out. So, we would like to also have an estimate of the organic load.

Now, we looked at hundreds of compounds, there are different classification of organic compounds in the last class, we would like to really know what is there in that, but typically before we get to that point, we would like to know exactly what is the load in the water. What is how much of organic matter may be there as a bulk as this thing, before we do a speciation of these things. So, in order to do that, there are two parameters that people look at. So, in order to just get an idea of how much organic matter is there, dissolved organic load is there in the water, okay.

The first one is called as Biochemical Oxygen Demand or BOD, many of you might have heard of this. This again goes back to the the basis of public health engineering which was to treat sewage. So, the assumption was all compounds are biodegradable. So the biochemical oxygen demand the premise is that the organic part is biodegradable, that is assumption that you make straightaway, okay.

So if it is biodegradable, the organic matter that is there, so organic compounds, let's if if you call organic compounds as you know, let's call it as give it a formula $C_aH_bO_cN_d$ and whatever, anything else can be there, we will call it as X, okay. This will become CO_2 + H_2O plus you know ammonia or NO_2, any of these things, okay, plus we will call it as y. This transformation, this oxidation that happens happens when this is happening, it happens in the presence of in the presence of microbial degradation.

This is microbial degradation that's happening and some oxygen is consumed in the process for this to happen. So, larger the amount of organic compounds are apparent here, larger the more amount of oxygen is consumed by the microbial process in order to generate this byproduct. Therefore, the the presence the amount of organic load that is present is estimated by estimating how much oxygen is being used. So, this is oxygen demand, okay.

So, if you go by this nature, the this BOD, if the BOD is high, the oxygen demand is high which means that if there is a lot of load in a in a particular water body, the oxygen will be depleted faster. Oxygen depleted faster when it cannot sustain a lot of other life in the in the system. The oxygen is renewed in the system by different processes, and that processes, if you put additional load on the oxygen, the demand for oxygen is higher, then it will the system will go into an imbalance and then you will have other problems, it will become anaerobic and then other reactions can take place there.

So, so this Biochemical Oxygen Demand is one way of characterizing how much oxygen is there, so this is an indirect thing because this is we are really talking about when we measure this, we measured this in terms of milligrams per liter, this milligram per liter is demand of oxygen. It really doesn't give you a direct measure of the chemical that you are using, it is oxygen that you are measuring. How much of oxygen is consumed in a given volume of the waste, that is what you are measuring, so it is notional.

It's useful because you can correlate this to actual concentration of something that is there in the waste, that that something that you can do. Ah, for you to know actual amounts, it may be important for you to correlate it with whatever else you are doing, but this is a good measure of doing ah a check on how much organic load is there. So, people routinely measure this in rivers, lakes, and even in seas, oceans to see how much oxygen demand is there, just to see if the system is renewing itself or not so.

The oxygen balance in water body is a very big thing, which we will in civil engineering studied quite a bit, we will touch upon that in a bit, but the problem here this is this works very well if your waste is biodegradable, but our waste is not always biodegradable, especially in industry. In industries, many of the industrial effluence may not be biodegradable because there are some of these chemicals are designed not to be biodegradable, okay.

Because one of the objectives of many manufacturers is if you look at any product, they say the product has last long, it should not expire quickly and all that. One of the ways in which that happens is it should not degrade. So if I make a medicine, expiry date of medicine, a medicine will something will happen to the medicine, now you do not want that, you want the expiry date to be longer because, I mean for medicine is not a good example because people don't usually like the store medicine, but other products, let's say, you know 'plastic'.

One of the attractions of plastic was initially very attractive because it was light, it was it did it could do things that metals, metal would corrode and all, plastics were meant to be extremely robust, they won't corrode and things like that, but you know, there is a flip side to that. We have a consequence for that now, we really know that nothing will last forever there are always other kinds of degradation that happens. It is not necessarily oxidation, but maybe other.

The issue of microplastics that you are hearing now, people are not sure what is happening, where is it coming from, it's from erosion, corrosion or just degradation by sunlight or whatever you know people are trying to figure out. So in order to do that, we can't do this, we have another method which we force the oxidation, which is called as Chemical Oxygen Demand or COD, where we actually add an oxidizing agent, a strong oxidizing agent, irrespective of whether it is biodegradable or not.

So, one of the strong oxidizing agents we have is, we have the organic compound, we have the CaHbOc whatever NdX plus we add an oxidizing agent which we we can use anything but we typically in the method that is we use concentrated sulfuric acid and chromium trioxide, it is called as 'chromic acid', a very strong oxidizing agent. It will oxidize everything that is anything that is organic, okay and it will give you usual products of oxidation.

So, this also does not measure the actual amount of organic matter, it will you know this is better than the other one, but does not measure oxygen, but it measures some, it gives you some measure of how much oxidizing agent has been used, that's how we calculate this, okay. So if you really want to know actual amount, you still have to go and correlate this to the amount we have to you have to analyzed what is there here, in this composition of that and figure out.

It is also quite possible that there if there are multiple pollutants in a given water body in a sample, each one of them may not react in the same rate as well, okay, but all that is not the the focus in this this kind of method, this is a screening method. The utility of this is these these things these things give you a common platform on which you can compare. For example, I want to compare a water in river 1 versus river 2, I do not have to worry about hundred other parameters, you know how many, which chemical is there and all that, this is a very quick screening parameter.

Say this is COD is 400, this COD is 100, which means obviously you know that 400 is higher than 100 and therefore something is wrong here. So, you go and then find out what is wrong okay. So, same with BOD, okay. It says there is also a correlation between BOD and COD, if everything is biodegradable, they should be the same. Now, same is that you can correlate it, you can take same sample and say, you can take an organic sample which is biodegradable and do it with COD and then see compare with the other same. At some point if they are deviate, you know that COD is, there are other nonbiodegradable compounds. So, the point I am trying to make is a screening parameters and should be taken as screening parameters. And the other advantage of COD and BOD are if you are trying to develop a control mechanism, so you are trying to do a treatment process, water treatment process, you are trying to treat the water or something. It is very easy to compare. So you say before treatment, a COD 100, after treatment COD is 20.

So, you can very quickly get, you can use this as a basis for the efficiency of a particular treatment process, ok, without going into the details of how it is doing it and all that. So very you can get a very quick estimate of it, okay. So, COD and BOD are the common water quality parameters that you will see. There is another and of course, there is microorganisms. Microorganisms have a special place because they are their role is very different, they are not just suspended solids, suspended solids here, we can microorganisms may be included in TSS.

So for example, bacteria and you know viruses not viruses bacteria and mostly bacteria ‘cause there are pathogenic bacteria are of the size between about close to about 1 to 10 microns in that range, okay? Viruses are small, very small, but the problem is virus often doesn’t hang around, viruses are nanoparticles, they are 100 nanometers or less than that, but they don’t they don’t float around by themselves, they usually are attached to something a lot of times. So, they may be included in TSS, they may not be, and why do this behave very differently, they don’t they don’t behave like bacteria.

So, the methods that we have usually for analysis are directed towards bacteria because a lot of pathogens are in the bacterial class. So, we will most of the focus is there, but there are people then use disinfection methods, they assume that the viruses are also gone. So, there are methods to detect the virus, but common methods that we use are only directed at bacteria because many of the common pathogens are bacteria in nature, okay. And the so, microorganisms have a special place because the number of water quality, water--related diseases or illnesses are very high. So, therefore, they cause by bacteria in the water, so there this is a special this thing. So, if you look at water quality parameters, if you go to the you to the CPCB or Central Pollution Control Board, the Government of India's website, I would strongly encourage you to go and look at this website. This can be this thing. So, you have standards. If you go and look at standards, there are water quality standards, water quality criteria, you will see all these things, okay.

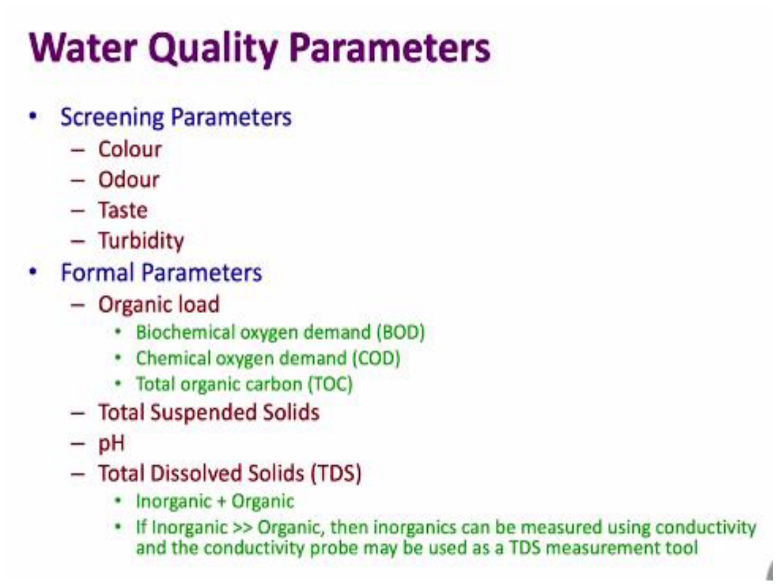
So, if you look at this, so you see yesterday what we talked about the designated usage of water, which water is important, drinking water with water source without conventional treatment, but after disinfection, this class is defined as some class, you can see the quality parameters that are here. You have total coliforms, which is a num number of bacteria, you are calling it as number, now some numbers per 100 ml, okay. The pH is another parameter. Dissolved oxygen 6 or more. So dissolved oxygen is measured because it is an indication of how much load is there, this basis is the bio biochemical oxygen demand, BOD. If dissolved oxygen is reasonably high, it means that there is not much demand for oxygen, which means inad inadvertently it means that this BOD is going to be under control and Biochemical Oxygen Demand 2 milligrams or less okay. So, you have a classification of these things here, so that’s all. So this is an example of this. So you can go and check this out.

There is a lot of data in the CPCB’s this thing. You know, these standards keep changing from time to time. So one of the things about standard is, we will come to that in a minute in a in the next section. Standards are not permanent. Standards are only as good as the information we have currently about anything, okay, 20 years back, 50 years back there was no CPCB. There was no US EPA, the environmental protection agencies because we didn’t know much, nothing was happening. And as we go progress, we know more and more about different systems and there was more information and there is more concern and therefore the standards keep changing. It is like as we have more access to information and to and I think as environmental professionals, we are responsible for sometimes people will come and ask suppose there is an emerging pollutant, it is a new pollutant. Somebody has made a new pollutant, one of the new pollutants is nanoparticles.

There is a lot of focus on nanoparticles and their effect, see there is a lot of this thing about nanoparticles, the nanotechnology and all. In the last 20 years, a lot of nanotechnology floating around, and literally floating around. So if nanoparticles enter the environment, they are floating around there, they are they are colloidal particles, they are submicron particles, they don't settle fast, they are in the air, in the water, and conventional processes cannot remove them, they are not designed for that, okay.

So what do you do? So, fate and transport of nanoparticles is a big thing and it is very challenging because it is very difficult to measure it is, you know it is expensive to measure it. And so as a scientist, if somebody comes and asks, if if government will come up with the thing, say can you come up with a standard for emission standards or quality standards for nanoparticles in the environment, so you have to do a bunch of studies and this this kind of the process is same.

(Refer Slide Time: 26:18)



Typically, of what we are going to be doing in the class and looking at essentially looking at the behavior of the nanoparticles in the environment. What does it do, under which circumstance will it change? Then based on that, we can give recommendations for their for their control or for remediation and or for protection and these kinds of things okay. This applies to a lot of emerging contaminants okay, it can be nanoparticles, is one example. There are a lot of chemicals that are new, which the pharmaceuticals is one big example, so.