Environmental Quality: Monitoring and Analysis
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Lecture – 14
Environmental Sampling: Quality Control/Quality Assurance - Part 2

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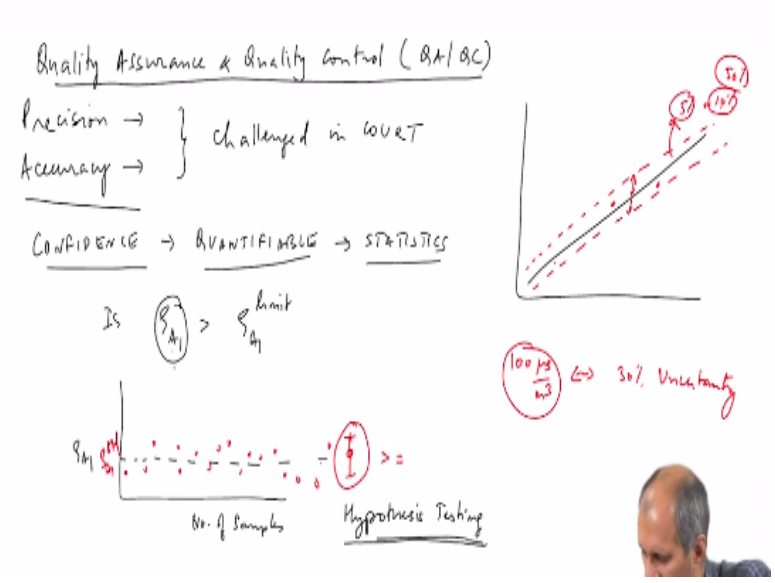

So, whatever the things that we were talking about yesterday in terms of precision and Accuracy, this come under the issue of whenever you do analysis, chemical analysis, it come under the issue of what is called as quality assurance and quality control or it is called as QA/QC okay. Quality assurance and Quality control, this is a very big part of environmental analysis. The reason this is important is when you ask these questions of precision and accuracy, people are going to make decisions based on the analysis you give.

So, this can be challenged in court. So it is subject to litigation in the sense that for example, CPCB or somebody, some regulatory agency can quote data that is measured by somebody saying that there is a concentration somewhere and whoever is the party that they are considered responsible for this thing can challenge it in court, saying that very simple answer. The question is that, I talked to you about this issue of environmental forensics.

So you determine that a particular pollutant of a certain concentration is coming from a certain source and that source is an entity of point source, specific corporation or somebody, and they say you are responsible for it. So, there is a liability associated with that, okay. So,

when there is liability, liability is usually in terms of either compensation or paying for whatever needs to be done. So, we will talk about it later, it is a slightly different issue, but all that is depend on this.

All the amount, the whatever measurement that one gives is indirectly linked to the precision and accuracy and the questions that we asked. So, this quality assurance and quality control in short called as QA/QC is part of an analytical method, okay. People do the analytical method design and they include quality controlling in it and that is why we make decisions when we sample. We are making decisions of where to sample? How many samples do we need to take? Because we have to account for quality control and quality assurance as well, okay.

So, there are several aspects of QA/QC that will come up. A very simple logical questions, there is no domain specific questions. In the sense, you do not need to be an engineer to ask these questions, anybody can ask these questions okay. So, most of the people who ask these questions are lawyers, so it is just common sense question, so you do not need to be, but the answers to this can only be provided by somebody who is trained in analytical sciences, they can prove to somebody that this answer is correct and what is the confidence interval.

So, what we are looking for in the QA/QC is some level of confidence okay. So you have some confidence and this confidence is quantifiable, and this is where you need to use statistics. A large number of statistical tools are available to do this, we will not go into a lot of them. So statistics, they ask questions, okay. For example, the questions of statistics can be is the concentration is rho A1 greater than rho A1 standard, rho A1 limit. So, you have a limit. Somebody has specified a limit.

There is a concentration of pollutant A cannot be greater than this number and you report this number. So, the simple statistical question can be is this number really greater than this number. Why are we asking this question? Because as we saw yesterday, this number is not a single number, this can be a distribution of this number. So, I go and measure every day, let it for a month, this number can be up and down. So, when you have to do a statistical analysis of whether this is greater than this, significantly greater than this okay.

So, if you have data like this, so you have this is the standard, this is concentration of something okay. This is the standard line, this is with number of samples and the number of samples could be with space or could be varying with time, it will be over a period of time or a month. If your measurements are like this, you will find it very difficult to make a judgment whether this really is greater than or lesser than this .So, what we do is we have to make this statistical analysis and we draw a standard deviation and mean for the entire period.

Then we compare this, whether this number is greater than or equal to the standard number which is this here rho A1 standard, you compare this is the standard and that by we do what is called as a hypothesis testing. We do the hypothesis testing to do that, and this is defensible. Statistics people have worked on it for a long time. So, instead of you going and making a judgment whether this is greater than or lesser than this number, you give it this thing.

So, in statistics also whenever you do this hypothesis testing, you have to make a judgment whether what is acceptable, yesterday in class you were talking about calibration, say we say calibration, the original calibration is like this and if the calibration moves and if the number that you are getting, this is your original calibration and every time you open the instrument, you check, you run one standard, and the standard is falling here and the next day your standard is falling here and so on.

So it is not on this line, but somewhere around the line. So, you decide that you give some boundary and say that as long as this is between some percentage of what my expected value is, I am okay with it and this number is your choice. I can decide this is 5% or 10% or 50% okay, so but your choice must be rational. So how do you choose 5, 10% or 50% because if it is possible to get the calibration all the time within 5% of this, you should be able to do it, you should do it.

It is going to cost money, it is going to cost effort, but that is fine, but so turns out that in some cases is not possible to get 5%, you have to expand that the best you can get is what we use. So, this number is also chosen by you. So this confidence level is something that one must be able to evaluate, what consequences that has is a different issue, but you must be able to know that this is the confidence of my measurement okay. This has the errors that are associated with it. Why is that? Because at least you can correct for it, okay.

Say I am getting a number, if I get say 100 micrograms per meter cube for some concentration. If I am not sure whether this number is correct, at least if I know what are the possible errors that are associated with it, which therefore, my confidence in this number is 70%, and say I am 70% sure that this is true, which means that I have a 30% uncertainty, this uncertainty is the error bar that is going up and down. So, the uncertainty is that this value really maybe between 85 and 115, it is this range in which I am expecting it to be and this is the only way.

So if it is established by several people that this is true, then this is acceptable, okay. For example, if you go and tell somebody in semiconductor industry that the error margin is 30% is okay, they will laugh at you. They will say that we are working at very precise this things, we know the measurements. So, therefore we expect much lower tolerance, much lower tolerance, but environmental industry you will often see that plus minus 30% is acceptable sometimes because of the inherent variation of samples.

Suppose I am going and doing air sampling, it is not a fixed sample, right? It is not like somebody has collected air in a bucket and keeping it well mixed. I am going and sampling, I will sample today, I will sample tomorrow, I will sample day after tomorrow. It is all varying because I do not know what is going on in the environment, something is moving, so it is like that. So, there is an expectation that the system will behave in a certain manner and so on. So, there are all these issues which are not very, which is not just setting stone, but the goal is to document the quality control as much as possible.

The word is document okay. If you are an environmental consultant, doing analysis, somebody says please do a measurement, you must do a measurement which will stand in court, which means that anytime somebody can take you to court and say that you, because you now have the NGT, national green tribunal here, so people can take you to court. That is a court, they will challenge you there and they say how did you do the measurement? Did you account for this error, this error, this error, this error, all these things are there.

So, the QA/QC now becomes a bigger part of your measurement, it will cost a lot more money than what your original. You just go and do a sample measurement it will not cost you anything, but if you want to take care of all the QA/QC, it will cost you a lot more, and therefore because you have to spend more time and money and energy to do this thing. So,

we will discuss more about QA/QC as we go on. So, the first thing we want to do is move on to the next stage of this thing where we are looking at analysis of other media, okay.

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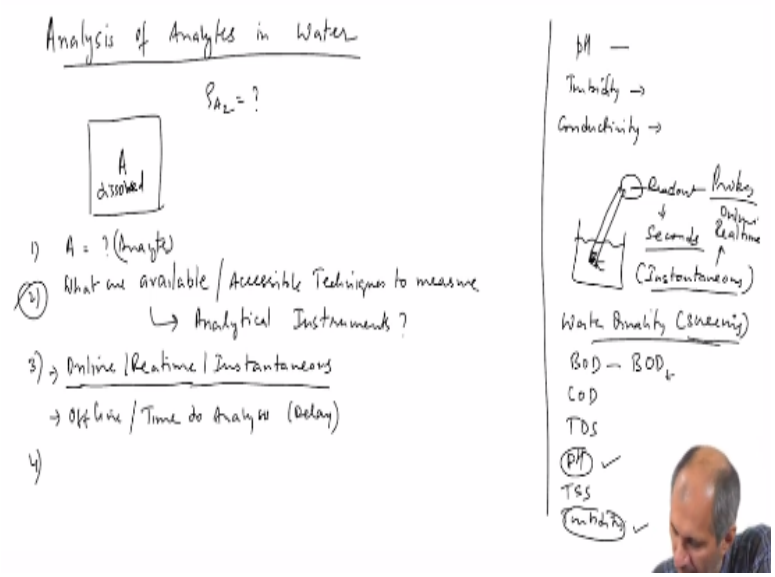

So we look at, let us take the case of analytes in water versus general methods. I am going to talk about general methodology. We will talk about specific methods later following this, okay. So, let us say that there is a chemical that is dissolved in water, yeah. If I want to measure the concentration of A in water, this is my objective. What are my options in doing this? First of all I need to know what is A, the A is what? This information must be defined very well. This is the first question you have to tell, say I am going to look at.

If somebody comes and says, tell me what is there in the water? It is a very difficult question because anything can be there in the water okay, you must have some, there are thousands of chemicals or entities that are possible. So, you must have one objective, some answer okay. If they do not tell, I can do whatever I want. I can decide and analyze whatever is available to me and do it. So, you must know what it is because once you know this, then the next question you are asking is what are the available and accessible techniques to measure?

Essentially what we are asking here is what are the analytical instruments? What analytical instruments are there to measure this particular analyte? A, we call it as the analyte because this number is a key word given to it, analyte. So you must know what are the instruments that are available to measure this particular this thing. That is question number. What is the next question that one needs to ask. In this analytes, analysis of A, what type of instrument.

So, give me an example of any instrument that you can measure a particular component in water.

Can you list any instruments, any parameters for which there are instruments that exist? You can measure some quality parameters. We have looked at a lot of quality parameters initially, right? So can you name anything? Any instrument that you do for water quality monitoring, water quality. **"Professor -student conversation starts"** PH. Anything else? Turbidity, conductivity. These are all indicative of something that is there in the water, we have seen that Okay. So these three. Have you used?

Have you made pH measurements, any of these measurements? How is pH measurement done? There is a pH meter. How do you analyze this in the water? How do you analyze the pH of water with a pH meter? Dip the probe. You dip the probe into water and you get a reading, that is all. So, you take the water sample and you dip the probe and the readout will give you. There is some element here that is interacting with water. Does it give you instantaneous readings? Immediate reading?

How long do you need to wait before you get a pH reading? Few seconds. Few seconds, yeah. **"Professor - student conversation ends."** So it is few seconds that, an order of seconds okay. So this will give you what is called as an instantaneous measurement. I am dipping it, reading comes out straight away, okay. This is very useful. This is ideal because now I have the freedom to do a lot of things. My sampling objectives can be very vast. I can say that I want to observe pH change over a period of time.

I want to observe pH change over this thing at very short timescales, it happens, processes happening very quickly, I can still measure the change in pH over a short period of time, okay? Any other instruments that, what about turbidity? So pH, if you want you can even put the pH meter into the water body. If you say I want to measure pH of a river, I can put it in the river itself and monitor real time pH is possible. Lot of people do not do it for other reasons, there are a few other reasons why people do not do it.

So, this is an instantaneous reading. Unfortunately, we do not have this kind of probes, this instantaneous probe for a lot of analysts that we are interested in okay. So our water quality parameters that we are looking at, screening parameters itself includes things like BOD,

COD, conductivity of course can be done, but conductivity is not, so we have TDS which is conductivity and then thus we have pH and TSS, turbidity. This, take the case of BOD. BOD as we discussed the preliminary method of BOD it is oxygen demand, which means you have to wait for the bio-organism to degrade up.

It is not going to happen in seconds. In fact, BOD is designated as BOD some time, this time is 1 day, 5 days, you will have to specify what it is. The BOD1 means 1 day is BOD of 1 day, you are not going to get instantaneous measurements, you are going to get, an instance of the measurement, but it is up that time, that is all. You are not going to get the accurate term for this is what we call as real time or online okay.

So here we are looking at online or real time measurement, which means that the moment within a few seconds or few minutes of my bringing a sample in contact with the water sample analyte, I am getting a measurement that is it. So, this is online, real time or instantaneous, all of these things mean different things, but they are all approximately the same type of instrument measurements, right. Opposite to this in contrast to this online, this is one option. The other option here is, it is not online, which means that I cannot dip a probe into water.

I have to take a water sample and go somewhere else, do something else, do something else in a lab, go to a lab, so it is not online, it is offline okay and it is not real time or instantaneous. Some of these measurements like BOD work over a period of time, but there is a difference. It still pertains to whatever sample you took. I take a sample now of say 100 ml and this whatever measurement I am getting is corresponding to that alone, okay.

So, anyway, this is offline and it takes non-instantaneous sample, it takes time okay. It takes time to analyze and there is a delay in the analysis, okay. These are easy things for you to think about okay. So, from this if you have an instantaneous readout like you have a pH, you have turbidity, these can give you quick indications whether it is useful or not straightaway, whether there is anything wrong with the water which is for a screening tool, this is important. Screening tool, you cannot take 5 days to do analysis and give back.

If you want immediately, say yes no answers to a lot of people. So, screening tools usually the aim is to make it very fast, very fast, but it does not have all information. Screening tools

usually, ideally we would like to have all the information at our fingertips as soon as possible, but we are not there yet. Technology is not there yet, people are working towards it. So, there are some measurements in which you can do this. People are always trying. Analytical chemistry in Environmental Sciences is a big aspect of research continuously progressing.

A lot of people are doing this kind of things. So, if one has to really look, so this question is very important. So this second question requires you to go and look scan the market if somebody has made an instrument, which can do what you want to do for the objectives that you are interested in, okay.

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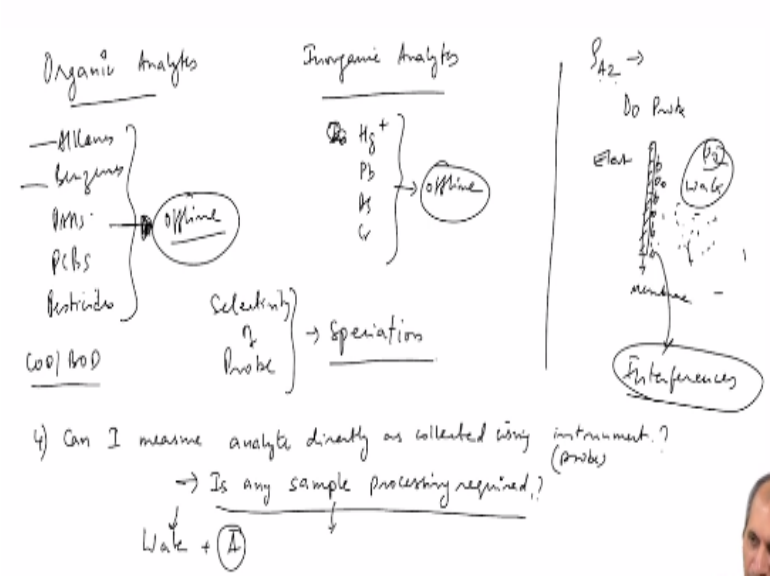
1. 

If you are interested in for example to look at the analytes such as say a wide variety of organic or inorganic, will go back a minute and then say. So, you have organic and inorganic analytes okay. A lot of organic analytes are very small concentrations in the water. So, you have say we have alkanes, we have benzene, we have PAHS, PCBs, all this bunch of pesticides they are all in the water. We would like to know if any of these are there. Unfortunately, there is no technique that will give you.

See if you have a BOD or COD, it will give you something, some information that this may be there, but they are all very low concentrations, you may not even see that if they are there. So, you really have to analyze these chemicals by some other method that you do not have a probe for. So, this is offline. You have to collect the water sample and take it somewhere else and do this okay. Same with inorganic. We have metal, say we have Hg plus, we are looking at Hg, we are looking at lead, we are looking at arsenic or chromium or other things.

You have to take it offline and do it. So people are trying to develop online techniques to do this, very specific thing, it is happening, but it is a long shot, it takes time and it takes a lot of effort to do this. So, people have sensors to do online measurement, people are trying to do it so in this case. So once we are coming to individual chemicals, we have this problem of selectivity of probes. Say a probe is the probe, can it measure only one particular analyte or can it measure all of them, can it give me complete information about all of them or can it give me bulk information?

What means, for example, this conductivity measurement is a bulk information, it does not tell me exactly what is there, which one, how much of it. It will tell me that all of these are probably there. The total conductivities is known, but I do not know if there is chromium or silver or arsenic or any of these things okay. So, that is what we call a speciation, selectivity of probe is the ability of a probe to do what is called as a speciation okay. Now, we consider if you want to look at, in all of these things, the one more factor that you need to ask and this comes only by experience.

Some of you have done analysis of chemicals in water. If you are saying it is an offline instrument, okay, one of the first questions that needs to be asked is, that is question number 4. Can I measure the analyte directly as collected in the instrument? This is a very important question. This is one of the reasons why online instruments are not very successful. What do you imagine this question means? Can I measure analyte directly as collected using the instrument, not in the instrument using the instrument or probe?

What it means is that can I take the water sample directly to an instrument and analyze it directly? Which means that indirectly means is that is any sample processing required? Why would you need sample processing? Why is this question even coming up? When you are looking at analyte in water, I am interested in the analyte, so sometimes it is possible that, I am asking the first question here is can I measure analyte directly in the instrument, which means that, what it means is can I use the water directly in the analysis or do I have to do anything before that?

So, what possible reasons could there be that processing is required? This brings another question that relates to the accuracy of the measurement okay, in the sense of accuracy,

sensitivity, precission all the analysis parameters we discussed, it comes into play. Suppose there is a river or a lake okay. I take a pH meter and put it in the lake as it is. What problems do you expect? Have you seen a lake, any of you, a lake water what it looks like? So, we have to be very careful here.

So, we are saying we are analyzing rho A2, which means it is rho A2 only, which is a concentration of A in water, theoretically we are saying we are interested in the concentration of A in water, this is important. Why is this important, it will become more apparent later, when we are talking about fate and transport okay. When we are saying it is a chemical in water, we are not interested in the water body as a whole, we are interested in water, aqueous phase only and this is a strict definition that we want, therefore this becomes important.

This question becomes important here. So, in lake water, when I take, say I put the this thing, I collect a bucket of water from the lake and I dip my probe. What are the possible problems with this measurement? **"Professor - student conversation starts"** The volume of water. Volume is all there, probe is small, it required 10 ml and I have a liter, I have 10 liters, bucket 10-15 liters. Rotations. Rotation, why? When you see a sample of water, any sample of water, what is your first concern in terms of the analyte accessing the probe? **"Professor - student conversation ends."**

You understand my question? Analyte has to access the probe. See all the probes have a certain principle of operation. The pH meter is an electrode system, it is a electrolytic cell, there is a small membrane or some, there is a junction. So, at one end of it is concentration of hydrogen ions and other end is something else. So, it looks at the potential difference between these two, for that to occur it needs to have clear contact between the across the junction between the analyte of interest and whatever is there inside okay.

Let us take the case of dissolved oxygen probe, it is even more interesting. Dissolved oxygen probe, if you take a look at dissolved DO probe. It is the same electrolyte cell, it is looking at water, oxygen in the water and on this side is some electrolyte okay. The oxygen has to diffuse through the membrane, there is a membrane here. So, when oxygen moves through, there is some potential difference that is created and that measure that is what is measured, and this concentration here is the rate of transfer is dependent on that and all, so it is a membrane transport based process, okay.

You do not worry about that, but this junction that is there which is important for the measurement has to access oxygen directly right. What can prevent it from accessing it directly? Is there anything that can prevent this contact to happen? **"Professor -student conversation starts."** When you use a pH meter, what is the first thing you do? pH meter has to be, repeat it, why? This is of course, this is the thing that I should do with all instruments, pH meter or any meter, first thing what do you do? Test. You, no before that? Clean it.

You clean it, why do you clean it? Because any residue? Residue, Where? On this thing? Where is the residue coming from? Earlier samples what it was there. Earlier samples and atmosphere, nothing in the water itself? That is why I asked you have you seen lake water. What is there in lake water? A lot of other things can be there in lake water. One of the things is collide, lot of colloidal particles will be there, they can all settle on this. Suppose there are large particles in the water.

These particles can go and block the interface, therefore influencing the measurement that you are making. Sir if you are collecting water, then also collides will be there? Yeah. that is why I am asking, that is why this question is asked, right. Does the sample require processing? So, to answer this question, what is a follow up question? What is this called? What is this particles that are present in a probe that affect the reading that you are seeing, what are these called general term. What are they doing with the analysis, interfering.

They are interfering with the analysis. **"Professor - student conversation ends."** So we have to find out if there are potential interferences in this. So, in this case, interferences is the presence of solids. Solid particles are present and your probe is a surface, solid particles go and hit the surface, you are not able to access your actual analyte that may be influencing it. The chemistry or physics or whatever is happening, the interface is modified, and therefore the reading that you get is modified. So, you have to look out for interferences.

So, one of the ways of dealing with interferences is you remove the interference. In the sample processing suppose there is particles, you determine that particles interfere with your analysis, you remove the particles. There is some sample processing involved okay. There could also be another analyte inside this, it may be another dissolved components that will

interfere with the analysis of your main component. If you determine that, that has to be separated.

You will not see it normally in this kind of DO and all that, but you will see it in more advanced analysis of organics. For example, you have different classes, you have alkanes and aromatics, a large amount of alkanes are say oils and things like that, so if you have a lot of one class of compounds, which will interfere with the analysis of another class of compounds, okay. So, we will see that when we do the mixture analysis. So, one has to look for interferences and sample processing is required for, what is the sample processing that you will do in this case?

If you take lake water, you have to remove the solids by some method filtration or something and you have to remove to the extent you know that your interference is removed okay. So, depending on the instrument you are using, your interference will be different and you have to remove that interference to increase your chance of sample processing is required. Second, the instrument that you are using may not, the interference maybe, what is the problem, there is an analyte, you have water plus A, this is your system, you want to analyze this.

What could be a really big problem for you? If the interference is, you are interested in this analyte by using some instrument. What is the interference is water. The analyte, the instrument can take care o, but it cannot handle water, yeah, we will see that later. **"Professor - student conversation starts"** What we do? You know the answer. If the analyte of accessible interest is accessible to instrument, but water cannot be put into the instrument. Instrument cannot take water, what do you do? Transfer the analyte to another. You will transfer the analyte to another solvent. **"Professor - student conversation ends."**

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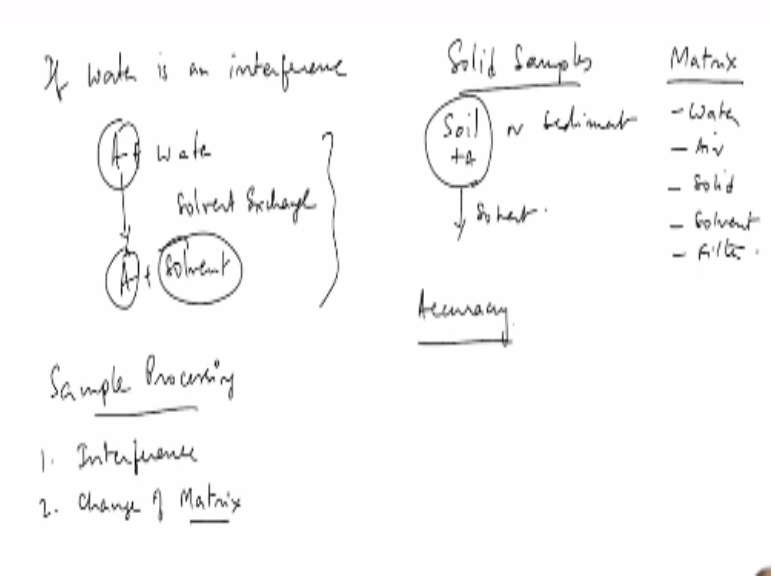

So, you have A plus water. Now this A is transferred to another solvent. So, you have what is called as a solvent exchange. Solvent exchange is a must transfer process. It can be done directly by bringing another solvent in contact with water or you can go through a third method, we will talk about that, whichever way you can do there are a lot of methods to do this. A solvent exchange which can be done so that this solvent is amenable, it is lower interference in the instrument that you are using than water itself, okay.

There are a lot of compounds, almost all the techniques that we use water to analyze organics in water do not handle water very well. So inevitably, most of the cases you have to transfer A into something else okay. This is involving sample processing, which means I have a sample in water, analyte, what I am taking it and putting it somewhere else. A lot of bad things can happen in this process. Sample processing is one of the steps where analyte can get lost. You can lose analyte, yeah. So, this is very important.

This step is also useful and important in when your sample is in a solid matrix okay. You have solid samples, when you want to do things like analysis of soil or sediment, there are very few instruments in the world that can analyze a chemical on solid directly, soil directly. There are a few, but they are very small size. Suppose, I want to measure the amount of chemical that is there in 1 gram, 10 grams of soil, it is very difficult for me to do.

I can do this on one grain of soil and I will say I will go and see the surface and see what is there by using some advanced technique, but bulk analysis if I want to say how much of phenanthrene or naphthalene or benzene is there in soil, I cannot do, I have to do this kind of

bulk interface exchange. So, I have to remove the A from the soil using the solvent, so I am exchanging here, soil definitely cannot be, soil is an interference, soil cannot be used in most instrument directly.

You have to pull it out, you have to pull out the analyte and use it using a solvent and the solvent is then introduced into the instrument. So, sample processing is required for interferences dealing with interference for change of matrix. This word matrix in environmental jargon, the word matrix is the medium in which the sample exists, analyte exists. So, for matrix can be water, matrix can be air, matrix can be a solid, matrix can be a solvent, anything, filter, all kinds of things are there.

Matrix is wherever the sample analyte is held in that is called as a matrix okay. So, when we say water is interfering with analysis, we say matrix interference with the analysis. So, you have to change the matrix, you move it from water to somewhere else or solid is interfering with solid interference, matrix interference, remove the matrix, we change the matrix, exchange it okay. Okay 5 more minutes, we will discuss few more important things.

So in all the analysis, let us say that I am taking a water sample and I am interested in analyzing benzene in the water sample from a lake okay. I collect the water sample. From a point of view of accuracy, so we talked about accuracy in the instrument yesterday. Now we are talking about accuracy in your measurement itself, the entire thing.

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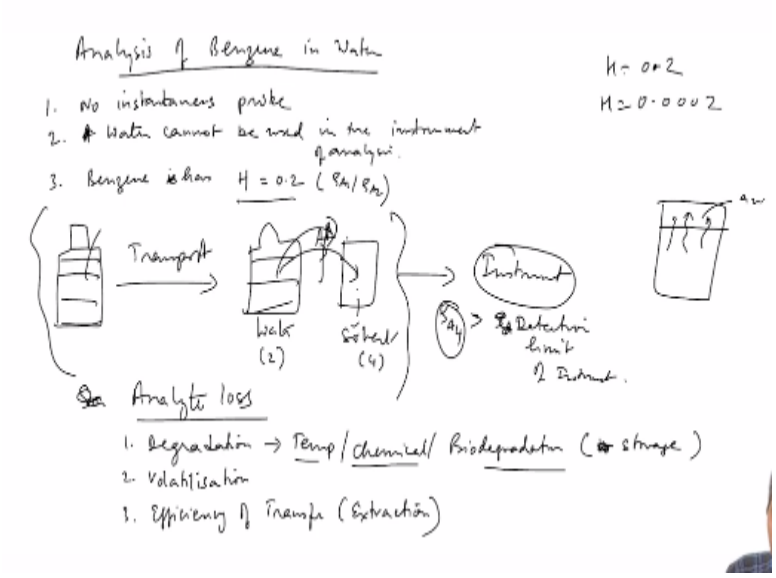

So, since we have discussed a few things, let us say we have analysis of benzene in water, we take this example. I give you prior information that there is no probe that measures benzene directly in water. So that is not an option over, one. Second, whatever the instrument we are proposing to use for benzene cannot take water directly, second constraint okay, 2 constraints. Third, benzene is benzene has a. I will write down the constraints here. One is no instantaneous probe, benzene has a Henry's constant of 0.2.

This 0.2 of benzene constant is rho A1 by rho A2 okay. What does this mean? H of 0.2 means what? It is a ratio of concentrations rho A1 to rho A2. So what does this mean? So I take the sample, I go to a site, I have a 1 liter bottle. I collect the sample and I bring it back to my lab because there is no instrument, so I have to bring it back to my lab. So, I am going far away, I am going 4 kilometers or 10 kilometers or 15 kilometers to collect water samples. I open a bottle, I dip the water sample, I do whatever I have to do there.

I close the water bottle, bring it back to the lab, and I have to do some processing because water cannot be used directly. So, the processing means we have to transport the water sample, then I have to transfer A, this is water to a solvent, A has to be transferred from this to this, yeah. Then I have to go to my instrument. In the instrument, I have to worry if this concentration that is now present in this thing, concentration of A in 4, solvent is we call it as 4, water is 2, is greater than rho A is greater than the detection limit of the instrument.

This is a concern because we talked about it yesterday. After doing all this, whatever is my amount that I have here is still below the detection limit, I have to increase that, we will come to that in the discussion later. So, all this is there, which means that I may have to increase the concentration and I will do that, but let us look at this process from here to here, yeah. What is the implication of Henry's constant 0.2? What does this mean? Henry's constant of 0.2 versus the Henry's constant of 0.0002, what is the difference between these two?

"Professor - student conversation starts" The second part losses will be less. Losses to what? Air. To air, Yeah. **"Professor -student conversation ends."** So there is air, 0.2 means 20%. If you keep it in equilibrium, the ratio will be 20, 0.2, 20%, that is a big number. So it depends on the volume of air and all that. So equal amount of volume. So if I leave it open, it is likely to volatilize okay. If I leave the sample open long enough, lot of water will go away. Now the question will also be asked.

Now the important question is, it is already open in the atmosphere, now why are you worried about it? It is already opened to the atmosphere, but so it has equilibrated there, you are bringing it back and you are equilibrating into a different system, so that original concentration is what you are trying to measure. This concentration is lost in the process. So lot of questions can be asked, so the goal is just to maintain the integrity of the sample, you do not care whether this happens in the field and all that, it does not matter.

You are taking a sample of water at that time. See what we are trying to replicate is you do not have a probe to measure the sample instantaneously, but we are trying to recreate the same thing by going through the series of progress, but it is not possible. So we are trying to find out how much is lost in the process. So there is possibility of volatile losses during this. Is there any other method in which sample can get lost from the analyte? **"Professor - student conversation starts."** Analyte loss, loss of analyte during sample processing and sample analysis.

Degradation. Degradation, by what? By temperature changes or environment. Temperature or anything else? Any other degradation. **"Professor -student conversation ends."** One of the main degradation pathways is there anything else in the sample that will degrade. So, again we are not worried about, say one can argue again water has those components degrading, but that is not our concern. Our concern is to measure that, we are trying to get that replicate, that instantaneous measurement there by doing this okay, so that should be.

So, other chemicals is, this is an interference potentially, not a biological biodegradation, this is very common. In many chemicals biodegradation will happen over a period of time, especially if it is in water. Second, what we just discussed is volatilization, it will evaporate. So, if you have a sampler, if you have a container, sample container that has some headspace, air above it. So, you have a sample container that I have not filled it up to the top, I fill it up to where there is some air here.

So, some chemical will always go up in the time that you are transporting it and storing it somewhere it will go. So to prevent degradation, you can store it at lower temperature. We are looking at storage that will reduce temperature degradation or biodegradation and all that, so it will reduce. So sometimes people will bring sample and store it in low temperatures or

they will transport in low temperatures also. It also reduces volatilization to some extent. Is there any other method in which sample loss can occur?

Analyte loss, not sample loss. **"Professor - student conversation starts."** While transferring from water to another solvent yeah, where, what will happen? Part may be left in water, so that we cannot transfer. Okay. So what does that mean? You are right. That is very important this thing. **"Professor -student conversation ends."** What is that? What he is saying is some parts of the analyte when you are transferring all of it is not transferred, yeah. So what is that, can you give a name to that? Translation. So the efficiency of transfer or efficiency or extraction.

We are extracting A from one matrix to another matrix. So the efficiency of it, and this is very important. This is probably the most important thing, especially when you come to things like soils. From soil, you do not know where the analyte is sitting in the soil, soil is a very complicated matrix and you have device an extraction method and if do not know this method of extraction is good enough or not.

So, we will discuss a little more of this tomorrow in reference to quality control. All these issues are there. So when I bring a sample and analyze it, I am not sure where I have lost everything. So you need to account for all that.