Life cycle Assessment

Prof. Brajesh Kumar Dubey
Department of Civil Engineering
Indian Institute of Technology, Kharagpur

Lecture – 11
Environmental Data collection and LCA Methodology

Welcome back to the third week of this course on Life Cycle Assessment. So, we will start with looking at some environmental data collection, how the environmental data collection is done, if you remember from the last week we went up to how the risk assessment is done, toxicological information and all that. So, if you remember from the last video I mentioned that for everything that you need to do; you need to collect data.

So, the first model or maybe first 2 module of this week will be focusing on the data collection part, how the data is collected and how it is analysed and what are the sum of the challenges we face especially when you are looking at the environmental sample environmental samples they tend to be not normally distributed they tend to be mostly log normal distribution. So, we will talk about that. So, this week we will be focusing on environmental data collection and then we also will look at life cycle analysis methodology. So, after we collect the data now let us do some LCA we will also use several examples. So, it should be clear as we make progress.

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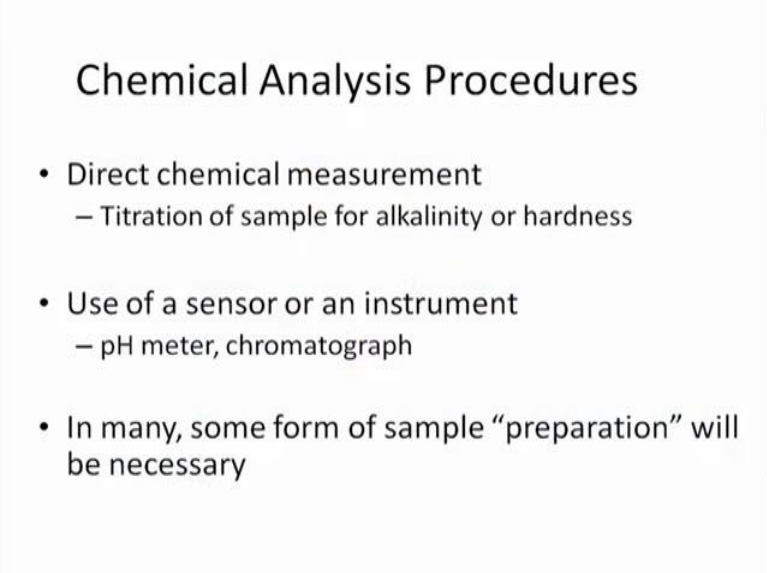

So, if you remember or like the first when you start doing any analysis if you have done a lab and assume you must have done some environmental lab. So, if you have done some environmental lab or even a; I would says chemistry lab you do some chemical analysis. So, the chemical analysis 99 percent it is done with some procedure there is some procedure associated with doing chemical analysis and if you remember last video we talked about that for doing this kind of analysis there is a standard methods there are standard methods out there which is used for doing the analysis of different samples.

So, in terms of the chemical analysis procedure, let us look at them what are the different procedures out there - one is our direct chemical measurement say if you have done a chemistry lab you must have done alkalinity or hardness. So, alkalinity hardness those measurements you are doing a titration. So, anything that chemical measurement is when you do a titration where are you at some samples you have a how you have water in a beaker or and then you are from your breath you are adding your tyrant drop by drop and using some colour change which is known as indicator you say that this has been neutralize. So, this is alkalinity of this sample we can calculate or the hardness of the sample and those that is the direct chemical measurement.

So, titration is a good example of that or you can use a sensor on an instrument which is

more common, even the pH metre is a very common like if you walk into any environmental lab you should have a they should have a pH metre because that is one of the very basic parameter. So, the pH metre is a instrument. So, what this instruments do? Like if you stick your; if you stick this instrument or pH probe for example, in a water sample the pH probe reads a data and then the data is transmitted in to the receiver which you have the bench top or you if you are a handheld and that receiver is synthesized in the data and gives you out the pH number. So, that is how these things work because there is a sensor involved and I will give you a some example of different instrument which will make it more clearer or you may have some sort of chromatograph if you have looked into any environmental lab it there are different types of chromatographs out there we have ion chromatograph for doing ions anions or cations we have gas chromatograph which is again used for gaseous sample.

So, that are different types of chromatographs used and the chromatograph as the name suggest the chromatograph is it is a basically what you are doing is the chromatograph means that your separating different chemicals. So, for example, when you work on ICs the ion chromatograph you put the samples you pass your samples through. So, this chromatographs; what does it do is it is all the iron, but what ions typically we will look at if you think about anion we have chloride, nitrate, nitrite, sulphide, fluoride, sulphate or bromate. So, your chromatograph separates these different compounds and then based on their affinity to the column the different compounds come out at a different time and that is called the retention time. So, chromatograph helps you separate these chemicals into different fraction.

So, before you go into any of this chemical preparation you will have to do what is known as sample preparation sample preparation very simple English you have to prepare the sample maybe some physical preparation or they could be some chemical preparation. So, we will look at that as well.

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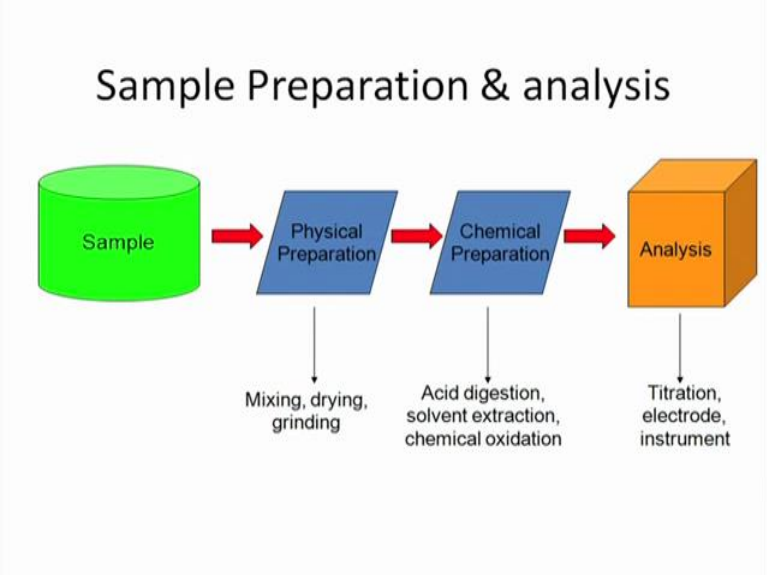

So, if you look at this particular chart over here you have a sample you bring your sample you collect the sample you bring it to your lab and then you may have to do some physical preparation physical preparation means you may have to mix it, mix it to get it more representative sample you may have to drive that is the drawing is done or grinding. So, either grinding again makes it more like bigger surface area better reaction. So, depending on the type of analysis that you are looking at you may have to either mix drive grind and there could be other as well. So, these are some examples of what the physical preparation will tell.

Then after you are done with the physical preparation you may have to do some chemical preparation as well. So, here there is some examples are given acidization. So, what is acidization? Acidization is essentially what you are trying to do is you take your sample and then you throw it in some acid like in a beaker with some acid in them what it does its breakdowns all the organic matter the organic bonds that you have say if you are looking at a soil sample and you are interested in to find out how much lead is present in the soil or how much cadmium is present in the soil with soil has there is a matrix involved.

So, many times what happens is your soil will have a matrix they lead or cadmium

present will have a matrix with certain organic matter or should be some inorganic material present and when you put it into this acid in the acid digestion is step what happens in those bonds gets released. So, now, your lead or cadmium is in solution it comes into the solution it is in the liquid and then you can take that liquid and analyse it in any of the instruments.

So, similarly there are other sample preparation like the chemical preparation method we also do organic extraction the organic extraction is done as you can see on this particular like on the chart we had acid digestion as one then we have solvent extraction this solvent extraction is very mostly use it for the organic material where we use benzene or benzene is used a lot methyl chloride is also used methylene chloride is also used quite a bit. So, when we have this what we do is we have say if you have a water sample you let the water sample mix with benzene the benzene what it will do is it will extract whatever the contaminants you are looking at say for example, TCE or PAH. So, benzene will extract these chemicals into the solution and then you take that solution concentrate in turbo up and then put it through GC. So, that is how that can be analysed.

Other things is done is on chemical oxidation. So, that is the last you see on the last examples. So, on the chart is a chemical oxidation where oxidizing the chemical before it is, so again chemical oxidation and acid digestion is kind of similar acid digestion is a form of chemical oxidation as well. Chemical oxidation if you remember the COD test is essentially a chemical oxidation test because there is it is a chemical oxygen demand. So, there if you if you have done COD you will know that it is a potassium dichromate which is used as oxidising agent and then it oxidises everything every chemical present in there which could be potentially oxidized.

So, once first you do the physical preparation then you do the chemical preparation if needed and after this you take the sample to analysis and the analysis could be done in a different way you could we either do a titration you could have a electrode you could use some instruments out there. So, there are different ways of analysing it after you analyse it you get the sample concentration certain milligrams per litre or micrograms per litre or milligrams per kilogram depending on what kind of matrix we are using. So, this is how predominantly the sample preparation and this is done like a quick summery of that and

then you take it to an instrument.

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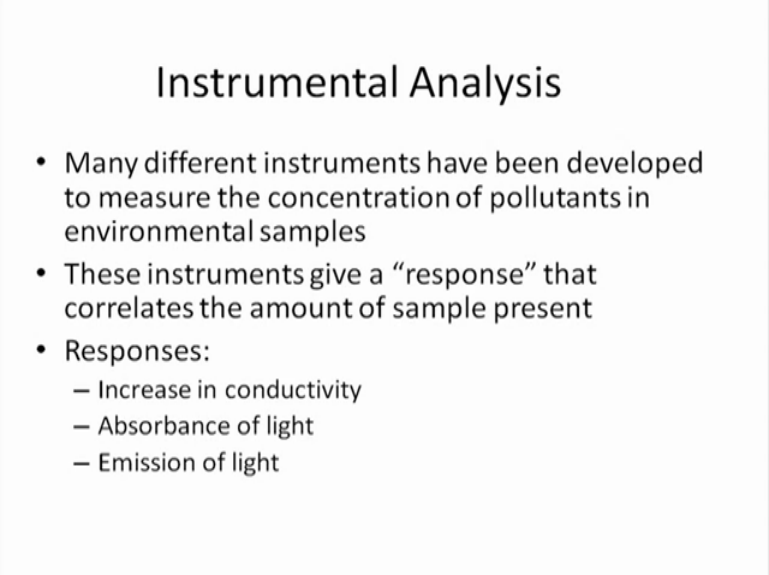

Now there are different instruments have been developed to measure concentration of pollutant in environmental sample it depends on what kind of contaminant pollutant you are looking at if you are looking at ions we have ion chromatograph, if you are looking at some gaseous pollutant we have the gas chromatograph, if you are looking for heavy metals we have a atomic absorption, spectrophotometer we have ICP which is a inductively coupled plasma atomic emission spectrometer there is a JF furnace there is a atomic absorption this is also like a GCM like a ICPMs mass spectrophotometer, there is GCMS gas chromatograph these are some of the example. There are lots more instrument out there which are used for analysing of different kind of samples. So, many different instruments have been used for measuring the concentration of pollutants and environmental sample these instruments they what they do they give you a response. So, it kind of gives you an response and based on the response that you get you correlate with amount of this particular pollutant which is present in this sample.

Now the response could be either increase in conductivity that is one response used a lot that is what used in even I c absorbents of light that is what a does absorbents of light even you have if you have worked with any environmental samples environmental lab

you been to you know that UV is like a UV spectrophotometer like the one of the company most popular is hatch, but there are a lot of other companies are there PerkinElmer some and other companies which makes a spectrophotometer. So, spectrophotometer it again works on the absorbents. So, that is why for the spectrophotometer we do not use any coloured sample in the spectrophotometer if you are using a coloured sample in the spectrophotometer it works based on the colorimetry it is becomes a problem I think I will show you a picture in the next slide which will make it more clearer.

So, there are different types of response either increase in conductivity absorbents of light or even emission of light emission of light is what is known what is used in ICPI will talk about that.

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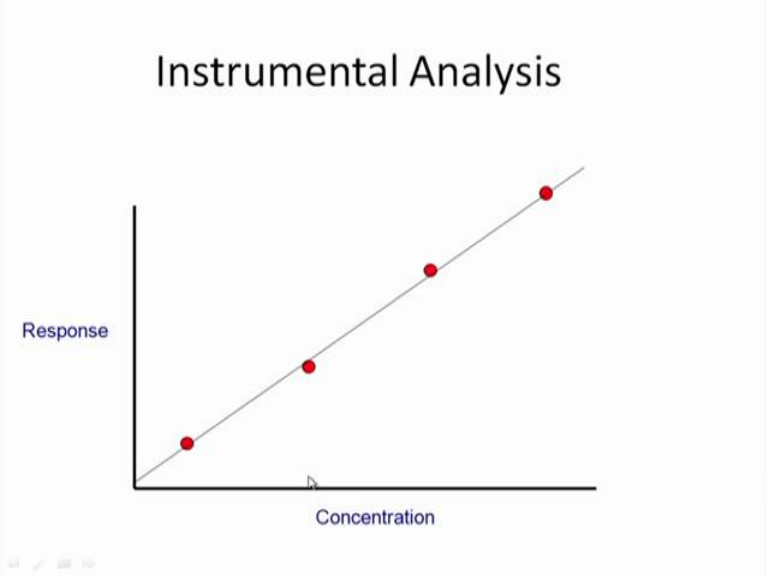

So, this is a if you have done any type of any kind of environmental work environmental lab work you will probably recognise what this graph is this is your typical calibration curve where the response is linear as you can see the equation this is a straight line. So, in a straight line means it is a linear is it not. So, we have a linear relationship as you are increasing the concentration to x-axis is the concentration the y axis is the response as we are increasing the concentration v c a increase in response. And if you do a best fit line

and then you get R squared value if the R square is close to 1 you say that you have a good calibration and then when you go back. So, if you go if you look at to this particular graph now this is your calibration curve. So, you have made a standards you made a certain standards say 1 milligram per litre 5 milligrams, 10 milligrams, 20 milligrams, just for example, and then you came up with the best fit line. Now you have a unknown sample you will sample for which you do not know what is the concentration you run that sample you get a response the machine will get a response and then it will go to this particular line and then say this is this is the response I see.

So, probably for this response the concentration is done over here. So, this is what you see as a concentration and since these days most of these works are done by the computer software the number that you the number that comes off is what you see is over at the concentration number. So, if you are within this celebration curve that number is good you can use it say if you are if you had a concentration which shows up somewhere here which is higher than the calibration standard that have been used for that case usually what to do is we will dilute this sample and then will bring it to this particular calibration range and then we will do the we will get that particular value out there.

So, it is the different way of this is the way you could do your instrumental analysis. So, this is and this is pretty much common what kind of instrument used every instrument has to go through a calibration curve one thing you need to be careful about that is the standards that you make to make calibration curve and that standard should be made very carefully because if your calibration curve is wrong; that means, your whole analysis will be wrong as it will take the wrong information as the correct information because your concentration is based on that line that you saw on that particular calibration curve. So, if your calibration standard goes bad for some reason then your whole data will come out to be a bad set of data and the other thing like how to check whether this celebration came out to be or not because for the unknown samples you do not know what the concentration is. So, what we do is we make some known samples for example, if you go back and look at that particular graph.

So, if you look at this other response and this is the concentration now if you make a

known concentration say if we make a sample for which we already know the concentration those kind of those samples are called calibration check sample because we have made this calibration curve we want to check whether this calibration curve is correct or wrong. So, we do not take any of these is standards because if you take this standard of course, it will come out to be corrected is not it because we our calibration curve is based on these four standard points. So, we make a new standard we go back all the way to the new like, to the source of the chemical we take it from the standard bottles of the bottle that we purchased from the companies.

So, we take a sample which we know the concentration now we run that sample as if it is unknown sample. So, it will give it a response then you go to a calibration curve you look at the concentration and this concentration should be the same concentration that you made your sample for if the concentration is different; that means, there is a mistake there is a mistake in the calibration curve or there is some instrumental error. So, we need to go and fix that error and then redo the whole analysis again. So, those of the things need to be very very careful in terms of the instrumental analysis because as any calculation you make is based on the data that you have collected. So, the data quality is very very important and as you will see when we go in that LC exercise getting good quality data to do environmental analysis is a big problem today if you think about we have these days, we have a lot of focus on this Swachh Bharat mission or we are building toilets, but at the same time we have been really focusing on waste management.

Now I have been I am doing some work with Bihar government on their waste management plans for several ULBs, we have already done it for 35 ULBs and we have to do possibly around another around 10 ULBs more we have been worked will be working on in the coming years in the coming I basically months. So, most of the places what we see is that lack of quality data. So, if you are designing something if you are designing say waste management system if you are designing a water for water treatment plant if a designing a wastewater treatment plant if the basic data is not correct if the basic data quality is not maintained of course, the product will have a some sort of shortcoming because if your data is not say as a civil engineer, if you are a civil engineer you want to design a beam, but you do not know how much load that beam will take how much load the beam should take you do not have that information very clearly you only

have a range.

So, what will happen you will end up either over designing or under designing and then you will be in problem later on if you are over designing it is a waste of resources waste of money, but again structurally you are safe, but if you end up under designing your building collapse. So, those things, that again the data is very very important similarly in the environmental area say in the waste management sector right now say the city wants to go for a compost plant, but they have to first look at what kind of food what kind of waste they have is the waste good enough for a compost plant or a anaerobic digestion plant will the anaerobic digestion plant will really work this is all this decision is based on data and if it is not a primary data mostly it is a secondary data. But even if it is a secondary data many times if you know it is a poor quality data your whole calculation may go (Refer Time: 18:15) and you may end up having a lot of problem and we already have seen this kind of problem happening with many waste management activities that have been planned and implemented in many cities across the country.

So, coming back to here again, the data quality is very very important. So, that is why I have been emphasis on again and again that you need to look at this calibration curve and the data that you generate very carefully that is one of the critical aspect now when once you have your celebration.

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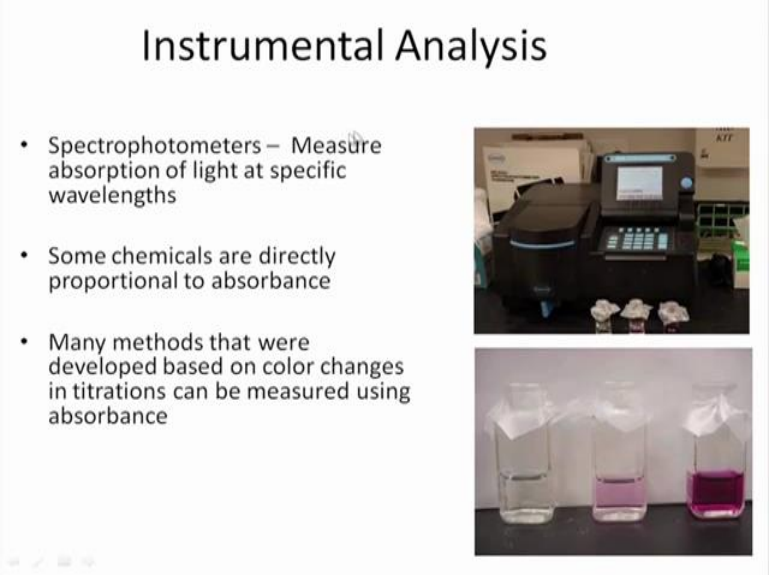

We will talk about the instrumental analysis this is just one example the spectrophotometer which is a very very common instrument you walk into any environmental lab you will see they will have a spectrophotometer for running the sample. So, this spectrophotometer what it does it measures the absorbents of light at a specific wavelength. So, here you see a picture of a spectrophotometer, this is the box where you open the lid of the box you stick the sample in there and what happens is the light passes through that based on the absorbents as you can see different colour, this is these are the sulphide samples and higher the colour more the colour density higher the concentration in this case. So, this is our blank.

So, very clear like a double DI water, VDI water or nano pure water and then you have this is this sample has little bit of sulphide this has very high sulphide. So, when you stick this sample in there with this blank sample will clear the background will just say everything is if it is this colour it is 0 sulphide and then when you stick this sample in there it will show some sulphide and this here it will show much much higher sulphide and there is a programming method which is already there, already programmed into this minicomputer right there. So, this is how this, so it works on absorbance of light. Some chemicals are directly proportional to absorbents based on the absorbents number it based on the calibration curve that we have done in the earlier with the standards we can

go back and predict the concentration of different samples that we are doing.

So, there are many methods are based on this colour change or using absorbents it can be measured using. So, whatever you do using the colour changes in titration can we measure using absorbents as well. The problem with the absorbents are this particular method is when you have here if you have a clear water sample its good, but if you have a sample which itself has colour if there is a sample with itself has colour then it becomes a problem because then you have a interference coming in there.

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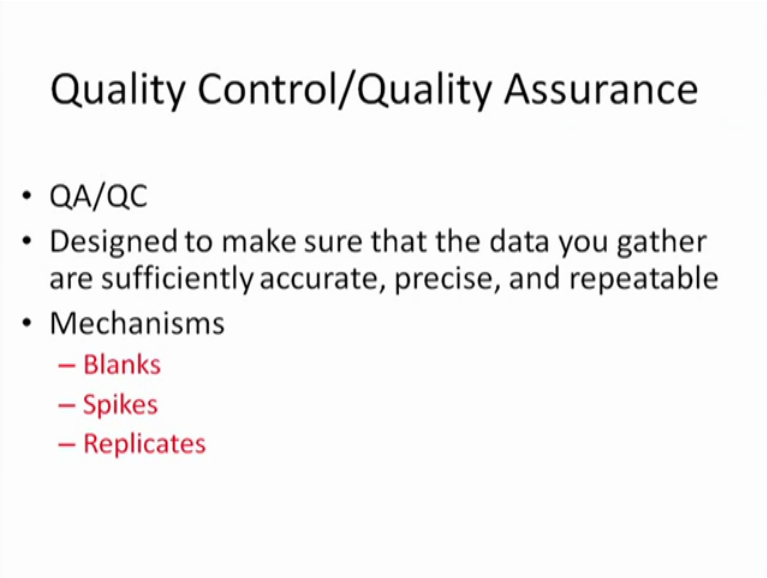

So, what I have been talking about is also relates to the QA QC; QA QC is quality assurance and quality control quality control and quality assurance and we are talking about their quality assurance and quality control of environmental data that we are collecting from environmental sample. So, what does it say? QA QC procedures are designed to make sure the data you gather are sufficiently accurate precise and repeatable. So, it says you are gathering accurate data you are getting precise data and you are getting repeatable data and how you ensure that? There are certain mechanism to do it we use blanks, what is blanks is your pure DI water or nano pure water. So, this DI water and nano pure water if there is no contamination of glassware, no contamination of say your instrument this blank samples should not show any concentration it should be

all below detect.

So, that is what we look at whether the blanks are coming out to be clean and if it does not come out to be clean that means, we have some problem. Either we are having some glassware and contamination issues and we have seen that happened in the past say for example, this happened few years back in my lab itself where we were working with electronic waste a lot those days and maybe one batch of students were not that careful once they did their stuff with electronic waste electronic waste lot of lead. And then next day like after couple of days we were using the same set of glassware the class was unfortunately were not clean very well. So, when we are used this soil samples and they almost all the soil samples even the clean soil which was the background soil which was supposed to be cleaned which were like a blank they also showed up some lead. So, that is that is kind of problem shows up if the if the that kind of problems can be easily detected if you have blanks if you do not have blank samples you cannot detect those kind of problem that is why you need the blanks to do that.

Then the next you see next on that 3 red bullets that they are there next is a spikes. Now what is the spikes? This is spikes is different than the spikes we talked about in the sportsman shoes these are actually spike samples. So, a spike we are spiking is certain concentration. So, what you do is you take your sample then add take another from the same bottle say if you collected a bottle of sample of a pond water or anything you take a sample as it is then you are take another sample from the same bottle, but at this time you add a known concentration of different analyze that you are measuring for. So, if you are measuring for heavy metals say arsenic lead, cadmium, chromium, mercury whatever. So, you add known concentration of this stuff in there. Now at the end when you do the analysis of the original sample and this sample with where added the known stuff is called spiked sample.

So, when you have you analysing the original sample and spike sample and what you can do is you can take the difference of the concentration you get from the spike versus original like a spike minus original and the difference gives you the concentration that you added. So, if you added x milligram per litre our concentration the difference of the 2 for that particular element should be closer to x milligram per litre, it will not be

hundred percent like it is we called them recovery like if it is how much comes back. It will not be 100 percent recovery for most of the heavy metals we assume a recovery of a round 90 to 110 percent to be very good, 80 to 120 percent is acceptable, if it is less than that then we need to we are worried we need to find out what is going on what is the problem. For organics depends on the type of matics some organics we even are happy with 40 to 50 percent rate recovery some we want 70 to 80 percent recovery.

So, depends on different types of organics, but this recovery gets an idea whether the for that particular matrix whether the instrument is working ok or not and then the last thing on that particular thing for particular slide is what is known as replicates, replicates as you from the English word replicates multiple sample. So, you have multiple same samples run multiple times. So, you have a same set of samples like if you want to run a sample that you run a duplicate of that and you run a triplicate of that to make sure the number are reproduced you get the same numbers coming out. So, it is not it is a same numbers which are coming back in when you look at those. So, that means, the machine is working ok, your instrumental method is working ok.

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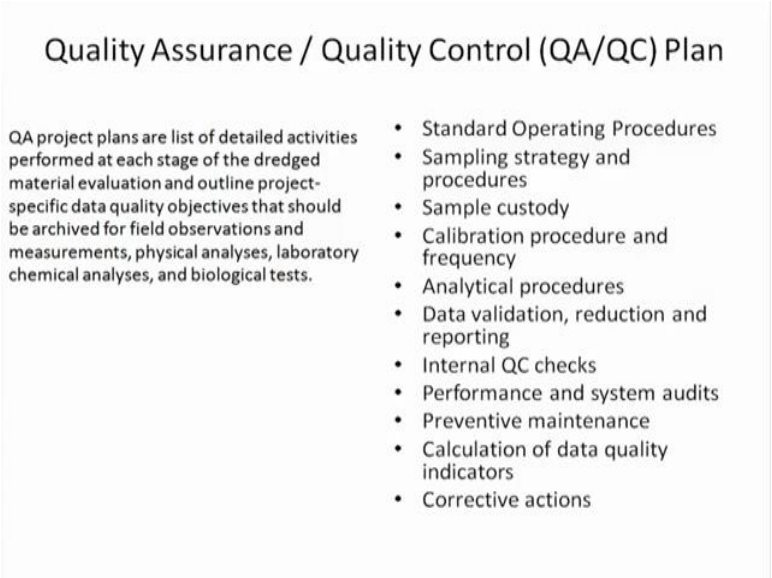

Don't worry too much about this particular slide its basically since as I said in the some earlier video as well we will give you this PDF version of this slides and you can read it

over there, but it is basically it is a procedure it is a procedure that the quality assurance quality control procedure needs to be followed when you are, especially if you want to become a good environmental lab. And for there are certain we call them like NELAC national environmental lab accreditation council or government certified lab or the government certified lab you have to follow many of these procedures some of these we have to have a standard operating procedure you have to sampling strategy procedure you have a sample custody calibration procedure analytical procedure data validation internal QC checks and all that. So, this basically a project plan there is list of detailed activities that needs to be done. Do not worry too much just you can read it for your information.

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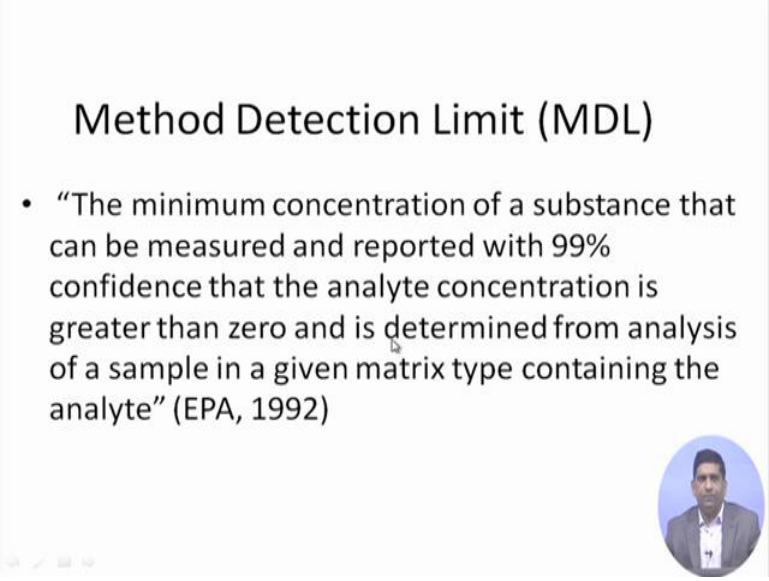

Now, when you are trying to look at a certain instrument any instrument has a detection limit. So, the instrument can detect only up to certain concentration below which the instrument may give you a number, but that number does not mean anything. So, that concentration at which them instrument can really detect that particular sample is defined as method detection limit or you can hear the term MDL. So, MDL is a minimum concentration of a substance it is again it is a from EPA document it has been taken from a team from there. So, essentially copying I am coating from there it is the minimum concentration of a substance that can be measured and reported with 99 percent

confidence that the analyte concentration is greater than 0 and is determined from analysis of a sample in a given matrix type containing the analyte. So, for a particular matrix type you are 99 percent confident that the analyte concentration is greater than 0 and its can be determined.

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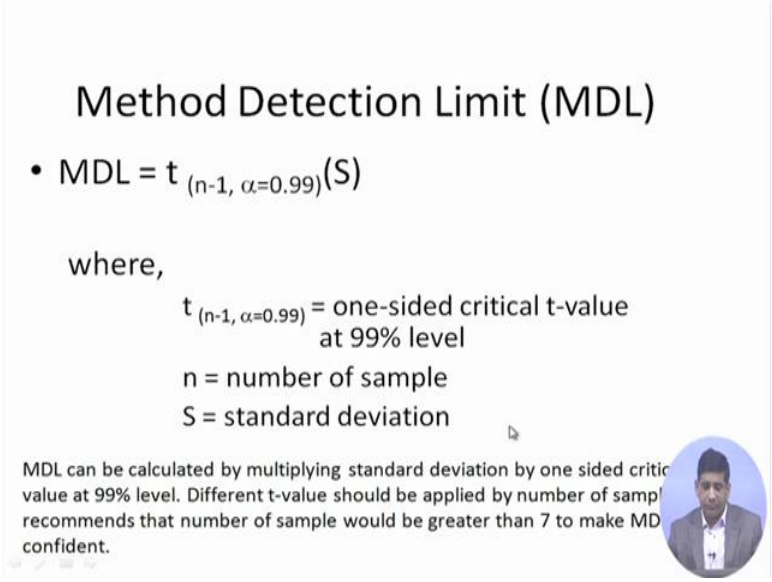

So, how we find out MDL? MDL is defined as MDL is t which is your student's t table from the statistics t n minus 1 and is the number of samples n minus 1 is your degree of freedom and with 99 percent confidence alpha is 0.99. So, t value for this times your standard deviation of the sample data set. So, here t n minus 1, alpha is 1 sided critical t value at 99 percent level 9; 99 percent is the number of sample S is the standard deviation. So, we can find out the MDL by getting the t value from the t table multiplies by the standard deviation.

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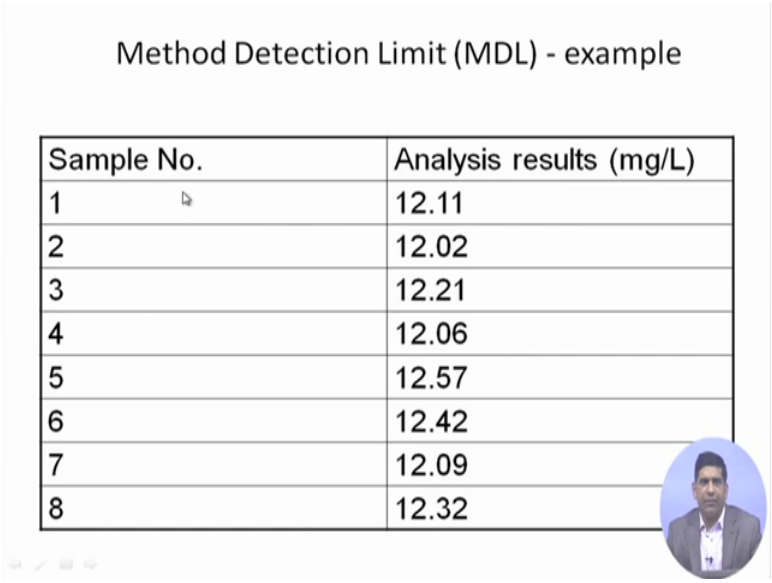

So, how we do it? So, for example, if you had a sample 8 replicates of that and for that 8 replicates, these are the values you got 12.11; 12.57; 99 percent. So, as you can see it varies from 12.02 to 12.57 not too much variation, but still it there is some sort of variation over there. So, for this particular element if you want to find out what is the detection limit we has the 8, n is equal to 8.

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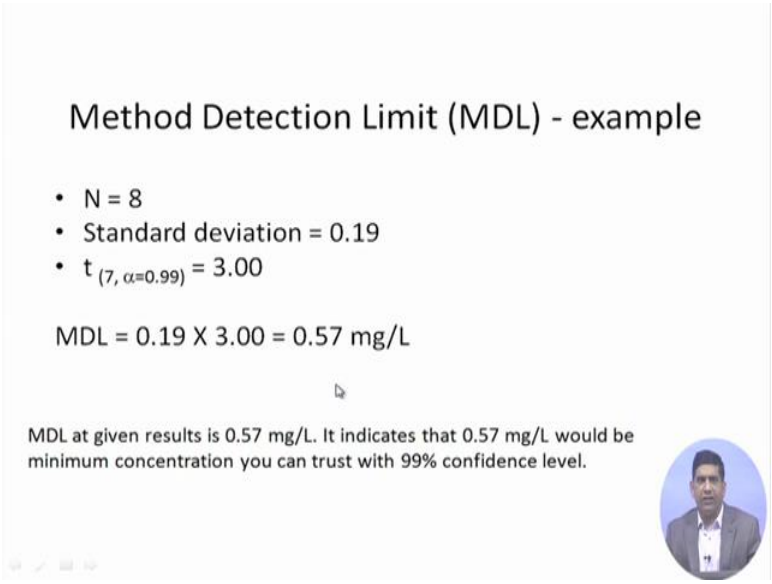

We can find out the standard deviation is for this data set you can use your calculator and find out the standard deviation s point one nine. So, we look at up in our like t table for n minus 1 with 7 and APLA is 99 the t value is 3. So, MDL is t value times a standard deviation which is 0.19. So, 0.57 milligram per litre, what does that mean is that MDL it indicate that 0.7 milligram per litre would be the minimum concentration you can trust with the 99 percent confidence. If the machine is giving you like a 0.5 values 0.4; 99 percent, 5.35; those values are not meant may not be trusted those values cannot be trusted. So, anything below 0.99 percent, 57; 99 percent; we really cannot trust that number anything closer to 5.7 also we need to little bit careful into dealing with those number.

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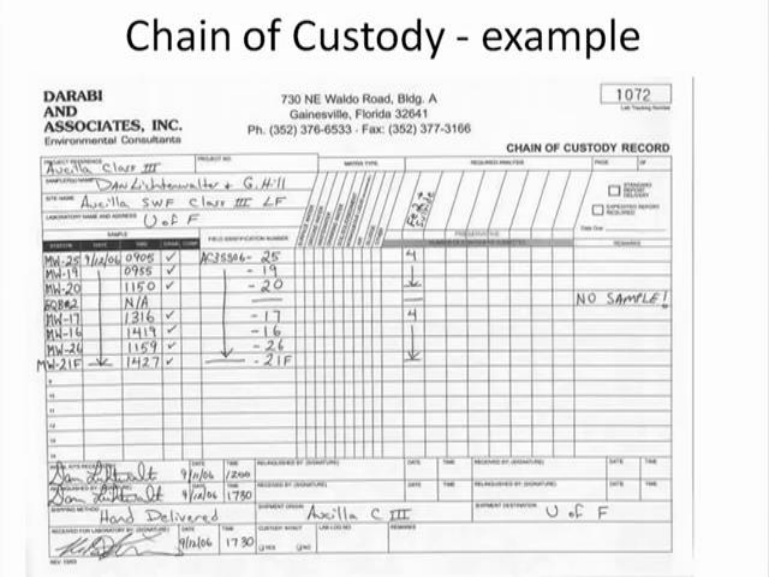

This is an example of chain of custody like the form that you typically use when the sample is collected from a lab and taken to a selected from a field and taken to a lab we need to have when the sample was collected who collected it, what was the some field parameters can be mentioned and what kind of analysis needs to be done.

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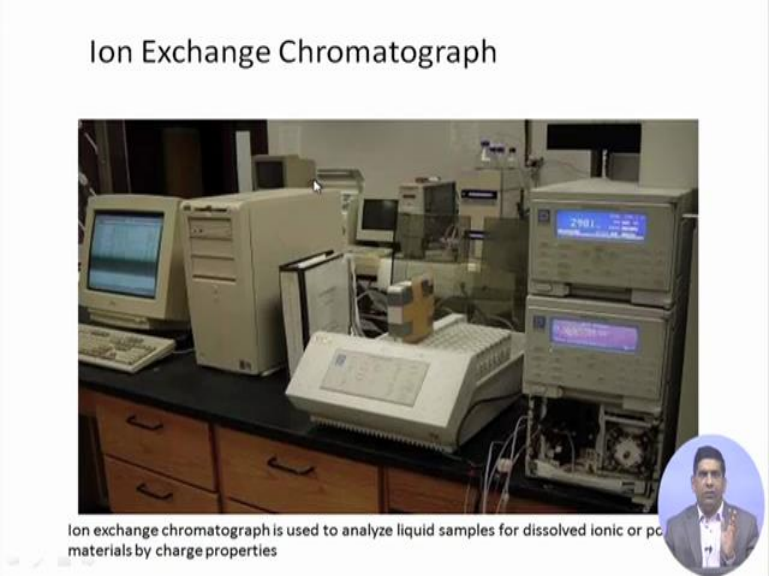

So, that just an example of that stuff; let us for this particular module let us stop here and then from in the next module we will look at some of the instrument that is used to generate the data.

So, if what we did in this module we talked about the importance of the data quality, we talked about how the data is generated, we look at the calibration curve, how the calibration curve concept works what are the different instruments are out there what are where they are and then the in terms of a spectrophotometer we talked about that how the absorbents reading works and then we also looked at in terms of the method detection limit how the detection limit is calculated and how it is used in terms of in terms of the analysis.

So, let us stop at this particular module and then will come back and look at the second module where we will look at those instrument which is used to generate the data I hope you are enjoying the videos so far and thank you very much and look forward to seeing you again.