**Electronic Waste Management – Issues and Challenges**

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**Lecture – 09**
**Environmental and Public Health Issues (Contd.)**

So let us get started from where we left in the previous video if you remember we were trying to talk about different ways of doing that those responses, those calculations that we were trying to do.

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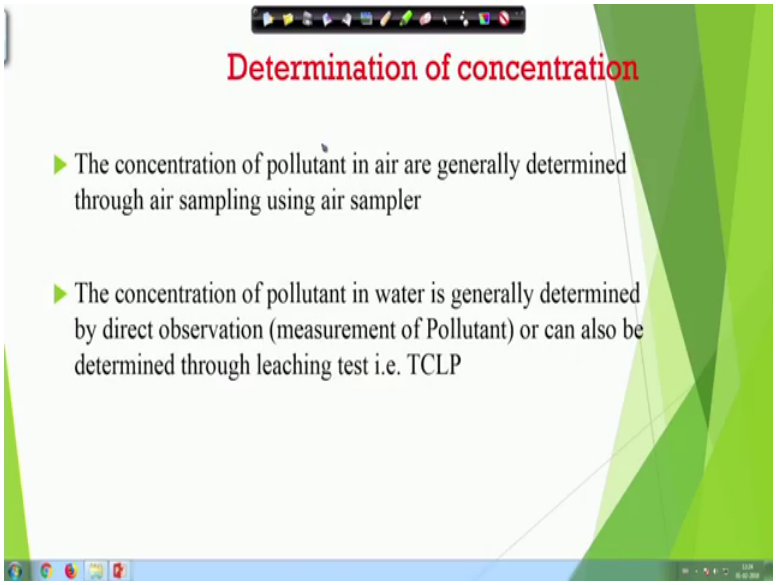


So, if you remember in terms of the calculation that we were looking at just to recap very quickly we were looking at the potential in factory for carcinogen chronic daily intakes.

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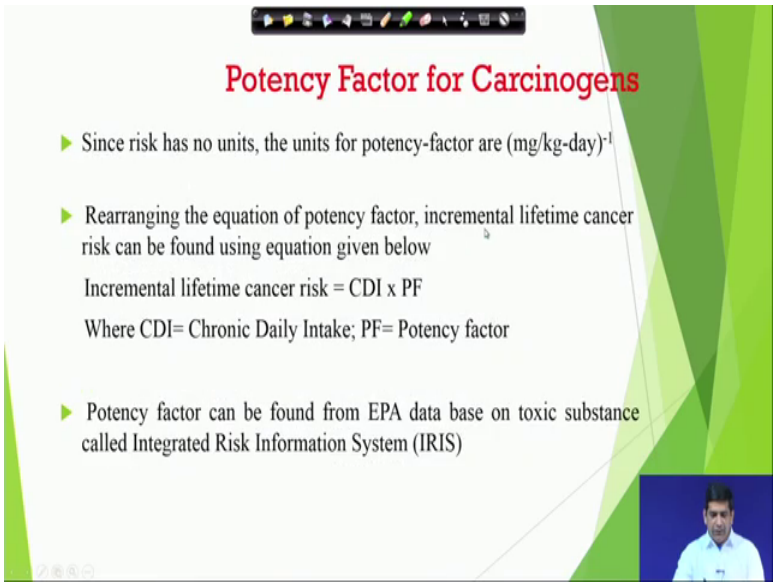


So, all these you see all these formulas all these values that will come for that we need to find out the concentration.

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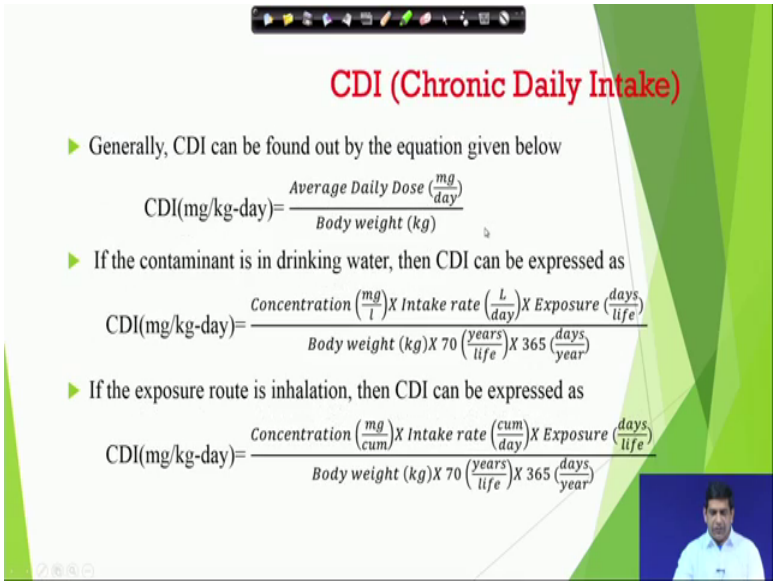


So, we need to know the concentration data then only you can use those formulas is not it you need to know what is there in that environmental sample and in terms of things coming from the what solid phase to liquid phase, we need to know the concentration which is present.

So, in this particular lecture we will try to talk about how we get those concentration if some of you have if you have taken either of my previous NPTEL courses there also we have talked about that. So, it could be a reputation, but again this is relevant for this course. So, we will talk about in terms of when how we get this environmental concentration and how we use the data.

So, let us start with this and then between depending on the time we can get to some other topic within this particular video. So, in terms of in terms of the determination of concentration usually for if it is an air sample what we will do we will we will do a air sampling using a air sample or we can find out how much is there, you always hear about particulate matter 2.5 pm 10 or sox or dogs how those data comes.

So, you always try to try to understand that first of all why we need that data and I think we have explained that good enough then how the data is collected that is very important to know, because if there is a something wrong with the data say tomorrow you become a in charge of a city where you are looking at the pollution for per one particular city or for a state or even from a country or global whatever. If you do not understand the data collection properly and then you cannot really pinpoint what could be the potential error in the data, because if you have the bad data you all those calculations that we did in the previous video will have the bad numbers.

So, to have a proper data collection is always needed. So, let us look at how they are done. So, in terms of the air pollution we generally determine using some sort of air samplers. So, we will have the air sampler at the site and the air sampler will get those air will pass through that and there is a mechanism will not worry too much about what mechanism is there that is the analytical chemistry people who will worry about that, but there is a mechanism through which with that said the data is extracted. So, when the say this is one sensor I am trying to pass air through that or if you if I pass through a air like let us keep it like this. So, I am passing an air from here and it will come out from this side.

So, while the air is passing through this particular many times we call them a column or some sort of filter and then I can separate those contaminant then I can have I may have a detector that when you I separate the contaminant it may react with the media present here, the with the reaction of the media is a sense take response will be generated and I

can measure that response and looking at the intensity of the response I can correlate that response with the concentration of that particular contaminant, just to explain you in a simple way it is a there are a lot. Of course, there is a lot of other things that goes in there and these things with this you have your computer you have your software. So, you can control many of things that is happening over you can even have the frequency of collection, you can set it up to a data logger where data can be directly transmitted to that particular data logger from data logger, you can use it you can even download it on your smartphone using an app.

So, a lot of things is possible and those things are being done in different places depending on how much money you want to spend and how much what is the severity of the situation.

So, concentration of pollutant we have to these are the ways like for the air pollution for the water what we are usually worried about is if things are in one of the one of the things that we worry about things coming to the water phase. If they if there is a contaminant in the solid phase if there is a contaminant which is present in the solid phase whether it will come to the water, in terms of the hazardous waste per scenario we try to determine using what is known as a TCLP test.

So, TCLP test is essentially is trying to find out if a hazardous waste when it is put in a landfill like municipal solid waste landfill condition, whether it will create with what does the amount of lead concentration which will come from the solid phase to the liquid phase and when it comes to the liquid phase in the event that there is a breakage in the liner, that leach it will percolate through the ground and can potentially contaminate the groundwater. So, that is that is in that is the scenario of TCLP.

But TCLP is we use TCLP protocol was developed earlier we do lot of other leaching tests today TCLP is just simulating what will happen in a landfill it does not simulate what will happen in a say outside it landfill environment when the rainwater is the it is the water which is in contact with this with the solid waste.

So, in that scenario we do other testing, but more or less nowadays for most of the batch testing procedure most not, all we use that the basic concept we use the same the leaching fluids keeps on changing. So, let us look at how this TCLP is done and then I will try to explain how the other tests differ from here and when we use what kind of

tests, to find out the concentration especially in the water phase when we are worried about things moving from electronic waste as a solid when it goes to the liquid phase.

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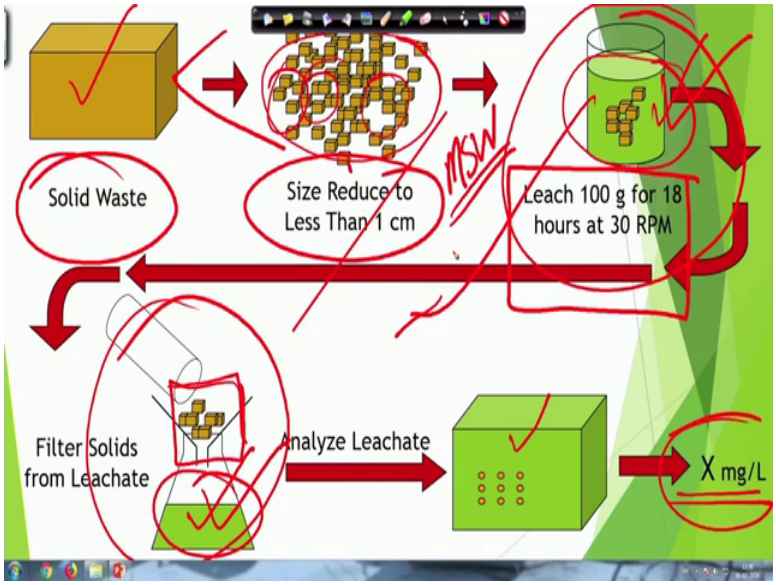


So, this is one example procedure in terms of how waste is like the leaching is done. So, you have a solid waste in the our case this will be electronic waste. So, here do you have a solid waste. So, this will be in our case it will be electronic waste. Now we have to size reduced to less than one centimeter. Now to reduce this is what is the protocol requires you have to reduce the size to less than one centimeter, but think about electronic waste you have a CPU. CPU has the steel, CPU has plastics, CPU has a lot of wires, CPU has printed wire board, motherboard, Ram all those different things are there.

Now, how will your size reduce it to less than one centimeter it is it is very very tedious job and if you reduce it to less than one centimeter there is always a argument that why we need to reduce it to length this and because that is will never happen in the environment. So, why this less than reduce reduction less than one centimeters is still there in any of these regulatory this is a regulatory test this is a test which is required as per regulation. So, why it is there the reason it is there enough of course, when it was made a waste was not there in the picture a waste is a recent phenomena this thing's was developed the TCLP test was developed in like early eighties late 70s early eighties.

So, at that time e waste was not there. So, they were not looking at e waste in terms of making this test, but since this is the regulatory test used for other waste it is also used

for electronic waste the stuff there is a challenges here challenge in terms of how to get the representative sample. So, as I said you have metals you have plastic you have casing you have pipes I am sorry, you have like a wires and then different types of wires, you have a motherboard your other component. So, when you have this whole thing together first of all how to take this 100 gram what is the basis of taking this 100 gram like whether if I take all this metals I do not include any of those circuit board will it will not be a representative sample, if I take those entire circuit board that also is not a representative sample.

So, we have to decide how to take a representative sample one approach for that is to do is take the weighted average. So, you what you do you take your CPU break it apart and then you weigh the different components and in the same proportion you take the waste to make a total waste of hundred grams. So, that is one way to do it now, but again as the regulation requires you to less than 1 centimeter.

So, you have to do it actually otherwise it is not a true TCLP, but then there are alternatives which we will talk about that you will see that we can go for even we do not have we can go for tests with which we essentially will be similar to TCLP test and maybe more realistic, but may not be, but does not have to be do the size reduction, but that is always a challenge, but why we do the size reduction of less than one centimeter the reason for that is to increase the surface area. So, as you can see there's a smaller pieces these are smaller pieces has a bit more if you add up all the surface area here that is actually greater than the surface area of this particular total hundred grams over there.

So, why surface area is important again more the surface area more the reaction better the reaction; that means, more leaching will takes place more contaminant can go from the solid phase to liquid phase remember these are the regulatory tests. So, regulatory test means you have to be you try to predict the worst case scenario, you are always trying to find out in the worst case scenario what can potentially happen. So, you are trying to be as conservative as possible in terms of predicting the potential environmental pollution coming from the disposal of this electronic waste or any waste for that matter.

So, once you have the size reduction of less than 1 centimeter you leach it for 100 grams I do not at 18 or 18 hours or 30 RPM. Now again why this leaching again we try what we are trying to do is we are in the in terms of as I said 30 RPM 30 revolutions per minute.

So, you are letting it tumble you are letting it tumble for thirty in a in a it is a basically it is a rotator. So, it keeps on rotating at 30 RPM.

So, why would do that to increase again the contact, we want maximum reaction to take place, we want whatever the things in the solid phase whatever could possibly come to the liquid phase, we want them to come to the liquid phase so, that we can have a more conservative estimate of potential environmental pollution.

So, once you have that then you filter filtering is done filtering where we are filtering solid with the leachate what we are interested in this part because this is even if it is there why if we are interested in the liquid phase the water concentration, what we are interested in what is whatever is present in this part and then we analyze the leachate and get the concern using some instruments and that a get a concentration of save certain milligrams per liter.

Now this concentration is important in terms of looking at what is the potential risk, what is the potential risk of having this electronic waste in a scenario where do we have this X milligram per liter of say lead, because lead is the one of the most common contaminant that we always encounter in terms of electronic waste.

So, we are always worried about like what is this lead concentration which will come out in the liquid phase and then it can contaminate the surface water or potentially groundwater and all that. So, this is how a typical leaching test is done now for the TCLP test, for the TCLP test what we do TCLP again what is the TCLP test it is caught toxicity, characteristic, leaching procedure.

When we do it where we do it to find out whether a solid waste is a hazardous waste or not there is a hazardous waste especially for a for the toxicity characteristic, there are other characteristics out there that that TCLP is not the only test for hazardous waste determination. There are a lot of other things that goes there in hazardous waste determination, but for the toxicity characteristic especially from the hobby metal and organics too, but most for my electronic waste point of view it is mostly the heavy metals that we are worried about and most number 1 is lead that we are worried about of course, we have cadmium arsenic and other things are also there, but in terms of the lead leach ability in the TCLP test what we are trying to predict is if we take this electronic waste and put it in a MSW landfill, which was the municipal solid waste landfill whether the

lead concentration or the contaminant concentration other contaminants as well whether those contaminant concentration that will come to the leachate is it is a high enough.

So, in case there is a breakage in the liner whether that will go and contaminate the groundwater. So, that is the whole rationale behind TCLP test which was explained in great detail in the solid waste class that we offered on NPTEL last semester. So, those videos are also available on public domain and on YouTube.

So, in case of this so once we have this concentration we can predict whether it is it potentially harmful or not. So, one thing I haven't explained to you yet if you go back and look at this particular is like a schematic one thing which I haven't explained into is in terms of here I said leach 100 grams for 18 hours at 30 RPM.

Now, when we say leach if you remember if you see the picture here we have a liquid now what is that liquid is it just a normal water or what kind of what kind of liquid we will use to simulate different conditions. TCLP test since it is to simulate the worst case scenario in a MSW landfill we are looking at an MSW landfill municipal solid waste landfill there we try to the liquid that we have here is essentially. So, like acetic acid. So, from this side let us see let us clean it up a little bit so we will have.

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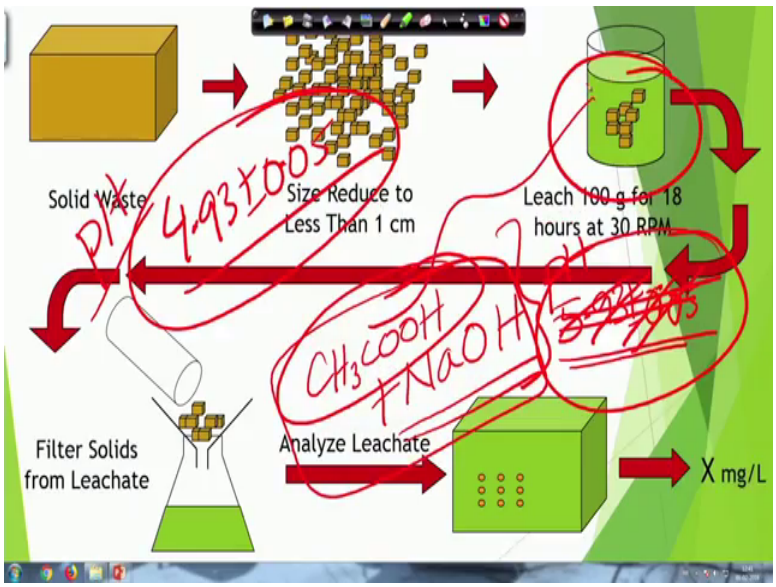

So, the liquid that is what we are using it over here is acetic acid CH 3 COH plus sodium hydroxide and it is a buffered solution with a PH of 5.9 3 plus minus 0.05 because it cannot have a exact PH. So, this is the PH value.

So, PH is around 5.9 3 plus minus 0.05 and it is a mixture of CSCO 3 plus sodium hydroxide. Now again why acetic acid, why acetic acid, because municipal solid waste landfill what we have municipal solid waste landfill mostly organic matter organic matter which would be non-organic is not really creating much difficulty there it is the organic matter. So, organic matter once it degrades will produce some acid and ultimate acid that is produced is the acetic acid. So, if you remember from any wastewater class that you have taken hydrolysis acidogenesis acetogenesis and then you have the methanogenesis.

So, acetogenesis produces you the acetic acid. Now the acetic acid is there in the municipal solid waste landfill that is what we are using acetic acid over here. So, just to simulate that condition, then why sodium hydroxide sodium hydroxide is added just to make it a buffered solution, now what is a buffered solution buffered solution; that means, is you have in buffered solution you are trying to have buffered means resistance to PH change. So, we want a PH of 5.9 3 oh sorry that is 4.9 3 sorry that is not 5.9 3 it is a 4.9 3 it is 4.9 3 plus minus 0.0 5 sorry for that. So, it is 4.9 3 see anybody can make mistake. So, do not feel bad if you make a mistake I always learn from mistakes.

So, it is 4.9 3 plus minus 0 5 that is the PH that we use. So, we what we are trying to do is sodium hydroxide is added to make it a buffered solution as you know. So, acidic acid is a weak acid it does not have much buffering capacity. So, that is why we add sodium hydroxide to have a buffered as it is a buffered solution at 4.9 3 PH you. So, that is the liquid that is used in here. Now if we want to use the same let us clean it up.

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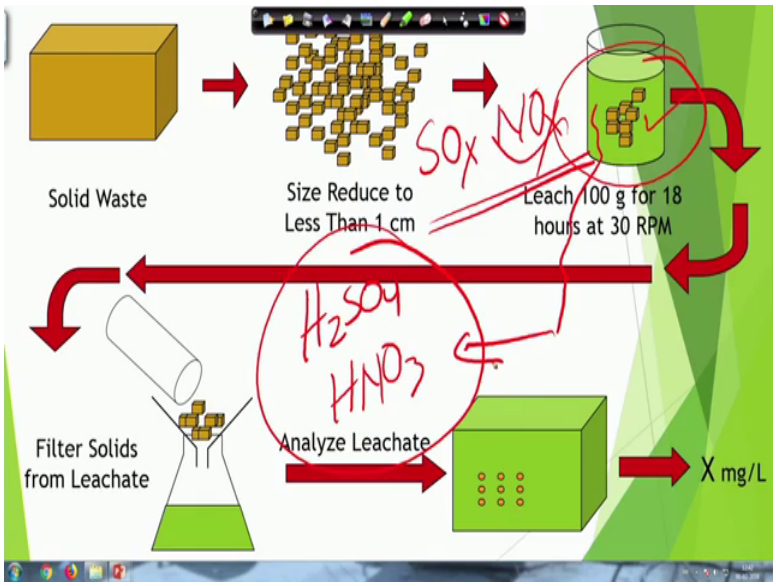


So, if you want to use similar procedures in some other tests if you want to use what will happen outside the landfill what then this liquid has to change, because acetic acid sodium hydroxide was for municipal solid waste landfill condition.

Now, if I am interested in to see what will happen with a natural rainfall. Now natural rainfall what is there if you think about natural rainfall just before we talked about the air pollution there I mentioned as well one of the things that we worried about from the natural rainfall is which can potentially come down with the rainfall is SOX and NOX. Now SOX and NOX means what sulfuric acid, nitric acid and they simulate acid rain condition that the acid rain condition if you want to simulate that is what you have.

So, in terms of acid rain condition what here the liquid that we will use to simulate those kind of is a diluted solution of sodium hydroxide H 2 so 4 and HNO 3. So, everything is there is a logic for everything again I keep on telling in my classes online offline all the time do not try to memorize try to understand, memorization we will forget the day your exam is over or what that, but if you try to understand it will be with you for a longer period of time and even if you forget something you can all once you come back and revisit it is quick to recovery collect, but memorization stuff does not is not really quick to recollect.

So, always try to understand the concept. So, that is more important. So, I think that is then we can have for other type of leaching. So, leaching conditions we can have other

liquids being used will not worry about that for right now, will as we if needed we will talk about that later in your when you try to understand something else you will see that too.

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So, difficult we are performing a TCLP is collecting a representative sample and size reduction as I said less than once intimate it is very difficult to do that. So, how what we do typically.

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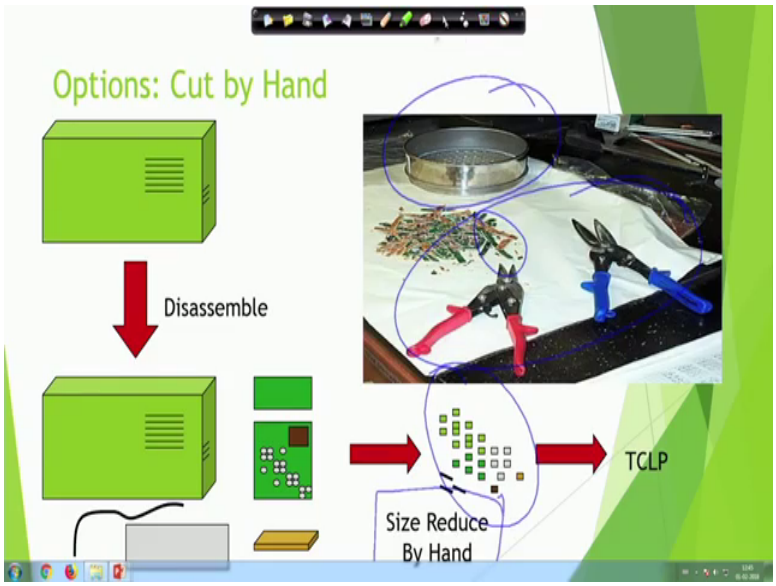

One option we try to do is we cut it by hand option 1 is you try to cut everything by hand it is. So, you have your CPU you disassemble and you have different components in here and. So, disassemble different components and then you try to size reduce my hand up sorry just a minute.

So, you have you are trying to size reduce using different types of like a precise reduce by hand which is not an ideal scenario, but you may have to do that use these tools to get that and here is your sieve if to make sure the size is less than 1 centimeter. So, it is. So, actually 1 1 dimension has to be less than 1 centimeter. So, that it can pass that sieve. So, that is not all the dimension has to be there. So, it basically you can make a long long strips of width is less than 1 centimeter, but thinking about that you may think that that is are you going crazy will this really happen in a natural scenario, we say if I put this E waste in the municipal solid waste landfill, whether it will really break it down to less than 1 centimeter that is typically will not happen, then the question is why you are even making me do that.

So, that they are trying to make you do that the regulation is trying to make it do that as I was trying to explain earlier as well to make it a worst case scenario. So, that we this is them this is the worst thing that can potentially happen 19 9.9 percent time probably it will not happen. So, then the discussion also comes at something which will not happen you know pretty much that it will not going to happen while you are because you are increasing the cost. So, why you are even doing this so, but since the regulation as I said when the TCLP tests were designed the us was not in picture this kind of waste is used for this kind of test is used for several industrial wastes like ash, contaminated soil and they already have a low particle sizes, but since now this is e waste and other stuff we may have to design a newer test, but until we have those tests we work with what is the existing test.

So, it does act as a screening tool, but it may not give you in a very good true picture which you will see as well that many times it does not do that, which we will talk about as we make progress.

So, that is one way of doing it and now that what is the other way of doing it you can grind it. So, you can put it in a grinder like this. So, you take your e waste and take it to a grinder, and then you grind it in here.

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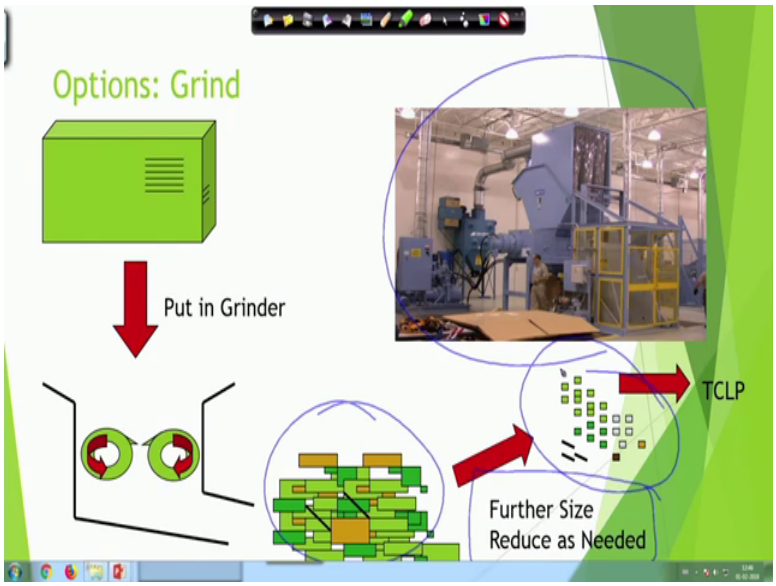


So, grinder will give you some some size reduction then you do the further size reduce by hand as we did in the previous slide and then you get here sample and you work with that sample in terms of the different leaching test. So, that is another option for us to try.

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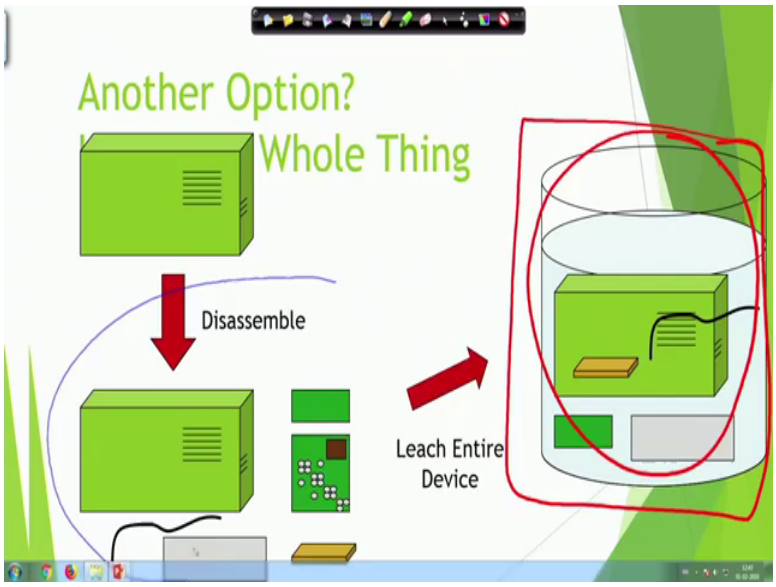


So, and what else we can do another option is we can drive we can let us bleach the whole thing because think about if when the electronic waste get disposed especially in a landfill setting, what will happen you have you have broken down the E waste it 1 compactor passes on top of that it may cross it a little bit, but other than this you do not

expect things to break down like metals plastics they will just stay there over time there will be some wear and tear, but you do not get less than less than 1 centimeter.

So, in that case one option is let us take let us just disassemble. So, you take the electronic waste and then just disassemble them you disassemble them up sorry you disassemble them and then you try to find out that concentration you try to try to get the concentration in here in terms of lube after you pass it through, but that in that case you need a much bigger vessel, you need a much bigger vessel than what is typically used for the TCLP test or these leaching test.

So, with that in mind that kind of gives you some idea of how the different types of leaching could potentially be done and why we are again why we are doing this leaching stuff to get the data, we have to collect the data to and that data will be useful in doing those cancer risk non cancer risk and all those calculations.

So, what I did is I just give you a very quick overview of how the data is collected and then let us try to look at once you have the data how will you try to make use of that. So, we have to look at what are the whether that contaminant is a carcinogen or non-carcinogen if it is a non-carcinogenic calculation is slightly different way, if it is a carcinogen the calculation is done in a safe different way the carcinogen will have to be more careful.

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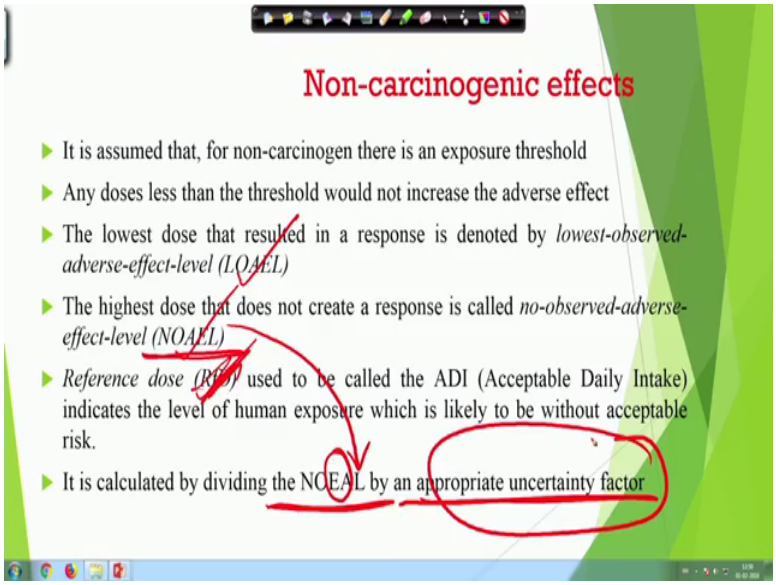

So, for the non-carcinogen effect we assume that there is the exposure of threshold. So, and what is an exposure threshold it is the amount it is the concentration above which you will is you start seeing adverse effect below which you do not see that. So, that is your assume that known carcinogen there is an as exposure threshold any toes less than threshold would not increase that adverse effect.

So, lowest dose is which is known as the lowest observed adverse effect level or we call it LOAEL, the highest dose that does not create a response is called no observed adverse effect which is called in NOAEL and then we can calculate reference dose called by acceptable daily intake we can find out that indicates a level of human exposure, which is likely to be without acceptable risk and you can you can take their noble values, which is a no observed adverse effect level and then there is a all typos here actually this should be NOAEL this needs to NOAEL which is no observed adverse effect levels. So, this is what needs to come here. So, ENA got switched. So, so for the non-carcinogen we take that noble value and then we have we used lot of uncertainty factor.

Now, why we use this uncertainty factor what is the what why we have to use this uncertainty factor the reason we have to use this uncertainty factor is since this data is always generated using Mais Guinea Pigs and the doses species and we are talking about humans. So, when you have these mice and guinea pigs that is being used as the species to get these numbers get these numbers we not in this one the other like no LOAEL and NOAEL and other values. So, we have to try to take that mice and rabbit data and extrapolate it to what could potentially be the human data and that is your in that case you apply certain uncertainty factor because you are moving from one species to another species. So, that is why you need to go those exercises.

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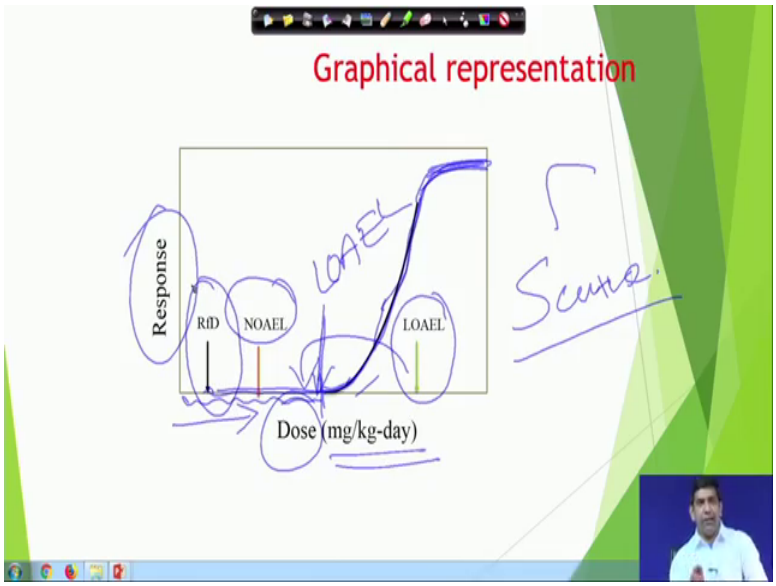


So, once you have that how we do that once you have the data what we do with that we plot this with what is known as the dose response curve. Now dose response curve is your you have a as you increase them. So, at a certain from here you are increasing of sorry just a minute. So, from here as you increasing the dose for one particular contaminant up to certain level there is no effect, because up to certain level say most of this contaminant whether you talk about chromium or arsenic or other stuff we do use them a little bit we do use them in terms of a dietary supplement and all that when they go at a higher concentration then only it becomes a problem.

So, how does the smaller concentration you do not see any effect at from here you start seeing some impact showing up and then you start looking at increase in the number. So, what you do is you will take the no observed of adverse effect level and this LOAEL is actually she needs to move to this side.

So, that should be on this side. So, that is your this is no up no effect here we start seeing effect. So, that needs to come just before this arrow that is where this LOAEL needs to come and then when it goes above that you start seeing increase in in the response and then ultimately what happens it kind of flats out.

So, it starts. So, if you keep you can start from it will you start from where I can S and then this is the on top like an S and the bottom S and the trace basically something like you have undo we I do not need to redraw that because it is right here. So, you have

these then you start seeing the effect and then after a certain concentration things get starts flattening out. So, that is a call a typical s curve that is the s curve for that dose response we call it a dose response curve.

So, that dose milligram per kilogram and the response could be the way we have measuring it. So, it is again just a quick what are the other things here. So, LOAEL will be here. So, after LOAEL you start seeing an increase in effect and then things get splat 2 out and we calculate this reference dose, which is actually much less than these values that we get. So, we are adding some uncertainty and then we are also adding some factor of safety there to get those RFD values. So, that probably explains that stuff and then we also talked about hazard index and Hazard Quotient.

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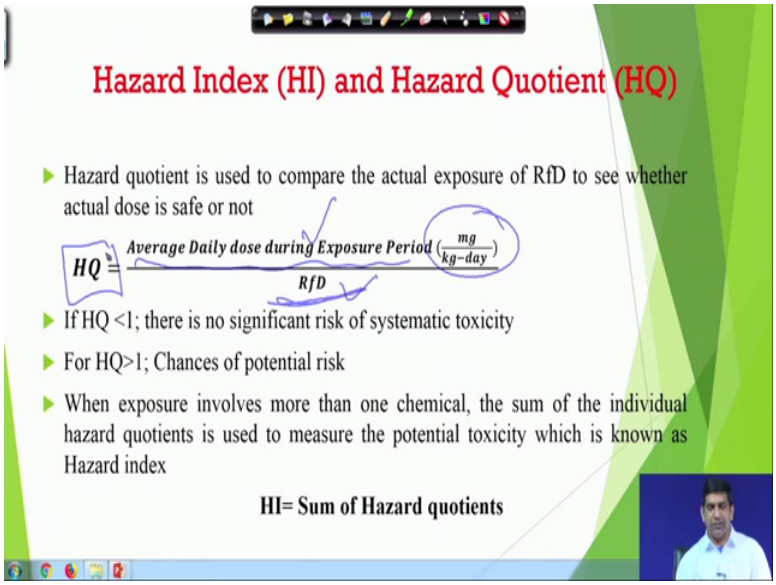


So, maybe we will start let us see yeah probably yet let us do this slide here and then we will close. So, that next we can talk about different concept.

So, in terms of the hazardous index and a hazardous quotient it is a terminology essentially, it is used to in the hazard quotient is used to compare the actual exposure of with the R f D to see whether the actual dose is safe or not. So, we will collect the data as I was trying to make I mentioned in the previous particular video, will collect their data will calculate the average daily dose will get the average daily dose during the exposure period we can get this data up from our collection and then we divided by R f D R f D

has been generated the over several years of research so, these R f D values now available for most of the common pertinent.

So, if average daily dose divided by R f D if that number is known as their HQ which is the hazard quotient. So, HQ is less than 1; that means, R f D is actually more daily dose is less. So, there is no significant risk of systemic toxicity, but if HQ is greater than 1 there are chances of potential risk.

So, if in that case is a chance of potential risk. So, when exposure involves more than one chemical the sum of the individual hazard question is used to measure the potential toxicity which is known as the hazardous index. So, we if he is more than one chemical is there we can put things together and then we can find out what it is a measure that ordinary potential toxicity which is also known as the hazard index.

So, HI is actually some of the hazard quotient. So, hazardous index is solve the hazard quotient and that is how we get these numbers. So, this is the important concept in terms of the hazard index and hazard quotient. So, with that let us stop in this particular video. So, this is the fourth video of the second week and then we have will have the last video coming up for this particular week and. So, this is again if you in this particular video what we try to learn we try to learn first of all in terms of the data quality, why the data is important, how it is going to how we are going to collect it different environmental sampling for that and then you look at the procedure in little bit in detail of, how we do it for the liquid to sample the concentration coming to the liquid phase from the solid phase different scenarios, how to get a representative sample and then we talked about this hazard index and hazard quotient.

So, with that let us stop now and in the next video we will continue this discussion, but with slightly different angle so a different angle in terms of the bio concentration bio magnification and all that. So, again thank you very much do take the quiz and I may I would encourage you to take the exam it is up to you of course, it is up to you have to register for the exam the information probably you before given to you or maybe already been provided. So, enjoy the course any question send us an feedback send us an email I am sorry send us a question on the discussion forum and we will respond to you again.

Thank you.