Electronic Waste Management - Issues and Challenges

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Lecture – 10
Environmental and Public Health Issues (Contd.)

So, welcome back. So, this would be the last module for the second week. So, we will continue our discussion in terms of those data collection and all that and one of the major thing in this particular module is we will try to solve some problems is not it I many of you might be engineers or even science people we always like numbers.

So, we like numbers we use numbers. So, let us all the stuff that we said we will have to collect this number and we have to collect that number, but how those numbers are relevant. So, we will talk about some of will I will give you some math problem I will solve a I think 1 or 2 problem on this video walk you through the solution, but then I give you some questions and I also tell you how to solve it and we will go over that and then my encouragement to you will be to go and solve it by yourself we can we will see if we cannot we will try to provide the solution not right now after the fourth week.

But I right now I want you to I will post it as a PDF on the website, but right now you have I would encourage you to practice those problems by yourself, because unless you do it what happens these days if I give the solutions to the students they just try to memorize the solution those of you who are taking planning to take the exam the and then memorization is not going to help you need to understand, it that is why I want you to solve it first and then if you are not able to solve it ask question to us on discussion forum we will be more than happy to give you some hint try to give you some directions on how to solve it if you are confused in doing that which we are more than happy to do that.

So, let us start with some this is a concept again we which we use in terms of risk assessment and all that it is a bio concentration.

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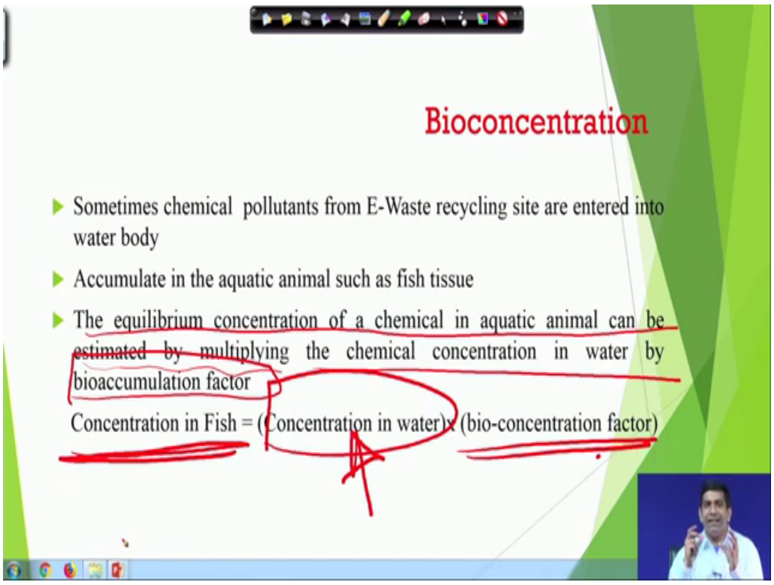

Now what is the Bio concentration? We talked about just before that how the concentration will be measured in the water phase now. So, many of these chemicals from the electronic waste especially say if you have the mercury, in the methyl mercury phase, some of these organics chemical which is present they have a tendency to accumulate in the aquatic animal such as fish tissue.

Now, when say a chemical has those kind of kind of property to accumulate, they have to be lipophilic you may have heard the term hydrophobic hydrophilic phobic means what phobia phobia means they are afraid. So, hydrophobic means what something, which is afraid of water something, which is afraid of water relates means what, something which is afraid of water means it will not be soluble in water, if something which is soluble in water is having trying to have party with water like really they love water that it say a hydrophilic. Because it is a it has the affection for water and it will be soluble in water, but hydrophobic will be not soluble in water.

So, that is what the water part and that is also important here when we are trying to talk about bio concentration, we are talking about very same concept, but here we are we are looking at lipophilic and Lippo phobic. Now what is that what is lip lipii like lipophilic what does that mean it is phobia for lipids the fats in the body and affinity for the fats in the body? Now if contaminant if it has a affinity for fats in the body it will go and accumulate in the bodies and it will go into our fat and then try to be accumulated over there if it is phobic it will not accumulate.

So, it will just go through the system it can come out in the fecal matter will come out in the urine and all that it will not accumulate. So, at the effect the adverse effect will be much less, is something which is lipophilic will accumulate and then it will try to react with all those our internal stuff which I do not know much about it is a medical science, but that is how there was the accumulate they start creating trouble for different organs in the body.

So, this is a so in terms of how much I up to what level it will accumulate. So, we do calculates many times we have this equilibrium concentration of a chemical we try to have this equilibrium concentration of a chemical in the aquatic animal or aquatic species we can estimate, by multiplying the chemical concentration by a bio accumulation factor like what is that bioaccumulation factor for those particular for that particular organic chemical.

So, for example, like if you want to know concentration in fish for a particular contaminant you know the concentration in water and then you multiply by bio concentration factor. So, you take the average concentration in water multiplied by the bio concentration factor that gives you an idea of what could be potentially the concentration in fish. Now from the concentration in fish if you and I consume that fish I am right now like you are you are watching this video which have been recorded at IIT Kharagpur; Kharagpur, West Bengal people love fish here so as from Kerala and several other parts of India and of course, Abroad.

So, if things get this bio accumulated in fish people who love fish people who eat fish will get exposed to that and that is true for other food item still. So, that is how we can get potentially exposed. So, we do calculate we that is a the bio concentration or this concept of bioaccumulation is a very important concept in terms of looking at the environmental risk and human health risk from electronic waste essentially the chemicals in the electronic waste which is a problematic.

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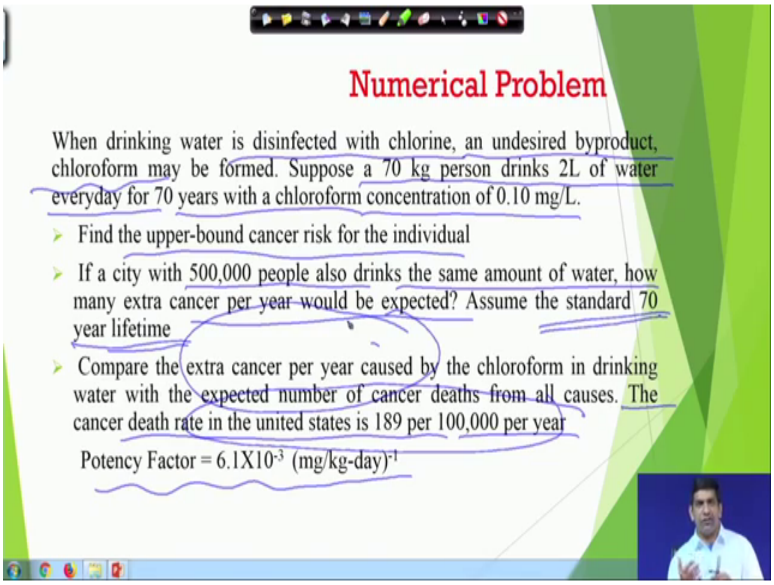

So, let us look at some of the drinking some of the examples will let us try to solve the example here. Now as you can so there is a simple example say if you have a drinking water, which is a disinfected with chlorine this is we use chlorine, if you have taken water treatment class you know that chlorine is used as one of the disinfectant then we do have we also leave some residual chlorine, but what are the problem with when we add chlorine is it produces an undesired by product which is a chloroform many of these you may have heard the term disinfection by product.

So, disinfection by product which is a term used for this kind of product so when it is dis disinfected with chlorine we get it by a product chloroform and say now if there is a chloroform is there in the water we are consuming that chloroform. So, chloroform will have certain adverse effect to our human body.

So, not taking a scenario that suppose a 70 kg person drinks 2 liters of water per day for 70 years and which has a chloroform concentration of 0.1 milligrams per liter because he has been taking that water from a drinking water plan, the drinking water plant was to have a disinfection with chlorine and of course, these days we are actually trying to not to have chlorine and go for UV and other stuff, but if they have a chlorine and you have this chloroform can being formed average concentration of chloroform over that 70 year period is say 0.1 milligrams per liter. So, with that data we have to find the upper bound cancer risk for this individual as chloroform is a carcinogen and if the city has 500,000 people, they drinks the same amount of water how many extra cancer per year you can expect assume this standard is we have 70 year lifetime as a standard and then if you compare the extra cancer per year caused by the chloroform in drinking water with the expected number of cancer death from all causes the cancer death rate in for example, in the us has 189 per 100, 000 per year.

So, we have a potency factor has also given to us for that. So, we have been given what is the total cancer death that is happening in that particular country and then if you look at the extra cancer that is done from this chloroform we can put these things in a little bit in perspective.

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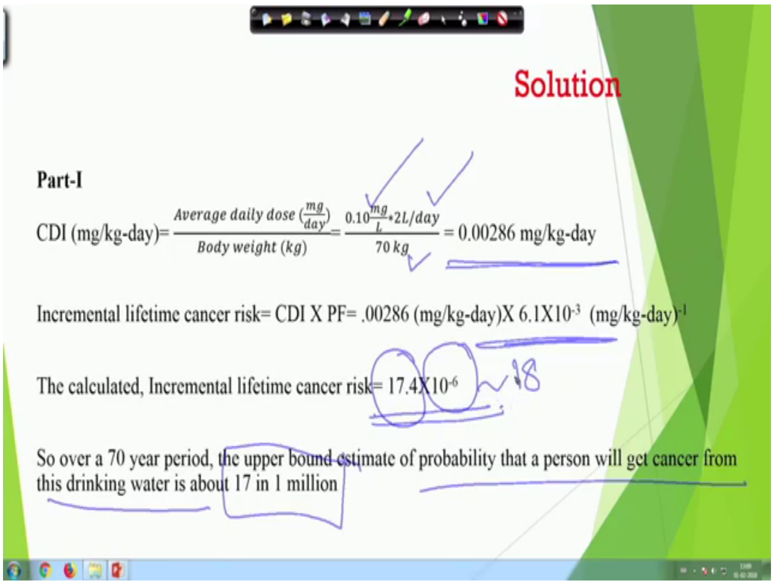

So, with that particular data now if we try to approach the problem and so first of all we will try to see that CDI calculation that we did earlier that is where which was average daily dose divided by the body weight. So, it is you can find out. So, that is average daily dose divided by the body weight it was 0.1 milligram per liter was the concentration. So, we are working on part 1.

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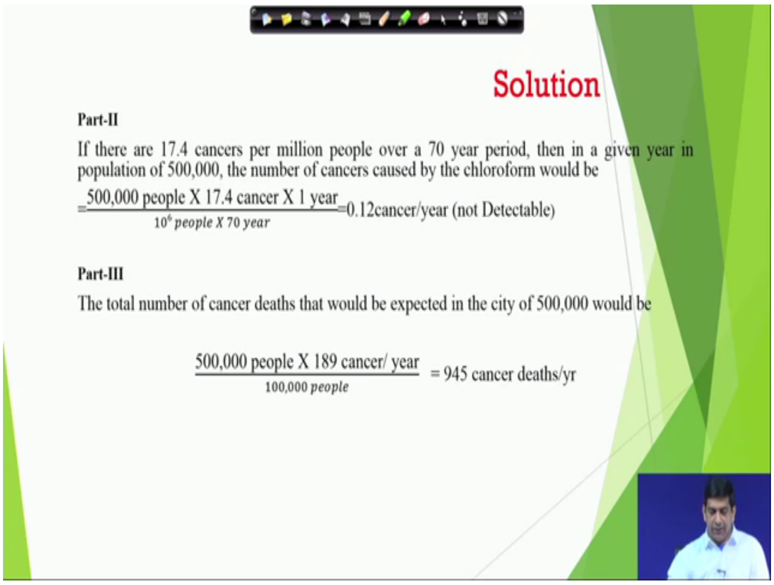

So, 0.1 milligram per liter was the concentration 2 liters per day divided by 70 kg. So, that if look at this number you have liter will cancel out. So, you have milligram per kilogram per day. So, that is your average so milligram per kilogram per day. So, that is what you will see in terms of. So, we haves units seem to be. So, we got this number 0.00286 milligram per kilogram per day.

Now, if you take the CDI multi and the multiplied by the potency factor which was given to us 6.1 times 10 to the power of minus 3, we can multiply the CDI which is 0.00286 with that and then we get total lifetime cancel risk as 17.4 times 10 to the power of minus 6. So, that is how we can calculate the total lifetime cancer risk which is there. So, over a 70 80 year period so, in a 70 year period the upper bound estimate upper. So, probability that a person will get cancer from this drinking water is about 17 in 1 million, because 10 to the power of minus 6 is 1 in a million 10 to the power of 6 is a million. So, 10 to the power of minus 6 would be 1 in a million. So, out of so nearly we are talking about 17.4 people or 7 or 18 people, nearly 17.4 or 18 people which will have which can potentially get cancer by drinking this water over the 70 year period. So, that is the that is the like a how we can do this calculation. So, that is the part 1 now part 2 there is a 100 and 17.4 cancer per million people, for a 17 year period that I was told to us then in a given year have a population of 500, 000.

So, for a million people we have 17.4 cancers. So, 500, 000 people we are talking about 0.12 cancer per year. So, it is not too much it is not detectable. So, this infection will create cancer probably not because of the calculation that we just saw. So, total in terms of the total number of cancer death that is expected in the city of 500, 000 we have been given 189 cancer per year, 500, 000 people and then out of then it is we have a 100 100, 000 people if you remember let us look at that problem in a minute just to see the data.

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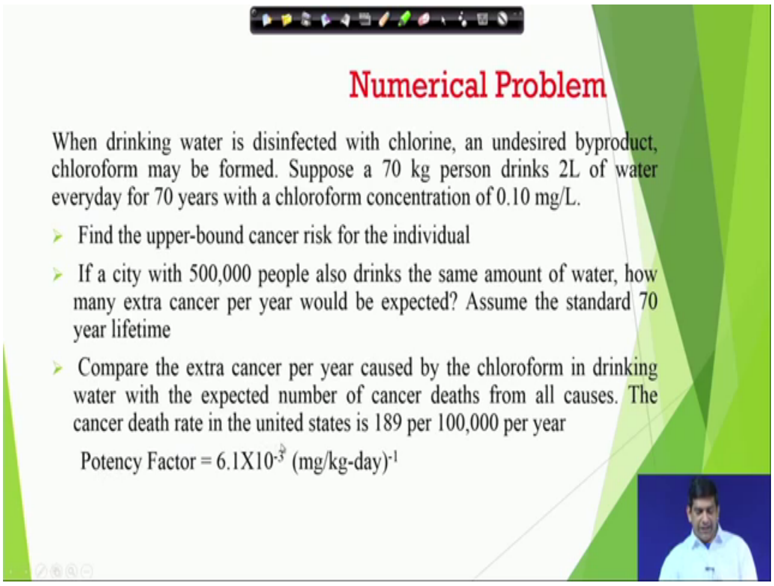

So, we had I compared the extra cancer per year caused by chloroform in drinking water with the expected number of cancer death from all causes, the cancer death rate in united states is 1 to 89 per 1000, but the 100,000 per year. So, that is why we have that.

So, we have 189 cancer per year out of 100 and 1000 people. So, if you do this calculation you get around 945 cancer deaths per year. So, this much amount of cancer deaths you can expect when you have a population of around 500, 000. So, nearly less certainly less than thousand people will be dying from that particular cancer.

So, this is how we can we can calculate these numbers. So, this is we had the 3 parts in this problem. So, 1 by 1 we can calculate these numbers and this this gives us. So, now, we know that yes the potentially 945 death can happen. So, in in that case how to manage now. So, they will talk about we will have to do some risk management in terms of the managing this well as so that we can reduce this fatality to in terms of how much people potentially you can die from that.

So, now in terms of like in terms of some other problem like I have I think we have 3 problems here which has been listed for you to solve, what I will do in this 3 problem is I will just tell you how to solve it and then when is you are doing it in discussion forum on the discussion forum will try to put you give you this answer not the solutions.

Solutions just before your exam or towards the end of the course we will try we will we can upload the solution of this, but I want you to practice that is why I am not going to give you the solution. So, I right now. So, say there are 3 problems let us look at 1 by 1 just give you I will give you a quick overview. So, that if we can you can get the clarification on say how basically I will try to highlight the things which I think may confuse you and just try to give some clarity on that, but if you have again any questions put it on the discussion forum we will answer that. So, you have just taken a job. So, this is a problem number 1 which I want you to work on you have taken a job add a metal plating plan and some of the metals you work with contain arsenic as impurity.

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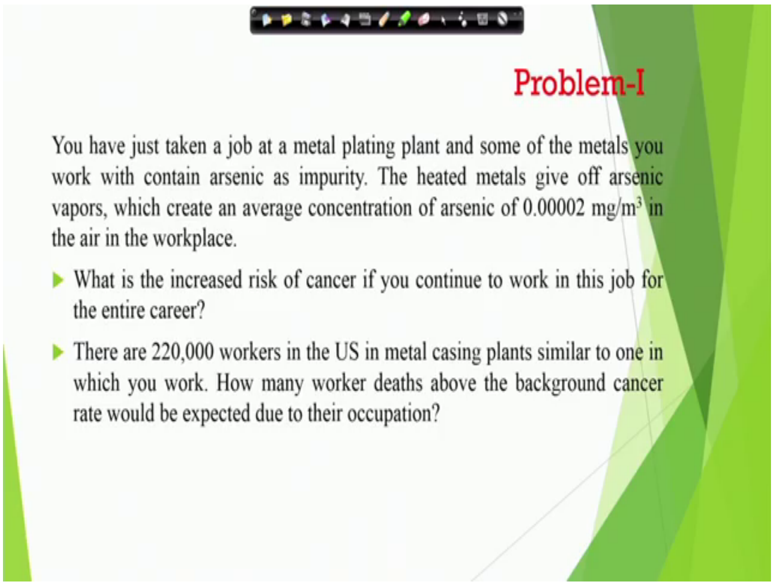

So, not directly arsenic, but some of the heavy metals that you are working with it does pretty has arsenic in them. So, when you heat those metals it gives off arsenic vapor which creates an average concentration of arsenic as 0.00002 milligram per meter cube in the air in the workplace. So, it is more like a occupational health and safety question what is the increased risk of cancer if you continue to work in this job for the entire career say there are 200 and 20 000 workers in the us in metal casing plant similar to 1 in which you would work how many worker deaths above the ground above the background cancer rate would be expected due to their occupation.

So, if you have an average concentration and there in the workplace you wanted to have increased risk of like whether there will be an increased risk of cancer or not. So, it is say what is the they we have you need to calculate that if you work for the entire career. So, you can take maybe 35 years or forty years I would say 35 would be a good age good time period to take for any job because somebody getting a job of saying on been on 25 years people retired at 60. So, we are looking at around 35 years and then we also looking at. So, from 200 20 000 workers how many worker death wave of the background and we can use the similar approach as we used in the previous example. So, I wanted to do that. So, what we find out the increased risk and the in terms of the people like what is your would like to have how you we want to calculate that. So, I want (Refer Time: 15:19) to this problem.

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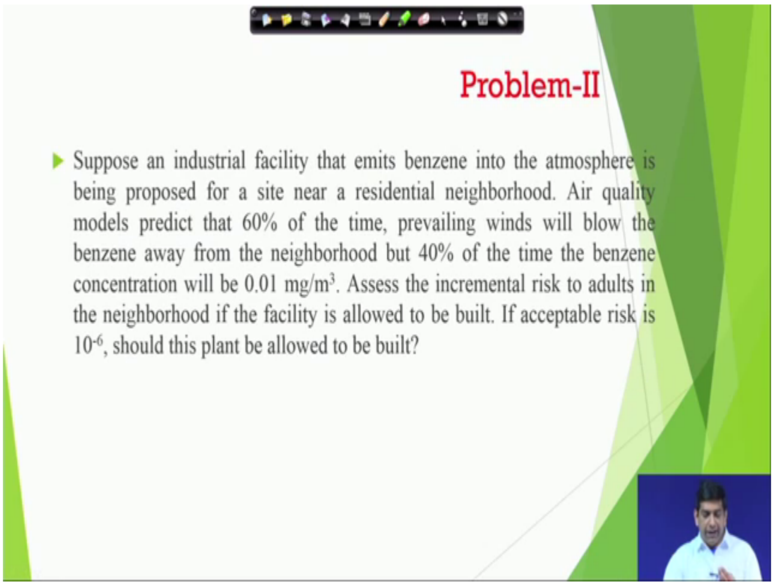

And then the second one is you have the suppose an industrial facility it emit it is benzene into the atmosphere he is being he is being proposed for a site near a residential neighborhood air quality model produces that 60 percent of the time, prevailing wind will blow the benzene away from the neighborhood, but 40 percent of the time the benzene concentration will be 0.01 milligram per meter cube.

Now, here although it is residential neighborhood we are saying that 60 percent of the time benzene concentration will not be high, it is only 40 percent of the time and it will high, that has to be reflected in our calculation when we are trying to do that calculation in terms of the impact. So, that has to be reflected. So, it is only the 40 percent of the time which is of concerned. So, what we need to assess is the environmental risk incremental risk to adults in the neighborhood the facility is allowed to build and if acceptable risk is 1 in a million should this plan be allowed to build that is we want to hear from you in terms of. So, you can put on your discussion forum let us have a discussion there in terms of whether we should we have a X there is a and let us see what different people from this class thinks about it.

And then we can like as I said every 24 hours we will try to some we will try to respond back to you we will definitely respond back to you we can respond earlier as well, but every 20 within 24 hours it is our goal to respond back to you on any query you have on discussion forum. So, here again like we can have these things going on as I say in a thread and then I can come back I can re look at every 20 hours and give my feedback on what are the different comments that have been made on that.

So, that would be interesting it would be like a 2 way conversation rather you just listening to my videos, but I need to listen your voice too when I say voice it does not have to be literally voice it can be even what your thoughts are what is your thought process for this course see we are now approaching the end of second week. So, you need to kind of let us know that whether the course you are enjoying what are the I hope you are enjoying, but if you is there is any feedback constructive feedback which can help us improve it a little bit as always welcome. So, please do that. So, in terms of this second problem what we have to calculate is say we have based on this incremental risk which is I am going to have into there like a neighborhood is it acceptable is it which other we should allow this plant to be built. So, what is what is your thought based on the data. So, you need to first collect the data and try to find out whether it is a higher than whether it is a whether is R f D value or slow factor and how it compares with the slow factor and RfD is it increasing higher concentration than that or lower concentration in that. So, those things you need to do the calculations and then you will have you will know whether it is an acceptable risk or not.

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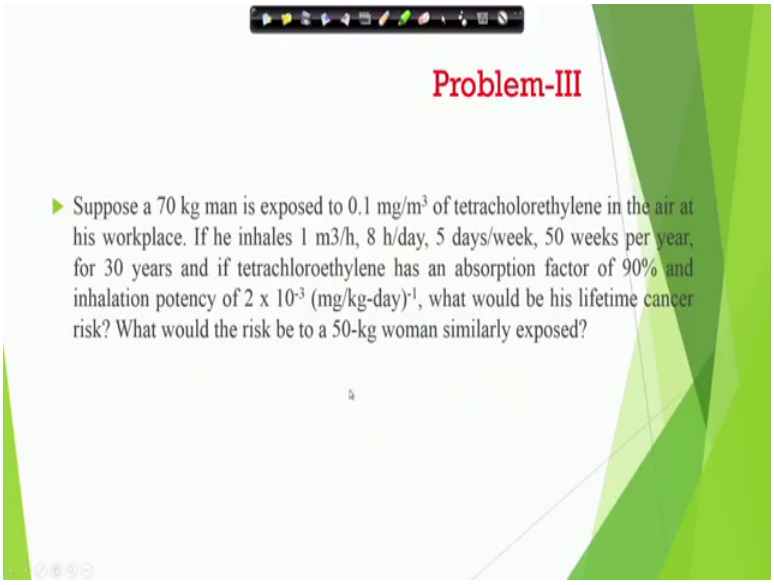

So, the third process so that is gives you that example of first 2 problems in the third problem if again it is a 70 kg man exposed to point one milligram per meter cube of tetrachloroethylene which is TCE and the it is getting exposed at his workplace if he inhales 1 meter cube per hour 8 hour a day 5 days a week 50 weeks per year and 30 years and if tetrachloroethylene has an absorption factor of 90 percent and the inhalation potency of this 2 times 10 to the power of minus 3, what would be his lifetime cancer risk and what the risk had been had a 50 kg woman was similarly exposed. So, rather than 70 kg men it is a 50 kg woman.

So, again most of these calculation how it needs to be done we have already done things in the example calculation that I just showed you or the other 2 which I was trying to explain. So, it is if you in well if somebody inhales 1 meter cube per hour 8 hours a day 5 days a week with this much of in terms of absorption factor 90 percent inhalation potency is given. So, we should be able to calculate based on the example that that was provided earlier you should be able to calculate what would be the risk to a 50 kg woman or what would be the lifetime cancer risk for a 70 kg men.

So, in both the cases we should be able to find out. So, I will not I did not give you like a step by step solution for this problem that is on purpose I want you to solve it the previous theory and the solid examples that we showed is good enough for you to do this solution this problem solve solving, but again if you get stuck with something feel free to put it on discussion board say that what is what is the problem what is exactly you are having a problem. If needed we can respond back on discussion board if as early as possible, if needed we will try to have some extra kind of tidbits of a like a small video or something up there as well. So, do not worry, but do try this do try this and try to make good use of this problem.

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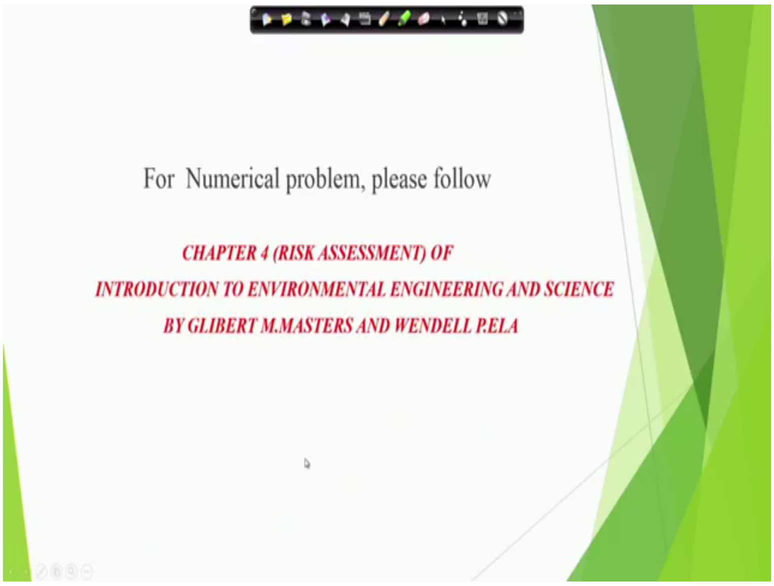

And 1 place where you can find some of the information now if you are for this numerical problems chapter 4 which is the risk assessment chapter of the Glibert masters book, Glibert masters and Wendell Ela introduction to environmental engineering and science. So, that the particular book does have similar problems there. So, you and then they had will have some exercises on the problems as well.

So, I would encourage you to look at that if possible it is a I guess it is available and it will be available in the central library and of course, prob possibly in your other libraries in your campus or wherever you are. So, in that look at the chapter 4 which is a risk assessment chapter of this particular book and that will help you in terms of trying to understand some of this concept which we try to explain, but if just in case it will not clear it will help you to make it more clear from there.

So, that kind of brings the end to that, but that kind of discussion that we were having in terms of looking at the fate another stuff fate and transport that kind of gives us kind of closer to that, and then now what we want to get into is looking at how to recover these metals. That is another big area in electronic waste right now we are producing lots of electronic waste.

In fact, the developing country India china they are going to prevail they have already surpassed the developed country. So, total E waste produced in the developing country is more than the total E waste produced in the developed country because most of the developing country has higher population as well. So, say in that way it is it helped it we kind of we have looking at the electronic waste we are looking at the potential environmental harm and all that, but one of the thing about any waste is waste is a resource I told you waste is a misplaced resource.

So, if we can and many of these electronics they have lots of heavy metals which can should be potentially recovered. So, in this case we are trying to see like in this particular lecture we will try to continuation of course, we are now it is in this particular lecture we will try to look at in terms of how we can do the recovery of metals what are the things that is needed for recovery of metals for electronic waste. So, let us get started on this particular topic.

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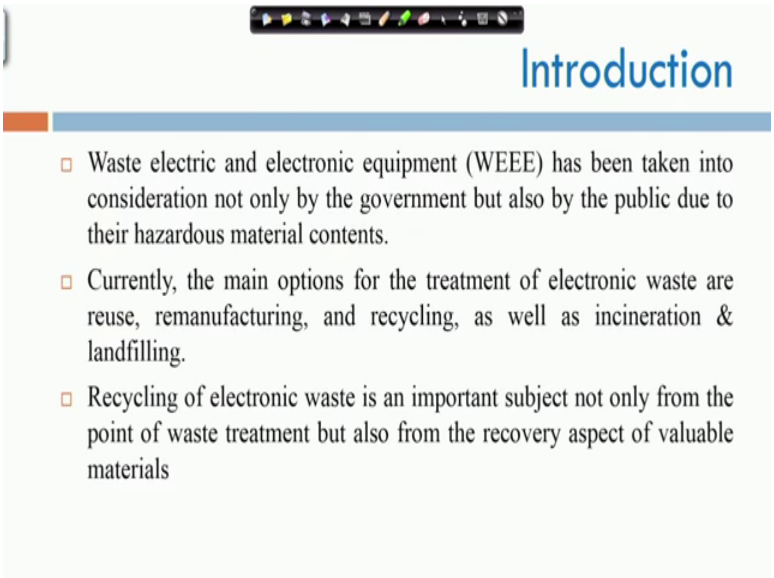

So, again in terms of the introduction we know that we which is wastes electric electronic equipment has been taken into consideration not only by government, but also by public due to their hazardous material contents, currently the main opposition for treatment of electronic waste are reuse remanufacturing and recycling as well as incineration and landfill.

So, recycle of in power E waste is an important subject not only from the point of view of waste treatment, but also from the recovery aspect of valuable material. So, because there are certain rare earth metals which are rare. So, it is very difficult to get them and only like a 1 or 2 country in the world where you can get those 4. So, question is can we recover those material rather than going back to the mining side trying to mind 1 more set of stuff can we recover these material and use it. So, that is cons that is thought Process is also there.

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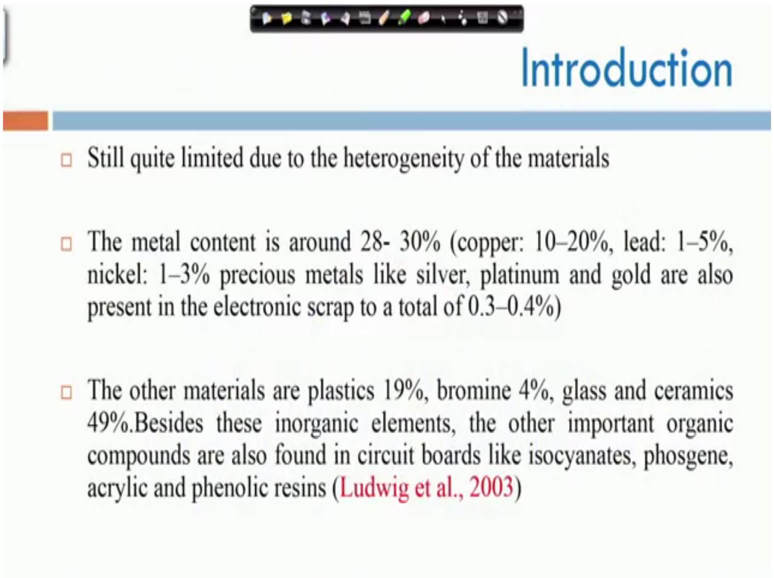

And it is what is the present situation it is still a little bit of limited due to the heterogeneity of the material, if you look at the metal content it is nearly 28 to 30 percent out of that you have 10 to 20 percent 10 to 20 percent is copper. So, we can that is why some of the initial work initially 1 of the prof 1 of the metallurgy professor on our campus also he focuses on recovery of copper. So, it is a can we recover copper then lead is around 1 to 5 percent earlier it used to be more as I showed you some pictures earlier in the earlier video, but nowadays lead is around 1 to 5 percent in the newer electronics we have nickel round 1 to 3 percent then we have precious metal like silver platinum and gold which is around 0.3 to 0.4 percent, but if you think about the huge amount of electronic waste even at 0.3 at 4 percent these precious metals are really available you can get lot of let us say precious metals out from these electronics and that that could be a good value proposition in terms of the business here.

So, one thing we need to be we need to worried the think about that when we talk about this E recovery of electron recovery of rare earth metals it has to be economically feasible economically sustainable. So, for that you need to have a certain critical mass and the and of course, technology. So, that we can recover this gold platinum silver and other and then we can sell it to make money that is how it will run for a longer period of time.

So, but these are the common metal like copper is number one then we have lead we have nickel and then of course, silver platinum and gold which is you hear a lot about in especially gold you hear a lot. Other materials which is their which a plastic bromine is there glass and ceramics which is 49 percent beside this we have some electronic inorganic elements, some other organic compounds are there in circuit boards like isocyanides phosgene acrylic and phenolic resins and all that. So, those are also present over there.

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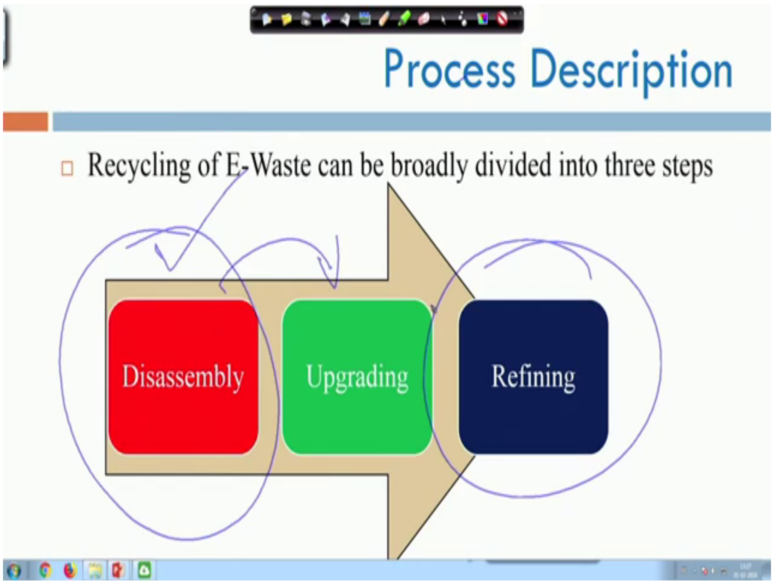

So, in terms of the recycling let us look at the big picture recycling in this particular and then we will go into nitty gritty detail in in the next video which will be the video of week 3 the we first video right now we are in the week 2 last video. So, if you look at the recycling E waste that is the essentially this is what is happening we you have you can do disassemble and in India although a lot of formal recyclers are coming up, but unfortunately the way the system is working right now because of implementation issues and that is what we have been talking many times even when I go to certain meetings ministry meetings as well. We have very good rules probably one of the best rules in the world we have the technology know how I am talking about in general not only E- waste E- waste municipal solid waste. So, or any of this plastic waste biomedical waste for all these waste stream we do have the rules are is good enough in terms of environmental teeth may not be in from an implementation point of view of course, we can debate whether it is say implementable or not whether we do not have the infrastructure to support it.

So, and then sometimes it is implementable sometimes it is not, but we can it is a case specific there cannot be a blanket statement there so, but in terms of E waste specifically for E waste the most of the E waste collection and management in developing country including in India is still being done by informal sector. So, the informal sector is what is that they are getting the electronics they are trying to dismantle they are trying to get the material out. So, what they do is the disassembly is done by it by every any whether it is a formal informal disassembly is done once it is disassembled some companies what they have is they have they try to say if one particular unit may be bad in that particular computer, but you get several other computer.

So, between you can other like 2 3 other computers you can salvage enough components to make it a brand new computer and. So, it is not brand new it is a refurbished computer you make a refurnished computer and then if you want you may want to sell it to. So, that is that is it is done. So, disassembly is done then you may have to do you can do some upgrading as well you can do the refining, but ultimately what we are trying to do the disassemble then you try to like a put the metals and other stuff in that particular market then your circuit board which is the core that you try to refine. So, you try to use the circuit board to refine and basically it is a refinery. So, it would be an E waste refinery and then you try to get the material out from there.

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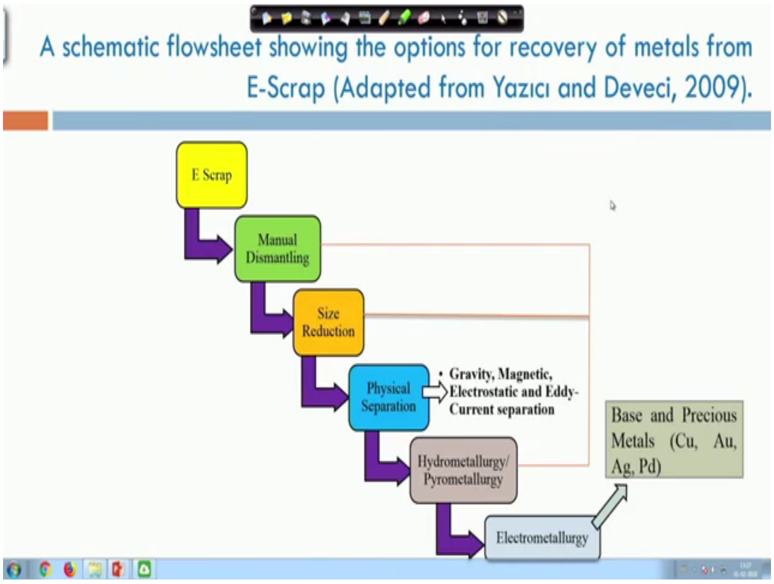

So, a flowchart how the material is option for recovery of metals so, it starts from E scrap then you do the manual dismantling there is a size reduction then you it could be a physical separation hydro metallurgical and pyro metallurgical stuff or electrometallurgical stuff, to get the base in places metal like copper gold silver and palladium and all that.

So, this is a typical schematic for options for recovery of metals from the E scrap. So, this is how typically it works and. So, in terms of let us say I think stop here.

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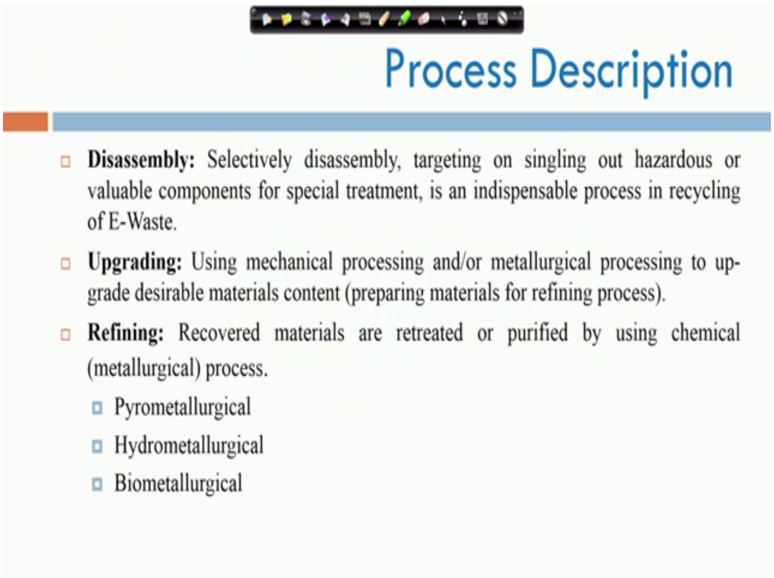

So, there we will get to this we will start from this slide again next in the next video and we will go over the process description existing E waste recycling technique and all that what are the different techniques, how we use them what are the pros and cons of using those different techniques.

So, in this particular video what did we what did we learn I am trying to summarize you this time in every video at the end am trying to have a summary that what we learn in this particular video, because at the beginning I am trying I am telling you what that what you will learn in the this particular video that the end we should see whether we really learned that or not and what should be the follow up. See all these courses that we are offering it is only to generate interest this is these things are lifelong electronic waste you take this 4 week course that does not mean that you do not have to look at electronic waste after say a year or 2 because things keeps on evolving the market becomes. So, dynamic type of waste is changing, types of products and of course, products are changing there is E waste is changing composition is changing.

So, a lot of things are happening today. So, in terms of this particular video what we try to do in the as I mentioned in the beginning the goal was to expose I first talked about this bio concentration concept which we did, then we talked about where it work through a solved examples of how we do some of these calculations in terms of getting this different factor in terms of the exposure, duration, what whether how many people can potentially get sick potentially get cancer and all that.

So, we did one problem we have to walk you through a problem then I have given you 3 problem to work on. So, please do that and then we started talking about recovery of heavy metals recovery of precious metal and we are kind of just in the middle of that. So, we will continue this discussion in the next video this is where we start. So, that would be the week 3 material. So, week 2 material ends with this particular particular video. So, again thank you we are just halfway done this is a 4 week course 2 week is done 2 more week is left I hope you are enjoying it again any feedback to I will like to hear from you through the media of discussion forum.

Thank you.