Electronic Waste Management - Issues and Challenges
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Lecture - 19
Electronics and LCA

So, let us get back to where we started, where we left in the previous video. We were talking about this lifecycle impact.

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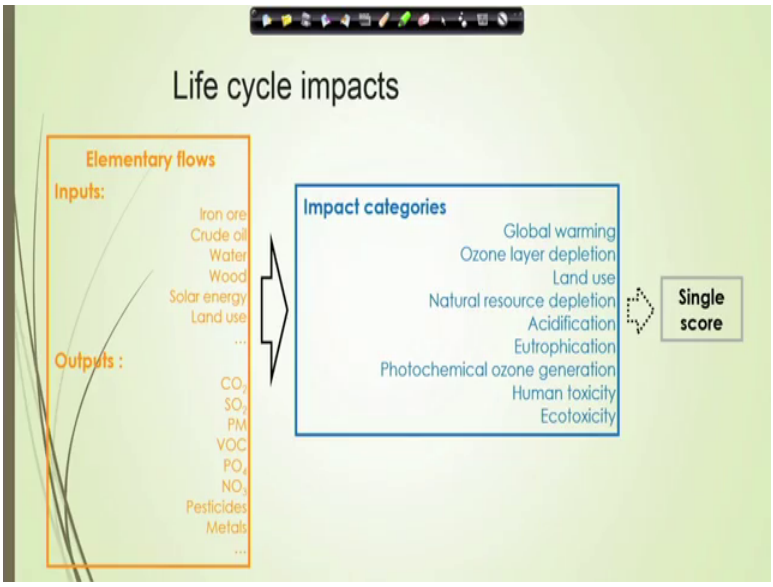

If you remember from that example, that I showed you we had 2 different types, we have different types 2 types of bulb, we looked at their input and output in terms of what gets into making those bulb for that particular functional unit, and reference flow. And then what are the emissions, from the emissions we can get that what is known as the midpoint indicators, if you had remember we were talking about these are the midpoint indicators in terms of radiation in a small climate change acidification.

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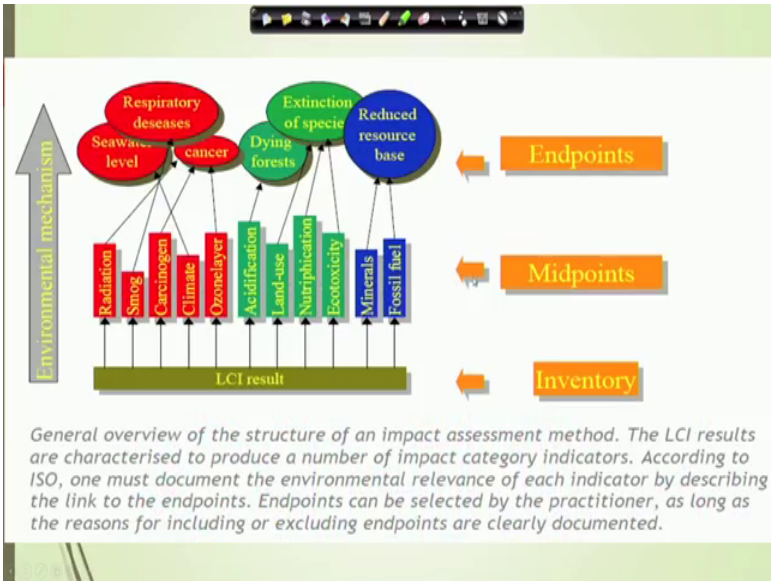

So, that is your midpoint, from emissions data we can quantify in terms of what will be these values, in terms of what is how much is a carcinogen, what is going to potentially about how much is the ozone layer depletion potential. And using that we can get these endpoint values which we talked about in terms of extinction of a species, dying for is respiratory disease.

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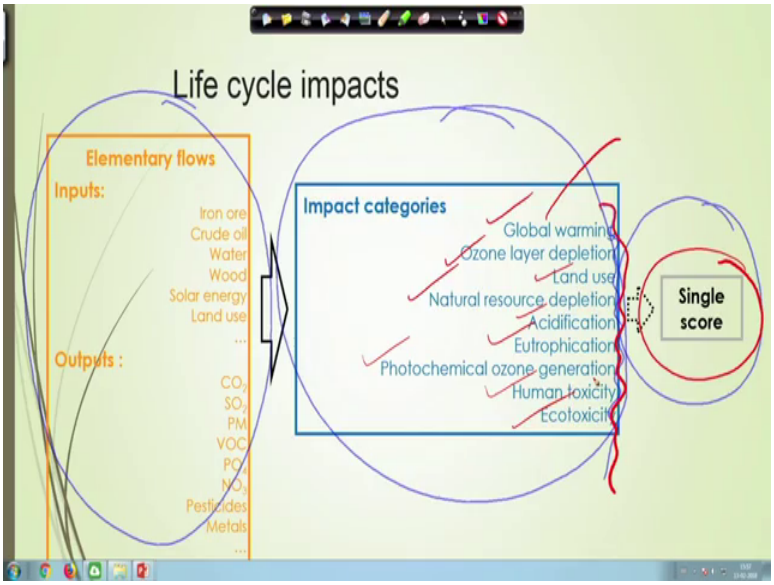

But if you take all these num, all these values like that and present it to a common public to the regulators, to the decision makers to the politicians or the ministers, it becomes very difficult for them to follow.

So, like we have example in the other domain, in terms of air quality index, water quality index, or even B S E Sensex index, we have decided in terms of the LCA also, the goal is to put everything in terms of a single is score. So, from the elementary flow, we get the impact category, as you can see on this particular on the screen right now. So, you have the elementary flow, from the elementary flow you can get the impact, we can get to the impact categories, from the impact categories we can get a single score.

So, the single score is used to a to use to compare between different products, different processes different systems. So, when you look at the single score, it is easy for people to understand. And the single score is got from the data collected as part of the impact category. And here the these impact categories are like, then these the single score has the weight edge for each of these categories that is there.

So, these different categories have been, has been given different weightage. So, what weightage is each of this category will get depends on how you interpret the data, how you put those weightages. So, it is it becomes a bit subjective. So, that is why there are several methodology out there, as well there are several is there is several protocol out there, in terms of how to get this in like a single score, how to get do this weightage in the so there are several guidelines are out there. Presently, there is one method called recipe 2009 that is more common. Earlier it was impact 2002 plus, that was used there are other methods out there, as well which can be used, in terms of getting this single score out of that.

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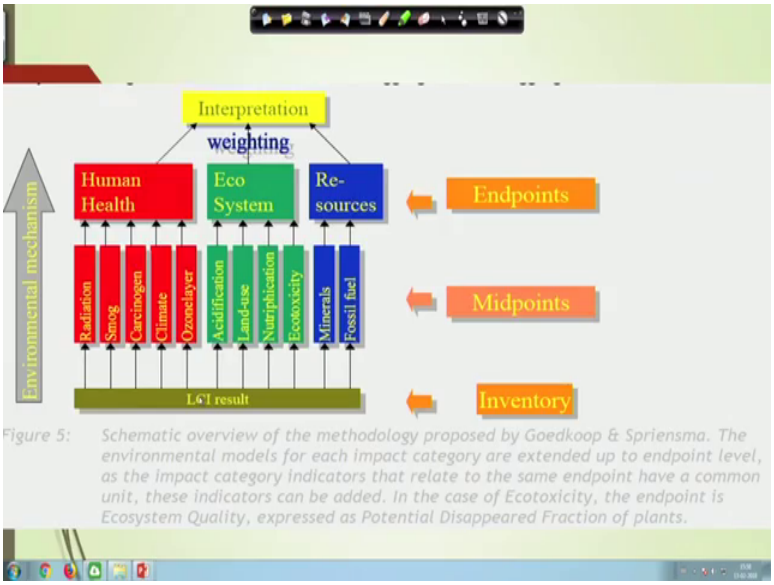

So, again you have the LCA result you get the midpoints, you get this end points from there you get some mood you do some weighting you get the interpretation, and from interpretation you get to a single score. So, that says this shows you a overview of the methodology proposed by this particular LCA researchers, what is goedkoop and spriens spriensma the environmental model for each impact category are extended up to end point level, as the impact category indicates. So, the relate to same end point, or have a common endpoint. These indicators can be added to in the case of ecotoxicity the endpoint is ecosystem quality expressed as potential disappeared fraction of plant.

So, that is the way things are interpreted interpreted as well.

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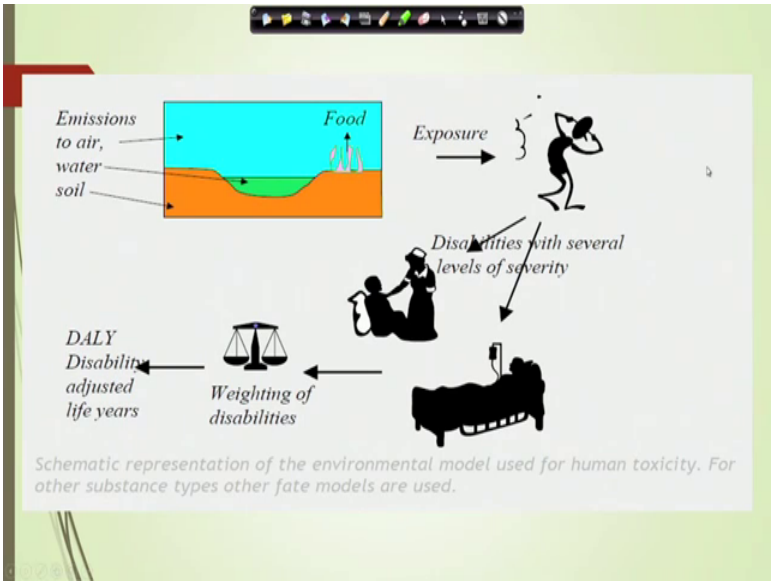

Then so, the other stuff we look at like the emissions to air water the exposure level the disability with several level of severity, what is that disability adjusted life years waiting waiting of disability people getting sick of this is used for model use for human toxicity, this is the schematic representation of the model used for human toxicity for other substance types and other fate models are also used. So, this is how we talk about in terms of human toxicity data, how to try to interpret all this data.

So, those are some examples. So, if you in terms of the LCA it is the big picture.

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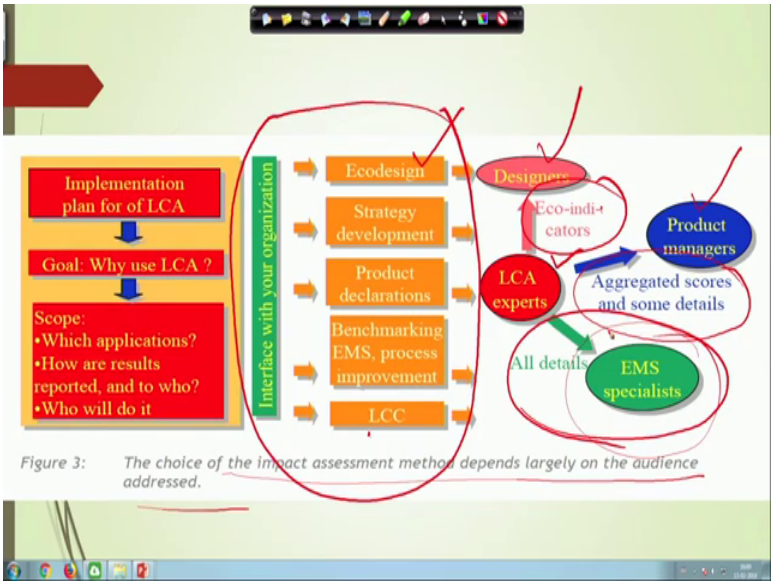

You can use it first of all, you need to know why use LCA, but you need to have a plan, a plan for our lifecycle analysis scope which application, how the results would be used who will do it what is the use , what is the big picture objective of this work. Then you try to have you interface with your organization, then you try to have eco design strategy development product declaration benchmarking life cycle costing. Then this can be used by the designers can be used by LCA factors in terms of eco indicators, agreement with some source and some details product managers your environmental management systems is specialist.

So, all these the choice of impact assessment, depends on the audience you address. If you are talking about designers you will talk about eco design. If you are looking at the safety in safety development strategy development, or product declarations you can you can go to the LCA experts, and LCA then it can be used for eco indicators, it could used for the product managers as well, they can use if you look at all environmental management systems a specialist environmental, they can use that as well.

So, depending on who is going to use the data, who is going to use that information, you interpret it in the way so that it becomes useful for that particular person to use it. So, that is how, but basic concept is the same try to reduce the environmental footprint of any product process or system that is the goal of any LCA exercise.

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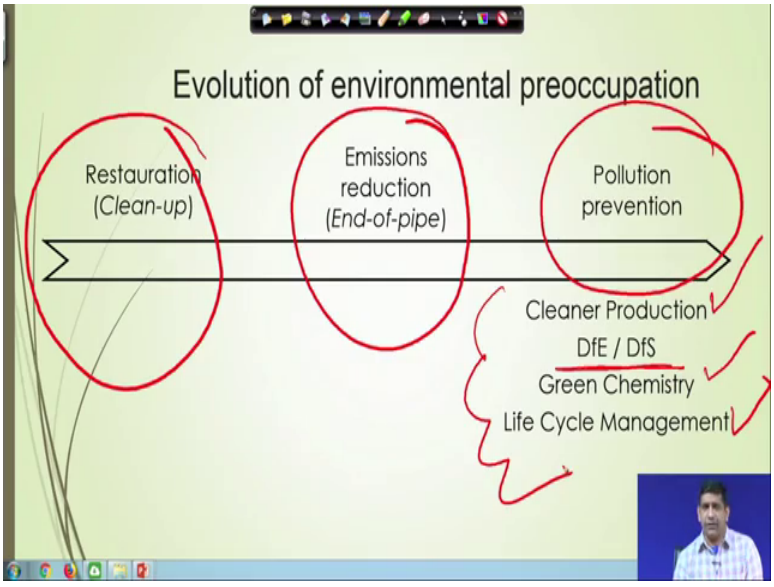

So, if you look at how the environmental profession has evolved, including in for electronic waste. Once we have started this electronic waste being produced we people there is a panic in terms of there is a still a panic, in many places in terms of how to manage this e waste effectively, because we are producing a lots and lots of e waste, more and more e waste is getting added to the disposal stream. This is the most there is a huge steep rise in e waste that is being produced, we look at that graph as well earlier. So, more and more e waste will be produced. Now it is expected that actually there will be more us in the developing country rather than in developed country, because most of this developing country is high population.

As well like those bigs countries Nigeria all these high population countries. Yeah, even in the per capita waste e waste generation is much less is the population is very high. Effectively, you see more e waste that is being produced. So, for all this waste management or electronic waste management or in general went for environmental stuff, the thing was the concept until very recently was mostly on focused on clean-up it is still.

Now, we do a lot of clean up because a lot of contaminated sites are there lot of clean-up is required. But the focus was mostly on restoration on clean up. Emissions reduction like end of pipe approach looking at the end of pipe approach that is what is called. Now for our last say decade or so we are focusing more on pollution prevention, like how to have a cleaner production, how designed for engine design for environment design for sustainability, green chemistry, lifecycle management, all these things are coming into the picture including in the design of electronics.

Now, it is actually T U Delft; where I had a chance to spend few weeks a purely a couple of years ago, there they are working on with several electronics manufacturer, Samsung, LG, Sony all these they have actually work very called sodium, and they are funding this project a together, can you imagine that and we to design? So, how to design electronics in a more sustainable way? How can do we like a, because they are also they are also realizing that this the concept of produce use and dispose.

So, the linear economy concept, where you have a story explaining you earlier, in one of the video that you keep on producing stuff go to mother art to get the material produce use dump. That cannot last forever. Because we need to start recovery of those material, putting back into the cycle, and many times you need to think do we really need like the

whole product needs to be changed. Think that example of your laptop, when you buy and save if you have a older laptop 2 years old or 3 years old and now you are going to buy a new one. Maybe 60, 70 percent of the old laptop is a still like, good enough I still you do not need to replace that what needs to be replaced maybe 25 to 30 percent, because the new processor has come, some new stuff has come into the market things have evolved, to make them with graphics to look better maybe high definition whatever.

So, you have those things to do that you can replace only 25 30 percent, but to make that happen the design has to be more as a modular based design. If it is a modular based design, we can do it we can make we can take those parts away which is out dated, put the new parts in and maybe update the software and the computer is ready. So, because the casing is screen or other things it is good enough.

So, just a little bit of kind of maintenance, and some cleaning and other stuff and can make it look almost as good as a new. So, that is and with much less cost. So, if there is a less cost of course, we need to look at how the business model will work, how because we have to produce jobs as well. So, how the jobs would be created how the people will get jobs to do these kind of stuff. So, that is the in terms of we need to talk about in terms of how this newer business model is going to use to work in circular economy. That is a concept of circular economy, rather than going for a linear economy.

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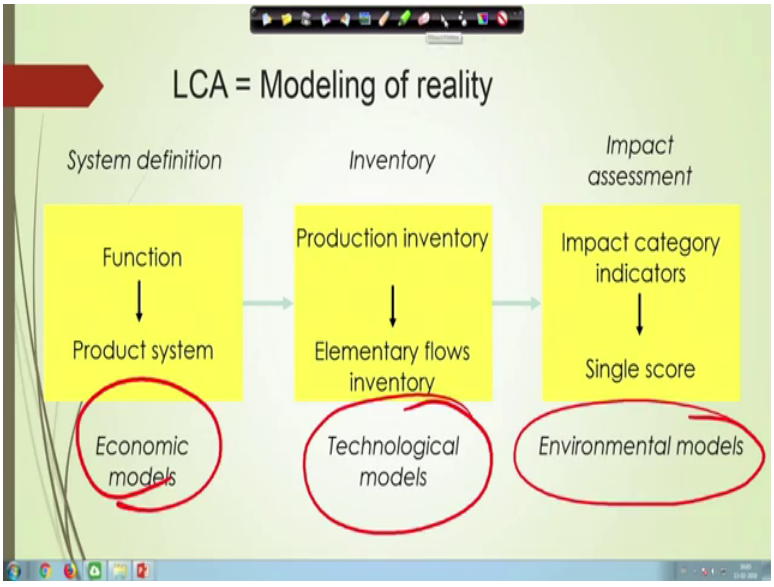

So, in the in terms of LCA what we are trying to do we are trying to model the reality. We are trying to model reality, we have a system definition function product system, we have inventory.

So, product a system function and the product system is our economic model. And technological model is our elementary flow inventory then impact category indicator single score that is our environmental model. So, we are using these 3 model and try to model the reality, whenever you try to model reality of course, you will have some challenges because you have to use lot of assumptions which is not true.

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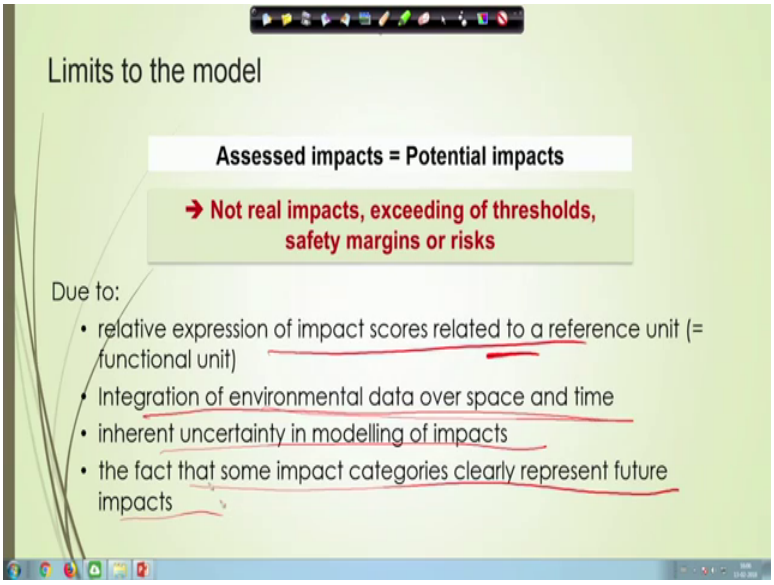

So, we cannot really model reality 100 percent, we will try to get there. Any limit to the metal it is assess impact, it is a potential impact, it is not the real impact. So, it is exceeding of thresholds safety margin. Due to the relative expression of impact scores, there is a relative expression of impact score. Integration of environment data over space and time so, that is again the inherent uncertainty of modelling, fact that some impact and it was clearly represent future impact. So, based on all that , there will be always a limit to any modelling exercise that we do, and those who are working in the environmental field and especially on invar with some models which it snows much better, that more our models have limitations including the life cycle models.

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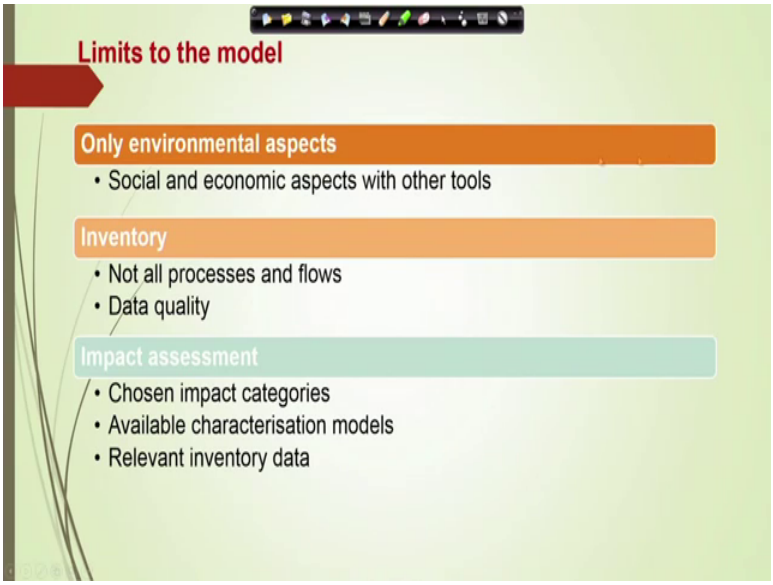

Here we are only talking about environmental aspect. The social and economic aspect is used with the other tool. And in the inventory sometimes you do not have all process and flows. Because it gets to bigger you do not have that information available. Data quality is a question. In terms of the Indian, in India we do a lifecycle assessment a lifecycle management conference every year, and I am one of the organizing team, member there it is it is actually done by ficky in Delhi.

So, it there last year we had one presentation, where the question was asked, what is the major, what is the major concern in terms of LCA in India. The answer that, whether the 3-major concern and the gentleman, who was presenting it his answer was data, data and data because getting good data in all spheres, you look at the water quality, wastewater even the river Ganga, clean up having a good data along the river Ganga, is always needed waste management in general municipal solid waste we do not have a good data base in terms of how much waste we are producing how much is being managed in informal sector. How much really ends up in the dump sites, and what ends up in the dump site, what is the composition of that waste which ends at dump site.

So, lot of data is required, and those are again missing. And then we have the impact assessment, what is the chosen impact categories available characterization model, relevant inventory data so, all those things is needs to be taken into consideration.

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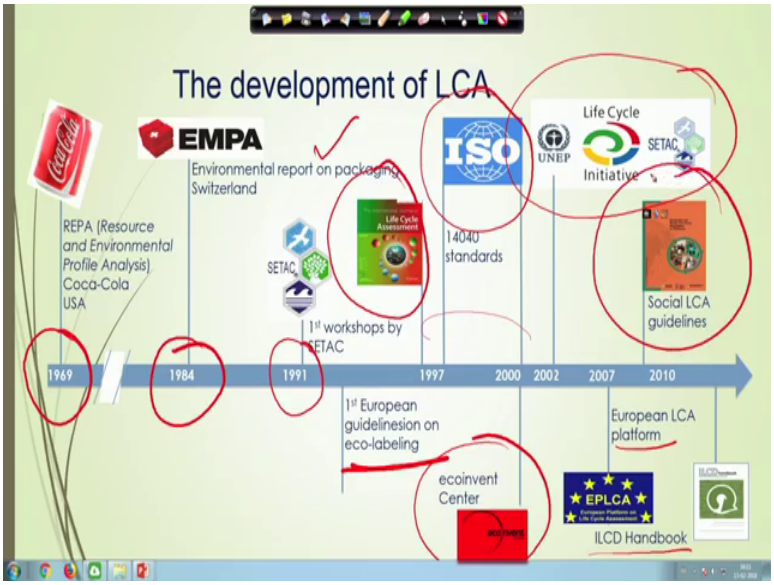

So, we will end with a little bit of development of LCA, how the LCA has evolved over time, and then we end with this LCA part like introduction to LCA then we look at how this data, how it is being used in different applications.

So, development of LCA, it is I believe it or not it started in 1969, even before I was born. So, it is pretty old stuff, but at that time they were not calling it a LCA, it was coca cola in resource and environmental profile analysis of coca cola and USA was done in 1969. They were looking at whether they should go for aluminum versus glass, in terms of whether it should be cocaine, or whether it should be coke bottle. And not I think they were using for glass versus glass versus aluminum cans. So, but that was done it was an inherent exercise there was no ISO standard at that time.

So, we do not know whether that we can really call it LCA, but something like LCA study was done, the first it was done in 1969. Mostly from a business perspective of coca cola then the real that LCA study that as we know of today kind of started in 1984, where environmental report on packaging in Switzerland. That is where they started working on that. In terms of reducing the packaging, they have been thinking from an environmental point of view.

Then the SETAC come up with a LCA workshop in 1991 SETAC has done, a lot of work in this area. SETAC if you, those of you do not know it is a society of environmental toxicology and chemistry. It is a huge organization; it is a panworld global organization,

people along the world as all the members of SETAC. And SETAC has done lot of work in terms of LCA; they were the initial like a flag barrier of lifecycle and method. Then in 19, then the first European guideline on eco labeling came, eco invent database centre was launched in that 2000. Before that in 1997 there was a lifecycle assessment. Generally started international journal for lifecycle assessment a very popular journal very difficult to publish these papers in this job it did not earlier now.

Earlier probably it was not that difficult, but now it is very competitive. Then ISO standard came between 1998, 1997 and 2000, where the ISO standards were developed. And that is what to be use it now. Then 2002 the unep life cycle initiative SETAC all came together. And they make a this life cycle initiative group, which is now kind of taking this lifecycle forward. And 2007 European LCA platform, I will say the handbook came up too, and sometime in 2008, 2000, 2009 the social LCA guidelines were released ah.

So, lot of things are happening in the LCA sector. So, for any topic that you study, try to understand try to get a little bit of history about, that topic it is always fascinating. See all it is always fascinating in terms of looking at the history. There is like a everything this morning I was teaching a different class, and everything we were talking about that how you need to tell a story.

They technically story technically story in a simple way, that is if you can do that you would be a very good the students will love your lectures. At least the students like me will love your lecture. If you can tell the technical content in a simple way and so, that it is easy to understand see. It is very easy to complicate things and makes life difficult for the students or anybody, you know for your audience. To explain things in a simple way, us and try to break it down and so, that the students can follow it, that is why I keep on telling you if you do not understand anything.

Let us know on the discussion forum. So, that we can make those immense we can make those corrections. We are out now kind of in the 4th week you should have done it earlier, if you have not done it, yet in terms of telling us that if we if there is any modification.

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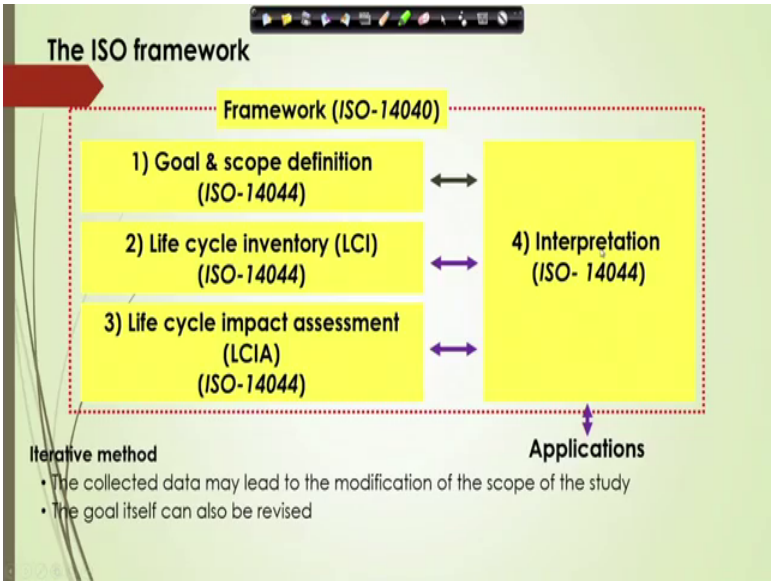

Because I am trying to I am I am putting my effort to make you turn this material. If there is some modification needs to be done to so that you learn, it better always welcome let us know any constructive feedback is welcome. So, in terms of; then the ISO as I said I also came up, and there is the ISO guideline in terms of 1440, which is a goal and scope definition inventory impact assessment and interpretation. So, we use ISO methodology to do LCA today. And so, this is let us kind of give you a very, very brief description in maybe a what nearly one in half video. So, less than an hour or maybe slightly around an hour video, I am just to give a quick overview of life cycle. And as you know that is a 8-week course.

So, we I mean I may not be able to do a very good justice for those of you who and who have no idea about this, but I wanted to let you know that this is a newer concept, and there is a lot of application of that from electronics and e waste perspective as well. So, how this is being used? Actually, as you as probably you know as I introduced myself in the very beginning of this course, I am essentially e waste management person and my movement from waste management to resource management, and from the resource management to lifecycle analysis, it happened because of e waste.

I was working on a project on e waste, along back almost, almost 12 years ago, and maybe more than that nearly may say 10 12 years ago, does not matter. This is a trillium there we got this project, where a company was trying to move away from lead, and

because I as we explained in this course as we saw in this course lead is used in solder in a soldering iron material. This company was moving away from lead and trying to produce this alternate solder.

Now, when they are trying to produce this alternates order, they wanted to know how much environmental good actually they are doing by moving into this alternates. Order whether their things will it still be a problem from alternates solders, whether things will leach off, when I say things that heavy metals are being used in place of lead, and our likes I will show that to you just in a minute. that, but what were their alternates solders. So, this project and where myself along with my balls, and other people we were developing this life cycle inventory data from the disposal point of view.

So, when this solder and e waste connect e waste containing this orders will come into the environment at the end of life, if it ends up in the landfill what kind of leaching it will happen, if it goes to a surface water what kind of leach what kind of contaminant leaching contaminant released you want you would see. So, we are trying to develop those LCI inventory. So, when we are developing this LCI inventory, then I that was the first time I heard then was dialogue this is something called lifecycle analysis in which it will be used. And of course, I had to study and all that and then of course, in 2008 for the first time on this particular topic actually, co offered this course with one of my colleagues and in New Zealand, and that is how this story if that lifecycle analysis journey started for me.

Now, we have several students who did project on theirs they happen we have published few papers, and we are trying to do some wall trying to give courses in this area. So, that more and more people get aware this is a very in my view it is it is very much needed in country like India, to or any country for that matter to have a better environmental policy. The environmental policy which are really going to make an impact many times we do things without really going for the science.

We have to understand the science the policy and the science to hide needs to have a good marriage. So, every good policy should be based on good science. So, it is in for the good science, you need to do it especially environmental policy, you need to do this stuff in terms of ELI, LCA and those things are very, very important. And so,. So, going

back to the first project that I worked on here LCA has I told you that I will give you some examples. So, this was an alternatives solder.

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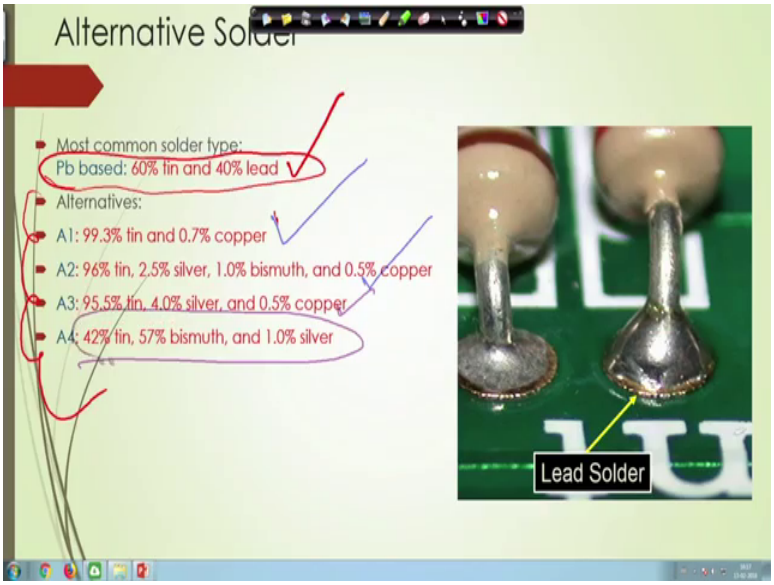

Now, what is this alternatives solder, as you can see alternative solder most common solder type is the lead based, we you saw this picture in the very beginning of this course I think as well. Most common loss sorry, most common solder type is the lead base, which is 60 percent tin and 40 percent lead. So, lead as we have been talking about lead is not good for health, lead is not good for brain development lead is; so, we have unleaded gasoline, and lead based paint and all those things we have talked about class.

Now, there was there was a certain alternatives that was proposed. The alternatives A 1 A 2, A 3 and A 4. A 1, 99 percent tin 3 percent copper. So, 99 percent tin and 3 and 0.7 percent copper. So, that is your A 1 , and then A 2, 96 percent tin 2.5 percent silver, then we have copper , and what were bismuth, and other things are there. Then we obtain silver copper, we have tin bismuth and one percent silver. So, there are different these are the 4 different alternatives. None of them has lead alternatives do not have lead, but they have higher tin 3 of them.

Then in one of them which has less tin has bismuth. So, bismuth, silver, copper for that matter, they do have certain toxicity level especially for different types of organisms like copper is toxic to aquatic species silver has a toxicity, number silver is one of the TC element as well bismuth has degree water element. So, all this has certain type of toxicity

associated with that. So, we wanted this particular company who had given as this project, they wanted to know that what happens when these things get into the disposal site , what kind of leachability takes place from these different solder types.

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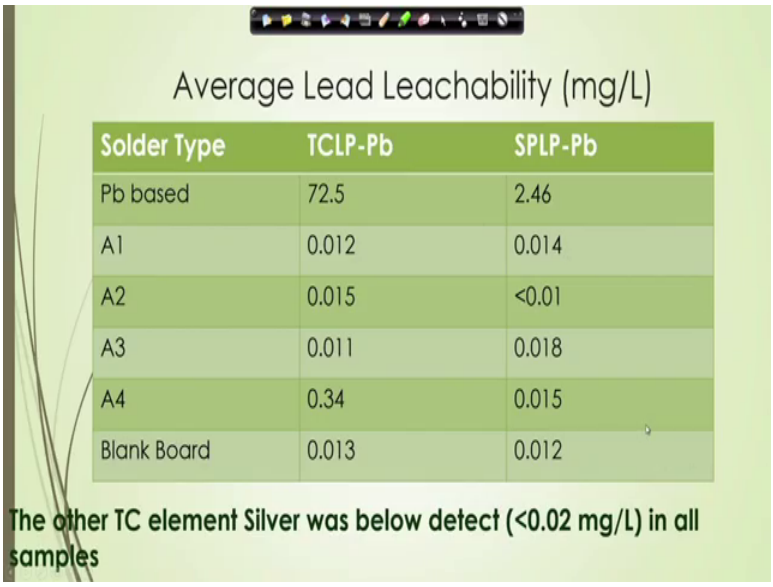

So, we try to do we collected this data. And so, the average we try to first look at the lead leachability, because that was the number one ah. So, we had a lead base and then alternatives. Alternatives, maybe because it was there in the printed printed wire board was there. So, wire board may be can blank board has some lead as well. So, that could be the reason why we saw a little bit of lead showing up. So, in terms of average lead leachability from the first if you look at the lead-based TCLP, TCLP is the test remember we talked about the TCLP is the test value which you do, to find out whether e waste is a hazardous waste or not. We talked about the TCLP on electronics how difficult it is to get a representative sample.

So, if you do a TCLP test on that which will simulate what will happen in a landfill environment SPLP simulates which will happen, outside the landfill in a assateague rainfall conditions. So, what we saw is in the lead based, paint lead this stuff very high TC, if these are all in milligrams per liter. So, 72.5 in TCLP SPLP or 2.46 again, why it will leaches too much and TCLP. You should have the answer, because this is what we discussed quite in length in the previous I think first week videos, where we talk where we are talking about the TCLP.

TCLP what kind of leaching fluid it uses, sodium hydroxide acetic acid. So, you have the acetate in solution, lead an acetate makes a very nice complex and comes in solution. So, that is the reason you see lead showing up in TCLP, let acetate soluble complex. We do not see it is although both same sample we see things leaching off in 72.5 and SPLP, it is only 2.46 that is almost 36 times less. So, maybe 30, 30 sometimes less.

So, why it is so? Because there is no acetate there in SPLP it is acid rain condition. So, we have sox and nox no acetate. So, notice you know lead acetate in solution. So, that is why you to see very low. So, it depends it is depend on what is the chemistry actually. So, but as per the test the protocol is there, we have to follow that protocol, we already know why acetate is there, because of the municipal solid waste landfill acid forming conditions.

So, we saw lead coming out in both these cases. And usually we compare this with the TC limit to know as the hazardous waste or not we compare this data to the drinking water limit. Because this is we are trying to simulate a surface water condition. Then A 1, A 2, A 3, A 4 you saw those force solder types. And the TCLP lead is much less. And blank board has some TCLP lead also and SPLP lead showing up. So, because of the blank board or maybe some other impurities showing up we do see some lead, showing up in these situations.

So, it is a let us show up a little bit in different solder, that is coming out, but much less than what is coming out from the lead-based solder.

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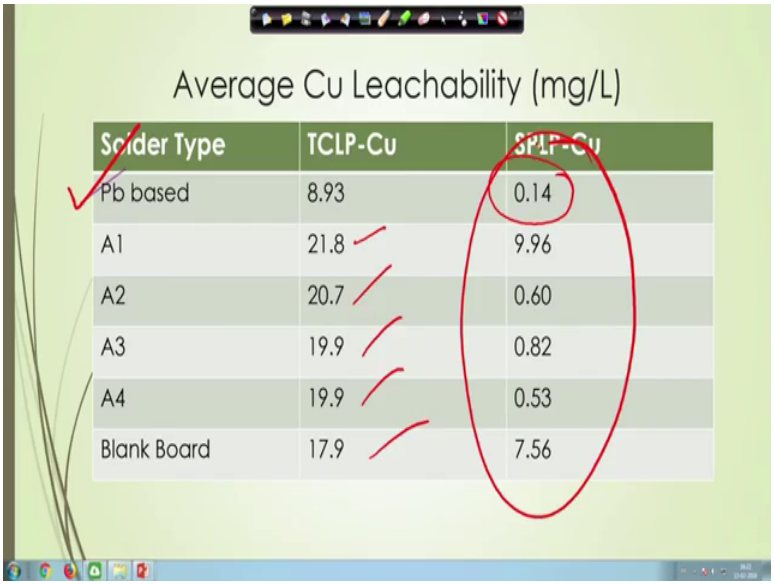

Copper leachability, we saw the copper leachability copper leachability was actually less in TCLP, and if you even if you look at the SPLP. It was copper leachability is much less when we look at the copper lead based , when we look at this lead based it is less, but this is higher than the this is also higher, this is also higher. So, all these things actually is showing much higher. So, it may be the reaction between them.

So, the TCLP copper was much less compared to other from the ledd based sold ledd based solder as supposed to the other solder. And SPLP again was in fact, was the lowest was in this compared to the others. So, it is in terms of the copper copper leachabilities more.

So, if you think about from a aquatic species impact point of view, this the newest order types were actually worse, then is if you look at these data , newer solder types seems to be worse, than the older lead based. If you think about just the copper toxicity to the aquatic species also, that is although this copper is by available or not by available that is a different question we talked about that as well in this class , but that is in terms of. So, we have to look at these kind of data what kind of base.

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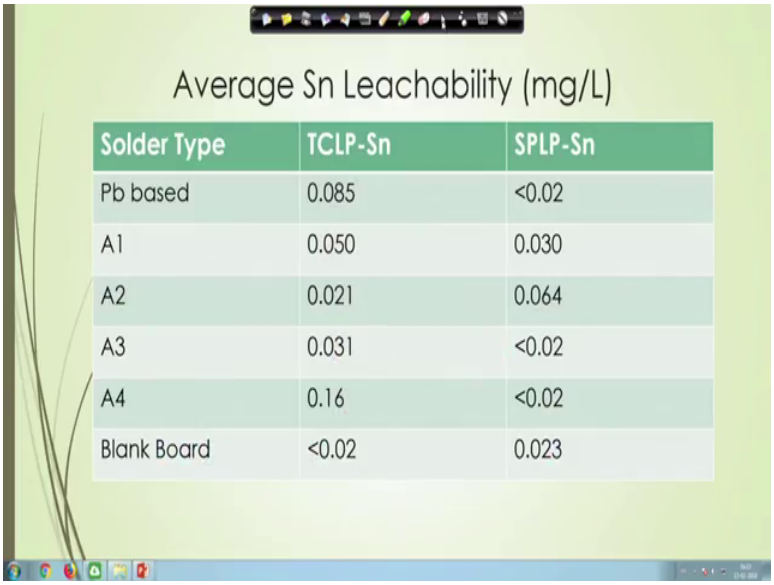

So, this data went there in terms of getting into the database.

So, eco invent database will have this kind of data when you look at like the leachability or the potential impact of different categories from these solders. So, this is the tin, tin leachability as you can again different values out there will then we had; so, average bismuth concentration was below detect for type 2.

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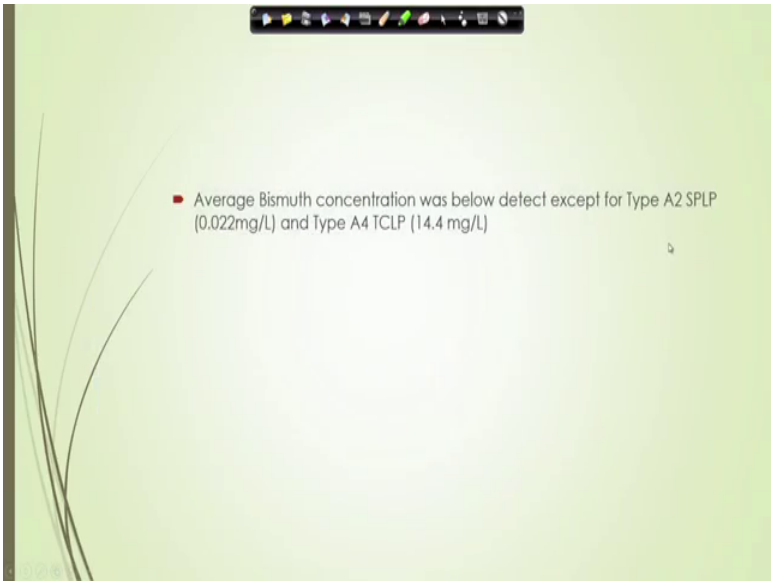

And type 4 TCLP, it was 14.4 milligrams per liter.

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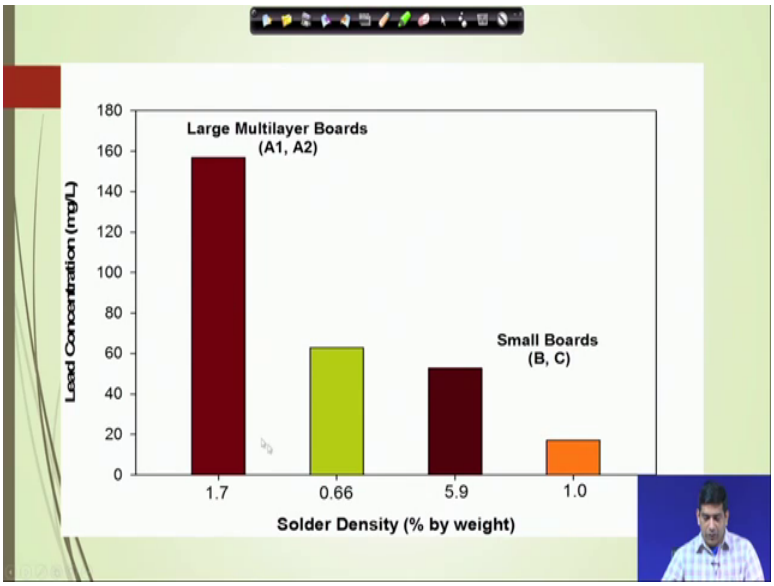

And when we look at the solder density, lead concentration was more larger multi-layer boards A 1 and A 2, we saw slightly higher than the smaller boards has less solder density percentage by weight. So, these are how they were there. So, based on so, these are the kind of data that you would generate in terms of the LCI inventory. So, that is also that also is a very big unfortunately, we do not that is the, is not considered research the data collection. In many parts of the world including in India like, whenever we go to DST or other places, they say this is not really the research because you are just collecting the data. But collecting this data is also very, very important, unless we have this data.

So, maybe the government has to provide some sort of funding from somewhere, where we need to collect this data. What is that inventory data? We have to have LCI inventory from the Indian context, to do a real-life cycle analysis. For any project that it is a electronics whether it is a different stuff we need to know, we need to have the data. So, some of the some of the electronics data probably we can use foreign data, because it is a similar stuff we can use the data from abroad from the literature, but again in terms of the disposal site in terms of their conditions in the Indian scenario is different than the western scenario.

So, it is always better to have a primary data, data collected by ourself in terms of the research. So, I if in terms of the LCA research, LCA exercise especially for an electronic

waste data collection data generation is very, very important even the environmental risk assessment is very, very important. And to make it in more environmental friendly the newer design needs to come in, we need to look at the better design. So, in the next video which would be kind of the last video of the course, because we are in the 4th week fifth module.

We will get into the fifth module, in the next video we will talk about lifecycle assessment of a laptop computer. This is what we will start with, and then we will talk about some of that how to design a eco-friendlier a electronics. So, and then we will end, and then you will have another video which will be an additional video with some solve examples. Some of you have requested or through discussion forum to have some solved examples done of the different types of problems that we have looked into this course. So, we will have that made and uploaded and which will be part of week 4. So, thank you. And again, any questions, feel free to put it on the discussion forum. I will see you again in the next video.

Thanks.