Course On Integrated Waste Management for a Smart City
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Module 12
Lecture No 58
E-Waste Management (Contd.)

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Okay welcome back so will continue that discussion that we are having in the previous module. So we looked at already in terms of definition, how the waste is defined in globally, different definitions, so now we will talk about characterising the e-waste. As we as I have said in the electronic waste sorry in the municipal solid waste, also in the C and D waste modules, that first we need to know that what is in there, so that is then only we can take about how to manage it.

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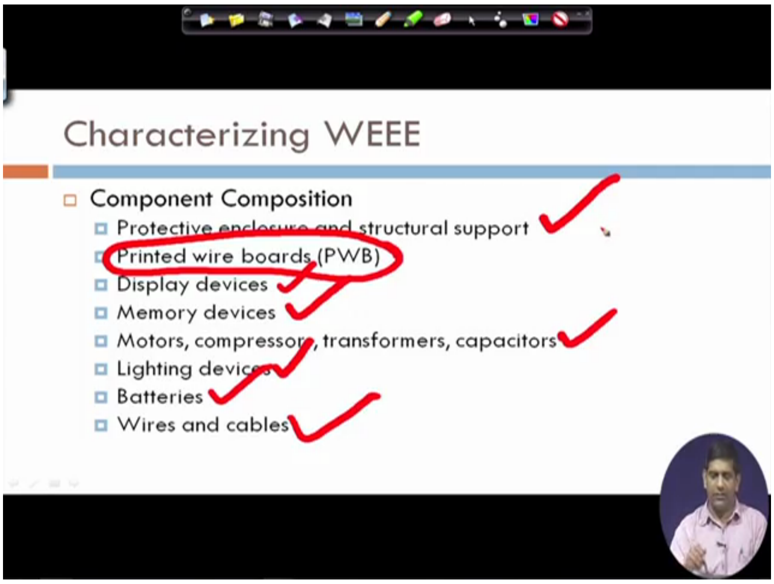

So in terms of characterising the e-waste let us look at the composition, what is there in electronic waste, what is really there and I keep on saying that if in your cell phone you have if you look at your cell phone, your cell phone has around 35-40 elements right there depends on what kind of model you have. So 25-30, maybe 35 things are there in one cell phone. So similarly like what are the things in there, let us look at those.

So there are if you think about any electronic equipment there are some protective enclosures so there are some protective enclosure and structural support, what are those? Those are the ones in the pair like what you see, the protective enclosure you will have and then some structural supports, some plastics, some metals and other, depending on what kind of equipment you are looking at.

Then there is a printed wiring board which is the important stuff, so it is a printed wiring board which is all those chips and other things in there. Then you have a display device, there is a memory device like, for our laptops and desktops we have those RAM and also our hard disk then we have some motors, compressor, transformers, capacitors, those things are there, there could be some lightning device which, batteries, wires and cables.

So in general like these are the different components it is there in a electronics. If you take an electronic waste or electronic product you take it apart but the different components you will find these are the one which shows up there. And what proportion that depends on type of some type of instrument that we are looking at some the composition percentage wise will change, but these are the different components that you will potentially see if you take any of these electronics.

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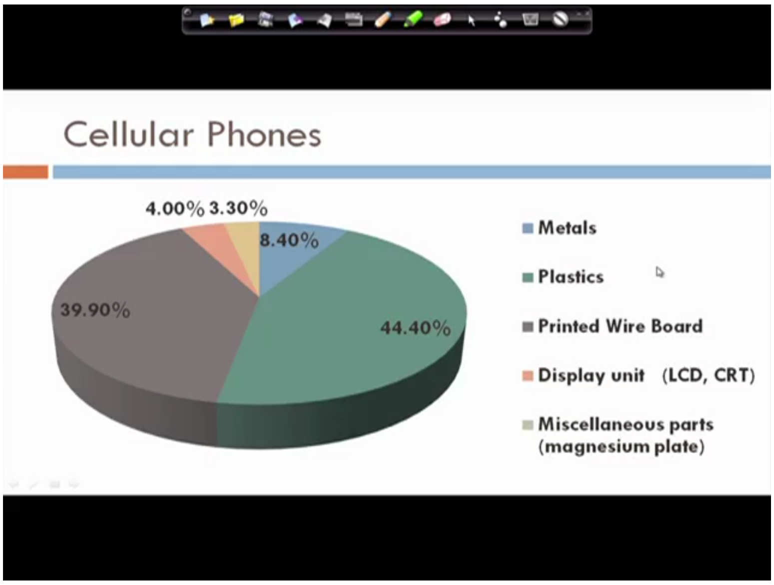

So for example, if you go to a cellular phone, cellular phone here you have around 8.4 percent is metal, we have lots of plastic in cellular phones and plastic are actually going up, metals are coming down. Then we have printed wiring board chairs around nearly 40 percent, we have display unit is 4 percent and there are some miscellaneous part which is there as well.

So overall as you can see, we have like cellular phone means, a good amount of plastic and there is a then we also have printed wire board, so that is printed wiring board will have different types of heavy metals and other things present there. So that is and then more as we make progress, we are actually reducing the metal, we are using more and more of plastics.

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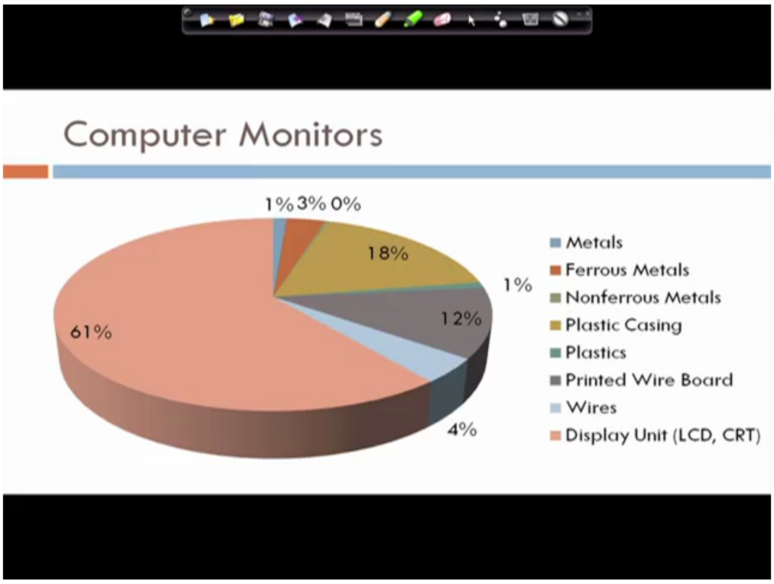

If you go to the computer monitors again we have display unit, LCD, CRT like the glass is very high and then we have some ferrous, some nonferrous and plastics, printed wire boards, wires those things are there in computer monitor.

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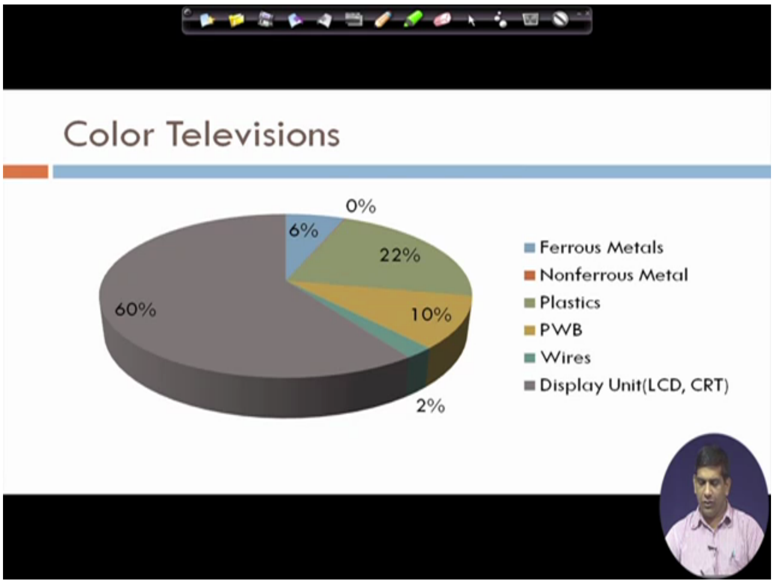

Colour television, again you have some ferrous metals, nonferrous metals, some plastics, printed wire board, display unit is the major ones. Then you have printed wire board which is around 10 percent, wires lots of will have plastics is around 22 percent. So if we can replace all this say you think about this kind of pie chart, those ferrous, plastics, if we can take those plastics out that can go to a plastic recycler that is what we can think and at some point, at some places, probably it can, but the problem comes because these plastics that is used in electronics they are not either like a usually when we talk about plastic we have these numbers, is not it? PET, HDPE, PET is number one, be it resin that is a resin code as well 1,2,3,4,5,6,7.

So the problem is in the kind of plastic that is used in electronics industries are blended plastic, it is not just one either it is not PET, HDPE, many times there could be at some point they used as it is, but most of the time it is kind of blended plastic and the blended plastic is very difficult to separate. So it is not a it may not be a good recycling it maybe more it is may be a good candidate for incineration rather than the recycling, so those things are shown up there.

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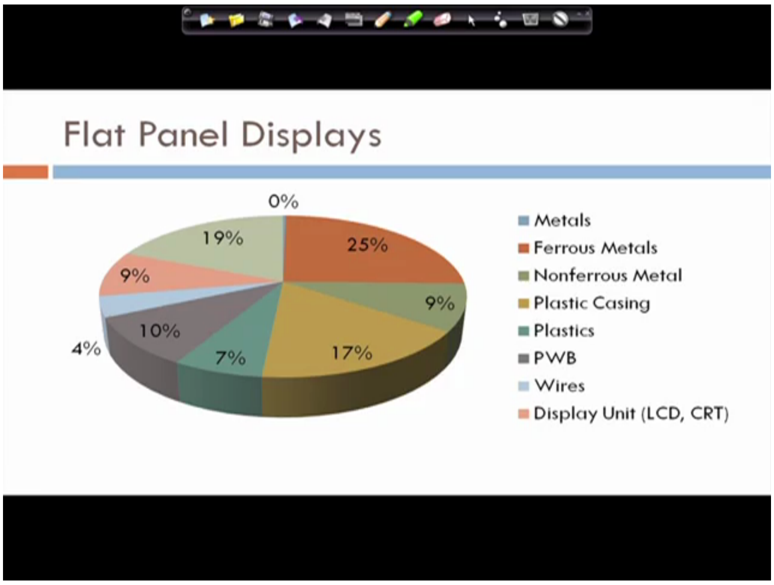

Then the flat panel display, as you can see the flat panel display unit has gone down. The percentage for display unit has gone down, we have some wire the highest that we see is the plastic again over here and metals, ferrous metals we saw that quite bit and ferrous again is coming down as well, so those things are there.

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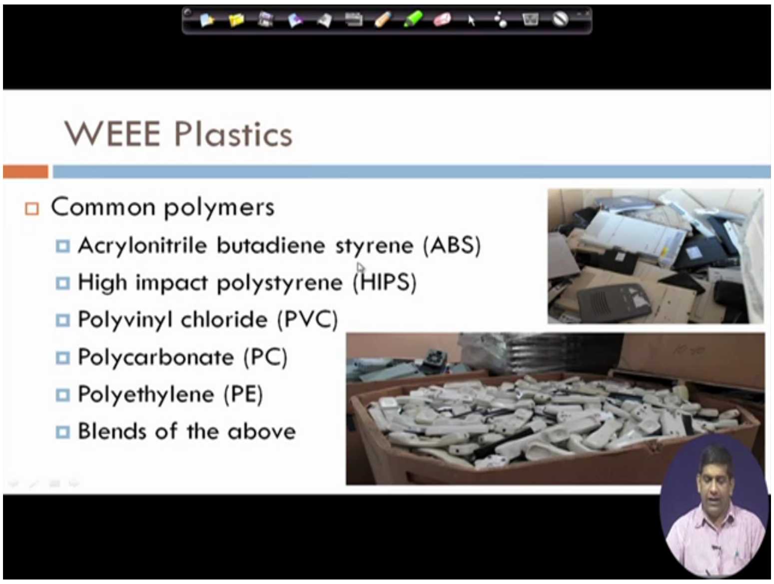

Then in terms of the plastic as I was saying, there are there is kind of mixture of you have acrylonitrile butadiene styrene ABS, high impact polystyrene, polyvinyl chloride, polycarbonate, polyethylene and the blends of above. So all this common polymers are there where we use lots of mixture of those different types of plastics which is out there.

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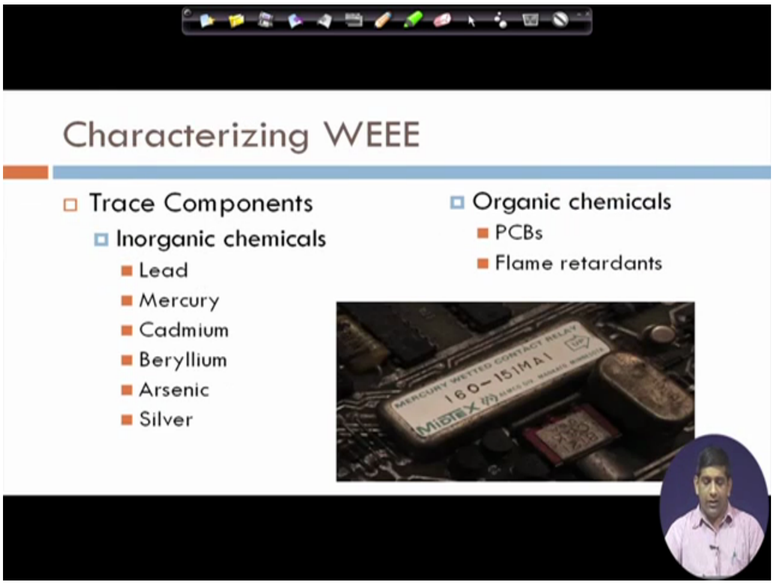

So and then there are lot of trace components, so there are some inorganic chemicals which is lead, mercury, cadmium, beryllium, arsenic, silver, so those are the inorganic chemicals are there. Then we have some organic chemicals in terms of PCBs and flame retardants, so those are the organic part. So we have both inorganic as well as the organic which is present and many of these for example lead, mercury, cadmium, beryllium, arsenic, all these are has certain toxicity, they are listed as certain adverse environmental and human health impact and similarly PCBs are known as has some sort of negative impact as well and the flame retardant are known for the negative impact, it is been in used in recent years for like environmental and human health impact.

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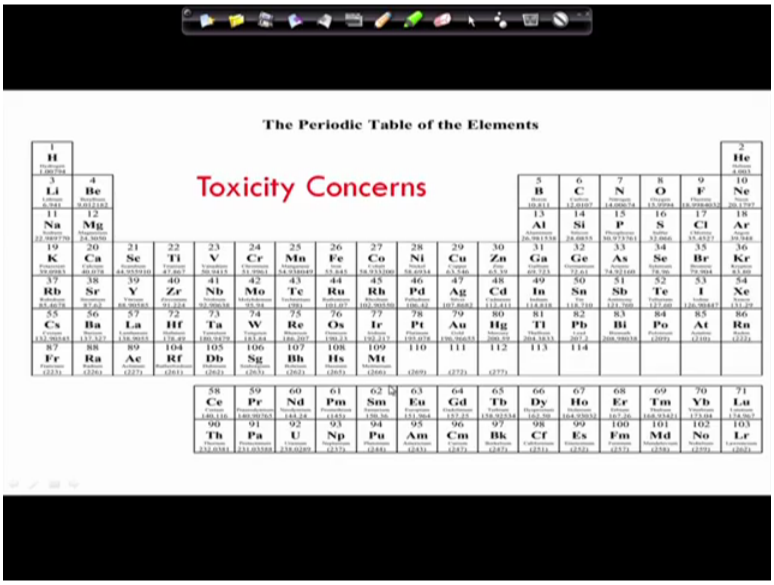

So there is a toxicity concern, so this is your periodic table, I have been keep I have been talking about periodic table for so long and I thought now we are coming to the end of the course, why do not I show you this periodic table at least you will remember this is what you have already have you all of you have seen it. And so anything on the periodic table cannot be created nor cannot be destroyed, I have said that many times, so we can change its forms.

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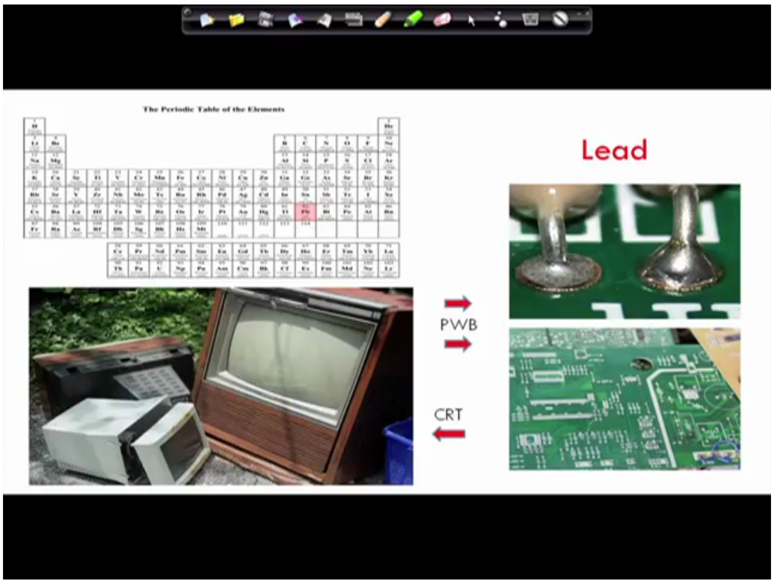

So what are the toxicity concerns from the e-waste prospective? So lead, lead is we are concerned about lead, it is the printed wiring board mostly CRTs. So lead why that is why we are concern about lead? Which I have explain earlier as well, lead is a it does affect the brain development, it is a neurotoxin, basically it affects the affect the brain development, especially of small babies brain does not develop very well if they get exposed to lead.

So that is why many countries in the world they actually as soon as the baby is born they look at the blood lead level of the baby and then if it has high lead level they try to treat it so that baby has a proper growth. So this is lead is one of the major concerns, that is actually the number one concern which cause lot of e-waste issue around the world, like lot of e-waste media coverage around the world was because of the lead, because lead showing up because of lead it was becoming a hazardous waste.

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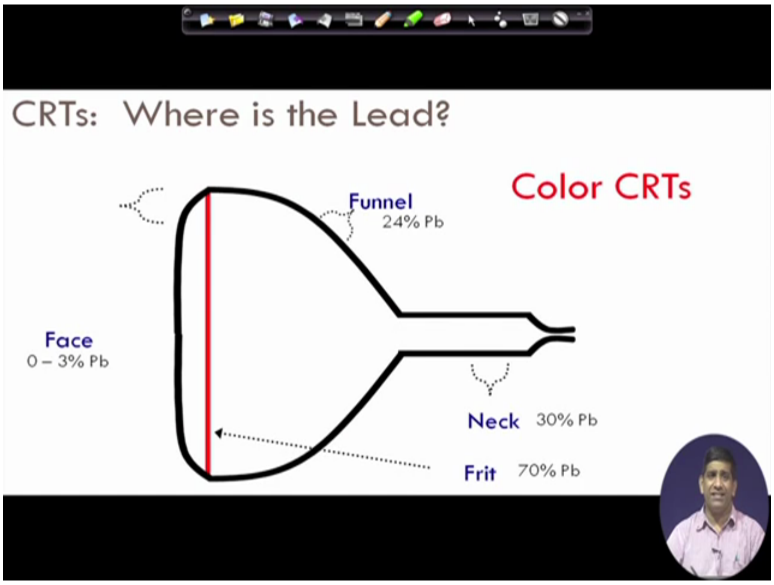

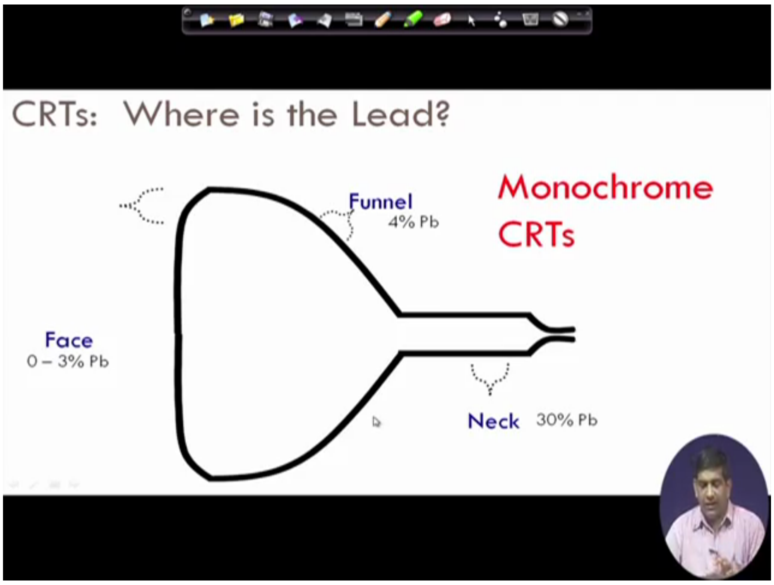

So but where is the lead? If you look at the old colour CRT, the funnel has 24 percent, Neck has 30 percent, Frit has nearly 70 percent so that is what if you the old colour CRTs that you see it here. And monochrome CRTs, when you look at the monochrome it is a neck around 30 percent, funnel is 4 percent, faces is around 3 percent.

And when we say 4 percent 3 percent these are actually percent by weight of that particular, it is not the percentage of lead there, it is not that is why the total does not add up to 100, it is maybe more than 100, if you add up all this thing here actually it will come out more than 100, but what we are talking about that funnel is 24 percent lead means the out of the weight of the funnel 24 percent is lead. Neck, out of the weight of the neck 30 percent is lead, out of the weight of the frit 70 percent is the lead, so that is what is trying to tell there.

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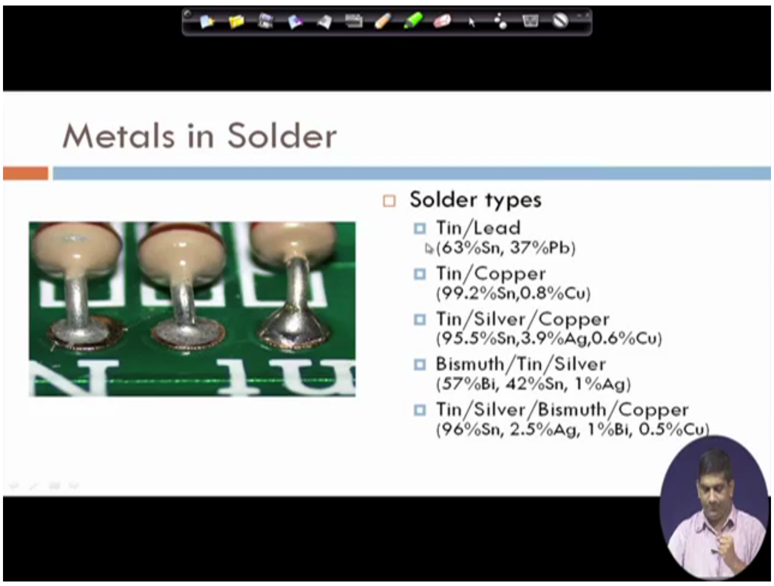

So and there are metals in solder, different types of solder, tin lead solder was very famous it was used a lot, now we have for last several years we have been phasing out tin lead solders and try to use other solders. So tin lead was the most common that, then tin copper, tin silver copper, bismuth tin silver, tin silver bismuth copper, so there are a lot of different combinations are out there which people are trying in terms of different types of solders in for electrical electronic purposes.

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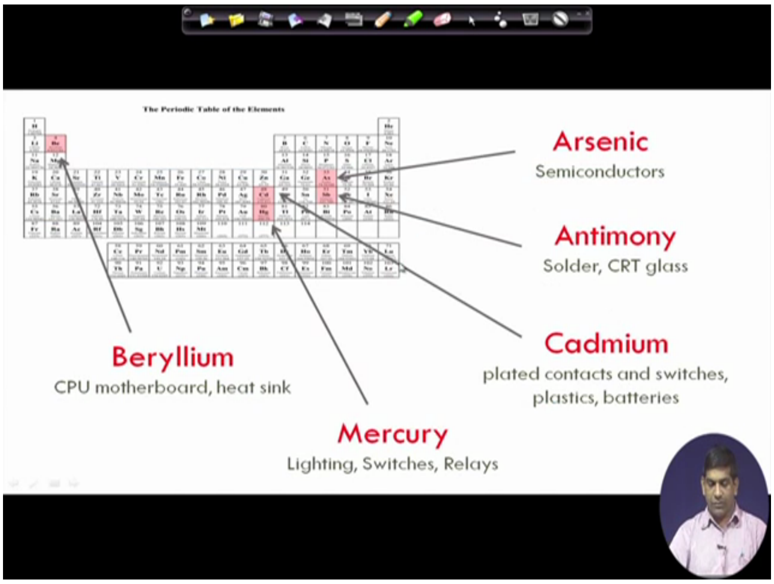

So another is your arsenic which is a toxicity concern. Antimony, cadmium, Mercury, beryllium and so these are some examples of the concerned and this is arsenic is used as a semiconductor. Antimony is used in solder and CRT glass. Cadmium it is a used for contacts and switches, plastics and batteries. Mercury we have again lighting, switching and relays. Beryllium CPU motherboard, heat sink, so those are the ones where use these elements so we need to use those elements.

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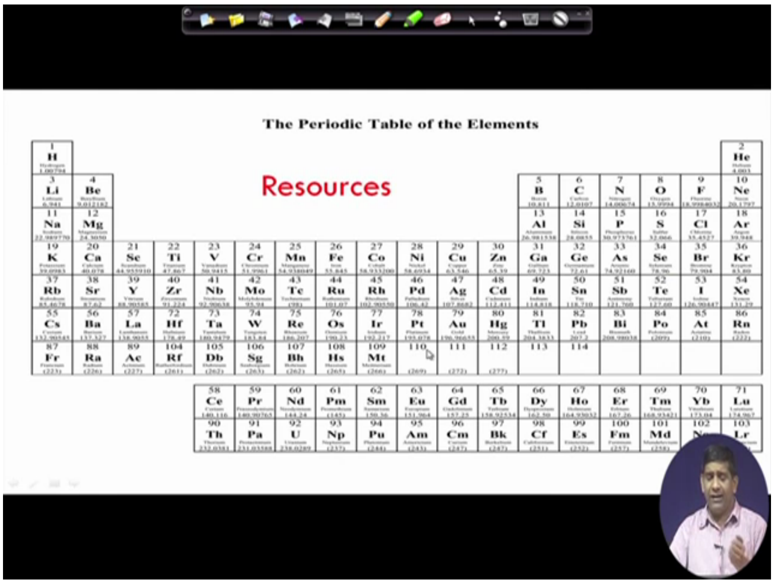

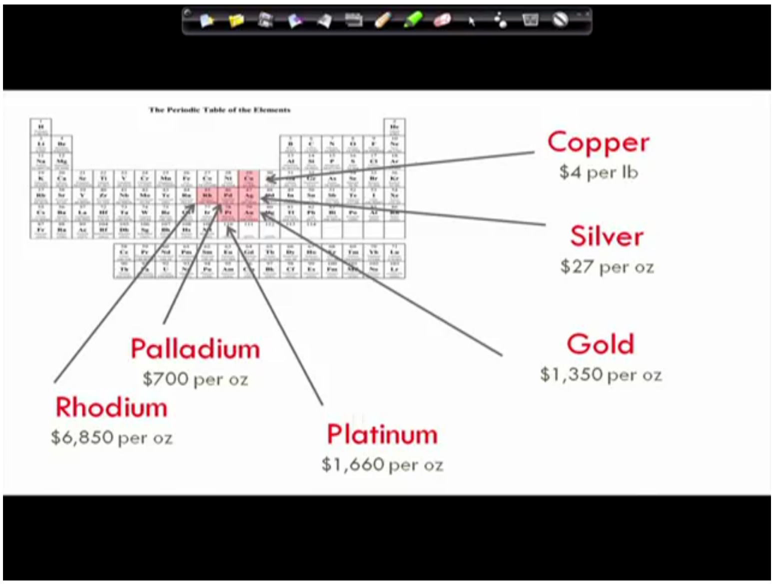

And then it is a resource, so toxicity is a concern and at the same time it is a resource. So why should we just throw it away? Why do not we try to recover material from out of that? So in terms of the resource if you look at copper is around dollar 4 per pound, so 4 dollars say even for our calculation says let us take 60 rupees as a dollar, so it is around 240 rupees per pound.

So it is a if you multiply it by, so it is around rupees 500 a KG something around that. So that is and then silver, we are silver, we have gold, we are platinum, palladium, rhodium and as you see their prices, they are pretty expensive stuff. So if you go and try to buy these stuff from the market, they are pretty expensive. So the question is why cannot be recover? And these are there in the electronic waste, they are not there in a great quantity, they are there in a fraction and then the trace amounts, but that is why it is difficult to take out them as well.

But say if we can recover this element from this periodic table in a environmentally safe, human health safe manner and at the same time not polluting the environment and using the technology which might be out there. So if you can use this and recover these elements out of those waste stream, it will really help in terms of our like a as a resource, so as you can see these are these are not cheap stuff, these are expensive stuff.

And as you can copper, then silver, gold, gold off course lot of even there are there has been many times we hear that there is lot of gold in US that will probably will be enough for the country, I am not sure whether that is true, but at least there is a substantial amount of gold is there, several researches, several papers have been published trying to project how much gold is there and in Japan and some other countries they are recovering gold. In India also people are recovering gold from this electronic waste, but it is mostly done in a informal sector and where they use all sorts of crude methods to get that little bit of gold and little bit of copper.

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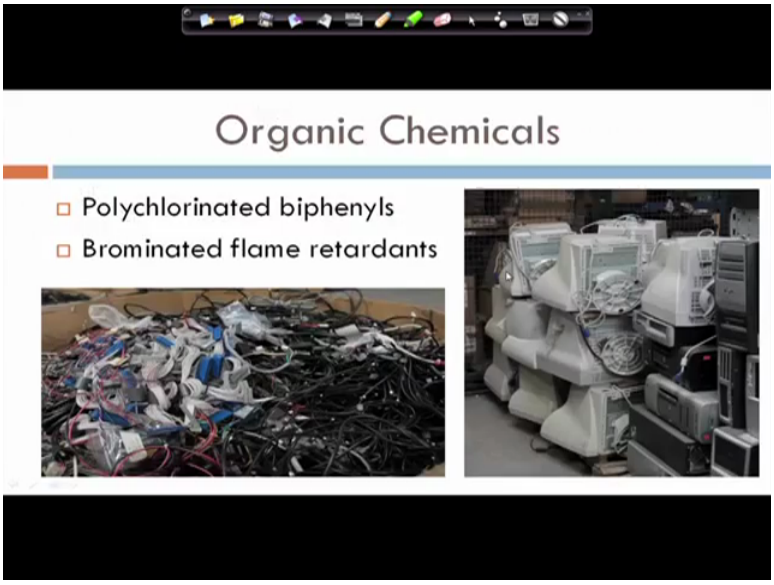

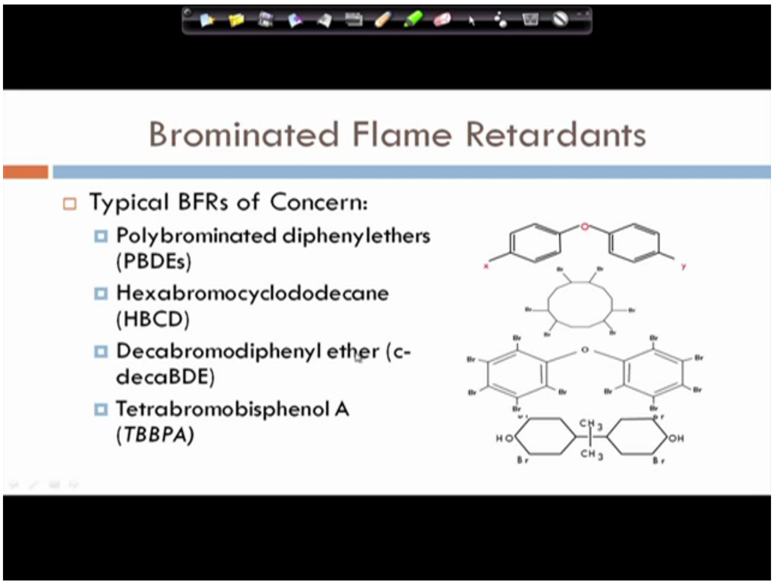

Organic chemical, PCBs, brominated flame retardant those things are there. PCBs are say potential carcinogen, brominated flame retardant also has like a human health impact and again some picture of different types of wires, different types of desktop and all that. Typical BFR of concerned is PBDEs which is the poly-brominated diphenylethers which is then you have the Hexabromocyclododecan, then you have seen C-decaBDE, then you have Tetrabromobisphenol A so TBBPA.

So there are different types of BFR brominated flame retardants which is used in terms of its application for electronic industry. So the thing is that we need to find out which one of them is like what is the environmental impact from these, what is the human health impact from these, so that we can manage them in a proper way.

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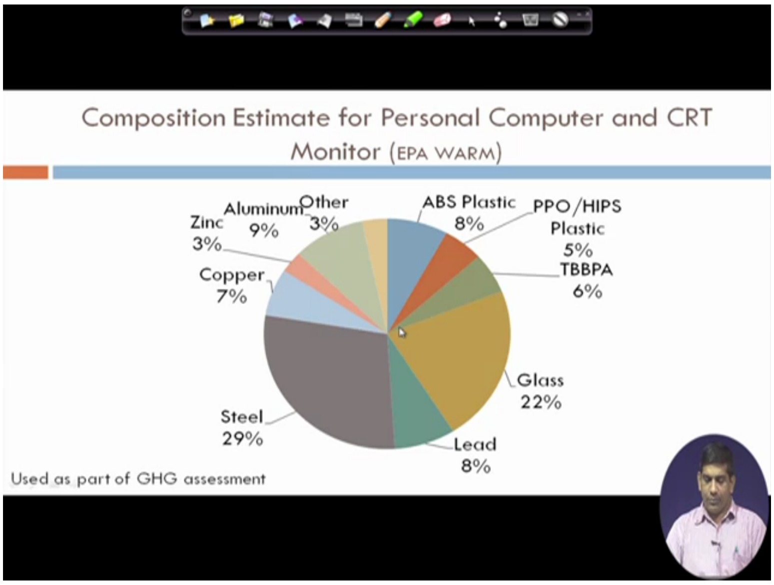

So that is in terms of what are the different elements present there, but in terms of now the estimate the composition estimate for personal computer and CRT monitors. As we can we can see over here, there is some lead, there is a class, TBBPA, plastic, PPO and HIPS plastic, ABS plastic, aluminium, zinc, copper, steel, so as you break it down further you see that there are lots of different components which is there, most of it could be potentially recycled some of these which could not be recycled or recovered has to go a landfill and based on what is the waste characterisation we can decide whether it will go to a hazardous landfill or a regular landfill.

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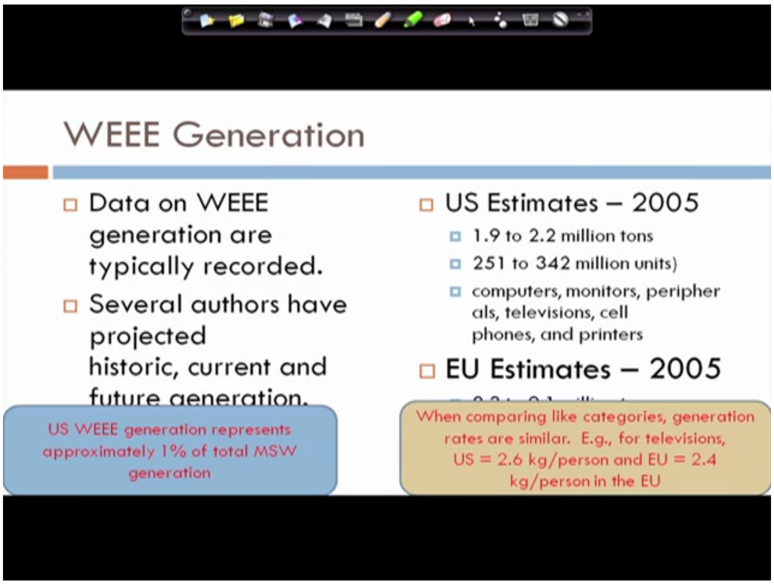

So in terms of so that is in terms of like a composition and then we have to look at the generation. So first of all how much is how many how much what we are doing so far, we first started with defining the e-waste as per the European union definition and some other definitions, then we also talked the talk we about this one we talked about in terms of what are the different components, what are the steps in terms of the e-waste management.

And then we start looking at in terms of what are the composition? What is what is in there? What are the what kind of toxicity they have? If it is a resource loss, what kind of resource we are looking at in terms of loss of the resource? And then after that we are trying to see in terms of like a organic chemical, brominated flame retardants and other stuff in terms of how these are being if it is there in the environment, if it does come out from electronic waste, any impacts like a on human health and environment, what are the different components which is there which will have a negative impact?

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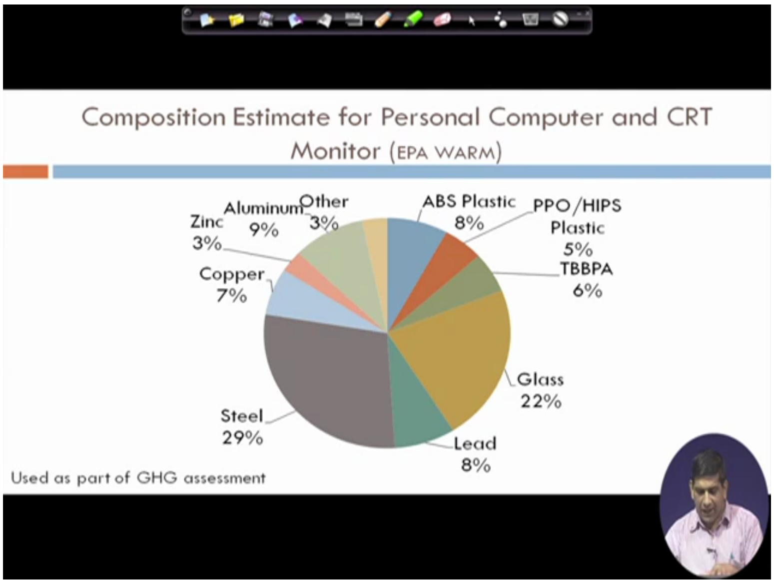

So being and there are we also had if you look at this particular pie chart we also saw that what are the now we are it is a more detail pie chart, we are looking at the individual components, most of this components can be potentially recycled, but some of this component has to go to the landfill.

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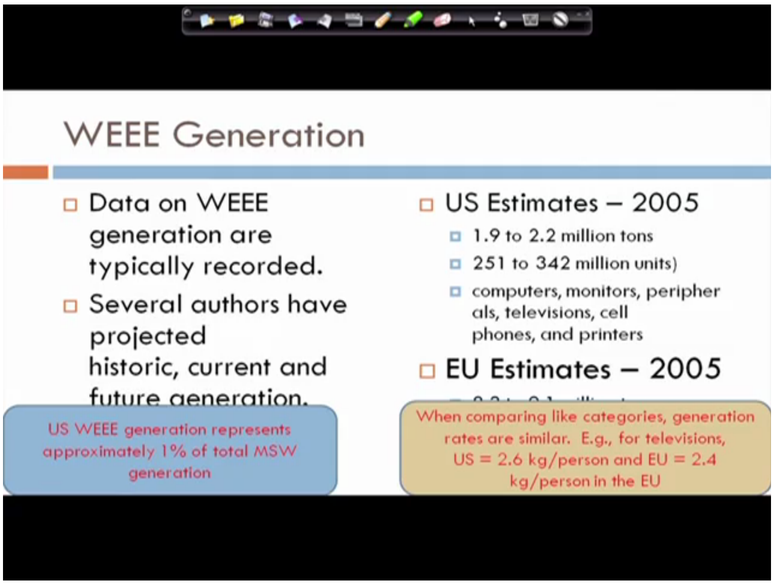

So being said that so this is kind of in general about e-waste, now we want to know in terms of quantity, how much e-waste is actually being produced? Not only in India but around the globe, how much e-waste is actually being produced? And there is a there are several authors are projected historical, current and future generation and it says that generation represents approximately 1 percent of total MSW, that is a old one.

They found that around 1 percent of MSW waste is e-waste, now that number will be much higher. Similarly in European Union also they were trying to look at e-waste that they found that in European union they produce little bit less than US, but they still produce some substantial amount of e-waste.

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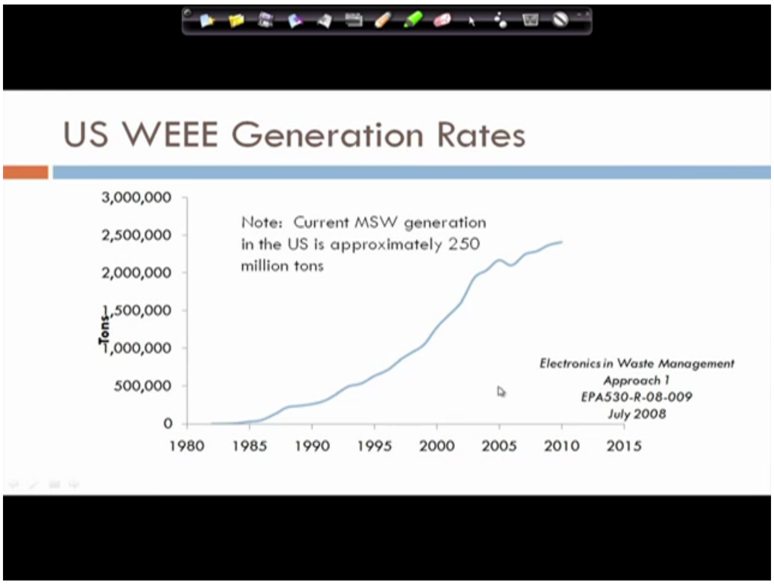

So in general and then this there was a study done earlier in where they found that if you look current MSW in the US is approximately 250 million tons, so based on what is the electronic waste being produced? So electronics in waste approach where they looked at how much waste is this is the MSW figure in terms of how the MSW is being produced.

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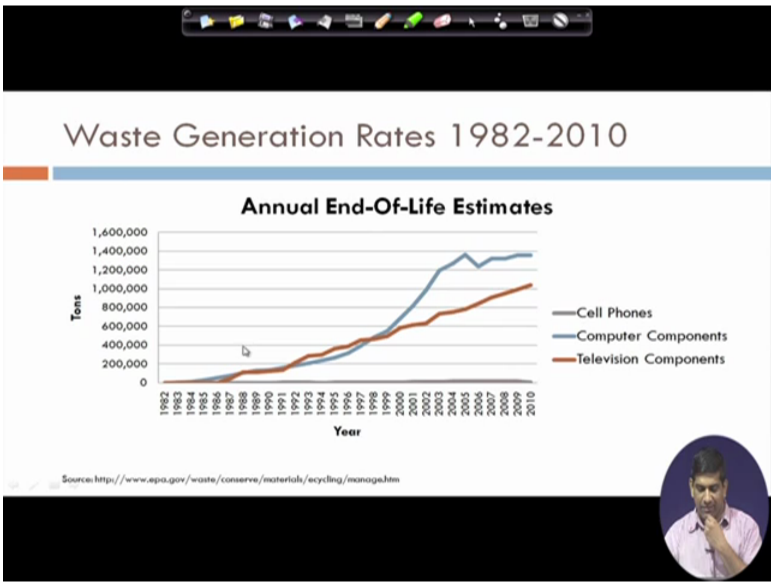

So out of that MSW there electronics are also coming up, in terms of electronics we see we did not see much of cell phone coming out until 2010, but there were computer components and television components stuff was much higher and the computer components actually took over earlier it used to be the television, computer which use to be higher for most part it was kind of going back and forth.

But after that would be year of 1999-2000 we had a cell phone like a computer components. So computer basically took over the television, so the computer components becomes much higher and if you do it like now or few years down the line you will see actually the cell phone components now is the leading one, because lots of people are using cell phones.

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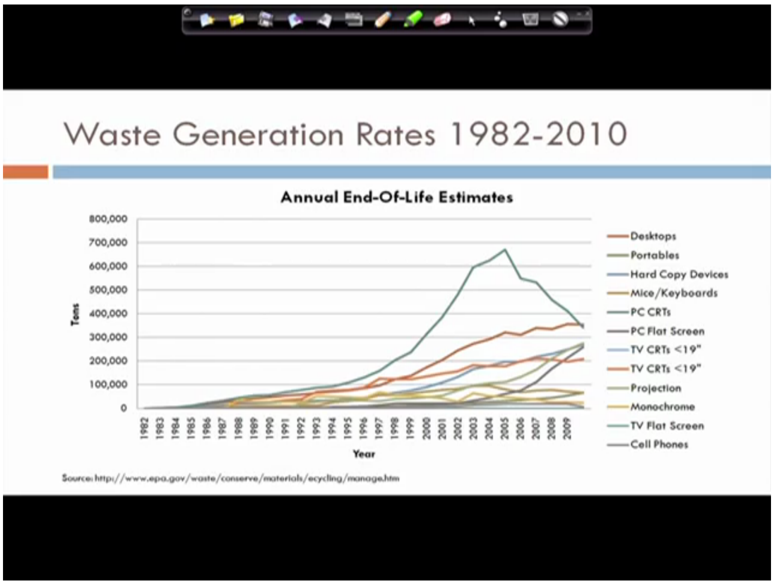

So here are some of the individual end of life estimates between 1982 to 2010. So in terms of desktop, portable, hardcopy drive, mice and keyboards, CRTs, flat screens, TVs, projection, monochrome, TV flat screens, cell phones, so as you can see the cell phones is almost towards the bottom . We see cell phone is actually right at the bottom, those grey line that you see over there and then on top is the toppest one is actually is I think is the PC CRTs and then there was a drop in PC CRTs after 2005-2006 and the reason for that is the old TVs or old computers has used to have those CRTs.

Now from early 2000's we have started going away from CRTs and started using those flat screen, so flat screen started in so CRT was gone. So as the CRT was gone so you start seeing less and less of them going up in the waste stream, because people are not buying CRTs for almost 10 years now, more than 10 years, so will you will not see those CRTs showing up in the waste stream. So that is kind of give you some idea so as you can see for the different types of categories, again you have different for different types of waste category waste stream, you have different amount in terms of waste generation rate.

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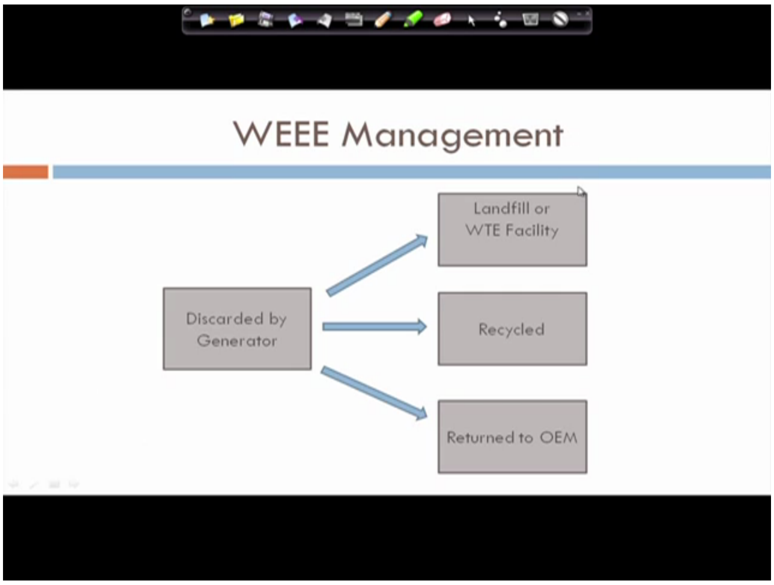

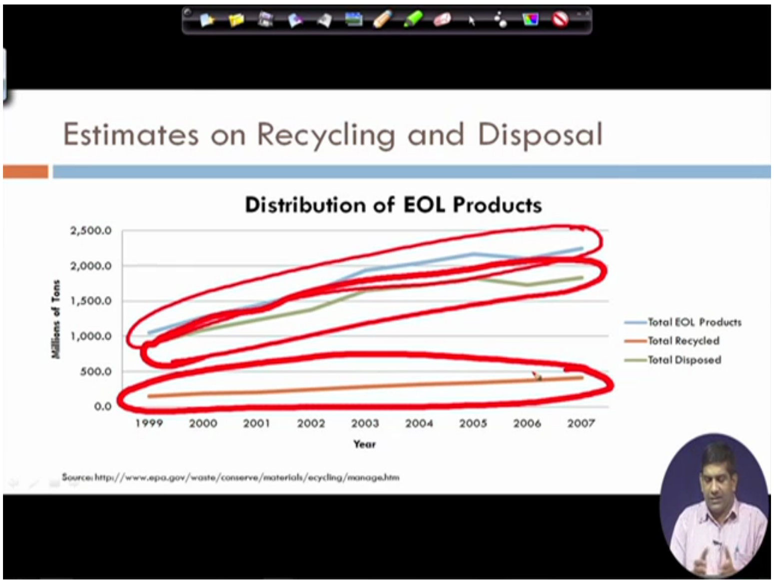

So in terms of the management, either we go to a landfill or waste to energy can be recycled, can be written to for to the owner or manufacturer. So this is how it is discarded by the generator, these are the ways it is kind of managed. So estimation on recycling and disposal, if you look at the distribution of end of life products out of total end of life, which is the blue line, so this is the total blue line and this is a kind of a US figure or the I think this is the US figure.

So it is a this is the blue line of your distribution total end of life products. So the Green is total dispose, so Green is the one which kind of shows total whatever is there, most of it was disposed and so total recycled is what we see at the bottom over here so recycling is very-very low. So what is this graph the message I want to convey from this graph is, we have been producing lot of end of life products from electronic waste and end of life product from electronic waste is keep on increasing.

Again these are in tons, so one thing we need to understand is since they are in tons earlier the e-waste used to have more and more ferrous, things used to be heavy, so when you go to the lighter version now, things are becoming lighter, your cell phones are becoming lighter, everything is becoming lighter, so if it becomes lighter this is your the numbers will get affected over here too.

So in the waste stream all in your million tons you may have more item now, but total weight would be less. That is that is the impact of like a where you have change in the product, the way the product is made and the way the product composition is since more and more plastic are being used also more although more and more electronic might be coming in. So with this graph as you can see that the slope is not that high in terms of production, but we cannot assure in terms of production maybe the quantity is going up in case of production of e-waste so in case of discarded the waste products, there value is the volume of that is going up, but since they are lighter products when you look at the weight of them it may be still the same or maybe little bit lower, so that is why the slope you see a very gentle slope rather than a steep slope as you would probably expect from electronic waste the way the things are produced.

So as you can see the recycled part was very low, which is in fact is less than if you look at just less than 500, so maybe around 400 and then if you look at around the total it is more than 2000, so less than 20 percent actually is getting recycled. So that is kind of same and that is where we need to kind of move on, move and do stuff.

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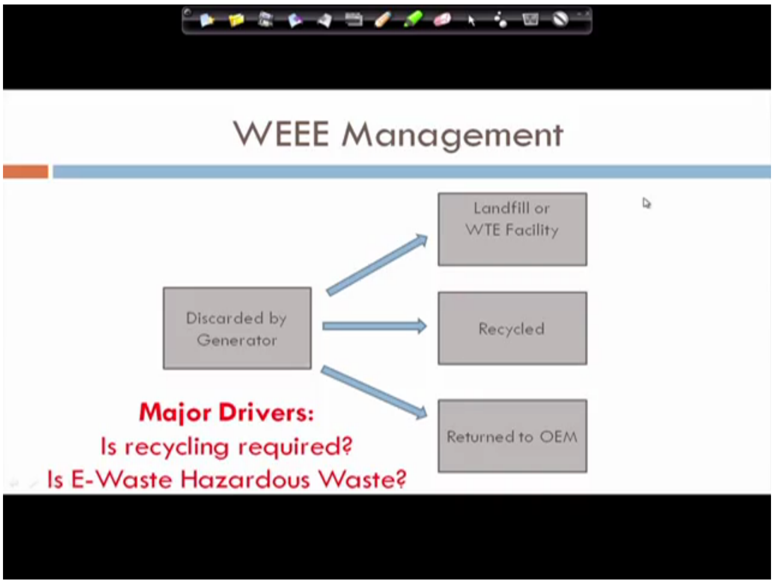

So in terms of management, once it is discarded by the generator it can go to landfill, can recycled, can return to QEM, but the major driver is, is recycling required? Is the recycling mandated? Is a recycling is mandated then probably people will do that. Is e-waste is a hazardous waste? That is another thing. Is the e-waste that we have is the hazardous waste, if it is a hazardous waste again people will try to it has to be managed as a hazardous waste. But as I said, as per definition of rules e-waste is exempted from the definition of hazardous waste.

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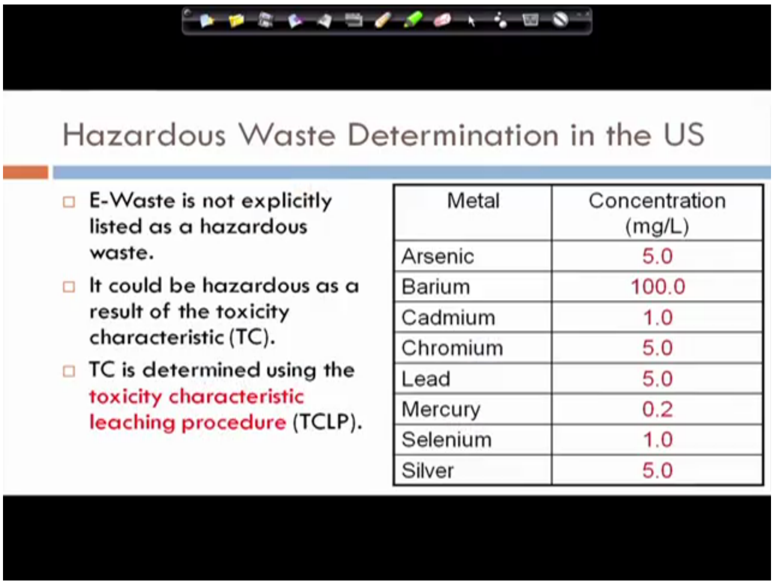

So hazardous waste determination, you saw this slide earlier, probably we try to do it. It is not explicitly listed as a hazardous waste, it said e-waste is not listed as a hazardous waste, it could be hazardous as a result of the toxicity characteristic. So toxicity characteristic is dependent using determine using TCLP test so that is TC is determined using the TCLP test, so you do the TCLP test and you compare that to the standards. This is some examples standard shown here in arsenic, barium, cadmium, chromium, lead, mercury and all that. So you can use like we will can do that and then look at the same time we can compare with the standard, so that is TCLP test.

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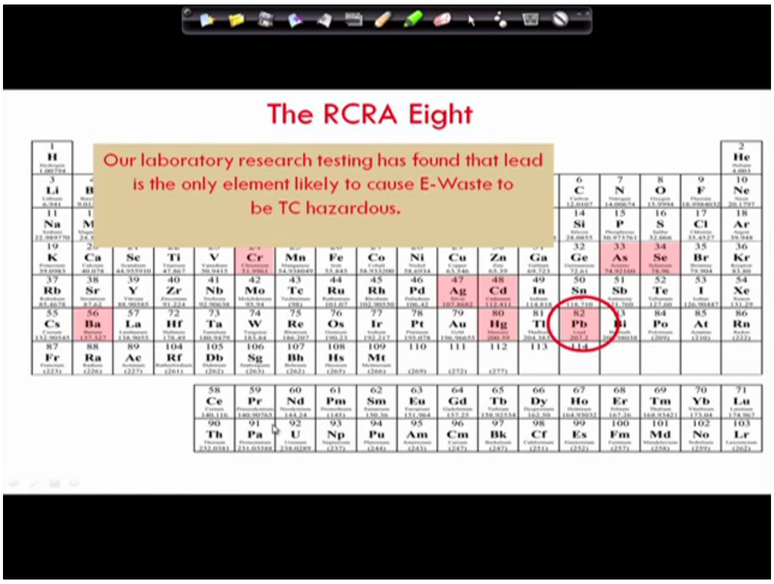

So in terms of RCRA eight so we did lot of testing and then we found that led is the only element likely to cause e-waste to be TC hazardous. So lead was showing up when we do the TCLP test and thing is for lead is lead does show up a lot with the presence of acetic acid. Because of acetate ion and lead ion they really like each other and then they come together and that is a lead does leachability shows up. So there has been some research done in our lab as well we found that lead is the only element that is causing e-waste to TC hazardous, but other things also do Leach out.

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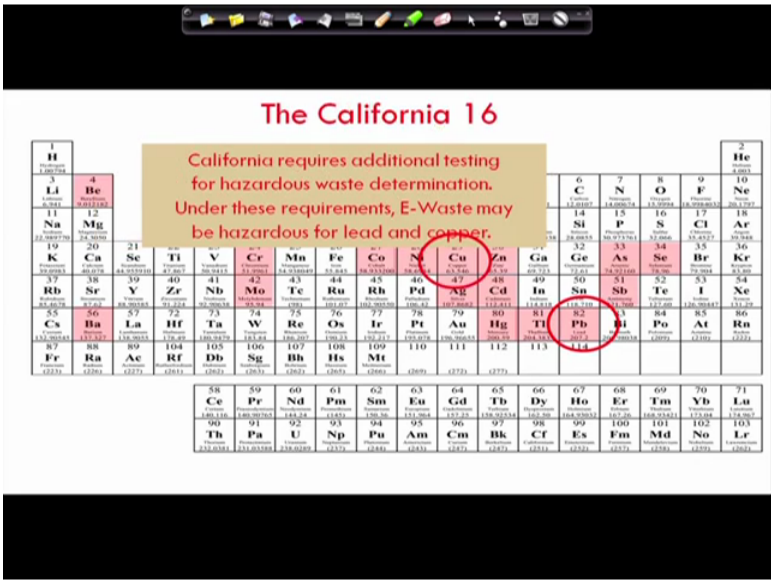

Then there is a California 16, so if you are California has additional testing for hazardous waste determination. So under this requirement e-waste may be hazardous for lead and copper, so you need to better like a check whether it is there or not so in case you have been asked to do that. So lead and copper is what we found it to be a maybe hazardous one for lead as well as for copper.

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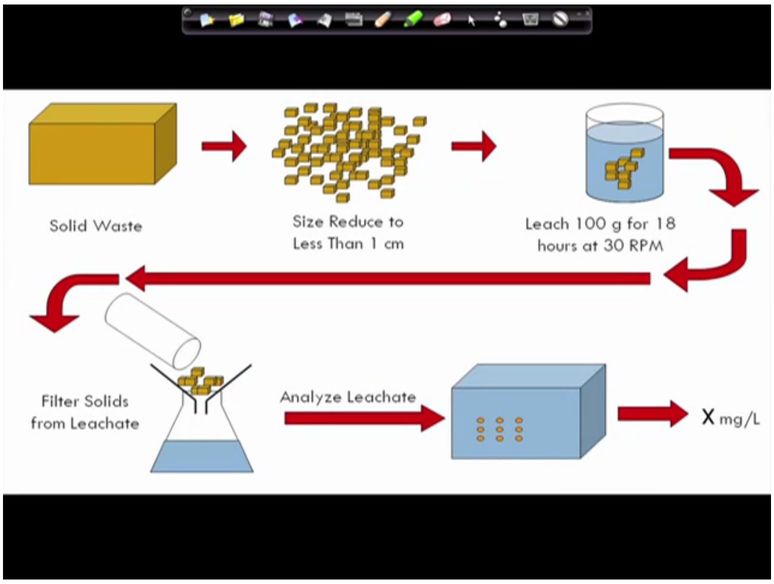

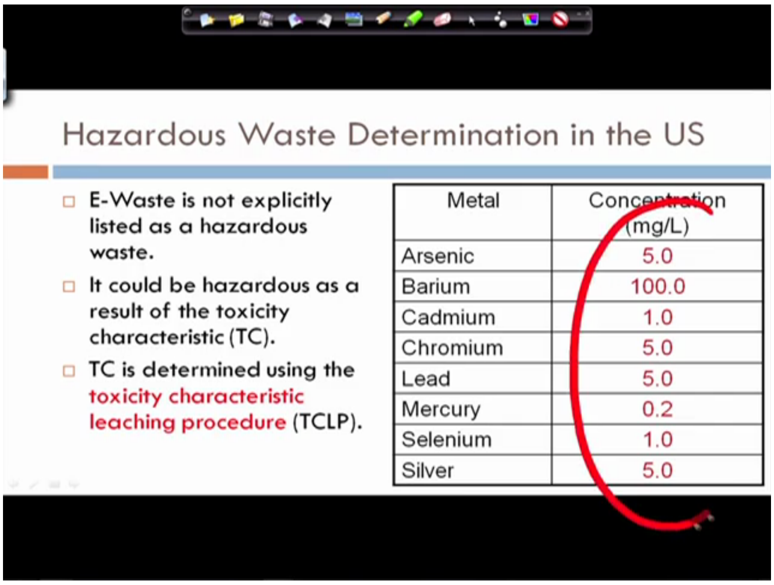

So in terms of TCLP test again as I was I mentioned this earlier, you take your solid waste size reduced to a less than 1 cm, leach 100 grams for 18 hours at 30 rpm, filter the solid, analyse the leachate and then you get your numbers and then you take this number and compare with the previous slide that you compared with the data over here. So you take those X-value, that is there in that particular slide and then you compare that with these numbers and if it exceeds any of these numbers, it becomes a hazardous waste, so that is now we have talked about TCLP test earlier.

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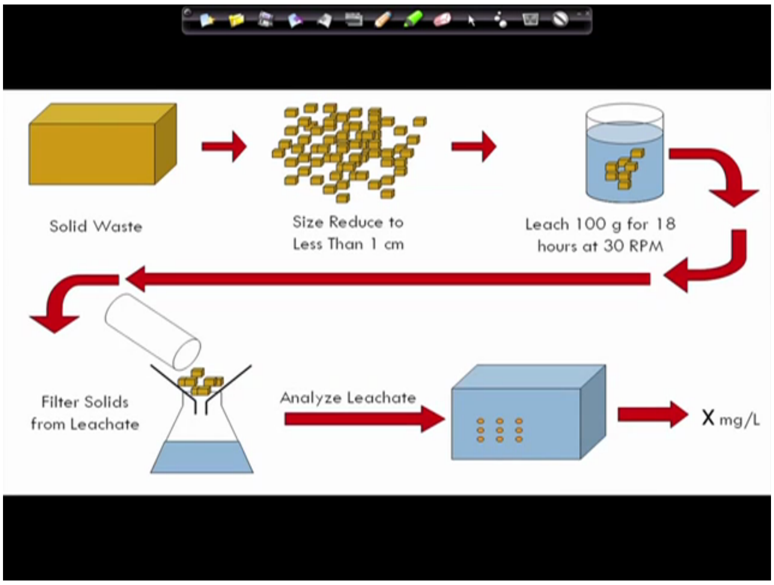

So okay so what is the chance of in terms of the TCLP test, how to do it on e-waste? So as you if you remember from this previous slide we have to get this size reduced sample. So we have to do size reduced sample, so to do the size reduced sample you have to get a like basically why it is a to get a representative sample to make the reaction go faster. To have a representative sample for electronic waste we need to so we need to get a representative sample.

So how in the world to think that you will from this kind of stuff, you will kind of get a representative sample, so there are different items in there. Say we already talked about that thing concern is on the thing of concern is the our like a printed wiring board and things containing heavy metals and organics. So not entire electronic waste is has hazardous nature, the casings, the glass in the front may have some lead little bit, but we do not know but those like so those casing and other stuff some of those wires and other things too they are not have any adverse environmental impact when it is disposed, it is that heavy metals and organics which will create a problem.

So how to get a representative sample from this waste pile to do a TCLP test, it is challenging, is not it? So how to get 100 grams? So could I just take 100 grams from one particular aspect here or if I am doing a like a computer or a monitor, this is the monitor or a copier this is a copier machine I think so like a printer machine. So should I just take the plastic casing and get that 100 grams or what should I take it? So the question the answer to that is you should try to take the different components in the proportion that they come into the instrument into that particular waste.

Say we have to take, if there is plastic, there is a glass, there is a metal and there are some other components so you look at as per the weight of that machine, what are the weight of individual category whether it is a plastic, glass and other stuff. So based on that you take, say if it is a plastic is 10 percent, so out of 100 grams you take ten grams plastic, printed wire board is 30 percent, so you take 30 grams of plastics, so that is how you kind of sorry 30 grams of stuff which has printed wire boards, so printer wire board so that is how you come up with a representative sample.

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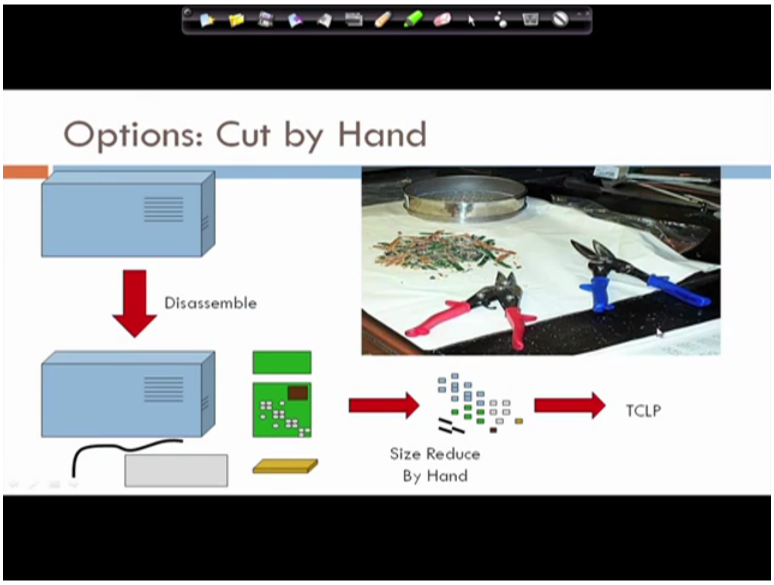

So and the other thing is to size reduced, like how will you do the size reduction, that is that is again a problematic how to do that. So option one option is to cut by cut by hand, so if you have cheap labour available, you can get this and let the people cut it, it does require some efforts you cannot do much in a day but you can size reduced it by hand and then take the sample and do that TCLP.

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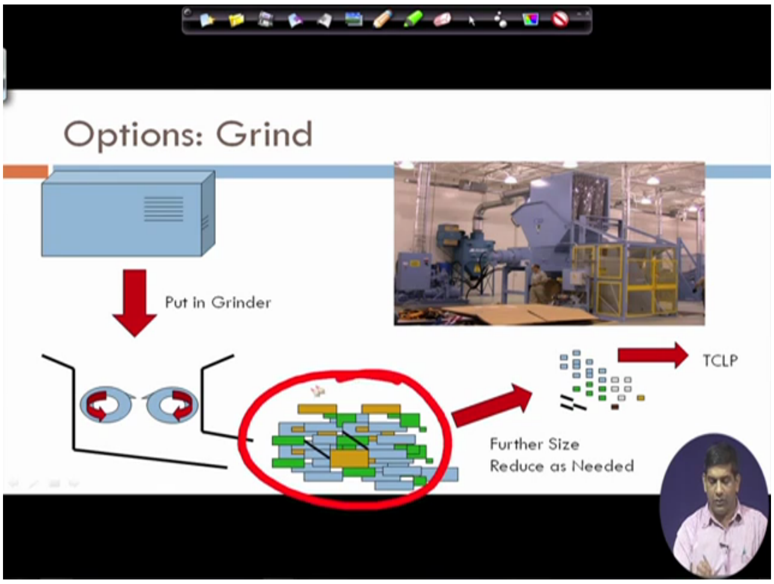

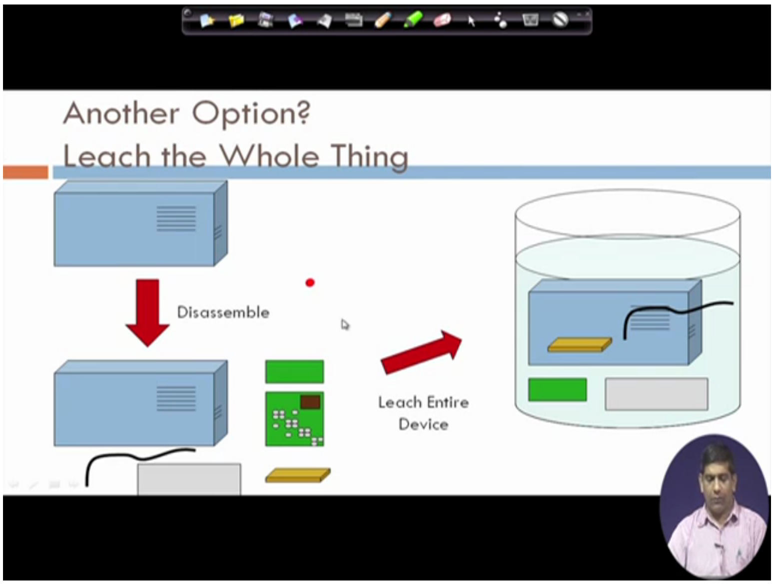

Other option is to grind it, where you can grind the sample and put it through a grinder and then you get this kind of sample after the grinding. And then you given further size reducing, so it is a further size reduce it to do the TCLP test. So then what are the another options we have, another option is you leach the whole thing.

Why to even get the 100 grams sample, because when many times in the electronic industry or when you talk to people working in the waste management field with the electronic waste, they say it when you put it in a landfill it is not going to broken down less than a centimetre, it is going to just stay as it is probably the compactor will come and it may just crush it a little bit, so why do not the other thought was why do not we just take this whole thing and make a big drum and do dump it the whole thing there based on the weight of instrument we will have 1 is to 20 liquid to solid ratio, multiply it by 20 to get a like a liquid there and let us let it rotates, so but to get a big drum rotator that we need that is what we need for doing this when if you want to do the leaching of the whole thing.

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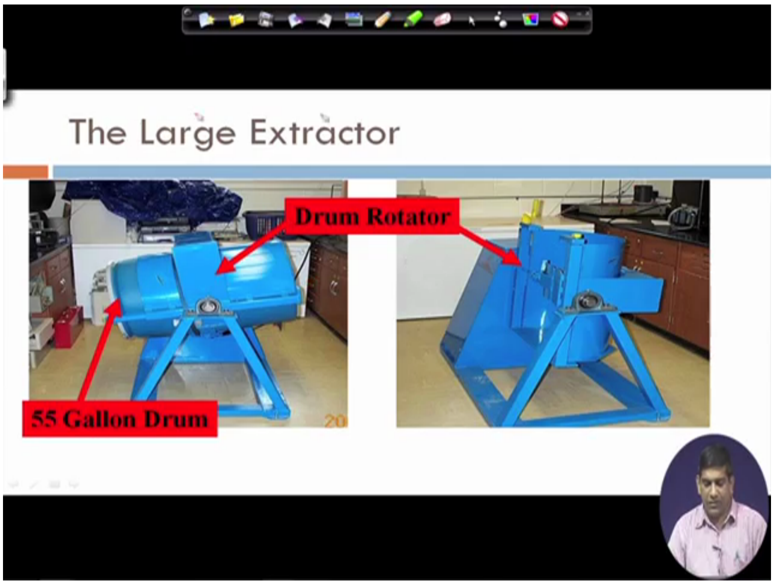

So we did had a chance to get this drum rotator made which was used to do this TCLP test in a big container so that really it is a like it is again has the same rotation as required for TCLP. So same revolutions per minute and we also tested out some samples, we did TCLP on this drum rotator as well as on regular TCLP rotator and the data was more or less kind of in the similar bulk parts, so then we decided that we can probably use that and he reduce the rpm as well. We rather than using 32 rpm we reduced it to around 23 or 24 rpm if I remember correctly and that also worked out to be okay. So those are stuff in terms of in terms of extractor, modification of the extractor to get a representative sample.

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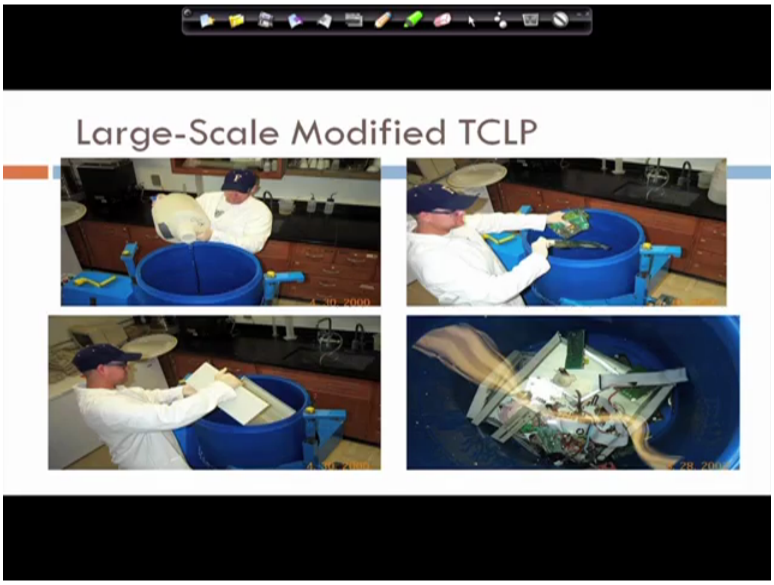

So how you do that? You disassemble your electronics. Then you put it on a large-scale modified TCLP rotator that is how it is getting rotated. Then once you have that large-scale you can have a data from different types of data, from different type of electronics all the different types of electronics were tested which I will share that will take some time so we are coming towards the end of this video, so I will stop at this point in terms of the lecture and then in the next video we will talk about, what are the results that came out and I will kind of maybe back a few slide to recap some of the this stuff.

But in terms of large-scale TCLP, TCLP test is done to find out whether the solid waste is hazardous or not. So for a thing like electronics waste it is very difficult to get a 100 grams sample, thought process is that why do not we do it on a large-scale. So when we do it on large-scale, it is a big drum to rotating that at 30 plus 30 rpm was difficult, you require so we reduce the rpm and to make it go little bit and then we tested whether there is an rpm effect, whether there is a rotation change in revolution impact all those things are tested as part of master's thesis which is already published out there.

So let us stop here, again do that small survey on e-waste, like you did for municipal solid waste. Please do that it will be really helpful to all of us because we will like to see how the e-waste is being managed in the country as of now and we will share that information with you toward the end of this particular course. So with that let us stop this video and then I will see you again in the next video. Thank you.