Electronic Waste Management – Issues and Challenges

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Lecture – 06
Environmental and Public Health Issues

Welcome back. So, we will start our material for week 2 now. We have done the week 1, if you remember from the week 1 we had a big overview of Electronic Waste. We talked about, what are the different components; we also looked at the different types of chemicals presence. We talked about the cost associated with that, how it is managed kind of had a big overview of that aspect as well.

And then we also tried to quantify, see if you have to quantify the amount of e-waste produced in a 1 particular city or region, how to go about that and I showed you an example of Kolkata city in terms of how to estimate, how much e-waste would be produced and how much money that can be generated by recycling of those e waste.

So, now we will, in this particular week will focus on and I hope you had done already the quiz; if you have not done please do the quiz. And submit it on time and. So, in this week we will be focusing on looking at the environmental and public health aspect. So, as I was telling in the earlier as well anything we are especially, from the environmental point of view we are always worried about its impact on the environment; its impact on the soil, water, air and also impact on the human health. So, that is what we are talking about when we say environmental and public health issues.

So, when we talk about that.

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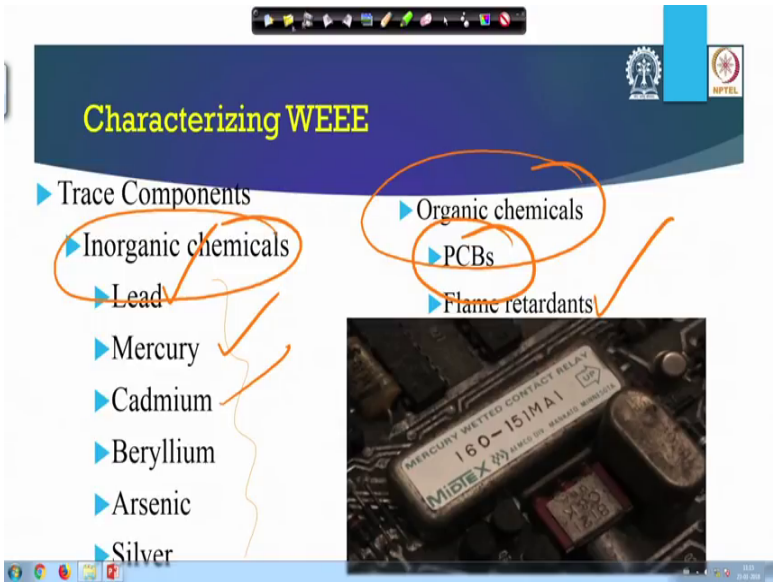

So, in there are different types of, we have a trace components. We have organic chemicals in terms of different types of trace material present. We are looking at Lead, Mercury and. So in terms of the different components as you can see, we have the inorganic chemicals and we have the organic chemicals. So, these are the 2 broad categories of contaminant

Among the inorganic, we have the Lead, Mercury, Cadmium, Beryllium, Arsenic, Silver and they are there because they are used for certain applicator, they do certain function on different electronics. Even in your cell phone, if you take your mobile phone, if you have a smart phone just go online and try to find out based on the make and model you have, if you start trying to find out what are the different components present.

You may be able to see that it is till many of the cell phones a little bit of Lead there; some Mercury is present, Cadmium could be there, Beryllium, Arsenic, Silver maybe there, may not be there depends on how like how much old is your cell phone and some mec has time to get rid off that and try to introduce other elements in there which is less environmental impact, less human health impact.

Then PCB's which is polycyclic, this is used a lot in the capacitors, in the transformers and other places. They were used for as a flame retardants as well; the other flame retardants are also there. So, there are a lot of different like a different chemicals which is used in different types of electronics industry and then these chemicals they do a certain

function, but at the same time they also lead to environmental impact or impact in terms of human health.

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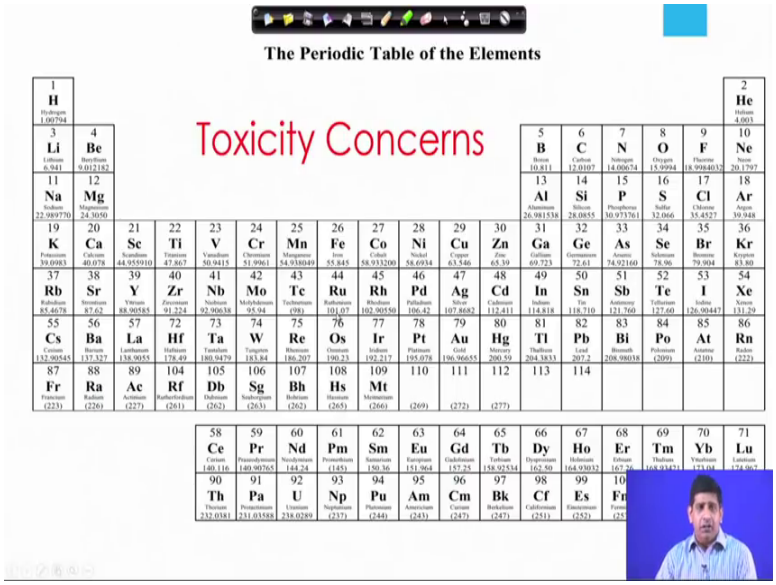

So, we have certain toxicity concern in terms of different types of elements present from the periodic table.

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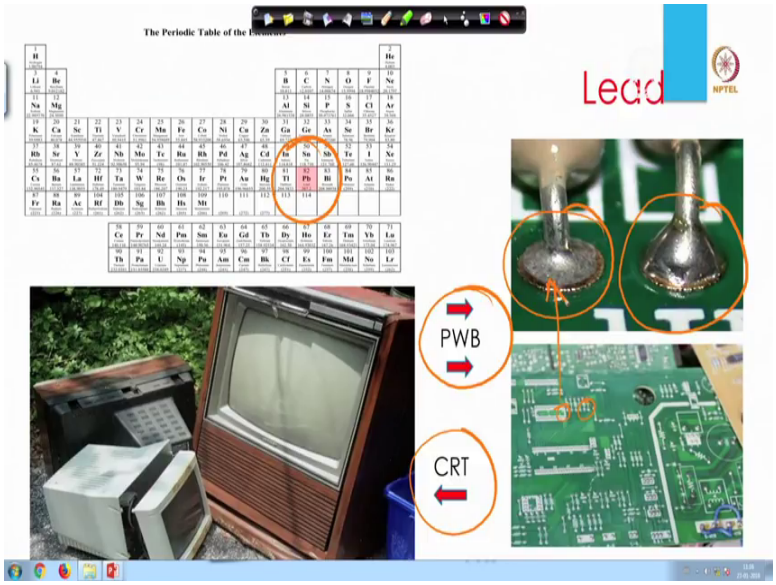

So, as you can see, Lead is the number 1, cause of concern in terms of when we look at the e waste. Lead from the periodic table if you remember, Lead is present; we have the Lead right over there. It is one of the heavy metals. Lead is used in printed wire board

that is where we see a lot and CRTs Cathode Ray Tubes. So, this is your when you do the soldering iron this is kind of a zoomed image of a solder on a particular printed wire board.

So, you see the printed wire board here. So, these are small - small sorters that has been zoomed in here and kind of solder zoomed image of that. So, that is where the sources of Lead are, that is where the Lead is being used in electronic industry. So, Lead is there and Lead base solder even if you have done a small science project in your high school or if your first year electronics project maybe you have done some soldiering on certain you made some call like call bell or any small toys even if you made, you can you will be using those lead base solder.

And so, that is what, so, that is where the lead is coming from in the electronics for the CRT is the lead is also used as a layer to protect the harmful ray from coming to us in terms of impacting our health I think we will look at it, yeah here it is.

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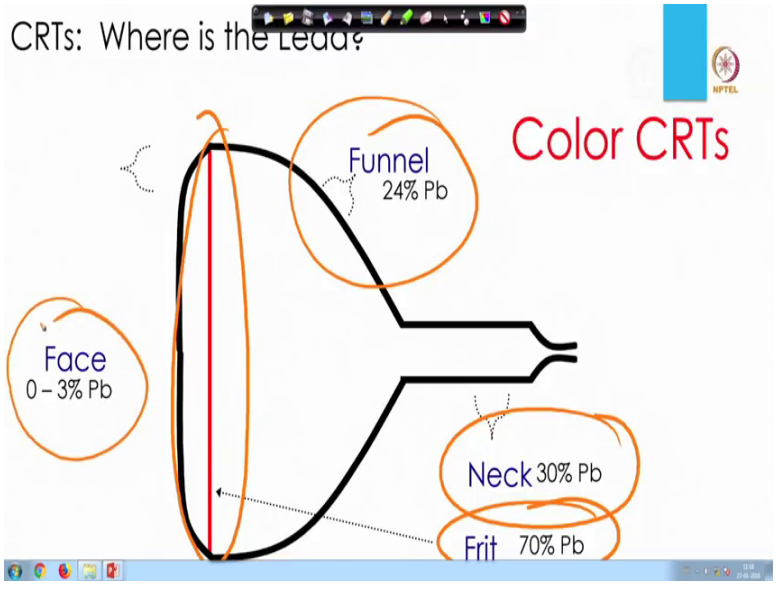

So, in terms of the CRTs, now we are phasing out CRT, you don't see these type of monitors, even in for the computers and also you don't see these type of monitors in your home. So, the newer that flat panel were probably that flat panel computer monitor of flat panel TV's, it still have a little bit of lead, but the amount of lead has gone down. So, that is, but it is still we use a layer of lead as you can see over here as you can look at this

particular you see this is like a one kind of it is called the Frit which the by weight it is nearly 70 percent Lead as you can see over here by weight its nearly 70 percent Lead.

The newer one is much less, but in the disposal stream is still we see lot of CRTs coming out. So, the CRTs do so up in the disposal stream that is where we still see a lot of Leads showing up. Then, we have in the Funnel we have 24 percent Lead in the neck we have 30 percent lead and these are all by weight. So, these are all by weight. So, we in the Face we have 0 to 3 percent lead.

So, why this Lead is there because it helps it keeping the harmful rays away and. So, that the harmful rays donot impact our health, when you are using these ah TVs or computer monitors. So, that is the reason why, it is there and. So, that is in terms of and then if you look at the Monochrome CRTs.

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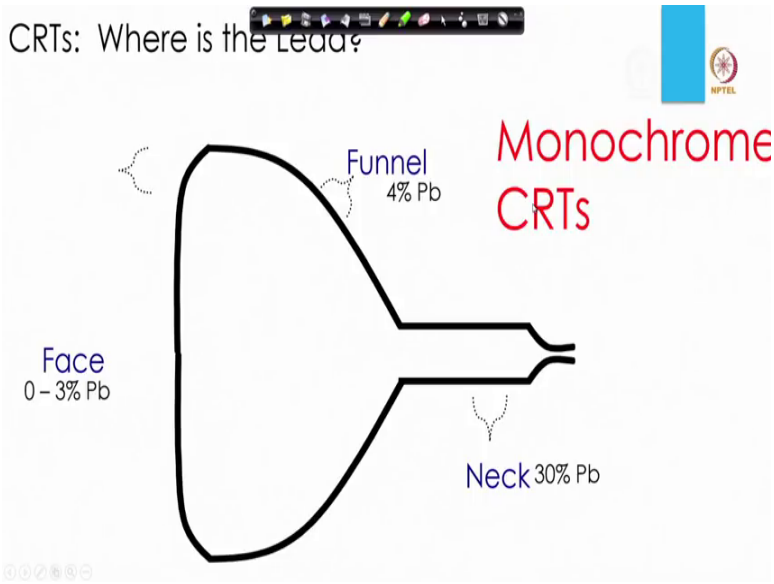

We donot have in the Monochrome again, we have the Neck, Funnel and the Face where you see these things are being used.

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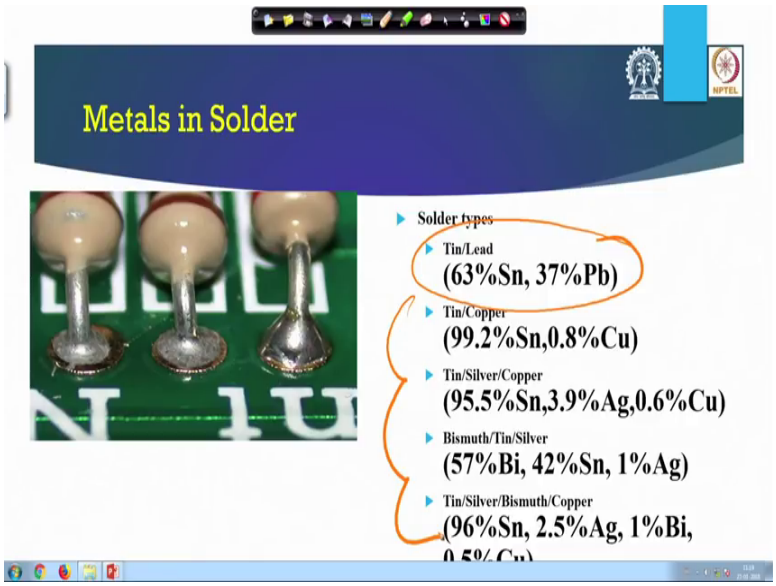

So, not only Lead there are other solders are also presents other sorry other elements other metals are also present since solders.

So, here as you can see one the different types of example we have Tin Lead solder which is the most common solder is still used in many parts of the world, many some countries have banned this use of Lead based solder and they have tried to go for these alternative ones. So, if we when we go for alternative ones there of course, any product that you have, it has a certain intended function is not it.

So, it has to do the function. So, this soldiering what did they do? They all these different chips which is there, on your printed wire. So, there they put these chips in position and then you have solder it. So, and it keeps it in the position. So, this new soldiering complex is should be able to do that as well. Since Lead and Zinc used to do that work very nicely, its easily available, easy to work with that is why they were popular.

Now, when we learned that Lead is not good for health, we are trying to replace Lead with other material. So, these are some of the other alternatives. So, what are those? We have some Tin copper which is essentially a lot of tin a little bit of ah like a 99.99 percent Tin and then. 0.8 percent copper, 99.2 percent actually. Then we have Tin Silver Copper, Bismuth tin and silver, Tin Silver Bismuth Copper. So, there are different options are there and based on their cost and other stuff of course, we know silver is costly and

copper also has certain price. So, we have to compare to other elements which is listed here.

So, we can use some of these elements in terms of replacing lead. But they are they also have for example, Silver or Bismuth; they also have certain like a toxicity values. So, we have to make sure whenever we are substituting 1 element with the other element, it is always we need to ensure that the other element should not cause another problem.

So, it should not become that one problem is solved, but the other problem got started. So, many many times it does happen that way because we don't look at things in a systems perspective we look things in a silos perspective; when we say silos we are actually looking at 1 compartment at a time.

One example I would tell you that if you have for the for example, in the water treatment plant. Water treatment plant if there we brought down our artistic is stranded from 50 micrograms per liter to 10 micrograms per liter. Now 10 micrograms per liter if the arsenic has to be removed it doesn't disappear, it doesn't go going to disappear, it is going to stay somewhere. So, where it will be? It will be in the sludge. So, the drinking water sludge that is produced will have more arsenic now.

Because we are removing this, arsenic from the water phase. So, it will be in the solid phase and now that the arsenic bearing sludge if not managed properly, if it just dumped on the side of a lake or dumped on the side of any surface water or put it in a dump site. So, what we are doing?

We are actually, what we did that arsenic problem from the drinking water we made it a solid waste problem and the over time it will become leaching of arsenic from there and it will be 002C it will go to lake and other places and contaminate the surface water and potentially groundwater as well.

So, we have to manage that arsenic bearing sludge properly. If you donot do that part of the job, just focus on the water treatment part; actually we are not really solving the problem 100 percent. We are just making 1 problem go away by creating another problem. So, we have to make sure the other problem also addressed.

So, here again, when we are getting rid of lead and using these other elements, we need to make sure that other elements also does this should not have leaching and other impact in a high concentration enough to become toxic because they also have certain toxicity values.

So, being said that.

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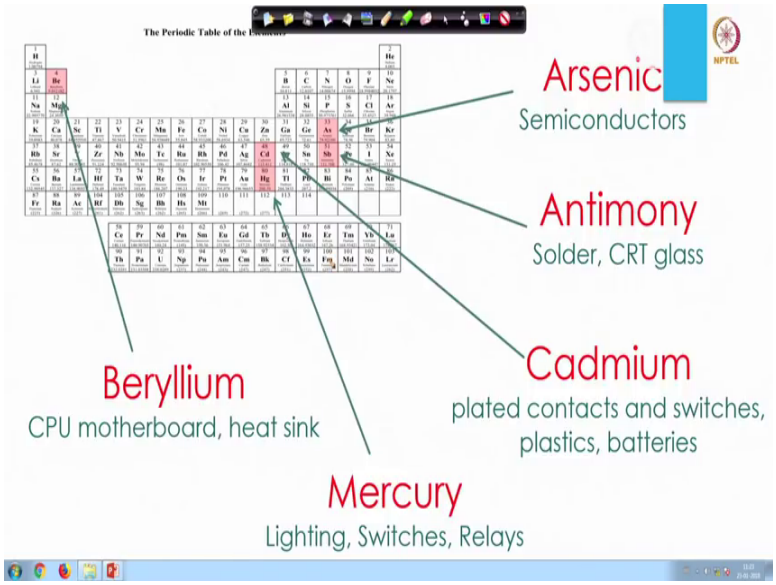

So, these are the, but there are different like we do have different elements present there. So, are and why they are there? We already I just try to mention that earlier that they are there because they do certain function. So, for example, Arsenic is used in Semiconductors, Antimony you will use in Solders, CRT glass, Cadmium plated contacts and switches, plastics, batteries, nickel cadmium batteries.

Cadmium is largely used a lot in the batteries. We have Mercury, which is used as Lightning, Switches and Relays. Beryllium, Beryllium is used in the motherboard; it also used as a heat sink because when things get started heating up Beryllium keeps acts as a heat sink to keep ah the heat away.

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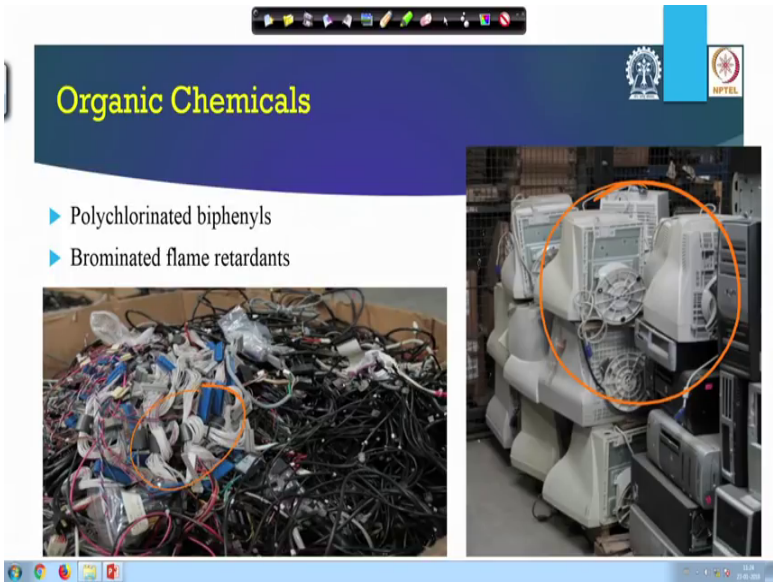

So, there are and then, there are some organic chemicals we have Polychlorinated biphenyls which is PCBs; we have Brominated flame retardants which are used we have different types of mixed plastic.

So, if you look at any of this you have, if you have a remote at home you look at the remote the type of plastic or even if as you see these pictures over see this picture over here, as you can see these plastic materials, these are not one particular type of plastic; these are blended plastic, many of these plastics over here is also blended plastic.

So, what do you mean by blended plastic? That 2 - 3 different types of plastic blended together. They do the function what it is intended to do. But it becomes a nightmare for the waste management people because since it is a blended plastic you cannot really recycle this plastic easily. They are 2 - 3 plastic together. Now you have to separate 2 - 3 different types of plastic to make it recyclable and it becomes a big, big problem it is not profitable; it is not economically viable to do that.

So, what happens? One option is these plastics will be sent to the waste to energy plans because they have a good heat value, they have a good calorific value and potentially can be used for energy production. So, that is option is there, but when you do that, you have to make sure that all the air pollution control systems are taken care off.

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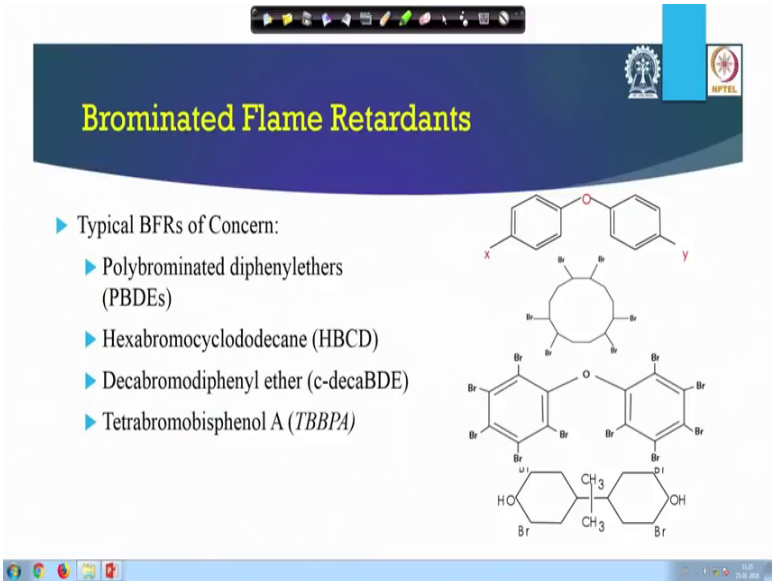

Then, we have the other aspect which is the Brominated Flame Retardants which is used a lot PBDEs which is Polybrominated flame retardant, Hexabromocyclodecane, c-deca BDE and TBBPA. So, Brominated Flame Retardants are used quite a bit and what is the use of as the name suggests flame retardants.

So, what does that mean? It is retarding the flame. So, where the flame will take place? Say when you are using your laptop, are you using an electronics, you see that over time it gets heated up. So, there are. So, it may catch fire if that the heating is not controlled.

So, that to control the heat, this flame retardants are there. And the flame retardants is not only used in electronics, it is used for furnitures, it used in your couches; it used in your mattresses and not lot other places. So, flame retardant. So, have you been used in different places and a still, a lot of research is going on in terms of what is the adverse health impact or environmental impact of flame retardants. Some results suggest that it could be potentially like a carcinogen or can have a different types of impact on human body. So, but, again it is needed. Flame retardants are needed for the functioning of those particularly electronics. So, that is the reason why it is there. It is there.

Because it is needed over there only thing is that, now to rather than using these flame retardants Brominated flame retardants also causes dioxins and furans. So, can we use some other flame retardants, which you will not cause these environmental contaminants? So, that is what we need to kind of look at.

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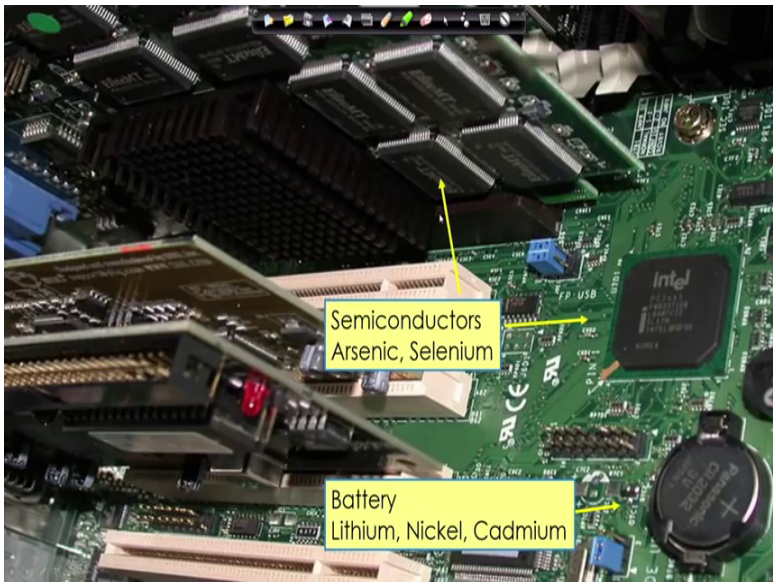

So, again some other like Semiconductors for Arsenic and Selenium, Battery you have the natal Nickel, Cadmium, Lithium; Nickel, Cadmium all those batteries are used. Nickel, Cadmium battery pack is there which is used.

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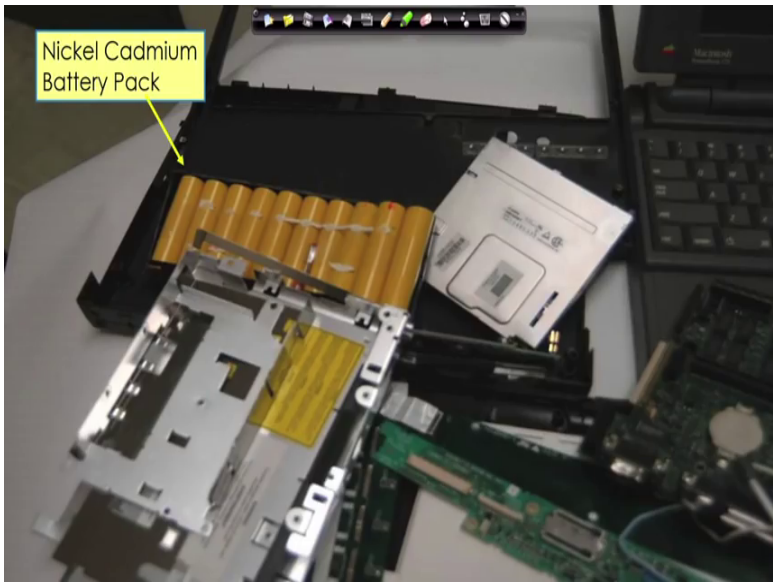

In different types of electronics, we have mercury lamps from laptop.

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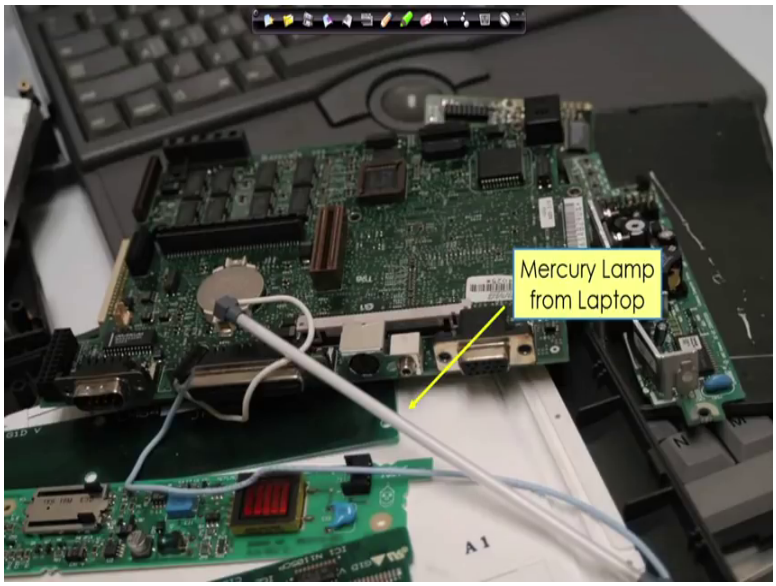

Some of the newer laptops, they don't have mercury lamps, but the older ones would do have, these you can see the mercury lamps being used from the laptop.

So, that is where it is being used and, so all these electronics which is being generated.

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So, we were looking at the different contaminant present in the electronics and once they are when they become part of the electronic waste, this contaminants comes to the electronic waste. What the in terms of the real impact on environment or real impact on human health will come if it is not managed properly.

If we can manage it properly; it is the impact can be minimized. What is happening today over things or kind of where most of these electronics from in the developed countries. There are some infrastructures where, they are trying to recycle; they are trying to manage these electronics.

But whatever electronics, they are not able to manage a good chunk of that is ending up in the developing countries. So, there has been lot of protest against that as well. So, but, this particular picture kind of shows you some scenarios which is, this is a bit older picture not brand because these kind of graphs does not get created every year. So, this is couple of years old picture. I would say nearly 4 years old now.

But this is what was the scenario? 4 5 years ago. Because if a 4 year picture the probably the data was collected in another 2 3 years back. So, this is some scenario, few years back and the scenarios have improved a little bit, but it is still not 100, it is not totally perfect.

So, if you can look at this particular image right here, what we are looking at is how the e-waste is moving a globally and it is an environmental justice issue. it is an environmental I would say kind of we need to look at carefully in terms of how to prevent this from happening. So, what is happen, what is what we are looking at here? If you look at carefully, I hope the color combination is good enough for to see the differences here.

So, we have few places which is been designated as the major source of electronics. So, we have European Union, US, South Korea, Japan, Australia. So, these are the known sources of the e-waste produced. Now the red dots and the dots and the size of the dot, bigger the size dot means bigger amount of waste is being produced. And then, the red dots are the ones where that e-waste are being handled.

So, as you can see you the most of the red dots where you see the red dots are being aware the waste is being managed and. So, as you can see the waste is traveling from US to Africa, from also from US to China and from European Union to India, from US to India and from even to South American countries, from Australia again to China and Singapore acts as a hub actually where, it kind of Indonesia, Thailand.

So, most of in terms of the electronic waste that is being produced again as I said this data would be 5/6 years old. So, electronic waste in the big hot spots where, the electronic waste are being produced is US, European Union, South Korea, Japan, Australia and those countries where they are mostly managed is China, India, Pakistan, Brazil, Mexico, Nigeria, Thailand, Singapore, UAE, Kenya, Tanzania.

So, that is where the e-waste is actually traveling and the problem with this model is most of these developing countries although the regulations are in place there is a e-waste Management rules 2016 and in India as well which was first one came in 2011 which has to be implemented in 2012.

So, we do have a new e-waste Management rules as well, but the problem is on the implementation type, the implementation side is still in Indian context as I was telling you in the 1st week and nearly 90 percent of the wastage gets managed in the informal sector. So, think about that our waste extreme is increasing and at the same time, we are getting the waste from abroad and it is creating more and more problem of in terms of the environment and human health impact.

So, there is a the that is problem needs to stop like a where the wastage needs, it needs to be managed. What happens in many times actually the waste when its gets sent over to these countries, they are not sent as a waste; they are sent as the old computers for donations, old computers for this and that and by the time it comes here most of it lately half of it will be dead on arrival.

So, it is becomes a waste over here and of course, it is not that one way to one way stuff things. We have people in these countries who want this waste to come because they kind of make living out of that. So, but there is a lot of adverse environmental and human health impact.

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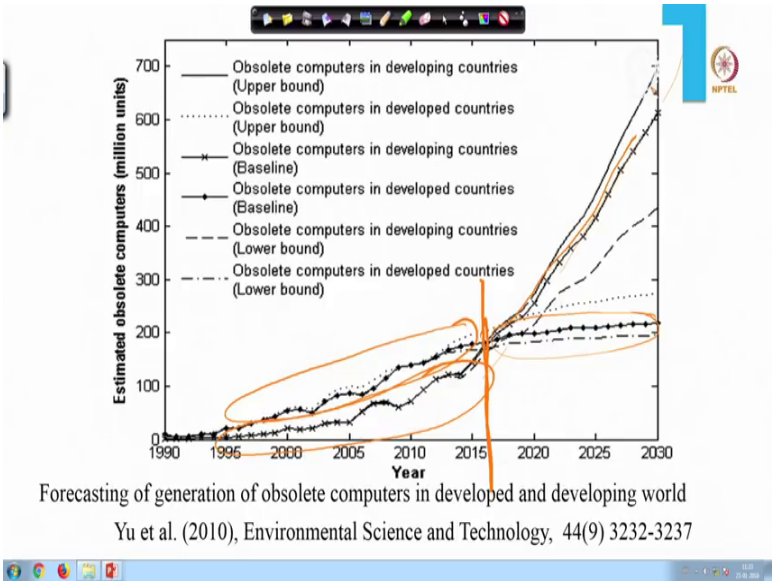

Forecasting of generation of obsolete computers in developed and developing world

Yu et al. (2010), Environmental Science and Technology, 44(9) 3232-3237

Now, if you look at in terms of how the waste is being produced and this is this was an estimate done again, nearly I think 2010. So, it was an estimate then, that by 2030 how the e-waste production will change. So, as you can see, if you can see over here the take home message from this particular graph would be if you look at developing countries and developed countries.

So, things at the bottom is your developed that the various where you see the cross, these are your developing countries at the bottom. So, here to start with we have the developing country data at the bottom and then we have the developed country data on top here.

Now, at some point like around 2016-2017, what we are looking at is actually the developing countries are picking up and the developed countries are still producing, but things are flattening out there because of the less population here more and more population and the affordability of electronics are going up. So, we see a increase in the waste that is being produced within the developing countries.

And of course, the this also is increasing, but the rate of increase is much less. Here basically you see kind of an exponential growth of electronic waste that is being produced in developing countries. So, that is and then there is a lower bound, upper bound, baseline kind of some estimation is there.

So, as you can see that as of today the e-waste that is being produced in developing countries is actually getting higher than the developed countries and then on top of that if we start getting the e-waste on the developed countries to the developing country that becomes a nightmare in terms of managing those. So just to kind of put things in perspective a little bit here.

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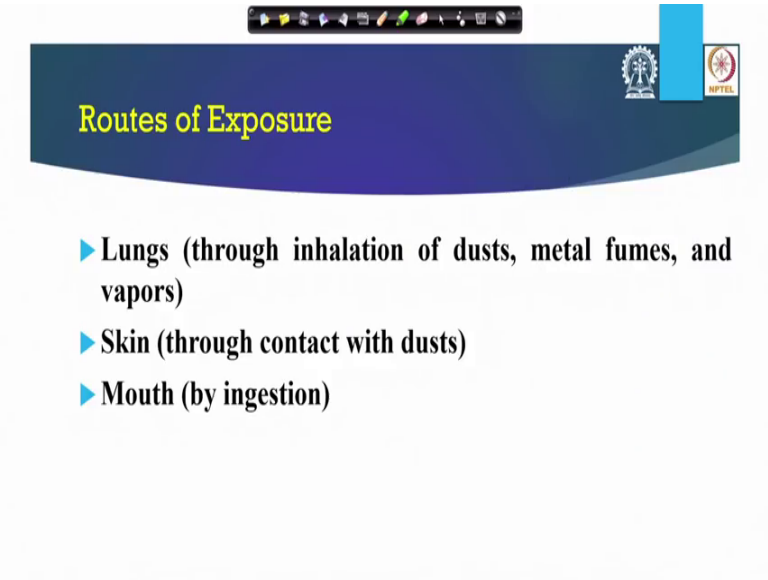

So now we looked at in terms of what is the different elements present. We looked at in terms of how the waste is traveling around and then the thing is that and then different chemicals different elements. So, thing is that why should we worried about, what is that what is really the harm, what is how, it is causing the heart?

So, let us look at that part. So, in terms of causing the harm, it will be through the exposure routes. How things are the different elements are explore are, how our body gets exposed to these contaminants.

So, either through Lungs, which is inhalation of dust, metal fumes and vapors while the e-waste is being produced, e-waste is being processed or through skin which is the through contact with dust or mouth by ingestion like if you contaminated soil or contaminated food or something contaminated water and that is how you get exposed. So, it is through inhalation dermal and ingestion. So, those are the 3 major ways of any contaminant where we get the exposure from.

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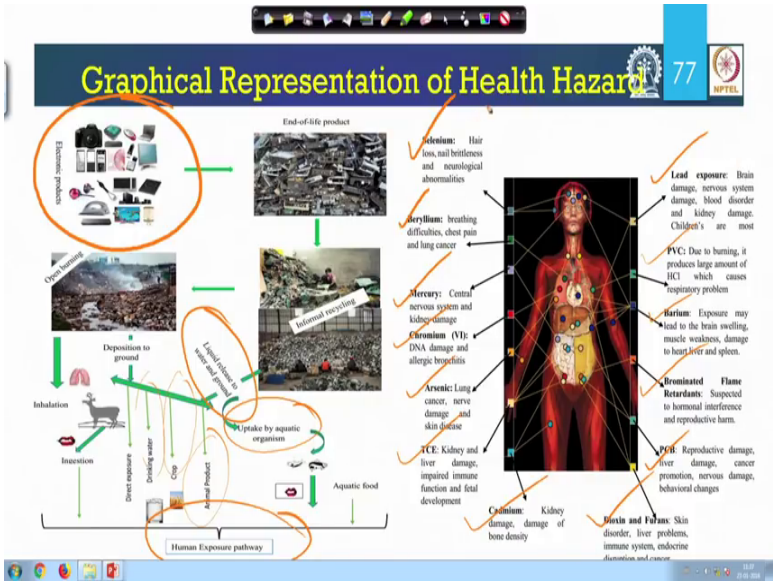

So, so, if you look at the in terms of the health hazard from these exposure, from the electronics. So, if you say these are the different electronic products; it is we are showing you here the different electronic products. Now if you have some the way it is being managed in terms of the end of life management, there is a informal recycling burning, things are being not done properly.

So, what it is doing? It is liquid is releasing to the water in the ground and the ground there could be some uptake by the aquatic organisms in those water. Now the aquatic organism will go to the aquatic food, from the aquatic food it will come to human food because fish and all that. So, we are a part of that food chain as well.

Then, if it goes to the it can into the land, it can go to the animal product, then it can impact the crop and impact the drinking water can have a direct exposure to and then if you are doing a burning of that, open burning. So, you things could be through inhalation that will be Lungs getting affected and. So, those are all, how things will get human exposure pathway that what you will see in terms of the health hazard.

Now, elements that you already kind of looked at, here is a brief summary of the different stuff in there I will not read all that, but this again this slides will be available for you to read. What are that we are looking at a Selenium where leads to certain Hair loss and other stuff nail brittleness, Beryllium much which is breathing difficulties, chest pain, Mercury central nervous system, kidney, Chromium VI, DNA damage; Arsenic

Lung Cancer. We all need a TCE, kidney and liver damage, Lead exposure brain damage, nervous system damage. PVC which is due to burning, it produces large amount of HCL which becomes respiratory problem.

Then, we have Barium exposure may lead to brain swelling, muscle weakness may be a far Brominated flame retardant suspected to hormonal interference of reproductive system. PCBs a reproductive damage, liver damage, Dioxin Furan is skin disorder, liver problem, immune order; Cadmium which leads to kidney. So, as you can see all these a different electronics that we use has certain impact, negative impact on our health. So, if the electronics is not managed in a proper way it is gets into our water, air and soil it will lead to our health hazard. So, that is what we were trying to stress upon on this particular slide.

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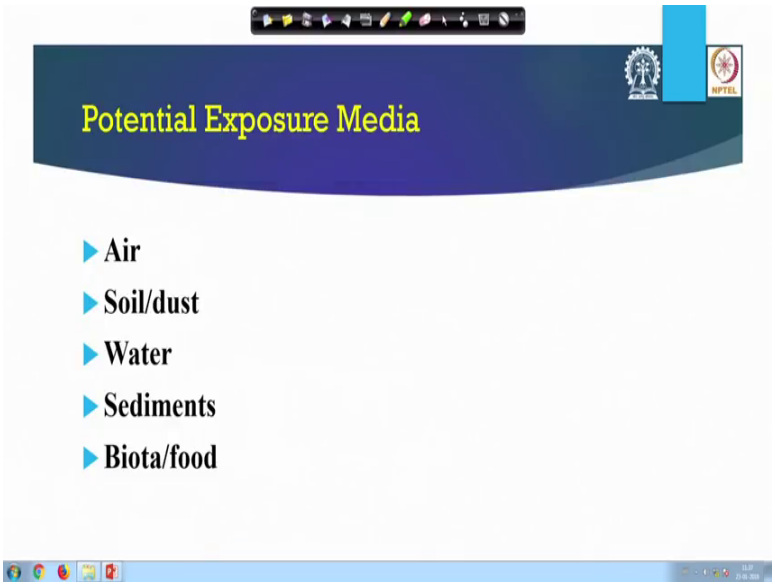

So, potential exposure media Air, Soil dust, Water, Sediments, Biota/food; we already kind of looked at in the previous, previous slide.

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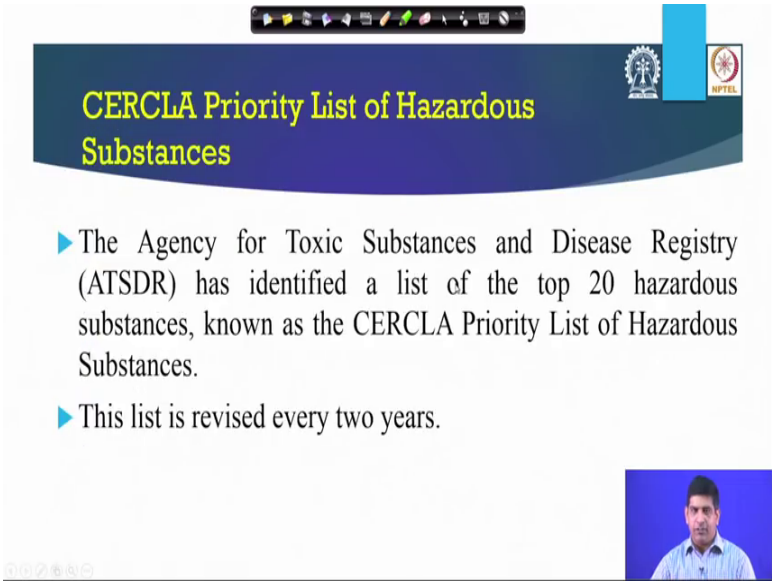

There is a list of 20 top hazardous substances; they are (Refer Time: 24:52) the priority list of hazardous substances. This is, this list is revised every 2 years to look at and the amount of stuff that we looked at right now.

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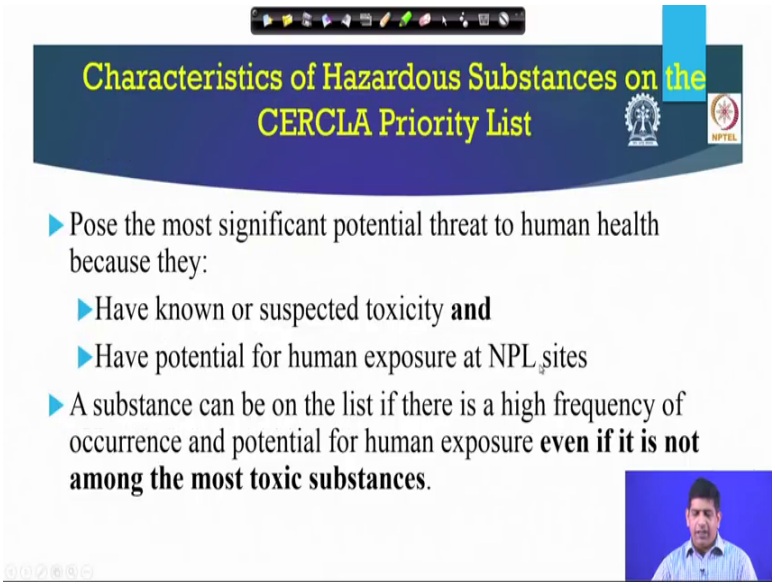

As you will see most of it will just go in a minute, they why they are listed because the pose the most significant potential threat to human health based on known or suspected toxicity and can be there if there if it is there on the list we are try it is a high frequency

occurrence and potential for human exposure. Even if it is not among the most toxic substance in terms of what can cause more harm.

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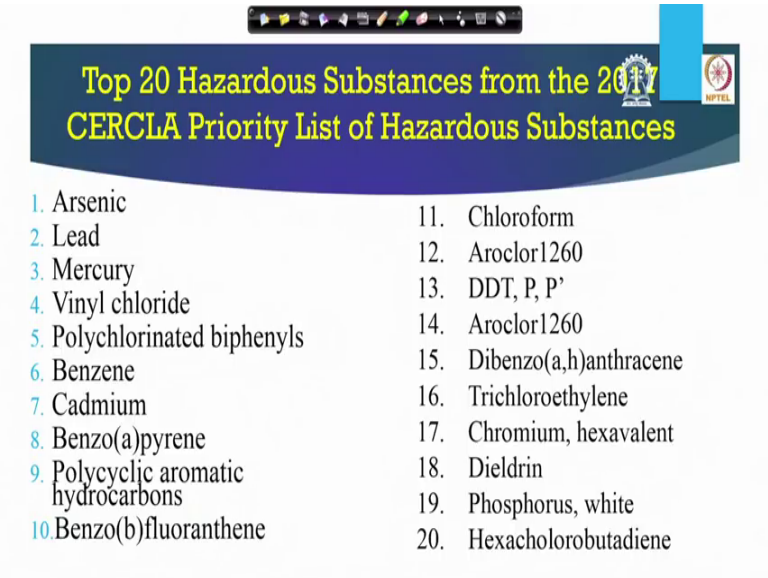

So, these are the amount different elements listed only on that particular list and if you remember, from the couple of slides back many of these also show up in that particular slide. So, Lead Arsenic, Lead, Mercury. Even Poly PCBs, Cadmium. We talked about like a, our different Chromium, Hexavalent Chromium.

So, all these different stuff that is show up on those E-waste list. This is not only related to e-waste, this list is general can be from different hazardous waste, but e-waste also has several of these stuff present that is the reason why we are worried about the E-waste management and you are I already showed you in a big picture in terms of it is human health impact.

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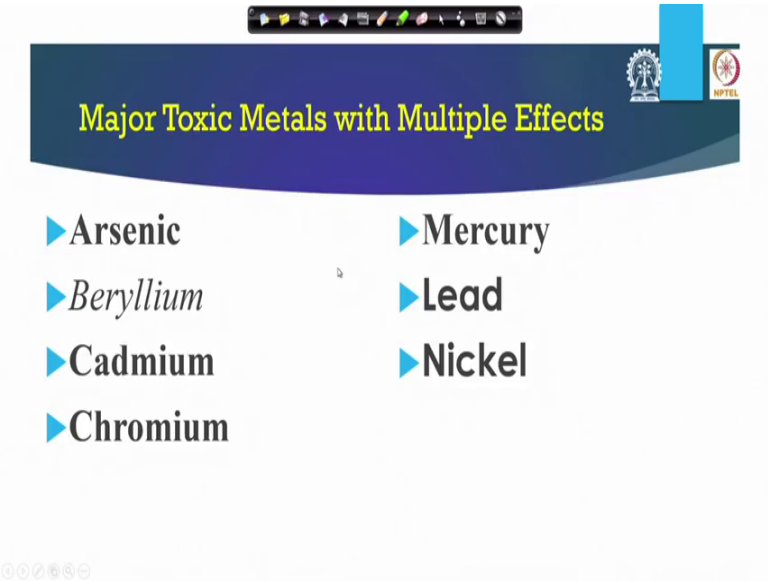

So, so that the may now, we will try to look at individually some of these metals little bit in detail. So Arsenic, Beryllium, Cadmium, Chromium, Mercury lead, Lead and Nickel; so, we will try to say if they are all Heavy metals.

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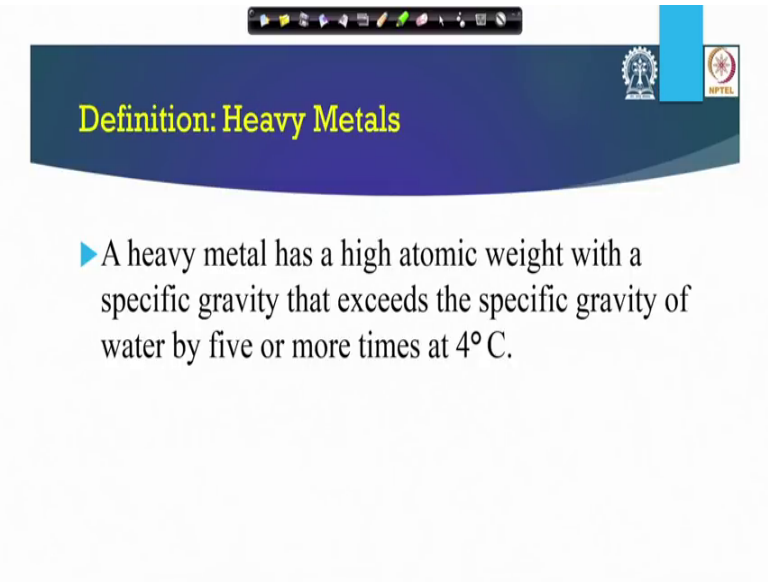

We probably you know heavy metal high atomic weight with a specific gravity of exceeds a specific gravity of water by 5 or more at 4 degrees centigrade. So, some of these just a recap for you.

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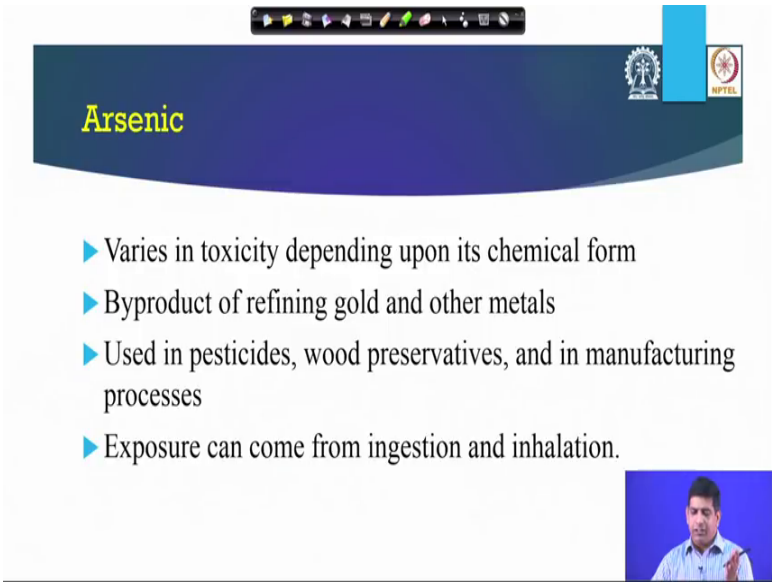

I would like you to Arsenic depends on the different chemical form, there in there gold refining of gold used in pesticides, when exposure can come from injection and inhalation.

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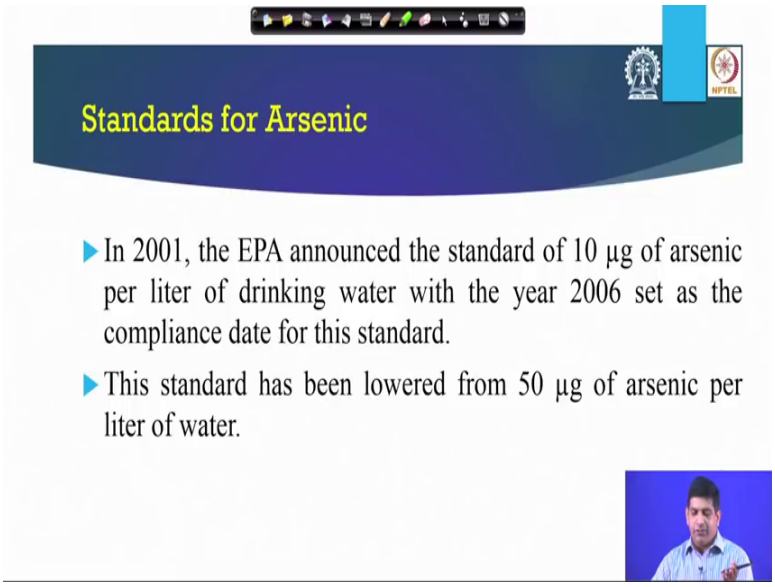

Now, we have 10 micrograms per liter has the standard. This standard has been lowered we know that.

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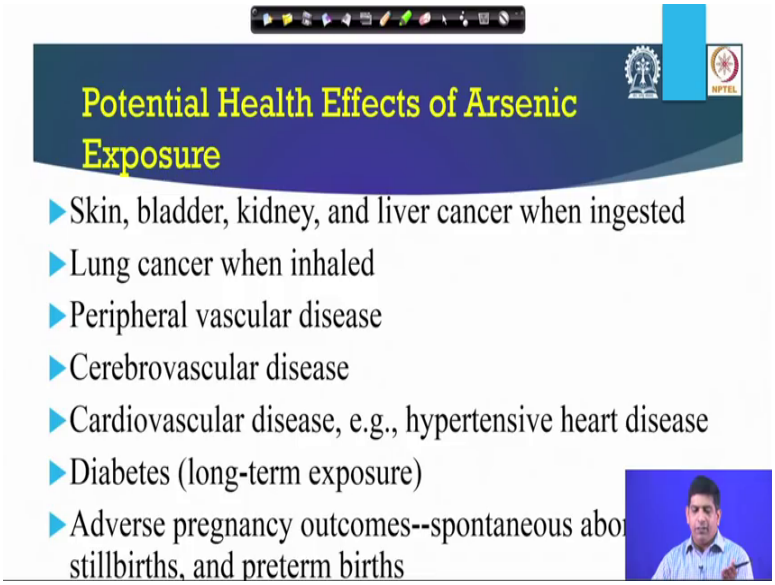

It causes all different types of stuff again, I am not going to read these stuff you just for your information, you can I will provide you this document as a reading material as well. So, just read that again, to find out why, why we should be worried about Arsenic especially from the e-waste perspective; obviously, it has certain environmental impact.

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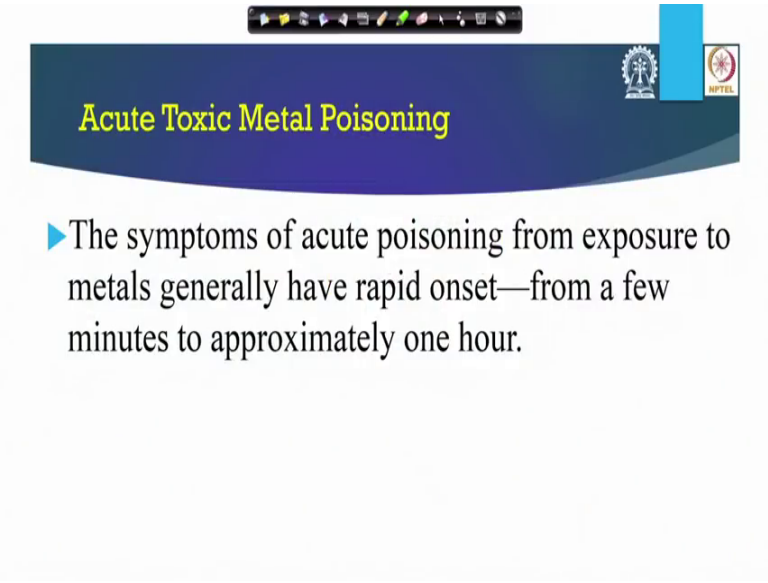

And we do see a Acute poisoning exposure from arsenic, a few minutes to approximately 1 hour, It is a if you have a long term exposure.

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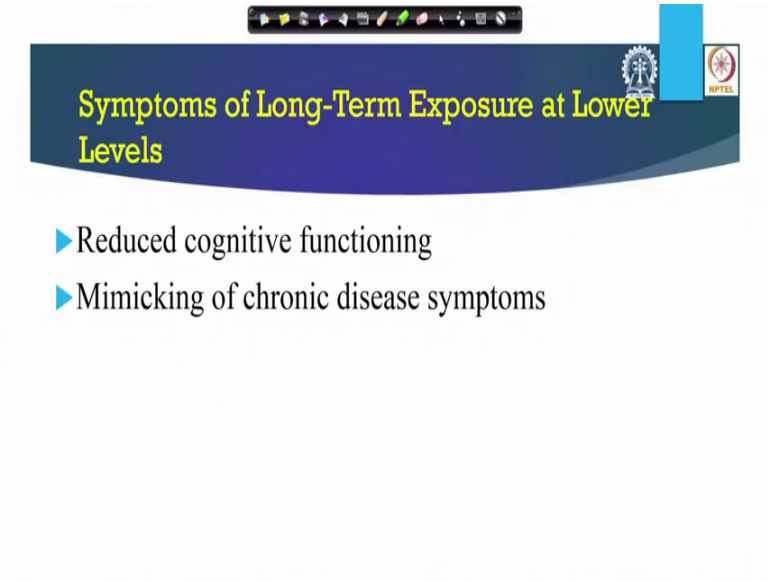

You can reduce cognitive functioning; Mimicking of chronic disease cyst symptom is there.

Then layer Cadmium.

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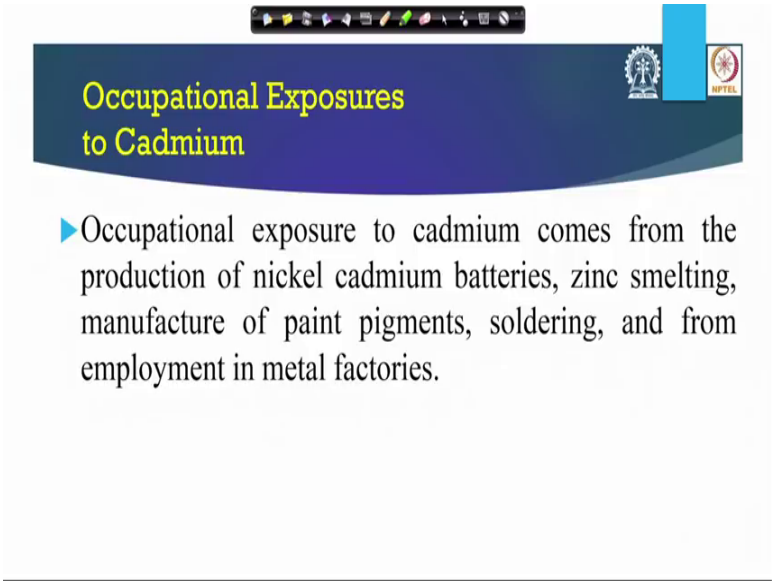

It is Occupational exposure to cadmium for production of nickel, cadmium batteries, zinc smelting and all that.

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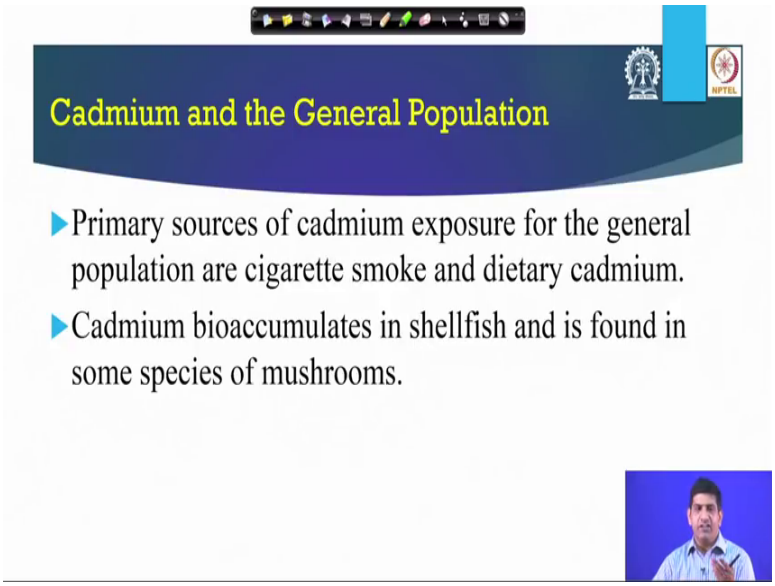

Cadmium there is a exposure is through cigarette smoke and dietary cadmium. Cadmium many times our body gets confused between cadmium and calcium. So, Cadmium gets up taken in the body in place of calcium. Cadmium bioaccumulates in shellfish and mushrooms as well.

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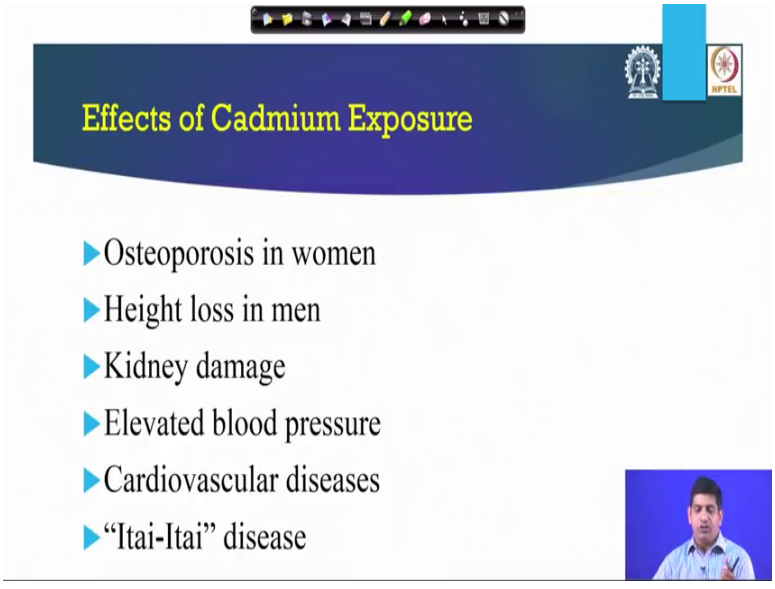

So, it does have an exposure in Osteoporosis and women, Height loss, Kidney damage, Elevated blood pressure, Cardiovascular diseases "Itai-Itai" disease which is will happen in Japan where, the cadmium was coming into the soil.

And when the people consumed that soil that calcium the body bones where, the calcium is used to be present Cadmium got, got in there and then it feels caught brittle bones and people who started breaking their legs and hands and other stuff. So, that is, what is the "Itai-Itai" disease was all about.

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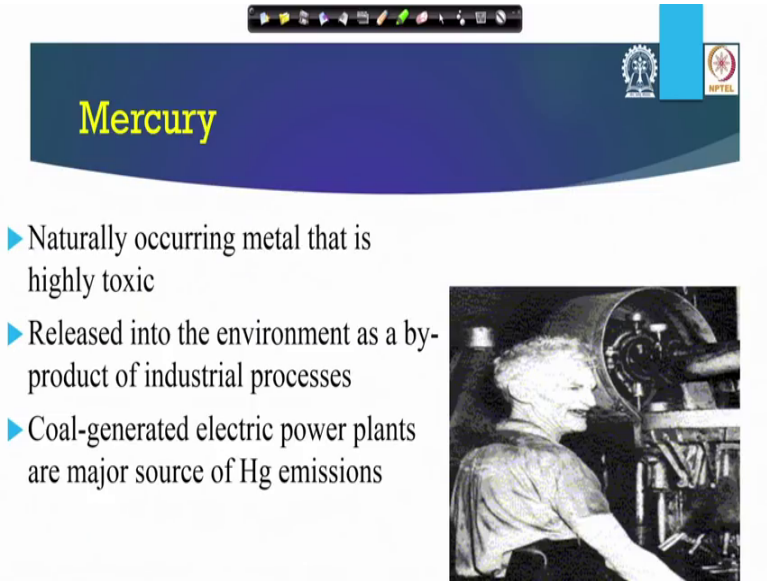

Mercury it is a natural occurring metal it is highly toxic released into environmental as by-product. Coal, coal also has mercury and exposure to mercury causes too.

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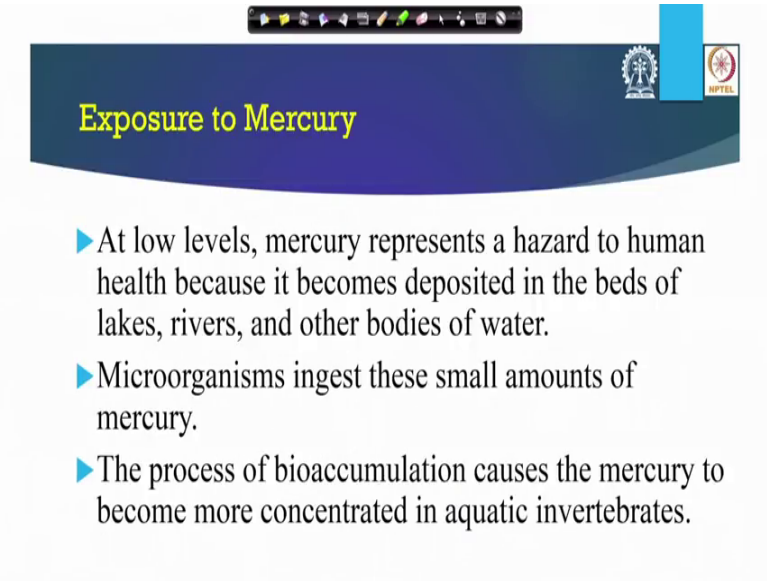

It comes from lakes, rivers, other pates. Microorganisms ingest. There is a bioaccumulation of mercury as well through methyl mercury.

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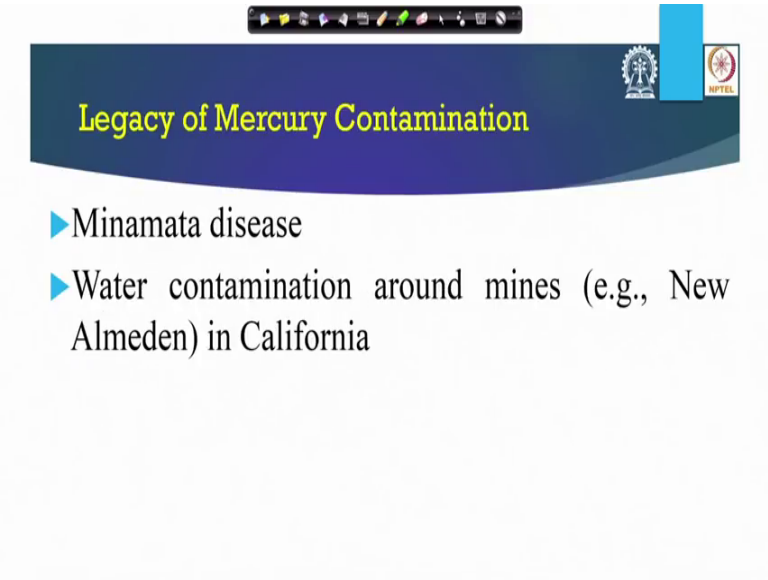

Minamata disease was actually Methyl Mercury. Again Japan if you can if you don't know about that google it, you will find it. Its base methyl mercury which was there in the water caused a lot of problem to the population there.

Then Water contaminant around mines that also causes Mercury contamination.

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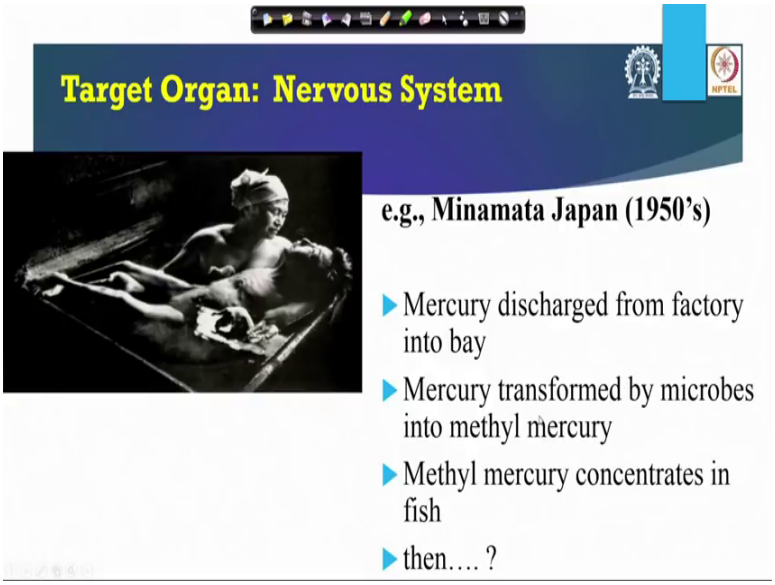

It targets the nervous system. So, in Minamata Japan Mercury got discharged from factory into the bay; Mercury transformed to by microbes into methyl mercury. Methyl mercury concentrated in the fish and that people when they consume that fish, they were affected.

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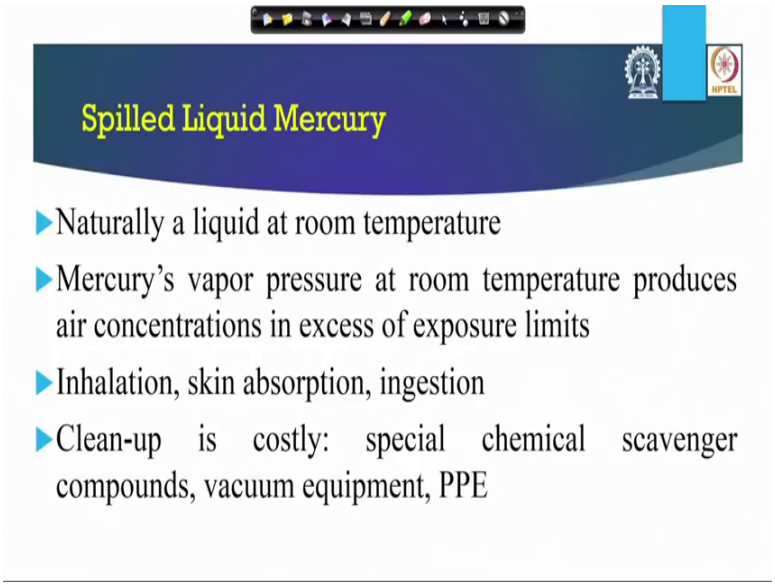

So, there could be Spilled Liquid Mercury naturally a liquid at room temperature. So, it is it access. So, vapor pressure at room temperature produces concentration in excess of exposure limit. So, we will actually, what we will do is there? We will also give you a reading material which talks about a little bit of this basic chemistry stuff.

So, that you can, you can read that material to get some idea about the different chemistry stuff because some of the stuff that we talked about a vapor pressure, vapor density and all those kind of, you have already read that, but you may not remember it. So, that would be a quick recap and we will try to post that particular material for you.

So, Inhalation, Skin absorption, ingestion those things are there cleanup is costly for mercury. Then we have other elements present.

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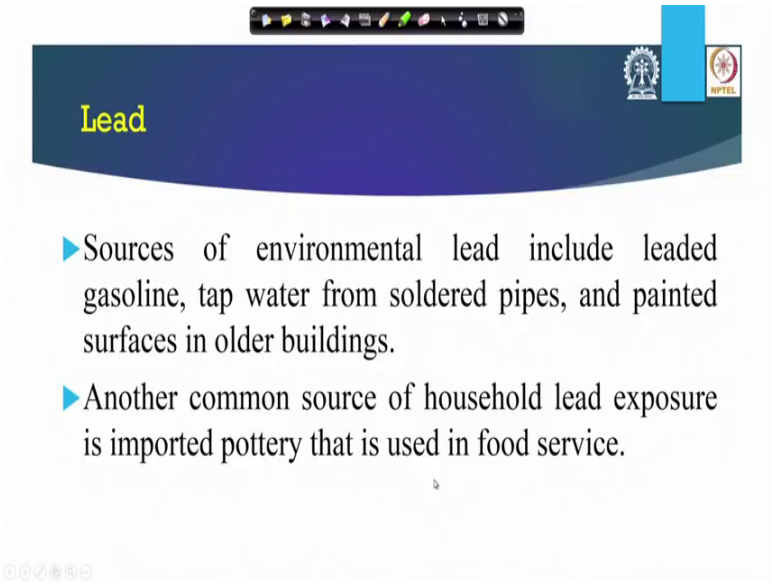

So, let us say stop in terms of where from at the mercury and then, we will continue this discussion in the next video. So, what we are being say if you, for any-any lecture video say we will try to summarize towards the end as you have you may have seen in the previous one as well; the previous week as well. So, in this video we started with looking at the environmental and public health impact.

So, we talked about what are the different elements with a different chemicals present and what, in what, what are the different negative impact associated with that; where they are in the electronics; how it is being used in the electronics?

Then, we had a nice summary slide where, we showed you how the different exposure scenarios and at the same time what are the different impact that will come on the body from some of these contaminants. Then for each individually so for some of the contaminant we are going into a little bit detail to give you some more idea and then we will carry our discussion further for in this particular aspect.

So, I hope you are enjoying the course so far. Again any question, feel free to put on the discussion forum; we will be more than happy to answer you. Do your homework, read the material and do the quizzes on time. And of course, if you have, I would look for out in, I would like each one of you to take the exam as well; if possible.

So, thank you and see you again in the next video.