Basic Environmental Engineering and Pollution Abatement
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Lecture 59
Management of Special Category Waste - 2

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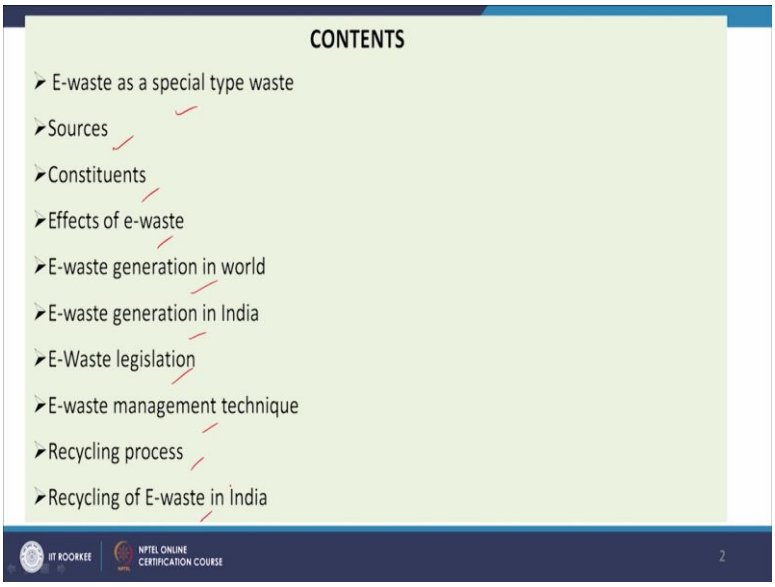

Hello everyone. Now, we will discuss on the topic Management of special category waste Part 2. The contents are E waste as a special type waste, then sources of E-waste, constituents of E-waste, effects of E-waste, E-waste generation in world, E-waste generation in India, E-waste legislation, E-waste management technique, recycling processes and recycling of E-waste in India.

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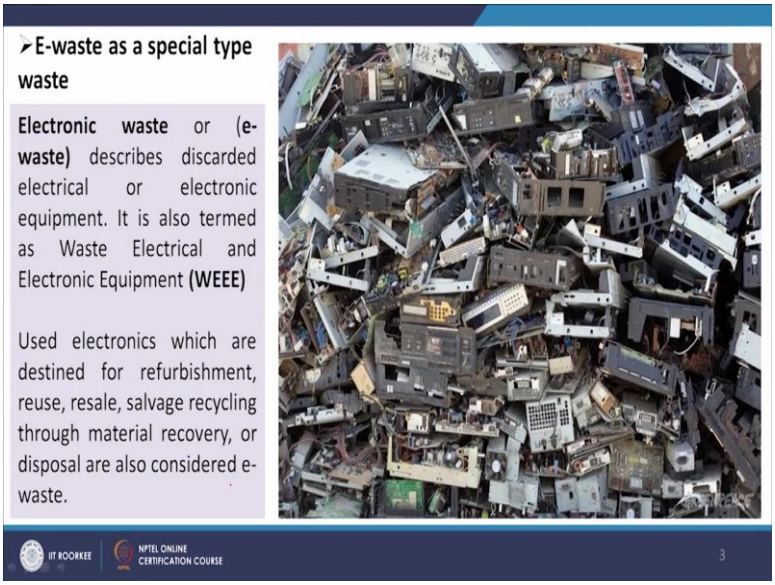

Now, we will see the E-waste at a special type of waste. So, E waste the name indicates that is related to E that is electronics and electrical. So, we can say the electronic waste or E waste describes discarded electrical or electronic equipment it is also termed as waste electrical and electronic equipment WEEE. And used electronics which are destined for refurbishment reuse, resale, salvage recycling through material recovery or disposal are also considered as E waste. So, you see this figure shows different types of items which belongs to this E waste.

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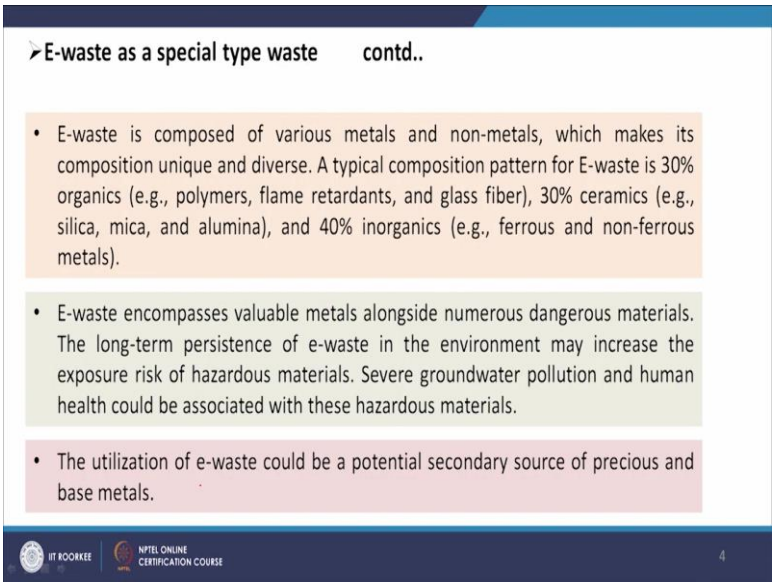

And, we will see that E waste contents different types of materials it may contain some metals it may contain some plastic materials, it may contain some inert materials, it may be say silica like this so ceramic materials. So, E waste is composed of various metals and non-metals which makes it composition unique and diverse. A typical composition pattern for E waste is 30 % Organics. This includes a polymer, flame retardants and glass fiber, 30 % ceramics that it is silica, mica and alumina and 40 % in organics that is ferrous and non-ferrous metals.

And E waste encompasses valuable metals alongside numerous dangerous materials. So, it contains valuable metals, but there are some other materials associated with this which are dangerous for the health. So, the long-term persistence of E waste in the environment may increase the exposure risk of hazardous materials, severe groundwater pollution and human health could be associated with these hazardous materials. The utilization of E waste could be potential secondary source of precious and base metals. So, this is the one advantage of recycling of this E waste we will discuss.

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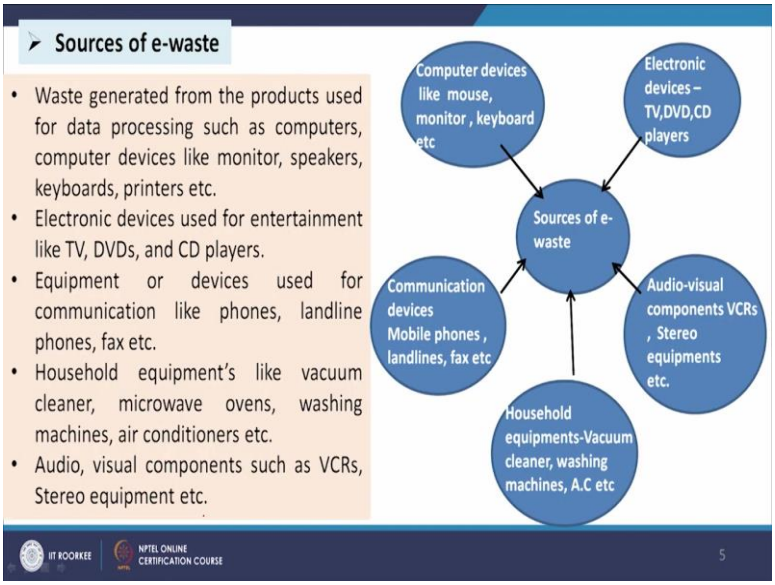

Now, we will see the sources of E wastes. So, E waste can be generated from different types of products, let us say from the products used for data processing, such as computers, computer devices like monitors, speakers, keyboards, printers, etc. Electronic devices used for entertainment like TV, DVDs and CD players. Equipment or devices used for communication like phones, landline phones, fax etc. Household equipment's like vacuum cleaner, microwave ovens, washing machines, air conditioners, etc. Audio visual components such as VCRs, stereo equipment etc.

And if we see the sources of E waste here, this figure also shows the same information that is electronic devices, TV, DVD, CD players and then audio-visual components like VCRs, stereo equipment and then household equipment's, vacuum cleaner, washing machines etc. And communication devices, mobile phones, landline phones, fax and computer devices like mouse, monitor, keyboard etc. So, these are the prime source of the E wastes.

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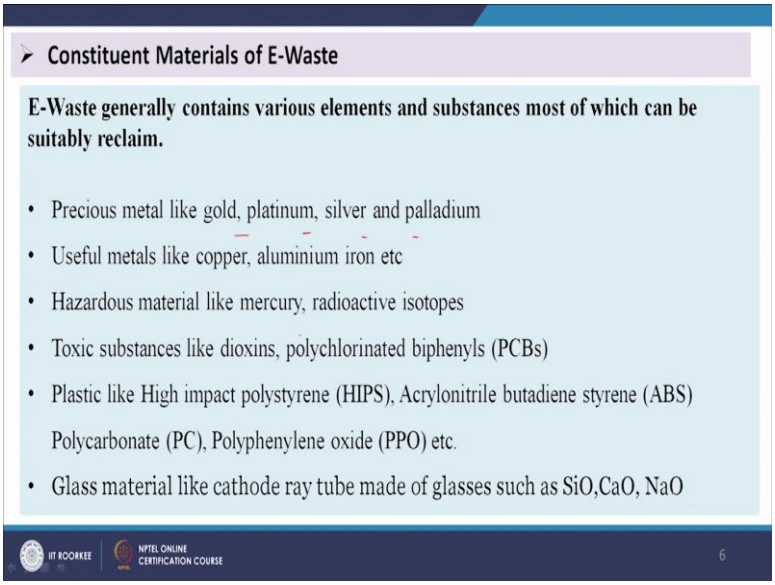

Now, we will see the constituents of E waste as already we have mentioned that E waste content different types of materials, like say metals, plastics, and ceramics.

Some important constituents are precious metals like gold, platinum, silver and palladium useful metals like copper, aluminum, iron, etc. Hazardous material like mercury, radioactive isotopes and toxic substances like dioxins, polychlorinated biphenyls. Plastics like high impact polystyrene, Acrylonitrile butadiene styrene. Polycarbonate, polyphenylene oxide etc and glass material like cathode ray tube made of glasses such as SiO, Cao, NaO etc. So, these are the different types of materials which are available in the E waste and can be recovered.

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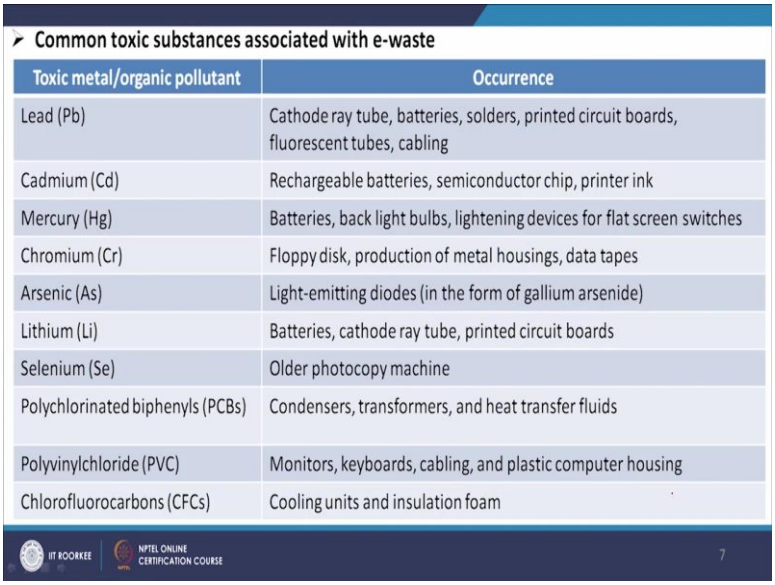

Here, we will see the common toxic substances associated with E waste and the possible source or the occurrence where it is available. Let us say Lead this is a toxic material. So, this is available in cathode ray tube, batteries, solders, printed circuit boards, fluorescent tubes, cabling etc.

Cadmium this can be available in rechargeable battery semiconductor chip printer ink. Mercury can be available in batteries, back light bulbs, lightning devices for flatscreen switches. Chromium, floppy disk, production of metal housings, data tapes. Arsenic light emitting diodes, in the form of gallium arsenide, arsenic is available in the form of gallium arsenide.

And lithium batteries, cathode ray tube, printed circuit boards. Selenium, older photocopy machine. Polychlorinated biphenyls condensers, transformers and heat transfer fluids. And then polyvinyl chloride monitors, keyboards, cabling and plastic computer housing, chlorofluorocarbons cooling units and insulation foam. So, we see that there are different types of compounds or materials present in the E waste which comes from different sources.

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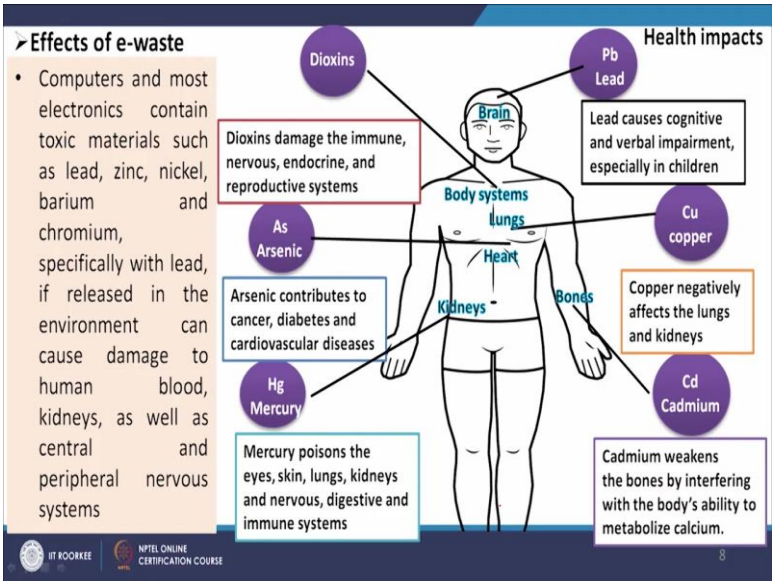

Now, you will see the detail impact of these pollutants. So, these materials will be having some negative impact on human health as shown here. So, see this is a human body, so, brain mainly affected by the lead. So, lead causes cognitive and verbal impairment especially in children. Then copper that affects on lungs. So, copper negatively affects the lungs and kidneys and Cadmium effects on bones. So, cadmium weakens the bones by interfering with the body's ability to metabolize calcium.

And then mercury, so Mercury effects on kidneys, Mercury poisons the eyes, skin, lungs, kidneys and nervous digestive and immune systems. And Arsenic, arsenic contributes to cancer, diabetes and cardiovascular diseases. The diseases related to the heart also causes due to the arsenic.

And dioxins, dioxins damaged the immune, nervous endocrine and reproductive systems the, body system is affected by them dioxins. So, these are the different pollutants or polluting materials or hazardous materials which are available in the E waste which can have these types of impacts on human health.

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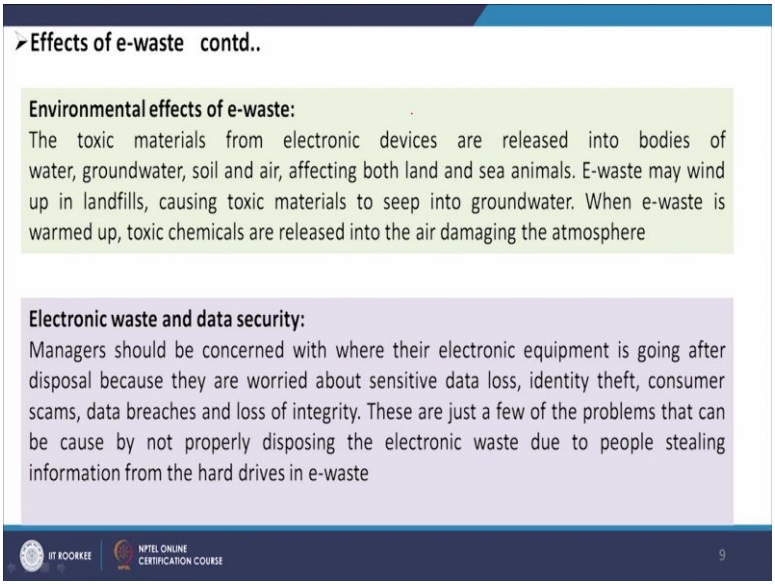

Apart from that, environmental effects of E waste is also significant. The toxic materials from electronic devices are released into bodies of water, groundwater, soil and air affecting both land and sea animals. E waste may wind up in landfills causing toxic materials to seep into groundwater, and E waste is warmed up toxic chemicals are released into air damaging the atmosphere. So, these are some atmospheric impacts of these E waste.

And electronic waste and data security. Another type of concern is also there, which is related to the misuse of the waste electronic items like say some data recovery. So, if data is recovered and misused, so that is also one point of concern for the users.

So, managers should be concerned with where their electronic equipment is going after disposal because they are worried about sensitive data loss, identity theft, consumer scams, data breaches and loss of integrity. So, these are just a few of the problems that can be caused by not properly disposing the electronic waste due to people stealing information from the hard disk or hard devices in E waste.

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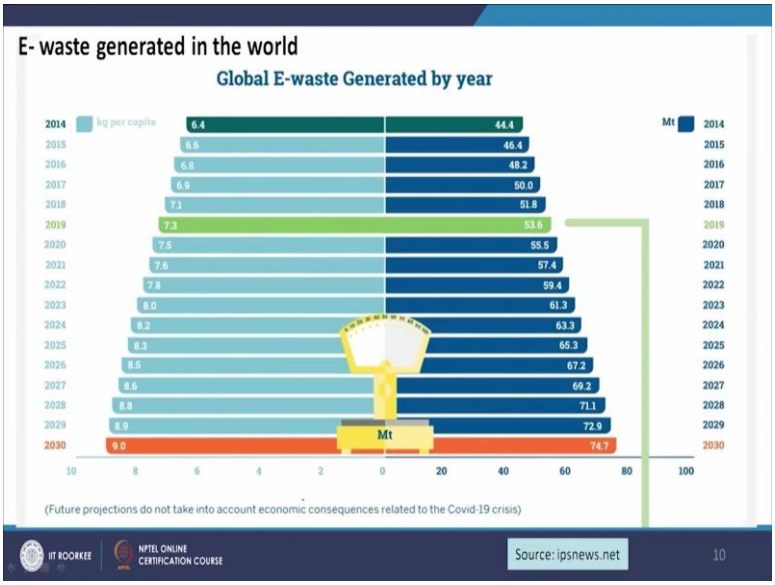

Now, we will see the E waste generation in the world. So, here this figure gives us some information on the E waste generation trend. So, 2014 to 2030. So, we are here in 2021. So, this data is developed on 2019 and these details are up to 2019 these are the actual data, but these data are predicted.

So, here this side data are kg per capita, E waste production globally and this side that is million tonnes in 2014 to 2030 it is shown. So, here it is very clear to us that day by day per capita E waste generation is increasing and it is expected to increase it in near future as well. And from 2020 to 7.5 to 2030, 9.0 this is a kg per capita E waste generation prediction has been made. Similarly, the total E waste generation globally is also is expected to increase from 53.6 million ton in 2019 to 74.7 million ton in 2030. So, that is a huge increase in the E waste generation.

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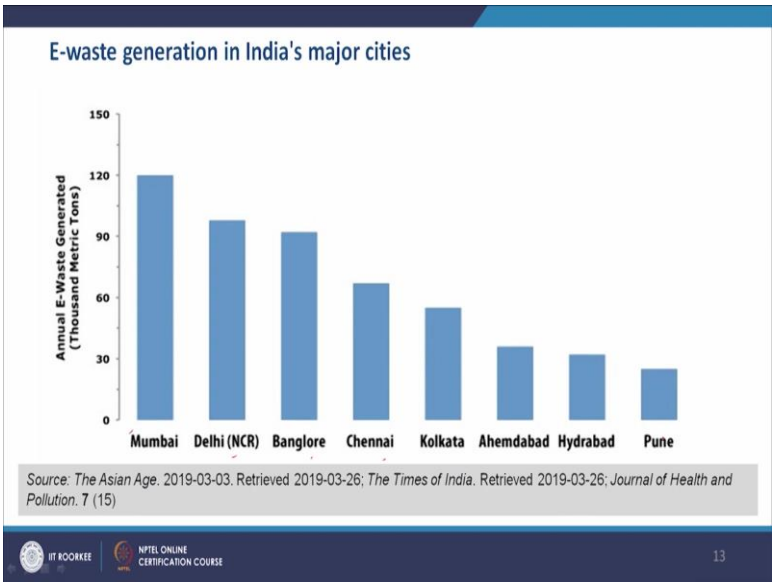

Now, if we see the E waste generation in India's major states, then you see Maharashtra is maximum followed by Tamil Nadu, Uttar Pradesh, West Bengal, Delhi, Karnataka, Gujarat and Madhya Pradesh. And if we see that E waste generation in different cities, then the maximum is in Mumbai, then followed by Delhi, Bangalore, Chennai, Kolkata, Ahmedabad, Hyderabad and Pune. These data are from 2019 report.

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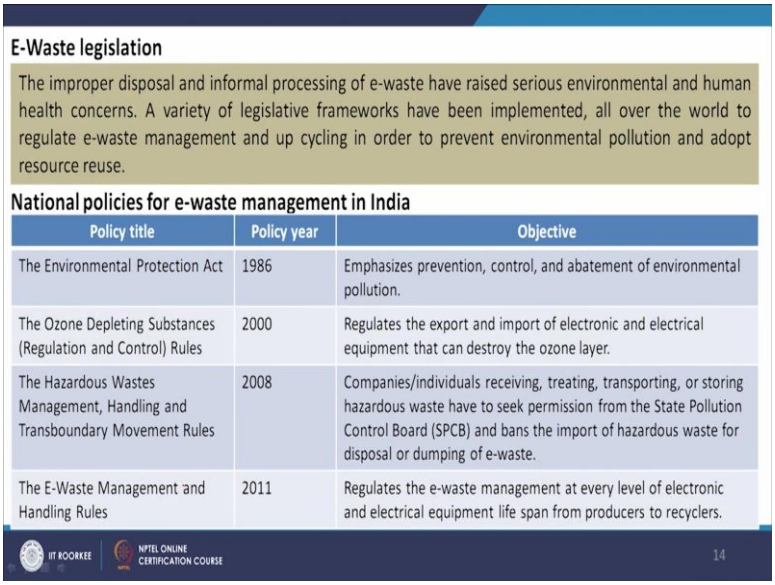

Now, we will see E waste legislation. So, it is very clear to us that E waste is generated in large volume and the generation is going to increase in near future or as well around the globe. So, where legislation is required to control its generation as well as to its proper management. So the improper disposal and informal processing of E waste has raised serious environmental and human health concerns. A variety of legislative frameworks have been implemented all over the world to regulate E waste management and upcycling in order to prevent environmental pollution and adopt resources reuse.

So, national policies for E waste management in India, if we see that the national policy has not ignored the issue of E waste, and it has taken care from the early stage to avoid any type of problems or negative impacts in the society. So, 1986 the Environmental Protection Act. So, that was objective was to emphasize and prevention control and abatement of environmental pollution. And 2000 ozone depleting substances rules that also takes care about electronic wastes, it regulates the export and import of electronic and electrical equipment that can destroy the ozone layer.

And Hazardous waste management handling and transboundary movement rules 2008 that also takes care about the E waste and companies individuals receiving treating, transporting or sorting hazardous waste have to seek permission from the state pollution control board and bans the import of hazardous waste for disposal or dumping of E waste. In 2011, E waste management and handling rules were introduced. So, here it objective is to regulate the E waste management at every level up electronic and electrical equipment lifespan from producers to recyclers.

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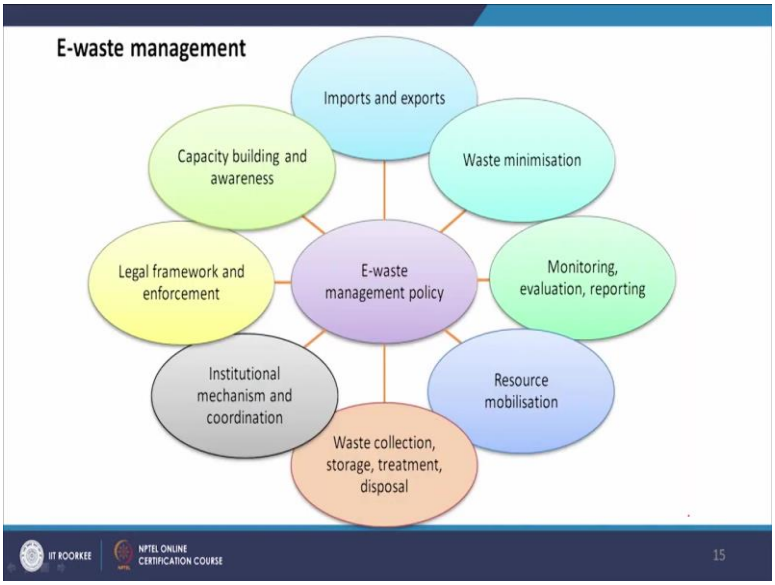

Now, we will see E waste management. So, in spite of regulatory framework and legislations still E waste will be generated and we need to manage those E waste effectively. So, for that, here also the philosophy will be to reduce, recycling and disposal. So, E waste management policy can include say different factors like imports and exports that will influence the strategy for the E waste management. And waste minimization we have to minimize the waste and monitoring evolution and reporting.

Now, we need to collect data and then we need to monitor it and then to evaluate the environmental pollution which is causing to this E waste. And then E waste mobilization, waste collection, storage and disposal. And then institutional mechanism and coordination. So, all these activities cannot be done without any institutional mechanism and coordination.

And legal framework and enforcement already we have so that has to be strictly followed like say CPCB or SPCB state pollution control board will be responsible to take care of whether these laws and rules are being implemented or not. And capacity building and awareness some program has to be arranged to make the people aware about the negative impact of these E waste if not managed properly and for the need of the proper management of E waste systems or E waste.

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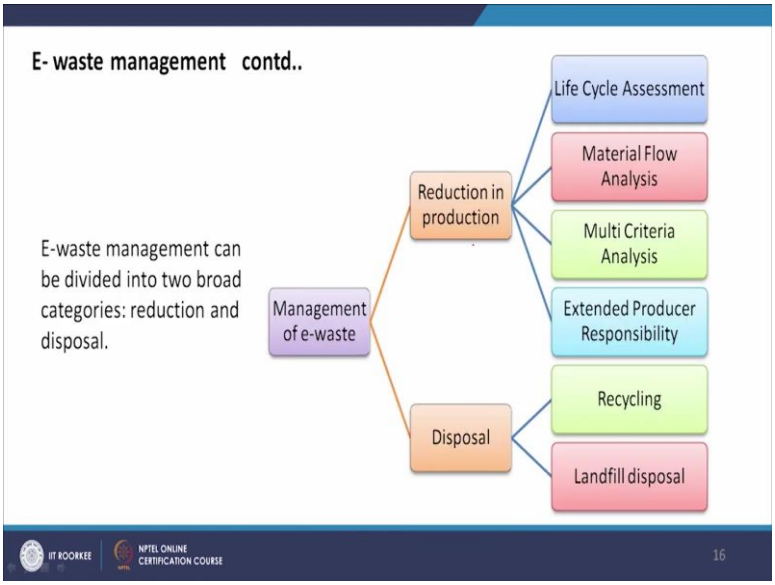

So, as discussed in the previous slide, that management of E waste can be made through two routes, that is reduction in production and disposal. For the reduction in productions, different types of activities can be considered like a lifecycle assessment. So, for any product, we can perform lifecycle assessment.

So, if we can perform lifecycle assessment of all products, then you can select the best suitable one that will be having lower environmental impact. And material flow analysis, we can make the material flow analysis that will help us to understand, whatever flow of material is taking place and where more precaution needs to be taken.

And multicriteria analysis. So, this is the date to take a decision and extended producer responsibility. So, this is being introduced more extensively day by day. So, that the from the generation to recycling the producers will be will need to take some responsibility for the management of the E waste. And then these are the reduction basically. So, if we take these steps, then the generation of E waste will be reduced. Then which is already produced the generated that has to be treated that is recycled and then it has to be disposed off. So, that disposal or landfilling, etc.

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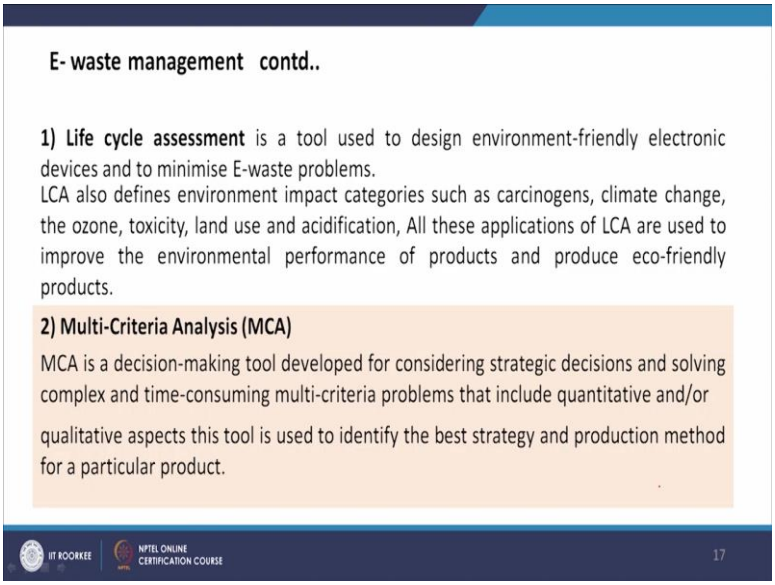

Now, lifecycle assessment, which is a part of the reduction philosophy or reduction route. It is a tool used to design environment friendly electronic devices and to minimize E waste problems. LCA also defines environmental impact categories such as carcinogens, climate change, the ozone toxicity, land use and acidification. All these applications of LCA are used to improve the environmental performance of products and produce eco-friendly products. So, LCA analysis will help us to select a select a more suitable product.

And multicriteria analysis, this is a decision-making tool developed for considering strategic decisions and solving complex and time consuming multicriteria problems that include quantitative and or qualitative aspects. This tool is used to identify the best strategy and production method for a particular product.

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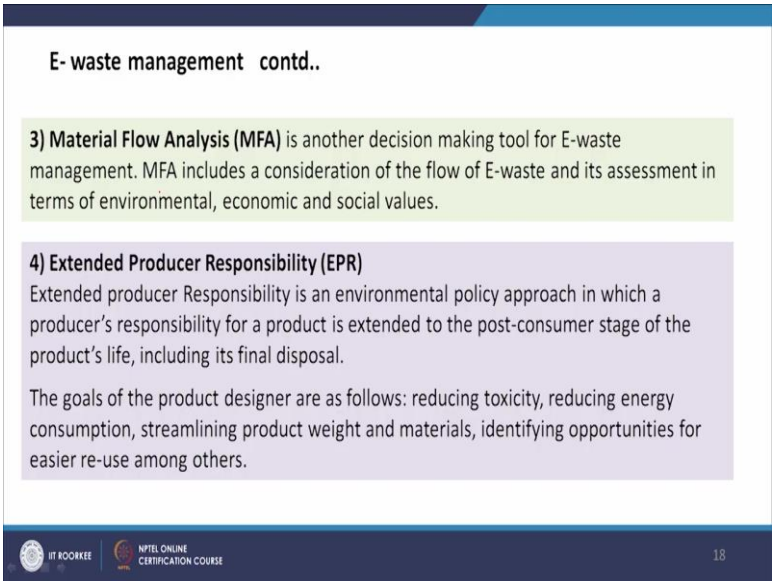

Material flow analysis is another decision-making tool for E waste management. MFA includes a consideration of the flow of E waste and its assessment in terms of environmental, economic and social values. And extended producer responsibility that EPR is an environmental policy approach in which a producer responsibility for a product is extended to the post consumer stage of the product's life including its final disposal.

So, this is also implemented for plastic waste management in the country. The goals of the product designer are as follows that is reducing toxicity, reducing energy consumption, streamlining, product weight and materials, identifying opportunities for easier reuse, among others.

So, once it is made compulsory for the producers, then producers certainly will think about all those things, how to make it lightweight, how to make it less toxic, etc. So, these are the main objective of the introduction of extended producer responsibility.

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Now, we will see waste management hierarchy. So, here as we mentioned that prevention is better than cure. So, prevention, then reuse, recycling and biological and thermal treatment and sanitary landfill. So, these are the different steps which are used for the management of the E waste. Out of these suddenly the prevention is most preferred. But if we see the triangle, so this is not implemented widely, and by that also we cannot prevent everything.

So, some extents we can prevent, then reuse. We can reuse some more additional and then recycling that is much more than this reuse and prevention and then biological and thermal treatment, it is also much more than this and ultimately the sanitary landfill, this is the least preferred. So, this is the management hierarchy.

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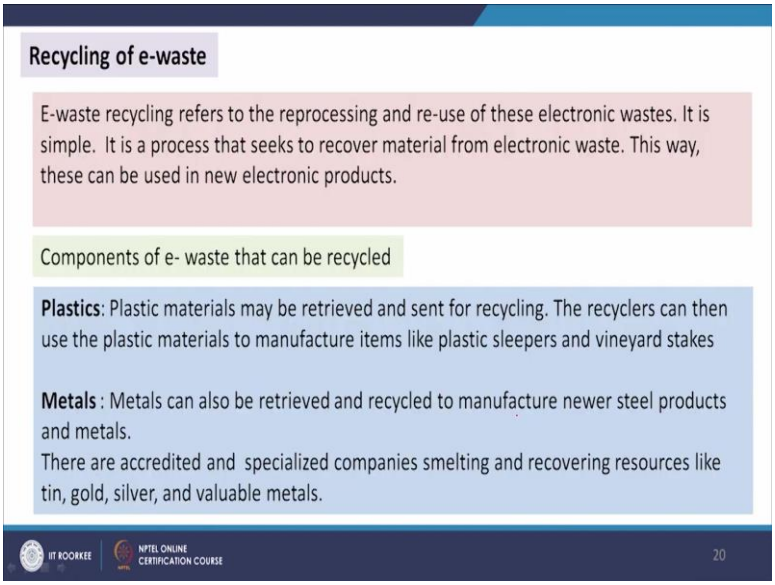

Now, recycling of E waste, we will be talking about the processing or resist treatment or recycling of the E waste. So, E waste recycling refers to the reprocessing and reuse of these electronic waste. It is simple, it is process that seeks to recover material from electronic waste. This way, this can be used in new electronic products. And components of E waste that can be recycled, the one is plastics, other is metals and there is Mercury batteries etc. So, plastics materials maybe retrieved and sent for recycling, the recyclers can then use the plastic materials to manufacture items like plastic slippers and vineyard stakes.

And metals can be retrieved and recycled to the manufacturer, newer steel products and metals, there are accredited and specialized companies smelting and recovering resources like Tin, gold, silver and valuable metals. So, some authorized organizations are working on this for the recovery of this type of metals.

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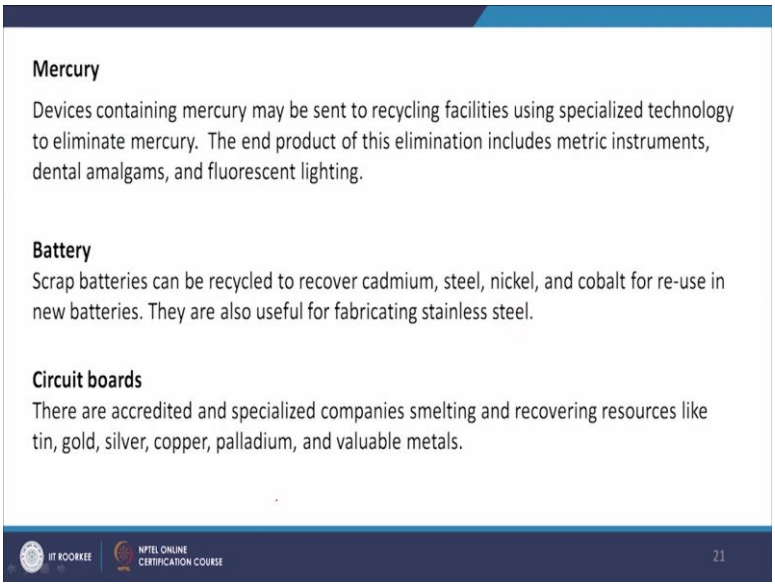

Then Mercury devices containing mercury can be sent to recycling facilities using specialized technology to eliminate Mercury, the end product of this elimination includes metric instruments, dental amalgams, and fluorescent lighting. Battery the scrap batteries can be recycled to recover cadmium steel, nickel and cobalt for use in new batteries. They are also useful for fabricating stainless steel and circuit boards, there are accredited and specialized companies smelting and recovering resources like tin, gold, silver, copper, palladium and valuable metals.

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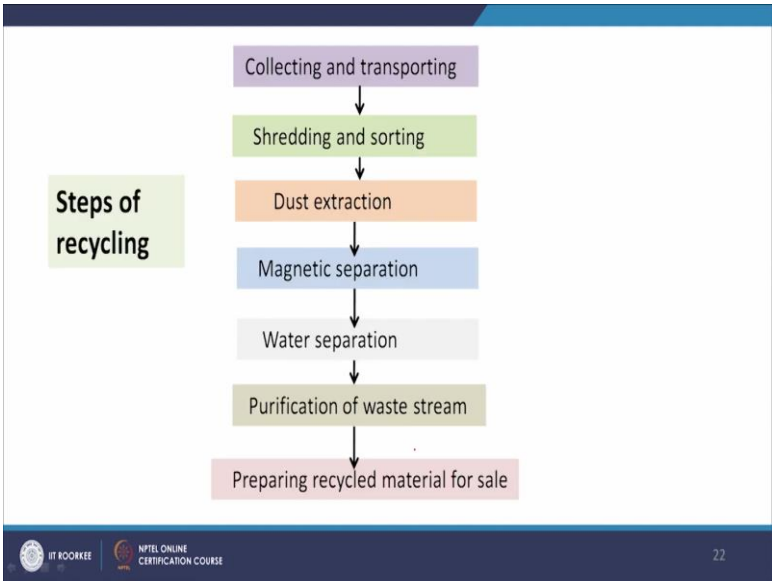

Now, we see the steps of recycling. So, certainly, we have to collect and then we have to shredding and sorting. So, collection and transporting, then shredding and sorting, then dust extraction, we have to remove the dust, then magnetic separation. So, Iron will be separated from this and then water separation, then gravity separation can take place and then purification of waste stream then we have to purify them waste streams and preparing recycled material for sale, which is our recycled material for further application or sale.

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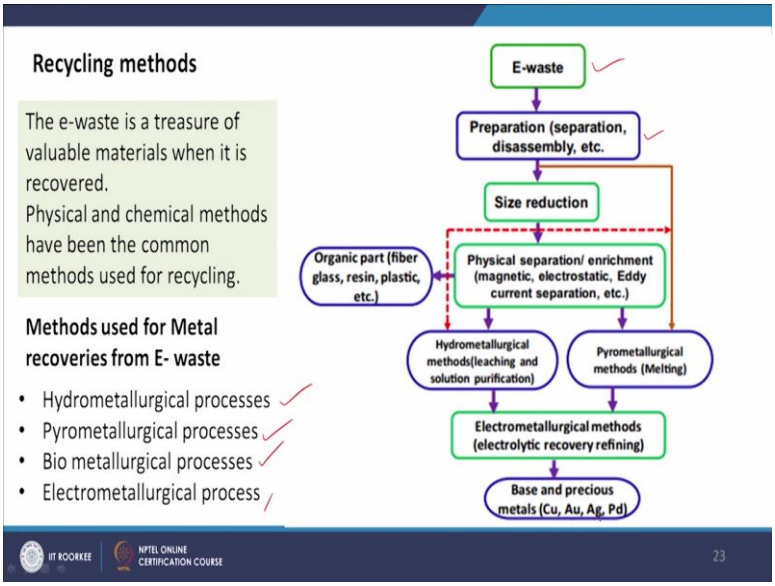

Now, we will see that recycling methods. So, E waste is a treasure of valuable materials when it is recovered so it can be the source of different types of metals already you have discussed in the previous slides. So, physical and chemical methods have been the common methods

used for recycling and different methods which have been used for recycling is hydrometallurgical processes, pyrometallurgical processes, bio metallurgical processes and electro metallurgical processes.

And in this figure, it is nicely explained. So, E waste we have to prepare it. So, separation and disassembly. So, we have to separate different parts and then size reduction. After that, we have to physical separation and enrichment. So, here magnetic, electrostatic, Eddy current separations as implemented and here we can you can separate the organic parts that is fiberglass, resin, plastic etc. from one part or that is your heavy metals that is the heavier parts that is metallic part.

So, that can be further processed through mainly two different routes. One is pyrometallurgical methods that is to the melting we can separate the metals or hydrometallurgical methods, that is based on the leaching and solution purifications.

So, we will be taking the metals in the solution and then again it will purify it. So, that these two main methods which are implemented and further purifications will take place in electro metallurgical methods electrolytic recovery refining. And ultimately, we will be getting base and precious metals. So, we may get copper, gold, silver, palladium etc. So, these different types of important and valuable metals can be recovered from the E waste.

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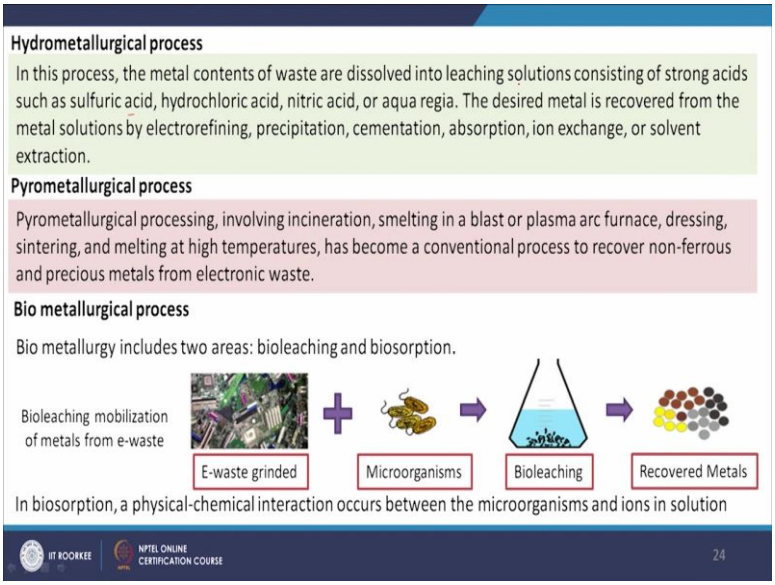

Now, we will see different methods which are applicable that is hydrometallurgical process. So, in this process the metal contents of waste are dissolved into leaching solutions consisting of strong acids such as sulfuric acid, hydrochloric acid, nitric acid or aqua regia. That desired

metal is recovered from the metal solutions by electro refining, precipitation, cementation, absorption, ion exchange or solvent extraction.

And pyrometallurgical processing involving incineration, smelting in a blast or plasma arc furnace, dressing, sintering and melting at high temperatures has become a conventional process to recover non-ferrous and precious metals from electronic waste.

Bio metallurgical processes these processes are also getting more interested in recent years. So, Bio metallurgy includes two areas one is bioleaching and biosorption. So in these bioleaching the metals are taken into the solution. So, waste grinded here, then microorganisms are there. So, bio leaching is taking place.

So, microbes will work on it, the microbes will produce some enzyme and then that will work on it and it will be coming into the solution phase and from solution phase will recover the metals.

Another is Biosorption, if physicochemical or physical and chemical interactions occurs between the microorganisms and the ions. So, metal ions and microorganisms themselves will have some interactions and the microbial biomass will capture the metals and then in the next step, we can isolate the biomass and we can separate the metals as well. So, these are the different routes through which the metals are we can be separated from the electronic waste through the use of this bioprocess.

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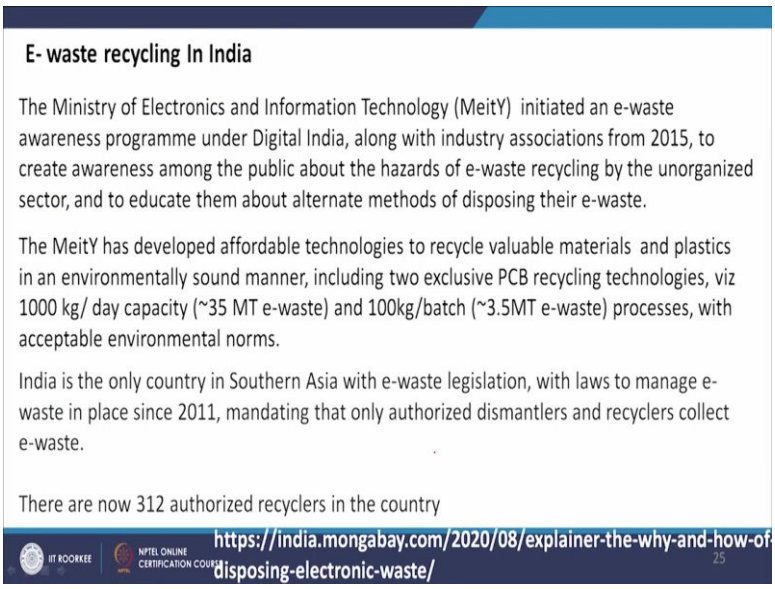

Now, we will see the E waste recycling in India the status. The ministry of Electronics and Information Technology, MeitY initiated, an E waste awareness program under Digital India, along with industry associations from 2015 to create awareness among the public about the hazards of E waste recycling by the unorganized sector and to educate them about alternate methods of disposing their E waste.

The Ministry of Electronics and Information Technology has developed affordable technologies to recycle valuable materials and plastics in an environmentally sound manner, including two exclusive PCB recycling technologies, that is 1000 kg per day capacity and 100 kg per batch processes with acceptable environmental norms.

And India is the only country in South Asia with E waste legislation with laws to manage E waste in place since 2011, mandating that only authorized dismantlers and recyclers collect E waste. There are now 312 authorized recyclers in the country, this information are available from these sources.

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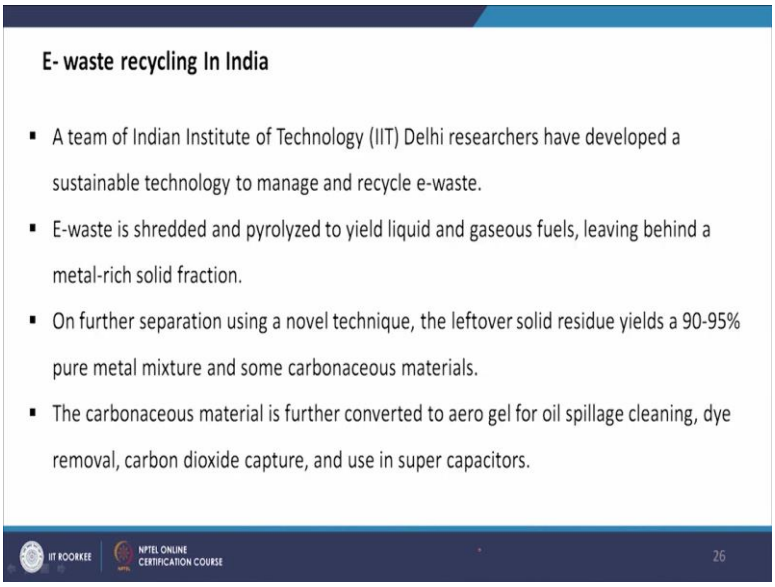

And a team of Indian Institute of Technology, Delhi, IIT Delhi, researchers have developed a sustainable technology to manage and recycle E waste. So, E waste is shredded and pyrolyzed to yield liquid and gaseous fuels leaving behind a metal rich solid fraction. So, this is a pyrolysis process. So, which have discussed in our previous classes detail on the pyrolysis process. So, that process has been applied and tested at IIT Delhi.

And on further separation using a novel technique. The leftover solid residue yields 90 to 95 % pure metal oxide, metal mixture and some carbonaceous materials. So, to the pyrolysis oil,

gas and metallics obtained in this metal oil, gas and solid is obtained. In the solid materials 90 to 95 % pure metal mixture and some carbonaceous materials are available.

So, the carbonaceous materials is further converted to aero gel for oil spillage cleaning, dye removal, carbon dioxide capture and using super capacitors. So, this is all about the electronic waste management. We wanted to discuss so up to this in this class. Thank you very much for your patience.