Sustainable Architecture
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Lecture – 31
Materials and Resources – I

Good morning, welcome to this week of lectures for the online ongoing course on Sustainable Architecture and I am your instructor Dr. Avlokita Agarwal Assistant Professor at Department of Architecture and Planning IIT Roorkee. In this week of lectures we will be talking about the Materials and Resources for Sustainable Architecture. Before we go on to talk about specifics of how the compliance can be achieved for sustainable architecture through green building rating programs.

Let us quickly go through some of the terms and definitions which we would be repetitively using through these lectures. Now, this materials and resources is through the lifetime of the building right from the construction stage till the post occupancy stage. So, all these terms and definitions are also spread across the lifetime of the building.

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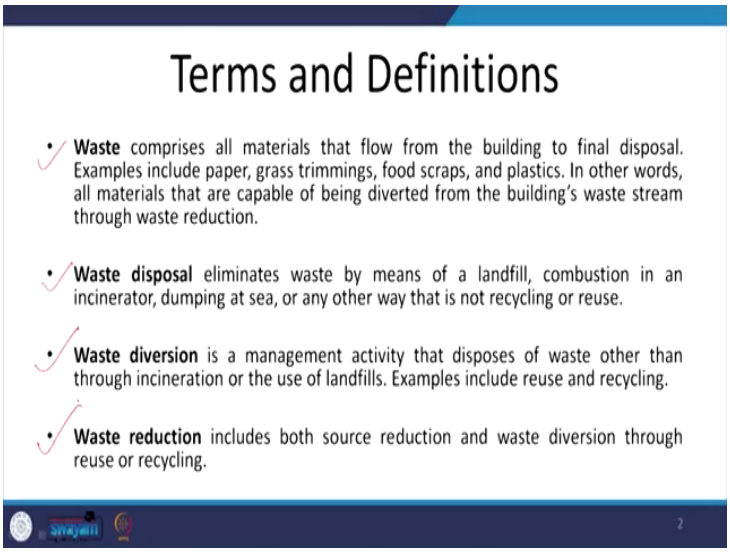

So, the different terms are first waste, which is very commonly used. So, it comprises of all the materials that flow from the building to the final disposal. Now, as I said it could be at any stage and hence the type of waste coming out of the building at different stages would vary. So, during construction phase of the building the more would be

construction demolition waste or construction waste, while when we move on to the occupancy stage when the building is occupied the waste could vary from a lot of these categories including paper, organic garden waste, food scraps, plastics and so on depending upon the type of building's we use.

The next is waste disposal. So, waste disposal is the process of eliminating waste by the means of a landfill, combustion, incinerator, dumping or any other way that is not recycling or reuse. Through waste disposal it means that we are just discarding the waste and not utilizing it in a proper manner.

Waste diversion is management of activity in such a manner that it disposes the waste other than through incineration or the use of landfills. So, for example, there was a construction waste which was otherwise going to the landfill while during the building design we use we decide to use this construction waste for paving of a road for the subgrade of the pavement. Now that through that we have diverted the waste from being sent ~~for~~ to~~the to~~ the landfill, that is what waste diversion is.

Waste reduction it includes both the source reduction as well as waste diversion through reuse or recycling. So, we are talking about the reduction at source of the waste and also the waste diversion together as part of the waste reduction.

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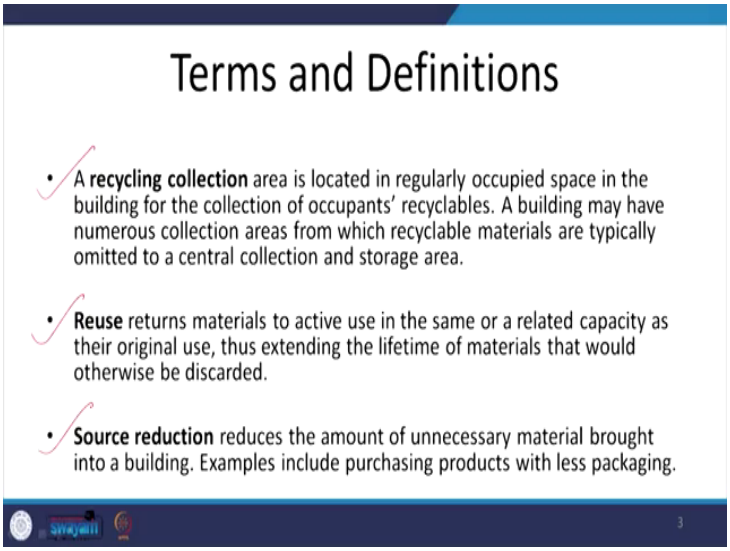

Recycling collection area is the area which is located in a regularly occupied space in the building or on the sitde which is for the collection, segregation and recycling of this waste. Reuse is returning back the material to it is active use in the same or a related capacity so, putting back the same material into another use. Source reduction is the reduction in the amount of unnecessary material brought into the building. For example, the amount of a particular material that is to be consumed in a building through construction or later on. So, if the quantity of it can be optimized and reduced thereby then it comes into the category of source reduction.

So, for example, if we are using a regular concrete slab 100 mm concrete slab and we calculate the amount of concrete to be used in that slab versus we use a filler slab where we have used the filler material and thereby we have reduced the volume of concrete by say around 20 percent or 15 percent, now this 15 percent or 20 percent is source reduction.

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Now, let us come to a little detail of it. So, waste is any substance which is discarded after primary use, which is of no use for the primary user.

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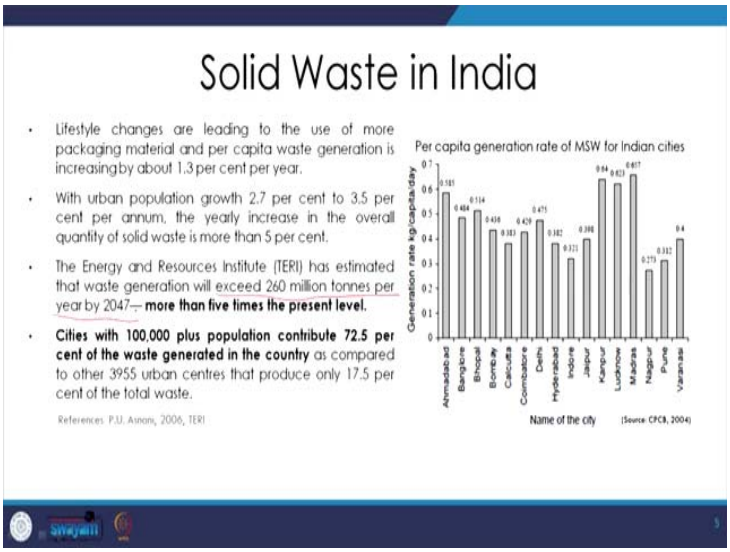

Now, this waste is becoming a huge problem all over the world and in India as well. So, if we look at the numbers the numbers are quite alarming quite huge and the per capita generation of waste municipal solid waste in different Indian cities it varies, but it is reasonably high as compared to the international trends this number is very low, but considering the density and the overall population of our country, the overall amount of waste volume of waste which is generated per day is quite huge.

And it is estimated that with the given lifestyle change that we are witnessing more and more areas are becoming urbanized and we are changing our lifestyle into a lifestyle which is more waste producing. So, as per a report from TERI the energy and resources institute it is estimated that the waste generation will exceed 260 million tons per year by 2047 that is more than 5 times the present level.

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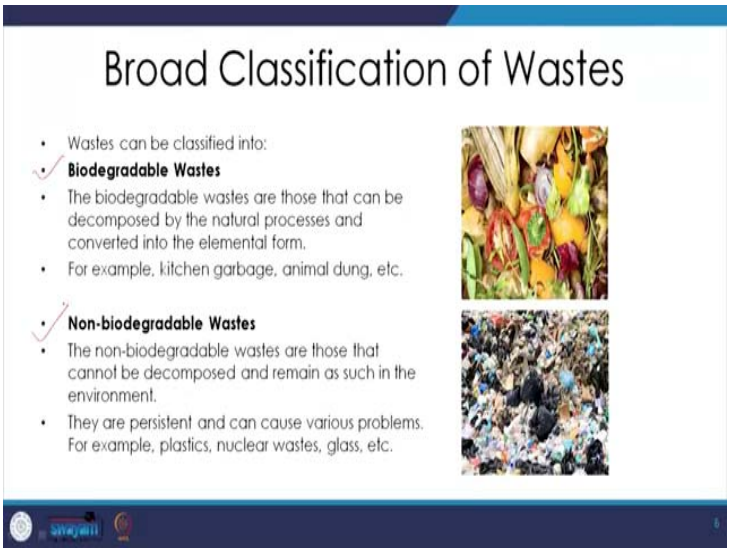

If we look at the broad classification of this waste, we can broadly categorize into two categories; one is a biodegradable waste and the other one is a non biodegradable waste. Very clearly all of us probably would have read in our schools and all and we know that biodegradable wastes are those which can be decomposed by natural processes and they can be converted into the elemental form.

The non biodegradable waste is the waste which cannot be decomposed and it remains as such in the environment. So, they are persistent and they can cause various problems, there is a variety of materials which fall under this non biodegradable waste.

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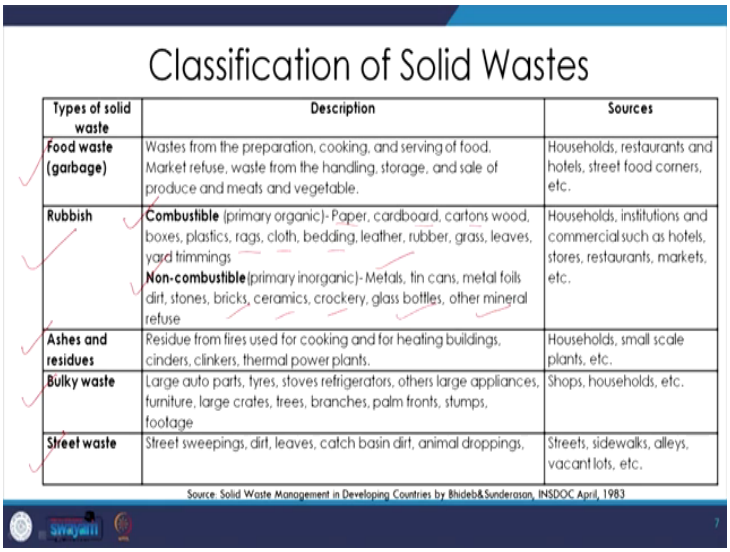

If we look at the classification of the solid waste as per a report solid waste management in developing countries we can see different types of waste. So, there is food waste, there is rubbish as part of that we have two, we have combustible rubbish and we have non combustible rubbish. As part of combustible rubbish we are talking about the paper, cardboard, cartons, we are talking about rags and cloth and bedding, leather, rubber, grass, garden trimmings etcetera. While in non combustible which cannot be burnt to produce energy, we have metals, all sorts of metals, we have construction waste and the glass wastes and other mineral refuse. So, this is rubbish.

Talking about the next category is ashes and residue. So, this is the residues from fire used for cooking and for heating buildings from thermal power plant, cinders and clinkers all of that comes into this. Bulky waste is huge waste for example, discarded refrigerator, television, other large appliances, huge trees etcetera. So, this is all bulky waste street ~~straight~~ waste is street sweepings and dirt, leaves, the catch basin dirt and animal droppings and all which is commonly present in on the street.

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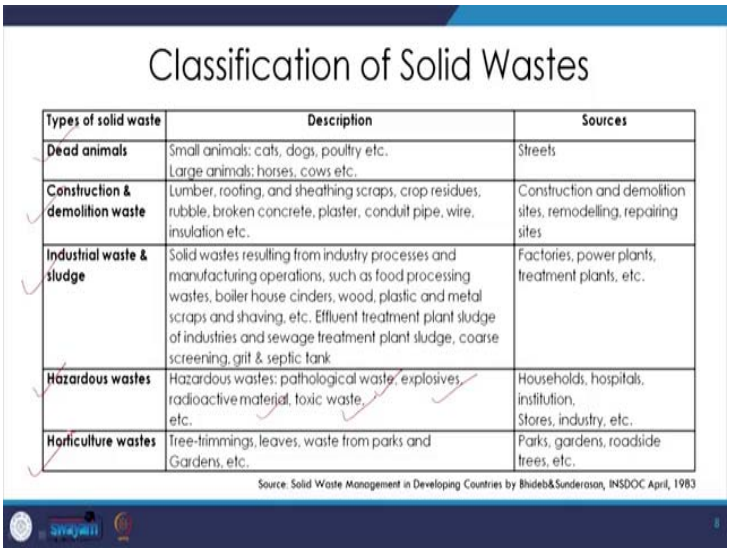

Then we have dead animals, we also have construction and demolition waste which is of a great concern when we are talking about sustainable architecture. So, some of these wastes might not figure as part of the solid waste management scheme when we are talking of sustainable architecture, but it is imperative to know about all these types of wastes. Then we have industrial waste and sludge, now this may vary depending upon the type of industry and the type of processing each industry has.

Then we have hazardous wastes, now this hazardous wastes includes the pathological wastes which is the medical waste, explosives, radioactive material, toxic wastes. Now, these types of wastes may be present in limited quantity in buildings depending upon the usage of the building. Then we have horticultural waste which is the garden waste, now all this waste as of now in India is largely being disposed on landfill sites they are being dumped on the land.

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And we can see huge areas like this and this scenario there the waste is also being dumped in the rivers alongside rivers and there is a huge environmental impact of this solid waste disposal on land and the situation is quite alarming. The first and foremost and the most serious of all is this groundwater contamination by the leachate generated by the waste dump. Unfortunately in dense areas the first aquifer which is the unconfined aquifer majority of the aquifer has got contaminated simply because of this leachate which is generated by the ~~waist~~waste which is dumped on the land.

So, this leachate passes percolate through the soil and it reaches the aquifer thereby contaminating the water. So, when we were talking about the problems related to water, we talked about contamination and solid waste disposal on land is one of the major causes of underground aquifer contamination. Another is surface water a contamination which is what we are seeing here. So, when the waste is disposed in sites which are close to the surface aquifers for example, rivers or ponds.

So, this leachate is actually going into these water bodies and not just the leachate, but also the~~y~~ runoff from the waste dump. So, the waste itself and they run off from that carrying the contaminants is taking taken into the surface water bodies. Then bad odour, pests, rodents and wind-blown litter in and around the waste dump is seen. So, a lot of pests and rodents for example, rats and insects and cockroaches and lot of these pests they thrive around this waste and there is bad odour as well.

There is generation of inflammable gases special methane within the waste dump because of this decomposition process which is happening. So, there is organic and inorganic and all types of waste which is mixed and dumped on the land which generates these gases which is also harmful.

Then there is a lot of bird meanness above the waste dump. So, we have we might have seen a lot of these birds, scavenger birds for example, eagle who create a menace above the waste dump. So, it not only affects the flight of aircraft which is one of the major concerns, but it is also difficult for the habitation around because these birds they create a lot of menace. Then because of these inflammable gases there are often fires within the waste dump. So, these gases may catch fire and also if part of the waste is being burnt which is also the usual practice.

So, the waste often catches fire and is further polluting the environment. There are erosion instability problems relating to the slopes of the waste dump. So, we might have recently heard that the waste disposal site one of the waste disposal sites in Delhi it collapse thereby killing couple of people and creating havoc around. So, such problems also are generated. Then there are epidemics through the stray animals so, because of all these rodents and pests and all this waste and stray animals coming in contact with them.

So, there is an increased chance of spread of epidemics because of this solid waste disposal on land. Then the surrounding soil becomes acidic, because of this leachate percolation.

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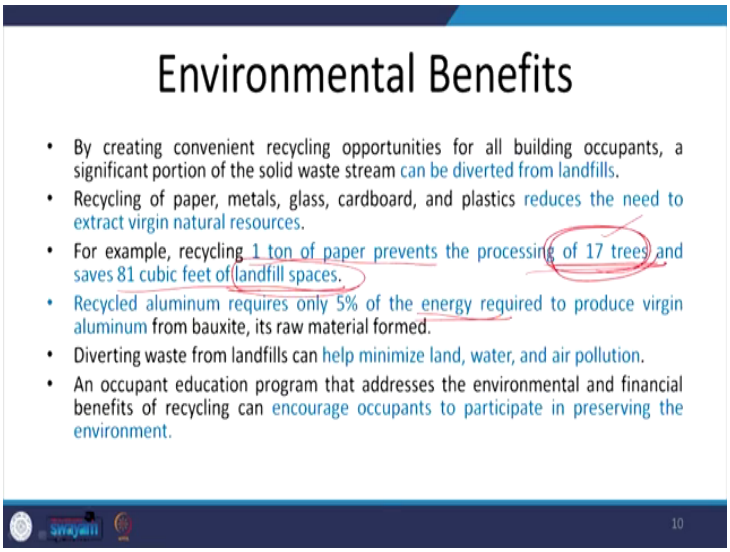

Now, besides this if we properly manage the solid waste, there are several environmental benefits which are just opposite of all the environmental impacts that we have just talked about. For example, if we recycle 1 ton of paper it prevents the processing of 17 trees and it saves around 81 cubic feet of landfill spaces.

So, it is not just that we are taking care of the environment by ensuring that it is hygienic it is clean, but simultaneously we are reducing the borrowing of virgin material from the nature and we are also saving on the land, because currently ~~there is very~~ land has become a commodity and it is very highly precious it is scarce in cities. Also we would be saving on resources like energy hugely. So, for example, if you recycle glass or ~~a~~ if we recycle aluminum. So, only 5 to 10 percent of the energy which is otherwise of the energy which is required to produce virgin material is consumed if the recycling is happening.

So, not just are we saving on the virgin resource, we are saving on land and we are saving on energy and same quality of material is again available to be used. So, a lot of environmental benefits come if we properly manage our solid waste.

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So, when we are talking about municipal solid waste management what does it imply. So, it implies the entire process starting from the collection, transport, processing, recycling and disposable and also the monitoring of these waste materials in case some toxic waste is there and then we may just need to seal it forever and keep it in isolation. So, in such cases even the monitoring of waste materials and of the overall activity, all of this in entirety is solid waste management municipal solid waste management.

So, there are two conventional principles of solid waste management, one is 'dilute and disperse' and the other one is 'concentrate and contain'. So, when we are talking about dilute and disperse we are diluting the contamination. So, we are either improving the quality of it through dilution or through processing and then we are dispersing it. So, that it is not contaminating and it is not concentrated to create problems. In case we are not diluting it we are further concentrating it and we are containing it in form of sealed boxes.

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So, the objective of solid waste management is to maintain clean and hygienic conditions and reduce the quantity of solid waste, in addition to that to recover the waste materials and energy from the solid waste. So, none of the resources which is contained in solid waste should go in vain and we are reducing the amount of solid waste disposed of in sanitary landfill facilities. So, we have to reduce the amount of waste which is going to the landfill sites.

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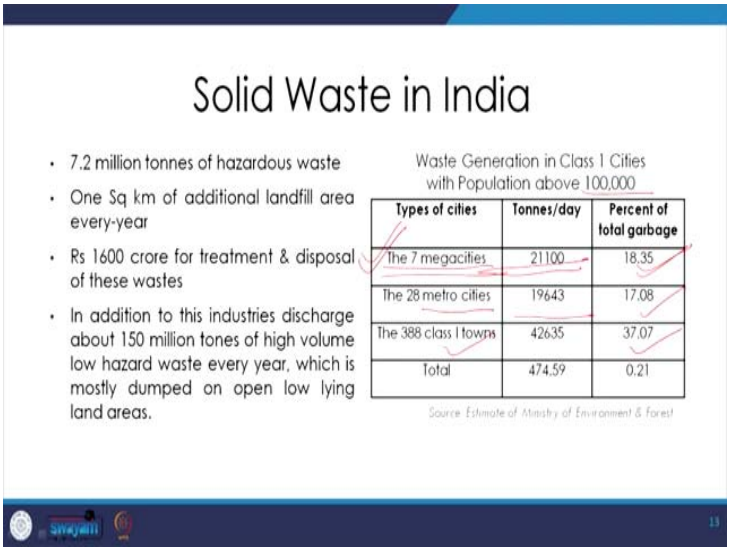

So, if we look at the waste generation in class 1 cities with population above 1 lac~~00000~~ we see that 7 mega cities in India, are responsible for around 18.5 percent of the total landfill which is alarming. So, are the bigger the city is the rate of waste generation per day is also higher and the overall percentage of waste which is generated. Looking at 28 metro cities, ~~it~~ they are generating around 17 percent of the total waste and 388 class 1 towns are generating around 37.07 percent.

If you look at the percentages which is in tons per day collectively and if we calculate for per city basis then we see that per city waste generation is much higher for mega cities as compared to the rest of the class 1 towns.

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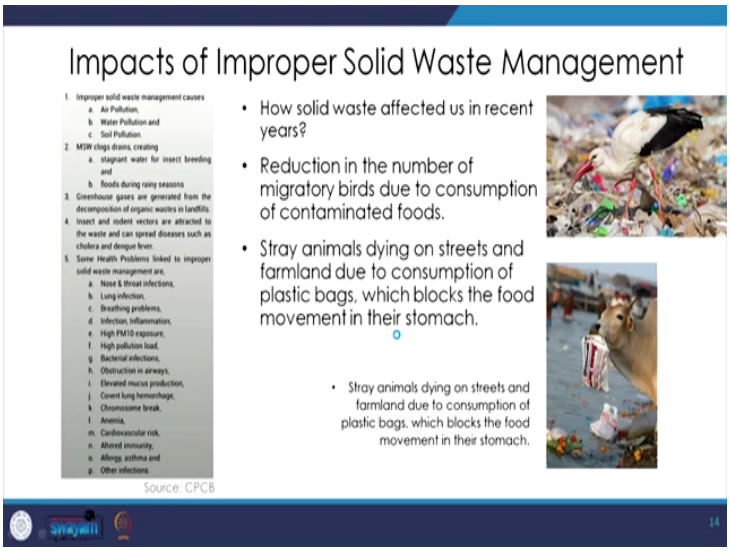

Now, when we are talking about an effective solid waste management we have already discussed the different environmental benefits that come along, but then the solid waste management has to be proper we have to look at a sustainable solution. Now, when we are talking about sustainable solution we are talking about the environmental dimension, we are talking about the environmental impacts and benefits from the selected process selected strategy. In addition to that we are also talking about the economic dimension so in the long run how economic is the strategy for treating the solid waste management and also the social acceptance.

So, how people can be brought in and it is not just human beings we are also taking care of the stray animals, the cows and dogs and all of those animals who are straying on the

streets. So, collectively we have to see that, what is the solution which will be beneficial for all. If you look at the health impacts of solid waste disposal on land we see that it causes tremendous health problems to human beings, we are not even talking about the stray animals, but to human beings because of all forms of pollution.

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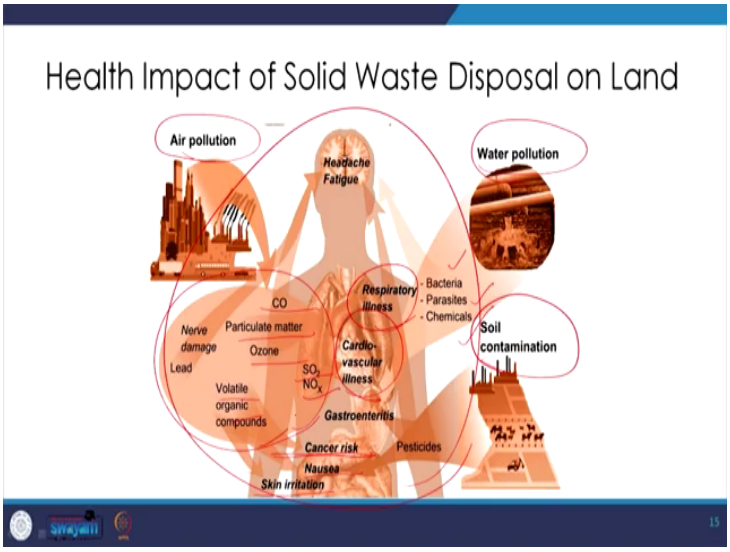

This solid waste management improper solid waste disposal causes further air pollution and water pollution and soil contamination all of which have a large impact on human health including the risk to have cancer, the skin problem is nausea, cardiovascular illnesses which is becoming quite rampant common in today's times, respiratory illnesses, a lot of contamination, lot of infection which is caused because of bacteria, parasites and chemicals as well. A lot of problems which are caused because of these air pollution and inhaling of these air pollutions the presence of pesticides.

So, all of this is quite costly if we look at it in terms of the GDP the percentage which is being invested on human health if we manage your solid waste properly a lot of investment which is required from for health facilities can automatically be reduced and diverted.

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So, if you look at this waste collection in India primarily it is the responsibility of city municipality, unfortunately there is no gradation of waste product into by degradable and recyclables and non-biodegradable across the municipalities after the ambitious program of government of India this segregated waste collection has been initiated in several cities of our country. And there is a Swacchtha Servekshan which is carried out by government of India and it is encouraging municipalities to collect all the waste and segregate it right at the source or later and then process it recycle it put into the recycling plants.

So, as of now not all the municipalities are actually collecting the segregated wastes, but yes collection through the municipality is happening now in majority of the cities. The next is through rag pickers. So, we as a community we as a society I am talking about Indian society at large have this habit of storing anything that is recyclable. So, whether it is paper or plastic or glass, metal. So, we have been in the habit of storing these recycle recyclables and these recyclables are then taken up by the local [FL] or what we call as rag pickers.

So, we select these items which are recyclables and these rag pickers they take these recyclables and sell it to recycling industries, where a useful product is for the formed produced out of this collected recyclables. Unfortunately with the changing lifestyle and

a lot of westernization of our culture even the recyclables are going towards the waste which is what we never did earlier.

So, rag pickers have a great role to play every locality we have at least 2 to 3 rag pickers who would keep visiting every week and they collect all the recyclables. So, these are the two means of waste collection in India and if you look at the structure of municipal solid waste.

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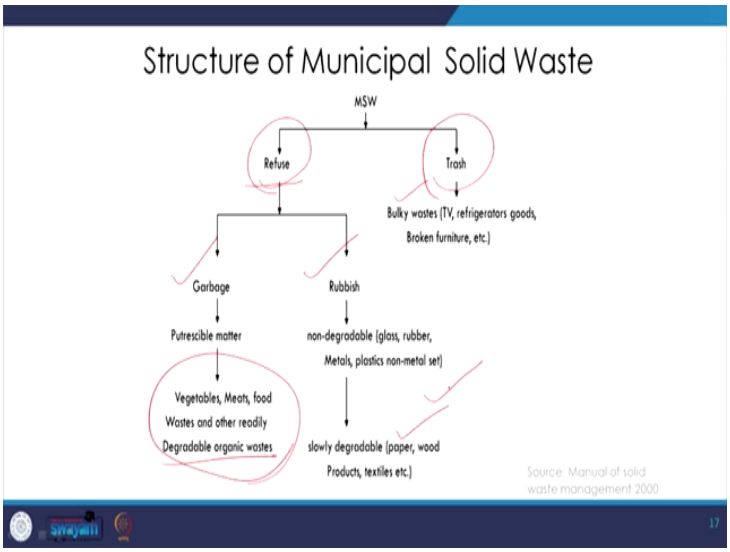

We can see that the municipal solid waste is divided into broad two categories, one is trash and the other one is refused. Now, trash usually contains the bulky waste and refuse contains the organic matter and the inorganic matter, the non biodegradable matter. The biodegradable matter if is further processed, it is decomposed and the manure or the useful compost can be produced out of that while rubbish can actually go depending upon the what kind of material it is.

So, if it is glass, rubber, metal, plastic so, all of that can actually go into recycling while some of this lowly degradable material for example, paper, wood products, textiles, may be sent for further composting.

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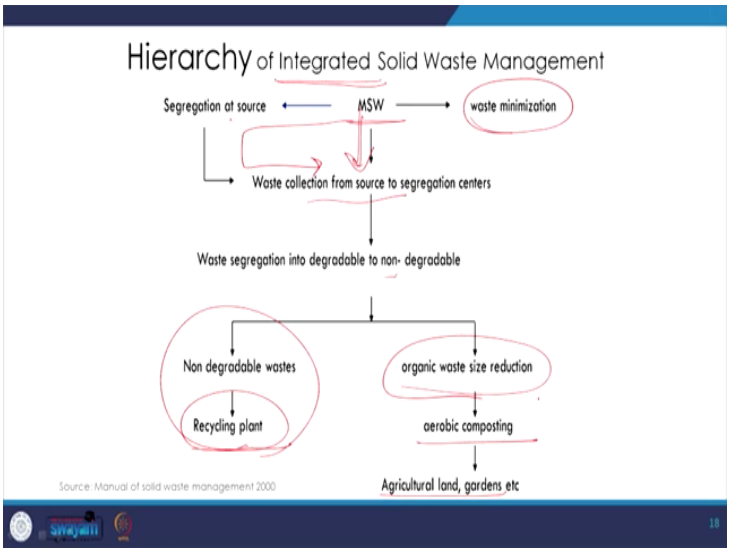

So, if you look at the hierarchy of integrated solid waste management. So, couple of years ago almost 15 years back we were not talking about the integrated solid waste management. So, there were different activities within solid waste management, but they were not integrated, fortunately enough today we have we are talking about only integrated soil solid waste management and here we talked about as the first strategy waste minimization.

After waste minimization whatever municipal solid waste is created generated, we talked about segregation at source and then the collection. So, it could be either this route or if it is segregation at source then it goes to the collection from source to segregation centers and then segregated into biodegradable and non biodegradable, for non biodegradable waste it is taken to recycling plants and for biodegradable waste we take it to aerobic composting or anaerobic composting any form of composting. There are mechanical composters as well which go for anaerobic composting and then to our gardens and agricultural lands etcetera.

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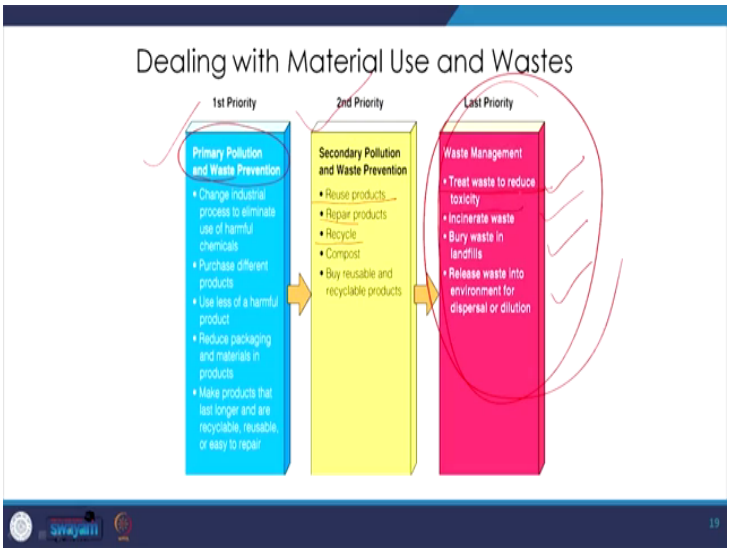

So, when we are talking about the material use and waste there are 3 distinct priorities. So, the first priority is to prevent the waste and primary pollution so, reducing the amount of waste which is generated. So, we have to reduce the different types of product consumption and thereby the generated waste for example, reduction in the packaging waste, reduction in the food waste, reduction in the paper waste, reduction in all types of waste that is possible.

The second is we are talking about the reuse and repair, reuse, repair and recycle. Now again this has been an intrinsic quality of our community of our society where recycling and repair and reuse of the products was an integral part of our lifestyle. So, there was nothing which would directly immediately go as waste. For example, the mop which is commonly known as [FL] so, couple of years back almost 20 years back none of the market shops would have a mop which would be available out there, because all the households would be using the used cloth as mop and that was a very common practice.

Unfortunately after the influence of western global market culture even the mops are now available. So, that is where a lot of waste cloth which is generated in the household now goes to landfills it now goes out as a waste, while earlier none of it would actually go as waste because it would further be reused we had this culture of repair we still have.

So, almost for everything we have a repair mechanic whether it is we it would be shoes or slippers or clothes or the equipment for example, mixer juicer or microwave or

whatever we have repair shops, while if you look at the developed countries they do not have the concept of repairing and reusing a product we still have and we have to further encourage it. So, first we reduce the amount of waste which is generated, second we repair and reuse repair recycle and reuse all these products and the last priority is that we treat the ways to reduce the toxicity or we incinerate it or bury it in the landfills or we release the last is to release the waste into environment for dispersal or dilution.

We should avoid all of this which our priority should be to reduce or to recycle and reuse and there should not be any waste we should actually be going into the environment through any of the means.

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So, when we are talking about municipal solid waste management the same priorities become the principle. So, we are talking about the waste reduction and then we are talking about the effective management, where we are talking about recycling repair reuse. So, if you look at the hierarchy of waste management options we would first try to reduce the waste at source.

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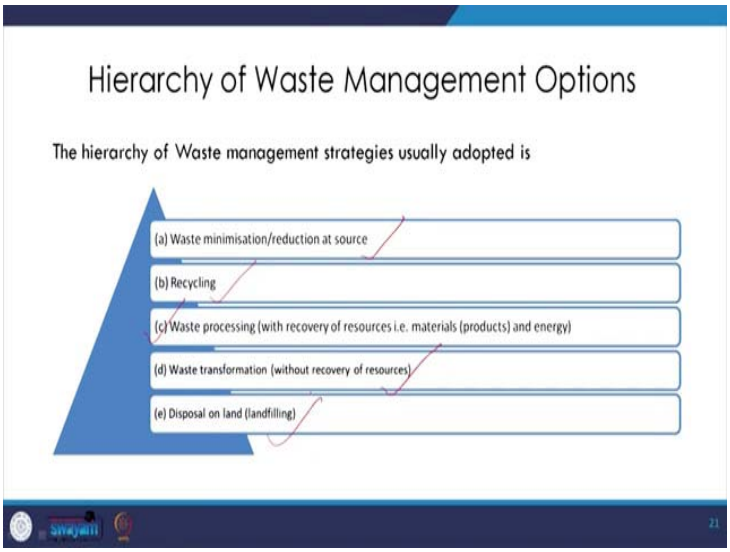

Then recycle it, process the waste, transform it and after that whatever little is left we will then dispose it on land after it has been converted into inert waste. Now all this is in a hierarchical manner. So, it is not that simultaneously all these steps would be taking place.

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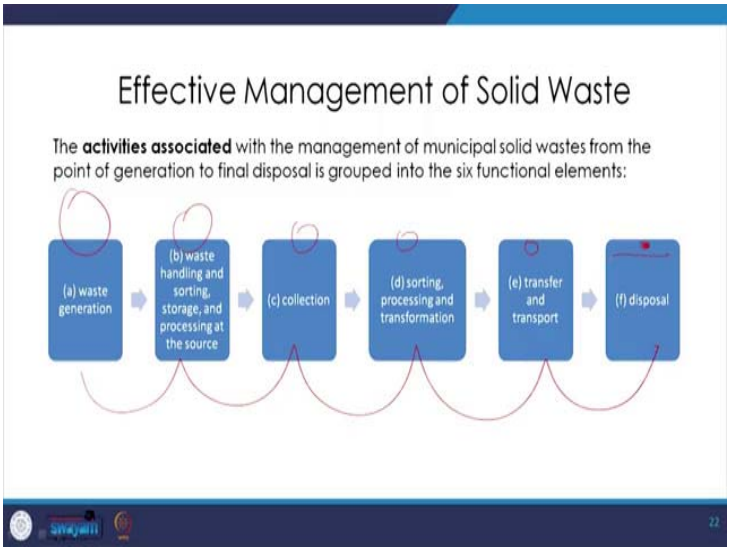

We will be going from one step to the other step in a hierarchical manner and thereby reducing the amount of waste which is generated at each site and the ultimate aim is to reduce the amount of each waste which is finally, disposed.

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So, if we look at all these steps of solid waste management in detail at waste collection we need to collect the waste from each facility and it should be collected from door to door or through a centrally organized facility. Once the waste has been collected either the waste is segregated at source or it is segregated with before it is sent for transportation and processing at a central facility.

If the waste has to be transported to the recycling facility then it we have to ensure proper transportation through covered transportation. So, that there is no littering which is happening, through transportation we will be sending it to the processing units where different types of wastes will be treated processed differently. So, recyclables will be going to specific industrial units where there will be recycled, the organic waste may be sent to mechanical composers or vermi composting or whatever appropriate strategy depending upon the waste type and once it has been processed it is either taken back for reuse or if it is inert.

For example, the compost has been created out of mechanical compost or so then it can be disposed. Now, this is a harmless waste it is not hazardous and it has been broken down decomposed to it is elemental form which can be then returned back to the environment.

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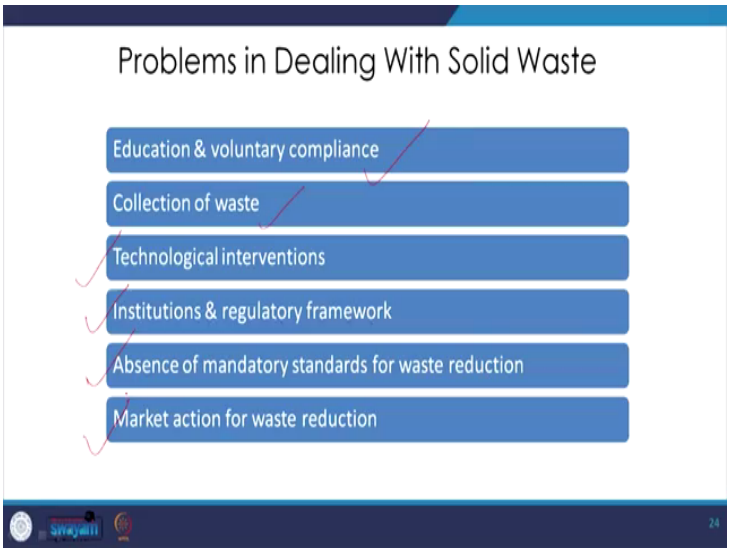

Now, there are several problems in dealing with solid waste. One of the major problems is in education and voluntary compliance. So, when we request the occupants to segregate their waste at source there is the biggest challenge and also the resistance. Then collection of waste which is efficiently being done handled by municipalities, then we are talking about technological interventions. So, not all technologies are appropriate for all scales and types of wastes so, identifying selecting the right type of technology.

And then institutions and regulatory framework so, how this regulation has to be enforced one creator and then enforced also in a country like ours. We have absence of mandatory standards for waste reduction specially, at the industrial level also monitoring of it. And then market action for waste reduction. Fortunately with a lot of impetus from the government through policies and kings a lot of this solid waste management and the policies, frameworks, action plans are being seen on ground.

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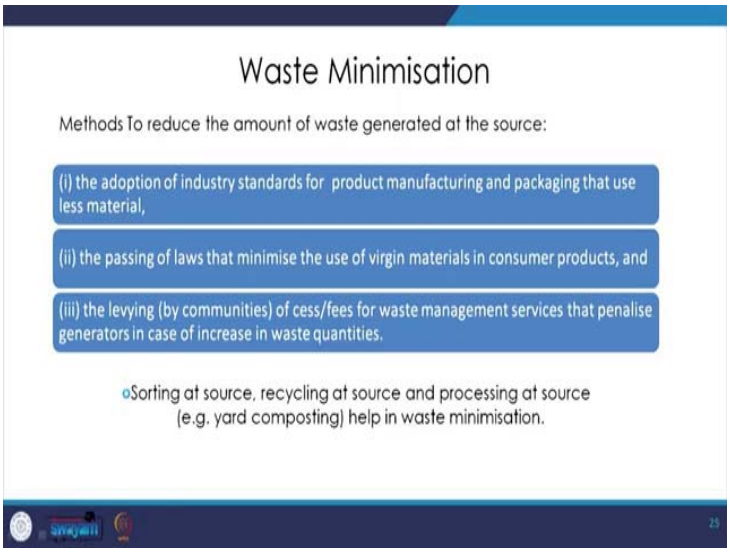

So, when we are talking about waste minimization we have to adopt the methods to reduce the amount of waste which is generated at source. So, we talking about adoption of industry standards for product manufacturing, we are talking about passing of laws to minimize the use of virgin materials in consumer product and we are talking about levying of fees, cess on communities for waste management services that penalize generation of waste and increase in the waste quantities. Then we are talking about resource recovery through material recycling.

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So, we are talking about segregation at source which will then lead to the resource recovery. Now, this resource recovery could be in terms of energy, in terms of material, for example, glass, metals, the entire material can be recovered resource can be recovered or we can also talk about the garden waste, the organic waste for example, bio waste or garden waste which can be then recycled to extract the elements the nutrients which are contained in it. So, we have different types of processes we have biological processes which can be anaerobic processes and aerobic processes ~~.s.~~

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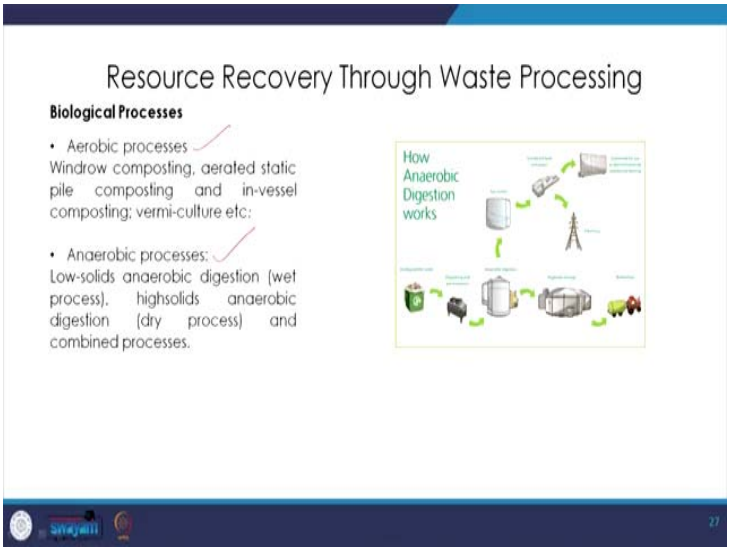

~~And aerobic processes as~~As we have also seen in the solid waste, water processing, recycling the difference between aerobic and anaerobic processes.

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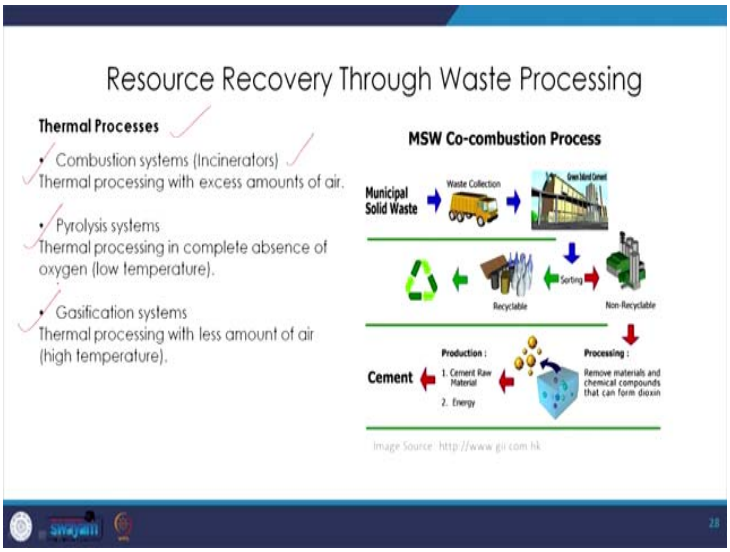

There are thermal processes which include combustion which is incineration where the products are burnt and the harmful gases are controlled they are captured before they are released into the environment. So, incineration is another process which is one of the thermal processes, but all the thermal processes require a lot of energy. Then pyrolysis where combustion in the complete absence of oxygen is taking place and then gasification where we are combusting in presence of very little amount of air.

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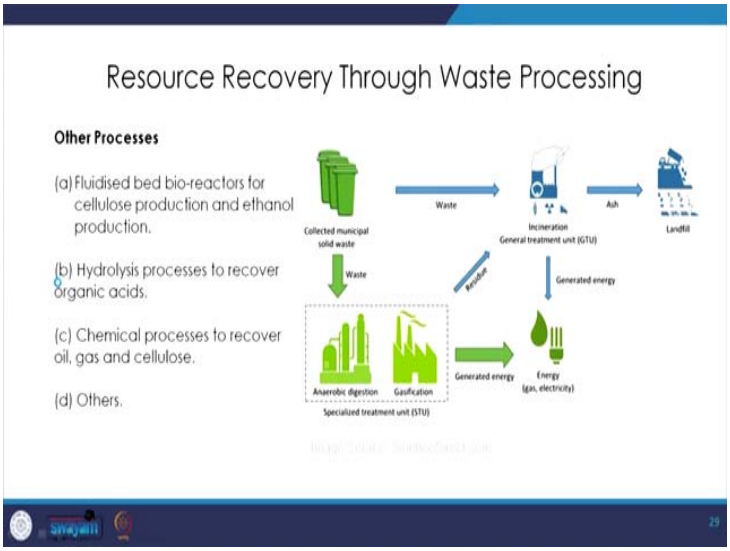

There are many other processes for example, hydrolysis to recover organic acids, chemical processes to recover oil, gas and cellulose. Ffluidized waste by reactors for cellulose production and ethanol production. So, a lot of technological processes are now available, in addition to that we are talking about the transformation processes where prior to the disposal the level of hazard that these materials contain that can be reduced. So, the hazardous materials can be converted into non hazardous materials and then they can be disposed.

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The disposal or land should be the last type of the last step if nothing else works and it can be classified or it can be designated as municipal solid waste landfill or sanitary landfill. Now, these sanitary landfills they are there are proper guidelines for them, how they have to be arranged in layers, what are the different layers and how high they can go, what is the total volume that each landfill site can contain and all of that.

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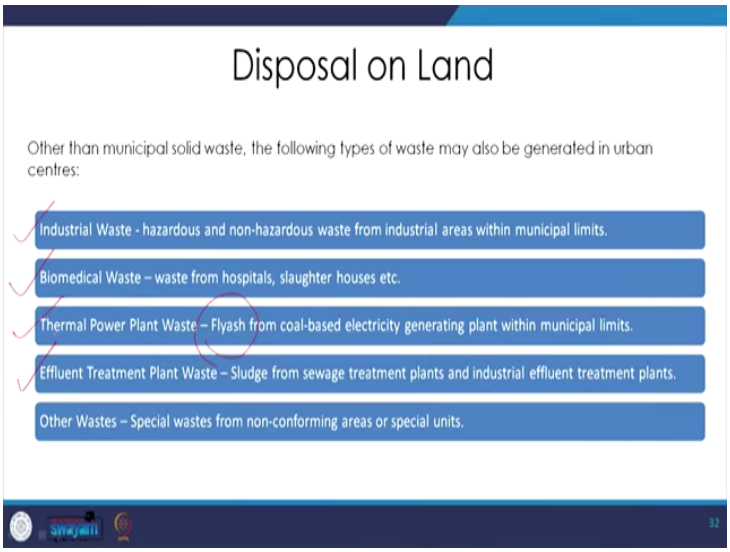

So, besides the municipal solid waste which we have been discussing so far, there are different types of wastes which are also generated in urban centers. We have industrial wastes which are generated out of our industries and we can see that the industrial towns have a very huge number of wastes, huge amount of waste which was generated because it is largely the industrial waste which is coming in.

Then we have biomedical waste. So, we have proper guidelines to collect the biomedical waste and treat it separately s. So, that it does not get mixed with the other municipal solid waste. We have thermal power plant waste which is largely the fly ash from coal based power plants. Now, we have identified different ways of reusing this waste product which is the fly ash because it is an inert material and can be used in multiple ways. For example, making fly ash based cement mixing it with cement making fly ash bricks and several other materials.

Then we have a effluent treatment plant waste. So, this is the sludge which is generated from the sewage treatment plants which we have seen in the previous lectures as well. This can be used for multiple purposes specially for composting for to be used as manure because it is quite rich in nutrients organic nutrients and there are many other different types of waste which are special waste from non conforming areas or special units.

So, we will stop here today and in the next lecture we will talk about more concepts related to the waste materials and resources.

Thank you and see you again.