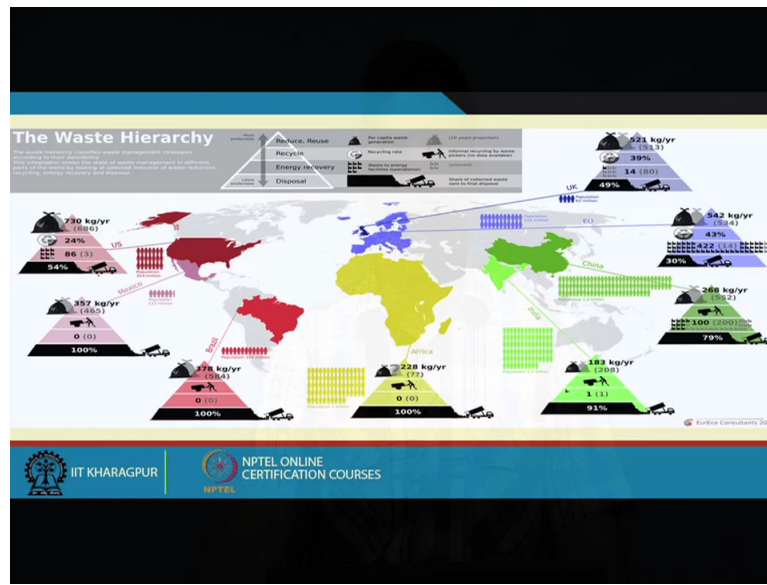


**Course on Integrated Waste Management for a Smart City**  
**Professor Brajesh Kumar Dubey**  
**Department of Civil Engineering**  
**Indian Institute of Technology Kharagpur**  
**Module 1**  
**Lecture No 3**  
**Introduction (Contd.)**

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Okay so let's continue for our discussion on where we left in the previous module, so as I was telling you a few slides back that we will I will show you that what is the de facto choice of waste management, so you we just had a summary in the previous towards the end of the previous module that the different components how the waste is managed and. So now look at what is actually happening on the ground, so if in a global picture in this particular map, where you see this map and a kind of go over this map explain you all the details. On the top as you can see there are that is again the same hierarchy that we talked about earlier disposal, energy recovery, recycle, reduce and reuse.

We wanted to more and more reducing reuse but unfortunately that is happening less and then on the after that you see that all these have been landfill is over here. Recycle, reduce and reuse some of the informal recycling waste-to-energy plants and all those different stuff has been talked about. So this map is it is slightly older like 2 - 3 years old but it is again things does not change overnight in any of these aspects anyway so and it gives you a kind of picture of...even if things have even if the landfill has gone down by a few percentage points but it is still as you can see that how the waste is been managed.

So let us look at one by one, so we will let's start with India, since we are in India right now let us start with India how we are we have been doing in terms of the waste management, so in the Indian context 91% of the land of the waste that we produce goes to this landfill. When we say landfill in India are actually those of mostly unregulated dumps. There are few landfills but most of them are unregulated terms so 90% of the waste is being just dumped in the environment, so that that is a big percentage so and then we have some waste minimization plant, so here this 183 kg per year (2:23) tell you based on the government initiatives in the waste minimization this is how much is being reduced.

Something what whatever is given the brackets kinds of tell you that what is the proposed regulations will pay in terms of the reduction. Then we have in terms of recycling where you this man with a cart that means it is mostly informal recycling, there is no formal much formal recycling going on, it is mostly informal recycling happening and then we have one waste to energy plant operational and the other one another one in pipeline and this number is definitely old as I told you in the previous module as well there is a portion having waste-to-energy plants in India.

So right now we have more than at least 3 or 4 of the waste-to-energy plants which are is operational and then several are there which is under pipeline and then the then the different levels of the pipeline, so may be a good idea would be like in may be in a year to 2 from now to update this graph for global picture and then the number to see how the number changes but as I said earlier for most part it will be kind of in a similar range so that is the India and then most of the time we compare ourselves with China.

So if you look at the Chinese part and one another thing I would if you have noticed these green you see like a small like a several the population that have been shown, that is these population data is proportional to the actual population, so this population figures out I should say, population sketch of population diagrams is proportional to the population of that particular area, so this is the it kind of shows you the population of India which is 1.2 billion than it shows population of China over here around 1.3 billion, so if you look at the way the Chinese people are doing it, so again there is some waste minimization, some informal again informal recycling.

They had 100 waste-to-energy plant operational and again this is a (4:27) old right now it would be much more than that, so hundred waste-to-energy plants are operational and then another 200 in pipeline, so there they have lots of waste-to-energy plants being built but even

after that, nearly 80% of the garbage 80% of the Chinese garbage is going to the land fill, so which some of them includes dumps as well, so that is how China is performing in terms of the waste management, then after seeing these 2 if you look at the best example which is of course the Western European countries and they have been put all together as one with a population of around 330 million.

So if you look at the Western European countries, only 30% goes to the landfill but it is again, one way of looking at is only 30% goes to the landfill the other way of looking at it is still they have 30% going into the landfill because Western European country working on waste management system for almost 3 - 4 decades now, so even after working on for on it for 3 - 4 decades, they have the waste going to the landfill so that is kind of tells us that landfills are going to stay. So if you are an environmental engineer, if you want to really make a career in this waste management sector.

One of the key thing that you need to understand and to learn is the landfill design, so if you know the landfill design you will have some jobs for sure and of course the compost and incinerator and all those things does come into picture but landfills designs are also very important and in fact many people are many people of Indian origin are working in Middle East and other places where there are new and newer landfills are being built up today, so that is one area where lots of jobs are available at least in near future. so in terms of 30% going to the landfill 422 waste-to-energy plants in the Western Europe countries, are of only 331 million population which is one nearly  $1/4^{\text{th}}$  of the Indian population, they have 422 waste-to-energy plants working and another 14 in the pipeline.

So that you can think about but why have you like a...When you look at those data of course the question as I said as I keep on saying again and again we should always think why it is that the Western Europe and countries are building so many waste-to-energy plants and the reason for that is, it is although the population is 330 million the area is also pretty small and since the area is small they or the whole Western Europe and so that is European Union or include so that that is kind of tells us that since the area is small, they cannot have the land for the landfill so they are building a waste-to-energy plants so that they can burn this garbage, reduce it to at least to 10% of the volume and the rest 10% goes to landfill.

Some places like Netherlands Denmark even they recover many things out of those residual and only 2 to 3% goes to the landfill, but so that is the and they have some they have recycling program and 43% of the garbage recycle, 43 possible the waste and that does

include all the kabadiwalas and stuff that we do it they do it in India there is no kabadiwalas in the Western world or developed countries, so they have a there is a recyclable is processed through the municipal solid waste collection system and then there are some process in terms of the waste minimization, so that gives you an idea about how things are happening in European Union and then if since the (8:00) has already happened and for some reason this graph has UK separate I do not know why but maybe they foresee that (8:07) couple of like a year down the line so in UK we have 49% landfill again UK is a struggling in terms of reducing the landfill.

They had 14 waste-to-energy plants another 80 in the pipeline nearly 39% recycle and some programs to reduce the waste. So that is the how things are happening in in UK and similarly UK if you go to US which is not that different US has 86 waste-to-energy plants and then they are building another 3 and 54% of the US waste goes to the landfill, so that is the much even higher than UK. So 54% goes to the landfill, why? Because again lands are available.

So since the land is available, landfill actually landfill is much cheaper so even from the Indian context, once these waste-to-energy plants are getting attraction today because of the land prices are pretty high. We do not have land to build a landfill, then again there is a debate on that like whether we need a land to be the landfill or whether we need land to build those raceway courses, that Formula One raceway which happened in which was built in Noida idea no.

So but it is if that we can debate along (9:30) but land is a problem in a country of 1.2 billion where so many population is out there we have to feed our people we cannot use up our cultural land we do need to have some industry, so the build a landfill is does like I said landfill areas are huge, so they are there is always a land issue. So but in US the land issue is not that much problematic so that leads to them having being able to having the landfilling although the landfilling is been discouraged in the United States as well.

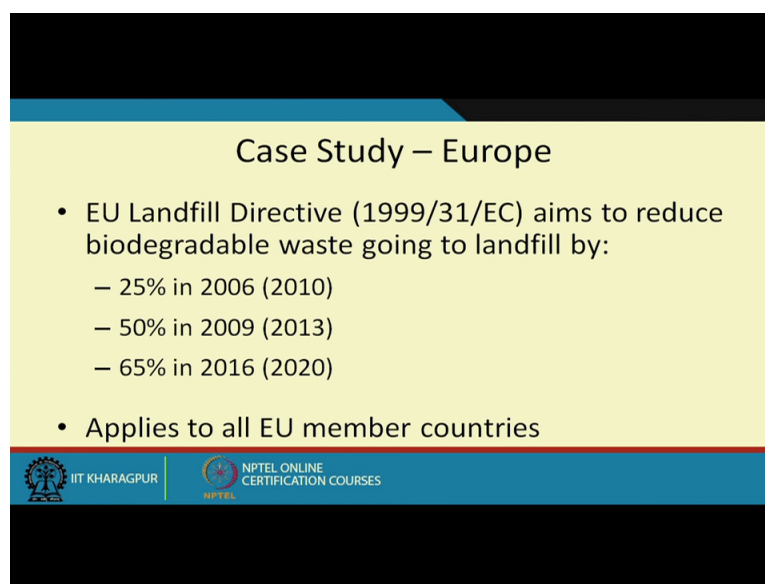
So is on 54% of the waste going to the landfill and if you go to like some other developed developing areas for example in Mexico, nearly 100% landfill, Brazil 100% landfilling, Africa 100% landfilling, so that is kind of gives you so things in Brazil, Mexico and in Africa seems to be even much worse than what ours are ours is but our situation is also not very good in terms of the waste management sector. 91% of the waste is just going to the dumb site or among them few are engineer landfills, so that is actually cause of concern because that because of all the heavy metals and other things present their, there it can potentially



leach this will things get leach into the groundwater and then it becomes a problem in terms of public health issues.

This particular map kind of gives you an idea of how the things are working as you can see landfills is still a predominant way of waste disposal, so having a good design of the landfill having an understanding of the landfill design is always very helpful in in this particular field. So now if you look at this Europe little bit more in detail there was again things get driven out by the regulation, since there are the policies in place which tries to drives things in a particular direction, so European Union does come up with certain guideline.

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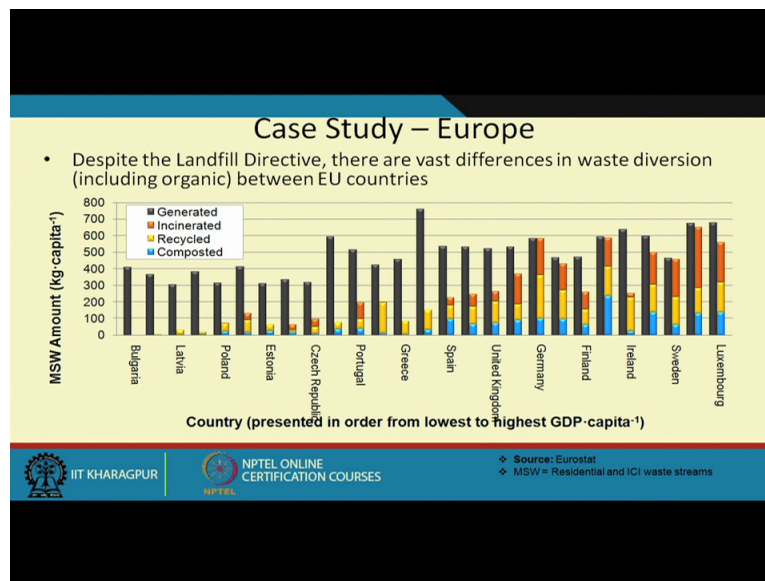


The slide is titled "Case Study – Europe" and contains a bulleted list of information about the EU Landfill Directive. The background is yellow with a blue header and footer. The footer includes the IIT Kharagpur logo and the NPTEL Online Certification Courses logo.

- EU Landfill Directive (1999/31/EC) aims to reduce biodegradable waste going to landfill by:
  - 25% in 2006 (2010)
  - 50% in 2009 (2013)
  - 65% in 2016 (2020)
- Applies to all EU member countries

They want to reduce the biodegradable waste going to the landfill by 25% in 2006, 50% in 2009, 65% in 2016. So it applies to all EU member countries but unfortunately they could not really meet all these deadline and so it was revised so 2006 target was revised for 2010, 50% target was revised for 2013 and 65% target is revised for 2020. So they have to work towards it, they have to work towards it they have to keep these biodegradable waste away from the landfill so will try to keep it away from the landfill you have to have some sort of compost point or anaerobic digestive plant so things are working in that area.

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So regulation does force people to do certain things, which are they would otherwise not do, so having a good regulation is always very helpful in terms of the waste management. So if you look at this, despite the landfill directive, there are vast difference in the waste diversion, including organic between the EU countries, so as you go from left to right you go actually what you have what you are saying is from the lowest GDP to the highest GDP per capita like a per capital.

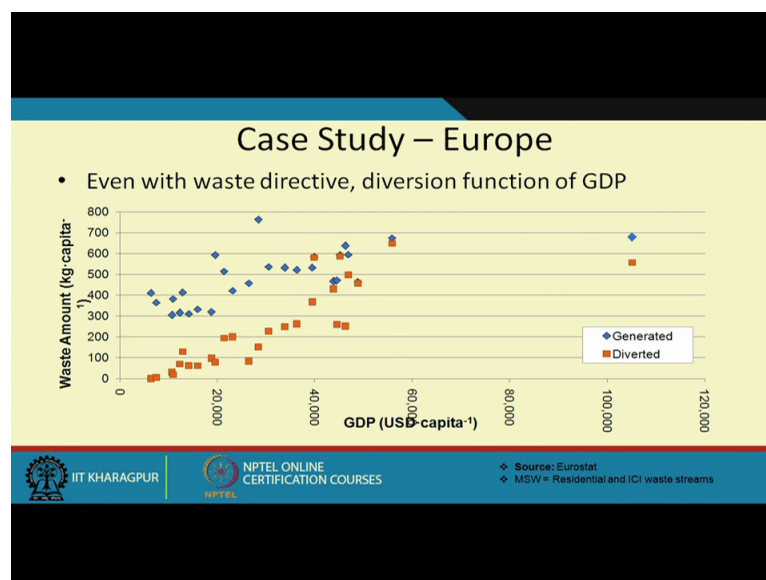
So as you go from lowest GDP the highest GDP in this particular graph you have that is your sorry x axis. X axis is the name of the countries which for which the bars are and then the y axis we have MSW amount per capita so how much waste is being produced per capita per day and the bars that you see over there for each of the country we have 2 bars, one is the black bar and the black bars actually showing us the it is there is a total amount of waste is generated and then next to the black bar is you see a bar which has multi-color mostly 3 colors and they have incineration, recycle and compost in number.

If you have the red is red color is the incineration plant that orange color is your recycle and your blue color is compost. So that is kind of how they are adding try to compare them on the left-hand side is mostly Eastern European countries you see that they do not have much diversion going on when we say diversion, diversion means the amount of waste not going to the landfill. So that is the diversion, so Bulgaria, Latvia to certain extent Poland and Estonia, Czech Republic we do not be do see some I would say waste being the averted.

But still they have to get that work done and so but if you as you as you make progress towards the Western European countries as you go towards the richer country on the right what you see is that more and more waste is being diverted and some examples for example Germany or Denmark or Sweden, Netherlands which is Austria, so those numbers on the right-hand side, they have are very close to achieving what is known as the 0 waste.

So that is the it is very important so it is so that is so that is the most of these countries they are sending very less amount of garbage in the landfills. So but still they are sending garbage into the landfills so that is that is the other so that is what it kind of signifies that even after working on this field for several years we cannot really get rid of the landfill, we may not like it is unfortunate part of that but landfills are going to stay for sometimes.

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So other graph of showing the same thing like how not the same I should not say the same thing but this graph is showing you the GDP which is the US dollar per capita and in the x axis and the y axis are showing the waste that is produced that is KG per capita per year. So if you look at this particular graph our blue is the generation part and the red is the diversion part, diversion means the amount of garbage which is not going to the landfill.

So as you can see as people are getting more and more well they have busier tendency of producing more and more waste, as we become more and more wealthier, we tend to produce more and more waste which you may have seen in your own life as well and so but at the same time since so these countries which are have a highest GDP like US dollar per capita,

So you see kind of co-relation your that more the waste more the GDP per capita more the waste being produced, more the GDP per capita more and more ways gets diverted, more and more waste goes to some other this may. So let us so the next we will look at why should we even worried about this waste stream like how long until it will be all gone. So, so far what we have seen in terms of the Europe part in terms of the more and more, more is the GDP per capita more the waste being produced at the same time more the GDP per capita more the waste gets diverted as well.

## HOW LONG UNTIL IT'S GONE?

Estimated decomposition rates of common marine debris items

Item	Estimated Decomposition Rate
Cigarette Butt	1-5 years
Disposable Diaper	450 years
Glass Bottle	undetermined
Plastic Beverage Bottle	400 years
Tin Can	50 years
Fishing Line	600 years
Styrofoam Cup	50 years
Wood Socks	1-3 years
Foam Ball	50 years
Plastic Grocery Bag	10-20 years
Plywood	1-3 years
Rubber	undetermined or 100 years
Aluminum Can	200 years
Cotton Swab	2-3 months
Rubber Band	10 years
Rubber Band	10 years
Rubber Band	10 years
Rubber Band	10 years
Rubber Band	10 years

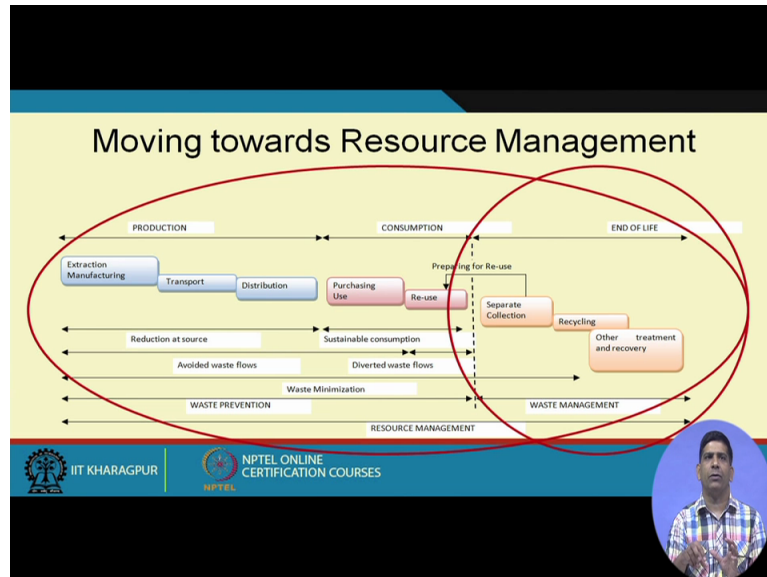
Estimated rate of decomposition based on published data. Actual rates may vary significantly based on environmental conditions. For example, some items may decompose faster in warm, wet environments and slower in cold, dry environments.

So the reason for that is the waste that is being produced, they are not biodegradable anymore, as you can see in this particular slide there is a there is estimated the composition rate of certain marine debris that is more and more waste that is been produced it is it is it is just days in the environment for a long time, they do not decompose they are staying in an environment for a like a certain.

Some of the stuffs that you can see over here the plastic bottles for 450 years, fishing line for 600 years plastic beverage holders for 400 years and even as simple as cigarette butts they

stay for 1 – 5 years, cotton shirts 2 - 5 months, so this waste that is being produced today they do not degrade very readily, so when they do not degrade the very readily, they stay in the environment they get into our water, they get into our sea and then oceans and then they create problem in terms of the contamination.

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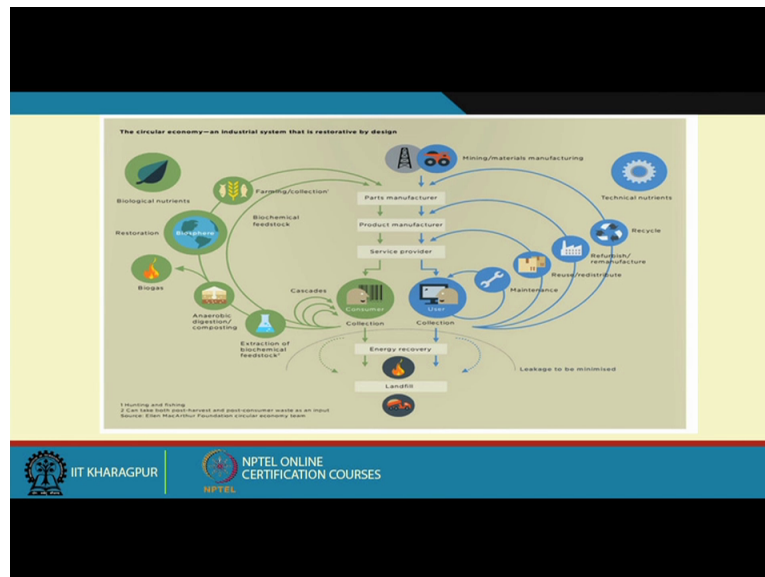


So that is why we need to kind of think about managing the waste being more responsible way and for that what is happening today is, we are moving to word what is known as research management. Earlier we were thinking more in terms of the waste management, waste management as the name suggests is mostly you are looking at the end of life, so you are more looking at towards the end waste product is being made, people are using it and when they throw it away that is where you kind of looking at the end of life approach.

So this is also known as what is known as you have a bottom of the pipe approach or it is it is in pipeline process you are looking at the end of pipe approach. But that is not where our discussion is leading us to. Nowadays we are focusing more on having a resource management rather than having a waste management. So what do we mean by resource management, so as you can see in this particular graph you start from production, consumption and end of life, presently in the waste management if you look at a waste engineer, you are mostly worried about in this portion where you are separate, collection, recycle and others. But these days the focuses more on looking at things in totality, so you start from all the way from production to consumption and the end of life.

So that is you are looking at the whole things in a totality where people are moving from end of life approach to a more system approach so this is how this concept of systems approach and systems engineering and also industrial ecology life-cycle and all of these have similar concepts, where you are trying to look things in a more holistic point of view.

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So that is where we are moving towards the resorts management and that is the concept of circular economy that you hear from time to time these days which is the circular economy concept and, what is the concept of circular economy basically you have a certain material used to make product, you use that product goes into the disposal stream, you extract material out of that and you again put it back into the economy so that is the concept of your circular economy.

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Why Do We Care How Solid Waste is Regulated/Managed?

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Source: Brown, Michael, "Drums Death", Audubon, 120 July 1980.

So why do we care? how solid waste is regulated or managed, so far after giving you a good old view of what is what is a like a waste, how it is managed, what are the different components? Now we will try to kind of give you more like why is it important, why do we really care or why the solid waste is how it is managed? Because it creates environmental problem, as you can see in these 2 pictures over here, these 2 pictures happened in United States in 1970s.

So as on the side of the road as you can see on the left picture over here on the side of the road certain industries, they just dump their like a waste drum filled after drums on the side of

the highway on one particular night, so they had like a value of it is called like a drums of death like a valley of lots of drums over there.

And on the right-hand side you can on a close up you can see the waste which is just percolating into the ground, it is getting leaks into the ground, so the incidents like this lead to the formation of solid waste management rules. So this is this was kind of a some of those signature events, this event as well as another event of Love Canal which was where waste got dumped into a in like in an inner subsurface then people made houses on top of that people got sick.

So you if you have not watched Love Canal incident you can go on YouTube and look at those Love Canal videos, there are several videos out there so that is again one of the important event unfortunate event which led to solid waste regulation throughout the world. If you do not do it properly you may have a problem of things catching fire as the can see in this particular slide, where if the waste is not managed properly it can catch fire and it leads to his catastrophe so that is you and we has a so we will be producing waste so it is would like a in terms of why do we care cause the human being will keep on producing waste but the when the waste is being produced it needs to be managed properly.

Some of the waste are very nasty which are the hazardous waste, we will not talk about hazardous waste in this particular course maybe some other course, but in term but even the municipal solid waste these days are becoming because of all the different types of heavy metal are being used, different pigments and the plastics batteries, electronic waste. So all those are becoming a pretty dynasty kind of waste mix that needs to be managed and if you even some of those stuffs in the household are could be flammable for example you have your nail polish remover or you may have some used paint or you may have some old stuff lying in the house like within an aerosol can and all those things can create some sort of trouble.



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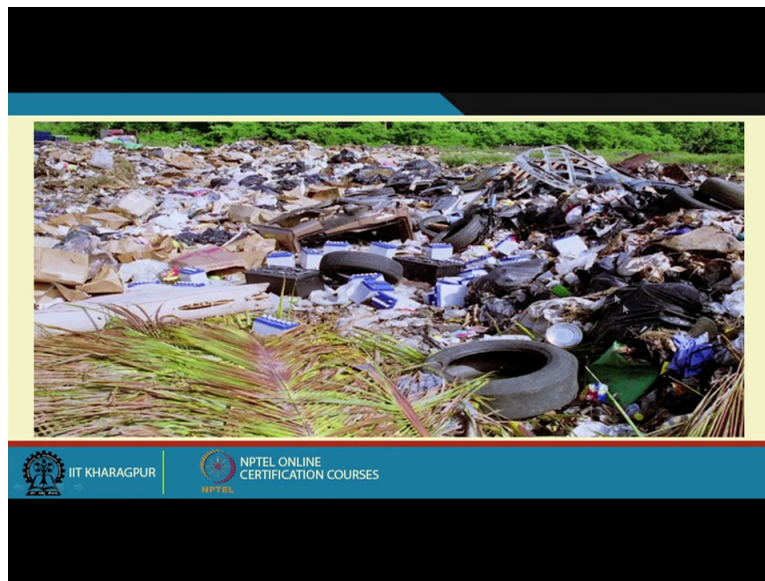
So as you can see on this particular picture, if the waste is not being managed properly that causes a lot of like a lot of can cause a catastrophe and can lead to lot to fire. So that is that is another reason why we need to manage the waste properly, so that is it is again cause fire. Mostly these are hazardous waste cause these are industrial waste but again as I said our municipal solid waste things are is also changing.

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Another scenario where you have waste just dump on the site here the picture if you can on the very end you have some very nice water body but the waste is being dumped along the slope and then gradually things will leach off and this (24:29) water drain will take all these chemicals from here to the water body and creates a problem.

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So that issue is there and in the older times the again this picture kind of shows you that lead acid batteries, you see lots of batteries over there these are the auto batteries, automotive batteries. These days most in most of the developed world I think in the developing countries as well if you when you go and re-change like when you change your old batteries with the new batteries for your car, you have to give the old battery to the to the shop owner because he has to kind of send that old battery away for recycling purposes.

But in older times these were they were being just dump and these are lead acid batteries so they have lead they also have acid. So this is really nasty stuff and if they are dumped on the side of the road and if they get broken down which it will eventually it will happen and then it will lead to soil pollution, groundwater pollution and surface water pollution as well.

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Sometimes the garbage will catch fire as you can see in this particular picture and then that creates a lot of air pollution problems where this dumps is on fire and reading the air pollution issues. People living on top of the dump, that is another issue where people are living there and then they are they are trying to have their livelihood and that is again it is that is why I said earlier it is not only a technical issue, it is not only a science issue there are a lot of social issues associated with that as well.

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So that is in which is people when they live on top of the landfill, it is their livelihood you cannot just tell them to go away because that is there way of making money (26:15) but when they live there, there is lots of health issues associated with that. Again this is another picture this is from Macedonia which is a Eastern European country you see the fire on the side of the on the on the garbage, garbage on the side of the road and fire on the garbage. So these things do happen even in other countries to, so not only in India.

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So again the same country different picture waste on waste dumped on the side of the like a slope on top of it is a road on top and then you have the garbage catching on fire and creating air pollution problem so again the same picture from a different angle. So this is from Delhi, you see this nasty leachate being just on the toe of a landfill and this landfill is unlined landfill does not have liner system.

So this leachate has a very high chance of percolating into the groundwater and of course it depends on how deep is the groundwater you can say fortunately for from this point of view that Delhi groundwater is (27:14) very deep. So it will take several years for this to reach there and it may get power of it will get remediated as well but again it lead it can lead to surface water problem and you have a cello what cello acrufer you have a tube well nearby that can lead to those kind of issues as well.



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So you can see the leachate being there is no leachate management so that creates a problem again this is from the Delhi landfill. Another picture here you see one particular person the sitting there and sees just trying to make some living out of the garbage, so he would go around from time to time and try to find out some recyclables and which she can use to sell it off.

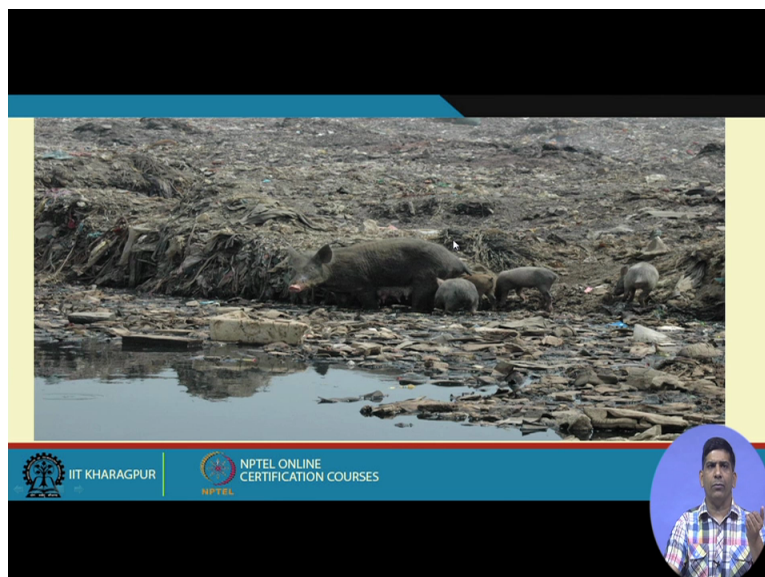
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Leachate again another picture of this leachate so these are some of the environmental issues associated with landfill. It is very close to a container yard in place, so you can see that this is the container yard they have a fencing but from areas they even the fencing has been broken down, so in terms of any of these if there is a landslide kind of issues things will go all the way over here and can create problem.

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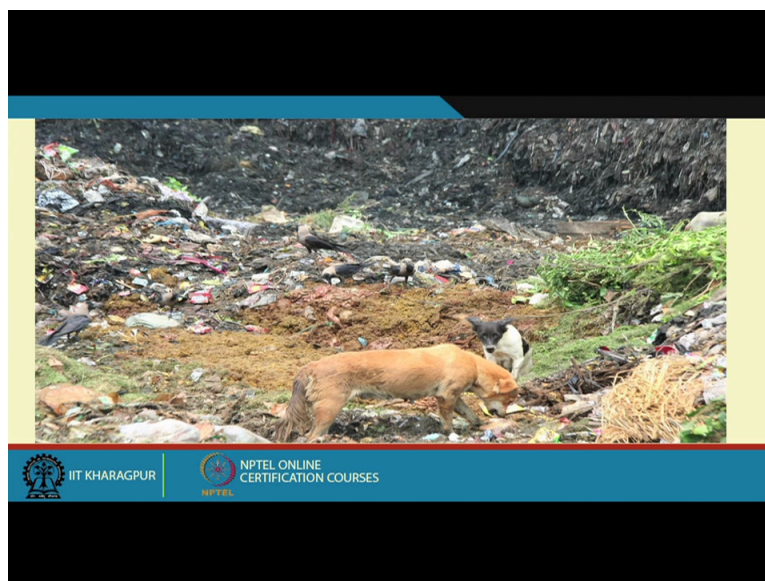




So you see animals in their this pigs and other things just into the garbage, not only has the cow like dogs, again the dogs will get lots of skin disease they are trying to consume the water which is essentially leachate so it will make them sick and that is kind of a like problematic for these people specially that say it creates lots of skin problems another stuffs and so you see dogs over there you also see cows over there on the cow is trying to eat lot of whatever is organics available in this garbage.

So what happens many times that they are not only eating the organic, they are also eating plastics by mistake and the plastic creates chokes there like a chokes their system and many times they even have health problems and even can lead to death. So we need to it is again of course cows getting into the landfill is very common, you see it from time to time so we are in terms of as a country we are bit sensitive about cows so we should be sensitive about their how they are living as well. So and again some other pitcher are there which I will just show you quickly those pictures and then we will wrap up.

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So it is this another picture of garbage you see where the cow animals getting exposed to it, people working on top of the landfill trying to get the livelihood out and trying to make some earning or of that again you see some cows on top of the landfill, these are again Delhi pictures, these are all Delhi landfill pictures and sum of people trying to make living try to get some recyclables. So that is we have kind of tells you that, these are some of the issues associated with like there is a in terms of the waste management when you look at the waste management it is not only the technical problem it is not only the these science related issues, it is also the management related issues especially from a social issues as well so and it is it is common to pretty much the many places in the world.

Some of the developed countries have kind of gone over that where you do not see these rack pickers and other people trying to go into the landfill and try to get some things out of it, but if you go to any developing countries you see these issues are there and so they have to be looked into how to make how to in incorporate this informal sector into a formal sector and that can pretty much done especially from an Indian context if you look at the a lot of government policies now in terms of the skill India or start up India, so if we can give this skill to these people, those who are working in a very informal way and in a very unsafe way at these landfill sites.

If we can skill them and use these people in a material recycling facility which where they can get the livelihood, they will try to recover material from the landfill from the waste material at a material recycling facility before it goes the landfill in a more scientific way, more controlled way in an environmentally friendly and a human health friendly way and then they can make a living out of that as well. So those in some areas people are doing some work in the Pune area there is some work going on with the help of some NGO along this line as well. So with this note we will try to close this particular video and then I show you I see you again in the next video. Thank you.