Waste to energy conversion

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Lecture – 01
Introduction - 01

Good morning. Myself Doctor Prasenjit Mondal, associate professor, department of Chemical Engineering, IIT, Roorkee offering an online course on Waste to Energy Conversion under NPTEL. This is the first module of this course and I will give you some introductions on the subject.

In 21st century, human society is facing three major issues; the first one is energy security, public health and clean environment. We know that the scarcity of fossil fuels particularly petroleum crude and gradually degrading quality of the fossil fuels is forcing us to develop some clean technology for the utilization of the fossil fuels as well as to utilize renewal resources. So, waste and biomass is considered as one renewal resource of energy.

But if we think about the waste say we will get different types of wastes like say if some waste may be hazardous some may not be hazardous, it may be solid waste water or gracious phase waste and all those waste will be having different properties and all waste are not equally suitable for the production of energy and as the composition of the waste varies. So, single route also will not be suitable to process the waste for the conversion of energy. There are different methods for the conversion of energy and we will discuss all those all those methods here and another important thing is that to implement one concept. So, waste to energy conversions in a nation in broader scale some policy issues are required. So, policy has to be developed and it is developed by government.

So, the institutes which are involved for the policy making for one energy sectors will also be discussed and in this module we will discuss the definition of waste and their classification important quality parameters of different types of wastes.

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Wastes suitable for the energy production solid waste and their classification waste water and their classification availability of agro based, forest, industrial and municipal solid wastes in India vis-a-vis world, availability of waste water in India vis-a-vis world, routes for solid wastes management, need of energy production from waste, energy from waste will provide some scenario, and then finally we will discuss on routes for energy production from wastes. So, all those things will be discussed in two parts the first part we will concentrate from starting to the routes for solid waste management and then in a second part we will cover the rest parts.

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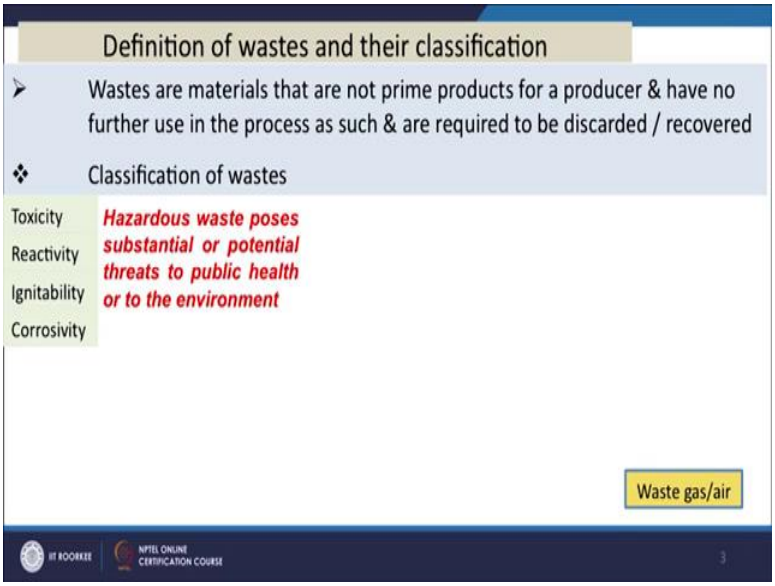

Now, will see what is a waste? If we see the definition then wastes are materials that are not prime product for a producer and I have no further use in the process as such and are required to be discarded. So, this waste can be classified either as hazardous waste or non hazardous waste. On the basis of hazardous nature of the waste and on the basis of phase this can be divided into three category that is solid waste, waste water and waste gas hazardous waste this is a special type of waste which has highest potential to create problem on human health and to be hazardous waste. The waste should have certain properties either toxicity, reactivity, inimitability, or corrosivity or any compositions of these.

So, now we will see both solid waste, waste water and waste gasses will have some specific quality parameters.

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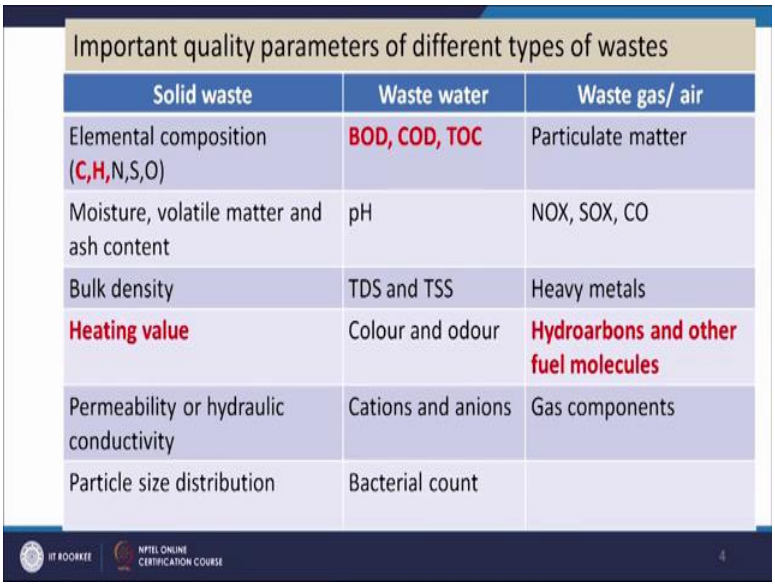

So, for solids we are seen here elemental composition moisture volatile matter and ash content bulk density heating value permeability or hydraulic conductivity particle size distribution for waste water we are having biological oxygen demand; BOD, chemical oxygen demand; COD, total organic carbon; TOC, pH, color, odor, Cations, anions, bacterial count, etcetera and for gases we will say particular matter NOX, SOX, CO and heavy metals hydrocarbons, (Refer Time: 05:21) and other gas components.

So, out of these qualities, for solid waste, heating value, high heating value and high carbon and hydrogen content are required for its application for energy production for

waste order high BOD, COD and TOC values are desired for to make its suitable for energy production and for gas waste gases. The (Refer Time: 05:47) of hydrocarbons and other fuel molecules in higher extent is desirable to consider it as the (Refer Time: 05:52) for energy conversion, but however, these options is not widely used because the waste gas with having higher concentration of hydrocarbons is not available much. So, we will be concentrating on solid and liquidates that must we will come to discuss on solid waste.

So, solid waste obviously, the waste will be in solid phase and solid waste comprise all the waste arriving for a human and animal activities and are normally solid and that are discarded as usually was unwanted.

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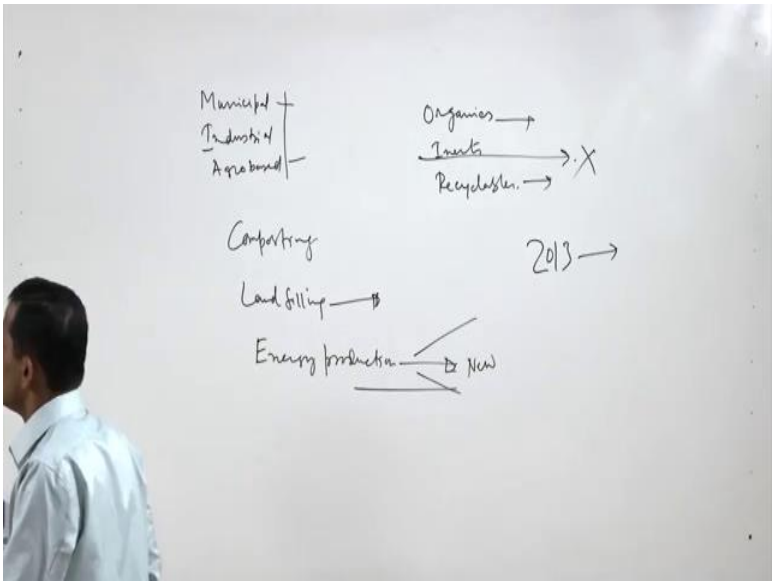

So, this is the definition of solid waste and solid waste can be classified on the basis of some facts say on the basis of source this can be classified as municipal industrial or agro based. So, out of this 3 the municipal and agro based these wastes are abundantly available on the basis of bio degradability the solid waste can be bio degradable and non-bio degradable on the basis of compostability, this can be compostable may be non compostable on the basis of usability this can be divided into 3 category that is organics inert and recyclable.

So, organics and recyclables these are important because these are having higher heating value and suitable for energy production in inerts are not is suitable candidate for energy

production this is not a suitable candidate for energy production and on the basis of bio degradability this can be divided into bio degradable and non-bio degradable now we will see the composition of municipal solid waste in India from this slide we see that 50 percent MSW in India is bio degradable twenty percent is recyclable and 22 inerts and 8 percent is other.

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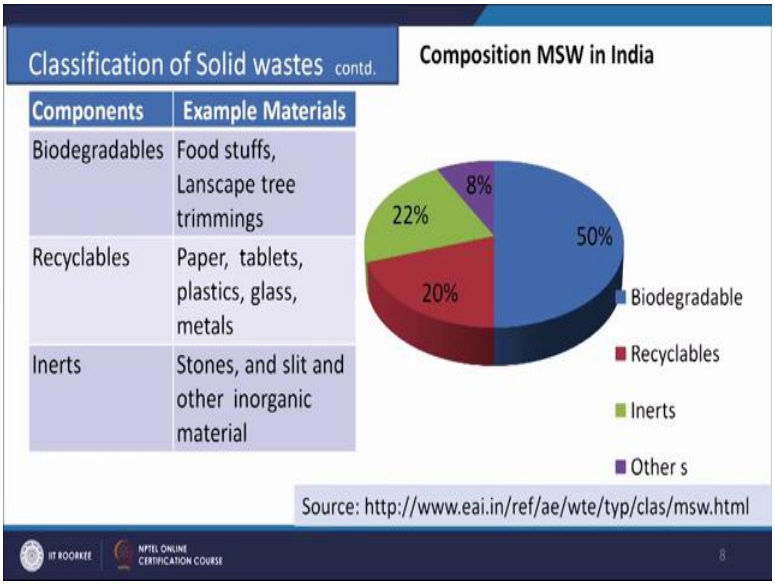

So, bio degradable some examples is given here that is all food stuffs. So, leafs trees and landscape tree trimmings and some recyclable examples paper tablets plastics glass metals. So, from these the recyclable materials can be used reused can be sent to industry for its reuse or some part can also be used by energy production. So, bio degradable material and recycle part of recyclable materials are responsible for the energy productions from these and are more suitable, but in inerts stones and slit and other inorganic material these are not having in energy value.

So, this will not be used for energy conversion and we will see some statistics that is composition and heating value of municipal solid waste in India. So, you see metros other cities and Eastern India, North India, South India, West India and then overall the information I provided here.

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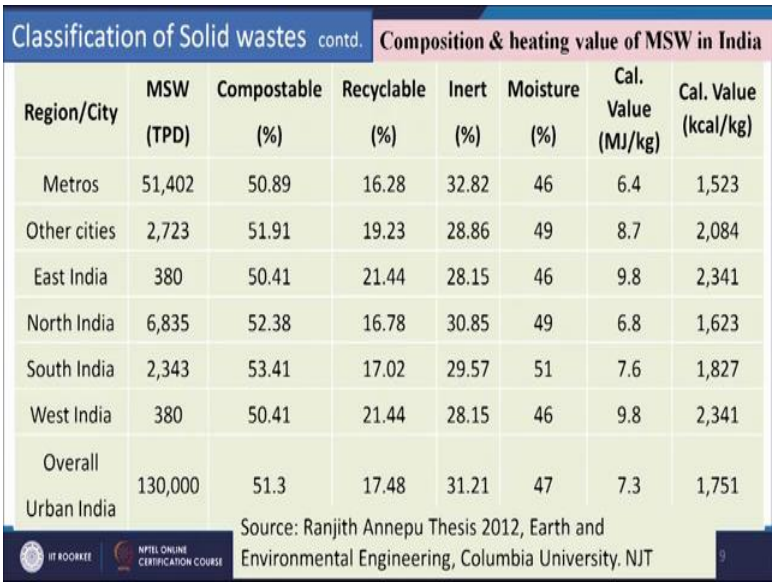

So, from these stabilities we have to ask that overall 130,000 ton per day MSW generated in the country which is having around 50 percent compostable materials and 17.48 percent recyclable and 47 percent moisture and 31.1 percent inert material important fact which we can get from this data is that heating value is not much and moisture content is also very high for the overall bases for this west generated in India. So, what is the solution with this low heating value and very high measure content it is really difficult to process the solids that is why there are some methodology to segregate the solid waste and to get separated the particular portions which is having high heating value.

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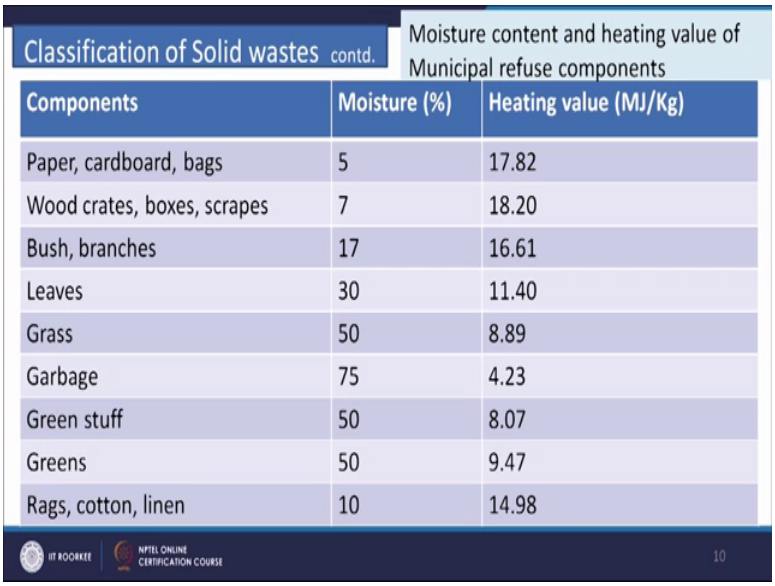

And low moisture content this table shows us some such examples say for paper cardboard bags moisture content 5. So, gradually wood crates boxes are 7. So, gradually the moisture content is increasing if we consider different types of (Refer Time: 10:35) or the waste available and heating values also decreasing. So, the first portion which is very high heating value those can be used for the energy production through thermal route, but where the moisture content is very high is about seventy 5 percent of moisture. So, we will not prefer for thermal conversion route we will be preferring for biological routes.

So, there are different routes which will be suitable for a particular type of waste for the energy conversion. Now we will see the characteristics of some agro based solid waste.

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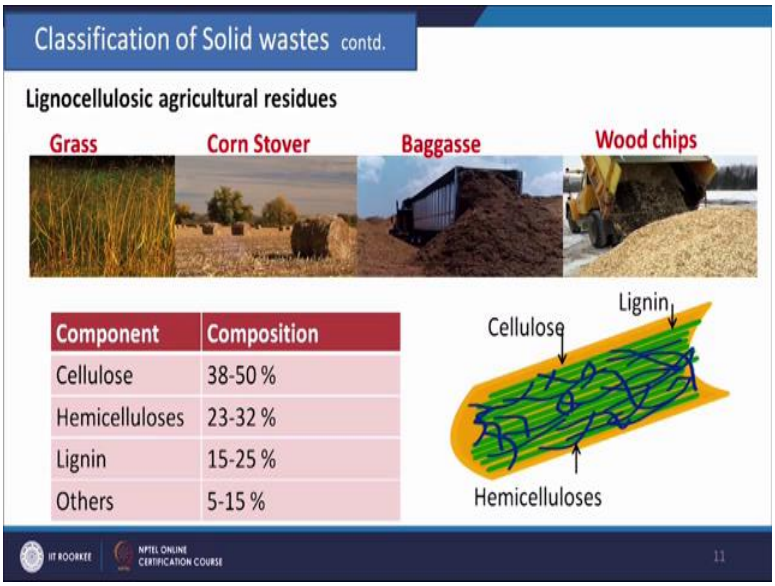

So, some examples of agro based solid waste that is lignocellulosic biomass or waste we can say are some example Grass, Corn Stover, Baggasse and wood chips. So, these solid wastes contend lignin cellulose and hemicelluloses and typical composition is given here, that cellulose 38 to 50 percent hemicelluloses, 23 to 32 percent lignin 15 to 25 percent and others 5 to 15 percent. So, due to the periods of these cellulose, lignin, hemicelluloses, these fixed stocks are highly suitable for conversion of energy.

Now we will see that characteristics of waste water generated in the country. So, waste water can be generated from different sources, from domestic sources, from industrial sources, from leaching or landfill leachates, other seeds, oil spilling, storm drains and sea water ingress. Out of these 6 sources when (Refer Time: 12:11) here the first three sources are very very important and we will see the quality parameter of the waste water generated through this sources.

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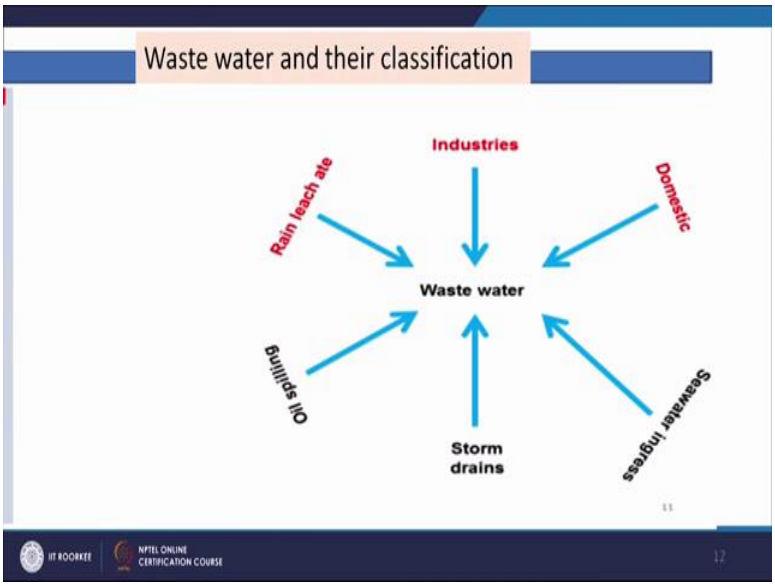

So, at first we will see the quality parameter of waste water generated through municipal domestic area.

So, here different parameters are have mentioned total solids dissolved solids suspended VOD, COD, TOC, choroid and sulfate choroid alkalinity grease etcetera.

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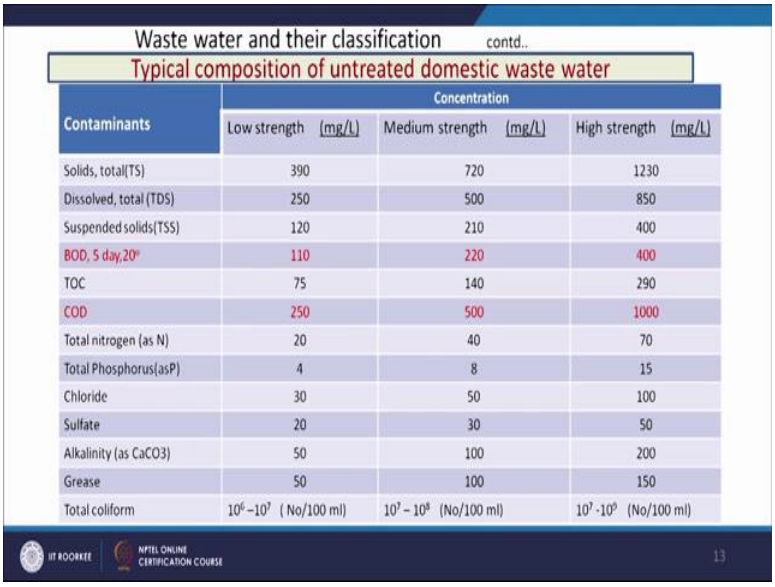

Contaminants	Concentration		
	Low strength (mg/L)	Medium strength (mg/L)	High strength (mg/L)
Solids, total(TS)	390	720	1230
Dissolved, total (TDS)	250	500	850
Suspended solids(TSS)	120	210	400
BOD, 5 day,20°	110	220	400
TOC	75	140	290
COD	250	500	1000
Total nitrogen (as N)	20	40	70
Total Phosphorus(asP)	4	8	15
Chloride	30	50	100
Sulfate	20	30	50
Alkalinity (as CaCO3)	50	100	200
Grease	50	100	150
Total coliform	10^6 –10^7 (No/100 ml)	10^7 – 10^8 (No/100 ml)	10^7 -10^9 (No/100 ml)

So, one important thing is that the strength of VOD and COD which are most important for the consideration for its used in energy conversion VOD COD value are not much VOD is 110 to 400 and COD 250 to 1000; so within this lower range of COD. So, there

is no suitable process for conversion of energy from it. So, waste water treated biologically and then sludge is formed and that sludge contains more VOD COD and it used for the energy production. Now we will see some quality parameters or quality of some industrials waste some examples are give here are for pulp and paper industrial distillery sugar oil refinery petrochemicals.

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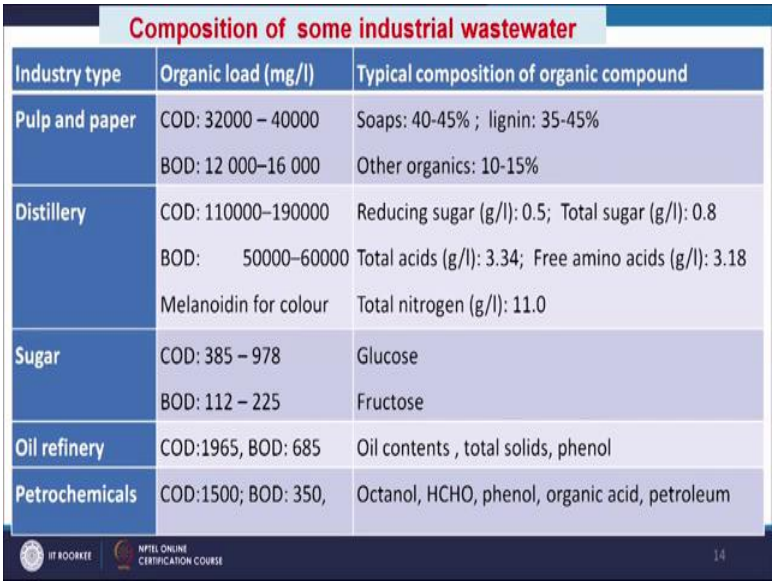

So, here we see the maximum VOD and COD available in distillery effluence followed by paper and pulp. So, very high COD and VODs available in these 2 industries makes the waste water suitable for direct applications in and will be digestions for the bio gas production, but here we see different compositions are available in the waste water generated through different industries. So, different micro organisms we have to choose all micro organisms will not be suitable to work on the waste order of all these industries.

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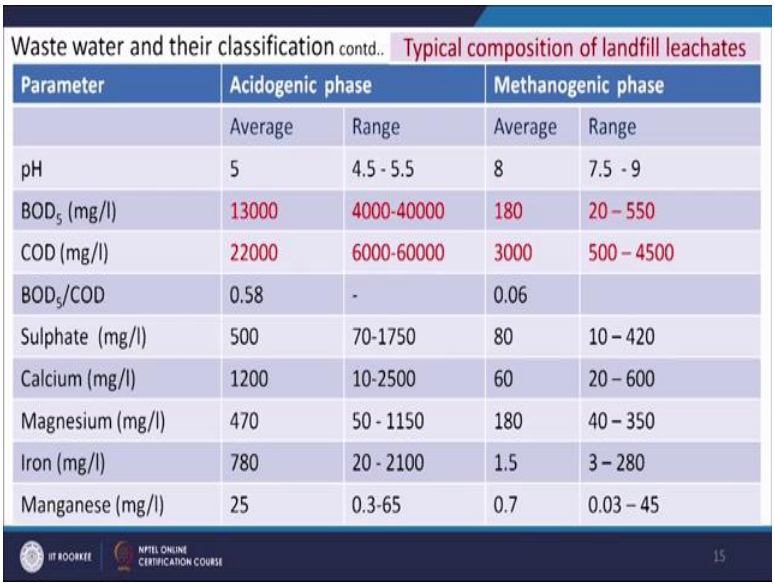

Now, we will see the quality parameter of the waste water generated through landfill leaching; landfill leachate are generated in 2 phases one is acidogenic phase methanogenic phase actually in landfills the organic compounds are degreed it in different through different steps the first step is acidogenic phase where higher molecular weight organic compounds are the get lower molecular weight acidogenic compounds and the second phase the acids are converted to methane.

So, we have to waste water which is generated during acidogenic phase contains more VOD and COD with respect to methanogenic phase this indicates that this acidogenic phase waste water will be more suitable for bio gas production. But however, this leachates contains higher amount of metals those can be detrimental to the micro organisms. So, we have to step specific action we have to take specific action and we have to use specific micro organism for the energy production from this type of waste water now we will see the availability of ago based industrial municipal solid waste in India vis-a-vis world.

So, in 1947 that it was 6 million tons of that MSW generation in the country in 1997, it increase to 48 million tons and now 2047; it is expected to touch 300 million tons for annum. So, the waste generation is increasing gradually and do you have good source of solids waste in the country and global generation of municipal solid waste is expected to rise by roughly 8 percent per year and as per a report into 2011 around 1.7 to 1.9 million

tons of municipal solid waste are generated around the world per year and in out of the 79.19 million tons of crop residues produced in Bangladesh in 2009, 41.56 million tons were available for energy use. Now we will see some availability of wastewater in India vis-a-vis world.

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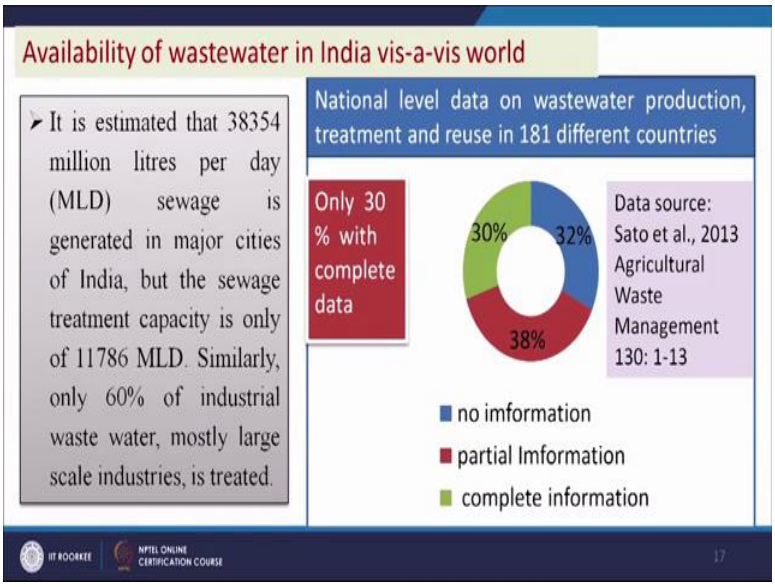

So, in India, it is estimated that 38,354 million tons per day that is MLD sewage is generated, out of it only 11,786 MLD is treated. Similarly only 60 percent of industrial wastewater mostly for large scale industries is treated, but it is very interesting that as per this report published in 2013, out of 181 different countries, only 30 percent countries have their complete data on water quality remaining 68 percent countries; 62 percent countries sorry; around 70 percent countries are not having complete data or they are having say partially data or no data on the water quality.

Now we will discuss on the routes for solid waste management. So, solid waste is generate generated we can manage it in different way and there are basically 2 philosophy one is the solid waste generated in the municipal area is collected in a central place and then it is segregated in to different fractions and managed another is the waste or waste is segregated at source then it is collected and managed. So, this is the later one is the better one the segregation at source it reduces the cost and makes the process easier. Now through this process we can segregate the whole solid waste generated into

recyclable waste into organic fraction into inert debris and hazardous waste. So, when we will get recyclable waste.

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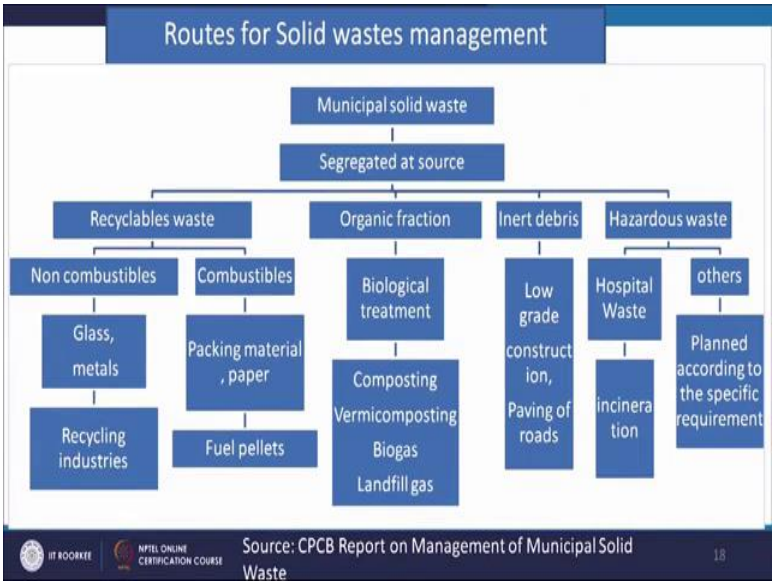

So, recyclable waste can be non combustibles and can be combustibles. So, non combustibles like say glass. So, that can be and metals. So, those can be sent to industries for recycling and if it is combustible, those can be use for (Refer Time: 18:32) production like say packing material, paper, etcetera. So, those can be used for the production of fuel pellets organic fractions those are the fractions which is having large amount of organic compound.

So, those can be process through composting vermicomposting energy digestion for biogas productions and landfill gas productions and inert debris which will get that can be process through low grade construction that will be use for low grade construction and for making the paving of roads and hazardous waste will be coming from hospital. So, hospital waste can be used through incineration and others we have to plan to manage this. So, these are the different options which we have to manage the municipal solid waste and the question is then why we will be considering for the energy production from this waste we may have different options we have say composting we may have say landfilling or energy production. So, this is a very new concept old one is landfilling in our country; in developing country.

If we do not have proper landfilling, we go for open dumping. So, this is not dissolvable, but the systematic way is landfilling that energy production through this the using the solid waste is a new concept and we will see here around the old efforts are on to introduce new methodologies to use the solid waste for the energy productions here I will show you some example.

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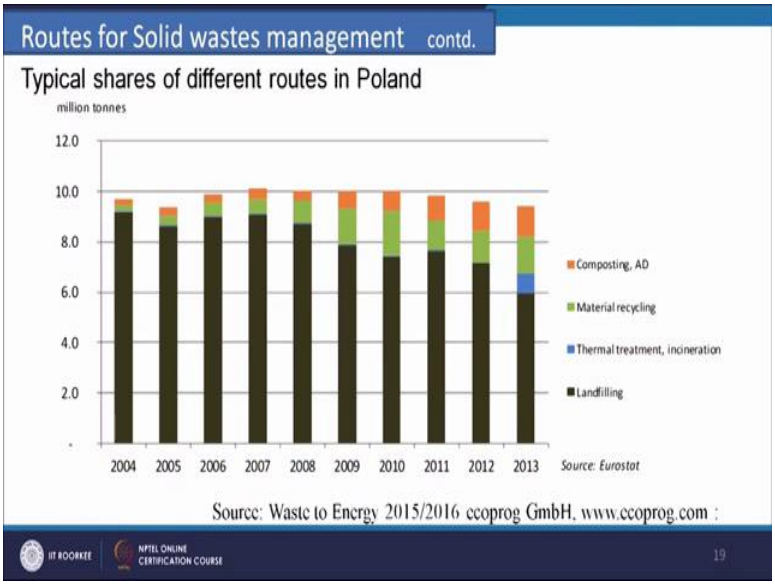

This is typical shares of different routes in Poland, Poland you see the composting (Refer Time: 20:51) digestion, material recycling, thermal treatment or incineration and landfilling. So, these are considered and data from 2004 to 2013 is provided. So, from this graph it is very clear that the landfilling is decreasing from 2004 to 2013 on average basis and material recycling is also increasing and composting is also increasing, but in 2013, we are getting one unique portion here that is blue color thermal treatment or incineration.

So, incineration or thermal treatment is introduced in 2013 and the use of this process is increasing around the world for the conversion of energy from the waste. And we expect that in coming years this will further improve and more energy will be produce from the solid waste, thank you very much. So, we will discuss in the next part of this module.

Thank you for your patience.