Municipal Solid Waste Management
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Lecture No - 19
Waste as a fuel

Hello students, so, today we will be starting the Module 8, chemical transformation, previous few lectures few lectures on physical transformation where we had discussed about the unit operations and recycling. Now the same transformation will continue as in chemical transformation, where we will talk about very important issue about whether waste can be used as a fuel. Then, we will talk about the incineration process, types of incineration process.

This course is specially designed for the Environmental Engineering Students whether it is from a graduate or postgraduate students. So, in this one, we need to discuss about the, gases produced during the incineration process or compression process that we called as the fuel gases and also the solid residue which is remained after the combustion process or incineration process that we will talk about this particular model. So first will start with the same function element.

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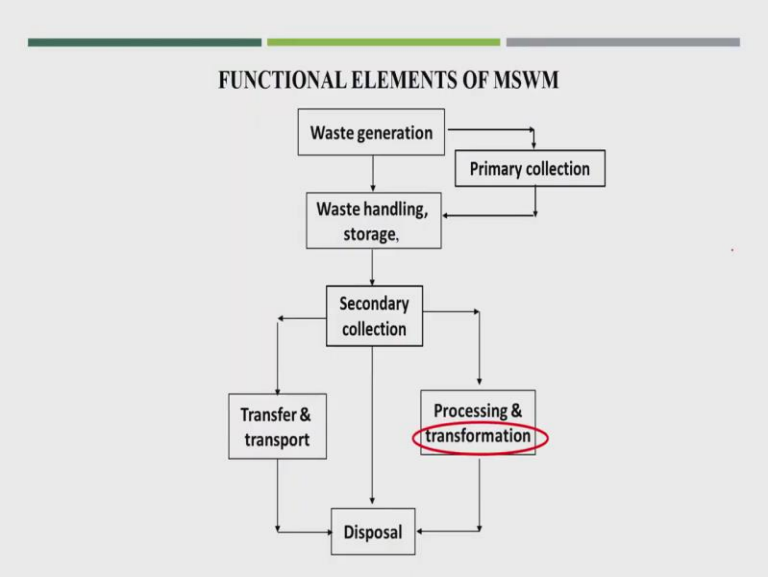

Now, the previous model was on processing. Now, we will talk about transformation which will start the chemical transformation. And now in this lecture can we use waste as a fuel?, that we will discuss today.

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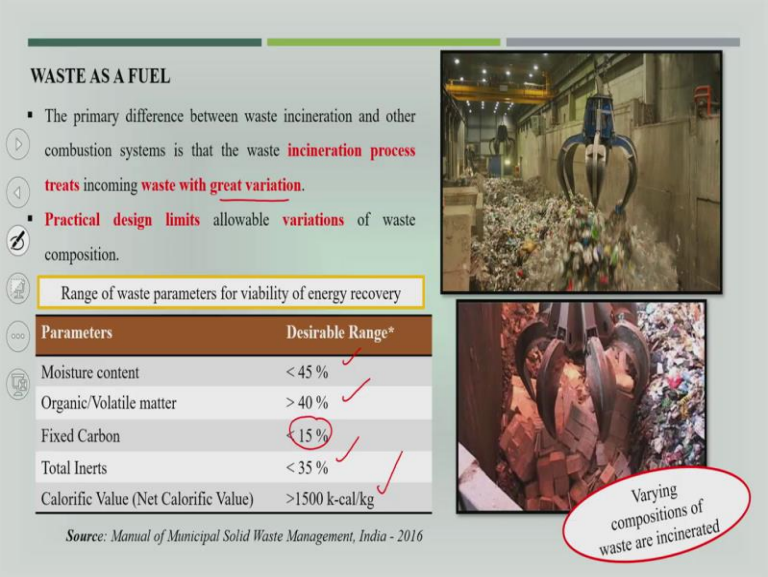

So, first we need to understand that primary difference between base incineration or other combustion system is that the incineration process treats incoming waste with great variation. So, normally in combustion process, whatever the fuel is any kind of material we are using that as a homogeneous kind of material. But here in the incineration process, the heterogeneous kind of material will come up under the combustion process. So, you can see here are the different variation of the waste will come up into the incineration process.

So, practical design limits allowable variation of the waste composition. So that was I was I was talking about various kind of waste under different base composition also could be used in to the incineration process. So this is one based on the manual of MSW in 2016 which was modified. It was given based on the few parameters. We can see that whether the waste could be incinerated or could be possible to produce energy from the waste.

So, here the moisture content should be less than 45%, the organic matter which is required for the combustion process or incineration process that is more than 40% should be there. The Fixed Carbon, is one of the very important parameter, which we have discussed in one of the lecture, also where we talked about the characteristic of the waste. So if fixed carbon is very high, then, there is no need of combustion process because it is unnecessary lot of energy will be required for the combustion process.

A totally inert also should be less than 35%, why because in India if you see the characteristics of a lot of inert content will come up into the waste, final waste and especially the calorific value. This is one of the important parameter should be more than 1500 kilo calorie per kg. Under this calorific value could be possible only and when the drive amount specially the paper percentage, plastic contents or whatever is a combustible material.

The percentage is very high then only we can get the, this kind of calorific value and if you know that in India, because India or developed countries are known for production of more biological waste. If biological content is more than 60% 70% so is very difficult to get this kind of calorific value.

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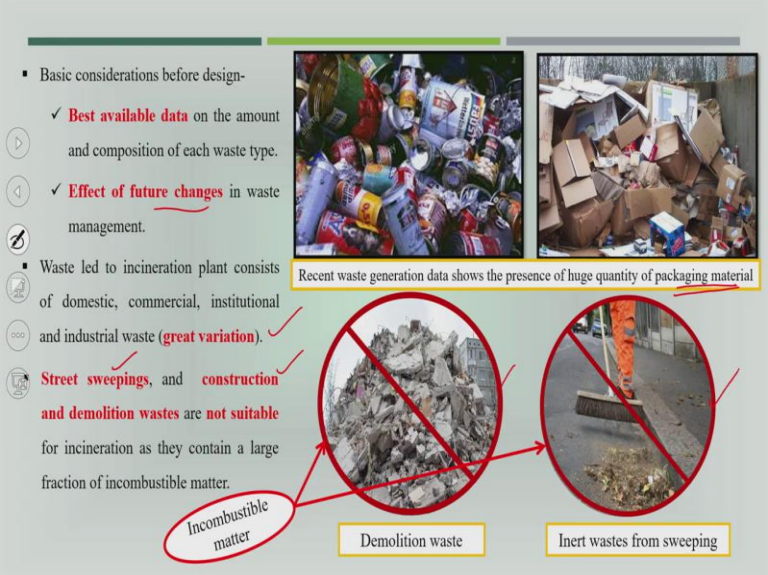

Now the basic consideration before the design what parameter also I show it but another consideration is like waste available date on the amount and composition of each waste type. That was I was talking about you need to know that the best available data should be available to us to see that whether how the compositions are changing with the time, under even future waste generation and few in future how these compositions are going to change, that kind of data should be available and effect of future change.

That is what future changes also need to be known because the same incineration process or combustion process will work for another 20 years. So, obviously your commercial facilities or Industrial Development will change. Obviously, the waste composition will also change so that affect also need to be understand and need to be considered. So, waste led to incinerations and consists of domestic, commercial, institution, industrial waste with great variation.

So, here you can see that the recent waste generation data shows presence of huge quantity of packaging material. I think we talked in many lectures huge amount of packaging material also is producing in India, and another the special kind of ways like Street sweepings waste, that is the inner here contains construction and demolition waste that is huge amount is getting produced in India is not suitable for the incineration process because this contain un-combustible matter ok.

You can see domestic demolition waste and specially the street sweeping waste is not visible for the combustion process. So here again there are very important issues. See, if you are planning for incineration process need to know this kind of very important considerations because when you collect the mix waste when you say the dry waste will go to the incineration facility, all kind of dry waste should, should not go to the incineration plant because this street sweeping also waste is very huge amount is getting produced.

That should not be reached to the incineration plant, incineration plant. And also that same dry waste is also again has to be segregated like metal, glass are not combustible. So that also has to be segregated before the waste is going for the incineration process.

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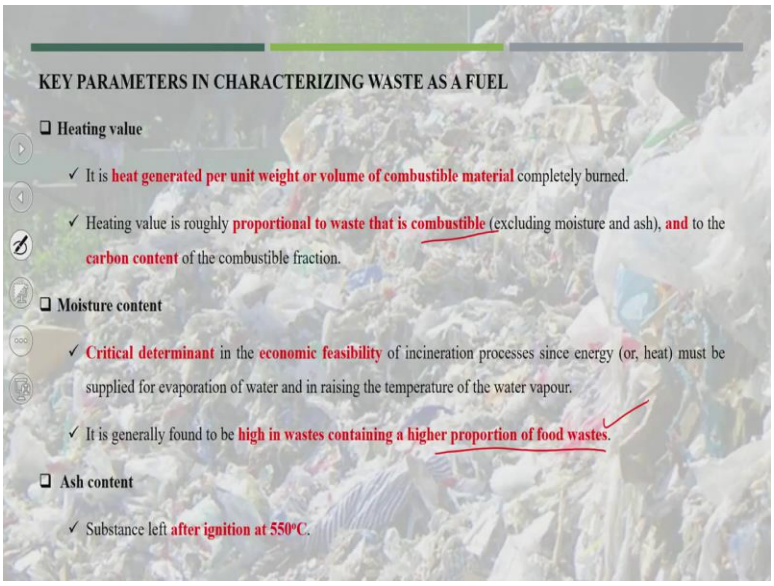

Now, the key parameters, so there are three major parameters need to be characterized or needed to be considered before going for the incineration process. First is the heating value. It is the heat generation for unit or volume of combustible material completely burned. That heating value has to be known that we called as a calorific value needs to be known, and under heating value is again proportional to the waste that is combustible more combustible percentage will be there obviously you will get the largest value of heating value or calorific value.

Next parameter is moisture content. So the critical determination is very important of the moisture content. If more moisture content is there, obviously that kind of waste will be required more energy for the combustion. So what could possible that? So, when you put the waste having more moisture content so initially the waste will get dry. So, unnecessary, lot of energy will be required for the just, just to dry the waste.

And suppose the waste consists of 70 to 80% of moisture content means only the remaining volume will be only 20%. So there is no benefit of combustion also and also to produce or to get Energy recovery from such kind of material. It is generally found to be high in waste containing the high proportion of food waste. This is what the problem in developing countries more amount of food waste will have more amount of moisture content and if it is not getting segregated.

Next point is the Ash content. This is also we have seen in the characteristic slide. This is analyses 550 degrees centigrade. Because in the incineration process also temperature goes to more than 2000 degree centigrade so need to know that how much is the Ash is getting produced. If more ash productions are there is obviously again the disposal of this ash is also another major issue could be so that also needs to be, this is also very important parameter to consider.

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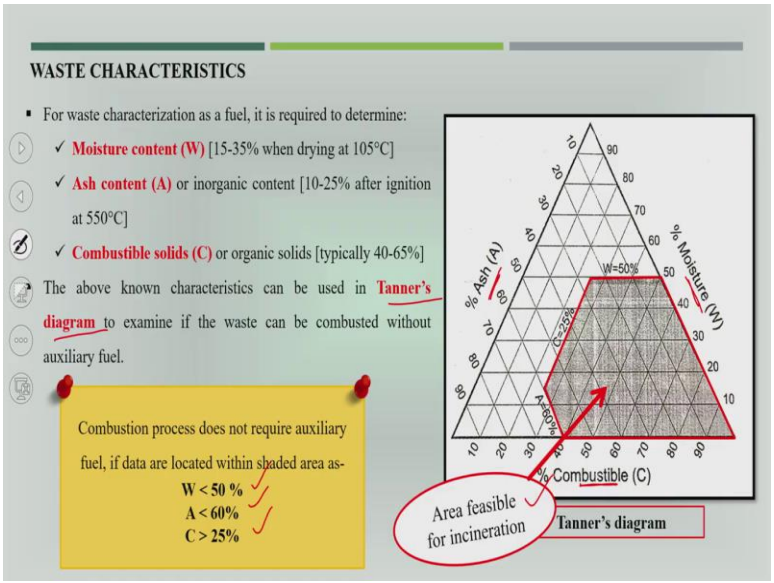

Now the waste characteristic is to see that wastage in fuel. It need to be determined moisture content that w under in another one of the class I have explained about how to measure the moisture content the Ash content. Combustible solid or we can say volatile solid. And and based on these three parameters, moisture content as contain and combustible solids or volatile solids will prepare standard diagram to examine if the ways can be composted without auxiliary fuel or waste can be incinerated or combusted state without adding of any fuel or any extra combustible matter with the waste.

So this is the tanner diagram you see here. So this is the Ash percentage. This is motion contain. And this is combustible percentage. And see here, this is the boundary like w moisture content, if less than 50% as contain less than 60% and combustible percent more than 25% so you will get this particular area. So this area is known for this is feasible for the incineration process. So if your base characteristic is under this, this particular area means waste is able to or feasible for the incineration process.

So I will be able to show some of the very basic slides suppose some data is given so how to prepare the tanner diagram and based on Tanner diagram how we can see that whether the particular kind of wastes required auxiliary fuel or it won't be feasible for the incineration process.

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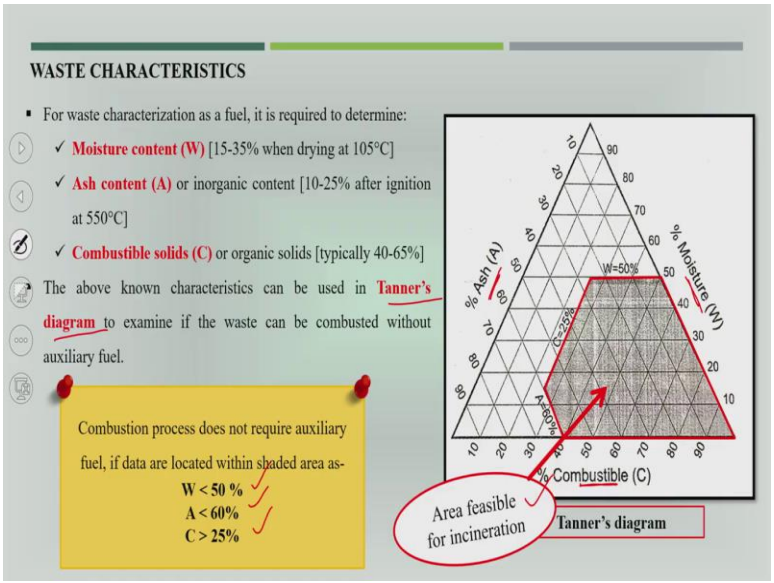

So, how to read a Tanner diagram? So, consider this one point is given in the Tanner diagram how to read that? So, based on that whether we can know that how much is the moisture content or Ash content or combustible percentage. So first to find the w draw a line like this and given point parallel to the percentage combustible to intersect the w side of triangle. So, this will be the w value, moisture content is 40%. Now, similar way to find a draw a line like in the same way and see here you like this is parallel to these lines.

And you can find the ash content that is 25% similar way will be a combustible percentage. So for combustible percentage in parallel line we can draw like the and you can find the combustible percentage that is 35% are coming. By that way we can understand how we can read the Tanner diagram. Suppose some data is given so what will be the moisture content, ash content or combustion percent of that particular waste characteristics.

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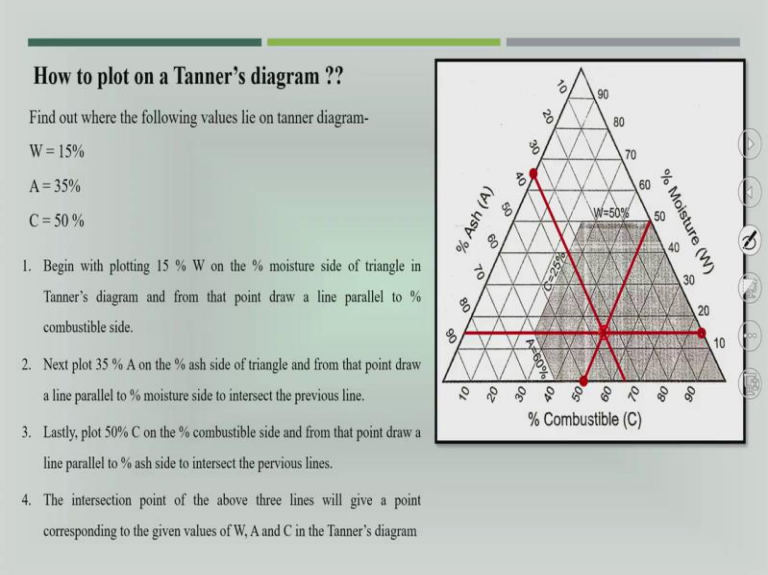

So, now how to plot it on a Tanner diagram. Suppose, now this values are given moisture content w is given 15% ash content A 35% and C that is Combustible percentage 50% is given. So now how to plot the particular waste characteristic into the Tanner diagram. So to begin with plotting of 15% w on the percentage moisture side. So now 15% we put it this is the 15% moisture content. So we put a line draw a parallel line to percentage Combustible side. Now next plot 35% a 35% a this is the 35% draw a parallel line onto the moisture side.

Now for C combustible percent 50% so this is the 50% and draw a parallel line to the Ash side. Now we will get one particular point the intersection point of the above three lines will give a point considered to the given value of W, A and C. So here the value of that particular base characteristic we got it. ok based on that will go for one problem also. And then we can see.

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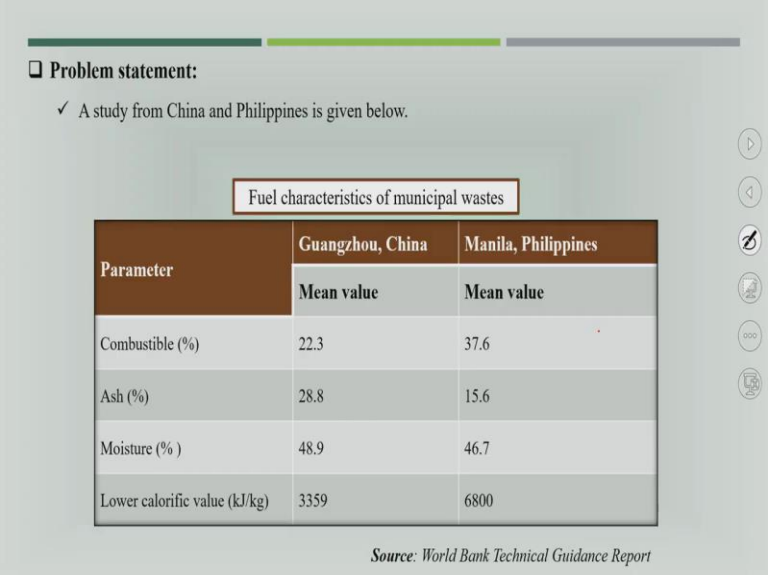

Problem statement is that a study from China and Philippines is given below. Best characteristics given like for Guangzhou, China the mean values of combustible percentage, ash content, moisture and calorific value is given and similarly Manila of Philippines some values are given. So now, we will plot based on the tanner diagram and we need to know that the problem statement is that which country will required auxiliary fuel for combusting their waste? Based on the tunnel diagram, we can know that whether the waste will be required auxiliary fuel or not.

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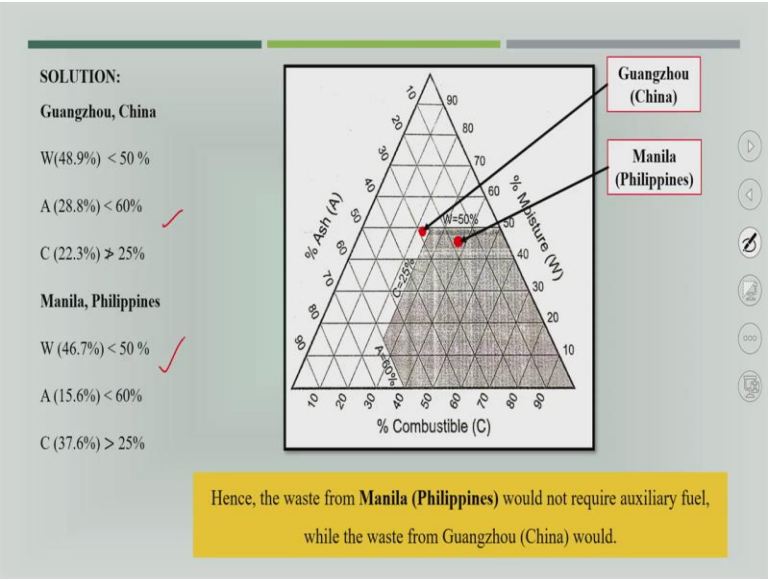

So now, this is China characteristic and this is Manila characteristic. So now will put first Guangzhou, China is coming like this. and Manila Philippines is inside this particular area means the answer is that the Manila because is feasible for the incineration process. So do not require

auxiliary fuel but the China waste is is out of that particular boundary so means it is having low percentage of combustible matter. If you see here if you plot like this, it is having only 25% of combustible matter. So obviously, it will be required extra auxiliary fuel for the combustion process.

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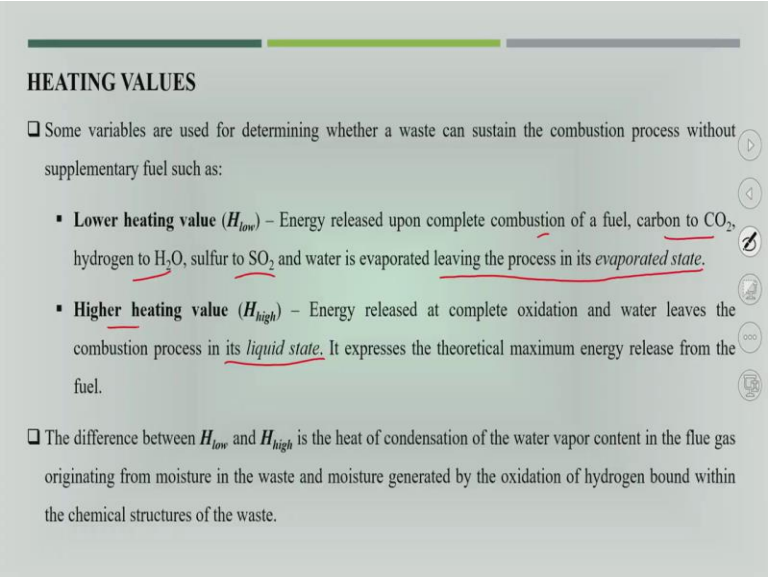

So now once we know that three major parameters like moisture content, combustible percentage and ash content, now the heating value or calorific value, what exactly is the heating value and how to measure that. So some variables are used for determining whether a waste can sustain the combustion process without supplementary fuel or such as the lower heating value that is one parameter based on that we can know that apart from the moisture, Ash and combustible percent. So is the heating value being the energy released upon complete combustion of fuel.

So when there is a complete combustion of fuel carbon to carbon dioxide, hydrogen to H2O, Sulphur into SO2 and water is operated leaving the process in its evaporated state. Understand that the lower heating value is calculate the complete combustion where water is evaporated leaving the process in its evaporated state. Similar way other parameter called higher rating value Hi that is energy released at combo complete oxidation and water leaves in the combustion process in liquid state.

That is the only difference between low heating value and high rating value. Under it expresses the theoretical maximum energy released from the fuel. So any equipments like a Bomb calorimeter is there from that we can analyze the calorific value of heating value. There we will get the higher heating value data, ok. and finally, we will calculate based on the high rating value. We can calculate the lower heating value parameter.

The difference between H2O and Hi is the heat of condensation of the water vapour content in the flue gas originating from the moisture in the waste and moisture generated by the oxidation of the hydrogen bound within the chemical structure of the waste.

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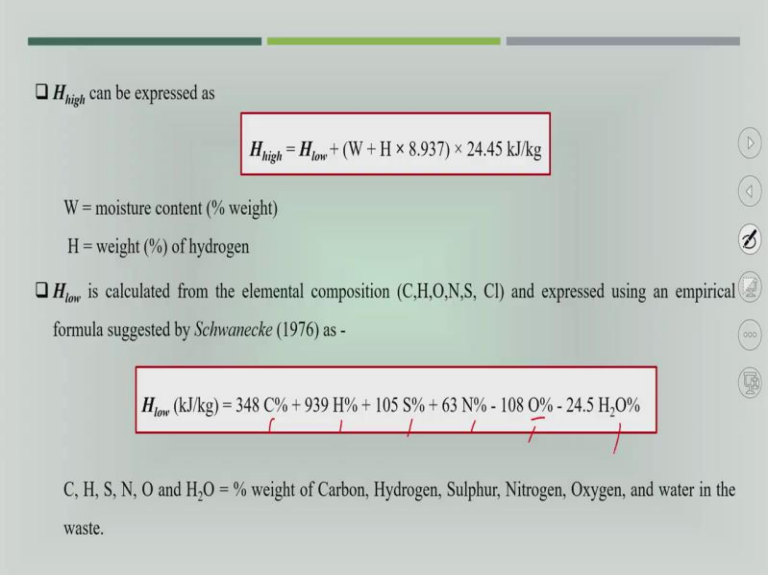

Now Hi can be expressed as H i is equal to H low + W + H into 8.937 into 24.45 kilo joule per kg. OK where W is the moisture content H is the hydrogen percentage ok. And H low is calculated from the elemental composition like C, H, O, N, S and expressed using the empirical formula. H low can be calculated by 348 C percentage + 939 H percentage + 105 S% + 63 N% minus 108 O% minus 24.5 H2O% Ok. So, this is the percentage of carbon, hydrogen, Sulphur, Nitrogen, Oxygen and this is water.

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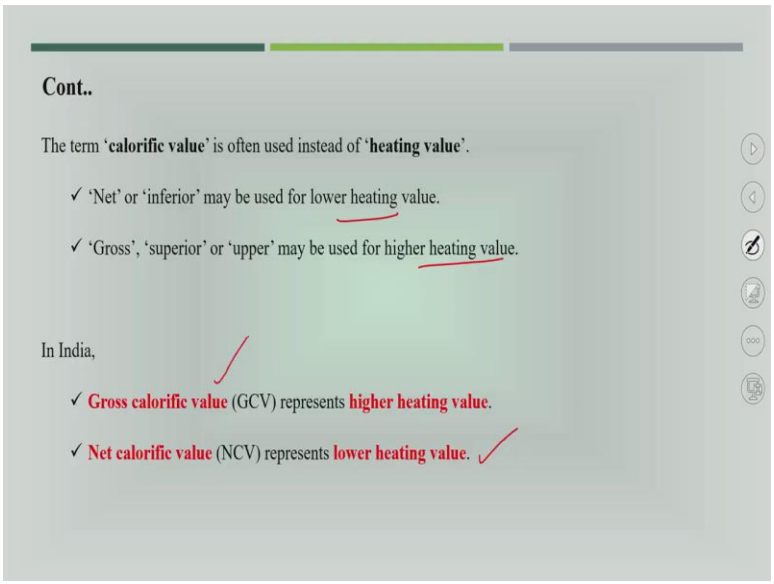

Under the term calorific value is often used instead of heating value. In specially in India, we never talked about the heating value. So this net or inferior may be used for low heating value. So in India we call gross calorific value and net calorific value. So low heating value in India we call net calorific value and High rating value in India, we call gross calorific value GCV and NCV, Ok. So, again I am repeating that in India we call a higher heating value as gross calorific value and lower heating value, we called as a net calorific value.

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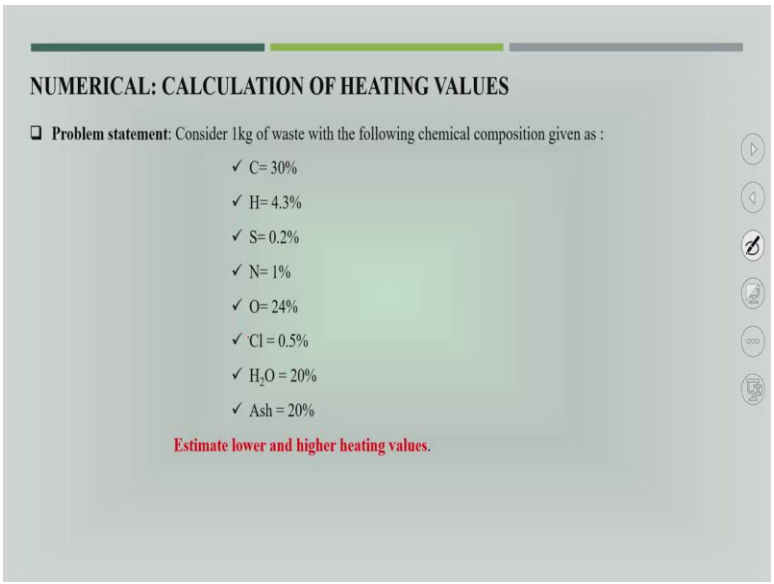

So this one numerical will solve were considered as one kg of waste with the following chemical compositions are given like carbon 30% hydrogen 4.3, likewise the percentage is given and now the question is that the problem Statement is that estimate the lower and higher heating value.

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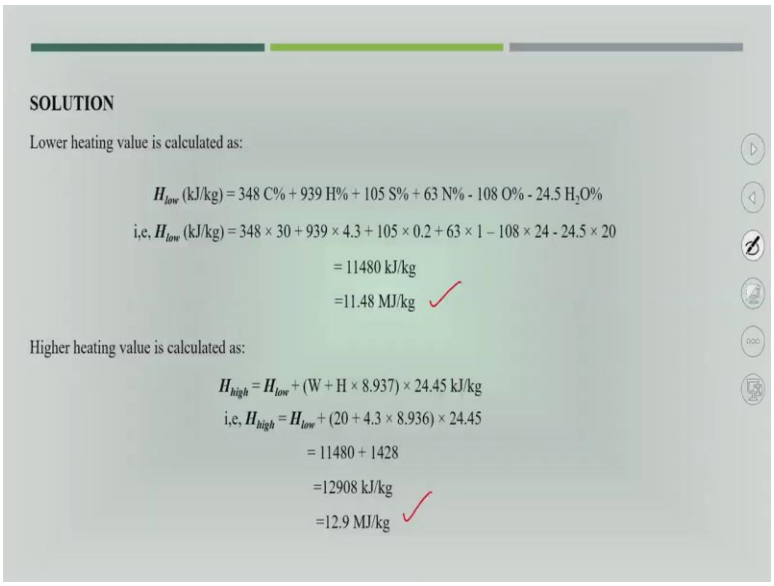

So first we will calculate the lower heating value by this equation. And we will get 11.48 mega joule per kg and high heating value by this particular equation we can calculate and will get high rating value 12.9 mega joule per kg. So once the characteristics are given like C, H, O, N, S percentage and H2O percentage will be given, we can easily calculate the theoretically net calorific value and gross calorific value. Based on that gross calorific value we can calculate.

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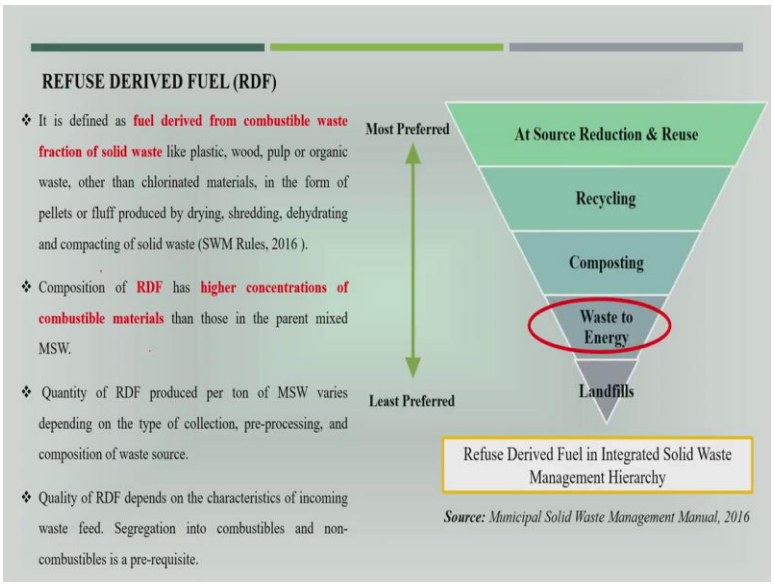

Now this I think we are already talking about wastage and fuel. Also we have to talk about RDF this is a very important word, especially in India, last 20 years 30 years were using that India had come up with RDF plants and recently under Swachh Bharat Mission also number of RDF plant

has been trying to install some plants are already started working and some plants will come up again. So will understand here what do you mean by Refuse Derived Fuel.

It is defined as fuel derived from the combustible waste fraction of solid waste this is refuse derived fuel me feel derived from the combustible waste fraction of the solid waste and these combustible fraction could be plastic, would even the organic waste also if the waste do not have more moisture content. These kinds of wastes in the form of pellet produced by drawing shading, compaction of solid waste.

This is based on the SWM Rules, 2016. Then again composition of RDF has higher concentration of combustible material than those in the parent mix MSW. so it's suppose mix MSW means obviously we are saying is a dry MSW but is a mix between RDF we need higher concentration of combustible material. Quantity of Idea food produced per ton of MSW varies depend on the type of collection 3 processing and composition of solid waste source.

Obviously, is again depend upon the how waste we are able to collect the waste and and how best we can preprocess the waste for the RDF process. Quantity of RDA depends on the characteristics of incoming waste field segregation into combustible and non combustible is a prerequisite. This is needs to understand the segregation into combustible and non combustible is a prerequisite. So this is what is based on the municipal solid waste management manual 2016. I think here why hierarchy is given under waste to energy is come.

I think just last you need. Once you do the recycling composting all biological treatment then the remaining waste should go for waste to energy before land filling.

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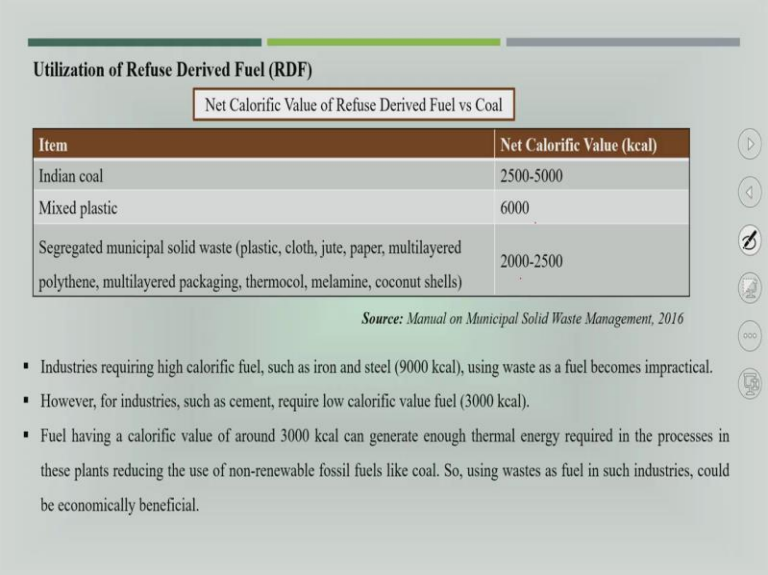

Now utilisation of refuse derived fuel, so you can see here net calorific value of Refuse Derived fuel versus coal. You can say that the Indian coal is having net calorific value is 2500 to 5000 kilo calorie per kg in 1 kg and mixed plastic is very high, 6000 but the problem is more flue gas will produce polluted gas will produce. But important in India that segregated miscible solid waste like plastic, cloth, jute paper or multilayered polythene, thermocol, coconut shells these kind of segregated means MSW will have to 2000 to 2500 kilo calorie per kg, calorific value means industry required high calorific value such as iron and steel like 9000 kilo calorie per kg,

That kind of calorific value required in such kind of industry like Iron industry and steel industry. Using waste is in fuel become impractical was obviously they will be required that kind of material which will get more calorific value is around 9000 kilo calorie per kg. But how you are the industry such a cement required low calorific value of waste around 3000 kilo calorie per kg. Obviously if these kind of mix or segregated MSW can be used for such kind of industries.

So fuel having calorific value of around 3000 kilo calorie per kg can generate enough thermal energy required in the processes in these plants like cement, cement kind of industry reducing the use of non renewable fossil fuel like coal. So, using waste in fuel in such Industries could be canonically beneficial. So, is not that ki and entire this kind of waste will put it into the cement industry. May be 5% 10% can be added into the as in fuel for this kind of industry.

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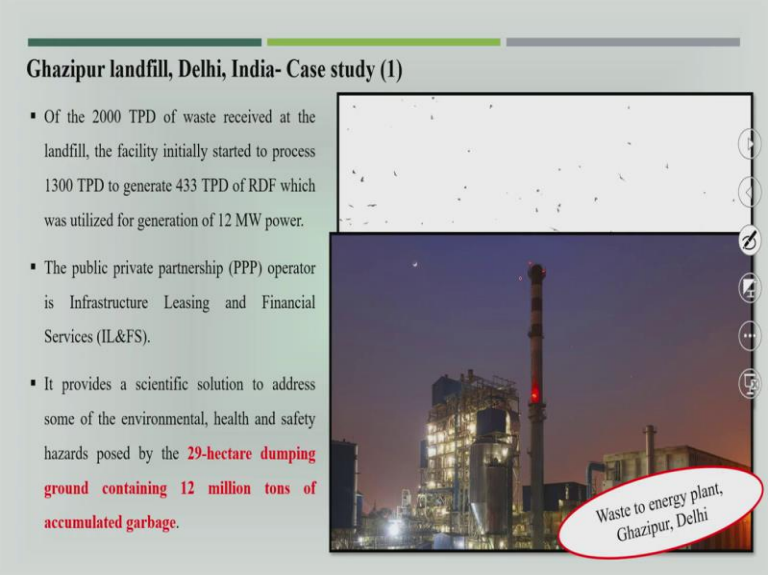

So I come up with two case studies one was a Ghazipur landfill in Delhi, you can see here, is the Ghazipur landfill. Of the 2000 tons per day of base received in this land fill the facility initially started to process 1300 tons per day to generate 433 tons per day of RDF out of 1300 tons per day will generate 433tonnes per day of RDF which will utilise for the generation of told megawatt power, that was the idea.

Under this project started under PP program public private partnership operates is infrastructure leasing and financial services, this is one company, the private company which was working with local corporation ILFS. So, this was the waste to energy plant in Ghazipur it provides a scientific solution to address some of the environmental health and safety hazard possessed by 29 hectare dumping ground containing 12 million tons of accumulated garbage. Ok,

But I think lot of issues has come up in the Ghazipur landfill also because you see here the very big stack flue gases used to come out from this combustion process incineration process.

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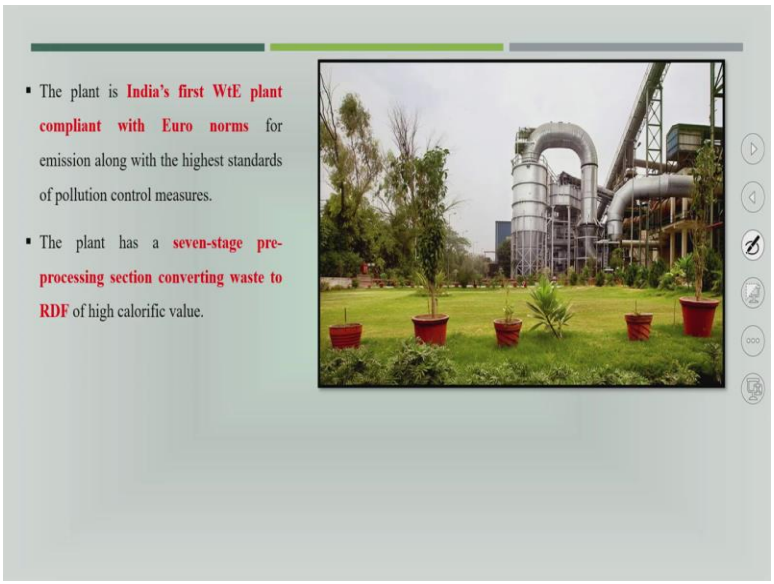

The plant in India first waste to energy plant compliant with Euro norms for admission along with the highest standard of pollution control measure. The plant has a seven stage pre processing section converting ways to RDF of high calorific value. 7 stage P pre-processing stations.

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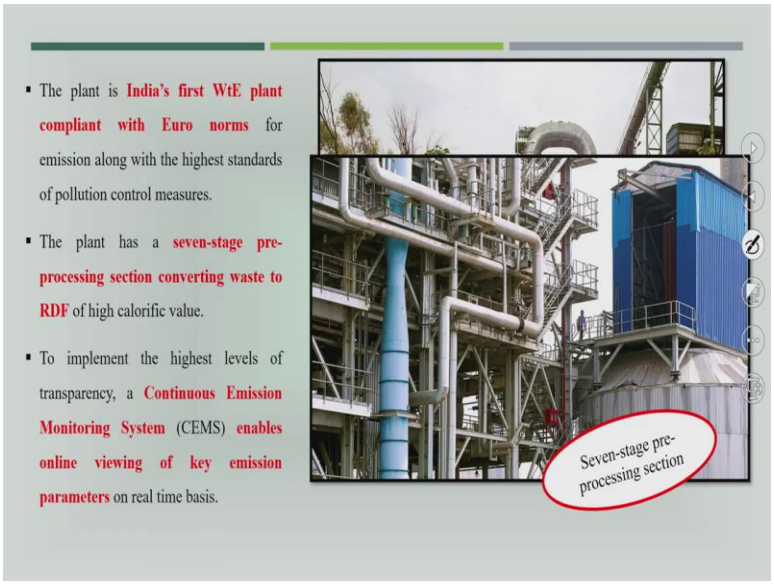

To implement highest level of transparency continuous emission monitoring system enable online weaving of key emission parameter on real time basis. That was the one very important issue under the incineration. We will talk in the fuel A1 special lecture. I put it for the emissions for from such kind of incineration plants or RDF plants.

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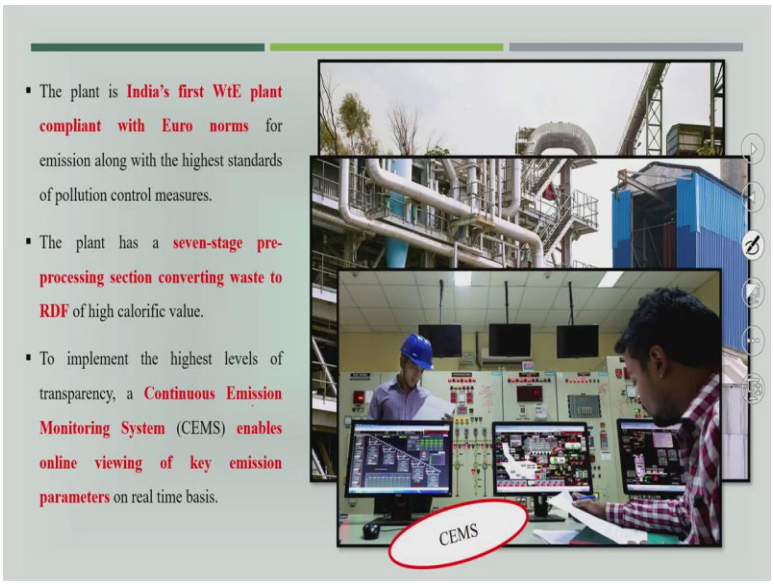

This was the online measurement or Emission monitoring.

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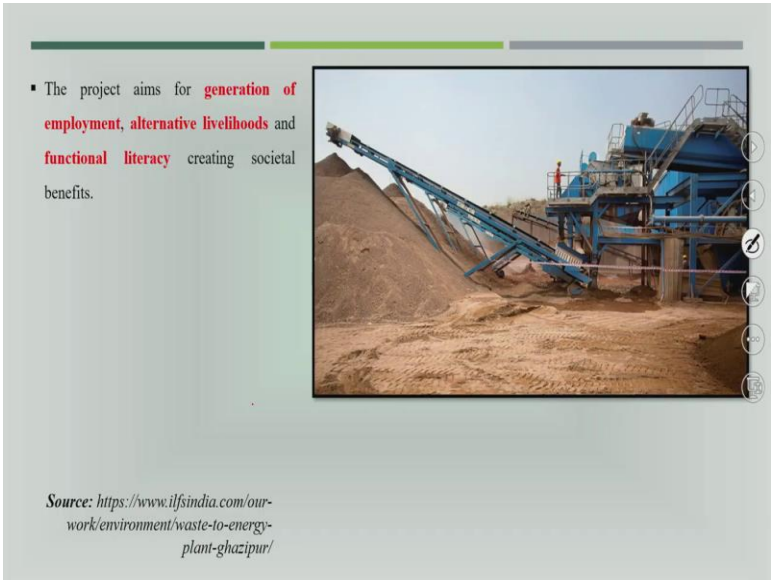

And project aim for generation of employment, alternate livelihood, fractional literacy, creating societal benefit. The idea was that because the segregation of preprocessing was very important. So local rag pickers how best they can get some kind of employment working in such kind of plants. That was also another benefit they found.

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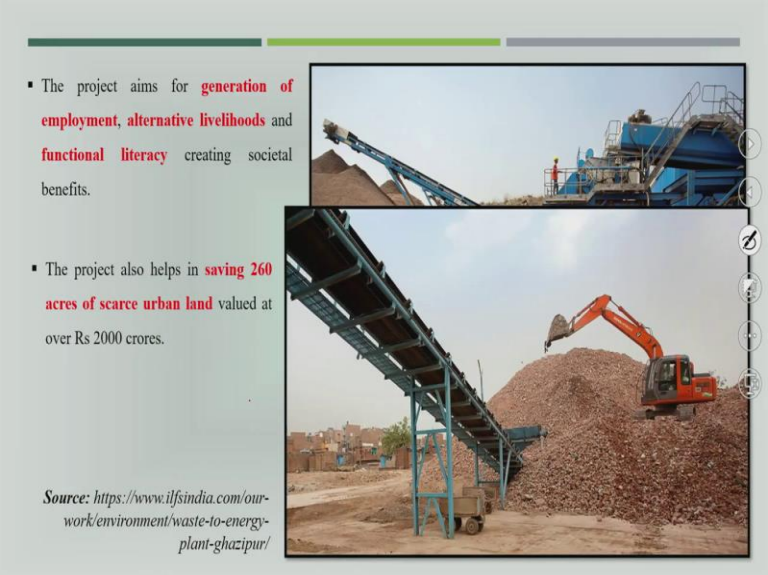

This is one of the photograph. The project also helped to serving 260 acres of scarce urban land value for rupees 2000 crores. Lot of area and you see here nearby residential area is also there. So obviously, and I personally believe that incineration process is one of the very important process to treat the solid waste because it will reduce 90-95% volume and in last lectures their characteristics are when you talked about weight and volume, to this volume is very important because the entire or most of the base is going to the landfill area and what is important now is how best we are able to reduce the volume of waste.

And incineration or combustion process is the best process where 90-95% of volume could be reduced. But the problem along with that incineration process will get a large amount of ash that will get produced in the combustion process. Also huge amount of flue gas will produce that is highly polluted gas and that kind of treatment facility is required. Treatment will be required later on but first need to understand the emissions, what kind of characteristics will come up.

Based on that, we need to install the proper treatment facility that is that is what I think we are going to talk into the next lecture.

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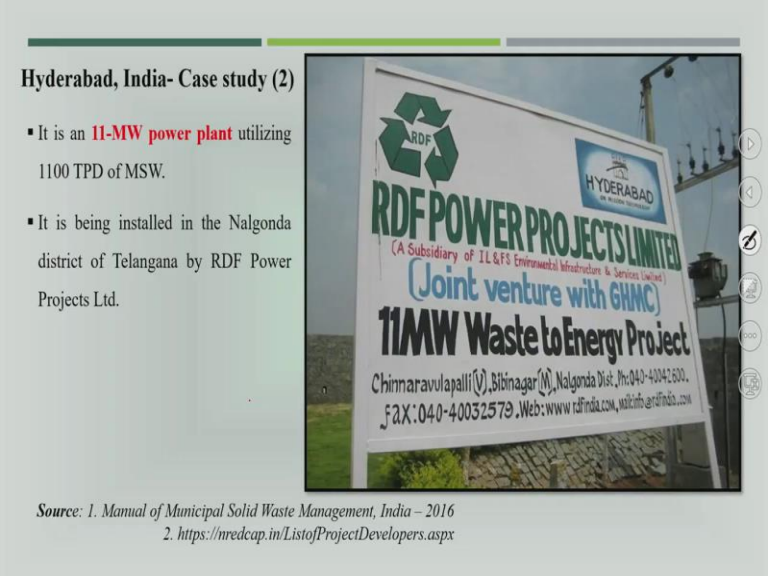

This is another case of Hyderabad it has recently started. It is a 11 megawatt power plant, utilizing 1100 tons per day of MSW. This is being installed in the Nalgonda district of Telangana by RDF power project limited. It can see that RDF power project limited. This was the subsidy of same company that of ILFS. The plant will produce refuse derived fuel for in-house incineration and power generation. That was the idea behind this plant.

So I will finish this lecture. Now you will understand that waste can be used for the fuel. Both way we can we can understand like one the volume how best we can reduce the volume then we can go for incineration. If we are getting the proper characteristics of that particular material and also while combustion or incineration, if you are able to produce some kind of energy then always a beneficial because the operation cost is very high of the incineration plants and suppose the local authority or under even under the PPP project is not able to run the incineration plant.

There are a number of industries which required energy or which required lot of fuel and most of the industry is there. They are using collagen fuel and coal is very costly for such industry. There are already looking for alternate of coal and this kind of material if you are not able to run the incineration facility from the local authorities or the quantity is not that large to install the incineration facility, we always look on to the RDF kind of facility where the entire material is getting segregated.

And this segregated material will have large amount of calorific value and more percentage will be the combustible fraction that we can properly transport to the such particular Industries. And these Industries can use for their combustion process. So recently, I think two years before, I came to know that Meghalaya is one of the Northeast state they made it is in particular rule that pollution control board because they have a number of cement industries in Meghalaya.

what rule they made is that the EA cement industry in need to be used minimum of 5% of plastic waste for in their cement industry for the combustion process. That was one of the very important news and I also showed it that cement industry which required 2500 to 3000 kilo calorie waste or fuel so MSW if it is segregated and specially the plastic which is having very high calorific value that can be used for such kind of industries.

But also because I am an environmental engineer, so I am always looking on the two major pollution from the incineration process: one is flue gas how best we will be able to treat that and how best we can dispose the solid residue produced from the combustion process that has to be looked upon. So the next lecture we will talk about first I will talk about incineration process followed by environmental treatment ok thank you.