Environmental Quality: Monitoring and Analysis
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Lecture-40
Dispersion Model Parameters - Part 2

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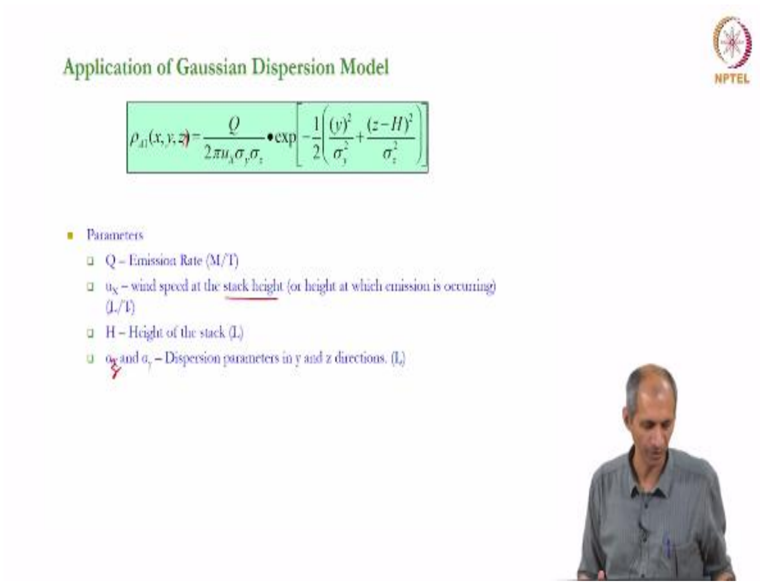

So lets saw the parameters that we are interested in order to calculate roh A 1at x,y,z and there is another H here. Four things are important: Q is emission rate, Ux is wind speed at the stack height. So this is the wind speed at stack height. So What we mean by that is, we will come off to each point separately. H is the height of the stack and stigma z and stigma y, in the z and y and z directions. You also see dimensions of these things.

Emission rate is mass per time L byT the height of the stack is length dispersion is also length. So you could look at that the dimensions here, this is length and length square, length square, length square they will all cancel out.

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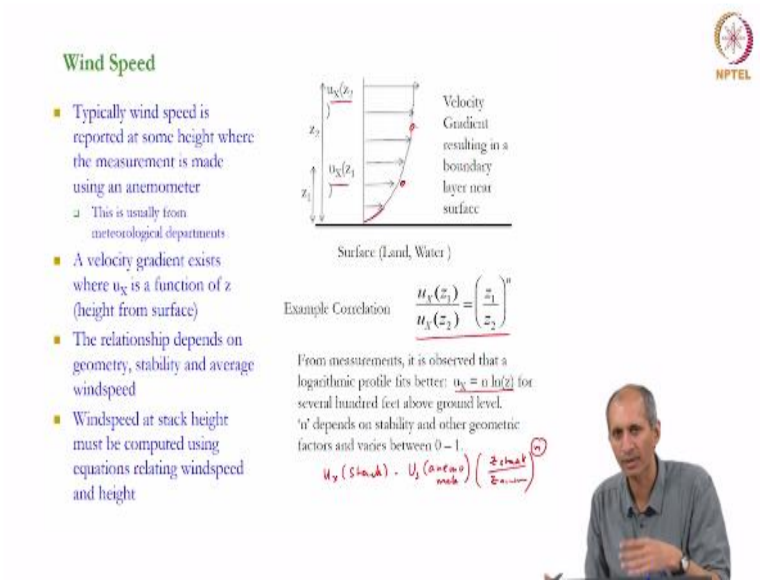

So the first parameter, wind speed. You need to calculate wind speed at the stack height, so where stack height may be 50 meters, 50feet, 100feet or whatever it is. There is also the observation that typically wind speed if you look at wind speed. If I say I am looking at a stack in some place in Chennai, then what is the wind speed? When you go to the nearest wind measurement? There is an anemometer in an airport or some place, somebody would have measured the value.

It will usually say at what height it was measured. Why is this important? Because typically we see that there is a velocity gradient of material of air as it flows across on a surface. This velocity gradient itself is a function as we are discussed in some one of the earlier classes. That, there is friction on the ground, so the Earth is this surface that is drawing energy from the air mass,and therefore the velocity that is present near the surface is smaller than something higher.

And this energy transmission is happening in this direction and there is big loss towards the ground. So velocity is decreasing towards the ground. So there is a velocity gradient that you expect. So as a result you find that the velocity at different heights is different. So if I make a measurement here if I have an anemometer here, but the stack is here then you have to estimate what is the velocity here based on this mean if I know this gradient equation by some equation.

So this is an example it could be different correlation could be linear almost never linear. It is non linear, it can be parabolic sometimes, sometimes its power law equation. Sometimes it is a logarithmic equation. logarithmic means it is Ux equals to n ln z, this is not the same,this is power law. So a lot of times this is the equation that will fit nicely. You have to measure the velocity gradient at a given location.

Typically you have to get multiple heights, velocities and then fit it to see what is the form of the velocity gradient? There is logarithmic or power law or anything and that is the easiest way of doing it because the fluid dynamics is very complicated because in the place in urban areas the velocity gradient will be something. Because the friction offered by the surface here is different from the friction offered in an open ground or a forest or sea.

So a lot of cities, all are changing within a city itself. So it is best to get measurement, but if you do not have measurement then whatever is the nearest measurement you have you make an estimate. So this is how it is done, so if you have the relationship of velocity at the function of height then you calculate the wind speed required for your Gaussian model, dispersion model, at that point.

So it is typically we do this so Ux at stack Equals to Us at an anemometer multiplied by whatever, say we are using this equation we have z stack by z anemometer, there is n. So this n now depends on whatever is the structure of wind, that depends on a lot of things, that depends again on the magnitude of wind, it also depends on stability. Stability its mixing is in a different direction, then you have different stability classes.

So the value of n depends on stability is, generally varies between 0 and 1, but actual values are very specific to what is, we will leave it at this, for this time give you other equations for that also. So this can get very complicated if you want there is entire body of work that talks only about turbulence in the environment, velocity gradients and we will touch upon it a little bit later. What temperature profiles and all that.

But if you go there and you need a lot of data to resolve any of these issues. So there are simple ways of doing it. So people use simpler methods to get an estimate. So first of all people need quick ideas, where is this zoom moving? And what will be the cause? So we need worst case scenarios quickly and for that;

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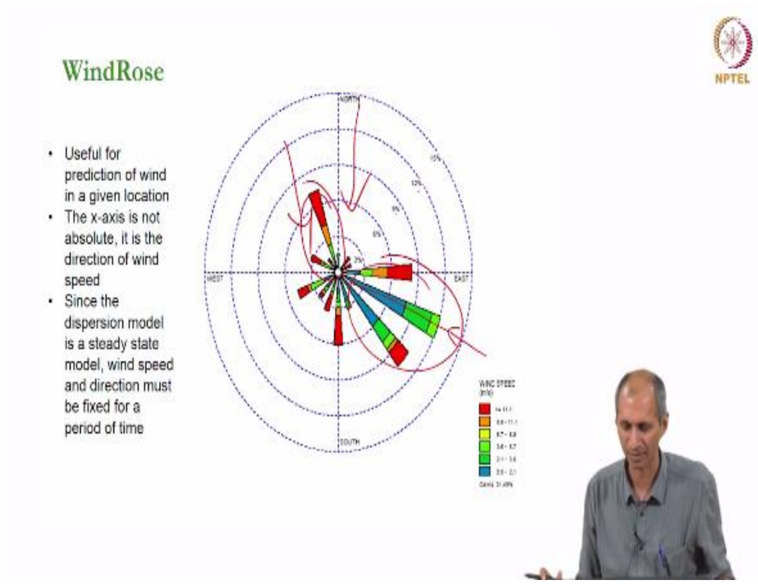

Typically what people use is Windrose for average wind directions. This windrose is a compilation of wind speed in a given area. This is an example of how wind patterns in a given location, for example, this could be a windrose for a given city for a day, for a month, for a year. So this is an average windrose. So what the way this is red is, for example, there are different representations, you can go and search for windrose and will give you different kinds of representation.

What this is you can see this scale here, it is colour coded with wind speed. So the red is the highest, so greater than 11 meters per second and no color is 0. So the center most point is no color 0. The radius of this represents how much, what fraction of the time is this calm region 0. So the radius of this we can see number is 3%, 6%, 9%, 12, 15, please this is the indication magnitude of what particular value of wind speed?

How long did it persist? For if you are taking for 1month I am collecting data every hour. I have that much data. I have 24 into 30 that many data points. What fraction of this is in distribution?

some of, 10 of them are 11meters and higher. 20 of them are between 8 and 10 meter and so on. so we make a distribution and we represent this distribution. You can see that there is a certain length for the light green, dark green, blue and all that.

So this also gives you additional information, what is the direction of this wind? So you are plotted it on a polar graph north-south, east-south. So you have to be careful. So this wind directions from and to typically this you have very nice representation, is this usually from direction wind speed usually is reported as from. A wind is north, northerly wind which means it is wind coming from the north. Which means its direction is in this direction, it is coming like this.

So, but here this representation is the highest, which means that wind is coming from the south east. But you have to be careful some people plot the opposite way, this wind going two directions. It is coming from the north and it is going to the south. So they also represent it as 2, wind 2 direction, which is a very confusing way of doing it, but you have to watch somebody is giving you data you want to find out whether it exactly means the opposite.

It will change by the Gaussian dispersion model. If I am saying to and from interchange my entire dispersion model will change. I am looking at concentrations in opposite directions rather than this direction. So wind data meteorology is very important that determines the entire thing. So a lot of times if you are looking at say, for example, I am looking at estimating Gaussian dispersion for a given factory. I am setting up a factory and I know that this is going to be the emission.

I want to find out what is going to be the impact on a given, this thing. If I am locating the factory in Chennai, this is the Windrose for Chennai, predominant wind direction is in this south east or east south direction. For a large fraction of my time and there is some fraction of time wind that is coming in this direction. So I need to, this will help me in finding out where I should put the, if the pollutant is released it goes in this direction or in this direction, one of these which I can determine I can locate the factory, where I should locate the factory and all that.

The windrose is useful in doing that qualitatively. Quantitatively of course, you are to take the wind speed and it also will give me an idea what is average wind speed over a period of time. Which is so far, for example what people normally do is they take windrose monthly windrose, will take January, February March monthly wind, they will see how this wind is changing.

You are doing the estimate for this month and this month and this month everything will change. So you have to do it for one month. You can not do a year, year is useless, this will give you an average picture. Especially in places like Chennai it will give you average. in places like Chennai you can do hourly also if you want but wind speed is reported every hour, it is not reported if you go to meteorological this thing, they do not report they report every half hour, so it is useless. But daily windrose is reasonably useful.

So as I said at the beginning you have to find out why you are doing this? And what is the objective of this? So it all goes back to our original plan of why you want to do this? That objective must be clear.

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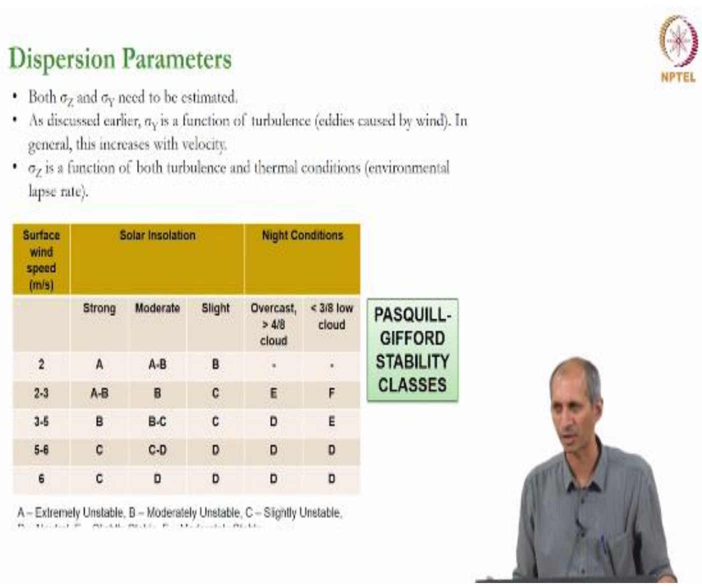

All these are only tools for doing it. The next thing the dispersion parameters sigma z and sigma y need to be estimated. So these are caused by two things one is turbulence eddies caused by turbulence in both directions y and z directions and the thermal stability class. So a very old classification in the system of what is called a stability classes. This is very old 50's or 60's by PASQUILL and GIFFORD popularly known as this.

This is not the current state of the art, but this is very useful and for the reasons I will, reasons are the previous slide, reasons are, to get the full information of dispersion you need thermal profiles. You need to calculate the adiabatic lapse rate and the environmental lapse rate. Lot of times information is not available. Some people are just, this is simpler as you can see this table you have surface wind speed there is no specification as to where which height and all that.

It gives very simple instructions as solar insulation, insulation means solar radiation. Very strong solar radiation means it is a bright day, sunny day. To very high winds, moderate winds, light winds. And some cloud colour, no cloud colour. And then at night conditions there is no solar radiation and you may have cloud colour or no cloud colour. See in the night when there is no cloud colour. You can expect that cooling happens very rapidly the inversion will happen very nicely.

We do not have any cloud colour, if you have a cloud colour inversion will not happen because variation will be blocked. Cloud colour will stop and the inversion will stop. So this is a very qualitative way of doing it based on data and so you can, people have defined stability classes based on this, so your A; is extremely unstable, B;- is moderately unstable and so on, F; is moderately stable slightly stable and so on.

As a classes increases you are going from unstable to very stable conditions D; is neutral and so on. How is this to be used? You get this stability class based on this observation, which means that from weather data you know, or it was very cloudy the wind speed of this much across the sun day time I am going to use stability class A or B or C or whatever.

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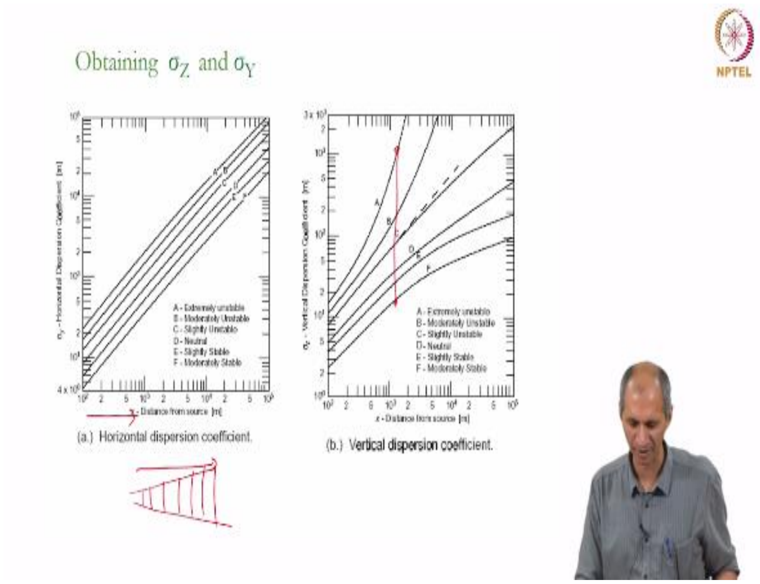

Then I use these charts, this is also given by them to give the value of sigma y and sigma z, so sigma y does not change a whole lot. So you can see stability A to B are very close to each other. It is on the y axis, x axis is the distance from the source. This exactly gives you the plume shape as the distance from the source is increasing along the x axis, you are going from here along the x axis, you see that the sigma y is increasing which means the plume is increasing if we are looking at sigma y is increasing.

So this distance is what we are plotting versus the x axis distance. So it is kind of going nicely all of them are close to each other, irrespective of stability classes distance difference is not that much, what if you go to the other one sigma z stability class is A extremely unstable, you can see the difference between that and the difference between this, several orders of magnitude, 2 orders are magnitude. F is very stable, moderately stable, is very low, the lowest dispersion and it is consistent with our physical model of what stability can do to this.

So this is a very simple way of doing it. It is a very old, this thing and so the data that you need for this is wind speed, average wind speed and data about qualitative information about whether it is sunny or cloudy and all that, but there is a current state of their model I will describe separately, we need little more discussion on fundamentals how it is done. And that is what is done in the current model which requires a lot more data, so what happens sometimes is you may have to go back to this method.

To get some preliminary estimate before you go and do it with the real model device, if you do not have data you can not just fold your hands and sit down you have to get some estimate this is very true with all modeling because you do not have data that is why you have simple models and more complicated models, the difference in estimation, there will be a difference but know that difference will exist and then you know how to correct for it based on their information you have about the system.

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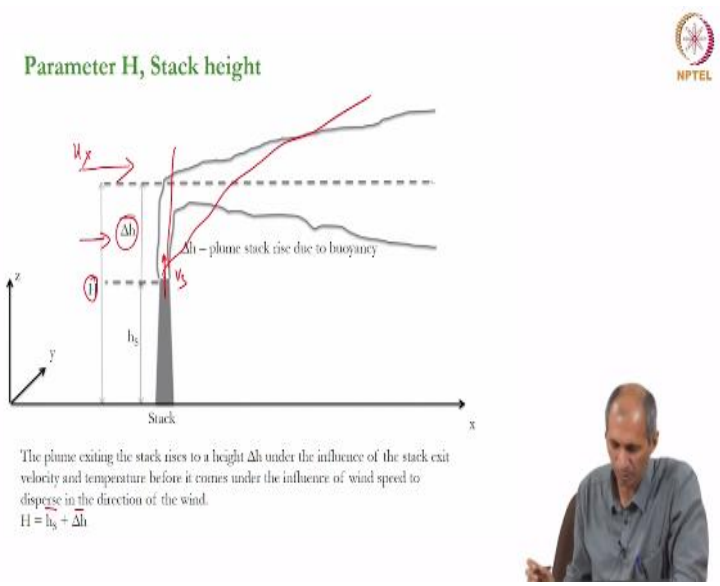

The third the last parameter that we have is a parameter H, so this is simply as we see in this case it is not just the height of the stack, it is the height of this center point where you have the highest concentration. Which means that will happen for these things will happen. For example, in this example we are seeing that this plume is getting out and is going up to a certain height before it starts turning and going in the direction of the wind, why does this happen?

This is one scenario, why does this happen? What is this a function of? Why will it go up and then start moving? 2 reasons why this can happen. There are only 2 reasons for all of this. One is density difference because of temperature, high temperature emission coming it will go up buoyancy will drive it up, but this buoyancy force of buoyancy also has to be accompanied by something else for it to go up. It can go up like this, why is it going up straight?

It can go up like this and it will eventually affect the adiabatic lapse rate, effect the plume, shape and the sigma Z and all that will come there. Why is it going straight up? What else is there? Buoyancy is one which is the other force? Velocity, there is a stack velocity. If you are in industry, industry is pumping these gases out and there is velocity of pumping, sending around some flow rate and this is a velocity is very high it goes up, it shoots up like a jet. It shoots up a lot of energy, a lot of buoyancy, it keeps going up and up before this, this a Ux here.

Takes over, it loses the energy and then it is just hanging there. You can see that if I light, if I burn something I am not sending any air or anything. I am just burning it. It just goes up, just raises up no wind and then I put a turn of fan and it will start getting carried away in the direction of the fan, so it is like that. This wind direction is there also but this force is so much that is energy is that it goes up to a certain height before it loses energy and then it gets carried.

So this is delta H here is called as the stacked rise of the plume and this is a function of 2 things both, so we calculate H the actual H is the sum of the physical height of the stack and the plume rise. The plume rise is a function of 2 things.

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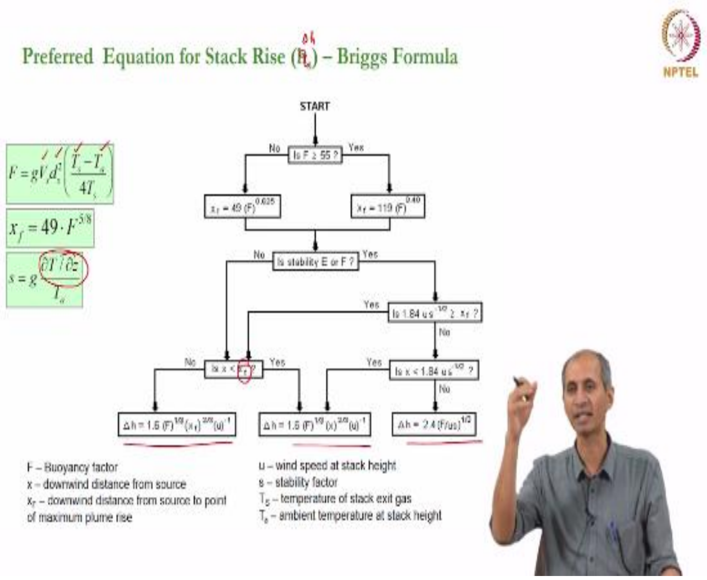

Something the velocity of the stack and the temperature is the formula that people have derived, I am not going through this, we will just give you an idea of this several things. This is a preferred equation for calculating stack rise, Hs is delta h not Hs. So you are calculating all these parameters, F is given here, so here you can look at the parameters here this is velocity of stack, this is the diameter of the stack, this is the temperature of the gas coming out of the stack, this is the ambient temperature and this is the gradient dau T by dau z is gradient.

This is ambient temperature gradient, which will tell you if there inversion or no inversion, stability class determination is done like this, which means you need a lot of data for this, at least in the near height. So based on this you calculate the delta h. There is some other parameters here xF, sometimes the purpose of xF here is this following. Sometimes what will happen is, you have the stack here. This will happen and then it will start moving up. So the rise will happen.

Here is going very straight sometimes this will happen and before that, then it will start spreading out. So there is a certain distance that is xF, so that distance moves the entire thing, it goes in a jet but the jet is going moving like this it is not going up straight and moving like this before it starts spreading and that is a starting point for this spreading. So in the next equation, you see the term called xF here.

The xF is calculated using the buoyancy, so these are empirical equations there a lot of empirical equations is not the only one. Which I am not given the other equations here. They are in the other ppt I think you can take it but use this, this is the most comprehensive one. And this is also used in some of the regulatory models for this. This is also used in designing, so when you do the entire the;

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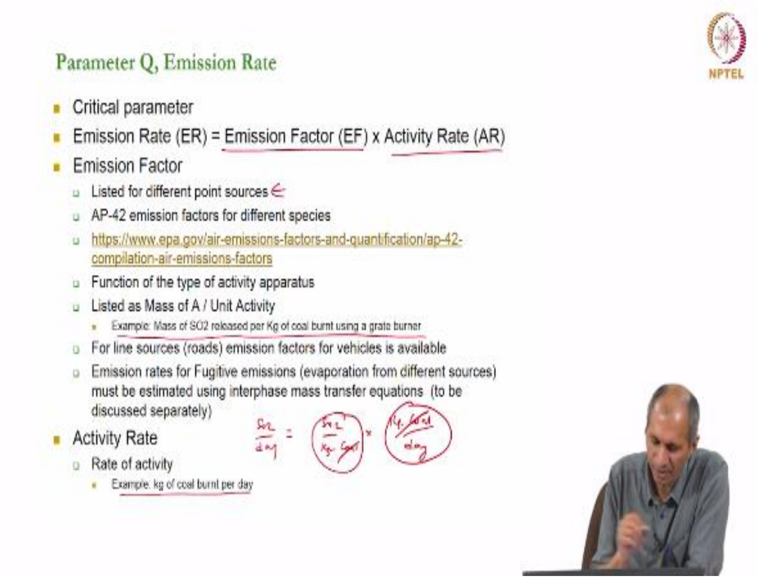

We will come back to that in a minute, so the last thing we have is what is called as emission rate, this is the most important parameter without this there is no Gaussian dispersion model, this is emission. You must know what the emission rate? So emission rate in general there are different types of way in which we estimate emission rate for different processes. But when you have things like point sources.

Point source is a different particular activity, is particular industry. Emission rate is calculated by the product of what is called as an emission factor and multiplied by an activity rate. Emission factor itself is for example mass of sulphur dioxide released per kg of coal burnt using some kind of burner. Kilogram of what coal, which coal everything comes here, kilogram of Indian coal, burnt using open stuff.

I can burn coal, I can burn different kinds of coal, I can burn coal differently. In different types of burner combustion devices, I can burn coal in power plants. I can pulverize the coal and burn it, do all kinds of things right and then, what is the activity? Activity is how many kilograms of coal am I burning per day. So essentially the emission rate for SO2 per day, this is the emission rate. SO2 release per day equals, SO2 per kilogram of coal multiplied by kilogram of coal divided by per day.

This flow different number, this number and this number. This number is independent of this number. The activity rate I can burn one gram of coal, I can burn 50 tons of coal a day it is different but emission factors should be the same more or else. You are doing under different conditions, so the emission factor is listed for different sources.