Air Pollution and Control
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Lecture 07
Sources and Classification of Air Pollutants

Hello, friends. Today we will discuss about sources and classification of air pollutants. Basically, as you know we are discussing about air pollution and control in totality. So, we need to know what is the air pollution, what are its main sources and then we need to know different kinds of air pollutants because to control them we have to have different policies, different technologies for different pollutants.

So, unless we know what kind of sources are there and what kind of pollutants are released, then how can we control them? So, basic knowledge of fundamental knowledge about sources and classification of air pollutants is very important.

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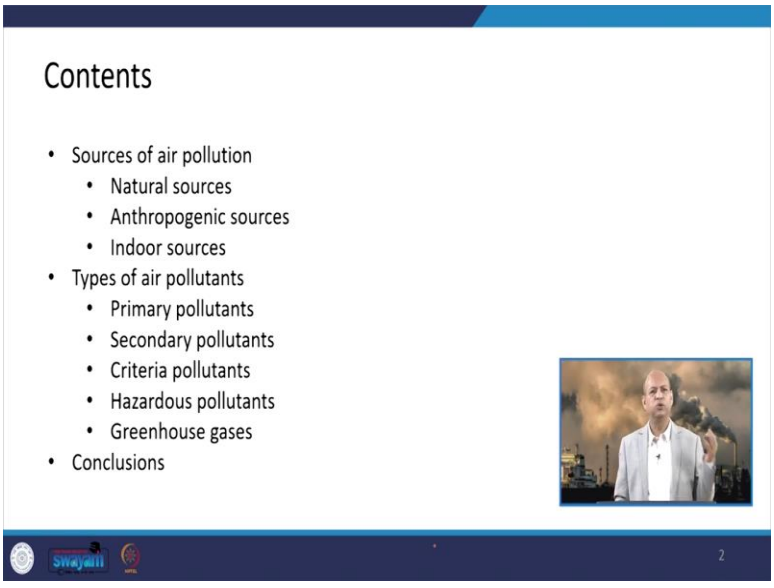

Well, so, when we talk about the sources of air pollution, basically you can divide it into like natural sources or anthropogenic sources, anthropogenic means manmade sources, then you can also divide them like indoor and outdoor sources. So, that way major sources, then within natural sources we can say different kinds of sources we will see

what kind of sources are there which can be categorized as natural sources and what are those sources, which we categorize as anthropogenic sources.

Then, within indoor sources also different kinds of microenvironment related sources can be there. When we talk about types of air pollutants, then there are many ways, several ways to classify the air pollutants basically, depending upon their size depending upon their shape or physical and chemical characteristics. We can say that, physical aerosols or biogenic aerosols, those kinds of things.

Similarly, the major components regarding types of air pollutants can be like primary air pollutants, secondary air pollutants or criteria and non criteria pollutants. Within known criteria like hazardous or toxic pollutants, then there are greenhouse gases. Strictly speaking some greenhouse gases like CO_2 is basically not pollutant. This is part of our inhalation and exhalation process. CO_2 is part of our system. It is not toxic pollutant.

But other pollutants are there which are also greenhouse gases like ozone, etc. They are air pollutants as well as greenhouse gases. So, in that way to control the greenhouse gases, to avoid climate change, to avoid other effects on global warming etc, we need to discuss them as part of the air pollutants.

Also, some people talk about like, noise pollution. That is also the part of air pollution according to them. So, there are different authors different high schools of thoughts. And then even people talk about like, light. In the in the cities, so much light is there in the night that they can disturb the path of birds, migratory birds etc. That is also known as space pollution or air pollution. Even some people talk about like banners advertisements, those spaces are occupied. So they call it like air pollution of different kinds.

But strictly speaking, the health impact related air pollutants are those pollutants which affect our health, which affect the ecological systems and other effects they have. Then we will discuss about conclusions after all.

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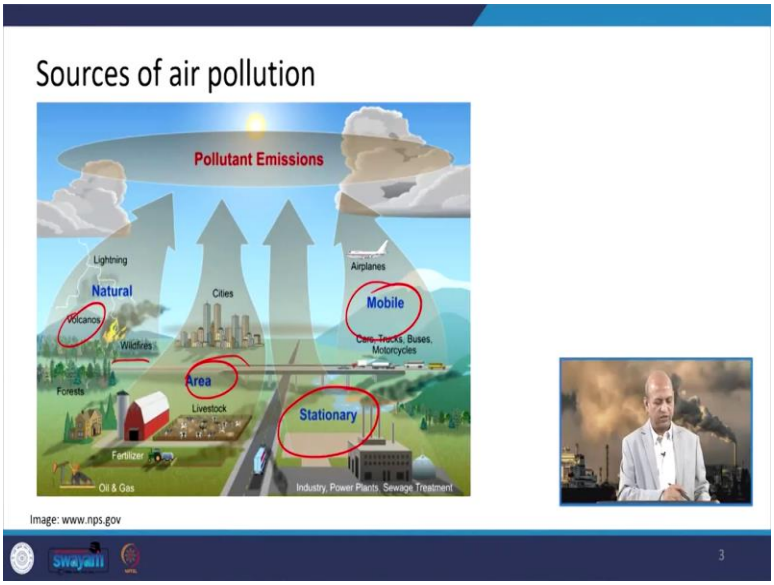

So, in this picture, you can see in totality what are different sources of air pollution. You can see like natural, natural are volcanoes. Then wildfires, natural fires may occur in the forest. So, they can emit lot of carbon dioxide or particulate matter or other pollutants. So, forest can be also the source of air pollutants. As I said earlier, like pollens and VOCs, hydrocarbons, whatever smell is coming from a plant or flower, this is basically VOC, Volatile Organic Compound.

So, those kind of emissions may also be there naturally. Whenever you cut the grass, in the lawn, then also you have certain smell. All those are VOCs, basically. So, natural emissions of VOCs can be there.

Then when we talk about like, these manmade sources or anthropogenic sources, so, they can be classified like stationary sources or area sources, mobile sources or line sources. So, point sources or stationary sources are basically emissions from certain stacks or chimneys, a point source, you can say. Also, like definition sometimes depends upon the context also. Like city is an area source, but if you look at the continental scale city can be a point. In that context that can be kind of point source.

But in daily life, when we talk about urban air quality management etc then point sources are only those sources like which are coming, the pollution, plumes are coming out of a stack or a small heap is being burned. So, those are the points sources.

Area sources can be like number of points sources are there. Like, each household is emitting when we are cooking. So, in the whole colony or city emissions are coming from kitchen, or in some industries, industrial area, so many pollution is coming from different industries. So, that kind of in total can be termed as Area Source.

Then mobile source or line source is basically like, on the road vehicle is traveling. So, that can be line source or mobile source. Line source can also be because of like, there are a number of stacks like some industries are in parallel of a river bank. And those in the line, so, that is also the line source, or agricultural waste is being burnt in a line in a field. So, that is also a line source, in that way. So, that way you can see like natural sources, manmade sources and also we can categorize like a stationary sources mobile sources and area sources.

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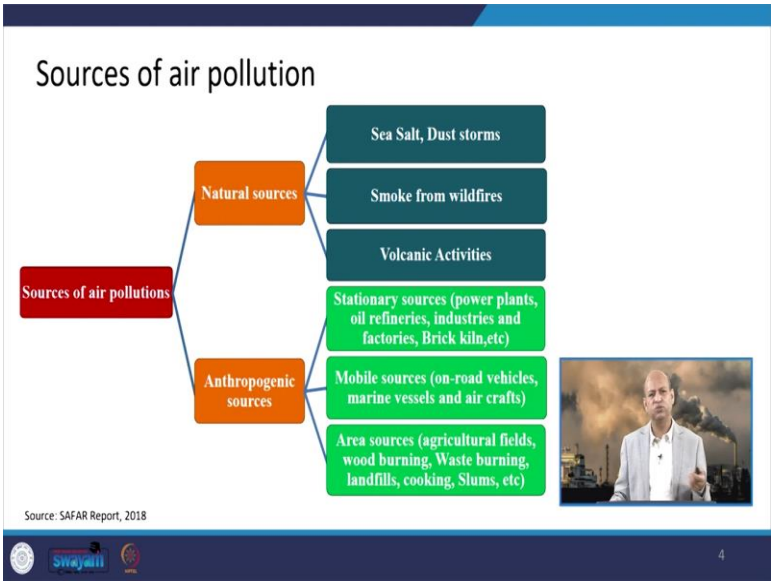

Well, so, we have talked about in that picture. So, like natural sources may be sea salt or dust storm, sand storms and then smoke from wildfire, volcanic eruptions, volcanic activities are also natural occurring sources of air pollution. Anthropogenic sources,

stationary sources like power plants, so, again stacks are chimneys, oil refineries or industries and factories brick kilns, etc wherever a stack is there, chimneys there and a plume is coming out of it, we call it a stationary source or point source.

Mobile source, on road vehicles or marine vessels, ships etc which are moving. So, emission is going on, coming out of a chimney of that, or stack of that particular vehicle, like exhaust pipe or in the ship some exhaust pipe is there, and then aircrafts, also mobile sources you can call.

Area sources like, lot of agricultural field emissions are there, or wood burning in a large area, then waste burning also like wherever these landfill sites are there, several hundreds of yards or meters occupied by waste, and if it is burned, then that can be area source. And then the cooking or slums, wherever emission sources are in a large size area, then we call it as area source.

So, basically why do we worry about line source or point source, area source? Because when we try to model, so according to the area source, point source or line source modeling techniques are different. So that we will discuss later on.

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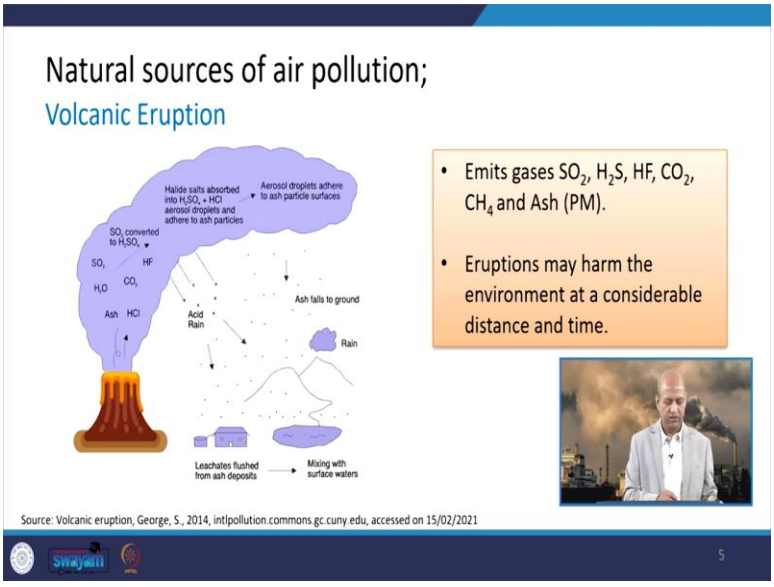

Now, we go for natural sources one by one. So, like volcanic eruptions. In volcanic eruptions, a lot of emissions come of different nature, like huge quantity of sulphur

dioxide and ash content, particulate matter, those kinds of things like CO_2, even moisture, hydrogen fluoride, and hydrogen chloride, all those things, they come out of this particular activity.

Then SO_2 is being converted into H_2SO_4, so it can also get converted into acid rain. So that falls as a precipitation or dry depletion that can be there. So this is the way of, emitting, this volcanic eruption emitting lot of gases and particulate matter.

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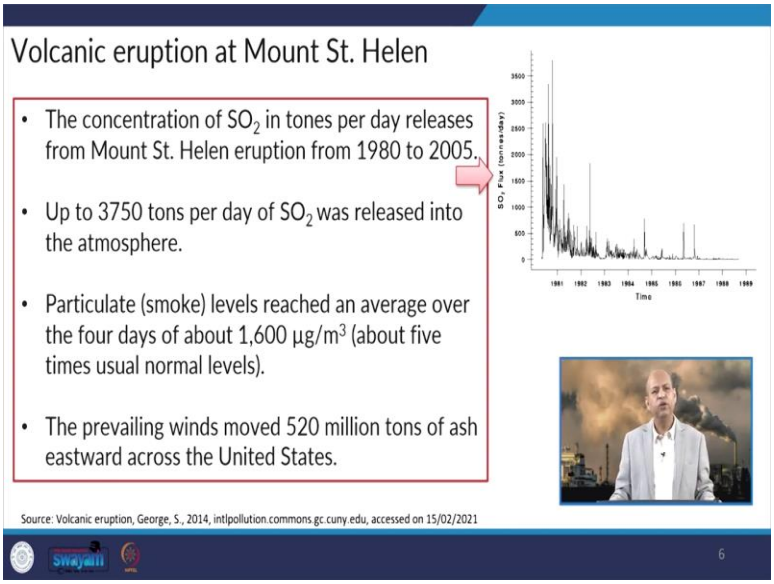

Well, the gravity of volcanic eruptions can be visualized with this example. Like the concentration of sulphur dioxide in tons per day, which was released from Mount St. Helen eruption from 1980 to 2005 was huge. It was around up to 3,750 tons per day of sulphur dioxide, it was released during that span of period. So it was huge quantity, you can say.

Particulate matter in the smoke and the levels, in the ambient air because of that eruption, over the four days of eruption, it was around 1,600 micrograms per cubic meter, it is a very high concentration in ambient air. And that was around 5 times of usual normal levels, which were observed daily in that area. And the prevailing winds moved around 520 million tons of that ash or particulate matter eastward across the United States.

So the whole region was affected by this volcanic eruption emitting a lot of particulate matter.

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Well, if we talk about in today's context or in current context, so as on 19th August, August 2021, around 50 volcanoes were counted as, in active eruption status around the world. These 50 volcanoes. So you can imagine that they are emitting huge quantity of gases and particulate matters etc.

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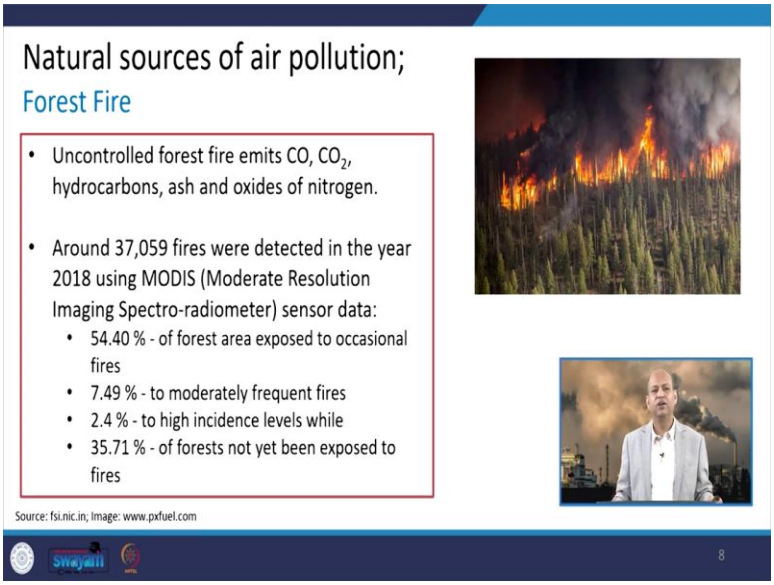

Well, then there are natural sources of air pollution in terms of forest fire. So uncontrolled forest fire emits a lot of carbon monoxide and carbon dioxide and hydrocarbons also, and ash content that is particulate matter and oxides of nitrogen. Like around 37,000 fires were detected in the year 2018 using this MODIS (Moderate Resolution Imaging Spectro-radiometer) sensor data through the space.

So, and if we count like how much part of the forest is affected by these fires, so around 54 percent of forest area is exposed to occasional fires, and around 7.5 percent to moderately frequent fires, and around 2.4 percent to high incidence level and 35.7 percent around, means not yet exposed, that is unexposed, you can say, in that way, means that was the kind of study based data.

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When we talk about like Australian bushfire, it is, the area and intensity and extent was very worst, the extreme bush fires that blazed across southern eastern part of Australia in late 2019 and early 2020 it released around 750 million tons of carbon dioxide into the atmosphere.

And then unprecedented fires burn across, as much as 74,000 square kilometer of mostly that particular variety of plants. And then, this around Southeast Australia was affected.

And it was the area larger than, if you want to visualize, larger than Sri Lanka. That kind of visualization, you can see.

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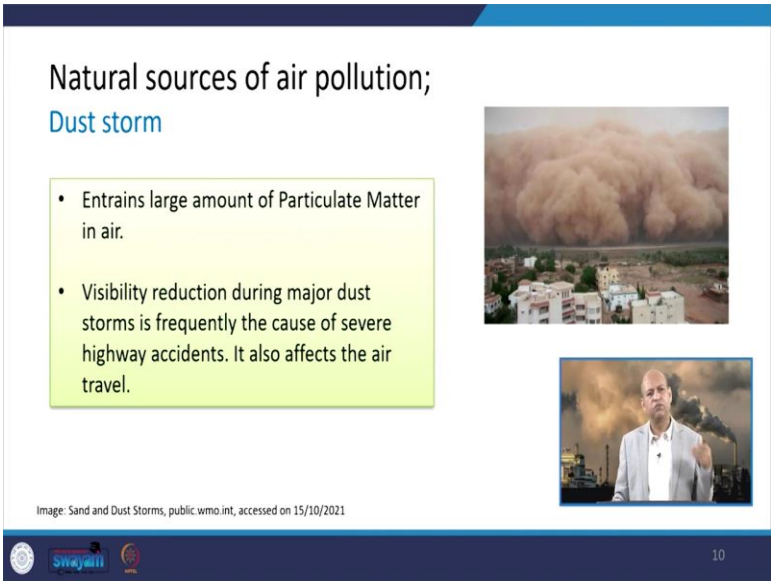

Well, when we talk about like other natural sources for example, sand storms or dust storms, so they also entrains large amount of particulate matter into the atmosphere. And because of that, particulate matter concentration increases several fold and also it reduces the visibility severely, and because of that sometimes accidents happen on the road.

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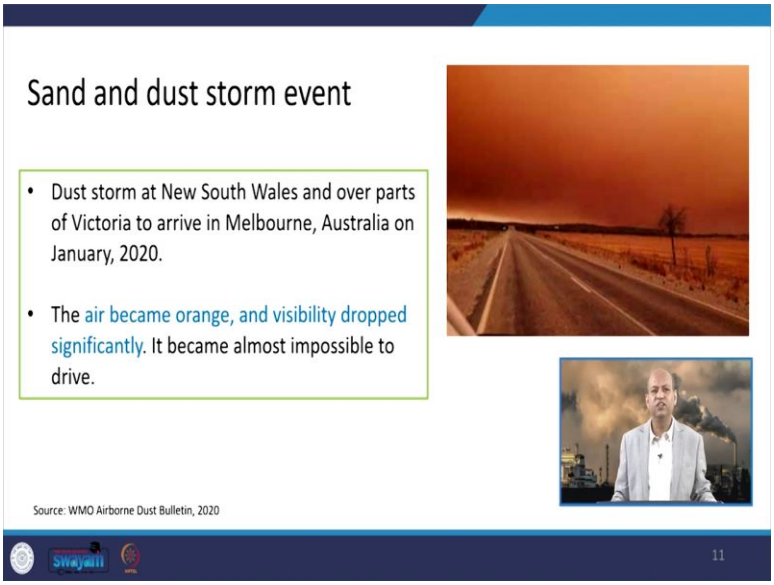

Well, you can see here, this dusty storm at New South Wales as an example, over parts of Victoria, to arrive in Melbourne, Australia on January 2020. So the air, atmosphere became like orange, because of this scattering of the light and the visibility dropped significantly, and it was almost impossible to drive in that situation. So those are the effects of sand storm related air pollution episodes.

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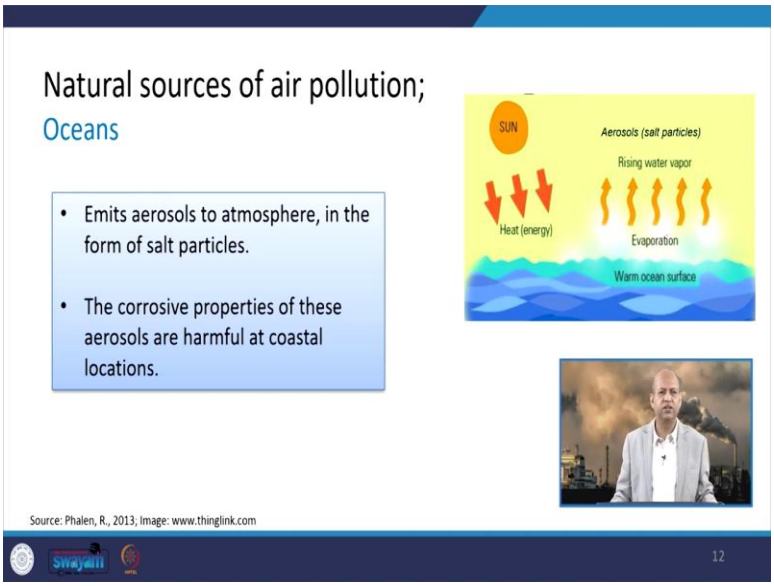

When we talk about, further in case of natural sources of air pollution, so the oceans are also very vast emitting sources of air pollutants. And they emit aerosols, basically, in the form of salt particles, because wind and that friction is there, then lot of salt becomes part of these aerosols. And then corrosive properties are there because of, these aerosols have a lot of chlorides etc. And the coastal locations, buildings get affected severely because of that.

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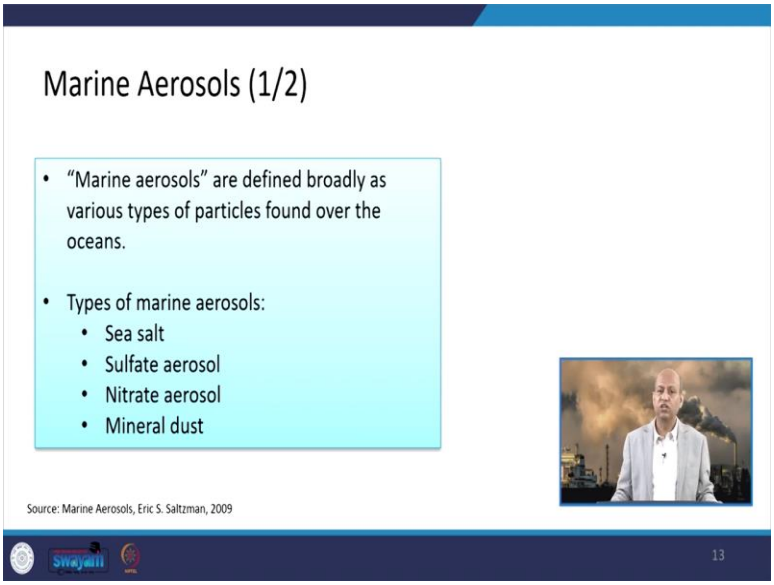

Well, these marine aerosols are defined broadly as various types of particles, which are found over the oceans, for example, like sea salt or sulphate aerosols or nitrate aerosols, mineral dust, so according to their, these physical chemical properties, we can classify them in different types of aerosols.

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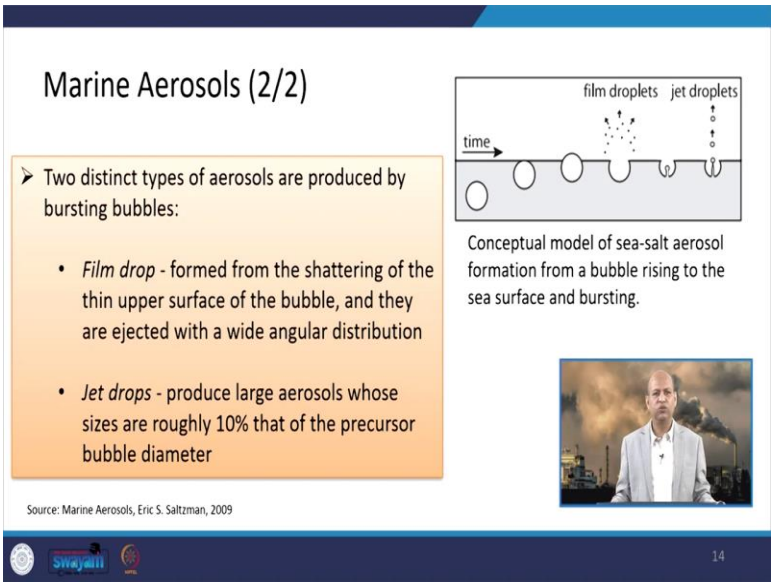

Then, there are two distinct types of aerosols which are produced by bursting bubbles. You can see here like bubble goes up, and it bursts, so this film drops and form from the

shattering of the thin upper surface of the bubble, and they are injected with a wide angular distribution. So that is one way of creation of aerosols in the air.

Another one is like jet drops, so which produces large aerosols whose sizes are roughly 10 percent of what is a precursors of bubbles diameter. So that way size related differences there because of different way of their production.

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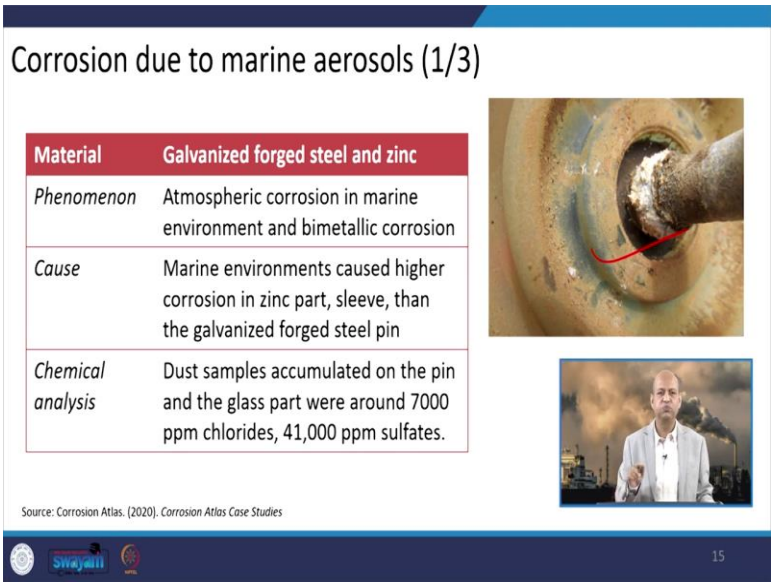

When we talk about like their effect, so a lot of corrosion related things happen because of these marine aerosols. As you can see, like, this atmospheric origin in marine environment and bimetallic corrosion happens, you can see in the figure also. So marine environments cause higher corrosion in zinc part or these sleeve related parts and galvanized forged steel pin, you can see here. So that corrosion is because of this marine environment emitting aerosols.

Then dust samples accumulated on the pin and the glass part were around 7,000 ppm fluoride, or 41,000 ppm sulphate. So that kind of high concentration can easily corrode whatever metal it is there, unless it is, non corrosive metal is there.

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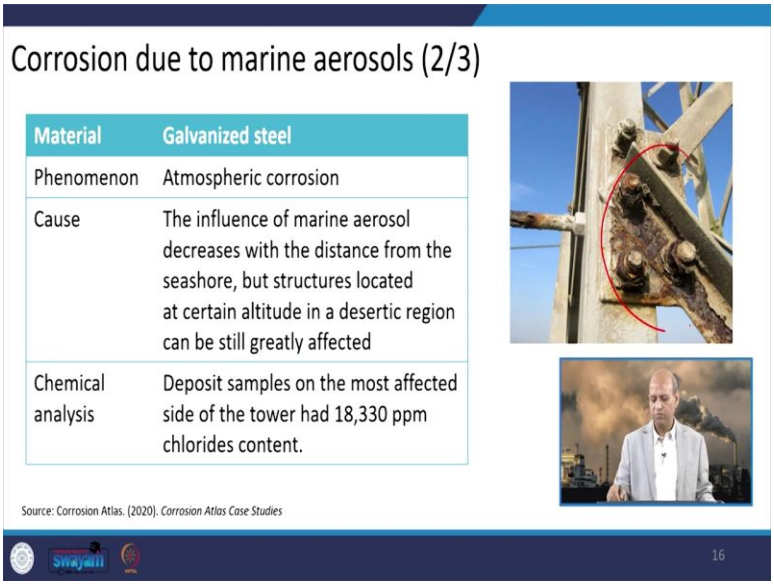

Well, similarly, in another study this was seen that the influence of marine aerosol decreases with the distance from the seashore, naturally because their concentration decreases, but the structures located at certain altitudes in a desertic region can be still greatly affected as seen in this particular picture. And the, these deposit samples on the most affected side of the tower had around 18,000 ppm fluoride content, so that is again very high concentration.

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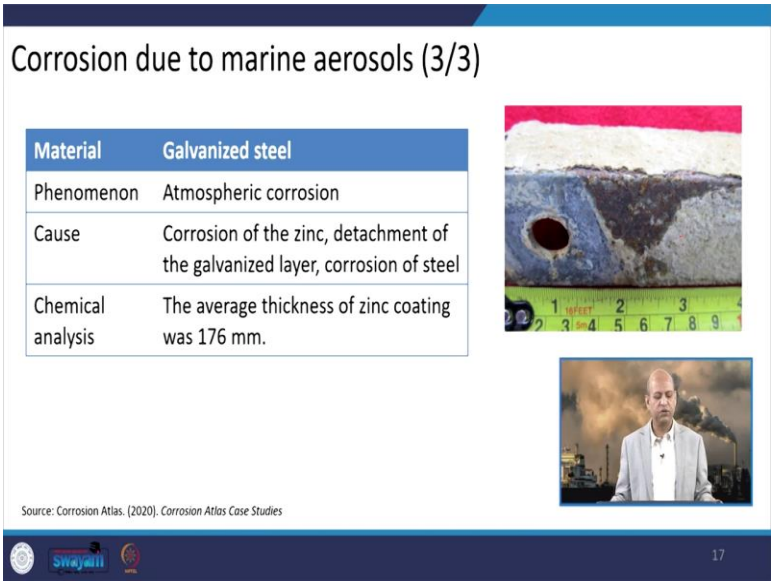

Similarly, this is another example of atmospheric corrosion, corrosion of zinc, detachment of galvanized layer, corrosion of steel etc, they are part of this particular chemical attack because of marine aerosols.

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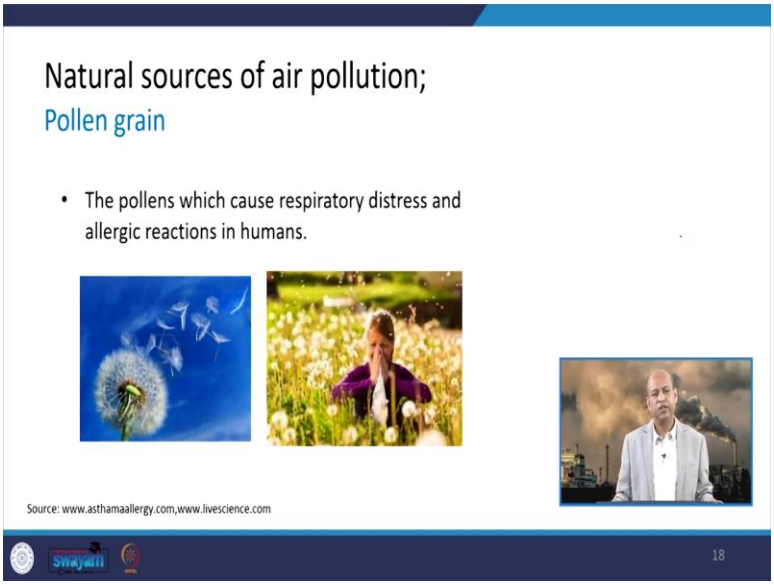

Then, in this, the part of natural sources can be like pollen, pollens grains, from flowers from plants, which can cause several respiratory distress and allergic reactions to many people and animals also.

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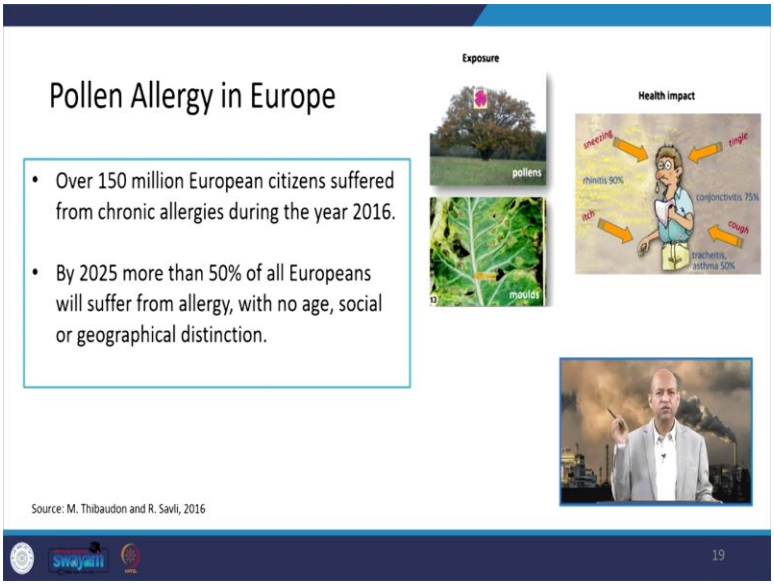

Well, so pollen allergy data if you want to see, to have a kind of context, then around 150 million European citizens suffer from chronic allergies during year 2016 As per one data. And by 2025 it is estimated that more than 50 percent of Europeans will suffer from allergy with no age, social or geographical distinction. So those are negative effects of these natural sources or naturally emitting pollens, which, again you can call them kind of particles, but they travel and they can affect our respiratory system.

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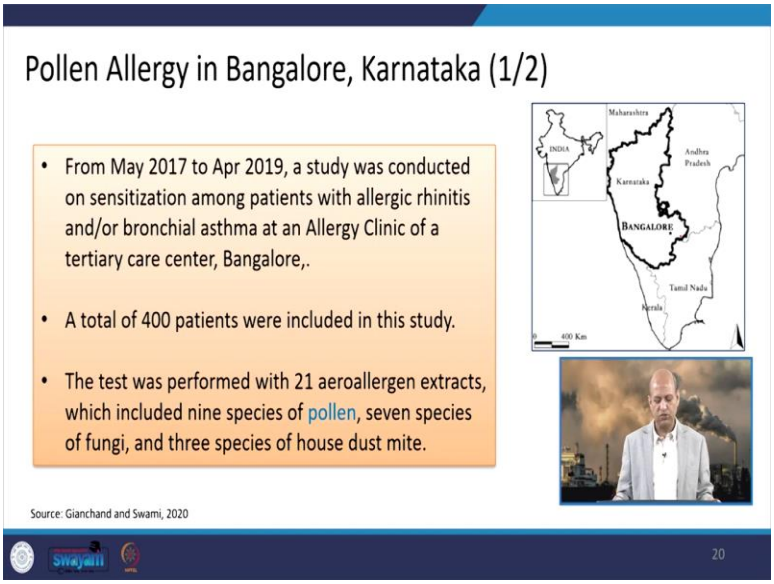

If we see, in Indian context, like Bangalore, sometimes people write it as a city of allergens or pollens. So in a study from 2017 to 2019, this study was conducted on sensitization among patients with having allergic, rhinitis kind of, or bronchial asthma kind of symptoms.

So in clinics, they were observed and some data were collected. So around four 400 patients were included in this particular study. And it was performed with 21, aeroallergens extracted from different kinds of pollens and 7 species of fungi and 9 species of pollen and three species of house dust mite were considered in this particular study.

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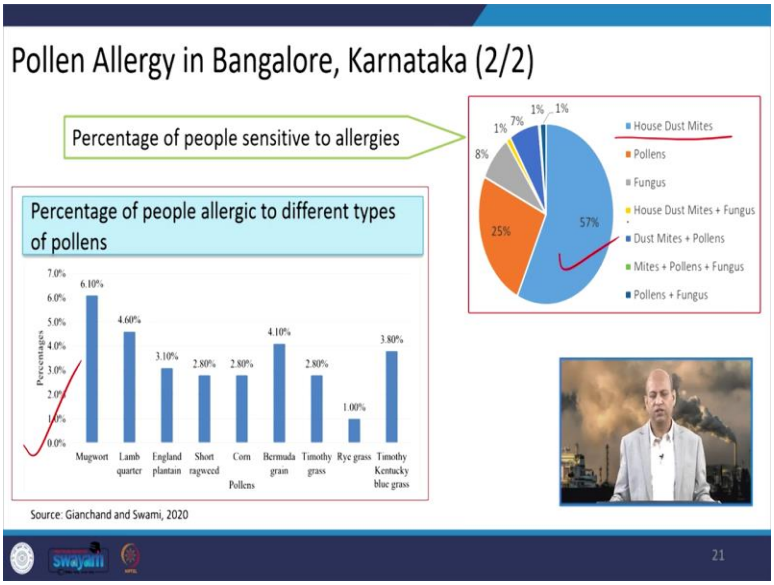

And you can see the result of this particular study. Like, percentage of people are allergic to different types of pollens, you can see in this particular chart. Similarly, if you see the percentage of people sensitive to allergies, so like house dust mites having maximum role in giving allergy to people.

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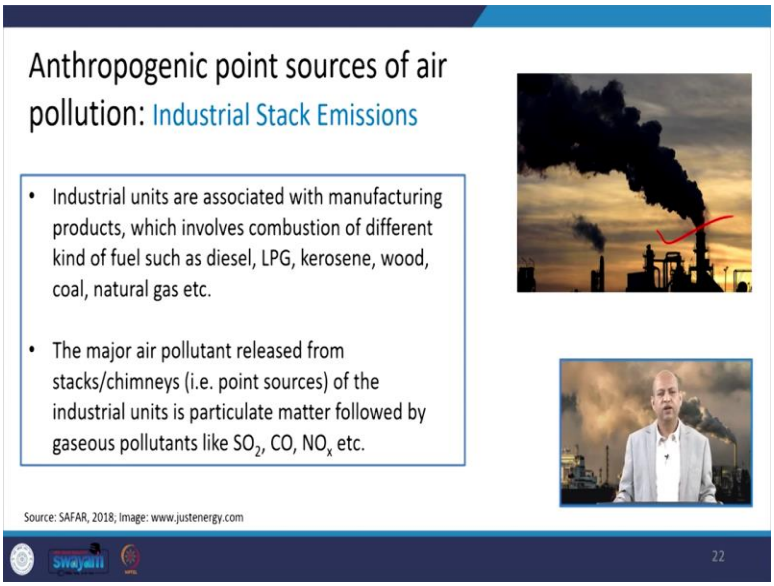

Now, if we talk about, from natural sources, if we shift our attention to anthropogenic sources, so if you talk about like point sources, then industrial stack emissions are

basically the point sources, as it is shown in this particular figure also. And they can be like from manufacturing of different products. So you need energy, and some sort of fuel is burnt there and that emission will go out of the exhaust chimney.

And if it is, not controlled by some equipments, those pollution controlling equipments, then lot of pollution is emitted in the air. And the nature of the pollutant will depend, of course, on the nature of fuel which is being burned. The major pollutants which are released from stacks, chimneys, like these point sources of the industrial units, maybe like particulate matter or sulphur dioxide, carbon monoxide oxides of nitrogen depending upon which kind of fuel we are using.

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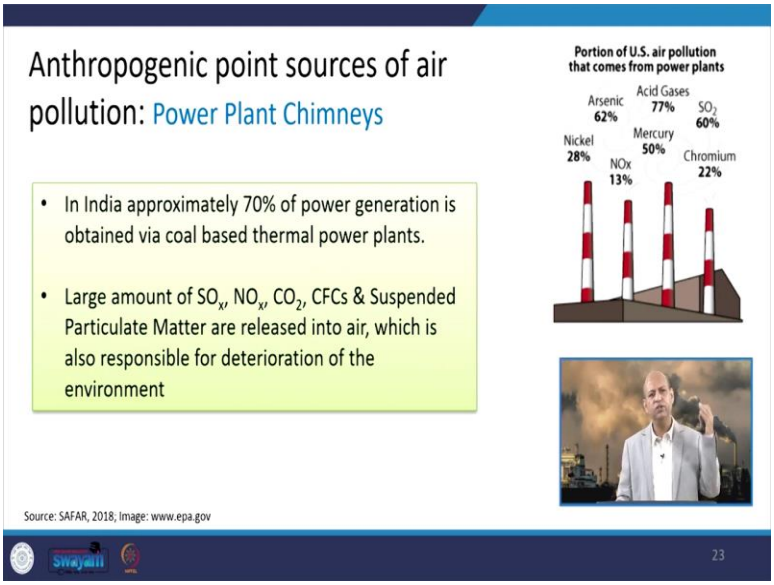

So, you can see here like this portion of U.S. air pollution that comes from power plants, you can see around 62 percent of arsenic, 77 percent acid gases, 60 percent sulphur dioxide, those kinds of data they are from plant, power plant emissions. In India around 70 percent of power generation is obtained via coal based thermal power plants. And coal is, people say that this is the dirty source of energy because it emits a lot of particulate matter and a lot of sulphur dioxide etc, depending upon the coal quality.

But nowadays this coal is treated well before taking to power plants. So then pollution levels are a little lesser and then controlling equipments, air pollutant controlling

movements are also there, like electrostatic precipitators etc. So pollution level becomes low in that sense, but it is still huge quantity of coal is burned, then a lot of pollution comes out.

Large amount of sulphur dioxide, NO_X, CO_2, CFCs those kinds of things may come out of those power plants.

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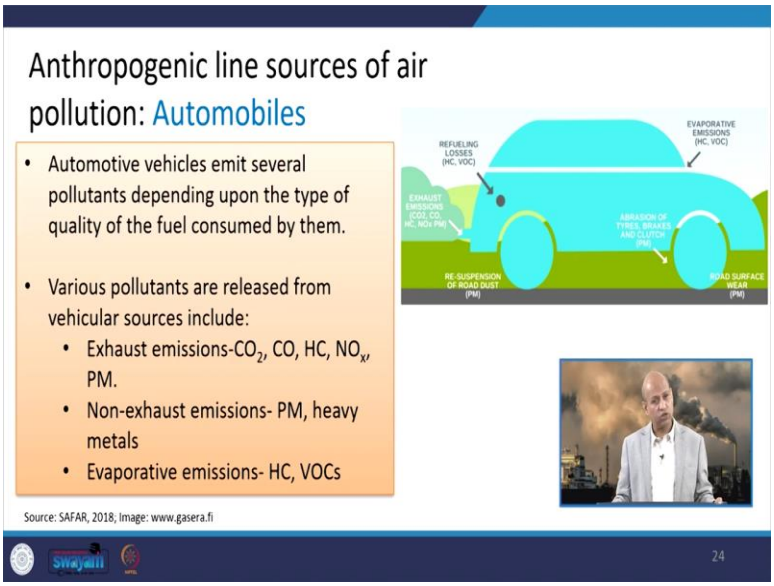

Well, when we talk about line source or mobile source, automobiles are the major source of air pollutants in that sense. And NO_X emissions or carbon monoxide emissions largely come from these automobiles based on gasoline or diesel etc in the urban setting. So if you try to compare pollutants, then you will find that in a particular city, these CO emissions, NO_X emissions are coming largely from automobiles, and hydrocarbons also, VOCs are also in huge quantity.

And there may be some other non exhaust emissions also that could be from petrol pumps or like tires etc, those kinds of emissions may also be there from automobiles.

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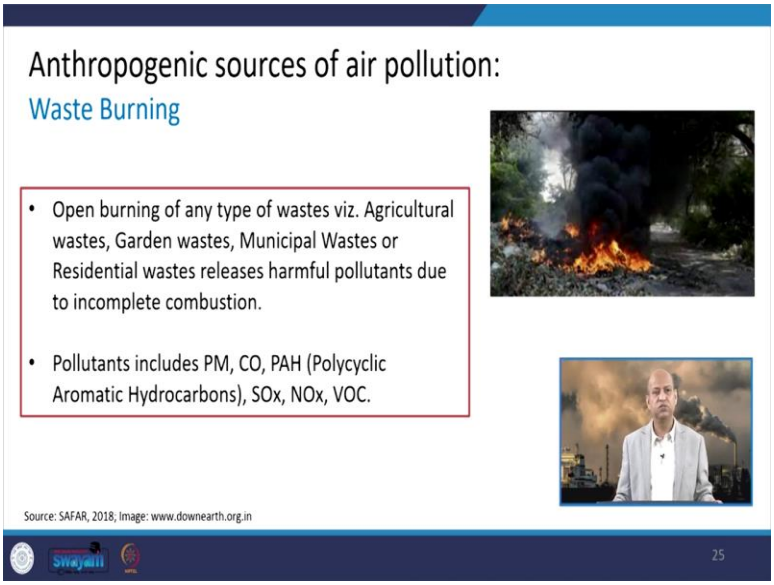

When we see like area source, a lot of waste is burnt in a large area, then waste burning can be a large source of particulate matter. This is uncontrolled combustion, you can say. So like a lot of CO_2 emission is there. And people throw away plastic etc, so toxic chemicals also comes out of these waste burning sites. That is very dangerous, basically. Like polycyclic aromatic hydrocarbons, VOCs, CO, particulate matter and many other things come into the fuel of these waste burning sites.

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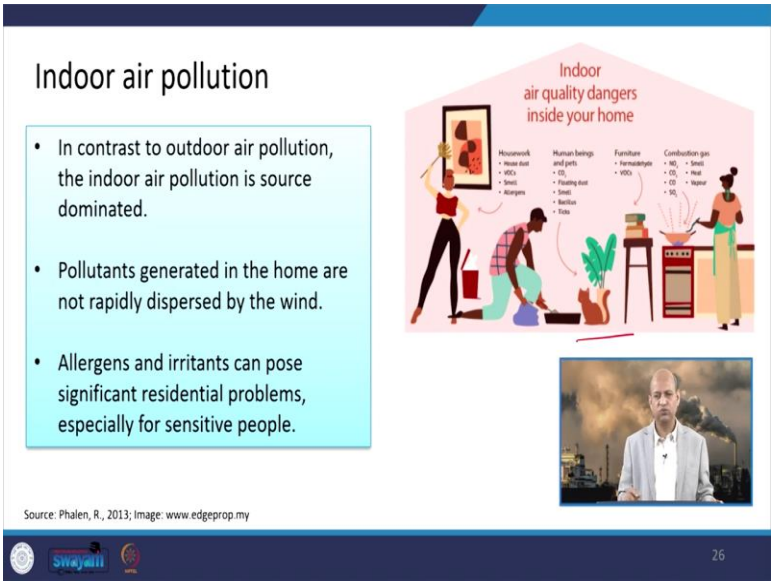

Then, if you talk about indoor air pollution, so in micro environment, several sources maybe the air of the indoor air pollution. Like from even our sofa, kitchen activities, even like, these washing machines, and when we are mopping the floor, so we are using certain chemicals, so washrooms etc, several sources may be there for the indoor environment.

So we have to be careful of those sources. Even pets are also source of certain aerosols etc. So there are several sources in the in the indoor environment, and if you are not attentive enough, then a lot of harmful effects can be there to our health. And we are not aware of it, but they are coming from our own setting, our own dwelling units.

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Then, if we see like this scenario of a major source of air pollutants in Europe, then around like, means, if you want to visualize the, in a city, European city, so 90 percent of these ammonia emissions and 80 percent of methane emissions come from agricultural activities in European setting. And the waste or landfills, these coal mining and long distances these transmissions are sources of methane.

Similarly, the 60 percent of sulphur, that sulphur dioxide or sulphur oxides, they come from energy production and distribution kind of activities. And many natural phenomena including like volcanic eruptions are also contributing different kinds of air pollutants.

And 40 percent of emissions of nitrogen oxides come from road transport. So as I said NO_X emissions in large quantity come from transportation sector.

So you can see different kinds of pollutants in, in European setting, coming from different activities, anthropogenic sources, in a way.

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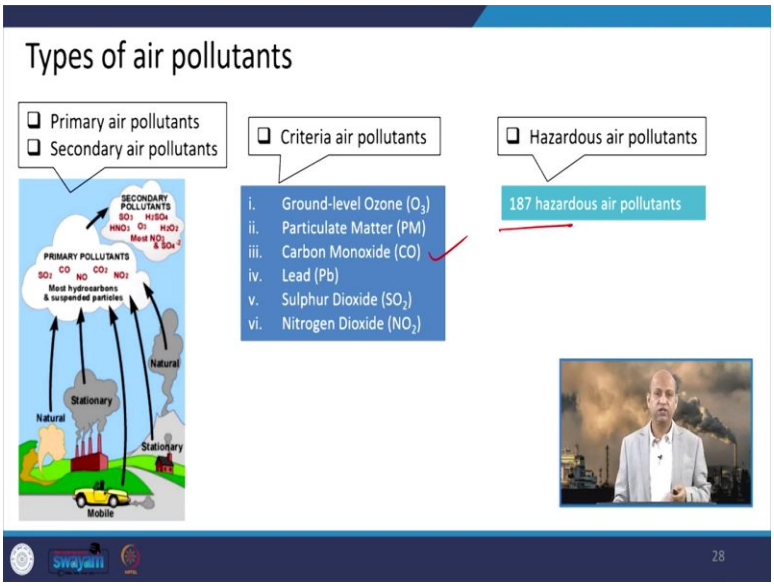

Well, then, when we talk about types of air pollutants, because when we want to control, so if we have kind of emission inventory, so we have different quantities of air pollutants with the name, so then we have idea that this particular pollutant is being emitted in a large amount and this is also contributing to certain negative impact to our life, weather environment or our human health, then we want to control it.

So we want to reduce this. So, unless we have that data, type of air pollutants, their emissions or their concentrations in the air, controlling technique or controlling policy would be difficult to devise. So we need to know the types of air pollutants. So we classify them into different categories like primary air pollutants, secondary air pollutants, so criteria, non criteria or hazardous.

So primary air pollutants and secondary pollutants you can see, primary air pollutants basically they are emitted directly by exhaust sources. And secondary pollutants which are, when primary pollutants are in the atmosphere, then they interact or react with each

other or they react with constituents of the atmosphere, so then the transformation happens, and that transformed pollutant is known as the secondary pollutant.

When we talk about criteria air pollutants, basically, they have certain threshold limit. So like whatever National Ambient Air Quality Standard related pollutants are there, so they are criteria pollutants, because based on certain health impact studies, scientists and engineers have prescribed certain limits. Below that limit it is not much harmful. So that threshold limit is there. Well, so those are like ground level ozone or particulate matter or CO, lead, sulphur dioxide, nitrogen dioxide etc, there are criteria pollutants.

Then there may be hazardous air pollutants. And you can see around 187 hazardous air pollutants are listed as toxic pollutants, because they, they can affect our health in any quantity, even if they are presenting very small quantity. So they do not have a threshold limit. They are very toxic and a small quantity can also be dangerous to our health.

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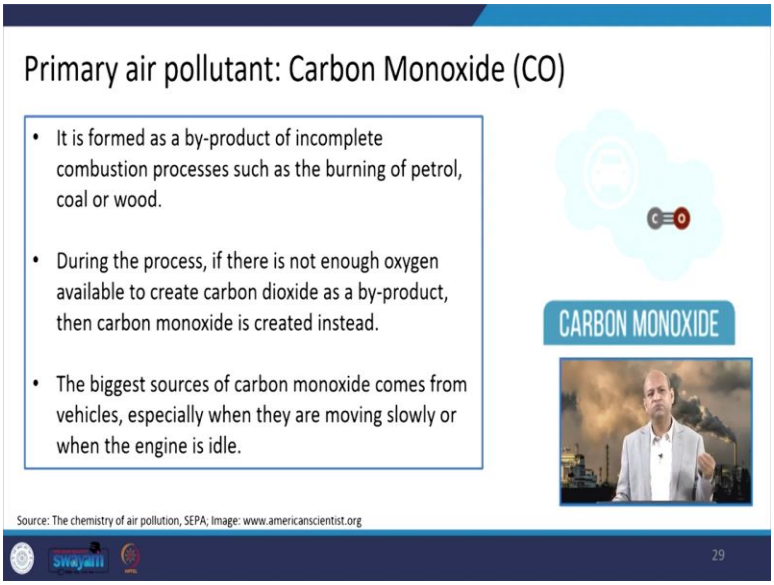

So when we talk about primary air pollutants, as I said, it is formed by, as a byproduct of incomplete combustion processes, as the burning of petrol coal or wood. Complete burning is there then basically it is converted into carbon dioxide and those stable products, moisture or what, those kinds of things. But incomplete combustion results into

certain pollutants, which are unstable. They will react with some other things and they will result into some harmful impact.

So during this process there is not enough oxygen available when this incomplete combustion happens. So they create carbon monoxide as a byproduct, and you know carbon monoxide is problematic to our this respiratory system because it goes into the blood and it reduces the carrying capacity of the blood for oxygen, and with the lack of oxygen we faint and even death can occur if a lot of carbon monoxide is absorbed in our body.

And the biggest source of carbon monoxide are basically the vehicles, transport sector in any city, you can see. But good part is that like government of India is propagating now the policy of decarbonization of transport sector. So that way if we shift towards battery operated electric vehicles in a large number, then this kind of emissions can be ruled out from the transport sector. But this is the future scenario.

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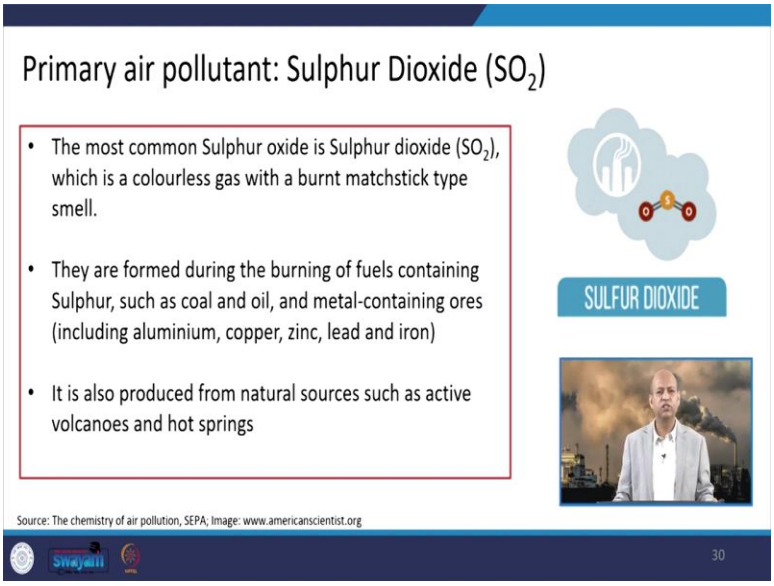

Well, similarly, sulphur dioxide is also the primary air pollutant. And the most, the most part of the sulphur dioxide comes basically from these coal burning power plants. And other fuels like oil and, they may contain other pollutants also. Well, this, this is produced

in natural sources also, but, like volcanoes and hot springs, but anthropogenic sources are also, they are quite predominant in terms of thermal power plants.

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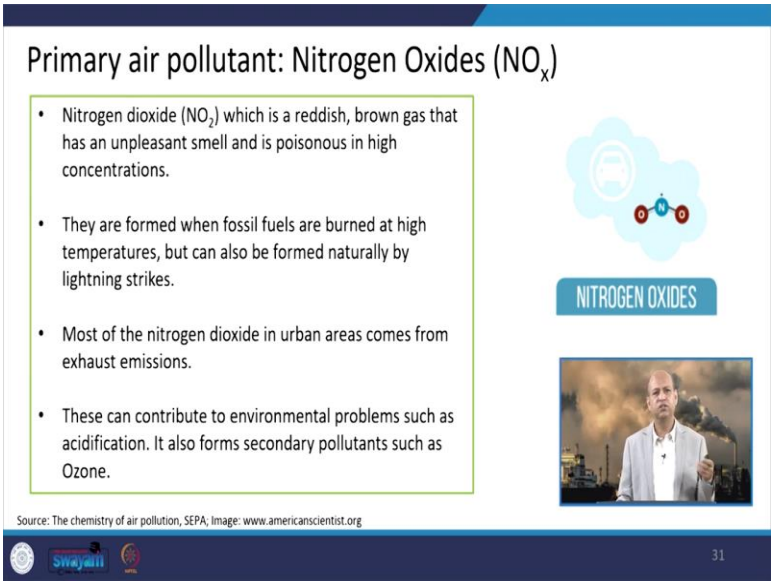

Similarly, NO_X, that is the oxides of nitrogen is there, and which is emitted by fossil fuel burning and that can come from different activities including transportation sector, or power plants or other activities, you can see. And these sulphur dioxide and NO_X emissions they get converted into acid rain kind of thing.

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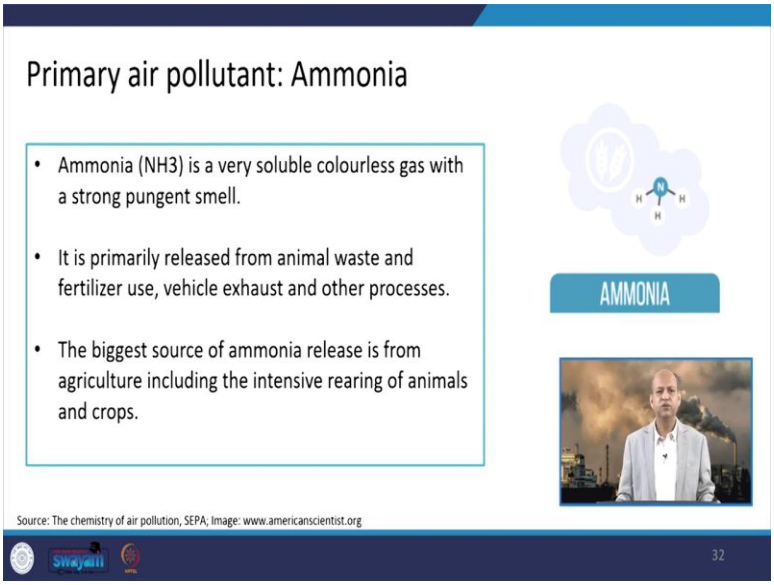

Then there is ammonia. This ammonia is like soluble, colorless gas and it has very strong pungent smell. And it is primarily leached from animal waste, like fertilizers, etc when uses in agriculture, and vehicle exhaust can also produce a certain amount. The biggest source of ammonia, releases from agriculture practices, basically, and from crops from animals and that becomes part of atmosphere.

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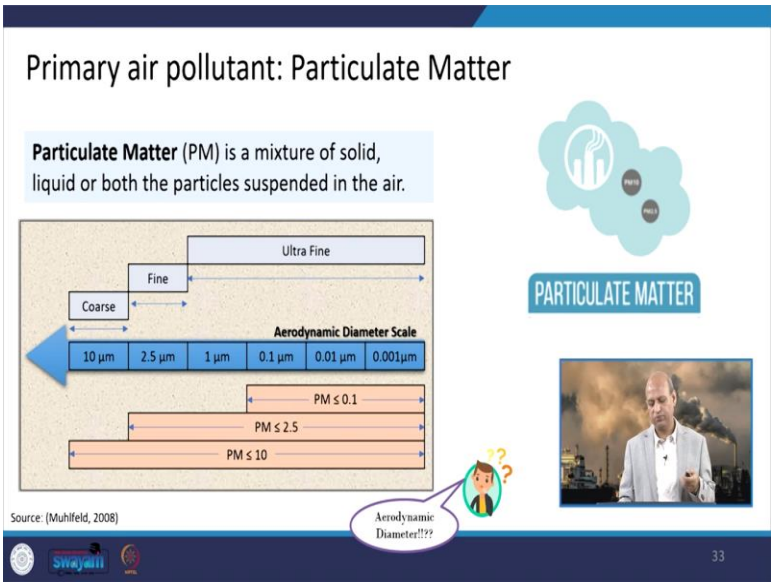

Well, when we see in this particulate matter, which is, this is primary air pollutant, so that can be of different size and shape also. Ultra fine, fine, coarse. So according to the size, like coarser, PM_{10} etc, and $PM_{2.5}$, particulate matter which are equal to or less than 2.5 micrometer, they are fine particles basically. And less than that like, PM_{1}, $PM_{0.1}$, they are ultra fine particles. And now, people talk about nano particles also. Those kinds of research is going on.

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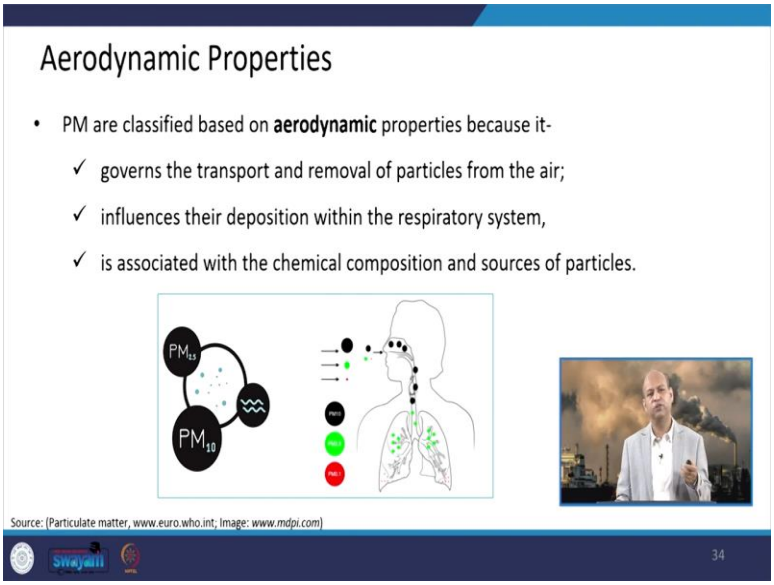

So, aerodynamic properties are particularly matter, they decide which size is very dangerous and which is not much dangerous, depending upon our respiratory system. So you can see here like, particles go inside and depending upon their size, some particles will come out, some particles will get deposited in the lungs and very small ultra fine particles or nano particles, they can even go to the bloodstream.

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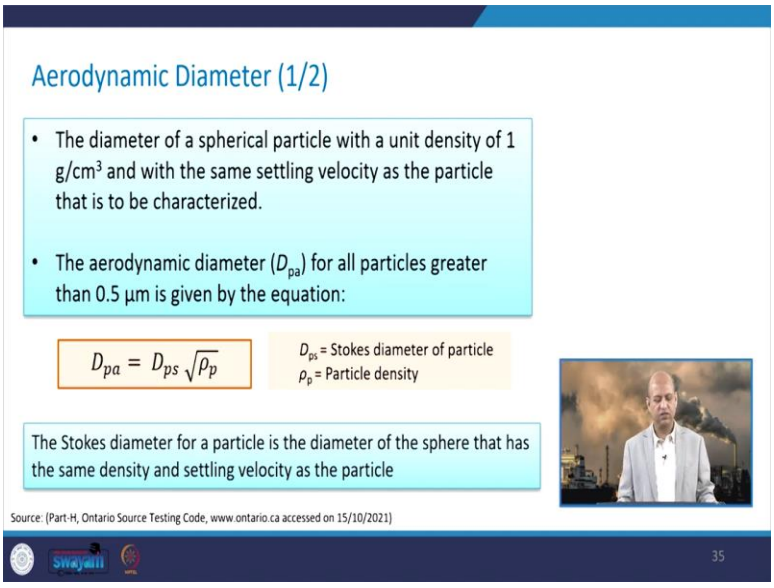

Well, this is the aerodynamic diameter related equation, you can see, which decides a particle's velocity and its impact on human body or respiratory system.

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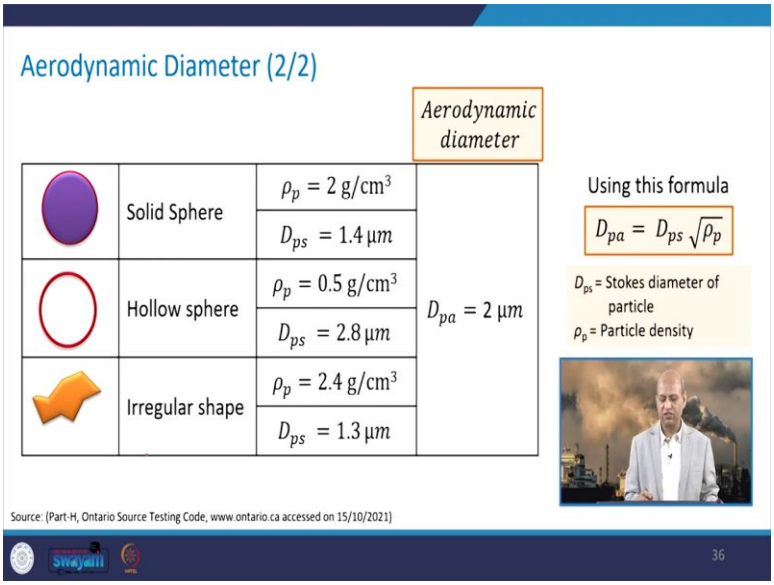

When we talk about these diameters, so different kinds of values are given, solid sphere, hollow spear, irregular shape, so they basically influence the aerodynamic diameter and impact on the, our respiratory system.

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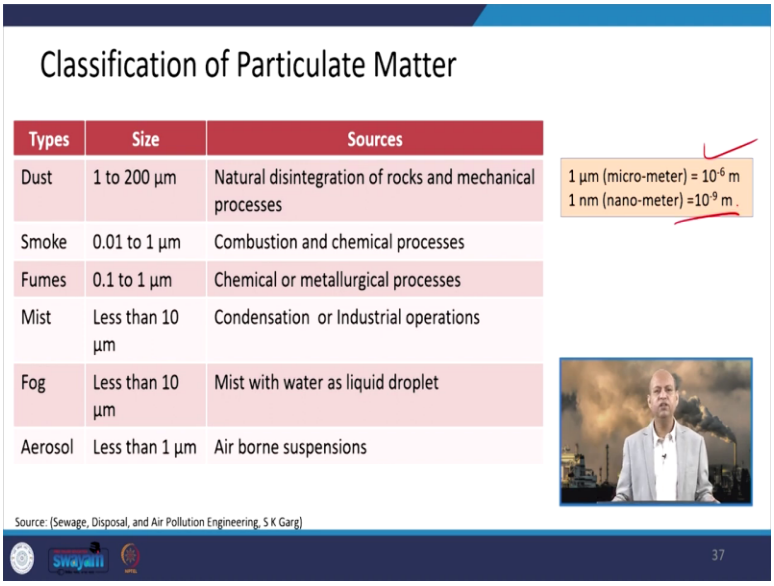

When we talk about like, the size and their sources, like dust, then dust is basically 1 to 200 micrometer size. So it is quite coarser particulate matter, and it will deposited, it will get deposited by gravity very quickly. So natural disintegration of rocks or mechanical processes are there, the sources, and in sand storm, lot of that dust is, or like resuspension of dust because of vehicles also occurs. So these are the particles, basically of that large size.

Then if we talk about smoke, so that has like, fine particles around 0.01 to 1 micrometer. And this, is the basic sources combustion and chemical processes. And chemical or metallurgical processes, they also release some sort of fumes, which are of 0.1 to 1 micrometer size. Then if we talk about the mist, which is because of condensation or industrial operations, which is less than 10 micrometers, so PM_{10}, you can talk about in the mist.

In fog, less than 10 micrometer, basically, the mist with water as liquid droplets. And aerosols can be less than 1 micrometer, which are airborne suspension. So as you can see 1 micrometer is 10^{-6} meter, 1 nanometer 10^{-9} meter. So depending upon the source, different sizes of aerosols or particulate matter come into the air.

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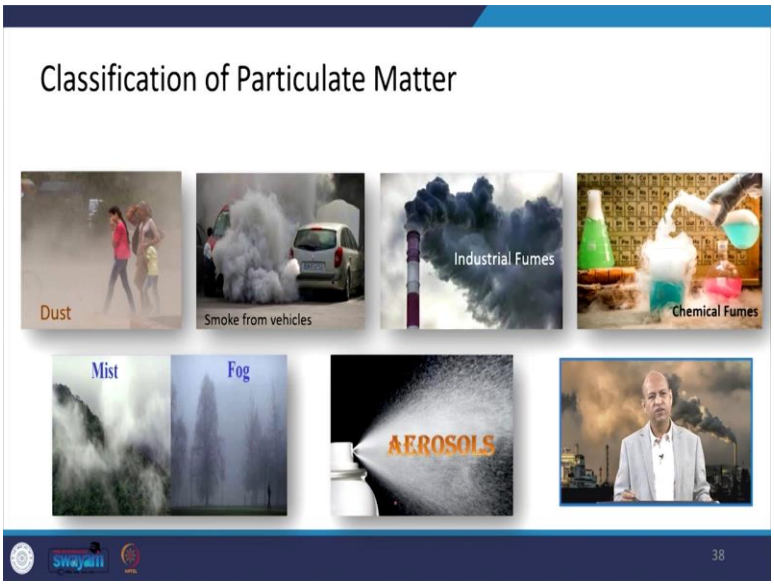

So these are the pictures you can see, you can visualize, like the dust source, resuspension of dust etc, smoke from vehicles exhaust, vehicular exhaust pipes, industrial fumes, and then chemical fumes can also be there because of some reactions. Mist, fog, aerosols there are different sources, you can see here, according to the classification of particulate matter.

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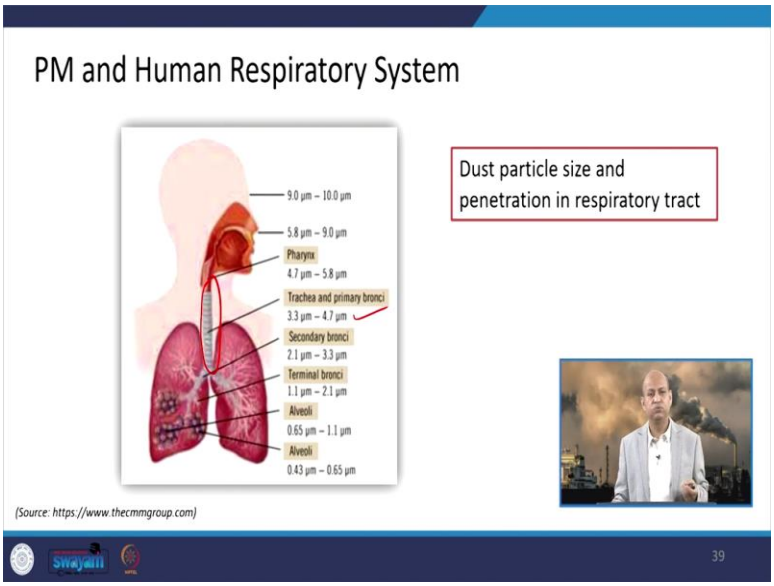

When, we talk about the dust particle size and penetration in respiratory tract. So these very small particles, ultra fine particles can go up to the lungs and even this part of the lungs which are alveoli, where this transaction of exchange of oxygen happens in the lungs and the blood. So that may be affected by those ultra fine particles.

Otherwise, coarser particles get trapped into our nose, which is natural filter system, you can say. And then 3.3 to 4.7 micro, kind of size, this can be part of this, our windpipe. So they can deposited, they can cause some allergy and this windpipe gets swollen and then it becomes uneasy too breathe. So those kinds of things can be there.

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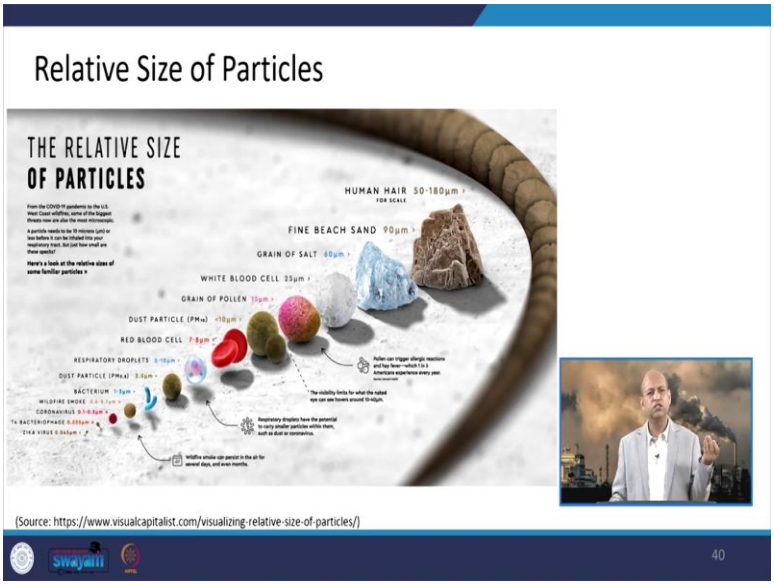

When we try to see what is the relative size of particles, so it is a good picture which can help you to visualize the particle size according to like human hair. So human hair, around 50 to 180 micrometer. So according to that you can see fine beach sand can be around 90 micrometer, of that size. Similarly, you can see other like grains of pollen of 15 micrometer.

So that way you can see there are particles, which we cannot see from naked eyes, so small, and they are hanging around, floating, and suspension, in the suspension in the air, and they becomes part of our respiratory process and affect our health.

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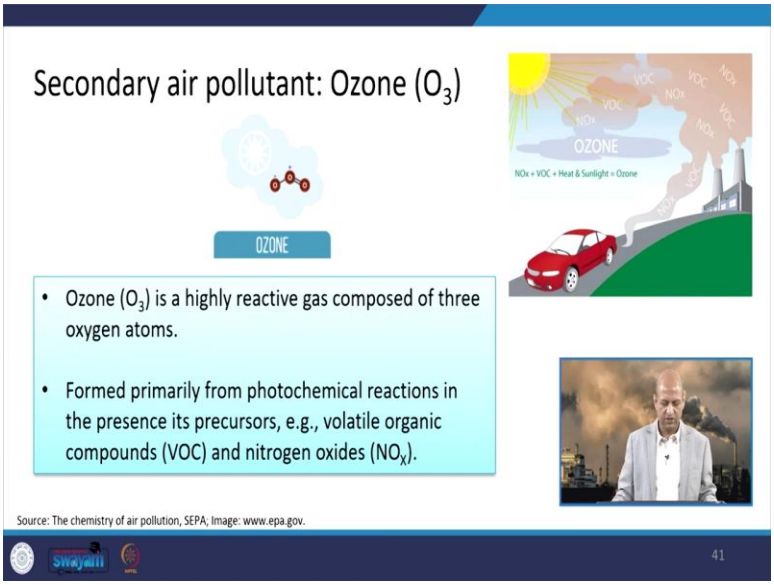

Well, when we talk about secondary air pollutants after the primary air pollutants, then we talk about the major secondary pollutant which is ozone. And ozone, it is very dangerous, it is having multiple negative impacts. Like it is greenhouse gas, which contributes to global warming. In tropospheric ozone, I'm talking about, where it is really problematic for us. But in the stratosphere it is good, because it prevents ultraviolet rays to reach to the planet earth as. So there it is good, but in troposphere, it is very bad.

And then ozone is also very toxic to our body, because it is highly oxidizing agent. So in that way it is highly reactive gas and composed of three oxygen atoms as you know, and it is formed in the photochemical reaction in the presence of sunlight when precursors are there, like volatile organic compounds, VOCs, and nitrogen oxides, those, plus carbon monoxide also. Those are the hydrocarbons, etc. They are the precursors of ozone.

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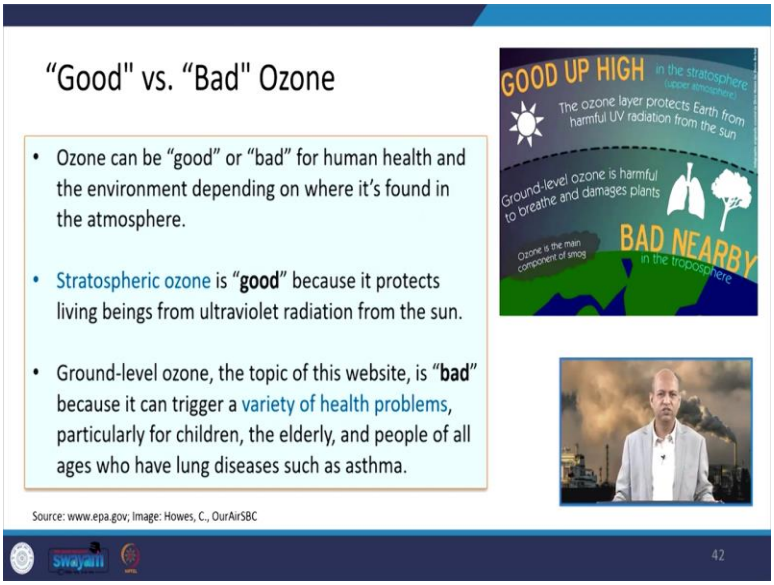

Then if we talk about good and bad ozone, so that is nothing but the stratosphere ozone and troposphere ozone. Troposphere ozone, we call that it is not good because it is harmful in several ways. It damages our property, rubber tires etc.

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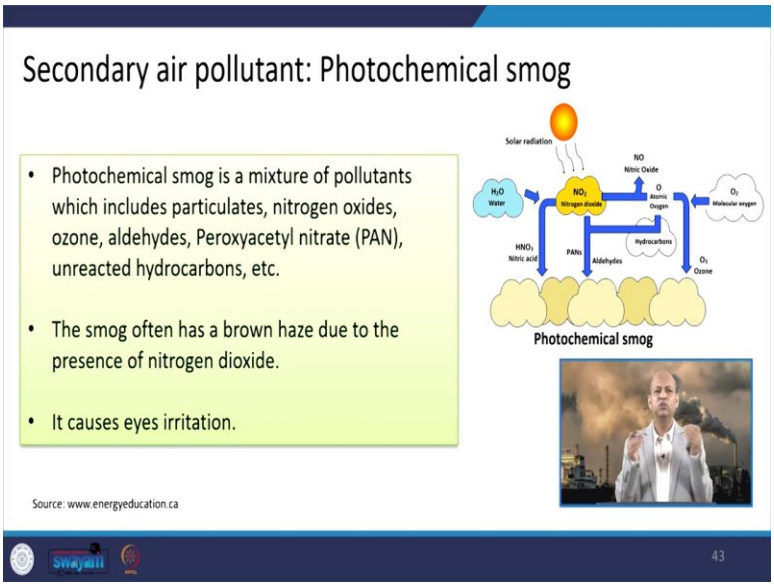

Then if we talk about like photochemical smog, so that is again because of several reactions in the atmosphere. It is composed of particulate matter, oxides of nitrogen,

ozone, several kinds of aldehydes, then peroxyacetyl nitrate (PAN) and then there are unreacted hydrocarbon also. So they, in total create some sort of smog.

And this smog is often in brown, in brownish haze, and it reduces the visibility also, and it can cause eye irritation and those kinds of things, and nitrogen dioxide is also part of that.

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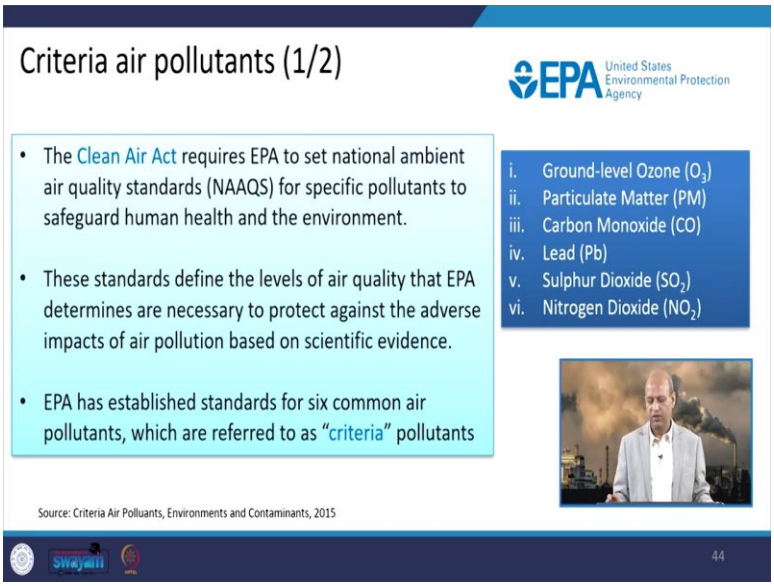

Well, similarly, if we talk about criteria air pollutants, so, those pollutants which are having certain threshold limits, and certain guidelines that concentrations should not exceed from that, below that it is not very problematic. So these are ground level ozone or particulate matter, carbon monoxide, lead, sulphur dioxide, nitrogen dioxide, etc.

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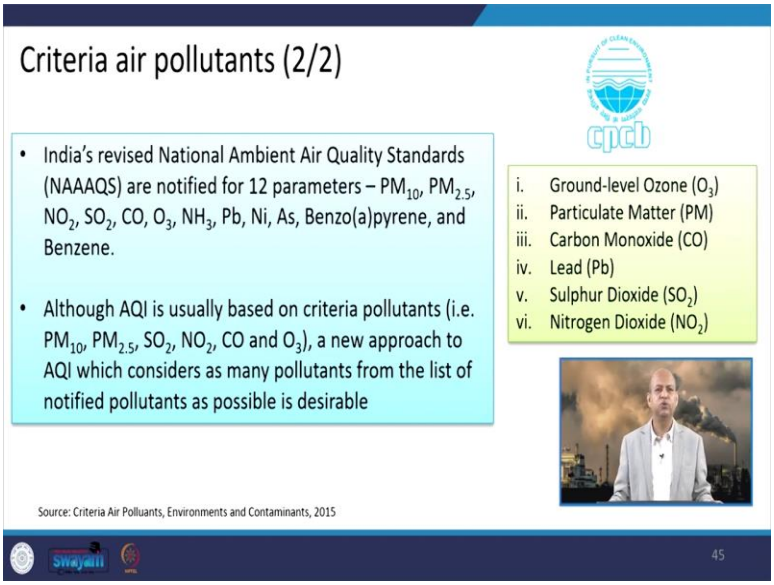

So they are defined in National Ambient Air Quality. I would request you please visit the website of Central Pollution Control Board, and then see the National Ambient Air quality standards. Similarly, you can find for USA at the EPA site. WHO has also provided certain guidelines for certain criteria air pollutants. But for us, like in Indian context, we need to follow these NAAQS, (National Ambient Air Quality Standards) of Ministry of Environment and Forests through CPCB, Central Pollution Control Board.

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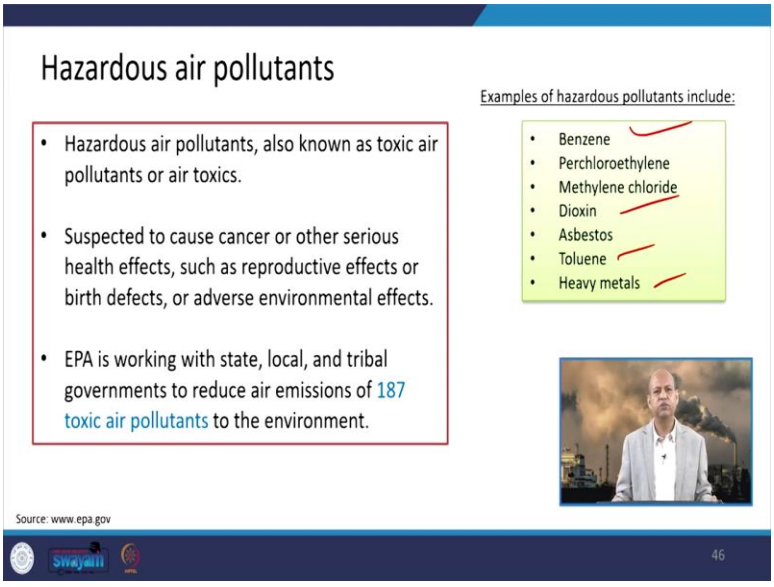

When we talk about hazardous air pollutants, so these are non criteria air pollutants. And even small concentration also very dangerous. Like benzene, dioxin, toluene, heavy metals all these are very toxic and a small concentration can also disrupt our system. Some are carcinogenic, which can trigger the cancer into the body.

So we should be aware about the exposure to these hazardous pollutants and we should try that they are not emitted in our surrounding and they are captured properly and they are not part of the ambient air or indoor environment also.

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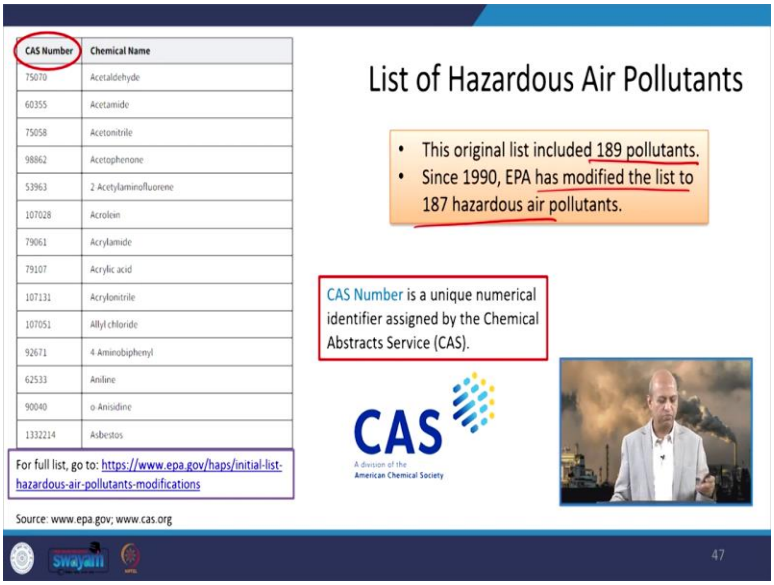

So these are around, 189 pollutants are listed by EPA. In 1990 modified List of 187 hazardous air pollutants are there. So CAS number is a unique numerical identifier, which is assigned by Chemical Abstracts Service. So that way you can find their names and their number. And when we click that number we can get the detailed information about that particular pollutant.

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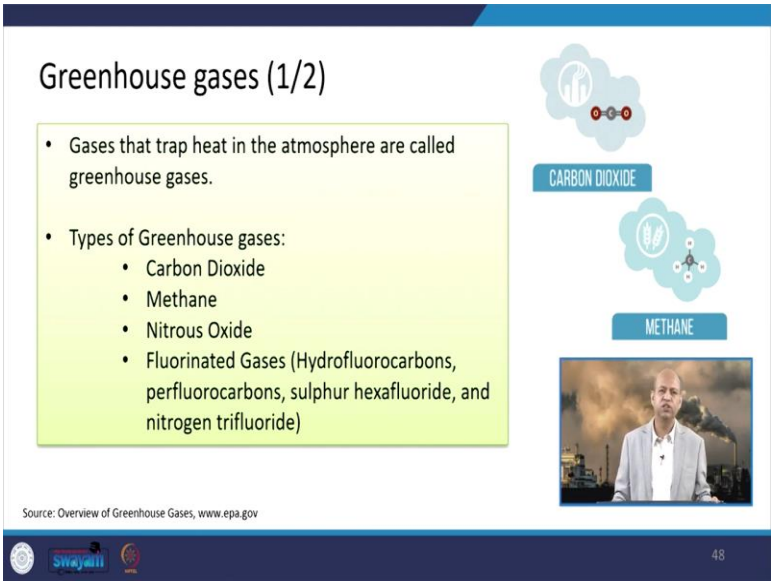

Then we talk about greenhouse gases. So as I said like, CO_2 is not a problematic. It is not strictly air pollutant, but when we talk about other like methane, nitrous oxide or these ozone etc, they are problematic. They are also air pollutants. So when we are controlling air pollutants, so it is easy to list them as a part of air pollutants so that we can control their emissions also.

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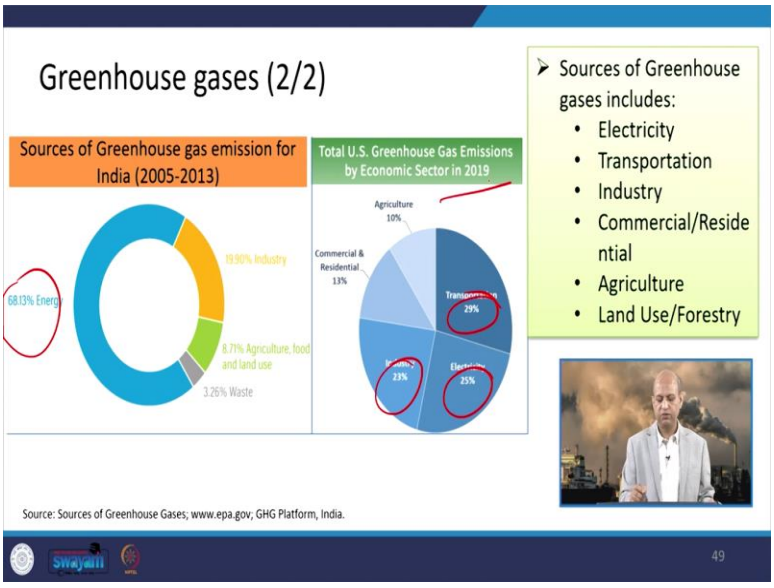

So if you see greenhouse gas emissions, around 68 percent in India, the greenhouse gas emissions are coming from energy sources. So energy sources, basically, like thermal power plants etc. In the U.S., if you see like industry 23 percent, electricity generation 25 percent, transportation 29 percent, and commercial residential they release around 13 percent of greenhouse gases as per 2019 data.

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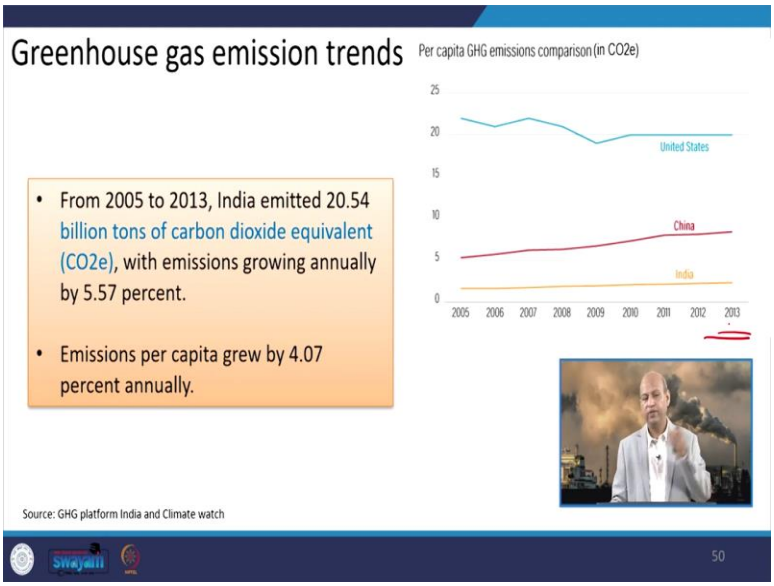

And then if we see the trends, greenhouse gas emissions trends from 2005 to 2013 in Indian context, so you can see it is not very sharp rise like China, but it is still increasing trend, but it is up to 2013 data. Now, government is giving a lot of incentives for going for solar energy, renewable sources of energy, etc. So that way, and this decarbonization policy for transport sector. So in future I hope air pollution emissions as well as greenhouse gases emissions will be reduced in India significantly.

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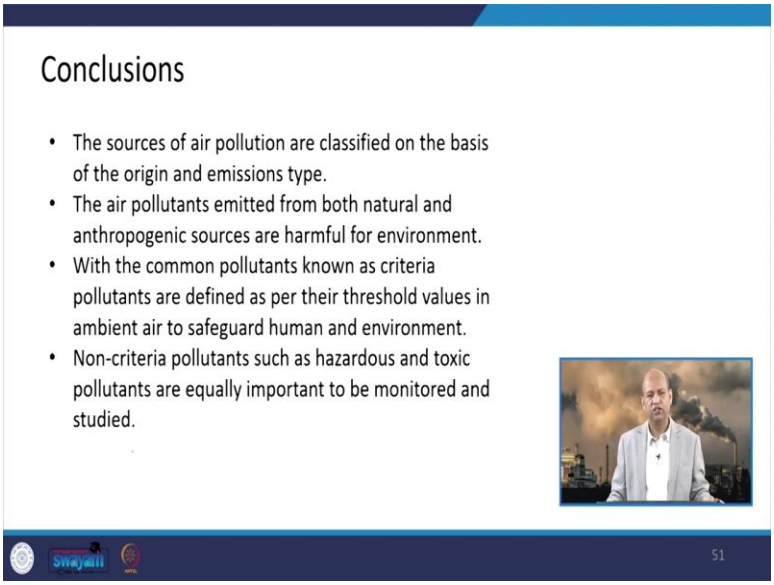

Well, so in conclusion, we can say that the sources of air pollutions can be classified on the basis of their origin or types of emissions, natural, manmade and indoor, outdoor etc. And those air pollutants can be categorized in different way like criteria or non criteria pollutants, hazardous pollutants,

And for air quality management, we should know basically, what are different kinds of sources and what is the difference between different types of pollutants, whether it is primary, secondary, so that we become more aware, which kind of pollutants is responsible for deteriorating our air quality. So particular that pollutant, we should first target, so that we can have better air quality.

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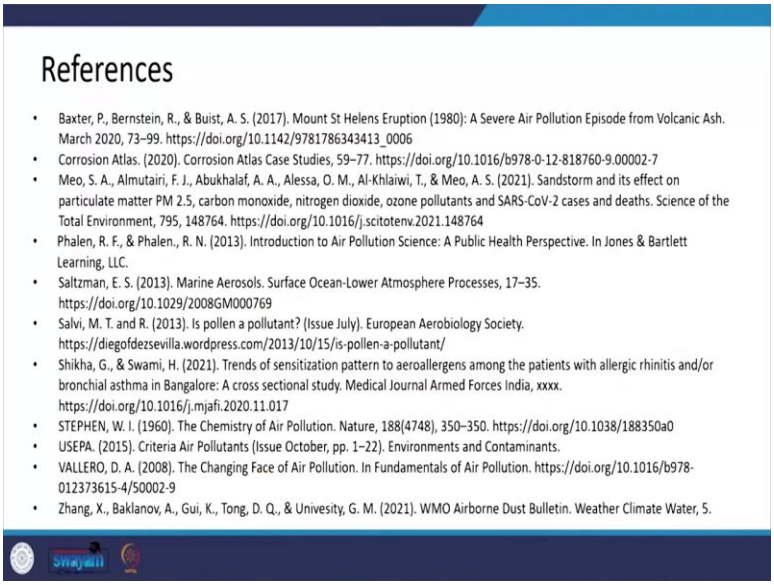

So this is all for today. Thank you for your kind attention. And you can go through these references for additional information. And see you again in the next lecture. Thank you.