Air Pollution and Control
Professor Bhola Ram Gurjar
Department of Civil Engineering
Indian Institute of Technology, Roorkee
Lecture – 02
Introduction to Air Pollution- 2

Hello friends, welcome back. So, today is the second lecture on Introduction to Air Pollution. In first lecture, we discussed about kind of history of air pollution, how it was evolved and what are the major sources, then pre-industrial era, postindustrial era and then its negative impacts all those things we discussed. So, today we will continue and we will see how this Earth's atmosphere really participate in dispersion of air pollution, what is their significance. Then, what is basically, unpolluted air in the atmosphere, how do we come in comparing the polluted and unpolluted air.

Then different scales of the air pollution, local, regional, continental those kind of things we will discuss today and different types of the pollutants we will see and the role of atmosphere in source and sink relationship, source and then where it is sinking or absorbed that kind of thing and then we will conclude.

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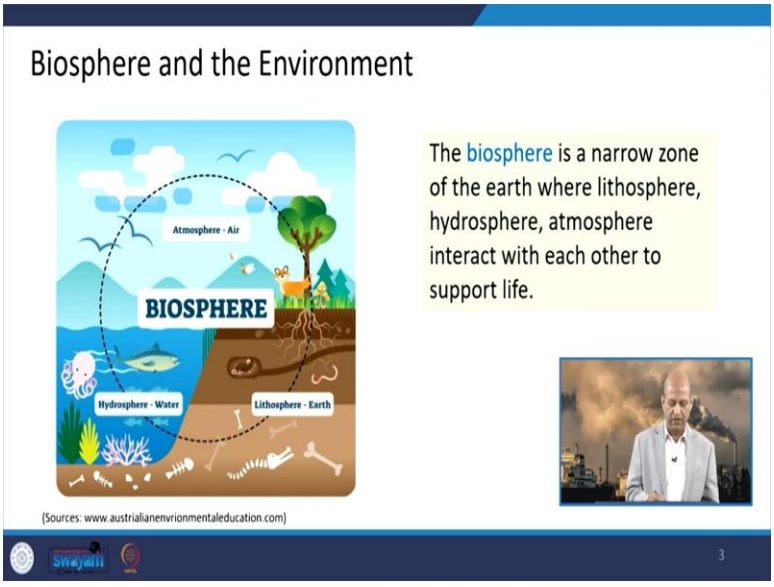

So, when we talk about the, this biosphere and the environment so, basically the biosphere is nothing, but a narrow zone of the Earth, where this lithosphere, hydrosphere and atmosphere

they interact with each other to support the life. So, you can see the biosphere is combination of these three lithosphere like this earth crust etc., and the hydrosphere, sea and the water cycle atmosphere related to air. So, all these three in combine or collectively they support the life. So, this is known as the biosphere.

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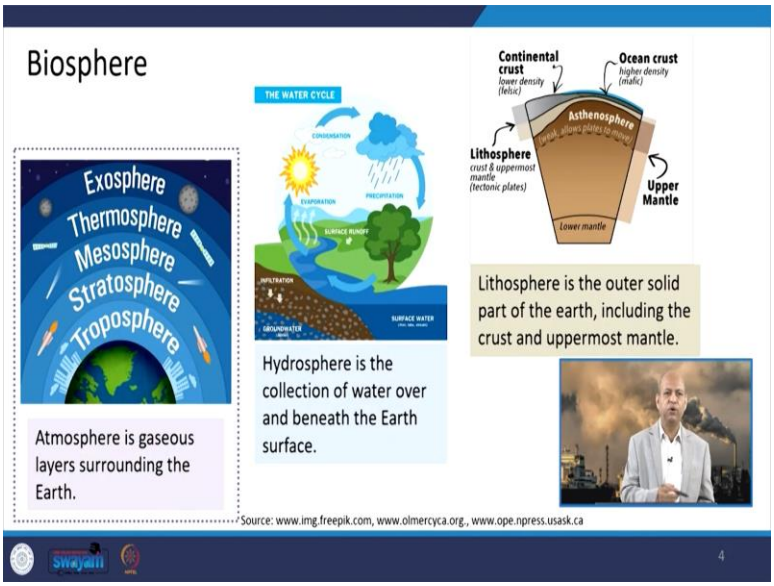

When we talk about different components of the biosphere like atmosphere. So, this is basically the gaseous layers and it can be divided into different layers like troposphere, the lowest layer near the earth planet, then the stratosphere, then mesosphere, thermosphere, exosphere and those kinds of things. When we talk about the hydrosphere, then it is the collection of water over and beneath the earth's surface.

So basically, aquifers etc., are the part of this hydrosphere and the sea, river or lakes etc. When we talk about lithosphere so, this is nothing but the outer solid part of the Earth, including the crust and uppermost mantle. So, you can see this particular layer which is known as the lithosphere. So, they really support the life because of their wonderful integration with each other.

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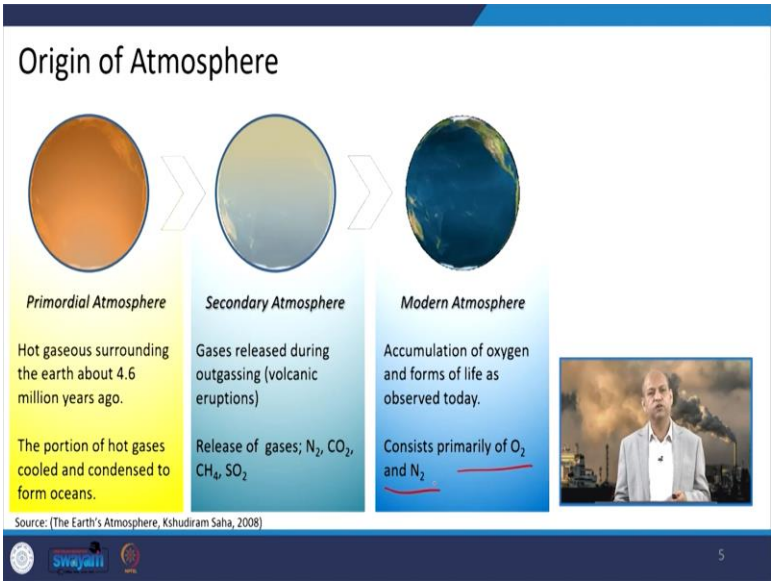

When we talk about how this atmosphere came into existence, so, the scientific theory is like the hot gases surrounding the earth about 4.6 million years ago, this was completely, the sphere of the gas you can say and the portion of hot gas is cooled and condensed to form the oceans. And then, the secondary atmosphere evolved. So, gases released during like outgassing or volcanic eruptions, so the release of like nitrogen, CO_2, methane and sulfur dioxide, those kinds of gases got released in the secondary atmosphere.

Then the modern atmosphere which we know today, like the constituents of the nitrogen, oxygen etcetera. So, that is basically the accumulation of oxygen and the forms of life as observed today. Otherwise, initially scientists say that the total environment was anaerobic kind of and anaerobic means, because oxygen was not present at the initial stage, the anaerobic conditions were there. But later on the aerobic condition occurred oxygen came into existence, and then this primarily oxygen and nitrogen is the part of modern atmosphere that is the atmosphere which is supporting our life, which is the aerobic life you can say, oxygen based life.

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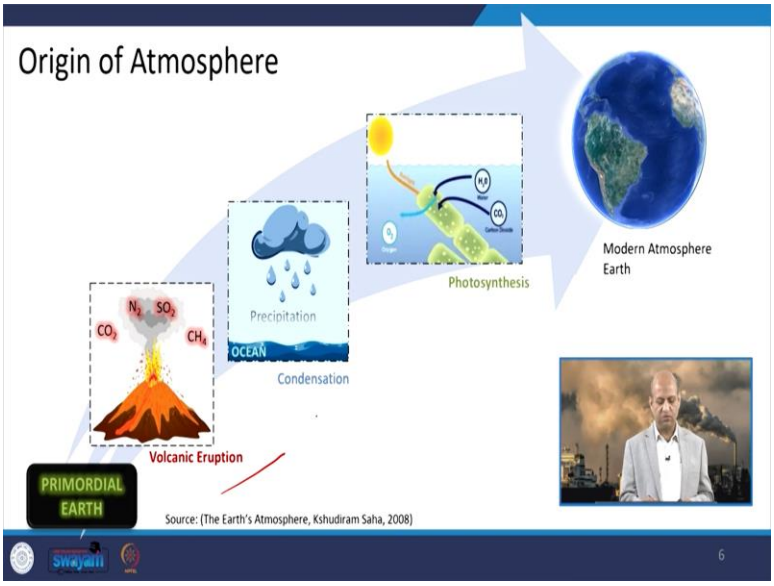

So, you can see with these stages, so this is primordial Earth and then volcanic eruptions, CO_2 Nitrogen those kind of thing. Then precipitation condensation and then photosynthesis so, this H_2O, CO_2, O_2 all these things for life started to come into existence. So, CO_2 absorption and CO_2 was used and then the release of oxygen and CO_2 came into balance and this modern atmosphere was formed in that way.

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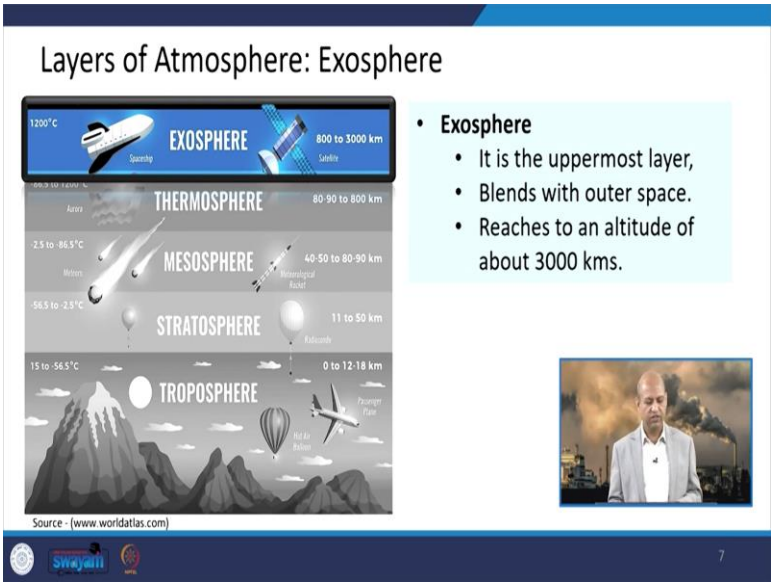

When we talk about different layers of the atmosphere. So basically, like the upper most layer is the exosphere and that is it blends the outer space you can say and it reaches to an altitude of around 3000 kilometers. So, that is like spaceships cross that particular height otherwise, for us as an environmental engineer or when we talk about life, so, we talk about only the lowest layer that is the troposphere.

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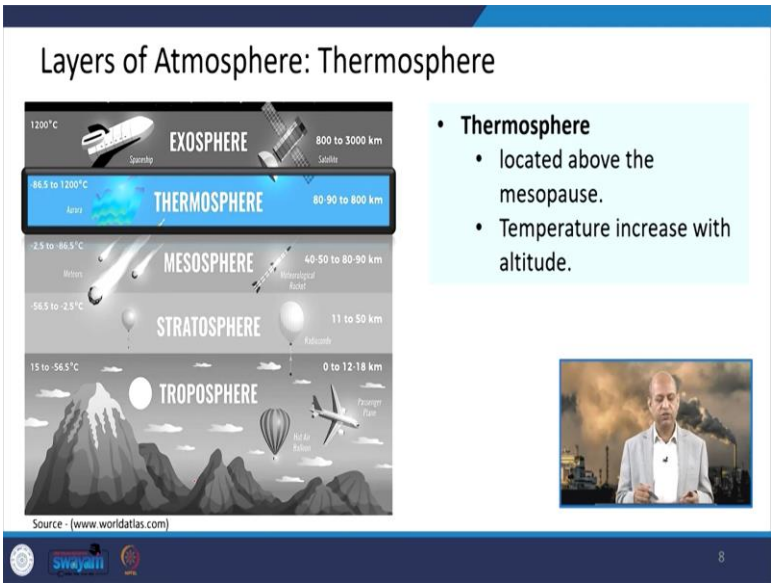

When we talk about the second highest layer that is Thermosphere which is located around 80, 90 to 800 Kilometer. And the temperature increases in this particular layer from minus 86.5 to 1200 degrees Celsius that is very huge increase of the temperature is there at that altitude.

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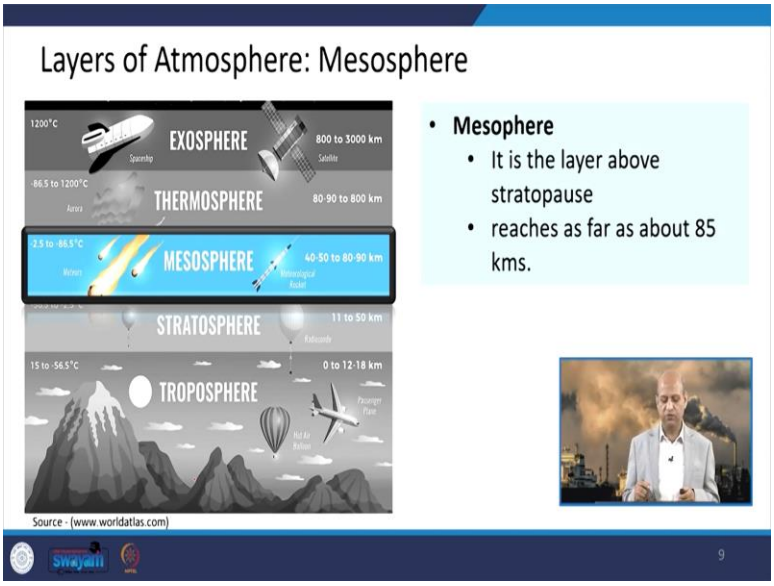

Mesophere it is the midway of the layer and this is around 40-50 to 80-90 kilometers around 85 kilometers you can say up to that. And the temperature is around minus 2.5 to minus 86.6 degrees Celsius so, temperature decreases in that way.

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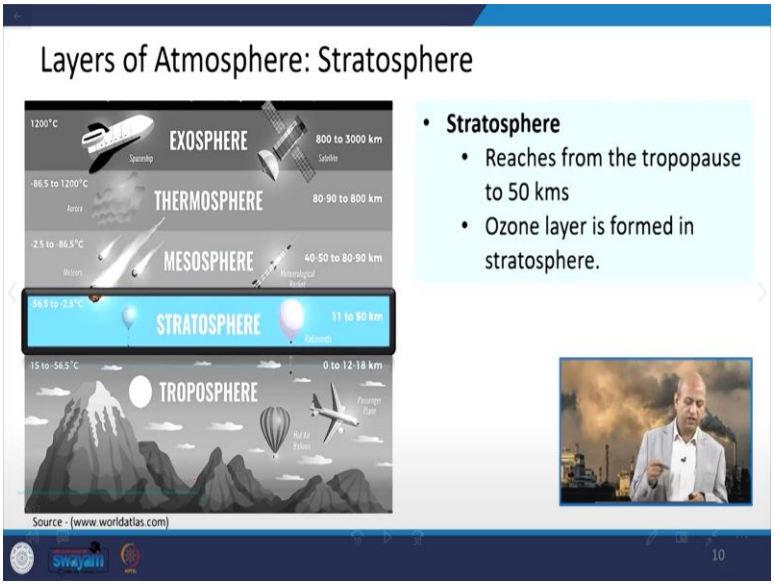

In the stratosphere temperature increases from minus 56.5 to minus 2.5 degree Celsius and the height is 11 to 50 Kilometer that kind of thing.

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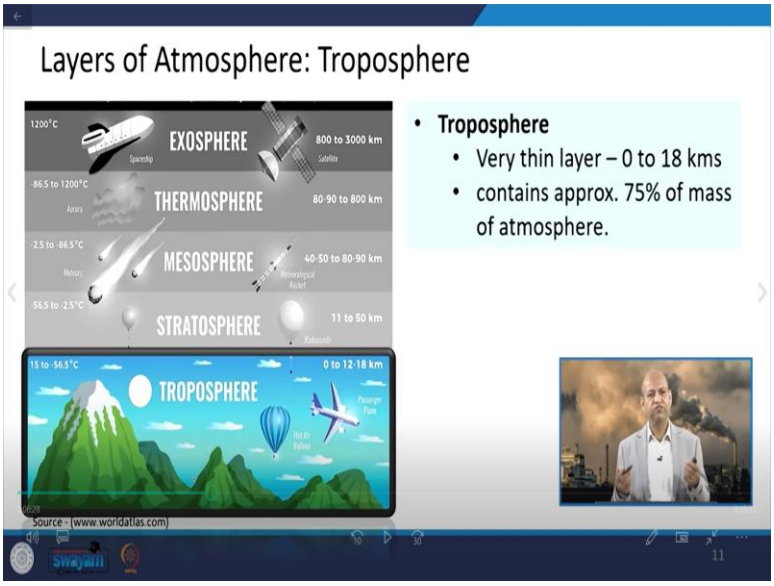

And the lowest the layer is the troposphere, where life is the air and where we really interact with the atmosphere through whether aircrafts or our all activities happen in this troposphere and that is around 12 to 18 Kilometer height up to from surface and all these activities happen. So, that is why we environmental engineers mostly relate ourselves to the troposphere and we concentrate only to this particular layer.

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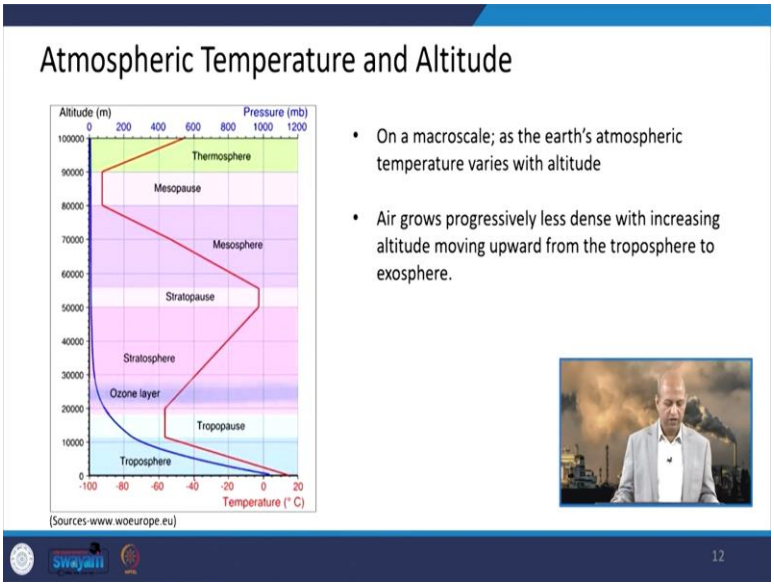

When we talk about, temperature and the pressure with respect to the altitude. So the temperature decreases with the height in troposphere, and then for certain height it remains constant and then

in stratosphere it increases again and then it decreases in the mesosphere and thermosphere it increases again. So, that kind of linear decrease or increase of the temperature occurs in different layers.

And there are reasons you should try to find out what are the reasons, why the temperature is decreasing in the troposphere with respect to the height. Why it is increasing with respect to height in the stratosphere, then again decreasing all these there are, interesting reasons, I request you to go through those reasons, we will discuss those later on also. Well, when we talk about no pressure, then pressure decreases exponentially, you can see its way of decrease.

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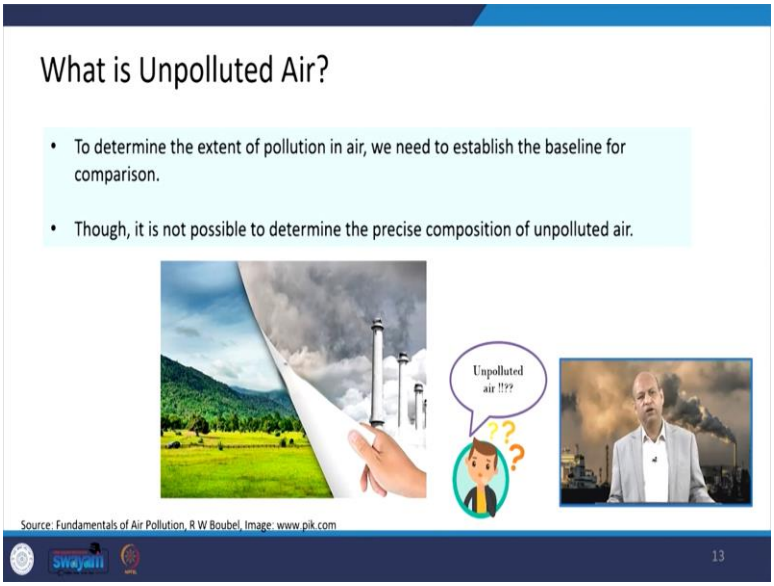

So, when we talk about air pollution, so naturally we also think about what is the unpolluted air. Because when we are talking about polluted air, that means, there is also air which is unpolluted. But basically, it is very almost impossible to find the unpolluted air because, when the atmosphere was not filled with so many gases or pollutants in primitive ages, which was the atmosphere which was clean atmosphere, even then human beings started to use the fire and forest fires were also their natural emissions were there from volcanoes.

So, you cannot say that we cannot get unpolluted air, there are some sort of pollutants or contamination is there in every atmosphere only we can differentiate that those remote places they are the background atmosphere, which can be seen as baseline data or unpolluted air. Otherwise, we cannot find in reality absolutely unpolluted air.

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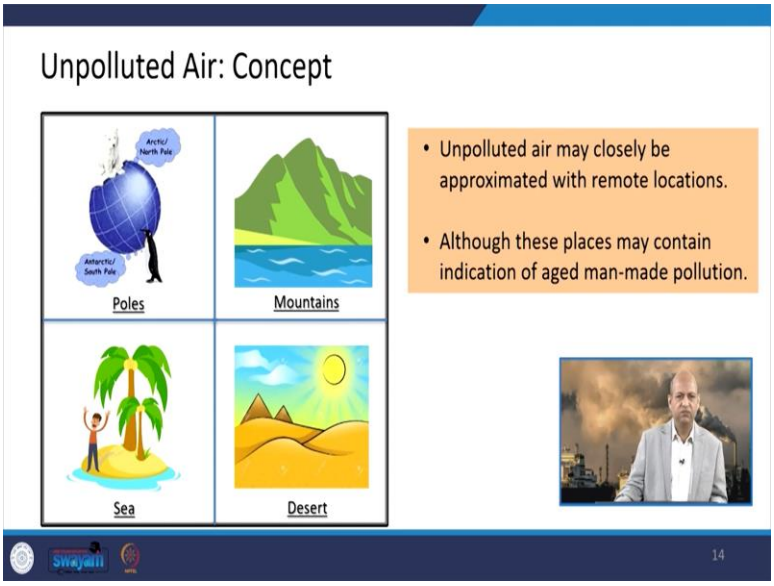

So, the poles are mountains, sea desert all these, localities or topographies we imagine that these are unpolluted air, but as a fact of matter pollution is there also. Because of this global circulation of air, one pollutant source can contribute to air quality of other parts also, because pollutants can travel thousands of kilometer. Even at poles people have found some pollutants, the source of which cannot exist at that location.

So, they are manmade pollutants, because of emissions from the ships or emissions from industries and then because of this convection pollutants go up to stratosphere. Then that travel at the upper layers of the troposphere, they go thousands of kilometers in the downwind direction then they get deposited. So, this is the common phenomena.

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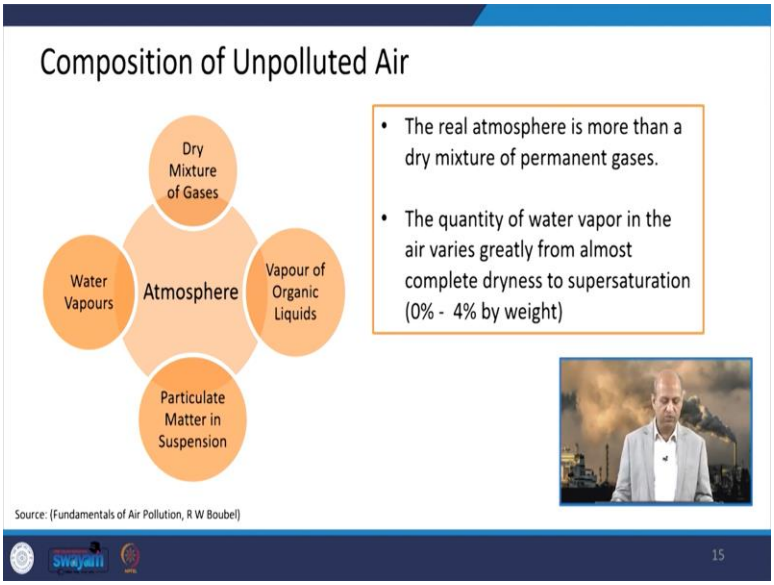

When we talk about this composition of unpolluted air so, basically you can see these water vapors or some particulate matter suspension maybe they are all those kinds of things. So, they are the part of that composition of so called unpolluted air.

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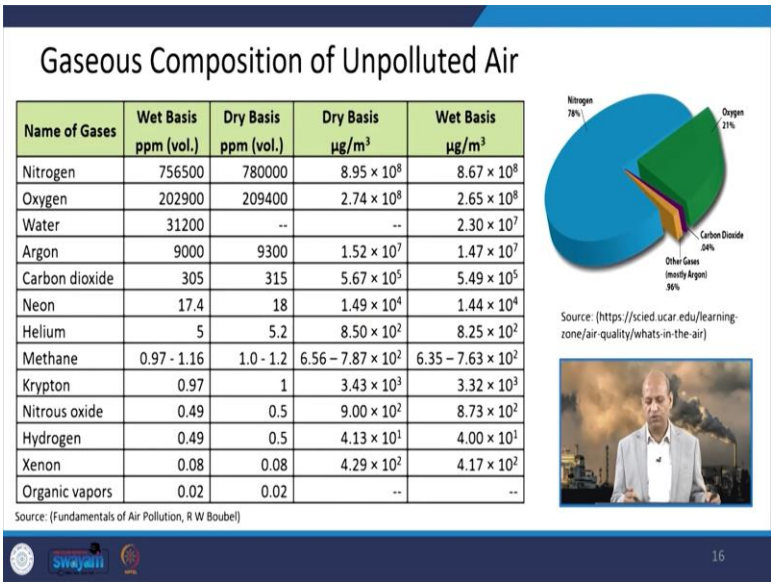

Otherwise, the gaseous composition as you already know that around 78 percent nitrogen is there in the atmosphere, 21 percent oxygen and very small quantity of carbon dioxide, argon and other gases are there. But still the carbon dioxide is very less in quantity, but this is the greenhouse gas

and climate change related phenomena associated with this very tiny gas composition of the atmosphere.

So that is to be kept in mind that if something is very small in quantity even then that can create big problem. We will study like how CFCs that were imagined like Wonder chemicals, but that were responsible later on for ozone layer destruction. So, these kinds of things happen and the science gives us the answers the real answers.

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Well, then what is the polluted air. So polluted air is basically that whatever the natural atmosphere is polluted by unwanted air pollutants or contaminants in huge quantity which is unbearable to our system, then that is the polluted air or which is exceeding the permitted quantity of concentration of those pollutants.

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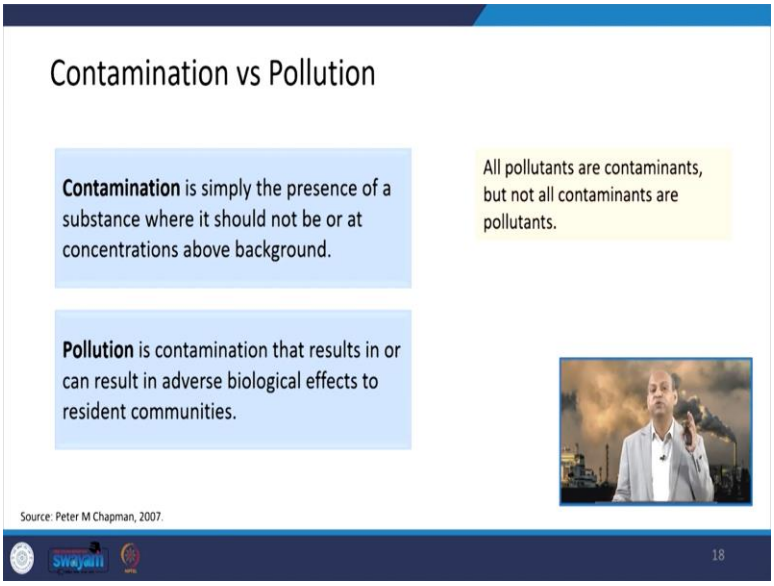

And then, people talk that contamination and versus pollution is different, some people say that it is one and same thing. Some people say no, no, no, this is different thing like contamination, it is simply the presence of a substance where it should not be there.

And that concentrations which does not harm you, it is bearable in our system, because there is a range of tolerance in our system. Then the pollution is contamination that results in or can result in adverse biological effects to the residents communities, whether aquatic life, whether planetary life or whosoever, ecosystem etc. So, those negative impacts or harmful impacts if it can cause then we say that it is pollution otherwise, it is the contamination simply.

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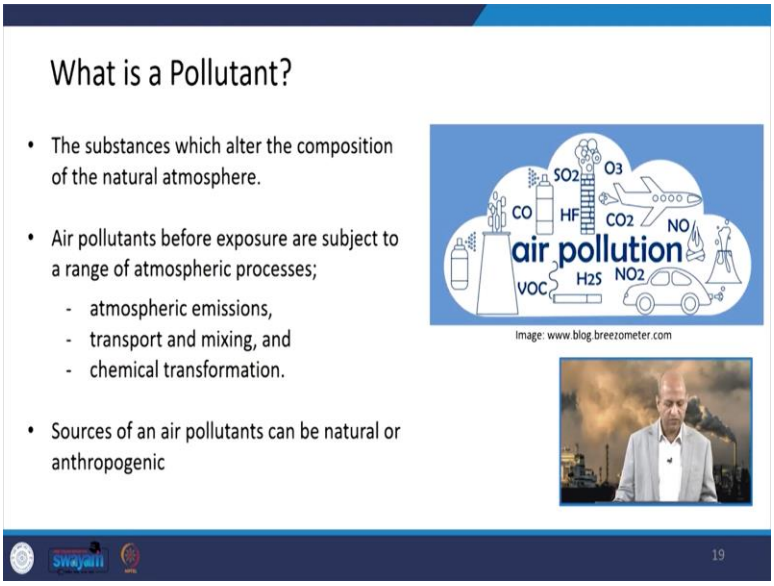

So, the pollutants basically they come from atmospheric emissions or they get transported and they get mixed, and then a chemical transformation also occurs when the pollutants transport from one place to another. So, basically those substances and compositions compounds interaction of different constituents of the atmosphere with chemical emissions or those chemicals or compounds. So, those are the basically the pollutants.

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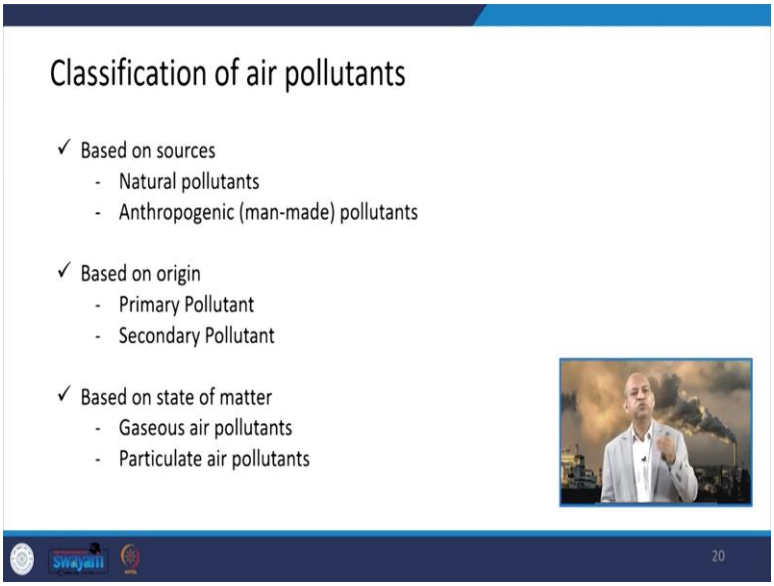

When we classify the air pollutants, then we can classify in different ways like based on the sources we can say the natural pollutants like due to forest fire or even plants emit many kind of

air pollutants like VOCs volatile organic compounds. Whenever you are having some smell that is basically, some chemical that may be a pollutant many people are allergic to some sort of smells or those VOCs which are emitted from the plants.

And then anthropogenic or manmade pollutants, maybe they are because of our human made activities like factories or domestic activities, power plants, transportation sector, all those. Based on origin we can also call like primary pollutants or secondary pollutants. So, the primary pollutants are those pollutants which are directly emitted, like CO_2, greenhouse gas that is basically or SO_2 or particulate matter PM_{10} etc. But secondary pollutants, which are formed by primary pollutants by interacting with themselves or by interacting with the constituents of the atmosphere like ozone, ozone is not emitted directly by any source, it is not a primary pollutant it is secondary pollutant.

So, there are many secondary pollutants basically, even phase transformation occurs like SO_2 can get converted into SO_4 and then it reacts with the particles calcium magnesium, it can get converted into magnesium sulphate, calcium sulphate. So, the from the gas it can be converted into particles. So, phase transformation can also occur. So, those kinds of small particles are secondary particles, they are not primary particles. Then when we talk about state of the matter, so the gaseous air pollutants or particulate air pollutants.

So, that way also even this liquid those droplets are also like mixed and in the fog, they are also pollutants. So, the pollutants can be of nature, like aerosols, or parasols, parasols means particles plus aerosols. So, the new terminology is there parasols. Similarly, smog is smoke plus fog so, that is known as the smog and visibility decreases in the smog.

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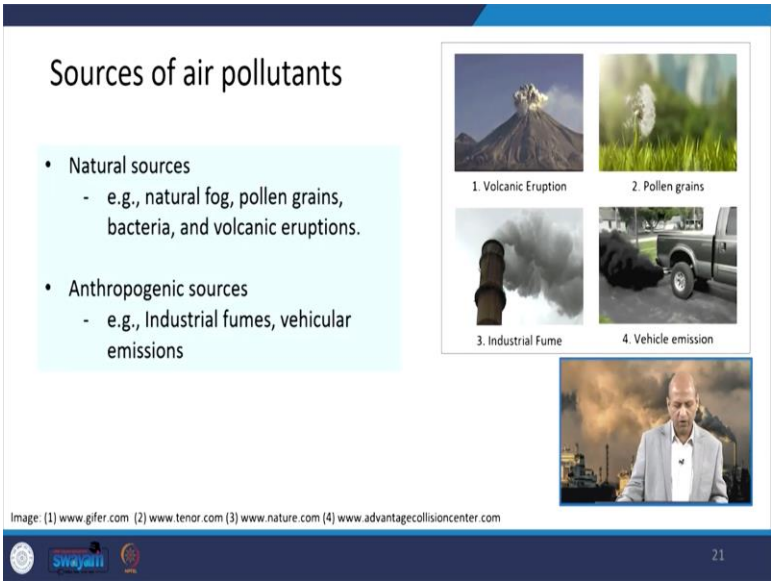

Well when we talk about sources of air pollutants so they can be natural sources as I said, it can be due to volcanic eruptions, it can be due to forest fires or pollens from plants etc, bacteria may be there from debris or those kinds of things. And it can be anthropogenic, like industrial fumes or vehicular emissions. So, mean sources can be natural as well as anthropogenic I would say. So, that means it is not true that only human beings add to the pollutants even nature adds to the pollutants.

So, please do not get confused that forests are completely clean even forest add to the pollutants, many VOCs volatile organic compounds are emitted by forest and in even in forest you can find some sort of a smog because of those VOCs because VOCs get converted into ozone and these ozone VOCs etc. The mixture of pollutant particulate matter etc, they become a kind of smog. So, natural smog may also be there.

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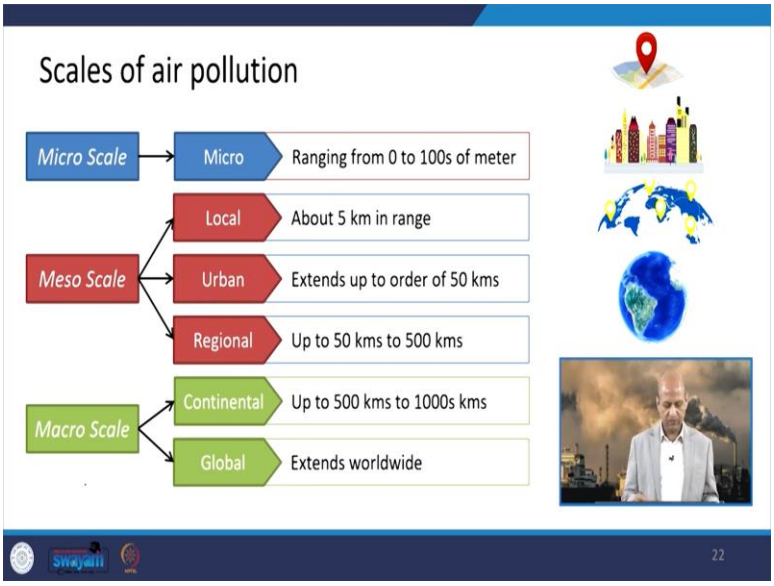

So, when we talk about scales of air pollution, scales can be like micro scale, meso scale or macro scale. In micro scale basically, like indoor environment or in a vicinity of our existence. Then in meso scale like local, urban, regional, about 5 kilometers in the local urban like up to 50 Kilometer even like Delhi's pollution can be urban pollution, you can say. Regional it can be up to 50 To 500 kilometer. When we talk about macro scale, so, the continental or global scale, they are the part of macro scale.

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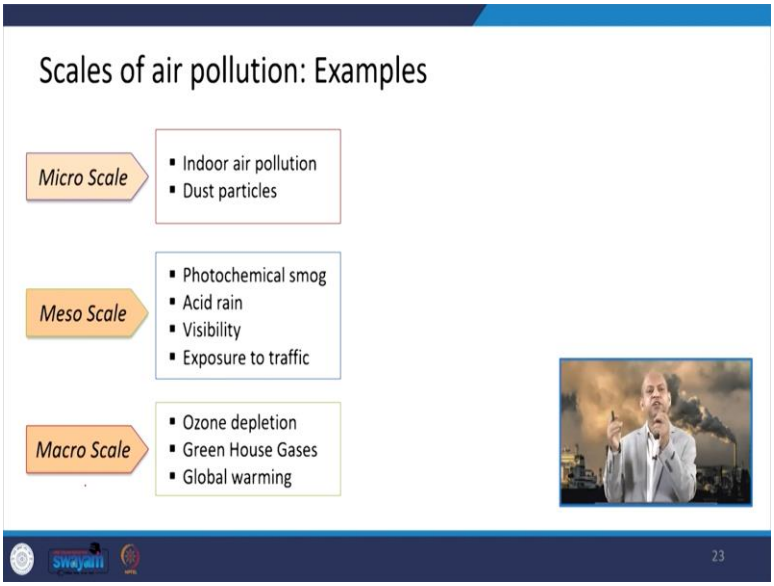

So, the micro scale as I said indoor air pollution or the dust particles otherwise, they do not travel. Dust particles these SPM suspended particulate matters, which are higher in diameter, large size diameters and more mass they settles down quickly. So that they do not travel they cannot be part of longer scales so they are part of the micro scale.

But in meso scale photochemical smog is there, acid rain related, visibility related phenomena or exposure to traffic emissions, those kind of there so, that is part of the meso scale. In macro scale like ozone depletion, greenhouse gas emissions or global warming phenomena, they are the part of macroscale related pollution problems.

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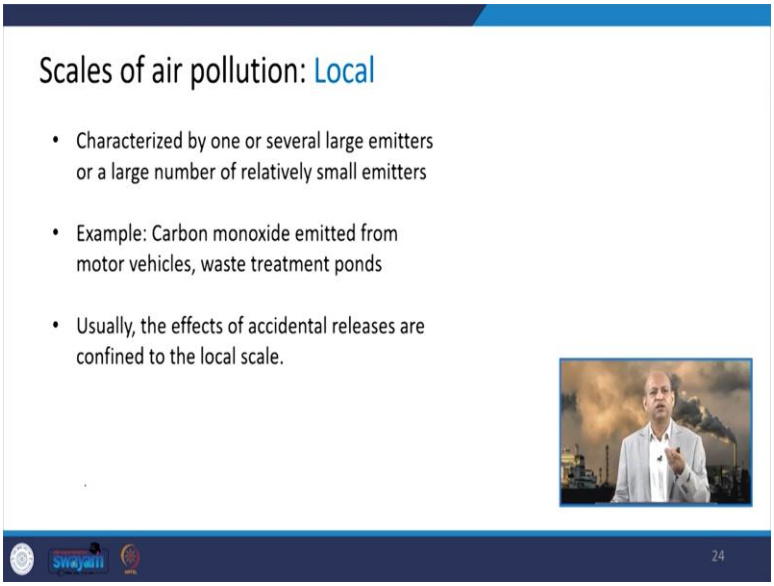

So, when we talk about the local phenomena, then it is characterized by one or several large emitters or a large number of relatively small emitters though in a collective way they can contribute to the local air pollution problem. And the examples are because of like carbon monoxide emitted from a motor vehicle and carbon monoxide can get converted into CO_2.

So, for like in regional related problem, it may not be a big part in that sense. The waste treatment ponds they also emit those pollutants that become the local phenomena of pollution. So, they affects the accidental release with confined to the local scale. So, those are the part of local scale air pollution problem.

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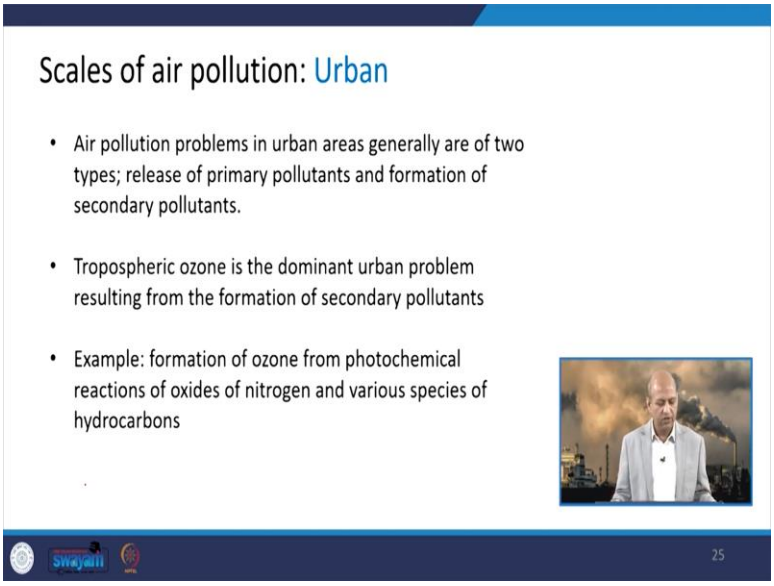

When we talk about urban scale air pollution. So, basically these are two types like primary pollutants and then the formation of secondary pollutant that become part of the urban air pollution. And that tropospheric ozone is the dominated urban problem, because of those precursors of ozone are present there, precursors are those pollutants, which participate into producing of ozone that chemical reaction, photochemical reaction.

And formation of secondary pollutants also occur, examples are photochemical reactions of oxides of nitrogen and hydrocarbons they convert into ozone. So, that is the example of urban scale problem.

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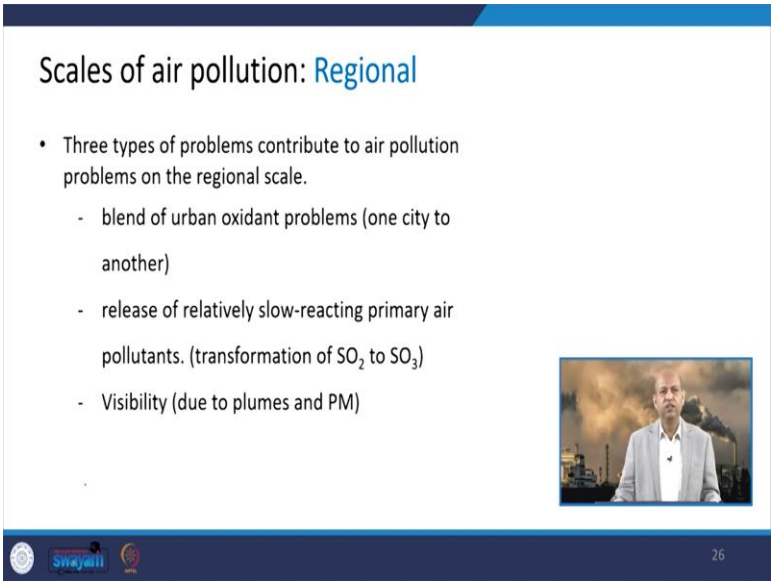

Then when we talk about the regional scale problem, then this urban oxidants and then the release of other primary air pollutants like SO_2 they get converted into SO_3. And then visibility get reduced so those are the regional scale air pollution problems.

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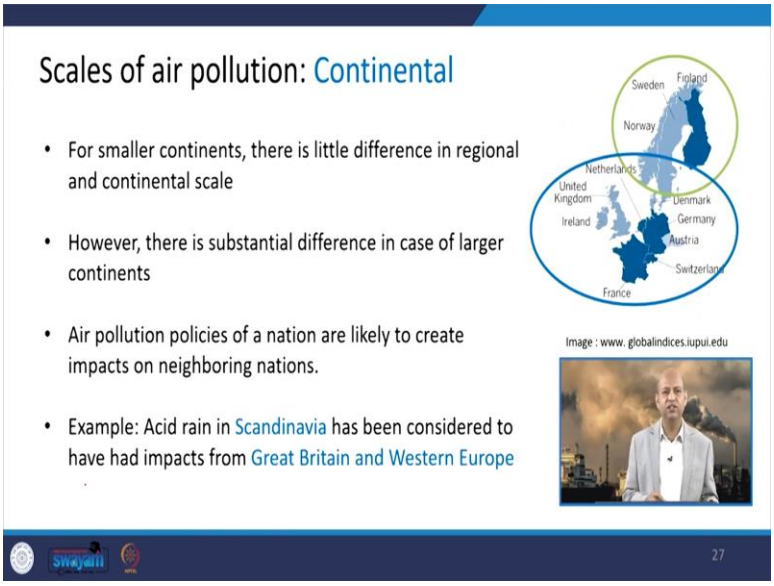

When we talk about the continental then the pollution problems are related like acid rain. So, in Germany Black Forest was very much damaged by acid rain and the scientists researchers found that the source of those pollutants were from Great Britain. So, then this international treaties are signed and those power plants were tackled with cleaner fuel or technological solutions were

provided and later on this Black Forest was revived. So, those kinds of acid rain is part of regional scale problem or even continental scale problem.

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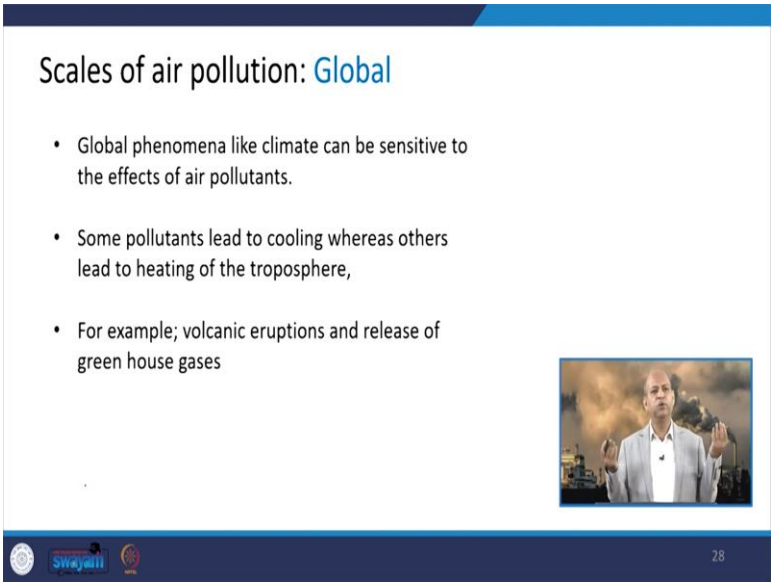

Global scale problem as we know that this global warming or these volcanic eruptions related they contribute into those kinds of problems like climate change.

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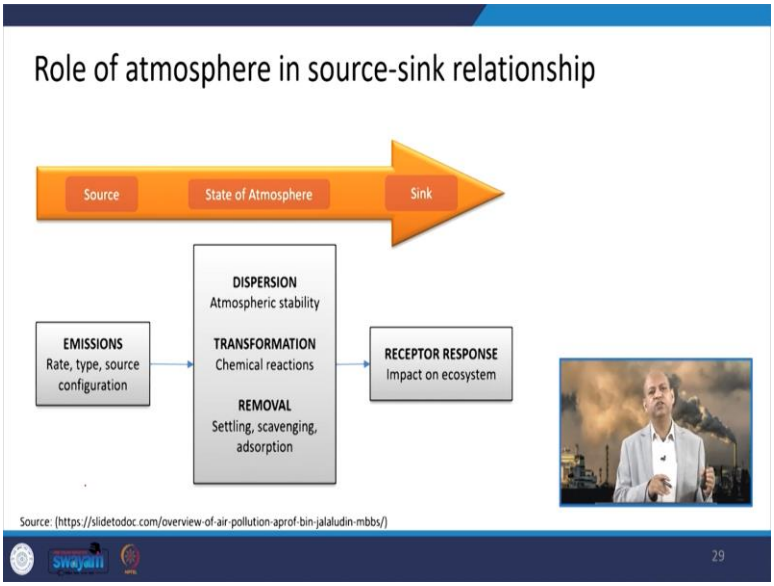

So, the role of atmosphere in terms of source and sink relationship when we talk. So, wherever emissions occur, they are the sources basically. And then, the dispersion occurs or transformation, chemical transformation may occur then the removal settling that dry deposition or wet deposition occurs. And the receptor response means, whenever exposure is there to a human being or the animal or the ecosystem or property whatever that is the receptor where they get exposed and then this chemical reactions may occur negatively.

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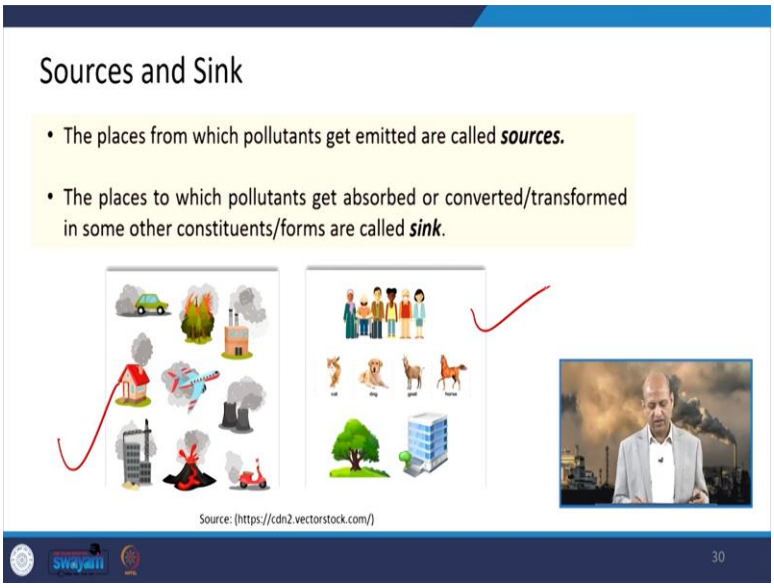

So, the sources and sinks are basically you can see these are the sources and these are the sinks or the receptors and where pollution get absorbed and they can get converted into some sort of problem.

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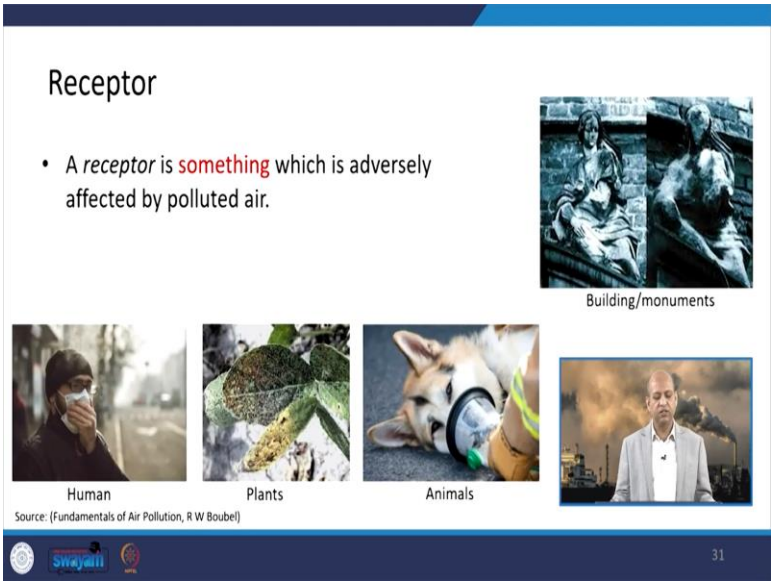

So, the receptor is nothing but something which is adversely affected by polluted air. So, it can be human being, it can be some plants or agriculture farms or forest area or animals it can be also buildings and these monuments because of this abrasion and those kind of acid rain etc. These monuments get damaged because of air pollutant.

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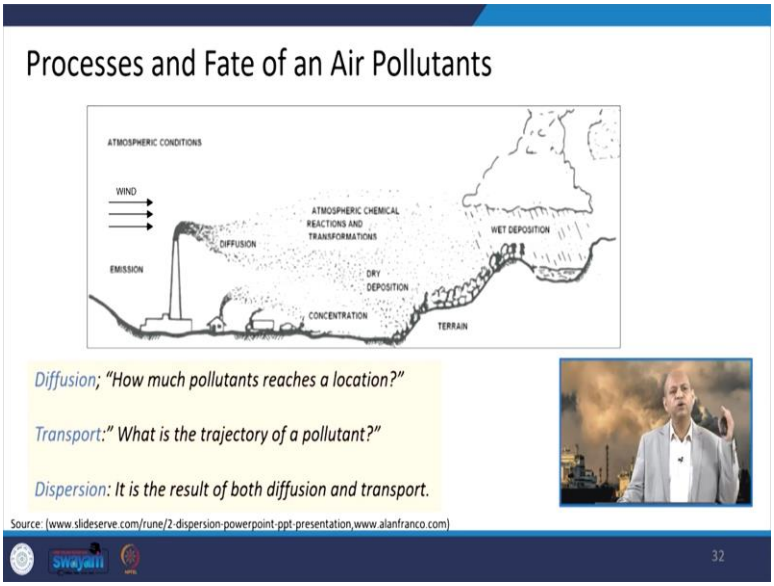

When we talk about different processes and fate of the air pollutants. So, this pictorial representation demonstrate or illustrate in a nice way. So, like emission is there from the stack

and the wind is blowing in that direction. So, the diffusion and dispersion is occurring molecular phenomena diffusion and more physical phenomena of dispersion with the air.

And then it can happen dry deposition or it can happen wet deposition because of precipitation that can happen. So, the diffusion, transport and dispersion all these three phenomena decides the fate of the air pollutants, where it will get deposited, where it will go up to what distances in the downwind direction, it will travel and exposed to the receptors.

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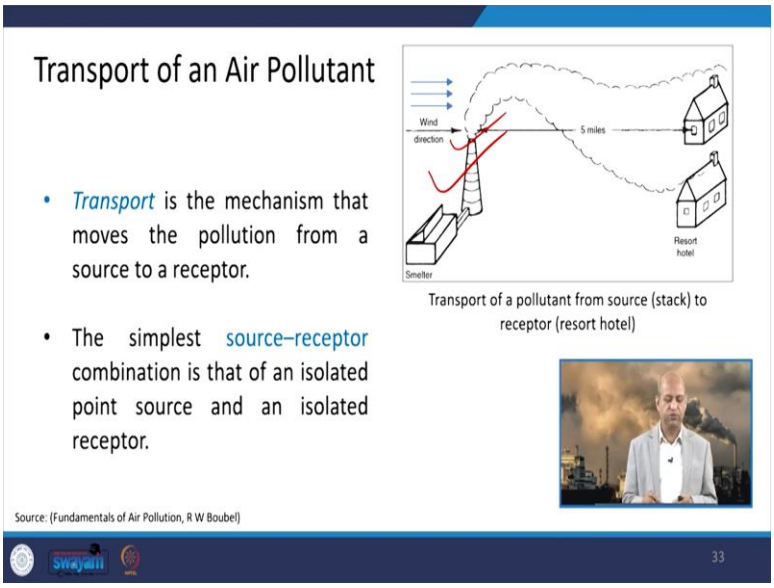

So, in transport phenomena you can see it can the source receptor relationship, this is the smelter which is the source and this is some whether hotel or some house where it goes in some concentration. There are ways to calculate how much concentration will be contributed by this particular source, we will see that later on. So, that is the relationship of and contribution of the transport in the source receptor relationship.

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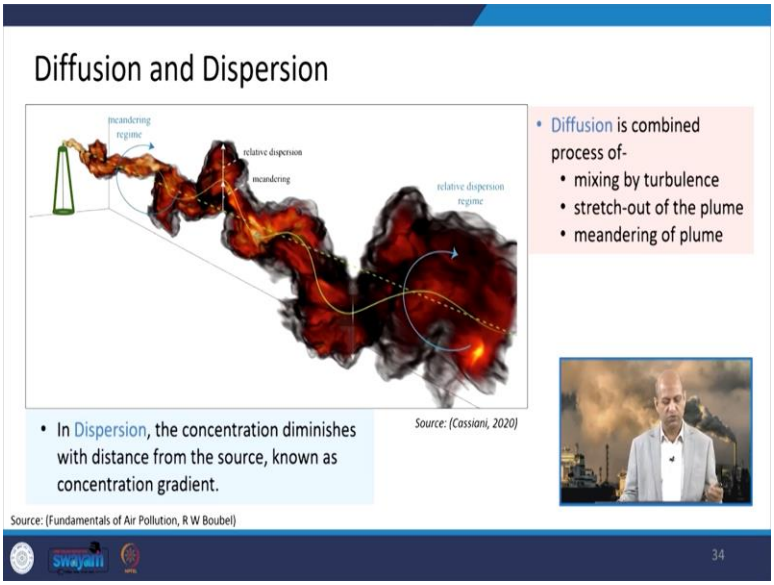

And the diffusion and dispersion as you know this diffusion is mixing of because of turbulence and molecular diffusion. And the dispersion is basically it can travel with the air and larger eddies of the air etc. So, this happens diffusion and dispersion takes together, toll to the air pollutants, and that is why the size of plume increases because of those eddies of the air etc. And then they also get deposited or comes down to the surface of the earth. So, high stakes are there then less amount of pollutants come to the surface, that is why these high stakes help in dispersion otherwise there are other uses of the stakes we will see later on.

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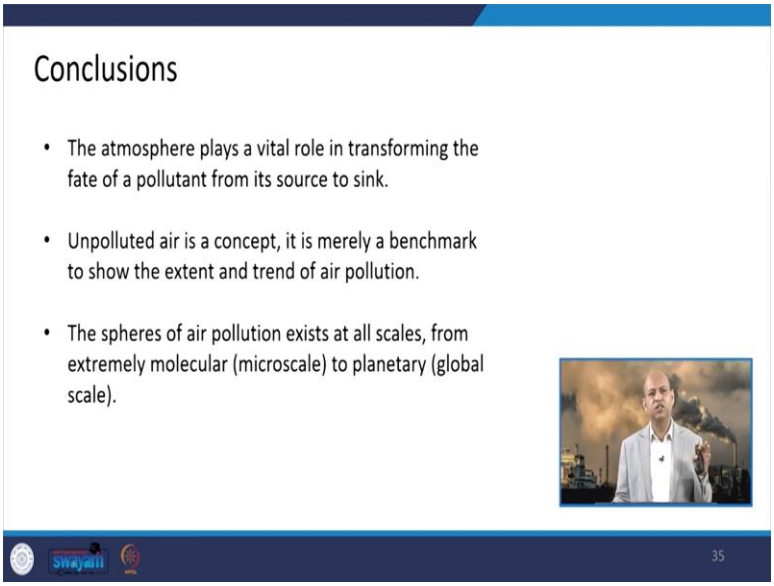

So, in conclusion, we can say that the atmosphere plays very important role in transforming the fate of the pollutants from its source, when it travels to the sink or the receptor. And the unpolluted air is a concept and it is merely a benchmark to see the baseline kind of scenario, otherwise, it is very difficult to find the unpolluted spot at the earth.

And the spheres of air pollution exist at all scales from micro scale to the global scale, it can be a different kind of problems, as you see indoor air pollution to the global warming or climate change related issues are there. So, these two introductory lectures sets the kind of way forward for this air pollution and control course for you. So, a kind of visualization may be there in your mind that what is the real problem related to air pollution. So, slowly now, we will go in detail like in next lecture, we will see its impacts, negative impacts on the health or the Eco environment all those things.

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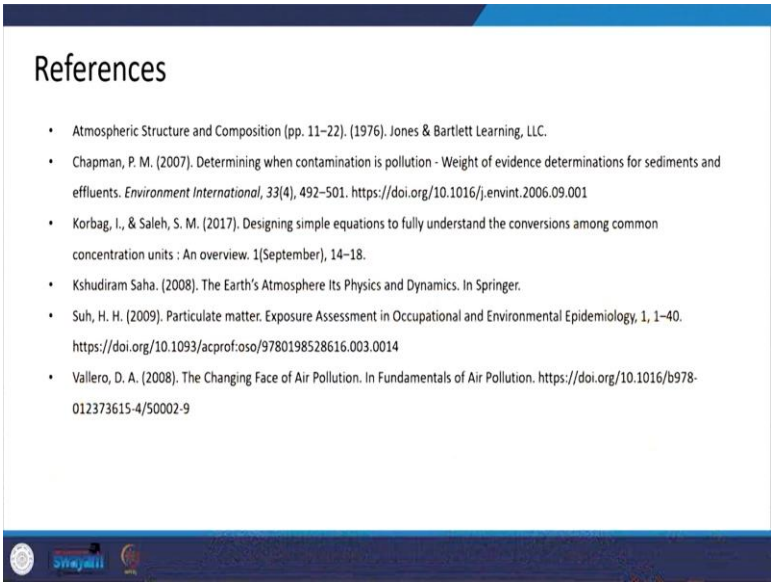

So, these are the references which you can go through to get more information. Thank you for your kind attention. See you in the next lecture. Thanks again.