Air Pollution and Control
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Lecture – 01
Introduction to Air Pollution- 1

Hello friends, welcome to the online course on Air Pollution and Control, which is a course of NPTEL under the Ministry of Education's initiative for online courses. And I welcome all of you who have registered for this course. And you might have seen the introductory video, the short video in which I have given you very brief information about this course.

So, under the series of 60 lectures, each lecture of 30 minutes, we will have the complete basics, fundamentals and practical aspects of air pollution and control. So, today we have the first lecture, the introductory lecture, we have two introductory lectures to set the ball rolling for kind of setting the criteria of this course and the baseline of this course.

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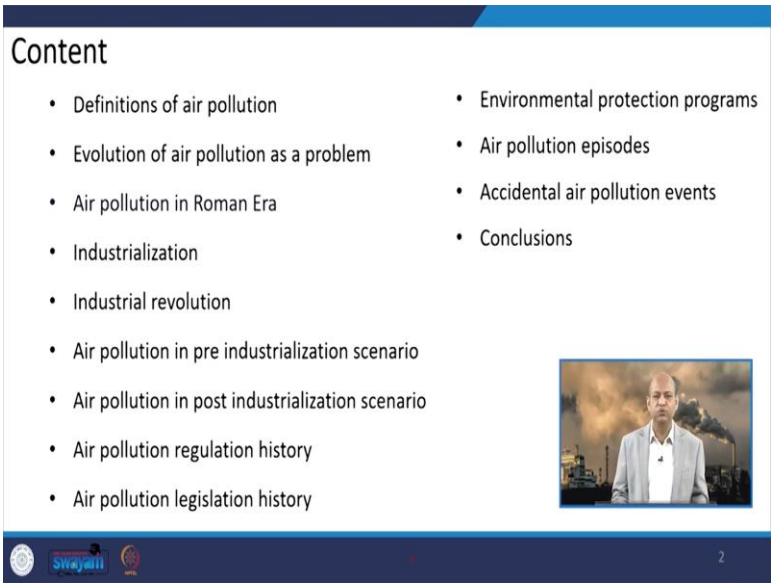

So, today we will discuss about various definitions of air pollution, evolution from ancient times to the present one, then what were the impacts of the industrialization, industrial revolution, and pre-industrial era, post-industrial era, what are the impacts, then, there are the legislations or regulations, which have been developed over the years. Then, we will also see some environmental protection programs related information and we will also go through certain

episodes and accidents, there is a basic difference between air pollution episodes and air pollution accidents. So, those also we will discuss and then we will conclude.

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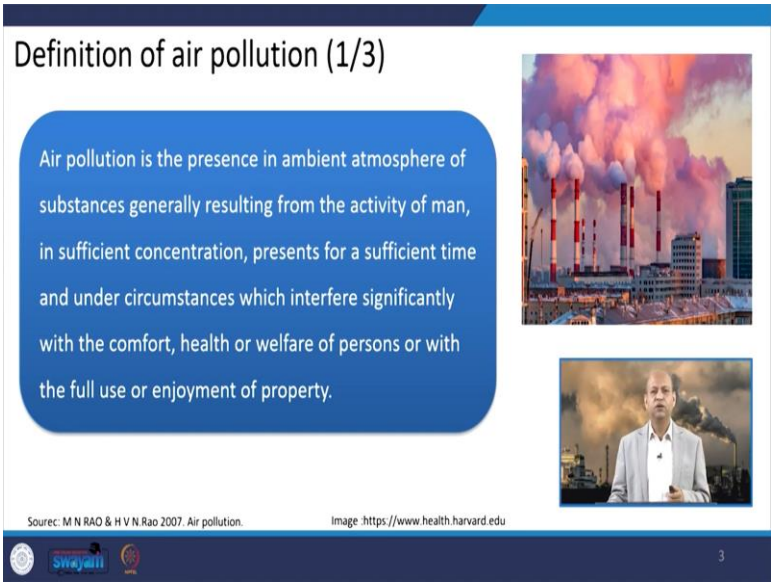

So, when we go about the definitions of air pollution, there are numerous definitions, but they basically center on the presence of some foreign elements or undesirable compounds or pollutants. So, the pollutants are basically like, someone defines that air pollution is nothing, but the presence in ambient atmosphere of those substances, which are generally resulting from the activity of man means, manmade sources in sufficient concentrations and presents for a sufficient time and under circumstances which interfere significantly with the comfort and health or welfare of the people or the full use or enjoyment of property. So, those kinds of adverse or negative impacts, because your presence of those substances in the atmosphere.

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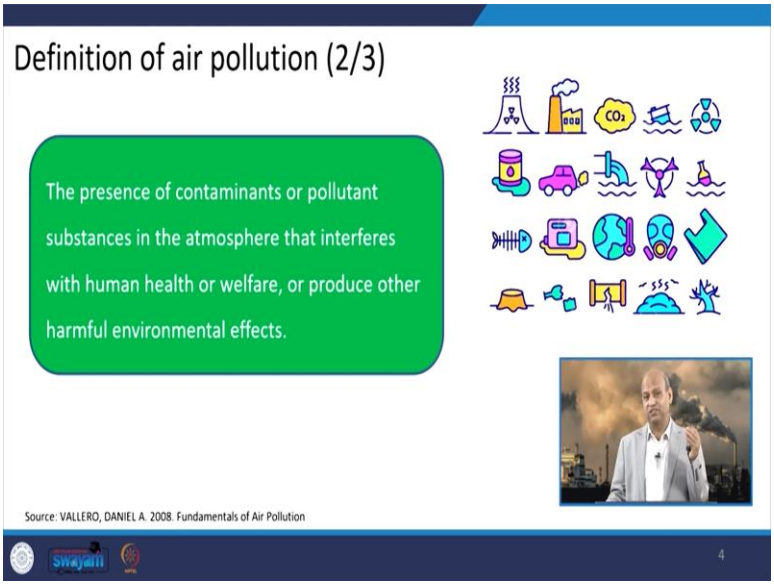

Another definition talks about the presence of contaminants or pollutants. So, there may be a little bit difference between contaminants and pollutants, that we will also discuss, some people say that they are, one and the same thing, some people, define them differently, so, that we will go through. So, one definition is the presence of contaminants or pollutants substances in the atmosphere that interfere with human health or welfare or produces other harmful environmental effects.

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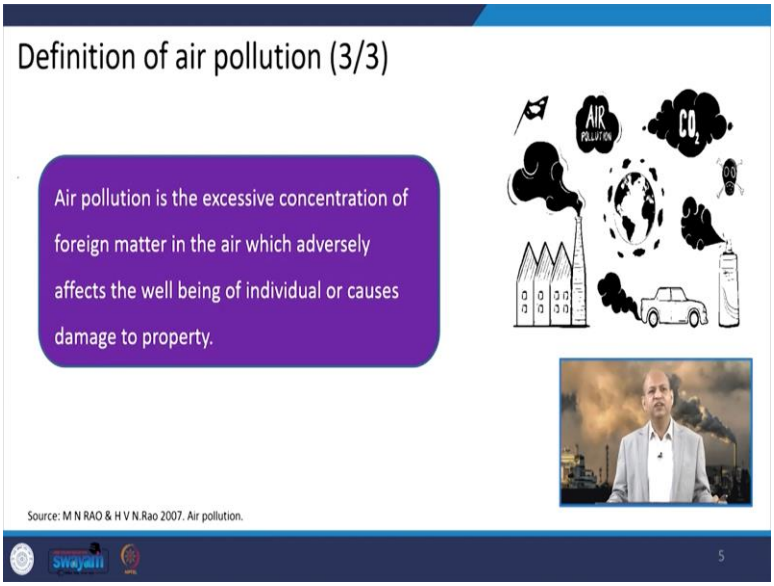

Another definition is like air pollution is the excessive concentration of foreign matter in the air, which adversely affect the wellbeing of an individual or the public community and causes damage to the property or the environment like these, there are other different definitions. But, all definitions are like the presence of some material in the atmosphere, which really impacts in a negative way to our life, whether directly to our health or through some property or environmental impacts in a negative way.

So, when we talk about the evolution of air pollution as a problem, then basically, we go to those ancient times when human beings started to use fire. So, at that moment itself, we started to contribute to the atmosphere, some sort of pollutants, but the quantity was so less that it was insignificant. Until the industrial era, when the pollution emissions were in huge quantity, and then they change the ambient air quality, only then this was figured out as a problem. Otherwise, initially, the fire was the sign of safety, power, many things like because it protected from animals, and it started to give us many other benefits.

But, when the industry started, then the stakes emissions, those kinds of chimneys and the plumes. Those were the Science of growth, economic growth and that kind of thing positive aspects of economic growth. But, nowadays whenever we see the stack emissions or the plumes, then we see that there is pollution.

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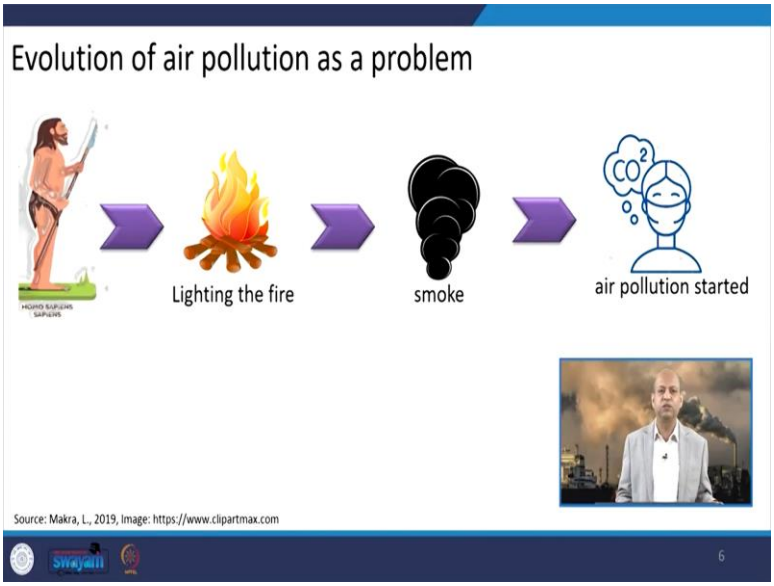

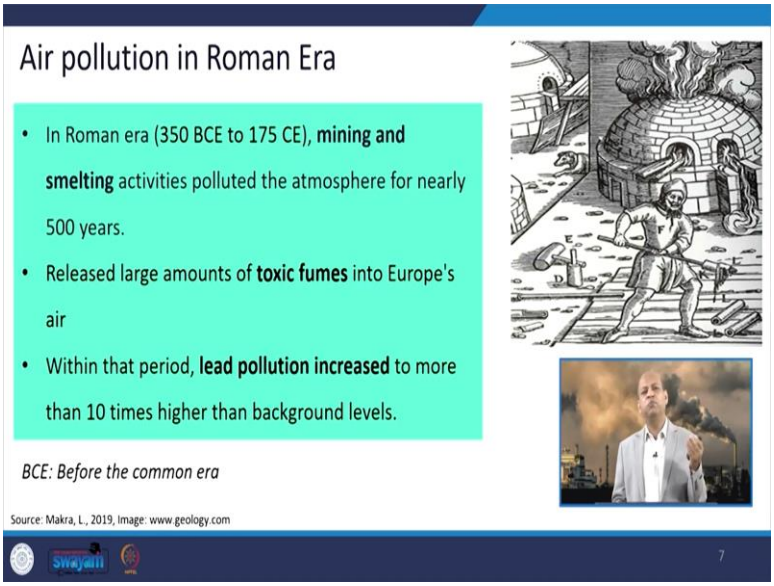

So, the negativity of these pollutant emissions from extraction emissions was not figured out until the industrial era came into huge existence. So, air pollution started when this industrial era came into existence. So, if we talk about like the Roman era before that also some problems were there in cities or in a localized problem otherwise, like right now, this air pollution problem is a global problem, which was not at that time. So, when we talk about the Roman era that is 350 BCE to 175 CE.

So, the mining activities, smelting activities of, metals etc, those were the polluting activities and they were polluting the atmosphere for around 500 years, but only in a localized form. And it also released large amounts of toxic fumes into, Europe's here because there were a lot of activities at that time. And within that period, the lead pollution increased to more than 10 times higher than the background level of the lead concentration in the atmosphere.

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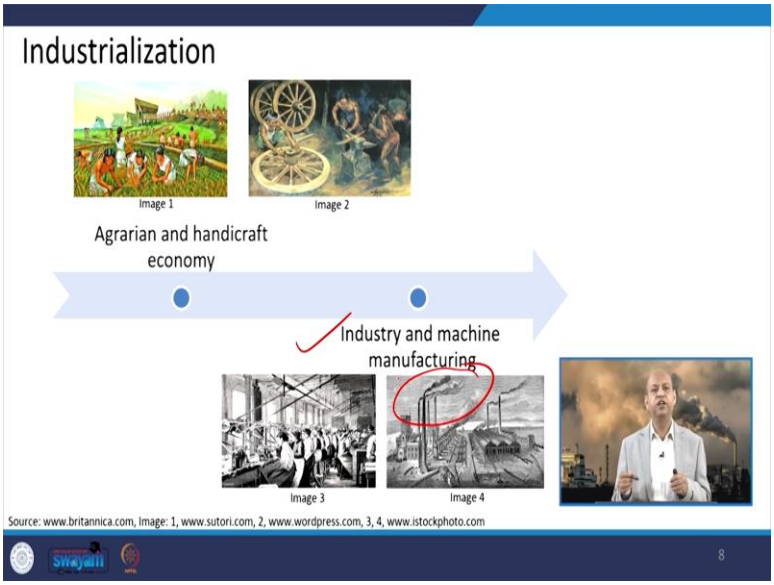

Similarly, when we talk about, industrialization, so, before industrialization, if we see, this agrarian way of life and the handicraft or cottage industry, then again the pollution was very, very localized, wherever these activities small activities were, they are like blacksmith related activities, those kinds of things.

But when you can see like in this industry and machine manufacturing era, then people started to work in masses in big factories. So, you needed the power to fuel those factories, whether through coal or through oil, those kinds of energy sources. So, that is why pollution emissions became part of this particular industrial activity.

So, when we talk about the industrial revolution, basically the term industrial revolution in between 1760 to 1840, it was first popularized by the English economic historian Arnold. This process of Industrial Revolution began in Britain in the 18th century and from there it is spread over the different parts of the world first in Europe and then other continents also and colonization, all those political issues were also associated with this industrial revolution.

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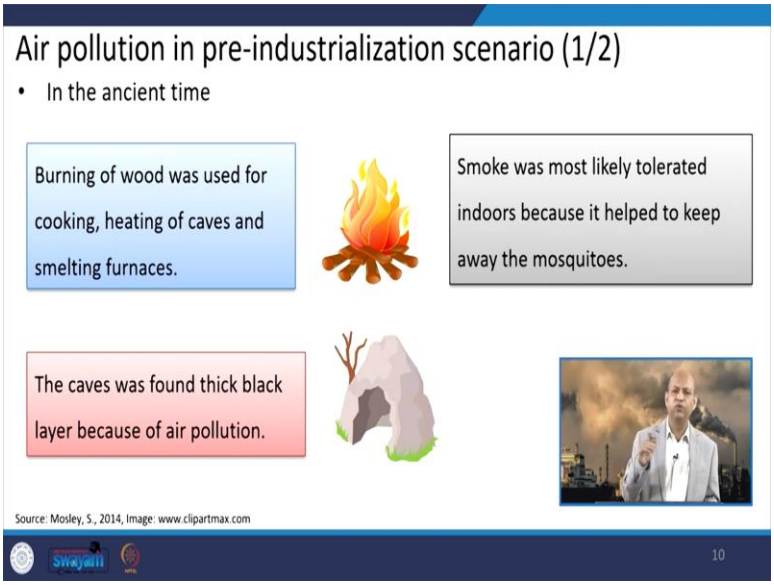

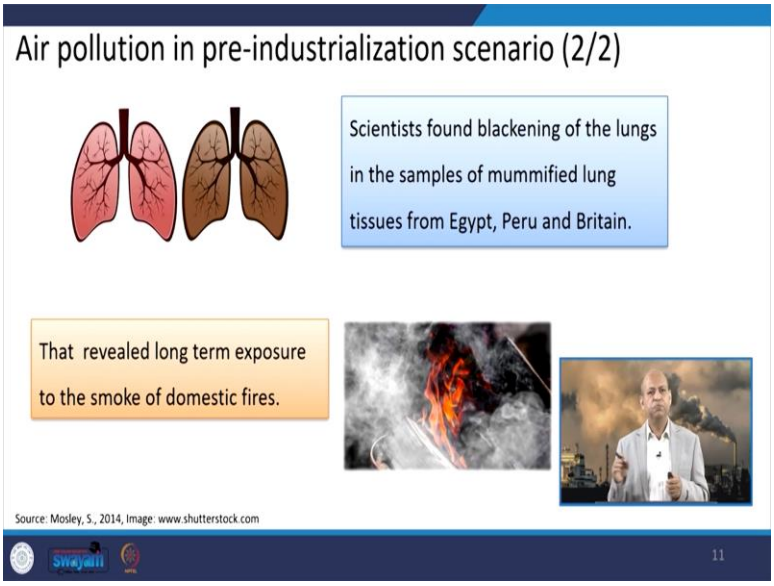

Well, when we talk about air pollution in the pre-industrialization scenario, then in ancient times, like the burning of wood was the source of energy or source of light for cooking activities or eating even in the caves, and smelting some furnaces. So, this wood was used, but when activities started to concentrate in masses, then the other fuel came into existence like coal etc. But for centuries this wood was the source of energy, source of heat and light.

And that is why even in caves a lot of the thick layer of black carbon and all those things can still be found. And most likely, this indoor air pollution was used for keeping away, animals as well

as even mosquitoes. So, that was the positive aspect, but that was kind of affordable amount of air pollutant.

But it also contributed in negative aspects of the health, like scientists have found blackening of the lungs in the samples of mummified lung tissues from Egypt, Peru and Britain that revealed long term exposure to the smoke of domestic fire. So, those were the reasons why these lungs were exposed to the high concentration of smoke. So, in pre-industrial scenario, that kind of source was of air pollutant was there.

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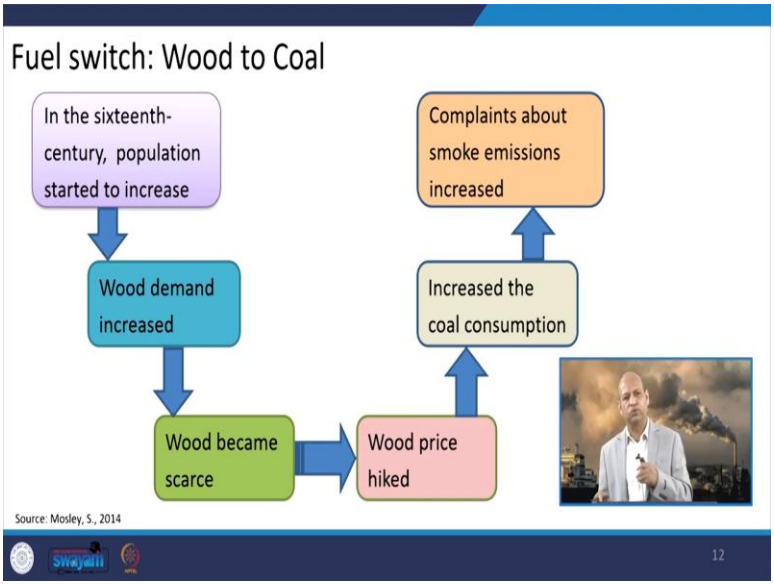

And then the switch of fuel occurred from wood to the coal and the reason was because in 16th century, the population started to increase. Better quality better living style and then wood demand increased significantly. So, the wood became scarce. Those kind of struggle was there in forest ownership of the kings and then people's taking the wood. So, then wood prices started to increase, the price hike was significant.

Then increased coal consumption started because the coal replaced the usage of the wood and because of coal lot of smoke was there because of coal's quality like ash content is there, sulfur content is there. So, the emissions of the air pollutants also increased along with the coal consumption.

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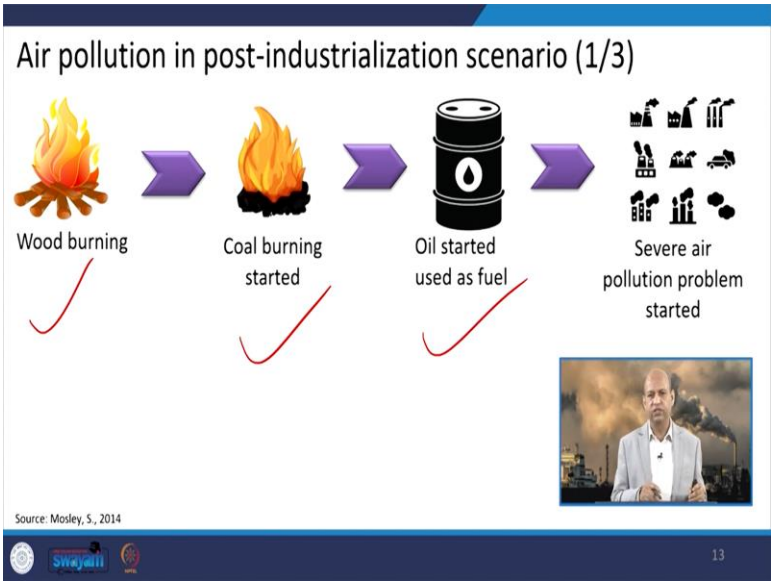

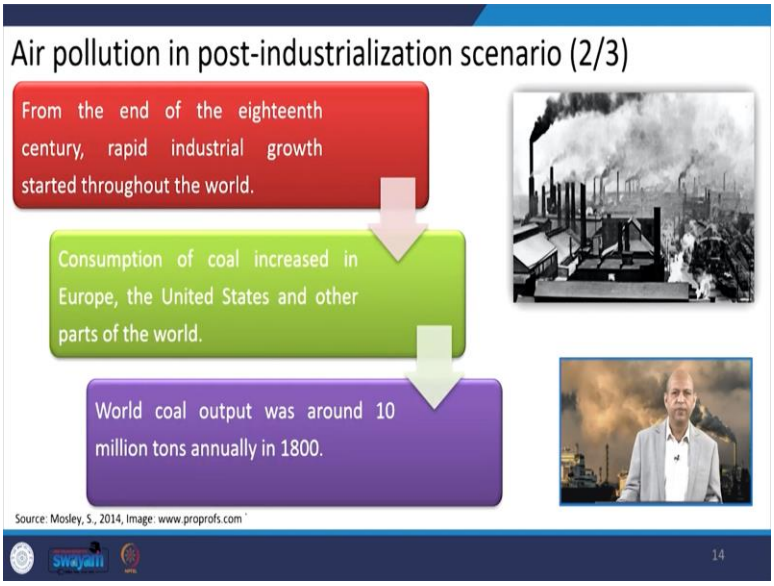

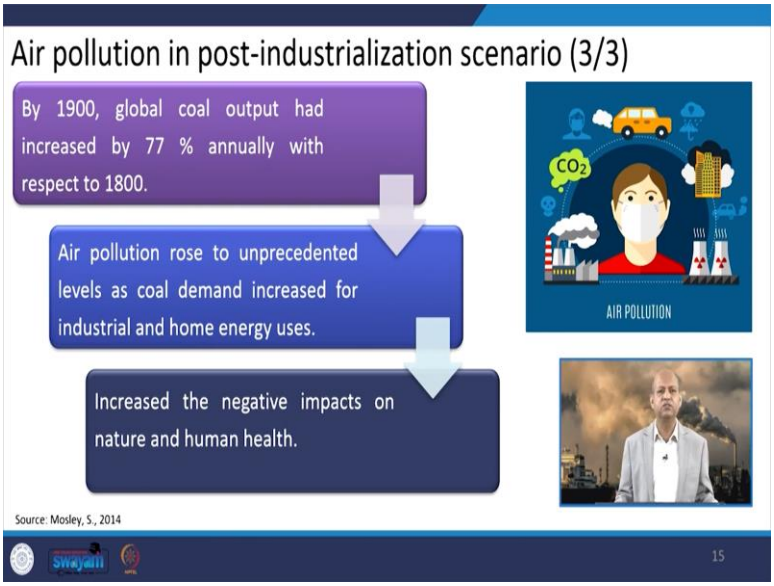

When we talk about air pollution in post-industrial scenario, so from wood burning, we switch to the coal burning and after that this oil was discovered and the use of oil also started. So, you can say from solid fuel to the liquid fuel switchover was there and then gas like LPG or CNG, or natural gas those kind of fuels were also they are in post-industrial scenario. So, at present they are the sources of pollution basically, whether, in the power plants which are based on the coal or you are using oil in generators, diesel generators or in transportation sector or in factories, they are the sources of air pollution.

So, well when we talk about like from the end of the 18^{th} century, this rapid industrial growth started throughout the world, the factories started to work mass production was started and the cities came into existence mega cities, like up to 1950s only, Tokyo was the biggest city, but later on because of this industrialization and this fossil fuel based economy, people started to gather into big cities and factories around industrial clusters.

Then the consumption of coal increased in Europe and the United States and other parts of the world. And the world coal output was around 10 million tons annually in 1800, at that time, but later on it further increased. So, you can see these are the science of coal based power plants and factories.

In 1900 global coal output has increased by 77 percent annually with respect to the 1800. And then air pollution rose unprecedented levels as coal demand increased for industrial and home energy uses. So, the quantity of coal was burned a lot of quantity. So, the pollutant's quantity

which was emitted by burning of coal also increased. And the negative impacts on the nature or human health was also associated with increased coal consumption and associated pollutants.

Well, when we talk about air pollution regulation history, so, it started even from 14th century like 1307, King Edward first of England, he banned the use of the coal in certain seasons in certain parts of the cities or the kingdom.

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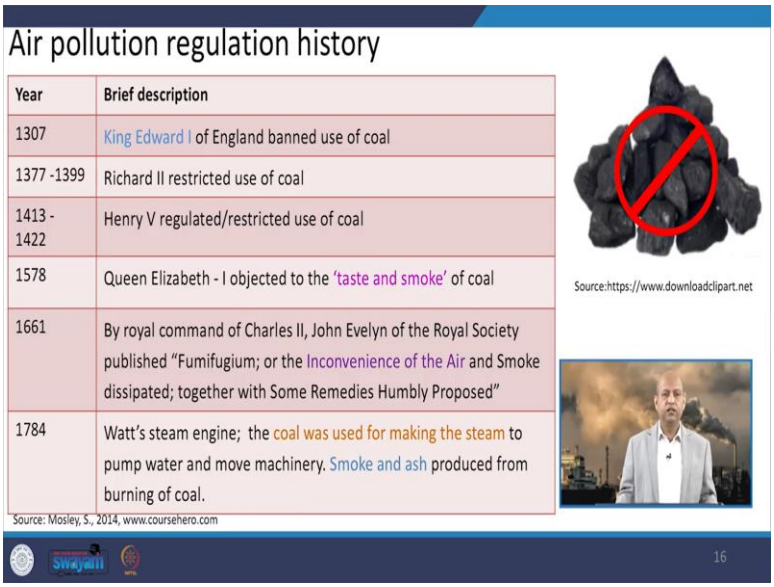

In 1377 to 1399 Richard II restricted the use of coal. Similarly, like 1413 to 1422 Henry V regulated or restricted use of the coal. So, you can see means they were aware of the negative impacts of the coal usage. In 1578 Queen Elizabeth I objected that taste and the smoke of the coal fumes. In 1661 the royal command of Charles II and John Evelyn of the Royal Society published this Fumifugium or the inconvenience of the air and the smoke dissipated together with the smoke remedies, humbly proposed.

So, those kinds of documentation started to get prepared, because they needed something to be done to reduce the problem. And in 1784, watt's steam engine started to be used, the coal was used for making the steam and to pump the water and move machineries and smoke and ash produced from the burning of coal. So, more and more use of coal started at that time particularly. So, even regulations were started to take form at that time also, you can see means that is the part of the history of air pollution regulation history.

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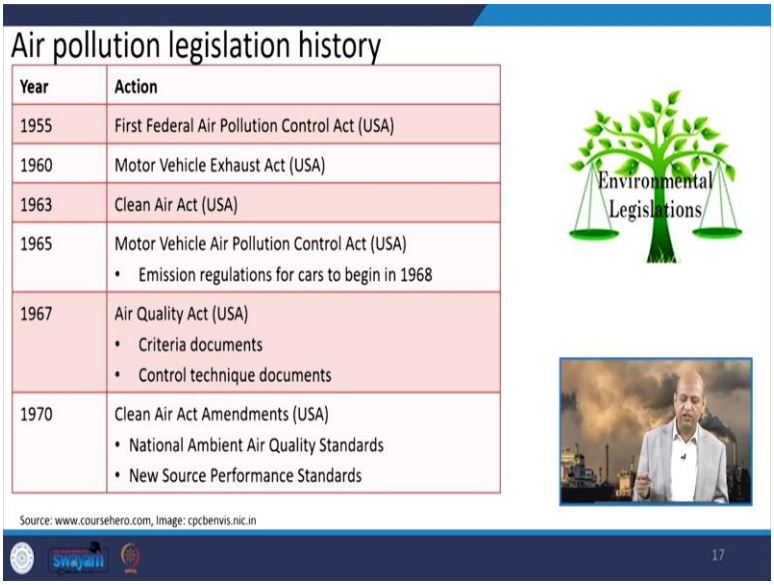

When we talk about legislations so, the recent legislations which have been in different countries, so, if we give the example of USA, so, in 1955, they had this first Federal Air Pollution Control Act of the USA. And in 1960, they had Motor Vehicle Exhaust Act, and in 1963, Clean Air Act was formulated, in 1965, then Motor Vehicle Air Pollution Control Act was enacted. And this emission regulations for cars to begin in 1968 after three years of the 1965.

In 1967 Air Quality Act was again refined you can say and it was criteria documents and control technique documents all those documentation started to prepare. In 1970 Clean Air Act amendment was brought and the National Ambient Air Quality Standards were defined and the new source of performance standards were also taken into account.

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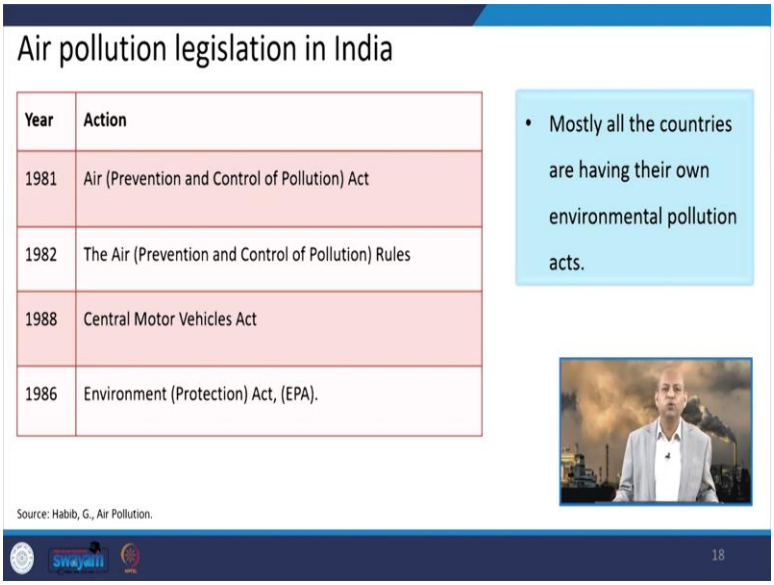

When we talk about in India like in 1981 Air Prevention and Control Pollution Act was enacted in 1981. In 1982, the Air Prevention and Control Pollution Rules were executed. In 1988 Central Motor Vehicles Act was there, then after that several additions of these acts and regulations came into existence.

In 1986 the Comprehensive Environmental Protection Act was enacted and then after that other improved versions were brought into existence and implemented. So, the mostly all the countries are having its own environmental pollution acts related to air, water, soil, all those things. But if you talk about only air pollution, then again all countries have, most of the countries. Otherwise, World Health Organization, they also give some guidelines so, many countries follow those guidelines.

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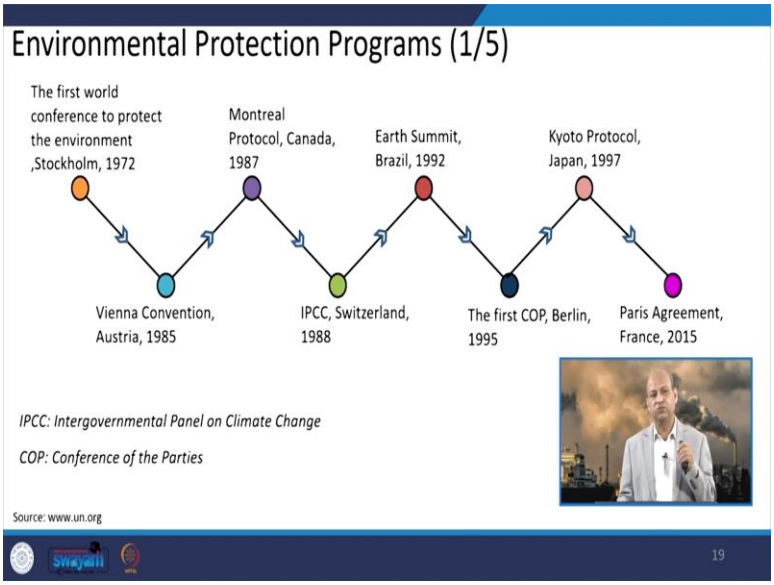

Environmental Protection Programs, if we talk about this historical aspects. So, in 1972, the first World Conference to protect the environment at Stockholm was organized in 1972, and after that, in 1985, this Vienna Convention was organized in Austria. Then in 1987, Montreal protocol in Canada. And then in 1988, this IPCC, Switzerland came into existence that is Inter-governmental Panel on Climate Change, which gives periodically, the reports on climate change and its relation with the greenhouse gas emissions.

Well, when we talk about 1992 in Brazil Earth summit was organized and in 1995, the first COP that is the Conference of the Parties, the first COP in Berlin, it was held and the Kyoto Protocol came into existence in 1997. And then Paris Agreement in 2015. So there is good history of this environmental protection programs, especially air pollution, you can say.

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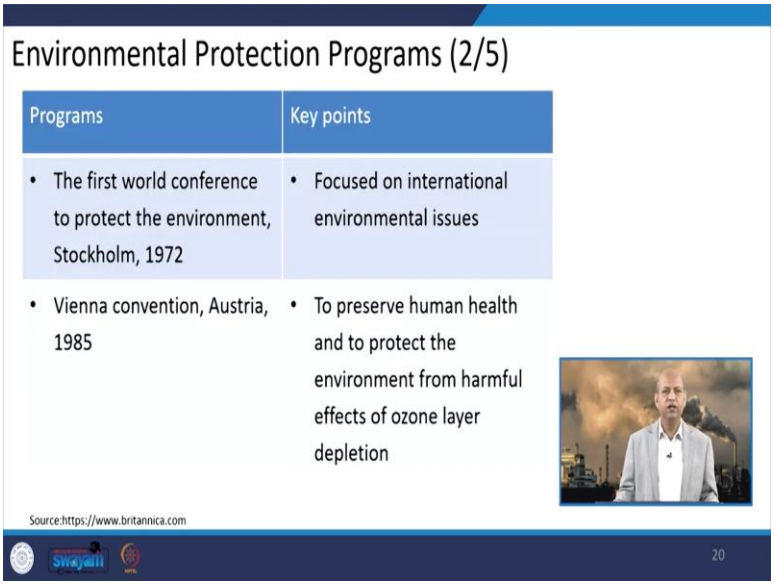

Well, when we talk about different programs and their key points to which kind of activity or negative impacts they are associated with then the first World Conference to protect the environment in Stockholm in 1972. It was focused basically on international environmental issues, those were different kinds of issues. But the Vienna Convention it was very much focused or concentrated on to preserve the human health and to protect the environment from harmful effects of ozone layer depletion.

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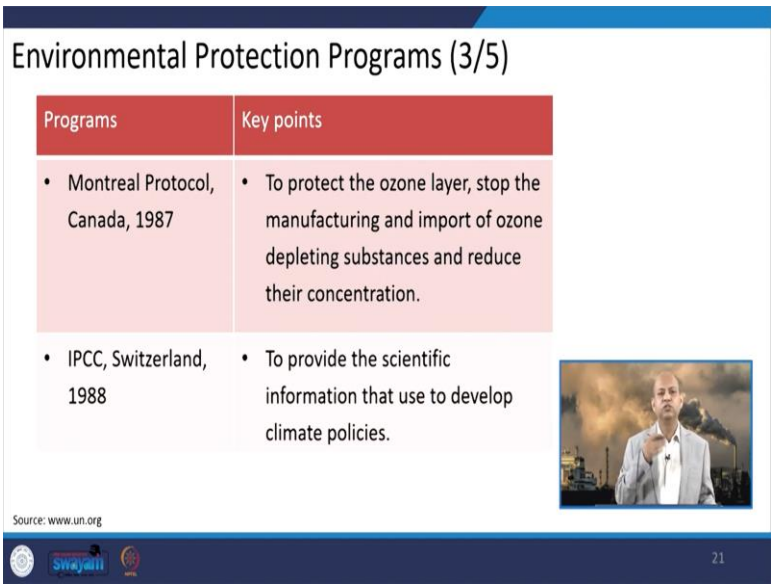

And later on the Montreal Protocol was signed to reduce the emissions of those CFCs etc, which damage the ozone layer. And in 1988, this IPCC was formed to provide the scientific information that use that is used for development of climate policies.

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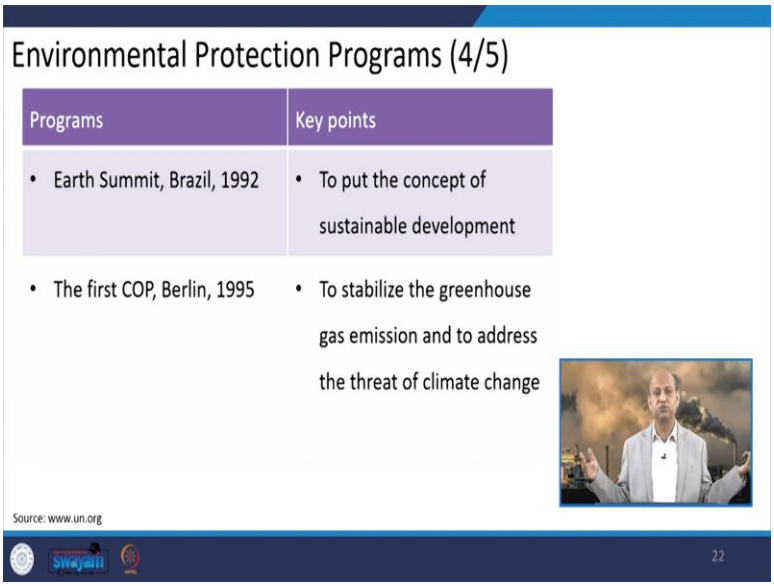

And then Earth Summit in 1992, it included the concept of sustainable development. So better concepts of sustainable development which could include many other aspects beyond the environment with socio-economic poverty, education, accessibility to infrastructure, so many things, you might be knowing about those SDGs Sustainable Development Goals. So, that concept came into existence in 1992. Then the first COP Berlin 1995, okay, it was a stabilized to stabilize the greenhouse gas emissions and to address the threat of the climate change. So, all country heads participated in this particular conference.

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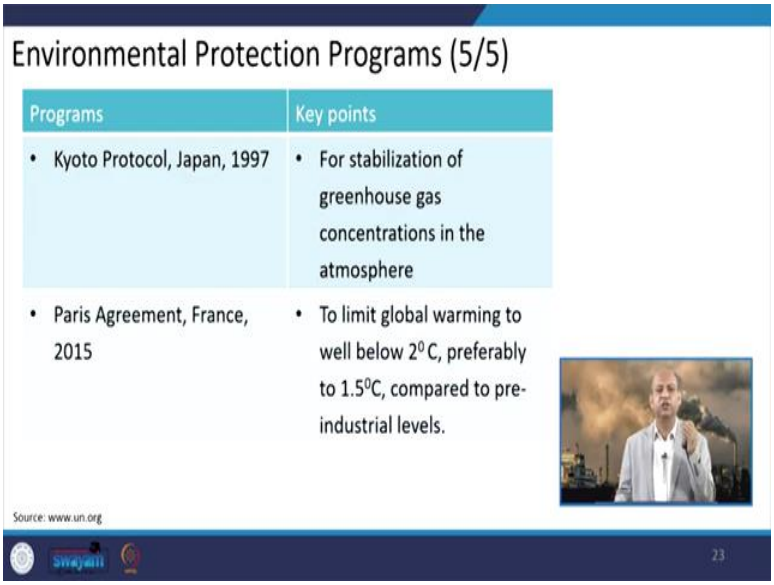

Then the Kyoto Protocol was signed for stabilization of greenhouse gases, concentrations in the atmosphere in 1997. And then Paris Agreement in 2015 to limit the global warming to well below 2 degrees Celsius preferably to 1.5 degrees Celsius compared to pre-industrial levels. Because otherwise, the scientific evidences are there, that if it goes this global warming goes on, then the climate change can be very severe and it would be very threatening issue for the whole humanity you can say.

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Well, when we talk about air pollution episodes, as I said, there are air pollution episodes and there are air pollution accidents, basically, episodes are nothing but the combination of emission sources and metrological conditions. So, at particular season particular day, you will find a lot of pollution, but other day, even sources are same emissions are same, but air is not so polluted so, episodes happen sometimes. Accidents happen when because of some human error or because of machinery failure etc.

Some release of toxic gases or report air pollutants happens and the exposure is instantaneously very high of very high concentration to the people so it can threaten the health even it can result in fatalities or mortalities or death. So those are the accidents like Bhopal Gas Tragedy etc., we will see later on. So the air pollution episodes even started in 1930 this was the first episode this Meuse Valley in Belgium. Okay, we will see what were the characteristics of those episodes.

And in 1940, the gas attack of Los Angeles that was the nomenclature was the gas attack. This was kind of confusion in perception, erroneous perception, but it was basically the episode because of local emission sources and metrological conditions. Then when we talk about this Pennsylvania Donora 1948 that was another episode. In 1952 Great London Smog, the Winter Smog which is also known as this was big episode very life threatening. Then Los Angeles smog in 1954 which is known as summer smog. Okay, then inversion over New York City 1966, acid rain in 1969. In 1978, again, West Virginia acid rain related episodes were there.

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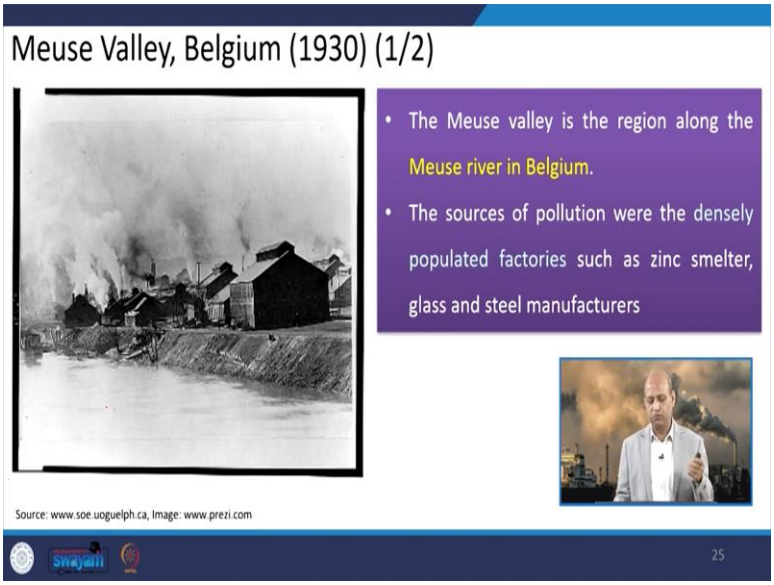

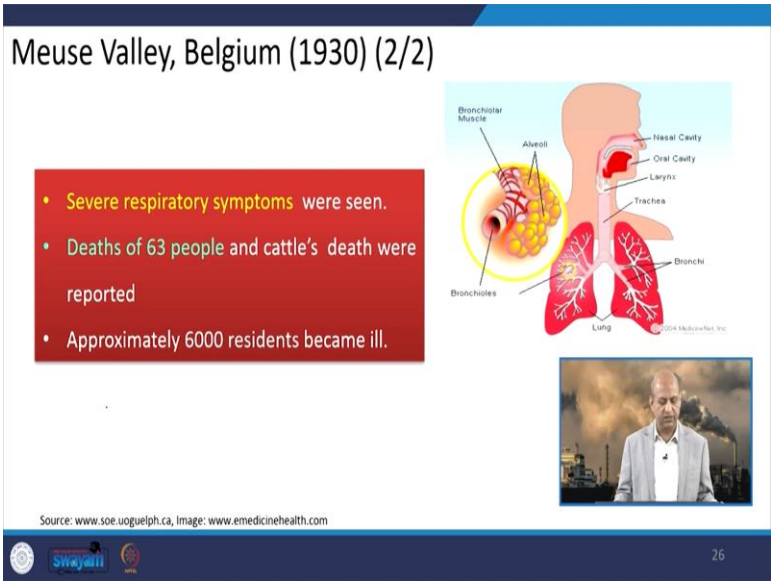

When we talk about this Meuse Valley Belgium episode. So, because this is lot of sources of pollution were there due to densely populated factories, and like zinc smelters, glass and steel manufacturers. So, because of certain weather conditions, this started to build up a lot of pollution levels, and the effect was severe respiratory symptoms to the people and around 63 people died, because of this respiratory problems, and even cattle's died because of the exposure of high concentration. Around 6000 residents became ill because of this air pollution exposure during that particular episode.

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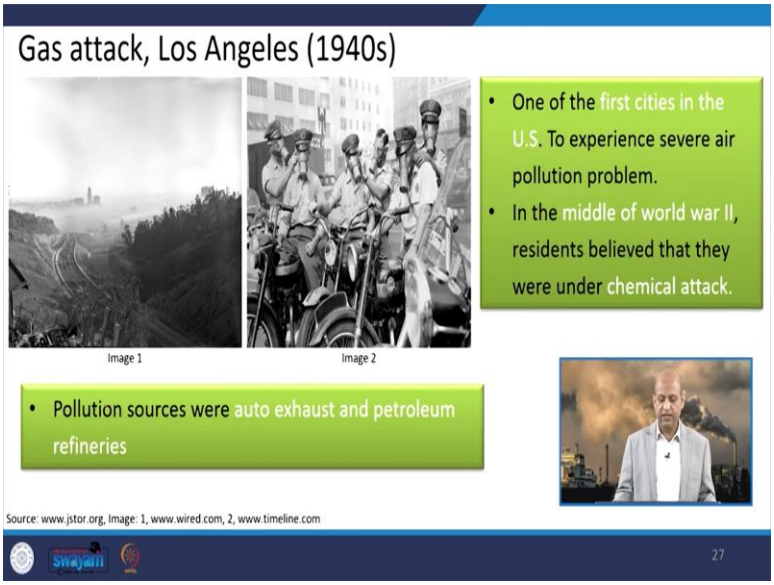

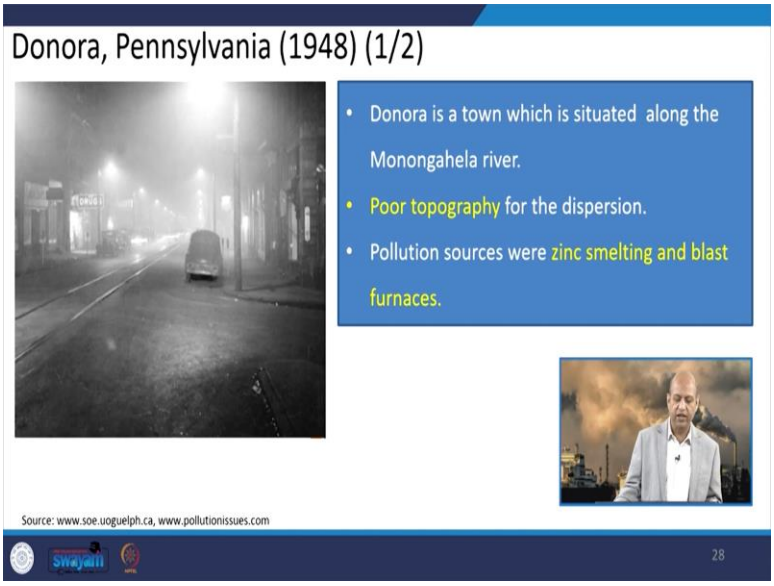

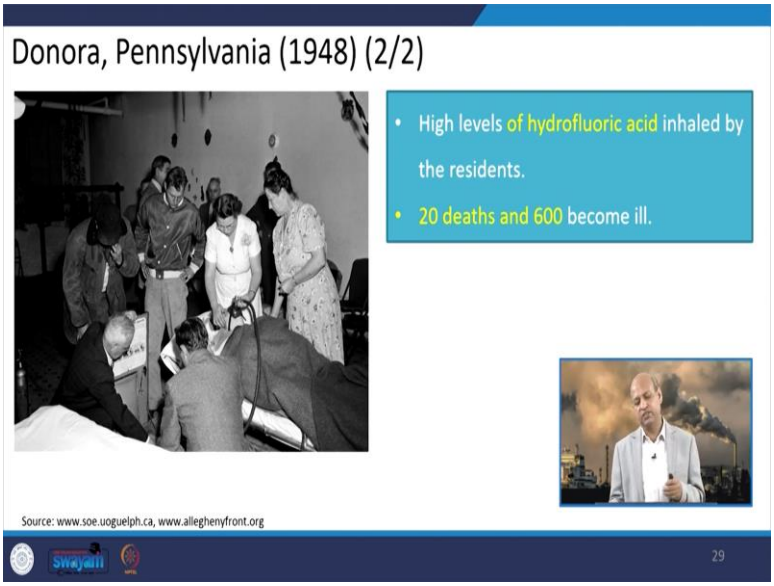

Gas attack one of the first cities to experience severe air pollution problem. And then this was in the middle of World War second. So the residents believe that this is a kind of, again attack from the enemy country, but this was again the episode because of pollution sources and certain weather conditions. And this was basically auto exhaust emissions, petroleum refineries, those kinds of emissions were responsible for this particular phenomena.

Later on, like in this Donora this is the town situated near a river. So the poor topography results in poor dispersion of air pollutants, and that he started to build a lot of emissions of zinc smelting facilities and the blast furnaces emissions. So that resulted in high levels of hydrofluoric acid inhaled by many residents, and around 20 people died, and 600 became ill. So, the high levels of hydrofluoric acid inhaled by many residents, and resulted in 20 deaths of the people and 600 people became ill.

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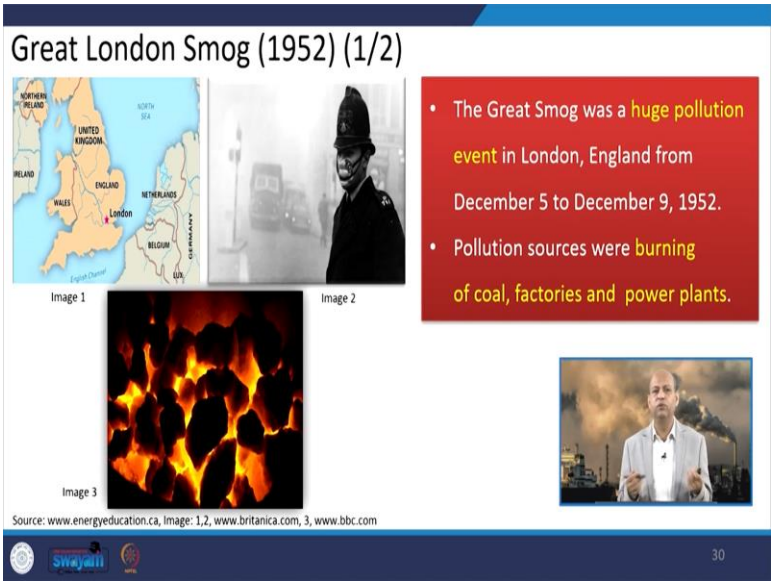

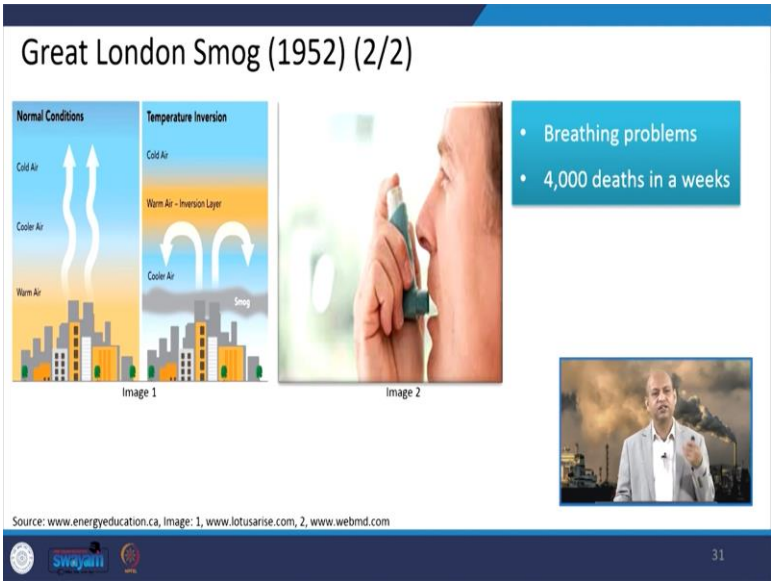

Great London Smog in 1952. Again, because of inversion winter season was there, inversion phenomena means the vertical dispersion became completely nil and because of winter people started to burn more and more coal to heat up their indoor environment. And this was a kind of vicious circle, and lots of emissions of these coal related like sulfur dioxide ashes, they were there in the atmosphere.

And so from fifth to ninth December around four or five days, this was very polluted time in London, and many people died around 4000 people died in a week's period, because of this

breathlessness and those were old people and having some respiratory problems, they were the large number of victims.

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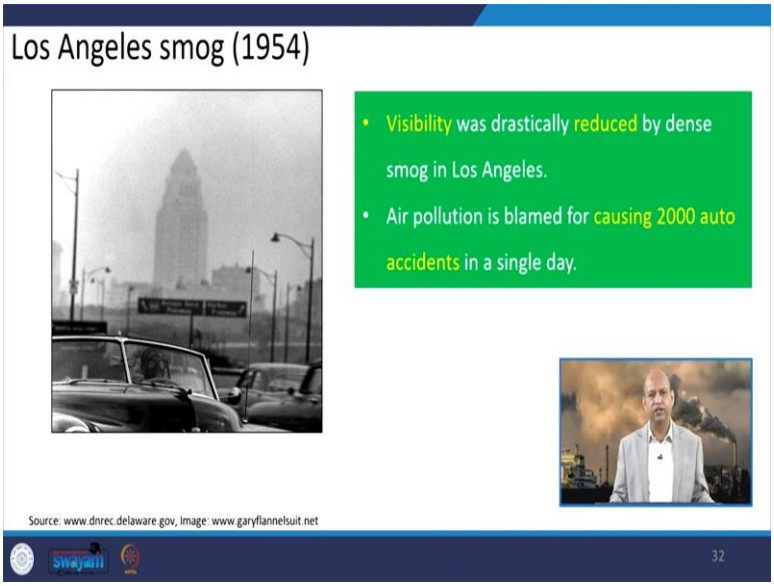

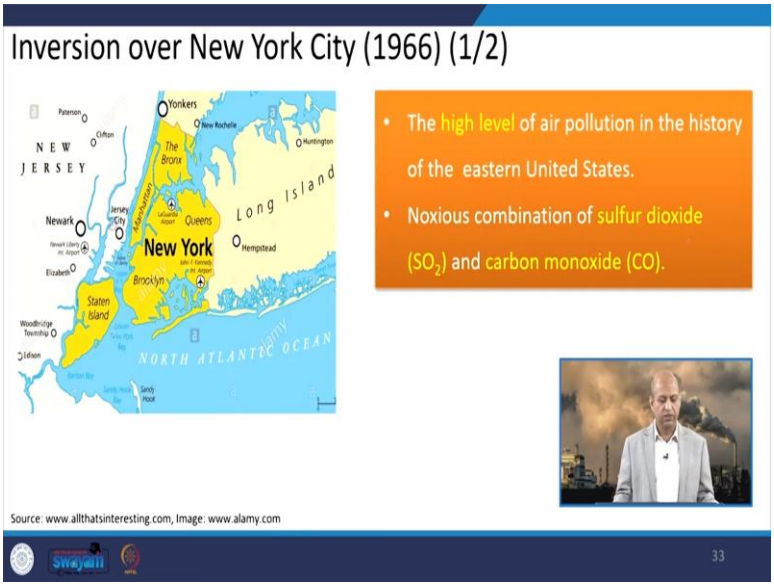

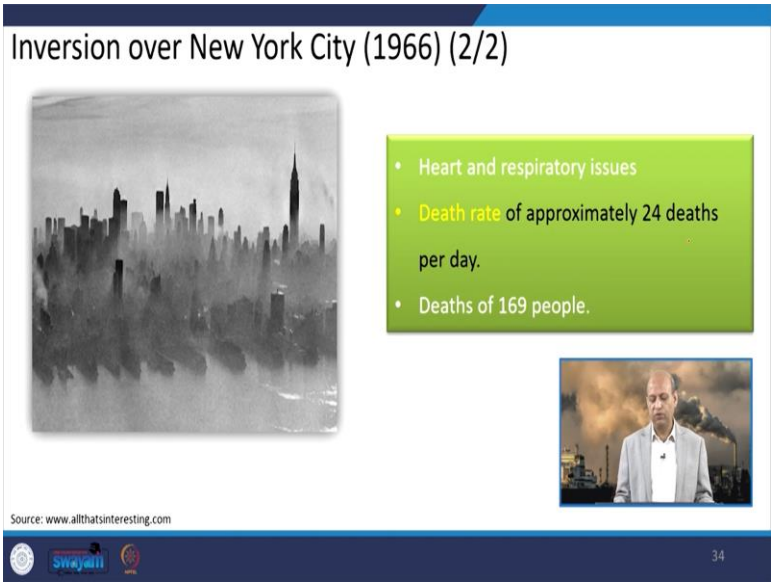

Then this Summer Smog, Los Angeles smog also known as this was because of emissions from transportation sector. And again, Valley effect, because dispersion was very poor. So, visibility reduced, eye irritation, those kinds of things happened. And around 2000 total accidents occurred because visibility was poor. So, it was the cause of those accidents.

Inversion over New York City in 1966, the high level of air pollution in the history of the eastern United States and the noxious combination of sulfur dioxide and carbon monoxide that resulted in very negative health impacts. So around 24 deaths occurred because of this, and heart and respiratory related issues were there. Around 169 people died 24 deaths per day happened basically, and the total deaths were around 169.

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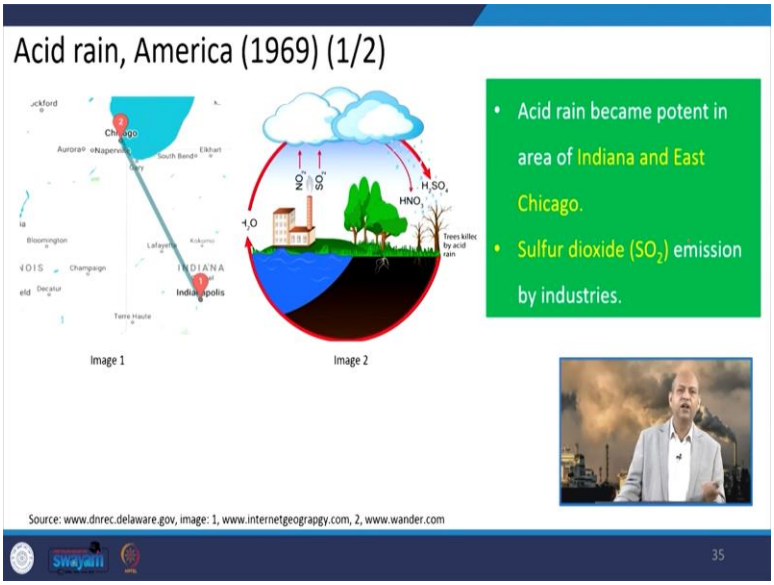

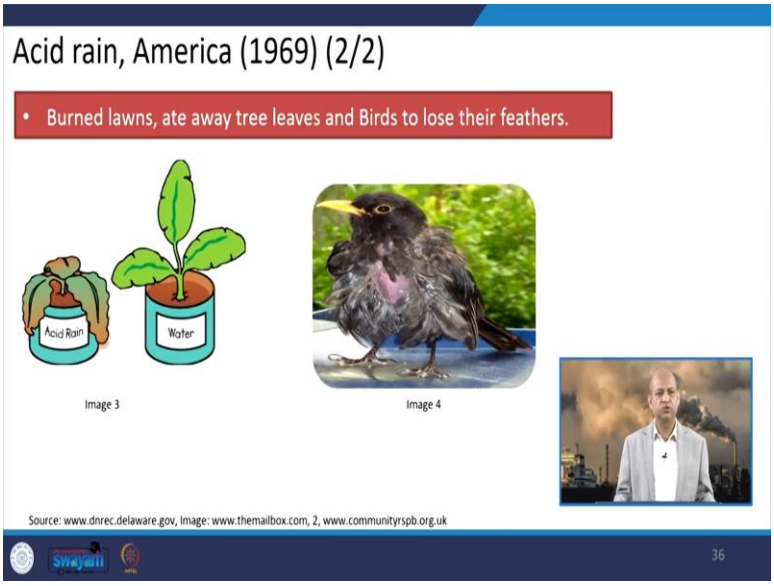

And then acid related phenomena occurred in America in 1969 you can see because of sulfur dioxide emissions they react with H_2O water moisture in the atmosphere then converted into H_2SO_3 and the sulfuric acid and they reduce the pH and acid rain occurs okay. So, they impacted negatively the plants and even birds etc, because they burnt the lawns and the leaves of the plants and the feathers of the birds were also burnt because of the acid rain.

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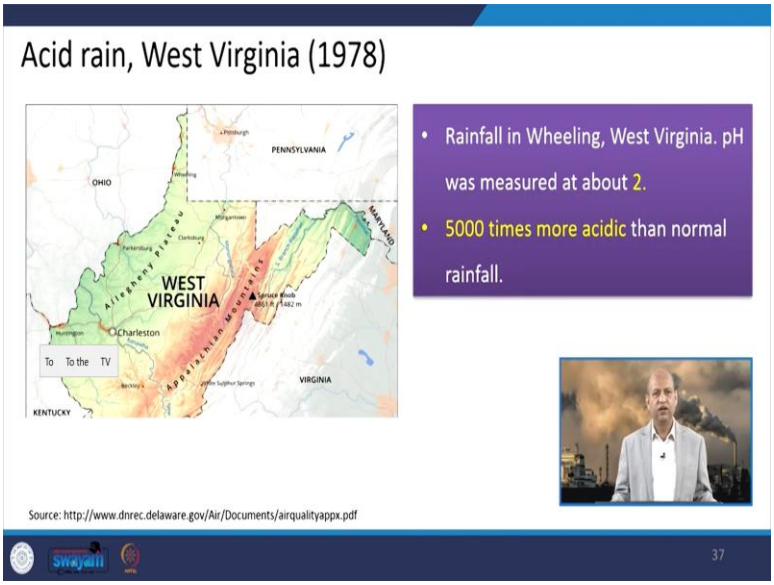

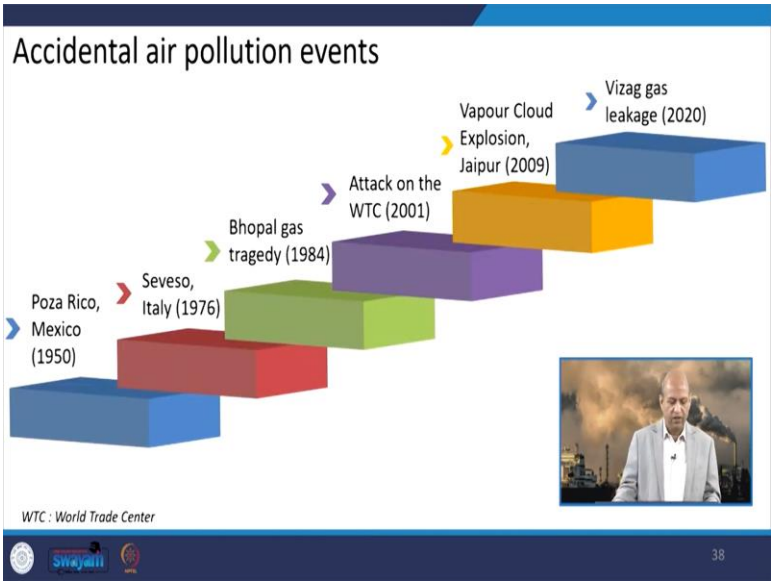

Another episode of acid rain in 1978 occurred in West Virginia. So, 5000 times more acidic than normal otherwise the rainwater is having some acidic component, but this acid rain becomes when pH is very low. Well, when we talk about accidental air pollution events, so episodes were there, those metrological and emissions related issues accidents means that the quick release of some toxic gases etcetera. So, 1950 Mexico and this Poza Rico this accident happened and in Italy Seveso in 1976, this Bhopal Gas Tragedy in India occurred in 1984. Attack on this World Tower Center in 2001. So, that was also accidental air pollution source because lot of fuel of this aircraft and then building material was burned.

So, air pollution occurred lot of in dense quantity. Vapor cloud explosion in Jaipur in India because of this oil, leakage in Vizag gas leakage in 2020. So, these are some important accidental air pollution events otherwise, there are many we are just giving you a kind of information.

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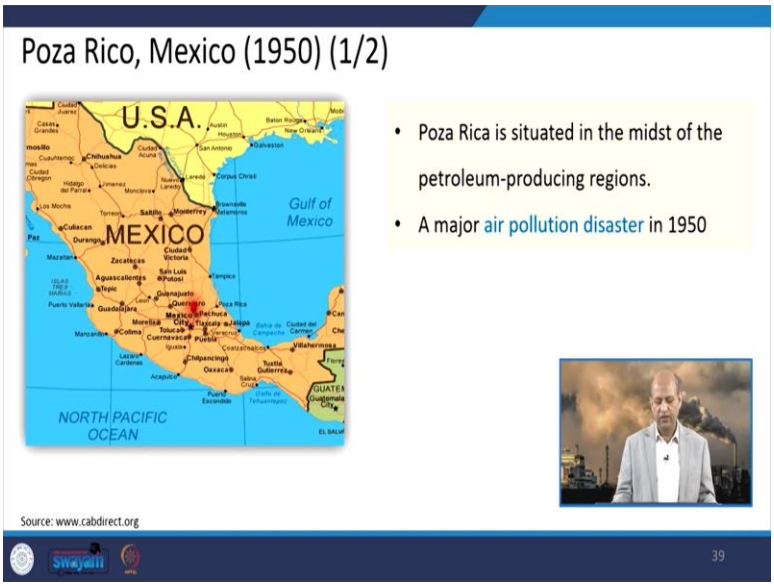

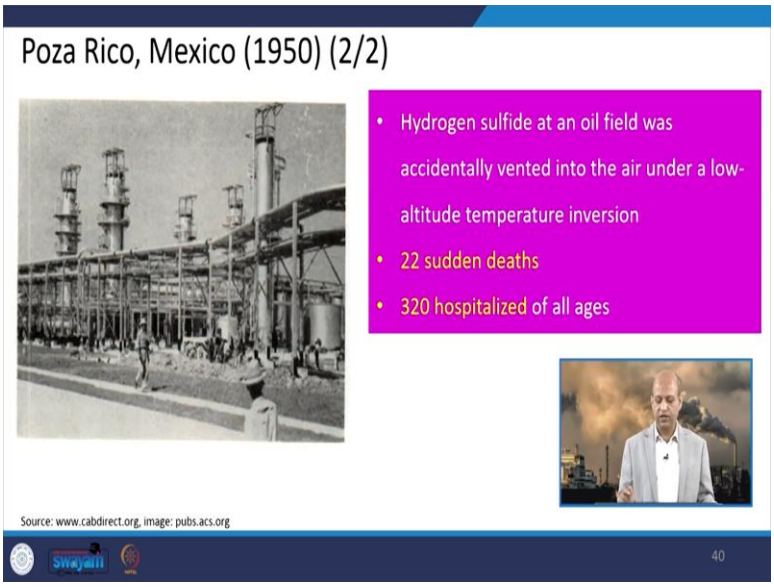

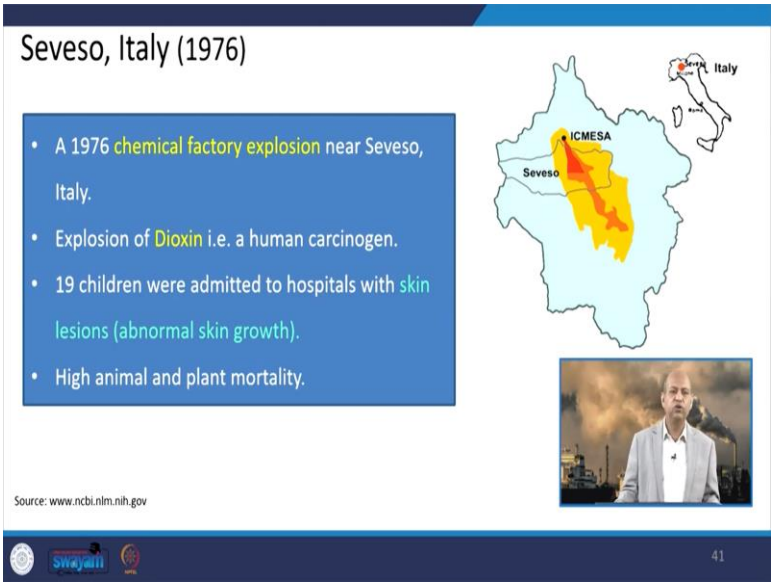

So, in Mexico, Poza Rico this accident happened in 1950 petroleum production regions are there in this particular location and this was like 22 sudden deaths occurred because this hydrogen sulfide at an oil field was accidentally vented into air under a very low altitude temperature inversion. So, the dispersion was not there and very high concentration of ambient air quality in ambient air this concentration became very high and 320 people were hospitalized of all ages.

When we talk about the Italy's accident in 1976 Chemical factory explosion occurred and this was the explosion of dioxin. So, that is very dangerous chemical it is carcinogenic element, 19 children were admitted to hospitals with skin related diseases and the high animal and plant mortality occurred because of this particular accident scenario you can see this modeling scenario.

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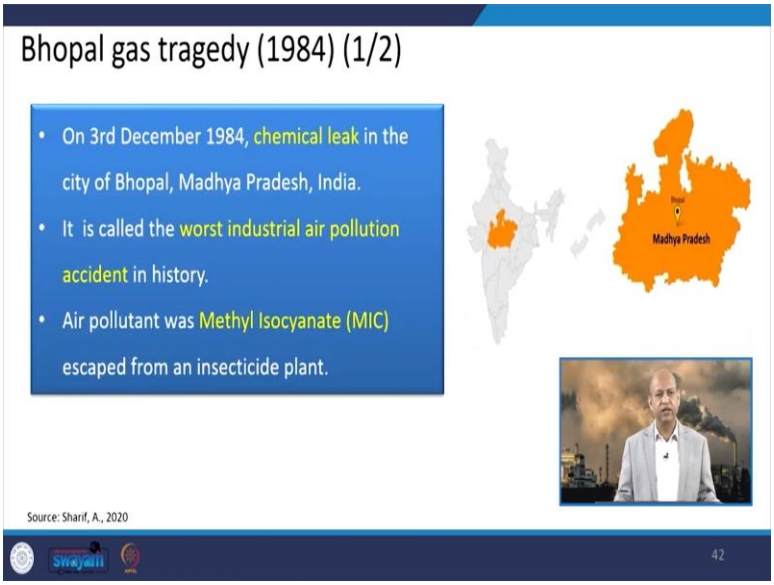

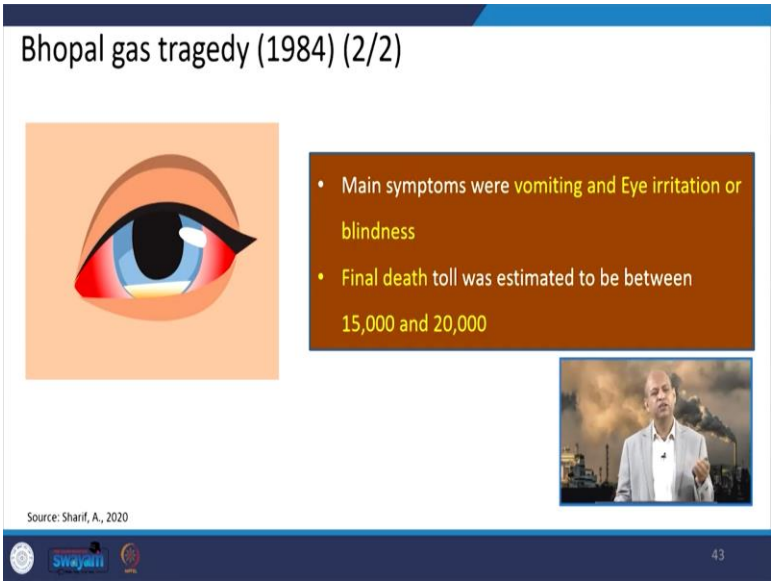

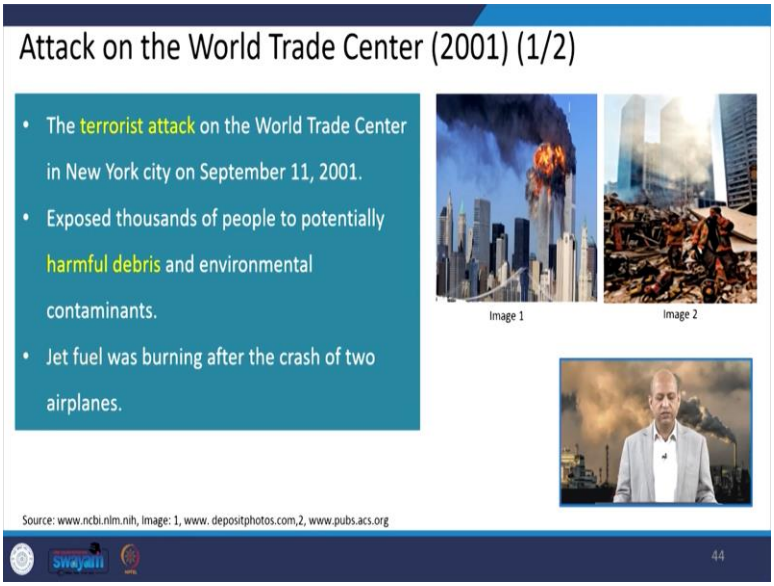

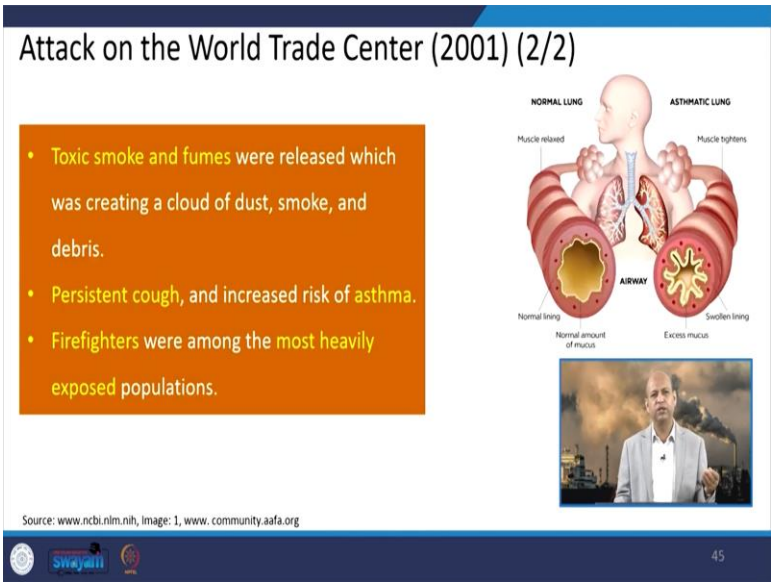

Then when we talk about Bhopal Gas Tragedy in 1984 in winter December month. So, this Methyl Isocyanate MIC this was released accidentally so because of this very high concentration of MIC the symptoms were like initially vomiting, eye irritation, etc., blindness, but later on a lot of people died around 15,000 to 20,000

Well attack on the World Trade Center so terrorist attack was there on September 11. And it exposed 1000s of people with harmful, debris and environmental contaminants and the jet fuel was burning after the crash of the two airplanes and other building material also caught the fire. So a lot of smoke and fumes were there and people were exposed to very high concentration of

air pollutants, fumes and toxic gases, dust, smoke, debris, etc., and firefighters were at the, very high risk.

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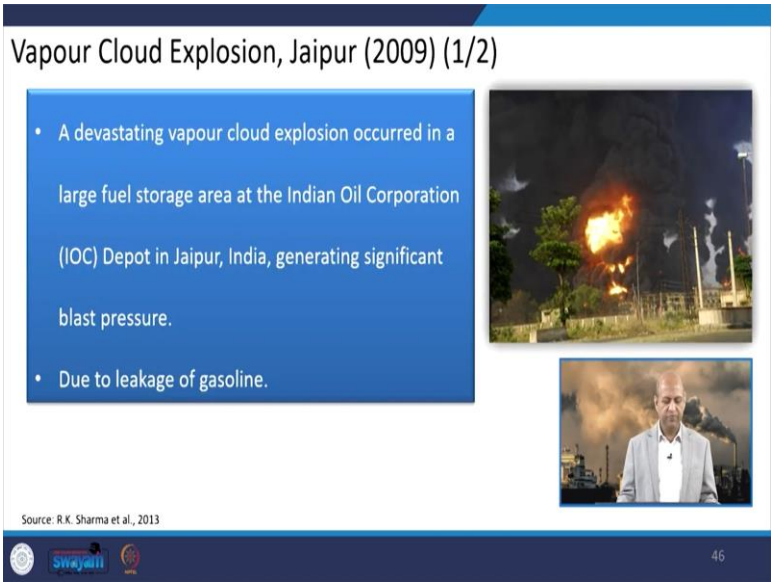

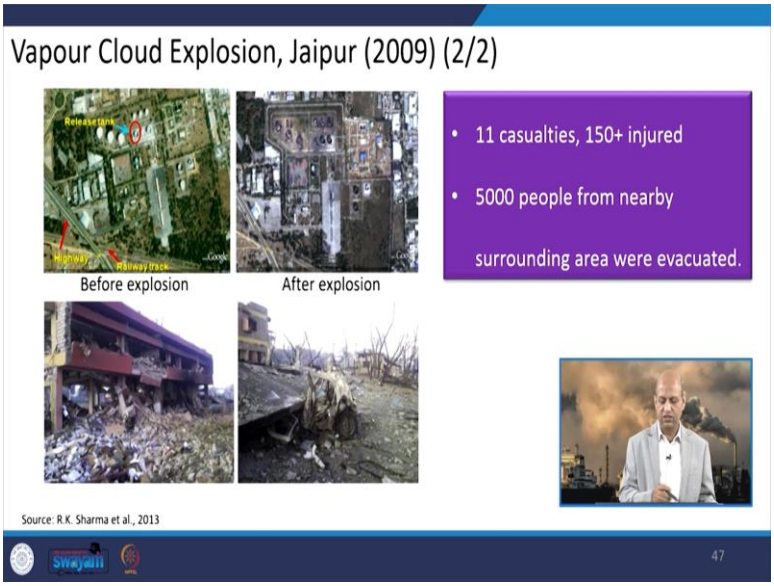

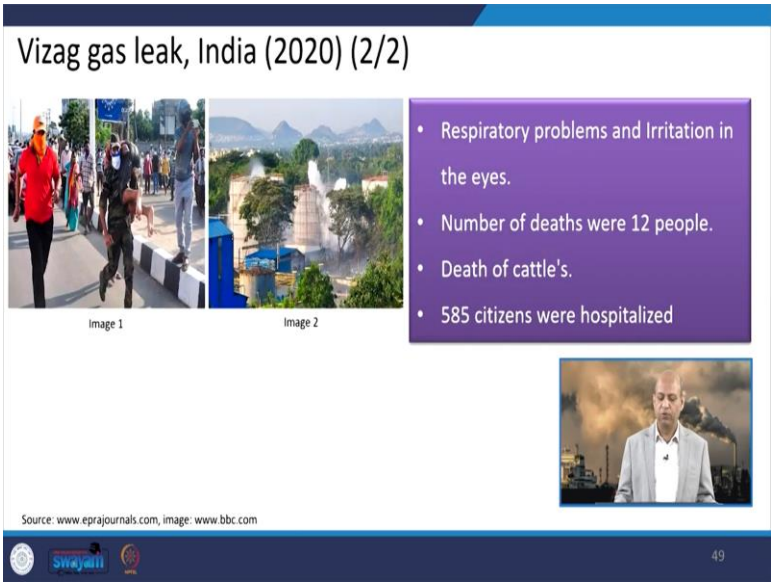

Vapor cloud explosion in Jaipur in 2009 it occurred because of large fuel storage area because of some leakage of the gasoline this occurred and the fire was there, explosion was there and then because of fire, a lot of pollution occurred, the fuel burned and you can see the impact. Around 11 people died, 150 people injured and 5000 people from nearby surrounding areas were evacuated because of this.

Then Vizag gas leak in 2020 so that is also like a release of Styrene vapor in the area. This resulted in respiratory problems and irritation in eyes and the number of deaths were around 12 people died and the death of cattle's occurred and 585 citizens were hospitalized.

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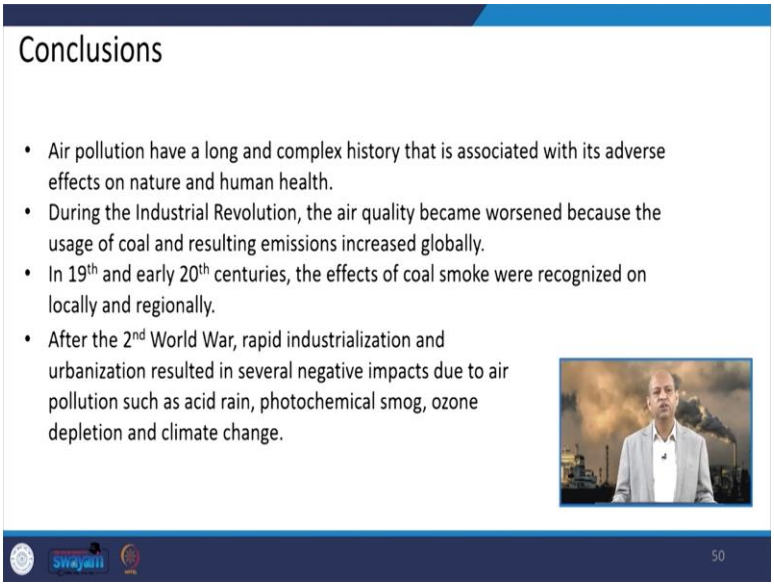

So in conclusion, we can say that air pollution has a long history, but complex also the history is very complex, and it is associated with the its adverse effects on nature and human health environment and ecosystems. And during the industrial revolution the air quality became worsened, because the usage of coal and resulting emissions increased globally.

And the 19th and early 20th centuries the effect of coal smokes were recognized on locally and at the regional level also. And after Second World War, rapid industrialization occurred, urbanization occurred, this resulted in several negative impacts due to air pollution such as acid rain, photochemical smog, ozone depletion, and climate change so, and all those issues are associated with air pollution.

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So, for today, this is all and these are the references you can go through to have more information about this introductory part of air pollution sources, and its history as well as its general effects. So, it is all for today and I will see you in the next lecture. Thank you for your kind attention. See you in the second introductory lecture. Thanks.