Air Pollution and Control
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Lecture 06
Impact of Pollution on Atmosphere, Soil and Water Bodies

Hello, friends, today we will discuss impact of air pollution on atmosphere soil and water bodies.

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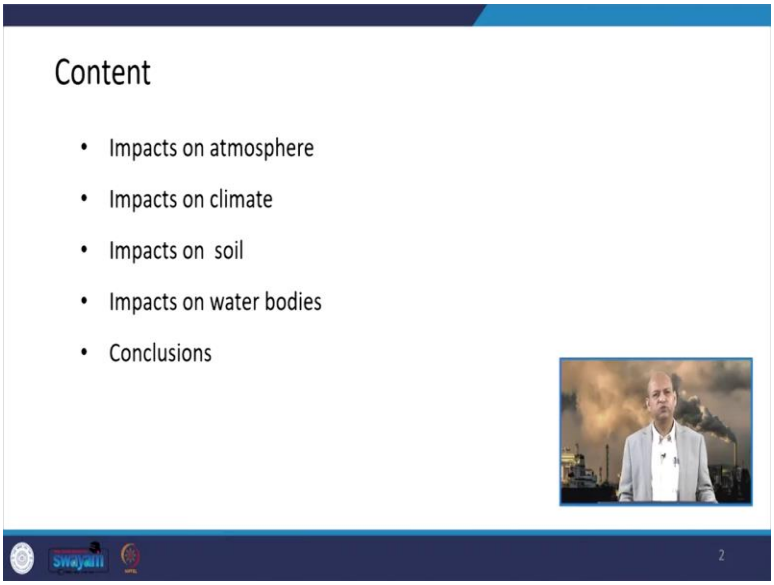

So this would be the content list of today's lecture, like impacts on atmosphere and when we are talking about impacts on the atmosphere basically we would also talk about impacts on climate because atmosphere and climate is interrelated through global warming effect induced by greenhouse gases and other issues of air pollutants.

Then we will also see impacts on soil because dry deposition or wet deposition through this process. Acidic pollutants interact with soil and they have negative impacts. Then we will talk about impacts on water bodies. Again, pollutants of different nature, basically the acidic content which can change the pH of water bodies, and on soil basically not only pH but those heavy metals also can take a toll on the soil quality. So that way we

will see the complete impact of air pollution on atmosphere, then soil, and water and climate.

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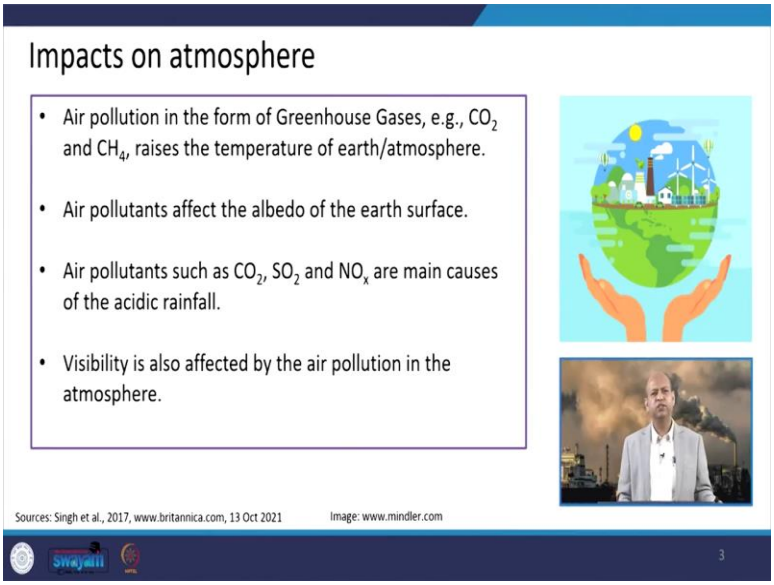

Well when we talk about impacts on the atmosphere, so the largest impact on atmosphere through greenhouse gases, frequently say that greenhouse gases strictly not air pollutants but there are air pollutants also which are also having greenhouse gas impact. So that is why clubbing with carbon dioxide sometimes we also talk about greenhouse gases as part of air pollutants, like methane. So this is a pollutant as well as it has greenhouse gas impact, or ozone which is also pollutant also has greenhouse gas impact.

So this greenhouse gas impact of these pollutants like methane or ozone along with the carbon dioxide, they have this global warming impact because they avoids, or it does not allow the wavelength, the longer wavelength radiation to go out from the earth's surface because as you know the short wave radiation comes to the earth surface and it is absorbed by earth's, and then when earth radiates back the long wave radiation or infrared radiation.

So if these greenhouse gases are there, they capture it. They capture it. And because of capturing this temperature rises of the atmosphere, and of entire earth’s surface. Then air

pollutants influences the albedo of the earth's surface. Albedo, we will see, like reflectivity, because of air pollutants the reflectivity also gets changed.

Air pollutants like sulphur dioxide or NO_X and of course, CO_2 is always there in the atmosphere, they also cause certain impacts which is known as acidic rainfall. So acid rain is contributed by NO_2 or oxides of nitrogen and oxides of sulphur. Visibility is also an issue. When aerosols are there or smog is produced by different kinds of air pollutants then visibility is reduced of the atmosphere, and it has several negative implications which we will see later on.

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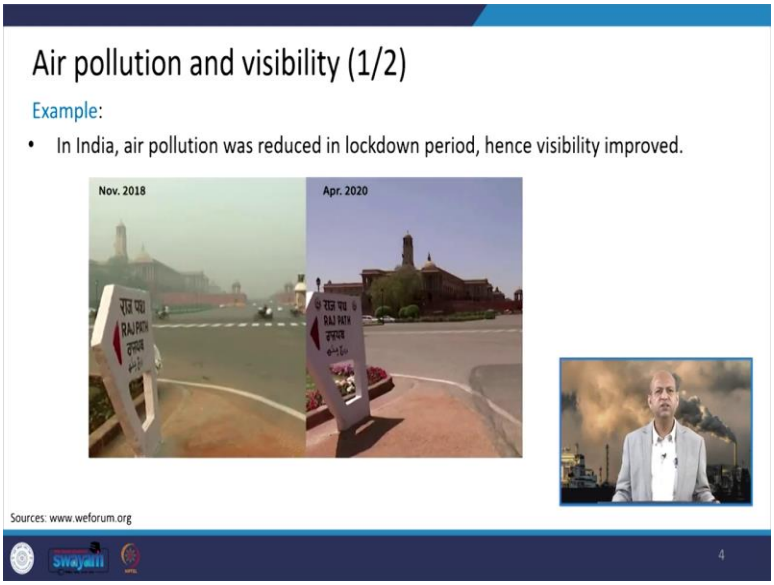

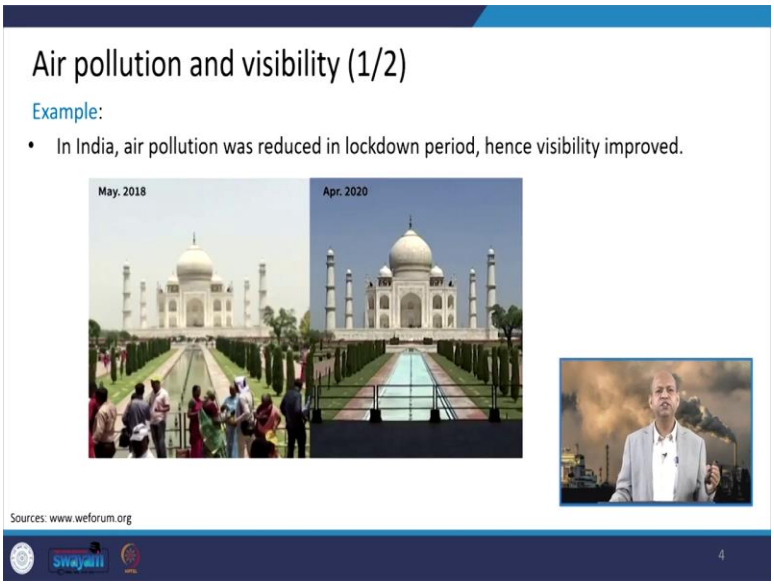

You can see here, the air pollution and visibilities relation. Those periods when air pollution was high, so what was the visibility of, like you can see a particular place in Delhi, Rajpath. So November 2018, and you can see April 2020. So before lockdown and after lockdown, you can see the clear cut visibility related issue even in Taj Mahal also. So 2018 and 2020, these are the two very short videos which can easily give you the realization that how this clean air really helps us to have greater visibility.

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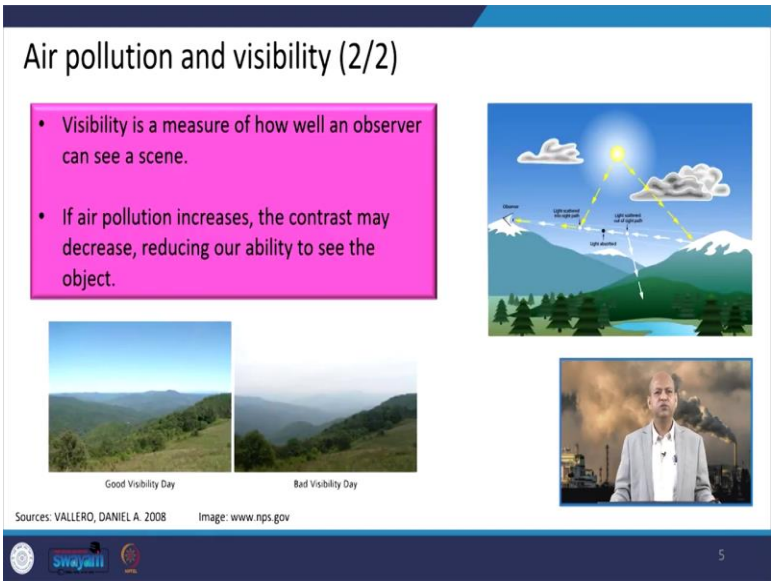

Well, the visibility is basically a measure of how well we can see or observe an object or scene around us. So if air pollution increases, the contrast decreases. Contrast really helps us to see an object clearly. So when contrast is reduced the abilities to see the object clearly also reduces.

So you can see here, this, if there is a visibility issue then this kind of scene, the same place if atmosphere is clean then you can have very good scenic beauty. So aesthetic beauty or scenic beauty is dependent upon the clarity of the atmosphere. And that is dependent on pollution. If pollution is more clarity is reduced, contrast is reduced because of this scattering of sunlight etc.

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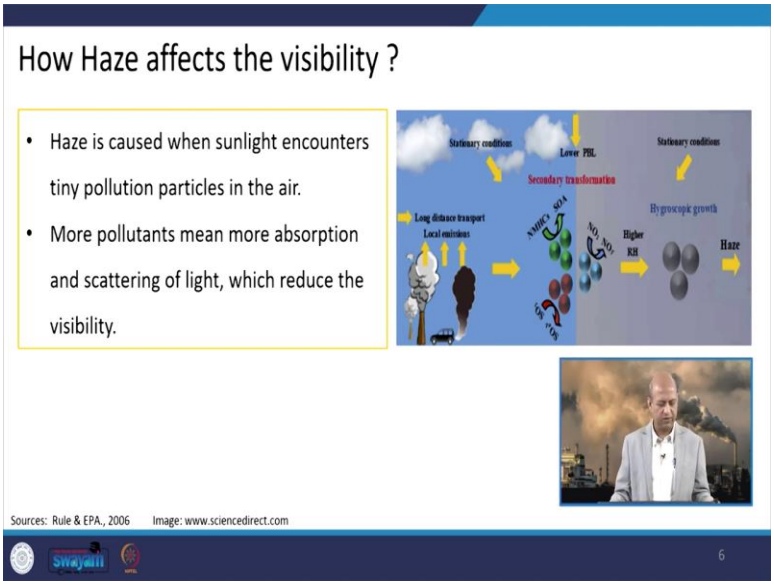

And then, this haze effect is also there on the visibility. So haze is basically caused due to sunlight. When sunlight encounters tiny pollution particles they have this scattering effect. And then more pollutants are there so more scattering of light happens. So this reduces the visibility. So you can have these tiny particles which can contribute in reduction of visibility.

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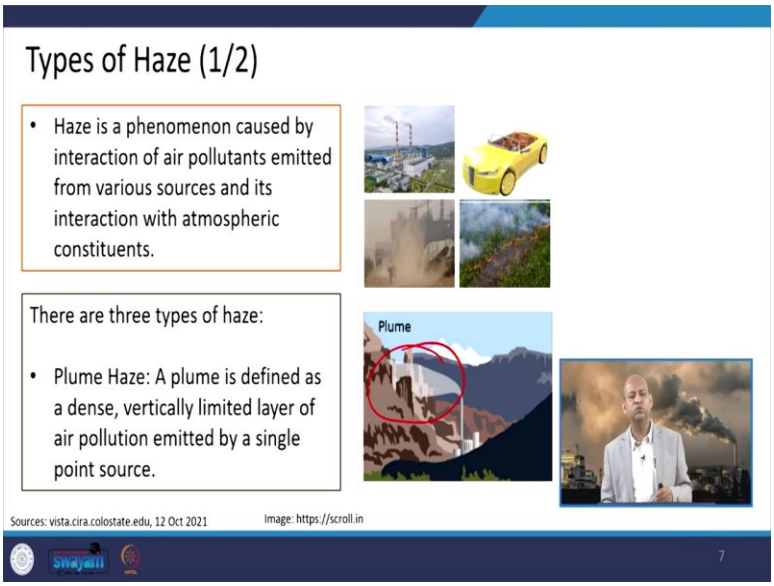

Well, there are several types of haze, basically. And haze is caused by interaction of these pollutants which are coming out of various anthropogenic sources or natural sources also and then they interact with atmospheric constituents. So when this man-made activity like industrial activity, power plant etc and plume is coming out of a stack, so within the dispersion of plume in that area visibility will be reduced.

So it is called as plume haze. This much area only where this plume is passing through, haze will be created because of this scattering of light because this plume has lot of particulate matter.

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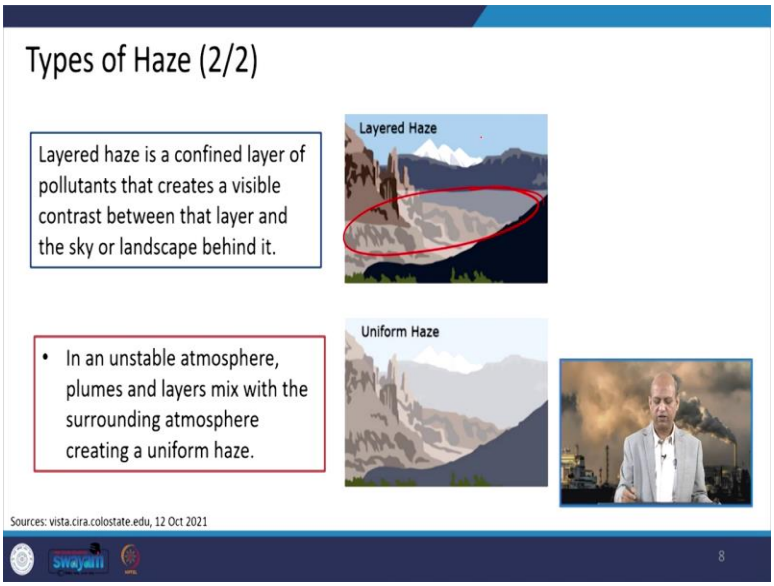

Then there is this layered haze. So in layered haze because this contrast reduces and there may be one clarity related layer and reduced visibility related layer. So in that layer where this visibility is reduced significantly we call it layered haze. And in upper layer you can have better quality of the visibility and even lower also it can be there, greater visibility.

Then there is uniform haze. When the pollutants are dispersed properly, uniformly, and the whole atmosphere get affected in our range of the visibility, then this is the uniform haze. And the whole atmosphere is having very reduced level of visibility. We cannot see properly in the air.

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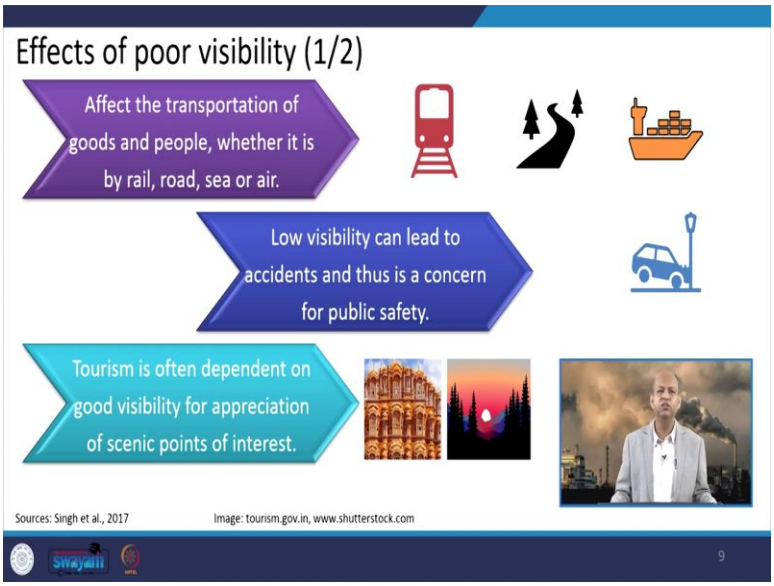

When we talk about the visibility then we also talk about negative impacts of the visibility. Because this transportation of goods, or people from different kinds of vehicles railroads, air traffic etc they are affected by reduced visibility. When dense fog is there then it is difficult to take off and landing of the flights.

Similarly speed of the rails gets reduced, you cannot see properly at good distances, and several safety issues emerges because accidents may happen on the roads when the visibility is very poor and you cannot drive your vehicle at the proper speed because you cannot see properly at larger distance.

Then even if the visibility is an issue at the tourist places where people try to see sunrise or sunset or they want to enjoy the sight scenes, so if visibility has an issue then they cannot enjoy that aesthetic beauty to full extent. So that is also one more negative impact, you can say.

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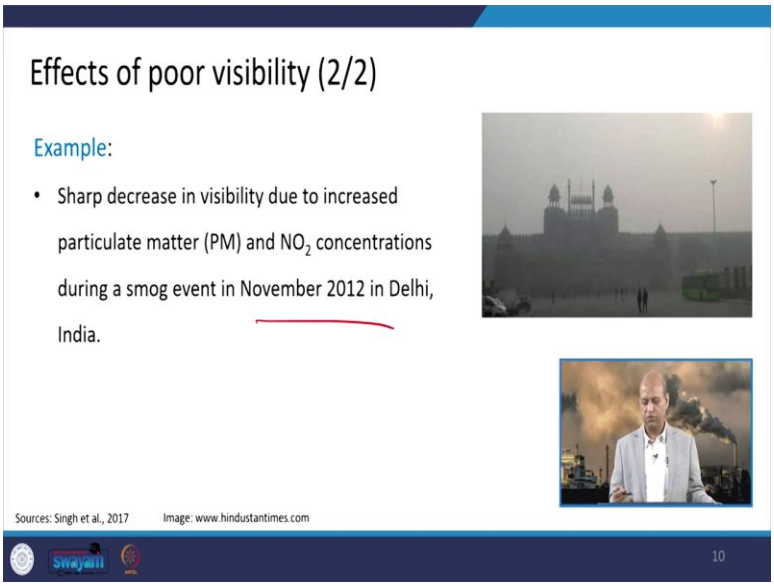

And this is one example. You can see the sharp decrease in the visibility due to increase in particulate matter and oxides of nitrogen in Delhi in November 2012. So this was the picture you can see. Very poor visibility. And it was take, may be taken, this picture was taken quite at the near distance but still, you cannot see properly. You cannot enjoy the scenic beauty or aesthetic beauty of that particular place.

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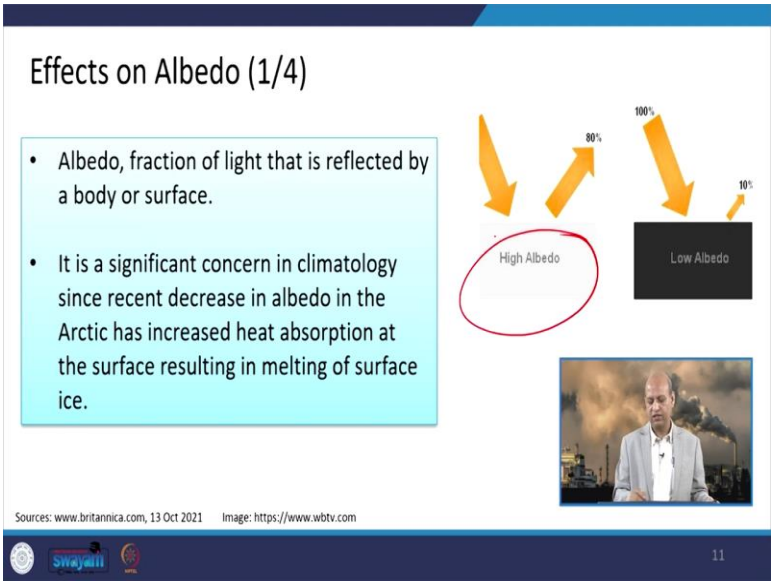

Then there is this issue of effects on albedo. So albedo is basically the fraction of light which is reflected by a body or surface. So this reflectivity is influenced by particulate matter and air pollution because that surface is basically either damaged or it, the enhanced, the reflectivity may be enhanced depending upon the physicochemical characteristics of aerosols.

So basically when this albedo is decreased then absorption of sunlight increases, and temperature increases. So one negative impact is related to arctic ice. Because of pollution its albedo is reduced means the reflectivity is reduced and heat is being absorbed. So because of that surface ice melts. And this increases a kind of vicious cycle because surface ice melts then rough surface is there to absorb more, this solar radiation and to increase the heat content.

Here high albedo means like, very reflective surface. So 80 percent solar radiation is reflected. When low albedo is there because of soot or carbon particles etc, then the whole light is absorbed, only 10 percent is reflected. So those kind of pictorial representation is there.

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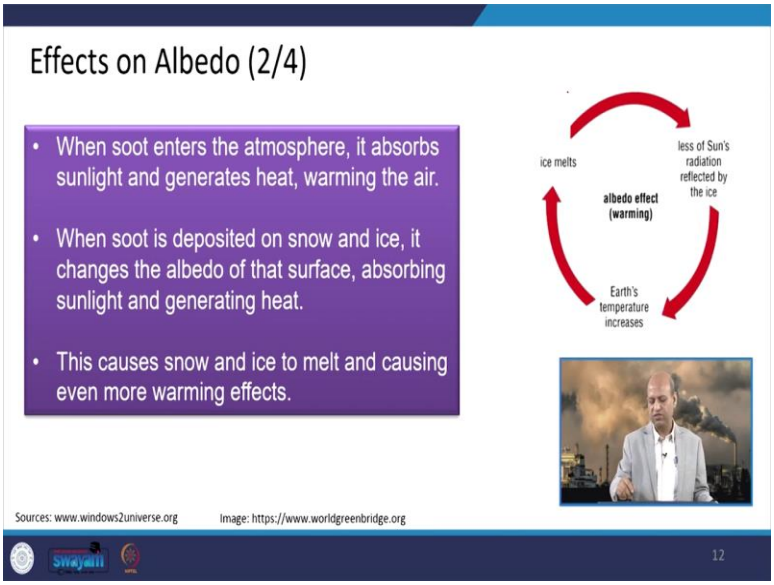

So as I said that because of this soot particles or those particles which can absorb sunlight, then it can generate the heat and it can warm the air. And when soot is deposited

on snow or ice it changes the albedo because its reflectivity is affected, and then it absorbs the sunlight and it generates the heat, and then it causes the melting of snow and ice and more warming effect, as I said, because of this vicious cycle kind of thing. More ice melts, then more surface is out to absorb the heat content and the heat and temperature rises.

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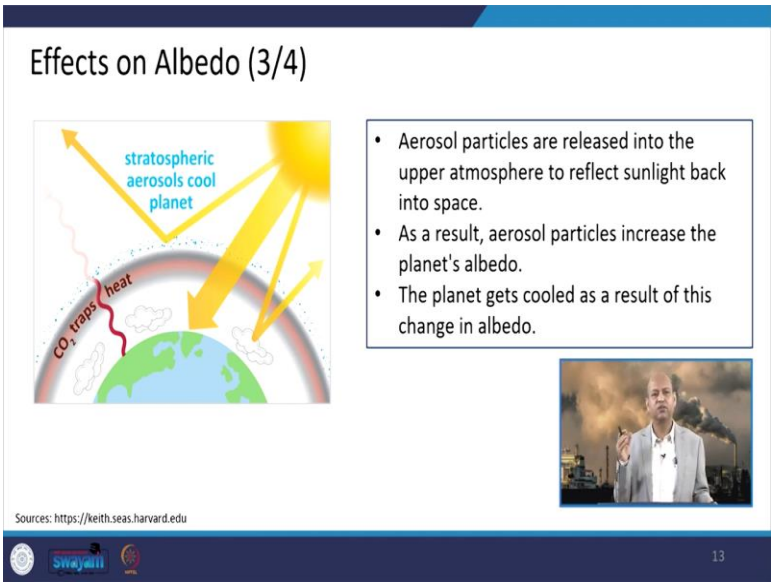

Here you can see, the aerosol particles which contributes into affecting the albedo. So there are particles like sulphate particles or sea salts etc, they are reflective in nature. So they can reflect and they can have cooling effect. They can reflect the sunlight or solar radiation into the space and, but the other aerosols which have carbon aerosols or carbon particles, soot etc they absorb the light and they increases the heat content or they generate the warming effect.

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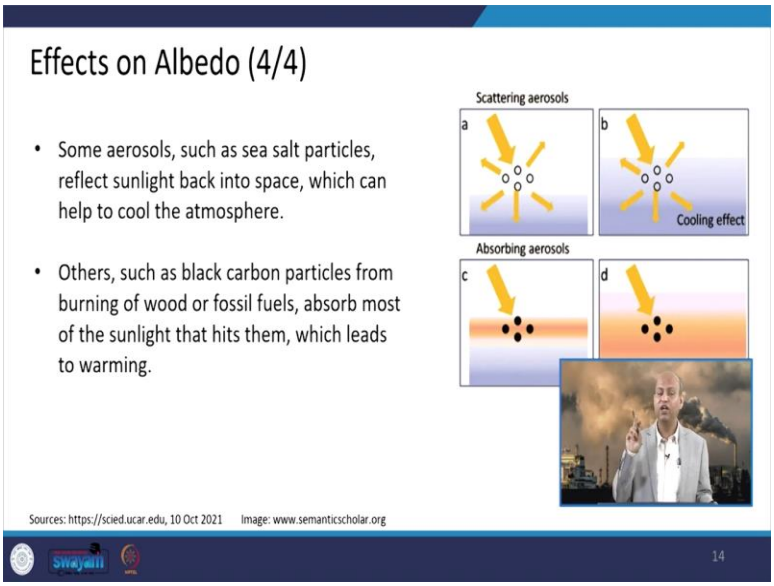

So that is why these are the scattering aerosols, which are light in color. They reflect lot of this solar radiation. So they cause the cooling effect in the temperature. And those, the carbon particles, etc, soot etc, they absorb the light and they have the warming effect. So aerosols can have both effects depending upon their physicochemical characteristics.

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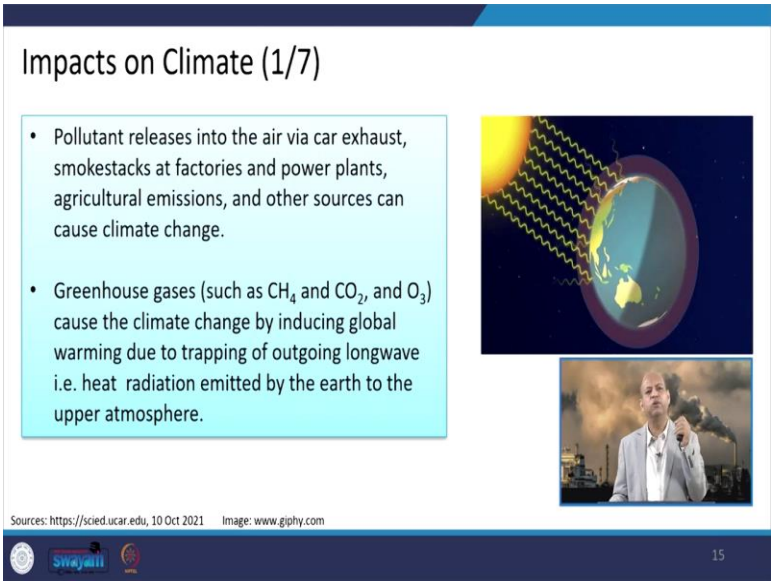

Then if you talk about impacts on the climate, as you know the climate is basically governed by this solar radiation. So because of this disturbance in solar radiation through

albedo as well as through go this global warming effect, because of greenhouse gas contained in the atmosphere this can change the climate, and climate can change the temperature as well as the precipitation patterns also. So those are the impacts related to the climate, that it can change the heat radiation or it can change also the precipitation patterns.

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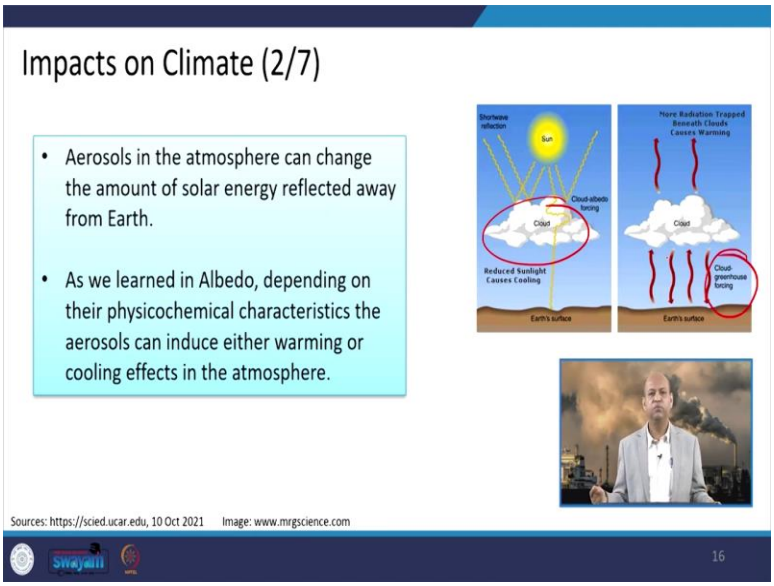

So you can see here, like these, the reduced sunlight causes cooling effect because of those particles or aerosols which are reflective in nature, and then if lot of cloud formation is there then water content is there then the earth surface get this greenhouse gas effect more because warming effect is there because of clouds, clouds act as the, this blanket kind of thing. So albedo has a lot of change or role in changing the climate along with the greenhouse gases.

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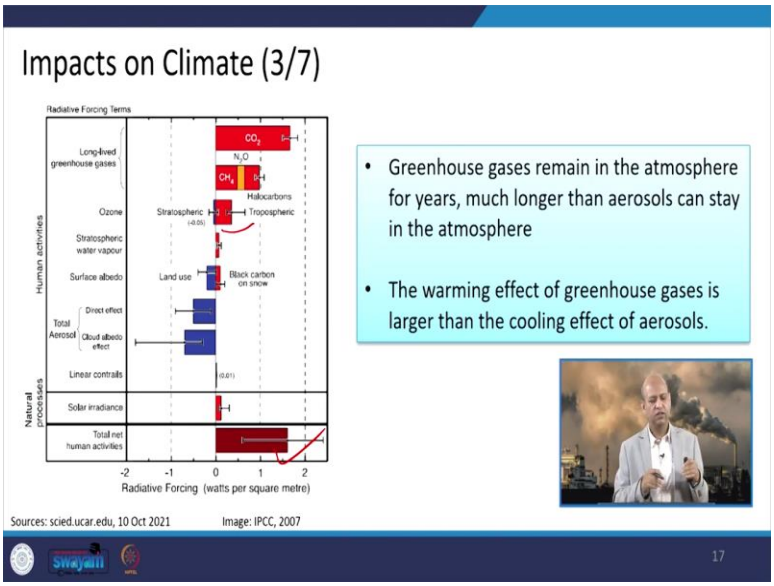

And this is a very good picture. You can see here radiative forcing is depicted because different greenhouse gases as well as natural phenomena and particles. Here CO_2, you can see the highest greenhouse gas impact or radiation impact of CO_2. Very positive. Then methane also has, in stratosphere this ozone has cooling effect in the stratosphere, but positive effect or warming effect in the troposphere.

Similarly this surface albedo, so black carbon on snow, they have positive impacts but in the land use you can have this negative impacts plus the total aerosols you can have the direct effect and cloud albedo effect. So they are the negative in the sense because they are reflecting the solar radiation so they are having the cooling effect.

Then lot of effect of greenhouse gas as well as in totality we can call the total impact is positive. Total impact is positive because this cooling effect you can minus and you can add all these positive impacts. So ultimately the, there is this impact on the climate or radiative forcing because of greenhouse gas and particles, the net result is positive. That means it will warm the atmosphere or the surface earth, earth's surface.

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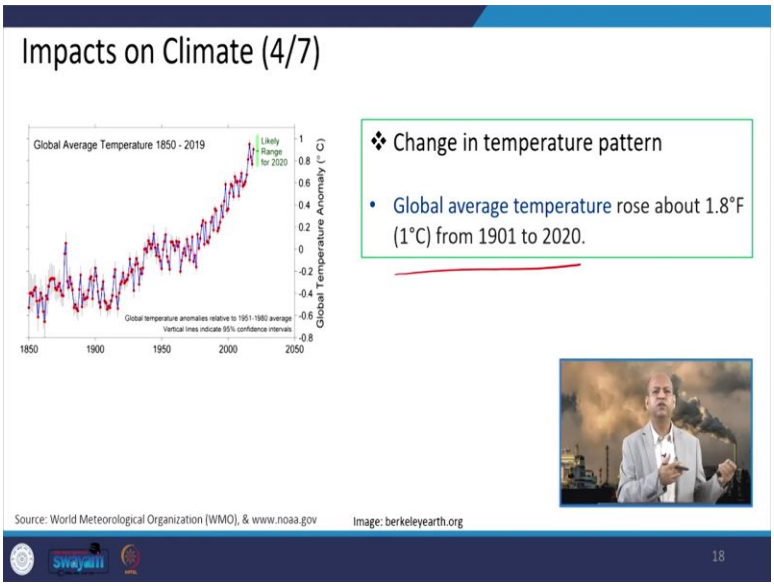

And when we talk about this change in the temperature pattern, so from this 1850 to 2050, this kind of hockey stick curve you can see here, so the temperature is increasing. So you can relate it with the industrial era. When this industrial revolution started then emissions of greenhouse gases especially CO_2 etc also increased and accordingly the temperature, overall temperature has increased.

And now the temperature rate increase has rapidly enhanced because of high concentration of greenhouse gases. And now you can see 1 degree Celsius from 1901 to 2020. This much rose this temperature between these 120 years, you can say. So that is a very rapid increase of temperature if you look into the context of several hundreds or thousands of years.

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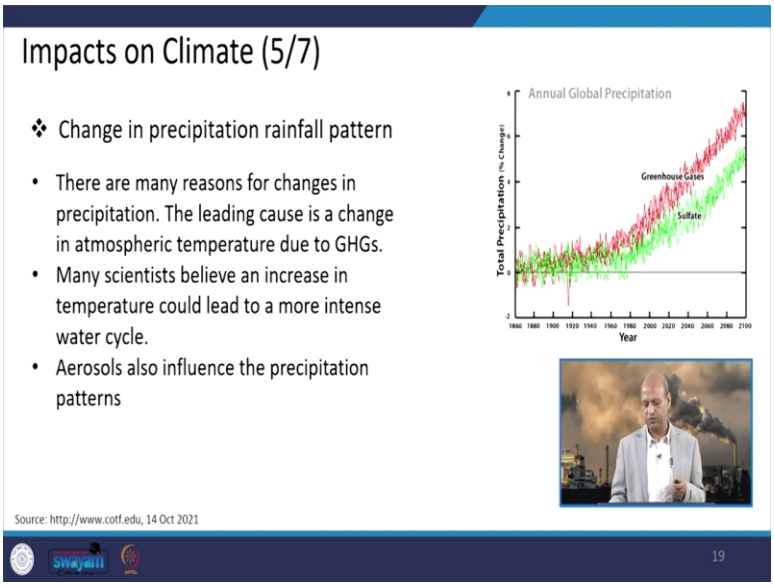

Well, the change of precipitation or rainfall is affected by climate change because of temperature change as well as change of the, these aerosols. Because aerosols have of different size and shape. Small aerosols, like they result into small droplets because they cause like nucleation for condensing of water vapor. So cloud formation because of very small particles tiny particles, so small aerosols, so that will hang around. It will suppress the precipitation.

So there are studies which show that because of these small particle emissions precipitation can be suppressed, but at the same time then if sizes of the particles are more they can enhance the precipitation. So that kind of two way effect may be there depending upon the, this aerosol size. But greenhouse gas impact because of this global warming, this temperature change, it can has this positive effect on the precipitation.

So it has been realized that this precipitation intensity will increase, and you can see, several times storms, this thunderstorm is increasing, at several places very high intensity rains occur. So these are the part of the climate change issues. And here the patterns of aerosols because of sulphates and greenhouse gases on the precipitation has been shown, relationship.

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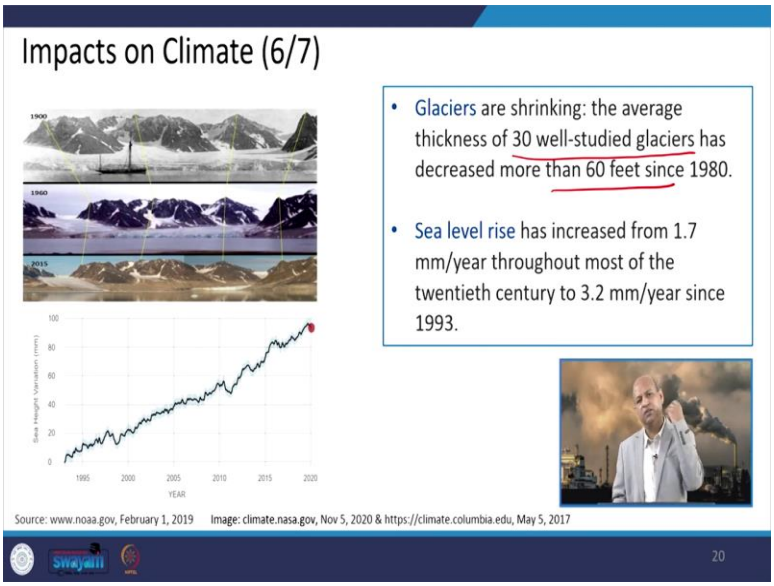

When we talk about these glaciers, because aerosols has deposited on the glaciers and they are having this trapping of the heat and that is why the thickness of 30 well-studied glaciers has decreased more than 60 feet since 1980. So its a huge, big issue in that sense because there are so many rivers which are fed by glaciers. If glaciers recede it will impact the complete water cycle and our irrigation patterns and availability of the water, all those things.

Similarly, at the same time when glaciers are receding, they are giving more water to the rivers etc, so the more water is going to the sea and sea level is also rising. And you can see this, around 1.7 millimeter per year throughout most of the 20th century this has been observed because of this global warming impact on the sea levels. And 3.2 mm per year since 1993. So the rate of increase of sea level has also increased. And that will have very negative impact on coastal cities and island countries, and all those issues are there.

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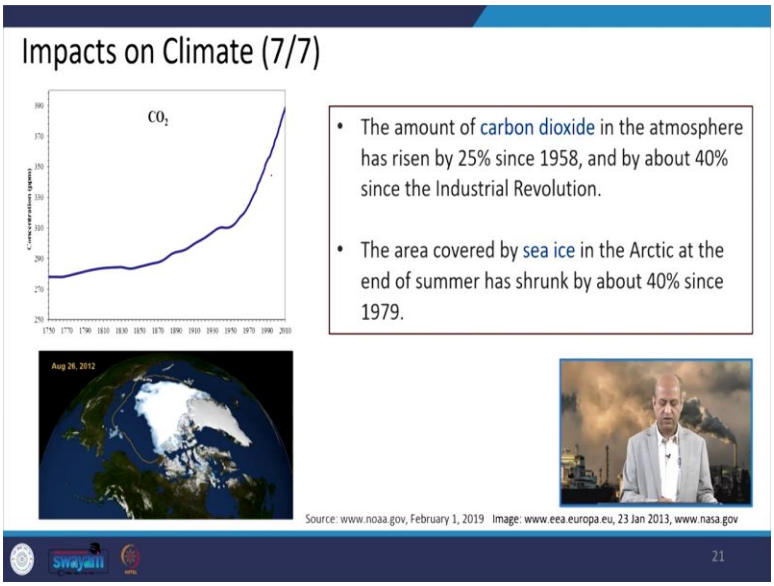

Well, when we talk about this carbon dioxide in the atmosphere which has risen by 25 percent since 1958 and about 40 percent since the industrial revolution, and this has also related to this ice cover. The area covered by sea ice in the arctic region at the end of summer has shrunk or decreased by about 40 percent since 1979. So this is a very worrisome issue.

So CO_2 is increasing and this surface area covered by the eyes in arctic is decreasing. And this is not only a very simple association of the concentration of CO_2 and receding area of the ice cover on arctic, but there are well established facts, scientific facts and scientific studies which really relates the greenhouse gas impact through global warming on glaciers as well as on sea levels etc.

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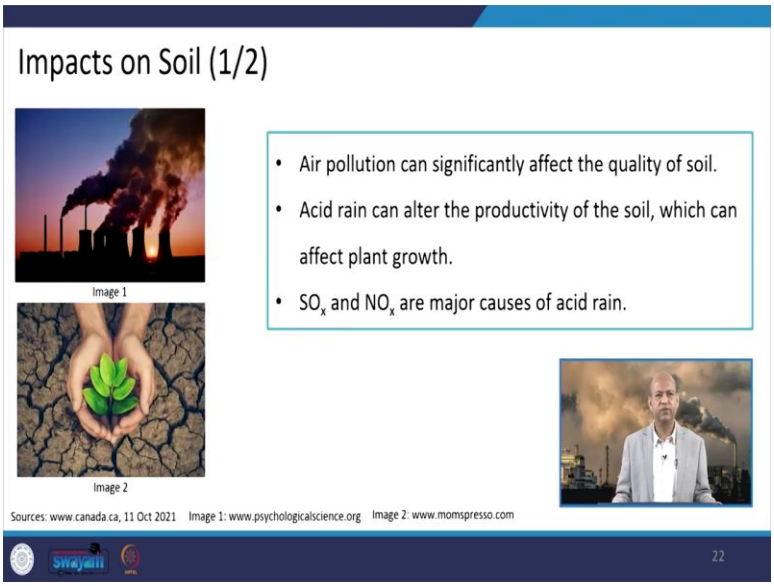

Well, so now we can talk about like impact on the soil. We have seen the impact on the atmosphere and climate because of this air pollution, and air pollution is associated not only these toxic pollutants which we have discussed on, like negative healthy effects, but there are also greenhouse gases along with the air pollutants and they impact the atmosphere and climate.

Now we can see what is the impact on the soil. So air pollution they can also affect the quality of soil because of dry deposition and wet deposition occurs, and this acidic rains occur and the productivity of soil can be affected because this will change the pH level of the soil when lot of NO_X and sulphur dioxide are deposited through acid rain on the soil.

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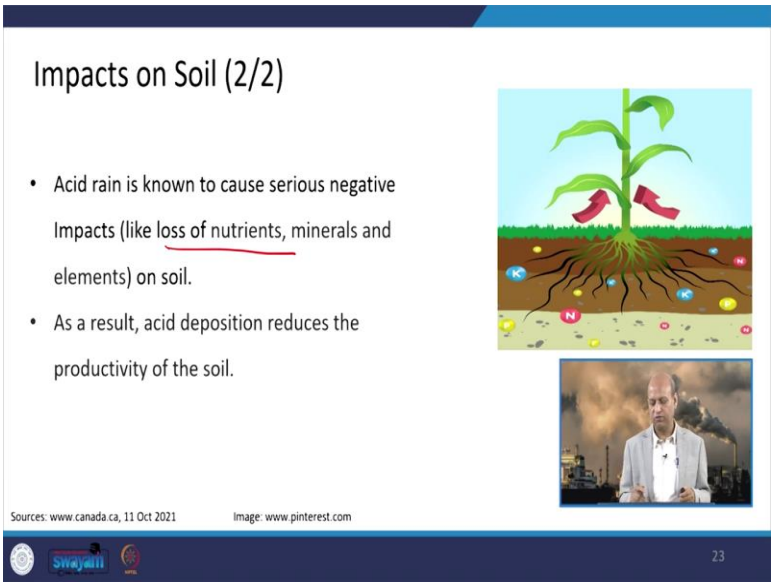

So you can see here, acid rain, this can have the detrimental effects on the soil through, like loss of nutrients or loss of minerals and the elements which are required for the proper growth of the plant. And then as a result this acid deposition reduces the productivity of the soil. So total productivity is reduced and even soil can be unfertile also after some time if we do not really do some helping hand for revitalizing the soil.

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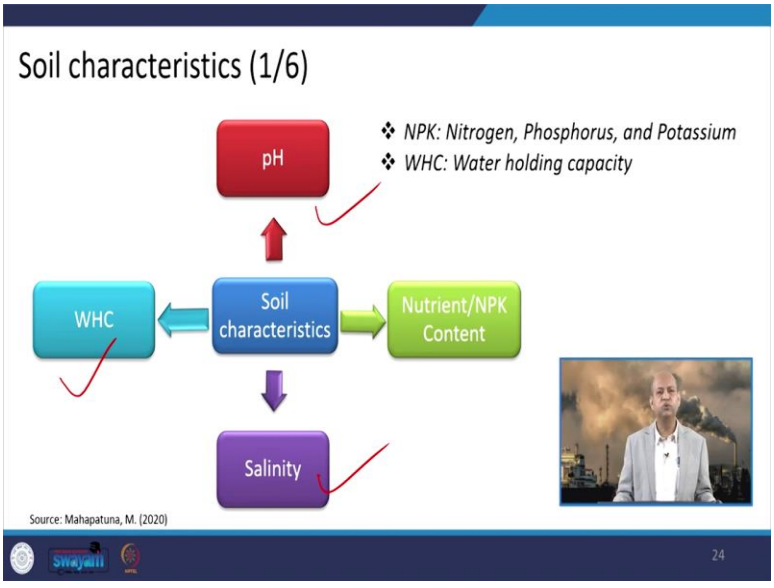

Then if you see the characteristics of the soil which are important for plant growth etc, like pH level or this water holding capacity, salinity, nutrient or nitrogen phosphorus, potassium content, all these are the, like you might have heard about, like government of India is issuing soil health card to farmers.

So these are the things if you see if they are in the real balancing then the plant growth occurs very nicely, otherwise if they are disturbed then growth is reduced. It affected negatively. So because of air pollution all these factors can be affected negatively.

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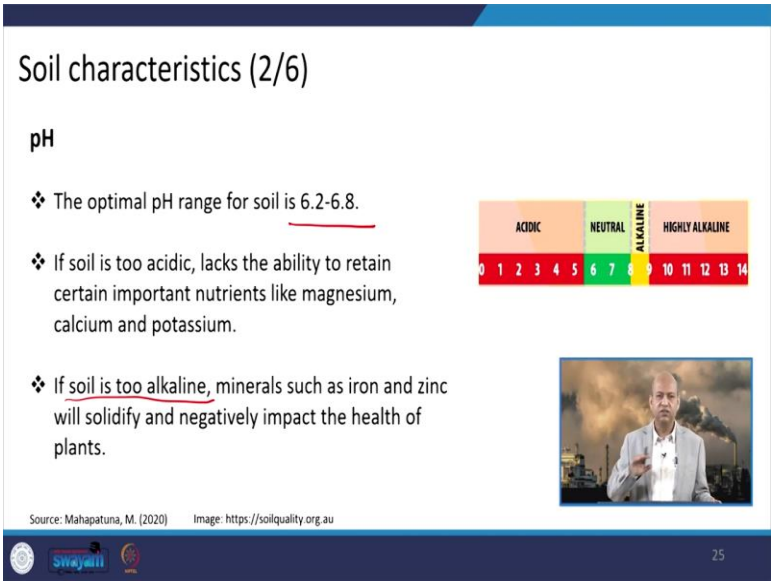

For example pH level so the optimal pH range is right like 6.2 to 6.8, and there is the range acidic neutral and highly alkaline. All these, then, if soil is too alkaline then minerals such as iron and zinc will solidify. So because of pH level many things may happen. Its ability to retain some nutrients like magnesium and calcium, potassium, they reduces because of acid rain.

And similarly if alkalinity increases because of changes in the pH levels of the soil because of certain pollutants then can also, it can impact the iron and zinc, the concentration of iron and zinc which is also very important nutrient for the plants' growth.

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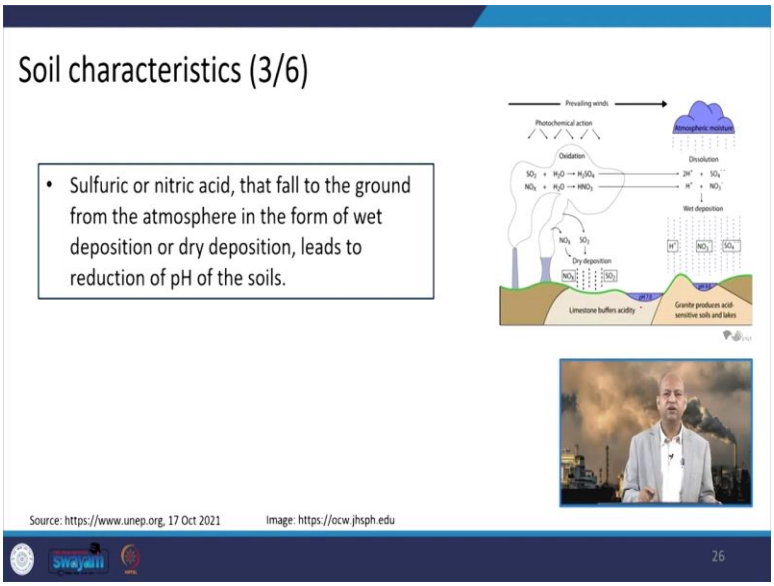

Soil characteristics, in terms of like, you can see these emissions of NO_X, and SO_2 etc, they come through dry deposition or bad deposition and it can reduce the pH levels of the soil.

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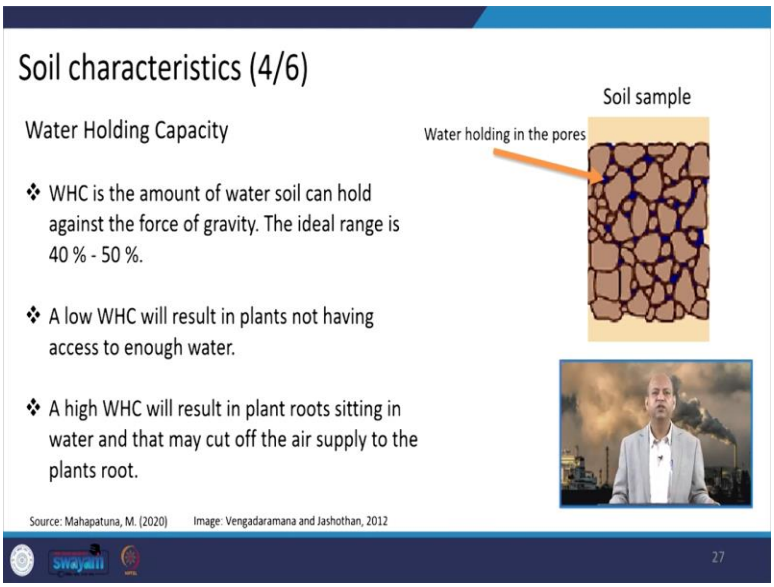

So, then another is part in terms of water holding capacity. This can also get affected because of interaction of soil with the air pollutants. So its holding capacity for the water,

it can be reduced or it can be enhanced depending how this chemical composition of soil is affected.

And both way, if the holding capacity water holding capacity is reduced, then drought may occur or it may not give the proper water to the roots. Similarly if lot of water is hold by the soil then again the roots sitting in water that can be damaged and the supply of nutrients becomes less in that term because roots will be damaged if a lot of water is there.

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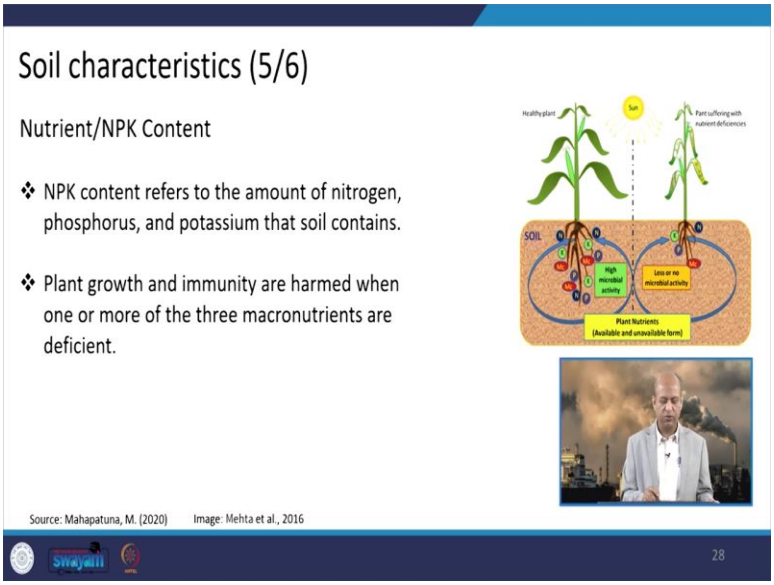

Then if you talk about like nutrients value nitrogen, phosphorous and potassium etc, so because of oxides of nitrogen the nitrogen imbalance may be there and that can have some impact on this soil quality and the plant growth because its immunity and the plant growth is harmed when one or more of the three micro nutrients are deficient or the imbalance occurs. So there must be some balance.

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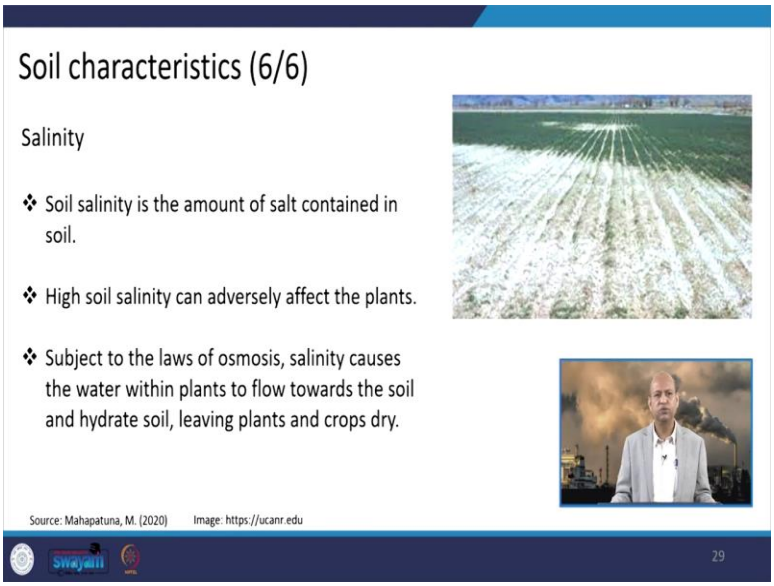

Well, salinity is also an issue. So soil salinity is the amount of salt which is contained in soil. And high soil salinity can adversely affect the plant growth. So it subjects to the loss of like osmosis. And salinity causes the water within plants to flow towards the soil when higher salinity is there.

So it can hydrate the soil and, leaving the plants and crops dry because that water will flow towards the soil because of this salinity. So if salinity increases because of air pollutants so negative impact on the plant growth can happen.

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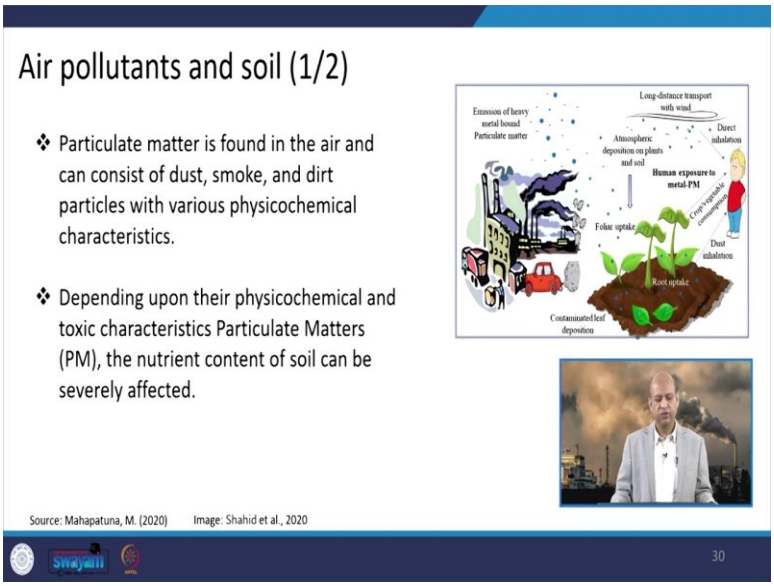

Then here you can see this particulate matter and they can change the physiochemical characteristics because particulate matters, several pollutants as coated ones, sulphates etc. Then depending upon physiochemical and toxic characteristics of particulate matter, the nutrient content of soil can also be affected. So in that way the total growth can be affected because of these air pollutants.

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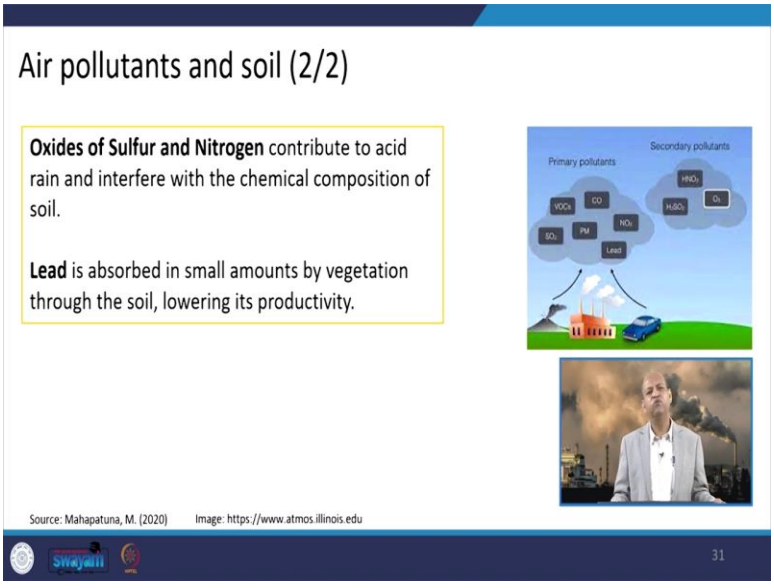

And then oxides of sulphur and nitrogen, as we have seen because they contribute in acid rain, and this like lead is absorbed in small amounts by vegetarians, vegetation through the soil so it can also lower the productivity. So heavy metals and these acidic depositions etc, they will cause harmful effect on the soil quality. And then it will be translated into negative impacts on the plant growth.

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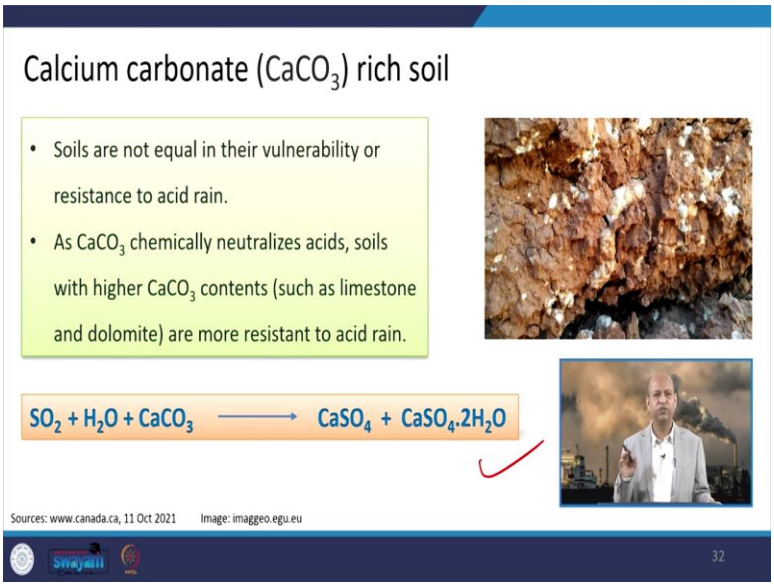

When we talk about, like calcium carbonate rich soil, then the negative impact of acid rain can be reduced because this carbon, this calcium carbonate acts like a buffer zone. It absorbs this acidic content through this reaction and that way the soil has kind of less vulnerability, or more resistance to acid related negative impacts.

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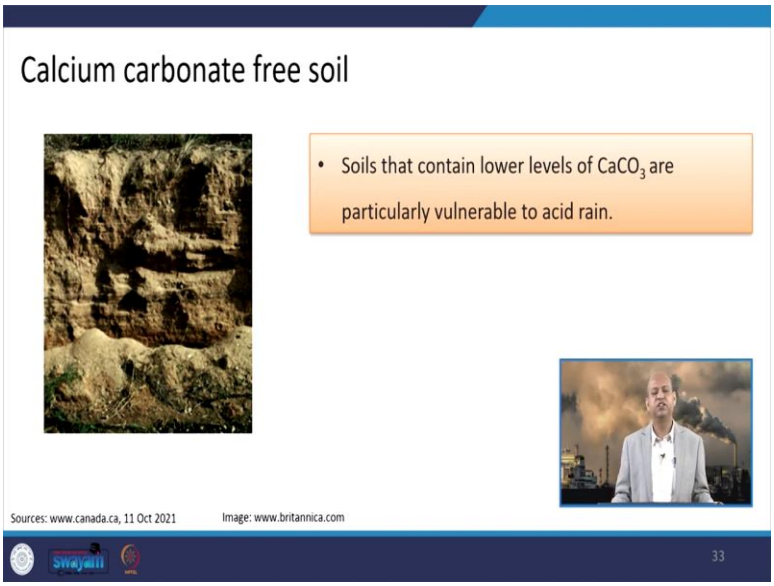

But if soil is not having this calcium carbonate that soil is basically affected severely by this acid rain, and its quality becomes very low and the nutrient capacity and enriching capacity to plants decreases very severely.

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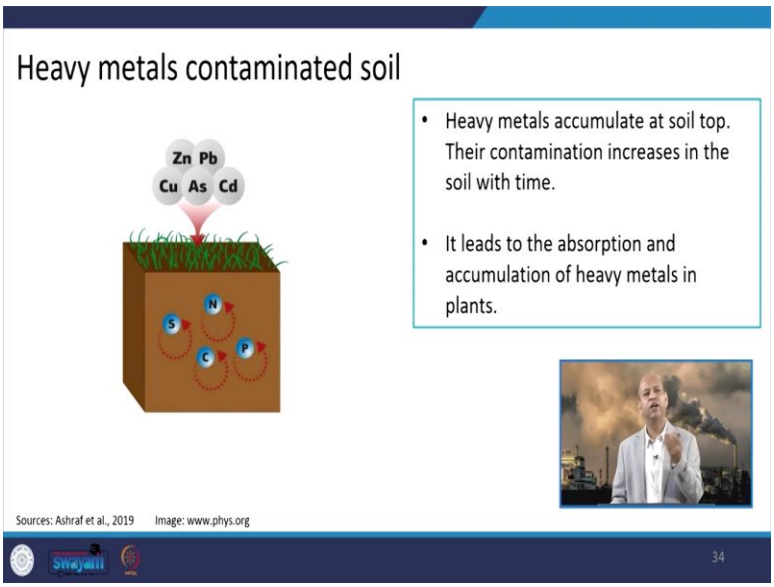

When we talk about heavy metals, they also accumulate in the soil top because of this dry deposition of the particulate matter and because of wet deposition also at the same time. So the increases in, in its concentration and it is absorbed and accumulated in the plants

also. And that way plants becomes unhealthy and when this plant is eaten by animals or it goes in the diet of human beings then it is also dangerous because of bio accumulation of heavy metals.

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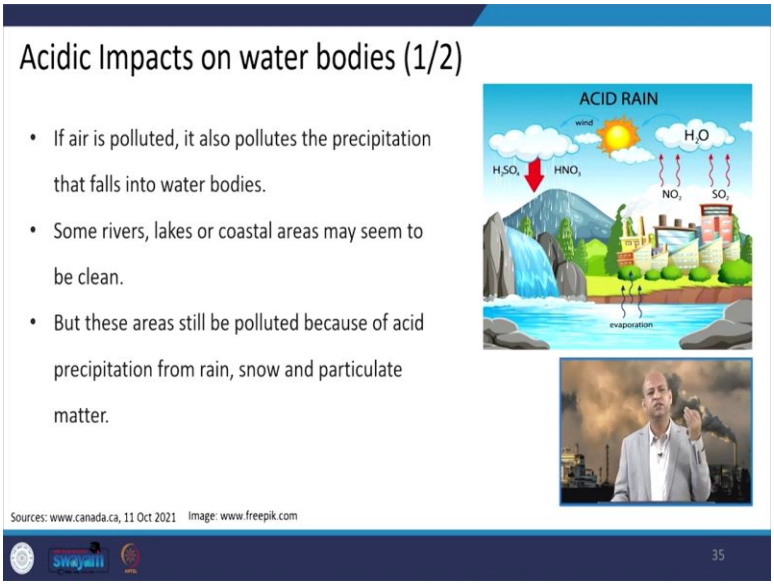

Now, we talk about negative impacts of acidic nature of precipitation to the water bodies. We have already discussed impact on atmospheric climate and soil, now on water bodies. So again, because of this acidic deposition of this nitrogen oxides and oxides of sulphur this pH of the water gets changed.

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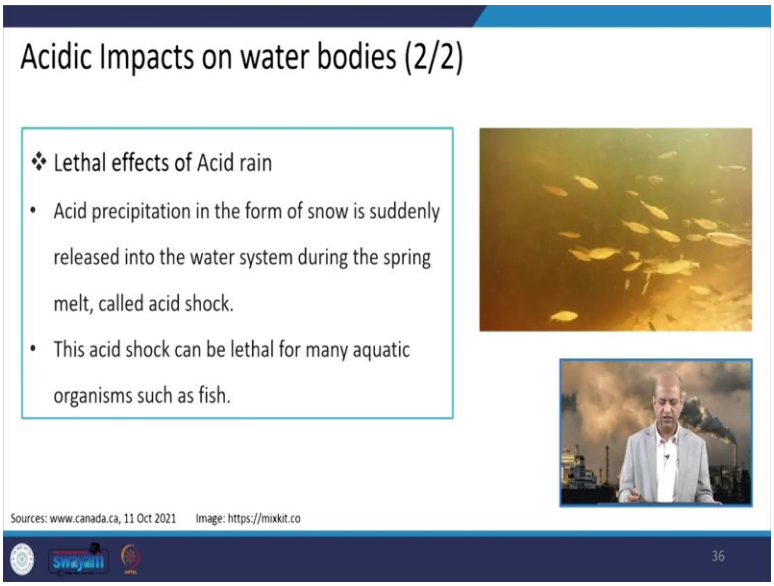

And when pH is changed, it can affect this, the aquatic life like, lethal effects may be there. For example acid precipitations in the form of snow is suddenly released into the water when in, during the spring period. And this gives the shock to the fish because this pH level drastically decreases suddenly, and they cannot survive in that particular environment.

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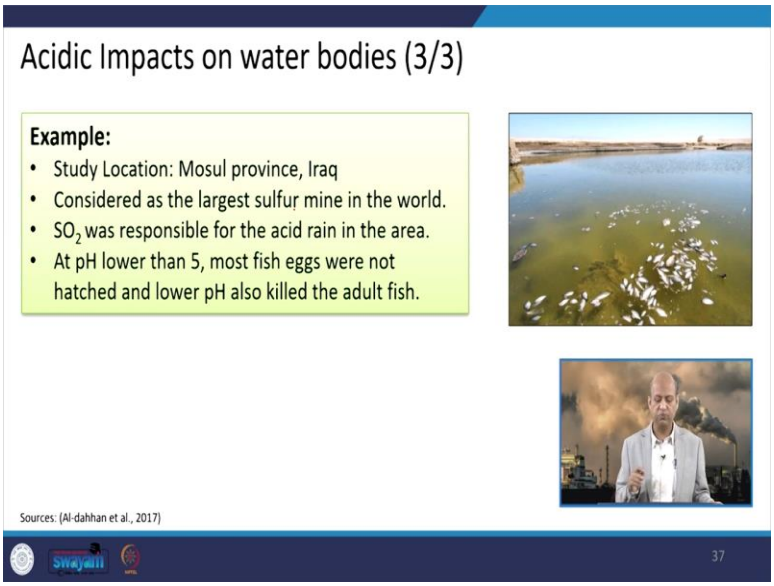

There is one more example to illustrate this particular concept, like in Iraq, at a place this Mosul province, it was considered the largest sulphur mine in the world. And this SO_2 was responsible for the acid rain in that area because of mining activities and so. And the pH got reduced below 5, and this affected hatching process of the fish, and also, it also killed the adult fish also. So lot of damage was there in that particular water body.

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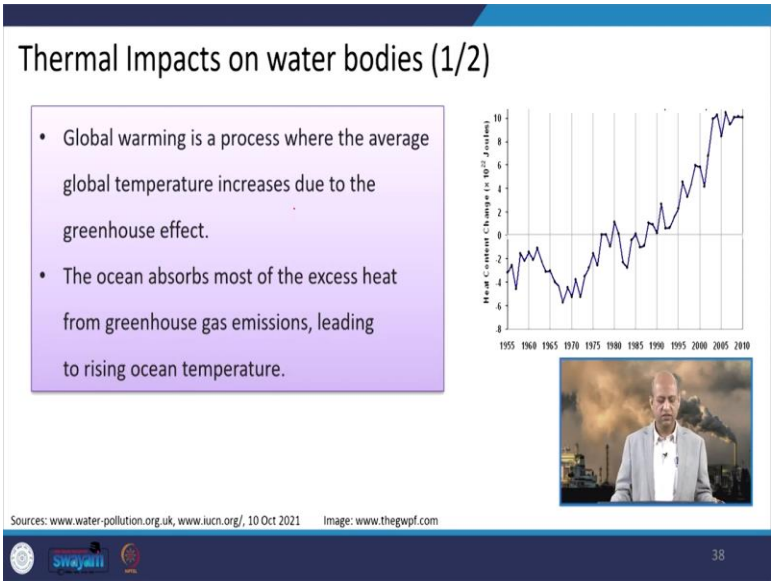

Now, we come to thermal impacts on water body, because global warming is increasing the temperature of like sea. And this increase in the temperature of sea is really translating into negative impacts on the coastal ecosystem.

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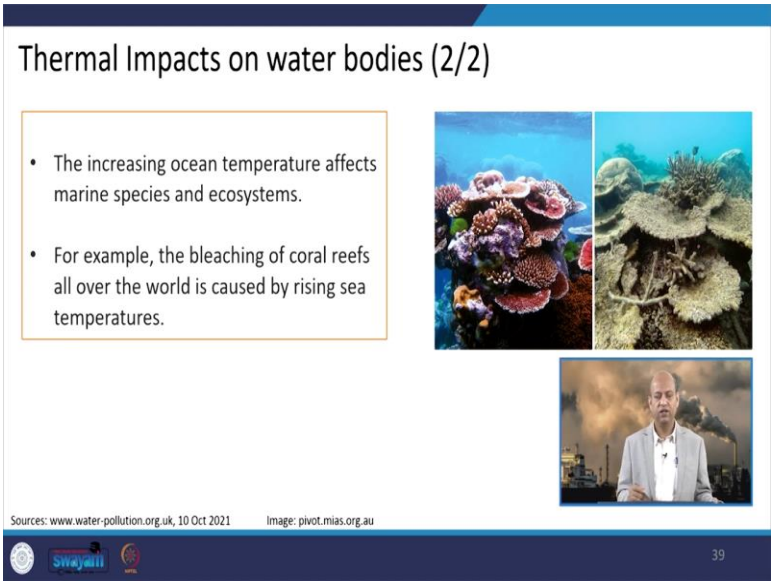

For example, you can see this bleaching of coral reefs. This is so beautiful coral reef in the clean water but because of temperature increase this kind of bleaching happens. And other pollutants may also participate in that kind of activity, but thermal impact may be there in, in this particular fashion.

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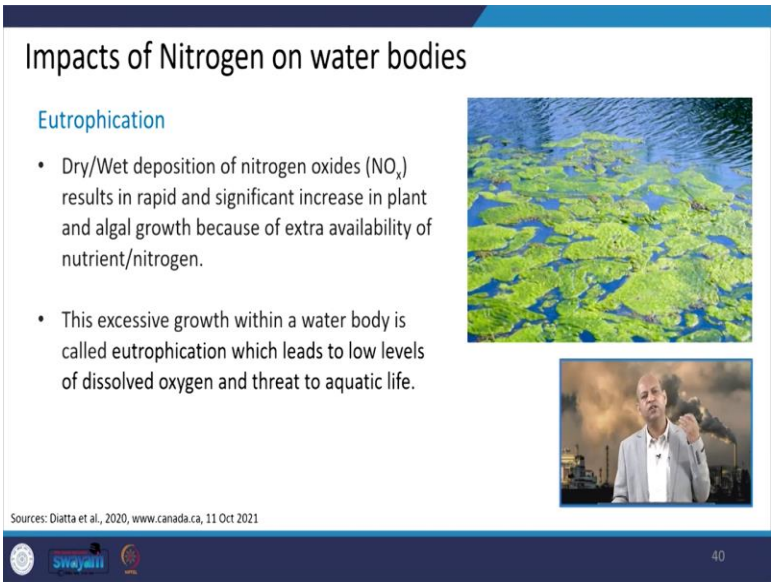

Then there is impacts of nitrogen on water bodies, because as I said nutrients like nitrogen and phosphorus they are very important for the, enhancing or reducing the growth of the plants. In certain water bodies if nitrogen increases, which is micro nutrient, so this can result into the bloom of algae and those kind of plants in the water body.

And it results into reduction of oxygen. Because of eutrophication, oxygen is reduced, and anaerobic conditions may prevail and when oxygen content or dissolved oxygen of the water body reduces, then aquatic life suffers. They need certain amount of oxygen to survive. So that becomes kind of, if it is not properly checked or something, constructive measures are not implemented then that particular water body becomes like a mars or those, those kind of things.

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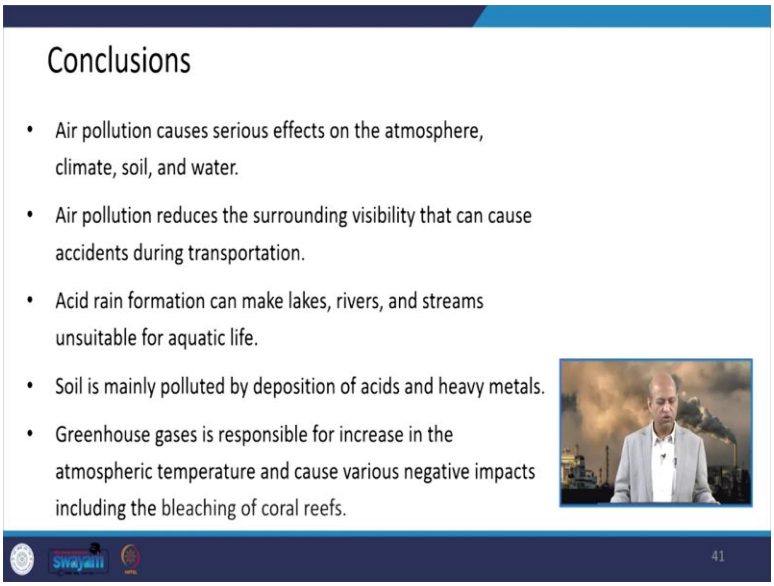

So this is all for today. In conclusion we can say that air pollution can cause different kind of effects on the atmosphere, climate, soil and water bodies. And it can reduce the surrounding visibility, this air pollution can reduce the surrounding visibility because of that scattering effect of particulate matter. And it can cause accidents during transportation, it can delay flights, all those effects may be there.

Then there is this acid rain formation. It can makes lakes and rivers acidic and it can disrupt the aquatic life. Similarly soil nutrients can be affected negatively because of heavy metals because of air pollutants and this acidic patterns of precipitation.

And these greenhouse gases is responsible for increasing the atmospheric temperature, and it can cause several negative impact through climate change as well as the thermal impact can be there on the, these coral reefs also. So there are multiple effects you can see on this environmental components, whether soil water and air because of this air pollution emissions.

So this is all for today, and we will continue to see other related aspects of air pollution in the same way. So see you in the next session.

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And before that, I request you to go through these references which gives the additional information about this topic.

So that is all for today. Thank you for your kind attention. See you in the next lecture. Thanks.