Air Pollution Control
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Lecture 48
Air Quality Standards

Hello friends, today we will discuss about air quality standards. You might have heard about ambient air quality standards which every country basically has like in our country, we have national ambient air quality standards. So, they are prescribed by CPCB central pollution control board which is the nodal agency for having environment related regulatory things in entire India and we have then these state pollution control boards also.

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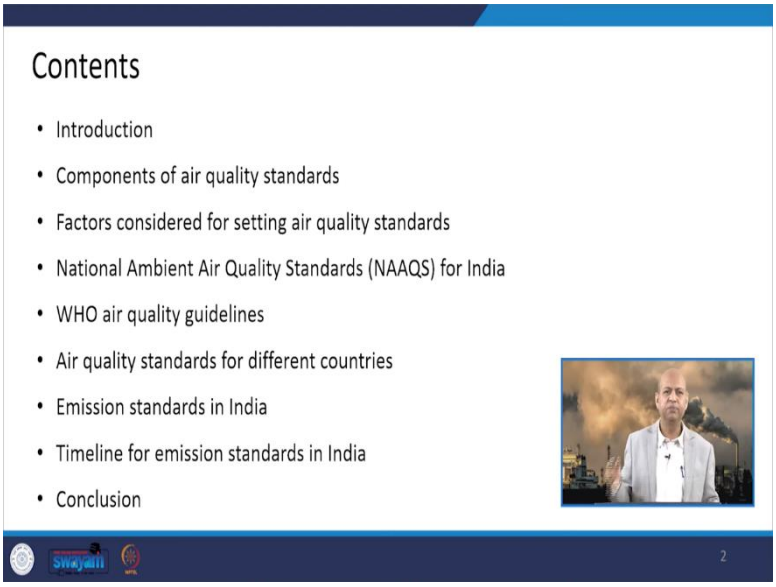

So, in this particular lecture, we will first of all discuss what are the air quality standards, why they are so important? What are different components of the air quality standards? How they are developed? Which are the factors which are taken into account when we develop or set the air quality standards?

And then which are the national air quality standards in India at present which we are following what is their little bit history and then WHO, World Health Organization related air quality guidelines because WHO also prescribes certain guidelines. The reason is because not each country has national air quality standards because it needs a lot of resources to develop ambient air quality standards.

So, WHO prescribed guidelines and those who are under developed countries or who do not have their own ambient air quality standards, they can follow those guidelines basically. Air quality standards for different countries we will compare then some emission standards we will look into which are at present prevalent in India and then the timeline presenting representing the emission standards in India and then we will conclude.

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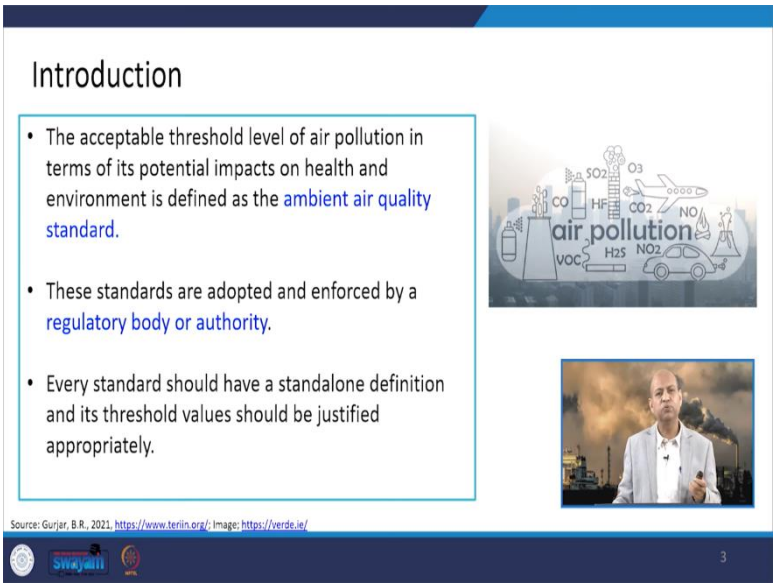

So, when we talk about this introductory part of ambient air quality standard so basically this is nothing but a kind of threshold level of air pollution which is acceptable and acceptable because of certain scientific reasoning certain rational not just arbitrary.

So, this is an acceptable threshold level or quantity of air pollution in terms of potential health effects that means below that the quantity of ambient air quality standards it will not be very much adversely affecting the health of the people or ecosystem depending upon which kind of air quality standards.

And these standards are adopted and enforced by your regulatory body like, we have central pollution control board for that and every standard that every air quality standard should have a stand-alone definition that means they are exclusive.

It is not like that SO_2 to have certain quantity and we can apply it for NO_2 also no. Every pollutant has certain guidelines or the reasoning behind the definition of their value is of the threshold level which is justified because of certain reasons.

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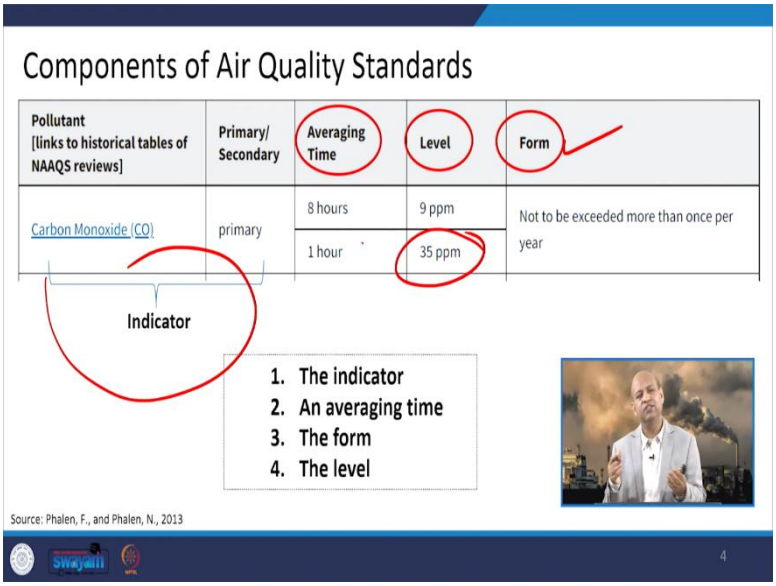

Well, when we talk about the components of air quality standards, so there are basically four basic components like the indicator, indicator means some pollutant like SO_2, NO_2 or carbon monoxide, whatever pollutant we are talking about that is the indicator and we also know whether it is primary pollutant or secondary pollutant.

So, this is the part of the indicator, then the second is averaging time means it is defined whether it is for 8 hour average or 24 hours or 1 hour or annual average. So, that span that duration has to be defined. So, this is another important component of air quality standards. Then the level means how much threshold level is there beyond that it should not exceed in the ambient air otherwise, it will be problematic it will affect our health negatively.

So, that level that threshold level has to be defined like 9 ppm for 8 hours in carbon monoxide 1 hour 35 ppm, shorter duration higher concentration may be. But for larger duration small concentration must be there, ultimately what is important dose? Dose means concentration multiplied by the duration of the exposure.

So, that dose should not be of that extent or level which can affect our health in a very negative way. Then the fourth is this one is this form. Form means what is frequency whether once in a year or three times in a quarter when it can exceed or not exceed those kinds of statistical parameters are related to these components of the air quality standards.

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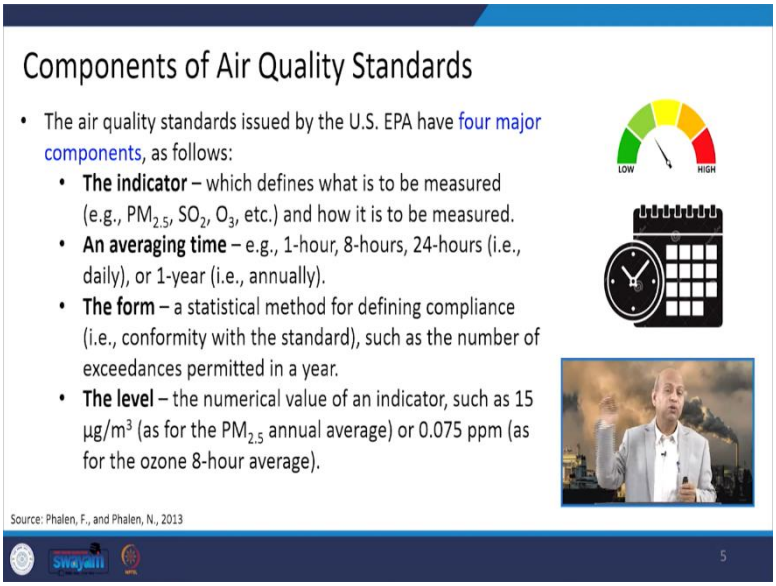

So, these pollutants are the indicators which are defined in terms of measurements which can be measured properly and the averaging time can vary from 1 hour to 8 hour 24 hour and annually also or monthly also the form is basically statistical method defining their accidents.

And the frequency and the level is basically that threshold quantity that threshold level which should not exceed or below that this pollutants concentration will not affect us very negatively it will be reversible if something happens otherwise, we are means adaptable to that particular quantity.

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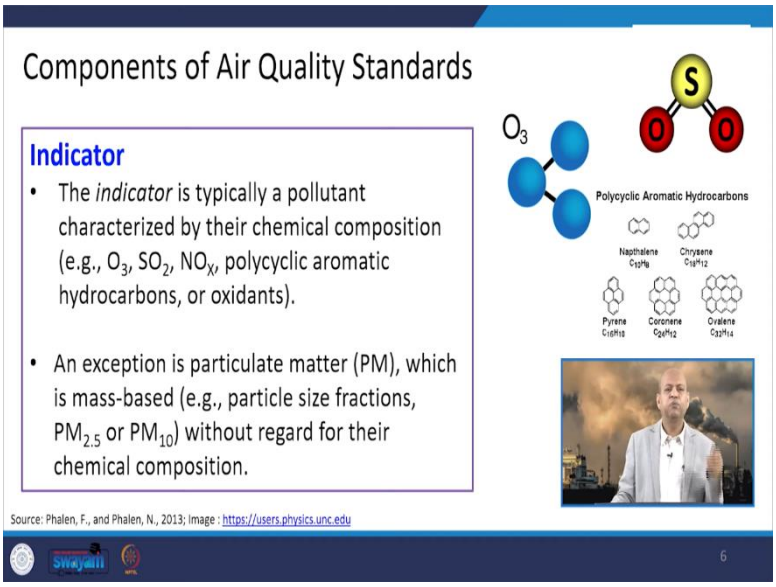

So, when we talk about in detail to the about the indicator let us say so like ozone or sulfur dioxide or NO_x. So, these indicators are basically pollutants and these pollutants have characteristic of some chemical composition. Some chemical characterization is there, like ozone had some kind of chemical characterization.

SO_2 has or NO_x, has they are having some particular chemical composition or characterization but PM particulate matter it says that which is defined by mass by their mass per unit of volume concentration or size and say physical parameters irrespective of their chemical composition.

Although these days people also talk about some presence of the chemical coating on the particulate matter because then it will further cause very negative consequences to the health basically otherwise, this mass concentration or they are even nowadays number concentration, that is also very important because very small particles which may have very less mass concentration but their number is very high.

And they can go into our respiratory system they can go into our body and they can damage our health in terms of some diseases. Well, when we talk about averaging time, so this is basically the exposure time. It depends upon the exposure and the intensity like for very acute effect very small duration also can cause very acute effect if concentration is very high but if a span is more, then a small concentration can also be tolerated.

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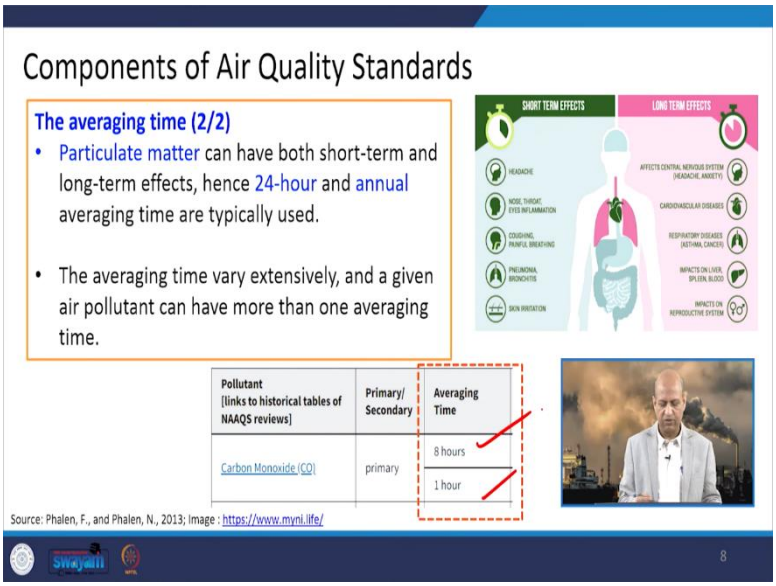

So, these averaging times are 8 hours or 1 hour or 24 hours something like that.

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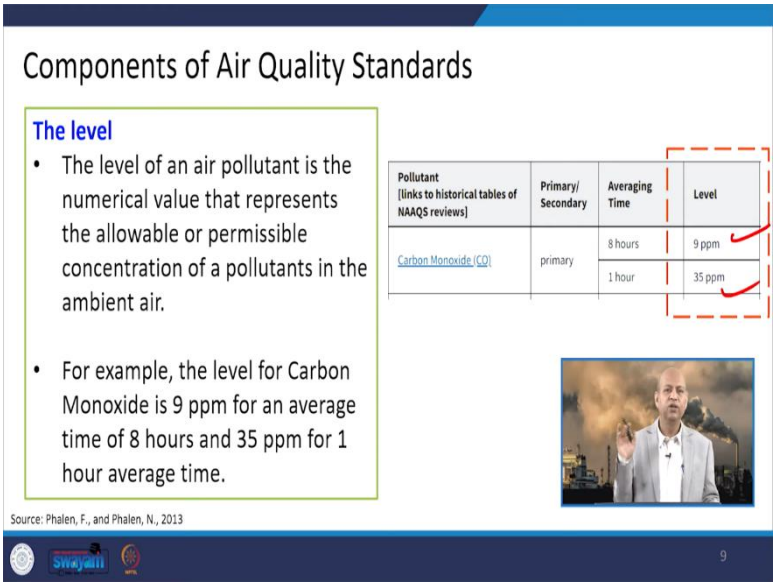

Level we have seen these values like 9 ppm 35 ppm or in case of SO_2 or NO_2 different values are there. So, those levels are basically depending upon several studies of health-related lab-based studies which scientists conduct and then they come to these values that this is the threshold value. So, below that, there is no problem if we can have if we have that pollutant in the atmosphere.

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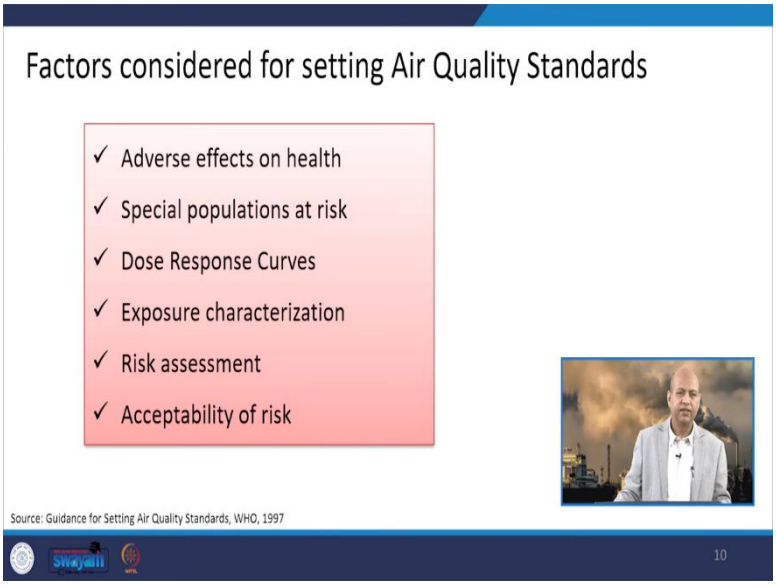

When we consider several other factors for setting these air quality standards, then like adverse health effects are taken into account and then these special populations at risk means, like, some are diseased people, old age people or children, those kinds of things, maybe they are so

if they are at risk, so in that sensitive area, we should have different kinds of air quality standards. So, that is taken into account, dose response curve.

So, these are the scientific reasoning how they are taken into account when we want to set some air quality standards. Exposure characterization, again that duration and some people can get exposed to very high concentration depending upon their occupation, like if somebody is working in hazardous pollutant related scenario like some or mining area or where extraction of some heavy metals are there.

So, those kinds of issues may be there. Risk assessment so again, we have to assess the risk, what is even concentration high, but risk is not there, because of certain meteorological parameters when we calculate the risk, then it's fine in that particular area, but if a location is such that even small concentrations are emitted and then they build up over the period of time because of some peculiar metrological conditions or topographical conditions, then, in those locations, we should have different kind of air quality standards.

It is not that the same standard we should have although, to begin with, we are having uniform standards across country, but several researchers, several policymakers also argue that we should have air quality standards as per the context as per the atmosphere or the environment where people are working and of course in these industrial areas, people have different kind of air quality standards.

Like indoor air quality standards are nowadays being developed, then acceptability of the risk. Risk factor is very important to consider because, we get exposed to several kinds of risk like traffic accidents or we also have health risks due to some consumption of other material or there are issues people talk about like people get exposed to occupational risk people get exposed to other kinds of risks which are not in our control like earthquake.

And so the estimate how much risk is there in the background, whether that is acceptable or not, if some industry is coming and some emissions will be added and that will add some risk in that particular environment. So, whether that risk is acceptable or not because trade-off is there, we get some benefit like economic growth will be there, we may have better health facilities, education facilities because of some industrial developments.

So, those risk benefit analysis is to be done and what is acceptable that is also considered for setting the air quality standards.

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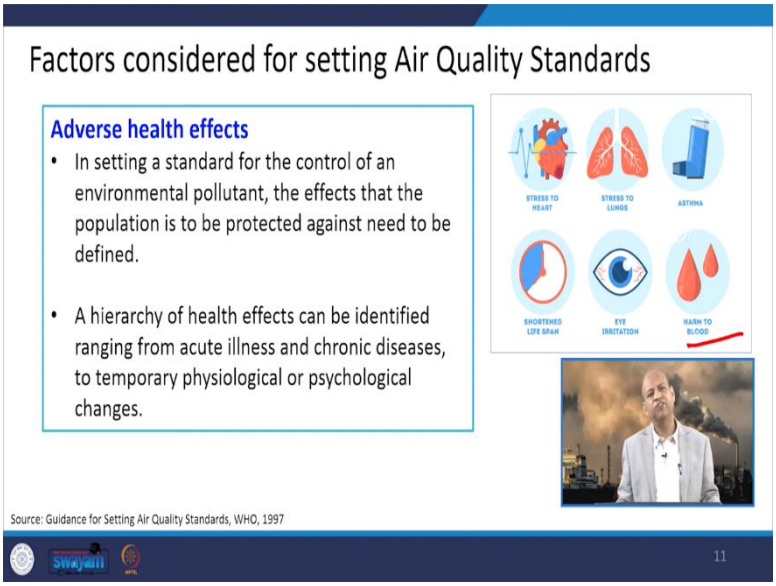

So, adverse health effects that can be we have already discussed at several locations, like they can have respiratory related problems, they can have eye irritation, because of certain pollutants, and you can go into blood, they can cause asthama also. So, there are several ways air pollutants can affect our health. So, we have to see those health effects and we have to consider which is important and which particular pollutant is causing a peculiar kind of health effects. So, accordingly we have to take those considerations into account.

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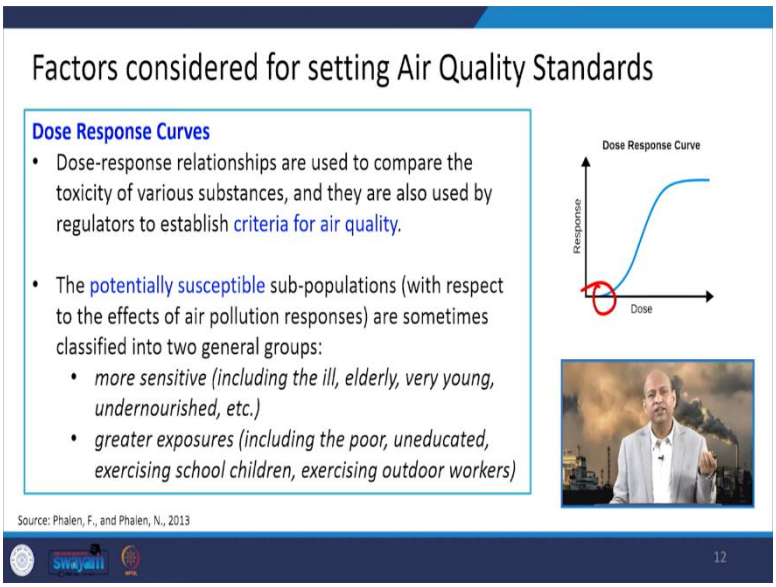

When we talk about dose response curve some dose is there, so dose means duration and the concentration both these. So, this is the relationship, dose increases and response also increases

some relationship is there and we can get but there is some threshold quantity also below that, there is no effect and another way of looking at this problem is like potentially susceptible as people are ill or they are elderly or very young, they are more sensitive even to small concentrations of pollutants.

Then there may be occupational related exposures like and like somebody working outdoors. So, higher concentration of pollutants can get exposed to that person, some occupational related issues may be there, some people may be unaware of some issues of pollutants hazards and they might be working in hazardous situations like landfill emissions maybe there, there may be different kinds of waste material and people are not aware of those harmful effects which they carry because of exposure. So, those reasons may also be there. So, that thing has to be taken into account.

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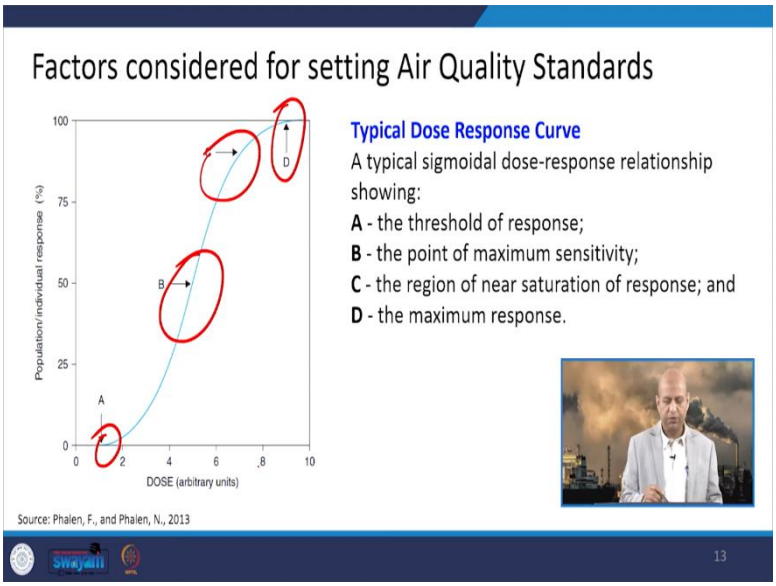

This is the sigmoidal dose response relationship as we have also seen earlier. So, this A is the threshold of the response below that there is no problem means below this level, there is no problem. When this increases, then of course, problems start to occur some responses there in terms of health effects.

So the point of maximum sensitivity at this most of the people have problem related issues, health related issues, C is the region near saturation response means kind of it has exposed to most of the population and maximum response is occurred at this particular level. So, these are the based on the studies scaling up those dose response curves.

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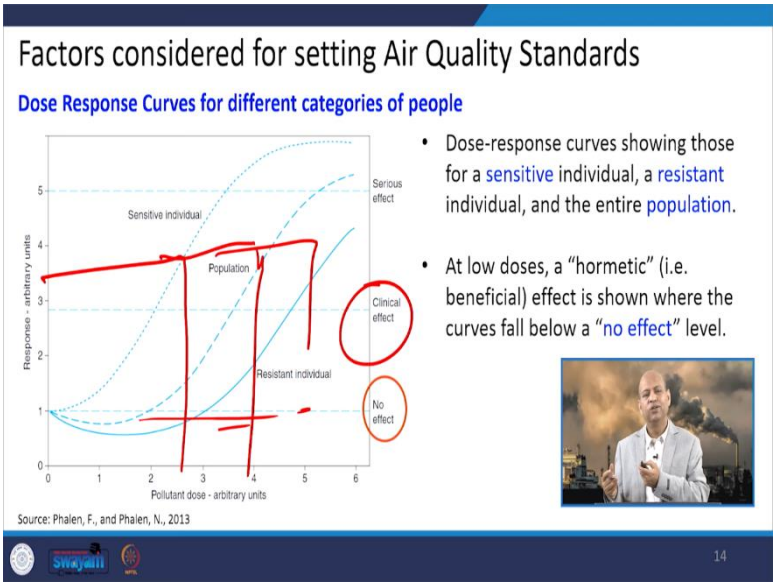

And also there are certain levels, there is no effect after this below this level. Then clinical effect have been observed at this particular level, but, the same concentration will have different effects on different kind of segment of population like sensitive people, even smaller concentration will have some response, whereas, high concentration of this population means average population can expose to higher concentration.

And resistant individual who have good immunity, good health, they can even get exposed to higher concentrations. So, depending upon the segment of the population, again different standards may be there but we have to take here worst case scenario. So, we go for sensitive population, we have to protect them.

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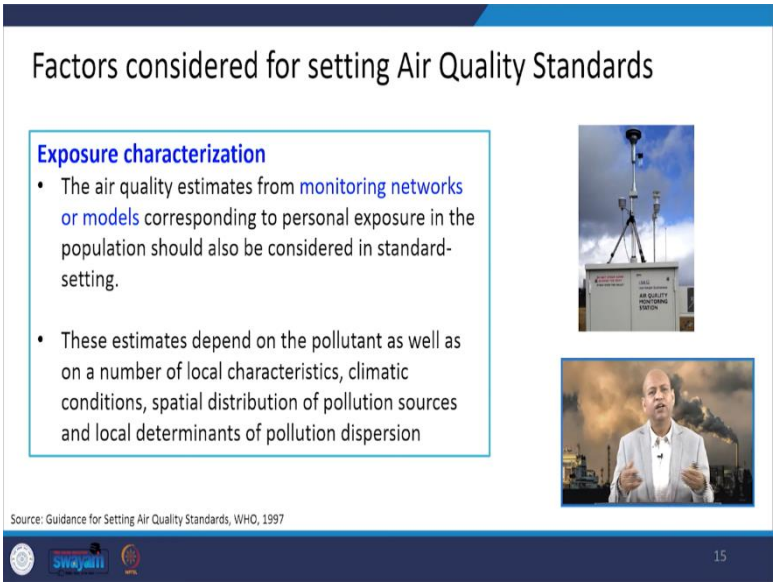

Then exposure characterization because of monitoring like air quality monitoring must be there. Otherwise, how can we implement our air quality standards if we do not have monitor data? So, we have to have monitor data or modelled data of the concentrations at several locations. So, monitoring capability also restrict air quality standards.

Suppose some country or some particular organization start arguing that we should have very stringent air quality standards fine but what is the huge with they do not have any instrument to monitor to compare whether the concentration is there of that nature or not. So, those air quality monitoring capabilities, skilled manpower, then resources to support that particular monitoring network, all these issues economic factors are also there.

Means whatever policy can be implemented, those air quality standards can be properly implemented, regulated only then it is making sense otherwise having those regulations or these air quality standards and not having infrastructure to support those guidelines, then there is no fun. So, that is why this monitor network related issues are also important.

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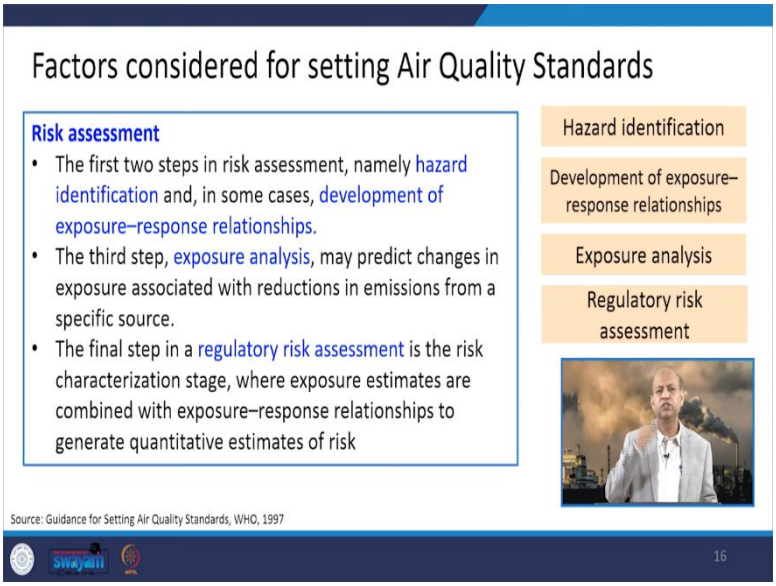

And in risk assessment, there are various issues like hazardous components identification, development of exposure and response related relationships, then we analyse the exposure assessment and the regulatory risk assessment is also taken into account and it is carried out. In New Zealand, Canada, Australia, those countries, they basically have this risk based related processes to set these air quality standards.

Other countries have other ways to go for threshold quantities for criteria pollutants. So, several countries have different kinds of methodologies.

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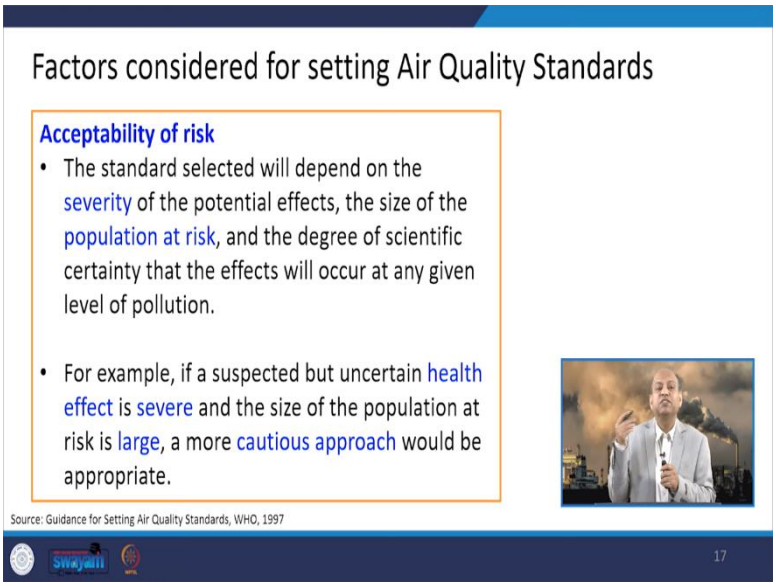

And as earlier also I said that acceptability of risk is very important, how much risk we can accept by trading with the benefits or by trading with other kinds of risks which are every day we face like traffic accidents are there and there are several kinds of risk basically, so you have to compare which kind of risk is more and already if we are having some more risk in terms of background concentration, then we should not allow other industries to come up.

Like emissions adding there to exceed those standards but the standards when we set the acceptability of the risk is also primary factor because if you can afford more risk in terms of exposure, then you can have higher level of standards. Otherwise, if some situations are there where you do not want to get exposed to even very small concentrations because of certain regions like in that area maybe school children are there or maybe hospitals are there in that case in that particular area, we cannot go for normal standards.

So, we have to specify sensitive standards air quality standards as per sensitive zones sensitive areas, we will see those kinds of situations.

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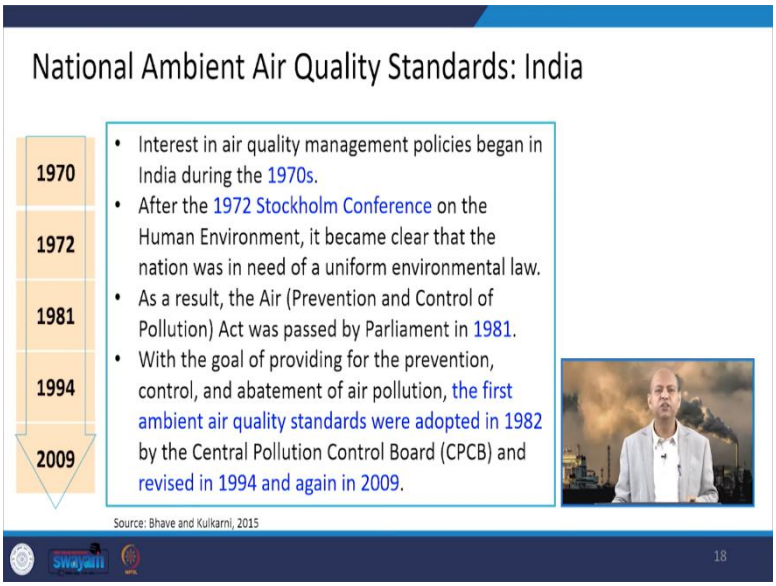

Well, if we look into timeline for the setting of national ambient air quality standards for India, so in 1970 basically this interest grew in management policies, spheres or circles and then in 1972 after this Stockholm Conference on the Human Environment, it became very clear that we need, uniform environmental law and then as a result or as a consequence of that year prevention and control of pollution that was passed by Parliament in 1981.

And with the goal of providing for the prevention, control and abatement of air pollution, the first ambient air quality standards were adopted in 1982 by the CPCB central pollution control board and they were revised in 1994 and 2009, we will see how much values are changing according to that.

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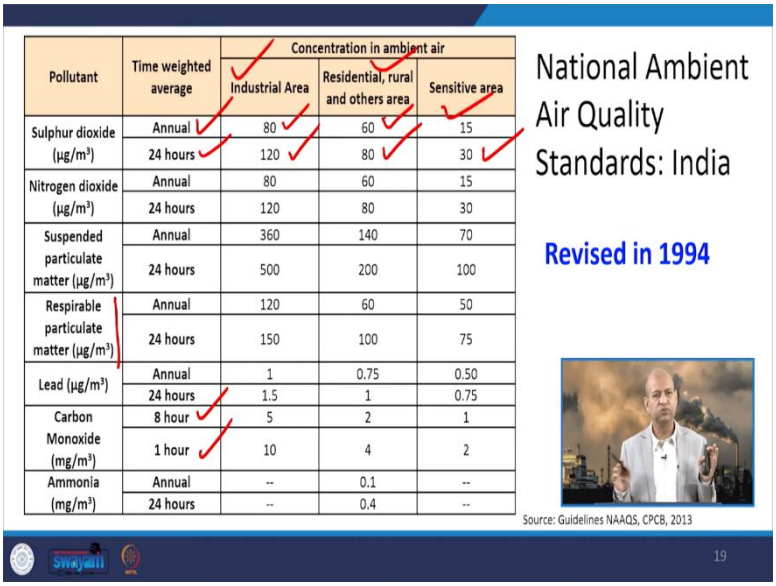

Pollutant	Time weighted average	Concentration in ambient air		
		Industrial Area	Residential, rural and others area	Sensitive area
Sulphur dioxide (µg/m³)	Annual	80	60	15
	24 hours	120	80	30
Nitrogen dioxide (µg/m³)	Annual	80	60	15
	24 hours	120	80	30
Suspended particulate matter (µg/m³)	Annual	360	140	70
	24 hours	500	200	100
Respirable particulate matter (µg/m³)	Annual	120	60	50
	24 hours	150	100	75
Lead (µg/m³)	Annual	1	0.75	0.50
	24 hours	1.5	1	0.75
Carbon Monoxide (mg/m³)	8 hour	5	2	1
	1 hour	10	4	2
Ammonia (mg/m³)	Annual	--	0.1	--
	24 hours	--	0.4	--

Like in 1994 this was basically the national ambient air quality standards. So, concentration defined in industrial area, residential, rural and other areas and sensitive areas. So, three particular categories were defined and then as per pollutant, the time weighted average like annual average or 24 hours average depending upon the pollutant like for carbon monoxide it was only 8 hour and 1 hour because of the toxicity level.

Ammonia annual at 24 hour. So, mostly those were suspended particulate matters, these were around 100 this micrometre respiratory particulate matter RSPM that is basically PM_{10}. So, for that annual and 24 hours are there and different values are there. For industrial area it was higher like 80 annual and residential area 60 and sensitive area 15 very less.

Similarly, 24 hours for industrial area of sulphur dioxide it was 120, for residential area it was 80 and for sensitive area it was 30. So, different areas have as per the time exposure or average time different values but then researchers had better perspective over the years.

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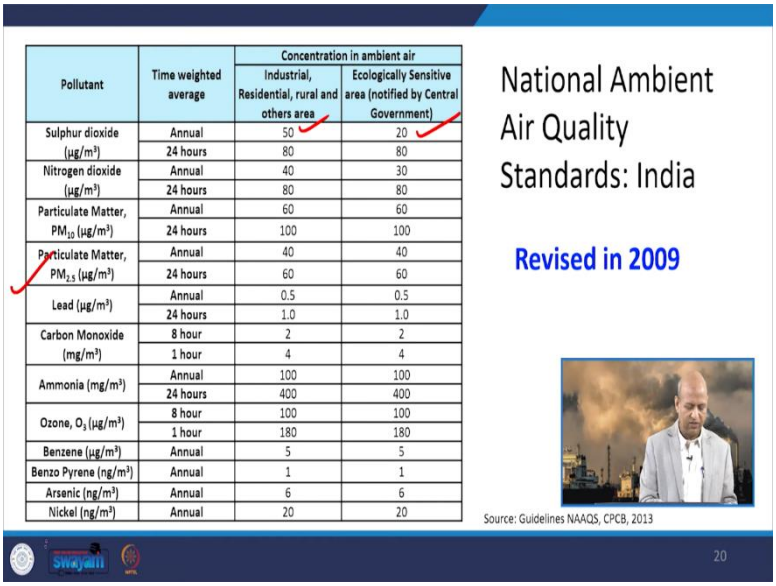

Pollutant	Time weighted average	Concentration in ambient air	
		Industrial, Residential, rural and others area	Ecologically Sensitive area (notified by Central Government)
Sulphur dioxide ($\mu g/m^3$)	Annual	50	20
	24 hours	80	80
Nitrogen dioxide ($\mu g/m^3$)	Annual	40	30
	24 hours	80	80
Particulate Matter, PM_{10} ($\mu g/m^3$)	Annual	60	60
	24 hours	100	100
Particulate Matter, $PM_{2.5}$ ($\mu g/m^3$)	Annual	40	40
	24 hours	60	60
Lead ($\mu g/m^3$)	Annual	0.5	0.5
	24 hours	1.0	1.0
Carbon Monoxide (mg/m^3)	8 hour	2	2
	1 hour	4	4
Ammonia (mg/m^3)	Annual	100	100
	24 hours	400	400
Ozone, O_3 ($\mu g/m^3$)	8 hour	100	100
	1 hour	180	180
Benzene ($\mu g/m^3$)	Annual	5	5
Benzo Pyrene (ng/m^3)	Annual	1	1
Arsenic (ng/m^3)	Annual	6	6
Nickel (ng/m^3)	Annual	20	20

And in 2009, then they were revised. People argued that even if people are living in industrial area, they have equal to clean air. So, industrial areas, residential areas, rural areas, all these areas were clubbed and the standards were defined uniformly for those areas but of course, ecologically sensitive areas which are notified by central government of India.

So, those were taken as a separate entity and standards were prescribed differently. Sulphur dioxide annual 50 earlier it was 60, residential area 80 was in industrial area, then 24 hours 80 ecologically sensitive 20 and 80. So, 24 hours, almost say exactly same but for annual average because of, regular exposure and their harmful effect. So, it was taken as 20. Different values like PM_{10} then $PM_{2.5}$ was also added in 2009 and then this benzene and arsenic nickel all other additional pollutants were added in the list.

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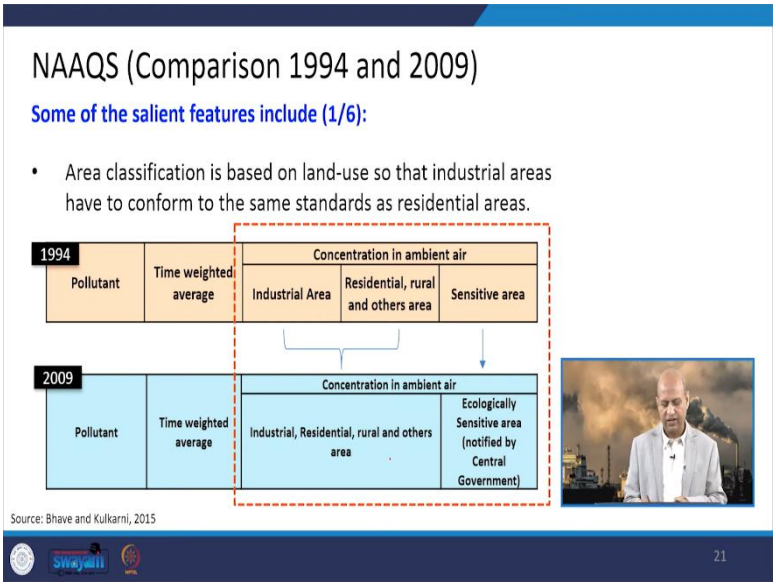

So, if we compare 1994 and 2009 air quality standards, so like concentrations were divided into three categories earlier industrial, residential, rural other and then sensitive area and in 2009 only two categories, this industrial, residential rural in one and ecologically sensitive in the second.

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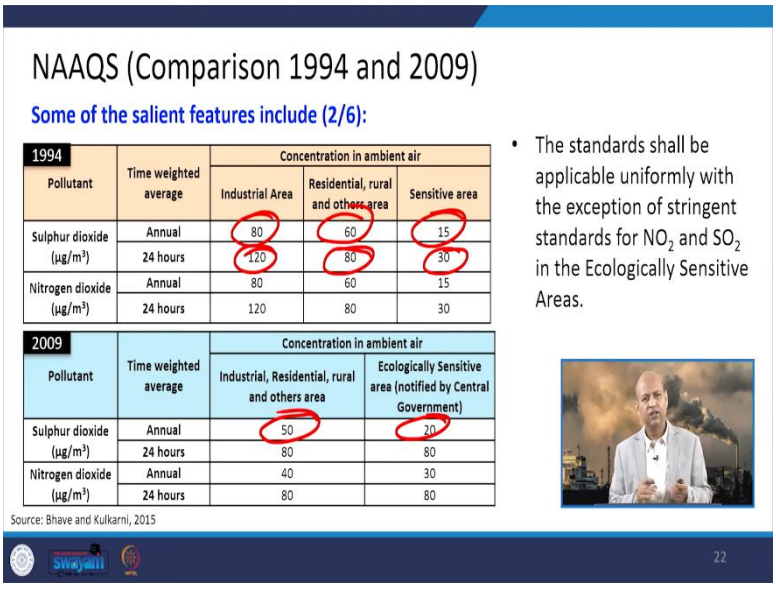

Different values who have different variations are there earlier, like for annual, this is 80 and 60 and it was fixed as 50 then when these were club, so little bit more stringent we have become. Sensitive area, it was earlier 15 for sulfur dioxide now, it is 20.

So, means more evidence based literature was there to afford get to getting exposed for higher concentrations annually while other this 80-80 values are same for 24 hours earlier it was 120 and 80 in residential areas. And it was 30 sensitive areas. So, that way a lot of difference means in residential industrial areas values were reduced, it became a little bit stringent and for sensitive areas depending upon the definition more concentrations were allowed.

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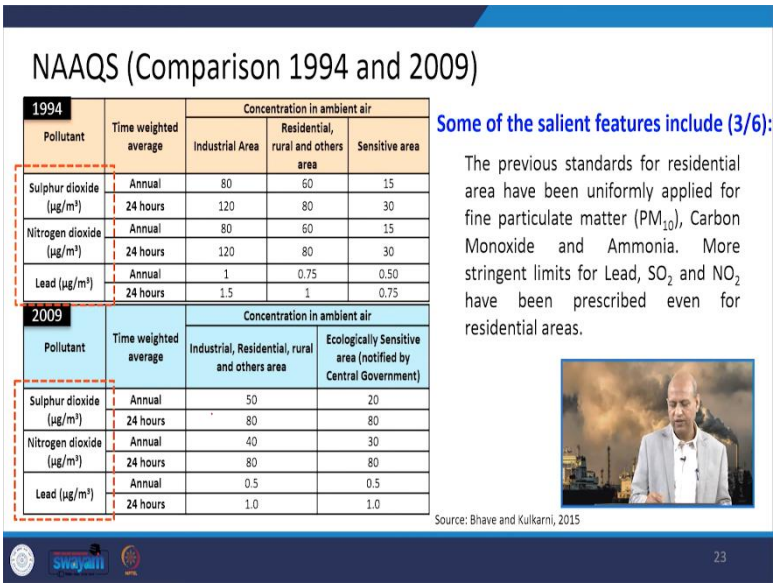

So, everywhere whether it is nitrogen dioxide, lead, you will see that kind of variation.

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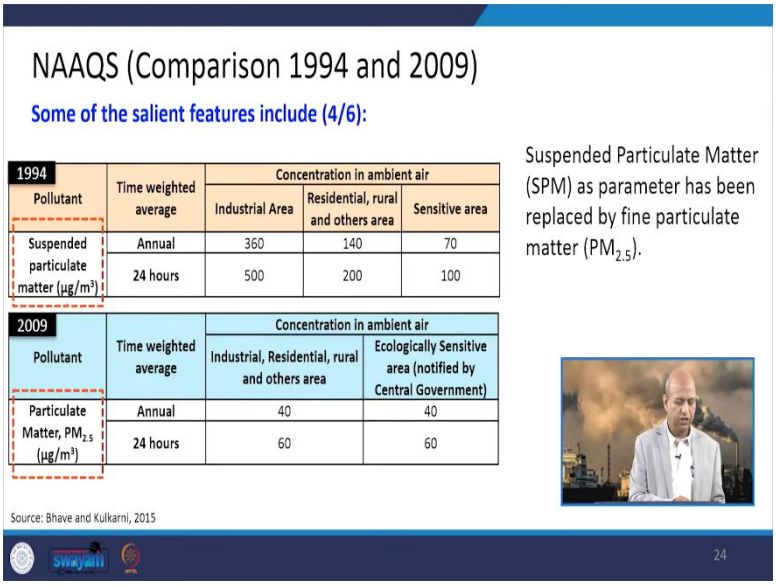

Suspended particulate matter was there then $PM_{2.5}$ was added. So, that is also again new addition the reason is because it was found that $PM_{2.5}$ is more dangerous because it can go up to our lungs and it can result into several kind of problems basically.

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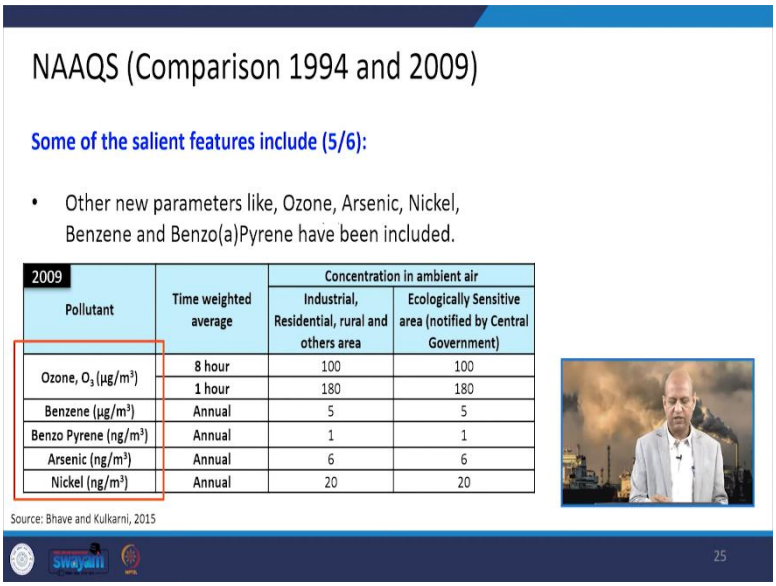

Then, if we talk about other parameters like ozone, arsenic, nickel, these benzo pyrene all these have been added and their standards have been defined.

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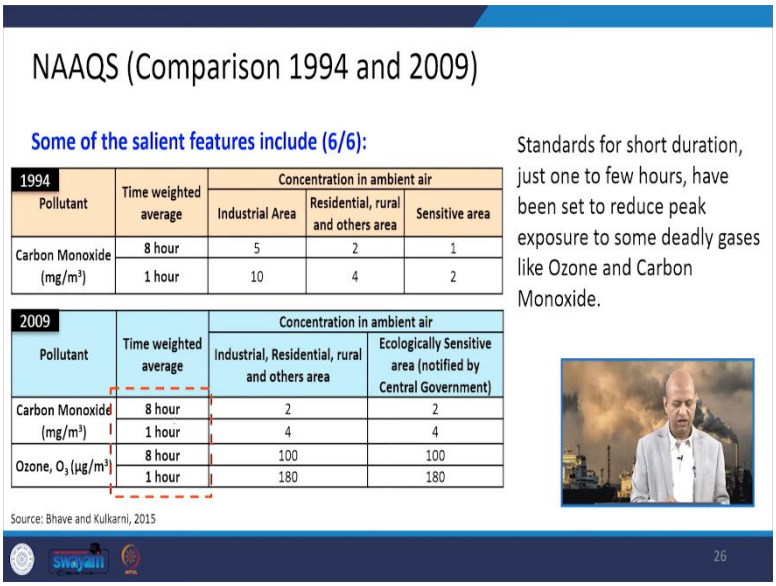

Well, then carbon monoxide, ozone there this time weighted average is 8 hour and 1 hour because of their toxicity.

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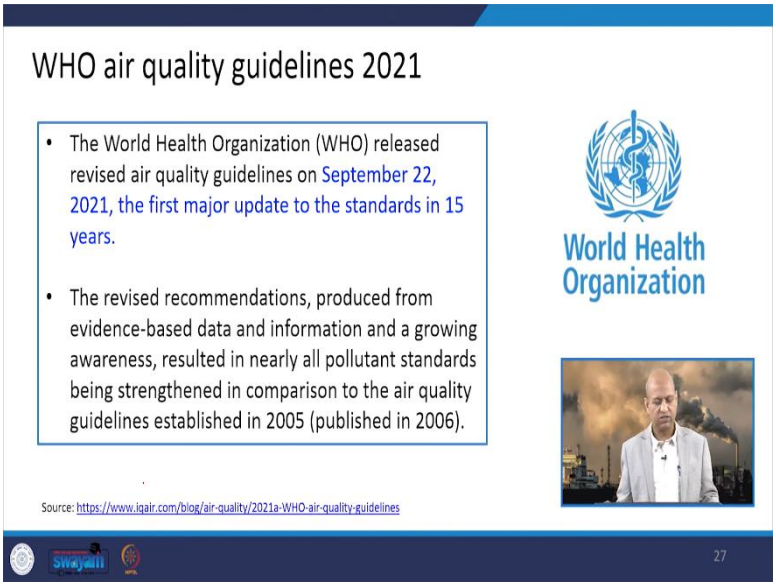

Then as I said, because not every country has that much resources to develop their own air quality standards. So, better they go for WHO air quality guidelines and they try to follow them.

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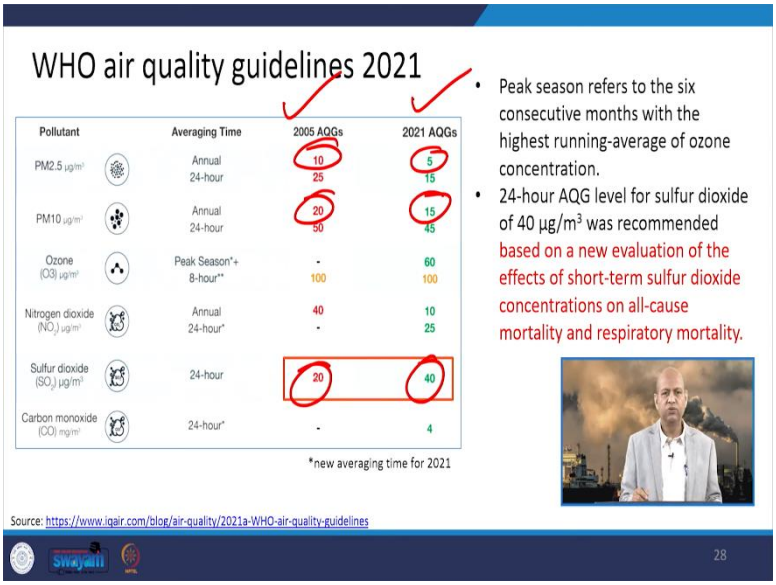

So, WHO has produced certain guidelines like in 2005 there were some values in 2021 they have given more stringent values like from $PM_{2.5}$ annual this was 10 this is a microgram per cubic meter and this is 5, then in PM_{10} annual it was 20 earlier, now it is 15. Sulphur dioxide it was 20 earlier, now it is 40.

So, means, when we have like new evaluation methodology, new values new scientific data, so change can be on either side, but mostly we go for more stringent depending upon the situation, but in this particular case concentration rather than reduce it increased means air quality standards increase.

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When we talk about of different countries air quality standards, so they vary as I said because of their technological capabilities because of their economic status, all these things influence how much a standard they can afford to apply or implement.

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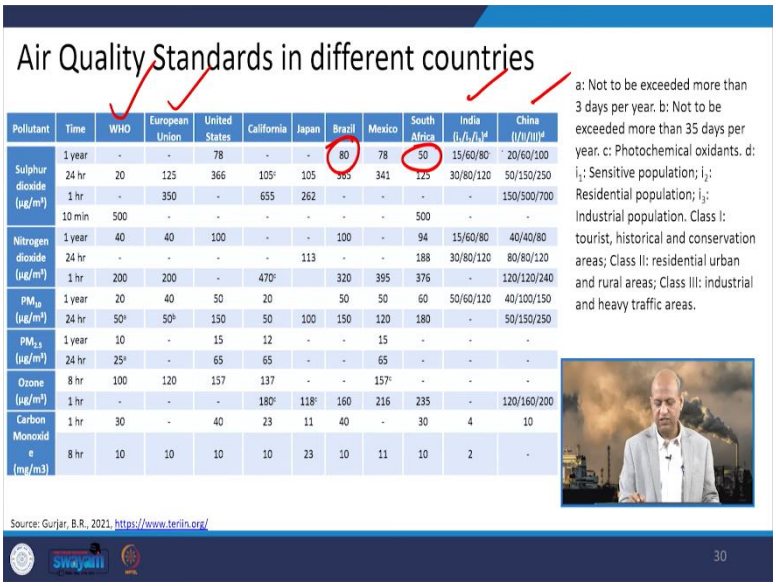

So, we have taken from different sources and compiled this data. So, WHO, European Union, United States, California they have different set of standards. Japan, Brazil, Mexico, South Africa, India, China all these different for different pollutants, we have tried to compile and compare air quality standards.

Different values are there for different countries and the reason is means if some country is capable to monitor in a big way they can have stringent standards they can apply they can execute those standards, some other countries which do not have that much capability so accordingly their standards are a little bit different like Brazil 80 is there. South Africa having 50, India 15, 60, 80 depending upon different situations, like sensitive and those residential areas.

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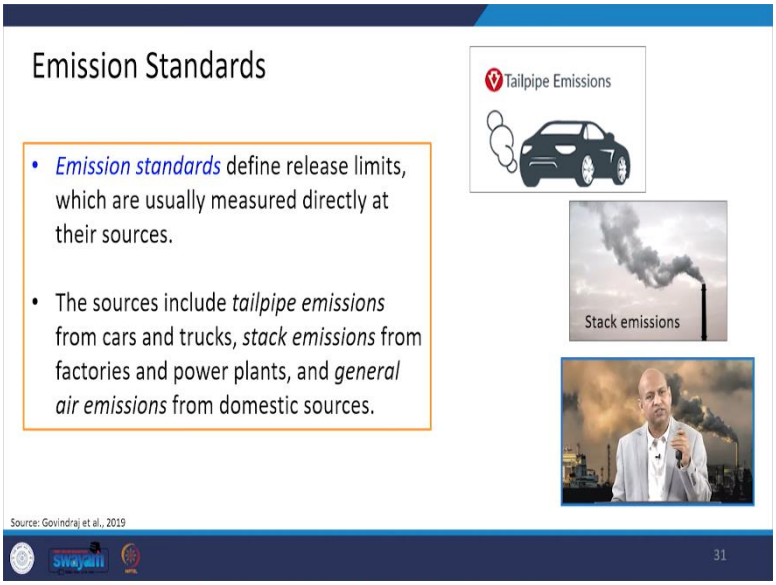

Now, we come to emission standards. So, basically air quality standards are the concentration of air pollutants into the ambient air, indoor air quality standards are also nowadays people are talking and they are in the process of development but as such ambient air quality standards are very popular till now, then where these concentrations come to the air because of certain emissions.

So, there must be some emission standards also so that we can prevent to build up more concentration. So, like from tailpipe emissions or from stack emissions. So, all those emissions are also regulated.

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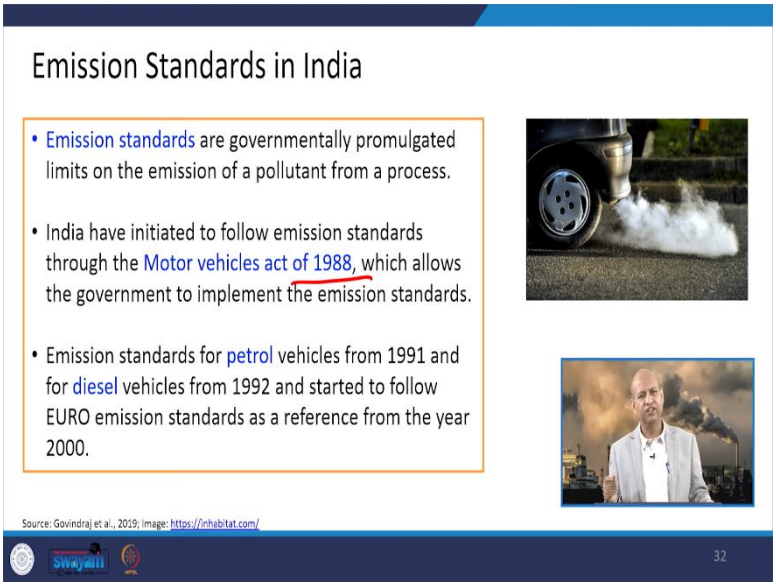

And some standards are given by the government, like Motor Vehicle Act 1988 was there. So, for petrol for diesel, different cars or different vehicles are there and different standards are there.

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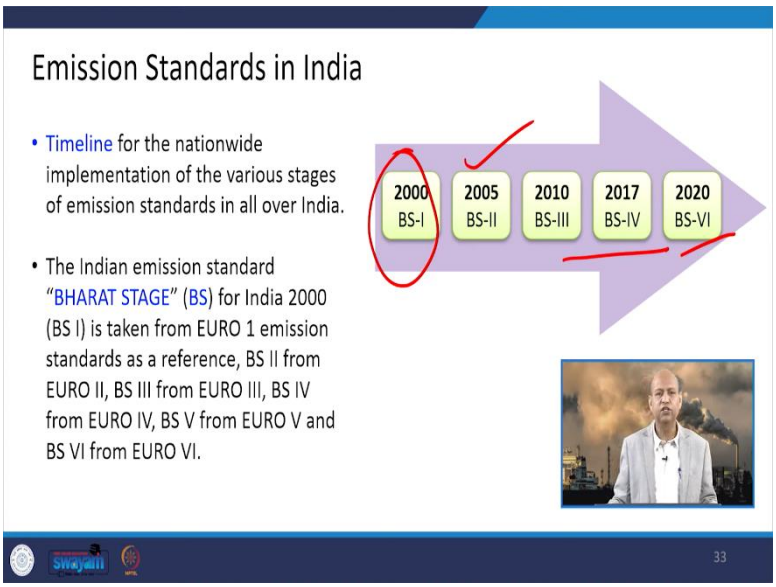

Like 2000; BS-I, Bharat Stage-I, so they were borrowed from European Union standards like Euro-1, Euro-2. 2005; we implemented BS-II that is Bharat Stage-2. And similarly, like we came to BS-IV in 2017. But then we did like leap frogging. And in 2020; we went directly to BS-VI Bharat Stage VI that is equivalent to Euro-6. So, we did not go for BS-V and that way

big jump or big leap has been achieved. And that is a great contribution to reduce emissions because as we grow in this term, the emissions become very less.

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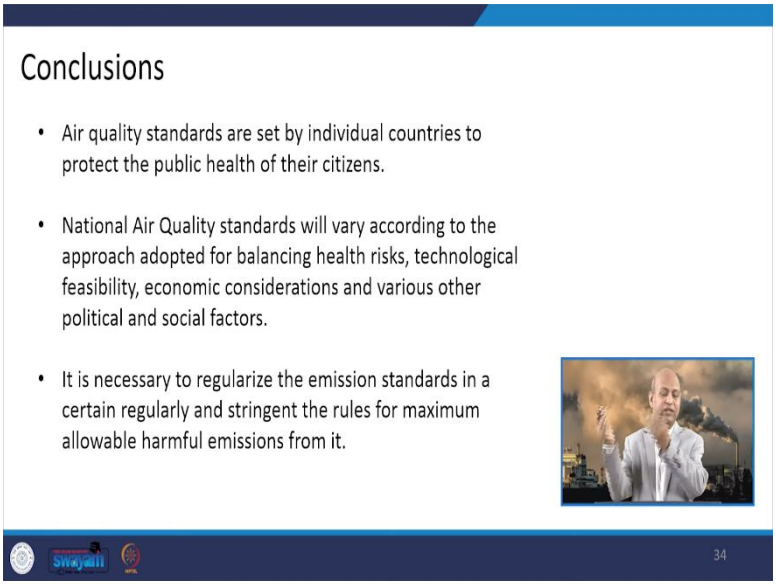

So, in conclusion, we can say that the air quality standards are very important and individual countries develop their own air quality standards depending upon the scientific evidences as well as their capabilities in terms of economy, technology, etc.

And these are important because of health risk related issues or other like sensitive areas production those kinds of things. And emission standards are also needed, so that we can meet those air quality standards, we can curb the emissions at the source itself. So, emission standards for that purpose is very important to set to achieve the ambient air quality standards.

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So, this is all for today. Thank you for your kind attention. And these are the references for additional information. See you in the next lecture. Thanks again.