Air Pollution and Control
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Lecture – 31
Health Impacts Due to Indoor Air Pollution

Hello friends, you may recall last time we discussed about specific sources and pollutants in indoor environment. Today we will look into health impacts due to indoor air pollution. So, you may recall, we also discussed like general health impacts of air pollutants. But, specifically from indoor air pollution, what kind of health impacts can be there today we will focus on that.

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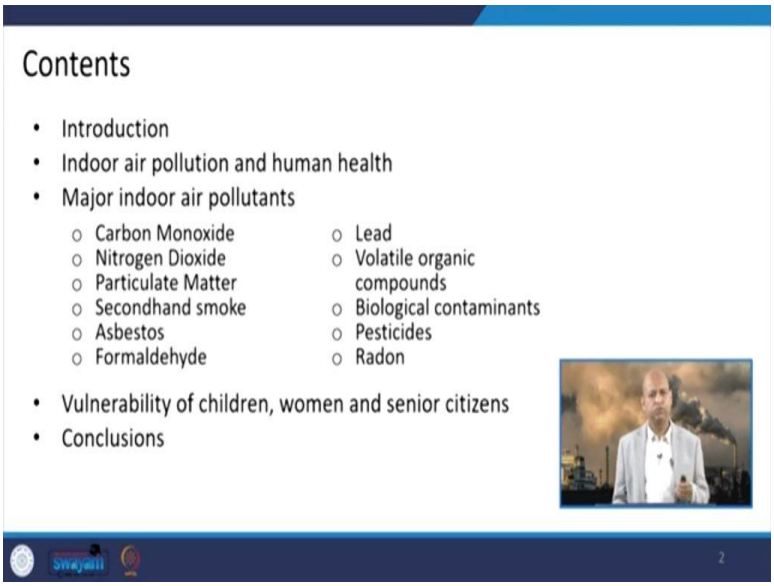

So, in that line we would first look into a very general kind of brief introduction on indoor air pollution and human health, their relationship. And then we will go one by one; means those major indoor air pollutants and their health impacts like carbon monoxide, nitrogen dioxide, or particulate matter, lead, volatile organic compounds, biological contaminants, and pesticides everything those listed in this particular slide. Then, at last we will look into like a special vulnerability of children, women and senior citizens, who spend a lot of time in the indoor environment; and at last we will conclude.

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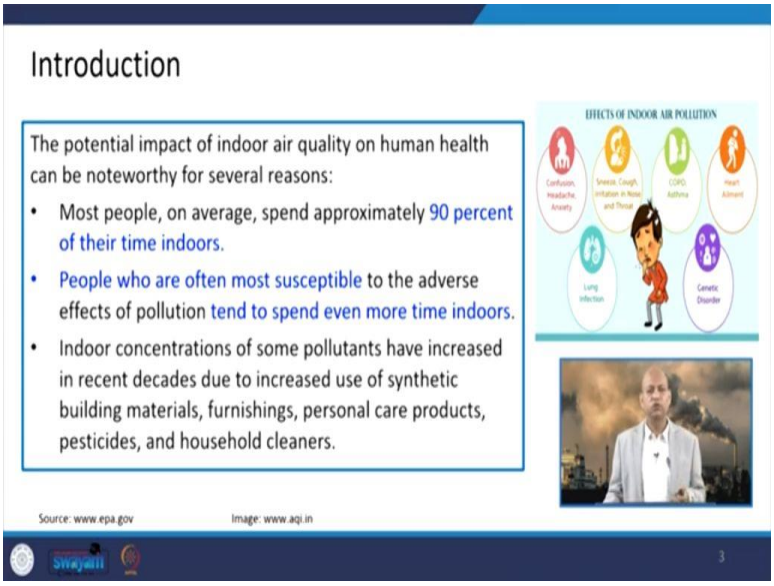

So, when we go for a brief introduction, then most of the people nowadays, not only women, children and old people, but also working population; because lot of things are going on into indoor offices. So, the occupation hazard you can say from indoor environment, if that is exposing the people to toxic elements, so that that is increasing; because lot of office work is being done in indoor environments. So, there are studies which we which give this data that approximately 90 percent of their time indoors average; most people on an average, they spend approximately 90 percent of their time in the indoor environment.

And people who are most susceptible or vulnerable to the adverse effects of pollution, tend to spend even more time because of their peculiarity; like age related peculiarity, if old people are there, then normally they stay indoors. Children also, women who are homemakers basically they also spend a lot of time indoors.

And they get exposed to indoor air pollutants because of cooking and so many activities which are sources of indoor air pollutants. Then, indoor concentrations of some pollutants have increased in recent decades due to increased use of synthetic building materials; because, the building patterns have also changed over the years.

Now, we use a lot of chemical bond related building material, furnishing, personal care products, they also emit lot of VOCs etc. Then, pesticides, because we have certain plants inside our houses;

and we use sometimes pesticides also for pest controls and other things. Then, household cleaners are also there which are for moping etc; so they emit lot of hydrocarbons or toxic elements.

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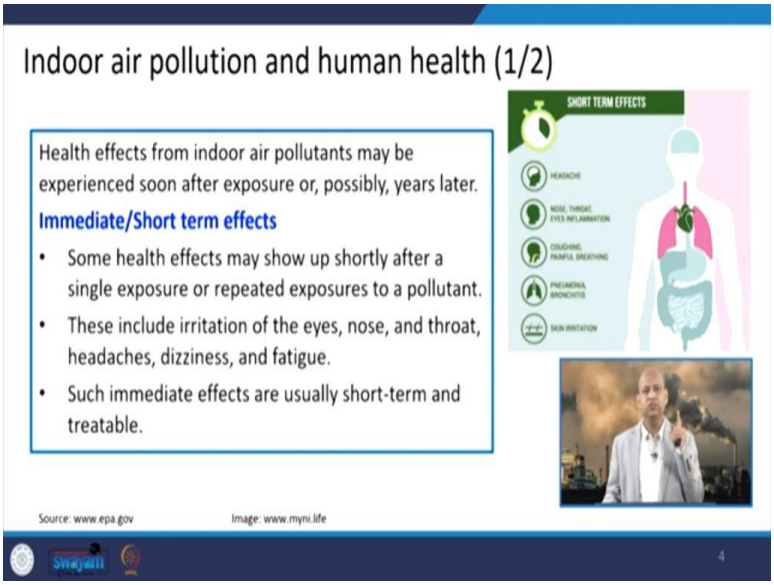

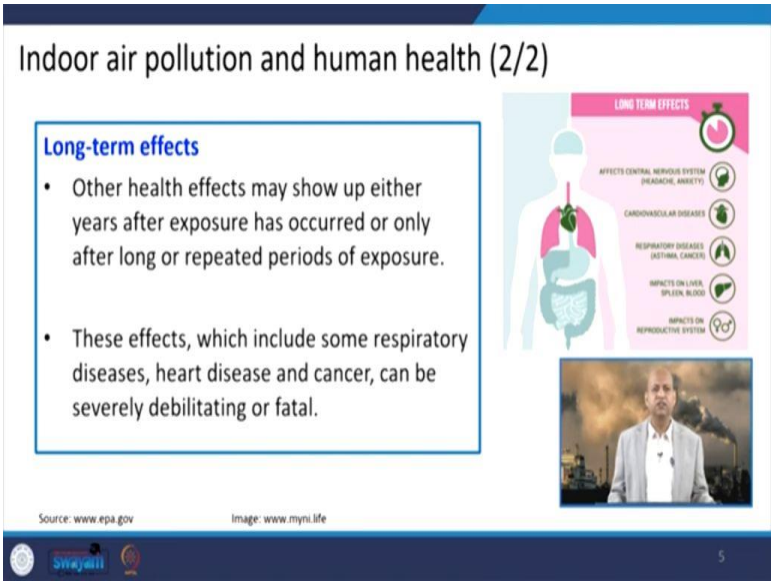

When we talk about indoor air pollution and human health, then there are short term effects as well as long term effects. And short term effects, people may feel irritation into eyes, or nose or in the throat, or headaches, dizziness or fatigue; means even if you are not working very hard, you sometimes feel fatigue, very tired, those kinds of things. And the reason maybe the indoor air pollutants. So, these things you need to keep in mind. And then there are some immediate effects

like kind of sneezing and those kinds of things; very quick sneezing, if some allergens are present there.

When we talk about long term effects, then there are other diseases which can be of heart diseases or cardiovascular diseases, respiratory diseases, even cancer can be there because of some indoor air pollutants. So, these things are into this category of long term effects when we are get exposed to for long term to the indoor air pollutants. When we talk about major indoor air pollutants, then there are several air pollutants.

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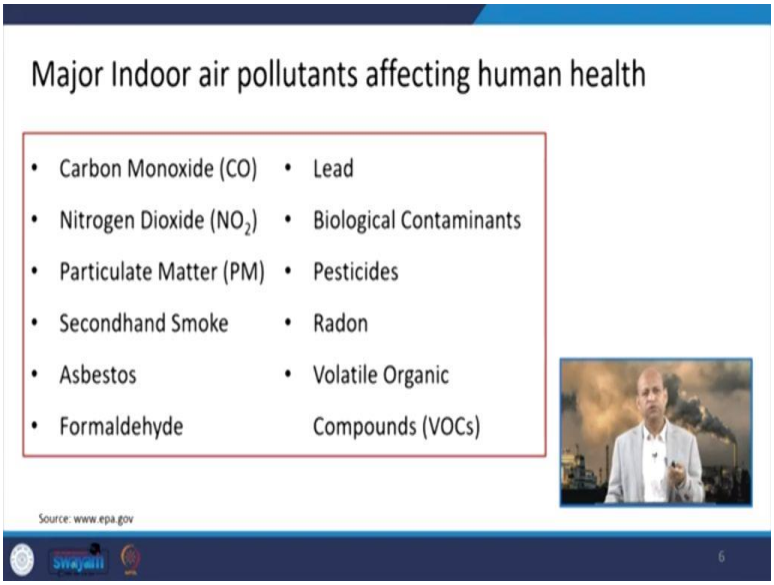

And some of them are common; they may be present in outdoor also like carbon monoxide, nitrogen dioxide, particulate matter, etc. But, there are certain pollutants which are more, they are present in more quantity, or more chances are there in the indoor environment, like asbestos or formaldehyde; they maybe also in industrial locations also. But chances of their presence in indoor environment is also high, lead because of paint, etc. Then, biological contaminants, pesticides, radon, Volatile Organic Compounds, because of certain chemicals we use in the washrooms, etc.

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Carbon Monoxide (1/3)

Health Effects Associated with Carbon Monoxide

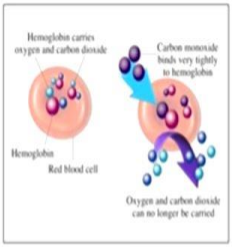
- Acute effects are due to the formation of carboxyhemoglobin in the blood, which inhibits oxygen intake.

Lower concentrations:

- At low concentrations, fatigue in healthy people and chest pain in people with heart disease.

Moderate concentrations:

- At moderate concentrations, angina (suffocation), impaired vision, and reduced brain function may result.



Source: www.epa.gov Image: Kruti Davda (2020)

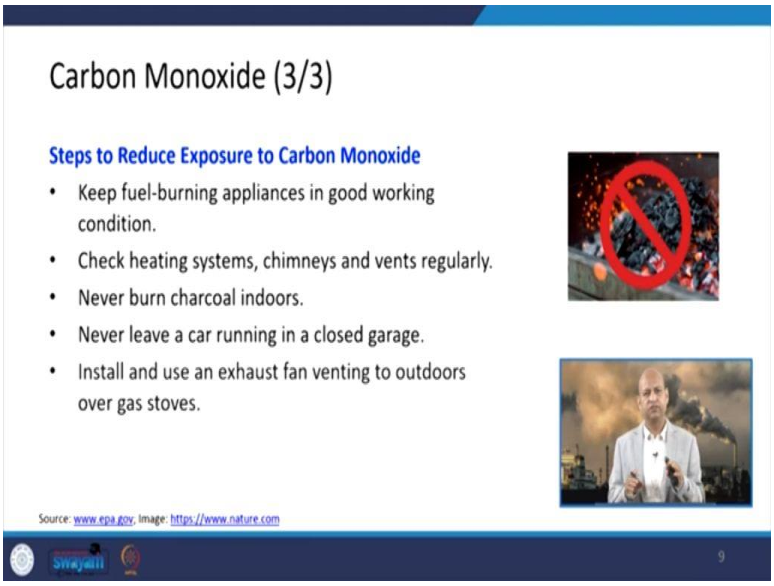
Carbon Monoxide (2/3)

Health Effects Associated with Carbon Monoxide

Higher concentrations:

- At higher concentrations, impaired vision and coordination; headaches; dizziness; confusion; nausea.
- Can cause flu-like symptoms that clear up after leaving home.
- At higher concentrations, CO exposure can be fatal.

Source: www.epa.gov Image: www.verywellhealth.com



When we talk about a specific pollutants and their health impacts, then we go one by one; we take carbon monoxide. So, what are their health effects? Their acute health effects maybe there; because of formation of carboxyhemoglobin in the blood, which inhibits oxygen intake in the body as you know because CO gets into the blood, and it forms this carboxyhemoglobin. And then the carrying capacity of the blood for the oxygen get reduced drastically. And this can cause like fatigue, or tiredness something like that, because you are not getting sufficient oxygen in the body.

So, that affects negatively to the body, the complete body system, physiological system. And then the moderate concentrations may cause like suffocation or impaired vision; means sometimes you feel that dizziness, you are not looking at things properly, things are not visible properly. Then, there maybe some reduced brain function also, means your alertness, your attentiveness get reduced, you are not very much focused; and that could be because of carbon monoxide exposure to the carbon monoxide. When we talk about high concentration because low concentration, moderate concentration, high concentration, they have different effects.

High concentrations can cause very acute headache, dizziness, confusion, nausea; and you can get unconscious also, when oxygen content in the blood is very low, and even people can die. And that is why, sometimes you might be reading some news that some people when they forget to have proper ventilation; and they use some sort of in the winters those kind of sources of heat, which emit lot of carbon monoxide, like coal burning those sigdi. So, those things emit lot of carbon monoxide and because it is colorless, odourless and it does not warn you beforehand. So,

the people in the during sleep, they inhale lot of carbon monoxide; they get unconscious and sometimes they die also; so that is very fatal and very problematic.

So, what we do to get the less exposure of carbon monoxide, or reduce the exposure of the carbon monoxide. So, basically we need to keep fuel burning appliances in good working condition; because, when the burning is not proper, then CO_2 emission is less, carbon monoxide emission is more. When the complete combustion occurs, then there is hardly any carbon monoxide; lot of carbon dioxide get released, but incomplete combustions they emit lot of carbon monoxide. So, when these stoves, or fuel burning appliances, or devices are in good condition, then they will have; they will favor the complete combustion that would be better.

Then, you can check the heat systems, or chimneys, or ventilation systems regularly, so that proper ventilation occurs, proper incoming of the air and outgoing of the exhaust gases are properly done. Never burn charcoal indoors; because that emit a lot of carbon monoxide. So, that need to be kept in mind, we should not burn charcoal inside the houses; because, otherwise, it will produce a lot of carbon monoxide. And never leave a car running in a closed garage, because again this when car is idle and engine is running; then lot of carbon monoxide is produced.

As you know, vehicular emissions are large in quantity for carbon monoxide or NOx emissions, those kinds of things. Then, install and use the exhaust fan venting to outdoors over gas stoves. So, proper chimney must be there, proper that kind of exhaust fan must be there; so that all these exhaust gases whether it is carbon monoxide or other pollutants, they get out quickly.

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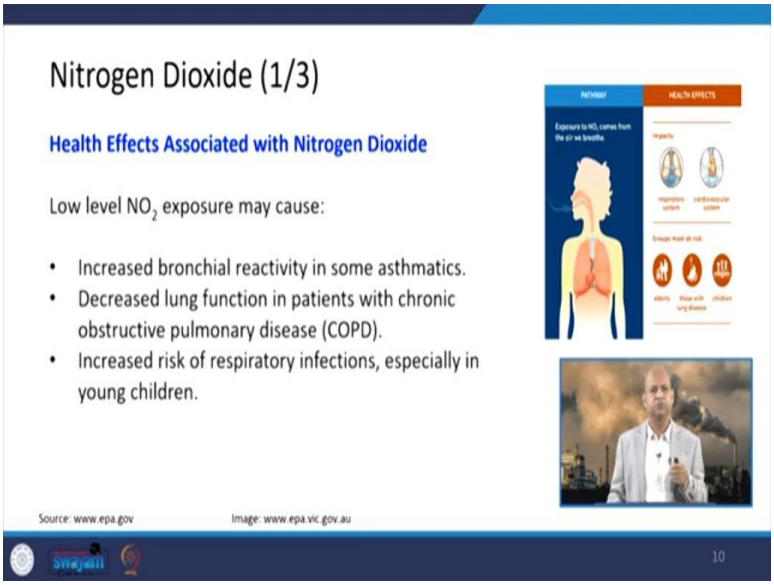

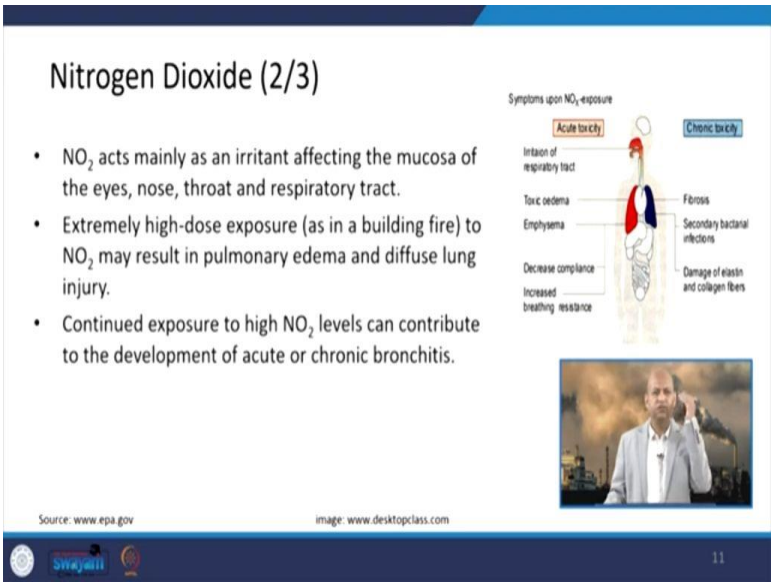

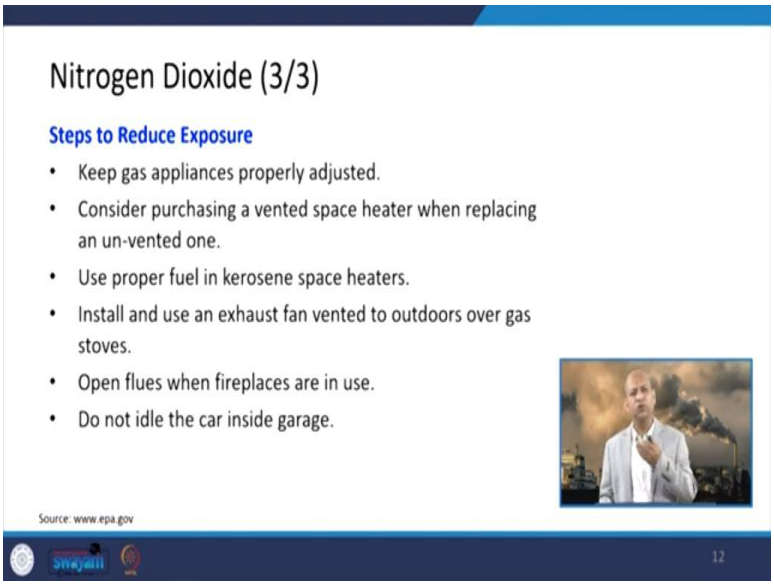

If we talk about nitrogen dioxide, then it has also some health impacts. For example, it can increase the bronchial this reactivity in asthmatic patients, this respiratory system, as you know. And it can decrease the lung function because of Chronic Obstructive Pulmonary Disease COPD, which is quite dangerous if it goes beyond certain limit.

It can increase the risk of respiratory infections especially in young children. So, the nitrogen dioxide is also problematic inside the this micro environment. Then, when we talk about like their health effects, like they have irritating effecting this mucosa of the eyes; mucous or those that liquid portion or moisture which we have in the eyes and nose or throat.

So, that is natural thing for proper functioning of these organs. So, that moisture is irritation is there in that or respiratory tract also, and lot of problem may occur. Then, extreme high doses of this NO_2 can cause this pulmonary edema and diffuse lung injury. So, those kind of things maybe because of lot of NO_2 like fire is occurring, then lot of NO_2 emissions maybe there. Then, if we get continued exposure to high NO_2 levels, which can contribute to the development of very acute or chronic bronchitis; so again, respiratory problem may aggravate and this can be very severe in fact.

When we talk about what are the steps which we can undertake to reduce the exposure of NO_2? So again, there are certain common features in all indoor air pollution related problems, like ventilation is good. Everything related to the ventilation when we talk about the concentrations of indoor air pollutants. So, when we keep these appliances gas appliances properly adjusted, then

NO_2 production is reduced. Then we can have better ventilation space is like heating devices and un-vented corners should not be there. Then, we should use proper fuel in kerosene space heaters; otherwise, that can produce lot of NO_2.

We should install and use exhaust fan as we have discussed in last this carbon monoxide case also; so that is important part. Then open flues when fireplaces are in use, so, that should be there. We should not have idle cars in the garages, as it can also cause lot of these NOx emissions.

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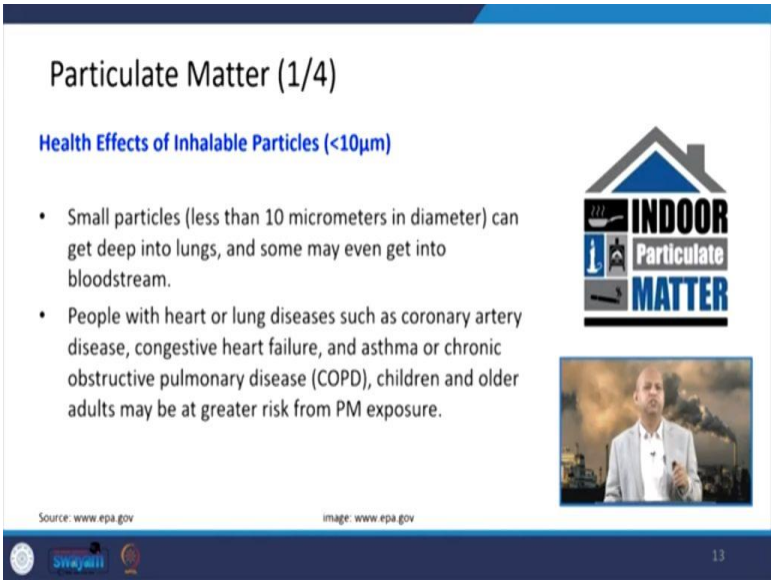

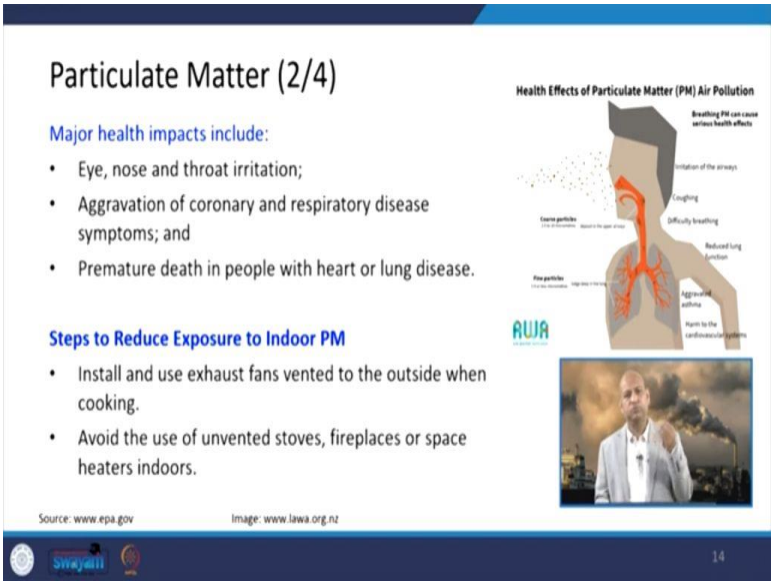

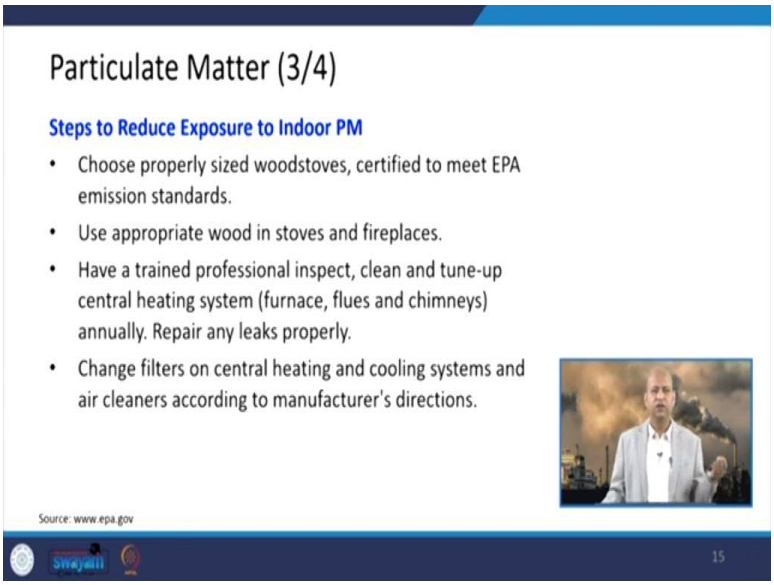

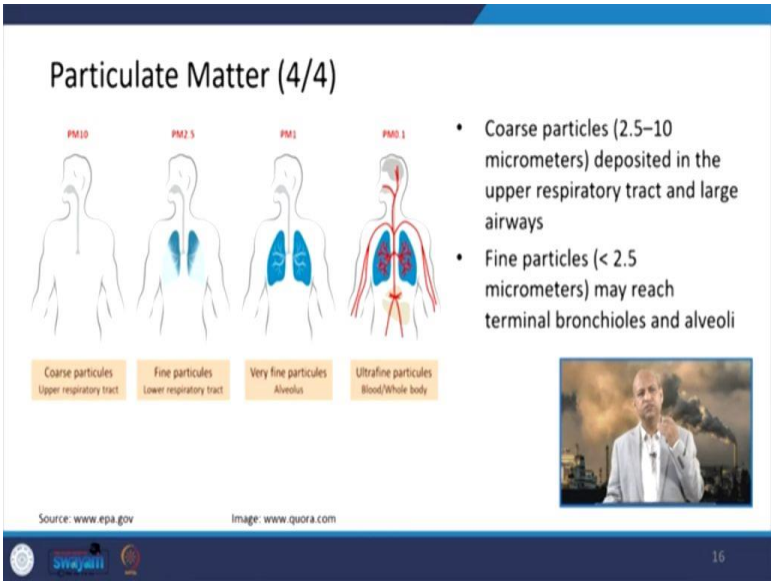

When we come to the particulate matter; so these are small particles less than 10 micrometer or $PM_{2.5}$. So, they can cause problem to the lungs or our respiratory system they get into the system depending upon their size. And they can enhance or increase the diseases which are coronary artery disease, or congestive heart failure, or asthma or Chronic Obstructive Pulmonary Disease (COPD). Children and older people are at greater risk because of this exposure of very fine particles. Then, if we talk about major health impacts, so again eye and nose irritation, throat irritation can be there.

It can aggravate this COPD as we have discussed, even premature death it can cause because of certain heart and lung related diseases it can it can trigger. And if you want to reduce its concentration, then again we should have good ventilation. And we should not have those strobes

or those kind of fireplaces which can emit a lot of particulate matter; so those things we need to keep in mind. We should also do like for example, if we are using some wood stove, then certified wood stoves we should use? Which are certified by some agency like in the USA it is EPA; in our country like CPCB and other agencies are there.

We should use and trained professional inspectors should be there in indoor environment of industrial setup. And these central heating systems must be properly managed by those skilled people; chimneys must be proper, and the repair and leakage those kinds of things must be maintained nicely. There should not be inside leakages which can cause lot of emissions of particulate matter. We should also change filters if we are using some filters in the heating system or cooling system; because if those filters are choked, then they also become the source of indoor pollution of particulate matter. So, the cleaning of those filters is very much required time to time.

Even those as you might have heard like nowadays, many people use air purifiers, and air purifiers use the filters. If you do not clean those filters, basically, it will add into the indoor air pollution. So, rather than reducing it will be an additional source; so those things we should be careful about.

When we talk about their health impact, then the size is very important; like coarser particles from $PM_{2.5}$ to PM_{10}. They can go to upper part of this respiratory system; but less than $PM_{2.5}$, they can go up to the lungs. And when they are like PM_1 or so, so they can go to alveoli, which are those parts of the lungs where this exchange of oxygen occurs into the blood and those particular parts.

And further ultra-fine particles, basically, they can go into the blood streams. And as I said earlier also in one lecture, that if those ultra-fine particles if they are coated with some carcinogenic elements or toxic elements, they can trigger certain diseases in the body. So, we must be a very much alert about these health impacts.

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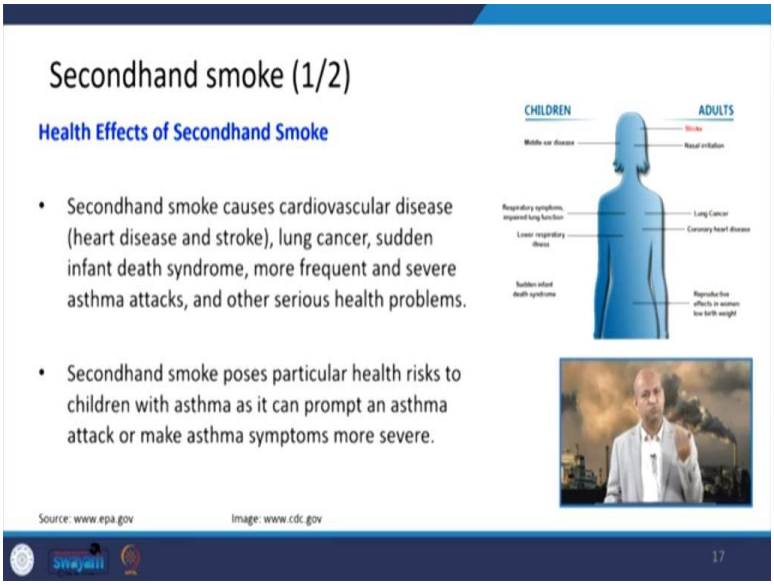

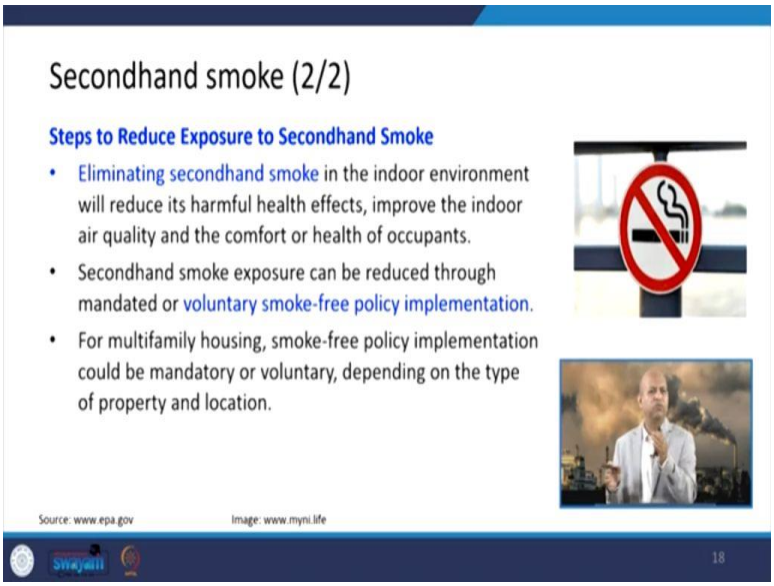

When we talk about secondhand smoke, like some people are smoking and other people who are not smoking; but they are exposed to that smoke which is coming out of because of cigarette smoking or like that. So, they have several toxins basically, and they can affect influence or impact the health of the other people who are in the surrounding. Not only the person who is smoking, but to the persons of passive nature; means they are not the smokers, but they are smoking because of this vicinity, closer proximity to the smoker. These particulate matters can be there or other toxic elements can be there and serious health impacts can be because of those passive smoking or secondhand smoke.

So, how to reduce the steps, or how to take the steps to reduce exposure? Means we should have specified corners where a person can smoke. And in living spaces where most of the people are there it should be kind of prohibited. If somebody wants to smoke, then he or she should go outside balcony or somewhere where these people are not there. And in public places as nowadays lot of awareness is there. And there are certain corners where it is written that smoking is allowed here only; so you cannot smoke in public places except those designated places. So, that way this exposure to the secondhand smoke can be reduced significantly.

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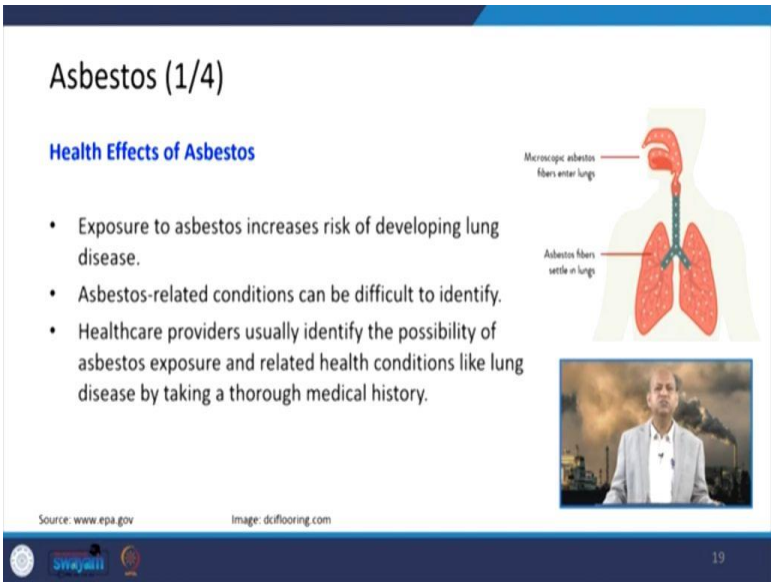

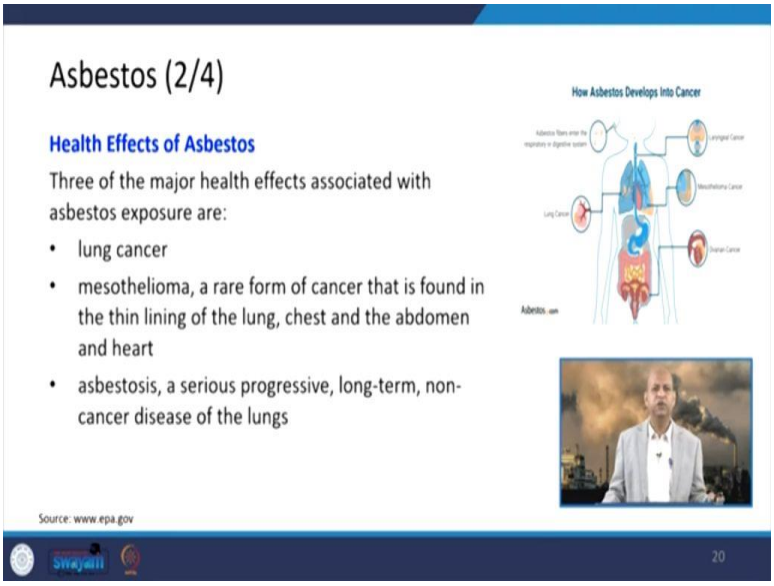

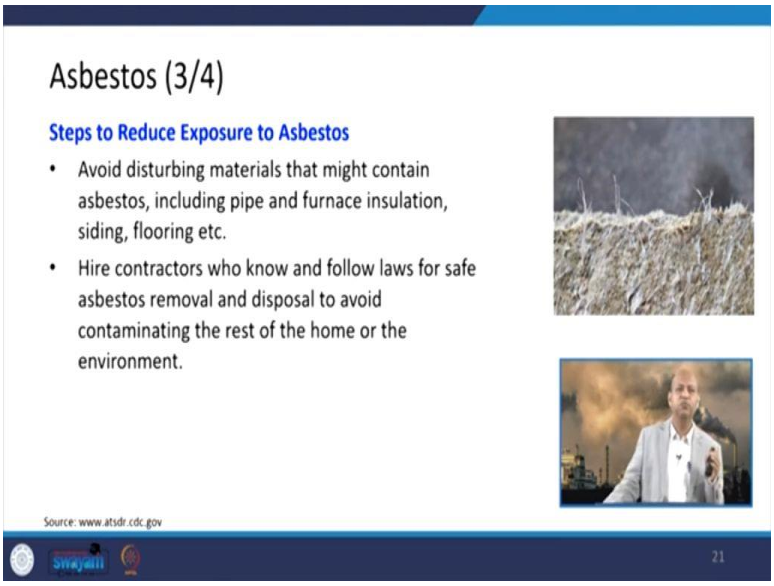

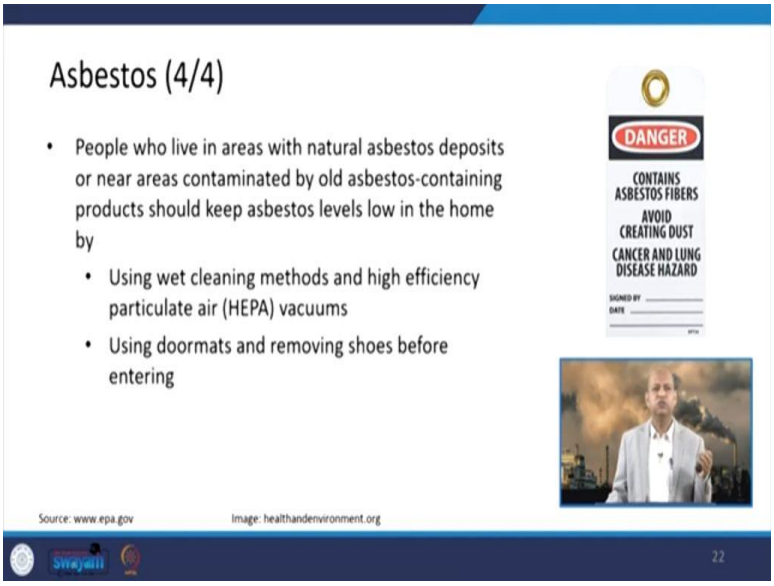

Then there is like asbestos. So, asbestos as you know, it is available in several kind of building materials or from soil those exposure is there. And it can cause several problems like you can see these health effects like lung cancer it can cause. So, that is very problematic exposure to the asbestos.

So to reduce that, again we should be very careful about, we should not disturb materials that might contain asbestos; like pipes, furnace, insulations, siding, flooring, all those kinds of things. If we are disturbing them, then we should have proper contractor who is expert in handling those things; otherwise, lot of emissions maybe there off the asbestos.

And people who live in the areas where these natural asbestos deposits or near areas contaminated by all asbestos containing products are there; they should keep asbestos levels low in the home by using several kind of ways. For example, wet cleaning methods are there of High Efficiency Particulate Air, vacuum cleaning can be done; or you can use door mats to remove shoes before entering. So, in Indian culture, there are most of the houses they remove the shoes outside the house when they enter into the house. So, these are cultural behavior, but they are very good in getting rid of those pollutants which can come with the shoes, etc.

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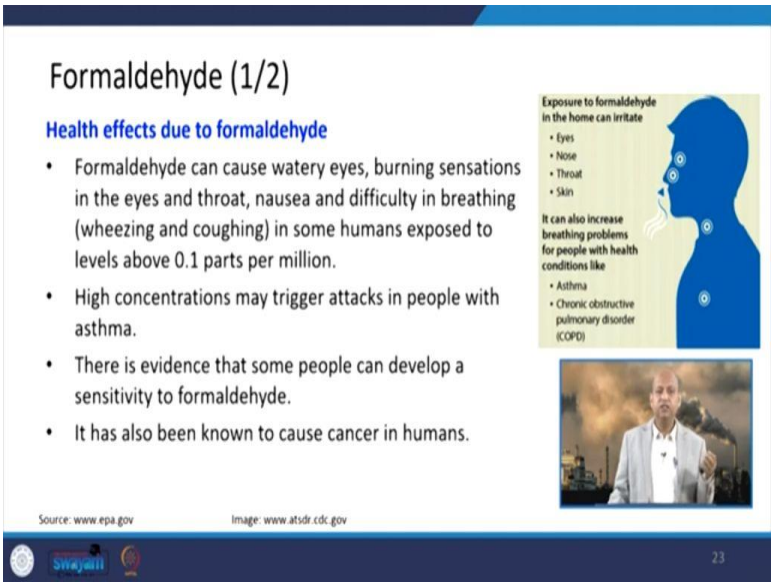

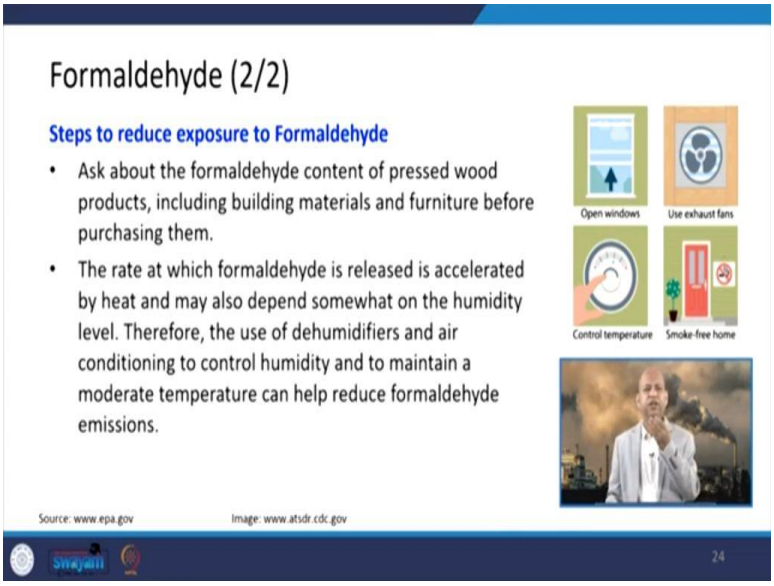

Then formaldehyde, again this can come because of several sources we have discussed; and the health effects are watery eyes, or burning sensation in the eyes and the throat, nausea, difficult in breathing, or wheezing kind of coughing kind of things may be there. And it can be when people get exposed to levels above 0.1 ppm; so, it is very problematic.

And high concentrations may trigger attacks in people with asthma; so asthmatic attacks maybe there, it is very dangerous. And there is evidence that some people can develop sensitivity to formaldehyde, when they are just get exposed to, then these kinds of things happen like allergens do something similar to those eye irritation, etc. And it is also known for causing cancer in the human; so it is very dangerous or problematic.

Again, to reduce it, we have to do several steps those formaldehyde content of pressed wood products maybe there, including building material and furniture before purchasing them, we can ask that we should be having those kind of things which have minimum of this formaldehyde; or do not have the formaldehyde content. Then, you can also go for, when in which condition they are released, formaldehyde they release? The rate at which formaldehyde is released is accelerated by heat, or may also be deepened somewhat on the humidity level.

So, we can do dehumidifiers, we can use air conditioning in the system to control humidity, so to maintain the moderate temperature; and that will reduce the chances of emissions of formaldehyde.

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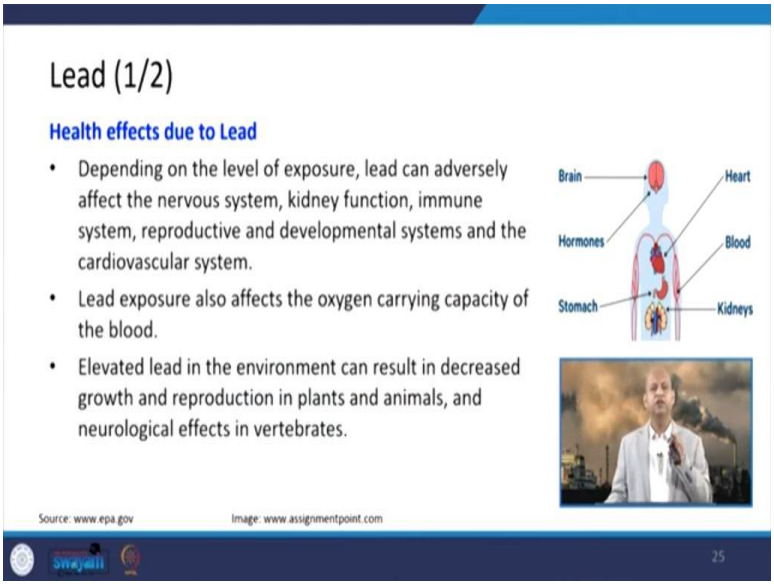

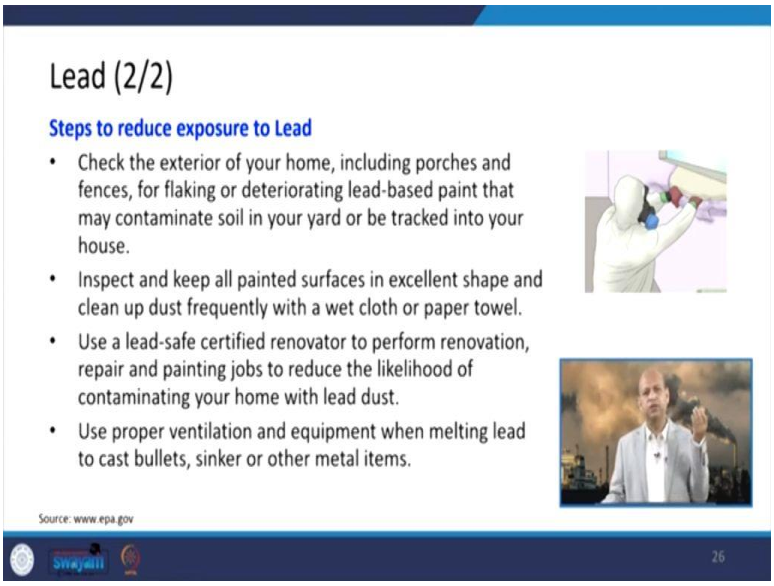

When we consider this lead, lead related health effects, so depending upon the level of the exposure of lead, it can adversely affect the nervous system, kidney function, immune system and reproductive and developmental systems and the cardiovascular system. So, means multi negative impacts are there okay.

It can also affect the oxygen carrying capacity of the blood like CO does. And the elevated or high lead concentration in the environment can result in decreased growth of reproduction in plants and animals, and neurological effects in these animals, or those kind of which are having like spines and those kind of animals and birds, etc.

So, this is very dangerous in that sense. And to reduce the exposure of the lead, you can have unleaded petrol in ambient environment that can reduce the lead content. But, in indoor environment like paints, which are the sources of the lead pollution; so you can go for those paints which do not have lead or very minimum quantity of the lead. So, and then ventilation and other things we should go. Plus we should be careful that paint should not peeled off those kind of. If there is a situation of not a good situation, then have a better paint; otherwise, it can be a source of the lead pollution.

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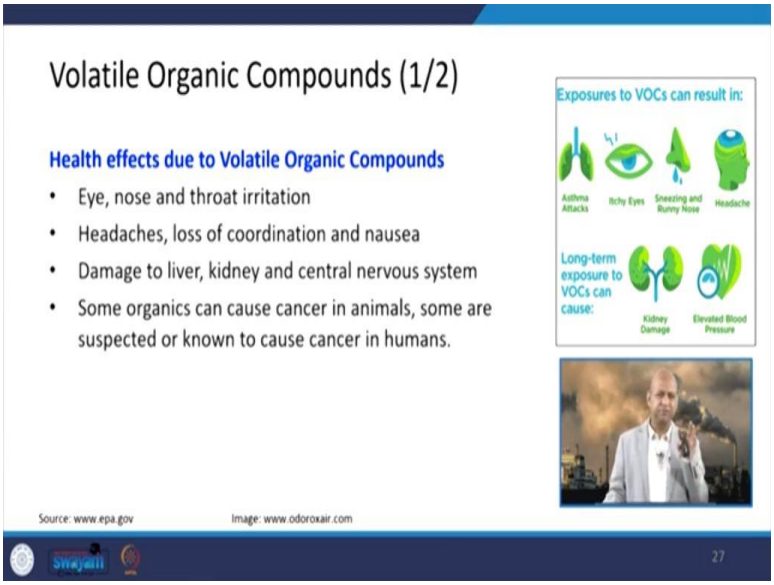

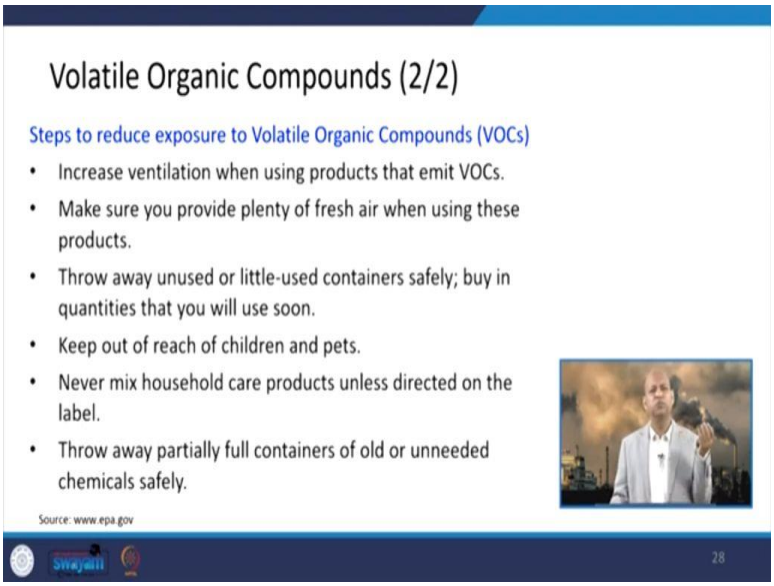

When we talk about volatile organic compounds, so there it can come from several sources as we have discussed inside the houses. And the health effects are eye irritation, nose irritation, throat irritation, many people have allergy to VOCs basically. It can also cause headache, and low level of coordination, confusion, nausea, that kind of thing. It can also damage the liver, kidney and central nervous system; so many negative health impacts are there. Then, some organics can cause cancer in animals, some are suspected to be known as causing cancer in human also.

So, VOCs are of several kind and they can have different negative health effects. When we want to reduce the exposure, so we should reduce their sources very simple; we should not use those

kind of room fresheners, which can increase the levels of VOCs. And also we should be careful about good ventilation, fresh air should be there. So, we can deal with this and we can reduce the VOCs concentration quite drastically.

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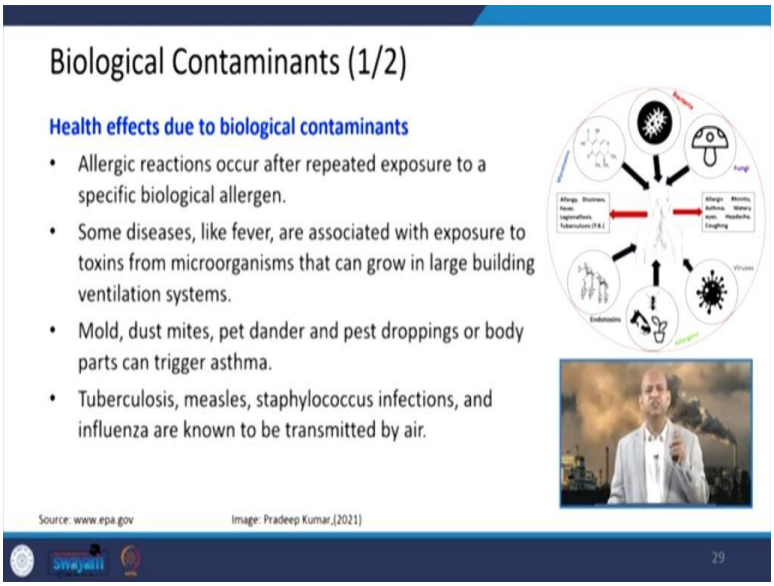

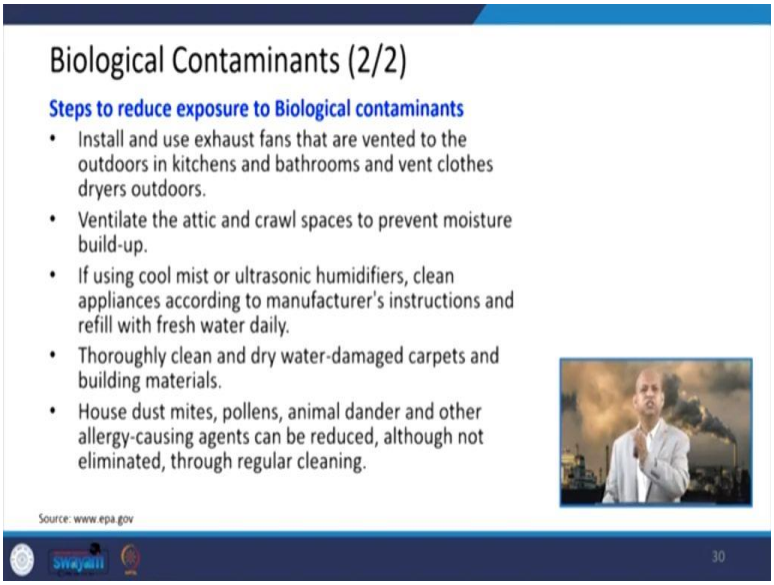

When we talk about biological contaminants, then there are several sources of allergens. And the allergic reactions are the major health effects of these biological contaminants; because some disease like fever or these toxins can go for these like mold, or dust mines, dust mites, or pet dander or pet droppings. They can also be source of biological contaminants. And the tuberculosis or

measles, or there are many infectious diseases which can be caused by these biological contaminants.

So, again, if you want to reduce the exposure to these biological contaminants, then we should tackle at the source level that would be better. And like, if there are pets, then we should keep them away from our living environment; and we should keep them clean.

Similarly, like those kind of kitchen and bathrooms, the ventilation must be proper; otherwise, this in seepage leakage is there. Then, molds and fungi those kinds of things may occur; and then that can trigger many kind of allergic reactions. So, we should be using cool mist or ultrasonic humidifiers, and clean appliances according to the manufacturer's instructions; refill and fresh water daily those kinds of things we should take into account.

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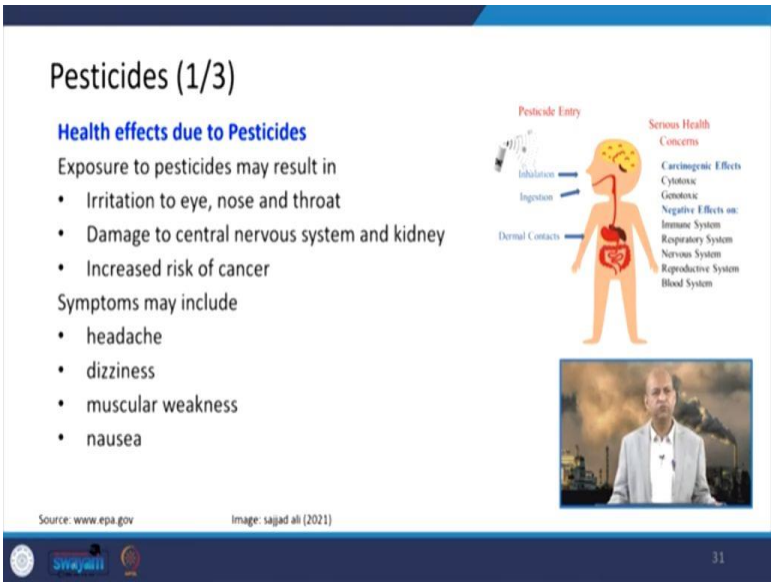

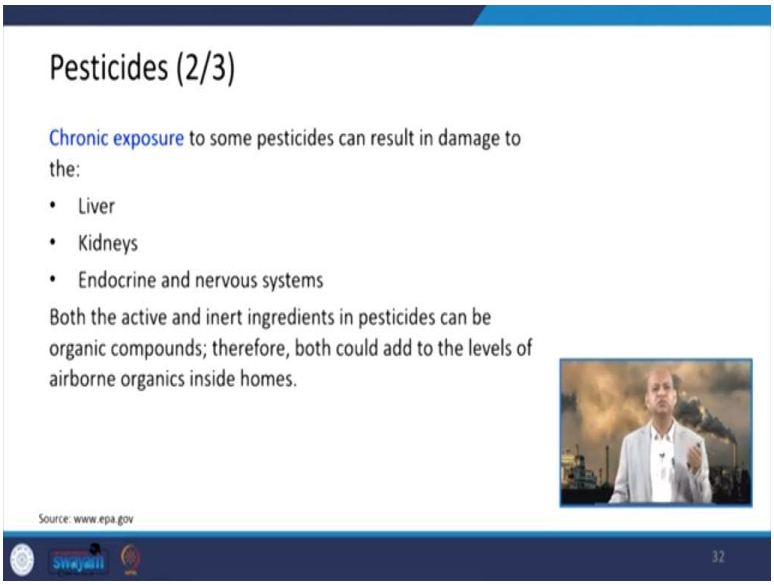

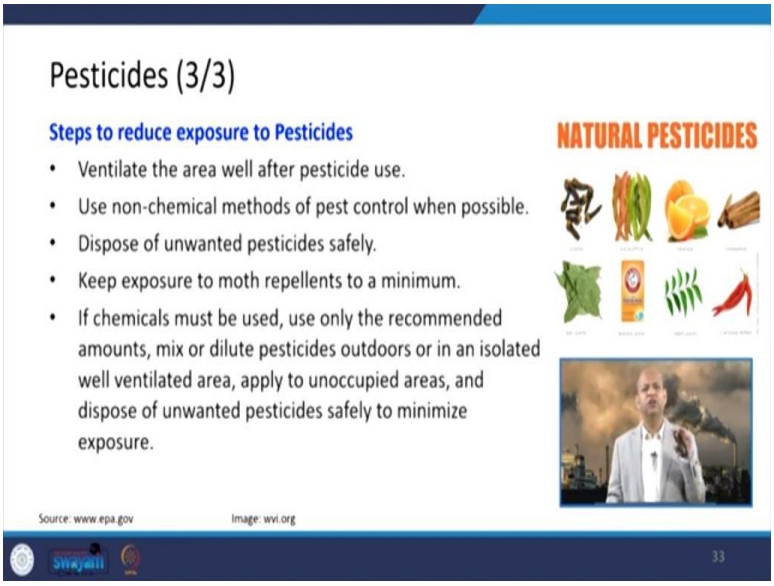

When we talk about pesticides because nowadays we deal with our kitchen garden, or we have indoor plants also. So, sometimes we should we use pesticides; and they can be source of these pesticides concentration, the indoor environment. And they can cause irritation to eye, nose and throat; it can damage central nervous system also, kidney also get affected. It can increase the risk cancer because of these pesticides. Then, symptoms may also include like headache, dizziness, muscular weakness, nausea, all those kinds of things can be there because of pesticides.

It can also chronic exposure is there, longer exposure is there; then it can affect the liver, kidney; and then endocrine, and nervous systems. Endocrine and nervous system means it can change even different systems of these at the cell level, DNA level.

When we talk about how to reduce the exposure to pesticides, so again ventilation must be good; and we should go for non-chemical methods of pest control rather than using these pesticides. And we should dispose of unwanted pesticides safely; otherwise that could be source of pesticide emissions. We should keep exposure to the moth repellents to a minimum. Then the chemicals must be used when recommended in a recommended amounts only.

And we should not go for larger or more amount than the recommended ones; and safety precautions are very much needed. And better is that rather than being dependent on chemical, these pesticides etc; we should go for other organic ways to control the pest.

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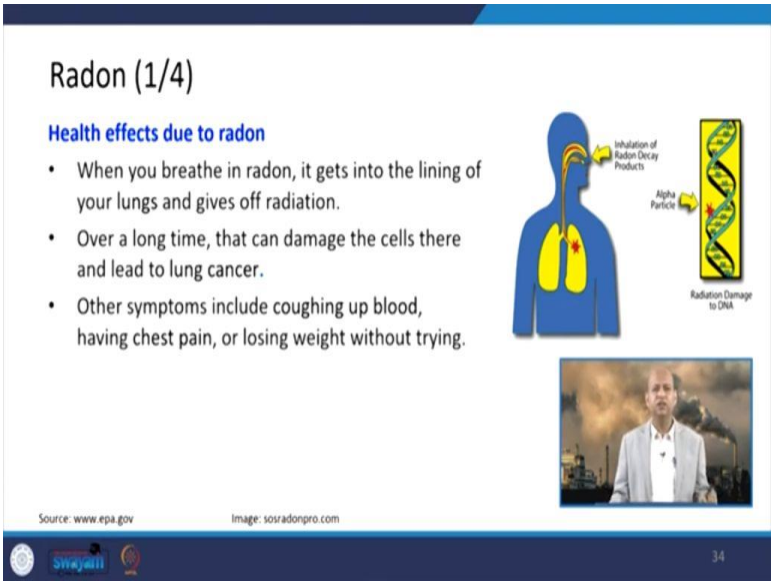
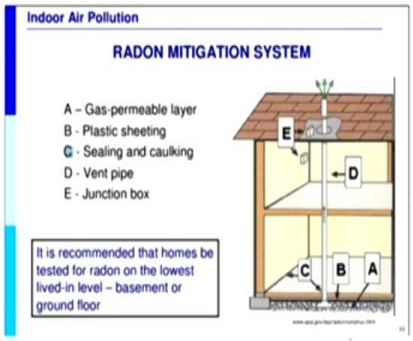


Radon (2/4)



Source: www.epa.gov Image: www.myni.life

Radon (3/4)

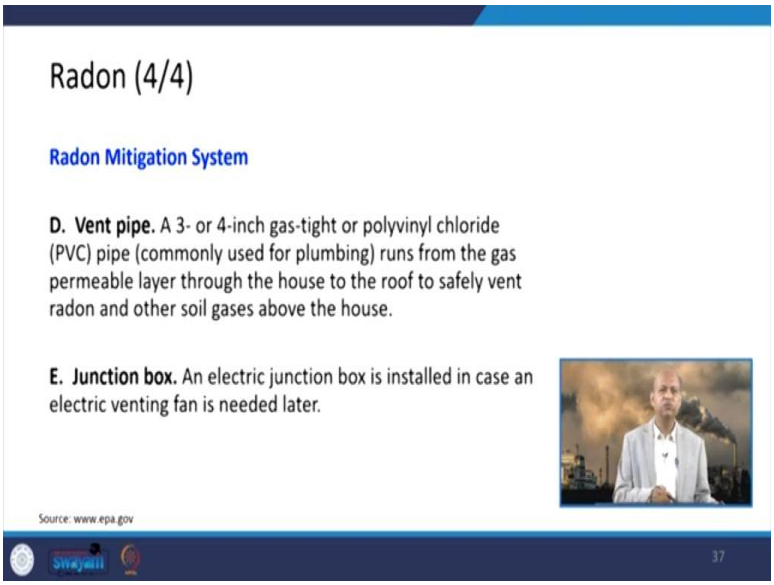
Radon Mitigation System

A. **Gas-permeable layer.** This layer is placed beneath the slab or flooring system to allow the soil gas to move freely underneath the house.

B. **Plastic sheeting.** Plastic sheeting is placed on top of the gas-permeable layer and under the slab to help prevent the soil gas from entering the home

C. **Sealing and caulking.** All openings in the concrete foundation floor are sealed to reduce entry of soil gas into the home.

Source: www.epa.gov



When we talk about health effects of the radon, so, it can have we can breath, we can inhale the radon when it is present in the indoor air. And it can damage the lining of the lungs, and it can gives of the radiation. And over the long period if exposure is there, then it can damage the cells, and it can lead to the lung cancer there. So, that is very problematic because it gets exposed to the lung because of respiratory system.

And when we go about the symptoms of this exposure of radon, then it can coughing of the blood; blood can come out of because of it reduces the lining of that our respiratory system. And chest pain or losing weight without trying, so those kind of things are there which are negative impacts, health impacts of the radon.

And when we go for how to manage it, so better you can have better ventilation system, where it can come from the underground soil; so for that special these ventilation pipes can be installed. Then, when we also go for gas-permeable layer, or plastic sheeting or sealing and caulking; those kind of measures are there which can be used, which can be good uses for mitigation of the radon. You can also use these vent pipes and junction box; these are things for mitigation purposes of the radon.

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Vulnerable Population: Children (1/4)

- Infants and young children have a higher resting metabolic rate and rate of oxygen consumption per unit body weight than adults. Therefore, their exposure to any air pollutant may be greater.
- In addition to an increased need for oxygen relative to their size, children have narrower airways than do adults. Thus, irritation caused by air pollution that would produce only a slight response in an adult can result in potentially significant obstruction in the airways of a young child.

Source: Moya J. (2004)

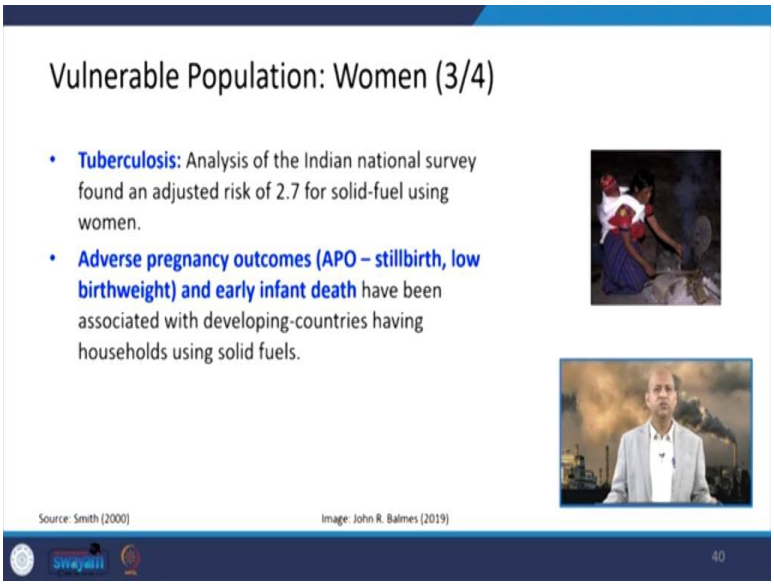
Image: aircentraltexas.org

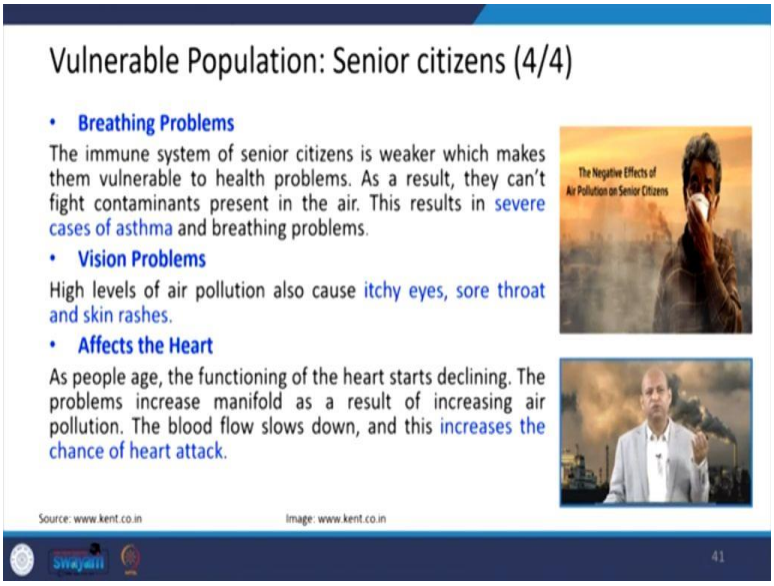
Vulnerable Population: Women (2/4)

- **Chronic obstructive pulmonary disease (COPD),** such as chronic bronchitis, in women accounts for about 1.5% of deaths in India, and 16% in China.
- **Lung cancer** in women is a well-demonstrated outcome of cooking with open coal stoves in China.
- **Cataracts :** An adjusted odds ratio of 1.3 for blindness in women was found in biomass-using homes.

Source: Smith (2000)

Image: blog.iiasa.ac.at





Then, when we talk about vulnerable population in the indoor environment like children; so, they are the population because they spend lot of time inside the indoor environment, so, they get affected. Similarly, women who are using kitchen, etc. so they can get exposed; and there are studies that like COPD related diseases are much more in the women folks. So, then lung cancer, cataracts, those kinds of things, they are associated with their indoor environment related pollution.

Similarly, the senior citizens breathing problems, vision problem, heart related problem. There are health related or age related issues, and then it can also increase those kind of things like sore throat, etc. because they are more exposed, because they do not go outside much more than the adult population.

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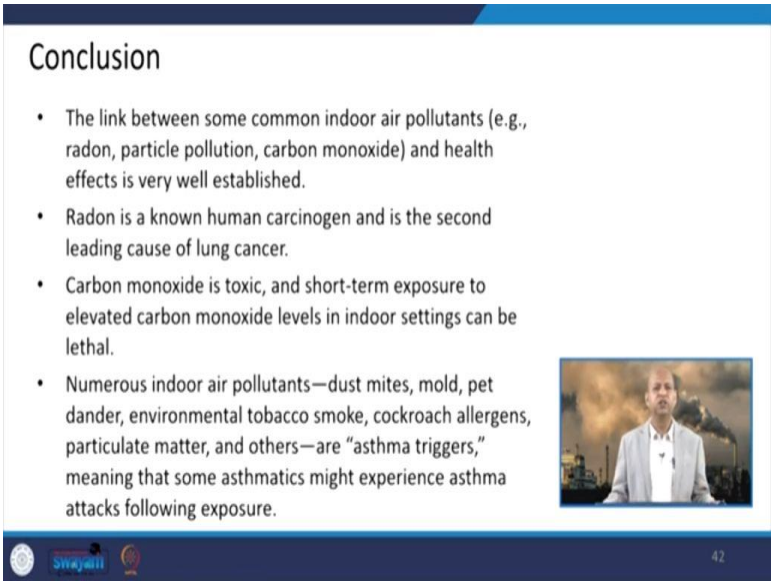

So, this is all for today. In conclusion, we can say that there is the link, very strong link between some common indoor air pollutants like radon, particulate pollution, carbon monoxide, and their negative health impacts. Radon is known for human carcinogen and it is the second leading cause of the lung cancer in developed countries; or where these kind of sources are there.

Carbon monoxide is toxic, and short term exposure and the elevated carbon monoxide levels can be there in the indoor settings; and it can be very dangerous also sometimes. Then, numerous indoor air pollutants are there of biological nature like dust mites, mold, pet dander; and then these smoke maybe there, secondhand smoke.

So, all the allergens are there which can trigger asthma, which can have many other negative impacts. So, we should be careful about those things; and we should have good ventilation, so that the indoor environment is safer or clean air is maintained.

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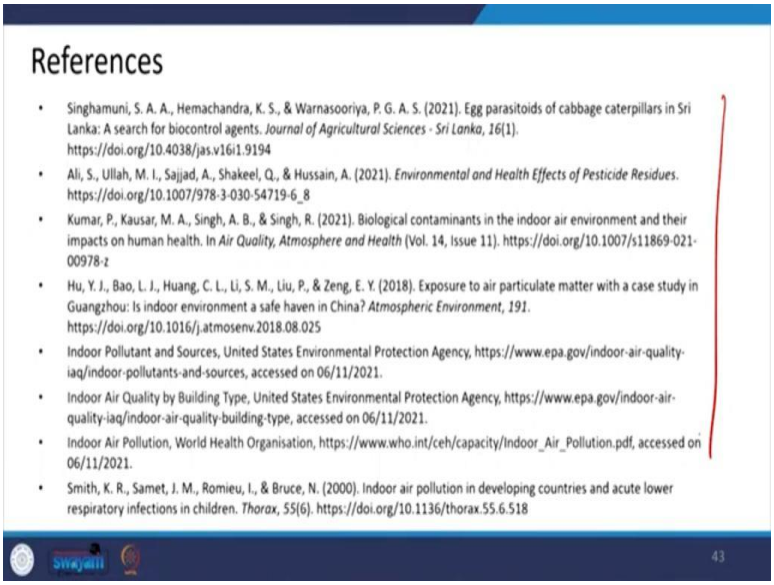

So this is the references, you can go through them for additional information. So, this is all for today. See you in the next lecture. Thank you. Thank you very much.