Air Pollution and Control
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Lecture 34
Technologies to Mitigate Indoor Air Pollution

Hello friends. So, in the series of indoor air pollution its effect and its sources, then assessment of indoor air pollution. Today we will discuss about the technologies which are used for mitigating or controlling indoor air pollution.

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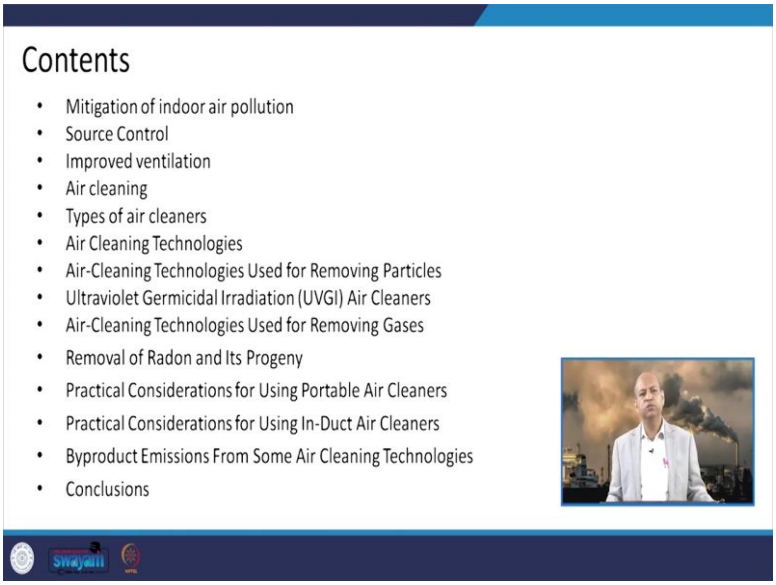

So, in this lecture we will include like what is the requirement of mitigation of indoor air pollution, why do we need it? Then, what are the sources that can be controlled to reduce the contaminants in indoor environment, and then how to improve the ventilation which is one important aspect of improved indoor air quality.

Then air cleaning and types of air cleaners which are used for cleaning the air. Air cleaning technologies, different kinds of technologies, like, removing particles or using ultraviolet germicidal irradiation, UVGI air cleaners, and then air cleaning technologies which are used for removing gases, removal of radon and its progeny and other products, practical considerations for using these portable air cleaners or in-duct air cleaners because there are issues means it is not always true that air cleaners will be very nice in handling to remove air pollution.

Sometimes, if you are not maintaining them properly then they can be also sources of indoor air pollution basically. Then by-product's missions from some air cleaning technologies as I

said that if we have to maintain them properly, otherwise, there can be additional sources from these controlling devices. If you do not maintain, we do not repair them timely, and then we will go for conclusions.

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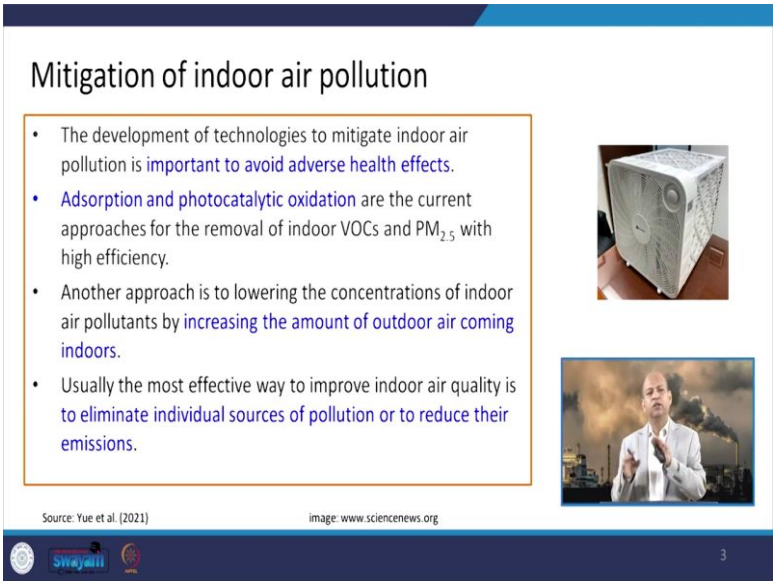

So, when we talk about mitigation of indoor air pollution, why it is required? So, the development of technologies which are needed for mitigating indoor air pollution is very important, because it otherwise the indoor air pollution can result into several kind of health effects or adverse health effects. So, to avoid that kind of situation, its necessary to employ certain technologies to mitigate, or to control, or to remove to reduce the indoor air pollution levels. Then there are several techniques, but adsorption and photocatalytic oxidation these are the current approaches which are kind of popularly they are used for removing indoor VOCs volatile organic compounds and fine particles like $PM_{2.5}$ with high efficiency.

These adsorption and photocatalytic oxidation these two processes are very popular in that sense, but there are other approaches like lowering the concentration of indoor air pollutants by increasing the amount of outdoor air coming indoor through ventilations. But it is a tricky thing, because if outdoor air quality is not good, then polluted air may enter into the indoor environment. So, we have to first see that the outdoor air must be clean, only then we can go for this kind of situation where we increase the amount of inflow of the outdoor air to indoor environment, then it can improve the indoor air quality. Otherwise, if the outdoor air quality is not good, then this is not the right approach.

Usually, the most effective and successful way to improve indoor air quality is to eliminate individual sources of pollution, or to reduce their emissions inside the indoor environment

itself. There should not be any source means, at the source itself we should do something which can eliminate these emissions of air pollutants.

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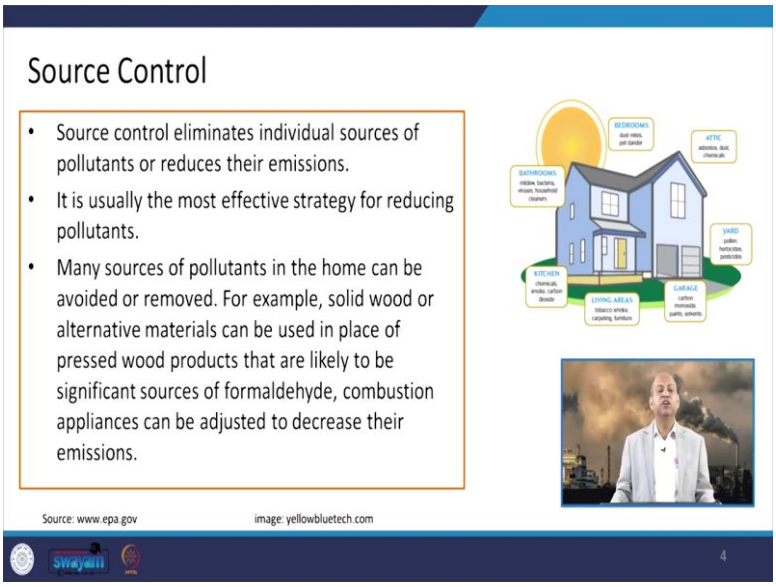

So, basically the source control mechanism eliminates individual sources of pollutants or reduces their emissions. And this is usually the most effective strategy for reducing pollutants inside the micro environment. Many sources of pollutants in the home can be avoided or removed for example, like if we these solid wood or alternative materials can be used in place of the pressed wood or those ply woods or boats etc, which are basically significant sources of formaldehyde.

And the combustion appliances can be adjusted to decrease the emissions in kitchen etc. So those kinds of things we can accomplish through interventions of technological interventions or some changes in the usage of different products.

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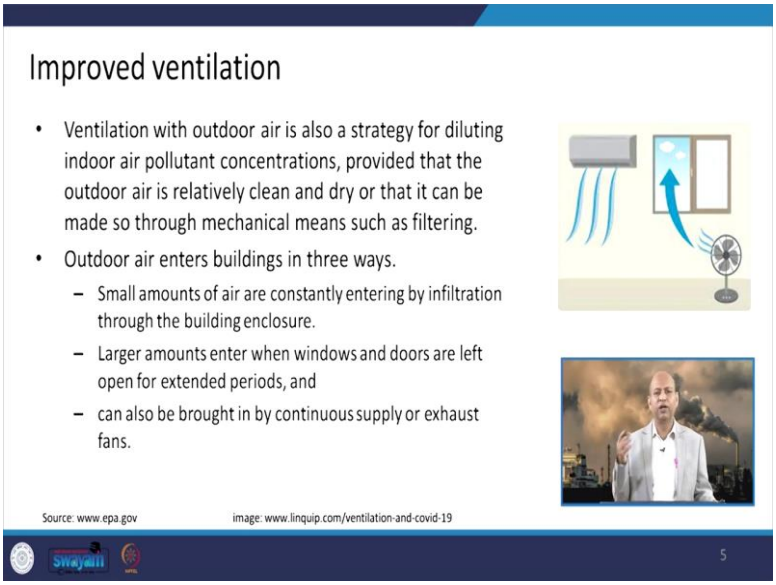

Well, when we talk about it improve ventilation. So, the ventilation with outdoor air is also a strategy for diluting indoor air pollutant concentration, but, in that case the outdoor air must be clean with respect to the indoor environment provided it is relatively clean and dry means it should not be humid also, because humid air if it enters into the micro environment indoor environment, then there are several issues like moles or many kind of microbes can grow in the humid environment. So, the outdoor air is clean and dry only then it is a good strategy to bring it inside the micro environment of indoor environment.

Well, then outdoor air enters buildings in three ways basically like small amount of air constantly enters through various infiltration, building enclosures etc, then large amount can enter through windows or doors whenever we open them. And then it can also be brought by like a continuous supply or exhaust fans means that kind of mechanism can be developed where certain fan are there only for bringing air inside the indoor environment only.

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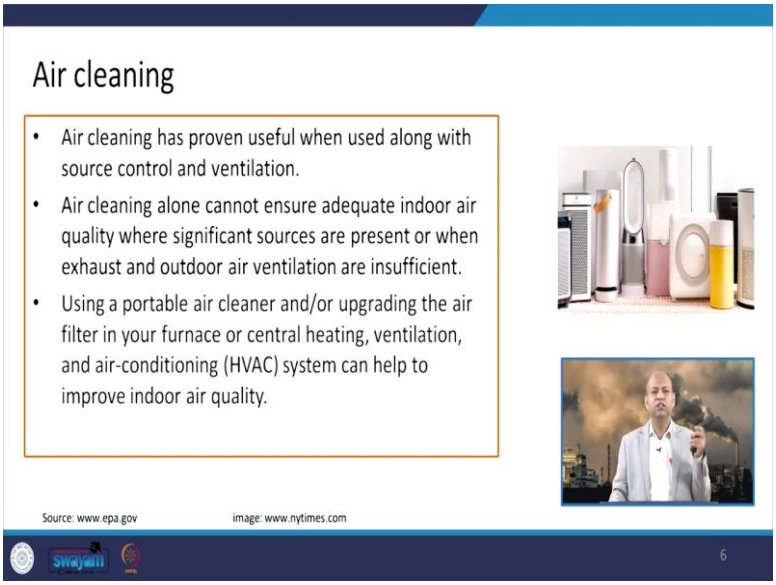

But the outdoor air must be clean and dry only then it is better to improve the air quality of indoors environment. Well, then there are air cleaning mechanism like air cleaners or these various devices are there portable as well as you can have mounted in the ducts etc. So, this air cleaning has proven useful basically and it is used along with the source control and ventilation. Air cleaning alone cannot ensure adequate indoor air quality where significant sources are present because then sources may be very dominating kind of these air pollution emissions.

So, when exhaust and outdoor air ventilation are insufficient, then alone this air cleaning may not be so effective. So, it is a kind of integrated approach you also have those ventilation mechanisms plus you also do air cleaning. So, using a portable air cleaner or upgrading the air filters which are used in the furnaces, because indoor environment does not mean only the domestic or residential houses. Indoor environments are there in factory spaces, industries, there are these occupational spaces where workers are working. So, those indoor environment are also needed to be clean. So, the Heating, Ventilation and Air Conditioning (HVAC), this system is there always for cleaning the air and to improve the indoor air quality.

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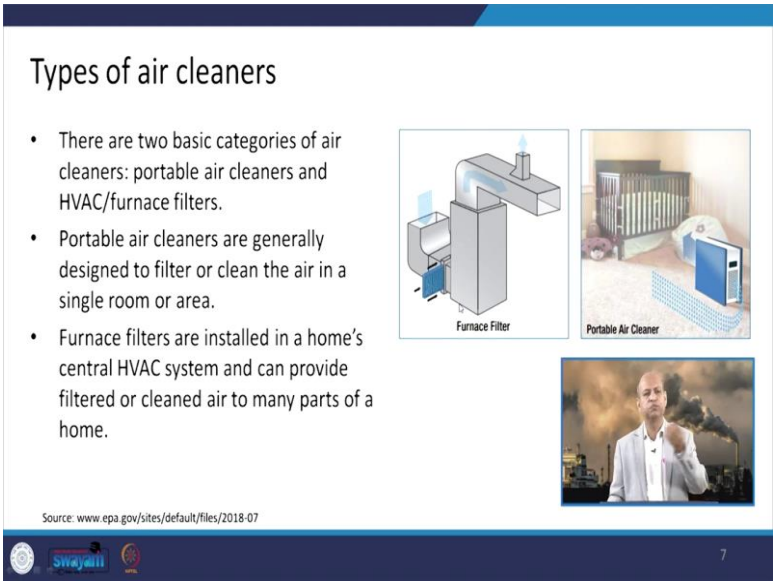

Well, so, there are two basic categories of air cleaners like portable air cleaners, and HVAC these heating, ventilation and air conditioning at the furnaces and other kind of locations. So portable air cleaners generally used where you can have these kind of filter mechanism where it sucks air and then passes through after capturing particulate matter etc. Furnace filters are there in these occupational spaces, in the factories etc. So, those kinds of HVAC systems can also be used.

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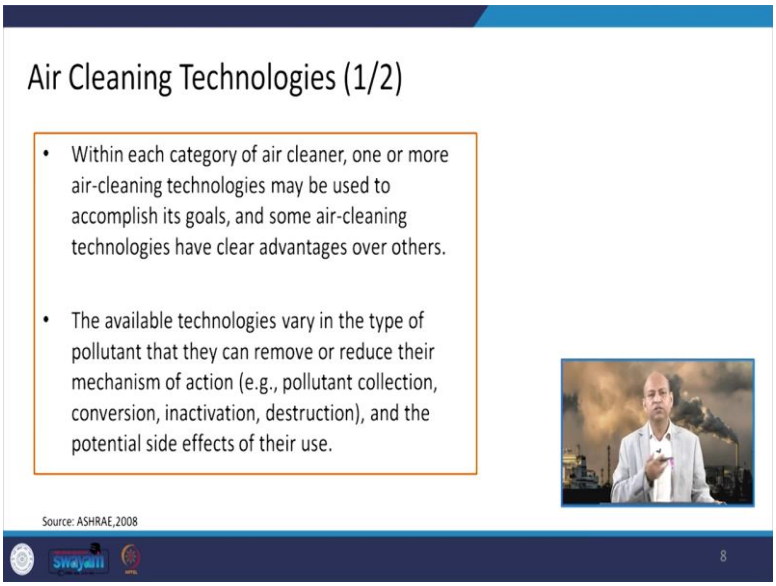

And within each category of these yair cleaners one or more cleaning technologies may be used to accomplish the aims of better air quality. And, the available technologies can vary in the type of pollutant, when some gases has to be controlled and reduced then other kinds of

technology can be used, when particulate matter is the target then some other way of removal of these mechanisms can be employed.

So, like, pollutant collection, or conversion, or inactivation, destruction, all these kind of mechanism can be there in different technologies. And there may be some potential side effects also, we have to see like filters if we do not change filters of the portable air cleaners, those filters can be sources of the indoor air pollution. So, rather than cleaning the air, they can pollute it. So, that has to be kept in mind.

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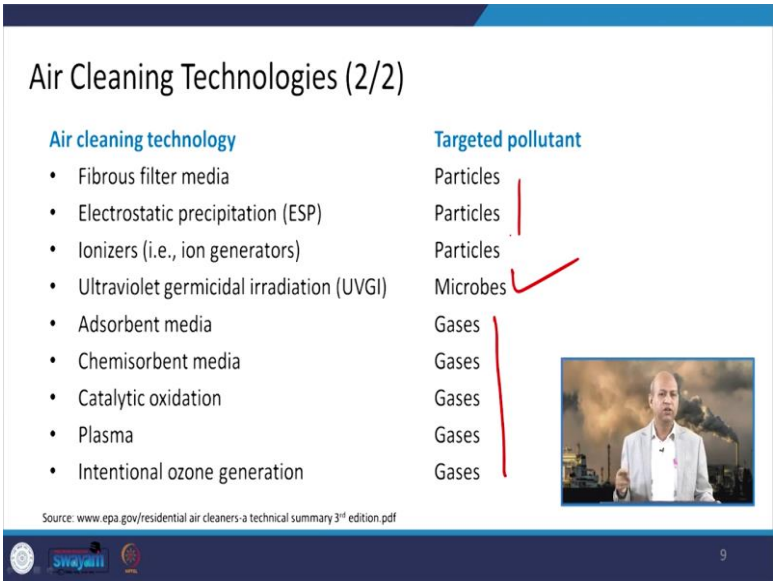

Well, when we talk about different technologies of air cleaning, then you can see this is the list like fibrous filter media can be used, or electrostatic precipitation; ESP can be used, which you have studied, we have studied in the like industrial air pollution control mechanisms. So small size ESPs can be used in indoor environment also.

Then ionisers can also be there. I am repeating it again that please do not feel that only the residential rooms or those houses are the indoor environment. Indoor environment can be of various kinds like big factories, or libraries, or museums, or whatever built environment is there where people are working.

So those large size indoor environments can be there, and you may need these ESP etc, those kinds of instruments. Well, then Ultraviolet Germicidal Irradiation (UVGI) can also be used, adsorbent media can be used, or chemisorbent media can be used, catalytic oxidation like the three way catalytic things are used in exhaust pipes of vehicles.

So, similarly, in indoor environment also some catalytic oxidation mechanism can also be used, then plasma related technology is there. Then there is like ozone generation because ozone is your oxidizing agent. So, for oxidizing those gases which are pollutants ozone can be generated and that can be used.

So, for gases these adsorbent media, chemisorbent, catalytic oxidation, plasma, intentional ozone, these are the better technologies. For microbes these UVGI, and for particles filter media, or these ESPs and ionizers can be used most effectively.

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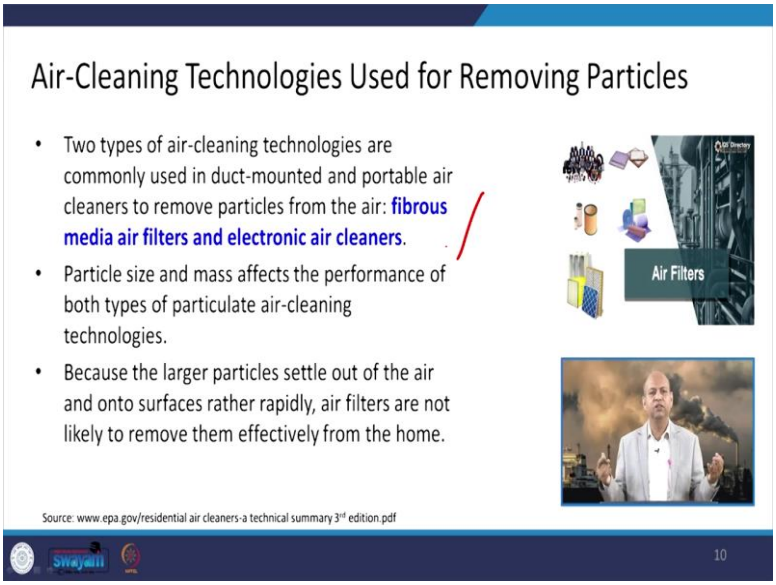

Well the two types of air cleaning technologies are commonly used in duct-mounted, ducts are there and then portable air cleaners to remove particles like fibrous media filters and electronic air cleaners. So, these are the two types which are very popular. And the particle size or the mass of the particles they influence the performance of these kind of air cleaning technology basically, because the larger particles settle out of the air and onto the surfaces rather rapidly. So, the air filters are not likely to remove them effectively from the home. So, that is why other kinds of technologies are employed.

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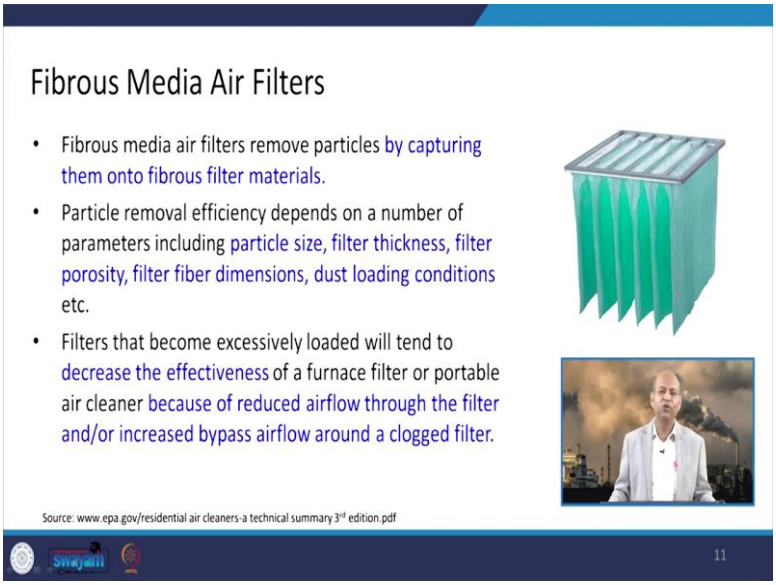

Well, fibrous media air filters remove particles by capturing them onto fibrous filter material. So, this may remind you the bag filters also. So, those kind of fibrous filter materials are there and, depending upon the particle size or fiber thickness, then filter porosity and filter fiber dimensions dust loading conditions, all these things influence the efficiency of the removal of these particles.

And, these filters that become excessively loaded will tend to decrease the efficiency or effectiveness of the filters basically when porosity is less and because of reduced airflow through the filters and increased bypass airflow around a clogged filter can rather pollute the indoor environment instead of cleaning it. So, these kinds of things we have to keep in mind to do better maintenance or frequently we should do something to remove those clogging kind of situations.

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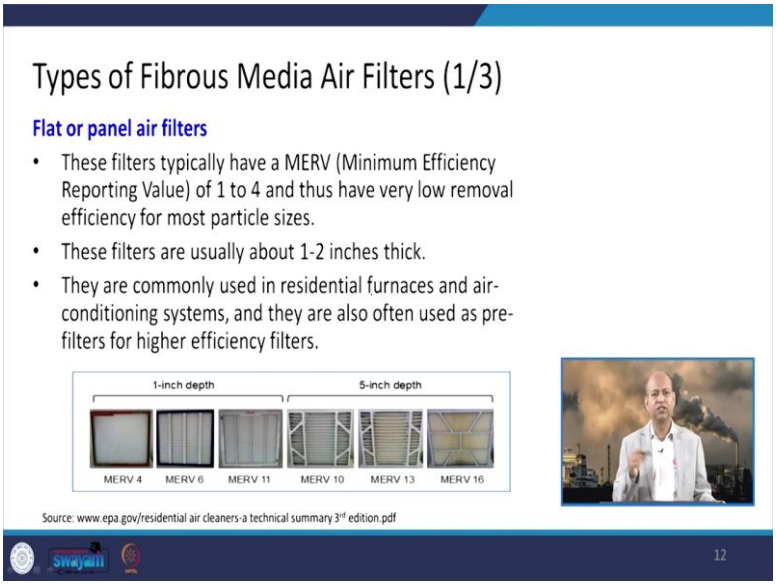

Well, then flat panel air filters can also be there. So, this is again typically they have this MERV (Minimum Efficiency Reporting Value) 1 to 4. So, different values are there depending upon their efficiency, then thickness can also be a matter of concern. So, all those things we have to see.

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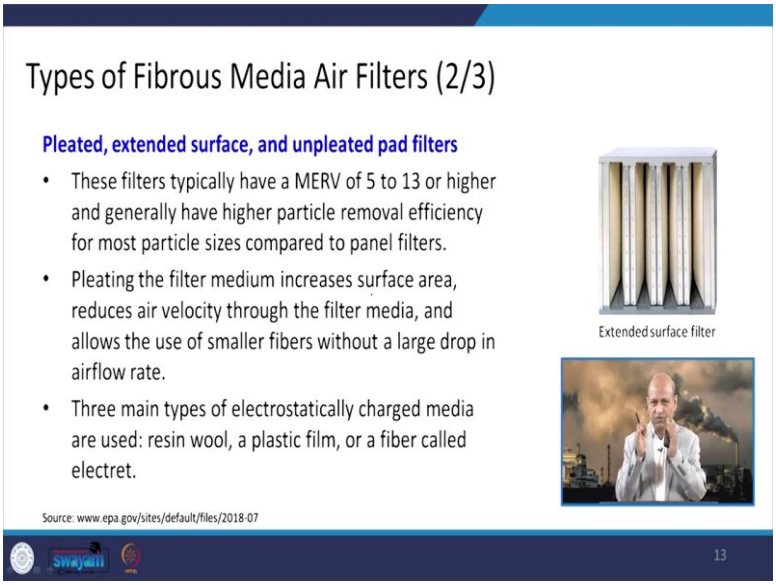

Plus at the same time, this pleating of these pleats of these filter media can also give us better surface area and it can reduces the air velocity and better efficiency can be achieved.

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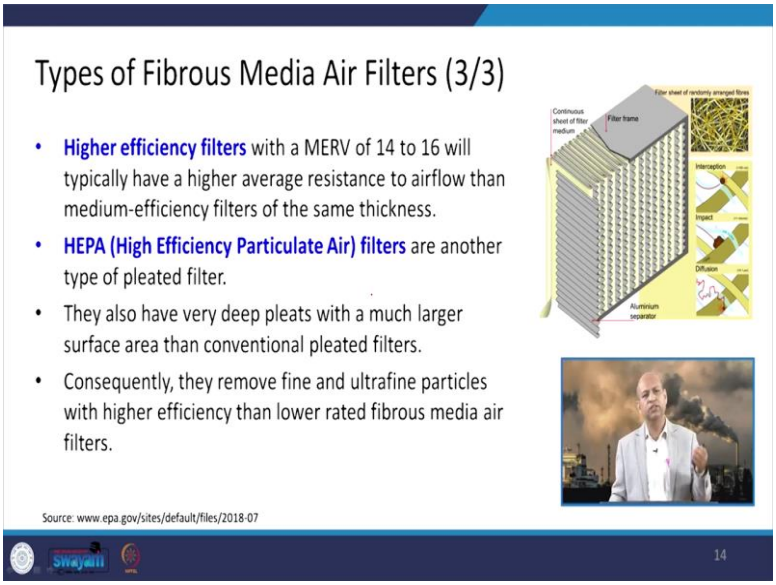

Well, when we talk about efficiency of these fibrous media, higher efficiency with the MERV of 14 to 16 will typically have a higher average resistant to air flow then medium efficiency filter, so, that again so it need more power you can say. Then HEPA (High Efficiency Particulate Air Filters), those kinds of filters are another type of pleated filters, they have more pleats and they also, they are very deep pleats and much larger surface area in comparison to the conventional pleated filters. So, that is why there performance is better and they can remove fine, ultrafine particles very efficiently in that way.

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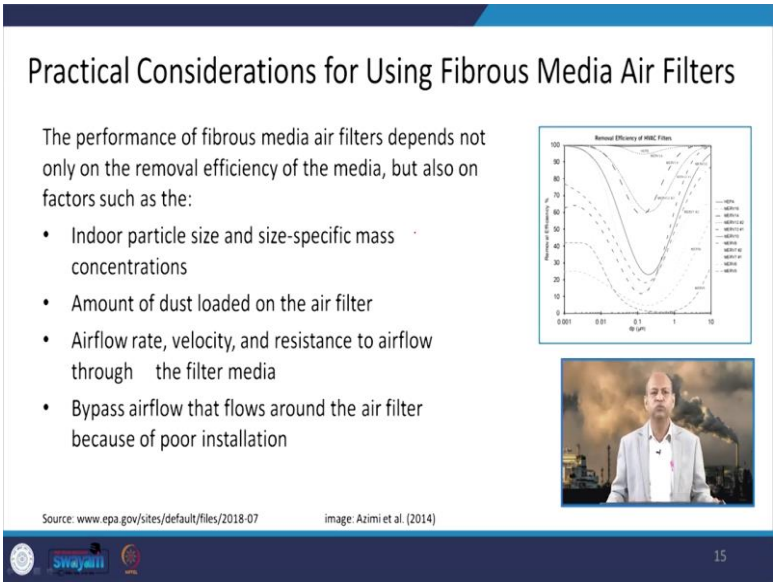

Well, when we talk about these practical considerations for using fibrous media air filters, because if you do not use them properly, then rather than creating the air quality making air

quality better they we, deteriorate it. So, the indoor particle size or size specific mass concentrations, amount of the dust loaded on the filter, and then airflow rate, velocity and bypass airflow that flows around the air filters, all these things have to be kept in mind and the optimization has to be done to have greater efficiency of those filters.

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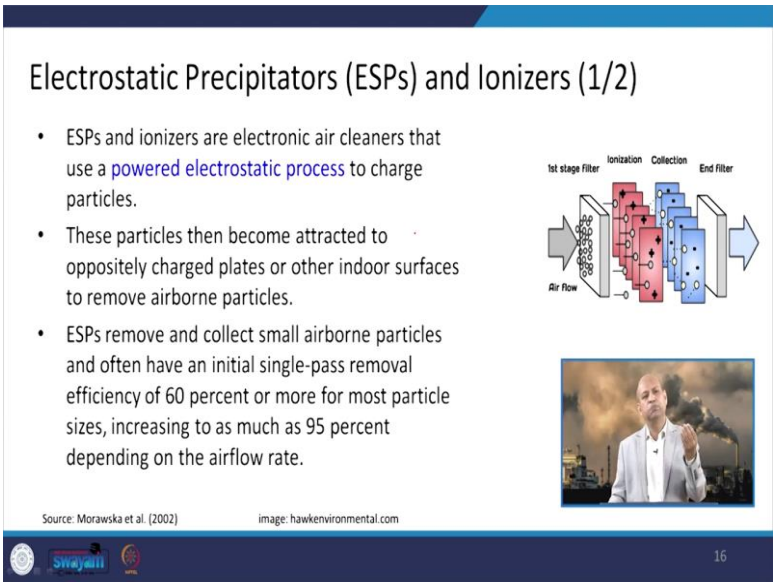

Well, when we talk about electrostatic precipitators or ionizers. So, as ESPs can be used for removing particles with high efficiency. But they can collect a small airborne particles and, they can have efficiency varying from 60 percent to even 95 percent depending upon what is the size of the particles and how much path is there, how many number of plates are there, all those issues are there.

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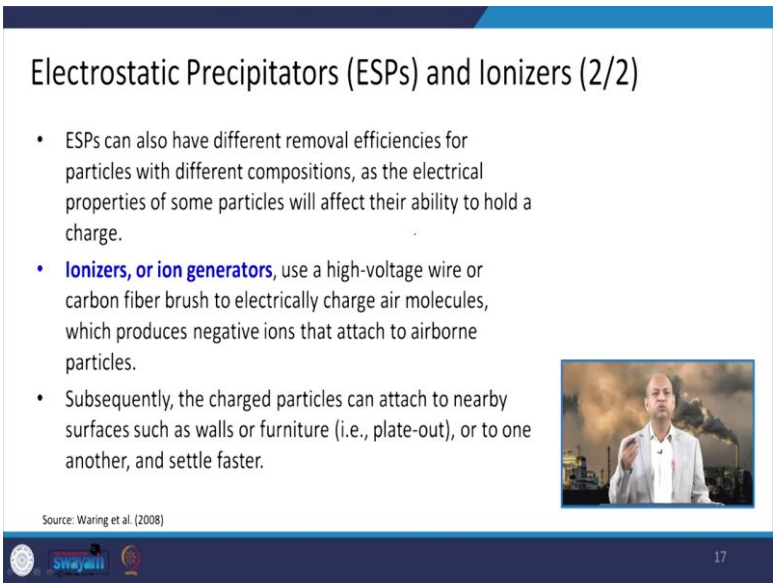

Then ionizers can be there, ion generators. So, they also create some situation where different of charged particles can be captured by other filters or those plates of different charges.

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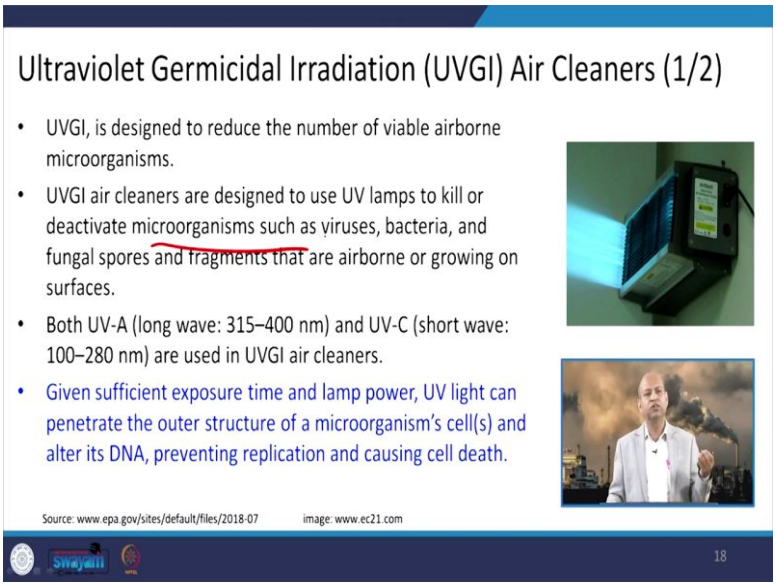

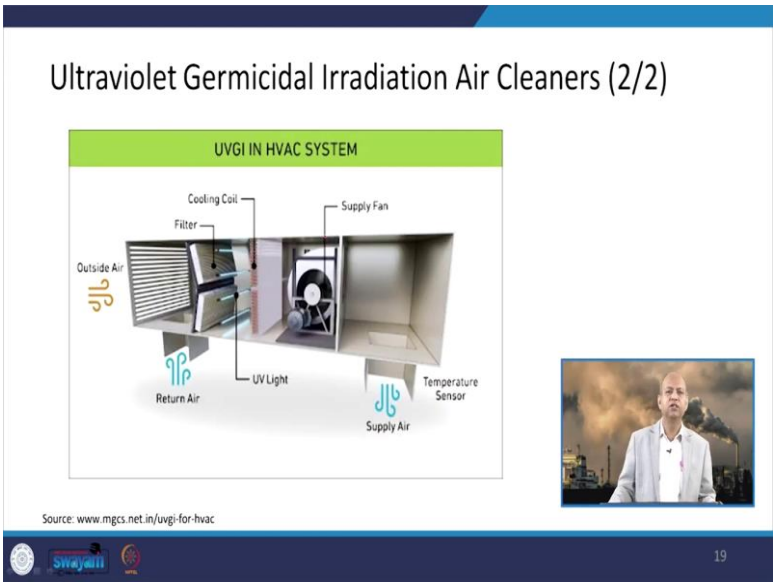

Well, when we talk about Ultraviolet Germicidal Irradiation (UVGI) air cleaners, you might have seen during COVID period these UV-based cleaning devices has come into the market. So, similar devices are there already for deactivating microorganisms such as viruses or bacteria. So, those are the devices which can be used for killing these kinds of microbes. And that given sufficient exposure in terms of time and the lamp power, these UV light can penetrate the outer structure of the micro-organism cells and they can alter its DNA so, they can prevent its replication or further multiplication and then they can cause the cell death. So, that way the bacteria or virus can be killed.

Well the ultraviolet, these UVGI kind of air cleaners, this is the diagram which shows how it is installed in the indoor environment, there can be different types of these UVGI cleaners, like air cleaners designed for air stream disinfection, where those rays UV rays are passed to the air and whatever microbes are floating into the air they will be killed, then surface cleaners like when we put something and then in the box there is this UVGI those rays are there, radiation are there then they kill. So, those kinds of devices which are cleaners for the surface, they are more efficient basically, in comparison to the air stream.

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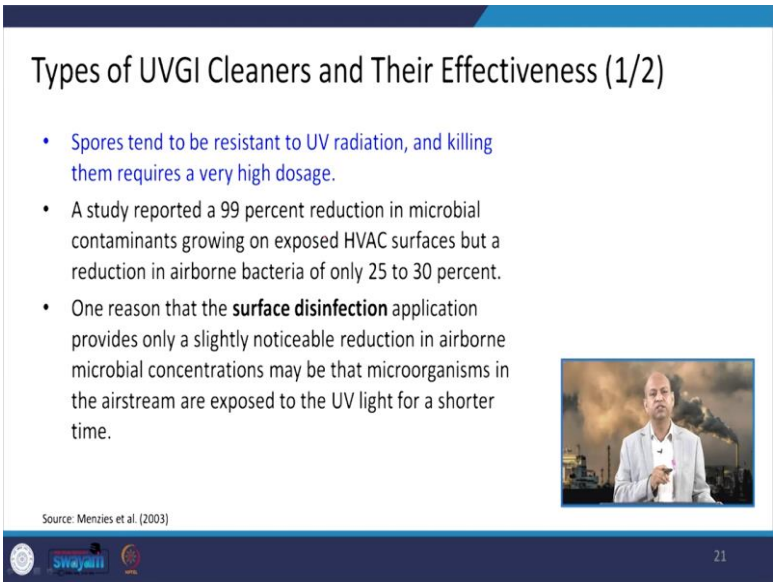

So, I know more time is needed for air stream cleaning. These spores tend to resistant to UV radiation and killing them requires a very high dosage. So, depending upon what kind of indoor environment is there, we have to settle down with the intensity of the UV rays as well as the time of the exposure for those cleaning purposes.

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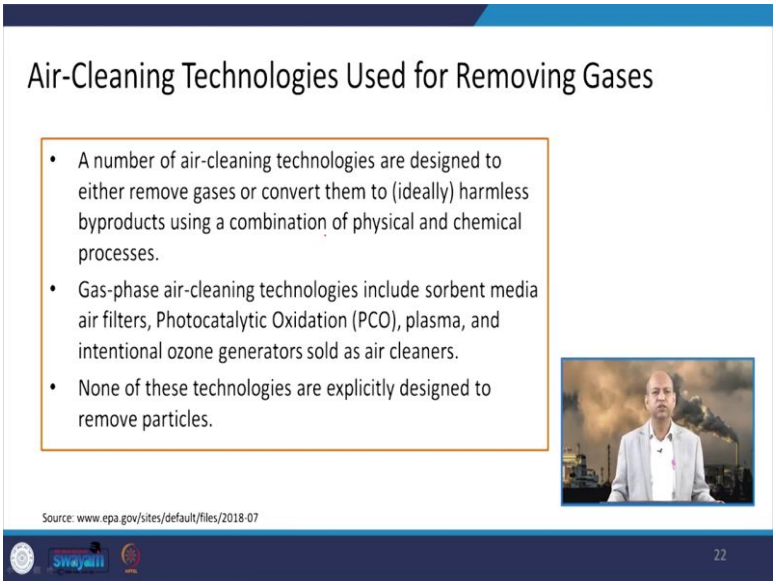

Well, when we talk about like technologies for removing gases, then number of technologies are there like gas phase air cleaning technologies can be there for like Photocatalytic Oxidation, (PCO). Plasma-based technology can be there, or ozone generation. So, we will see one by one.

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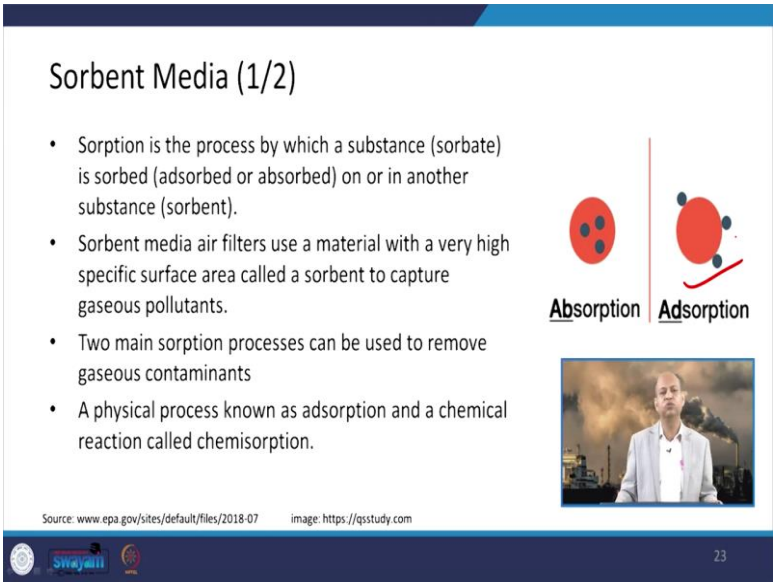

Like sorbent media means sorption can be there absorption or adsorption. So, absorption means inside it can absorb some chemical reactions can be there. Adsorption maybe through attraction, physical attraction it can keep on the surfaces. So, the both the phenomena are used for removing those gaseous pollutants.

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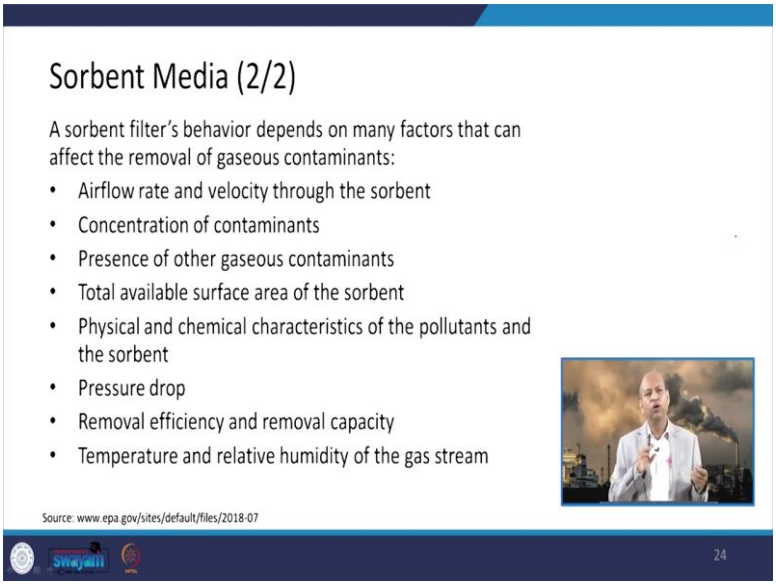

Wherever, you can see the sorbent media filter's behaviour depends on many factors like air flow rate or velocity through the sorbent media. Then what is the concentration of the contaminants or pollutants, presence of other gaseous contaminants rather than in addition to the gases which we want to remove, then total available surface area for adsorption purpose, physical chemical characteristics of the pollutants and the sorbent media.

Then pressure drop or removal efficiency, removal capacity, temperature and relative humidity of the gas stream. All these issues are there, or factors are there which influence the efficiency or performance of these absorption or adsorption related cleaning mechanism.

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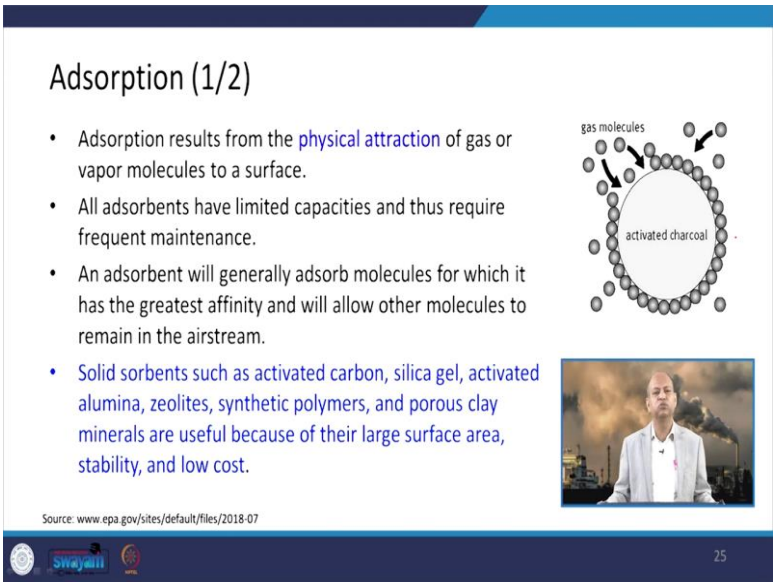

So, in adsorption you can see the physical attraction of the gases which can captured on the molecules of the surfaces. And the solid sorbent and such as activated carbon, silica gel, activated alumina, zeolites, synthetic polymers, and porous clay minerals they are useful because of their large surface area and the stability and low cost. So, that is why in adsorption process they are the most popular media.

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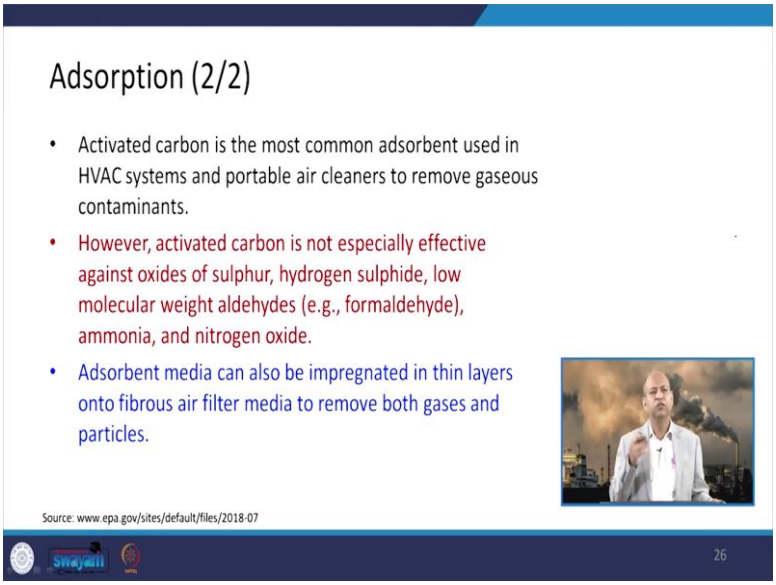

Well, when we talk about like adsorbent media can also be impregnated in thin layers on to fibrous and filter media to remove both gases and particles. So, that way it is again versatile, but we have to be very cautious because the activated carbon is not especially effective against oxides of sulphur or hydrogen sulphide or low molecular weight aldehydes and even ammonia or nitrogen oxides. So, depending upon the nature of the gaseous pollutant, we have to use which kind of adsorption material we can use.

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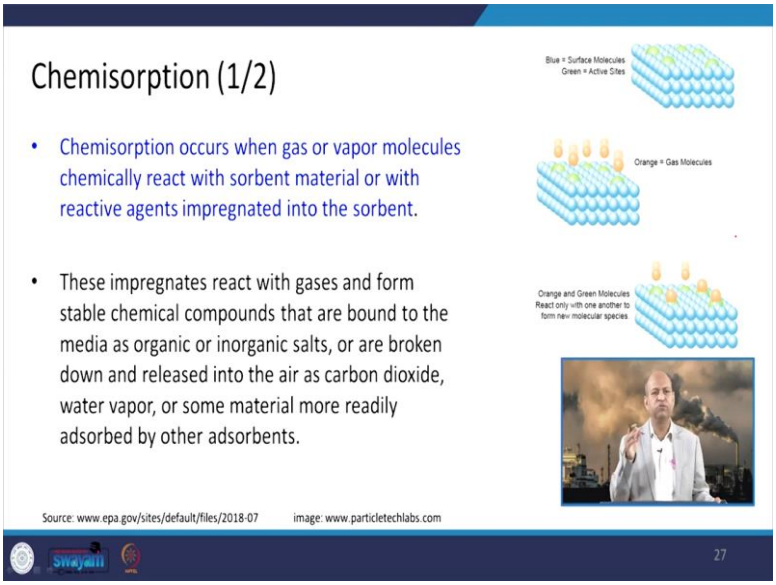

Then chemisorption can be there where it can have gas or vapor molecules chemically it can react with the sorbent material or with the reactive agents, this impregnated into the sorbent. So, the chemical bond is there basically that is why we call it chemisorption.

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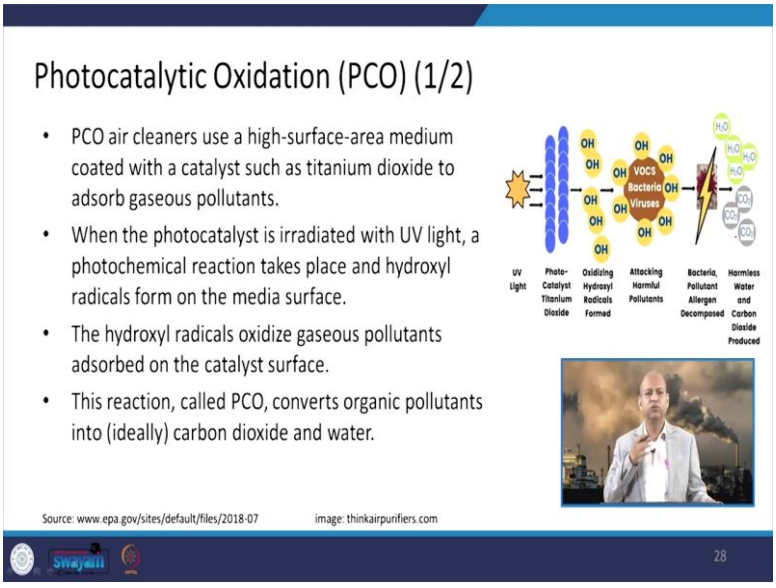

Then there can be like photocatalytic oxidation, as I gave that example in vehicular exhaust. Three-way catalytic converters are used so, that we also in PCOs this photocatalytic oxidation in indoor environment. They can use a high surface area medium coated with a catalytic such as titanium dioxide to adsorb gaseous pollutants. So, when the photocatalyst is irradiated with ultraviolet light, a photochemical reaction takes place and these hydroxyl OH, hydroxyl

radicals, they are formed on the media surfaces. And, as you know these OH radicals, or hydroxyl radicals are very quickly they oxidize whatever they come into contact.

So, these hydroxyl radicals, they can oxidize gaseous pollutants and they can be adsorbed on the catalytic surfaces, so, that way very quickly action occurs and this reaction which is called PCO this converts the organic pollutants into carbon dioxide or water. So, they are harmless in the sense they are not pollutants, but of course, both are greenhouse gases. So, from that perspective, although things are there, issues are there, but from health point of view, at least they are not problematic.

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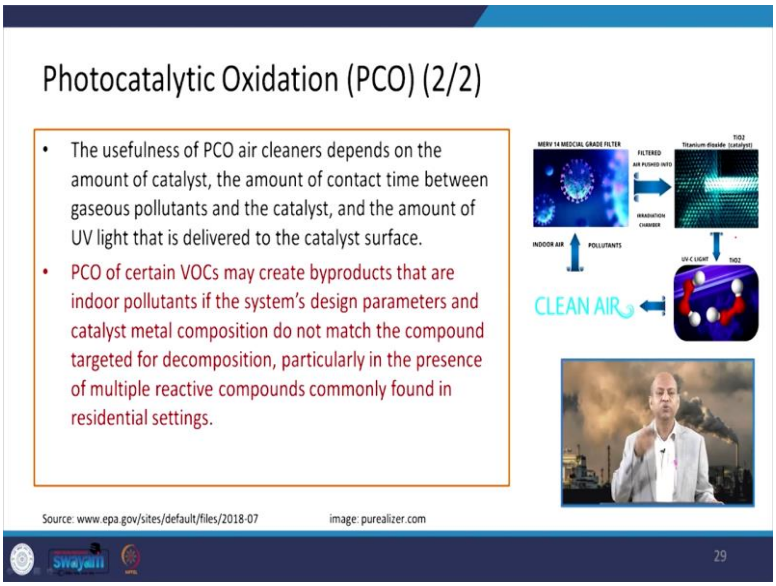

Well, when we talk about further in this PCO technique. So, the usefulness of these PCO cleaners depends upon this amount of the catalyst and the amount of contact time between gaseous pollutants and the catalyst, and the amount of UV light that is delivered to the this catalyst surface. So, all these factors are there for influencing the efficiency or efficacy of the PCO devices and the PCO have certain VOCs like volatile organic compounds or hydrocarbons may create some by-products which are indoor air pollutants in itself.

So, the system design parameters are not good, rather than removing the pollutants it can generate some other pollutants by-products, so, we have to be very careful in that handling the PCO related techniques and so, it should clean rather than adding some pollutants, so, these side effects we should be careful about.

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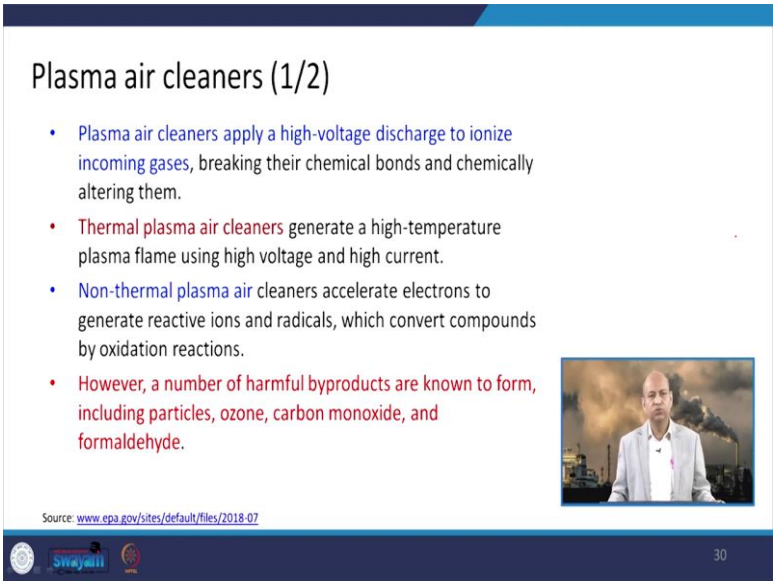

Plasma air cleaners can be there. So, these in thermal plasma air cleaners can be there or non-thermal plasma air cleaners can be there. So, depending upon their voltage and then the radicals we can use any of them. But a number of harmful by-products again in like in PCO in this plasma technology also there may be some particles or ozone, carbon monoxide, formaldehyde, they can be by-products if we do not handle properly this technology. So, these technologies are good if we are handling them properly otherwise, they may be problematic because they can also add some pollutants.

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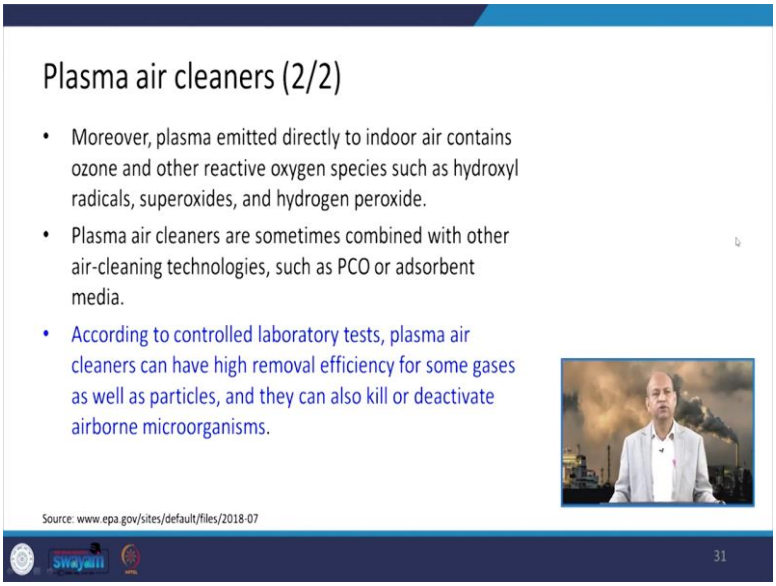

Well, according to the control laboratory tests when we use properly these plasma air cleaners can have very high removal efficiency to some gases as well as particles as they can also kill

and deactivate airborne microorganisms. So, that way plasma air cleaners are very good, if it is, used in a controlled manner with those skilled people they can use otherwise, it can be dangerous also.

So, if we use it in a controlled way, this can be a very good technology because it can remove particles as well as gaseous pollutants, and it can also kill or deactivate airborne microorganism. So, skilled people or, personnel are needed for plasma air cleaners for using the plasma air cleaners, otherwise it can be problematic also, we should be careful.

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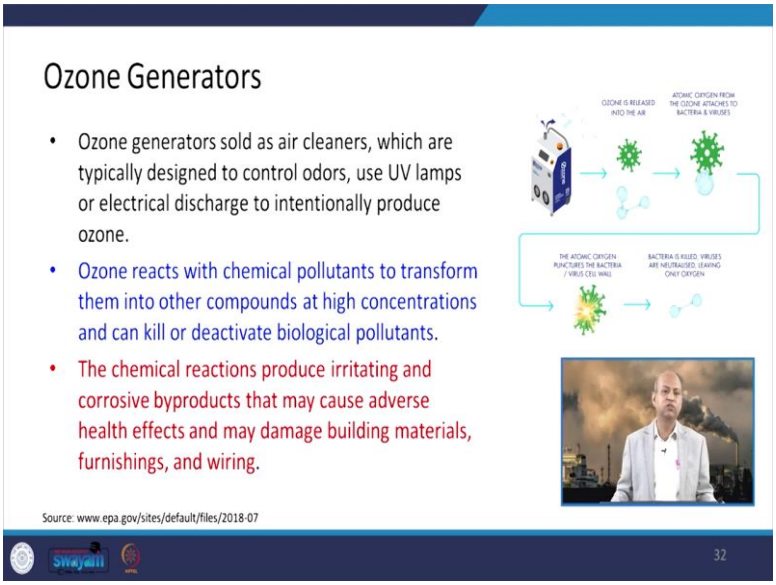

Then there can be ozone generators and, this also needs very careful handling otherwise, ozone itself is a problematic pollutant, but it can be used as a oxidizing agent also, as you know this ozone has nascent oxygen, so, it can oxidize and it can clean, it can oxidize the pollutants, and it can react with chemical pollutants to transform them into other kinds of compounds at high concentrations and it can also kill and deactivate biological pollutants.

So, that way similar to plasma technology, it is also good technology, but the chemical reactions produce irritating and corrosive by-products that may cause adverse health effects and may damage building materials also or furnishing or wiring etc. So, again, we have to be careful, and we need to handle it with the caution.

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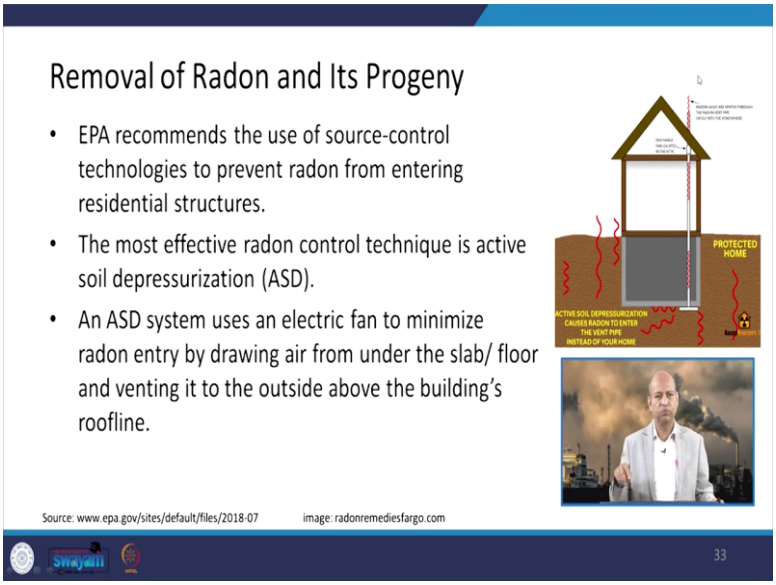

Well then, when we talk about removal of radon and its progeny, so, the Environmental Protection Agency of USA recommends the use of source control technologies to prevent radon from entering residential structures. So, the most effective way of controlling the radon technique is Active Soil Depressurisation (ASD). So, the ASD system uses electric fan to minimize the radon entry by doing air from under the slab or floor and venting it outside the building. So, it does not enter into the air, you can see here, this kind of vents are there and it can take it out. So, from subways or those kind of locations.

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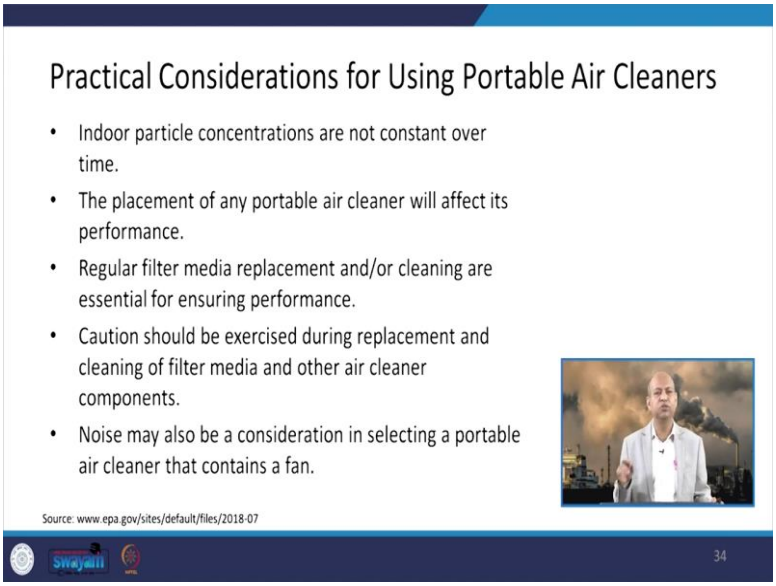

Well then there are practical considerations for portable air cleaners, because indoor particle concentrations are not constant over time. Then the placement of any portable air cleaner will

affect its performance. So, we have to be careful where we need to put it. So, that efficiency is high.

Regular filter media replacement is needed otherwise it will be source of pollutant rather than cleaning. Replacement or cleaning of the filter media, again it needs to be handled carefully otherwise, this will add to the pollution. Noise may also be a concern when we are using some particular portable air cleaners. So, the noise pollution may be there. So, accordingly we need to do something so, that less noise related portable air cleaners are used.

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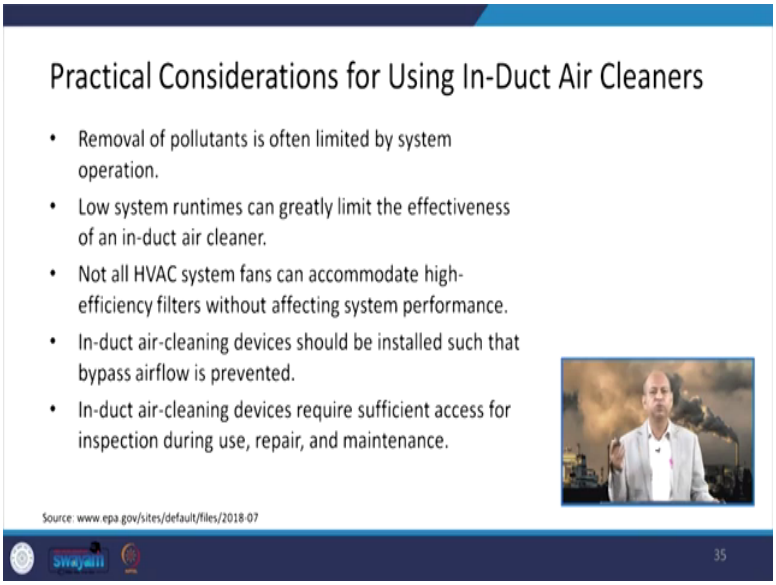

Well then removal of pollutants is often limited by system operation and the low system route these runtimes can greatly limit the effectiveness of in-duct air cleaner. So, means the system has to be designed properly so, that it has sufficient time. Then not all HVAC systems fans can accommodate high efficiency filters without affecting system performance. So, it is a kind of trade off you have to see where you can install it and run the HVAC system properly so, that it also do air conditioning as well as it removes the pollutants.

Well in-duct air cleaning devices they should be installed such that bypass airflow is prevented otherwise, efficiency will be greatly reduced, and the in-duct cleaning devices they require sufficient access for inspection during use, repair, and maintenance. Otherwise, if we do not have a proper access, then some kind of pollution accumulation can be there inside the ducts etc.

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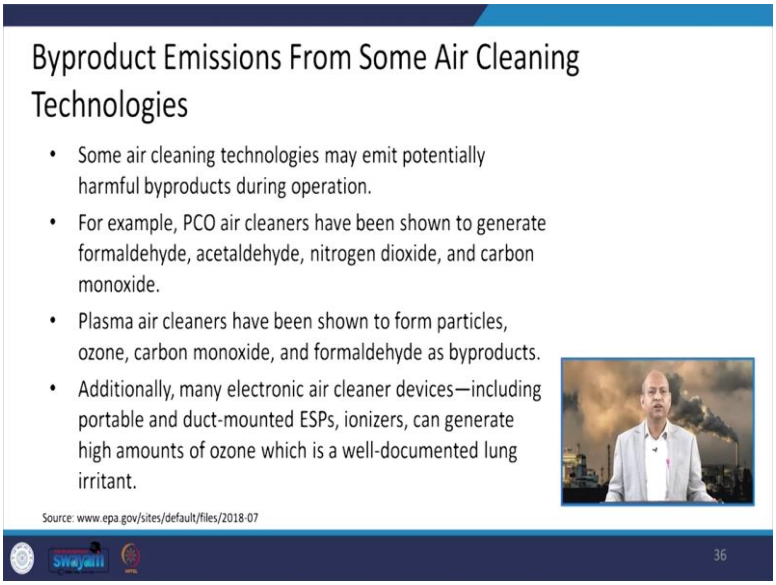

Well, the byproduct emissions from some air cleaning technologies can be an issue. So, we have to see those technologies as we have seen that in PCO, or plasma, or ozone related devices. If careful handling is not there then rather than removing the pollutants, they can add into some other pollutants like formaldehyde, acetaldehyde, they can be generated in PCO technology. So, those things we have to be careful about.

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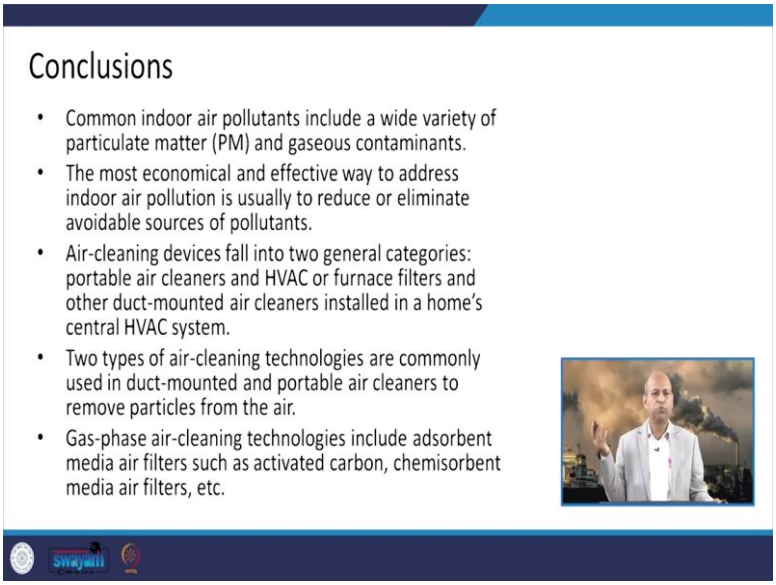

Well, so, in conclusion, we can say that the common indoor air pollutants, they can be removed in terms of particulate matter or gaseous contaminants by certain technologies depending upon particulate matter is more or gaseous pollutant is more you can select the technology. And the

most economical and effective way to address the indoor air pollutant is usually to reduce or eliminate the sources itself at the source pollutants, we have to remove.

Then air cleaning devices they can be of two general categories portable air cleaning, and HVAC or furnace filters, which we have seen just now. And they can be mounted the duct mounted can be there or they can be at the central HVAC system. So, they can be independently installed or they can be part of HVAC system. And the two types of air cleaning technologies are commonly used in-duct mounted or portable.

Then gas-phase air cleaning technologies include adsorbent media, or absorption media, activated carbon, chemisorbent media filters. Then there are other technology like plasma or these kind of which we have seen like ozone related but they need very skilled people to handle it.

So, they are used only in industry related installations where indoor environment occupational hazards related issues are there, and well-trained people are there to handle those kinds of devices. Otherwise, we can go for simple filters and proper ventilation in residential areas. So, this is all for today for controlling or mitigating indoor air pollution.

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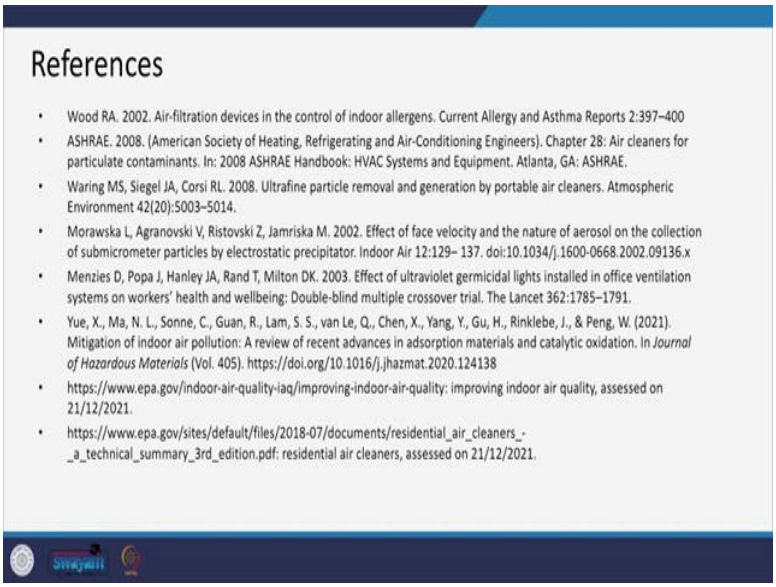

And these are the references for additional information. And you can go through that at the ledger. So, thank you for your kind attention and see you in the next lecture. Thanks again.