Air Pollution and Control
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Lecture 36
Indoor Air Quality in Nursery Buildings, UAE – Case Study

Hello friends. So, today we will discuss again one more case study and this will focus on indoor air quality in nursery buildings, this is a case study taken from one report of UAE. So, this will be included like in this contents.

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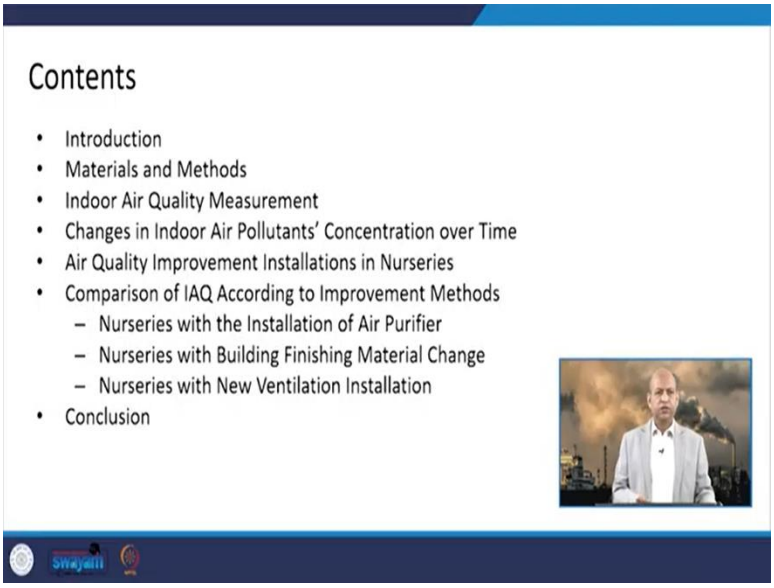

So, this is the contents list according to which we will go into this presentation. Like first of all, we will introduce the problem setting in which context this case study has been carried out, what are the materials and methods which have been used to conduct this study? Then different measurements of indoor air quality in terms of pollutants concentrations, we will see.

Then what are the changes in air quality, concentrations over the period of time so, that we can see the variation as per different reasons. And then, we will see like air quality improvement installations which can be done in those nurseries which are under the consideration or under this study, so, that air quality can be improved.

So, whether those improvements are there or not there. So, according to the changes which have been made in those nurseries like installation of air purifier or changing in the building finishing materials or installing some new ventilation system. So, according to those changes, the

comparison of indoor air quality will be made so, that we can see or we can find which particular change is effective, then we will conclude.

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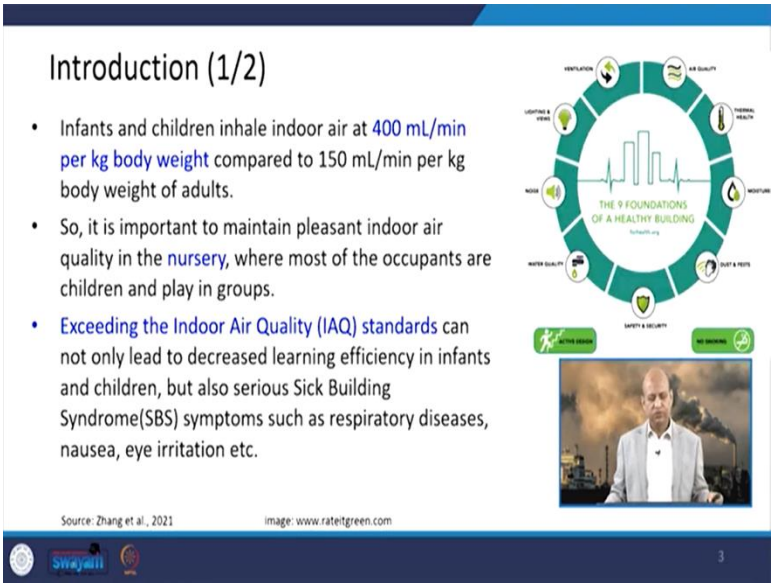

So, you can see this particular data like as you know the infant our children they breathe very frequently, if you compare our adults breathing patterns and the way children breathe, they breathe very frequently and their speed is also higher. So, in that way, they basically inhale indoor air around 400 milliliter per minute per kg body weight, if you compare with that. Although they are breathing, it is a means it is a not so long as we breath, it is not so deep, but still if you calculate or estimate how much amount of the air or how much volume of the air they are inhaling per minute per kg weight of the adult.

Then the competition is like 400 milliliters per minute per kg body weight is inhaled by children and adults, inhale around 150 milliliter per minute per kg bodyweight in case of this adult size population. So, huge difference is there, that means, the inhalation is much more in case of children. So, if air is polluted that means, most means, the large quantity of pollutants may be inhaled by children if they are living in that polluted indoor environment.

So, the importance is very significant in that sense because like in nurseries or play schools, if children are living there for several hours, and if their conditioning is not good, if their indoor environment is not good, then we will see that children will be inhaling polluted air. And that can cause certain health issues also respiratory problems or other diseases can be there even like sick

building syndrome can be there or some symptoms related to eye irritation those kinds of things may be observed in case of children. So, we need to ensure that wherever our children are playing or living, those indoor environment must have clean air.

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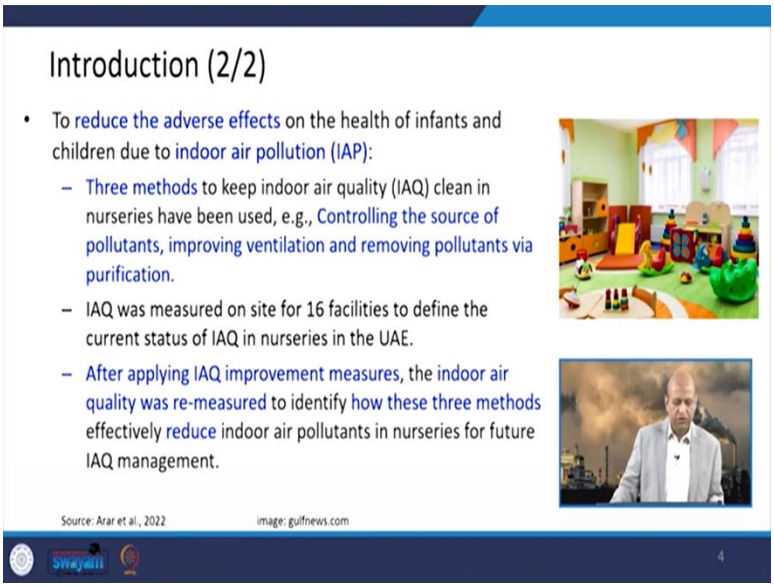

To reduce with the aim of reduction of these adverse effects, which is possible because of polluted indoor air, we want to go to improve the indoor air quality. And that improvement can be ensured or can be achieved by three methods which are quite popular like either we can control the sources of the pollutants. Whatever sources of the pollutant to deteriorate the indoor air quality if we can control those sources, then naturally we will improve the indoor air quality or we can improve the ventilation.

So, in case there are some sources, the ventilation will ensure that fresh air comes and the polluted air goes out or we can also remove those pollutants by certain devices like air purifiers. So, those kinds of devices can be fit into the indoor environment and the air quality can be improved.

Well, so in this particular case study 16 facilities have been studied in terms of indoor air quality of those facilities and this is the case of nurseries in UAE and after applying those some improvement measures and before the installation of those measures, air quality have been measured and comparison have been made. So, that before installation of some devices or carrying out certain changes to improve the air quality, what is the air quality before installation of those devices and what is the air quality after installation of those devices, so, that we can know the

difference whether those devices or those majors are effective or not. So, that kind of study has been conducted in this particular case.

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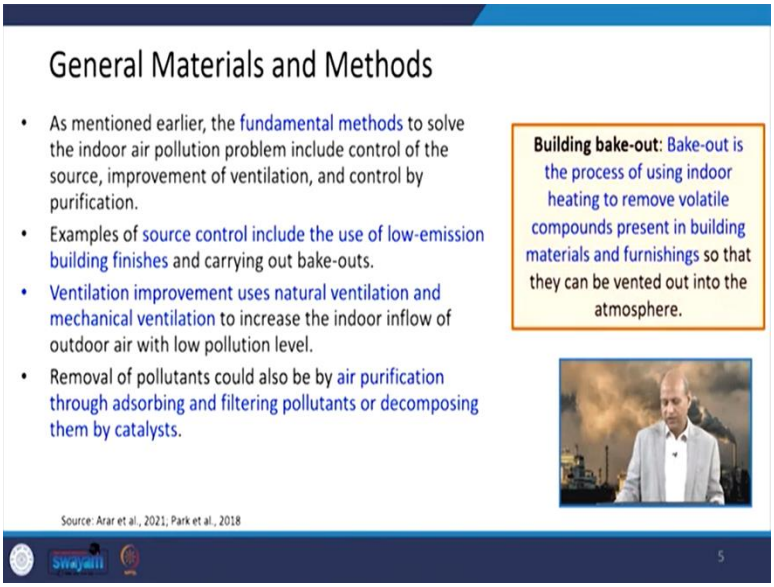

Well, when we talk about general materials and methods to improve indoor air quality. So, basically three major things are there as just we have seen like ventilation, control at the source or purification, and those devices like to control the source or control the emissions at the source. So, maybe something can be done like low emission related building finishing materials can be used, because as like furniture or the wall paints or there are so, many sources of indoor air pollutants.

So, if you go for good quality of furniture, maybe low emission can be ensured or either you can do some bake-out related majors or methodologies, in bake-out basically, the indoor environment is heated.

And because of that heat, those VOCs volatile organic compounds and those kinds of air pollutants, they went out and then very least amount of emissions are observed afterwards. Another method is like ventilation improvement. So, ventilation improvement can be ensured either through natural ventilation or through mechanical ventilation as air conditioning is there, exhaust fans are there those devices can be installed. So, it can increase the indoor inflow of the air from the outdoor, but we have to ensure that outdoor air is cleaner than the indoor air. If you are bringing the polluted air rather than improving it can deteriorate the air quality of the indoor environment.

So, if outdoor air is clean, then this works this ventilation system works otherwise other devices can be like removal of the pollutants through air purification devices through absorption or through filtration, decomposition of the pollutant through some catalyst devices, catalyst base devices. So, those air purifiers can be used to improve the air quality.

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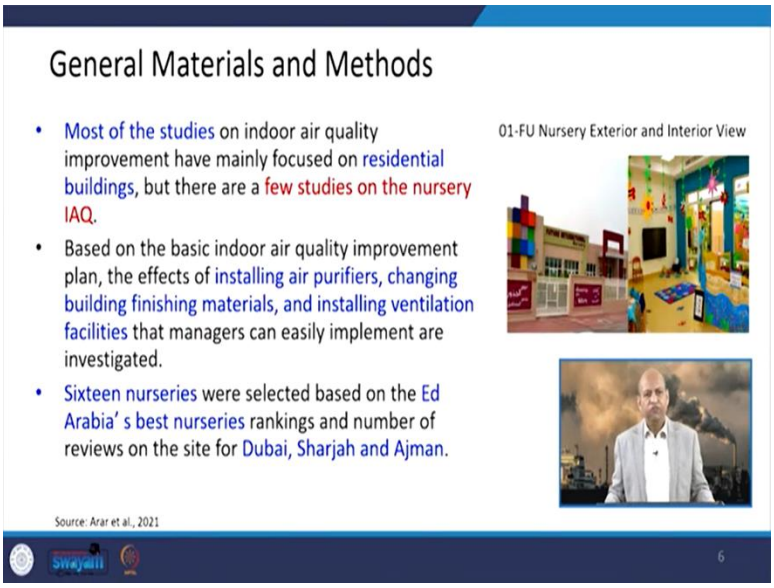

If we talk about like the studies, which have been carried out in terms of indoor air quality. So, mostly those studies have been in micro environment of let us say like residential buildings or maybe certain office buildings, only very few studies are they are focused on nursery where children are living indoor. So, those indoor air quality of nurseries related studies are very few.

So, based on basic indoor air quality improvement plants, like installing air purifiers or changing the building materials or installing some ventilation facilities or systems. Those nurseries which were taken to consideration for this study like 16 nurseries have been taken. So, these three major changes have been made and before making those changes, air quality was observed and after making those changes, air quality was observed and though comparison was made. So, that it could be seen whether the air quality has been improved or not.

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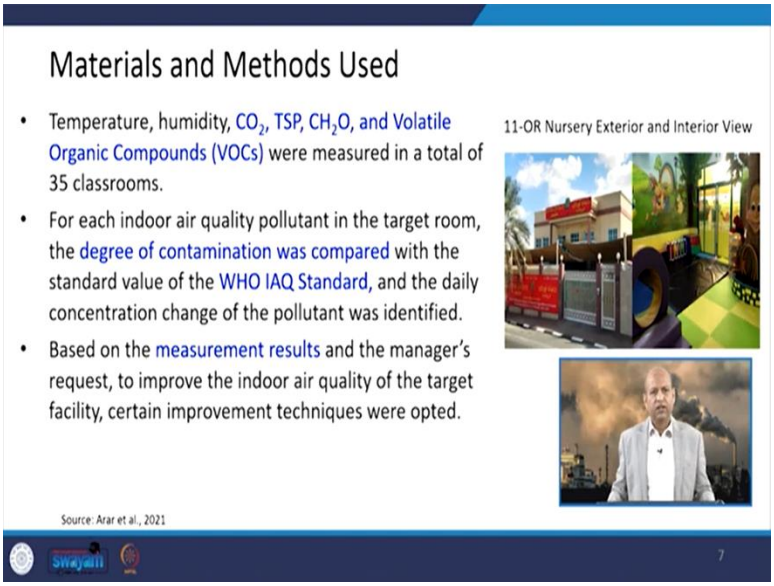

And the materials and methods which have been used are related, like observations made pertaining to temperature, humidity, then carbon dioxide levels, total suspended particulate matters, then formaldehyde and volatile organic compounds VOCs. So, how much quantity of these pollutants are there.

So, those were measured in total 35 classRoom s which are belonging to these nurseries basically. And for each indoor air quality pollutants, those target Room s, so, the degree of contamination was compared with the standard values of WHO IAQ standards, which are given basically those World Health Organization, they also prescribe some standards for the indoor air quality.

So, the observations were compared with respect to indoor air quality standards of the WHO and based on those measurement results and taking into account the managers of those nurseries, so, they have made some requests. So, the improvement of indoor air quality of the target facility and certain improvements, techniques were obtained. So, this was a kind of participatory case study where researchers and those clients you can say, or those people stake holders were they opined and their opinions were taken into consideration to design the study.

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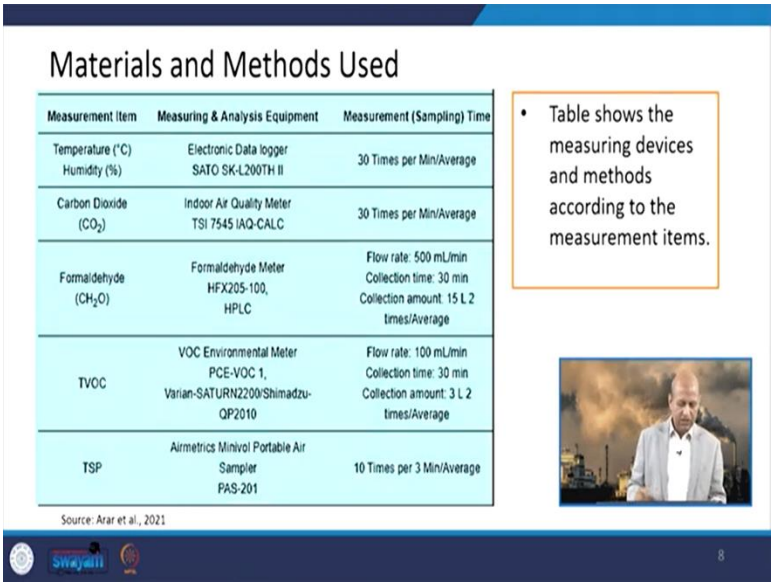

So, you can see here like measurement items which were measured like temperature, humidity or CO_2 and formaldehyde TVOC or TSP total suspended particulate. So, equipment's which were used for measurement of these entities are listed in second column. And sampling time is also given like for how much frequency or sampling was, done for each kind of entity. So, this is measured here or mentioned here.

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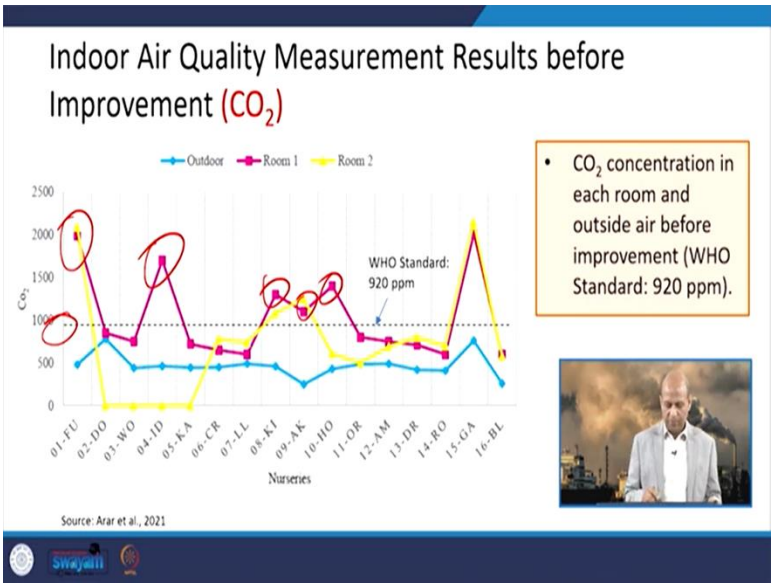

Now, if we try to see what is the measurement data? So, this dotted line is basically the WHO standard like in case of CO_2 920 ppm is prescribed by WHO standard that should not exceed in

indoor environment. Otherwise, suffocation will be there, we will be feeling suffocated because oxygen will be less CO_2 will be more in the indoor environment. So, this standard 920 should not exceed but the measurement show that in several Room s like here you can see these points which are exceeding these are exceeding the WHO prescribed guidelines of CO_2.

So, this is worrisome issue basically you can see, but outdoor this blue line outdoor environment CO_2 is less than the prescribed one. So, that way means you can imagine if we bring the outdoor air inside by through ventilation or some other system, there may be these kinds of concentration can be reduced.

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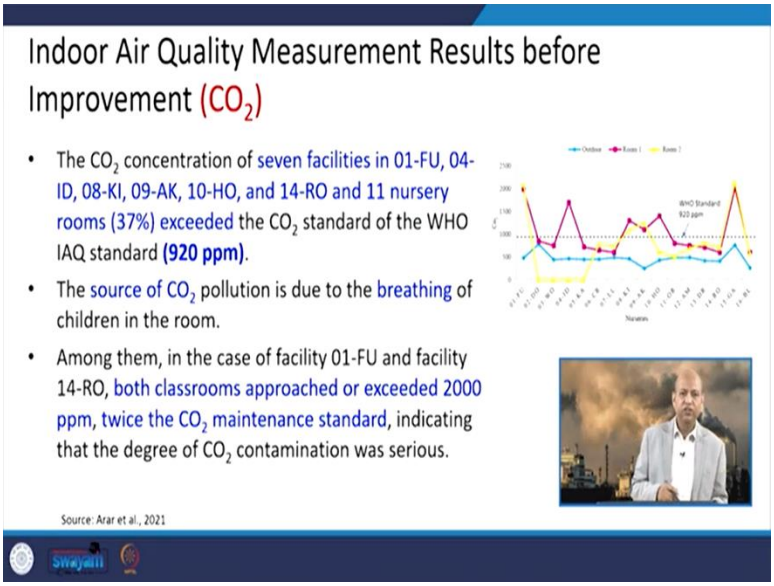

But if we look into the data, statistical data, how many Room s or facilities are there which are having very high concentration of CO_2. So, you can see like seven facilities which are given names are given 01 FU, 04 ID. So, those kinds of names are given for those facilities. And 11 nursery Room s, around 37 percent of the total facilities and Room s were found having CO_2 much more than the WHO standards.

And the source of this CO_2 Pollution is because of breathing of the children and staff members, because every time we are inhaling and exhaling. So, when we are inhaling then we are consuming oxygen when we are exhaling we are exhaling basically the CO_2.

So, that CO_2 is built up the concentration built up if there is no proper ventilation that is one basic fundamental reason. So, those you can see the sources are our own breathing, children's breathing

and staff's breathing. Now, among them in case of facility 01FU and facility 14 RO both classRoom approached around 2000 PPM like more than twice of the prescribed standard. So that is very worry some basically serious issue, because in those Room s a lot of suffocation will be felt and that environment is not good for learning or playing for their children.

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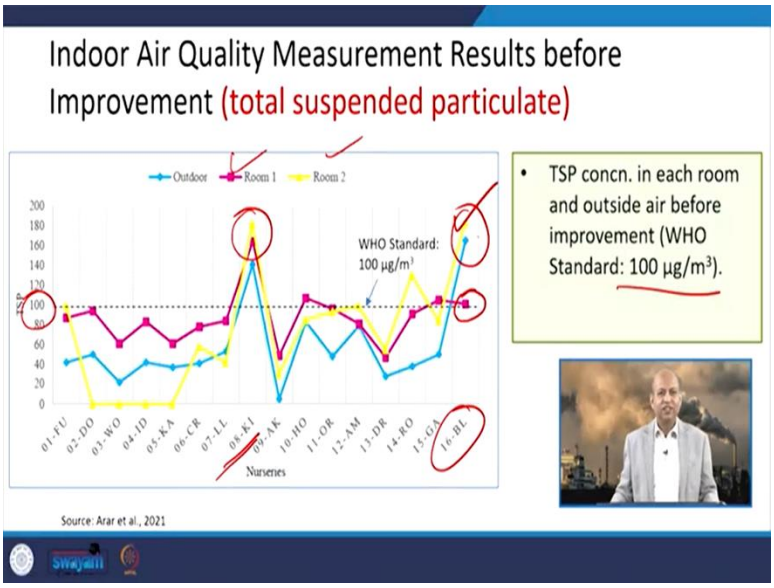

Now, if we look into this indoor air quality measurement results in terms of total suspended particulate matter TSP. So, the WHO standard is 100 micrograms per cubic meter, you see this line dotted line is 100 micrograms per cubic meter of the TSP total suspended particulate matter. Good thing is that in all most of the facilities or Room s, the concentration observed of TSP is less than the prescribed limit means it is not exceeding. But at certain places like this particular location, you can see outdoor as well as indoors Room 1, Room 2, they are having higher concentration of TSP.

Similarly, at 16 BL you can see this Room 1 is having almost a similar TSP, but the this outdoor and the Room 2 and outdoor they are having more concentration of TSP that means this TSP maybe coming from outdoor into the Room 2 that may be one reason means we have to look at the real site.

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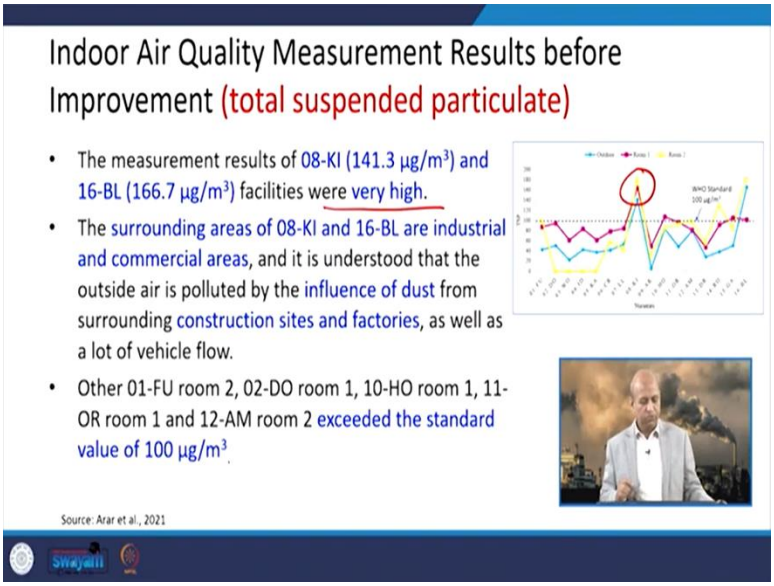

So, if we compare these total suspended particulate matter related data, you will find that 16 BL facility is having high concentrations of TSP and 08 KI also they are because these facilities are nearer to industrial and commercial areas basically. So, TSP sources may be from those industrial activities or commercial activities. So, we have to take care maybe some measures have to be adopted to reduce the inflow of TSP from the outdoor environment.

So the influence of the dust has to be reduced surrounding construction sites or factories may be there and the low vehicle flow maybe they are so, those kinds of interventions are required to reduce the TSP concentration into the indoor environment.

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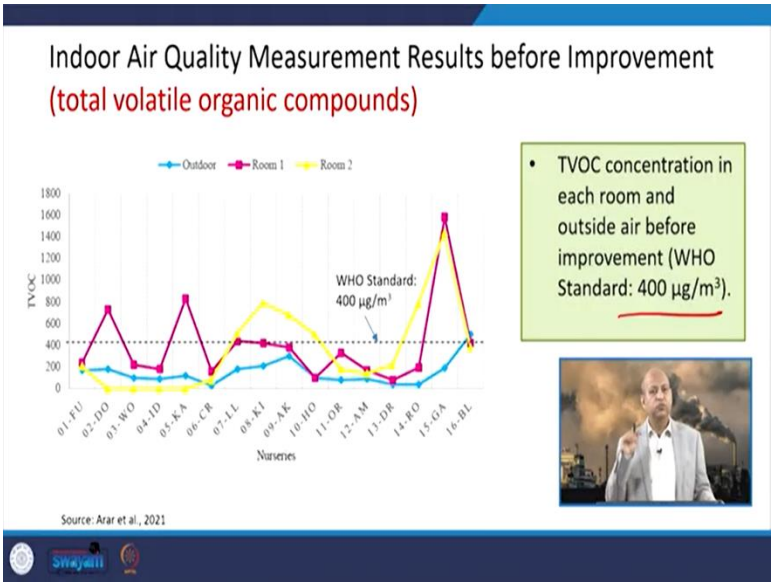

So, in case of this total volatile organic compounds, this WHO prescribed standard is 400 micrograms per cubic meter and this is the line you can see here. So, again we find there is TVOCs exceeding at several facilities or Room s of the nurseries, you can see here and this 02 - DO and then 05 - KA and it is very high concentration of TVOC here both Room 1 and Room 2. Although, outdoor air concentrations of TVOC are less than the prescribed one.

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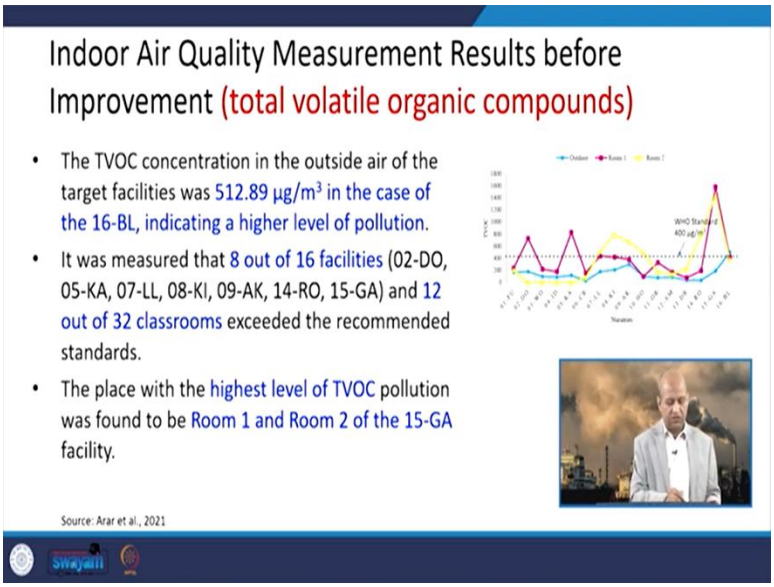

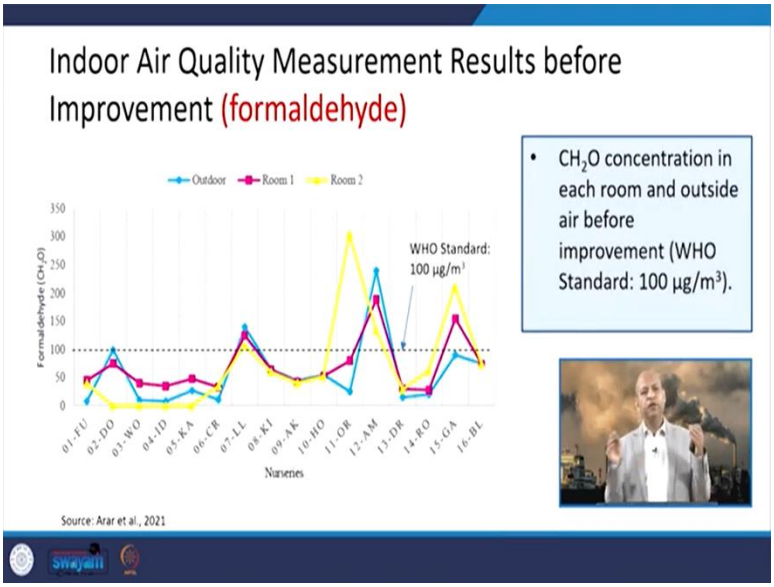

So, you can see the comparison the 16 BL facility indicating higher concentrations of TVOC and other places also in Room 1 and Room 2 you can find here higher concentrations of TVOC. If we compare the formaldehyde with the measurement data and the WHO standards, WHO standard is around 100 micrograms per cubic meter, you can see here this dotted line and we have observed or measured means, we have taken from the case study. So, those researchers who have measured these data we can compare.

So, in many facilities or sites, the concentration observed of indoor environment as well as outdoor is less than the prescribed limit although here this outdoor is having almost a similar to the prescribed limit, but here it is exceeding both outdoor as well as indoor environment and in these facilities like 11 - OR and 12 - AM. So, these facilities also having higher concentrations like in Room 2 or Room 1 as well as in outdoor particularly in this particular location and again here also it is exceeding.

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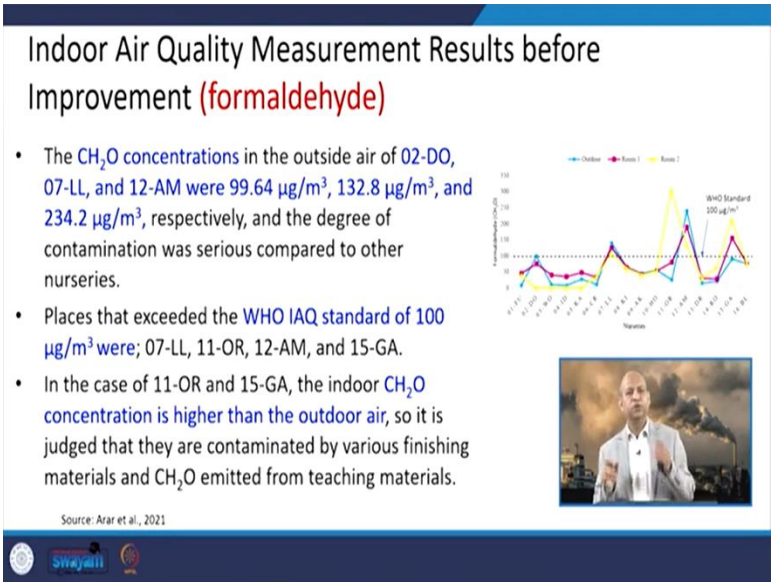

So, we have to look into those facilities, whether in nearby areas some sources are there of the formaldehyde or majority of the formaldehyde basically comes from furnishing and other indoor environment basically. So, we have to look into those localized sources and can we do something through purification or through ventilation can we reduce them. So, you can look into these comparisons and at several locations it was found that formaldehyde is exceeding the prescribed limit those kinds of you can see here.

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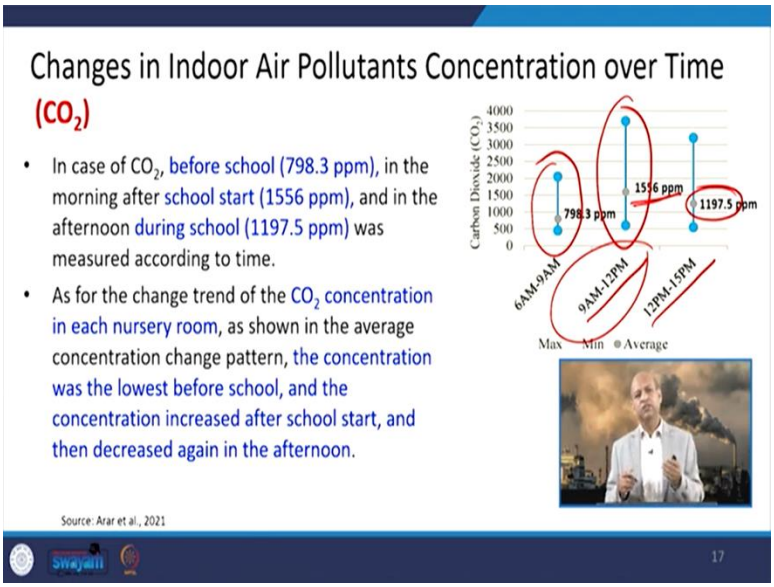

Now, we want to see in whole day how these concentrations vary for different pollutants. For CO_2, you can see like 6AM to 9AM, the concentration of CO_2 is this much and then 9AM to 12AM the concentration has increased like average value was around 798 and now, it has increased average value around 1556. Then, 12PM to 3PM so, this has reduced up to 1198 ppm. So, basic idea of this, CO_2 variation is because when 6AM to 9AM least activities there it is opening and then when children are coming staff is coming, then CO_2 acceleration is much more. So, in this particular time a lot of pollution built up is there and CO_2 concentration increases.

Then up to 12PM children go and some staff is there. So, slowly this CO_2 concentration decreases basically. So, you can see the diurnal variation is there, there is low CO_2 then it increases, then again it starts to decrease according to the school time basically.

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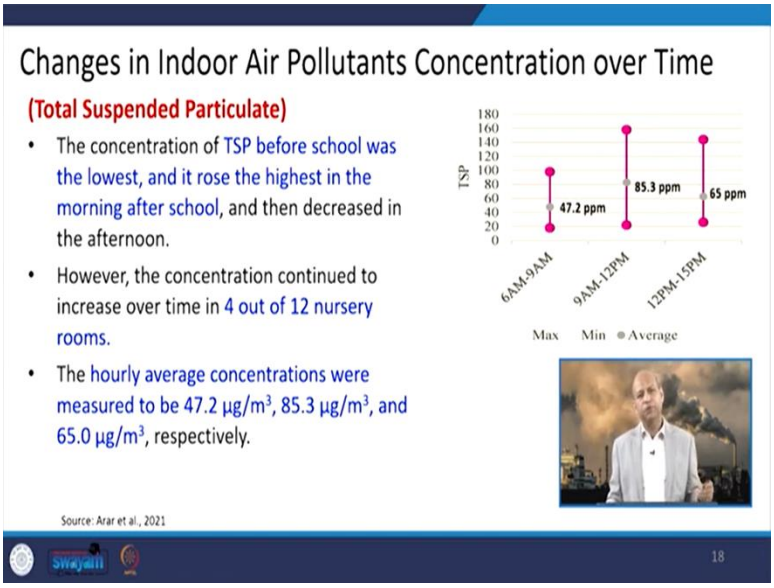

If we talk about the total suspended particulate matter, similar variation is there as it was observed in case of CO_2. It is less during morning hour 6AM to 9AM, when activities least because children are not there at 9AM when children comes then doors are opened windows are open. So, the TSP that may come from the outside also and that this it becomes almost double. Then again after 12PM when children have gone only staff is there. So, the concentration of this TSP decreases.

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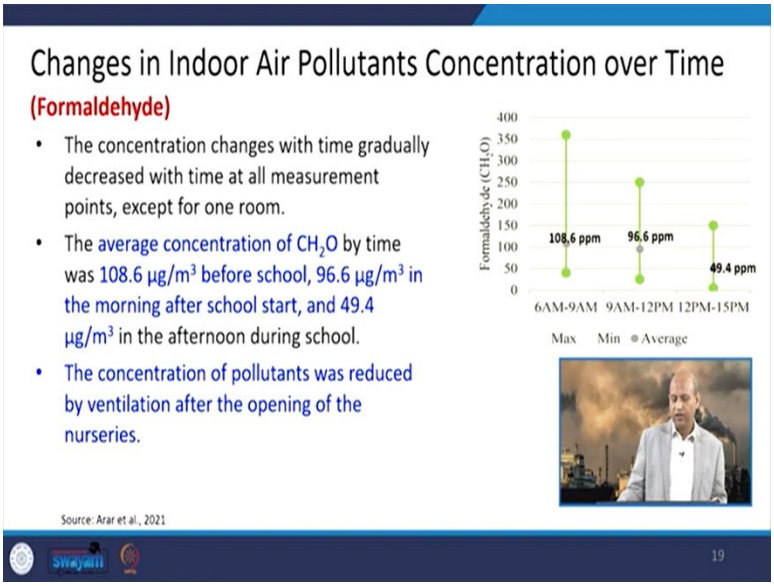

Formaldehyde having completely different pattern 6AM to 9AM very high concentration of formaldehyde is there inside. And when a school is open, then formaldehyde concentration goes down and further it goes down up to 3PM. The basic reason is because formaldehyde sources are inside the those Room s of the nurseries because of furniture because of paint or those whatever sources of those formaldehyde is there. So, there is no ventilation whole night it is closed. So, the buildup of formaldehyde is there, and when those measurements were taken from 6PM to 9AM. So, high concentration of formaldehyde was observed.

But later on when ventilation came into effect, because the Room s were opened and then because of dispersion and diffusion through air movement this decrease of the formaldehyde have been observed.

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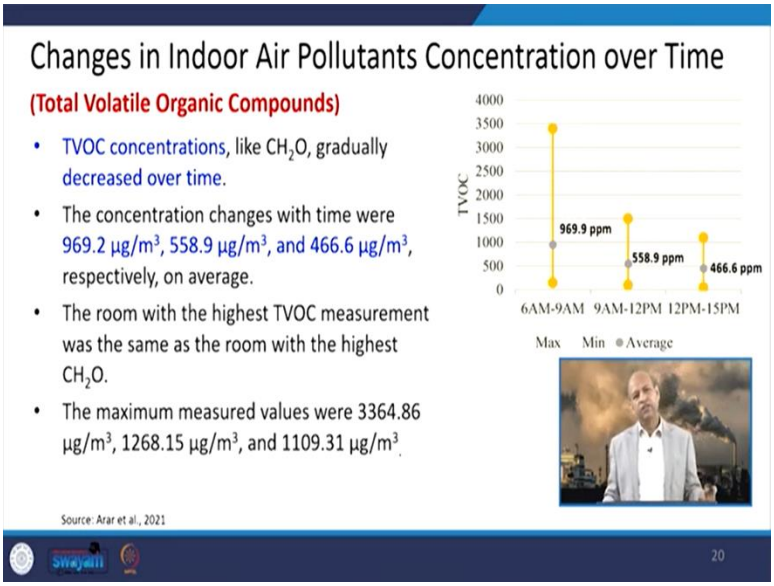

The similar pattern have been observed in case of total volatile organic compounds TVOC. So, again, VOCs are also emitted in large quantity from inside sources, whether paints or furniture and other kinds of activities. So, the same pattern is there because the concentration built up during night there is all things are closed, windows are closed doors are closed. So, there is no escape route for formaldehyde and this totally VOC volatile organic compounds, that is why they are high in concentration and then later on they goes down.

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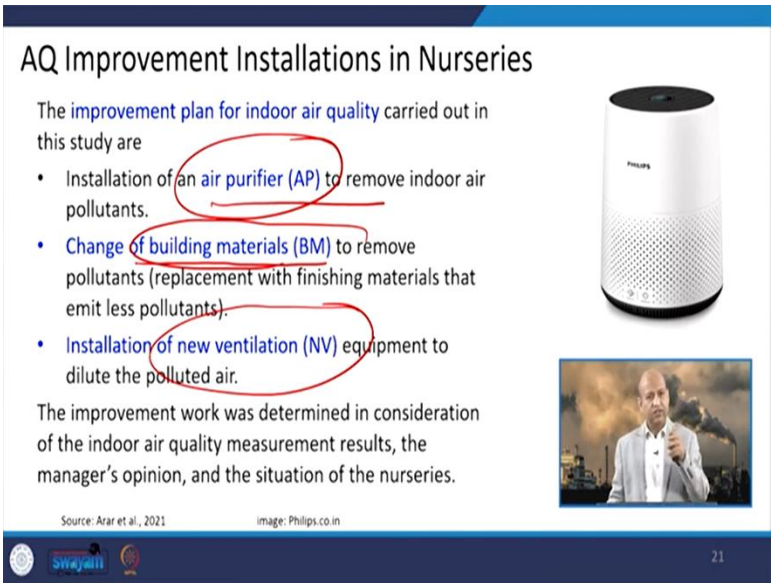

Now, so then it was discussed with those nursery managers and some improvement installations were installed inside the nurseries. So, some nurseries were taken for like installation of air purifier so, that purification, activity could be done through certain devices. Some other nurseries were taken to like changes in the building material furnishing material, so that we could compare if some change is made, so, how much improvement in the indoor air quality is there.

So, some lot, some group of the nurseries were provided only air purifiers, some were not provided air purifiers, but changes were made into building material and other group were like installation of new ventilation system. So, three groups were divided and three, interventions were made in terms of application of air purifier or changing the building material inside the indoor environment and installing new ventilation system.

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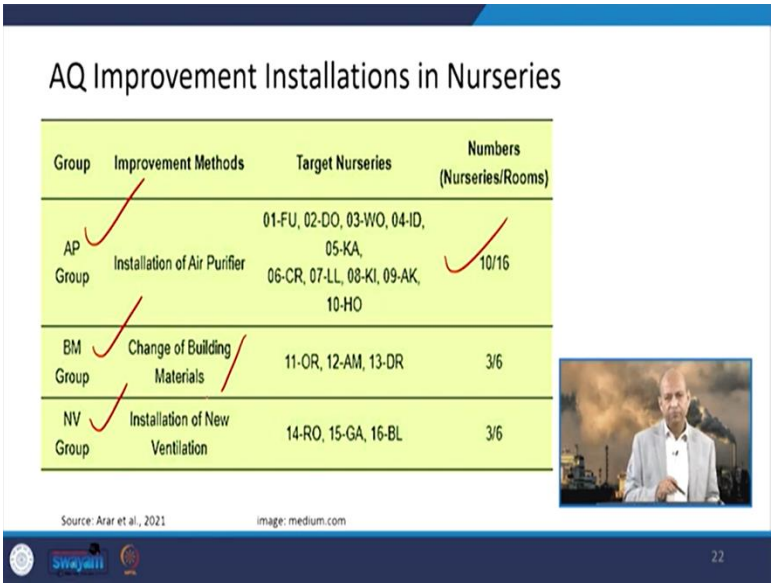

So, now you can see like this one was this air purifier group, then building metal related group and new ventilation group. So, in this air purifier group, basically out of 16, 10 nurseries were provided and out of 6 facilities, into three change of the building metrics were made, and our remaining three and these installation of new ventilations were and showed or made.

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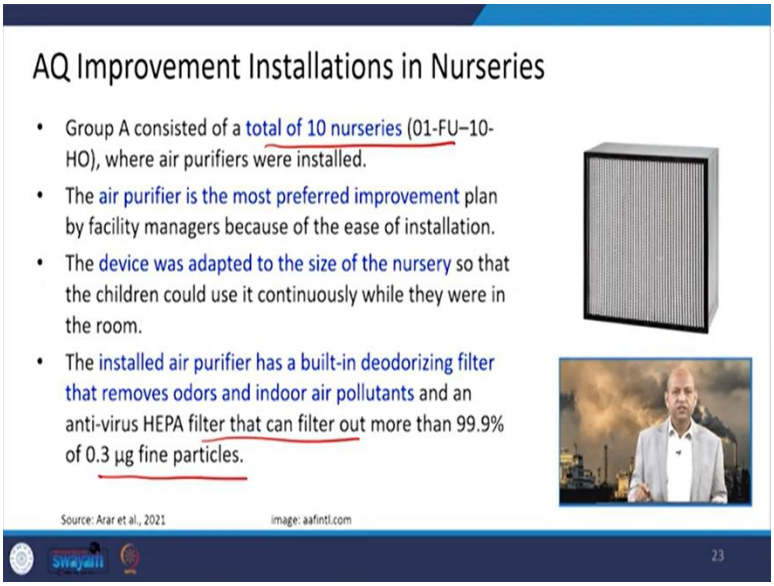

So, you can see now the effect of these air quality improvement installations. So, group A like total 10 nurseries the number is given and then these air purifiers were run by those electric power. And they could do like filters were there HEPA filter and odor could be reduced because of they are having that kind of filter which has property of antivirus, you can see antivirus HEPA filters. So, odor remover was there plus particulate matter was removed in up to 0.3 microgram fine particles were removed basically. So, basically this air purifiers were of that nature, which could remove odor as well as very fine particles up to 99.9 percent removal was there.

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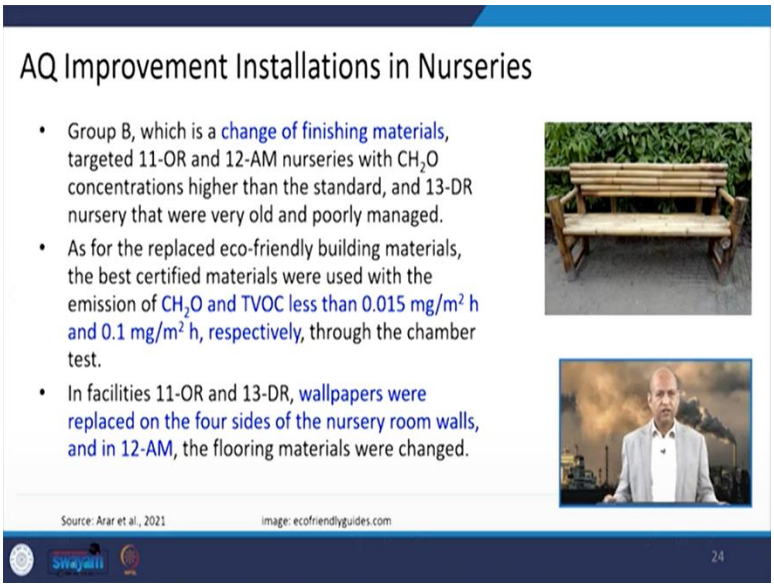

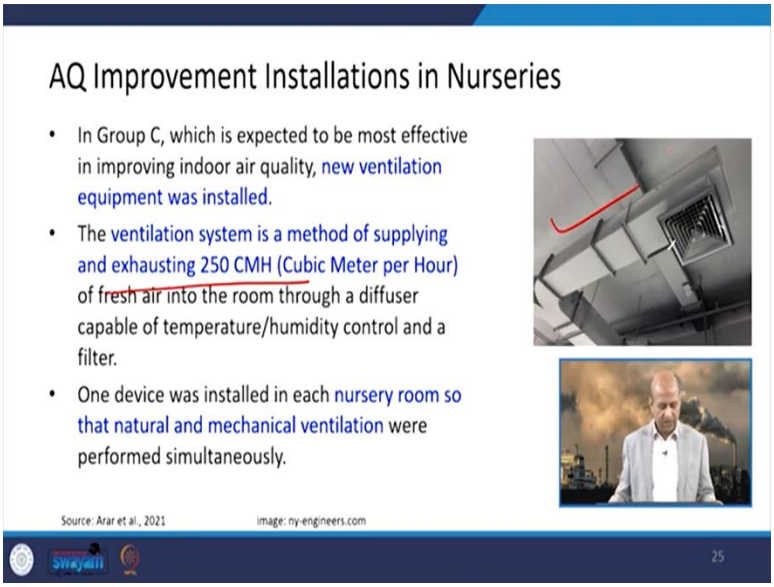

Then in Group B the change of finishing materials were made inside those Room s or facilities. So, ecofriendly building materials were used in place of the old conventional ones. So that like least amount of these VOCs or formaldehyde could be emitted from those particular new material which are ecofriendly.

And then the group C were related to ventilation systems. So, new ventilation system was provided and the system was related to like this exhaust system around 250 cubic meter per hour fresh air could be taken into the indoor environment. So, diffusion could be ensured properly and the temperature humidity control could be also provided with this kind of ventilation system.

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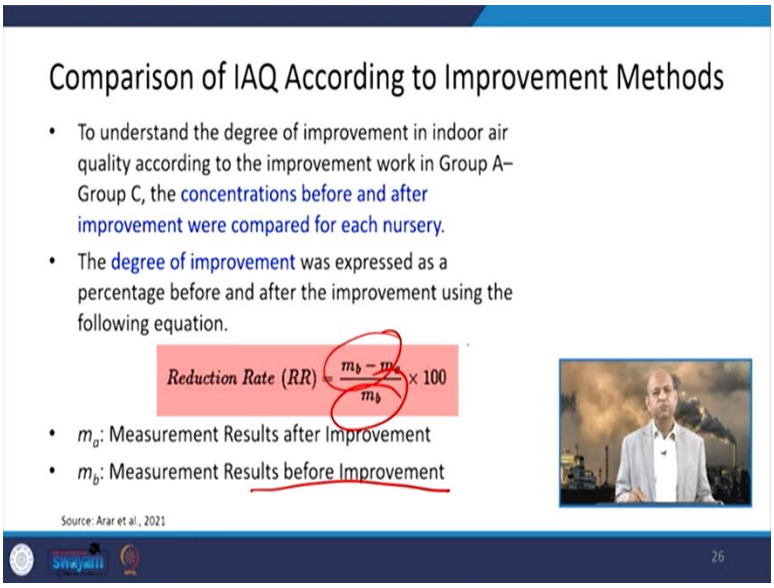

So, means then comparison was made that the readings were of those pollutants before the installation of any method whether air purifier or new ventilation or the building material. So, what was the concentration of a particular pollutant before that installation and what was the concentration of that pollutant after those measurements were taken into account. So, the difference of that divided by the measurement results before the improvement and multiplied by 100. So, how much percentage reduction rate is there that could be easily measured.

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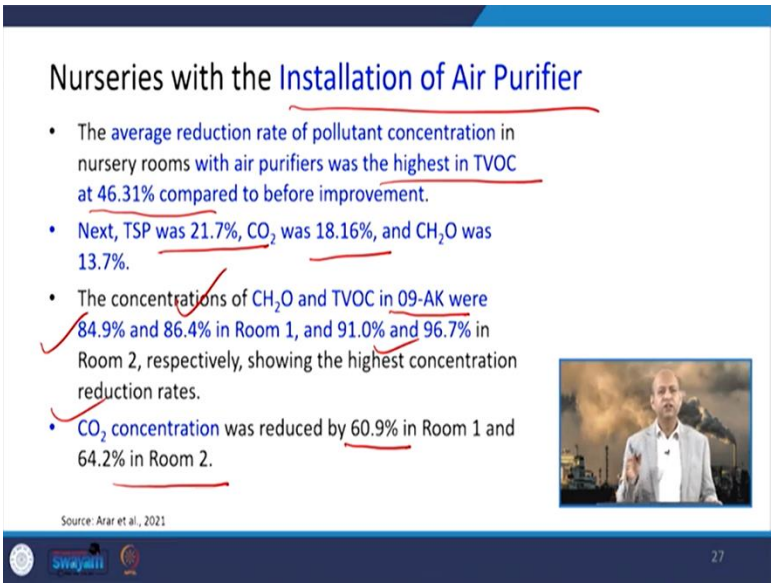

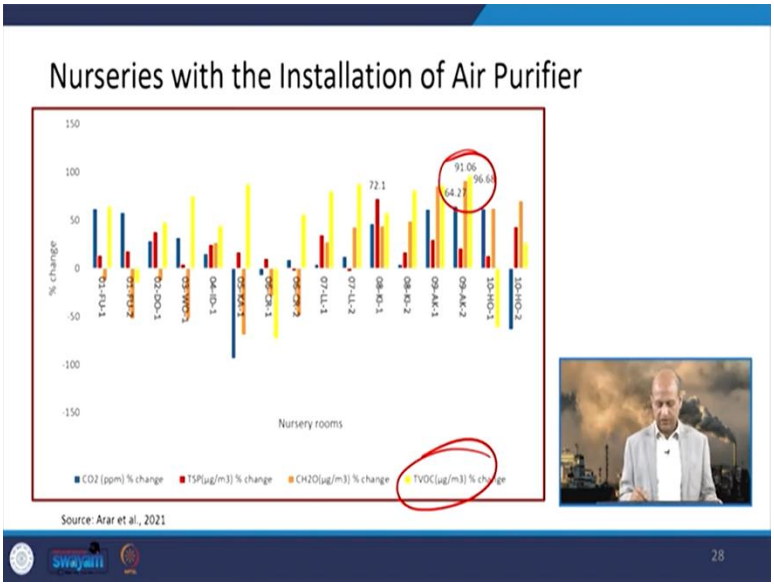

So, you could see like around in when this air purifier was installed around 46.3 percent TVOC highest TVOC removal was absorbed basically in certain locations and the TSP was removed or

reduced around 21.7 percent CO_2 was around 18.6 percent. So, air purifier was very good in case of TVOC total volatile organic compounds. The reduction maximum was observed above 46.31 percent. Then 64.2 percent in Room 2 and 60.9 percent in Room 1 this CO_2 concentration was observed. So, that way in different facilities, different reduction of different pollutants were observed.

The concentration of the formaldehyde and TVOC in this facility 09 AK were around 84.9 percent 86.4 percent in Room 1, 91 percent and 96 percent in the Room 2 respectively. So, showing highest concentration reduction rate. So, different pollutants had different reduction rates, different facilities in nurseries as well as rooms. You can see like 91.6 percent of the removal of these TVOC highest percentage there in some percentage 64 and other like 96 to 91 you can observe.

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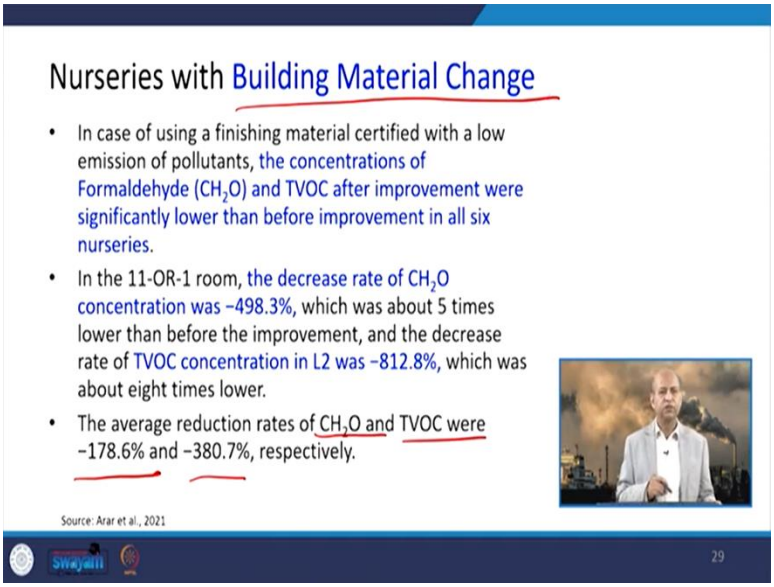

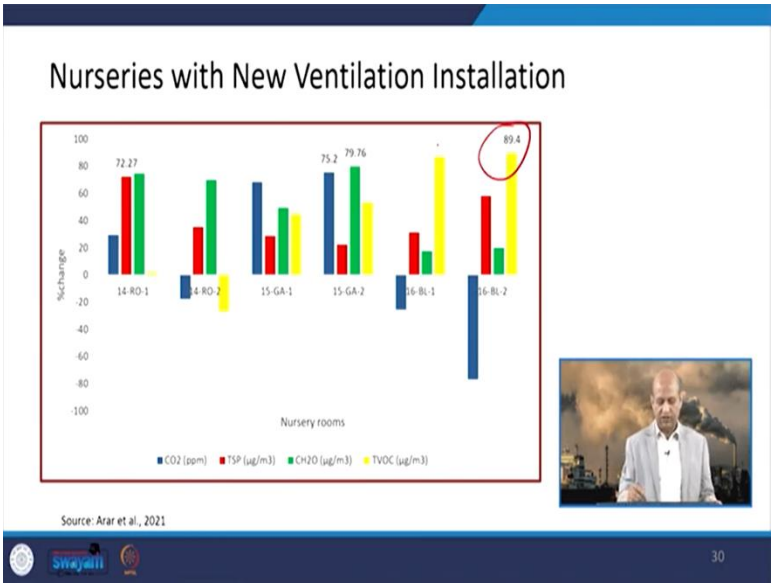

Then in building material changes, so, they again could see the average reduction rate of formaldehyde and TVOC around 178 percent or 380 percent means. This is huge reduction, basically, in case of formaldehyde and in total volatile compounds by changing the building materials. Because, those are the basic sources of these volatile organic compounds and formaldehyde. So, you can see these kinds of changes reductions were very high in the in those cases.

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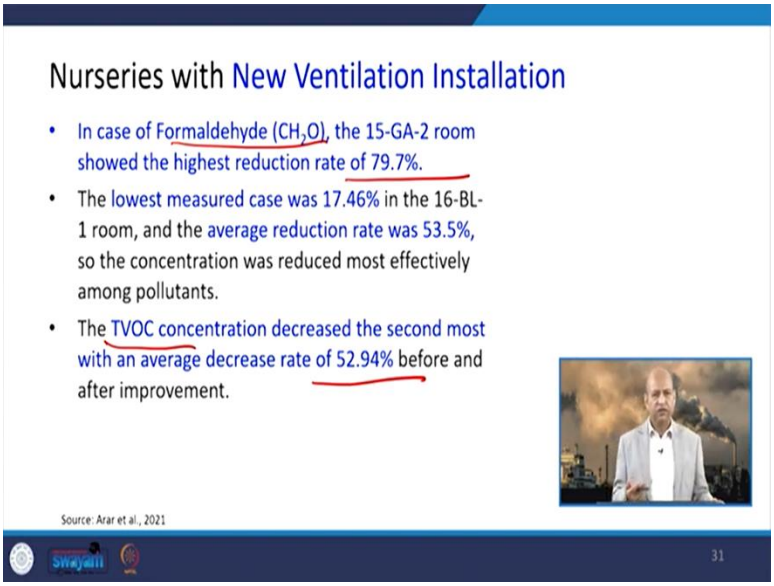

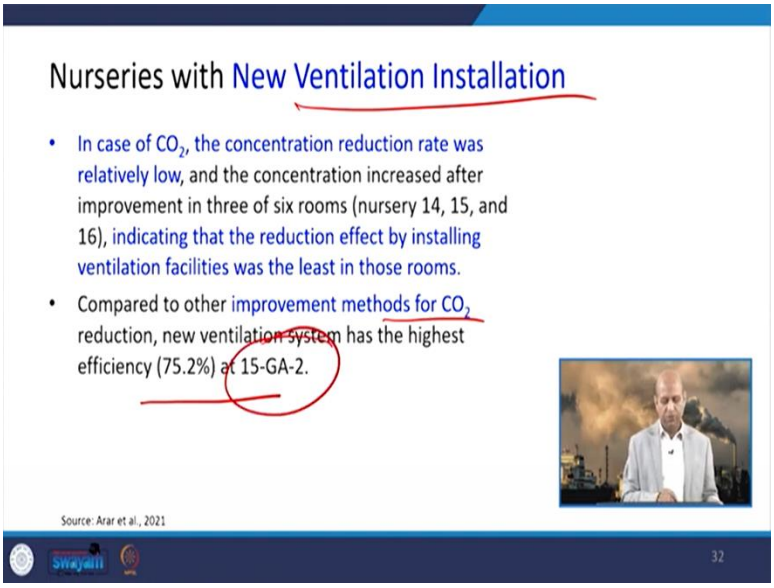

When new ventilation system was installed in certain groups in certain facilities. So, around this formaldehyde reduction was 79 percent TVOC reduction was around 52.94 percent. So, different facilities have different effects, because they were exclusive, it was not that the same facility was provided with all these three installations at different locations, so that we could compare the effectiveness of these systems in particular facility. But different groups were there and we could see their effectiveness or their efficacy. You can see here this 75 percent efficacy or efficiency of CO_2 reduction is there by new ventilation system, in particular, this 15 GA 2 facility.

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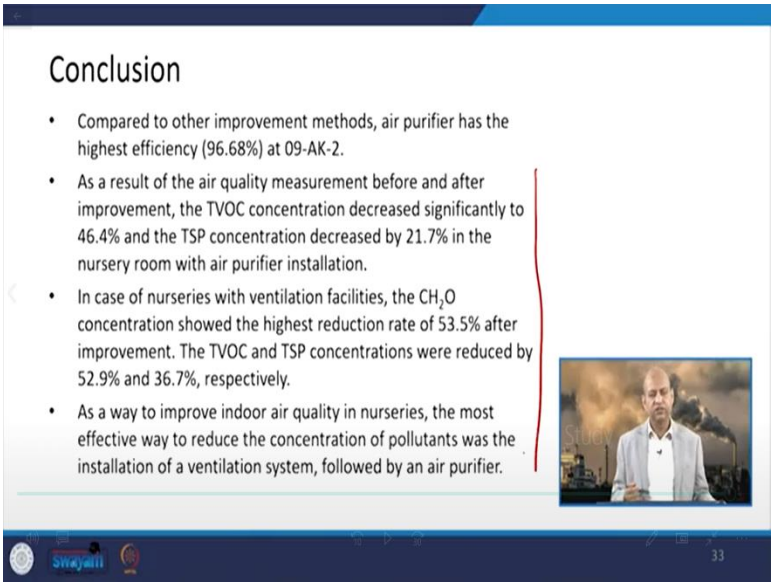

So, in conclusion, we can say that, the nursery is indoor environment is very important to ensure the good air quality. And there are methods, whether it is through ventilation, or through air purifiers or changing the furnishing, building furnishing material, so that we can improve the air quality. And this case study gives us insight that which kind of intervention could really target which particular pollutant inside the micro environment. So, that way you can have good insight and information based on this nursery related case study and it can be replicated into other kinds of setups or micro environment. So, this is all for today.

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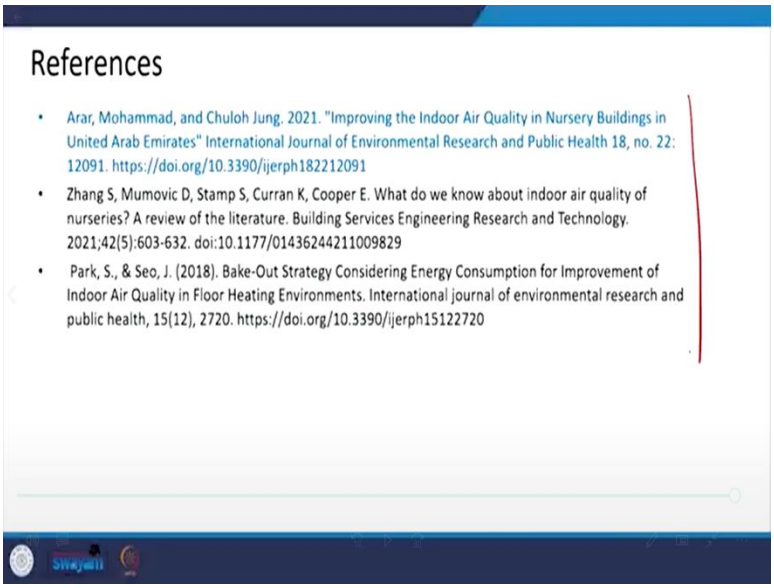

These are the references for additional information. Thank you for your kind attention. See you in the next lecture. Thanks again.