Air Pollution and Control
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Lecture 35
Personal Exposure to Fine Particles: A Case Study

Hello friends, these days we are discussing about indoor air pollution. So, in that series, today we will discuss about personal exposure to fine particles that is $PM_{2.5}$. And this is basically a case study based on a city.

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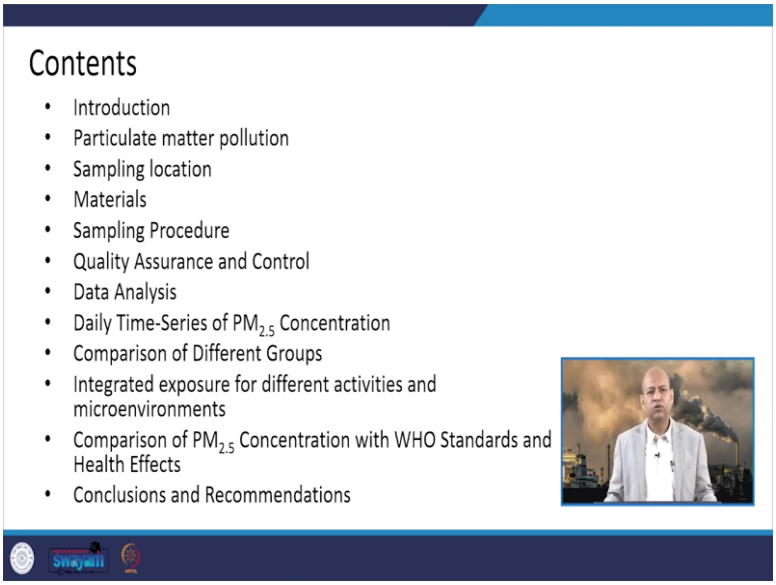

So, this will be the contents of this particular lecture, like we will see the introduction part means, where the study was conducted, what is the setting of the study. And then the, why particulate pollution is important, what are the locations of sampling which were carried out which materials or methodology was used, what was the procedure of the sampling.

Then to assure the quality what preventive measures were taken or what protocol was followed, how data were analysed, and then the time series related to $PM_{2.5}$ concentration. So, their analysis and comparison of different groups, we will see different occupational groups, which are considered in this study, then integrated exposure of different activities within the given micro environments and the comparison of $PM_{2.5}$ concentration with the standards, which have been prescribed by World Health Organization and their health effects. And then we will conclude with some recommendations.

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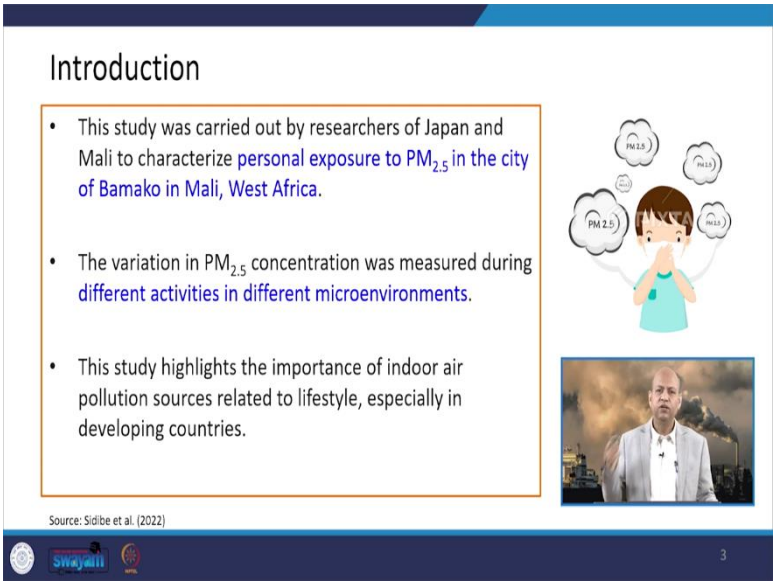

So, basically this study was carried out by, kind of joint research study by researchers of Japan and the Mali, the country which is in West Africa and the city where this study was conducted is Bamako, which is capital city of Mali, and the variation in $PM_{2.5}$ concentrations were measured during different activities and different micro environments, we will see what are those micro environments.

And, this study highlights the importance of indoor air pollution, their sources then the lifestyle or occupational related exposure, in basically developing countries. So, this study is very important in that sense, how developing countries occupational related settings influence the indoor air pollution exposure to people.

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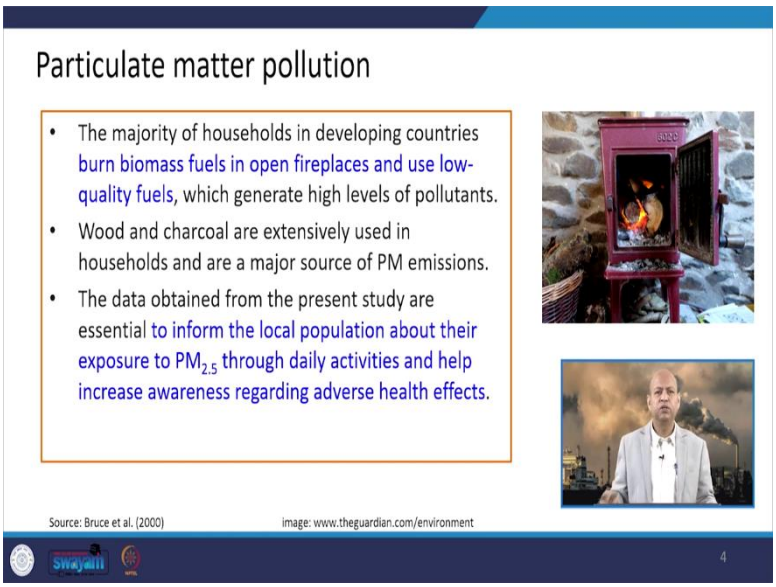

Well, basically, why this particulate matter pollution is so important because, in developing countries still large, large number of people use biomass fuels in their household activities for cooking and other activities, this wood, charcoal, those are the fuels which are extensively used in households, and they are the major sources of particulate pollution basically.

The data obtained in this present study are essential to inform the local population about the exposure to $PM_{2.5}$ and their relationship with the daily activities so, that they can change in daily activities, if they find that at a particular activity, they are getting exposed to very high level of concentration of $PM_{2.5}$. So, awareness generation will be because of this study and also there will be some informed decision making process for the policymakers.

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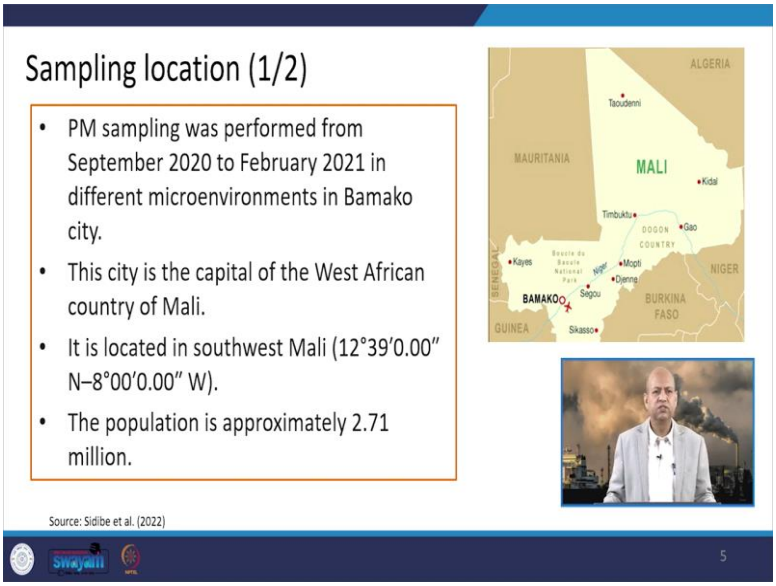

Well sampling locations if we consider in that particular city. So, they are basically personal exposure was taken up through different sampling techniques, which we will discuss later on, but the city is basically, capital city of Mali and the sampling, duration was from September 2020 to February 2021, around five to six months, and the population of the city is around 2.71 million. So, that is basic sampling location related data.

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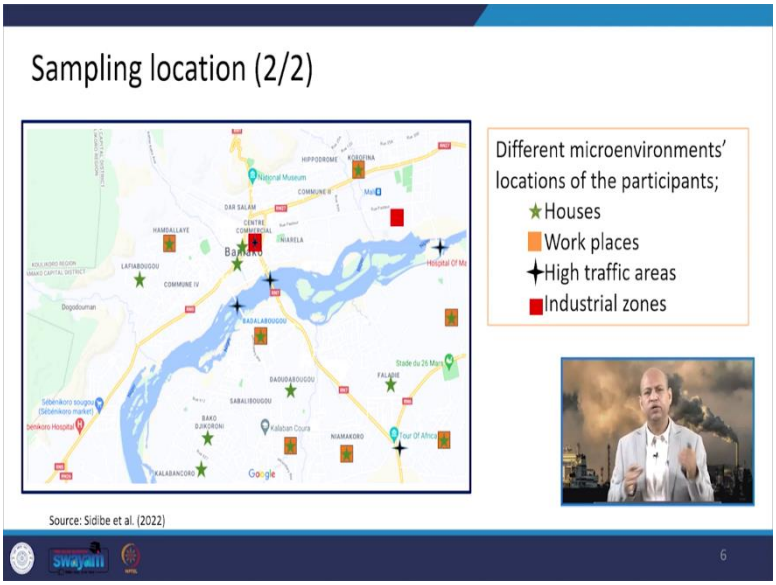

The locations if you look at are basically related to household environment that is the houses. Then the workplace, where people are working that is the office. High traffic areas where people move around and get exposed to particulate matter and industrial zones. So, these were the locations where our subjects were studied as per their exposure to $PM_{2.5}$.

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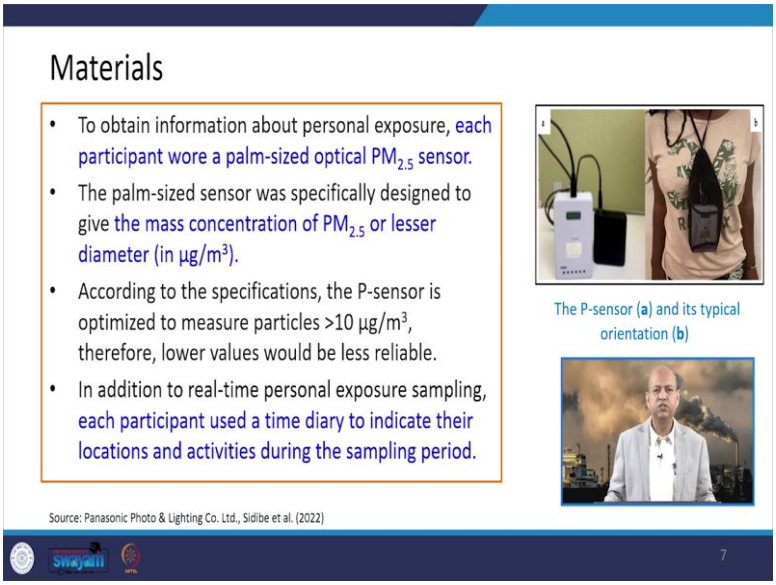

And the materials or the technique which was used is basically the P-sensor. So, to obtain the information about this personal exposure each participant was given this palm sized optical $PM_{2.5}$ sensor, this is also known as P-sensor. And they were specifically designed to give the mass concentration that is microgram per cubic meter and then per unit of time that kind of

unit, and $PM_{2.5}$ means, as, the particulate matter which has the size of 2.5 micrometre or less than 2.5 micrometre.

The limitation of this particular sensor is that because it is optimized for the particulate matter which is of the size let us say PM_{10} or more. So, that way a little bit, less reliable you can say means the preciseness will be affected if we consider for $PM_{2.5}$ but still means for the sake of preliminary information, this sensor base study was found quite okay.

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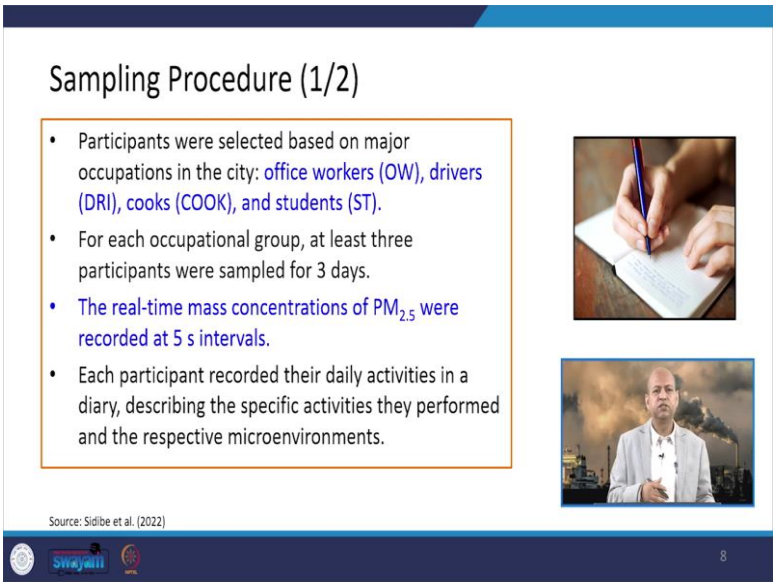

Well, when we talk about different kinds of groups, which were taken for this study, they are 4 groups. Like office workers, and in the data analysis, we have given them this acronym OW. Drivers, so, we are using DRI for them, COOK that is the cooks who are getting exposed in the kitchen of hotels or wherever they work in the households also, then the student's community. So, ST have taken has been taken as students for nomenclature of the students.

And the study was conducted for three days. And for each group, at least three participants were considered. So, maybe more than three, but at least three participants were there from the each group. And this $PM_{2.5}$, the data, real time data was recorded in this P-sensor and, each five second interval, this sensor was recording the data. So, huge data set was there basically.

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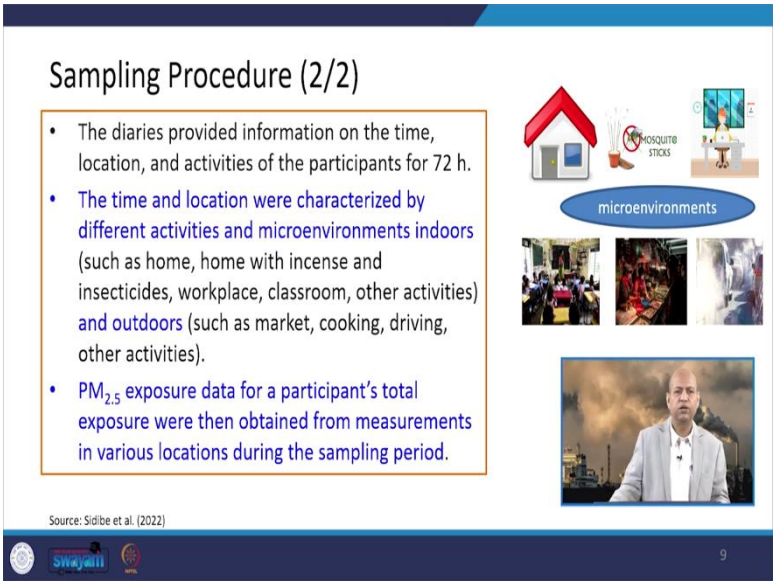

And daily activities related to participants they were written in diaries, whatever activities they were doing at a particular location or some activity changes were there. So, within those, 72 hours or three days, in different locations, if there were change the activities or a special kind of exposure related possibility was there. So, time and the location and that activity was noted down by the participants. So, those were related or associated, when data were analysed. So, all those activities and the time of that exposure, those were associated and they were used for analysis of the data.

And, those locations or micro environments, which were used were basically homes household means indoor environment of the homes with the incenses and insecticides like, mosquito coils people burn those kinds of insecticide. Then the workplace where office maybe there, and then the classroom for students and other activities and also some outdoors like in the market, then for cooking, driving, all those activities have been taken into account. $PM_{2.5}$ exposure data for participants total exposure were also obtained. So, integrated assessment has also been carried out.

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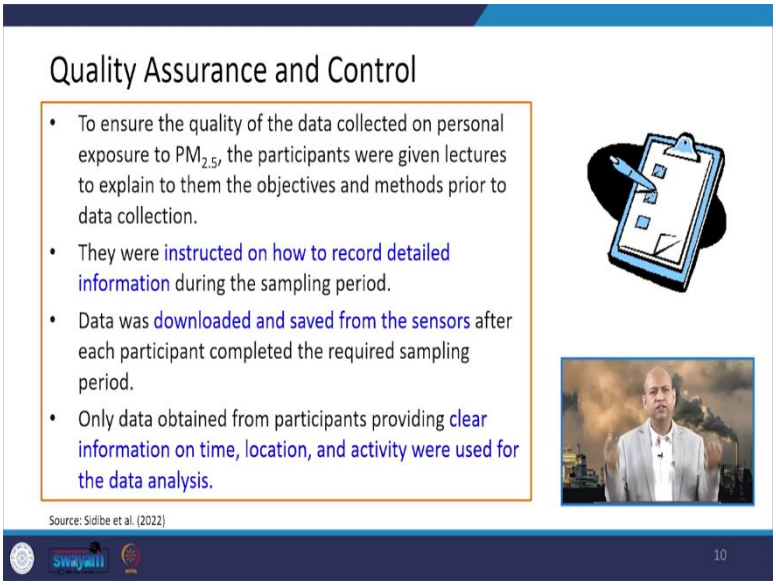

Well, for quality assurance, all these collected data were given for collection of the data. So, each participant were given awareness program or you can say seminar or lecture. Through lectures, kind of training was conducted, so, that they know, how to note down the data and how to handle those sensors. So, that way fairly good quality assurance was accomplished in that way. And the data was downloaded when all those saved sensors were taken to a particular for a particular sampling period, and those data were downloaded in the computer and then they were analysed.

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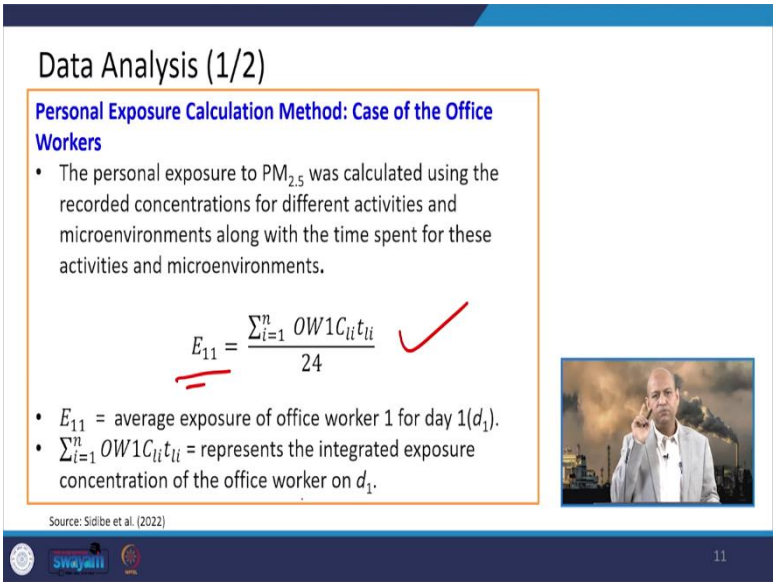

Well, when we talk about data analysis, then this particular relationship was used like, personal exposure or $PM_{2.5}$ for different activities. So, that is why this submission is there integration i

=1 to n. So, that is the number of participants. E_{11} is like average exposure of office worker 1 for day 1. So, for day 2, it is E_{12}. For day 3, it is E_{13}. For worker 2, it is E_{21}, E_{22}, E_{23} like that, this changes and accordingly this office worker here OW1, it may be ST1 student for students, for driver, it will be DRI1. And then C_{1i} and T_{li} are basically the concentration on the particular day of i, that is 1, 2, 3 those particular numbers are there.

$$E_{11} = \frac{\sum_{i=1}^{n} OW1 C_{li} t_{li}}{24}$$

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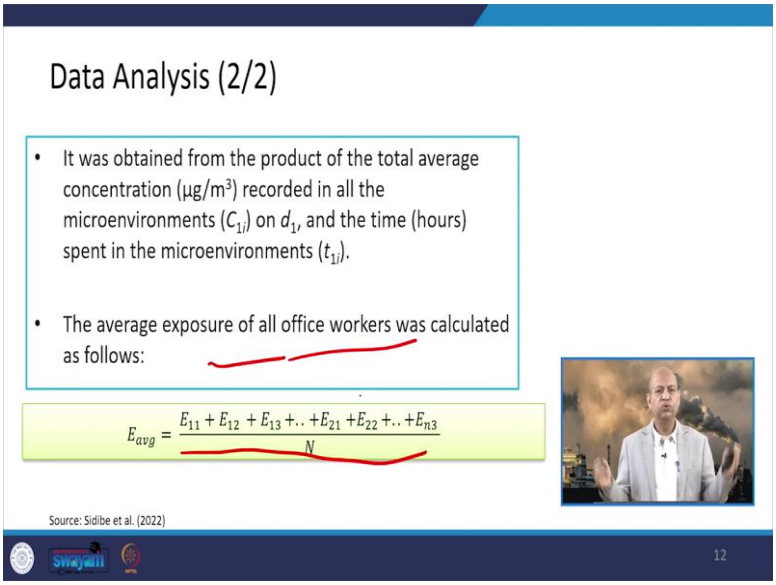

So, the days and the number of participants those have been taken into account and then the average concentration or exposure was achieved by or calculated by this particular simple relationship, all those, data were added and divided by the n number of data.

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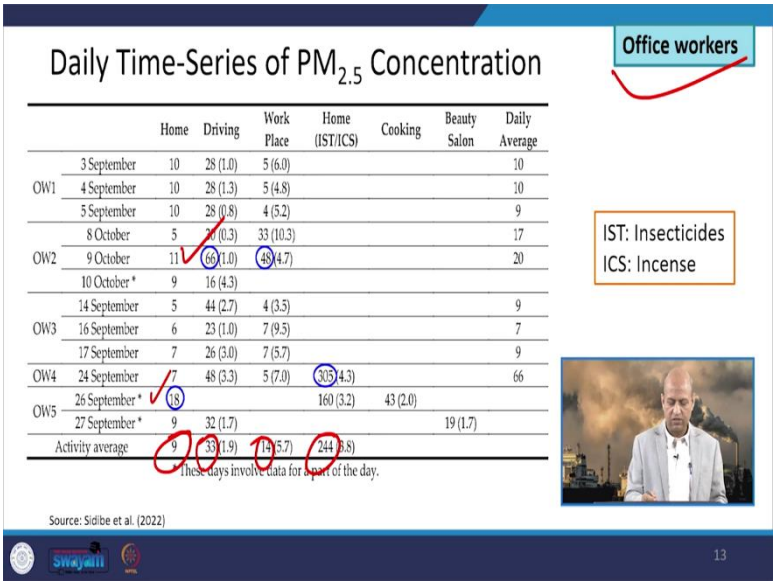

		Home	Driving	Work Place	Home (IST/ICS)	Cooking	Beauty Salon	Daily Average
OW1	3 September	10	28 (1.0)	5 (6.0)				10
	4 September	10	28 (1.3)	5 (4.8)				10
	5 September	10	28 (0.8)	4 (5.2)				9
OW2	8 October	5	27 (0.3)	33 (10.3)				17
	9 October	11	66 (1.0)	48 (4.7)				20
	10 October *	9	16 (4.3)					
OW3	14 September	5	44 (2.7)	4 (3.5)				9
	16 September	6	23 (1.0)	7 (9.5)				7
	17 September	7	26 (3.0)	7 (5.7)				9
OW4	24 September	7	48 (3.3)	5 (7.0)	305 (4.3)			66
OW5	26 September *	18			160 (3.2)	43 (2.0)		
	27 September *	9	32 (1.7)				19 (1.7)	
Activity average		9	33 (1.9)	14 (5.7)	244 (3.8)			

These days involve data for a part of the day.

When we talk about daily time series of $PM_{2.5}$ concentration for particularly office workers. So, you can see this table OW_1, OW_2, OW_3. So, five these workers were there, office workers were there, who were given those samplers or sensors and they collected the data on different dates.

So, you can see like average value is around 9 in the homes and in driving it is around 33, in workplaces it is 44, at home it is around 244 but the maximum values are also there in different settings like at home it was 18 and during driving like in car or so, it was 66, at the workplace it was 48 and at home when they were using those insecticides like mosquito repelling coils or other things and or incense, they are using then it was very high 305 or so. Well daily average concentrations were also calculated.

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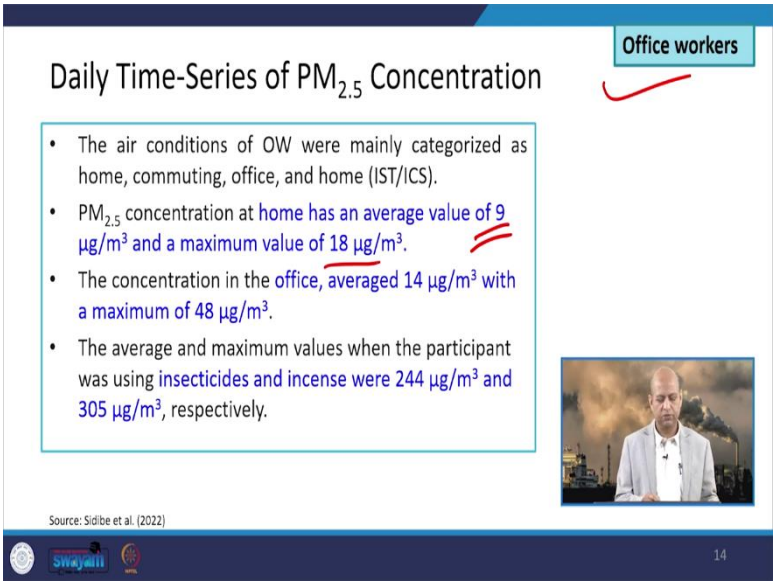

So, daily time series of $PM_{2.5}$ concentration for office workers give some insights like this concentration at the home average value as I said it was 9, and the maximum value was around 18. For concentration at the office, it varies from like average value 14, and the maximum value was 48. So, as I already explained in that table, the average and maximum values of this exposure to the participant were maximum during these insecticides and incense usage that were 244 average value and 305 maximum value.

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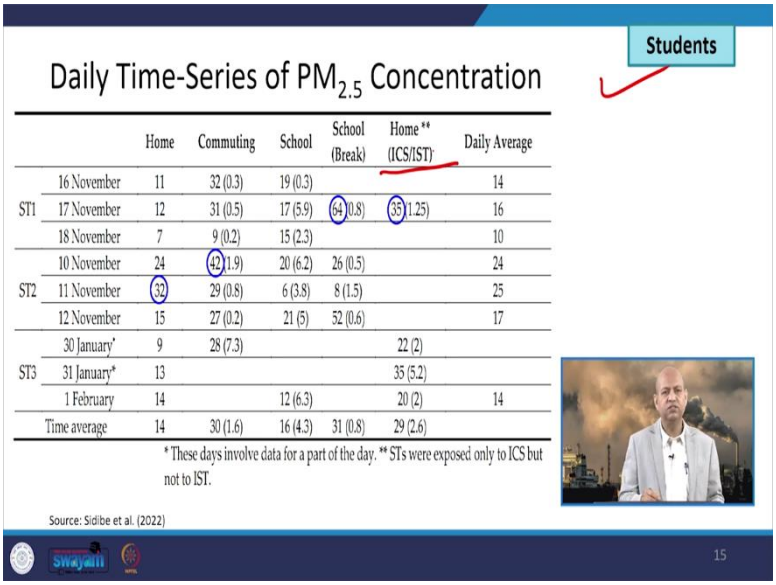

Similarly, if we talk about students, so at home and then commuting means going to college or school, and then during the school classrooms and at the home when these incenses were used. So, all these concentrations values are given maximum value as well as average value.

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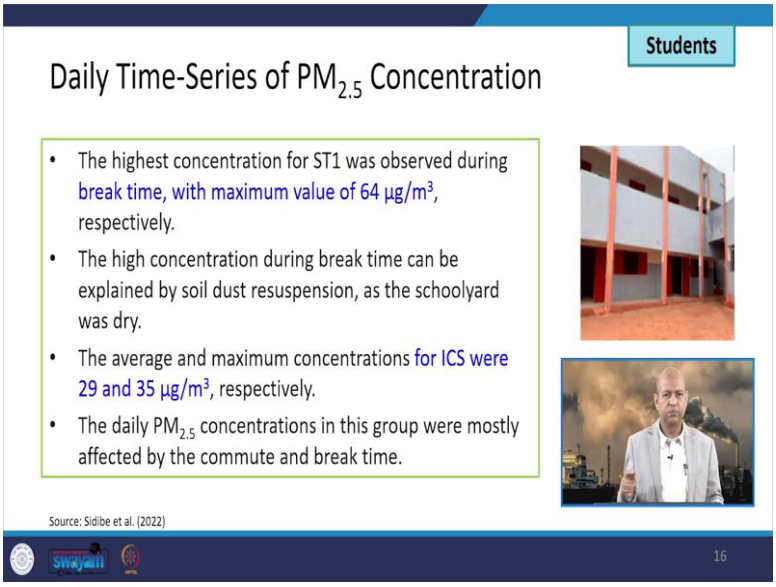

So, all these have been given and it has been analysed as per the data obtained.

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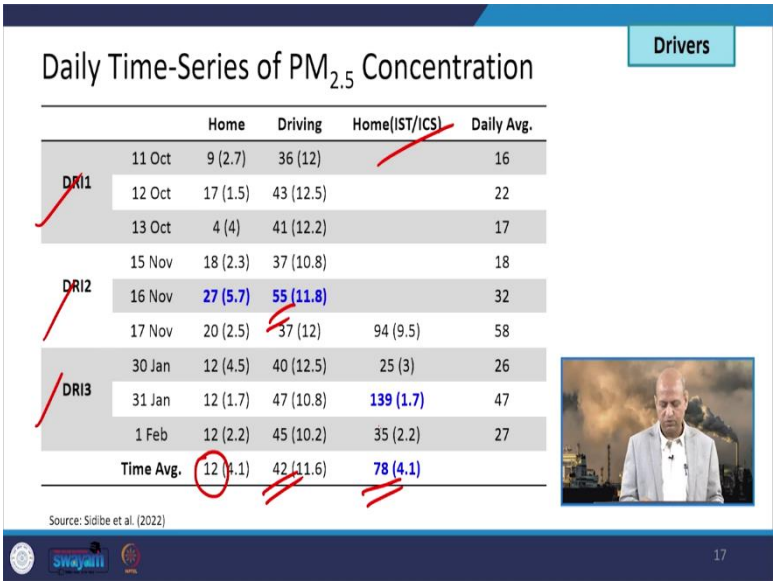

		Home	Driving	Home(IST/ICS)	Daily Avg.
DRI1	11 Oct	9 (2.7)	36 (12)		16
	12 Oct	17 (1.5)	43 (12.5)		22
	13 Oct	4 (4)	41 (12.2)		17
DRI2	15 Nov	18 (2.3)	37 (10.8)		18
	16 Nov	27 (5.7)	55 (11.8)		32
	17 Nov	20 (2.5)	37 (12)	94 (9.5)	58
DRI3	30 Jan	12 (4.5)	40 (12.5)	25 (3)	26
	31 Jan	12 (1.7)	47 (10.8)	139 (1.7)	47
	1 Feb	12 (2.2)	45 (10.2)	35 (2.2)	27
	Time Avg.	12 (4.1)	42 (11.6)	78 (4.1)	

Similarly for drivers these data were collected, so, like DRI1, DRI2, DRI3 and different dates are there. And you can see the values, it vary values vary for home 12 to 27 means average value 12, 27 is maximum 42 average 55 Maximum 78 average when these insecticides or incenses were used and 139 is the maximum.

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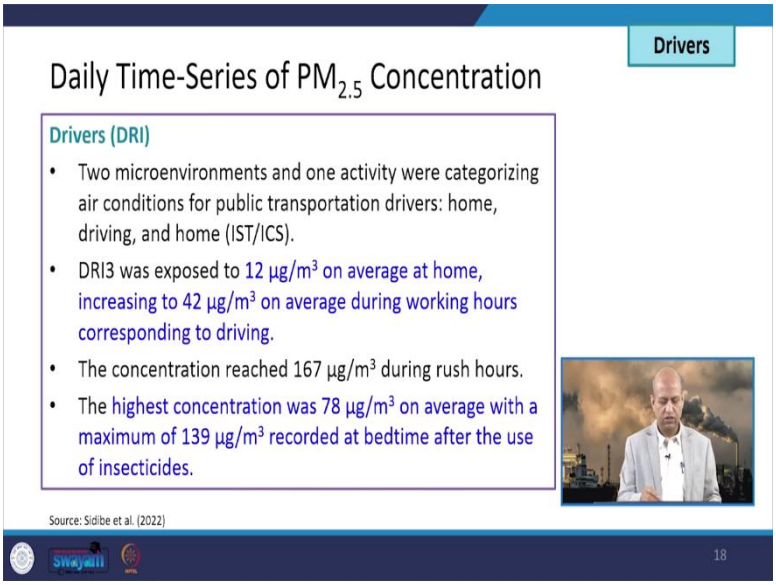

So, these values have been described here also.

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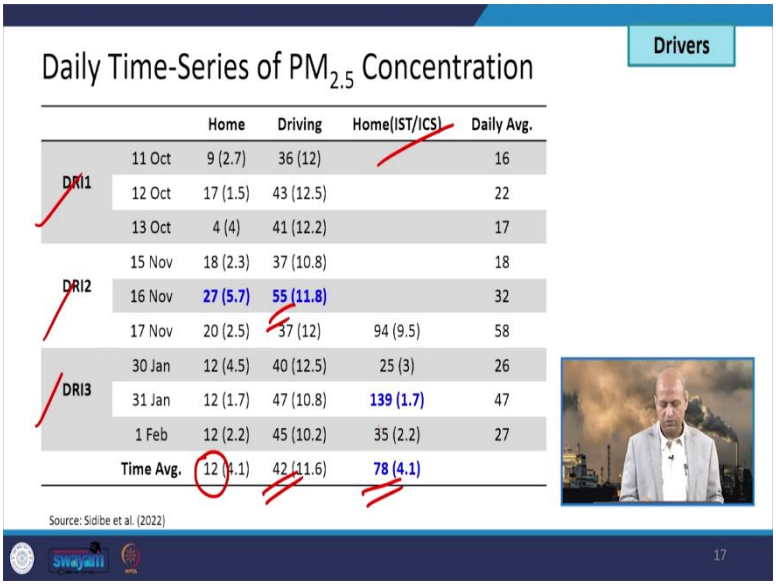

Well, when we talk about cooks. So, again you can see home and then cooking atmosphere where they are doing this cooking activity. Homes with these insecticide dusts and incense, you can see these 3 cooks were used for sensors, exposure data and homes 18 is the average value 29 is the maximum. During cooking it varied 41 to 47. So, you can say the average value is also quite high, when we talk about homes with these insecticides, then this varies 300 to 880. Very high concentration because of those coils burning activity or combustion of those coils.

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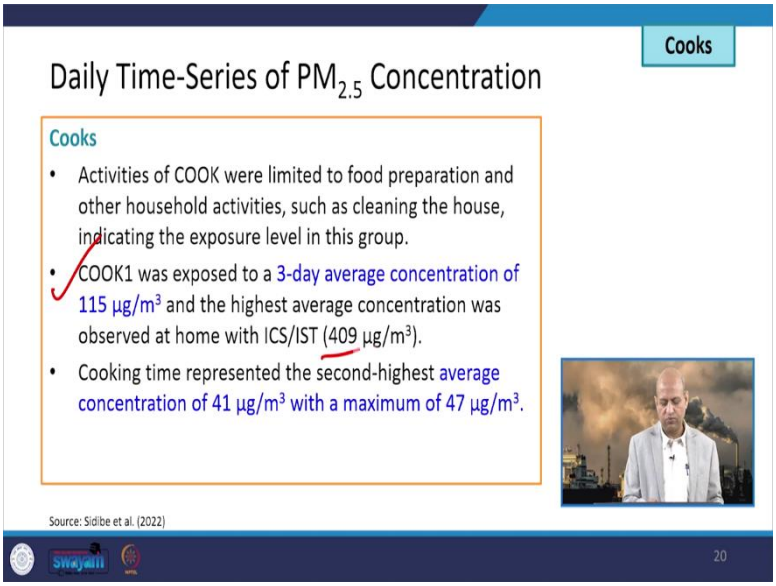

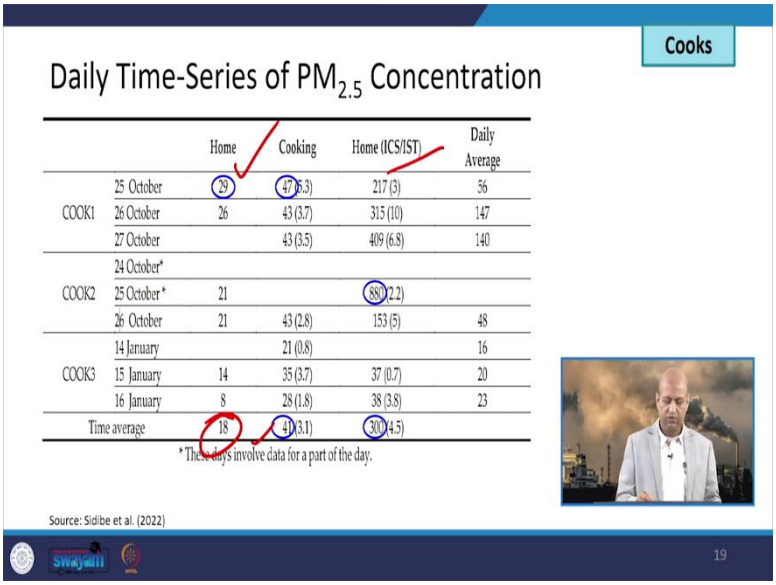

Well, so, 3-days average concentration around for COOK1 basically 115 microgram per cubic meter was observed average value, and maximum was 409. Otherwise, it could 880 for COOK2. So, different cook set different atmosphere. So, they could get exposed to different values of concentrations.

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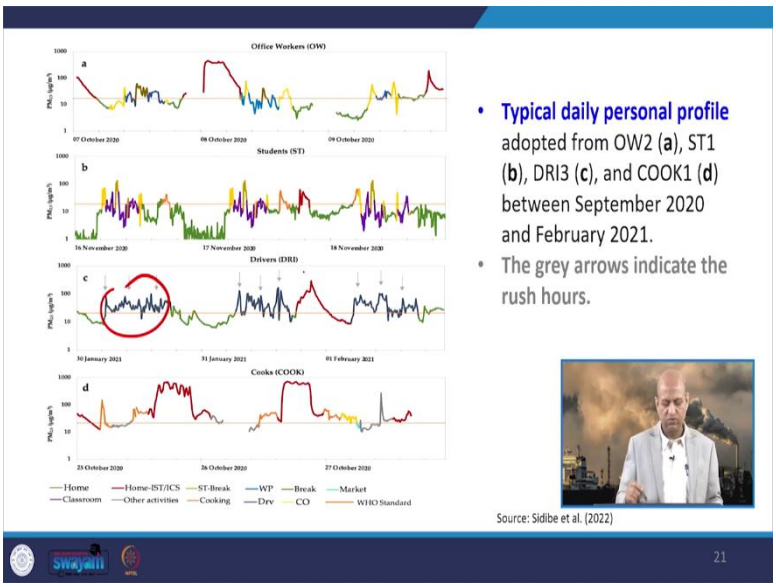

When we talk about typical daily personal profile of these office workers or students and drivers and cooks in between that September 2020 to February 2021. So, you can see these grey arrows indicate the rush hours where those values were varying according to that particular activity.

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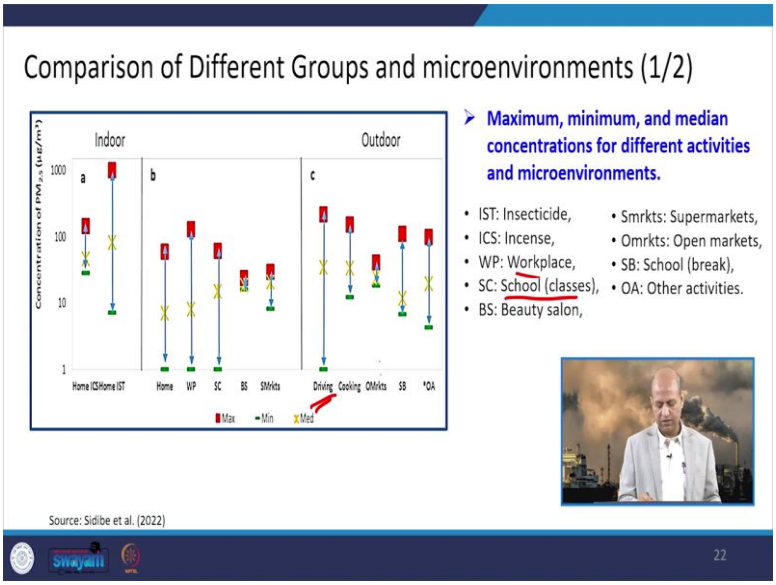

If we compare different groups in different micro environments, then we can see like this school SC, and then WP is the workplace. Homes are there. So, for different activities like with or without these incenses, all these data are given. So mean value, median value is there, then minimum and maximum values also there. So range is also given that way you can see during driving this range is quite high in that sense and for these open markets its almost constant kind of value.

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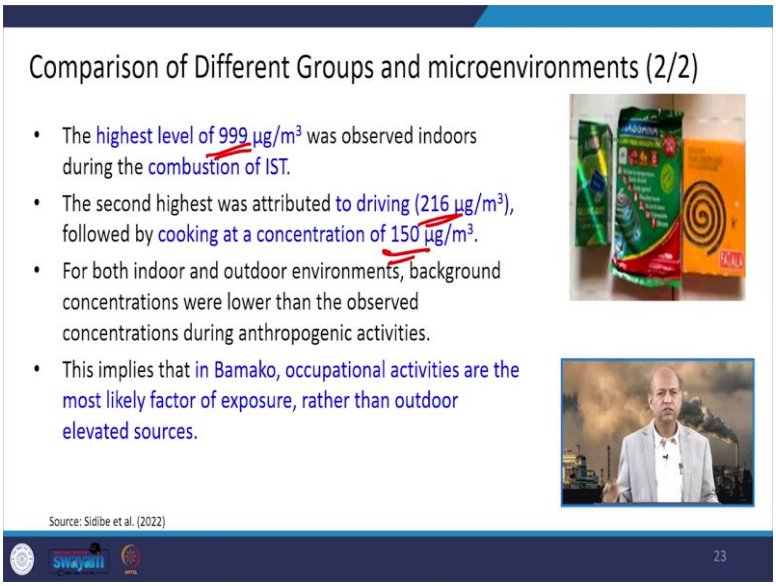

When we compare different groups and for different micro environments, then highest level around 999 microgram per cubic meter was observed indoors when the combustion of these

insecticides were there. And the second highest was activity to driving activity around 216, followed by this cooking that was around 150.

So, this implies basically in Bamako occupational activities are the most likely factors of exposure rather than the outdoor elevated sources, because it was found that the these, outdoor environment concentrations were lower than the these indoor concentrations for anthropogenic activities, which these participants were doing.

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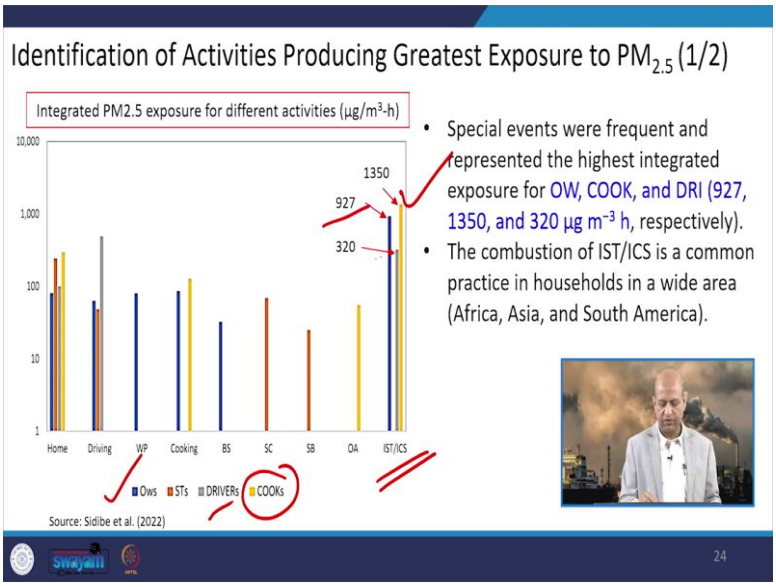

Well, when we talk about activities which are producing greatest exposure. So, you can see like these when we are using incenses or insecticides, then around 1350, for cooks, they are getting exposed to very high concentration. And these, office workers were getting around 927, and drivers were having 320.

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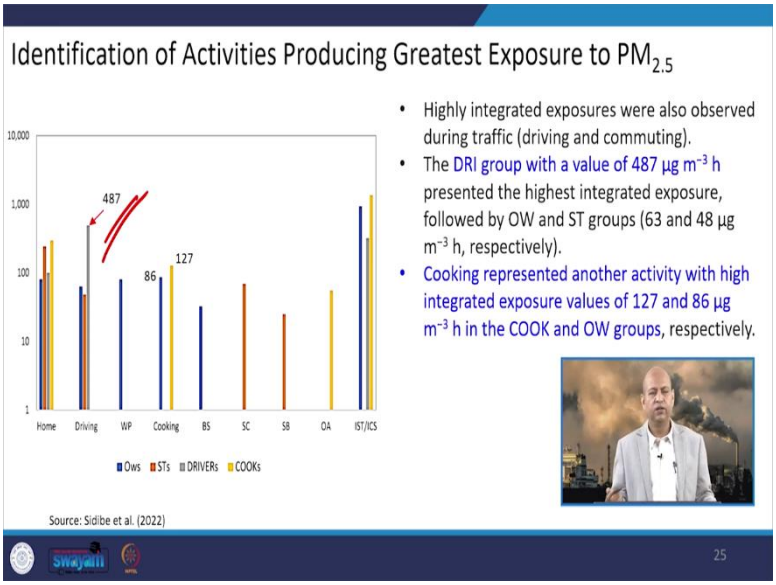

In different setting you can see like driving for driving activity, these drivers were having the highest exposure around 487. So, you can see different settings or different these micro environments give different exposure.

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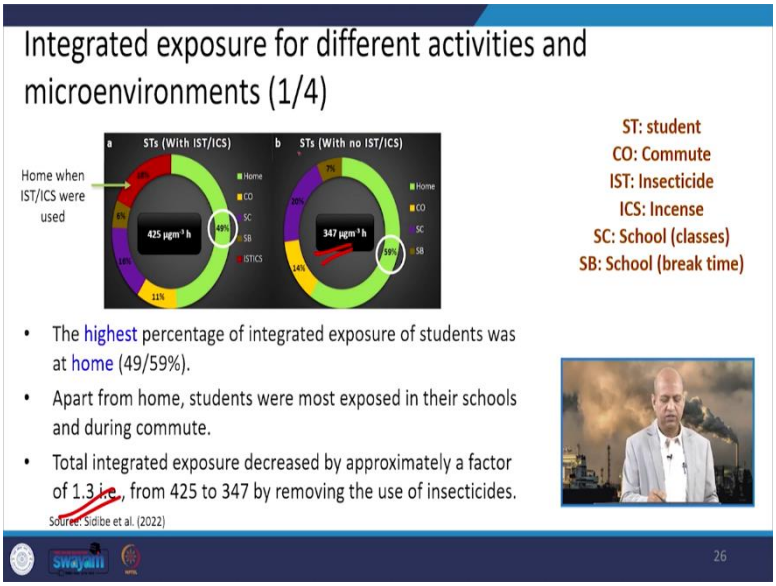

When we talk about integrated exposure that is the combined one for different activities, then another situation emerges like you can see here around this 425 microgram per cubic meter per hour exposure is there when these insecticides and incenses are used. And when they are not in the use, then this drops around up to 347. So around by a factor of 1.3 this concentration reduces. Well, and this concentration is highest for this in the home basically 49 to 59 percent for these students basically.

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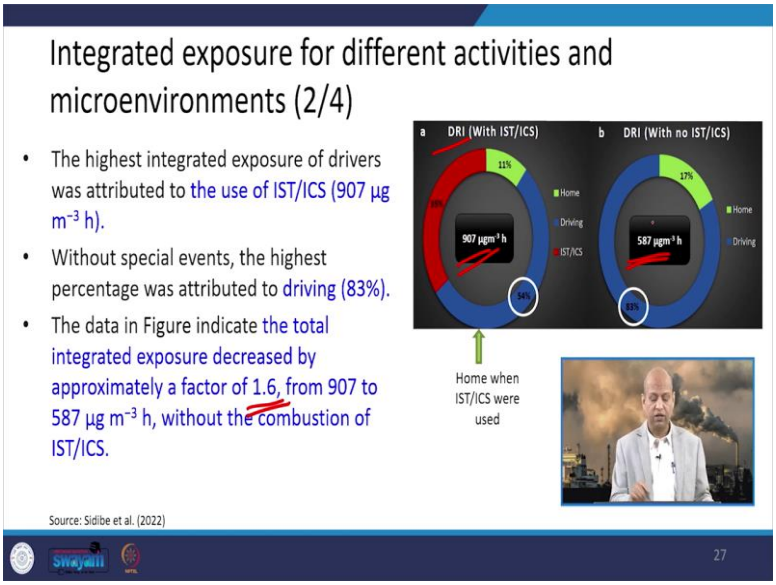

Then, if you talk about this driver's community, then again you can see the exposure is very high around 907. When we are using insecticides, or incenses and then it drops to 587, when these are excluded. So, variation is there around up to 1.6 factor difference is there, and you can see the driving is the activity for drivers which get them exposed to very high concentration of 54 percent or 83 percent depending upon whether we are using insecticides or not into integrated measurements or analysis.

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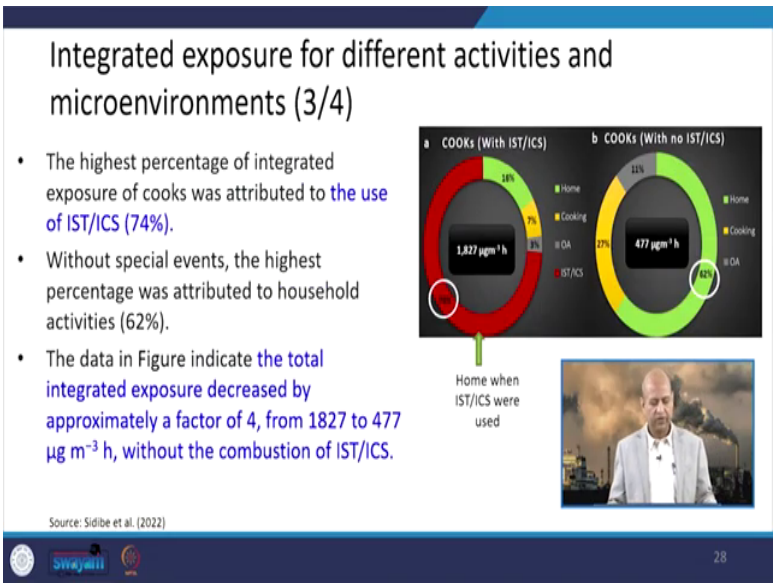

When we talk about cooks, so, around 74 percent. You can see home these they are getting when they are using insecticides very high concentration, but it drops to 62 percent If we are not using that particular incenses or insecticides. So, around 4 times difference is there in values like 477 and 1827 it makes a huge difference basically.

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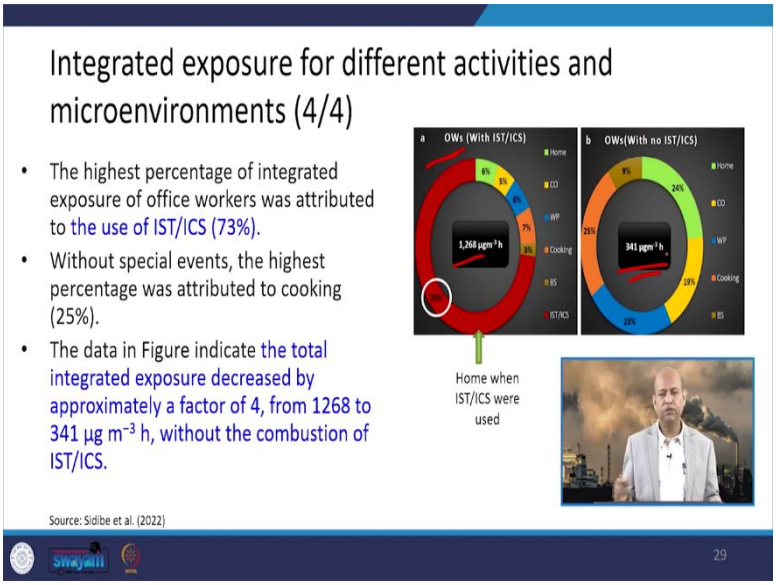

Similarly, in case of, office workers, again very high concentration around 1268. When we are using these insecticides, without this it is only 341. So, again by factor of 4 difference is there into the exposure.

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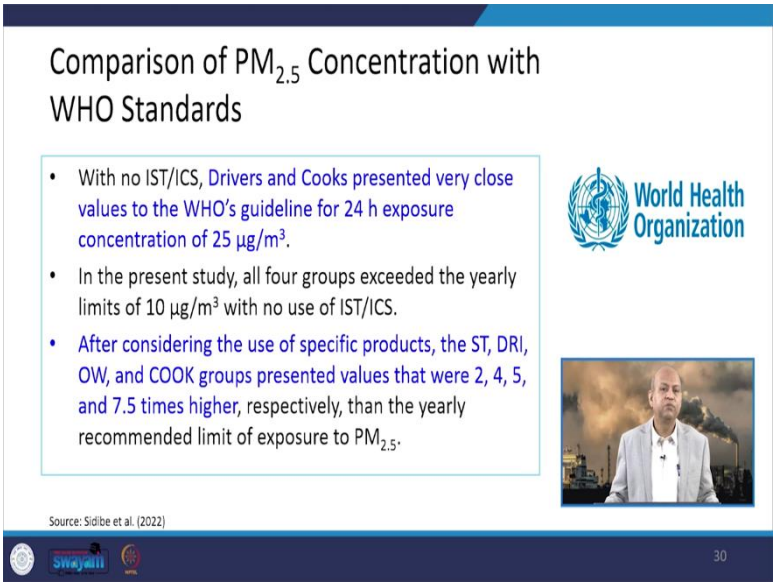

When we compare $PM_{2.5}$ concentration with WHO standards. So, basically, with no IST, ICS that is no insecticides or incenses in use, then drivers and cooks presented very close values to the guideline concentrations for 24 hours by WHO that is around 25 microgram per cubic meter.

And in present study it was observed that in all four groups, they exceeded the yearly limit of 10 microgram per cubic meter without using these insecticides or incenses and after

considering the use of specific products, so, student, whether students or drivers or office workers or cooks, they presented values around 2, 4, 5 or 7.5 times higher than the yearly recommended limit of the exposure of $PM_{2.5}$.

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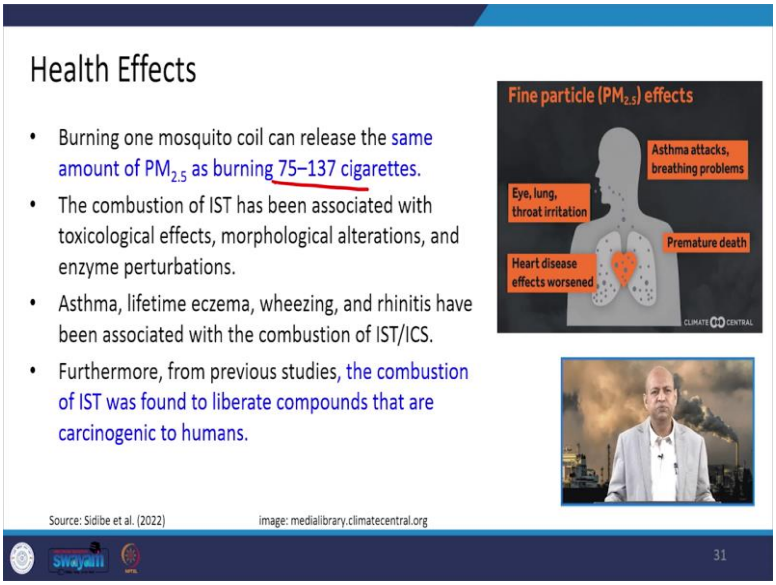

Well, health effects are there as we have discussed at several times that indoor environment because of this particulate matters, lot of respiratory problems happen and basically these mosquito coils etc . They have been found that they release lot of $PM_{2.5}$. As we have also seen in these data, so, around 75 to 137 cigarette smoking is equivalent to burning of these coils into the indoor environment these kind of data are there. And they are also like toxic and they some people are allergic to those smells and their fumes etc . So, we should avoid those particular incenses and insecticides. If we have other ways of repelling those mosquitoes, etc .

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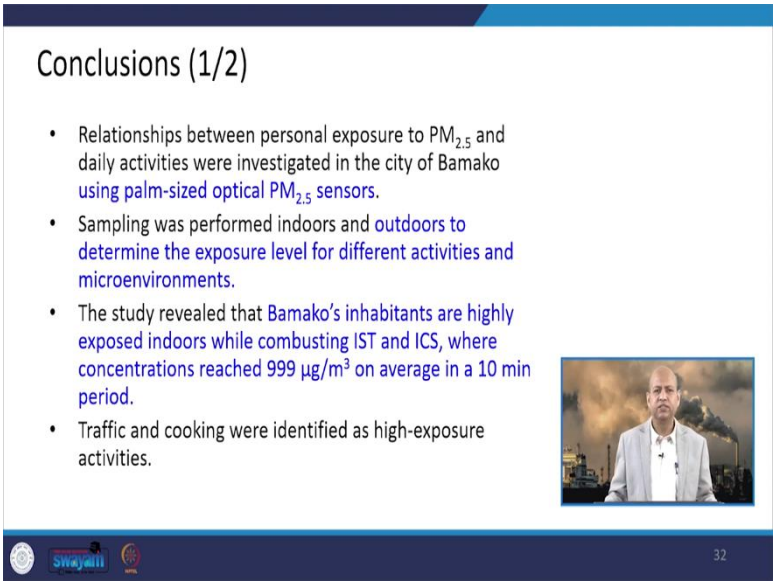

Well, in conclusion, we can say that there is specific relationship between the concentration of $PM_{2.5}$ and different activities in the city of Bamako. And different groups have different occupational hazards you can say, in the sense of high exposure for different micro environments.

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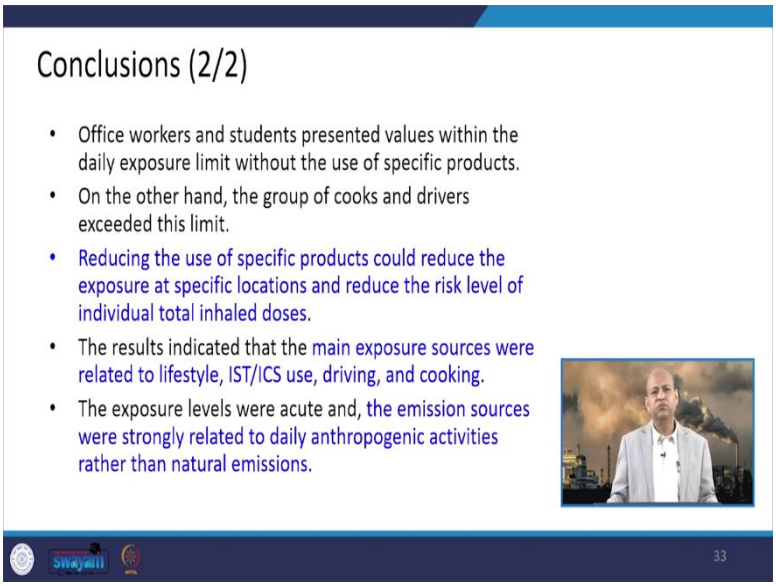

And if we can remove at least those usage of insecticides or these incenses, we can really improve in terms of less exposure, you can say, less exposure, and that way, we should give emphasis to these kinds of recommendations.

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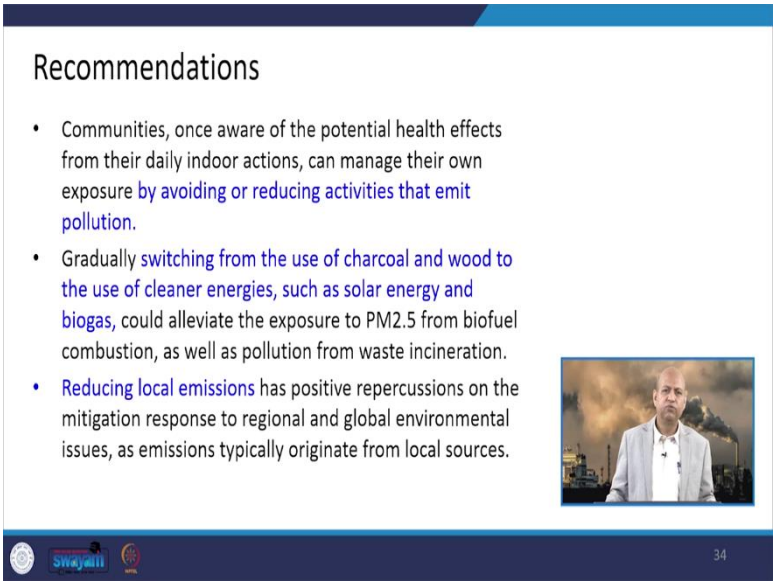

That communities once aware of the potential health effects, from their daily actions indoor environment, they can do some things so that lot of built up of indoor air pollution does not happen, they can have better ventilation or other things they can take into account. And local emissions can also be, reduced by different activities, that way additional benefits can be accomplished. So, this is all for today.

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And these are the references where we have taken this case study and you can go through it during leisure. So, thank you for your kind attention and see you in the next lecture. Thanks again.