Air Pollution and Control
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Lecture 60

Sampling and Analysing of Particulate Matter (PM10 & PM2.5) using Spectrometer

Hello friends, you may recall we discussed about gravimetric methodology to do the sampling or monitoring of like PM_{10} and $PM_{2.5}$ using the high-volume sampler, we can also do sampling and analysis of particulate matter especially PM_{10}, $PM_{2.5}$ even less than $PM_{2.5}$ like PM_1 using spectrometer-based instruments basically. So, this methodology today we will discuss and this is the last lecture of this particular course.

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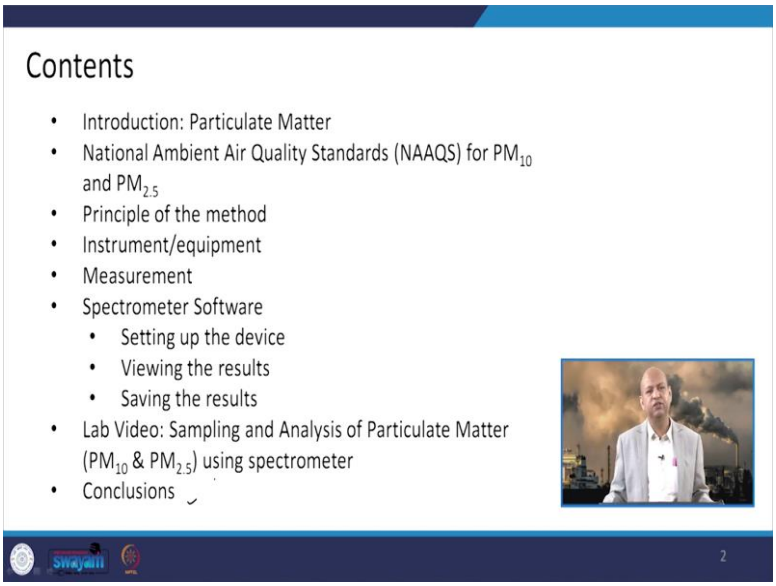

So, first of all, we will discuss briefly about the introduction, why particulate matter are so important, the National Ambient Air Quality Standards for PM_{10} and $PM_{2.5}$, what is the principle of the method of a spectrometer and which kind of equipments are used and how measurements are carried out. Then, the software which is used for this purpose, so how it is used and how does it help in analysis of the data, then the lab-based video we will screen and we will conclude.

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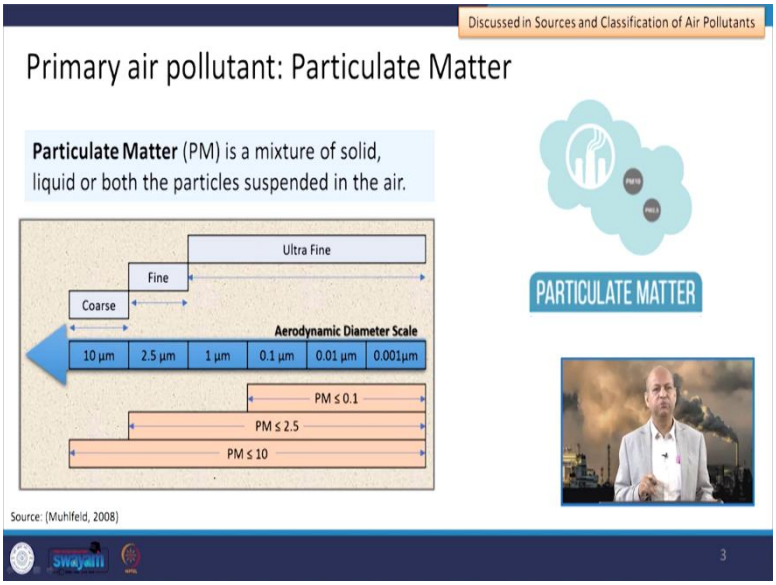

So, as this primary air pollutant particulate matter is very important because of its effect on the environment as well as on the health and these fine particles they can go to the respiratory system and they can cause several kinds of health issues basically. So, ultra-fine particles are also very important like PM_1 and less and they can also be measured but in this presentation we will discuss about only PM_{10} and $PM_{2.5}$. But using the spectrometer I repeat that even PM_1 and less than PM_1 can be measured basically.

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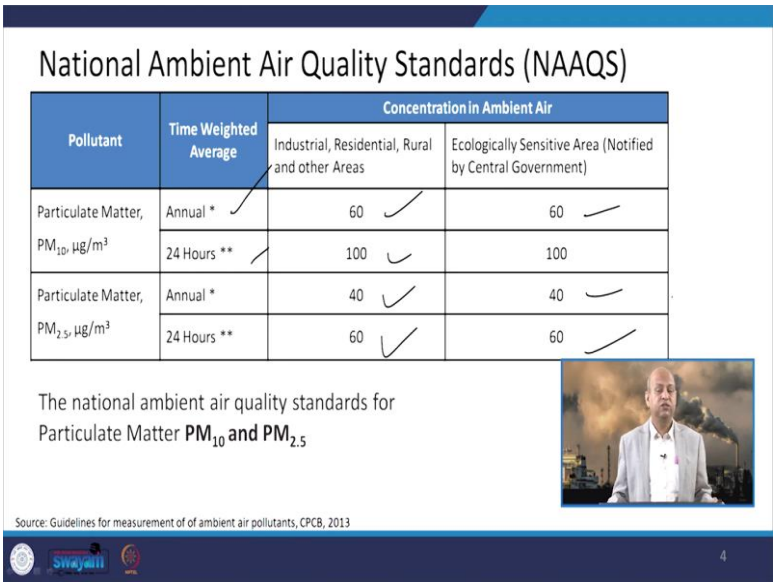

So, this PM_{10} and $PM_{2.5}$ air quality standards, National Ambient Air Quality Standards are there like annual 24 hours. So, for those like industrial residential areas or ecologically sensitive areas values are same, like annual concentration of PM_{10} is 60 in both cases, 24 hours

concentration is 100 in both cases. Similarly, for $PM_{2.5}$ annual concentration is 40. So, this should not exceed if we go on getting exposed throughout year and 60 is the 24-hour maximum concentration it should not violate or it should not exceed at a particular location for $PM_{2.5}$.

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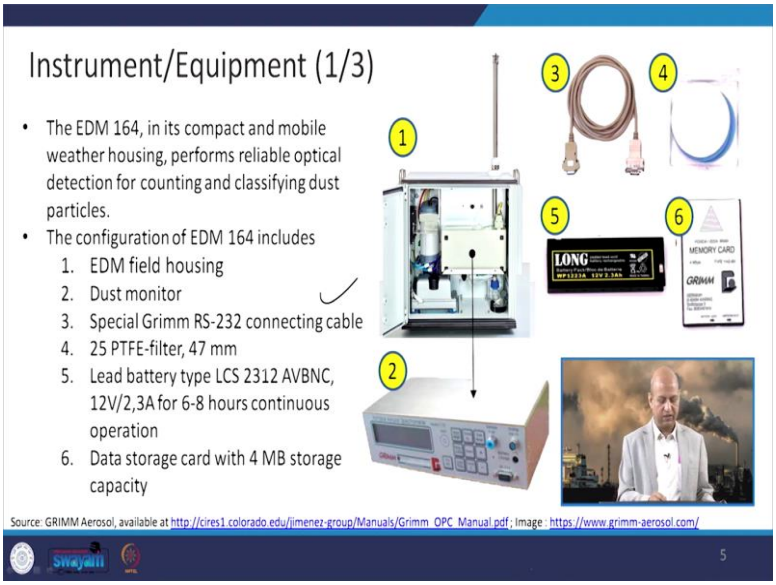

If we talk about the spectrometer based instrument, so basically we have used this GRIMM instrument which houses many these parts or components like EDM, this field housing where the instrument can be put in, then this is the dust monitor, which monitor the particulate matter and you can see like there is a connecting cable and then there is a filter paper with a small size which is put into this instrument and data storage that memory card is there and this is the battery which is used if there is no current available, power available there.

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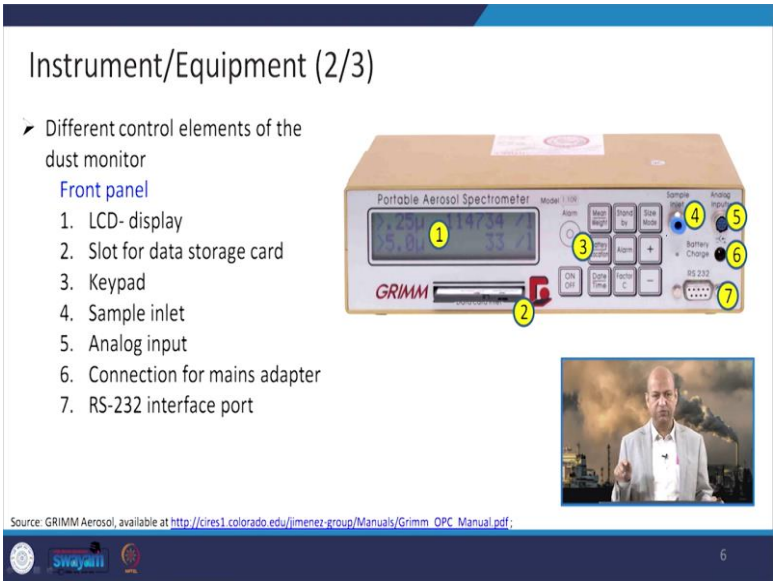

Then if we look into dust monitor, so the front panel houses this LCD panel as well as the keypad here, then this is the slot for data storage that particular card, then sample inlet is there at four number where air inflows and analogue input 5 number, 6 is connecting with the main adapter. And then interface port is the 7 number which can be used for connecting with the like desktop computer.

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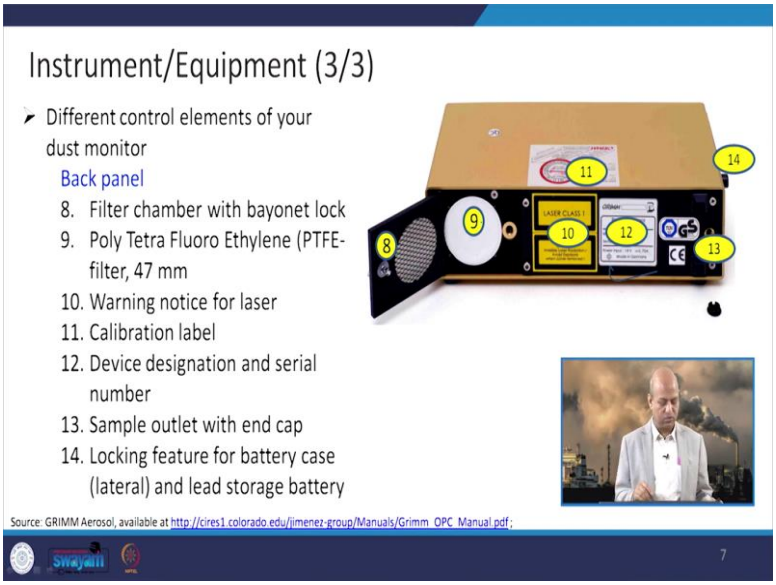

Back panel has a space for this putting filter paper and then there are different like for cable and other outlet is also there. So, all these parts are on the backside of the instrument.

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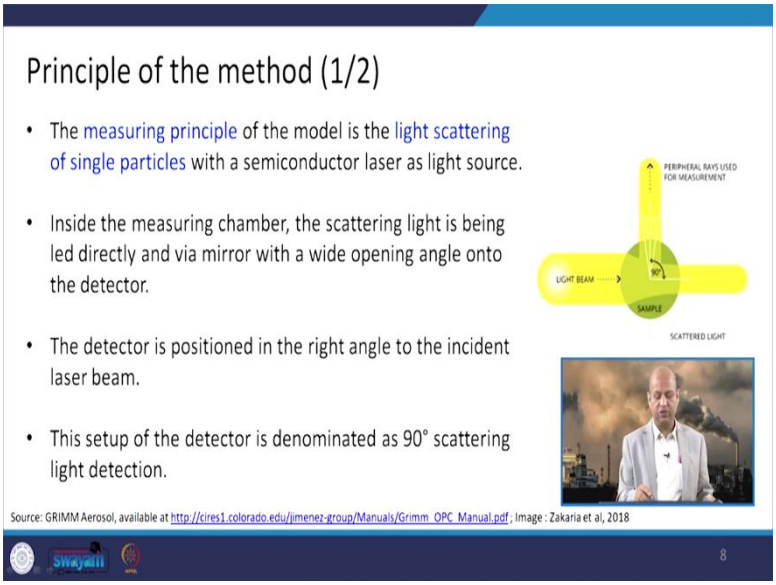

And the basic principle is which is used for this spectrometer they use the light scattering by the single particle. So, each particle that is why this instrument gives not only the mass concentration, but count also, count means number of the particles. So, count is also available in this particular spectrometer. So, this is the way light scattering is there and the light scattering is detected by some method which we can discuss here, detector is there.

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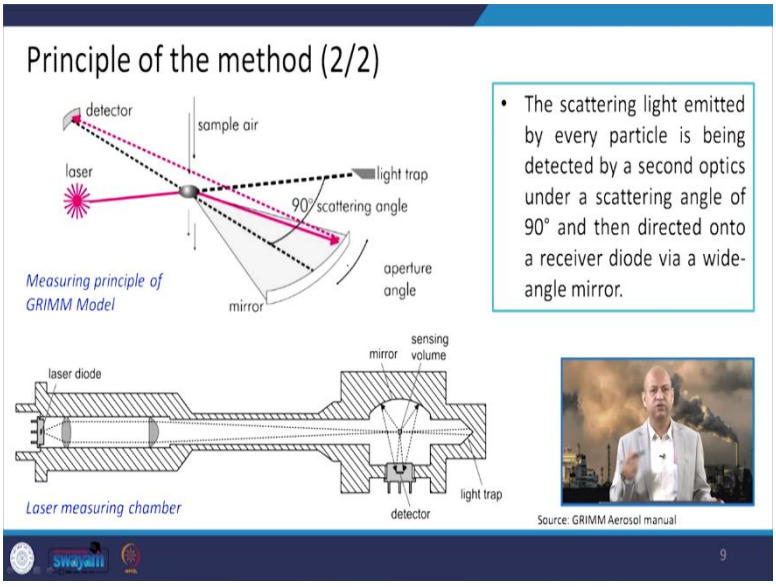

So, at the 90 degree the laser past so, when it strikes with the particle it scatters the light and then through mirror it is reflected and detector detects it and then that is monitored or that is stored accordingly the number of particles and then the mass concentration can also be monitored.

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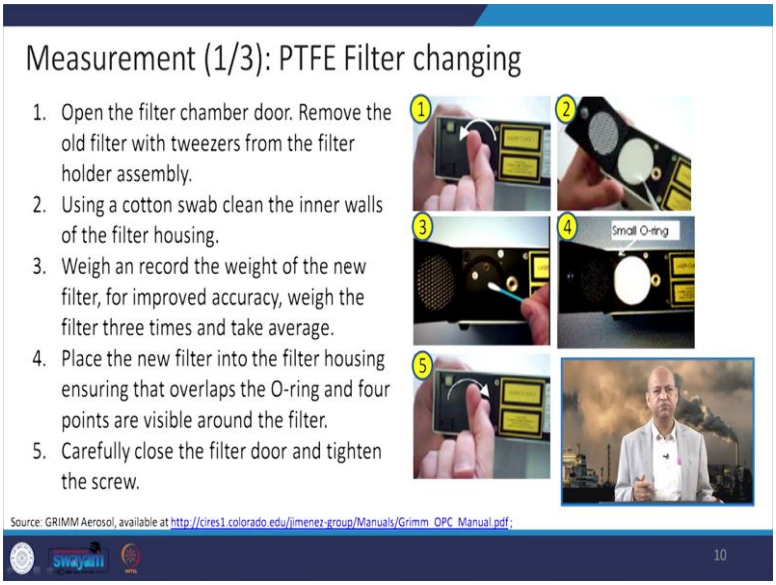

When we do the monitoring. So, basically the filter paper we should particularly be careful about how to put it so remove using these tweezers the old one and then clean it very properly and then put a new filter paper and it has to be weighed also 3 times so, that because it is small, so the average weight is taken after weighing it for 3 times and then monitoring is to be done.

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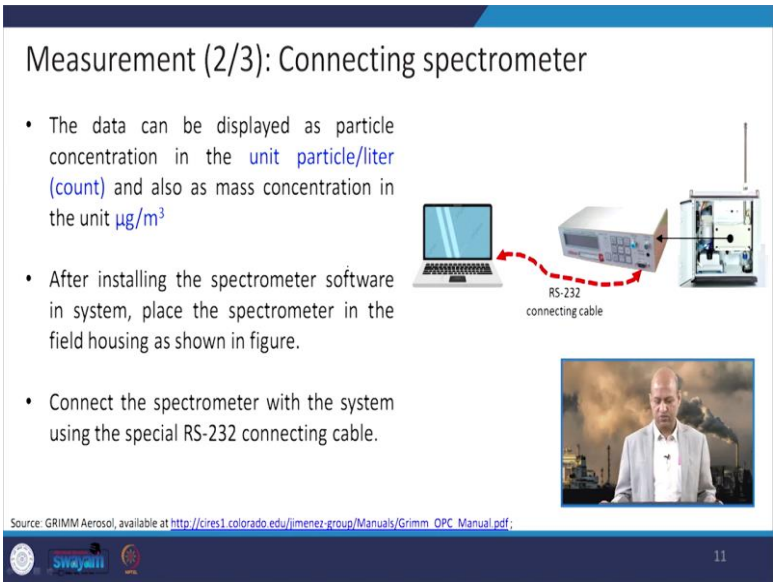

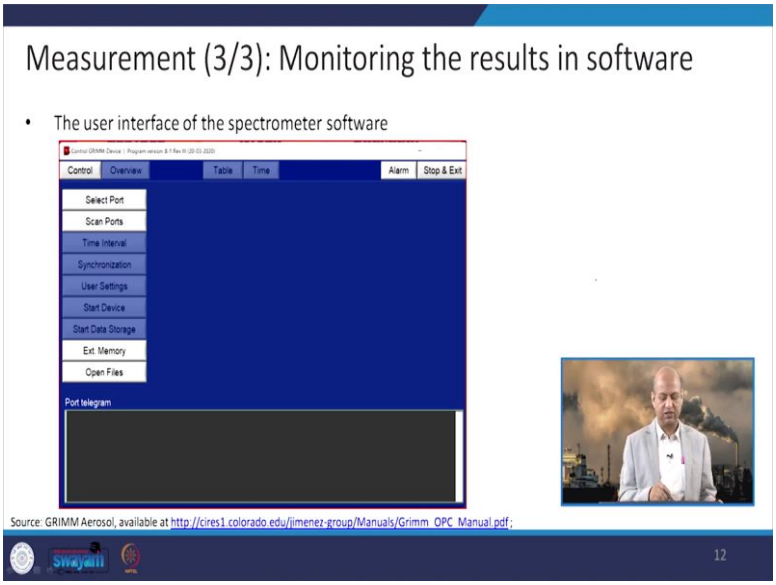

When data is taken into the desktop and data as I said, it can be like particle per litre count means how many particles are there in per litre, or microgram per cubic metre, the mass concentration can also be there. So, this is the way data is transferred to the laptop or desktop and the software is there its own software is there which gives us different buttons like we can select the port, the time interval, all those things can be set to start the monitoring.

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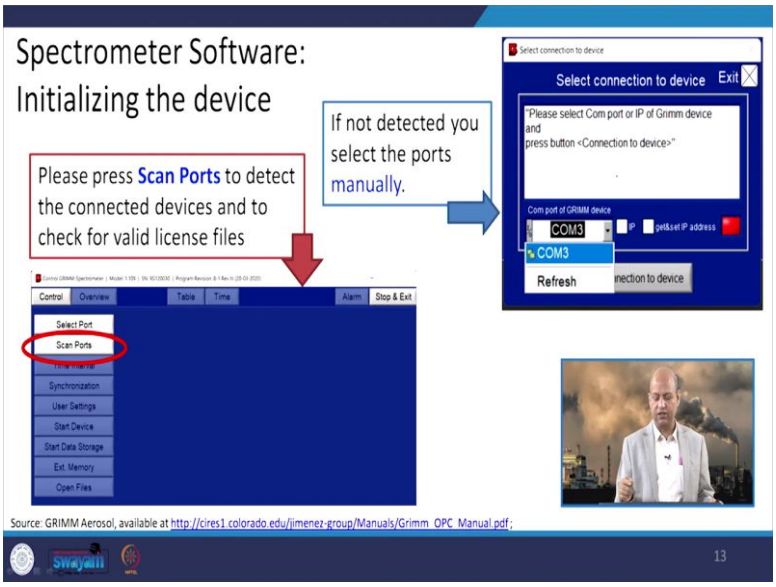

So, you can see here the scan ports are selected, then it can automatically take which particular port it is using otherwise manually we can give the name of this particular port and this is the device which can give the display of this particular port related information.

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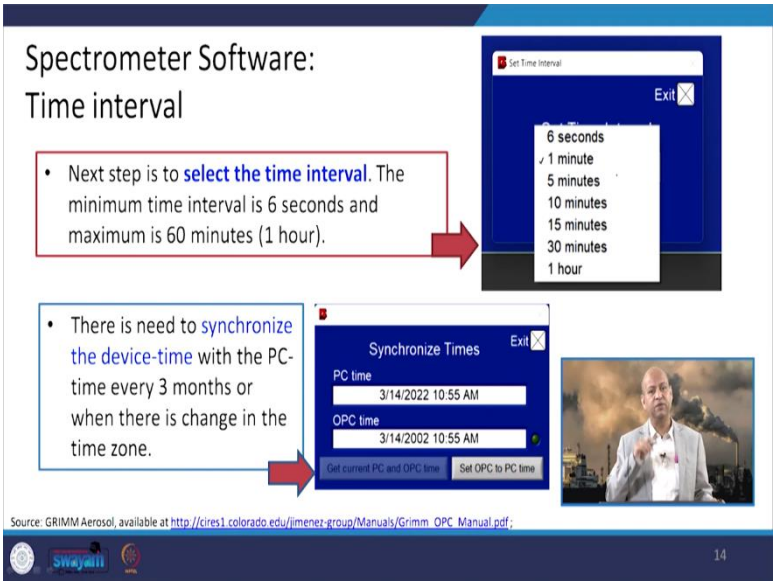

Then time interval can be set like from 6 seconds to 1-hour huge range is there. So, depending upon the necessity, we can select how much at the what time interval we need data to be stored like 5 minutes each or each 10 minutes or something like that. So, there is one need of synchronise of the device time with the PC time so that there is no error of the time recording. So, every 3 months they should be basically synchronised otherwise, if a site is changing, time zone is changing particularly in time zone then you can synchronise it more frequently.

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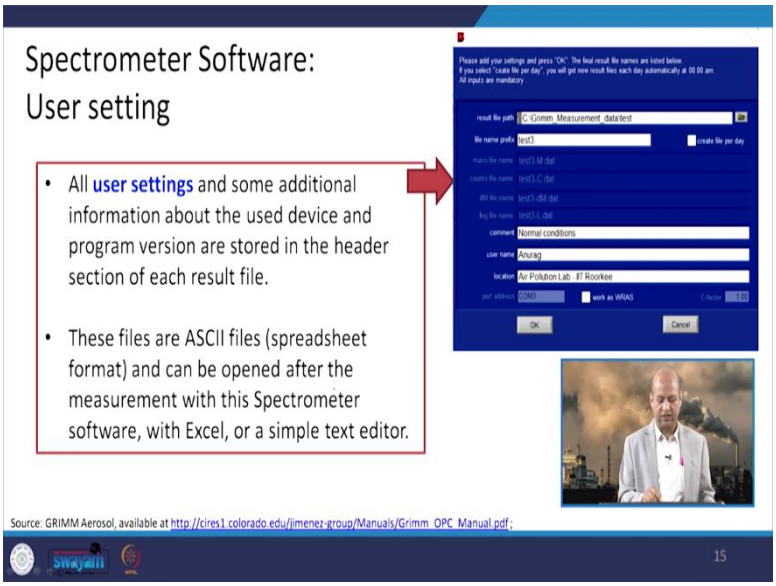

Then if we took into this user settings, you can see how this is taken all these parameters and headers are there and spreadsheet files are created basically like Excel etc. So, that data analysis is very easy.

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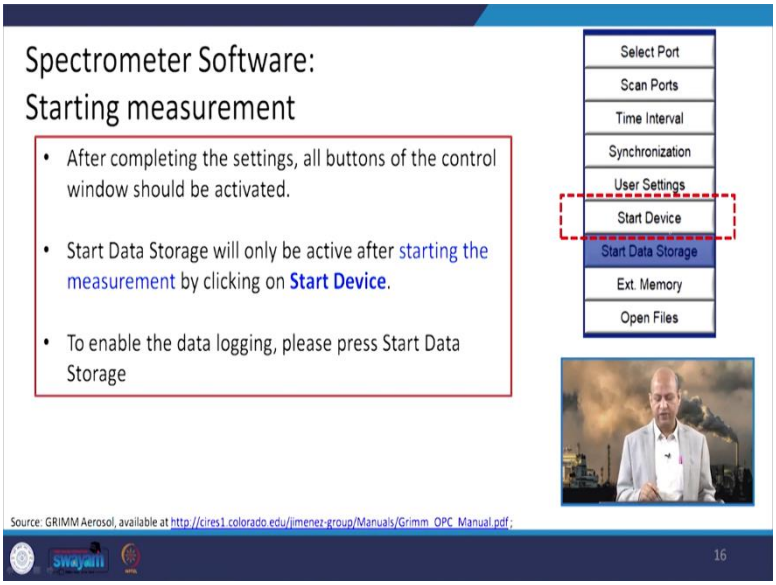

Now, this is the button when we start monitoring. So, the start device button is to be clicked and then this instrument starts functioning and recording the data.

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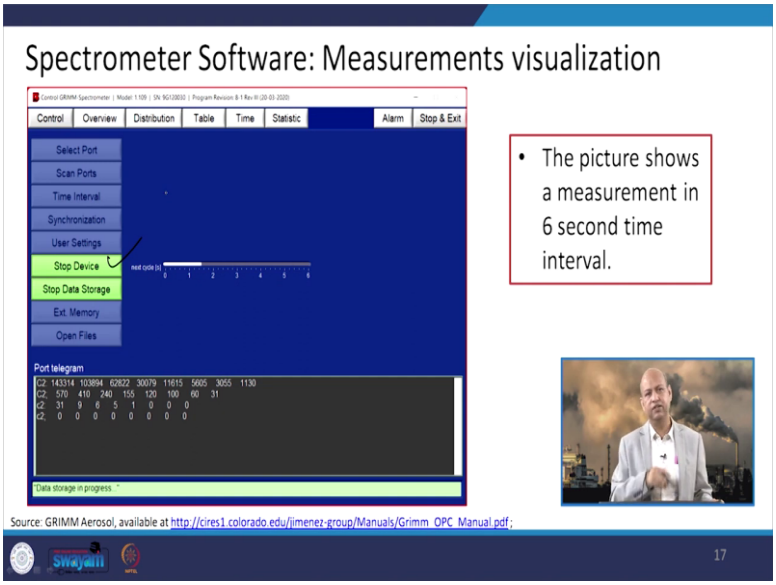

Well after that when monitoring is complete, then a stop device button can be pressed and data is stored and then data can be taken whatever time interval we have selected and it can be transferred to the PC.

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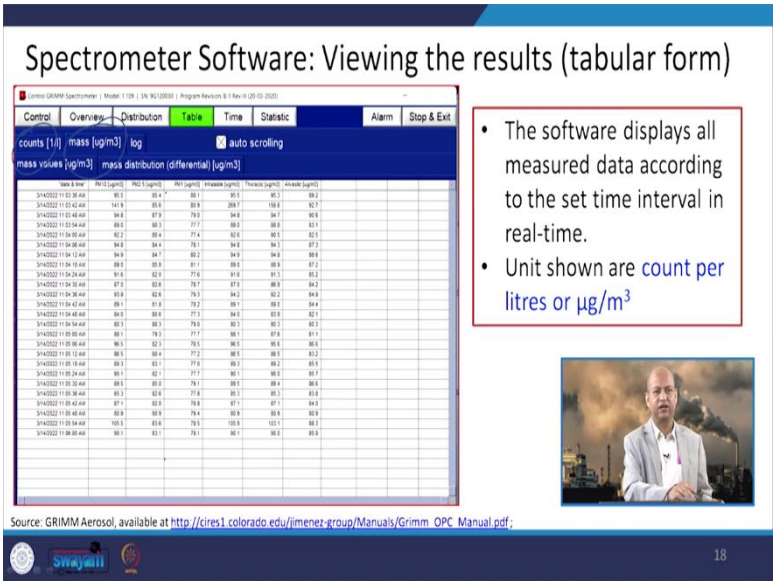

So, this is the way data is collected basically different columns are there and then whether it is count or whether it is mass concentration, we can select according to the requirement.

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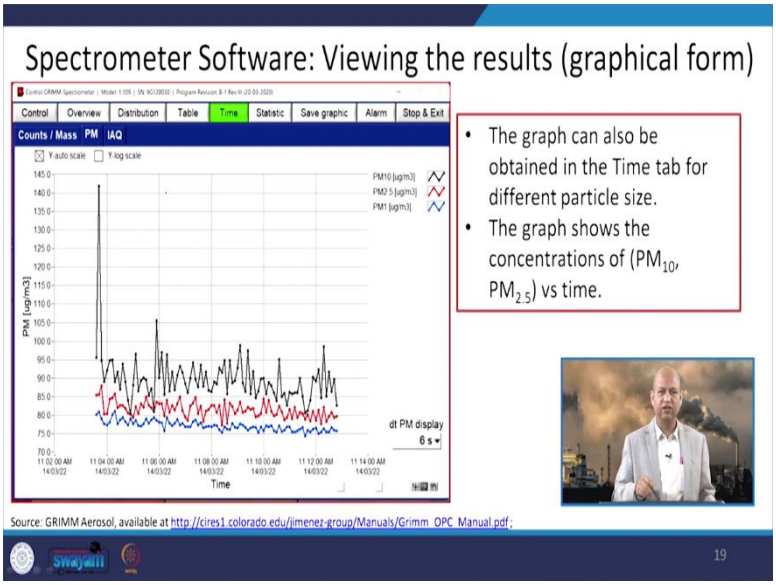

We can analyse the data at per like time interval like particulate matter and mass concentration or count. So, we can analyse and see how data is varying from time to time.

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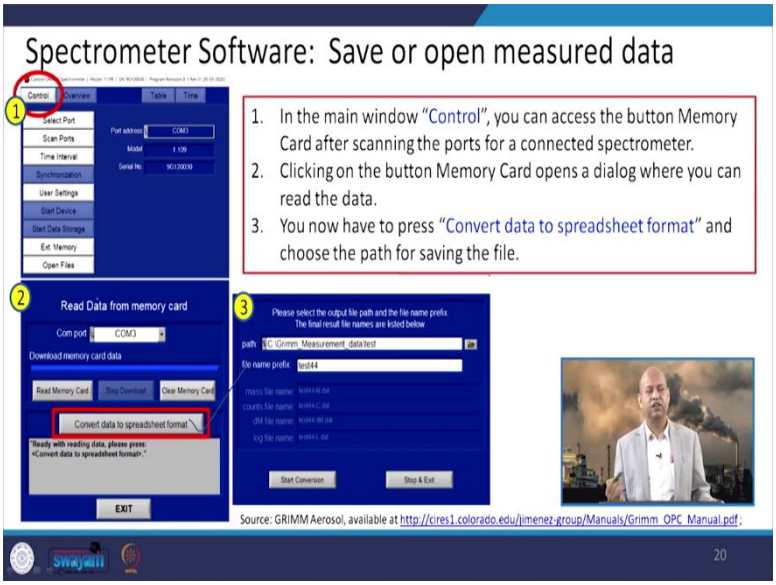

So, these are the software of the spectrometer, which we are using. So, control software is there which can give different kinds of possibilities and as per the site where we have monitored data is transferred to the particular file and then it is analysed later on.

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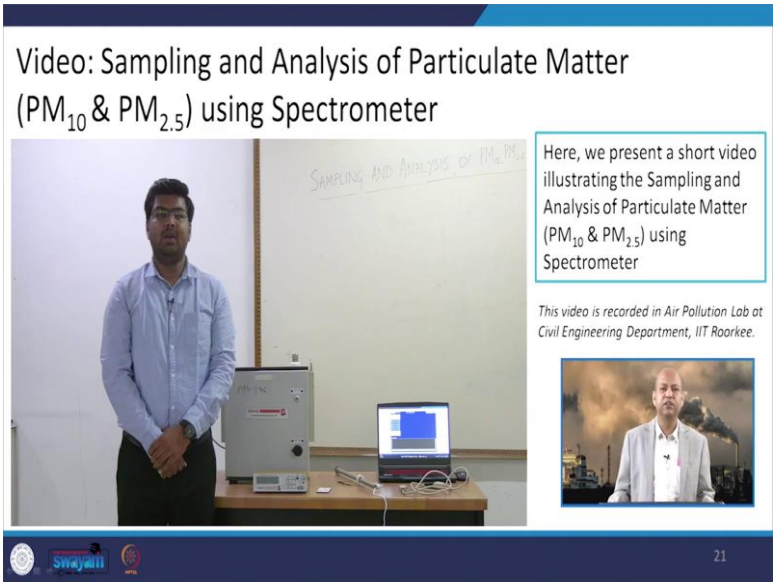

So, here we present the short video illustrating the sampling and analysis of particulate matter especially PM_{10} and $PM_{2.5}$ using a spectrometer. So, now you can compare the high-volume sampler and a spectrometer, how do they function, what is their difference in the procedures and whether one is robust or second is robust, and the possibilities the range like it can also give PM_1 etc and this video has been recorded in air pollution laboratory of Civil Engineering

Department in IIT Roorkee. So, enjoy the video and learn about the PM_{10} and $PM_{2.5}$ monitoring using spectrometer.

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Narrator: Good afternoon everyone. And I welcome you all in this lab-based series of this lecture for NPTEL. And this is the last lecture in the lab base measurements. And today we will be discussing on the sampling analysis of PM_{10}, $PM_{2.5}$, PM_1 using the GRIMM model.

And for that we will be using this apparatus that is the GRIMM EDM, EDM 164 that is Environmental Dust Monitor and in that it is the field housing and this is the spectrometer and this is the memory card which has been inserted in the spectrometer. So, let me just give you a quick intro of this, the parts of this field housing and the spectrometer so as you can see this field housing here we are placing the spectrometer right now.

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So, this is the spectrometer and this is the front panel of the spectrometer, here you can see this LCD screen where we are seeing the readings of all the PM_{10} $PM_{2.5}$ all the particles and these are the control buttons, where we are using these buttons we are controlling this spectrometer and this is the sample inlet. So, in this sample inlet this sampling pipe is being fitted in this spectrometer and this spectrometer is being placed in this field housing.

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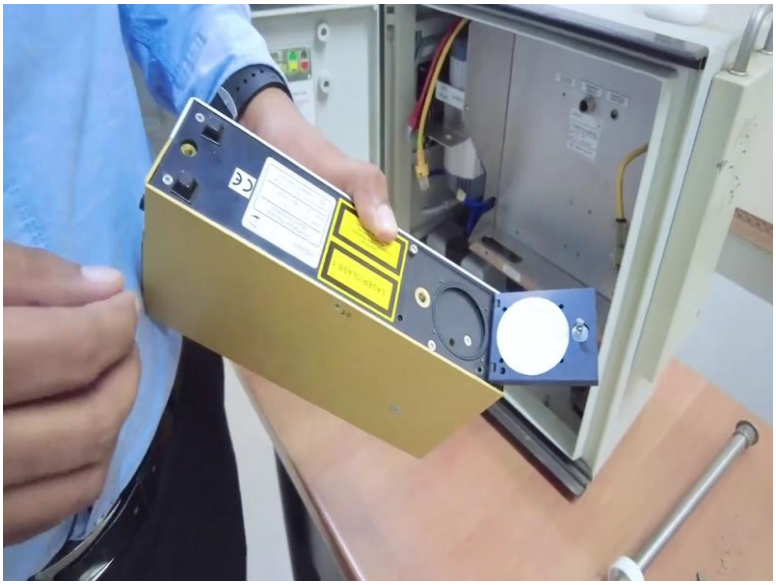

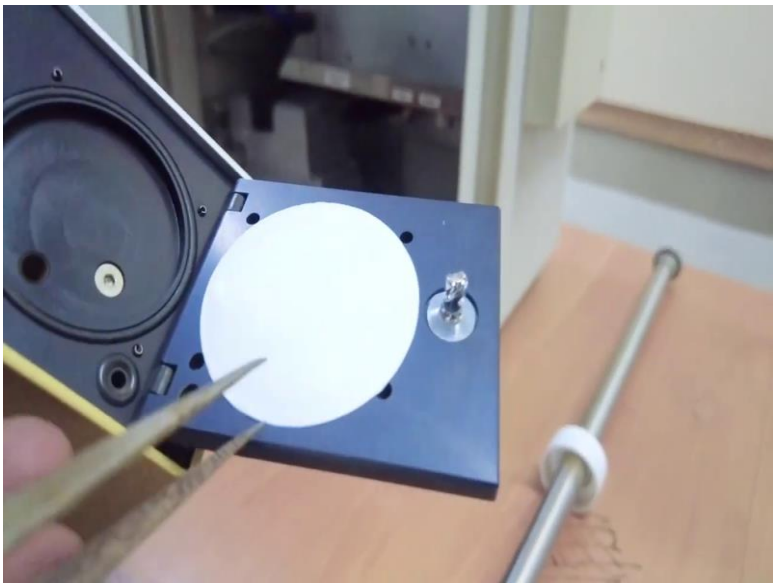

Let me just give you the intro of this back panel, in back panel you can see that lock is there, if you open this lock there is a PTFE filter. So, this PTFE filter this let me tell you this spectrometer or EDM 164 can monitor or sample the PM_{10}, $PM_{2.5}$ using the two modes that is by the optical particle counter and by the gravimetric.

So, optical particle counter can be attained using the spectrometer and also using the gravimetric analysis you can weigh this PTFE filter and you can just analyse or sample the $PM_{2.5}$ sample. So, after this taking the readings you can weigh this PTFE filter before the sampling and after the sampling then you can analyse the $PM_{2.5}$ particles.

So, you can see we are placing the PTFE filter using these forceps and it is so placed that all the four points I hope you are able to see these four points this 1, 2, 3, 4 actually it is placed

this PTFE filter is placed this side, so it is so placed there like that these four points so that is 1, 2, 3, 4 these four points should be visible. So, after placing this filter we have to play close this panel. So, after this closing the panel and assembling that this PTFE filter your spectrometer is ready to be placed in the field housing.

So, let me just place this spectrophotometer and one more thing that is this spectrophotometer will be attached with the system and software is provided for monitoring the particles and this software is also provided by the GRIMM model and this system and this spectrometer is attached using this RS 232 cable.

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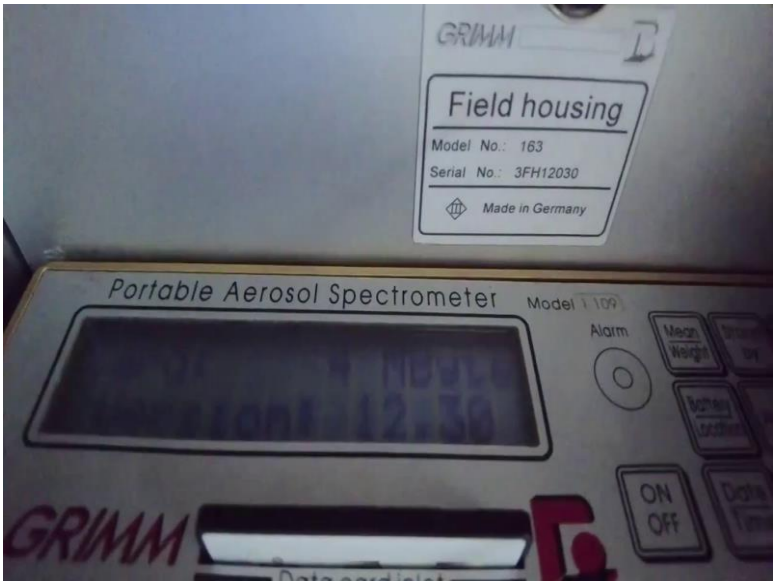

So, let me just attach all the things, so as you can see that the spectrometer is fitted in this field housing and it is connected with this system using this RS 232 cable and the field this sample pipe that is placed in this sample inlet that the port where I have shown earlier, so let me just on the system.

So, as soon as I on the system I hope you are able to see that right now if not I will just let me just tell you as you are on the system you will be seeing the model name first and then the date and time we are displayed in this LCD screen and then thereafter the available memory that how much duration you can go for measurement on analysis that is being displayed and after that it will ask you to this have you change the filter or not.

So, in response you have to just press this plus button in the spectrometer for a few seconds. So, after hearing this beep sound the spectrometer will go for self-test and the self-test is for 30 seconds and after self-test it will start measuring the particles and it will be showing the counts per litre in this spectrometer the units are in it is in counts per meter. I hope you can see right now, it has being starting, I have received a signal like self-test is okay. So, after receiving the signal of self-test is, you can see that a PM_{10} and $PM_{2.5}$ these two particles are being displayed in this spectrometer.

So, now spectrometer is started now we need to configure the spectrometer according to our requirements and for that we have to go for conferring the spectrometer using the system. So, this is the software which is provided by the GRIMM. So, let me just give you the hands on how to measure or monitor the PM_{10}, $PM_{2.5}$ and PM_{1} samples using this software.

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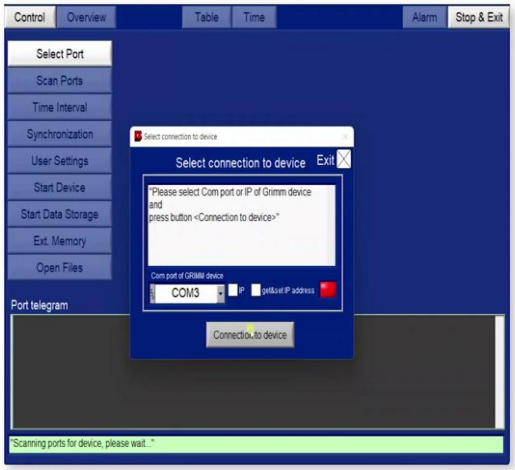

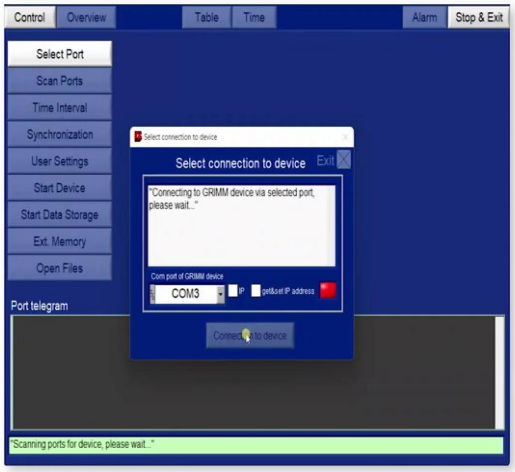

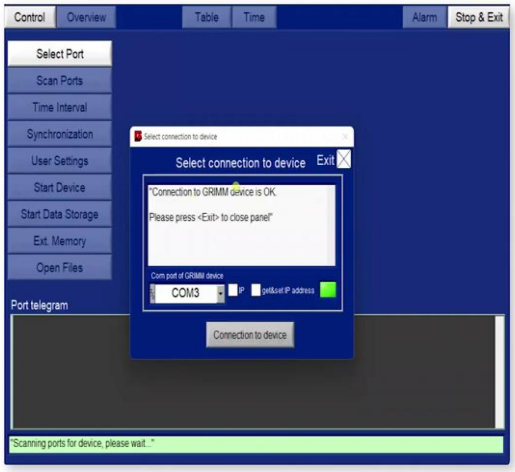

So, this is the software provided by the GRIMM as you can see this is the UI of the software and here you can see different kinds of options are available this is, first is the control panel next is to overview so, as soon as I connect the software then it will be showing other options as well.

So, here you can see you have to first select the ports or you have to scan the ports, if you know already the port is there, then you can directly or manually select the port right now I am clicking on this scan port, as you can see, it is detected the COM 3 port that is the GRIMM port so the port is already selected. So, now you have to simply click on this connection to device so while connecting with this software and the code you will be hearing some sounds from the spectrometer as well. So, I have got the message that device has connected.

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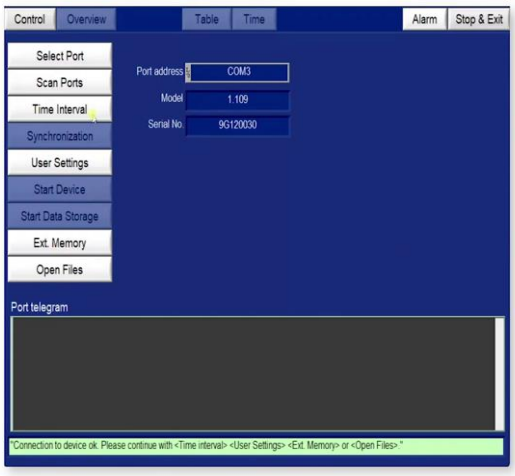

So, simply you have to click on exit now you can see it is searching for some analogue sensors and reading the data it will take a while, so the port is now selected that is COM3 and you can see the model and serial number is all the details are there.

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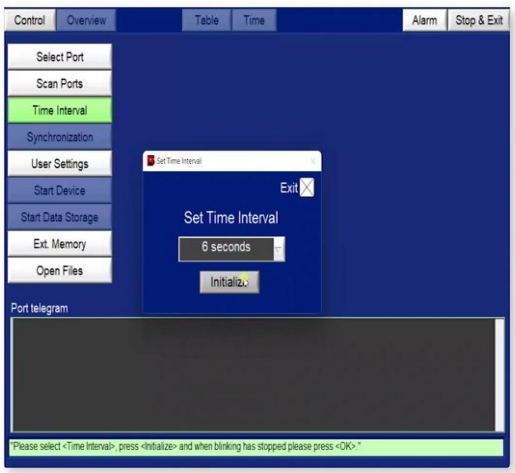

Next step is to decide the time interval. So, as you can see, the time interval is shown is you have to set the time interval. So, the range varies from 6 seconds to 60 minutes or you can say 1 hour. So right now, I am selecting the 6 seconds and as per the requirements you can select any of the options available right now I am selecting 6 seconds and I am clicking on the initialise, that the time interval has been set, now I simply click on exit.

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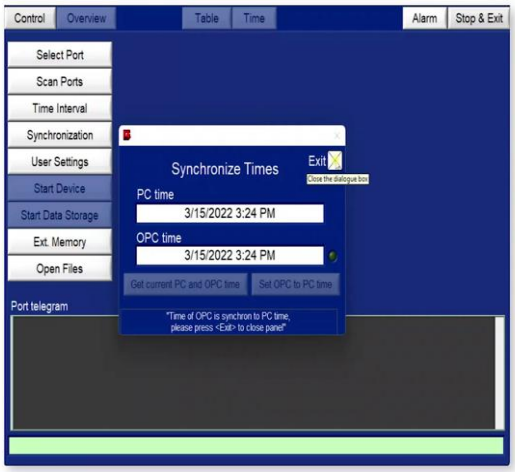

Now, you have to sync the time of this spectrometer or you can say the optical particle counter, you have to sync the time with your PC time. So, you can see that you can see the option that is to get the current PC time and OPC time is the Optical Particle Count time. So, that will sync the PC time with your Optical Particle Count OPC time. Here I have got the message time on

OPC is synchronised with your PC time. So, the date and time which were we were seeing in the spectrometer that is now synced with your PC time. Now, I am clicking on exit.

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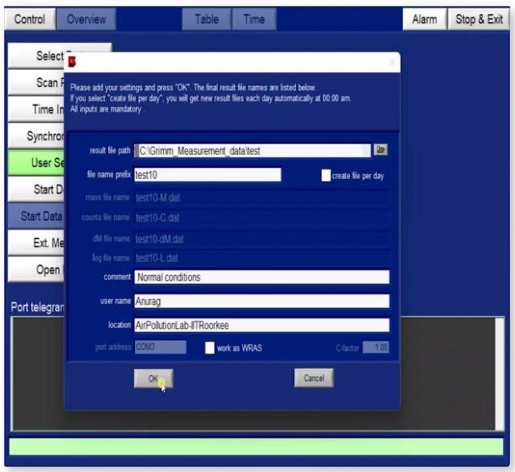

Now, next step is the user setting. So, here we are giving the details of the output file. Right now, this is test 8, for example, I am just giving the name as test 10, so you can see all the relevant files, the mass file, the count files, the dM files and the log files all are being set up accordingly. And also, you can add the details like comments. So meanwhile, I have just set that normal conditions. And I have added the user name, as my name is Anurag and also location. So, right now, we are just taking the readings on air pollution lab at IIT Roorkee. So, I have selected that location, I will click on OK.

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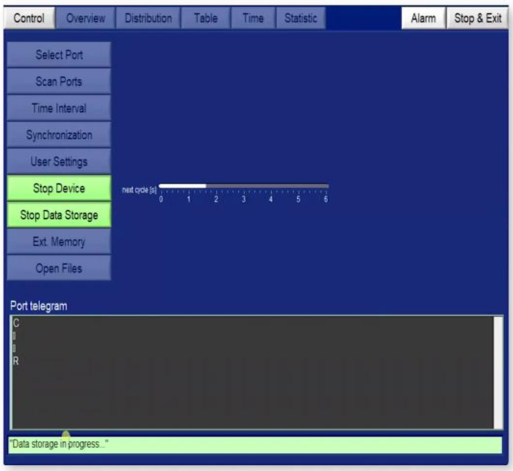
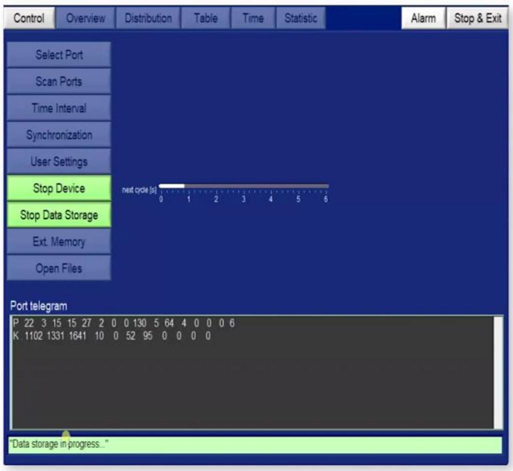
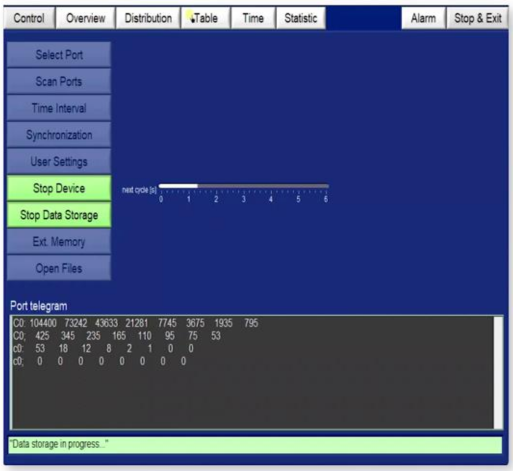
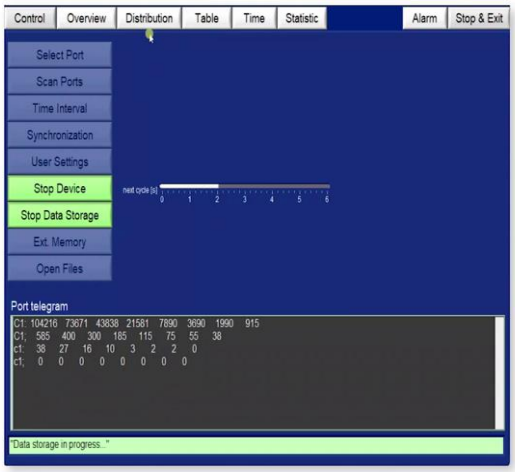
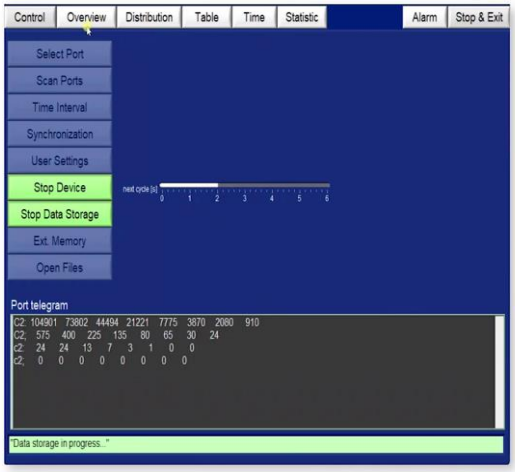






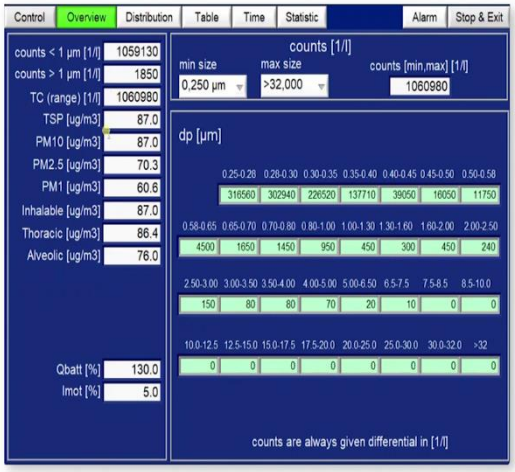


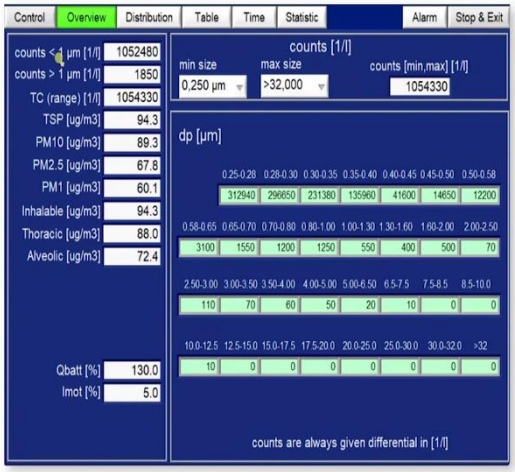


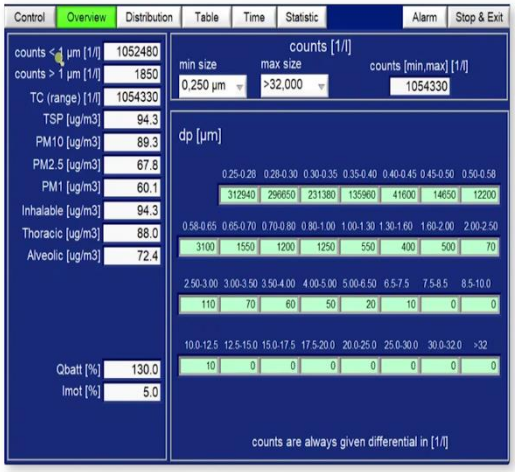
Now, by defining the user setting now you can start the device message is being displayed in the bottom you can see measurement is in progress. So, yes you can see the measurement is now being started and in this port telegram, in this window you will be able to see as soon as the reading has been started. So right now it is preparing to start the taking the readings there it will take a while. So, the next message you can see this data storage in progress.

So, as soon as it starts taking the reading, you will be hearing a sound for a spectrometer and all the other options like control, overview, and distribution table. Now, you can see that all the options are now available, you can toggle with all the tabs. So, let me just give you an idea of all the tabs.

(Refer Slide Time: 19:05)



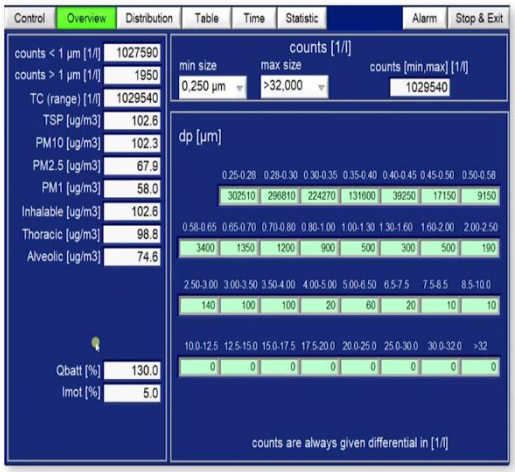





Control
Overview
Distribution
Table
Time
Statistic
Alarm
Stop & Exit
counts < 1 µm [1/l] 1031320
counts > 1 µm [1/l] 1950
TC (range) [1/l] 1033270
TSP [ug/m3] 92.9
PM10 [ug/m3] 87.9
PM2.5 [ug/m3] 68.6
PM1 [ug/m3] 58.4
Inhalable [ug/m3] 92.9
Thoracic [ug/m3] 86.9
Alveolic [ug/m3] 73.7
Qbatt [%] 130.0
Imot [%] 5.0
counts [1/l]
min size
0,250 µm
max size
>32,000
counts [min,max] [1/l]
1033270
dp [µm]
0.25-0.28 0.28-0.30 0.30-0.35 0.35-0.40 0.40-0.45 0.45-0.50 0.50-0.58
302860 296890 227320 131650 37200 17600 10900
0.58-0.65 0.65-0.70 0.70-0.80 0.80-1.00 1.00-1.30 1.30-1.60 1.60-2.00 2.00-2.50
3300 1250 1250 1100 550 450 300 180
2.50-3.00 3.00-3.50 3.50-4.00 4.00-5.00 5.00-6.50 6.5-7.5 7.5-8.5 8.5-10.0
170 110 130 40 10 0 0 0
10.0-12.5 12.5-15.0 15.0-17.5 17.5-20.0 20.0-25.0 25.0-30.0 30.0-32.0 >32
10 0 0 0 0 0 0 0
counts are always given differential in [1/l]


Control
Overview
Distribution
Table
Time
Statistic
Alarm
Stop & Exit
counts < 1 µm [1/l] 1071420
counts > 1 µm [1/l] 1650
TC (range) [1/l] 1073070
TSP [ug/m3] 122.2
PM10 [ug/m3] 111.8
PM2.5 [ug/m3] 68.5
PM1 [ug/m3] 61.5
Inhalable [ug/m3] 122.2
Thoracic [ug/m3] 107.3
Alveolic [ug/m3] 74.8
Qbatt [%] 130.0
Imot [%] 5.0
counts [1/l]
min size
0,250 µm
max size
>32,000
counts [min,max] [1/l]
1073070
dp [µm]
0.25-0.28 0.28-0.30 0.30-0.35 0.35-0.40 0.40-0.45 0.45-0.50 0.50-0.58
319930 300540 236040 136910 42000 17100 10500
0.58-0.65 0.65-0.70 0.70-0.80 0.80-1.00 1.00-1.30 1.30-1.60 1.60-2.00 2.00-2.50
4050 1400 1300 1650 500 400 250 90
2.50-3.00 3.00-3.50 3.50-4.00 4.00-5.00 5.00-6.50 6.5-7.5 7.5-8.5 8.5-10.0
110 80 80 60 20 30 0 10
10.0-12.5 12.5-15.0 15.0-17.5 17.5-20.0 20.0-25.0 25.0-30.0 30.0-32.0 >32
20 0 0 0 0 0 0 0
counts are always given differential in [1/l]


Control
Overview
Distribution
Table
Time
Statistic
Alarm
Stop & Exit
counts < 1 µm [1/l] 1029980
counts > 1 µm [1/l] 1500
TC (range) [1/l] 1031480
TSP [ug/m3] 78.9
PM10 [ug/m3] 78.9
PM2.5 [ug/m3] 62.8
PM1 [ug/m3] 58.8
Inhalable [ug/m3] 78.9
Thoracic [ug/m3] 78.2
Alveolic [ug/m3] 67.5
Qbatt [%] 130.0
Imot [%] 5.0
counts [1/l]
min size
0,250 µm
max size
>32,000
counts [min,max] [1/l]
1031480
dp [µm]
0.25-0.28 0.28-0.30 0.30-0.35 0.35-0.40 0.40-0.45 0.45-0.50 0.50-0.58
305310 289840 224620 134960 38800 18050 11650
0.58-0.65 0.65-0.70 0.70-0.80 0.80-1.00 1.00-1.30 1.30-1.60 1.60-2.00 2.00-2.50
3750 1050 950 1000 600 450 250 0
2.50-3.00 3.00-3.50 3.50-4.00 4.00-5.00 5.00-6.50 6.5-7.5 7.5-8.5 8.5-10.0
0 50 50 50 40 10 0 0
10.0-12.5 12.5-15.0 15.0-17.5 17.5-20.0 20.0-25.0 25.0-30.0 30.0-32.0 >32
0 0 0 0 0 0 0 0
counts are always given differential in [1/l]

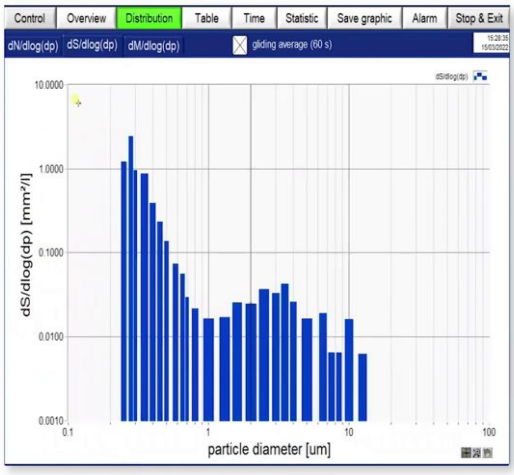


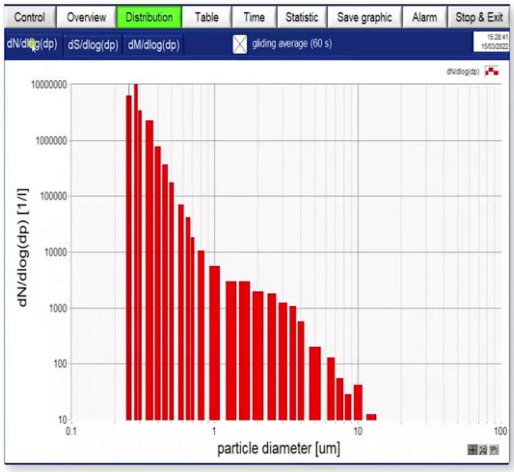
So, control tab we already discussed. The next tab is the overview tab. So, in overview tab, you can see all the details of your readings counts like what are the particles which are less than 1 micrometre what are the particles which are greater than 1 micrometre and total count of the particles total suspended particles PM_{10}, $PM_{2.5}$, PM_1 and other particles like it is classified as inhalable, thoracic and Alveolic. So, all the particles like the details of the particle as shown here as an overview, in this particular time.

(Refer Slide Time: 19:45)

So, coming to the next step that is distribution. In distribution tab you can see a log table is being shown. So, in this first table, that is the log table. You can see the X axis you can see the particle diameter or particle sizes and in Y axis, you can see the this microgram (())(20:04).

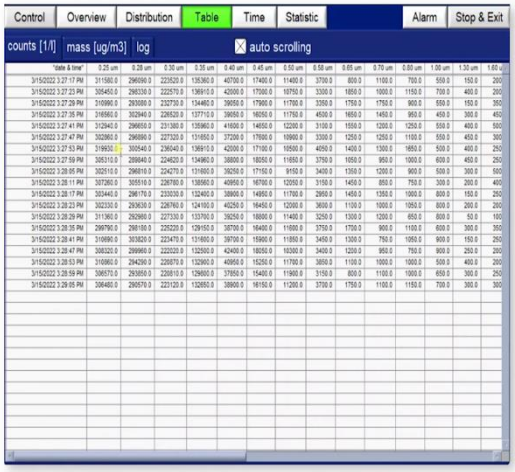
(Refer Slide Time: 20:04)





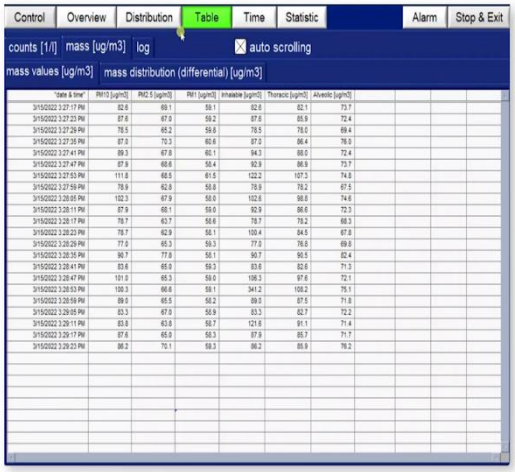
And in this you can see the area divided by this volume of the air being sucked by this sample pipe and in first tab you will be able to see the counts per litre.

(Refer Slide Time: 20:18)



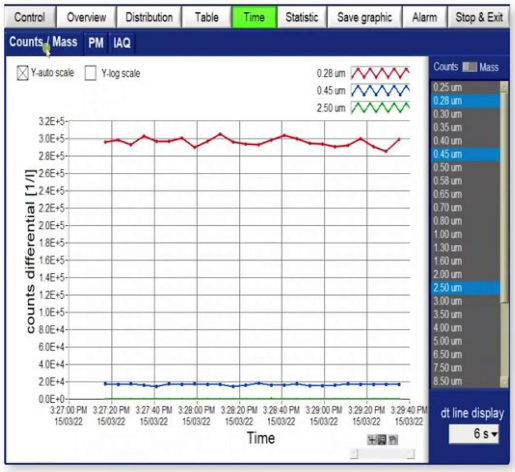
So, this log graph is being shown in distribution tab, in the next tab you can see the live reading you can be able to observe that it every 6 seconds that is the what interval we have decided at every 6 seconds it is showing the readings of all the particles.

(Refer Slide Time: 20:38)



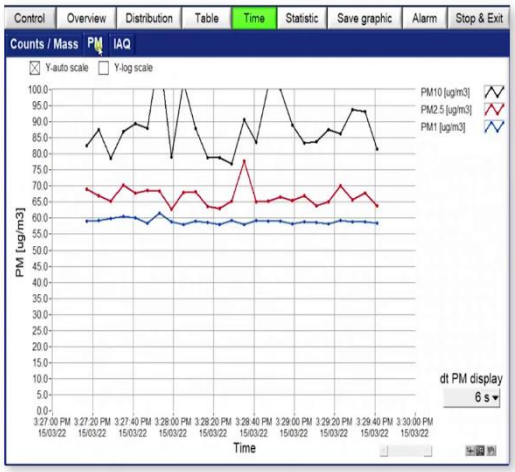
And in the first tab you can see the counts per litre in the next tab you can we will be able to see the PM_{10}, $PM_{2.5}$, PM_1 and other particles that is the indoor air quality you can say. So, in this here you will be able to see in microgram per metre cube the unit.

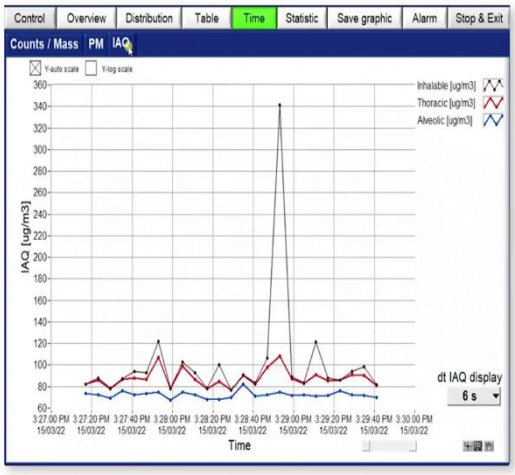
(Refer Slide Time: 20:53)

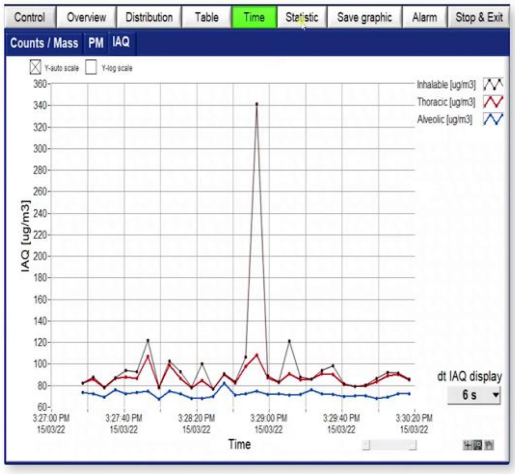


And coming to the next one now this is the graphical presentation of we were seeing earlier that is in tabular form and this is the graphical form.

(Refer Slide Time: 21:01)







That is count per unit of mass is being seen and this one is particulate matter and next one is IAQ. So, in particulate matter this PM_{10}, $PM_{2.5}$, PM_1 are being shown in this indoor air quality this Inhalable, Thoracic, Alveolic, so these are related to this particle is related to the size ranging from according to these organs present in the lungs. So, according to the size of whichever be the sizes like in Alveolic part there is some size ranges and according to that this measurement is being done. So, that particular part is called as Alveolic.

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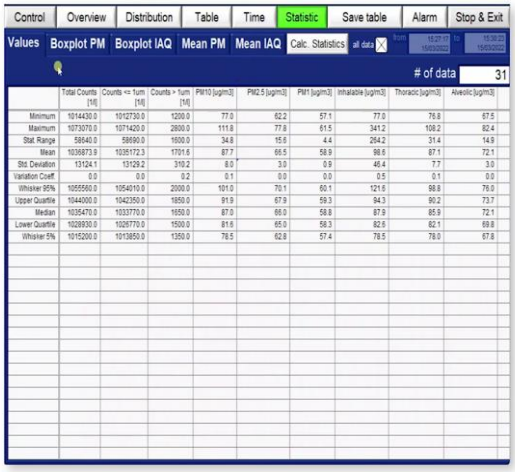
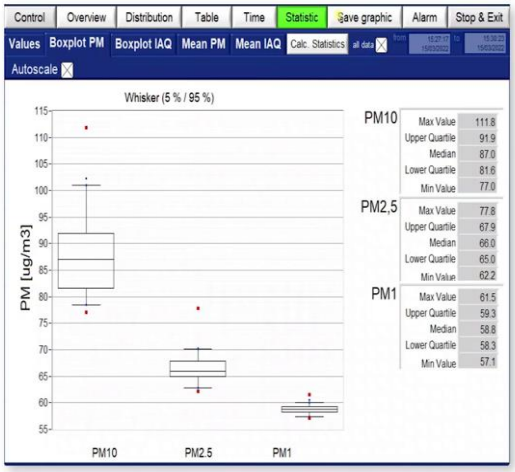


In next step, that is the statistics, you can see the values which we are measuring and then all the again the units are there that is counts per litre and microgram per metre cube. So, you can calculate the stats using this particular time.

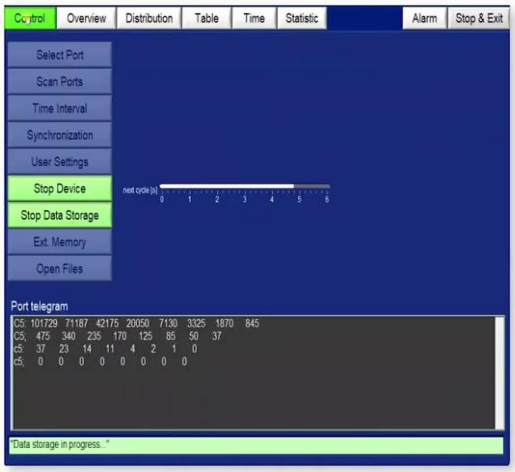
(Refer Slide Time: 21:56)

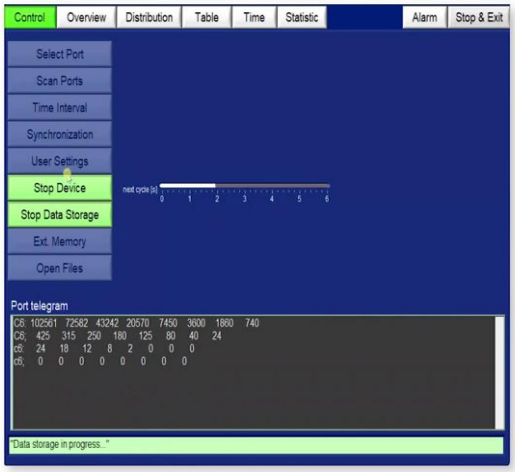


And also, you can plot the graph now, this showing the stats of this particular measurement. So, boxplot or whisker plot you can say, and at 5 percent confidence interval at 95 percent they are being plotted. So, you can see the PM_{10}, $PM_{2.5}$, PM_1 are being plotted. So, in this whisker plot you can see this lower part is the lowest range, the bottom part and this particular line shows the uppermost range and this box, this box shows the interval, confidence interval of 5 percent and 95 percent that is being shown and that this line shows the median, median of the

readings and the values you can observe in this particular window. So, after this what we are going to do, you can also save all the graphics or all the graph right now, it any particular instant.

(Refer Slide Time: 22:52)

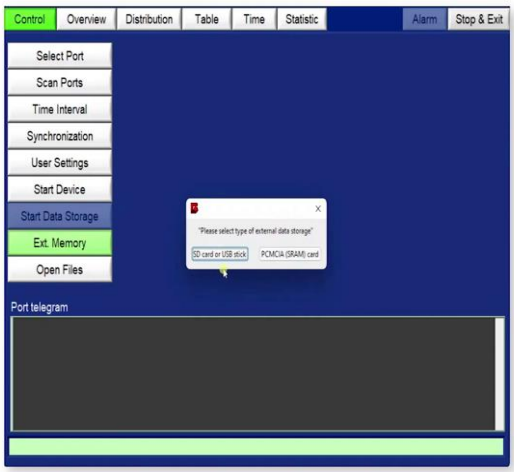




So, this is all about the, this line monitoring real time monitoring. So, now we have to save the data. So, for saving data you have to first stop the device. So, after stopping the device, what do we have saved that I hope you are remembering that we have saved by using the name test 10 that is being saved. So, the question arises from this like for going for a field condition we cannot take our system and for example, if we want to monitor the particles, for 8 hours or 24 hours or maybe any of the requirements.

So, in that case, what we are doing, we are simply connecting the device and initialising data using the software. So, after initialising the software starting the device, we can disconnect the cable, this device will still be working and the data will be stored in the memory card. So, sampling time is completed for example, we are taking the reading for 8 hours. So, after starting the device and after completion, you can simply turn off the spectrometer using this on off button that is already in the inner spectrometer. So, using that button you can simply off the device.

(Refer Slide Time: 24:18)



And now to extract what data has been saved you can simply click on the external memory. So, it will ask that whether the data has been saved in SD card or that card that is known as SRAM card or PCMCIA card.

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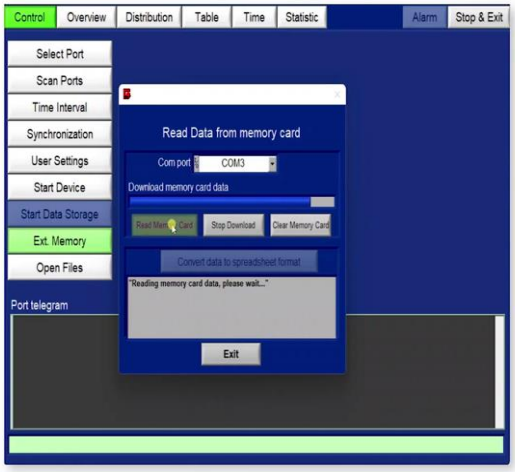
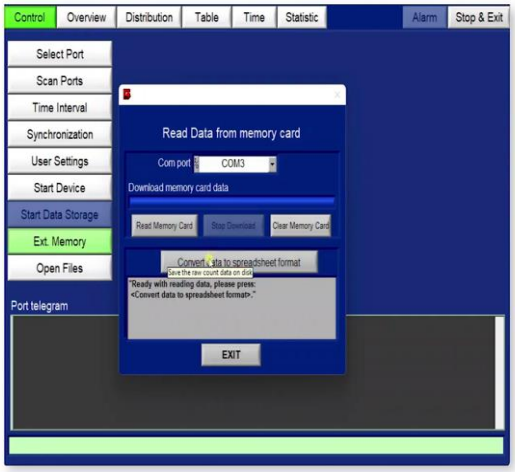
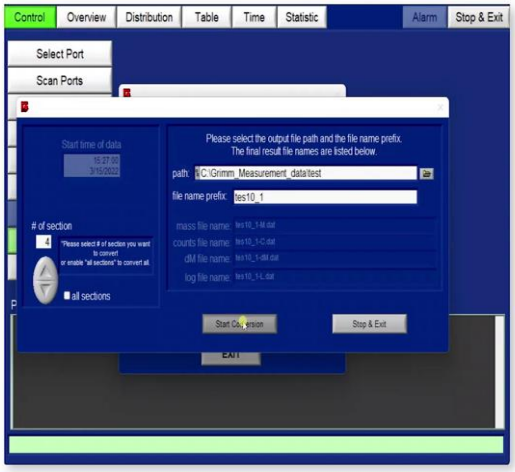
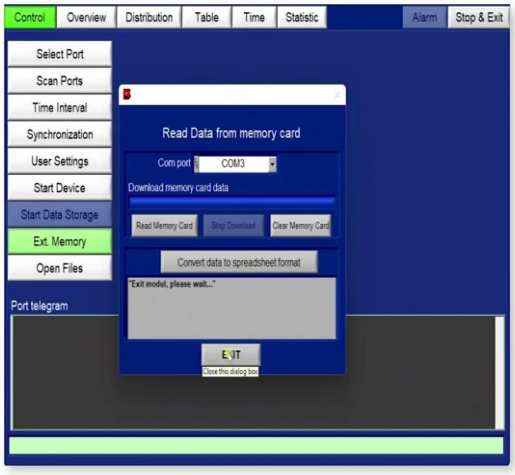




So, right now, I am clicking on SRAM card. So, again that particular COM port has been selected. Now, you have to go for read memory card after clicking on read memory card it will read the card data it will take a while the data will be downloaded one more information about data if you are going for fresh reading. I would recommend that clear the memory card for going for fresh reading so that the previous reading should not be altered, you can see memory card is being downloaded.

(Refer Slide Time: 25:03)

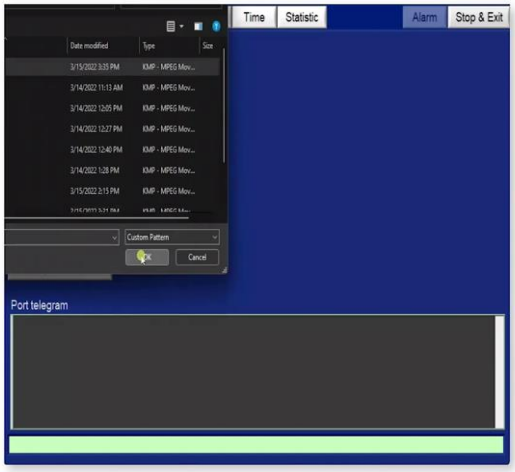




So, after this data has been downloaded that data can be converted into spreadsheet format using these options, so as soon as I click on data convert to spreadsheet format, this particular window opens and you can see the whichever data we have recorded, right now that you can select the data using this toggle keys that is present here. So right now, I am selecting the fourth one, and you have to just give a name.

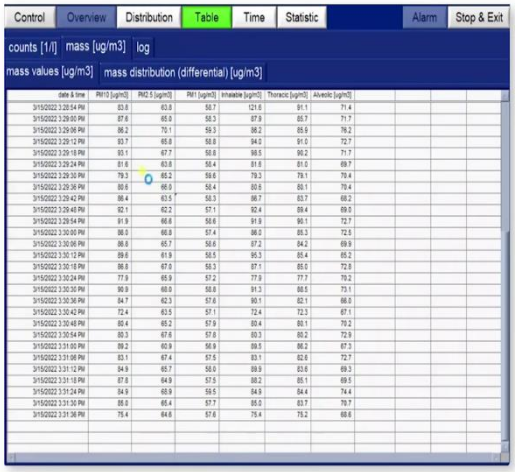
So again, I am giving the name as test10_1. Now, I will click on the start conversion data has been is already been converted. So, let us assume that you have converted the data and we have obtained the 8 hours of reading in particular spreadsheet format. So also, you can import that particular spreadsheet in this software also.

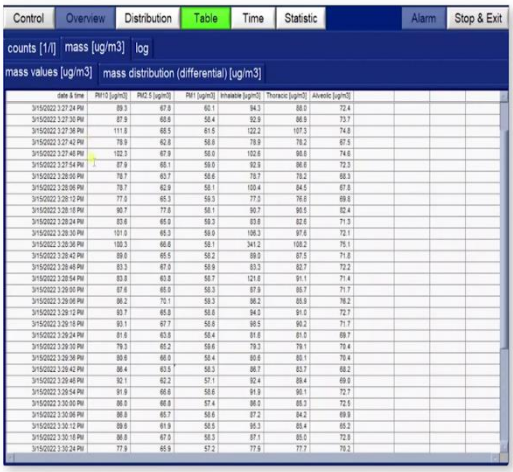
(Refer Slide Time: 26:07)



So, for that we can go for open files, and open files you can see right now it is bar by default, taking the file which I have already saved, okay also you can select or browse at particular locations. So, right now I am again selecting that file just for information.

(Refer Slide Time: 26:21)





And you can click on the open files with the software and you can click on exit. So, you can see now that all the readings which you have taken and that is present here. So, this is the procedure by which you can measure the PM_{10}, $PM_{2.5}$ and PM_1 using this GRIMM model. So, this is software all about the software, thank you.

Professor Bhola Ram Gurjar: So, you have seen and you know how to use the spectrometer. So, this is a versatile instrument which can give you count as well as mass concentration of particulate matter $PM_{2.5}$, PM_1, PM_{10} huge range is there as I said, and all these data are very important because whenever we want to do so, suppose meant or identification of different sources where they are coming from and if we want to relate different kind of concentrations of PM_1 or $PM_{2.5}$ etc, then we need these kinds of data and also to compare whether it is violating the standards or not, so monitoring is very much needed. So, this is all and this is the last lecture of this particular course.

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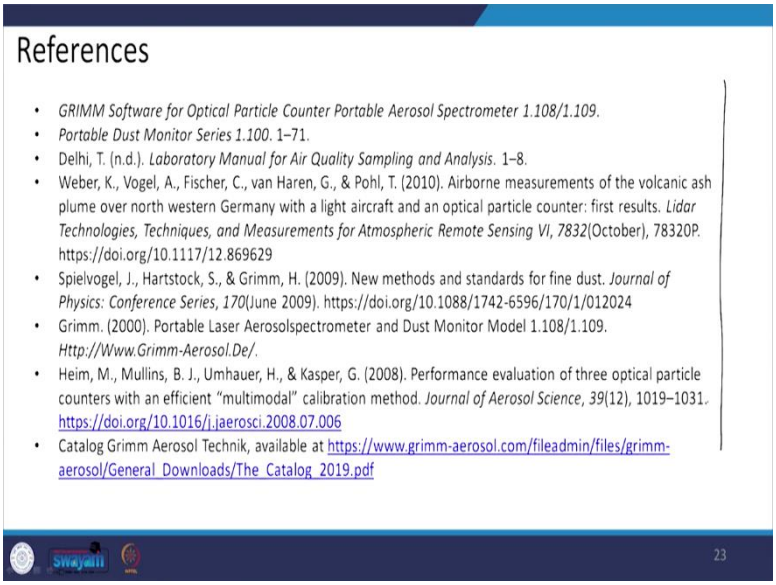

These are the references which we have used for this particular lecture. So, I take this opportunity to thank all of you who took so keen interest in this particular course, we enjoyed your interaction through emails etc. And I thank E-Learning centre of IIT Roorkee specially Binoy to schedule lecture recording times as per our convenience and I also thank TAs Anurag and Gaurav and other students like Ria and Apshay and Rahul they have also contributed a lot in this particular course.

So, thanks all and I wish you all the best for your pursuits regarding air pollution control and air pollution studies, whether you are studying as a student or whether you are trying to implement this knowledge in the field. So, all the best for your pursuits. And thanks again.