**Air Pollution and Control**
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**Lecture 56**
**Sampling and Analysis of PM 2.5 in Ambient Air**

Hello friends. So, these days we are discussing about experimental part of air quality monitoring. As you recall last time we discussed about sampling and analysis of PM 10 particles, the size of the particles 10 micrometer or less than that. So, today we will discuss about sampling and analysis of $PM_{2.5}$ in ambient air, means the particles of the size equal to or less than 2.5 micrometer. So, it is more or less similar the way we monitor or do sampling of $PM_{10}$, but let us discuss it separately so, that we can know certain differences are there in the instrumentation basically.

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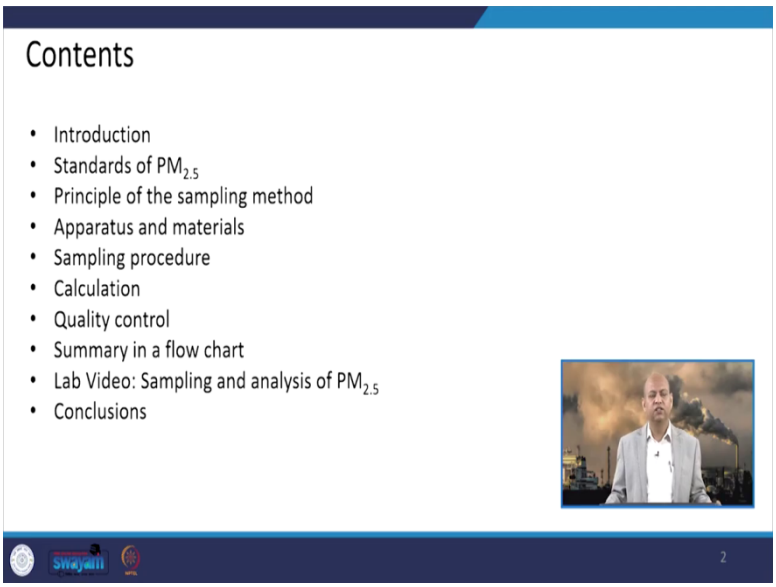


So, first of all, we will discuss the background like introduction and then we will look into the standards which are prescribed by CPCB regarding $PM_{2.5}$ and the principle of the sampling method of this particular particulate matter and the apparatus and materials which are used then what is the procedure of sampling and how do we calculate the concentration, ambient air concentration of $PM_{2.5}$ after observation is made.

So, then we will look into the summary of the flowchart of the procedure then we will have a short video which will explain the procedure of $PM_{2.5}$ monitoring and then we will conclude.

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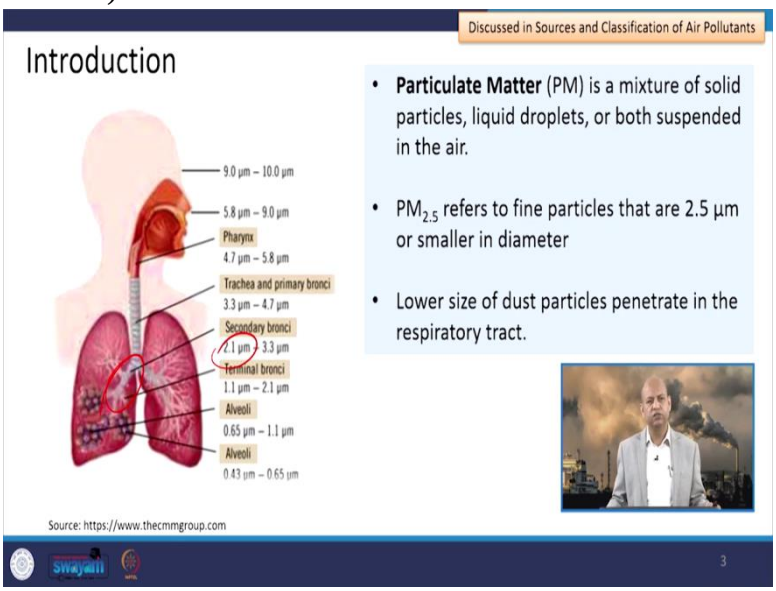


So, as we discussed last time also that fine particles have tendency to go into our respiratory system. So, $PM_{2.5}$ basically these are very fine particles of this size let us say this 2.1 micrometer these secondary. So, this can go up to this part of lungs, they can do damages to these parts of the lungs basically. So, they may have irritating kind of behavior as well as they can kind of hamper the function of the lungs.

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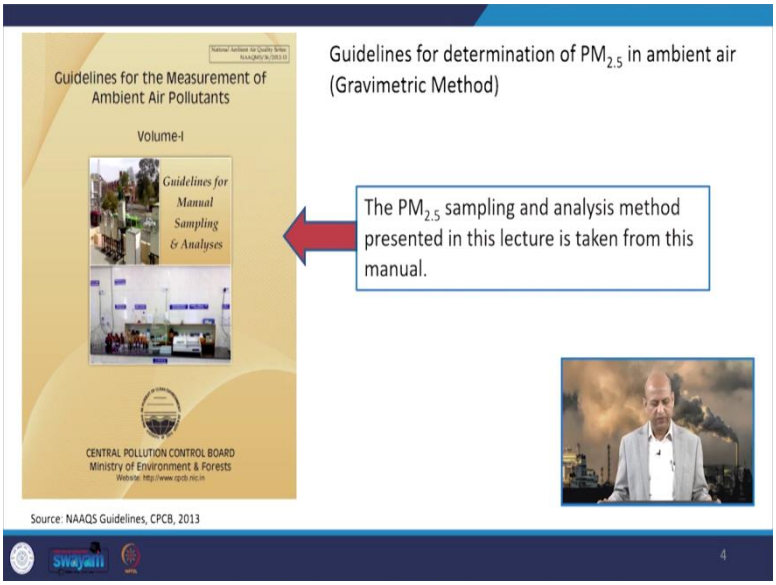


Well so, guidelines for determination of $PM_{2.5}$ in ambient air is basically the gravimetric method which are taken from CPCB's manual on guidelines for the measurement of ambient air pollution which has all particulate matter as well as gaseous pollutants. So, the $PM_{2.5}$ sampling and analysis method which we are describing in this particular lecture is basically based on the information which we have derived from this particular document.

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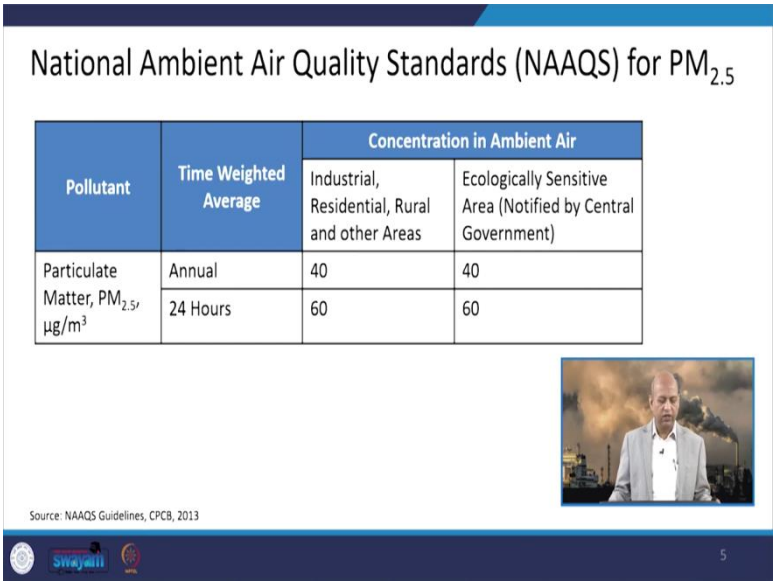


Now, if we talk about national ambient air quality standards that is NAAQS for $PM_{2.5}$ which has been prescribed by CPCB central pollution control board. So, this is like for industrial residential and rural and other areas it is around 40 to 60, 40 for annual average and 24 hours average is 60 Micro gram per cubic meter, the same quantities are there for ecologically sensitive areas also, which are notified by central government.

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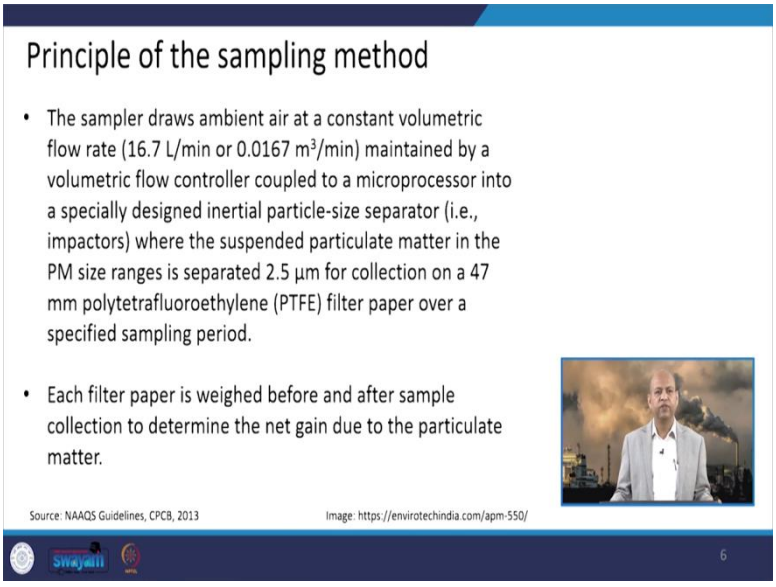


Well, so, what is the principle behind the sampling of $PM_{2.5}$ It basically draws the Air, ambient air at a constant volumetric flow rate around this 16.7 liter per minute or 0.0167 cubic meter per minute which is maintained by a volumetric flow controller which is coupled to a microprocessor into a specially designed this inertial particle-size separator which is also known as impactor, where the suspended particulate matters in the PM size ranges, which are

separated for 2.5 for collection on a particular filter paper which is 47 mm, this PTFE filter paper which is known as over a specified sampling period.

So, that we know how much air has been passed through that filter papers because we will require the volume of the air for calculation purposes of the concentration because, we will calculate the mass which is deposited on the filter paper then if we know how much air has passed through this filter paper that means, what was the volume of air that had this particular amount of particulate matter.

Then each filter paper is basically weight before and after the sampling collection is done, so that we can know the difference of the particulate matter after the final weight and before sampling so that the difference of the weight is the particulate matter which is collected on the filter paper.

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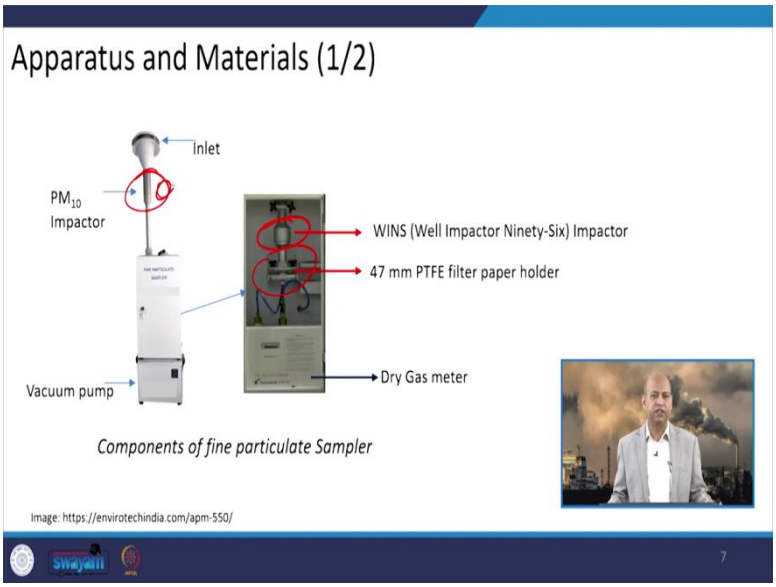


Then this is the apparatus basically. So, inlet is there and then $PM_{10}$ impactor is there, so, that the coarse particles are removed and $PM_{10}$ is only collected here, but then it passes through at the lower place. So, at this particular location, this $PM_{2.5}$ is collected on a small filter paper. So, that means, $PM_{2.5}$ to $PM_{10}$ is collected in this particular portion.

So, if we are interested to know, how much particles are there in the ambient air of the size which is more than or larger than $PM_{2.5}$ but less than or smaller than $PM_{10}$ then we can also get this value here, but we are interested especially in $PM_{2.5}$. So, the collected particulate matter on this filter paper is of our interest basically.

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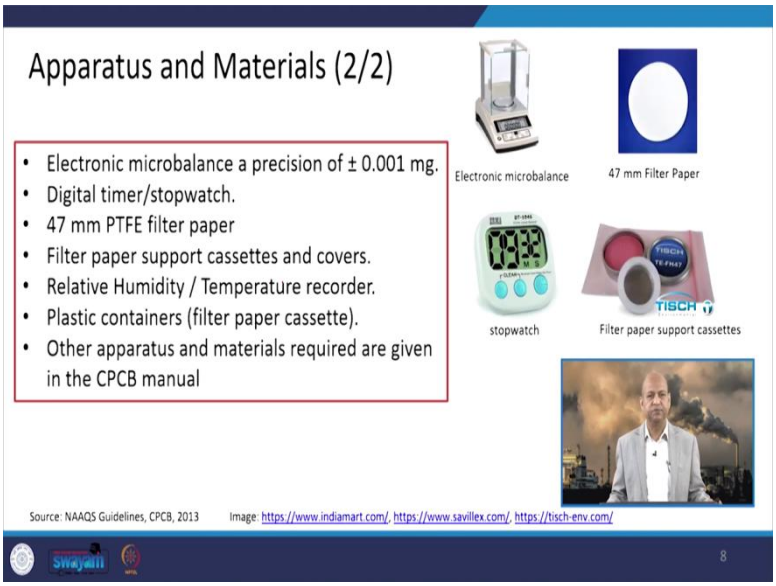


So, different kind of devices in addition to this particular apparatus we need like weighing machine electronic micro balance and then filter paper is also needed, Stopwatch so that, we know how much period is there because we have to maintain the flow rate also, how much time we are doing sampling like 4 hours or how many hours then filter paper supporting cassettes are there so, that it is not disturbed, it has to be protected from other kind of issues. Well, so, this weighing machine is used for weighing the filter paper before sampling and after the sampling basically.

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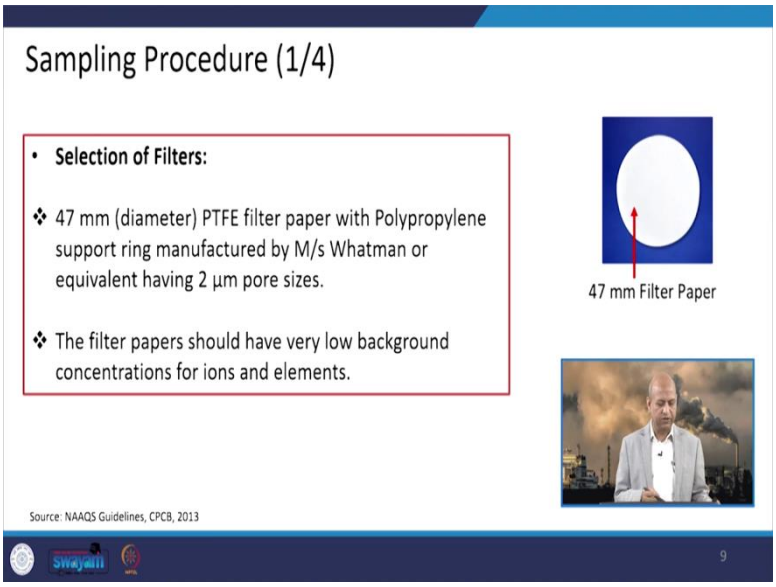

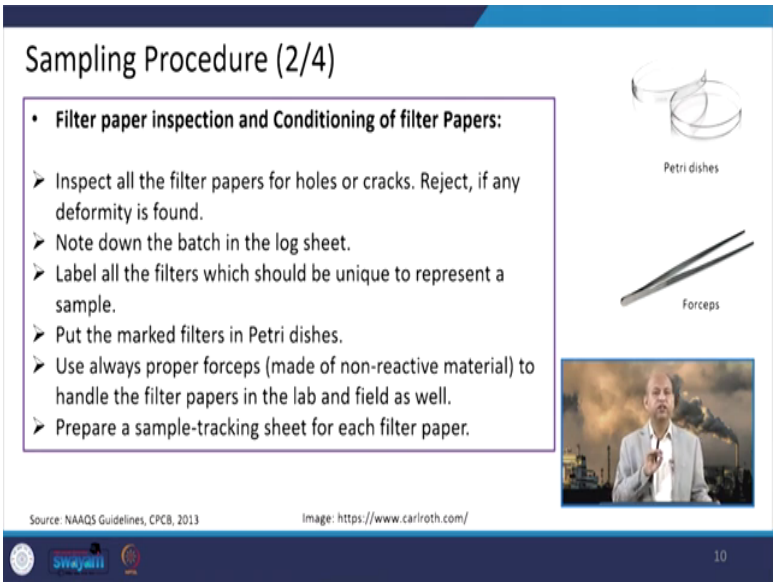


So, if we go to the sampling procedure, we basically follow this particular path that we first of all inspect the filter paper so, that it does not have any kind of holes or short circuit will be there particles will not be deposited, but air will take the particles through the that punctured filter paper. So, that kind of filter paper we do not need if there are cracks or holes we should reject that filter paper it should be completely intact.

Then we have to note down the batch of the sampling and the log sheet where we mentioned every kind of information, then we have to label the filter paper so that we know at which site is has been used, because each filter paper represents a unique monitoring site basically, then we placed them in a petri dish and we also use it with some of these forceps, so that you do not touch it and you do not interfere in the way or you do not put some particles if they are in the hands.

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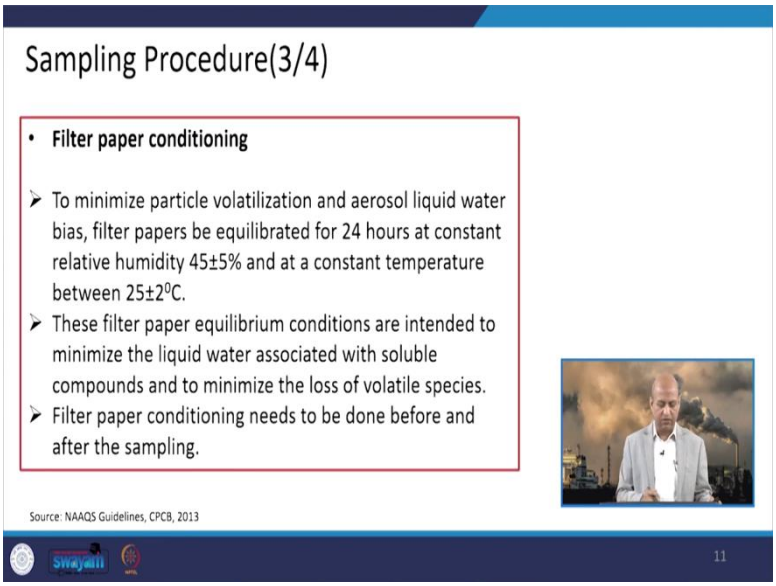

Then we prepare this filter paper after conditioning because conditioning is needed. So, that any kind of moisture can be removed from the filter paper otherwise it can interfere in the collection of the particles as well as calculations. So, you can condition it at a particular temperature. And then after conditioning you have to weight and note down the weight that is the weight of the filter paper before sampling.

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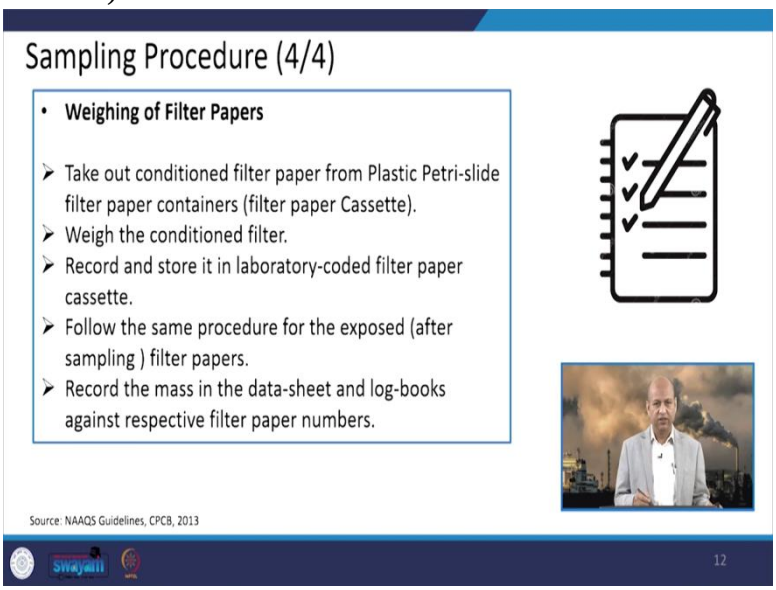


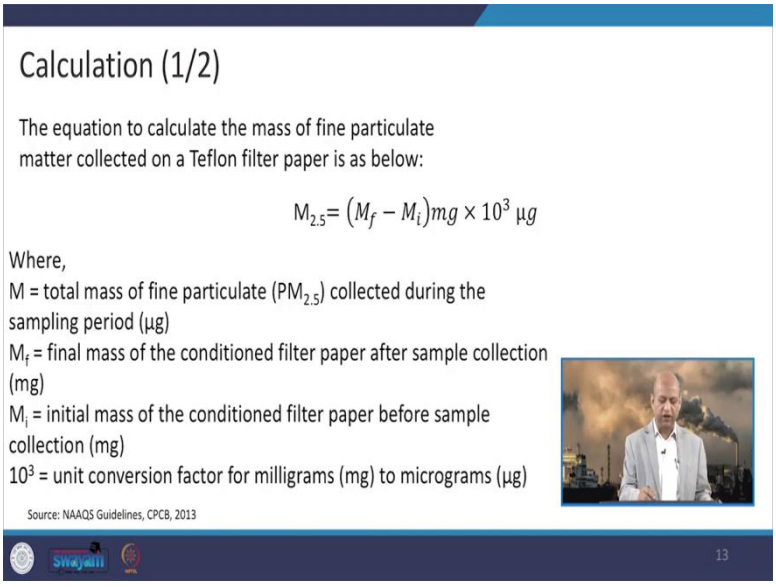


Then we do the sampling and after this is exposed to the particulate matter which is passing through that device for a certain period, then we again we weight. So, that is the weight of final and the initial we have weighed just before sampling and after sampling this final weight is there. So, difference of these is the basically mass of the 2.5 particles, particles of the size of 2.5 micrometer which is collected on this particular filter paper and if this is in milligram then we multiply it by 10 to the power 3 to convert it into microgram.

$M_{2.5} = (M_f - M_i)mg \times 10^3\ \mu g$

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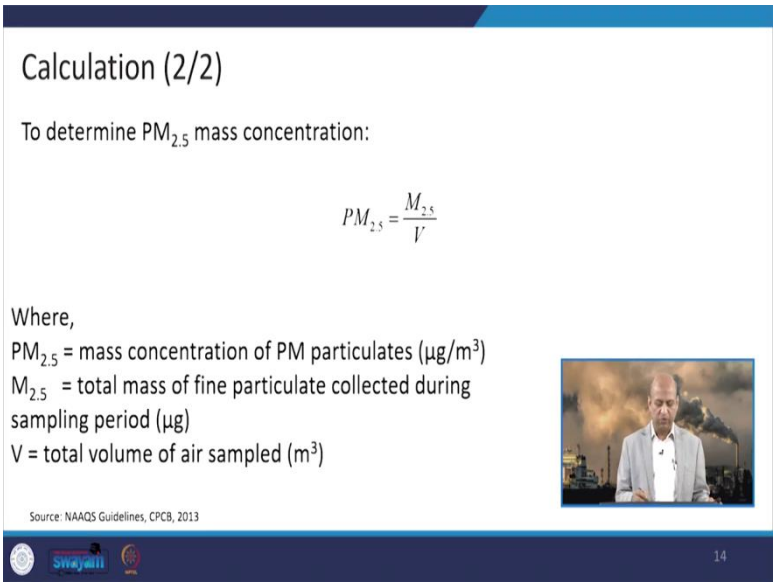


Then we divided this mass of microgram by this volume, volume of the, total volume of the air which has been sampled which is responsible for the collection of this particular amount of or weight of or mass of particulate matter.

$$PM_{2.5} = \frac{M_{2.5}}{V}$$

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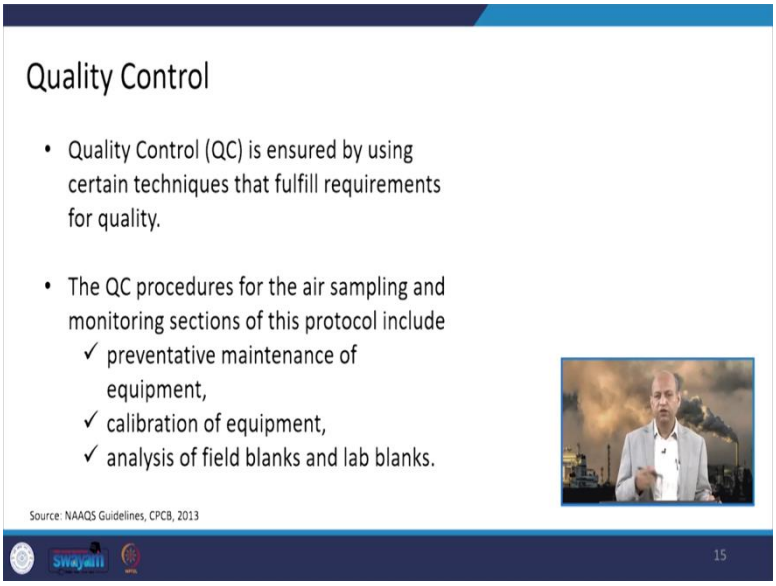


We need to do quality control some protocols are followed like to prevent like we do maintenance of the equipment calibration of the equipment time to time and other protocols we need to follow so, that quality is properly control.

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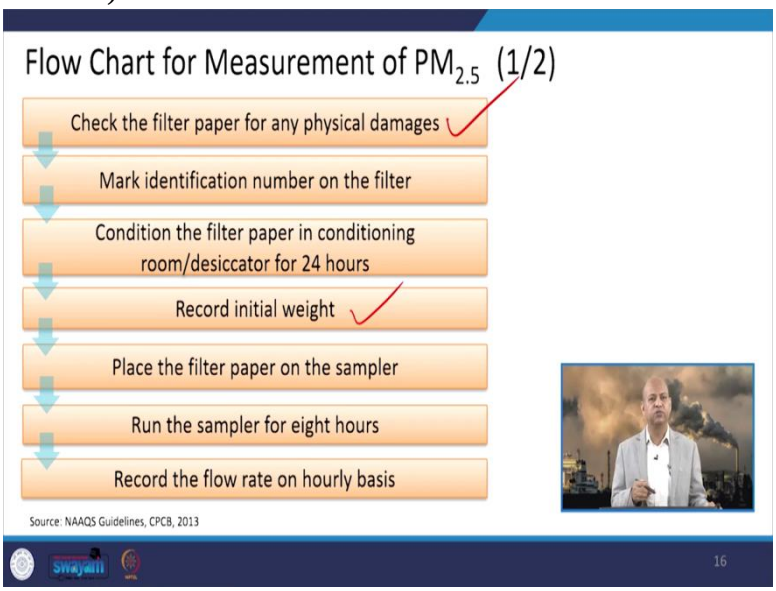


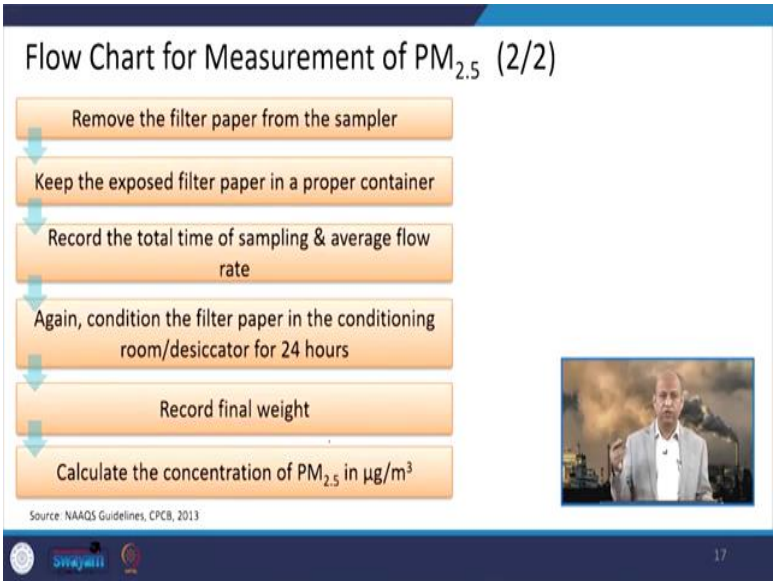


If we go for summary of flowchart regarding measurements of $PM_{2.5}$ then first of all, Let us check the filter paper for any physical damage if there is any damage, reject it, get another fresh or new filter paper and then mark the identification number of the filter paper which represent a particular site of the monitoring, then you need to condition it at the particular temperature for 24 hours.

So that all those moisture and VOCs related issues are removed. Then we record the initial weight after conditioning. Please remember, after conditioning we have to record the initial weight, then we place this filter paper on the sampler, we run the sampler for 8 hours or 4 hours depending upon the requirements, then we record the flow rate on hourly basis.

So, that we can if there is difference in the flow rate, then we can get the average value for that 4 hours or the 8 hours, then we remove the filter paper from the sampler and then we keep it in a particular container so, that it is not disturbed, and we take it to our laboratory and then we

record all the values of the flow rate as well as then again we condition the filter paper in a conditioning room for 24 hours, and then we record the final weight.

So, the difference of the final weight and initial weight gives the total mass which is collected and we know the volume of the air by that flow rate and the time duration. So, we can divide it and calculate for the concentration which is available or present in the ambient air.

So, now, we present a short video which will illustrate you about the sampling procedure of $PM_{2.5}$ using this particular sampler of fine particulate collection, and this video has been prepared in the air pollution laboratory of civil engineering department of IIT Roorkee. So, please watch this video and it will give you a better perspective about the sampling of $PM_{2.5}$.

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Good morning friends, welcome to the experiment of the subject Air pollution and Control. And this is our second experiment where I will demonstrate you the purpose of the experiment is to measurement sampling and analysis of $PM_{2.5}$ in ambient air using gravimetric analysis, like in previous experiment, we have learned about how the measurement of $PM_{10}$ in ambient air is carried out. Similarly, we also have a device to measure the $PM_{2.5}$ concentration in ambient air and for that the instrument that is used is called as Fine Particulate Matter Sampler of Envirotech called as APM 550.

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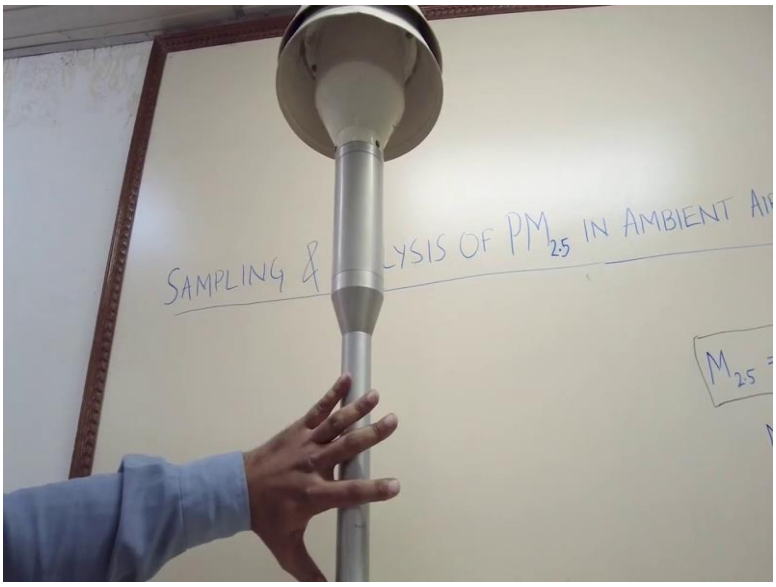


So, initially I will explain the different components of the instrument. So, you can see this is the upper part of the instrument that is called as the inlet and after the inlet this part is called the impactor which is the $PM_{10}$ impactor to segregate the particles which are larger than 10 micron in size and those particles which are smaller than 10 micron will go through the air stream passing down and this is the down tube and this is the housing of the APM 550 sampler.

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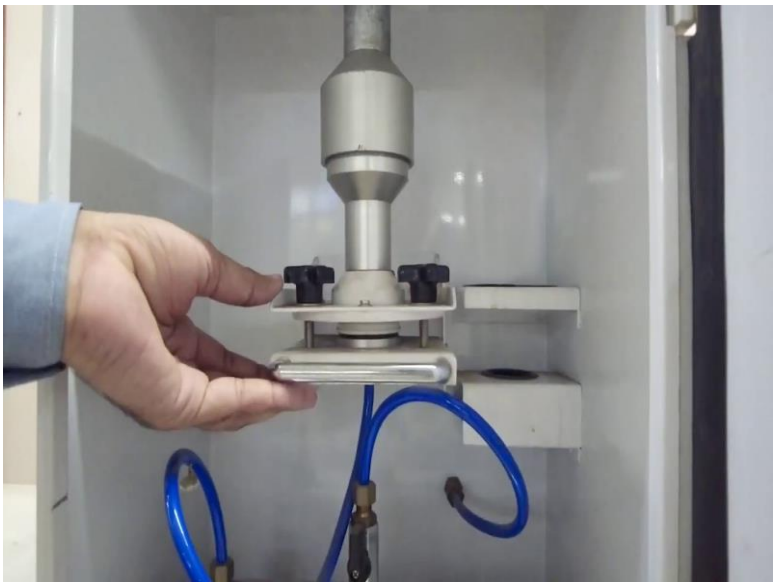



So, in the housing we have the 3 major component this is the winds impactor assembly and this is the filter holder assembly and this is the dry gas meter and this other part that is the oil less

vacuum pump, so, these are the major components of this instrument. So, what is the purpose of different component I will explain and this is the inlet so, to the inlet, this is the circular inlet basically, so that like the air which enters through this circular inlet, it will not affect the direction of the wind flow.

So that, the air will enter through this circular inlet and immediately this we are having this impactor. So, the purpose of this impactor is that those particles which are larger than 10 microns in size will be trapped here and those particles which are less than or equal to 10 micron or $PM_{10}$ will say they will pass through the instrument in the following airflow.

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So, this air will pass through this down tube and then it will pass through these winds impactor and here the purpose of this winds compactor is to trap the particles which are falling in the range of 2.5 to 10 micron in size. So, those particles which are less than or equal to 2.5 micron will pass through the air and pass through these winds impactor and then those particles have

to or we can say the $PM_{2.5}$ particles they will be collected here in this filter holder assembly we have a filter cover, so, in which we have the PTFE filter I will explain in the separate part.

So, those particles will be collected over this filter. So, what basically happens from the ambient air the particles which are larger than 10 micron, they will be trapped here and those particles which are in the range of 2.5 to 10 micron they will be trapped in winds impactor.

So, only the air which is crossing these winds impactor will be having the concentration of particles less than or equal to 2.5 micron and that will be collected over this in the filter which is holded by this filter holder assembly.

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Now, the other part is like dry gas air meter. So, you can see here we can directly measure the volume of air through this meter. So, we do not have to calculate the flow rate multiplied by time things like that directly we can get the volume of the air and the point is like how we create the suction in the stream and so in order to create the suction, we have the oil less vacuum pump.

So, that should be attached with the, this device. Generally this device is placed over this oil less vacuum pump and it is hold through this part so that like we can wherever we are moving. We can easily take entire as a single unit and place anywhere where we are doing the sampling. Now, the point is like what happens inside the winds impactor.

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So, in order to understand it I have just another unit of winds Impactor. So, this is the winds impactor we have and here we have the PTFE filter, which is 47 mm size and we have a GFA

filter, glass microfiber filter that is for the impaction purpose. So, I will explain this. So, this is our winds impactor. So, we have to gently open it when we are setting the instrument.

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So, you can see here in this impactor assembly we have this part that is called as the oil well. And in oil well we have to remove this upper part of this oil well and here inside you can see we have one filter that is the 37 mm GFA filter. And before starting the instrument or before starting our experiment, we have to place this GFA filter. So, we have already placed here and you can see here some wetness there that is because of we have added some drops of silicone oil.

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So, silicone oil we have placed into this that is a dropper. So, when we place the filter through this forcep and then we place this upper part of the oil well and then simply using this dropper we add the drops of the silicone oil on the filter so that it becomes wet and so that what happens when the air which is coming down through the down tube it will impact here.

So, those particles which are falling in the range of 2.5 to 10 microns they will stuck here and only the air which is coming out having the particles less than or equal to 2.5 micron that will pass through the filter assembly. So, then replace here simply so that and then we cover it, like this.

So, now what happens whatever air is coming from this lower part that will be having the $PM_{2.5}$ micron particles. Now, here we have a filter holder in which we have added the place the filter PTFE filter, which is 47 mm in size in diameter. So, this is the filter holder and we place this filter here and then we put this cover up like this.

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So, the air which comes out from here that will pass through this and whatever the mass of the $PM_{2.5}$ will be collected on this filter and this filter is basically placed in the filter holder assembly like you can see here we have already placed this. So, we have to open it and then we have to place it. So, until now I explained you the different components of the device and how the air comes into it and then it passed through the filter and the $PM_{2.5}$ particle is collected on the filter that advantage this instrument is having that like if we want to suppose measure the $PM_{10}$ only.

Then we can simply take out this winds impactor assembly and we can directly allow this air through this down tube to pass to the this filter here that time we have to replace this filter from the glass fiber filter, so that we can measure the $PM_{10}$ also. So, this is how the 10 and 2.5 is measured the $PM_{2.5}$. Now that we come to the calculation part, so, the calculation is very similar with the calculation of the $PM_{10}$ as we have seen our previous experiment.

So, I have explained here you can see this upper equation is giving the mass of the $PM_{2.5}$ particles which are collected over this filter. So, what we have to do, we have to do the preconditioning and post conditioning for the filter which we are going to use for measurement of $PM_{2.5}$ and after doing this preconditioning we take the weight of the filter and that is called as the initial weight of the filter and after doing the sampling, we again take the filter weight that is the following the post conditioning which we have done similar to the pre conditioning.

So, after doing this conditioning, we take the post weight of the filter and the difference of these two will be placed in this equation and then we get the mass of the $PM_{2.5}$. Now we need to have the volume and as I said like volume, we can directly measure through this dry gas meter. So, this reading is directly giving you the volume in meter cube. So, we can simply place

use the second equation and we can calculate the $PM_{2.5}$ concentration in the ambient air. So, this is how using these winds impactor and this assembly, we are able to measure the $PM_{2.5}$ in the ambient air. Thank you.

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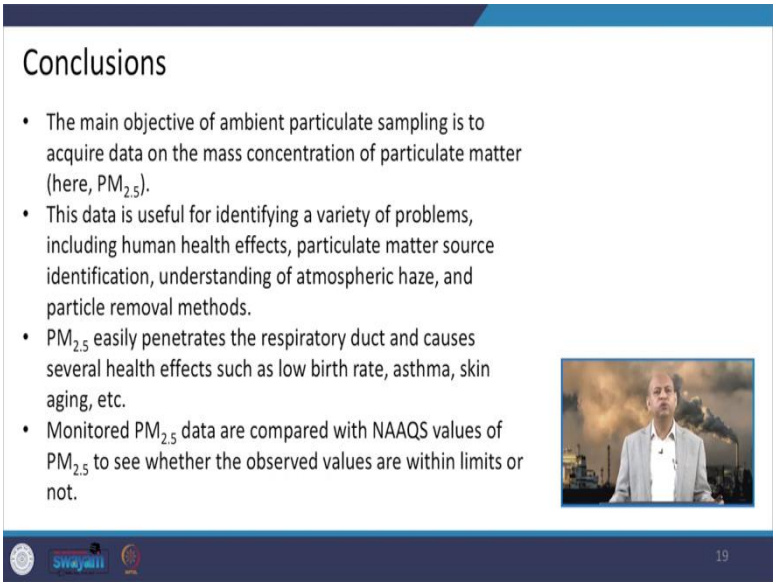


Well, so, you have seen this video and we can conclude at last that the main objective of ambient air particulate sampling whether $PM_{10}$ or $PM_{2.5}$ here we have done this $PM_{2.5}$ sampling related description, we have to do because we need the data to compare with the ambient air quality standards and whether it is exceeding or not. And if it is exceeding then how to control it, how to remove or reduce the concentration. So that, we can target certain sources like through source apportionment studies etc. So, for various purposes, we need to monitor the air quality and different kinds of pollutants.

So, $PM_{2.5}$ is the part of this particular illustration and this data is useful for all kind of calculations like health effects or whether this air quality standards are being met or not. So, we can get these data at certain locations and use this particular instrument for sampling purpose and do calculations and compare with the air quality standards and know whether it is exceeding or not.

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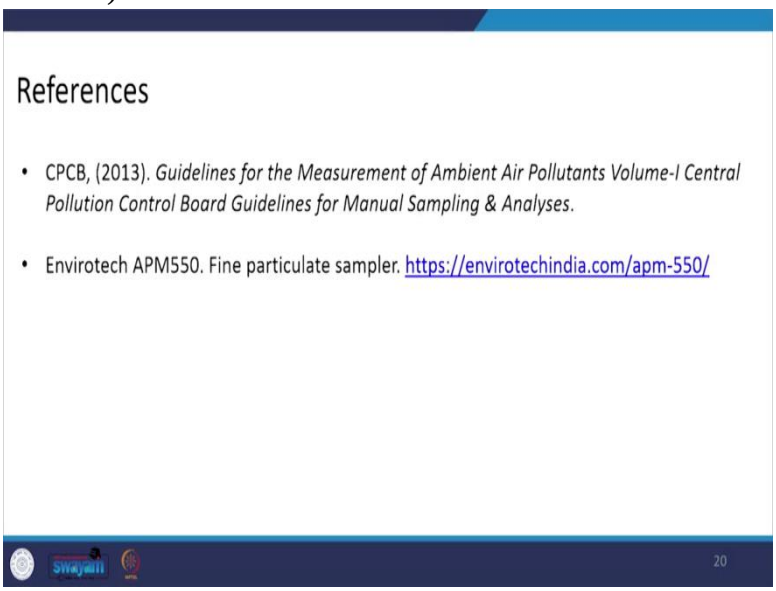


And these are the references based on which we have prepared this presentation. So, thank you for your kind attention and I will see you in the next lecture where we will look into how to monitor Sulfur Dioxide and Nitrogen Dioxide. Thanks again.