Air Pollution and Control
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Lecture – 55
Sampling and Analysis of PM10 in Ambient Air

Hello friends. So, you may recall that last time we had a kind of concluding lecture, which could give a summary of all the aspects of air pollution monitoring and modeling. And we also discussed about the challenges which we are facing to control the air pollution and the way forward.

Now, today onward we will look into sampling and analysis of various air pollutants in the ambient air. So, today first we will discuss about sampling and analysis of particulate matter PM_{10}, which is also known as RSPM (Respirable Suspended Particulate Matter). So, in ambient air how do we sample and analyze the PM_{10} today's lecture is related to that.

Also we will have a small video demonstration, which will give you the real feeling how these instruments are used in the field, so, that you can have a better perspective and you can later on use this instrument at a particular location to monitor the air quality in terms of particulate matter.

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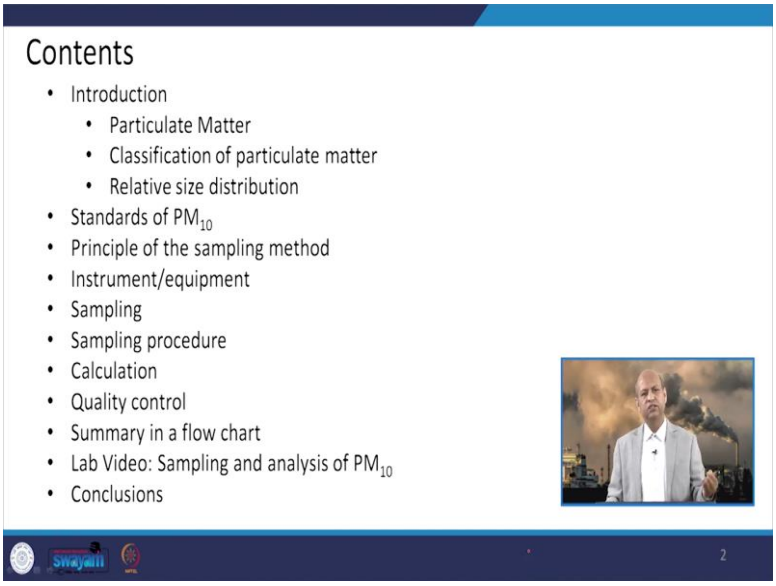

So, this particular lecture is including like a small introduction of particulate matter which we will revise basically, we have already discussed in certain lectures, then we will look into what are the standards or National Ambient Air Quality Standards for PM_{10}. So, that we can compare the observed data with the standards.

And we will then know that whether air quality is meeting the requirements or it is exceeding from these standards which has been prescribed by CPCB we will also look into the principle which is being used for sampling purpose and the instruments which are popular in the field for monitoring the air quality in terms of PM_{10}.

And then we will see the sampling procedure and little bit calculation formula and then we will see the video we have prepared in laboratory of IIT Roorkee and later on we will conclude.

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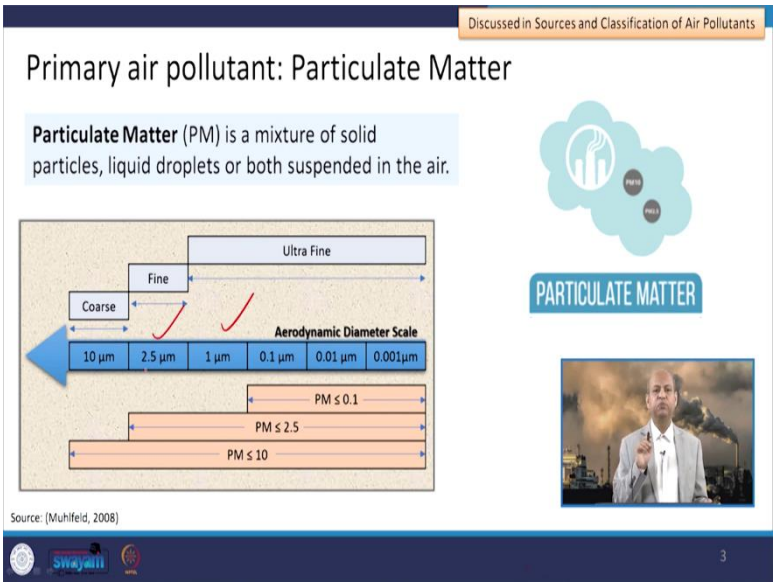

So, if we come to this revise or region of few slides which we have discussed in sources and classification of air pollutants long back. So, the particulate matter is nothing but either solid particles suspended in the air or they may also contain these liquid droplets or both maybe they are suspending in the air.

And according to their size we define them like coarser particles or fine particles. So, like PM_{10} is known as coarse particles you can say and $PM_{2.5}$ is known as fine particles and less than $PM_{2.5}$ like 1 micrometer or 0.1 micrometer, they fall into the category of ultra fine particles.

You can see here this PM_{10} is coarse and PM_{10} means the particles which are having size equal to or less than 10 micrometer. So, PM_{10} also includes $PM_{2.5}$, PM_1 also. So, all these smaller particle sizes are included in the higher sizes. So, PM_{10} is basically having the size of the particles which are $PM_{2.5}$ also PM_1 also and $PM_{2.5}$ will not have PM_{10}, $PM_{2.5}$ micrometer will have the size of 1 micrometer also 0.1 micrometer also like that.

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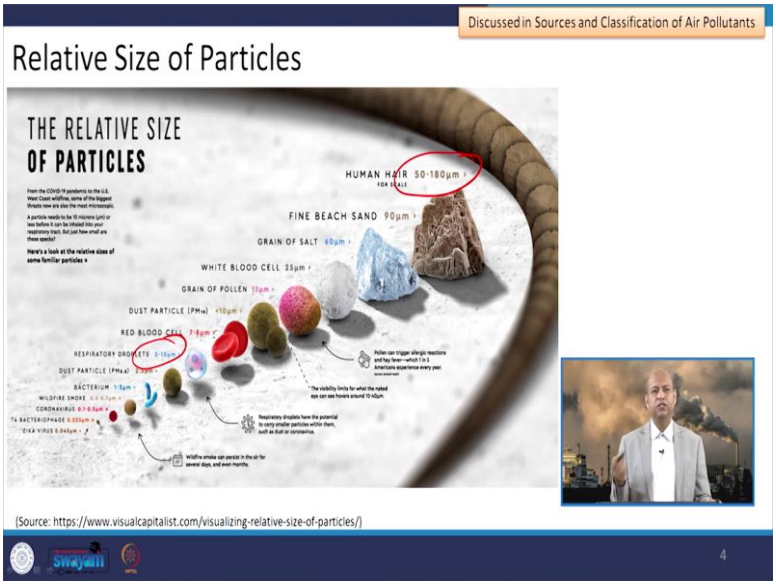

Well, if you want to have a kind of visualization, what is the size of these particles, how small particles they are. So, you can compare with human hair, if human hair is like 50 to 180 micrometers size. So, you can say that it is one tenth or 18 times size this human hair is then the PM10 particles because like 180 micrometer if it is then certain hair maybe finer like 50 micrometers so, you can say 5 times then the PM_{10}.

So, that way you can see like these respiratory droplets maybe having size of 5 to 10 micrometer. Dust is having particles of $PM_{2.5}$ size so that way you can compare with the sand grains or human hair size and these $PM_{2.5}$ PM_1 etc are very, very fine particles and we cannot see them through naked eyes. Basically they becomes part of our respiratory inhalation and exhalation and they can go up to the lungs.

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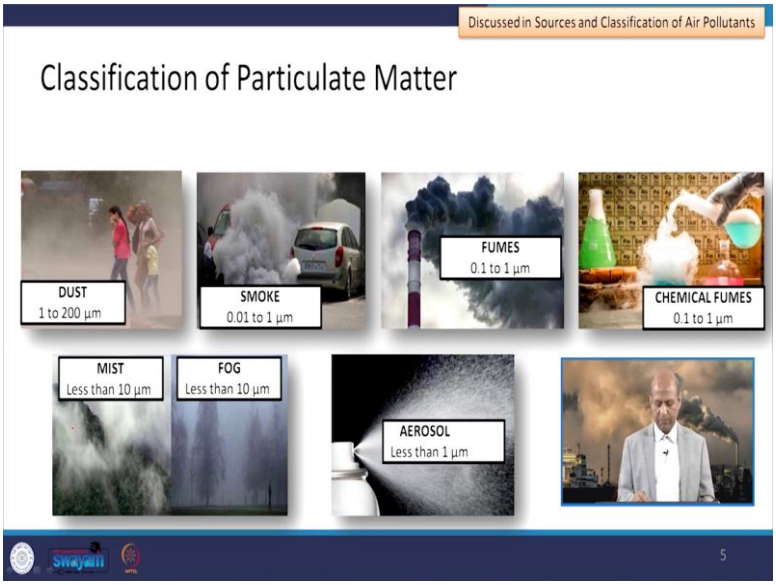

And if you want to again compare the sizes depending upon different kinds of particulate matter like fumes or smoke or dust. So, dust is basically 1 to 200 micrometer sized particles are found in the dust. And in smoke 0.01 to 1 micrometer sized particles can be found. In fumes it is 0.1 to 1 micrometer.

Chemical fumes or simple fumes plus mist can have less than 10 micrometer PM_{10} or so. Fog also less than 10 micrometers size particles. Aerosols are like whatever particles which are of size less than 1 micrometer.

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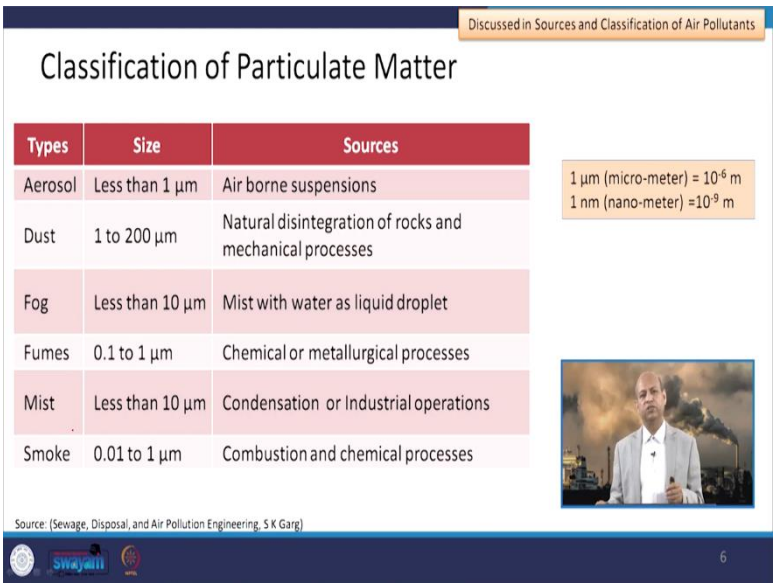

So, in this table also, the nomenclature has been given according to the size and their sources like aerosols are the particles which are less than 1 micrometer and they are basically airborne

suspensions and dust is 1 to 200 micrometer, natural disintegration of the rocks and mechanical processes they create the dust, resuspension dust also occurs.

Fog less than 10 micrometer and mist also with water and liquid droplets in hanging in the air in wintertime basically, we look into these kinds of situations. Fumes 0.1 to 1 micrometer through metallurgical processes or chemical processes, these can be the sources of the fumes then mist could be like again less than 10 micrometers.

And because of condensation during industrial operations or naturally also mist can occur and this is having the particles of less than 10 micrometers. Smoke is 0.01 to 1 micrometer and from combustion and chemical processes smoke emitted.

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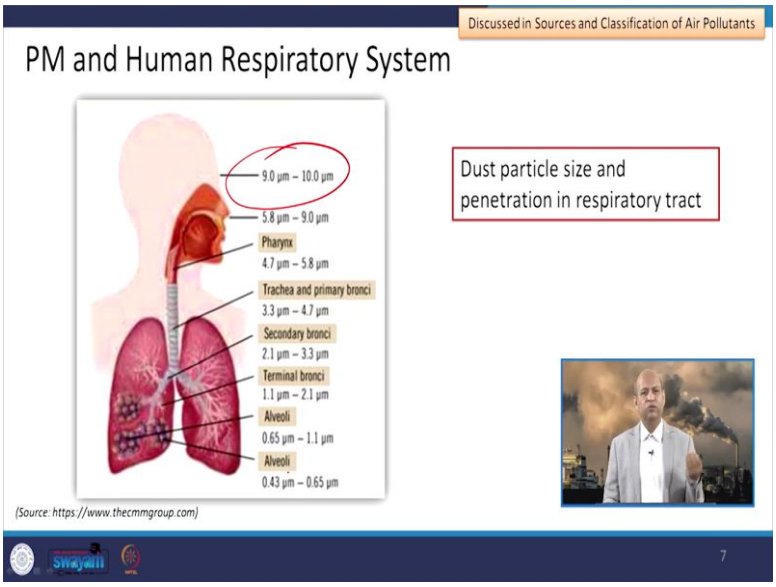

Then if we relate particulate matter and human respiratory systems, how, where they can go up to like 10 micrometers size basically up to the nasal opening they can go and it can be removed there. But the smaller particles can go through this respiratory tract and up to lungs it can go like very fine particles like 0.65 micrometer or 0.4 micrometer size, they can go up to the lungs and very fine particles ultra-particles or ultra-fine particles they can even go to the blood that is the problem with these very ultra-fine particles. And if they are having like some toxic material with them. Then of course they can create some problem health problem and other issues.

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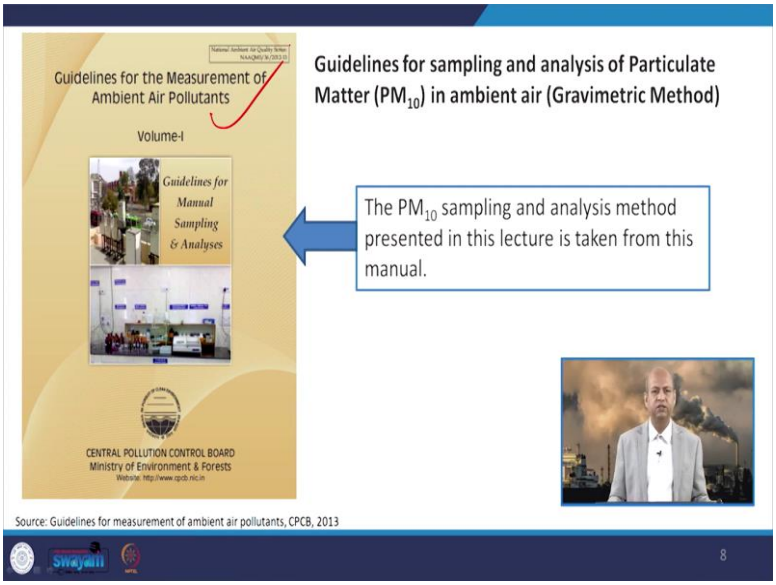

Well, so when we come to how to monitor these PM_{10}. What kind of instrument do we use? So, we have taken this process of monitoring the PM_{10} or RSPM respirable suspended particles. So, guidelines for sampling and analysis of particulate matter in ambient air which is through gravimetric method, this has been taken from this particular manual.

This is guidelines for measurement of ambient air pollutants, this contains several pollutants, measurement techniques. So, we have taken this PM_{10} sampling and analysis method presented in this particular manual or document.

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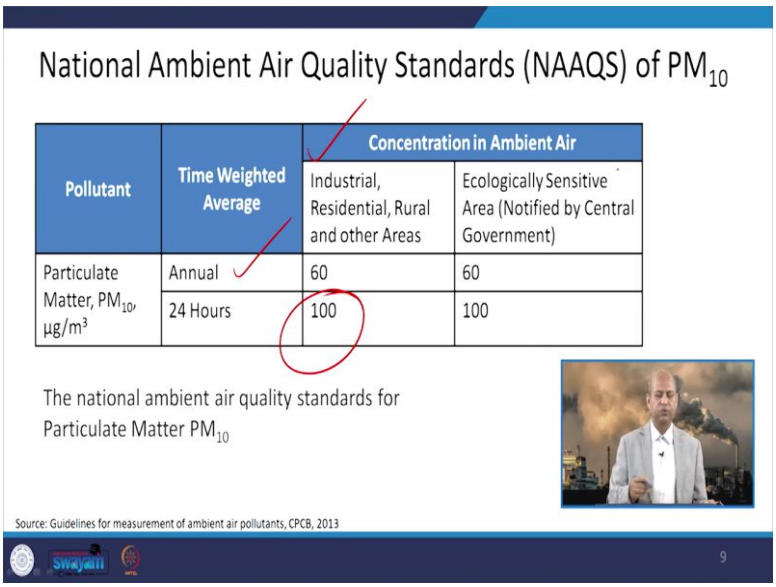

If we look into national ambient air quality standards of PM_{10} basically two situations like industrial, residential, rural, or other areas, they are like annual standards are 60 micro meter

per cubic meter and 24 hours are 100 Micro gram per cubic meter and the same is like in ecologically sensitive areas, which are notified by the central government. In other pollutants like SO_2, NO_2, etc these values may differ but it depends upon their health effects and environmental effects.

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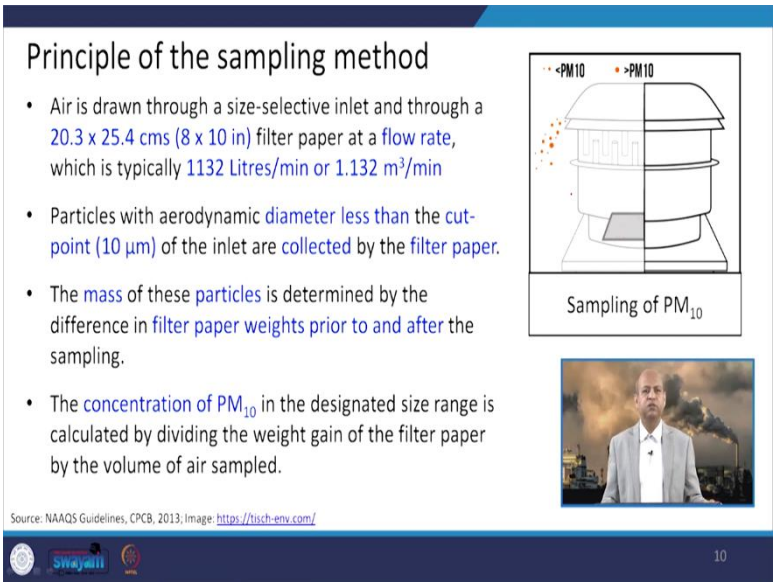

Now, if we come to the principle which is the basis of the sampling methods. So, basically air is sucked or drawn through some inlet and it goes inside this instrument and it passes through a filter paper and we also note down the flow rate which is like around typically 1 cubic meter, 1.13 cubic meter per minute that average we have to maintain.

And there is technique that this diameter less or less than or equal to 10 micrometer are passed towards the filter paper others are removed and collected in other kinds of hopper. We will see that particular part of this high volume sampler. Then we find how much mass is collected at the filter paper.

Then we weigh and then we divide it with the total volume of the air which has passed through. So, that comes that gives us the value of concentration microgram per cubic meter mass per unit of the volume.

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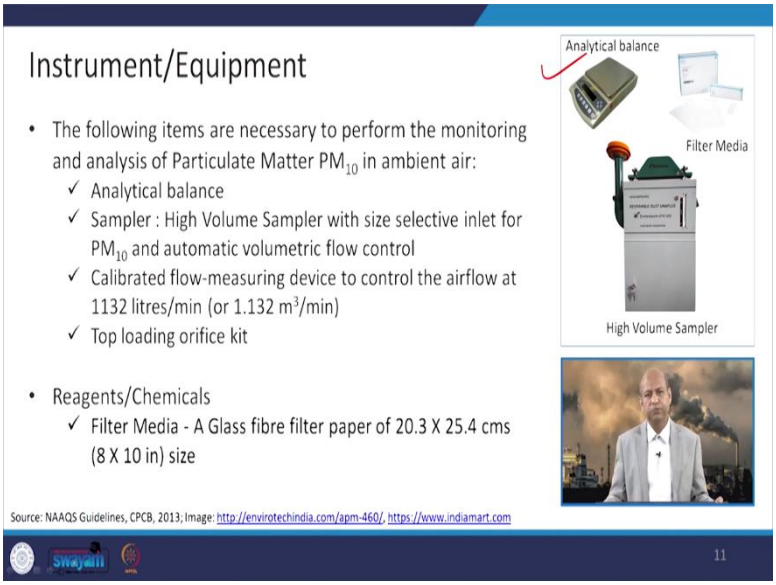

Well, if you look into the instrument which is which are required for calculating ambient air concentration of PM_{10}. So, we need first of all analytical balance where we can weigh it we can find what is the weight and we have this high volume sampler and there is ways to control the flow and we can see like initial flow rate, afterwards flow rate and then we can have the average.

There is also the way like top loading this mechanism where we put in the filter paper and also we have to have a particular type of filter paper, every kind of filter paper is not used there. So, glass fibre filter paper are mostly used for this particular purpose.

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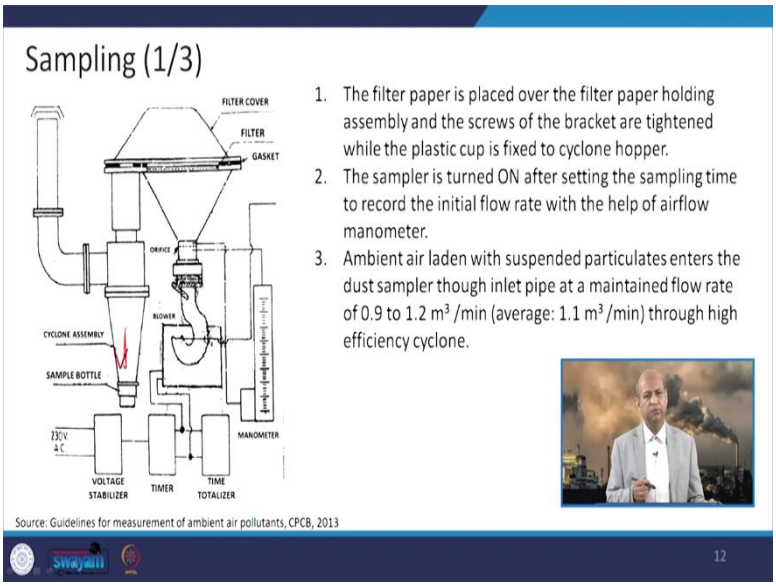

If you look into different parts of this particular high volume sampler, then this filter paper is placed at this particular location where no filter paper loading assembly is there, you just remove this lead and put out put this filter paper and then you start the instrument and means, you switch on the instrument and then air start to flow and the particles less than 10 micrometer goes through this filter paper.

And the more the size is higher than the 10 micrometer, they are collected in this particular cyclone kind of assembly. So, in the hopper it is collected and we can also weigh it and know how much value is there of the particle size more than the PM_{10}. So, that is the basic idea.

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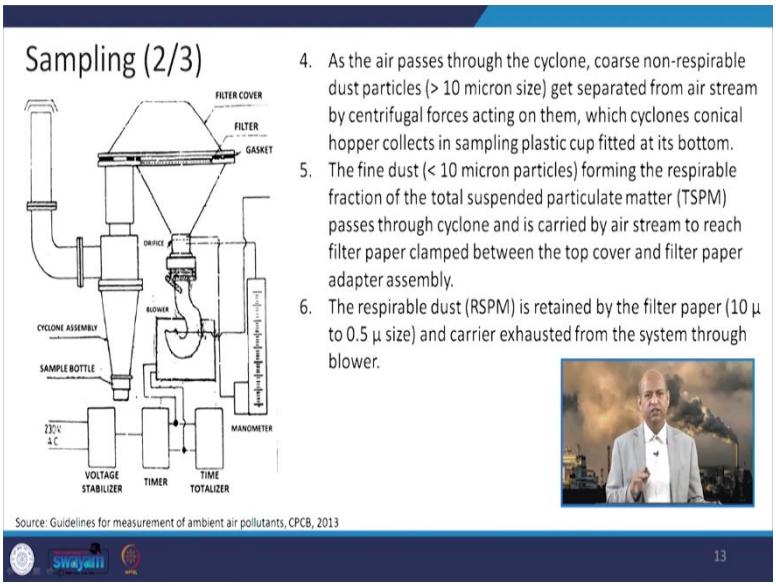

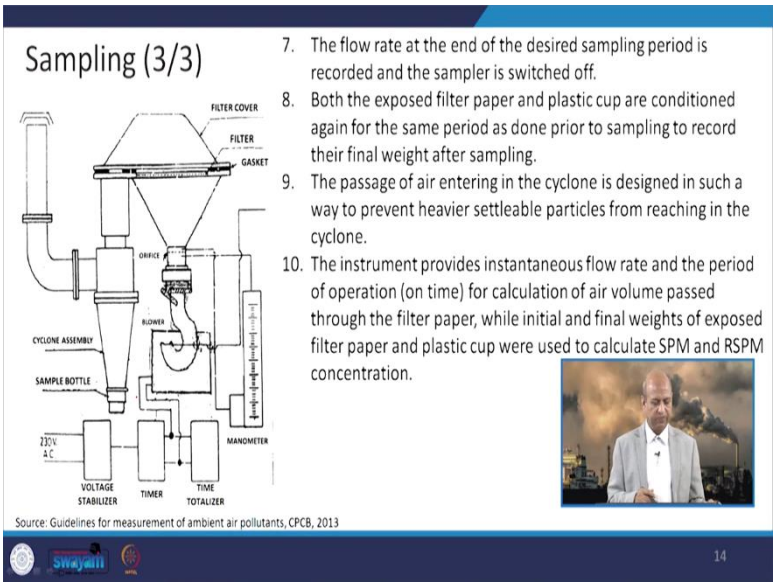

And also we need to look into like filter paper must be free from moisture. So, it is conditioned basically at a particular temperature.

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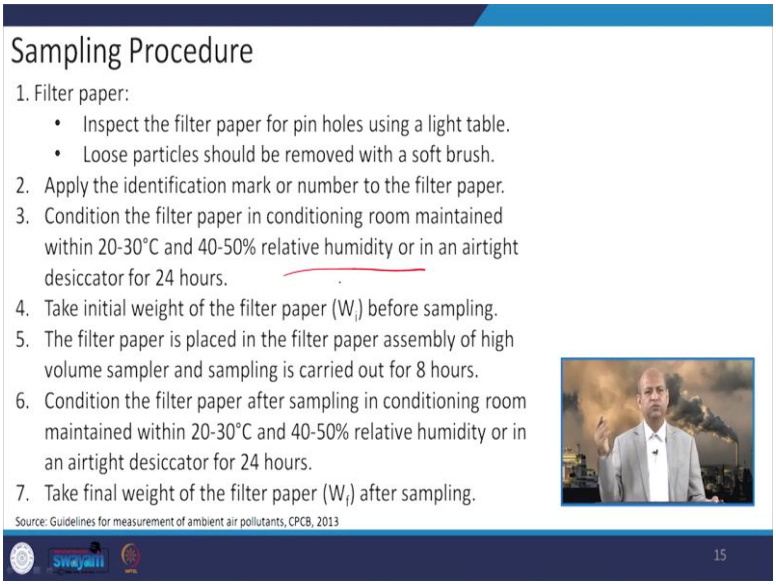

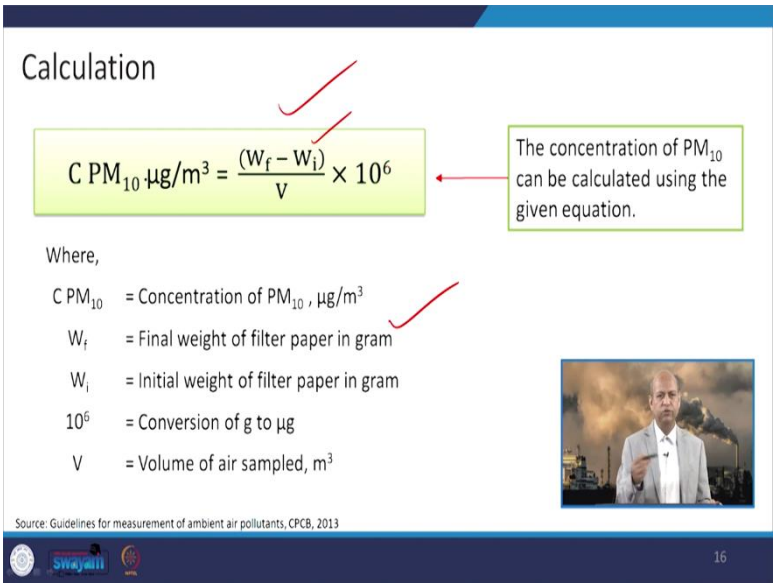

And then the sampling procedure like first of all you have to inspect the filter paper which you are going to use it should not be punctured, it should be properly intact. So, we have to inspect it and see there is no any kind of holes etc. And then loose particles are there if they are then it should be completely removed and it should be completely clean.

Then we have to put some mark of the site like where this filter paper has been used. Because there are so many like if you are conducting experiment or having monitoring at various sites, then how would you differentiate where this filter paper has come so, we have to mark that this particular filter paper has been used at that specific location then you condition it.

So, we have to for 24 hours, we have to put in a particular oven and a particular place where 20 to 30 degree Celsius temperature is there and 40 to 50 percent relative humidity. So, that

kind of those parameters are maintained then initial weight of the filter paper is measured W_i. Then filter paper is used, sampling is done and again filter paper is taken there because after collection we have to take it to the laboratory again conditioning is done.

Then final weight is observed and we use this simple formula to know the concentration in the air. So, that is the final weight of the filter paper in grams initial weight of the filter paper in grams a difference of that divided by the volume of the air which has passed through that filter paper basically.

So, that we know from the instrument itself there are we have seen there are knobs which can give the reading basically of the flow rate then we multiply it by 10 to the power 6 to convert gram into micro gram and we get the concentration of PM_{10} in ambient air.

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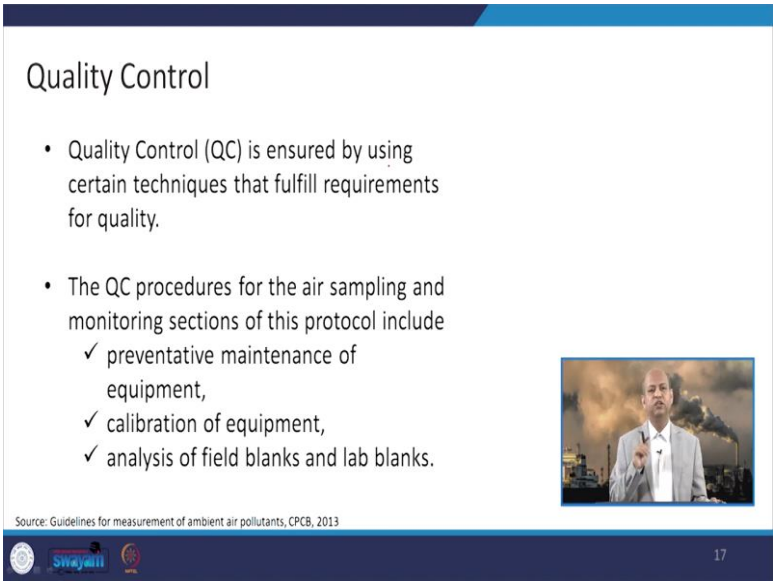

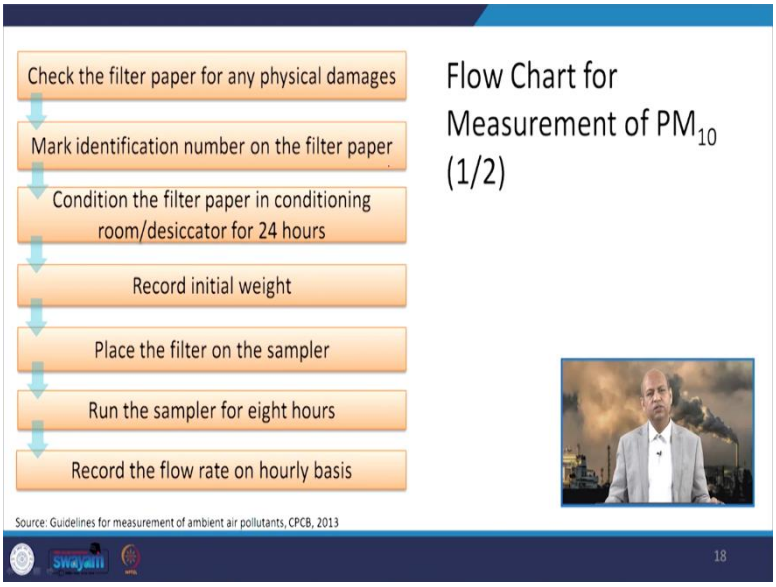

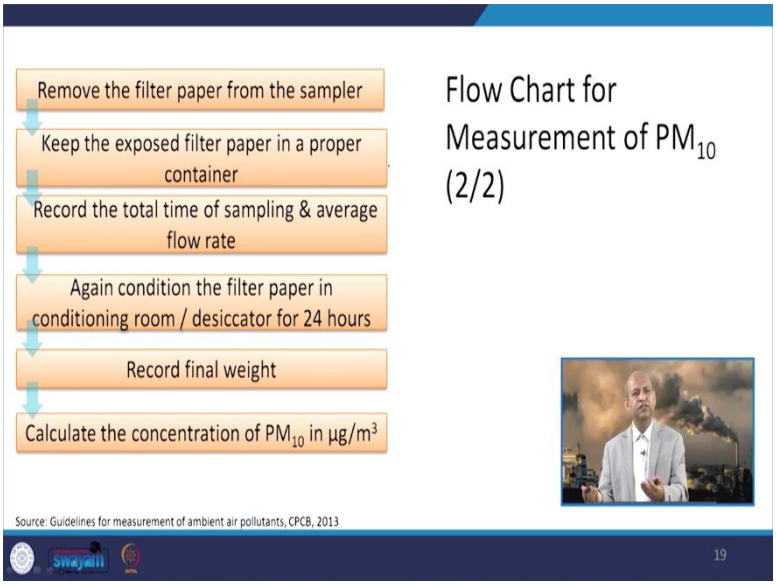

Of course, we need to do the quality control so, that proper protocol is followed. And that way to prevent maintenance related problems or calibration of the equipment is done periodically, an analysis of the field blanks and lab blanks is also carried out because sometimes the same kind of paper may have some sort of impurities.

So, the blank reading will give us to differentiate between the observed one and the reading which has been obtained with the blank filter paper. So, the flowchart for this measurement of PM_{10} is given in a very simple way like check the filter paper for any physical damages if it is damaged, remove it, take another filter paper which is of good quality.

Then mark the identification number for that particular site condition it for 24 hours so that it is free from moisture etc record the initial weight then placed on the that in high volume sampler at that assembly where it is to be placed. And then close the nuts and start it then remove after this observation of 8 hours or so.

Because for 24 hours observation we take three samples of 8 hour each then keep that filter paper in a proper container and take to the laboratory recondition it then record the final weight and calculate by using that formula. So, now we will look into this demo video which will illustrate you the sampling of PM_{10} using the high volume sampler.

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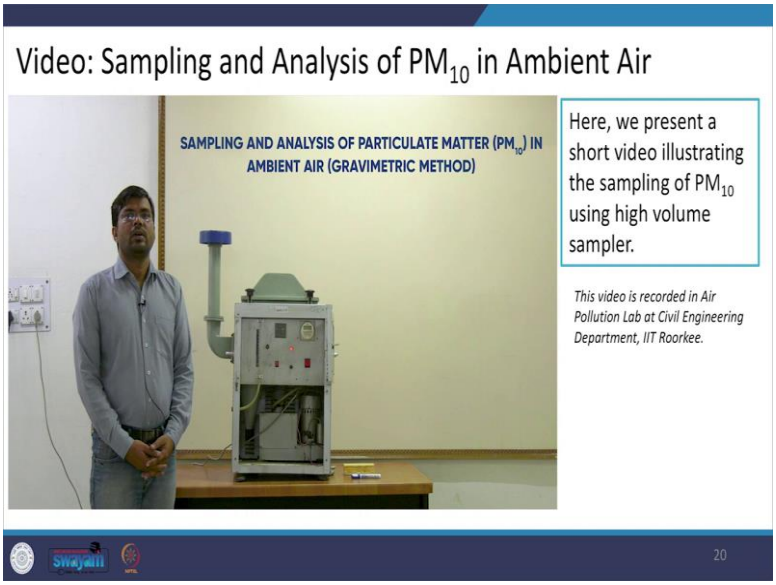

So, this is the video which has been recorded in air pollution laboratory of Civil Engineering Department at IIT Roorkee. So, that will give you the complete picture of the real instrument which is used for this particular purpose.

Narrator: Good morning friends, I welcome you all in experiment part of the subject air pollution control in this series of lecture will explain the demonstration of different instruments which are used for measurement of air pollution in ambient air. So, today I am going to discuss the first experiment of this series and the first experiment is your sampling and analysis of PM_{10} in ambient air using gravimetric analysis.

So, in order to analyze this or in order to measure the PM_{10} in ambient air, we use the instrument that is called as the high volume sampler. So, this is the instrument which we use for measurement of PM_{10} or RSPM in the ambient air. So, I will explain the different components of this device.

So, we can see this is the part of the device which is called as the inlet through which the ambient air is sucked into the device and after air enters through this inlet is passes through this part, which is the size selective inlet and the purpose of size selective inlet is to segregate the particles which are means smaller than 10 micron and those which are heavier than those. So, whatever the particles which are smaller in size from 10 micron. They will go into the filter assembly.

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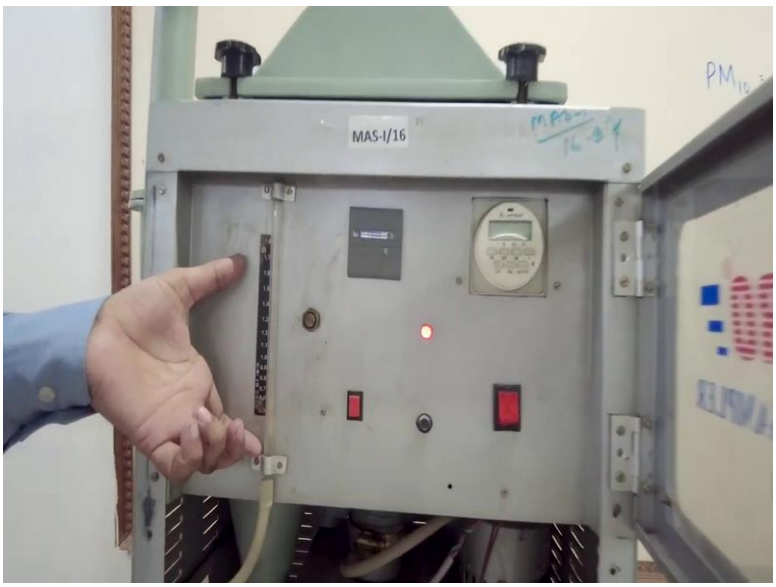

And those particles which are heavier they will be collected here this is the cyclone so, they will be collected in the hopper of the cyclone. This is the hopper so, here the heavier particles will be collected and those which are smaller than 10 micron or we will call them as PM_{10} will go into the filter assembly.

So, this is your filter assembly. And in order to suck the air from the ambient, we use this pump that is the suction pump. So, it sucks the air and it creates the negative pressure inside it and apart from that this is the filter assembly and this is your manometer and along with that scale bar is there. So through which we can directly measure the flow rate which is passing through this device. And this is your time totalizer for measurement of time. So, this is a broadly different component of the device. Now I will explain the workings of it.

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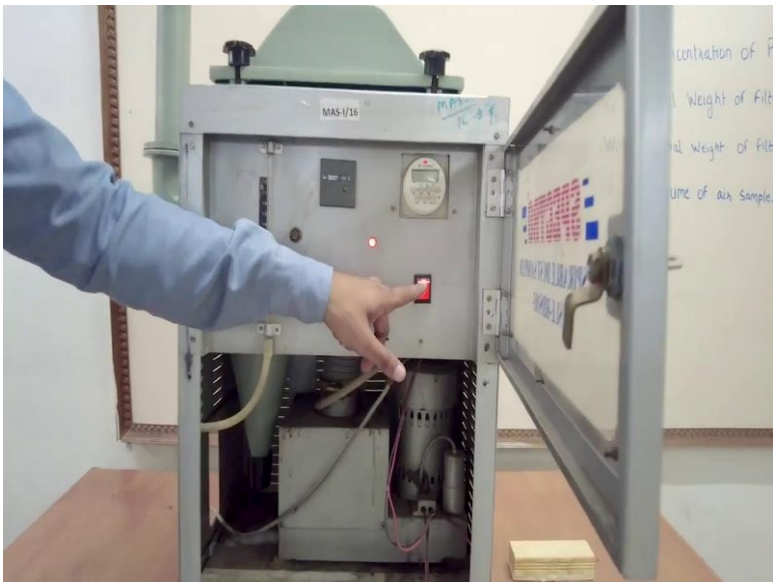
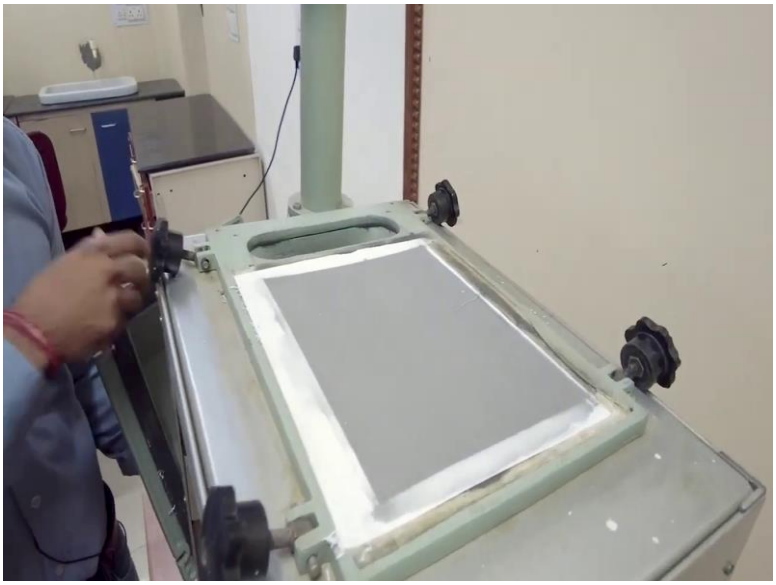



SAMPLING & ANALYSIS



So, when we switch on the device what happens the suction pump sucks the ambient air and it enters into the inlet part. So, this is the inlet part and then when it pass through this size selective inlet those particles which are smaller than 10 micron or equal to 10 micron will go into this filter assembly.

So, this part is the filter cover and these are the wing nuts. So, what we do before starting the instrument, we have to place the filter into the filter assembly. So, I will tell the different component of it. So, this is the filter cover, we have to take it out very gently and you can see that here a filter is already present. So, it is pretty dark and indicating that some sampling has already been done. So, this is the 8 into 10 inch filter and this is the upper cover generally the upper part of the filter is kept as a rough surface. When we are placing the filter over here.

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And you can see here there is a slot so, the air which is having the PM10 particles then it will come through this slot and will go into this filter assembly and it will enter through this filter. So, whatever the particle which are of the size 10 or less than 10 micron will be collected on this filter paper.

So, once we place this filter paper gently over here, then we place the filter cover like that and after placing that we have to close these wing nut tightened such that like it should not be disturbed while we are doing the sampling. Now, the important part for ensuring the quality control is that like the filter which is the quad fiber filter and 8 into 10 size.

So before placing the filter into the filter assembly, we have to do its preconditioning and for doing its preconditioning we kept it at 20 to 30 degrees centigrade, as well as at 40 to 50 percent relative humidity for nearly means 24 hour. And after doing this preconditioning we measure its weight.

So, that is called the filters pre-weight and upon doing this, then we place this filter here and upon placing this filter here, then we cover the filter from the filter cover and tighten all these wing nut. So, now our instruments is ready for doing the sampling and then we take our instrument into the sampling site and generally they are at a relatively height.

So, that like nearby obstacles will not have an impact and we will be able to get the true ambient air quality. So, after doing all this arrangement and placing the filter here and placing the device to our sampling site, we start the monitoring. So, I will just start the monitoring for demonstration purpose here.

So, you can see here in this manometer the liquid is moving up. So, through this manometer and through the scale bar, which is directly present to our cubic meter per minute flow rate. So, we can get our flow rate from this scale bar and the time from this time totalizer. Now, what is the purpose of these two things? Actually, as I said like, we will take the pre-weight and post-weight or the filter.

And from the difference of these two values, we will be able to get the mass of the PM_{10} which will be collected on the filter paper. But mass of the PM_{10} will not be sufficient because we have to present our PM_{10} pollution loading in the ambient air in terms of microgram per meter cube. So, mass per unit volume we need.

Now, from where the volume will come. So, in order to get the volume of the air which pass through the device. We have to take the two measurement, the first measurement is from the

time totalizer and second measurement is from the flow rate. Which is the taken from this scale bar directly.

So, the time totalizer reading we have to measure when we start the sampling. So, initial reading we take and when the sampling gets over, we take the final reading of this time totalizer. So, the difference of these two readings will give the total time of the sampling. And then from this manometer we will be able to measure the flow rate of the air which is passing through this.

Now the question is like, when we are placing the device in ambient air and we are doing the sampling initially your filter will be clean. So, there will be a resistance for the air to pass through it. So, we will be having a relatively higher flow rate. But as soon as the sampling process and goes further the filter starts getting dirty.

And once the filter starts getting dirty we will get the more resistance. So, pressure drop will be relatively high and because of that the flow rate will be going relatively down. Now, the question is which flow rate we should take. So, the point is to take the representative flow rate what we do the protocol is that like we generally measure the flow rate at every hour while the sampling is going on.

So, what happens generally this flow rate varies between 0.8 to 1.2 cubic meter per minute. So, let us say we have carried out the sampling for 8 hour. Then we have taken the 8 representative samples of this flow rate and then we take the average of those 8 value.

So, that will give us the average flow rate of the air which pass through this high volume sampler during the sampling. So, we got the average flow rate and through the difference of time from the time totalizer we will get the total volume, total time of the sampling. So, the product of these two quantity will give the volume of the air that pass through this device.

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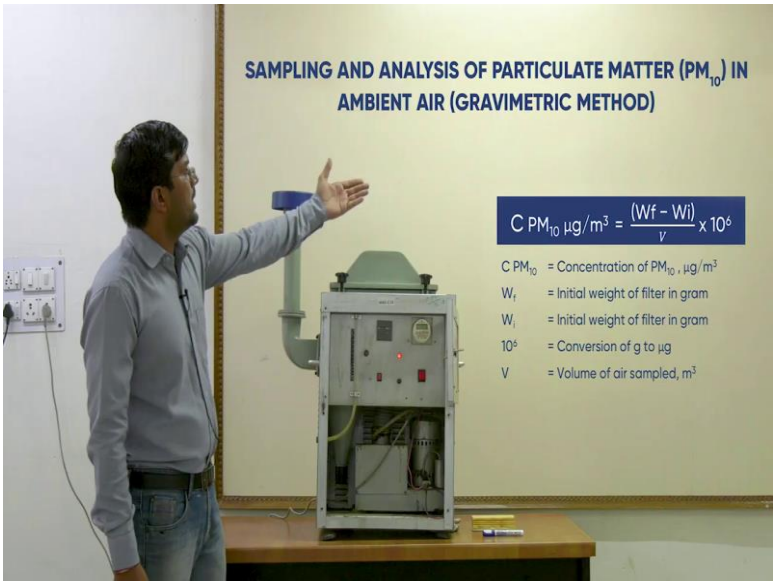

So, now I will explain you the calculation part, which I presented here. So, PM_{10} here it is representing the concentration of PM_{10} microgram per meter cube, W_f and Wi is the means initial and final weight like W_i is representing the initial weight of the filter that is presented in grams and W_f is the final weight of the filter that is presented in grams.

$$C\ PM_{10}\ \mu g/m^3 = \frac{(W_f - W_i)}{V} \times 10^6$$

So, difference of these two will give you the mass of the PM_{10} which is collected over the filter paper. And V is the volume of air which is sampled. So, which we can get through the product of the time of sampling and the average flow rate we have taken through the manometer. So, by using this formula, we will be able to get the PM_{10} concentration in the ambient air. Thank you.

Professor: Well, so, you have seen this video and I am sure that now you have better perspective, better visualization, how the high volume sampler is used for monitoring purpose or sampling purpose of PM_{10} in the ambient air. So, particulate matters of aerodynamic size less than or equal to 10 micrometer in ambient air. It is simple through this high volume sampler which we have seen it is also sometimes known as RSPM sampler.

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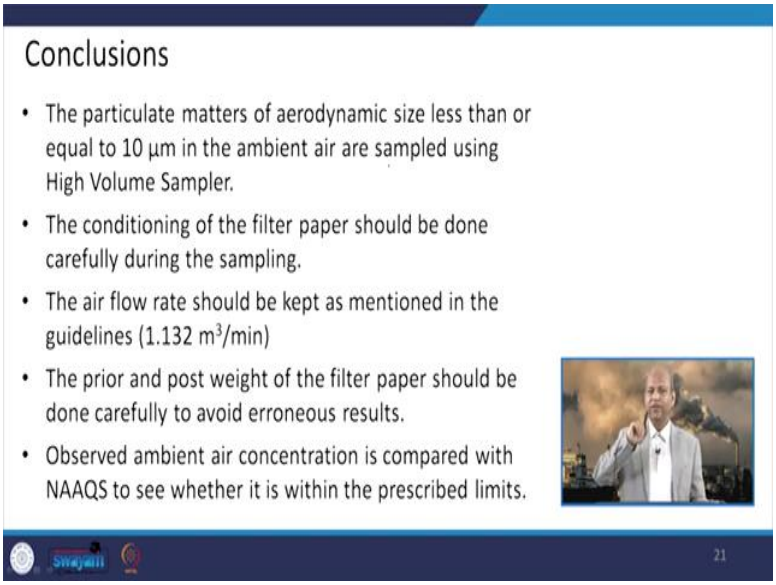

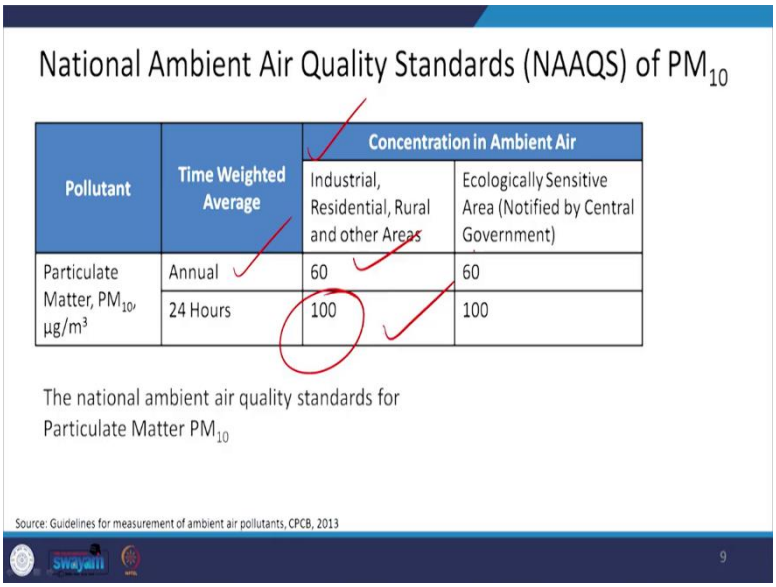

And the conditioning of filter is very important you have to remember it and the air flow rates should also be kept average like 1.132 cubic meter per minute. So, you have to note down initial, final and that way if it is changing then you have to maintain the flow rate because as this filter paper get clogged the flow rate becomes down.

So, pressure drop is there. So, you have to maintain it with the help of that motor then this difference of the final and the initial weight will give you the mass of the particles which has been collected then you divide with volume of the air and you get the concentration then you can compare it with the national ambient air quality standards of the PM_{10}.

And then you can know whether that site is okay, okay in the sense whether the concentration is less than the ambient air quality standard like for 24 hours it is 100 and for annual it is 60.

So, the observed data you can compare means if you have so, many data for annual then you calculate the average value of the annual and you compare with the annual data.

Otherwise if you are having only 24 hours data then compare with this if it is exceeding 100 then it is a problem and you have to see what the sources are and how can we control the air pollution. So, this is all for today, you can now know about and you can practice whenever you have a chance to monitor the PM_{10} by using this high volume sampler.

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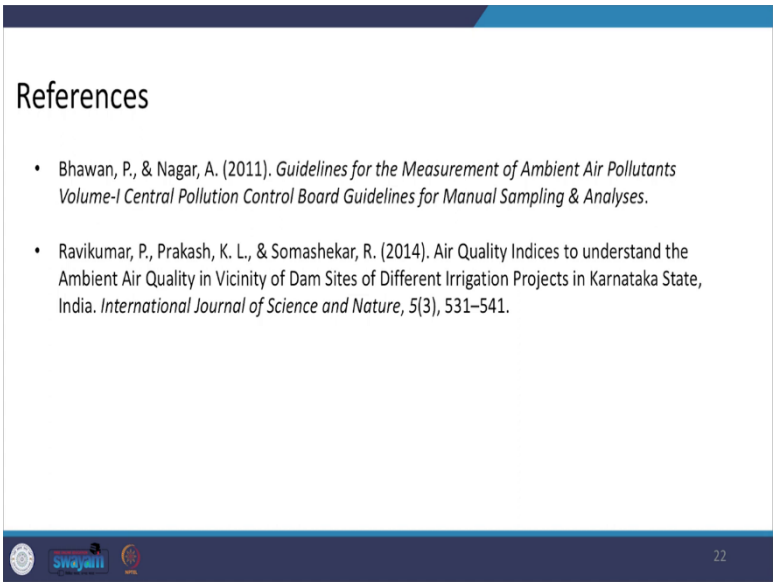

So, these are the references which we have used for this particular presentation. You can go through them if you want to know more about the procedure of guidelines which are used for sampling purpose of PM_{10}. So this is all thank you very much for your kind attention and see you in the next lecture for demonstrating to sample another air pollutant. Thank you.