

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 PM₁₀, which is also known as RSPM (Respirable Suspended Particulate Matter). So, in ambient air how do we sample and analyze the PM₁₀ 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 PM₁₀. 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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Discussed in Sources and Classification of Air Pollutants

Primary air pollutant: Particulate Matter

Particulate Matter (PM) is a mixture of solid particles, liquid droplets or both suspended in the air.

The diagram illustrates the Aerodynamic Diameter Scale for Particulate Matter (PM). It is divided into three main categories: Coarse, Fine, and Ultra Fine. The Coarse category ranges from 10 μm to 2.5 μm . The Fine category ranges from 2.5 μm to 0.1 μm . The Ultra Fine category ranges from 0.1 μm to 0.001 μm . Below the scale, three standard designations are shown: PM_{10} (covering 10 μm and below), $PM_{2.5}$ (covering 2.5 μm and below), and $PM_{0.1}$ (covering 0.1 μm and below). A red checkmark is placed under the Fine and Ultra Fine categories. A small video inset shows a man speaking in a laboratory setting.

Source: (Muhlfeld, 2008)

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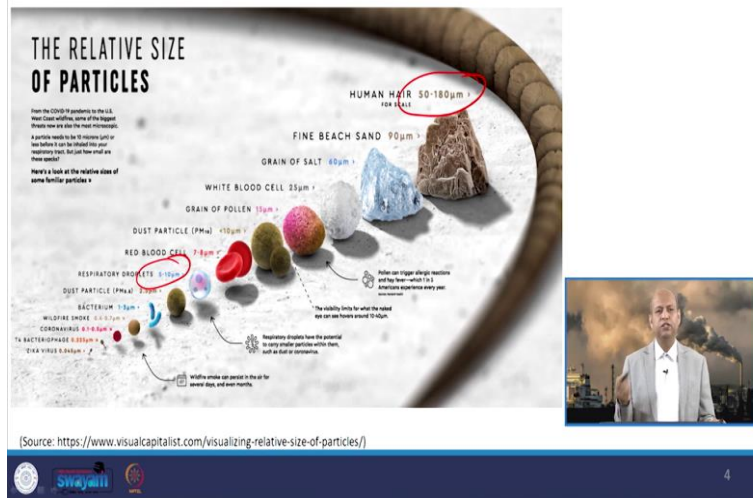
So, if we come to this revise or region of few slides which we have discussed in sources and classification of air pollutants long back. So, the particulate matter is nothing but either solid particles suspended in the air or they may also contain these liquid droplets or both maybe they are suspending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



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 PM₁₀.

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} PM₁ 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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Discussed in Sources and Classification of Air Pollutants

Classification of Particulate Matter

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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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Discussed in Sources and Classification of Air Pollutants

Classification of Particulate Matter

Types	Size	Sources
Aerosol	Less than 1 μm	Air borne suspensions
Dust	1 to 200 μm	Natural disintegration of rocks and mechanical processes
Fog	Less than 10 μm	Mist with water as liquid droplet
Fumes	0.1 to 1 μm	Chemical or metallurgical processes
Mist	Less than 10 μm	Condensation or Industrial operations
Smoke	0.01 to 1 μm	Combustion and chemical processes

1 μm (micro-meter) = 10^{-6} m
 1 nm (nano-meter) = 10^{-9} m

Source: (Sewage, Disposal, and Air Pollution Engineering, S K Garg)

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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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Discussed in Sources and Classification of Air Pollutants

PM and Human Respiratory System

Respiratory Part	Particle Size Range (µm)
Nasal opening	9.0 µm - 10.0 µm
Pharynx	5.8 µm - 9.0 µm
Trachea and primary bronchi	4.7 µm - 5.8 µm
Secondary bronchi	3.3 µm - 4.7 µm
Terminal bronchi	2.1 µm - 3.3 µm
Alveoli	1.1 µm - 2.1 µm
Alveoli	0.65 µm - 1.1 µm
Alveoli	0.43 µm - 0.65 µm

Dust particle size and penetration in respiratory tract

(Source: <https://www.thecmmgroup.com>)

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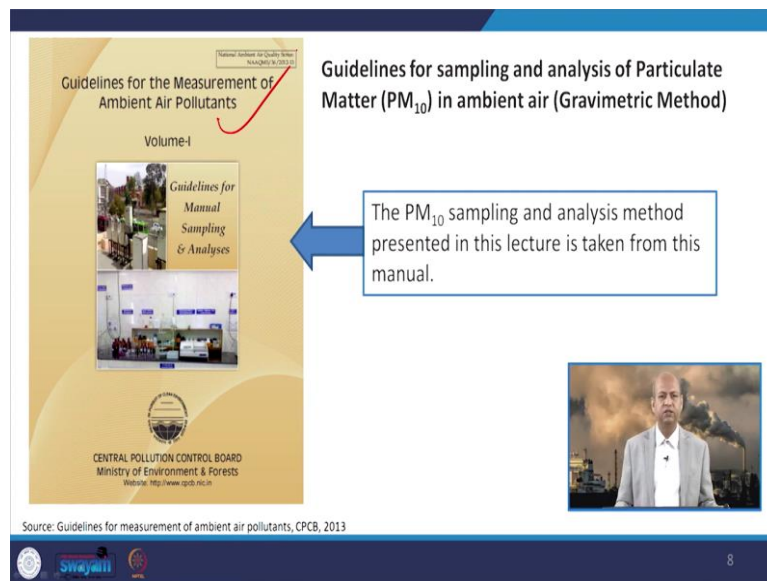
Then if we relate particulate matter and human respiratory systems, how, where they can go up to like 10 micrometers size basically up to the nasal opening they can go and it can be removed there. But the smaller particles can go through this respiratory tract and up to lungs it can go like very fine 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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Guidelines for the Measurement of Ambient Air Pollutants
Volume-I
Guidelines for Manual Sampling & Analyses
CENTRAL POLLUTION CONTROL BOARD
Ministry of Environment & Forests
Website: <http://www.cpcb.nic.in>

Guidelines for sampling and analysis of Particulate Matter (PM₁₀) in ambient air (Gravimetric Method)

The PM₁₀ sampling and analysis method presented in this lecture is taken from this manual.



Source: Guidelines for measurement of ambient air pollutants, CPCB, 2013

Well, so when we come to how to monitor these PM₁₀. What kind of instrument do we use? So, we have taken this process of monitoring the PM₁₀ 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.

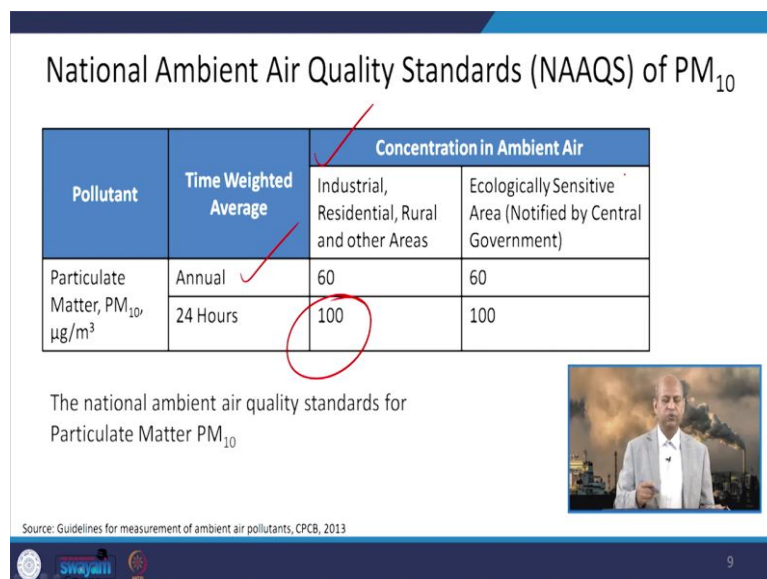
This is guidelines for measurement of ambient air pollutants, this contains several pollutants, measurement techniques. So, we have taken this PM₁₀ sampling and analysis method presented in this particular manual or document.

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National Ambient Air Quality Standards (NAAQS) of PM₁₀

Pollutant	Time Weighted Average	Concentration in Ambient Air	
		Industrial, Residential, Rural and other Areas	Ecologically Sensitive Area (Notified by Central Government)
Particulate Matter, PM ₁₀ , µg/m ³	Annual	60	60
	24 Hours	100	100

The national ambient air quality standards for Particulate Matter PM₁₀



Source: Guidelines for measurement of ambient air pollutants, CPCB, 2013


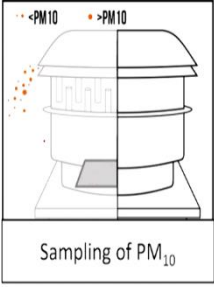
If we look into national ambient air quality standards of PM₁₀ basically two situations like industrial, residential, rural, or other areas, they are like annual standards are 60 micro meter

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 SO₂, NO₂, etc these values may differ but it depends upon their health effects and environmental effects.

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Principle of the sampling method

- Air is drawn through a size-selective inlet and through a 20.3 x 25.4 cms (8 x 10 in) filter paper at a flow rate, which is typically 1132 Litres/min or 1.132 m³/min
- Particles with aerodynamic diameter less than the cut-point (10 μm) of the inlet are collected by the filter paper.
- The mass of these particles is determined by the difference in filter paper weights prior to and after the sampling.
- The concentration of PM₁₀ in the designated size range is calculated by dividing the weight gain of the filter paper by the volume of air sampled.



Source: NAAQS Guidelines, CPCB, 2013. Image: <https://tisch-env.com/>

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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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Instrument/Equipment

- The following items are necessary to perform the monitoring and analysis of Particulate Matter PM_{10} in ambient air:
 - ✓ Analytical balance
 - ✓ Sampler : High Volume Sampler with size selective inlet for PM_{10} and automatic volumetric flow control
 - ✓ Calibrated flow-measuring device to control the airflow at 1132 litres/min (or 1.132 m^3/min)
 - ✓ Top loading orifice kit
- Reagents/Chemicals
 - ✓ Filter Media - A Glass fibre filter paper of 20.3 X 25.4 cms (8 X 10 in) size



Source: NAAQS Guidelines, CPCB, 2013; Image: <http://envirotechindia.com/apm-460/>, <https://www.indiamart.com>

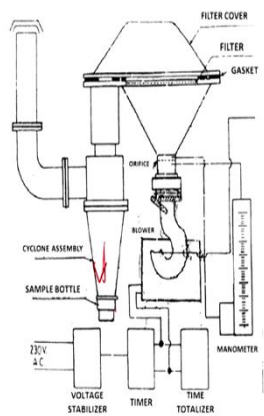
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Well, if you look into the instrument which is which are required for calculating ambient air concentration of PM_{10} . So, we need first of all analytical balance where we can weigh it we can find what is the weight and we have this high volume sampler 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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Sampling (1/3)



1. The filter paper is placed over the filter paper holding assembly and the screws of the bracket are tightened while the plastic cup is fixed to cyclone hopper.
2. The sampler is turned ON after setting the sampling time to record the initial flow rate with the help of airflow manometer.
3. Ambient air laden with suspended particulates enters the dust sampler through inlet pipe at a maintained flow rate of 0.9 to 1.2 m^3/min (average: 1.1 m^3/min) through high efficiency cyclone.



Source: Guidelines for measurement of ambient air pollutants, CPCB, 2013

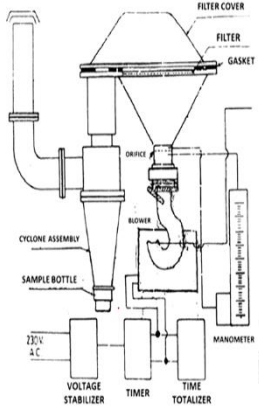
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If you look into different parts of this particular high volume sampler, then this filter paper is placed at this particular location where no filter paper loading assembly is there, you just remove this lead and put out put this filter paper and then 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 PM₁₀. So, that is the basic idea.

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Sampling (2/3)



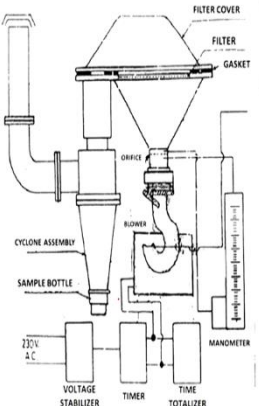
4. As the air passes through the cyclone, coarse non-respirable dust particles (> 10 micron size) get separated from air stream by centrifugal forces acting on them, which cyclones conical hopper collects in sampling plastic cup fitted at its bottom.
5. The fine dust (< 10 micron particles) forming the respirable fraction of the total suspended particulate matter (TSPM) passes through cyclone and is carried by air stream to reach filter paper clamped between the top cover and filter paper adapter assembly.
6. The respirable dust (RSPM) is retained by the filter paper (10 μ to 0.5 μ size) and carrier exhausted from the system through blower.




Source: Guidelines for measurement of ambient air pollutants, CPCB, 2013

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Sampling (3/3)



7. The flow rate at the end of the desired sampling period is recorded and the sampler is switched off.
8. Both the exposed filter paper and plastic cup are conditioned again for the same period as done prior to sampling to record their final weight after sampling.
9. The passage of air entering in the cyclone is designed in such a way to prevent heavier settleable particles from reaching in the cyclone.
10. The instrument provides instantaneous flow rate and the period of operation (on time) for calculation of air volume passed through the filter paper, while initial and final weights of exposed filter paper and plastic cup were used to calculate SPM and RSPM concentration.



Source: Guidelines for measurement of ambient air pollutants, CPCB, 2013

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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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Sampling Procedure

1. Filter paper:
 - Inspect the filter paper for pin holes using a light table.
 - Loose particles should be removed with a soft brush.
2. Apply the identification mark or number to the filter paper.
3. Condition the filter paper in conditioning room maintained within 20-30°C and 40-50% relative humidity or in an airtight desiccator for 24 hours.
4. Take initial weight of the filter paper (W_i) before sampling.
5. The filter paper is placed in the filter paper assembly of high volume sampler and sampling is carried out for 8 hours.
6. Condition the filter paper after sampling in conditioning room maintained within 20-30°C and 40-50% relative humidity or in an airtight desiccator for 24 hours.
7. Take final weight of the filter paper (W_f) after sampling.

Source: Guidelines for measurement of ambient air pollutants, CPCB, 2013



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Calculation

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

The concentration of PM_{10} can be calculated using the given equation.

Where,


$C_{PM_{10}}$ = Concentration of PM_{10} , $\mu\text{g}/\text{m}^3$

W_f = Final weight of filter paper in gram

W_i = Initial weight of filter paper in gram

10^6 = Conversion of g to μg

V = Volume of air sampled, m^3



Source: Guidelines for measurement of ambient air pollutants, CPCB, 2013

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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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Quality Control

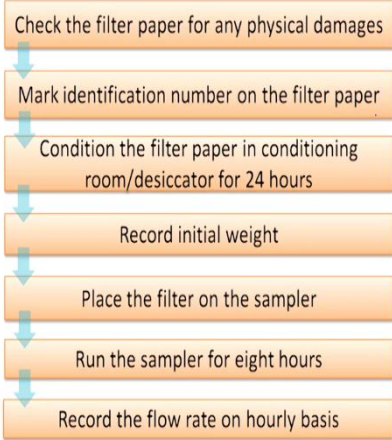
- Quality Control (QC) is ensured by using certain techniques that fulfill requirements for quality.
- The QC procedures for the air sampling and monitoring sections of this protocol include
 - ✓ preventative maintenance of equipment,
 - ✓ calibration of equipment,
 - ✓ analysis of field blanks and lab blanks.




Source: Guidelines for measurement of ambient air pollutants, CPCB, 2013

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Flow Chart for Measurement of PM_{10} (1/2)

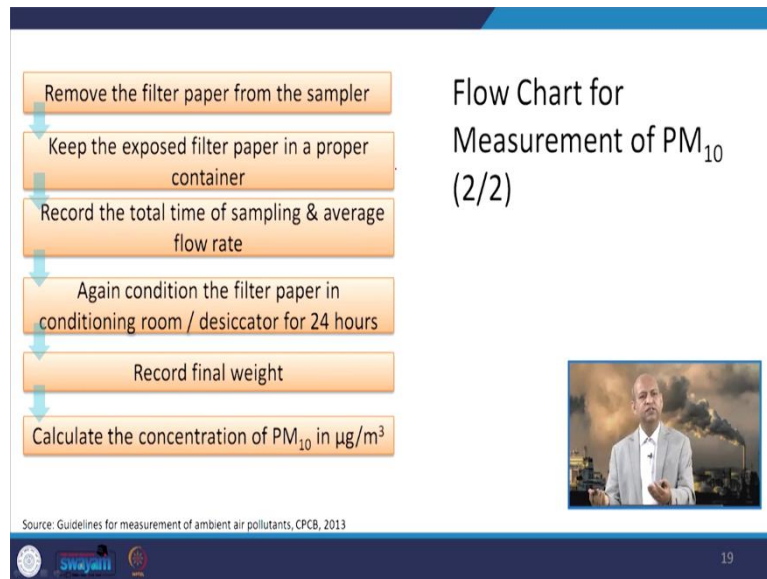


1. Check the filter paper for any physical damages
2. Mark identification number on the filter paper
3. Condition the filter paper in conditioning room/desiccator for 24 hours
4. Record initial weight
5. Place the filter on the sampler
6. Run the sampler for eight hours
7. Record the flow rate on hourly basis



Source: Guidelines for measurement of ambient air pollutants, CPCB, 2013

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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.

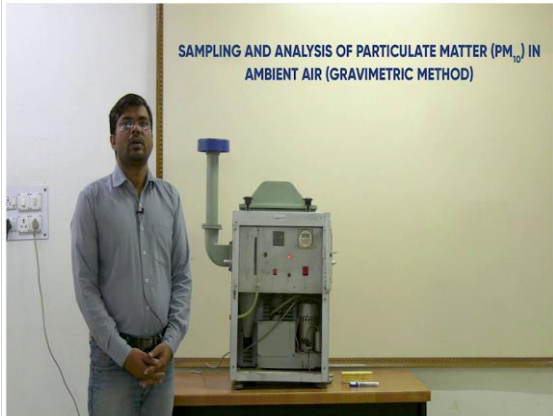
So, the blank reading will give us to differentiate between the observed one and the reading which has been obtained with the blank filter paper. So, the flowchart for this measurement of PM₁₀ is given in a very simple way like check the filter paper for any physical damages if it is damaged, remove 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 PM₁₀ using the high volume sampler.

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Video: Sampling and Analysis of PM₁₀ in Ambient Air



SAMPLING AND ANALYSIS OF PARTICULATE MATTER (PM₁₀) IN AMBIENT AIR (GRAVIMETRIC METHOD)

Here, we present a short video illustrating the sampling of PM₁₀ using high volume sampler.

This video is recorded in Air Pollution Lab at Civil Engineering Department, IIT Roorkee.

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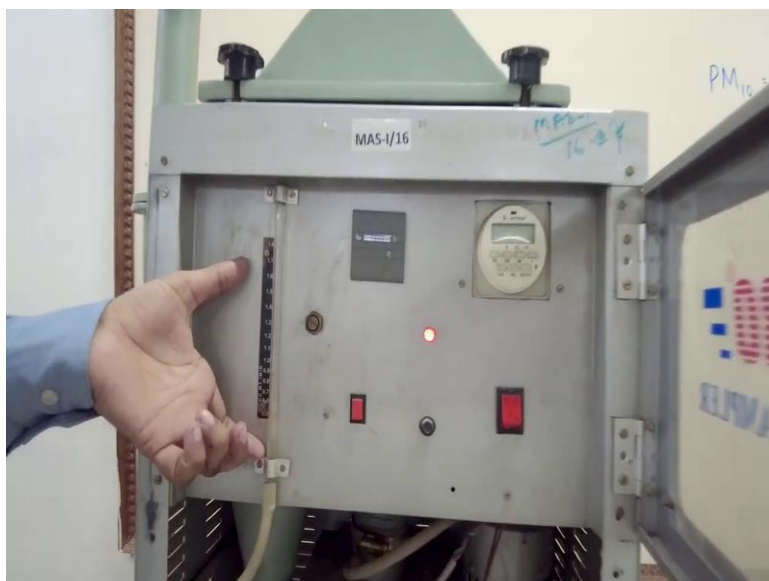
So, this is the video which has been recorded in air pollution laboratory of Civil Engineering Department at IIT Roorkee. So, that will give you the complete picture of the real instrument which is used for this particular purpose.

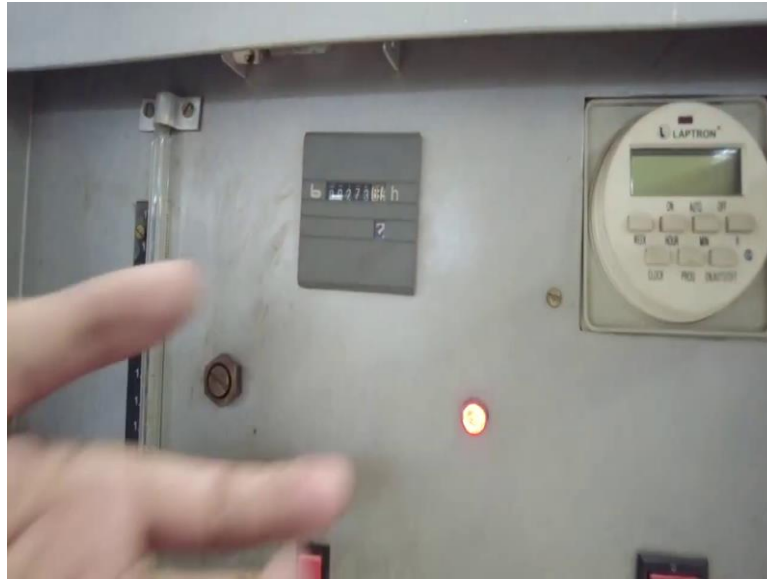
Narrator: Good morning friends, I welcome you all in experiment part of the subject air pollution control in this series of lecture will explain the demonstration of different instruments which are used for measurement of air pollution in ambient air. So, today I am going to discuss the first experiment 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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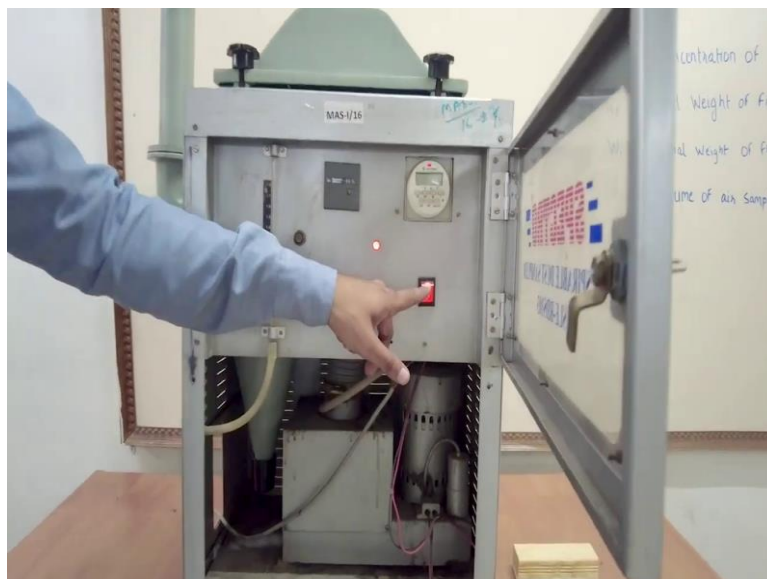




And those particles which are heavier they will be collected here this is the cyclone so, they will be collected in the hopper of the cyclone. This is the hopper so, here the heavier particles will be collected and those which are smaller than 10 micron or we will call them as PM_{10} will go into the 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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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 PM₁₀ which will be collected on the filter paper. But mass of the PM₁₀ will not be sufficient because we have to present our PM₁₀ 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 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.

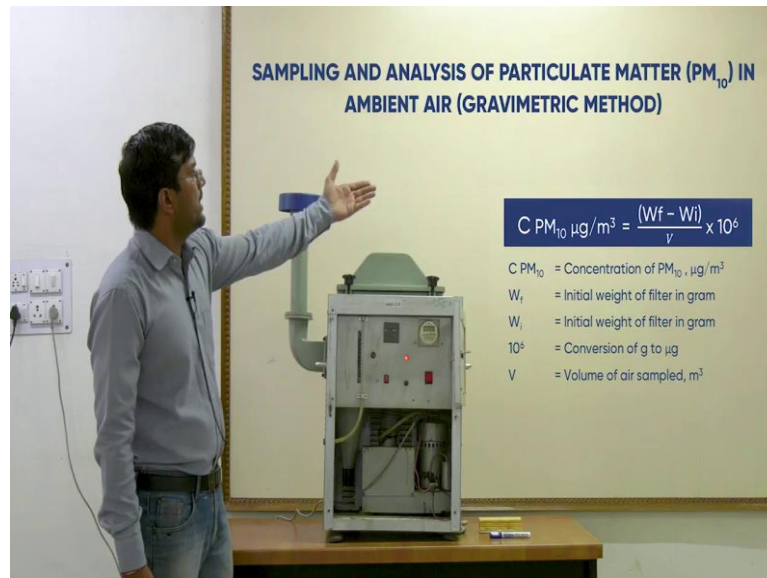
Now the question is like, when we are placing the device in ambient air and we are doing the sampling initially your filter will be clean. So, there will be a resistance for the air to pass through it. So, we will be having a relatively higher flow rate. But as soon as the sampling process and goes further 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, PM₁₀ here it is representing the concentration of PM₁₀ microgram per meter cube, W_f and W_i 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.

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


So, difference of these two will give you the mass of the PM₁₀ 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 PM₁₀ 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 PM₁₀ 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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Conclusions

- The particulate matters of aerodynamic size less than or equal to $10\ \mu\text{m}$ in the ambient air are sampled using High Volume Sampler.
- The conditioning of the filter paper should be done carefully during the sampling.
- The air flow rate should be kept as mentioned in the guidelines ($1.132\ \text{m}^3/\text{min}$)
- The prior and post weight of the filter paper should be done carefully to avoid erroneous results.
- Observed ambient air concentration is compared with NAAQS to see whether it is within the prescribed limits.



Pollutant	Time Weighted Average	Concentration in Ambient Air	
		Industrial, Residential, Rural and other Areas	Ecologically Sensitive Area (Notified by Central Government)
Particulate Matter, PM_{10} , $\mu\text{g}/\text{m}^3$	Annual	60	60
	24 Hours	100	100

The national ambient air quality standards for Particulate Matter PM_{10}

Source: Guidelines for measurement of ambient air pollutants, CPCB, 2013

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.

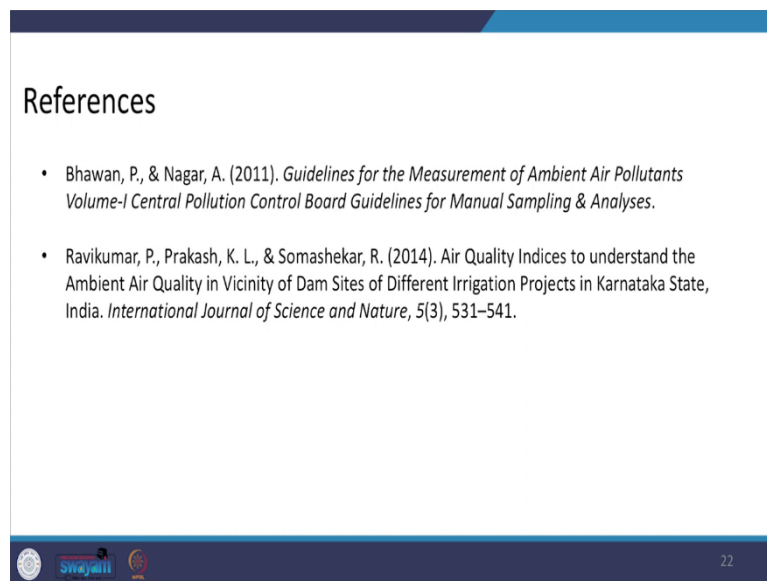
So, pressure drop is there. So, you have to maintain it with the help of that motor then this difference of the final and the initial weight will give you the mass of the particles which has been collected then you divide with volume of the air and you get the concentration then you can compare it with 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 PM₁₀ by using this high volume sampler.

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The slide is titled "References" and contains two bullet points. The first bullet point is: "Bhawan, P., & Nagar, A. (2011). *Guidelines for the Measurement of Ambient Air Pollutants Volume-I Central Pollution Control Board Guidelines for Manual Sampling & Analyses.*" The second bullet point is: "Ravikumar, P., Prakash, K. L., & Somashekar, R. (2014). Air Quality Indices to understand the Ambient Air Quality in Vicinity of Dam Sites of Different Irrigation Projects in Karnataka State, India. *International Journal of Science and Nature*, 5(3), 531–541." At the bottom of the slide, there are logos for "Swayam" and "MOE" on the left, and the number "22" on the right.

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 PM₁₀. 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.