Sampling

Types of pollutant sampling and measurement:

Air quality monitoring:
Sampling and measurement of air pollutants generally known, as air quality monitoring. It is an integral component of any air pollution control programme.

Monitoring is important:

- Air quality can be evaluated
- Information is helpful in implementing control measures for reducing pollutant concentration to acceptable levels
- Assessing the effect of air pollution control strategies
Sampling

Classification of sampling methods:

1. Sampling of impurities of every nature (Ranging from particulate matter to gases)

2. Sampling under various environmental conditions (ranging from samples taken from chimneys to samples taken in the open air)

3. Sampling methods varying according to the time factor (Ranging from intermittent to continuous sampling)
Sampling

Air Quality measurement is undertaken in two situations:

1. Ambient air quality measurement
2. Stack monitoring

**Ambient air quality measurement:** Where the pollutant levels in the ambient atmosphere are measured.

**Stack sampling:** It deals with the pollutants emitted from a source such as smoke stack and is known as stack sampling.

It provides information on the nature and quantities of various pollutants that are emitted into the atmosphere.
Sampling

Difficulties encountered in sampling:

• Collecting samples of true representative character

• Errors arising from methods used for the collection and separation of the various components of pollution.

• Difficulty in preventing any change in the concentration of particulate matter in suspension, as a result of sampling operation.
Sampling

Preliminary considerations and stages of sampling:

Following principles should be followed to ensure correct sampling

1. Statistical studies

   - Important to establish the basic data e.g. size and frequency of sampling
   - It use the basic principles of the probability

2. Size of samples

   The sample should be large enough to make analysis possible.

3. Change in the sample during and after sampling
Sampling

4. Continuous and intermittent sampling

An automatic continuous recording apparatus is preferable.

5. Sampling of volatile constituents

Carry out sampling with large volumes of air (To avoid error)

6. Sampling of particulates

Errors may be introduced due to agglomeration or breaking up of particulate matter.
Sampling

In order to eliminate the sources of error

- Sampling should be carried out under conditions that are as iso-kinetics as possible.

- A gas stream should be sampled as far as possible in the same direction and at the same speed itself but never counter-current.

- The collection surface should be as close as possible to the source of the gas stream.

- To avoid reducing the efficiency of sampling, deposits and condensation should not be allowed to form on the walls of sampling vessels.
Sampling

Sampling of waste gas

Å **Difficulties** are encountered due to high temperature, lack of uniformity in the composition of gas flow and difference in speed due to disturbances.

Å **Hence to avoid error**, the gas stream should be sampled at several points and maximum number of samples should be taken to get the average value.

Sampling in the open air

**Difficulties** arise due to
- High dilution of the pollutants dispersed in air
- Consequent need to collect large number of samples
- Difficulty of sampling under iso-kinetic conditions.
Sampling

To minimize the error of sampling continuous recording instruments should be used and samples should be collected at various places.

Also meteorological data like wind speed and direction, should be collected to know their effects on dilution or concentration of pollutant in the air.

Basic consideration of air sampling

1. The sample collected must be representative in terms of time and location
2. The sample volume should be large enough to permit accurate analysis
3. The sampling rate must be such as to provide maximum efficiency of collection
4. The duration of sampling and frequency of sampling should reflect accurately the occurrence of fluctuations in pollution level
5. The contaminants must not be modified or altered in the process of collection
Sampling

Air sampling set-up

(a) Sample collector → Flow meter → Pump

\(\Delta P_{\text{low}}\)

(b) Flow meter → Sample collector → Pump

\(\Delta P_{\text{high}}\)
Sampling

Sample collector

Nature of pollutants                  Method of analysis to be used

Sample collector

To collect gaseous pollutants       To collect Particulates matter

Grab sampling                      Sedimentation (Dust fall Jar)
Absorption in liquid                High volume filtration (Hi volume sampler)
Adsorption on solids                Tape sampler
Freeze out sampling                 Impingement
                                             Electrostatic Precipitation
                                             Thermal Precipitation
Sampling

Instruments for sampling waste gases and for atmospheric sampling

1. Devices for general use
2. Devices for sampling gases and vapors

1. Devices for general use

Meters

- They are used to determine accurately the volume of the gas collected.

- They are fitted with manometers and thermometers to indicate the pressure and temperature of the gas stream sampled.
Sampling

Probes

- They are tubes suitable for penetrating into the gas stream and should be constructed of material which are non-corrosive and which can withstand special temperature conditions.

- They should be constructed of materials (S. S, Glass or Quartz) that do not react with the substances to be sampled.

- A probe should have suitable length and diameter.

- To ensure iso-kinetic sampling condition the opening of the probe should face the gas stream to be sampled.
Sampling

Sampling probe
Suction Devices

Any suction device that has the required volumetric capacity can be used. Vacuum pumps driven by electric motors are very commonly used.
Sampling

2. Devices for sampling gases and vapors

Absorbers:
Effluent gases are passed through absorber (scrubbers) which contains liquid absorbents that remove one or more of the pollutants in the gas stream.

The efficiency of this process depends on

1. Amount of surface contact between gas and liquid
2. Contact time
3. Concentration of absorbing medium
4. Speed of reaction between the absorbent and gas

Absorbent are being used to remove sulphur dioxide, hydrogen sulphide, sulphur trioxide and fluorides and oxides of nitrogen
Sampling

Equipments using the principle of absorption for the removal of gaseous pollutants includes (1) Packed tower (2) Plate tower (3) bubble cap plate tower (4) Spray tower (5) Liquid jet scrubber absorber.

A gas can be sampled by means of a suitable absorption reagent. For this purpose, U-shaped absorbers are used.

This absorber is filled with a certain amount of reagent and fitted with a porous glass partition. So that the air or gas led into them passes through the reagent solution in the form of fine bubbles thus ensuring intimate contact

Sampling is carried out at an average rate of about 100 to 150 liters per hour of gas stream

Oxides of sulphur, Oxides of nitrogen, Ammonia, Hydrogen sulphide, Hydrochloric acid, Hydrofluoric acid, Hydrocynic acid, ozone, H/C, organic solvent are measured (0.1 ppm by volume)
Sampling

Sampling train
Sampling

Various gas absorbing devices. (A-B) Simple bubblers (C) Midget impinger (c) Greenburg Smith standard impinger (E-F) Fritted absorbers (G-H) Spiral type absorbers
Sampling

Utility and specification of various absorbers for air sampling

<table>
<thead>
<tr>
<th>Type of absorber</th>
<th>Absorbent capacity (ml)</th>
<th>Sampling Rate (L/min)</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample bubbler</td>
<td>10-100</td>
<td>1-30</td>
<td>General propose; short contact between gas and liquid</td>
</tr>
<tr>
<td>Standard impinger</td>
<td>50-100</td>
<td>28 or less</td>
<td>Useful for readily soluble gases and vapours</td>
</tr>
<tr>
<td>Midget impinger</td>
<td>10-25</td>
<td>2.8</td>
<td>Useful for readily soluble gases and vapours</td>
</tr>
<tr>
<td>Scrubber with fritted glass or other diffuser</td>
<td>25-100</td>
<td>5.20</td>
<td>Good gas-liquid contact, but diffuser has a tendency to glass or other diffuser plug</td>
</tr>
<tr>
<td>Spiral scrubber</td>
<td>10-100</td>
<td>0.004-0.5</td>
<td>Effective only at low flow rates</td>
</tr>
<tr>
<td>Packed tower</td>
<td>5-50</td>
<td>0.5-2.0</td>
<td>Variable resistance; effective only at low flow rates</td>
</tr>
<tr>
<td>Spray absorber</td>
<td>50-100</td>
<td>1-30</td>
<td>Capacity of absorbent depends on design and size of absorber; useful for large-volume sampling</td>
</tr>
</tbody>
</table>
Sampling

Gas absorbing devices

Simple bubbler
Disc type
Tip type
(Fritted absorbers)

Greenburg - Smith type
Impingers
Midgat type
Sampling

Adsorbers

Adsorption is brought about by aspiring the air or gas to be sampled through adsorption column containing silica gel, activated charcoal or another suitable agents.

After adsorption, the different pollutants can be extracted from the column in various ways. e.g. by rising the temperature

**Difficulties:** Selecting a suitable adsorbing medium

**Application:** used for **ozone** and **light H/C**
Sampling

Condensers

The gas stream sampled is cooled in suitable containers, thus bringing about the condensation of the Volatile substances.

Condensation trap can be arranged either series or parallel at decreasing temperature.

Using various coolants e.g. ice, liquid air or liquid nitrogen can separate the components separated by fractional condensation.

Used for the sampling of odoriferous substances.
Sampling

Condensers

The gas stream sampled is cooled in suitable containers, thus bringing about the condensation of the Volatile substances.

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**Used** for the sampling of *odoriferous* substances.
Sampling

Collector under reduced pressure

For some substances like nitric acid and aldehydes having high molecular weight, absorption in aqueous solution is sometimes incomplete.

In such cases, it is to use bottles of known volume of collecting under a pressure reduced to 200 mm Hg or even less.

The absorbent solution chosen is first introduced into the bottle and the pressure is thus reduced. Then the sample is admitted until the internal and external pressures are equal and the container is shaken continuously so as to ensure maximum absorption.

Use for sampling the oxides on N₂
Sampling

Plastics containers

Special polyethylene bags are used for collecting and transporting large volume of air.

Advantages:

They can be used for successive analysis of small fractions of sample taken.
Polyethylene is inert with respect to many substances including SO$_2$, and formaldehyde

Plastics bags are not suitable for collecting and storing aerosol suspensions because of the possible generation of electrostatic charges, as a result of which the aerosol tend to move towards the walls and condense on them.

Used for grab sampling and sample storage before analysis
Sampling

Samples for Mass Spectrometric analysis

Sampling for mass spectrometric analysis can be carried out by compressing the gas sample in a pressure flask so as to concentrate a large quantity of gas in a small volume or by fling evacuated containers.
Sampling

Duration of Sampling Period

Two types of sampling are used (1) Short period or Spot sampling and (2) Continuous sampling.

It is used to evaluate peak and average concentration over definite time intervals.

Spot sampling

Samples are collected over periods varying from less than 30 minutes to several hours for specific proposes.

The choice of sampling period depends upon

- Nature of the component under study
- Its stability to oxidation, light or other factors such as sensitivity, accuracy and precision of the analytical method to be used.
Sampling

Short sampling is useful for the random checking of pollution at many points.

Such samples have limited value because pollution levels fluctuate widely depending on meteorological conditions, topographical features and various factors associated with sources of pollution (e.g. Mass rates of emission of pollutants form smoke stacks, the temperature, velocity and density of stack gases the height of smoke stacks, the distribution of sources and downwind distance form the sources to the points where the measurement are made).
Sampling

Continuous sampling:

Techniques are useful in **systematic studies** of the nature and extent of air pollution if the data are to be value for epidemiological surveys, for evaluating the potential hazards to man, animal or vegetation and for control programmes.

It can be carried out by the subsequent analysis of pollutant by appropriate analytical techniques.
Sampling

Location of sampling sites

Sampling sites must be carefully selected so as to be representatives of the area under study.

A representative number of sampling stations for a given area may be established by means of a preliminary survey whose objectives should be

1. To gather information on the nature and magnitude of the emission from principal sources of pollution.
2. To review the available climatologically and meteorological data
3. To gather data on the concentration of pollutants in areas of severe and slight air pollution
Sampling

Collection of Gaseous air Pollutants:
1. Grab sampling
2. Absorption in liquid
3. Adsorption on solids
4. Freeze-out Sampling

1. Grab sampling

In grab sampling the sample is collected by filling an evacuated flask or an inflatable bag.

Plastics bag are widely used.

Bag sampling: Disadvantages: Losses caused by moisture condensation or diffusion through the walls of the bag. The losses can be minimized by performing the analysis immediately following collection.

Grab sampling may be taken using rigid wall containers made from glass or stainless steel.
Sampling

Various devices for collection of gaseous air samples
Sampling

Absorption in liquid
Absorption separates the desire pollutant form air either through direct solubility in the absorbing medium or by chemical reaction.

1. Fitted glass absorber
2. Impingers

Fitted glass absorber

The gas stream is broken up into extremely small bubbles, thus promoting an intimate contact between the gas and the liquid.

Frits designated coarse (50 µm pore size) are used for air sampling. The glass frit can become blocked and is difficult to clean after use. So pre filter the air prior to sampling.
Sampling

Impingers

In the Impingers the gas stream is impinged at high velocity onto a flat surface thus providing good contact between the gas and liquid.

The flat surface can be the bottom of the collector or a specially designed plate.

Two types of Impingers: (1) Wet Impingers (2) Dry Impingers

Wet Impingers:
Collect a particle by causing them to impinge a surface submerged in a liquid.

Dry Impingers:
Referred to as impactors collect particles by impaction on a dry surface.
Sampling

In both the apparatus, collection results as result of inertial force as the particles tend to resist a change in the direction when the air stream is deflected by a surface or other obstacle.

The efficient is very high whose diameter is 1 µ or grater.

There are two types if Impingers (wet collector)

- Greenberg- Smith
- Midget type

Devices can handled sample flow rate of about 30 and 3 liter per minute respectively

Easy to clean and maintain.
Sampling

Impingers
Sampling

Midget fitted impingers  Standard midget impingers

ALL DIMENSIONS IN MILLIMETRES
Sampling

Adsorption:
This method is based on the tendency of gases to be adsorbed on the surface of solid materials.

The sample air is passed through a packed column containing a finely divided solid adsorbent on whose surface the pollutants are retained and concentrated.

Solid adsorbent: Granular porous solids: Activated Charcoal, Silica gel
After adsorption, the sample gases are desorbed for analysis.

This may be accomplished by heating the adsorbent to volatilize the trapped materials or by washing it with a liquid solvent.

Most organic vapors are analysed by gas chromatographic techniques that directly use the adsorption of the gases.

Disadvantages: Desorption of gases are complicated
Sampling

Freeze out Sampling:

In freeze out sampling a series of cold traps, which are maintained at progressively lower temperature, are used to draw the air sample, whereby the pollutants are condensed.

The traps are brought to the laboratory, the samples are removed and analyses by means of gas chromatographic, infrared or ultraviolet, spectrophotometer, and mass spectrometry or by wet chemical means.

Disadvantages: Plugging of the system because of Ice formation
Freeze out Sampling:

### Coolants used for freeze-out traps

<table>
<thead>
<tr>
<th>Coolant</th>
<th>Temp. Attained (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ice-water</td>
<td>0</td>
</tr>
<tr>
<td>Ice-salt</td>
<td>-21</td>
</tr>
<tr>
<td>Dry ice and acetone</td>
<td>-79</td>
</tr>
<tr>
<td>Liquid air</td>
<td>-147</td>
</tr>
<tr>
<td>Liquid oxygen</td>
<td>-183</td>
</tr>
<tr>
<td>Liquid nitrogen</td>
<td>-196</td>
</tr>
</tbody>
</table>