1.8 STACK SAMPLING AND ANALYSIS OF PARTICULATE AND GASEOUS POLLUTANTS

Air sampling is the process of capturing contaminants in a known volume of air. The airborne contaminants are measured and compared against the volume of air and the results are stated as a concentration, usually as milligrams per cubic meter or parts per million.

- There are two main types of air sampling that can be conducted to estimate the levels of workers' exposure to a certain contaminants.

    1. Stationary or area monitoring
    2. Personal chemical exposure monitoring.

- Personal exposure monitoring measures an individual employee's exposure to a chemical or contaminant and area monitoring measures the concentration of a substance in a given area.

Levels of airborne contaminants can be compared with the following guidelines and standards:

The permissible exposure limit (PEL or OSHA PEL)

- It is a legal limit in the United States for exposure of an employee to a chemical substance or physical agent such as high level noise. Permissible exposure limits are established by the Occupational Safety and Health Administration (OSHA). Most of OSHA's PELs were issued shortly after adoption of the Occupational Safety and Health (OSH) Act in 1970.

Threshold limits value:

- The TLV for chemical substances is defined as a concentration in air, typically for inhalation or skin exposure. Its units are in parts per million (ppm) for gases and in milligrams per cubic meter (mg/m3) for particulates such as dust, smoke and mist. The basic formula for converting between ppm and mg/m3 for gases is ppm = (mg/m^3) * 24.45 / molecular weight. This formula is not applicable to airborne particles.

Three types of TLVs for chemical substances are defined:

- Threshold limit value − time-weighted average (TLV-TWA): average exposure on the basis of a 8h/day, 40h/week work schedule
- Threshold limit value − short-term exposure limit (TLV-STEL): A 15-minute TWA exposure that should not be exceeded at any time during a workday, even if the 8-hour TWA is within the TLV-TWA.
- Threshold limit value − ceiling limit (TLV-C): absolute exposure limit that should not be exceeded at any time
- There are TLVs for physical agents as well as chemical substances. TLVs for physical agents include those for noise exposure, vibration, ionizing and non-ionizing radiation exposure and heat and cold stress.

Recommended exposure limit (REL):

- It is an occupational exposure limit that has been recommended by the United States National Institute for Occupational Safety and Health
- These levels are the exposure that, in the judgment of NIOSH,will not cause adverse health effects in most workers.

Basic Principles of Sampling and Analysis

1. The components of the air pollution monitoring system includes the,
    - Collection or sampling of pollutants both from the ambient air and from specific sources.
    - The analysis or measurement of the pollutant concentration.
    - The reporting and use of the information collected.
2. Emissions data collected from point sources are used to determine compliance with air pollution regulations, determine the effectiveness of air pollution control technology, evaluate production efficiencies, and support scientific research.

3. The EPA has established ambient air monitoring methods for the criteria pollutants, as well as for Toxic Organic (TO) compounds and In-Organic (IO) compounds.
4. The methods specify precise procedures that must be followed for any monitoring activity related to the compliance provisions of the Clean Air Act.
5. The procedures regulate sampling, analysis, calibration of instruments and calculation of emissions.
6. The concentration is expressed in terms of mass per unit volume, usually micrograms per cubic meter ($\mu g/m^3$).

Sampling Guidelines

Survey for preliminary information

During ambient air pollutants sampling, it is also necessary to collect information on qualitative and quantitative data on the local sources of air pollution, topography, population distribution, land use pattern, climatology, etc., depending upon the objectives of the survey or measurement campaign.

Example:

An area map to locate pollution sources and monitoring, locations, sources of pollution situated at far distances, etc., and other relevant data that describe the behaviour of the atmosphere for a specific pollutant to be sampled may also be required.

- It includes:
  1. Selection of sampling procedures including procedures for analysis of sampler
  2. Sampling locations
  3. Period of sampling, frequency of sampling and duration
  4. Auxiliary measurements (including meteorological parameters)
  5. Processing of data.

Selection of Sampling Procedure

There are two types of sampling

- ❑ Continuous
- ❑ Time averaged insitu sampling

1. **Continuous Sampling**

Continuous sampling is carried out by automatic sensors, optical or electrochemical and spectroscopic methods which produce continuous records of concentration values.

2. **Time Averaged in-Sampling**
    - The specific time-averaged concentration data can then be obtained from continuous records.
    - Time-averaged data can also be obtained by sampling for a short time i.e., by sampling a known volume of air for the required averaging time.
    - Samples are then analyzed by establishing physical, chemical, and biological methods for the concentration values which are the effective average over the period of sampling.

Sampling Locations

- ➢ Sampling locations are in general governed by factors like objectives, method of sampling and resources available.
- ➢ If the objective is to study health hazards and material damages, then locations should ne kept close to the objects.
    - ❑ Where the effects are being studied and should be kept at breathing level in the population centres, hospitals, schools, etc.
- ➢ For vegetation, it should be at foliage level.
- ➢ For background concentration, sampling location should be away from the sources of pollution.
- ➢ Fit can also be done by gridding the entire area to get statistically recommended values.
- ➢ The number of locations, however, depends upon the variability of concentration over the area under survey.
- ➢ A spot checking may be done to decide the location besides considering practical factors.

- Period of sampling, frequency and duration: Period,, frequency and duration of sampling should be appropriate to the objectives of the study.
- It should be such that the measured quantities are trapped in the sample at the end of the sampling.
- It is preferable to observe a sampling period consistent with the average times for which air quality standards of the given pollutants are specified.

Sources and Ambient sampling analysis:

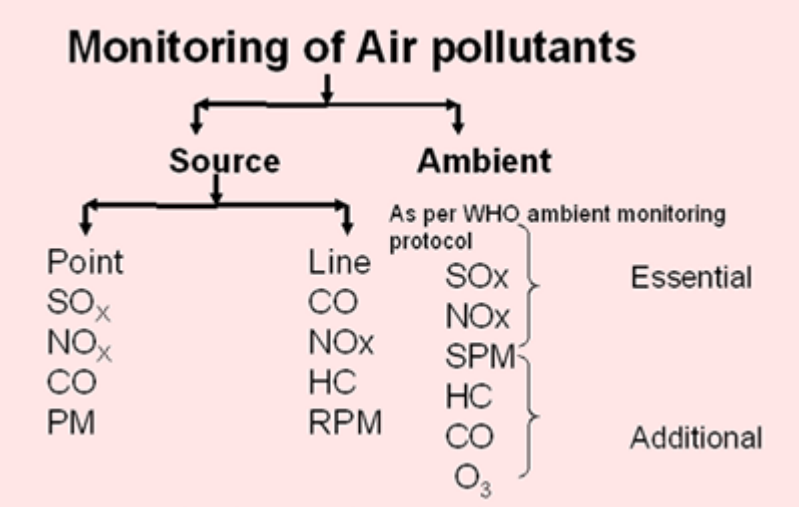

Figure 1.8.1 Sources and Ambient sampling analysis

[Source: https://images.app.goo.gl/GNYTY9nZER5McWYNA]

Most frequently occurring pollutants in an urban environment are particulate matters (suspended particulate matter i.e. SPM and respirable suspended particulate matter i.e. RSPM), carbon monoxide (CO), hydrocarbons (HC), sulfur dioxide (SO2), nitrogen dioxide (NO2), ozone (O3) and photochemical oxidants.

Source Monitoring Instruments:

- ❖ Pollutants
- ❖ Velocity
- ❖ Temperature
- ❖ Pressure

- The recommended criteria for siting the monitoring stations :

- ❖ The site is dependent upon the use/purpose of the results of the monitoring programs.
- ❖ The monitoring should be carried out with a purpose of compliance of air quality standards.
- ❖ Monitoring must be able to evaluate impacts of new/existing air pollution sources.
- ❖ Monitoring must be able to evaluate impacts of hazards due to accidental release of chemicals.
- ❖ Monitoring data may be used for research purpose.

Types of ambient monitoring stations:

Station type	**Description**
Type A	Downtown pedestrian exposure station- In central business districts, in congested areas, surrounding by buildings, many pedestrians, average traffic flow > vehicles per day. Location of station- 0.5 m from curve; height 2.5 to 3.5 m from the ground.
Type B	Downtown neighborhood exposure stations- In central business districts but not congested areas, less high rise buildings, average vehicles < 500 vehicles per day. Typical locations like parks, malls, landscapes areas etc.Location of station- 0.5 m from curve; height 2.5 to 3.5 m from the ground.
Type C	Residential population exposure station – In the midst of the residential areas or sub-urban areas but not in central business districts. The station should be more than 100 m away from any street.
Type D	Mesoscale stations – At appropriate height to collect meteorological and air quality data at upper elevation;

	main purpose to collect the trend of data variations not human exposure.Location – roof top of tall buildings or broadcasting towers.
Type E	Non-urban stations – In remote non-urban areas, no traffic, no industrial activity. Main purpose to monitor trend analysis.
Type F	Specialized source survey stations – to determine the impact on air quality at specified location by an air pollution source under scrutiny.

Table1.8.1Types of ambient monitoring stations

Frequency of data collection:

Gaseous pollutants: continuous monitoring

Particulates: once every three day

Number of stations:

- Minimum number is three.
- The location is dependent upon the wind rose diagram that gives predominant wind directions and speed.
- One station must be at upstream of predominant wind direction and other two must at downstream pre dominant wind direction.
- More than three stations can also be established depending upon the area of coverage.

Components of ambient air sampling systems:

Four main components are:

1.Inlet manifold

2.Air mover

3.Collection medium

4. Flow measurement device

Characteristics for ambient air sampling systems:

Five main characteristics are:

1.Collection efficiency

2.Sample stability

3.Recovery

4. Minimal interference

5. Understanding the mechanism of collection

Basic considerations for sampling:

- Sample must be representative in terms of time, location, and conditions to be studied.
- Sample must be large enough for accurate analysis.
- The sampling rate must be such as to provide maximum efficiency of collection.
- Duration of sampling must accurately reflect the fluctuations in pollution levels i.e. whether 1-hourly, 4-hourly, 6-hourly, 8-hourly, 24-hourly sampling.
- Continuous sampling is preferred.
- Pollutants must not be altered or modified during collection.

Errors in sampling by HVS:

- Particulates may be lost in sampling manifold – so not too long or too twisted manifold must be used.
- If 'isokinetic' conditioned are not maintained, biased results may be obtained for particulate matters.

Advantages of HVS:

- High flow rate at low pressure drop

- High particulate storage capacity
- No moisture regain
- High collection efficiency
- Low cost
- Not appreciable increase in air flow resistance
- Filter is 99% efficient and can collect the particles as fine as 0.3 µm
- Absorption principle is 99% efficient in collecting the gases.