Al-Karkh University of Science
College of Energy and Environmental Sciences
Department of Environmental

Second year level

Air Pollution Lab

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Lab (1)
Air Pollution

Air pollution is defined as the introduction of pollutants, organic molecules, or other unsafe materials(including those of biological origin) into Earth's atmosphere.

There is a certain percentage of gases present in the atmosphere. An increase or decrease in the composition of these gases is harmful to survival. This imbalance in the gaseous composition has increased Earth's temperature which is known as **global warming**.

Air pollution is probably one of the most serious environmental problems confronting our civilization today. Most often, it is **caused by human activities** such as mining, construction, transportation, industrial work, agriculture, smelting, etc. However, natural processes such as volcanic eruptions and wildfires may also pollute the air, but their occurrence is rare and they usually have a local effect, unlike human activities that are ubiquitous causes of air pollution and contribute to the global pollution of the air every single day.

We can divide the study of air pollution into:

1. The generation and control of air pollutants at their source. This first area involves everything that occurs before the pollutant is released "up the stack" or "out the tailpipe. "

2. The transport, dispersion, chemical transfonnation in, and removal of species from the atmosphere. This second area thus includes all the chemical and physical processes that take place between the point of emission and ultimate removal from the atmosphere.

3. The effects of air pollutants on human beings, animals, materials, vegetation, crops, and forest and aquatic ecosystems, including the measurement of gaseous and particulate species.

Classification of air pollutants :

The air pollutants can be classified in many ways as shown below:

1-According to origin: The air pollutants are classified into:

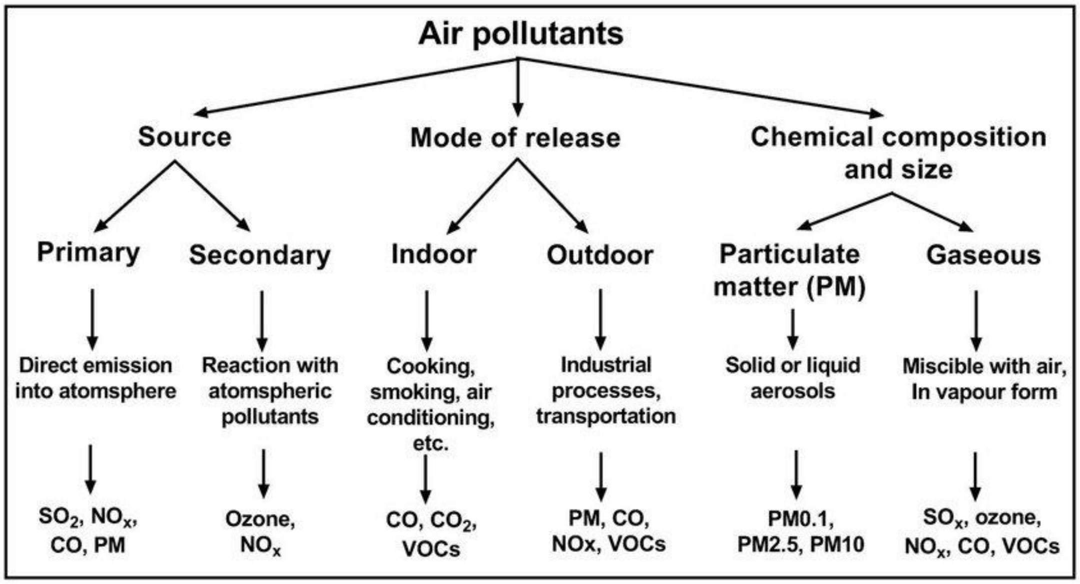
Primary Pollutants	**Secondary Pollutants**
The pollutants that directly cause air pollution are known as primary pollutants.	The pollutants formed by the intermingling and reaction of primary pollutants are known as secondary pollutants.

2-According to state of matter: The pollutants are classified into:-

Particulate Pollutants	**Gaseous Pollutants**
1. Lead 2. Fly Ash 3. Metallic Oxides 4. Nanoparticles	1. Carbon monoxide (CO) 2. Carbon dioxide (CO2) 3. Chlorofluorocarbons (CFCs) 4. Ozone (O3) 5. Nitrogen oxide (NOx) 6. Sulphur dioxide (SO2)

3-According to sources: Pollutants originate from:

Natural sources	**Man-made sources**
volcanic eruptions, deflation of sand and dust forest or wild fires of natural vegetation	human activities such as industries, factories. Automobiles Agriculture domestic burning of wood and burning of fossil fuels mining, waste treatment plants and power plant



Most Common Types of Air Pollutants

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Lab (2)

Measuring the average amount of particles deposited and accumulating on horizontal surfaces

Objective:

To test air quality by measuring the average amounts of particles deposited and accumulating on horizontal surfaces for different sites.

Theory:

A particular substance is produced by human activities, urban and industrial processes, and combustion processes, friction of car tires and the movement of vehicles, especially diesel-powered vehicles. This material is returns to earth after being released by earth's gravity and is usually more than 10 micrometers in diameter.

As a result of multiple particle sources, it is a mixture of different components with multiple chemical content and different physical properties different in terms of size, shape, diameter and mass.

The sedimentation method is one of the simplest and oldest methods for measuring the amount of particles in the surrounding air deposited on the ground.

In this experiment, calm, dry days (not rainy) should be chosen, because rain washes away these particles dropping it on the surface of the earth). The best places to carry out this experiment are commercial areas, crowded streets, and places where there are marketing.

The materials and tools used:

1 . Similar plastic utensils of equal capacity, 3 pcs.

2 . thread.

3. Permanent black pen.

4 . piercing machine.

5 . Electron microscope.

6 . Vaseline or glycerin.

7 . An electronic sensitive scale with four squares arranged after the sorter.

8 . Digital camera.

9 . plastic blade.

Procedure:

1 . Put a little bit of Vaseline on each container and then distribute it with the blade over its entire area as evenly as possible.

2 . Weigh the plastic containers separately using a sensitive scale and record your results in the table below.

3 . Number each of the plastic pots using the black pen with the numbers 1, 2 and 3.

4 . Punch the pots and insert pieces of string through them for the purpose of fixing the pots.

5 . Choosing 3 different locations in the open air far from sources of pollution and secure places, then fixing them with a string on horizontal surfaces above the ground, at a height of 2 m.

6 . Leave the utensils in the air for at least two days, recording the date and time.

7 . After the time has elapsed, bring the utensils to the laboratory and weigh the contaminated utensils.

8 . Subtract the weight of the container before exposure from the weight of the container after exposure to produce the weight of particulate matter pollutants.

The weight of the container before exposure - the weight of the container after exposure = the weight of the pollutants

9 . Record your results in the following table:

No.	Location	Weight before exposure	Time and date	Weight after exposure	Time and date	Weight of particulates

10. Examine the container under the microscope to identify the sedimented particles

Microscope to identify the characteristics of suspended particles through shape, color and size.

11. Measure some of these particles.

12. Calculate the areas of some of these particles.

13. Take a stock photograph of the collected samples by including it in your report.

Discussion:

Q1: Determine which sites have the most particulate matter? And why? Is it expected?

Q2: Compare the falling amounts of particulate matter on your city with the global permissible limit of 150 Ton/year?

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Lab (4)
Calculation of the dangers degree for some gaseous pollutants and particulate

Objective:

To determine the dangers degree of some air pollutants present in the city atmosphere.

Theory

Natural air (non-polluted) consists of a mixture of gases that are characterized by having almost constant rates at any of the vertical elevations or horizontal distances and at different times. Table (1) below shows the percentages of gases present in concentrations that have not changed during the life of humanity, despite the occurrence of some natural phenomena such as volcanic explosions and forest fires as a result of lightning. When these ratios are exceeded, it means an imbalance in the air, and thus air pollution.

Table 1. Abundance of the atmospheric gases

Permanent Gas	Symbol	% by Variable	Gas	Symbol	% by volume
Nitrogen	N2	78.08	Water vapor	H_2O	0.0 – 4.0
Oxygen	O_2	20.95	Carbon dioxide	CO_2	0.0351
Argon	Ar	0.93	Methane	CH_4	0.00017
Neon	Ne	0.0018	Carbon monoxide	CO	0.00002
Helium	He	0.00052	Ozone	O_3	0.000004
Hydrogen	H_2	0.00005	Sulfur dioxide	SO_2	0.000001
Xenon	Xe	0.000009	Nitrogen dioxide	NO_2	0.000001

In order to know the most dangerous major air pollutants, the risk of any pollutant depends on its concentration and duration of exposure to it. Carbon monoxide is the most common of these pollutants, and it can be considered a criterion for measuring the severity of the various main pollutants.

Table (2) shows the impact factore of these pollutants and the probability level in units of mg / m^3, **which is known as the highest concentration of the pollutant element can be tolerated by humans when exposed to it within one hour.**

The impact factor for a specific pollutant compute by:

$$\textbf{Impact factore} = \frac{\textbf{the probability level } \boldsymbol{for\ CO}}{\textbf{the probability level for any pollutant}} \quad \textbf{(1)}$$

For example, the impact factor of SO_2 pollutant is equal to 15.3, note Table (2).

Its hazard is about 15 times more than CO if they have the same concentration.

$$\boldsymbol{Dangers\ degree} = \frac{\boldsymbol{concentration\ of\ any\ pollutant}}{\textbf{probability level}} \quad \textbf{(2)}$$

Table (2) the values of the probability level and the impact factor for main pollutant .

Air pollutant and particulates	Probability level (μg/m^3)	impact factore
CO	5600	1
SO_X	365	15.3
Particulate matter	260	21.5
NO_X	250	22.4
Hydrocarbons (HC)	45	125

Materials and tools used:

1. Gaseous pollutants measuring devices, for example CO , CO_2, SO_2 and NO_2 meters.

2. Particulate matter measuring devices.

3- Table (2) and units conversion equations (equations in Lab 2) .

Procedure:

1. Measuring air pollutants such as CO, CO_2, NO_X, SO_2.

2. Make observations every 10 minutes for pollutants, and then find the rate, and in different places inside the laboratory, in the classroom, and in the open areas (university garden).

3. Make a table as shown below, containing the following data:

Pollutants	**Reading of device**				**probability level**	***Dangers degree***
	1	**2**	**3**	**Average**		
CO_2	632	630	630			
NO_2	265	267	265			
SO_2	100	105	102			

4- Then converting the units of measured pollutants, for example, converting ppm to mg / m^3.

Discussion:

Q1: Why CO consider as a measure of probability level and impact factor in a dangers degree determination experiment?

Q2: What is the relationship between the probability level and the impact factor, and why?

Q3: What is the relationship between the probability level and dangers degree, and why?

Q4: Which is more dangerous, NO_x or CO at a concentration of 300 mg / m^3 ?

Homeworks

Example: A pollutant of nitrogen dioxide (NO_2) (molecular weight 30 and a human tolerance level of 250 μg / m3) is widespread in the atmosphere of a city with a concentration of 0.1 ppm. What is its dangers degree?

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Lab (3)

Conversions of Gaseous and Particulate Pollutants Measurement Units

Objective:

To teach students to use gaseous and particulate pollutants measuring devices and to perform conversions between gaseous and particulate pollutants units.

Theory

The concentrations of gases other than ozone are measured in units of volume or mass.

The volume units(Volumetric) determine the ratio of mixing between the volume of the polluted gas, for example, to the volume of the original air, meaning the ratio of the number of pollutant gas particles to the total number of air molecules. There are three common expressions : (parts per million , parts per billion) and (gas part per trillion).

What Does Parts Per Million (PPm) Mean?

Parts per million (PPm) is a unit of measurement used when expressing a very dilute concentration level of pollutants in the air, water and other fluids. For example, 1 PPm of ink in water means that in a million mass units of water there would be one mass unit of ink. Thus, PPm refers to one item in a million of anything of the same size.

Mathematically, 1 PPm can be expressed as following:

- 1 PPm = 1 mg/kg
- 1 PPm= 1 mg/liter
- 1 PPm = 0.0001 %

As for the mass units (Gravimetric), the mass of a substance is determined for a unit of air volume, for example (g / m^3) or (mg / m^3), and it is advisable to use these units when extracting a gas concentration from the treated filter for chemical analysis or health effects related to the mass of the inhaled pollutant. Sometimes we use particles / m^3 to measure suspended particles, and the concentration of body pollutants can be measured by their weight per unit area, which is mg / cm^2 or Tun / $mile^2$.

That these units of measurement can be made conversions on them as desired (from volumetric to mass and vice versa).

Under standard conditions **(0° Centigrade, 101.325 kPa),** one mole of an ideal gas occupies **22.414 liters**. The mass of a pollutant *p*, **Mp** in grams can therefor be converted to its equivalent volume **Vp** in liters:

$$(1)\mathbf{V_P} = \frac{\mathbf{M_P}}{\mathbf{MW}} * \mathbf{22.4}$$

with **MW** the molecular weight of the pollutant. For measurements at pressure and temperature other than the standard conditions, corrections to the standard volume must be applied, based on the ideal gas law:

$$\mathbf{22.4\ l/g} * \frac{\mathbf{T}}{\mathbf{273.15}} * \frac{\mathbf{101.325\ kPa}}{\mathbf{P}} \qquad \mathbf{(2)}$$

where T and P are the ambient temperature and pressure at the time of measurement, respectively.

Therefore,

$$\mathbf{ppm} = \frac{\mathbf{V_P}}{\boldsymbol{Va}} \qquad \mathbf{(3)}$$

where *Va* and *Vp* are the air and pollutant volume, respectiviely. Combining the equations gives the conversion formula:

$$\text{ppm} = \frac{M_P}{MW} * 22.4\ \frac{l}{g} * \frac{T}{273.15} * \frac{101.325\ k\,pa}{p} \ /\ Va * 1000\ l/m3 \qquad (4)$$

Materials and tools used:

1. Gaseous pollutants measuring devices, for example CO_2, SO_2 and NO_2 meters.

2. Particulate matter measuring devices such as an aerosol measuring device or a particle measuring device, filters, the use of optical number and other devices.

Procedure:

1. We operate the pollutants measuring devices and aerosol measuring devices located in the air pollution laboratory, after making sure that the battery is working well.

2. We record the readings every two minutes that you get from each of the devices and record the measurements in the table below.

3. We carry out the conversion procedures for units measured by these devices according to the following table:

Pollutants	**Reading of device**				**Units Conversion**
	1	**2**	**3**	**Average**	
CO_2					
NO_2					
SO_2					

Discussion:

Q1: Is there an effect of weather factors on these readings and why?

Q2: Evaluating the readings obtained and comparing them with the permissible limits globally, what is the percentage of error in them and why?

Q3: How do you expect the readings of these devices to be if they are installed in other places, such as near the main street, a car intersection, or in the university corridors, and why?

Homeworks

1- Convert the air pollutants concentration from **μg/m3 to ppm** (with pressure P = 1013.3 Pa and temperature T = 298 K)?

Substance	**Mass formula**	**Mol.weight**	**μg/m3**	**ppm**
Nitrogen Dioxide	NO_2		1.8	
Nitrogen Oxide	NO		4.2	
Sulphur Dioxide	SO_2		3.5	

2- What is the mass concentration of carbon monoxide, CO, emitted from the exhaust of the car, which has a concentration of 1.5 ppm and a molecular weight of 28 under standard and non-standard conditions (with pressure P = 1013.3 Pa and temperature T = 298 K)?

3- What is the concentration in ppm of N_2O if its concentration is 1.25 µg / m3 in the atmosphere?

4- What is the concentration in units of mg / m3 if the pollutant was CO_2 gas (its molecular weight 44) with a concentration of 2.1 ppm in the atmosphere?

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Lab (5)
Calculation of the noise pollution level in the laboratory

Objective:

How to calculate average noise pollution from sound level measurements within a pollution laboratory.

Theory:

Noise is considered one of the types of environmental pollution, and it is defined as heterogeneous sounds whose intensity exceeds the normal permissible rate for the ear. Noise is measured in decibels (dB), which is the unit of sound intensity.

The sound has several characteristics, the most important of which are:

1. Sound intensity: the ear distinguishes between a strong sound and a weak sound.

2. Degree sound: Distinguish between sharp and thick sound.

3. Type of sound: a difference in the tone of the voice, even if its intensity and degree are equal.

In fact, the noise level should be less than 25 Db in order for a person to sleep and rest, but if it exceeds this limit, exposure to noise has effects on the general health of the person, both organically and psychologically, as it harms the auditory and nervous systems and affects the digestive and nervous systems, heart and circulation. bloody; As well as its effects on animals and birds.

The Materials and Tools:

1- used Sound level meter.

2. Loud tuning fork with kickstand.

3. Elastic stand.

4. An electronic stopwatch containing seconds.

5. 3 graph paper.

6. Metric ruler.

The procedure:

1. Make sure the device is running, especially the battery is working well.
2. Take the fork and hit it hard with the rubber stopper and put it on its stand and set it at the zero distance.
3. Measure the sound level reading after 15 sec of the fork stroke at a distance of 10 cm and record your results in the table below.
4. Measure the sound level every 15 sec with a dimension of 10 cm.
5. Repeat the previous step 9 times, recording your results in a table.
6. Calculate the frequency of the values to find the percentage of time equal to or greater than the SL readings, with the relationship: %of time = (.7 m N) ∗ 100 Where m is the rank number and N is the number of observations.
7. Make a graph between the greater or equal % of time values on the y-axis and the SL(dB) values in ascending order.
8. Pass the curved line that best passes through the points of the graph
9. Starting from the y-axis find the values of L10, L50, L90 from the % of time values of 10, 50 and 90 and pass parallel to the x-axis and at the intersection with the curve of the best line, go down to the x-axis and record the values of SL that correspond to the values of L10, L50, L90.
10. Calculate the value of (NPL)1 using the equation (7-1)
11. Repeat Experiment Steps 1 to 10 again to calculate(NP)2
12. Calculate the average noise pollution level $\overline{(NPL)}$ in the laboratory .

Discussion:

Q1: Compare the end result of the experiment with Table (7-1)?

Q2: Discuss the type of graphic relationship between SL values with distance by drawing them on graph paper combined for the two equations?

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Lab (6)
Air Pollution Control

Air pollution control equipments

The various air pollution control equipments are used to control the air pollution from stationary sources. These equipments are conveniently divided into two types, one type are those which applicable for controlling particulate, and the other that used for controlling gaseous pollutants as shown in Fig.1.

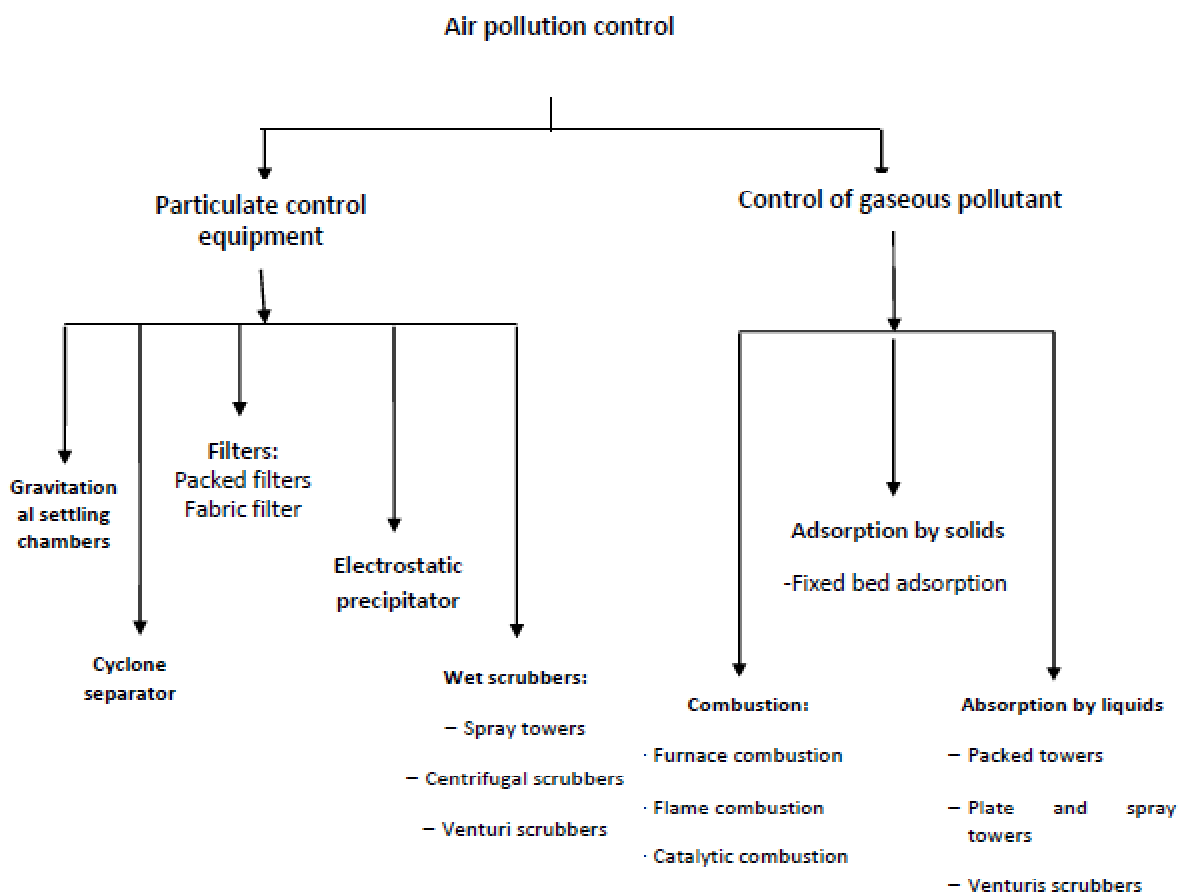

Fig.1. the most commonly equipments deal with air pollution control from stationary sources

Control of Particulate Pollutants

Particulate control equipment

A number of factors must be determined before a proper choice of collection equipment can be made. Among the most important data required are the following:

1- The physical and chemical properties of the particulates.

2- The range of volumetric flow rate of the gas stream.

3- The particulate size and concentration in gas stream.

4- The temperature and pressure of the flow stream.

5- The humidity.

6- The collection efficiency that required for outlet stream.

1- Gravitational settling chambers

Gravitational force may be employed to remove particulate in settling chambers when the settling velocity is greater than about 25 ft/min (13 cm/s).

In general settling chamber equipment is applied to remove of coarse particles larger than 50 μm from gas streams. Settling chambers offer low pressure drop and required simple maintenance, but their efficient is quit small for particles smaller than 50μm. Since most of particles in the gas stream are much smaller sizes than 50 μm, these devices are used as a primarily prior to passing the gas stream through high efficiency devices.

The efficiency of equipment depends on the residence time of the gas in the settling chamber which is related to the velocity of the gas flow and the chamber volume. The simplest form of gravity settling camber is shown in Fig.2.

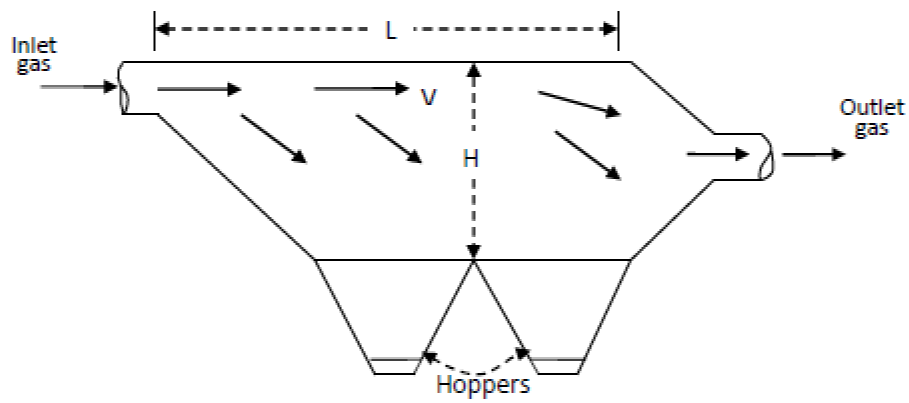

Fig.2. A gravitational settling chamber

2- Cyclone separators

Cyclone separators are the most popular and effective devices used for separation particulates from gas stream. Cyclone separators utilize a centrifugal force generated by spinning gas stream to separate the particulates from the carrier gas. The centrifugal force on particles in a spinning gas stream is much greater than gravity; therefore, cyclones are effective in the removal of much smaller particles than gravitational settling chambers, and required much less space to handle the same gas volumes.

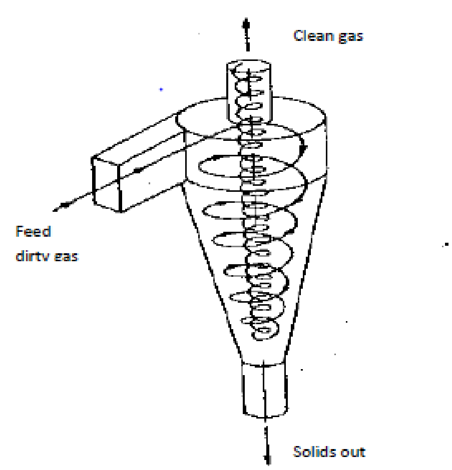

Fig.3. Reverse flow cyclone

The most commonly used design is the reverse flow cyclone, see Fig.3. The dirty gas flows tangentially into the cyclone at the top, and spiral down near the outer radius and then back upward in the center core, in a second smaller diameter spiral, and exit at the top through a central vertical pipe. The particle moves radials to the walls, slide down the walls, and are collected at the bottom.

Type of cyclones:

Three types of cyclones

1- **Conventional cyclones** :It is applied to remove of particles of 25 μm or larger with an efficiency greater than 90%.

2- **High efficiency cyclones** :The inlet gas velocity is higher, thereby importing a higher centrifugal force. These types are effective with particle sizes down 5 μm.

3- High volume cyclones: Particle size are generally larger than 50 μm are collected with great efficiency. They can handle larger flow.

Fig.4 shows typical curves for several types of equipment with their fraction collection efficiency as a function of particle size.

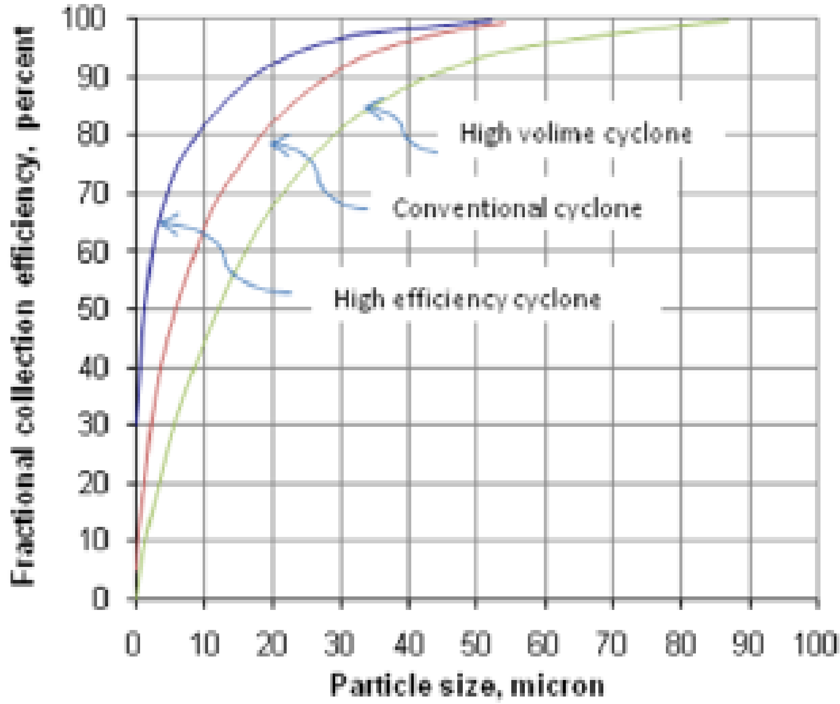

Fig.4. the fractional collection efficiency as a function of particle size for several types of cyclones.

3- Fabric filter (Baghouses)

Filtration is one of the oldest and most widely used methods of separating particulate from a carrier gas. A filter generally is a porous structure which tends to retain the particulate as the carrier gas passes through the void of filter, and allowing clean gas to pass out.

The fabric filter consists of several tubular bags or an envelope, called a baghouse, hanged in such a manner that the collected particle fall into a hopper. The dirty gas enters the bag at the bottom and passes through the fabric filter, while the particulate is deposited on the inside of the bag and passes out from their side to be finely released out of the filter system as a clean gas. Fig.5 shows a typical baghouse.

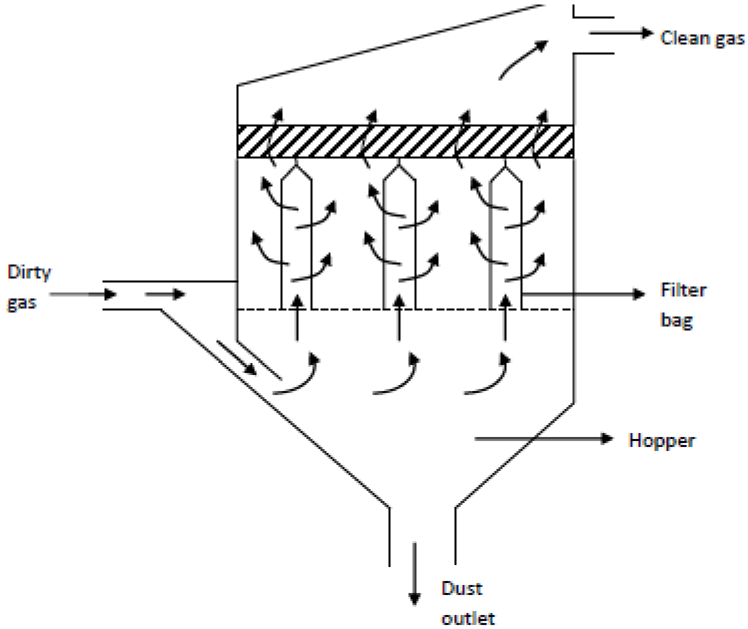

Fig.5. Typical bag house

The advantages of fabric filter

1- High collection efficiency over broad range of particle size.
2- Retention of finest particles.
3- Relatively low pressure drops.
4- Collection of particulates in dry form.

The main disadvantages of fabric filter

1- Their large size.
2- High construction costs.
3- Hydroscopic material cannot be handling.

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Lab (7)

4- Electrostatic precipitators, (ESP)

Electrostatic precipitator is a physical process by which particles suspended in gas stream are discharged electrically and, under the influence of the electrical field, separated from the gas stream. A typical wire and pipe precipitator is shown in Fig.6.

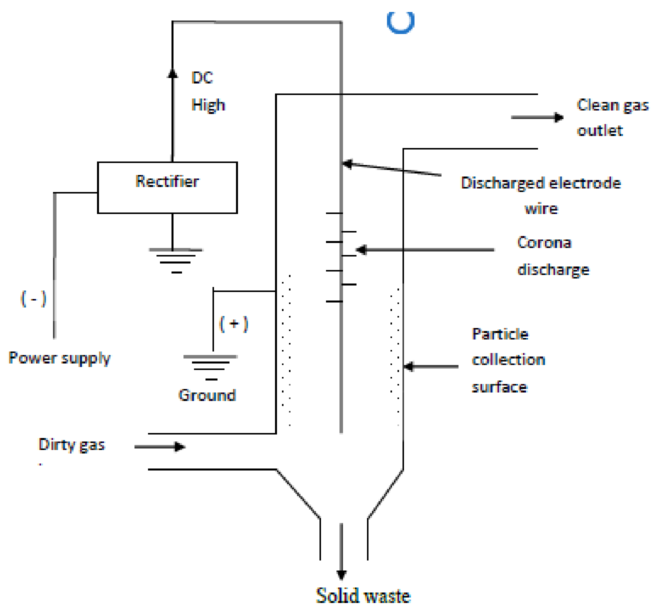


Fig.6. Electrostatic precipitators

Advantages of electrostatic precipitators

1- Pressure drop and hence power requirement is small compare to that of other devices.
2- High collection efficiencies very small particles can be collected wet and dry.
3- Can handle both gas and mists for high volume flows.
4- Low energy consumption.
5- Ability to operate with relatively high temperature gases.

Disadvantages of electrostatic precipitators

1- Relatively high initial cost and large space requirement.
2- It is necessary to safeguard operating person from high voltage.
3- Collection efficiency can deteriorate gradually.

5- Wet scrubbers

Wet scrubber is one of the particulate control equipment in which water is used to capture particulate dust. The resulting the solids are removed from the gas stream by water as slurry. The principle mechanism involved impact (impingement) of the dust particles and water droplet in order to achieve good contact time.

-The advantages of wet scrubbers

1- Simultaneously removal of gases and particulate.
2- Can effectively remove fine particulate, both liquid and solid, ranging from 0.1-20 μ from gas stream.
3- Equipment occupies only a moderate amount of space compared to dry collectors such as bag house.

-The disadvantages of wet scrubbers

1- Relatively high energy costs.
2- Problem of wet sludge disposal.
3- Corrosion problems
4- The wet sludge causes water pollution and there is need to treatment method to remove particles from the water.
5- Very small particles (sub-micron sizes) may not capture.

The major types of wet scrubbers are:

1- Spray scrubbers
2- centrifugal scrubbers
3- Venture scrubbers

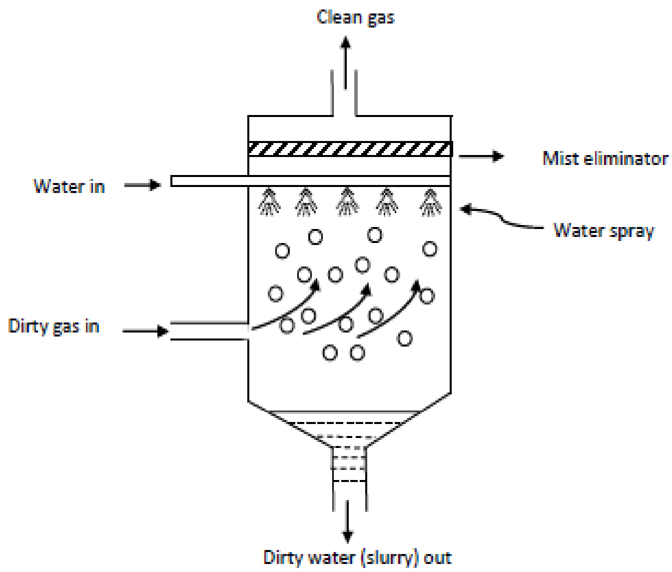


Fig.7. Sketch of a spray tower scrubber

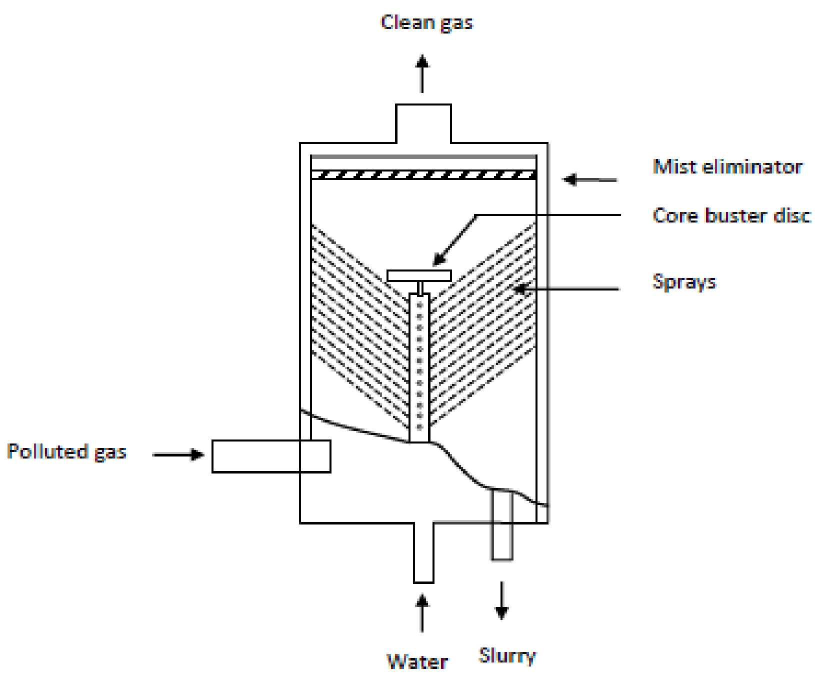


Fig.8. Centrifugal Scrubber, tangential entry

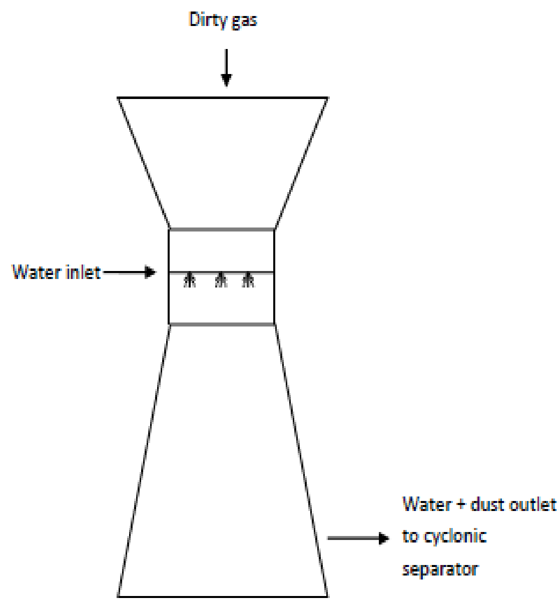


Fig.9. Vertical downward venturi scrubber with throat injection

Control of Pollutants Gaseous:

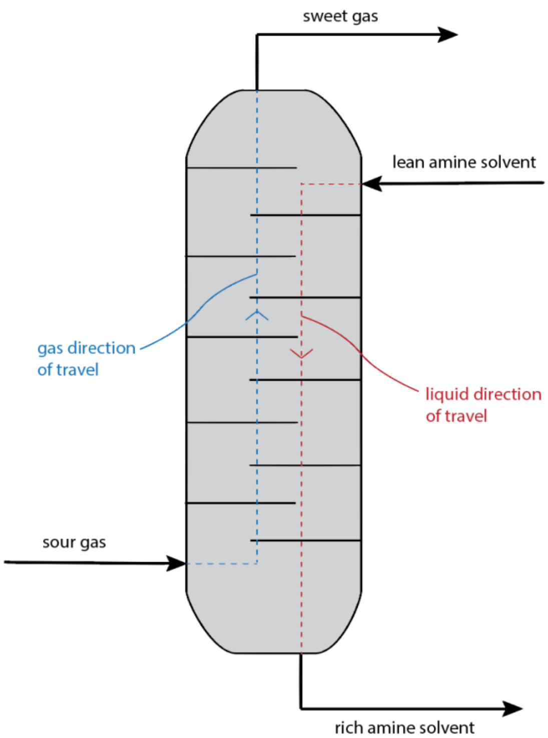
The selection of control technologies depends on environmental, engineering, economic factors and pollutant type.

Latest techniques of air pollution control are:

1-Combustion : This method is applied when the pollutants are organic gases or vapours. The organic air pollutants are exposed to ‘flame or catalytic combustion’ when they are converted to less harmful product carbon dioxide and product water.

2-Absorption : In this technique, the polluted air containing gaseous pollutants is passed through a scrubber carrying a suitable liquid absorbent, which absorbs the harmful gaseous pollutants present in the air.

3-Adsorption : In this technique, the polluted air is passed through porous solid adsorbents kept in suitable containers. The gaseous pollutants are adsorbed at the surface of the porous solid, and clean air passes through.



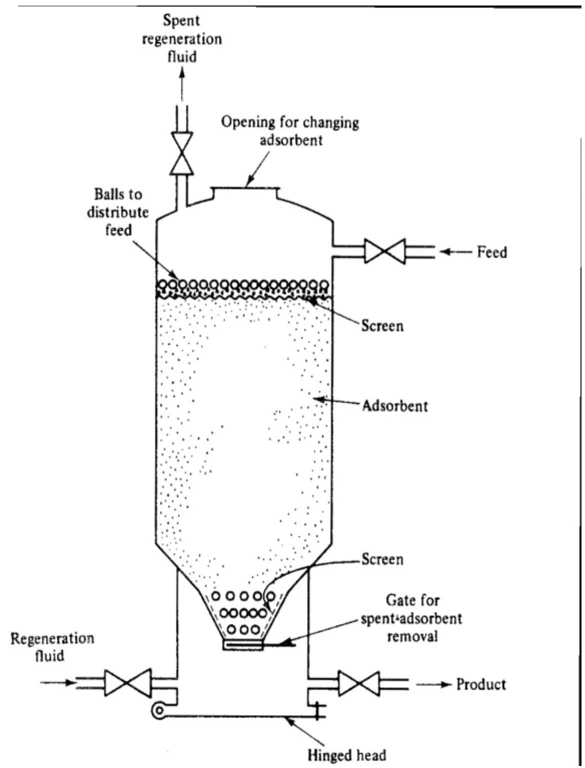


Fig10.Absorber column

Fig11.Adsorbtion column

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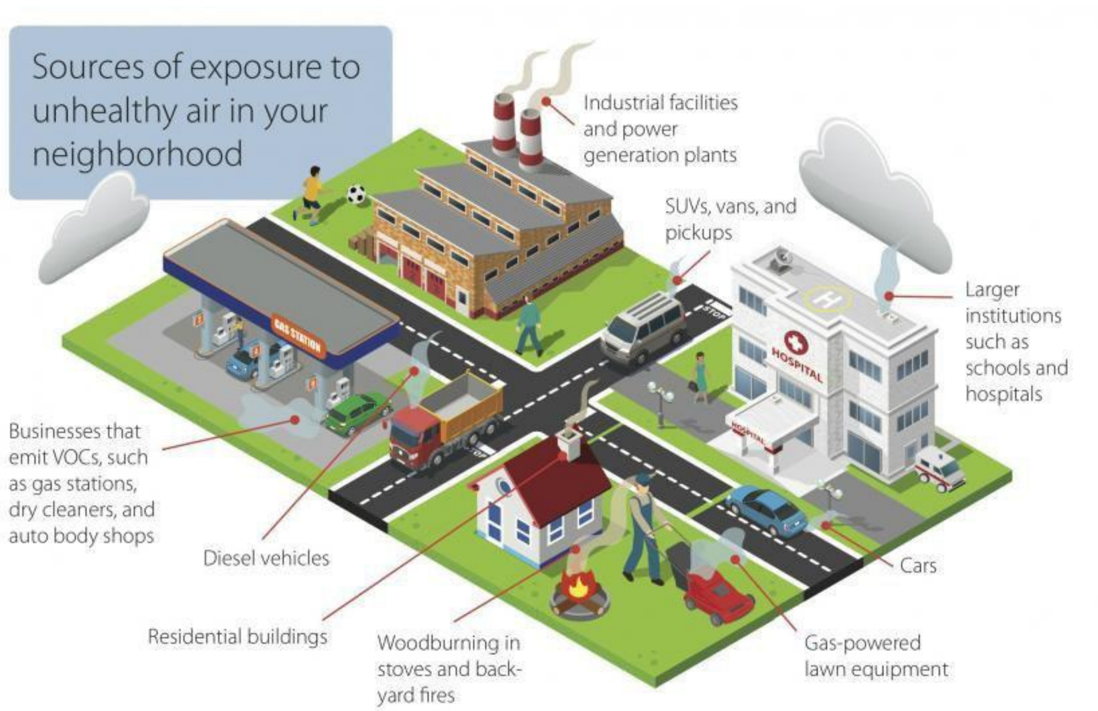
Lab (8)
Measurement Systems and Air Quality Monitoring

In order to ensure the safety and cleanliness of the surrounding air; It is necessary to constantly measure the concentrations of its components, whether the air is polluted or not.

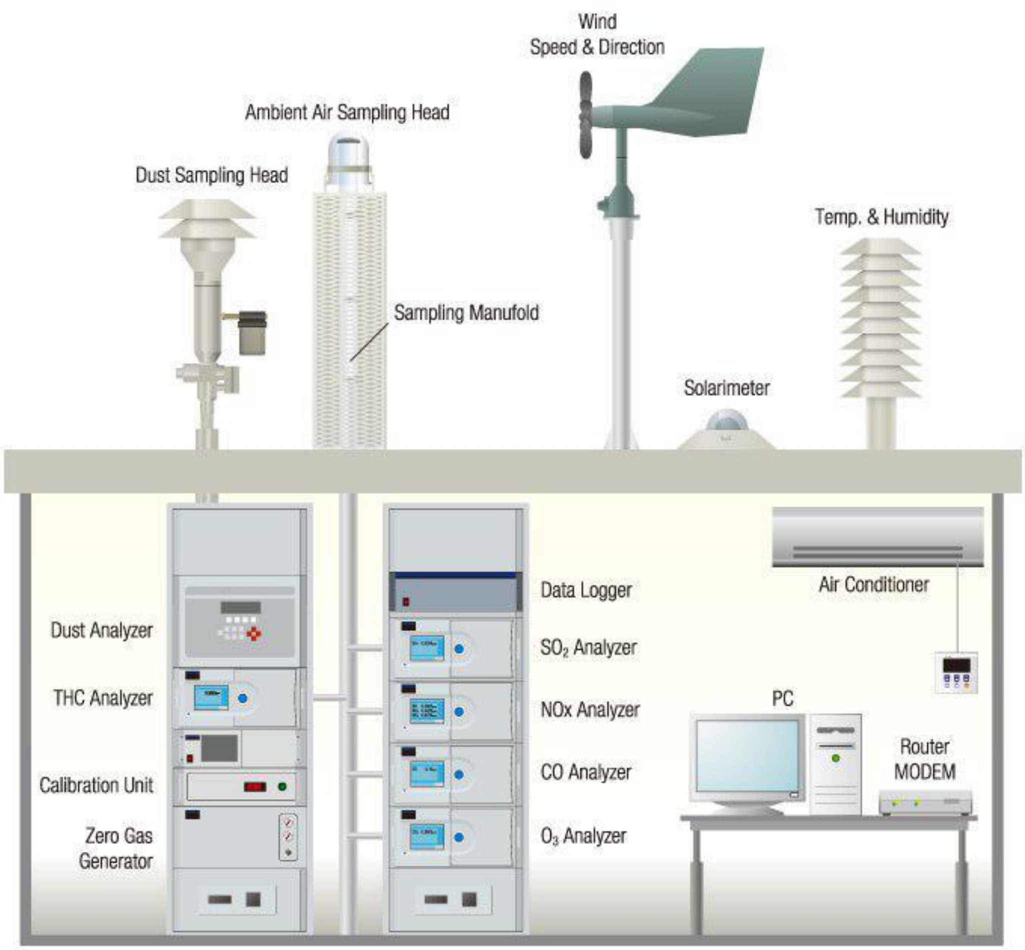


There are different types of air pollution measurements:

First: Ambient air measurements, such as measuring pollutant concentrations in the air to ensure general breathing, air quality and obtaining information about the nature of pollutants in the area's atmosphere. This is called ambient air monitoring.

Second: Measurements of concentrations or emission rates from inside pollution sources before they leave the surrounding air is **called source testing.** The purpose of these measurements is to know the emitted quantities of the pollutant and the extent of compliance with the approved specifications, or to measure the efficiency of the work of the equipment used in the treatment of waste gases.

Third: Measurements of anaerobic elements such as wind speed and directions, thermal gradient rates and others are necessary to determine how pollutants are transmitted from the source to the recipient.



Aerobic Sampling Basics:

1-The sample collector is placed away from surfaces, walls and barriers such as trees and plants, and is often placed at a height of 2-3 m above the ground level, provided that it is not located close to the source of pollution or close to road paths.

2. A canopy must be made for the devices if it is necessary to protect them from precipitation, or a simple fence should be made as a small building to provide adequate protection for them from strong winds.

3. That no influence affects the concentration of impurities at the measurement point, or the interference of local sources near the winds coming towards the site.

4. The site is easily accessible at all times and seasons, and it is safe from large animals or vandalism.

5. The permanent sites require sufficient heating and the availability of electrical energy for air conditioning in order to obtain a suitable and stable working environment for the operation of the devices.

Air pollution monitoring systems:

It is intended to determine the amount of air pollutants from their various sources and to study the weather factors that affect the spread of these pollutants, and thus determine their concentrations in the different parts of the area under surveillance.

From the term monitoring, it is understood as collecting and analyzing air samples by all available measurement methods, whether they are automatic or conventional devices. The goal of monitoring systems is :

1- Distinguishing the different sources of pollution, especially those responsible for certain characteristics in the air (or a certain pollution condition).
2- Warning of the existence of a case of air pollution in terms of quantity and quality.
3- Determine the direction of the pollutant path (pollution direction).

Air pollution monitoring systems type :

1. Stationary monitoring networks

The objective of establishing fixed stations is to monitor the real air quality within the borders of a single state or local government, as well as to determine the impact of modern sources of pollutants. This is why these stations are established at least a year before the establishment of modern factories in order to determine the air quality before construction. Finally, it has an important role in knowing the long-term conflicts of pollutants.

2. Mobil monitoring networks

It is done by placing pollution measuring devices on moving vehicles such as planes, cars, helicopters and the like, and since the air transport and chemical transformations occur between the source and the recipient, the benefit of mobile monitoring enables obtaining the necessary data to help understand the formation and transmission of photochemical fog, acid deposition and dispersion of gaseous pollutants from their source. Another benefit of mobile monitoring systems is their ability to obtain air quality information in the intermediate zone (between source monitors and stationary devices).

Among its determinants are the operation of appropriate devices in the environment of moving vehicles that are not equipped with the environment with a relatively constant temperature required in the operation of air quality devices, as well as the exposure of devices to sharp vertical changes in pressure. Most devices are designed to run on alternating current, which requires a large supply of DC batteries.

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Lab (9)
Guess the horizontal wind speed at the chimney nozzles

Objectives:

1 . Explain the uses of the wind tunnel.

2 . Calculation of wind speeds at different altitudes.

3 . Calculate the wind-power exponent rate.

4 . Use the law to calculate the wind speed at a chimney mouth using a low wind speed value.

Theory:

Knowing the average wind speed in the surface layer (constituting 10% of the height of the specific layer) is of special importance in air pollution, wind energy and other applications, when applying the **Causs equation** to calculate the concentration of pollutants at different dimensions of the chimney need to know the wind speed at the level of the chimney mouth. wind at altitudes high has a higher velocity than that at the low level near the surface of the Earth for a specific time and place, in general, the wind speed increases with the increase in height above the surface of the earth. The reduction in wind speed at levels low is due to the intensity of the disturbance resulting from surface roughness elements such as trees, buildings and others.

One of the equations used in engineering applications is the exponential force law of the wind, which is used to estimate the speed of the Winds for high altitudes less than 200 m are formulated below:

$$\frac{U1}{U2} = (\frac{Z2}{Z1})^{\alpha} \qquad \textbf{(1)}$$

Where U_1 and U_2 are the wind speeds at altitudes Z_1 and Z_2, respectively, α: an empirical constant that depends on surface roughness and atmospheric stability. It can be calculated from the above equation if wind speed data are available at two heights by rearranging them and assuming that $\frac{U1}{U2}$=U and $\frac{Z2}{Z1}$=Z:

$$\alpha = \frac{d \ln U}{d \ln Z} = \frac{Z\, dU}{U\, dZ} \approx \frac{Z\, \Delta U}{U\, \Delta Z} \qquad \textbf{(2)}$$

In order to obtain an average value of α through a complete vertical section, we divide the section into several layers and then calculate α for each layer and thus take the rate that represents its value for the whole section. After determining the average value of α, we can predict wind speed at any height we need using equation (1), as we will explain in this experiment.

Field studies and scientific research indicated that the value of the exponent changes according to the roughness and reliability.

This experiment can be carried out in the laboratory by using a wind tunnel or channel used to generate a specific layer with a gradation small (note Fig. 1 below). Wind channels are composed of an inlet orifice with a straight stream running through a long rectangular section length and cross section in which the tests are carried out. And the last one is an electric (pull) fan with different speeds controlled by a motor.

The materials and tools used:

1 . A wind channel for the stratified mantle.

2 . Models of chimneys of different lengths.

3 . Synthetic roughness elements to generate turbulent vortices.

50 cm

4. Sensor measuring flow speed.

The method of work:

1 . Fill the wind channel.

2 . Measure the velocity of the vertical flow and make sure that the laminar flow is equal velocity:

3 . Install the roughness elements in an irregular arrangement around a particular chimney in the test segment.

4 . Start by measuring the flow velocity for several altitudes listed in the following table:

5. Find the ratio of $Z2/Z1$ and $U2/\ U1$ between each two successive levels and record your results in the table above.

6 . Calculate the value of α for each two successive levels using Equation (2.3).

7 . Calculate the average value of α to represent the vertical cross-section of the air layer between 3 cm and 50 cm.

8 . Measure is the height of the top of the chimney, let it be z_2.

9 . Measure is the velocity of flow at a height of 5 cm = z_1.

10 . Calculate the value of the flow velocity at the chimney nozzle using Equation (1)

Discussion:

Q1: Draw the relationship between log z values and log U values, find the slope value? And what does it represent?

Q2: Draw the relationship between the values of altitude and wind speed and discuss the diagram?

Q3: What does the vertical section of the wind look like through an urban and a rural area?