TD 01: Environmental Concepts

1 – Definitions:

1-1 – Environment:

It is the set of elements in the vicinity of a living being that interact with it directly or indirectly. It includes biotic elements (living beings) and abiotic elements (physical space and climatic conditions).

1-2 – Ecosystem:

It is the set of living beings (biocenosis), animals (zoocenosis), and plants (phytocenosis), occupying a physical, biological, geological, edaphic, and climatic environment (biotope), within a network of energy and matter exchanges, enabling the maintenance of life.

1-3 – Ecology:

It is the science of habitat, studying the living conditions of organisms and all types of interactions that exist between them and their environments.

2 – Indicators of Environmental Degradation:

2-1 – Pollution:

It is the presence of substances or heat in the air, water, or soil, likely to harm human health or the quality of ecosystems, leading to the destruction or gradual degradation of the environment. Pollution can take three different forms:

- **Soil pollution:**

  This may involve salinization, often due to agricultural practices, or direct soil pollution of industrial or individual origin. The affected soil may become infertile and hostile to certain plant or animal species inhabiting it.

- **Water pollution:**
  It can be of different origins:
  - *Physical:* Thermal or radioactive. Thermal pollution is mainly caused by industries that use water as a cooling fluid, leading to significant warming of the affected watercourses.
  - *Chemical:* Discharge of various chemical substances from industry, agriculture, or domestic effluents.
  - *Organic:* Discharge of excess organic matter. This leads to eutrophication (abundant growth of algae at the expense of other species in aquatic environments).

- **Air pollution:**

  Toxic chemical gases, mainly from combustion, such as sulfur dioxide (SO_2), nitrogen oxides (NO_x), carbon monoxide (CO), hydrogen sulfide (H_2S), and certain other greenhouse gases (from industry or engines).

2-2 – Effect of Pollution on the Environment:

2-2-1 – Greenhouse Effect:

- *Natural greenhouse effect:*

Our planet is surrounded by a gaseous envelope (atmosphere), naturally composed of about 77% nitrogen, 20% oxygen, and traces of water vapor (H_2O), methane (CH_4), nitrous oxide (N_2O), ozone (O_3), and carbon dioxide (CO_2). About 50% of the energy emitted by the sun is reflected by the ground back into the atmosphere. These gases trap solar radiation, maintaining an average temperature of +15 °C instead of –18 °C without the greenhouse effect (Fig. 01). Thus, the natural greenhouse effect is a beneficial phenomenon, responsible for the mildness of our climate, while also contributing to global warming.

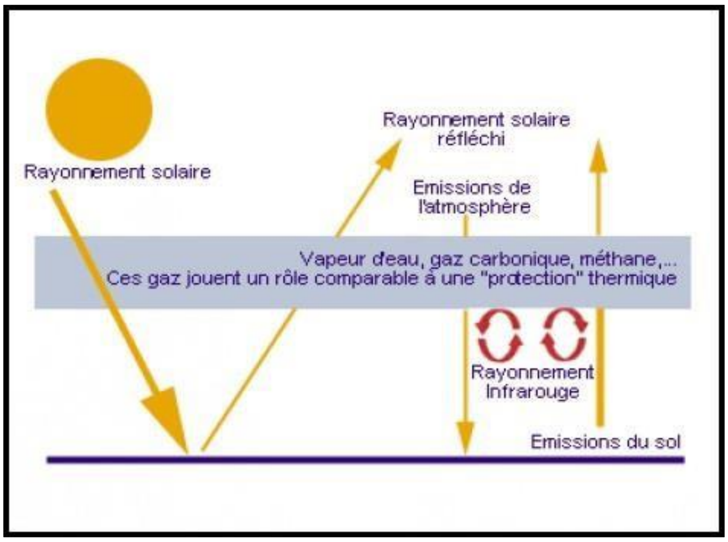

Figure 01. Additional Greenhouse Effect

- *Additional Greenhouse Effect:*

Since the Industrial Revolution (19th century), economic and demographic growth have increased exponentially, which has contributed to the rising combustion of fossil fuels (coal, oil, gas, etc.). The accumulation of these greenhouse gases (over +85%) has caused the *"additional greenhouse effect"*, a phenomenon that continues to threaten the planet's balance and endanger all existing life.

Between 1980 and 2010, Earth's temperature increased by about 0.85 °C, and if global warming continues at this rate, it will reach between 1.8 and 4 °C by 2100. The temperature of the sea surface has also increased by about 0.40 °C. Forecasts indicate that the average sea level will rise between 20 and 60 cm in the coming years. Due to global warming, infrared rays are increasingly unable to escape into space. It is estimated that one out of every ten people lives in an area threatened by rising temperatures and sea levels. At this accelerated pace of atmospheric warming, the planet will experience shortages of natural resources (water, biodiversity, etc.), a decline in agricultural land productivity, and an increase in extreme events (heatwaves, cyclones, earthquakes, storms, and floods, etc.).

2-2-2 – Ozone Layer Depletion:

The ozone layer is a part of the atmosphere located about 500 km above the Earth (a portion of the stratosphere). Its role is to absorb biologically harmful solar rays (ultraviolet radiation) that are dangerous to living organisms. These solar rays are responsible for activating oxygen molecules (O_2) in the stratosphere, which then combine with free oxygen atoms (O) to form ozone (O_3). This ozone acts as a natural filter for the Earth. The increase in global population and industrial activity has raised the level of greenhouse pollutants in the atmosphere. Once these gases reach the ozone layer, they cause the dissociation of ozone molecules into two oxygen molecules (O_2) and a free oxygen atom (O). The destruction of the ozone layer allows harmful ultraviolet rays to reach Earth, posing a real threat to all forms of life (causing diseases and natural damage). The amount of oxygen protected by the ozone envelope also decreases as the layer is depleted.

TD 02: Physico-chemical parameters of environmental analyses

1- Exercise 01:

The following table presents the results of the physico-chemical analyses of water samples taken from three stations in the Mila region. Comment on the table.

Table 1: Average values of the physico-chemical parameters of the three stations

Parameters / Sites	Site 1	Site 2	Site 3
Temperature (°C)	28.3	20.5	21.5
pH	7.2	7.8	7.5
Electrical Conductivity (µS/cm)	1292	1310	1232

2- Exercise 02:

Table 2 presents the results of the physico-chemical analyses of wastewater samples from five stations. Interpret the values in the table and rank the stations from the most polluted to the least polluted.

Table 2. Physico-chemical parameters of raw wastewater from several stations in Algeria:

Parameters / Stations	S01	S02	S03	S04	S05
pH	7.1	7.9	8.2	7.5	7.8
Electrical Conductivity (µS/cm)	529	2140	3103	2435	2066
Biochemical Oxygen Demand (BOD_5) (mg/L)	1.2	3.0	5.0	7.2	8.0

Exercise 01 Solution:

• Temperature

It plays an important role in the solubility of gases, the dissociation of dissolved salts, and the determination of pH. In the study area, water temperature values measured at the three stations range between 20.5°C (the lowest, recorded at station S3) and 28.3°C (the highest, recorded at station S1). According to standard tables, the two stations (S2 and S3) are of good quality for species survival, whereas the water at station S1 is of poor quality. The increase in temperature at station S1 may be due to the presence of a thermal spring in the vicinity of this site.

• pH

It is a measure of the degree of acidity or alkalinity of aquatic ecosystems. This parameter influences a large number of physicochemical equilibria and depends on multiple factors, including temperature and the origin of the water. It provides important information regarding the aggressiveness of the water **(**ability to dissolve limestone).

A pH between 6 and 8.5 allows for the proper development of aquatic fauna and flora (see Table 1 below). International legislation sets the standard pH range between 6.5 and 8.5. The measured pH values range from 7.2 to 7.8; therefore, all the samples studied have slightly alkaline (basic) pH levels.

• Electrical Conductivity

It is closely related to the concentration and nature of dissolved substances. The values of this parameter range between 1310 and 1232 µS/cm. These values exceed the authorized standards, indicating that the waters of these three stations have poor quality. This increase could be linked either to domestic discharges or to the presence of agricultural fields (use of fertilizers)

Exercise 02 Solution:

• pH

The pH values of the wastewater discharged from these outlets range from **7.1 to 8.2**, making them relatively neutral. The measured pH values are acceptable according to wastewater quality standards for irrigation. Since these values fall within the range of **6.5 to 8.5**, they are considered to comply with the permissible limits for direct discharge into the receiving environment. Water quality is optimal for aquatic species at **stations S01 and S04**, and optimal for plankton at the remaining stations (**S02, S03, and S05**).

• **Electrical Conductivity (EC):**

Electrical conductivity represents the ability of water to conduct an electric current. The conductivity value is influenced by the presence of dissolved solids such as sodium, chloride, sulfates, calcium, bicarbonate, nitrates, phosphates, iron, and magnesium. Therefore, conductivity reflects the mineral content of the water. The electrical conductivity (EC) values obtained for stations **S02, S03, S04, and S05** reveal a very high mineralization of the wastewater, with the highest value of 3103 µS/cm recorded at station S03

The only station characterized by good-quality water (relatively pure water) is station S01. The remaining stations (**S02, S03, S04, and S05**) are characterized by poor water quality (ranging from mediocre to polluted).

• **Biochemical Oxygen Demand (BOD_5)**

Regarding the values of the biochemical oxygen demand over 5 days (BOD_5), it is observed that the wastewater from all stations is of poor quality. On the other hand, the water from station S01 shows good oxygen activity per liter, indicating about 2 mg O_2/L, which reflects microbial presence and the absence of organic pollutants.

The remaining stations **(S02, S03, S04, and S05)** are characterized by moderate to moderately polluted water quality.

Conclusion

The analysis of the physicochemical parameters of the waters from the different stations studied indicates that station **S01** is the least polluted, whereas stations **S03 and S05** are the most polluted.

TD 03: Techniques for analyzing the chemical composition of an environment

1- Techniques for analyzing the components of a natural environment:

Unlike physicochemical parameters, which are evaluated through on-site measurements, the assessment of organic and inorganic parameters (chemical elements) requires the transport of samples from polluted ecosystems to various analysis laboratories. There are several techniques for evaluating the chemical components of an environment:

Figure 1. Steps for assessing the quality of natural ecosystems

1-1- Gravimetry:

It is based on determining the mass of a pure compound that is chemically related to the analyte. Its principle involves separating the sample into a form that can be weighed. Many organic substances are measured by gravimetry through several procedures:

- ❖ **Gravimetry by precipitation:**

This method allows the separation of ions from a solution through a precipitation reaction and the addition of a reagent. The compound is converted into a precipitate, which is then filtered, washed, and finally weighed.

- ❖ **Gravimetry by volatilization:**

In this case, the compound is volatilized at an appropriate temperature. The volatile product is then weighed, and the analyte mass can be determined from the mass loss of the samples **(Fig. 2)**. The difference in the tube's mass before and after absorption makes it possible to calculate the amount of sodium hydrogencarbonate in the medium.

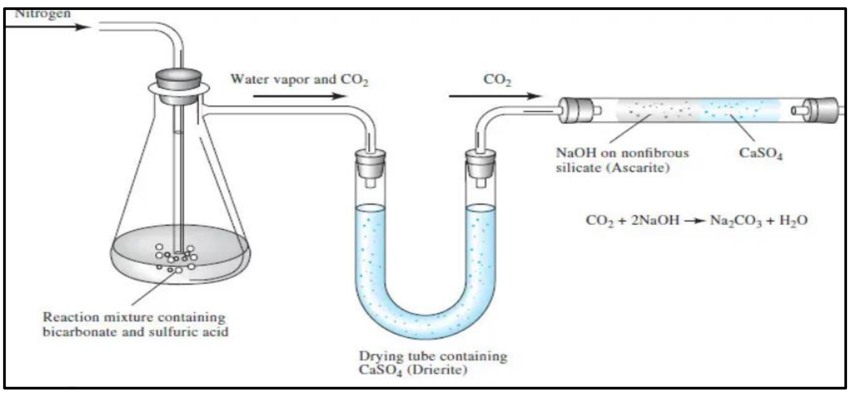

Figure 2. Gravimetry by volatilization

1-2- Titrimetry:

It is used to determine the concentration of a chemical compound through its reaction with a reagent. Titration involves a chemical or biochemical reaction between the compound to be analyzed and a reagent of known concentration, which is added incrementally.

- **Volumetric titration:**

This method consists of gradually adding a reagent of known concentration until the chemical reaction is complete **(Fig. 3)**.

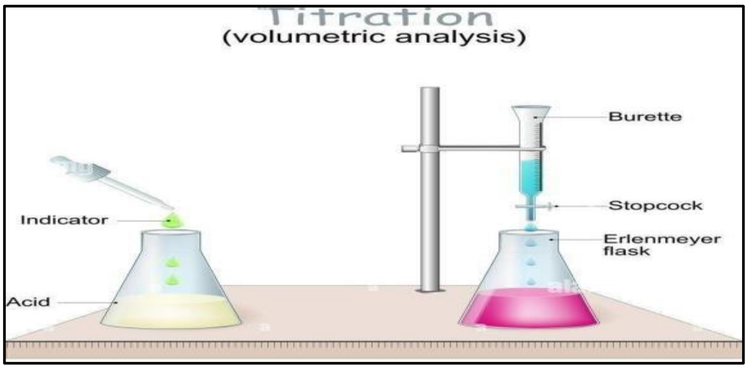

Figure 3. Volumetric titration

- **Gravimetric titration:**

The mass of the reagent required is measured instead of the volume used to complete the operation.

- **Coulometric titration:**

Electrons are gradually added to the system until the end point of the titration is reached. The time required to carry out the electrochemical reaction and the compounds are then estimated **(Fig. 4).**

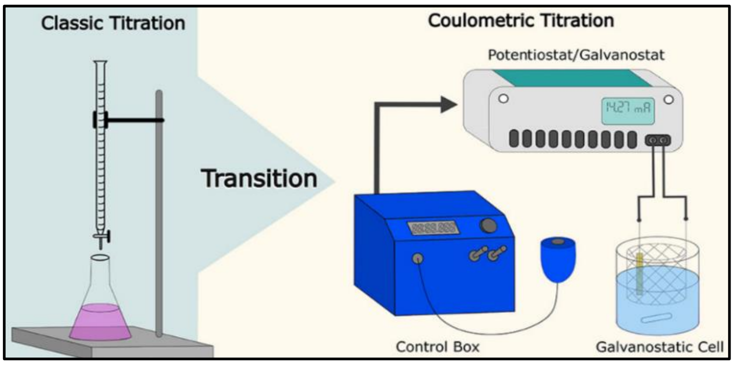

Figure 4. Diagram of a Coulometric Titration Apparatus

1-3- Potentiometry:

This technique is carried out using an indicator electrode and a reference electrode **(Fig. 5)**. The indicator electrode measures the potential (voltage) of a solution based on its elemental composition. This value is then compared with the readings obtained from the reference electrode.

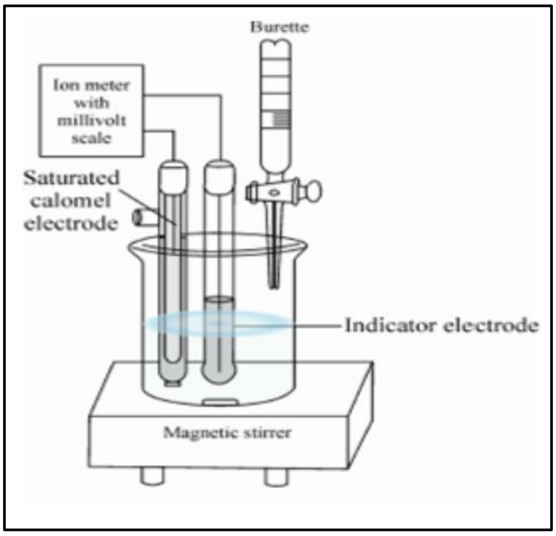

Figure 5. Potentiometric measurement device

1-4- Spectrophotometry:

This technique measures the abundance or optical density of a chemical substance. Its principle is based on estimating the difference between the incident light and the light transmitted through a solution **(Fig. 6)**. Indeed, when light of a specific intensity passes through a solution, part of it is absorbed by the solute (the components), while the remaining part is transmitted with a lower intensity. There are several spectrometric methods, among which the following can be mentioned:

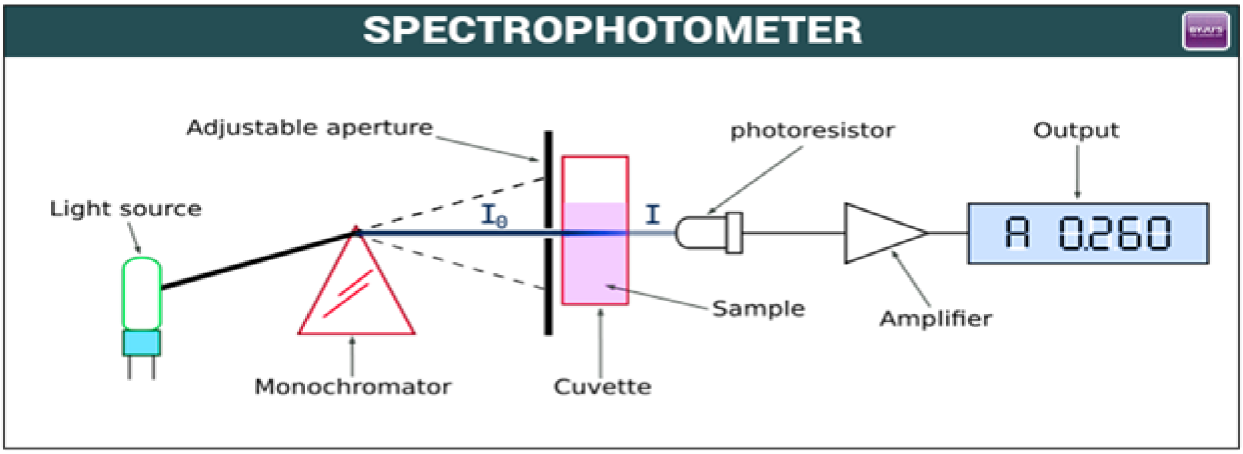

Figure 6. Principle of a Spectrophotometer’s Operation

- **Mass Spectrometry:**

It is an analytical technique used to identify and quantify the molecules in a solution by measuring their mass. Its principle lies in the gas-phase separation of charged molecules according to their mass-to-charge ratio (m/z) **(Fig. 7).**

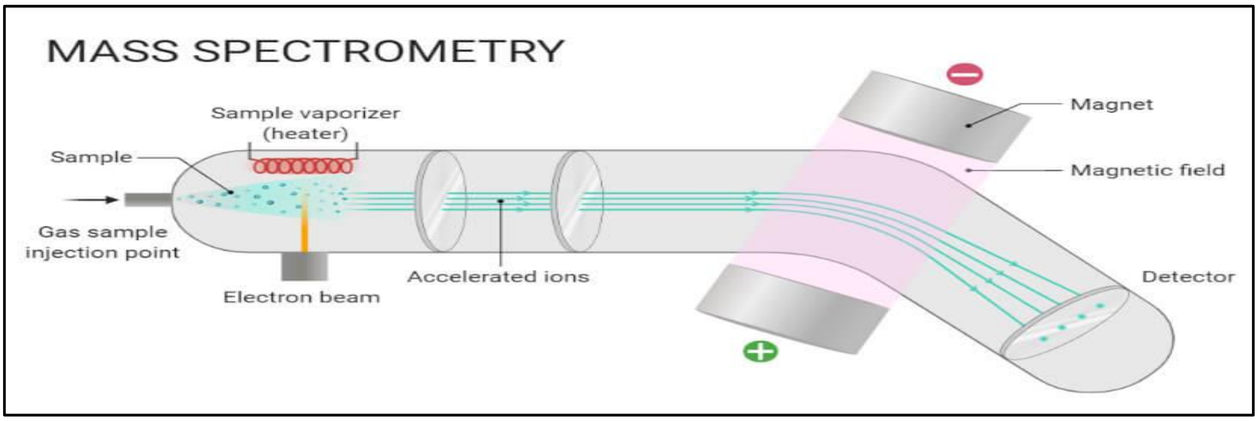

Figure 7. Diagram of a mass spectrometry System

- **Fluorescence Spectrometry:**

This analytical technique is used to determine the chemical composition of solid, liquid, sludge, or free-powder samples by exposing them to X-rays. The atoms within the sample transition from their ground state to an unstable excited state. When returning to their original state, these atoms release energy in the form of X-ray photons, which are then emitted a second time **(Fig. 8)**. The analysis of this secondary radiation makes it possible to determine both the nature of the chemical elements in the sample and their mass concentration.

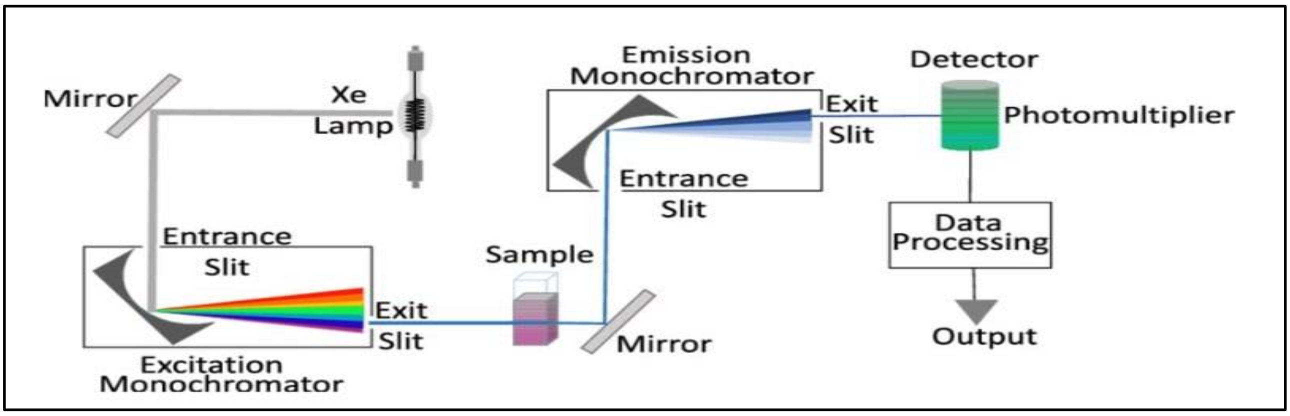

Figure 8. Principle of fluorescence spectrometry

1-5- Chromatographic Methods:

These are techniques used for the separation, identification, and quantification of the chemical constituents of a mixture. Their principle is based on the migration of solutes from a sample through two main phases: a

mobile phase, which carries the components through a liquid or gas (liquid-phase chromatography or gas-phase chromatography), and a **stationary phase**, which remains immobile. Among the most common chromatographic methods are:

❖ **Column Chromatography:**

This technique is used for purification in organic chemistry. The separation of compounds is achieved by the continuous flow of an eluent through a column **(Fig. 9).** The stationary phase is held inside a narrow tube, while the mobile phase progresses either by gravity or under pressure.

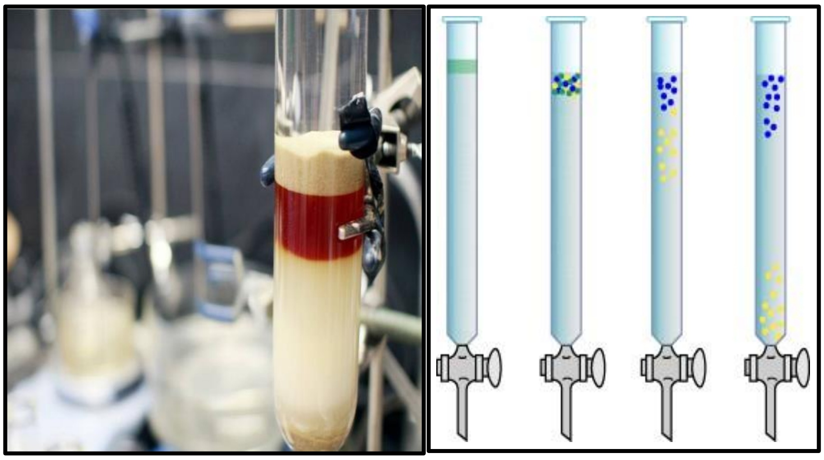

Figure 9. Column Chromatography

❖ **Surface (Planar) chromatography:**

This method is used to separate components for analytical or purification purposes. It has the advantages of requiring minimal equipment and providing easily interpretable results. The stationary phase in this technique is present on the surface of a flat support (thin layer) **(Fig. 10)** or on a cellulose sheet (paper). The mobile phase moves by gravity.

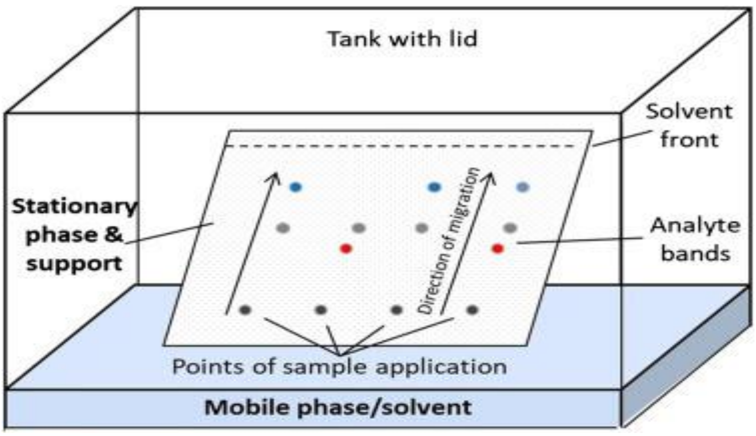

Figure 10. Planar chromatography (Surface or thin-layer cromatography)