

# التلوث العملي

## مدرسوا المادة

أ . م شيماء عبد الكريم	م . د بهاء مالك عبد الكريم
أ . م بيداء عبد القادر	
م اسيل نجيب	
م . م . هند جبار	
م . م . ميادة خزعل	
م . م . عامر احمد	

---

## **Determination of dissolved oxygen (Winkler method)**

**LAB 1**

### **Background Information**

---

Dissolved Oxygen (DO) is the amount of gaseous oxygen (O<sub>2</sub>) dissolved in the water. Oxygen enters the water by direct absorption from the atmosphere, by rapid movement of water, or as a product of plant photosynthesis.

Dissolved oxygen is measured as milligrams of dissolved gaseous oxygen per liter of water (mg/L), or parts per million (ppm).

The amount of dissolved oxygen needed for survival of individuals and for sustaining healthy populations of aquatic organisms varies by species. Fish tend to need more dissolved oxygen than other species of animals. Aquatic plants and algae even require dissolved oxygen to survive.

Generally, a higher dissolved oxygen level indicates better water quality. Dissolved oxygen levels are too low, some fish and other organisms may not be able survive.

### **Factors effects on Dissolved Oxygen amount**

#### **Photosynthesis**

While most photosynthesis takes place at the surface (by water plants and algae), a large portion of the process takes place underwater (by seaweed, sub-surface algae and phytoplankton). Light can penetrate water to the depth that it can be reach. Aquatic photosynthesis is light-dependent, the dissolved oxygen produced will peak to the maximum during daylight hours and decline to the minimum at night.

#### **Depth**

Depth also affects the light available to plants, In clear water, there is no longer enough light for photosynthesis to occur beyond 200 m, and aquatic plants no longer grow. In turbid water, this photic (light-penetrating) zone is often much shallower.

#### **Temperature**

Water temperature is important because it not only establishes the maximum oxygen-holding capacity of water, but also has direct influence on rates of biochemical reactions and transformation processes, the colder the water, the greater capacity it has to hold oxygen.

A difference in DO levels may be detected at the test site if tested early in the morning when the water is cool and then later in the afternoon on a sunny day when

---

the water temperature has risen. A difference in DO levels may also be seen between winter water temperatures and summer water temperatures.

**The atmospheric pressure**

The atmospheric pressure effects the amount of oxygen dissolved in water. At higher elevations, less oxygen can be dissolved in water.

**Turbulence**

The more turbulence that a stream or river displays, such as waterfalls or rapids, the more oxygen is absorbed into the water. Also, turbulence on the surface of a body of water caused by wind tends to increase levels of dissolved oxygen.

**Cellular respiration**

Cellular respiration is the primary factor for the low levels of dissolved oxygen. During cellular respiration organisms use oxygen to metabolize food energy.

**Organic matter**

Excessive organic matter as a result of uneaten food, runoff or other sources consumes oxygen during decomposition.

**Salinity**

The maximum amount of oxygen that can dissolve in to water is affected also by elevation of the water testing salinity (saltiness) of the water. An increase in salinity lower concentrations of dissolved oxygen.

**Dissolved oxygen Levels in water**

<b>DO Level</b>	<b>Water Quality</b>
-----------------	----------------------

<b>(PPM)</b>	
0.0-4	<b>Poor</b> Some fish and macro invertebrate populations will begin to decline.
<b>4.1 – 7.9</b>	<b>Fair</b>
<b>8-12</b>	<b>Good</b>
<b>12.0+</b>	<b>Retest</b> Water maybe artificially aerated.

**Test Procedure for the Winkler method:**

**1. Sample collecting**

When collecting your water sample, here are some important guidelines:

- Sample the water away from the bank and below the water surface level.
- Be careful not to get any air bubbles in the sample during collection; it may result in a false high reading.
- Allow the water to gently fill the DO sample bottle from bottom to top.
- Put a lid on the bottle while it is under water.

Test the DO level immediately. Biological activity in the sample and exposure to air can quickly change the DO level.

**2. Laboratory work**

1. Add gently, and just below the surface, 2 ml off  $MnSO_4$  reagent and 2 ml of the mixed NaOH-KI reagent. Do not mix the pipettes between reagents, and do not mouth pipette the reagents. Carefully stopper the bottle without introducing any air bubbles and mix vigorously by inverting the bottle repeatedly.
2. Allow the precipitate to settle, then shake vigorously again and allow the precipitate to settle to at least the bottom third of the bottle. If the rest of the analysis has to be delayed, the samples will normally keep quite well in this condition.

- 
3. Add 2 ml of concentrated H<sub>2</sub>SO<sub>4</sub>, inserting the tip of the pipette just below the surface of the sample. Carefully re-stopper the bottle, avoiding bubbles, and shake until all the precipitate has dissolved. Samples can also be stored in this condition if protected from light, but the free iodine has a high vapour pressure and tends to escape even from well-capped bottles. Delay of further analysis beyond 5 hours is not desirable.
  4. Measure 100 ml of the sample with a volumetric pipette and transfer to a 250 ml flask. For accurate delivery, the tip of the volumetric pipette should be touched to the side of the flask during delivery.
  5. Using a 50 ml burette filled with 0.025M standardized sodium thiosulfate solution; titrate with mixing until a pale straw colour is attained.
  6. Add 1 or 2 ml of stabilized starch mixture, mix to get a uniform blue colour, and continue titrating carefully but rapidly to a colourless end-point. The blue colour should return if the sample is left standing for 15 to 20 seconds, and can be ignored. If the blue colour does not return, the end-point has been overshoot. Record the volume of titrant used in ml, to 2 decimal places.
  7. Calculate

$$\text{mg/L} = \frac{\text{volume of titrant (mL) thiosulphate} \times (\text{Molar of Na}_2\text{S}_2\text{O}_3) \times 8000}{\text{Volume of sample} \times \left[ \frac{\text{volume of bottle (ml)} - 2}{\text{volume of bottle}} \right]}$$

Biochemical oxygen demand, or BOD, measures the amount of oxygen consumed by microorganisms in decomposing organic matter in stream water. BOD also measures the chemical oxidation of inorganic matter (i.e., the extraction of oxygen from water via chemical reaction). A test is used to measure the amount of oxygen consumed by these organisms during a specified period of time (usually 5 days at 20 °C).

Units of the BOD value is most commonly expressed in milligrams of oxygen consumed per litre of sample during 5 days of incubation at 20 °C and is often used as a surrogate of the degree of organic pollution of water.

Sources of BOD include leaves and woody debris; dead plants and animals; animal manure; effluents from pulp and paper mills, wastewater treatment plants, feedlots, and food-processing plants; failing septic systems; and urban stormwater runoff.

Microorganisms such as bacteria are responsible for decomposing organ waste. When organic matter such as dead plants, leaves, grass clippings sewage, or even food waste is present in a water supply, the bacteria will begin the process of breaking down this waste. When this happens, much of the available dissolved oxygen is consumed by aerobic bacteria, robbing other aquatic organisms of the oxygen they need to live. If there is a large quantity of organic waste in the water supply, there will also be a lot of bacteria present working to decompose this waste. In this case, the demand for oxygen will be high (due to all the bacteria) so the BOD level will be high. As the waste is consumed or dispersed through the water, BOD levels will begin to decline.

### Factors effects the BOD

#### Nitrates and phosphates

Nitrates and phosphates in a body of water can contribute to high BOD levels. Nitrates and phosphates are plant nutrients and can cause plant life and algae to grow quickly. When plants grow quickly, they also die quickly. This contributes to the organic waste in the water, which is then decomposed by bacteria. This results in a high BOD level.

#### Temperature

The temperature of the water can also contribute to high BOD levels. For example, warmer water usually will have a higher BOD level than colder water. As water

---

temperature increases, plants grow faster and also die faster. When the plants die, they fall to the bottom where they are decomposed by bacteria. The bacteria require oxygen for this process so the BOD is high at this location. Therefore, increased water temperatures will speed up bacterial decomposition and result in higher BOD levels.

### **Chlorine**

Chlorine can also affect BOD measurement by inhibiting or killing the microorganisms that decompose the organic and inorganic matter in a sample. If you are sampling in chlorinated waters, such as those below the effluent from a sewage treatment plant, it is necessary to neutralize the chlorine with sodium thiosulfate

### **DO**

Generally, when BOD levels are high, there is a decline in DO levels. This is because the demand for oxygen by the bacteria is high and they are taking that oxygen from the oxygen dissolved in the water. If there is no organic waste present in the water, there won't be as many bacteria present to decompose it and thus the BOD will tend to be lower and the DO level will tend to be higher.

Since less dissolved oxygen is available in the water, fish and other aquatic organisms may not survive.

### **Other factors**

The rate of oxygen consumption in a stream is affected by a number of variables: Photosynthesis, pH, the presence of certain kinds of microorganisms, and the type of organic and inorganic material in the water.

### **Test Procedure**

The BOD test takes 5 days to complete. The BOD level is determined by comparing the DO level of a water sample taken immediately with the DO level of a water sample that has been incubated in a dark location for 5 days. The difference between the two DO levels represents the amount of oxygen required for the decomposition of any organic material in the sample and is a good approximation of the BOD level.

1. Take 2 samples of water.

2. Record the DO level (ppm) of one immediately using the method described in the dissolved oxygen test in the last laboratory.
3. Place the second water sample in an incubator in complete darkness at 20 °C for 5 days. If you don't have an incubator, wrap the water sample bottle in aluminum foil or black electrical tape and store in a dark place at room temperature (20 °C or 68 °F).
4. After 5 days, take another dissolved oxygen reading (ppm) using the method described in the dissolved oxygen test in the last laboratory.
5. Subtract the Day 5 reading from the Day 1 reading to determine the BOD level. Record your final BOD result in ppm.

### **BOD Levels in water**

<b><u>BOD Level</u></b> (in ppm)	<b><u>Water Quality</u></b>
<b>1-2</b>	<b>Very Good</b> There will not be much organic waste present in the water supply
<b>3-5</b>	<b>Fair:</b> Moderately Clean
<b>6-9</b>	<b>Poor:</b> Somewhat Polluted Usually indicates organic matter is present and bacteria are decomposing this waste
<b>10 or greater</b>	<b>Very Poor:</b> Very Polluted Contains organic waste.

**NOTE:**

---

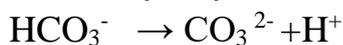
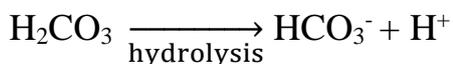
BOD test is most common test that used to determine the degree of pollution in sewage water, waste water from factories that have organic compound, and waste water.

## Determination of Free CO<sub>2</sub> in water

lab 3

### Background Information

Carbon dioxide (CO<sub>2</sub>) is present naturally as a result of animal respiration, the decay of organic matter, and the decomposition of certain minerals. It is the major source of acidity in unpolluted water samples. Surface waters typically contain less than 10 ppm (mg/L) dissolved CO<sub>2</sub>, while ground waters, particularly if deep, may contain several hundred ppm (mg/L). All aquatic organisms release this gas into the water. Some of it bubbles to the surface, some of it dissolves (mixes in) with the water, but most of the carbon dioxide found in the water is produced by organisms (bacteria mostly) that carry on decomposition of dead material. During daylight, all plants use carbon dioxide and give off oxygen by photosynthesis process. At night, the opposite is true. Plants use oxygen and give off carbon dioxide by respiration process. A high level of carbon dioxide usually indicates that there is a lot of dead material undergoing decomposition. This may occur naturally, but could be the result of different types of water pollution. CO<sub>2</sub> and water united to form carbonic acid (H<sub>2</sub>CO<sub>3</sub>), which-analyse to bicarbonate ion and positive hydrogen ion as in the formula:



The relationship between pH of the aquatic medium and CO<sub>2</sub> forms can be explained as following:

Medium	PH	CO <sub>2</sub> forms
acidic	low	Dissolved free form carbonic acid(H <sub>2</sub> CO <sub>3</sub> )
neutral	moderate	bicarbonate forms
alkaline	high	carbonate forms (CO <sub>3</sub> <sup>2-</sup> )

### Test Procedure:

1. Collect your water sample carefully to prevent gas volatilization.
2. Take 100 ml from water sample either supplement or irrigated water by cylinder and put it in a flask.
3. Add 10 drops from phenolphthalein as indicator solution.
4. Titrate with 0.025N sodium hydroxide solution (NaOH).
5. Stir the water sample gently during the titration.
6. The (end - point) of titration is the start of pink colour appearance in the solution.
7. Calculate:

$$\text{CO}_2 \text{ (PPM)} = \frac{\text{ml titrant (NaOH)} * (0,025) \text{ N} * 1000}{\text{Volume of sample (ml)}} \quad \text{mg/L}$$

---

## Measuring salinity by titration

## Lab4

### Background information

Salinity: is the total amount of dissolved salts in water such as sodium chloride (NaCl), calcium chloride (CaCl<sub>2</sub>)...etc, and it is expressed as parts per thousand (‰) units, which is approximately grams of salt per liter of solution.

### We study salinity to:

- Determines the distribution of plants and animals that lives in water.
- Affects other properties of water, such as its density and the amount of dissolved oxygen.

Different bodies of water have different salinities:

- 1- **Fresh water:** salinity less than 0.5 ppt (>0.5‰).
- 2- **Brackish water:** salinity rate between 0.5 ppt and 17 ppt.
- 3- **Marine water:** high salinity rate 35 ppt.

The relationship between salts ratio and dissolved oxygen (D.O) are inversely that if salinity increase, water ability to keep oxygen decrease.

**Biogenetics salts:** is the necessary dissolved salts for life and can be divided to:

- a) **Macronutrient:** which living organisms needed in large quantities like NO<sub>2</sub>, P, S, K, ... etc.
- b) **Micronutrient or trace elements:** necessary in small quantities like Zn, Cu, Mg ....etc.

The presence of salt ions is the primary reason for water hardness. Ecologists confirm the great importance of the phosphorus element (P) representing the basic limiting factor of productivity, decreasing phosphorus limits productivity more than other elements in any region, while other elements are less important like K, Ca, S and Mg.

Although many different ions in water contribute to salinity, six ions account for over 99% of the dissolved material: chloride (Cl), 55.0%; sodium (Na<sup>+</sup>), 30.6%; sulfate (SO<sub>4</sub><sup>-2</sup>), 7.7%; magnesium (Mg<sup>+2</sup>), 3.7%; calcium (Ca<sup>+2</sup>), 1.2%; and potassium (K<sup>+</sup>), 1.2%.

**Because** these six ions are very well mixed and are found in nearly constant proportions, therefore we can measure the concentration of one major constituent and

---

then estimate the total salinity. Since chloride is the most abundant ion, it is the easiest to measure accurately.

**Test procedure:**

1. Measure 25 ml from water sample by using cylinder and put it in volumetric flask.
2. Add 5 drops of the indicator potassium chromate ( $K_2CrO_4$ ) solution.
3. Titrate the sample carefully with (0.01) N silver nitrate ( $AgNO_3$ ) solution, which is a soluble silver salt that reacts readily with all ions, namely,  $F^-$ ,  $Cl^-$ ,  $Br^-$ , and  $I^-$  to form an insoluble silver chloride ( $AgCl$ ) precipitate.
4. Mix the water sample carefully during the titration.
5. The endpoint of titration is the appearance of pink—red color in solution.
6. This titration determines the chlorinity (Cr-/Litter ) in the sample . Chlorinity

concentration calculated from the formula:

$$Cl^-(mg/L) = \frac{\text{ml titrant } (AgNO_3) \times (0.1) N}{\text{volume of sample (ml)}} \times 35000$$

$$Cl^-(ppt) = \frac{\text{amount of chloride (mg/L)}}{1000}$$

Salinity can be determined from chlorinity by the following formula:

$$\text{Salinity (ppt)} = 0.03 + [ 1.805 \times Cl^-(ppt) ]$$

**Practical pollution**

**acidity &alkalinity in water**

**lab 5**

**Background information**

**1. Water acidity:** The acidity of water represents its ability to give protons that come from

1. De - ionized molecules of ionized weak acids such as (carbonic acid and tannic acid).
2. Ferrous sulfate and aluminum salts (**Lewis acid**).
3. Mineral acids. Such as (sulfuric acid or hydrochloric acid).

$CO_2$  is the most likely cause of acidity in water, its result of respiration and autolysis Process of plants & animals in water.

---

CO<sub>2</sub> concentrations effect to (pH) values in water that have different effects on aquatic organism, some of organism can lived in acidic medium reach to pH=2.

So (pH) values vary throughout the day due to respiration and photosynthesis process that cased different acidity values in water.

Procedure: Because CO<sub>2</sub> is the most likely cause of acidity in water, the water sample should be collected within a few hours of the time of analysis. The container used to collect the water should be filled completely and closed with an air-tight seal. A clean plastic soft drink bottle with screw cap is suitable for water sample tested in this procedure.

1. Take 100 ml from water sample either supplement or irrigated water by cylinder and put it in a flask.
2. Add 3 drops from phenolphthalein as indicator solution.
3. Titrate with 0.025N sodium hydroxide solution (NaOH).
4. Stir the water sample gently during the titration.
5. The (end - point) of titration is the start of pink colour appearance in the solution.
6. Record the volume of (NaOH), and calculate water acidity by following equation:

$$\text{Acidity} = \frac{(\text{mL NaOH titrant}) \times (\text{normality NaOH}) \times 1000}{(\text{mL water sample})}$$

**2. Water alkalinity:** The alkalinity of water represents its ability to accept protons that come from:

1. Bases such as sodium hydroxide or potassium hydroxide (and other hydroxide-compounds),
2. Dissolved carbonates.
3. Bicarbonates.

the total alkalinity in water range between (20-200) mg/L.

Alkalinity found in water sample as following forms:

1. CO<sub>3</sub><sup>2-</sup>

- 
2.  $\text{HCO}_3^-$
  3.  $\text{OH}^-$
  4.  $\text{OH}^- + \text{CO}_3^{2-}$
  5.  $\text{HCO}_3^- + \text{CO}_3^{2-}$

Alkalinity measurement is very important to treat waste & normal water and assign the irrigation water suitability, also its considered as a control balance on sewage water treatment processes.

### **Procedure:**

1. Take 100 ml from water sample either supplement or irrigated water by cylinder and put it in a flask.
2. Add 3 drops from phenolphthalein as indicator solution. (1) .
3. Add 5 drops from orange methyl as indicator solution (2).
4. Titrate with (0.02 N) standard sulphuric acid ( $\text{H}_2\text{SO}_4$ ) until solution colour change from yellow to peal orange.
5. Record the volume of ( $\text{H}_2\text{SO}_4$ ), and calculate water alkalinity by following equation:

$$\text{Alkalinity} = \frac{(\text{mL H}_2\text{SO}_4 \text{ titrant}) \times (\text{normality H}_2\text{SO}_4) \times 50000}{(\text{mL water sample})}$$

**Practical pollution**

**Free chlorine Information**

**lab 6**

Before water can be used as safe and reliable source for drinking water, it must be properly treated. Since water is a universal solvent, it comes in contact with several different pathogens, some of which are potentially lethal, and inactivation is accomplished through chemical disinfection and mechanical filtration treatment this treatment consists of coarse filtration to remove large objects and pre – treatment which includes disinfection using chlorine or ozone.

---

One of the first known uses of chlorine for water disinfection was in 1850 after an outbreak of cholera in London. Chlorine was first used in the USA in 1908 as a chemical disinfectant of drinking water, and the powerful disinfectant attributes come from its ability to bond with and destroy the outer surfaces of bacteria and viruses.

Today, chlorine is added to water as chlorine gas ( $\text{Cl}_2$ ), sodium hypochlorite ( $\text{NaOCl}$ ) or chlorine dioxide ( $\text{ClO}_2$ ) in two treatment stages, primary and secondary disinfection. Chlorine is relatively cheap and has a broad spectrum germicidal potency. In the primary disinfection stage of a drinking water plant, only chlorine can provide a residual or persistence in water distribution system and protect against re-growth of microorganisms and prevent water-borne diseases.

### **Forms of chlorine in water:**

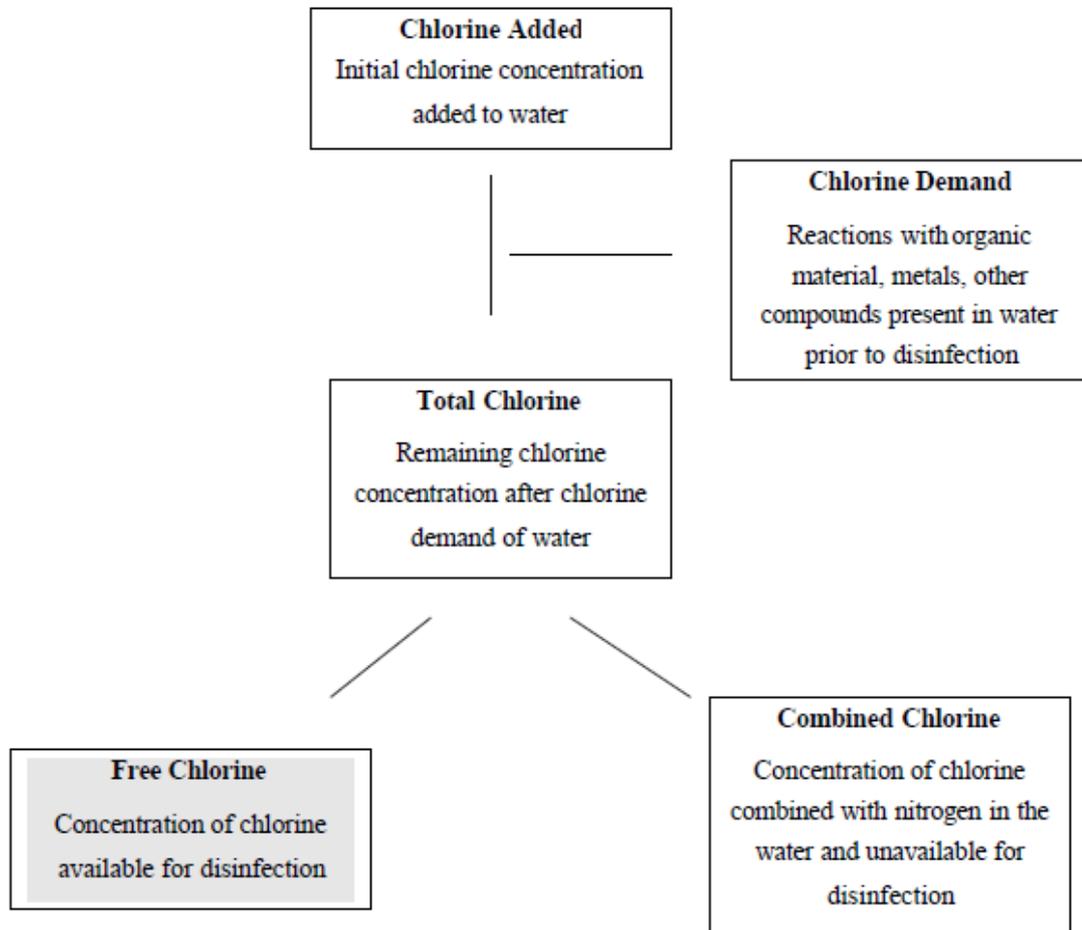
Chlorine interacts with drinking water, it proceeds through a series of chemical reactions which are described below.

When chlorine is added to water, some of the chlorine reacts first with organic materials and metals in the water and is not available for disinfection (this is called the chlorine demand of the water). The remaining chlorine concentration after the chlorine demand is accounted for is called total chlorine. Total chlorine has two main elements:

1. the combined chlorine which has reacted with nitrates and is unavailable for disinfection.
2. The free chlorine, which is the chlorine available to inactivate disease-causing organisms, and thus a measure to determine the degree to which water is drinkable.

---

## Chlorine Addition Flow Chart



Chlorine kills bacteria through a simple chemical reaction. When chlorine solution is poured in to water breaks down into many different chemicals, including hypochlorous acid (HOCl) and hypochlorite ion (OCl). The relative amount of each is dependent on the PH, and the total of HOCl and OCl is defined as free chlorine. To accurately measure free chlorine concentration, the temperature and PH value must be taken in to account

### **Disinfectant strength comparison:**

The germicidal strength of different forms of chlorine in water are ranked as follows:  
HOCl > OCl > inorganic chloramines > organic chloramines.

HOCl is 100 times more powerful an oxidant and disinfectant than is the hypochlorite ion. Consequently, free chlorine is most effective at a PH of 5 to 7 where HOCl is the predominant form. The effectiveness declines with increased PH.

---

## Chlorine residual:

The chlorine residual is usually tested at the following points:

Water requires 2.0 mg /L of chlorine to destroy all organisms.

1. When chlorine added as 1.5 mg /L water not disinfected.
2. When chlorine added as 2.0 mg /L all organisms restored but no chlorine left for future contamination.
3. When chlorine added as 2.5 mg/L all organisms destroyed and 0.5 mg /L residual chlorine remaining.

At the outlet of the consumer nearest to the chlorination point to check that residual chlorine levels are within acceptable levels- (between 0.5 and 0.2 mg / L).

At the furthest point in the network where residual chlorine levels are likely to be at their lowest. If chlorine level is found to be below 0.2 mg/L it might be necessary to add more chlorine at an intermediate point in the network.

## Test procedure:

1. Take ml of water sample and add 1 gm of KI then add of HCl to reach pH (3-4).
2. Titrate with Sodium thiosulfate solution to give pale yellow color because the I be free.
3. Then add 1 ml of starch solution and titrate with thiosulfate in until disappear blue colour.
4. The same procedure work for blank (D.W.).
5. Calculate Chlorine:

$$\text{Cl (mg / L)} = \left( \frac{\text{titrant thio.Sample (ml)} - \text{titrant thio.Blank (ml)} \right) * \text{M (thio)} * \text{m.wt.(Cl)} \\ \text{Volume sample (ml)}$$

**notice:** 1 ml of thiosulfate = 35.5 mg / L from Cl.

## Determination of Calcium and Magnesium in Water

### Background information

#### 1. Calcium (Ca):

The dissolved calcium water mainly gained by leaching rocks consist of  $\text{CaCO}_3$ , such as limestone or any calcareous deposited. While water leaching graphitic and siliceous sands have a low concentration of Calcium.

Calcium concentration ranges are 30-100 mg/L at the calcareous regions water.

Calcium is important for bio productive in water, in which is considered as the main component of the higher-class plant cells wall and the supporting skeletons for many animals like: bones in fishes, shells of mollusk's.

Calcium considered as micro – nutrient for most alga and it plays an important role in transporting ions through cell membrane.

Water of 10 mg/L Calcium concentration considered as oligotrophic, while of 25 mg/L is considered as autotrophic. The best Calcium concentration in water is 75 mg/L and the heights allowed concentration is 200 mg/L.

### Test procedure

1. Take 50 ml of water sample in a flask.
2. Add 1-2 ml of NaOH (1N) until pH become (13-14).
3. Add 0.2 gm from (murexide) powder until color become pink.
4. Titrate against EDTA with continuous stirring, record the end point by Change the indicator color from pink to violet.
5. Record the volume of EDTA.

### **Calculation**

Account from the equation:

$$\text{Ca (mg/ L)} = A * 3.213$$

While A represent the volume of EDTA from the titration.

---

## **2- Magnesium (Mg)**

The main source of magnesium is the carbonate rocks. It could be seen that the concentration of Magnesium might range between 5-50 mg /L. on regions rich with this type of rocks, and it effects water hardness, and its existence is necessary for plant growth, and plays an important role in constructing chlorophyll. The best high concentration of Magnesium is 30 mg /L and the highest allowed value is 150 mg /L.

### **Test procedure:**

1. Take 50 ml of water sample in flask.
2. Add (7-9) drops of buffer solution to reach PH=10.
3. Add 0.2 gm of Eriochrome Black T stain to become pale pink.
4. Titrate this mixture against EDTA slowly with continuous stirring until change the color from pink to pale blue.
5. Calculate by using the equation;

$$\text{Mg of hardness mg/L} = \frac{\text{titrate of EDTA} * 1000}{\text{Volume of sample}}$$

\*to get the filtrate water from soil:

Take 50 mg of soil and add 200 ml of distilled water and shake the flask to 1/2 hr. then take 50 ml from the product.

**Hard water:** is water that contains salts of calcium, magnesium, and other minerals (like iron, aluminum, and manganese). These salts require large amount of soap, or otherwise it may leave sediment when water is vaporized.

**Total water hardness divided into:**

- A- Temporary hardness.
- B- Permanent hardness.

Hardness can be identified as total concentration of calcium (calcium carbonate) in water measured by milligram per liter.

**Classification of hard water**

Hard water can be classified by brown et al. method (1970) to 3 types:

- 1- Light hardness (0-60 mg/L)
- 2- Moderate hardness (61-120 mg/L)
- 3- Severe hardness (121-180 mg/L)

**Calculation of total hardness**

**Materials:**

- 1- Buffer solutions: composed of ( $\text{NH}_4\text{OH} + \text{MgCl}_2 + \text{NH}_4\text{Cl} + \text{NaCl}$ )
- 2- Inhibitory solution: composed of ( $\text{Na}_2\text{S} \cdot 5\text{H}_2\text{O} + \text{EDTA} + \text{D.W.}$ )
- 3- Indicator: (Erichrome black T dye).
- 4- EDTA (ethylene diamine tetra acetic acid)

---

### Method:

- 1- Adjust the PH of 50 ml of water sample by adding few drops of buffer solution with concomitant of PH by litmus paper.
- 2- Add 1 ml of inhibitory sol. Then add 0.2 gm of indicator dye.
- 3- Titrate the solution against EDTA sol. And record the titration volume. From the pipette.
- 4- Calculate total hardness with the following equation:

$$\text{Total hardness (mg/liter)} = \frac{1000 \times \text{EDTA sol. volume (ml)}}{\text{water sample volume (ml)}}$$

### calculation of permanent hardness -

#### Method:

1. Take 250 ml of water sample, and boil the sample for 20-30 min., then leave it to chill, then a filter.
2. Take the filtrate, and complete till 250.
3. Take 50 ml of this water and follow the 1-4 steps for calculation of total water hardness.

### Calculation of Temporary hardness

Temporary hardness is calculated mathematically from this equation:

$$\text{Temporary hardness} = \text{Total hardness} - \text{Permanent hardness}$$

## **Air Pollution Laboratory**

### **Theoretical part**

Dust consists of particulate matter (PM) in the atmosphere. It represents one of the 'most significant air pollutants that produces several damages on humans, animals and plants especially when it exists in a large quantity to cover a large area.

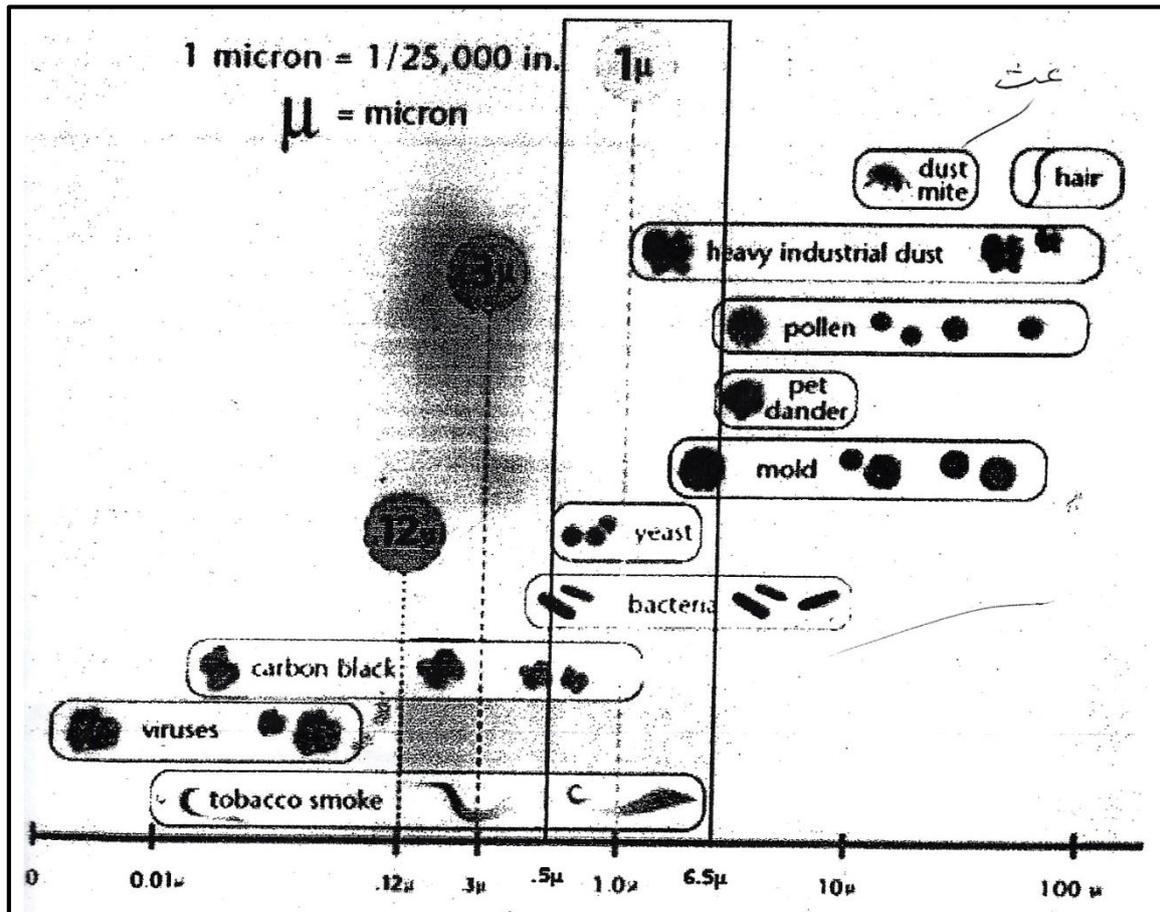
Dust particles come from various sources such as: soil, dust lifted by weather (an Aeolian process), volcanic eruptions, and pollution.

Dust in homes, offices, and other human environments contains small amounts of plant pollen, human and animal hairs, textile fibers, paper fibers, minerals from outdoor soil, human skin cells, and many other materials which may be found in the local environment.

Size is important to the behavior of PM in the atmosphere and human body and determines the entry and absorption potential for particles in the lungs. Particles larger than  $10\ \mu\text{m}$  are trapped in the nose and throat and never reach the lungs. Therefore, particles  $10\ \mu\text{m}$  in diameter or less are of most concern for their effects on human health. Particles between 5 and  $10\ \mu\text{m}$  are removed by physical processes in the throat. Particles smaller than  $5\ \mu\text{m}$  reach the bronchial tubes, while particles  $2.5\ \mu\text{m}$  in diameter or smaller are breathed into the deepest portions of the lungs.

**Dust particles are classified according to its size to:**

1. Accumulated dust particles: its size is more than 12.5  $\mu$ , and it has a slight effect on the respiratory tract because the nasal hairs are able to catch this type of particles, but it has a severe effect on eyes.
2. Suspended dust particles: its size range between (0.1 - 12.5  $\mu$ ). It deposits slowly as they remain suspended in air for long time, and it has a dangerous effect on human and animal's health and produce lung diseases.



### Practical part:

Accumulated dust measurement by using the opened glass method In this experiment, it must be taken in consideration that accumulated dust must be measured during natural conditions and non- stormy or rainy weather, because rain works to wash air dust.

Opened glass method:

1. weigh the empty glass (W1).
2. Put (150ml) of distilled water in the glass and leave it opened for one week in the outdoor environment.

