BIRZEIT UNIVERSITY

Civil Engineering Department

Sanitary Lab Lecture Notes
ENCE419

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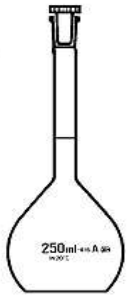

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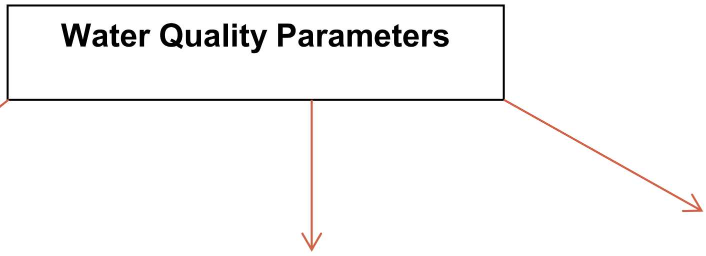
Introduction:

In general experiments in this lab can be classified into three groups:



Chemical	Physical	Microbiological
BOD	pH	Coliform
COD	EC	
N, TKN	TDS	
PO_4	Salinity	
SO_4	Turbidity	

Methods of analysis:

1-Volumetric Analysis: the analyst measures the amount of a solution of known concentration that reacts with a particular substance in the solution of a weighed or otherwise measured portion of the original sample. The weight of the material is found indirectly from the amount of the known (standard) solution that is required. The means of detecting the completion or "endpoint" of the volumetric reaction is the indicator. The process of finding the amount of the standard solution required is called a titration.

2-Gravimetric Analysis: the analyst measures the wastewater or sludge sample and then isolates and weighs an element or one of its components. Examples of gravimetric analysis are total solids (residue on evaporation) volatile solids, and suspended matter determination.

3-Colorimetric Analysis

4-Electrometric Analysis

Experiment # 1

Biochemical Oxygen Demand (BOD)

The BOD test measures the strength of the wastewater by measuring the amount of oxygen used by the bacteria as they stabilize the organic matter under controlled conditions of time and temperature.

In the presence of free oxygen, aerobic bacteria use the organic matter found in wastewater as “food”. The BOD test is an estimate of the “food” available in the sample. The more “food” present in the waste, the more Dissolved Oxygen (DO) will be required.

The BOD test is used to measure:

1- waste loads to treatment plants
2- determine plant efficiency (in terms of BOD removal)
3- determine the effects of discharges on receiving waters

A major disadvantage of the BOD test is the amount of time (5 days) required to obtain the results.

When a measurement is made of all oxygen consuming materials in a sample, the result is termed “Total Biochemical Oxygen Demand” (TBOD), or often just simply “Biochemical Oxygen Demand” (BOD). Because the test is performed over a five day period, it is often referred to as a “Five Day BOD”, or a BOD_5.

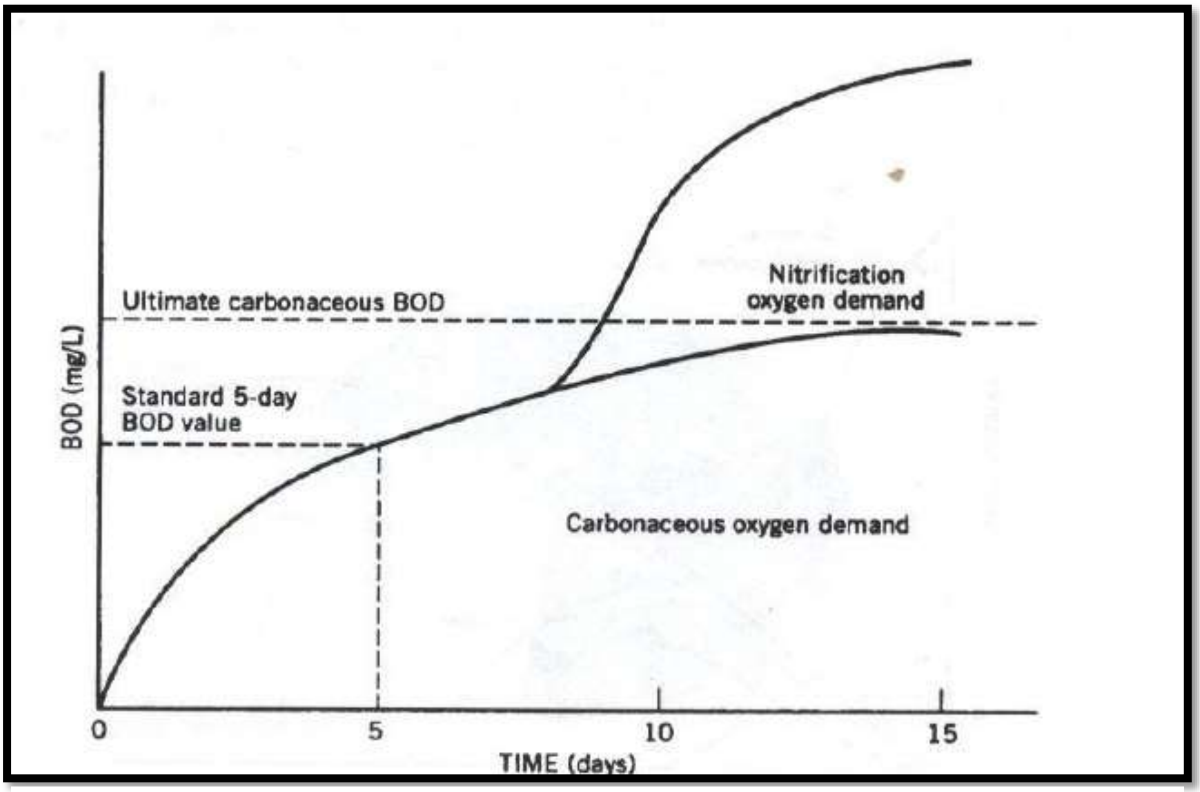


Figure 1.1: Carbonaceous and autotrophic BOD

Refers to Figure1.1:

Large numbers of nitrifying organisms which are developed during the treatment process. These organisms can exert an oxygen demand as they convert nitrogenous compounds (ammonia and organic nitrogen) to

more stable forms (nitrites and nitrates). At least part of this oxygen demand is normally measured in a five day BOD.
Sometimes it is advantageous to measure just the oxygen demand exerted by organic (carbonaceous) compounds, excluding the oxygen demand exerted by the nitrogenous compounds. To accomplish this, the nitrifying organisms can be inhibited from using oxygen by the addition of a nitrification inhibitor to the samples. The result is termed "Carbonaceous Biochemical Oxygen Demand".

Experiment Procedures:

لقياس قيمة الBODلعينة معينة نقوم باتباع الخطوات التالية:

◄نحضر Beaker حجمه 1 لتر ويتم اضافة المواد الكيميائية التالية والتي تعتبر مغذيات للبكتيريا خلال الخمسة أيام :

- **Phosphate buffer solution**
- **Magnesium sulfate solution ($MgSO_4 .7H_2O$)**
- **Calcium chloride solution ($CaCl_2$)**
- **Ferric chloride solution ($FeCl_3$)**

Figure 1 : Blank Sample (sample 1)

◄ يتم احضارBOD Bottleحجمها 300mlويتم تعبئتها بشكل كامل من ال Beaker وتسمى هذه العينةBlank Sample

Figure 2: W.W Sample (sample 2)

◄ يتم احضارBOD Bottleحجمها 300 ml

نضع فيها 3ml W.W وبعد ذلك يتم تعبئتها بشكل كامل من ال Beaker

وتسمى هذه العينةWaste water Sample

Figure 3: DO meter

◄ يتم قراءة $BOD_{initial}$ للعينتين باستخدام جهاز DO meter

◄ يتم حفظ العينتين بعد ذلك في Incubator على درجة حرارة 20 ولمدة خمس أيام في مكان معتم وبعد نهاية الخمس أيام يتم قراءة BOD_5 لكلا العينتين

$$BOD_5^{20} = \frac{D_0 - D_5}{p}$$

•Find dilution factor (p) = $\frac{\text{Amount of W.W added to the flask(ml)}}{\text{Volume of flask(ml)}}$

Where:

D_0: DO for sample immediately after preparation.

D_5: DO for diluted sample after 5 days incubation at 20°

P (Dilution factor): decimal volumetric fraction of sample used.

Experiment # 2

Chemical Oxygen Demand (COD)

The chemical oxygen demand (COD) is an indirect measure of the quantity of organic material in water and wastewater. The organic material in water is oxidized with a strong chemical oxidant (dichromate). The quantity of oxidant used in the reaction is measured calorimetrically and expressed as mg of O_2 per L of water.

The main limitation the COD test:

1- Dichromate $(Cr_2O_7)^{-2}$ will react with almost all organic compounds.
2- Test cannot distinguish between biologically-oxidizable and non-biodegradable compounds.

Advantages of the COD:

1- Needs only 2 hours to be completed.
2- Strong oxidizing conditions are somewhat independent of variations in experimental conditions and procedures.

Typical BOD5 and COD values for the wastewater are usually as follows:
COD = 2 BOD (in raw wastewater, influent)
COD = 4 BOD (in treated wastewater, effluent)

Experiment Procedures:

►Standard solution for COD test is (KHP): Potassium Hydrogen Phthalate.

$$\mathbf{1ml\ KHP = 1000\ \frac{mg\ O2}{L}}$$

1-Bring 5 volumetric flasks with 50 ml volume.

2-Fill all flasks with distilled water.

3-Bring 5 digestion tubes then from each flask 2.5 ml of the standard solution were transferred to the digestion tubes.

<u>For each digestion tube add:</u>

- **1.5 ml digestion solution**
- **3.5 ml H_2SO_4**

Then put all tubes in heating block at 150°C for 2 hours.

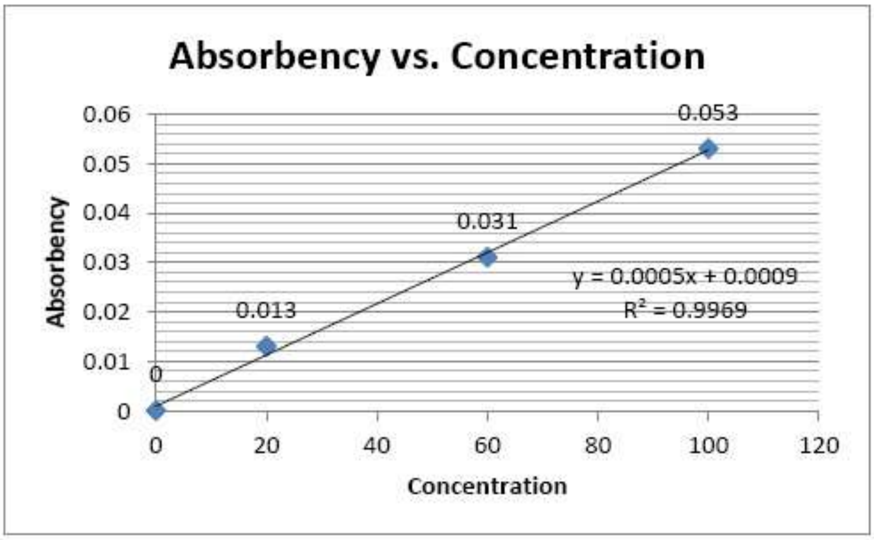
.

Read the absorbance by Spectrophotometer device @ 600 nm wave length.

Sample	(KHP) mg/l	W.W	Concentration	Absorbency
Blank	0	0	0	0
1	1	0	By equation	
2	3	0	By equation	
3	5	0	By equation	
W.W	0	3ml	???	

$$\text{Concentration} = \frac{\text{Amount of KHP}}{\text{Flask volume}=50\text{ ml}} \times 1000\ \frac{\text{mg O2}}{L}$$

2-Draw Calibration Curve (the following curve just example).



•**By using linear equation find X which represents the concentration of diluted W.W sample.**

•**Find dilution factor** $= \dfrac{\textbf{Amount of W.W added to the flask}}{\textbf{Volume of flask=50 ml}}$

$$\textbf{COD for W.W sample} = \frac{\textbf{X}}{\textbf{Dillution factor}}$$

Experiment # 3

Ammonia Determination by Direct Nesslerization Method (NH_3)

•**Total nitrogen** is comprised of **organic nitrogen, ammonia, nitrite, and nitrate**.

•**Organic nitrogen** is determined by **kjeldal method (كلدال).**

•**Kjeldal nitrogen** = **organic nitrogen + ammonia nitrogen.**

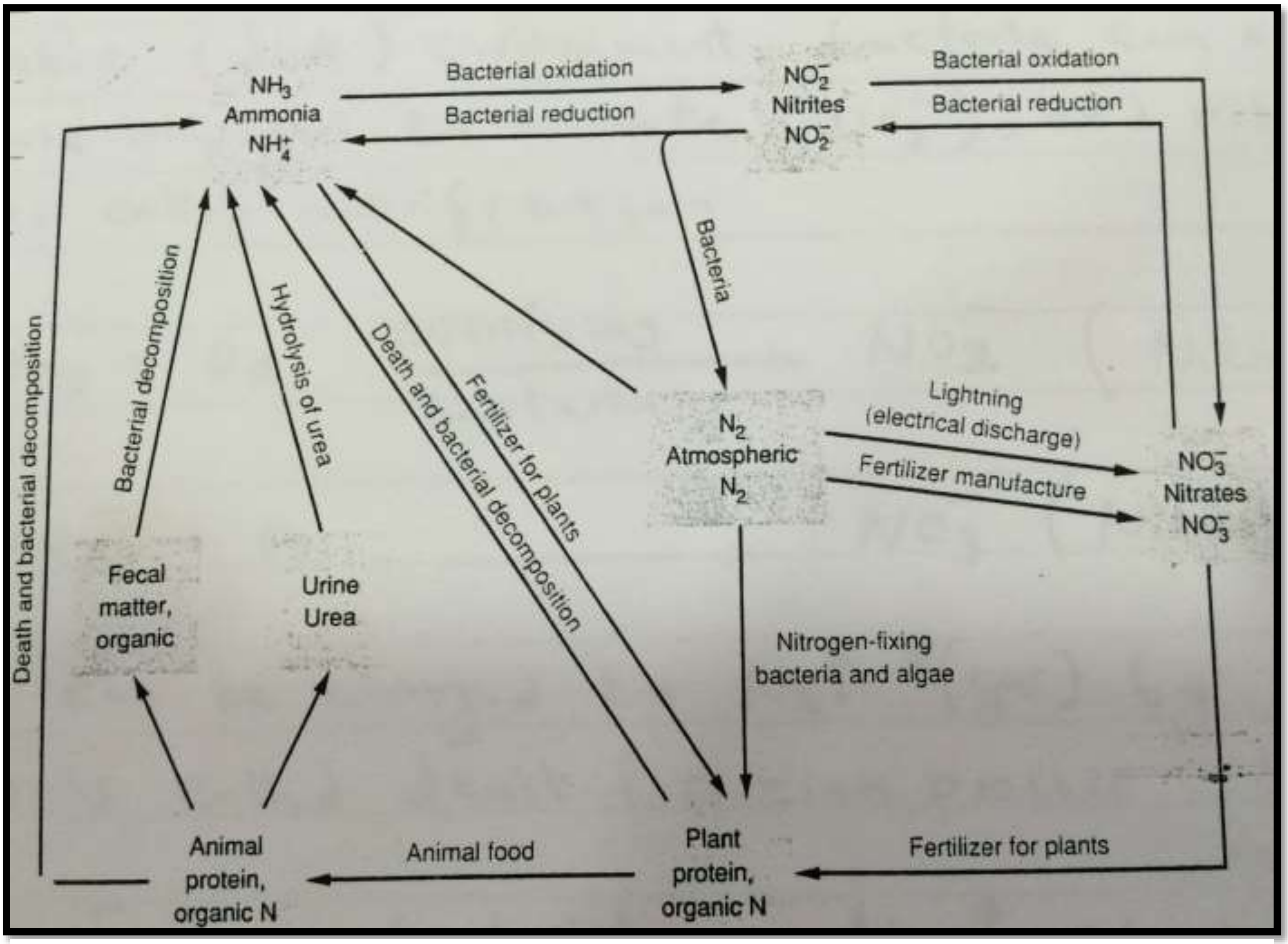


Figure 1: Nitrogen Cycle

•The nitrogen present in fresh wastewater is primarily combined in protenaceous matter +urea.

•Nitrogen is important for bacteria in treating wastewater.

•The age of wastewater is indicated by the relative amount of ammonia that is present.

•Decomposition (التحلل) of organic nitrogen by bacteria changes the nitrogen to ammonia (NH_3)

$$\text{Organic N} \xrightarrow{\text{bacteria decomposition}} NH_3$$

•**The nitrogen forms of interests are**: organic, inorganic, and gaseous nitrogen.

•In aerobic (هوائي) environment, bacteria can oxidize the ammonia nitrogen to nitrate (NO_3^-) and nitrite (NO_2^-), and this is called **nitrification**

$$NH_3 + O_2 \xrightarrow{\text{nitrifying bacteria}} NO_2^- \quad \text{(Nitrite)}$$
$$NO_2^- + O_2 \longrightarrow NO_3^- \quad \text{(Nitrate)}$$

•Nitrate can be changed to N_2 gas by bacteria and this is called **denitrification**

$$NO_3^- \xrightarrow{\text{bacterial denitrification}} N_2 \uparrow$$

•The inorganic nitrogen (NH_3, NO_2-, NO_3-) are water soluble (ذائبين في الماء) and serves as plant nutrients in photosynthesis (التمثيل الضوئي).

$$\text{Inorganic N} + CO_2 \xrightarrow{\text{sunlight}} \text{green plants}$$

•Ammonia can be air stripped from solution at high pH.

$$NH_4OH \xrightarrow{\text{Air stripping}} NH_3 \uparrow$$

•Feces, urine and food processing discharges are the primary sources of nitrogen in domestic waste.

•The predominance of nitrate nitrogen in wastewater indicates that the wastewater has been stabilized with respect to oxygen demand.

•Nitrates can be used by animals to form animal protein. Death and decomposition of plants and animals protein by bacteria yields ammonia.

•Nitrate (NO_3^-) can be reduced to nitrite (NO_2^-) which can be observed by blood, oxidizing the iron of hemoglobin. This interfaces with oxygen transfer resulting in cyanosis (ازرقاق) and giving the baby a blue color.

•Organic nitrogen: is associated with suspended solids in wastewater and can be removed by **sedimentation**.

Ammonia nitrogen → **changed to ammonia gas**

→ **changed to NO_3^- and NO_2^-**

•Nitrate nitrogen: if not removed by treatment plant, it will percolate to groundwater.

Experiment Procedures:

► **Standard solution is (NH_4CL).**

1 ml = 10 ug (N –NH3)

Where: 1 milligram/mL = 1000 microgram/mL

1- Bring 5 volumetric flasks with 50 ml volume.

Blank sample	2ml NH_4CL	5ml NH_4CL	7ml NH_4CL	2ml W.W

2- 2 drops of <u>Rochelle salt</u> and 2 ml of <u>Nessler reagent</u> were added to the 5 flasks.

3- Fill all flasks with distilled water.

4- The flasks were closed, mixed horizontally, and then left for 15 minutes.

5- The absorbency of the solutions was found by the spectrophotometer device that has a wave length of 425 nanometer.

6- Draw calibration curve in order to find concentration of W.W sample.

$$\text{Concentration} = \frac{\text{Amount of NH4CL x 0.01}}{\text{Flask volume=50 ml}} \times 1000 \ \frac{mg\ N}{L}$$

$$D.F = \frac{\text{Amount of W.W}}{\text{Flask volume=50 ml}}$$

Experiment # 4

Total Kjeldahl Nitrogen Determination (TKN)

- تنقسم هذه التجربة الى ثلاثة مراحل رئيسية:

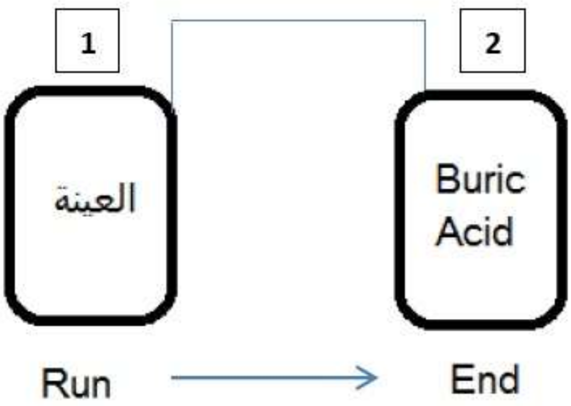
1. المرحلة الأولى وتسمّى بمرحلة ال **Digestion** وهي عبارة عن عملية تحويل ال organic nitrogen الى أمونيوم سولفيت ($(NH_4)_2SO_4$) باستخدام محلول السلفريك (H_2SO_4)، حيث نحضر أنبوب ونضع فيه 50 mL من ال wastewater، و 50 mL من reagent اسمه borate buffer ولونه أزرق فاتح، ثم نضع الأنبوب في غرفة خشبية تسمى Hood ولها باب زجاج حتى نراقب العينة من خلاله، وتكون درجة الحرارة 450 °C ويكون البخار الناتج من هذه العملية سام جداً، وتستمر العملية لمدة ساعتين.

$$\text{Organic Nitrogen} + H_2SO_4 \longrightarrow (NH_4)_2SO_4$$

2. المرحلة الثانية تسمّى بمرحلة ال **Distillation** وهي عبارة عن وضع العينة في جهاز كلدال الموضح في الأسفل

تتبخر العينة وتنتقل الى الأنبوب المجاور والذي يحوي Buric Acid فيتغير لون الحامض من بنفسجي الى أخضر.

وفي هذه المرحلة يتم إضافة محلول قاعدة وهو صوديوم هيدروكسيد (NaOH) الى العينة وذلك من أجل تحويل الأمونيوم الى أمونيا. وبما أن غاز الأمونيا NH_3 متطاير، ينتقل من أنبوب 1 الى 2 بحيث يمتصه ال Buric Acid فيتغير لونه من بنفسجي الى أخضر، وتستمر هذه العملية 20 دقيقة.



$$2NaOH + (NH_4)_2SO_4 \longrightarrow Na_2SO_4 + 2H_2O + 2NH_3$$

3. المرحلة الثالثة وتسمّى بمرحلة ال **Titration** أو المعايرة، وتعرّف بأنها إضافة محلول حامضي وهو (H_2SO_4) الى ال Buric Acid وذلك لإرجاع اللون الى البنفسجي وبذلك يتم حساب كمية ال (H_2SO_4) المستهلكة واللازمة لإرجاع اللون الى البنفسجي.

- يحسب ال **Total Kjeldal Number** حسب المعادلة التالية:

$$\text{Total Kjeldal Number (mg/L)} = \frac{(A-B)*(0.02*14*1000)}{\text{volume of sample (mL)}}$$

A: mL titration required for sample
B: mL titration required for Blank

Organic Nitrogen Determination:

Since TKN represents the sum of the organic and ammonia nitrogen concentrations, the amount of organic nitrogen normally can be determined by subtraction.

Organic nitrogen = TKN - Ammonia nitrogen

Experiment # 5

Sulfate (SO_4)

- Sulfates are a combination of sulfur and oxygen and are a part of naturally occurring minerals in some soil and rock formations that contain groundwater; it is formed from decomposing underground deposits of organic matter such as decaying plant material.
- Sulfate found in deep or shallow wells and also can enter surface water through springs.
- Sulfate is reduced biologically under **anaerobic** conditions to sulfide, which in turn can combine with hydrogen to form **hydrogen sulfide (H_2S).**

$$\text{Organic matter} + SO_4^{-2} \xrightarrow{\text{bacteria}} S^{-2} + H_2O + CO_2$$

$$S^{-2} + 2H^{+} \longrightarrow H_2S$$

- Hydrogen sulfide is released to the atmosphere and causes a bad smell. Accumulation of H_2S can be oxidized biologically to sulfuric acid which causes corrosion, Corrosion is most severe at the crown of the pipe, where the acid collects, and leads to a weakening of the pipe (or structure) and potential collapses if left unattended.
- Sulfurous acid dissociates to form HSO^{-3} which reacts with free chlorine to form chloride and sulfate ion.

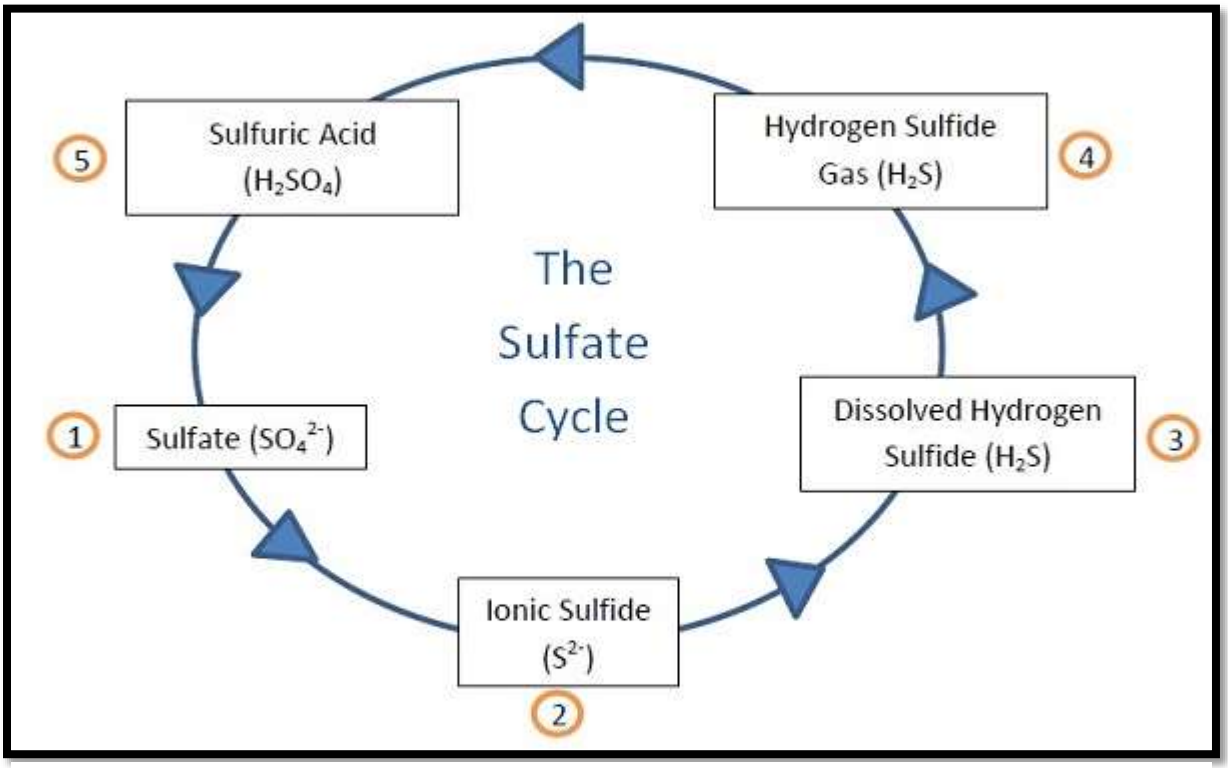


Figure 1: Sulfate Cycle

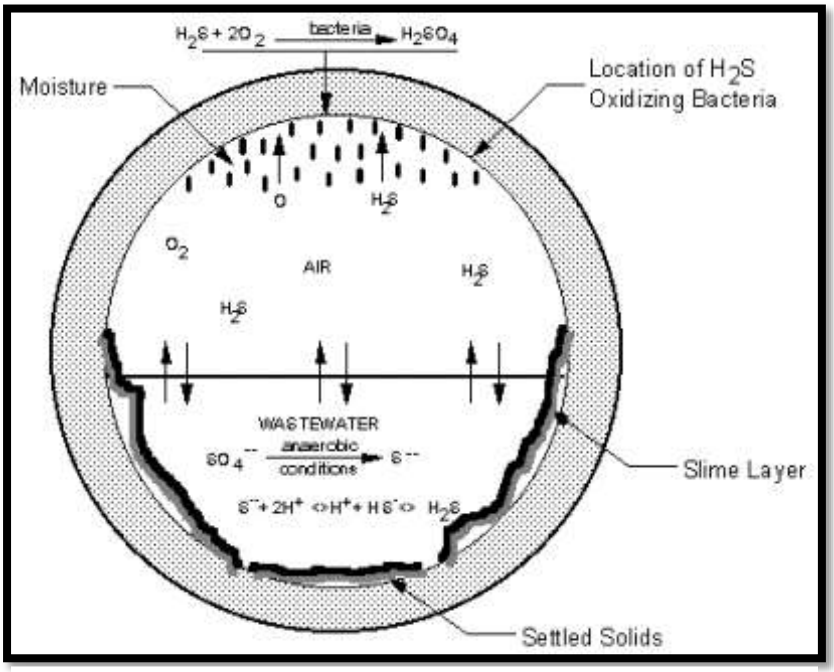


Figure 2: Hydrogen sulfide effects on sewer system

- Relatively high levels of sulfates in drinking water do not seem to be harmful. The US Public Health Service recommends that drinking water contain **no more than 250 mg/L** of sulfates, people can taste sulfates at a concentration **above 200 mg/L**.

- Water used for irrigation should have a sulfate concentration **below 200 mg/L.**

- It has been reported that fifty percent of good fishing waters have a sulfate concentration below **32 mg/L.**

- Sulfate concentrations **above 300 mg/L** increase the amount of lead dissolved from lead pipes often used in domestic water systems.

- The major observed health effect of sulfate is its laxative action (اسهال). No observed health effects have been noted for concentrations of sulfate **less than 500 mg/L.**

- **ملاحظات:**

- **يتم استعمال ال Buffer حتى يتم تعديل الحموضة (pH) في التجربة.**

$$BaCl_2 + SO_4^{-2} \longrightarrow BaSO_4$$

- **وهذا المركب $BaSO_4$ يكون معلق اي على شكل suspension لذلك يجب اجراء التجربة بسرعة حتى لا يحدث settlement.**

Experiment Procedures:

The sulfate determination uses the barium sulfate **turbidimetric method**. Barium ions react with sulfate ions to produce insoluble barium sulfate.

$$Ba^{+2} + SO_4^{-2} \dashrightarrow BaSO_4$$

► **Standard solution: Standard SO_4^{-2} ------> 1ml SO_4^{-2} = 100 µg SO_4^{-2}**

1- **Bring 5 volumetric flasks with 100 ml volume.**

Blank sample

5ml SO_4^{-2}

10ml SO_4^{-2}

15ml SO_4^{-2}

2ml W.W

2- **Fill all flasks with distilled water.**

3- **Put the content of each flask into 250 ml beaker.**

4- **For each beaker add 20 mL of buffer A solution and mix with magnetic stirrer.**

5- **Add a measured spoonful of $BaCl_2$ and stir exactly 1.0 min.**

6- **After 5 mins, measure the absorbance by spectrophotometer at 420 nm.**

7- **Draw calibration curve and find W.W concentration.**

$$\text{Concentration mg } SO_4^{-2}/L = \frac{\text{Amount of } SO_4^{-2} \times 100\ \mu g\ SO_4^{-2} \times 10^{-3}}{100\ ml \times 10^{-3}}$$

Then:

Concentration mg SO_4^{-2}/L = Amount of SO_4^{-2}

Experiment # 6

Ortho-Phosphate (PO_4)

- Phosphate is the most significant inorganic phosphorous which occurs in natural water and in wastewater.

- Phosphorous is essential to the growth of algae and other biological organisms like "Plankton" which can be defined as free swimming and floating organism.

- Phosphorus is often the nutrient responsible for accelerated **eutrophication** which is responsible for many problems such as fish kills, noxious tastes & odors.

- Most phosphorous entering surface water is from man-generated wastes and land runoff.

- Domestic waste contains approximately 1.6 Kg/capita/year, most are (60%) from synthetic detergents **(المركبات المنظفة)**

- Most common forms of phosphorous are organic phosphorous and orthophosphates ($H_2PO_4^-$, HPO_4^{-2} , PO_4^{-3}), and polyphosphates $P_2O_7^{-4}$ and $P_3O_{10}^{-5}$

- Total phosphorous = All types of phosphorous
  70% of Total phosphorous is soluble.

$$PO_4 + NH_3 + CO_2 \xrightarrow{\text{sunlight}} \text{Green plants (photosynthesis)}$$

$$\text{Organic P} \xrightarrow[\text{decomposition}]{\text{bacterial}} PO_4$$

$$\text{Polyphosphates} \xrightarrow[\text{in water}]{\text{hydrolysis}} PO_4$$

- In this experiment Phosphate will readily react with ammonium molybdate in the presence of suitable reducing agents to form a **blue colored complex**.

Experiment Procedures:

► Standard solution is (PO_4).

$$1\ ml = 5\ \mu g\ (PO_4\text{-}P)$$

Where: 1 milligram/mL = 1000 microgram/mL

1- Bring 5 volumetric flasks with 50 ml volume.

Blank sample	3ml PO_4	7 ml PO_4	10ml PO_4	4 ml W.W

2- For each flask add 8 ml of combined reagent which consist of :

Ammonium solution= 15mL

Potassium solution= 5mL

H_2SO_4= 50 mL

Ascerobic Acid= 30 mL

3- Fill all flasks with distilled water.

4- The flasks were closed, mixed horizontally, and then left for 15 minutes.

5- The absorbency of the solutions was found by the spectrophotometer device that has a wave length of 880 nanometer,Draw calibration curve in order to find concentration of W.W sample.

$$\text{Concentration mg P/ L} = \frac{\text{Amount of } PO_4 \times 5\ \mu g\ PO_4 \times 10^{-3}}{50\ ml \times 10^{-3}}$$

Experiment # 7

Alkalinity

• Alkalinity: is the capacity of water to neutralize an acid; it is the measure of how much acid can be added to a liquid without causing a significant change in pH.

• Total alkalinity is the number of equivalents per liter of strong acid required to titrate the solution to a pH of 4.5, this point is called **alkalinity end point.**

• Alkalinity is not the same as pH because water does not have to be strongly basic (high pH) to have high alkalinity.

- عند إضافة حمض إلى الماء مثل **(H_2SO_4)** يزداد تركيز أيون ال **(H^+)** مما يقلل من قيمة ال **pH** وبالتالي تزداد ال **acidity.**
- عند إضافة قاعدة إلى الماء مثل **(NaOH)** تتّحد جزيئات ال **(H^+)** الحرّة مع جزيئات ال **(OH^-)** مميا يزيد من قيمة ال **pH** وبالتالي تزداد ال **alkalinity.**

➢ There are **<u>three major classes</u>** of materials that contribute to alkalinity in natural water:

1. Hydroxide (OH^-)
2. Carbonate (CO_3^{-2})
3. Bicarbonate (HCO_3^{-1})

But most of natural alkalinity in water due to (HCO_3^-) which is produced by the action of CO_2 and H_2O on limestone, as the following equation: **<u>(See Figure 1 and Figure 2)</u>**

$$CO_2 + H_2O \Longleftrightarrow H_2CO_3 \Longleftrightarrow H^+ + HCO_3^- \Longleftrightarrow 2H^+ + CO_3^{-2}$$

• **Carbonate alkalinity** (or phenolphthalein alkalinity) refers to the quantity of strong acid required to titrate the solution to the phenolphthalein endpoint. At this point, **all CO_3^{-2} has been converted to HCO_3^{-1}**. If the pH of the solution **was at or below 8.3**, the carbonate alkalinity is zero or negative.

• Hydroxide alkalinity is the number of equivalents per liter of strong acid required to reduce the pH of an alkaline solution to 10.8

• Above **pH 9.5** (usually well above **pH 10**), OH^- alkalinity can exist or **CO_3^{-2}** and OH^- alkalinities can coexist together.

• Environmental Impact: Alkalinity is important for fish and aquatic life because it protects or buffers against rapid pH changes. Living organisms, especially aquatic life, function best in a pH range of **6.0 to 9.0**.

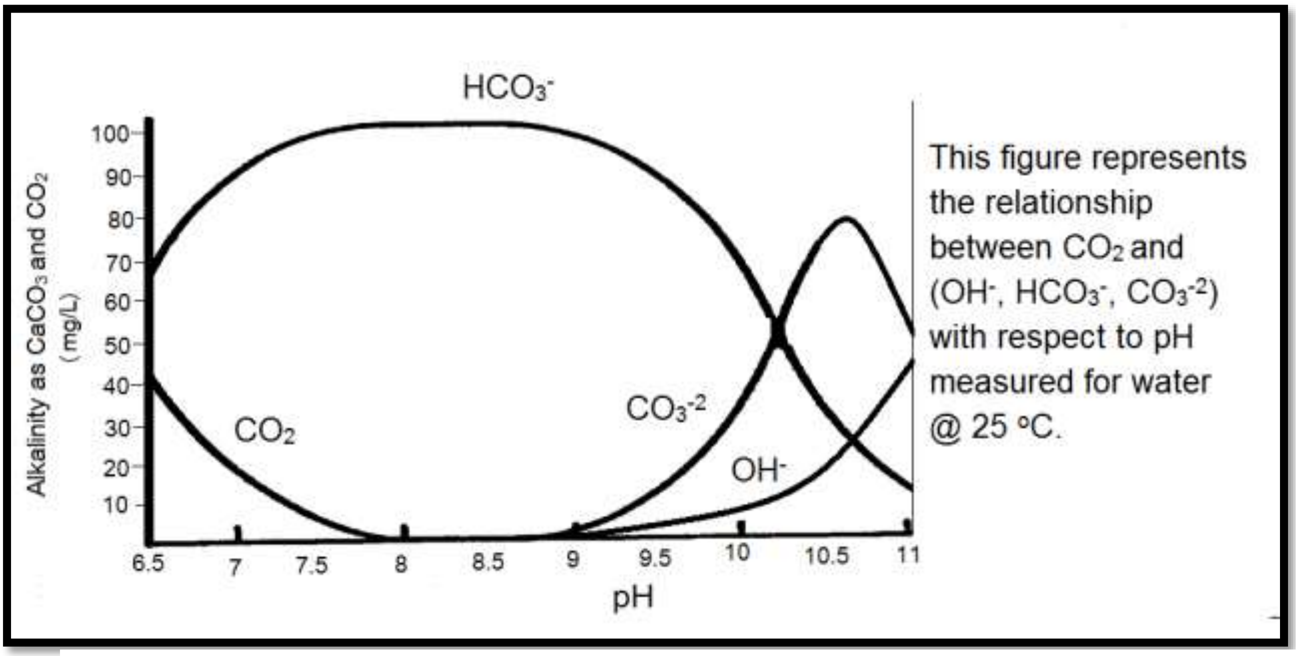


Figure 1

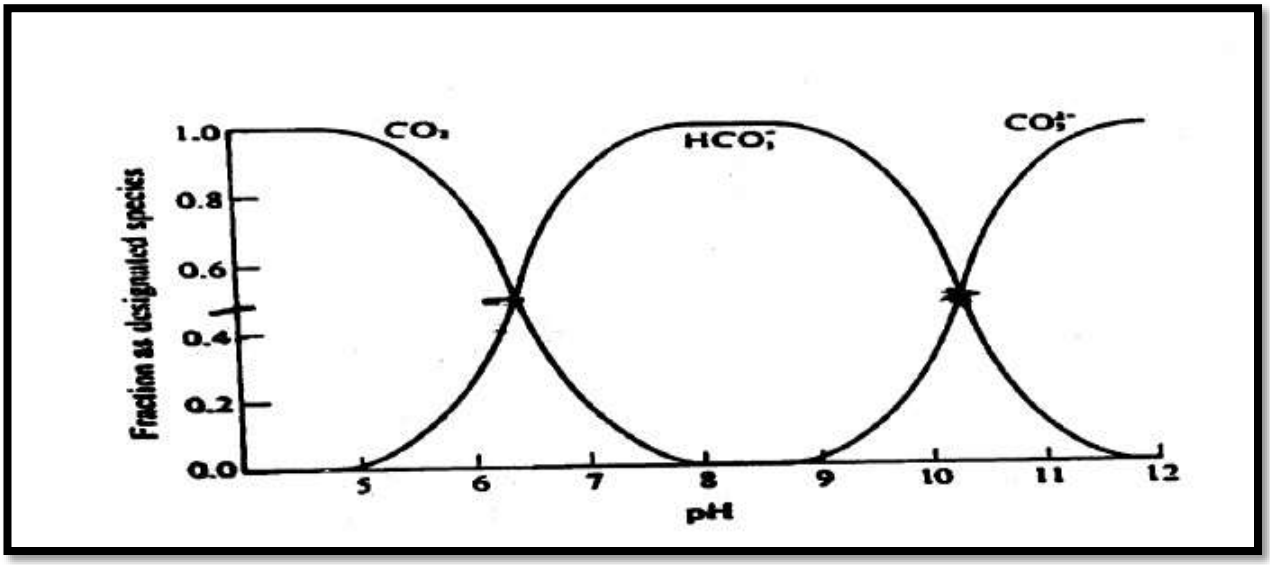


Figure 2: Carbonate equilibrium diagram

- حساب ال **Alkalinity**:

1. **نحضر عينة من الماء ذات حجم معروف (50 mL) أو (100 mL) مثلاً.**
2. **نقوم بقياس ال pHالبدائية للعينة و نضيف Green indicator كمؤشر لحدوث التفاعل**
   نضيف Green indicator كمؤشر لحدوث التفاعل
3. **نبدأ بإضافة حمض مثل (H_2SO_4) حتى يتغير اللون وعندها نتوقف عن إضافة ال (H_2SO_4) لأننا نكون قد وصلنا ل pH= 4.5.**

Alkalinity (mg $CaCO_3$/L) = $\frac{a*N*50000}{V}$

a: amount of H_2SO_4 used

N: molarity of H_2SO_4=0.02

V: volume of sample

Experiment # 8

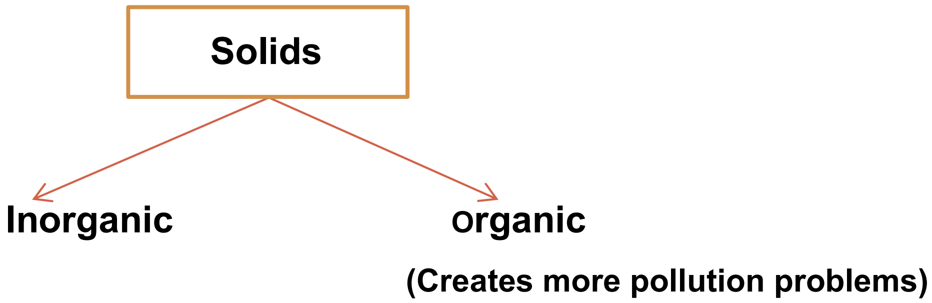
Solids

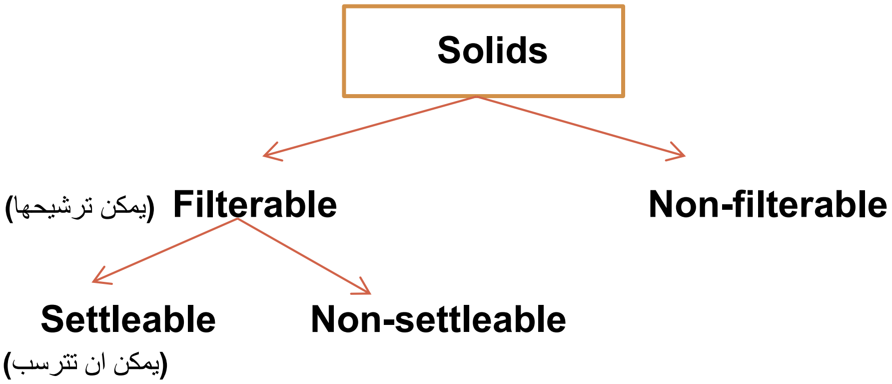
•Solids: any material suspended or dissolved in wastewater that can be physically isolated through filtration (ترشيح), or evaporation (تبخر).

- **هدف التجربة بشكل عام هو حساب كميّة ونوعيّة المواد الصلبة الموجودة في عينة W.W لتحديد مدى قوة هذه العينة ودرجة تأثيرها على محطة التنقية، وحساب كفاءة المحطة بالإضافة لتحديد الطرق المناسبة لمعالجة ال W.W**

- The amount of solids in wastewater describe the strength of the W.W sample

  More solids ⟶ stronger W.W





•(Materials setting out of a sample within 1 hour period, measured in **<u>ml\L</u>**)

See two Figures below which summaries all experiment procedures:

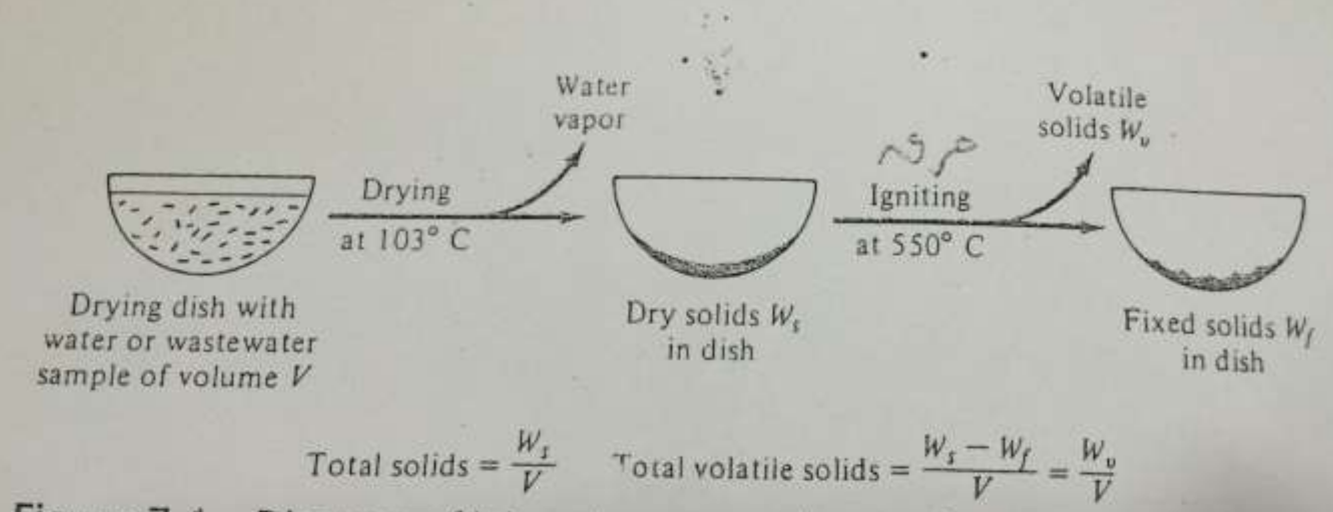


Figure 7.1 Diagram of laboratory procedure to determine total solids and total volatile solids concentrations of a water or wastewater sample.

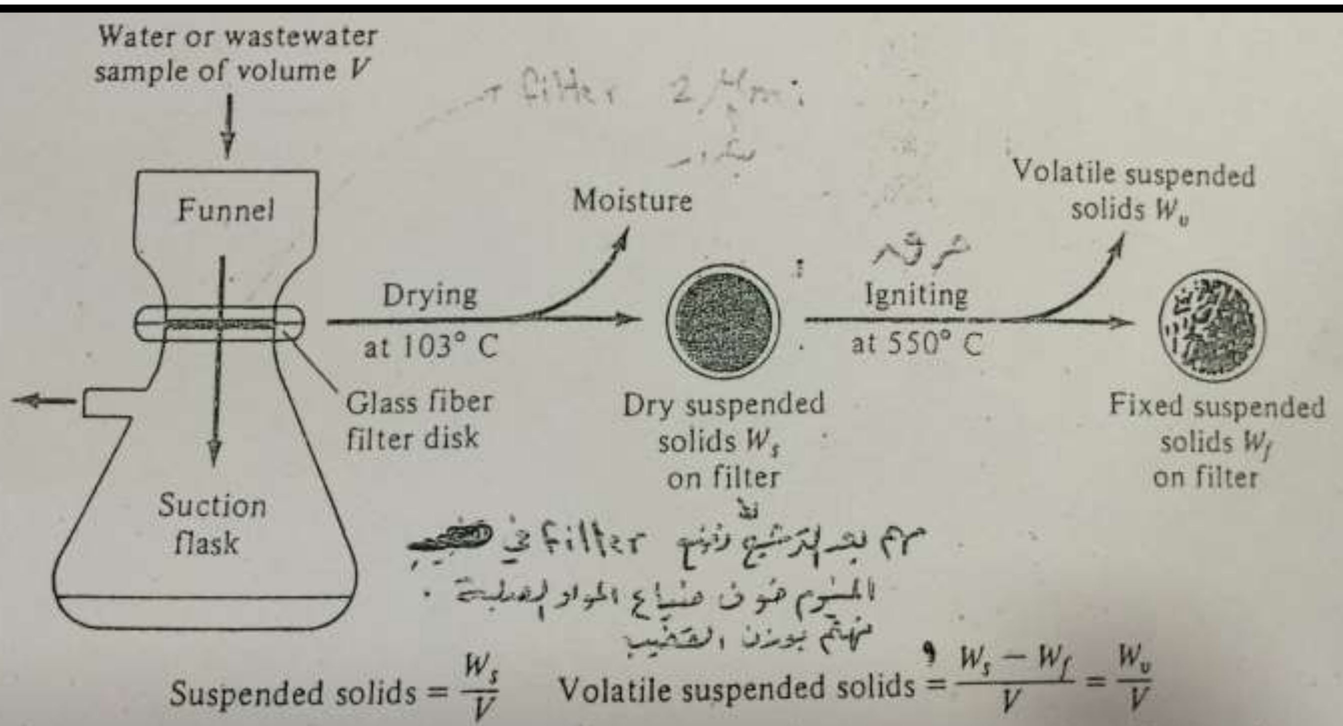


Figure 7.2 Diagram of laboratory procedure to determine the total suspended-solids and volatile suspended-solids concentrations of a water or wastewater sample.

General definitions, Procedure, and Calculations:

Part 1

1. نأخذ وزن الطبق الاول وهو فارغ (W1)

2. نحضر 25 mL من ال W.W ونضعها في Dish 1

3. نضع العينة في الفرن لمدة 24 ساعة وبعد انتهاء المدة نخرج العينة ونتركها في الهواء حتى تبرد ثم نوزنها (W2)

- **Total Solid (T.S):**

هي المواد المتبقية في **Dish 1** بعد وضعه في الفرن لمدة **24** ساعة على درجة حرارة **105** وتشمل

→ **Total dissolved solid**
→ **Total suspended solid**

$$\text{T.S (mg/L)} = \frac{W2-W1}{volume} * 10^6$$

- **Total Volatile Solid (TVS): In general it is Organic Material.**

وهي المواد التي طارت من العينة على درجة حرارة **550**

$$\text{TVS (mg/L)} = \frac{\text{W2}-\text{W3}}{\text{volume}} * 10^6$$

4. نعيد العينة الى الفرن ونضعها لمدة ساعتين على درجة حرارة 550 C وبعد انتهاء المدة نخرجها ونتركها حتى تبرد ثم نوزنها (W3). في هذه المرحلة تكون ال volatile solid هي التي تبخرت

- **Total Fixed Solid (TFS): In general it is Inorganic Material.**

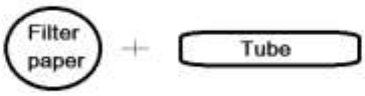
وهي المواد الصلبة المتبقية في **Dish 1** بعد انتهاء ساعتين من وضعها في الفرن على حرارة **550** والمواد قد تكون

- **Dissolved**
- **Suspended**

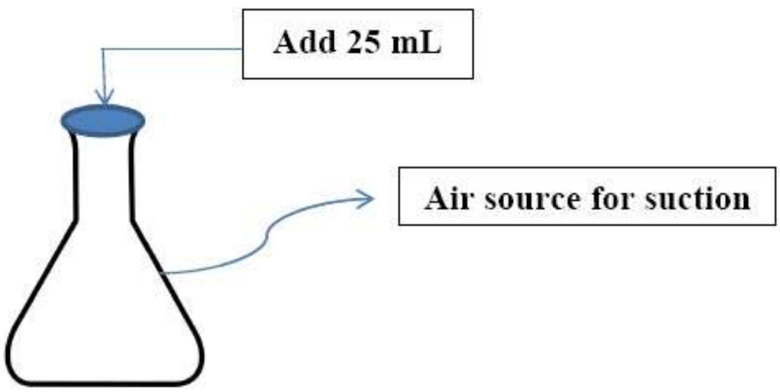
$$TFS\ (mg/L) = \frac{W3-W1}{volume} * 10^6$$

$$= TS - TVS$$

Part 2



1. نحضر **filter paper** ونضعها داخل **tube** ونوزنهم **(W1)**
2. نأخذ وزن الطبق الثاني وهو فارغ **(w1)**
3. نحضر **25 mL** من ال **w.w** ونضعها داخل جهاز ال **filtration**



Filtration Equipment

4. نأخذ ورقة ال filter paper مع المواد التي احتجزت عليها ونضعها داخل ال Tube

5. نضع عينة ال w.w التي مرت من خلال ال filter paper داخل Dish 2

6. نضع ال Tube + F.P وكذلك Dish 2 على حرارة 105 °C لمدة 24 ساعة وبعد انتهاء المدة نخرجهم من الفرن ونوزنهم

Tube + filter paper → W2
Dish 2 → w2

7. نعيدهم للفرن ونتركهم لمدة ساعتين على حرارة 550 °C وبعد ذلك نوزنهم

Tube + filter paper → W3
Dish 2 → w3

❖ Total Dissolved Solid (TDS):

هي المواد التي مرت من عينة ال **w.w** من خلال ال **filter paper**

$$TDS\ (mg/L) = \frac{w2-w1}{volume} * 10^6$$

❖ Volatile Dissolved Solid (VDS):

هي المواد التي طارت من العينة الموضوعة في **Dish 2** على حرارة **550**

$$VDS\ (mg/L) = \frac{w2-w3}{volume} * 10^6$$

❖ Fixed Dissolved Solid (FDS):

هي المواد المتبقية في **Dish 2** بعد ساعتين من وضعها على حرارة **550**

$$TFS\ (mg/L) = \frac{w3-w1}{volume} * 10^6$$

$$= TDS - VDS$$

For the last 3 equations:
w1: weight of Dish 2 empty
w2: weight of Dish 2 @ 105 °C
w3: weight of Dish 2 @ 550 °C

❖ Total Suspended Solid (TSS):

هي عبارة عن ال **solid** التي احتجزت على ال **filter paper**

$$TSS\ (mg/L) = \frac{W2-W1}{volume} * 10^6$$

❖ Volatile Suspended Solid (VSS):

هي المواد التي طارت من **Tube + F.P** على حرارة **550**

$$VSS\ (mg/L) = \frac{W2-W3}{volume} * 10^6$$

❖ Fixed Suspended Solid (FSS):

هي المواد المتبقية على **Tube + F.P** بعد ساعتين من وضعها في الفرن على حرارة **550**

$$FSS\ (mg/L) = \frac{W3-W1}{volume} * 10^6$$

$$= TSS - VSS$$

For the last 3 equations:
W1: weight of (Tube + F.P) empty
W2: weight of (Tube + F.P) @ 105 °C
W3: weight of (Tube + F.P) @ 550 °C

In General:-

- **TS = TDS + TSS**
- **TVS = VDS + VSS**
- **TFS = FSS + FDS**

10^6 في جميع القوانين السابقة من أجل تحويل الوحدات من :
ml into Litter
gram into milligram

Experiment # 9

Fecal Coliform

- The main groups of microorganisms found in surface water and wastewater are:
  1. Eucaryotes (Algae, Protozoa)
  2. Eubacteria (most of the bacteria)
  3. Archaebacteria
  4. Viruses

- The pathogenic organisms (ميكروبات) are found in wastewater and the main source is **human** who are infected with disease or who carries a particular disease, person discharges **100 - 400 billion** coliform organisms per day in addition to other types of bacteria**.**

●وجود الميكروبات في المياه يستخدم كمؤشر لمدى تلوثها والأمراض التي قد تتسبب بها**.**

- Because the numbers of pathogenic organisms present in wastes and polluted water are <u>few and difficult to isolate and identify</u>, the **coliform organisms**, which are more numerous and more easily tested for, is commonly used as indicator organisms.
- The **presence** of coliform organisms is taken as an indication that pathogenic organisms may also be present.

Fecal
(Can grow @ higher Temperature than non-Fecal, about 45 °C)

Non-fecal
(grows @ 35-37 °C)

- Coliform bacteria within 48 hours and 35 ^{o}C form rod shaped bacteria that ferment Lactose sugar.

- In recent years, tests have been developed to distinguish among:
  - **Total coliform**: used for **potable** water supply (المياه الصالحة للشرب)
  - **Fecal coliform**: performed on **non-potable** water, wastewater, bathing water, and swimming water.

Reagents: Bacto-Rosolic Acid, NaOH

Technique used: Membrane Filter (MF)

Calculation:

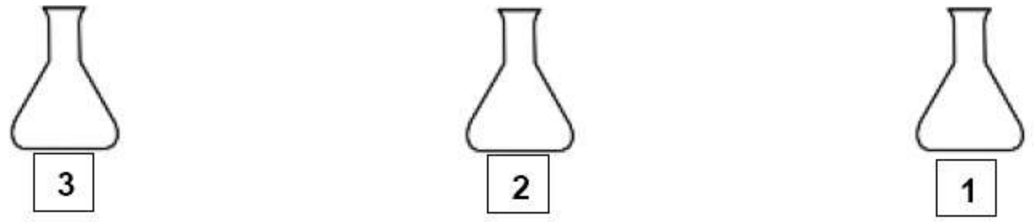
$$\text{Fecal coliform / mL} = \frac{colonies\ counted}{dilution\ chosen}$$

This equation applies also for the Total coliform.

Colonies are counted according to the color.

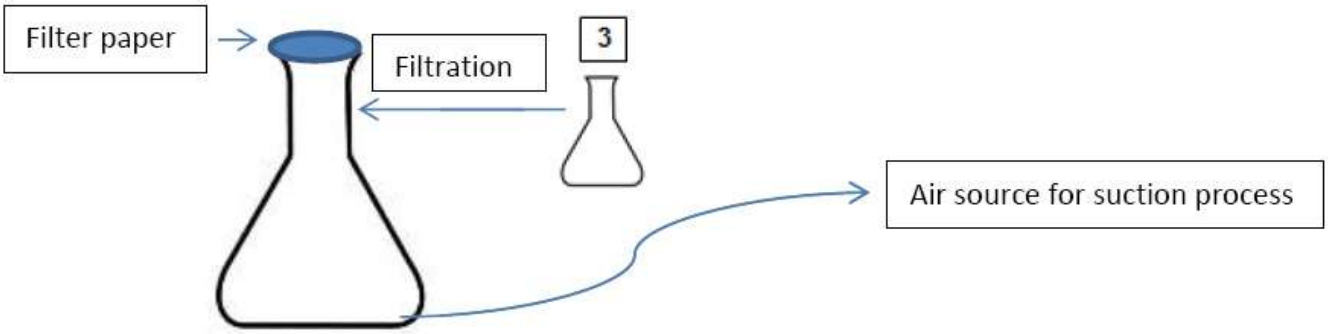
Experiment Procedures:

1. نحضر 1 mL من ال wastewater ونقوم بإجراء dilution ثلاث مرات



نأخذ 1 mL من flask 2 ونضعه في flask 3 ونملأه بالماء الى 100 mL	نأخذ 1 mL من flask 1 ونضعه في flask 2 ونملأه بالماء الى 100 mL	نضع 1 mL من ال w.w في flask 1 ونملأه بالماء الى 100 mL

2. نحضر filter paper وتكون (0.45 µm) ونضعها على جهاز ال filtration



3. نأخذ ال filter paper والمواد المتبقية عليها ونضعها في petridish وهي حاضنة بكتريا لمدة 24 ساعة على حرارة 37 °C
4. بعد انتهاء المدة، نقوم بعدّ ال coliform colonies ونميّز بينهما من حيث اللون

Fecal coliform → **Blue**

Total coliform → **Pink to dark red**

Experiment # 10

Physical Properties

Physical Parameters

Water Quality Parameters

Chemical	Physical	Microbiological
BOD	pH	Coliform
COD	EC	
N, TKN	TDS	
PO_4	Salinity	
SO_4	Turbidity	

❖ pH

pH: it is the hydrogen ion concentration

pH= - Log (H^+)

$$(H^+) + (OH^-) = 14$$

0 ← Acid → 7 ← Alkali → 14

- Acidic solutions have a pH between 1 and 6.9
- Alkaline solutions have a pH between 7.1 and 14

تزيد الحموضة $\longrightarrow CO_2 + H_2O \longrightarrow H_2CO_3 \xrightarrow{\text{تحلل}} H^+$

تزيد القاعدية $\longrightarrow NH_3 + H_2O \longrightarrow NH_4O \xrightarrow{\text{تحلل}} OH^-$

Importance of pH:

- most living organisms require pH's close to neutrality
- pH changes can completely wipe out biological processes in wastewater treatment plants
- Low (acidic) pH's also cause corrosion in sewers systems and increase the release of toxic sulfide gas
- pH unit less and measure by pH meter.

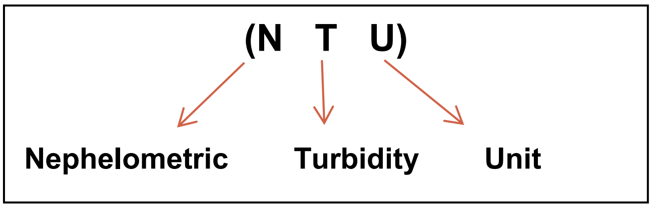
❖ Turbidity

- Turbidity: light-transmitting measurement (عكورة الماء)

- و هو عبارة عن قياس تشتت الضوء عندما يمر في المياه نتيجة وجود جزيئات داخل الماء تتسبب في هذه الظاهرة، ويعتمد مقدار التشتت على
  1. عدد الجزيئات
  2. شكل الجزيئات
  3. حجم الجزيئات
  4. معامل الانكسار للضوء

- اسم الطريقة المستخدمة لقياس ال Turbidity ← Nephelometric Method وتقاس باستخدام جهاز Nephelometer

- وحدة قياس ال Turbidity:



TSS (mg/L) = (TSS factor) * T $_{(NTU)}$

TSS: Total Suspended Solids

- بناءً على معايير ال (WHO: world health organization) يجب ان تكون ال turbidity لمياه الشرب أقل من 5 NTU والوضع المثالي ان تكون اقل من 1 NTU.

- **Importance of turbidity:**

- Suspended particles تمتص الحرارة من أشعة الشمس ، مما يجعل المياه العكرة تصبح أكثر دفئا ، و مما يقلل من تركيز الأكسجين في الماء وبعض الكائنات تموت مع ارتفاع درجة حرارة المياه
- Suspended particlesتمتص أشعة الشمس مما يؤثر على عملية البناء الضوئي

❖ Salinity

Salinity is the presence of soluble salts in soils or waters.

$$\text{Salinity} = \frac{gm \;(\text{Salts})}{1\,Kg \;(\text{solution})} = \frac{1}{1000\,gm} = \text{ppt}$$

ppt: parts per thousands ← وحدة قياس ال salinity

<u>The three main types of salinity are:</u>

- dryland salinity: تحدث عندما تتسرب المياه المالحة للاراضي غير المروية مما يؤثر على خصائص التربة ونمو النباتات
- irrigation salinity: ينتج عند الافراط في استخدام مياه الري
- saltwater intrusion:تحدث هذه الظاهرة في المياه الجوفية في المناطق الساحلية

<u>Salinity depends on:</u>

- **Landscape characteristics**
- **climate**
- **human activities**

<u>The sources of salts:</u>

- **rainfall**
- **weathering and erosion of rocks**
- **groundwater**

➢ <u>Salts Effects</u>

1. Industrial effects:

وجود الأملاح بنسبة عالية يتسبب في تآكل الأسطح المعدنية وصدأها كما أن ارتفاع نسبة الأملاح في المياه يؤثر على طعم المشروبات الغازية.

2. Health effects:

ارتفاع نسبة الجزيئات المذابة في الماء يؤدي الى العديد من الظاهر منها:

- ارتفاع نسبة جزيئات الكلور **(Cl^-)** يتسبب في تغير طعم مياه الشرب
- ارتفاع تركيز جزيئات **(Na_2SO_4)** و **($MgSO_4$)** في مياه الشرب عن **250 mg/L** يسبب إسهال **(laxative).**
- ارتفاع تركيز أيون الصوديوم **(Na^{+2})** يسبب **Toxemia** وهي تسمم الدم لدى النساء الحوامل.

❖ EC

Conductivity can be defined simply by Ohms Law (V= IR), the conductivity depends on the number of charge carriers (number of electrons) in the material and their mobility.

Conductivity is measured as micro-Siemens per cm **<u>(µS/cm)</u>** OR micromho, **<u>mho</u>**

❖ TDS

It is amount of mineral and salt impurities in the water TDS measure as parts per million **(ppm).**

Acceptable range for drinking water, TDS < 500 mg

Acceptable range for irrigation water, TDS< 1200 mg\L

•Salinity of irrigation water is determined by measuring its Electrical Conductivity (EC) and is the most important parameter in determining the suitability of water for irrigation.

●The Electrical Conductivity of water is used as surrogate measure of total dissolved solids (TDS) concentration and there is a correlation between them:

TDS (ppm) = EC $_{(\mu S/cm)}$ * 0.67

هنالك علاقة هامة بين ال **TDS** وال **EC** وال **salinity** وجميعهم انعكاس لبعض ولذلك جميع هذه الخصائص الفيزيائية يمكن قياسها من خلال جهاز واحد يسمّى **conductivity meter** والذى من خلاله يتم قياس ال **EC** وبعد ذلك استخدام المعادلات الرياضية الموضحة أعلاه لحساب بقيّة الخصائص ومقارنتها مع المعايير العالمية للحكم على المياه فيما اذا كانت صالحة للشرب ام لا.