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الملخص:

يسعى هذا المشروع إلى معالجة المياه الجوفية باستخدام النفايات المعدنيةالذييمكن أن يكون له تأثير إيجابي كبيرعلى البيئة،الاقتصاد، والصحة العامة من خلال تقليل النفايات وتحسين جودة المياه بتقنيات مبتكرة، ويساهم في تحقيق استدامة بيئية وتقليل التلوث .

التقنيات المستخدمة في معالجة المياه الجوفية بالنفايات المعدنية هي الامتصاص، في هذه التقنية تُستخدم عينة من النفايات المعدنية الناتجة من التعدين و مصدرها جبل العنق تبسة. بعد عملية خلط العينة مع المياه الجوفية وترسبها تُأخذ المياه لإجراء تحاليل فيزيوكيميائية في مخبر محطة تحلية المياه 19 مارس بالوادي .

من خلال نتائج هذه الدراسة تبين أنها تحوز على أهم دور في عملية التحلية وذلك بتحسن بعض المعاييرالفيزيوكيميائية.

الكلمات المفتاحية: المياه الجوفية، النفايات المعدنية،الامتصاص،تحاليل فيزيوكيميائية.

Résumé :

Ce projet vise à traiter les eaux souterraines en utilisant des déchets minéraux, une approche qui pourrait avoir un impact positif significatif sur l'environnement, l'économie et la santé publique. Cette méthode innovante permet à la fois de réduire les déchets et d'améliorer la qualité de l'eau, contribuant ainsi à la durabilité environnementale et à la diminution de la pollution.

La technique principale utilisée est l'absorption. Dans ce procédé, nous utilisons un échantillon de déchets minéraux issus de l'activité minière, provenant spécifiquement du mont El Onk dans la région de Tébessa. Après mélange de l'échantillon avec les eaux souterraines et décantation, l'eau est soumise à des analyses physico-chimiques au laboratoire de la station de dessalement du 19 Mars à El Oued.

Les résultats obtenus démontrent l'efficacité remarquable de cette méthode dans le processus de dessalement, avec une amélioration notable de plusieurs paramètres physico-chimiques clés.

Mots clés : Les eaux souterraine, Déchets Minéraux, Absorption, Analyse physico-chimique.

Abstract:

This project aims to treat groundwater using mineral waste, which could have a significant positive impact on the environment, economy, and public health by reducing waste and improving water quality through innovative techniques. It contributes to achieving environmental sustainability and reducing pollution.

The techniques used in treating groundwater with metallic waste include absorption. In this method, a sample of mineral waste from mining—sourced from Djebel El Onk in Tebessa is utilized , after mixing the sample with groundwater and allowing it to settle, the water is taken for physicochemical analysis at the March 19 Water Desalination station laboratory in El Oued.

The results of this study demonstrate that the method plays a crucial role in the desalination process by improving certain physicochemical parameters.

Keywords : Groundwater , Mineral waste, Absorption, Physiochemical analyses.

DEDICATION

إهداء من القلب

رياض

بِسۡمِ ٱللَّهِ ٱلرَّحۡمَٰنِ ٱلرَّحِيمِ

الحمد لله الذي بلّغني هذه المرحلة بفضله ورحمته، وأسأله أن يجعل هذا الإنجاز بداية خيرٍ وبركة.

إلى منبع الحب والعطاء، والدي الكريمين **أمي الغالية و أبي العزيز**، أنتما جذوري التي تغذيني، وأجنحتي التي تحملني. كلّ حرفٍ تعلمتُه، وكلّ نجاحٍ حققته، هو ثمرة تضحياتكم ودعواتكم الصادقة. مهما قلتُ لن أوفيكم حقكم، فجزاكم الله عني خير الجزاء، وأطال في عمركم، وأسعدكم كما أسعدتموني

الإخوتي الكرام، أخواتي العزيزات،

شكرًا لوقفتكم إلى جانبي، ولضحكاتكم التي كانت تُذيب تعبي. خاصةً لكَ يا أخي الأكبر **(مراد)**، كنتَ لي السند القدوة، ولكُنَّ يا **أخواتي البنات**، نور حياتي

إلى زملائي ورفقة الدرب

لكم منّي كلّ التقدير، سواءً كنتم قريبين أو بعيدين. شاركتموني لحظات النجاح والتحدي، فجعلتم الرحلة أجمل. أذكركم دائمًا بخير، وأسأل الله أن يوفقكم في كلّ خطوة

إلى صديقي الوفي **لخضر فريد** يا من كنتَ لي الأخ الذي لم تلده أمي،

شكرًا لك على كلّ كلمة تشجيع، وكلّ دقيقة دعم. كنتَ تُذكّرني دائمًا بأنّ المستحيل مجرد وهم، وأنّ الأفق البعيد يستحقّ السفر. هذا الإنجاز جزءٌ من تعبك معي، فلكَ منّي كلّ الحبّ والوفاء.

وأخيرًا..

هذا التاج الذي أحمله اليوم، هو تاجٌ منسوجٌ بدموعكم، وضحكاتكم، وصبركم. فلتتقبّلوه منّي كهديةٍ متواضعةٍ من قلبٍ ممتنٍّ يعرف أنّه لم يكن ليصل إلّا بكم

اللهم اجعله خالصًا لوجهك الكريم، وبارك لي في عملي، وارزقني ردّ الجميل لمن أحبّ

ابنكم المخلص RIAD CHAFOU.

DEDICATION

الحمد لله الذي أنار لي طريقي ووفقني لتثمين هذه الخطوة في مسيرتي الدراسية والصلاة والسلام على الحبيب المصطفى

وأهله ومن وفى أما بعد:

اهدي ثمرة الجهد والنجاح هذه إلى اللذان أرجو قد أكون نلت رضاهم أمي الغالية وأبي الغالي رحمه الله

إلى من شاركتني أحلامي ووقفت بجانبي في كل خطوة وساندتني في رحلتي العلمية، **زوجتي الحبيبة،**

إلى من كان لي السند والعون، أفراد عائلتي،

إلى الأصدقاء الأوفياء،

أهدي هذا العمل المتواضع، متمنيا أن يكون عند حسن ضنكم، وأن يسهم في إضافة لبنة صغيرة في جدار العلم والمعرفة.

ابنكم المخلص بلخير نقبيل

DEDICATION

الحمد لله الذي بنعمته تتم الصالحات، أخيراً تحقق حلم التخرج.

اهدي تخرجي إلى من احمل اسمه بكل فخر........ إلى من حصد الأشواك عن دربي ليمهد لي طريق العلم....

بابا حبيبي .... بشير....

اهدي تخرجي إلى اليد الخفية والقلب الحنون صاحبة الدعاء الصادق......

أمي الغالية ....فريدة ....

إلى ضلعي الثابت وأمان أيامي .... قرة عيني

أخوتي و أخواتي الغاليين(فؤاد-عبد الوافي-شفاء-نفيعة- رئيفة -عفيفة)

إلى الأصدقاء الأوفياء، الذين ما انفكّوا يومًا عن تقديم العون والمساعدة والدعم لي ....

خاصة سناء ومريم ....

ويبقى هذا اليوم محفور في الذاكرة،

لحظة نحتفل فيها بسنوات من التعب، والدعوات، والدعم…

ولا ننسى من كانوا سببًا في هذا الإنجاز بعد توفيق الله، فالحمد لله دائمًا وأبدًا

ابنتكم المخلصة فهيمة قعيد

Thanks, and Appreciation

بِسۡمِ ٱللَّهِ ٱلرَّحۡمَٰنِ ٱلرَّحِيمِ

[يَرْفَعِ اللَّهُ الَّذِينَ آمَنُوا مِنكُمْ وَالَّذِينَ أُوتُوا الْعِلْمَ دَرَجَاتٍ] { المجادلة: 11}

الحمد لله الذي وهبني العلم والصبر، وأكرمني بأساتذة ومشرفين كانوا نبراسًا يُضيء طريقي. في هذه اللحظات التي تسبق توديع مقاعد الدراسة، أجد نفسي مدينًا بالكثير لمن ساندوني، فلكم مني كلّ الشكر والتقدير. وكما أمني بأسمى آيات الامتنان إلىالأستاذ مخبري محطة 19 مارس لوحدة المياه بالوادي "عثمان قديري "على كلّ لحظة تعلمناها بين يديك، على نصائحك الصادقة، وصبرك الذي لا ينضب. كنتَ أكثر من مُعلّم، كنتَ أخًا ومُرشدًا، جعلتَ من المختبر مكانًا للتجارب وللذكريات الجميلة، فجزاك الله خيرًا كل الجزاء. وكذلك الأستاذة أمينة تابت شكرًا لكِ على عطائكِ، وعلى حنوّكِ الذي جعل من التعلم رحلةً ممتعة. فأسأل الله أن يجزيكِ عنا خير الجزاء،

وكذلك اللجنة المناقشة لوقتهم المبذول في تقييم وتحسين هدا العمل وقبل أن نمضي نقدم أسمى آيات الشكر والامتنان والتقدير والمحبة إلى الذين حملوا أقدس الرسالة في الحياة إلى جميع أستاذتنا الأفاضل إلى الذين شيدوا لنا طريق العلم والمعرفة والى جميع موظفين بدا من المدير إلى الحارس، ذكراكم ستظلُّ خيرَ زادٍ في مسيرتي القادمة، فما قدّمتموه من علمٍ وإرشادٍ هو أعظم هديةٍ حملتُها من هذه الجامعة، أسأل الله أن يبارك في جهودكم، ويجعلها في ميزان حسناتكم

وأن يُكتب لنا اللقاء دائمًا في جنات النعيم وآخر دعوانا أن الحمد لله رب العالمين.

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TDS Total dissolved solids

TH water hardness

EC Electrical conductivity

PH hydrogen potential

TU Turbidity

µm Micro meter

mg milligram

WEEE Waste electrical and electronic equipment

EEE Electrical and electronic equipment

ml milliliter

GENERAL INTRODUCTION

God Almighty said«And we made from water everything that lives», (verse 30 of Surat Al-Anbiyaa) and also he said,«It is He who sends down rain from the sky; from it is drink [and from it is foliage in which you pasture [animals (verse 10 of Surat Al-Nahl).

Water is one of God's great blessings to mankind, as it is one of the most important natural elements that are indispensable for the continuation of life on earth[1]. This renewable natural resource is characterised by the stability of its chemical composition, as its quantities available on the surface and underground remain unchanged for hundreds of years. At the regional level, most Maghreb countries suffer from the scarcity of water resources, mainly due to their geographical location within the arid and semi-arid region of the world. This issue is exacerbated by the rapid population growth in the Arab world, which increases the demand for water to meet the requirements of domestic, industrial and agricultural consumption, in light of limited resources that do not keep pace with the growing needs[1].

Water is the backbone of life and the basis of its continuity; without it, the wheel of existence stops and all human activities are disrupted[2].

It is a major component of human, animal and plant anatomy. It is characterised by a unique molecular structure that gives it exceptional physical and chemical properties, and its sources vary between surface (such as seas and rivers) and underground (such as groundwater), depending on its different forms and geographical distribution, due to the hydrological cycle that maintains its balance in nature, water is the most important vital element for the survival of living organisms, as it plays a pivotal role in meeting diverse human needs. With its easy accessibility historically, and its intensive use in the modern era, the huge diversity of its uses (industrial, agricultural and urban) has led to the depletion of water resources and reduced the quantities of water suitable for consumption[3], especially with the environmental pressures accompanying civilisational development, as water has become vulnerable to pollution, which has changed its three characteristics, threatening the aquatic ecosystem, especially in rivers that are used as outfalls for industrial, agricultural and human wastes[4]. This situation has prompted countries to adopt urgent strategies to protect water resources through advanced technologies to purify or reduce water pollution. Historically, human efforts to treat water were limited to improving its sensory properties (such as smell, colour and taste) using simple techniques such as sedimentation, boiling and filtration. The year 1807 saw a major breakthrough in this field with the establishment of the first centralised water treatment plant in the Scottish city of Glasgow, in an attempt to address the health challenges caused by pollution at the time[3].

The vital importance of water in human life is evidenced by its multiple roles that fulfil the needs of modern man, especially in the field of clean drinking water, which is the basis for survival. The demand for water is also increasing with the steady expansion of public facilities and recreational services, such as swimming pools, sports fields and entertainment areas, which consume huge amounts of water resources. Statistics show a stark disparity in consumption rates between countries, While the average European per capita consumption is about 4000 cubic meters per year, most Arab countries face serious challenges due to the decrease in the per capita share of water to less than 1000 cubic meters per year, which puts them below the threshold of water poverty. The challenge is not only limited to the scarcity of resources, but is exacerbated by the environmental impacts of intensive consumption; the increase in the use of pure water leads to an increase in the amounts of polluted water discharged into surface water bodies such as rivers, lakes and seas, threatening the ecosystem and complicating the global water crisis[5].

Groundwater is a vital source of drinking and irrigation in many regions, especially in arid and semi-arid environments, where Arab countries rely on it to a large extent, up to 80% of their water resources in some cases, but urban expansion and industrial and agricultural activities have led to the infiltration of groundwater (treated and untreated) into the ground layers, threatening groundwater quality with chemical (nitrates and heavy metals) and biological (bacteria and viruses) pollutants[6].

Studies show that 30% of global wells are contaminated beyond safe levels, due to poor sewage management or excessive use of fertilisers and pesticides. Protecting aquifers from contamination is a major challenge, as natural purification can take decades, while the cost of industrial treatment remains prohibitive[6].

Our main objective is to treat groundwater, using mineral waste.

To combat groundwater contamination, we are developing an innovative technology based on recycling mineral waste (such as industrial and demolition waste) to purify water from toxins such as nitrates, heavy metals and other contaminants.

-Why this method?

Environmentally friendly: Converts waste from pollutants to effective purifiers.

Low cost: Using cheap available materials instead of expensive technologies.

Double solution: Not only purifies water, but minimises the accumulation of harmful mineral waste.

CHAPTER I: GENERALITIES

I –Introduction

The topic of the environment and environmental pollution has received great attention from the specialists and the international public opinion, as studies have increased on the various forms of pollution such as water, air, soil and food pollution, especially after the spread of natural, chemical and biological pollutants. This pollution has contributed to the exacerbation of environmental and health issues, leading to the spread of diseases and the degradation of basic environmental components. Water pollution is one of the most dangerous types of pollution, as it not only contaminates water resources, but also causes poverty and drought, prompting people to use contaminated water wells despite their danger, whether due to the scarcity of resources or lack of awareness. This results in the infection of diseases, some of them may be fatal, especially since some health effects only appear after long periods of time, which complicates the process of diagnosis and treatment. [7]

Therefore, in this chapter, we will address everything related to water and types of polluted water, definition, types, sources, and characteristics.

I .1. Distribution of water on Earth

Earth is the most water-rich planet in the solar system, with water covering approximately 71 percent of its total surface area. The surface area of the globe is about 510 million km², which 361 million km² is formed by water bodies such as oceans, seas and rivers, while the land area is estimated to be about 149 million km² (the figure has been corrected to be accurate). This distribution makes water the most dominant element on Earth's surface, emphasizing its importance in shaping life and ecosystems. [8]

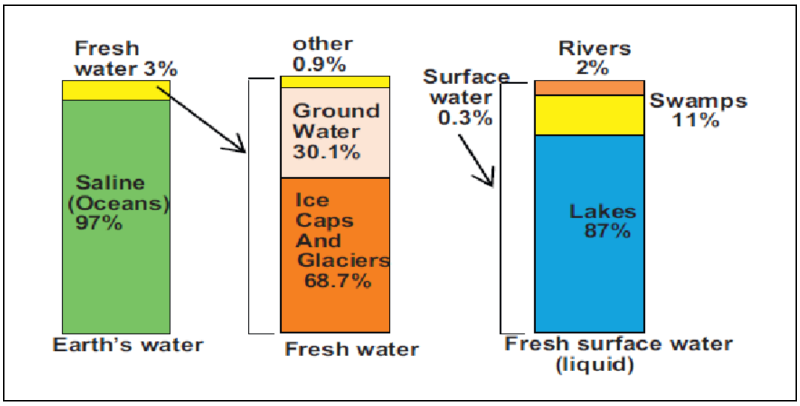


Figure I-1: Distribution of freshwater on Earth's surface[26].

Water is distributed over the Earth's surface as shown in the following table and figure:

Table (I-1): The distribution of water in the globe [9].

The natural reservoir	Size in million Km2	Percentage of total
Oceans, seas and salt lakes	1370	97.25
The frozen water	29	2.05
Groundwater	9.5	0.68
The fresh lakes	0.125	0.01
Soil water	0.065	0.005
Atmospheric water	0.013	0.001
The rivers	0.017	0.0001
Total	1408.7	% 100

I.2. The chemical composition of water

Water is a chemical compound characterized by an asymmetric quaternary molecular structure, where the two hydrogen atoms are connected to the oxygen atom via two covalent bonds, forming an angle of °105(2-I). This unique structure gives the water molecule a Dipole moment making it an excellent polar solvent capable of dissolving many substances. this characteristic makes water an essential component of the most gathering (Dimer) In many chemical and biological reactions, the double assembly of water molecules is considered stable due to the presence of two strong hydrogen bonds between the two molecules. These hydrogen bonds are created by the attraction of the partially positively charged hydrogen atom in one molecule to the partially negatively charged oxygen atom in another. This intermolecular interaction contributes to the increased stability of water aggregates, which plays an important role in determining the unique properties of water, such as high boiling point and surface tension, as shown in Figure (2-I).

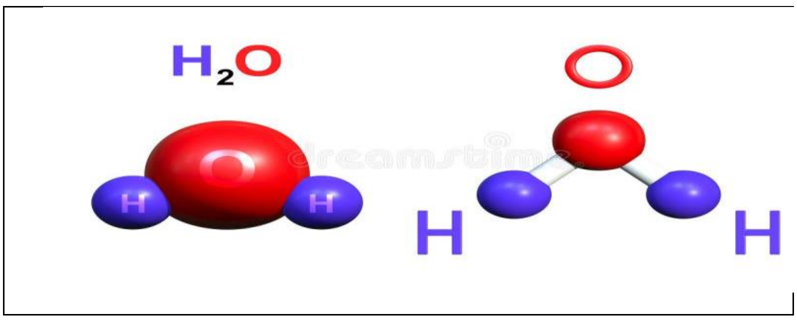


Figure I-2: The molecular structure of water [4].

I.3 Types of contaminated water

These water is categorized according to his contamination as follows:

l.3.1. Sewage (wastewater):

I.3.1.1. Definition of wastewater:

Wastewater is all kinds of used water resulting from various human activities, whether domestic, commercial or industrial. It is also known as sewage or wastewater, as it is usually transported through urban sewerage networks. Wastewater accounts for approximately 80 percent of the total freshwater consumed in urban areas. This water is mainly composed of about 99 percent water, while impurities and harmful pollutants make up the remaining 1 per cent. The amount of wastewater discharged into sewerage systems varies according to water consumption rates, resulting in different amounts depending on the time of day, days of the week, or even seasons.[11]

I.3.1.2. Categories:

Wastewater is divided into three categories:

a) **Grey water**: It is the product of water used except for toilet water, namely laundry water, shower water, bath water, laundry water .... etc

b) **Black water**: It is the water resulting from the use of toilets, which contains large amounts of organic pollutants resulting from human waste.

c) **Wastewater:** It is said to be a mixture of grey and black water [12].

I.3.2. Marine water (seawater)

Among the characteristics of healthy water are:

A). Physical (natural), the most important of which are:

- **Color:** The color of the water reflects the presence of dissolved or suspended organic or inorganic substances.
- **Odour:** Odour indicates the presence of certain volatiles or chemical compounds.
- In addition to this
- **Temperature:** Water temperature affects biological and chemical processes.
- **Turbidity:** Indicates the presence of substances stuck or not dissolved in the water.
- **Non-dissolved contents:** Includes suspended solids, oils and greases.
- They are classified according to solids:
- **Suspended solids:** Substances that remain suspended in water and do not precipitate easily.
- **Dissolved solids:** Substances that dissolve in water and travel with it.
- **B). The most important chemicals are:**
- **Volatile organic solids:** These are biodegradable organic materials.
- **Non-organic solids are**:non-biodegradable materials that remain stable in water… [13].

- C). **Biological:** components include the biological components in wastewater, the most important of which are:
- Pathogenic microorganisms (pathogenic):
- **Bacteria such as:**
- Escherichia coli (E. coli).
- Salmonella.
- Cholera bacteria (Vibrion cholera).
- **Viruses such as:**
- Hepatitis A virus.
- Rotavirus (causing acute diarrhea).
- **Intestinal worms (large parasites) such as:**
- Roundworm (Ascaris).
- Hookworm.
- **Parasites such as:**
- Giardia [14].

I.3.2.1. Definition of marine waters:

Seawater is the wondrous liquid that covers more than 70 per cent of our planet's surface, carrying with it scientific secrets and countless environmental benefits. With an average salinity of about 3.5%, each kilogram of seawater contains 35 grams of dissolved salts, mostly consisting of sodium (Na^+) and chloride (CL^-) ions. These salts not only give seawater its characteristic salty taste, but also affect its physical and chemical properties [15]. For example, the density of seawater at the ocean surface is about 1.025 g/ml, which is higher than that of fresh water or pure water. This difference in density is due to the fact that dissolved salts increase the mass of the water without significantly changing its volume. These salts also affect the freezing point of seawater, which freezes at -2°C (28°F) [15]. instead of the usual 0°C. The coldest liquid seawater ever recorded was in 2010 under an Antarctic glacier, with a temperature of 2.6°C (27.3°F) [16].

Not only that, seawater has a pH of between 7.5 and 8.4, making it a relatively alkaline medium. In addition, the speed of sound in seawater is around 1,500 meters per second, a speed that makes the oceans an effective medium for transmitting sound over long distances [11].

I.3.2.2. Characteristics

We summarise these seawater properties in a table for each case:

Table (I-2): Characteristics of seawater[16-17]

Mechanical characteristics	Thermal characteristics		Physical characteristics
Speed of sound	Thermal diffusion(a)	Thermal conductivity	**Density**

		(K)	
m.s. in seawater 1500	Freezes at -2°C (28) frnh	0.6w/m. k Centigrade °25°C	**At the ocean surface 1.025 g/mm on average**

I.3.3. Groundwater.

I.3.3.1.Definition of Groundwater:

Groundwater is a precious natural resource that forms an essential part of the Earth's water cycle. It is found in the pores of sedimentary rocks, where it accumulates over long periods of time that may span millions of years. This water reservoir is formed from various sources, such as rainwater, perennial and seasonal rivers, or even melting ice. The process of groundwater formation begins when water seeps from the earth's surface into the subsoil through the soil and rocks, a process known as ‘recharge’. The efficiency of this process depends on the nature of the topsoil; the more fractured and highly porous the soil is, the faster and more efficiently it can infiltrate water, leading to the formation of a good groundwater reservoir over time [18].

Groundwater is extracted in several ways, including drilling wells that reach the water-bearing layers, through naturally flowing springs, or even through the recharge of rivers and surface water bodies. Groundwater is a vital resource for agriculture, industry and domestic uses, especially in areas where surface water is scarce. However, this resource needs to be used wisely to ensure its sustainability for future generations [18].

I.3.3.2. Origin of groundwater:

The water cycle on Earth begins with the oceans, which cover about three-quarters of the planet's surface. Under the action of sunlight, ocean water evaporates into water vapor that rises into the atmosphere, where it condenses into clouds. Given the right climatic conditions, these clouds fall as rain, hail or snow, which is known as celestial water. This precipitation is the main source of fresh water on Earth surface [19].

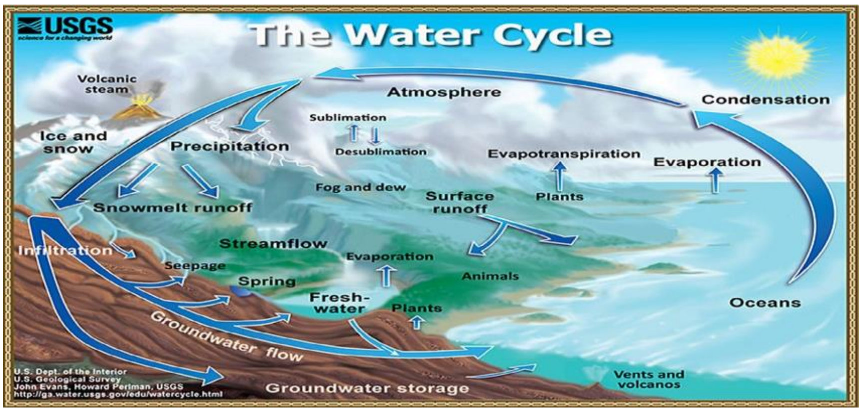


Figure I-3: Schematic representation of the water cycle in nature (hydrological cycle).

After precipitation, water is distributed over the earth's surface in several ways: Part of it flows into rivers, valleys and lakes, while the other part infiltrates into the soil. Part of this infiltrated water is retained in the root zone of plants, where it is absorbed by the plants or evaporates back into the atmosphere. The rest continues to penetrate deep beneath the earth's surface under the influence of gravity, until it reaches the water-saturated layers, forming groundwater. Groundwater moves slowly through the pores of rocks and soil, and may reappear on the surface through springs or rivers, especially in areas where the ground level is low. Eventually, this water returns to the oceans, completing the natural water cycle known as the hydrological cycle [19].

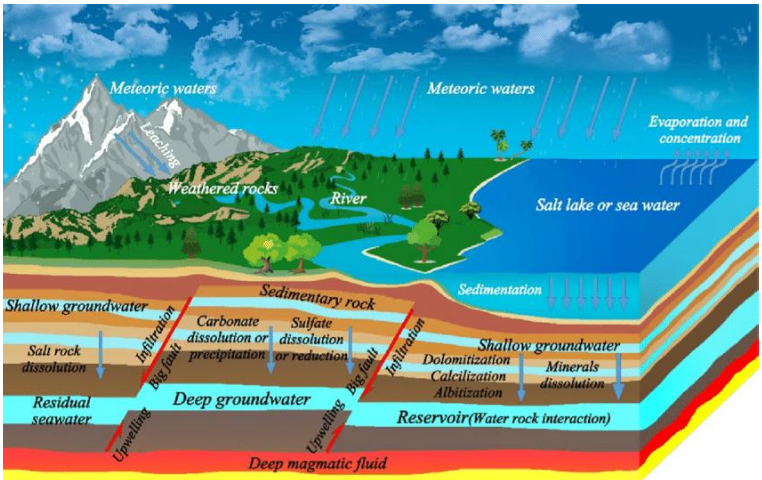


Figure I-4: Sedimentary rock formations containing groundwater in their central zone.

I .3.3.3.Types (groundwater).

Depending on its layers

Groundwater is characterized by its layers in terms of its ability to penetrate to the surface, and it should be noted that it consists of two parts as follows: [14]

Confined aquifer:

A confined aquifer refers to a subsurface geological formation that takes the form of a rock layer completely saturated with water, surrounded on top and bottom by two layers of impermeable material (such as clay or dense rock). This formation leads to high hydraulic pressure inside the aquifer, so that if an exploratory well is drilled to reach this layer, the water pressure will automatically rise to a level higher than the surface of the water-bearing layer, and in some cases it may reach the ground surface without the need for external pumps.

Unconfined aquifer:

An Unconfined Aquifer is defined as an aquifer whose upper surface (known as the water table) is directly exposed to atmospheric pressure. This means that the water level in this layer can rise or fall depending on the amount of water recharge it receives from rainfall or surface seepage. These layers are typically closer to the ground surface than confined aquifers, making them more vulnerable to climate changes such as drought. As a result, they may experience a rapid drop in water levels during prolonged droughts, making them less stable than confined aquifers.

I.3.3.4. Groundwater extraction methods

The water table may be deep or shallow, and it may rise or fall depending on several factors, for example, heavy rains and snowmelt cause the water table to rise, while heavy pumping of groundwater supplies causes the water table to fall, and there are two ways to extract groundwater and bring it to the surface, which are as follows. [21]

a)A natural method:

Groundwater is naturally released to the surface through springs or discharged into lakes and streams.

b) Industrial method:

In which man intervenes and extracts groundwater by drilling wells, then bringing groundwater to the surface using pumps, and in some wells, such as artesian wells, groundwater can be brought to the surface without the need for pumps; the water rises and comes out of the well due to natural pressure.

I.3.3.5. Characteristics (groundwater).

Groundwater has different characteristics in terms of pH and concentration of dissolved salts, leading to its classification into several types based on these characteristics. The following is a classification of groundwater types according to the ratio of salts and PH. [22]

- **Highly saline groundwater:**

This water contains a high concentration of dissolved salts, making it unsuitable for agricultural use or drinking without treatment. It is often found in areas near seas or dry areas where evaporation increases.

- **Brackish groundwater:**

Characterised by a moderate concentration of dissolved salts, it may be suitable for some agricultural or industrial purposes after careful assessment of the quality of the soil and crops.

Low salinity groundwater:

It contains a low percentage of dissolved salts, which makes it suitable for use in drinking, irrigation and industry, and this water is of high quality compared to other types.

- **Acidic groundwater :**

Characterised by a low PH (PH<7), which may make it unsuitable for direct use due to its corrosive effect on pipes and soil. This water often forms in areas that contain volcanic rock or areas that have been subjected to industrial pollution.

This classification helps in determining the appropriate uses for each type of groundwater, whether for drinking, agricultural or industrial purposes, taking into account the need to treat the water in some cases to improve its quality.

I .3.3.6.The importance of groundwater (its advantages).

Groundwater is an extremely important natural resource for humans and the environment alike, as it has several features that make it a vital element in the continuity of life and the maintenance of environmental balance. The following are the most prominent of these features. [23]

- **A vital source of drinking water**

Groundwater is a major source of drinking water, with nearly 50 per cent of the world's population relying on it in whole or in part. It provides essential water for around 2.5 billion people around the world to meet their daily needs.

- **Its role in agriculture**

Groundwater contributes 43 per cent of the total water used for irrigation, making it an essential element in enhancing food security and supporting agriculture, especially in areas where surface water is scarce.

- **A major freshwater reservoir**

Although hidden beneath the earth's surface, groundwater makes up 99 per cent of the planet's liquid freshwater, making it the largest natural reservoir of freshwater.

- **Its role in the water cycle**

Groundwater plays a pivotal role in the natural water cycle, interacting with surface water systems such as rivers, lakes and wetlands. It recharges these sources when surface water levels are low, and absorbs the excess when they are abundant, helping to maintain the water balance.

❖ **Mitigating the effects of drought**

Groundwater acts as a strategic and reliable store of water during periods of drought, providing a sustainable source of water when surface sources become scarce or unavailable.

❖ **Supporting ecosystems**

Groundwater contributes to the maintenance of aquatic and terrestrial ecosystems, recharging wetlands and rivers, supporting biodiversity and stabilising natural environments.

I.4. Water Pollution

Definition of polluted water: In 1954, Hopkins and Schulz defined polluted water as water whose quality is reduced due to mixing with sanitary or other wastes, making it unfit for drinking or industrial use. The effect of water components on its use depends on the concentration of these components; if they are at a low enough concentration, they may not have a harmful effect when the water is used for a particular purpose. In fact, there are many constituents that can be undesirable at high concentrations, but their presence may become acceptable at low concentrations when the water is used for a specific purpose [24].

Water pollution was defined by the World Health Organisation in 1961 as ‘any change in the physical, chemical or biological properties of water, which directly or indirectly alters its condition, making it less suitable for the various uses intended for it, such as drinking, domestic, agricultural, industrial or other purposes. [25]

I.4.1. Sources Water Pollution

Water pollution comes from multiple sources, depending on the quality of the water and the characteristics and locations of the water bodies.

The most prominent sources of water pollution include the following:

I.4.1.1. Natural pollution:

It is an ancient phenomenon that occurs when running water washes organic waste from plants and animals and mineral deposits into rivers and lakes. Although this is a natural process, human activities such as logging and destruction of vegetation increase runoff, resulting in greater amounts of pollutants reaching water bodies, thus exacerbating natural pollution. [25]

I.4.1.2. Pollutants resulting from human activity:

Sewage:

These are the pollutants found in wastewater and are considered one of the most dangerous pollutants as they carry many pathogens such as types of bacteria, fungi and viruses in addition to chemical detergents, soaps and suspended substances...

Activities associated with petroleum derivatives: -

Activities associated with oil derivatives, such as oil extraction, the use of solvents to deposit oil on the seabed, and the operation of oil tankers and large vessels, cause oil to leak into water bodies. When a spill occurs, the oil forms a cohesive layer covering a large area of the water surface, hindering the exchange of oxygen between water and atmospheric air. As a result, the percentage of dissolved oxygen in the water decreases, negatively affecting organisms that depend on it. In addition, this oil layer acts as a barrier that prevents or reduces the transmittance of light into the water, hindering the ability of aquatic plants to photo synthesise, thus weakening the entire aquatic ecosystem. [27]

I. .4.1.3. Pollutants resulting from industrial activity:

Food, chemical and fibre factories release waste containing harmful substances such as fats, bacteria, blood, acids, alkalis, alkalis, dyes, petroleum derivatives and toxic chemicals. They also contain heavy metals such as arsenic (As), mercury (Hg), lead (Pb), and cadmium (Cd), which pose a significant threat to human health and the environment. These toxic substances can cause gastrointestinal and urinary disorders, as well as birth defects in foetuses when pregnant women are exposed to them. Consequently, these pollutants negatively affect water quality and threaten the safety of the organisms that depend on it. [27]

I.4.1.4. Agricultural pollutants:

It is represented by soil water erosion, animal waste, (livestock and poultry farms), chemical fertilisers and pesticides, and irrigation water.

There are various other sources such as (construction activities, mines, groundwater, garbage and cement production sites .....etc.).[28]

I.4.2. Types of water pollution:

Water pollution is one of the most widespread types of pollution as it can reach all types of water surfaces, and the types of water pollution vary according to the source causing this pollution, and the following are a number of common types of water pollution. [29]

It is divided into four sections:

I.4.2.1. Physical pollution

a) Thermal:

This type of pollution results from an increase in the temperature of water bodies due to various factors, such as lava seeping into the water or the use of water as a means of cooling in power plants, factories and desalination plants. When this hot water is discharged back into lakes, rivers and streams, it causes the temperature of the water to rise dramatically. This rise in temperature disrupts the biological balance of aquatic systems, negatively affecting the organisms that live in them. For example, some aquatic organisms, such as fish and microorganisms, are sensitive to temperature changes, and higher temperatures can lead to their death or migration. In addition, thermal pollution can increase algae growth abnormally, depleting the oxygen in the water and increasing biological pollution.

Thus, thermal pollution causes an ecological imbalance, affecting biodiversity and threatening the sustainability of aquatic systems. Therefore, it is necessary to take actions to reduce this type of pollution, such as improving cooling technologies and reusing treated water [30].

I.4.2.2. Radiation:

It is caused by the accumulation of radioactive elements in the bodies of living organisms, causing serious diseases such as cancer. Human sources include mines, industrial waste, nuclear explosions, nuclear plants, and hospitals. Natural sources include surface water that may contain radioactive elements such as uranium and radium. This pollution affects living organisms and the environment, and requires careful management and continuous monitoring to minimise its harmful effects.[31]

I.4.2.3. Chemical pollution .

a) Industrial pollution:

It occurs when industrial facilities discharge their wastes and by-products untreated into waterways, posing a great danger to the environment. These wastes contain toxic chemical compounds that negatively affect environmental elements, and industrially polluted water is characterised by the presence of:

-Fatty and organic substances: Such as waste from food industries and skinning factories.

-Heavy metals : Such as lead and mercury from the metal industry.

-Acids, bases, and phosphorus compounds: From chemical industries.

-Radioactive substances : From nuclear reactors and radioactive waste treatment.

This pollution threatens the health of humans and other living organisms, and requires strict treatment of industrial waste before discharge to preserve the environment. [32,33]

b) Oil spill pollution:

It occurs when oil leaks into water bodies due to oil tanker accidents, refinery waste, or leaks from oil wells and pipelines. This pollution seriously affects aquatic organisms, as it causes the death of plants and animals due to its toxicity, and forms an insulating layer that prevents gas exchange between water and air. In addition, beach pollution leads to environmental and economic damage, such as: Tourism and human health are affected [28].

c) Acid rain pollution:

Acid rain is formed when gases such as sulphur oxide and nitrogen oxide react with water vapour in the atmosphere, forming acids such as sulphuric and nitric acids. These gases are emitted from volcanoes and the burning of fossil fuels. When they fall, they contaminate soil and water, harming living organisms directly by poisoning the water, or indirectly through the food chain. They also dissolve heavy metals from the soil, causing additional pollution of groundwater and rivers, threatening the ecological balance [35].

d) Organic pollutants: They are mostly man-made products of human activity [36].

e) Pollution by pesticides and agricultural fertilisers:

Agricultural pesticides are considered one of the most dangerous environmental pollutants due to their widespread use and their negative impact on the environment. Their overuse contaminates the soil, where they are absorbed by plants, affecting the herbivores that feed on them, and then these toxic substances are transferred through the food chain to other organisms, including humans. In addition, rainfall washes pesticide and fertiliser residues into waterways, polluting rivers and lakes and harming the organisms that live in them.

Agricultural fertilisers, despite their benefits in increasing agricultural production, also contribute to pollution when overused. Chemicals accumulate in the soil and water, poisoning animals and humans directly when consuming contaminated products, or indirectly through the food chain. This pollution threatens the ecological balance and jeopardises the health of living organisms. Reducing the excessive use of pesticides and agricultural fertilisers is essential to protect the environment and human health [37].

I.5. Biological pollution.

Biological pollution occurs when wastewater is discharged into water bodies such as rivers and seas, contaminating them with pathogenic bacteria and viruses. This pollution reduces the oxygen content in the water, causing fish kills and water fouling. In addition, algae utilise organic matter in wastewater as fertiliser, which increases their prevalence and density, exacerbating water pollution and threatening aquatic life [37,30].

I.5.1 Causes of water pollution

Water pollution generally arises as a result of the dumping of huge quantities of waste from urban complexes, factory waste, power plants and means of transport into running water, where a large part of it seeps into the ground and pollutes it, and untreated sewage and agricultural wastewater leaks with its various chemicals and toxins into sewage, where it contains parasites and toxic heavy elements such as lead, nickel and chromium And others, if they move to agricultural lands to be transferred to crops and then to the human who eats them, as well as the presence of percentages of pesticide compounds, fungicides and herbicides, as well as toxic phosphorus and chloride compounds, in addition to the presence of some metal and organic industrial detergent compounds, as well as the causes of water pollution include oil and its derivatives and radioactive substances, whether natural or synthetic [40, 39,38].

I.6. Effects of water pollution.

I.6.1 Impact on human health:

Water pollution is a major threat to human health, causing millions of deaths every year. According to The Lancet, 1.8 million people died from water pollution in 2015. Water pollution also leads to the spread of serious diseases such as cholera, typhoid, and giardia, especially in poor communities near polluted industrial areas. These diseases are transmitted through water contaminated with bacteria and viruses, making water pollution one of the biggest global health challenges [41].

I.6.2. Its impact on the destruction of ecosystems:

Water pollution in the environment destroys various ecosystems, and ecosystems refer to the interaction between organisms that belong to one place and depend on each other, and pollution works to significantly change these ecosystems or even destroy them, and it is worth noting that due to human negligence and causing pollution, the destruction of ecosystems will be retroactively harmful to them [42].

I.6.3. Its impact on the death of marine organisms:

The death of marine organisms in water sources is considered one of the main causes of water pollution, and marine organisms that are greatly affected by water pollution include fish, crabs, birds, seagulls, dolphins, and many other marine organisms: Fish, crabs, birds, seagulls, dolphins, and many other marine organisms [42].

CHAPTER II: METHODS AND MATERIALS

After addressing the generalities of water, in this chapter we try to introduce the mineral waste, its sources and its impact on the environment, the method of preparing nanocomposites through which groundwater is treated and the methods of water treatment .

We also present the water treatment station in Oued Souf 19 March City, the equipment used and the chemical analyses carried out in the laboratory.

II. Definition of mineral waste

Mineral waste, also known as mineral scrap, is the material left over after the process of separating valuable metals or elements from the useless parts of the extracted mass. It usually results from mining operations where ore is extracted and processed to separate precious metals such as gold, silver, copper or others, leaving behind materials that are not directly usable.

Mineral tailings are distinct from "overburden" or "waste rock", which refers to the layers of rock or soil that cover mineralised ore underground. These materials are removed during drilling and mining operations to access the mineral, but are not processed and usually do not contain significant amounts of recoverable metals.

Mineral tailings themselves can be in the form of solids, clays or even liquids containing tiny particles of useless minerals. In some cases, these tailings can be highly toxic or even radioactive, making their management critical to minimizing potential environmental damage.[43]

II.1. Sources of Mineral Waste :

Mineral waste is categorised into several types depending on its source, including : Household waste, commercial waste, industrial waste, and construction waste.

The types of mineral waste can also be identified based on their source as follows :

II.1.1. Heavy industry :

Heavy industry is an industry that includes one or more characteristics, such as large and heavy products ; large equipment and facilities (e.g. heavy equipment, large machine tools, large buildings) ; or complex or multiple processes.

Examples include steelmaking, artillery production, locomotive assembly, machine tool construction, and heavy mining. As the chemical and electrical industries developed, they included components from both heavy industry and light industry, which soon also applied to the automotive and aerospace industries. Modern shipbuilding (since steel replaced wood) is considered heavy industry. The construction of large systems, such as skyscrapers, large dams, and large missiles is often classified as heavy industry. [44]

II.1.2. Construction and Demolition :

Are the unwanted materials resulting from construction and industry directly or indirectly. They include building materials such as insulation, nails, electrical wiring, rebar, and can contain lead, asbestos, paint cans, asphalt, secondary roofing, etc. These wastes vary from one construction site to another but the benefits of reduction and reuse remain the same. [45]

II.1.3. Electronics :

Electronic waste (or e-waste) describes discarded electrical or electronic devices. It is also commonly known as waste electrical and electronic equipment (WEEE) or end-of-life (EOL) electronics.[46] Used electronics which are destined for refurbishment, reuse, resale, salvage recycling through material recovery, or disposal are also considered e-waste. Informal processing of e-waste in developing countries can lead to adverse human health effects and environmental pollution.[47] The growing consumption of electronic goods due to the Digital Revolution and innovations in science and technology, such as bitcoin, has led to a global e-waste problem and hazard. The rapid exponential increase of e-waste is due to frequent new model releases and unnecessary purchases of electrical and electronic equipment (EEE), short innovation cycles and low recycling rates, and a drop in the average life span of computers.[48]

1. IT equipment, including monitors
2. Consumer electronics, including televisions
3. Lamps and luminaires
4. Toys
5. Tools
6. Medical devices
7. Monitoring and control instruments
8. Automatic dispensers

Electronic scrap components, such as CPU, contain potentially harmful materials such as lead, cadmium, beryllium, or brominated flame retardants. Recycling and disposal of e-waste may involve significant risk to the health of workers and their communities.[49]

II.2. Impact of Mineral Waste on the Environment :

- Industrial activities significantly impact the environment and ecosystems.
- Water pollution: The discharge of industrial waste into rivers and lakes leads to pollution of water sources, affecting aquatic life.

- Air pollution : The emission of gases and solids can cause degradation of air quality, affecting the health of living organisms.
- Climate change : The emission of greenhouse gases from industrial activity contributes to global warming.
- Destruction of natural habitats : The construction of factories and infrastructure can lead to the destruction of natural habitats for living organisms, threatening biodiversity.[50]

II.3.Water purification methods :

The quality of water used for drinking, whether groundwater, desalinated, or bottled, depends on strict environmental and health standards. One of the most important requirements to ensure the safety of water is that it is completely free from any chemical or biological impurities that may affect health, in addition to checking the level of minerals, salts, colour, odour, and taste to ensure its quality. Therefore, we follow the following steps. [51]

II.3.1. Physical Methods :

This stage represents the first step in the wastewater treatment process, as it aims to improve the quality of the water entering the plant by removing or reducing the concentration of pollutants, such as suspended solids and large impurities, which may negatively affect the efficiency of subsequent stages of treatment. This stage facilitates the subsequent biological and chemical processes, helping to achieve more effective and efficient wastewater treatment, reducing organic and solid loads that may clog equipment or reduce the efficiency of the final treatment. [52]

a) Sedimentation :

Sedimentation processes aim to remove as much of the suspended matter present in the water as possible, which can increase in size during the coagulation process, making it easier to sediment and separate from the water. The efficiency of sedimentation depends on several factors, such as the quality of the raw water, the concentration of suspended substances in the water, and how effectively the coagulation process creates larger, denser particles that are easier to sediment .

In sedimentation basins, the removal of suspended matter can reach 90 per cent or more, depending mainly on the design of the basins, the velocity of the water flow, the duration of the water in the basin, as well as the operating techniques used in the sedimentation and coagulation units. The better the design and operation, the more efficient the sedimentation process will be, improving the quality of the resulting water and reducing the need for additional treatment processes[53].

b) Absorption :

In the water treatment process, adsorption technology is mainly used to remove organic pollutants, heavy metal ions, residual chlorine and other harmful substances in the water. Its principle is based on the surface area and pore structure of the sorbent, and the contaminants in the water are captured and immobilised on the surface of the sorbent through physical or chemical adsorption.

Commonly used sorbents include activated carbon, zeolite, silica gel, alumina, ion exchange resin, etc. Among them, activated carbon is one of the most commonly used sorbents because it has a large specific surface area and rich pore structure, and can efficiently adsorb a variety of organic substances and some inorganic substances. [54]

II.3.2. Chemical Methods

There are many chemical processes used in water treatment, as these processes play an essential role in improving water quality and making it suitable for various uses. Among the most important of these processes are the following:[55]

a) Coagulation :

Wastewater is characterised by a high level of turbidity due to the presence of insoluble fine solids, which remain suspended in water for long periods of time without settling. This turbidity is due to the addition of substances of different concentrations, such as organic and inorganic particles, which may be the result of physical or chemical processes within the water. Environmental interactions and human activities can also increase turbidity, leading to the formation of chemical deposits that may affect water quality and ease of treatment. [53]

b) Ion exchange :

Ion exchange is defined as a chemical process based on the exchange of ions between a solution and a solid [56], and this process can be applied so that unwanted ions are replaced with useful or desirable ions [55], Ion exchange is done by binding ions dissolved in water with similar charged ions fixed on a solid known as **Ion exchanger**, which allows water purification[57] .

Ion exchange leads to a change in ion concentration without affecting the overall charge of the solution, as the ions are exchanged in a balanced manner that maintains ionic equilibrium [58], Essentially, ion exchange is the process of exchanging ions between two media.

II.3.3. Biological Methods :

Degradable organic matter, whether suspended or dissolved, is removed through the use of microorganisms. The process of disintegration and decomposition takes place according to the following equation :

Water + organic pollutants + microorganisms (bacteria) + oxygen → increase in the number of organisms * (aerobic bacteria) + H_2O + CO_2 *

The most important methods used in this treatment include :

a) Phytoremediation :

One of the methods used in wastewater treatment is the water garden system, which is an artificial wetland designed to provide environmental conditions similar to natural wetlands. This system relies on the interaction of plants and microorganisms that break down pollutants and organic matter in the water .

Treatment Duration and Basin Size

To ensure effective treatment, it is recommended that the water stays inside the basin for 4 to 5 days, so it is important that the basin is large enough to allow the water to stay during this period, which contributes to improving the quality of the treated water.

- Stages of treatment in a garden system

1. Collection basin : This is the first stage, where wastewater is collected and pre-treated.
2. Plant Basin :

- This is the second stage and contains a thick layer of gravel that acts as a support for plant roots.
- The medium is always saturated with water, but the water surface is not visible, which means that the plants used are not fully hydroponic. [59]

3. Free-flowing basin :

Contains aquatic plants that are completely submerged in water .

At this stage, the water is exposed to sunlight, which helps to remove pathogens and promote water-purification.

This system is an effective environmental solution for water treatment, as it relies on natural mechanisms to improve its quality and make it safer before it is reused or discharged into the environment. [60]

b) Activated sludge :

This method is considered the most responsive, as it provides effective removal of pollutants, giving it a higher efficiency compared to other methods. However, process control can be complex, depending on the type of effluent to be treated, especially if it contains nitrogen and phosphorus, or when large variations in flow rates occur during treatment. [61]

This is the most basic stage of the treatment process, during which the water passes through several successive steps to ensure efficient purification, namely :

- **Primary settling basin :**

After the water exits the sand retention basins, it is distributed to the primary settling basins, which may be circular or rectangular in shape. The rectangular design is often favoured for easy collection of floating material from the surface. During this stage, about 40 per cent of the organic matter is removed and the removal of suspended matter (MES) reaches a high level of about 60 per cent. [62]

- Aeration basins :

These basins are an essential part of the biological wastewater treatment process .

The water leaving the primary settling basin is subjected to intense aeration using aerobic systems such as diffusers or compressors.

This aeration provides sufficient amounts of dissolved oxygen, allowing aerobic bacteria and other microorganisms to break down and oxidise the organic matter in the water. During this process, the bacteria multiply and form what is known as *activated sludge*, bacterial communities that attach to organic matter and break it down more efficiently .

As the biological oxidation process continues, the organic matter is broken down into simpler compounds, and contaminants are significantly reduced before the water moves on to subsequent treatment stages, such as final sedimentation, where the activated sludge is separated from the treated water. [63]

- Secondary sedimentation :

At this stage, the activated sludge settles to the bottom of the basin, while some of it returns to the biological treatment basins to resume its water purification activity. As this process is completed, the treated water becomes clear and floats to the surface, signalling the end of the treatment process. Sedimentation in this basin takes about 3 hours, while the remaining sludge is sent to the anaerobic fermentation units for further processing. [64]

II.4. About the Water Purification Plant 19 March in Oued Souf ALGERIA:

The water purification plant City became operational on 19 March 2019, with a production capacity of 30,000 cubic meters per day, distributed through a network of water towers to ensure the efficient supply of drinking water to all neighbourhoods of the city. The plant was designed and operated by the Algerian company CHIALI, which managed the full operation for two years after the handover phase, to ensure efficient performance and adherence to technical standards. The plant includes a water analysis laboratory, an administrative unit, an advanced control room, as well as multi-stage treatment devices that achieve the highest levels of quality. Studies have shown that the optimal design of the plant - through the selection of appropriate filters, optimisation of operational factors, and the structure of the desalination system adopted - contributed to reducing the cost of producing a cubic meter of desalinated water from $1 to $0.59, reflecting remarkable economic efficiency.

In turn, the plant relies on three main wells to provide raw water, namely the 19 March well, the Shuhada well, and the Touggourt Road well, with a total flow of 23,477 cubic meters per hour, ensuring the sustainability of production according to the planned needs.

Figure II.1 : Photo of the entrance to the El-Oued desalination station.

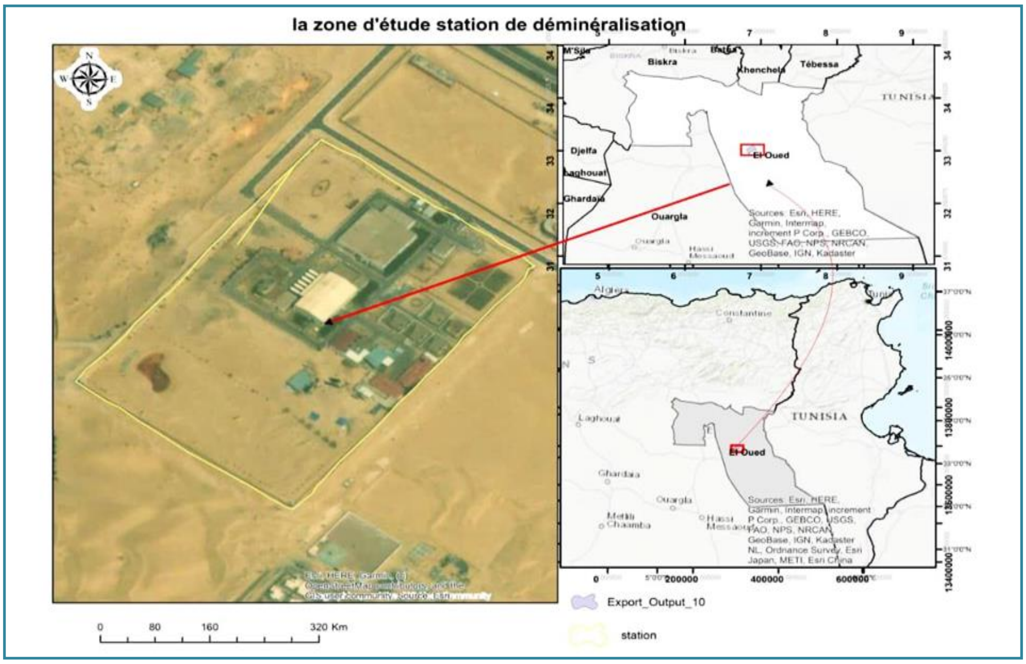


Figure II.2 : Satellite image the location of the station.

II.5. The station water treatment journey:

The Mars Balwadi Water Treatment Plant has two lines of reverse osmosis plant with a production capacity of 30,000 m³ per day, and is supplied with water through (3) three sedimentary wells (raw water) that is treated and cooled before passing through sand filters. The raw water is treated using 1.5 to 2mg/l doses of sodium hypochlorite and other elements. It is then collected in a 300 m^3 tank, then passed by the plant's pumps while receiving a dose of sodium metabisulfite and TD-ASCAL insulation, and finally passed through cartridge filters with a cutting threshold of ³5m. The water then passes through the first stage of the osmosis unit under a pressure of 13 bar by four large high-pressure pumps. The permeate (osmotic water) is placed in a tank, and the discharges from the first stage are injected into the second stage of the osmosis unit at a pressure of 10 bar.

The drinking water consists of 80% treated water and 20% filtered water, and the water is chlorinated at the plant level.

Figure II.3 : Photographs of the desalination plant in 19 March city in Oued Souf.

II.6. Technical characteristics of the plant and produced water:

- Production capacity of 30,000 cubic meters per day.
- Storage capacity from 5,000 to 10,000 cubic meters.
- Reverse osmosis is a technique used to reverse the phenomenon of osmosis.
- By applying a modification, salts are transferred from the more concentrated medium to the less concentrated medium.
- The water pressure is higher than with reverse osmosis.
- The three hot water wells projected in Alpine are 60°C wells.
- The temperature of the produced water is less than 25°C.
- PH : 7.5-8.5
- Salinity : TDS : 300 mg/L, less than 600 mg/L.

II.7.The treatment process :

- The image shows the main elements of the water treatment chain.
- Inert water tank.
- Supply and measurement of sodium hypochlorite.
- Water preparation for sand filtration.
- Sand filter feed pumps.
- Sand filter.
- Purified water tank.
- Low pressure feed pump.
- Dechlorination of filtered water.
- Filtration Equipment.
- High pressure feed pump.
- Reverse osmosis unit.
- Water tank osmosis.
- Improving water quality through disinfection.

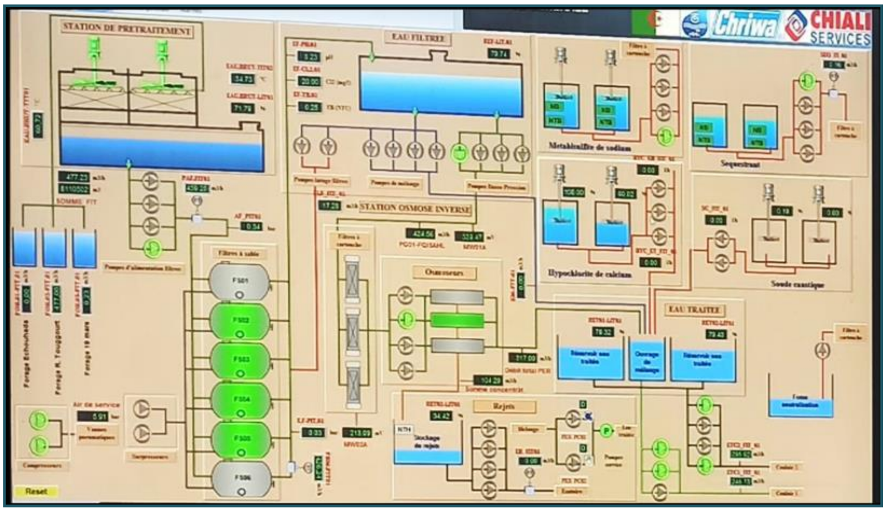


Figure II.4 : General diagram of reverse osmosis water purification.

II.8. Physicochemical parameters required for analyses

II.8.1 Physical parameters

a)Hydrogen Ion Concentration (PH)

Hydrogen ion concentration is more conveniently expressed as PH, which is the logarithm of the reciprocal of the hydrogen ion concentration in gram moles per liter. Thus, in a neutral solution the hydrogen ion (H^+) and the hydroxyl ion (OH^-) concentrations are equal, and each is equal to 10−7. A PH of 7 is neutral. A decrease in PH below 7 shows an increase in acidity (hydrogen ions), while an increase in PH above 7 shows an increase in alkalinity (hydroxyl ions). Each PH unit represents a tenfold change in concentration.

b)Electrical conductivity

Electrical conductivity is nothing but the measure of the capability of the material to pass the flow of electric current. Electrical conductivity differs from one material to another depending on the ability to let the electricity flow through them. Protons, electrons, and neutrons present in the material carry the current. Protons carry a positive charge, and each electron carries a negative charge wherever it goes. The flow of electrons inside the material is referred to as the electric current.

c)Dureté (TH)

water hardness is related to the dissolved minerals in the water. General hardness is a misleading term often confused with carbonate hardness or temporary hardness, which is related to alkalinity and relates to the "buffering capacity" of the water (its ability to resist PH changes). This means that if the carbonate hardness is high, then the PH will be highly stable, or if the carbonate hardness is low, the water's PH will fluctuate quickly.

d)Turbidity

Turbidity is a reduction in water clarity because of the presence of suspended matter absorbing or scattering down welling light, and water is considered turbid when the presence of suspended particles becomes conspicuous. Inorganic suspended materials, suspensions or triton.

e) TDS

Total dissolved solids (TDS) refers to a measure of all inorganic solids dissolved in the water. This means that it will measure ions that contribute to water hardness, like calcium, but also those that do not, like sodium. The TDS measurement is a better reflection of the total mineral content of the water rather than a water hardness measurement. However, for estimation purposes, the water hardness can be roughly calculated by dividing the ppm (parts per million) measurement of the TDS by 10, giving a hardness value with an error of only 2-3 French degrees. TDS measurements can also be derived from relative conductivity measurements.

II.8.2 chemical parameters

a)Calcium Ions (Ca^{2+})

Calcium ions are found in natural waters at varying levels depending on the geological nature of the watercourse. These ions result from the interaction between carbon dioxide dissolved in water and limestone rocks, or from the direct dissolution of calcium sulfate (gypsum).

Calcium is also present in natural waters in the form of dissolved acidic calcium carbonate, along with small amounts of other calcium salts (carbonates, sulfates, etc.) [65].

b) Magnesium Ions (Mg^{2+})

Magnesium is one of the primary components of igneous and sedimentary rocks and ranks second to calcium in terms of its abundance in groundwater, particularly in limestone aquifers. It constitutes 2.1% of the Earth crust.

The magnesium content in groundwater depends on the type of rocks through which the water flows. There are multiple sources of magnesium ions (Mg^{2+}) in groundwater: ferromagnesian minerals such as olivine, pyroxene, and biotite (black mica) are among the most significant sources in groundwater derived from igneous rocks. [66]

c)Bicarbonate Ions (HCO_3^-)

Bicarbonates originate from limestone and dolomite. Their concentration in natural waters is typically below 500 mg/L, but it may exceed 1000 mg/L in waters highly saturated with bicarbonates. [66]

d) Chloride Ions (CL^-)

All surface and groundwater contain chloride ions at varying concentrations. The primary sources of chloride ions include, dissolution of chloride salts in water percolating through saline soils, seawater intrusion into surface or groundwater basins, human, animal and industrial waste.[65]

e) Iron Ions (Fe^{2+})

Iron is present in water due to the dissolution of iron-bearing compounds from soil. Under normal surface water conditions (PH 5.5 to 5.8), iron primarily exists as (Fe^{2+}) (ferrous iron). However, due to its rapid oxidation, it can convert to (Fe^{2+}) (ferric iron) and precipitate as iron hydroxide ($Fe(OH)_3$).

II.9. Geology of Djebel Onk:

II.9.1. History of geological research at Djebel Onk:

Algerian phosphates were first discovered at BOUGARI by PH. THOMAS in 1873، shortly before the Gafsa phosphates in 1855. The Djebel Onk deposit was by JOLEAU in 1906, 1907where two phosphate layers were found in the Oued de Djibouti ravine. in the Oued de Djemi-Djema ravine south of Djebel Onk. In 1912, DESSERT provided the first information on Algerian phosphate deposits, particularly in the Djebel Onk region, with Djebel Onk region، with detailed lithological sections. Geological knowledge progressed thanks to studies by R .LAFFITTE (1939), L. Cayeux (1939-41-50) and R. FLANDRIN (1948).[67]In 1951, L. VISSE detailed the stratigraphy and estimated reserves of the Djebel Djemi- Djema phosphate deposit. From the1960 s, driven by the industrialization of Algeria, phosphate exploitation became a priority. Airborne radiometric prospecting trials were carried out from 1961to 1963, following the methods successfully used in the Tellian Atlas . RANCHIN (1963) drew up geological maps on a scale of 1 :5000. SONAREM relaunched research and prospecting phosphate prospecting in eastern Algeria from 1971 to 1974, based on aero-radiometric surveys.

From 1985 to 1987, E.N. FERPHOS commissioned EREM to evaluate the phosphate resources in the Djebel Onk region, which led to an extensive drilling program totalling 10,732 metres of core samples. [68]

In April 1992, a contract was signed between EN FERPHOS and the consultant BRGM/SOFREMINES for the compilation of technical and economic elements to draw up a development project for the Djebel Onk phosphate deposits. deposits at Djebel Onk. In 1993, BRGM provided a geological expertise report on all the deposits at Djebel Onk. [67]

II.9.2. Geographical location:

The Djebel Onk region is located in southeastern Algeria, around 100 km from the Wilaya of Tébessa and 20 km from the Algerian-Tunisian border, on the road linking Tébessa to El-Oued. It represents the natural boundary between the high plateaux of Constantine and the Saharan domain. The Djebel Onk massif, culminating at 1198 m at Djebel Tarfaya, is a limestone 20km long. This region, situated in the extreme NNE of Algeria bounded to the north by the wilaya of Souk-Ahras, to the south by the wilaya of El Oued, and to the west by the wilayas of Khenchela and Oum El Bouaghi. The lowest altitudes at the foot of Djebel Onk are around 635 m. [70]

The Djebel Onk phosphate massif comprises five deposits: Djemi-Djema, Kef Essenoun, Djebel Onk Nord, Oued Bétita and Bled El Hadba. [71]

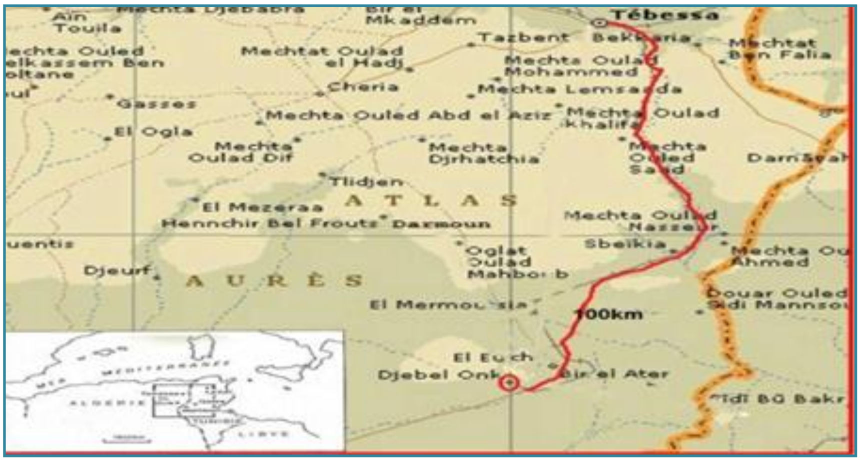


Figure II.5: Geographical location map of Djebel Onk.

II.10. Phosphate ore processing methods:

II.10.1. Mechanical preparation:

Prior to the actual processing, the ore undergoes an initial treatment designed to prepare it for subsequent processing stages. This treatment comprises several processes :[67]

a) **Crushing:** The aim is to reduce the block size from 1000 mm to a maximum of 200 mm using a "BABITLESS" gyratory cone crusher and a hammer mill (HAZEMAG) equipped with a scalping system.

b) **Grinding:** After the initial process, the ground product is further reduced to 20 mm with a reduction ratio of ten (10) using three articulated hammer mills (WEDAG). The product is then fed to the screening plant.

c) **Screening :** The screening process uses three vibrating screens (WEDAG) to eliminate products larger than 15 mm, with a weight efficiency of 95%. Two inclined vibrating screens (HAZEMAG) are used for Kef Essnoun materials. The screen rejects are recycled, while the WEDAG screen rejects are sent to slag heaps. The main objective is to obtain a product with a size of less than 15 mm to facilitate processing on the production lines.

II.10.2. Wet processing (de-sludging) :

This process, carried out in the calcination workshops (DK1), recovers ore which typically contains 69% to 77% tricalcium and 73% to 77% TPL, according to BRGM. The process comprises several stages :[71]

a) **De-sludging :** The purpose of this processing step is to purify the ore by removing impurities such as clays, silicates, organic matter and salts. It comprises several stages, including pulping, wet screening, classification, hydrocycloning and filtration. The ore is pulverized with water, then passed through curved screens to remove fine particles. Hydro cyclones recover fine particles, while high-grade particles are centrifuged to obtain a final product with a TPL content of 63% to 64.5% for further processing.

b) **Washing :** This stage improves ore quality by reducing its sludge content through washing. The water used is then treated in the washing thickener to eliminate the sludge and enable it to be reused.

c) **Drying :** The sludge by-product is a semi-finished product that must be dried to a moisture content of 1% before it can be marketed: kiln drying and horizontal kiln drying.

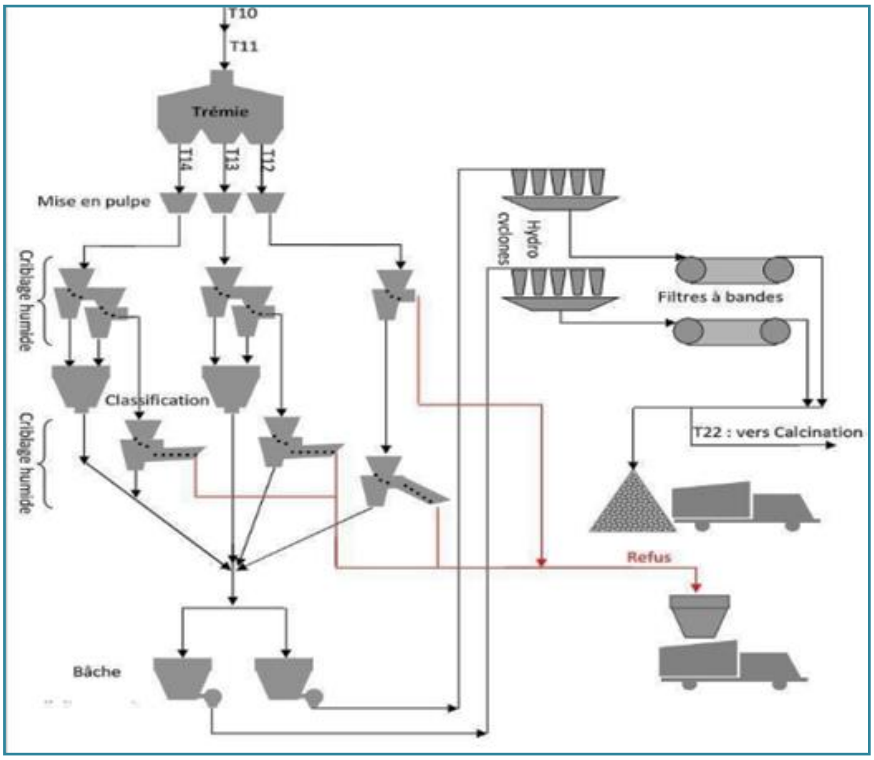


Figure II.6: De-sludging technology diagram. [72]

II.10.3. Dry treatment (dedusting):

The purpose of the dust removal process is to enrich phosphate ore physically and mechanically to obtain an average concentrate containing 29 to 26.75% P_2O_5 and 12.6% MgO.[72] The objective is to transform an initial ore of 54 to 56% DWT into a commercial product of 62.5 to 63.5% DWT, with particle sizes ranging from 800 µ to 90 µ. Each processing line has a capacity of 230 T/h in feed and 137.5 T/h in discharge, with a yield of 60 to 62% by weight. The process comprises five dry preparation and enrichment stages.[71]

a) **Fluidized-bed drying:** This process removes certain finer solids by entraining them in fluidizing gases .by entraining them in fluidizing gases. It comprises two drying furnaces with two types of behavior combustion and dilution, and fluidized-bed drying.

b) **2 mm screening :** Eliminates products larger than 2 mm using screens equipped with a 2 mm sieve, thus rejecting coarse materials larger than 2 mm (limestone). Materials smaller than 2 mm are accepted and sent to crushers (88 % efficiency).

c) **Attrition milling :** Releases part of the exogranous phosphate grains to enable betterfinal enrichment by granulometric separation, using DRAGAN" mills equipped with rotor hammers and grinding chamber.

d) Turbo-ventilated selection : Aims to enrich the product by eliminating fines below 00microns using fans.

e) **0.8 mm screening :** Follows the same principle as 2 mm screens, but eliminates phosphate grains phosphate grains larger than 0.8 mm.

CHAPTER III: RESULTS ANALYSIS AND DISCUSSION

To investigate the potential of metal waste in water purification using specific quantities under precise controlled conditions, we conducted the following experiment.

III.1.Water source:

We take the sample on April 13, 2025 from the water desalination facility located in 19 march El-Oued for the purposes of analysis and study.

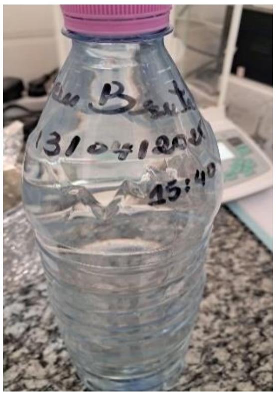


Figure III.1. vial for the sample (groundwater) to be analyzed.

III.2. Sample Preparation:

The mineral waste was initially treated to remove surface impurities by washing it three consecutive times with water and ethanol. This process aimed to eliminate dirt, soluble materials, and organic pollutants. Subsequently, the sample was dried until a completely dry and moisture-free state was achieved, making it ready for further processing.

Figure III.2. The sample of mineral waste

III.3. The Experience

- Adjust the sensitive balance to ensure accurate measurement.
- Then we weigh the different **10g, 20g** and **30g** blocks of steel

- Prepare three equal **200ml** volumes of the sample (groundwater).
- Assign each volume to correspond with one of the previously weighed masses (10g, 20g, 30g) in glass beakers after preparation.
- Pour the weighed masses into their corresponding groundwater samples.

- Shake the mixture vigorously to achieve a homogeneous solid-liquid mixture.
- Expose the mixture to sunlight for 90 minutes.

- Stir it periodically to enhance the dissolution of the solid material into the sample.
- Transfer the mixture into small test tubes after the designated time.
- Centrifuge the tubes to separate the solid-liquid mixture into distinct phases.

- Run the centrifuge for a short duration of 1 minute to complete the separation process.
- After separation, two distinct layers form:

A precipitate layer at the bottom of the tube (semi-dry metal waste), A supernatant layer containing pure filtrate (water), which is retained for further analysis.

- Transfer the filtrates (water) into small vials, ensuring proper containment.
- Take care to preserve each filtrate according to its corresponding mass measurement (10g, 20g and 30g).

III.4. Physicochemical analyses:

III.4.1. Measuring PH:

We measure the pH value of the sample with a pH-meter.

- We adjust the device with the (**ETALONAGE**) process, where we wash the **PH** meter cell with distilled water**.**
- We then dry it with special cotton wool and dip it in a **PH= 4.01** solution.
- The cell was then washed with distilled water and immersed at **PH=7.01**, as well as the same process at **PH=10**.
- We will have initialized the instrument to read the pH of the sample and then place the cell in the beeper containing the sample water, The device gives the PH value of the sample.

Figure III.3. Photographs illustrating the PH measurement process for filters.

III.4.2.Measuring electrical conductivity:

Upon completion of the PH measurement, we start with the transmittance measurement, which is based on the measurement of anions and cations in water and has units of **ms/cm** or **µs/cm**.

- We adjust the device with a prepared solution with electrical conductivity Cond = 1000 µs/cm.
- Then wash the hairy part of the machine with distilled water, We then dry it with special cotton wool and dip it in Bucher with the water to be analyzed.
- Then we press the **Cond** button and then press the **Read** button and it gives us the result directly.

FigureIII.4. Illustrating the process of measuring the conductivity of the filters.

III.5. Titration:

After measuring the conductivity and pH, a colorimetric titration is carried out to determine the concentrations of Ca^{2+}, Mg^{2+}, CL^{-} and HCO^{-}_{3}.

III.5.1. Titration of Total Water Hardness:

To determine the total hardness of the water sample, the following steps are followed:

water sample is taken10 mL, and 3 drops of Eriochrome Black T (EBT)are added, followed by 2 mL of ammonia buffer solution (PH = 10).

Titration is then carried out using EDTA ($C_{10}H_{16}N_2O_8$_Ethylenediaminetetraacetic acid) until the color changes from purple to blue.At this point, the equivalence volume of EDTA is recorded.

Figure III.5. The method of detection of TH.

- We can calculate the total hardness concentration according to the following relationship:

$$TH = \frac{V(EDTA) \times C(EDTA)}{V(eau)}$$

Where:

TH: Total hardness (°F).

$V_{(EDTA)}$: Volume of EDTA solution (mL).

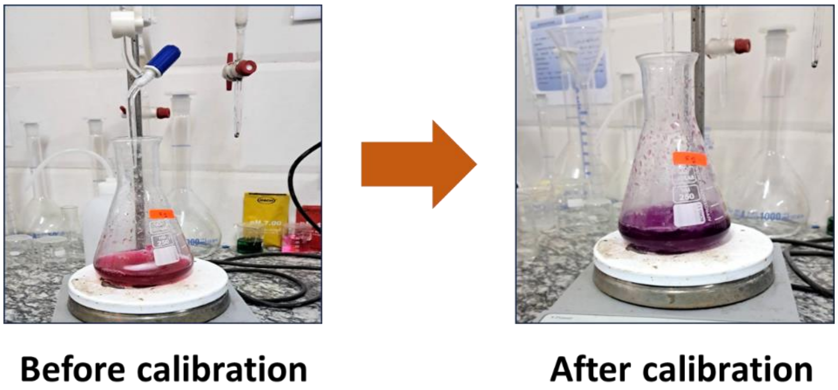
$C_{(EDTA)}$: Concentration of EDTA solution (mol/L).

$V_{(water)}$: Volume of the water sample (mL).

III.5.2. Measuring the concentration of calcium electrolytes: Ca^{2+}

To calibrate calcium ions:

- Take 50 ml of water to be analyzed.
- Add 2 ml of 2N, NaOH
- Add Murexide (H.S.N).



FigureIII.6. the color change in the calcium ion titration (Ca^{2+}).

Knowing the volume of the corresponding EDTA complex, we calculate each concentration of calcium ions according to the following relationship:

$$C_{Ca^{2+}}(mol/l) = \frac{V_{(EDTA)} * C_{(EDTA)}}{V(eau)}$$

And:

$$C_{ca^{2+}(g/l)} = C_{ca^{+2}(mol/l)} \times M_{ca2+}$$

Cca^{2+}: Calcium ion concentration (mole/l).

III.5.3. Magnesium (Mg^{2+}):

By measuring the concentration of calcium ions (Ca^{2+}) and the total hardness (TH), we can determine the concentration of magnesium ions (Mg^{2+}) using the following equation:

$TH = [Ca^{2+}] + [Mg^{2+}]$

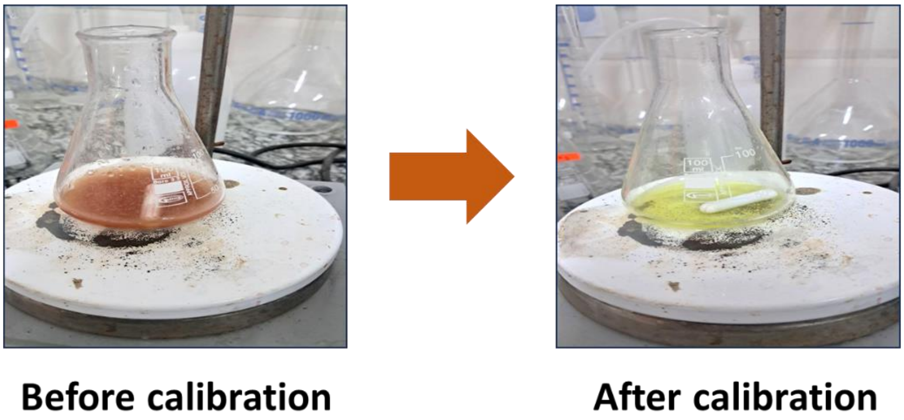
From this, we conclude the concentration of magnesium ions :

$[Mg^{2+}] = TH - [Ca^{2+}]$

III.5.4. Measuring the concentration of chlorine electrolytes CL^{-}:

For chlorine ion calibration:

- Take 5ml of water to be analyzed.
- Add 5 drops of potassium chromate (yellowish color), then shake.
- We calibrate using 0.01N systemic silver nitrate until a reddish brown color is obtained, We then record the volume V1.



FigureIII.7: the color change in the chlorine ion titration (**CL^-**).

- We can calculate the concentration of chlorine ions according to the following relationship :

$$C_{CL^-}\ (mole\backslash l) = \frac{C_{m\ (EDTA)} * V_{(AgNO3)}}{V_{(eau)}}$$

$$C_{m\ CL^-\ (g\backslash l)} = C_{n\ CL^-}\ (mole\backslash l)\ * M_{CL^-}$$

C_{mAgNO3}: Mass concentration of $AgNO_3$ used in the titration(g\l).

V_{AgNO3} :Volume of $AgNO_3$ used for calibration (ml).

M_{CL^-} :Chlorine molar mass (g\mole).

$C_{m\ CL^-}$:Mass concentration of chlorine(g\l).

III.5.5. Measuring the concentration of bicarbonate electrolytes (HCO^-_3):

- Take 100ml of water for analysis.
- Note the PH and titrate with 0.1N HCL to a PH of 4.3.

The mass concentration can be calculated as follows :

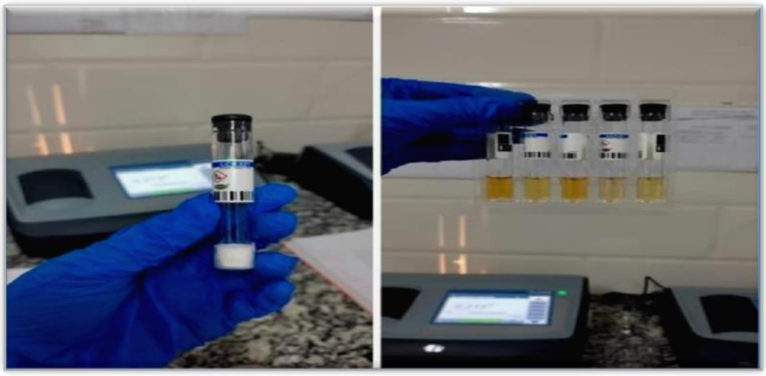
$$C_{m\ (HCO^-_3)}\ (g\backslash l) = V1*61$$

V1 :volume of **HCL** poured(1)

FigureIII.8: Demonstrates the detection of bicarbonate (**HCO_3^-**).

III.5.6. Measuring iron electrolyte concentration (Fe^{2+}):

- Place a 2ml sample of water (treated groundwater) in the iron detection tube and leave it for 15min.
- After that we put it in the spectrophotometer.



FigureIII.9: the measurement of iron concentration (**Fe^{2+}**).

III.6. Physicochemical Analysis Results:

III.6.1. PH measurement:

The PH measurement results obtained using a calibrated meter probe (HACH HQ40d) indicated alkaline conditions (7.1-7.3) throughout the study period.

Table III.1: PH measurement results before and after treatment.

Sample(g)	Ground water	10	20	30
PH	7.3	7.3	7.2	7.1

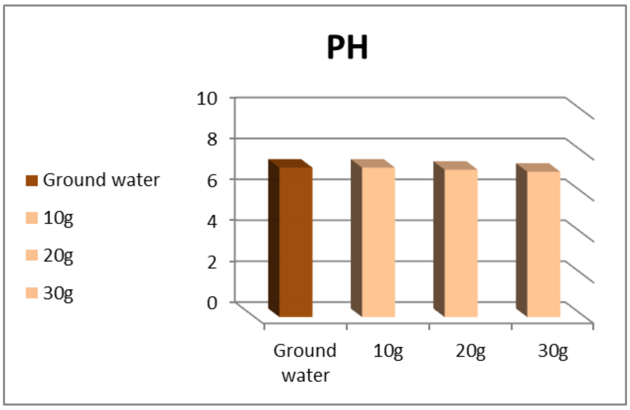


Figure III.10: Bar charts representing **PH** value variations.

❖ **Discussion:**

The graph convergence in PH with decreasing sample mass, meaning that the substance being studied does not affect the PH.

III.6.2. Temperature measurement (T°):

The obtained temperature results indicated the following:

Table III.2: Temperature analysis results T°.

Sample(g)	Ground water	10	20	30
Temperature(T°)	25	25	25	25

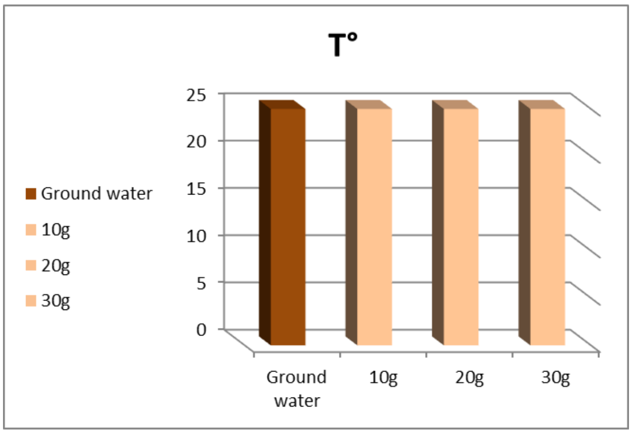


Figure III.11: Bar charts representing temperature value variations **T°**.

❖ **Discussion:**

The graph indicates that adding 10g, 20g and 30g of the substance did not significantly affect the water temperature, which remained nearly constant at the same level as the groundwater. This demonstrates that the studied substance has no measurable impact on temperature.

III.6.3. Electrical conductivity measurement:

The obtained conductivity (Cond) results indicated in the following table:

Table III.3: Electrical conductivity (EC) measurement results.

Sample(g)	Groundwater	10	20	30
Cond(μs/cm)	2780	3130	3220	3390

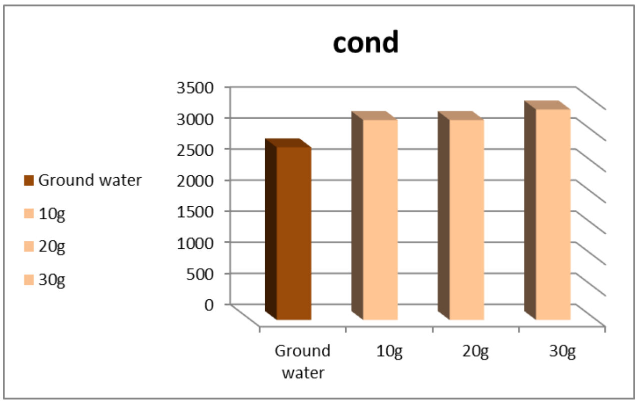


Figure III.12: Column graphs showing changes in electrical conductivity values.

❖ **Discussion:**

The graph shows the change in electrical conductivity (µS/cm) of a groundwater sample after adding different amounts of mineral waste (10 g, 20 g and 30 g). We note that the more of the studied materially we add, the higher the conductivity.

III.6.4. Turbidity measurement (TU):

The obtained TU results indicated in the following table:

Table III.4: Turbidity results illustration TU

Sample (g)	Groundwater	10	20	30
TU (NTU)	3.64	10.9	11.4	23.1

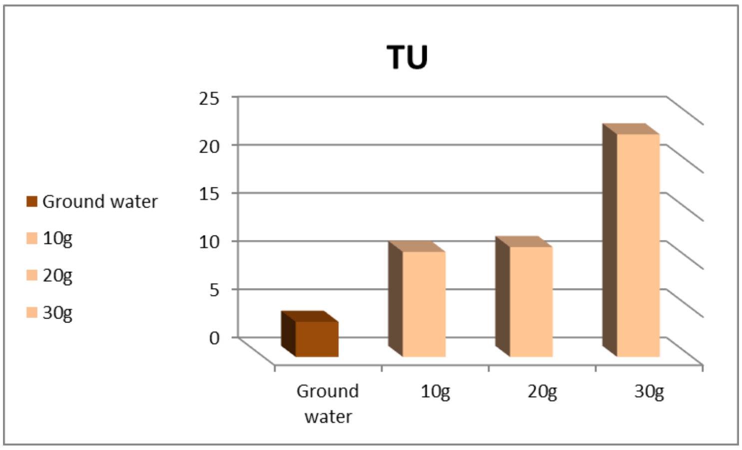


Figure III.13: Bar charts representing turbidity value variations **TU**.

❖ **Discussion:**

The graph indicates that turbidity (TU)increases significantly with the addition of larger amounts of the material (10g, 20 g and 30 g) compared to groundwater, i.e. it is inversely proportional.

III.6.5. Total Dissolved Solids (TDS) measurement:

The obtained TDS results indicated the following:

Table III.5: Results of dissolved salts measurements TDS.

Sample (g)	Groundwater	10	20	30
TDS (mg/L)	2108	1932.3	1835.4	1784.1

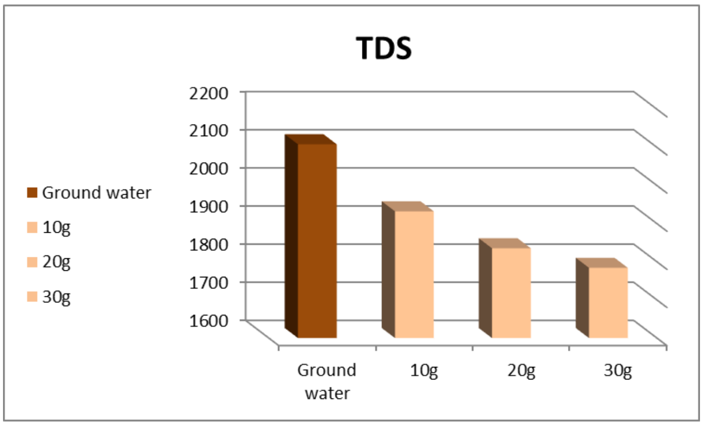


Figure III.14: Bar charts representing variations in dissolved salts concentration TDS.

❖ **Discussion:**

The graph shows the effect of adding different amounts of mineral waste (10 g, 20 gand 30 g) on the total dissolved solids (TDS) concentration in a groundwater sample. We can see from the graph that the TDS value gradually decreases as the amount of added material increases.

III.7. The following tables represent the results obtained before and after processing:

Table III.6: Analysis results of the metal (Ca^{2+})before and after experiment

Elements (ions)	Groundwater	10g	20g	30g
Calcium V_{titr} (Ca^{2+})(mL)	189.558	37.6	33	23

❖ **Discussion:**

The table illustrates the concentration of calcium ions (Ca^{2+}) in well water before and after treatment using different amounts of the substance (10g, 20g and 30g). We observe that the volume of the titration solution required for calcium determination decreases noticeably with an increase in the amount of the substance. This decrease reflects the efficiency of the material used in removing calcium ions from the water, as the adsorption increases with a greater quantity of the substance.

Table III.7: Analysis results of the metal (Mg^{2+}) before and after experiment

Elements (ions)	Groundwater	10g	20g	30g
Magnesium V_{titr} (Mg^{2+}) (mL)	116.75	54.6	54.6	54.6

❖ **Discussion:**

From the table, we observe that the volume of titrant consumed for the titration of magnesium ions in the groundwater 116.75 (mL) is significantly larger compared to the samples containing the added substance, where the volume remained constant at 54.6 (mL) despite the increase in mass from 10g to 30g. This indicates that the added substance is effective in reducing the concentration of magnesium ions.

Table III.8: Analysis results of the metal **(**HCO^{-}_{3}) before and after experiment.

Elements (ions)	Groundwater	10g	20g	30g
Carbonic acid V_{titr} (HCO^{-}_{3}) (mL)	268.4	2.8	1.8	1.6

❖ **Discussion:**

The table a significant decrease in the volume of the titrant used to titrate bicarbonate ions (HCO_3^-). This clearly indicates the effectiveness of the additive in reducing the bicarbonate ion concentration, demonstrating an inverse relationship between the amount of additive and the bicarbonate ion concentration.

Table III.9: Analysis results of the metal (CL^-)before and after experiment.

Elements (ions)	Groundwater	10g	20g	30g
Chlorine V_{titr} (CL^-) (mL)	795.2	11.2	10.3	9.1

❖ **Discussion:**

We note from the table that the volume of chlorine consumed during titration gradually decreases with increasing sample mass, demonstrating an inverse relationship. This means that the concentration of chloride ions (CL^-) decreases with increasing sample mass.

Table III.10: Analysis results of the metal(Fe^{+2})before and after experiment.

Elements (ions)	Groundwater	10g	20g	30g
Iron (Fe^{2+}) DR39000(LANGE) (mg\L)	0.237	0.06	0.04	0.02

❖ **Discussion:**

The table that the concentration of iron ions (Fe^{2+}) gradually decreases with increasing sample mass, indicating an inverse relationship - as sample mass increases, the concentration of(Fe^{2+}) decreases.

Table III.11: Analysis results before and after the experiment for(TH).

Elements (ions)	Groundwater	10g	20g	30g
TH (mg\L$CaCo_3$)	912	23.1	11.4	10.9

❖ **Discussion:**

The table that the total hardness (TH) value gradually decreases as the sample mass increases, indicating an inverse relationship between sample mass and hardness. In contrast, groundwater records the highest hardness value of 912 mg/L, indicating a high concentration of hardness-causing salts such as calcium and magnesium.

CONCLUSION

CONCLUSION

In conclusion, this study implemented an experiment aimed at purifying groundwater using metal waste, based on a scientific hypothesis. The work relied on precise laboratory experiments to explore the potential of utilizing this waste as a low-cost and environmentally friendly treatment material.

The results indicated that some indicators showed slight improvement, suggesting positive effects in certain aspects. However, the overall findings were contrary to initial expectations, as it became evident that the utilized metal waste did not lead to a comprehensive enhancement in water quality; rather, it contributed to an increase in some negative indicators related to the physical and chemical properties of the water.

Ultimately, it can be said that this experiment, despite its mixed results of both positive and negative outcomes, represents an important scientific step towards a deeper understanding of the impact of used materials on the environment. It serves as a reference for any subsequent studies in this field.

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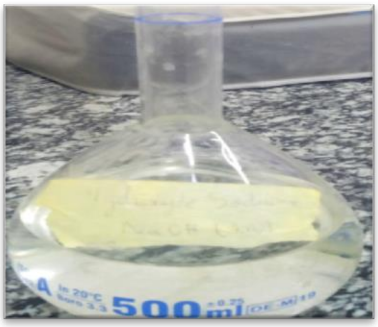
Annexes:

- **Attachment (1):**

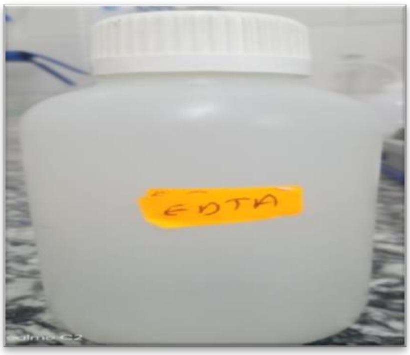
The materials and solutions used:

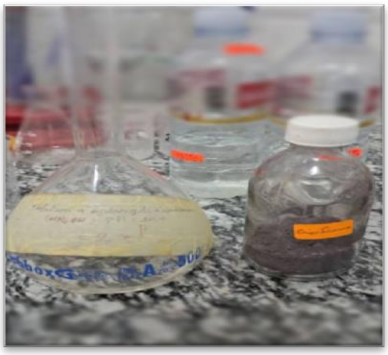


Potassium Chromate Distilled Water **Sodium Hydroxide (NaOH)**

(K_2CrO_2)

Ammonium Hydroxide(NH_4OH)Amount of water used Complex Solution(EDTA)





And **Sodium hydroxide pellet**

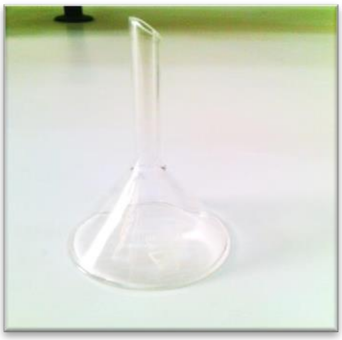
Peroxide Reagent(H.S.N) Hydrochloric Acid Solution **Silver nitrate solution**

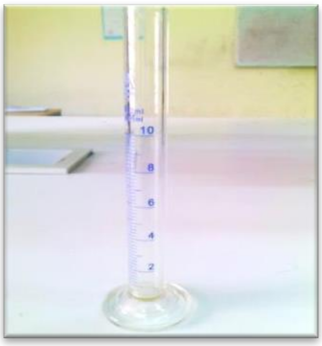
T indicatorand

Eriochrome Black

- ## Attachment (2):

Used Tools and Glassware:





Magnetic mixture

Repression

listed
experience 10ml

100mlglass beaker

Conical Flask 500ml

Serological Pipet 10ml