KASDI MERBAH UNIVERSITY – OUARGLA

Faculty of Hydrocarbons, Renewable Energies and Earth and Universe Sciences

Department of Earth and Universe Sciences

DISSERTATION : ACADEMIC MASTER

Domain : Earth and Universe Sciences

Field: Geology

Specialty :Hydrogeology

Presented by : HABBI abdelhamid

Theme :

Techniques used in water treatment (waste and drinking) In Ouargla region

publicly defended On :

Before the jury:

-President : Lamini Abdellah MCB University of Ouargla

-Examiner: Fifati Amria MCB University of Ouargla

-Framer: Bellaoueur Abdelaziz MCB University of Ouargla

Academic Year: 2023/2024

THANKS AND APPRECIATION

First and foremost, we praise God for granting us the strength to complete this work.

I would like to extend my sincere gratitude to all our professors, especially my supervisor, Mr. Belar Abdel Aziz, for their guidance and supervision throughout our training and research.

We would also like to thank:

The jury committee and everyone who assisted me, especially Professor Mahali Moustapha, Professor Ibrahim Khwaja, friend Chebboub Ayoub, Professor Nadia, and Professor Hamza Workers of both ONA - ADE - ANRAH - DHW . They have generously shared their knowledge, and I am deeply grateful.

Finally, we express our heartfelt appreciation to everyone who contributed directly or indirectly to the success of this work.

Abstract :

Our study aims to evaluate the efficiency of techniques used in drinking water and wastewater treatment. Drinking water treatment relies on reverse osmosis technology to provide clean and safe water, free from contaminants and harmful microbes, meeting national standards. Wastewater treatment focuses on primary, secondary, and tertiary treatment to remove pollutants, prevent disease spread, and minimize negative environmental impact. It also emphasizes reusing treated water for irrigation.

Results indicate that treated drinking water quantity is imbalanced with the capacity of the treatment plant. To address this, we recommend increasing water pumping or drilling additional wells to match untreated water levels with the plant's capacity, thus benefiting a larger proportion of the population.

On the other hand, while treated wastewater is currently used for irrigation, our findings suggest that the quantity exceeds actual irrigation demands. This highlights the need to explore technical solutions to enhance treatment quality, allowing for a broader range of reuse applications.

In conclusion, our study underscores the importance of assessing treatment technique efficiency. By addressing the imbalance between untreated water levels and treatment plant capacity, we can increase access to clean drinking water for more individuals. Improving treatment quality for wastewater opens up opportunities for expanded reuse, promoting sustainability and optimal utilization of our water resources.

ملخص :

تهدف دراستنا إلى دراسة مدى كفاءة التقنيات المستخدمة في معالجة مياه الشرب و مياه الصرف .

حيث تعتمد مياه الشرب في معالجتها على تقنية التناضح العكسي التي توفير مياه شرب نظيفة وآمنة، خالية من الملوثات والميكروبات الضارة و بمعايير وطنية.

بينما معالجة مياه الصرف الصحي فتركز على المعالجة الأولية والثانوية والثلاثية على إزالة الملوثات من مياه الصرف الصحي، ومنع انتشار الأمراض، وتقليل التأثير البيئي السلبي قدر الإمكان و إعادة استخدام المياه المعالجة في السقي لبعض النباتات.

تظهر النتائج أن المياه المعالجة للشرب غير متكافئة مع قدرة استيعاب المحطة ولذلك من الضروري زيادة ضخ مياه أكثر أو حفر أبار لتتكافئ نسبة المياه غير المعالجة مع قدرة استيعاب المحطة هذا و من شأنه زيادة نسبة السكان المستفادة من المياه المعالجة.

بينما مياه الصرف فهي معالجة بنسبة اقل من أنها تستعمل في نشاطات من غير السقي ولذلك من الضروري التفكير في الحلول التقنية التي من شأنها أن تجعل من الممكن تحسين جودة المعالجة بنسب أكثر.

Résumé :

Notre étude évalue l'efficacité des techniques de traitement de l'eau potable et des eaux usées. Le traitement de l'eau potable utilise l'osmose inverse pour fournir une eau propre et sûre, exempte de contaminants et de micro-organismes nocifs, conforme aux normes nationales. Le traitement des eaux usées se concentre sur les traitements primaire, secondaire et tertiaire pour éliminer les polluants, prévenir la propagation des maladies et réduire au minimum l'impact environnemental négatif. Il vise également à réutiliser l'eau traitée pour l'irrigation de certaines cultures.

Les résultats révèlent un déséquilibre entre la quantité d'eau potable traitée et la capacité de la station de traitement. Pour remédier à ce problème, nous recommandons d'augmenter le pompage ou de forer de nouveaux puits pour équilibrer la quantité d'eau non traitée avec la capacité de la station, augmentant ainsi la proportion de la population bénéficiant d'une eau potable traitée.

Par ailleurs, si l'eau usée traitée est réutilisée pour l'irrigation, sa quantité dépasse les besoins réels dans ce domaine. Il est donc nécessaire d'envisager des solutions techniques pour améliorer la qualité du traitement et élargir ses usages potentiels.

En conclusion, notre étude souligne l'importance d'évaluer l'efficacité de ces techniques pour garantir une eau potable saine à une plus grande partie de la population. L'amélioration de la qualité du traitement des eaux usées permettrait également d'envisager une réutilisation plus diversifiée, favorisant ainsi une gestion durable et optimale de nos ressources en eau.

Summary:

List of Figures

Liste of table

general Introduction

Water is an indispensable natural resource, vital for life on our planet, and it directly impacts consumer welfare and economic growth in any society. With the growing importance of water conservation and effective management, especially amidst the challenges of water scarcity and drought in the region, it is crucial to address concerns regarding water degradation and misuse, along with their consequences on the environment and society at large.

The significance of sustainable water management lies in ensuring the continuous availability of this vital resource for current and future generations. Water is essential in the daily lives of individuals, from drinking and sanitation to industrial and agricultural applications and the development of green spaces. The industrial sector is one of the largest water consumers, utilizing it in various processes. For example, water is used in cooling systems for condensers and heat exchangers. It is also a critical component in beverage and bottled water production, and it is essential in steel production, pharmaceutical manufacturing, and even in semiconductor technology.

Misuse or ineffective management of water can lead to negative impacts on the environment. Land subsidence due to decreased water reserves is one such effect, which influences geological stability. Additionally, pollution can disrupt the physical and chemical properties of water, rendering it unsuitable for various uses. The consequences of water-related issues can extend to the food chain, resulting in the death of plants and wildlife, and the spread of diseases.

To address these concerns, it is imperative for responsible authorities to embrace modern and effective techniques for water conservation and treatment. Among these advanced technologies are:

Biological Treatment: This technique leverages microorganisms to treat contaminated water and remove harmful pollutants. It is a natural and effective method that improves water quality, making it suitable for reuse.

Reverse Osmosis: A common method for water desalination and treatment, reverse osmosis employs semi-permeable membranes to separate contaminants and dissolved particles from water, resulting in clean and potable water.

By adopting such innovative technologies, the region can ensure sustainable and efficient management of its water resources, guaranteeing the availability of water for future generations. This step is crucial to maintain economic and social growth, as well as a healthy and productive environment.

In this context, this section discusses water usage in the region and the techniques employed to treat different types of water.

Chapter I:

GENERAL CONTEXT

1-1- General Presentation of the Wilaya:

1-1-1-Location and geography:

The Wilaya of Ouargla is one of the most important wilayas in the southern region of Algeria due to its significant resources, making it the lifeline of the country's economy and development. Located in the southeast of the country, this oasis jewel spans an area of 136,787 square kilometers and is situated approximately 900 kilometers from the Algerian capital.

Ouargla is bordered by the following:

To the north: The wilayas of touggourt, El M'Ghair, Ouled Djellal, and Djelfa.

To the east: The Republic of Tunisia.

To the south: The wilayas of Ain Salah and Illizi.

To the west: The wilayas of Ghardaia, Menaa, and Laghouat.

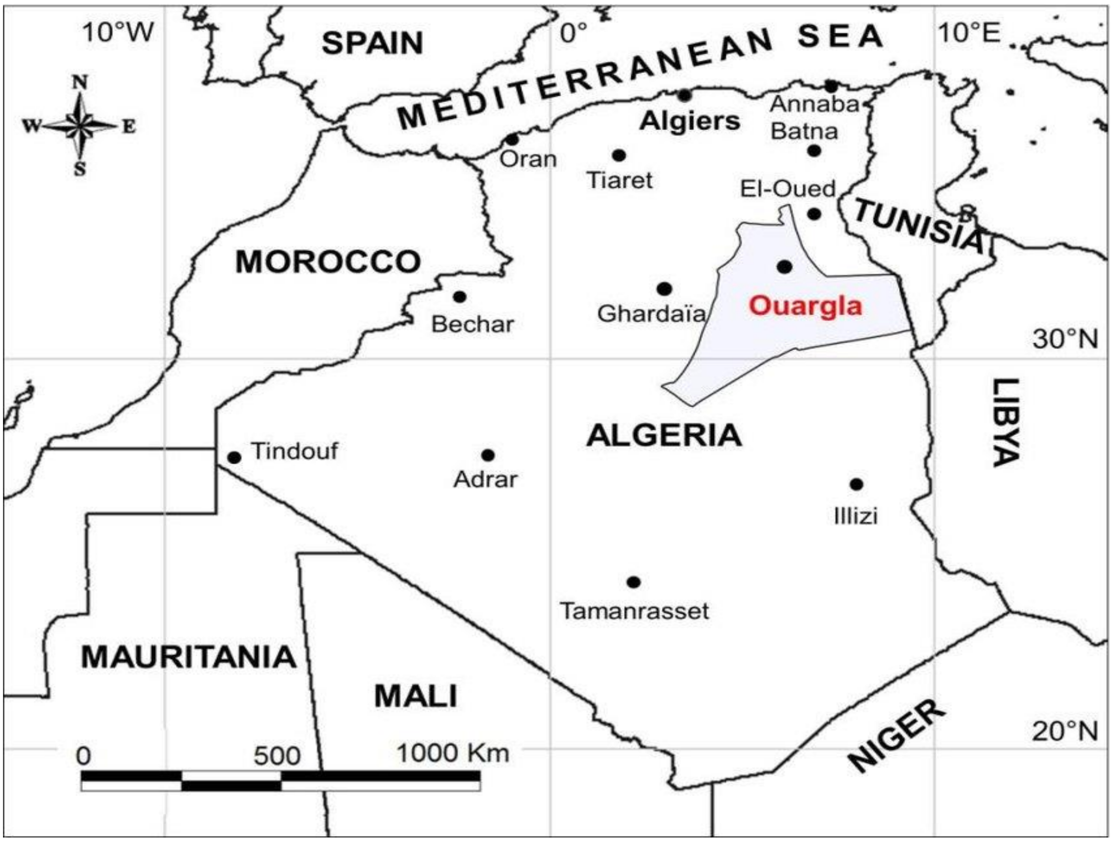


Figure I-1: Map of the geographical location of the wilaya of Ouargla

1-1-1- Demographic of the Area :

The demographic study significantly impacts the biotic component, namely water, through quantitative assessment in terms of population number and density. These two factors evaluate water requirements by considering water consumption by the population. Additionally, the industrial aspect, with its excessive exploitation of water resources, leads to environmental issues that result in water scarcity and quality deterioration. Both the industrial and population factors emphasize the need to explore water sources and strive for rational utilization to balance meeting the demands.

1-1-2- Population Size and Growth:

The population of Ouargla Province has significantly evolved over the years since the last administrative division in 1948 until 2008. However, it rapidly increased during the period from 2008 to 2017. The province's total population was estimated at 558,511 inhabitants in 2008 and 680,266 inhabitants in 2017 due to several reasons, including:

Improved educational level among the population

Increased population awareness

Resolution of many population crises

Economic development and the availability of essential facilities and infrastructure for the population

1-1-4- Climate of the Area:

The climate of Ouargla Province is characterized by a hot, arid desert climate. The region is known for its extremely hot summers and mild winters. Summer temperatures are exceptionally high, reaching 45°C or higher, while winter nights can be quite cold, with the possibility of frost. Rainfall is scarce in the province, with an average annual precipitation of around 70 mm, mostly occurring during winter and spring. The prevailing winds can sometimes be strong, especially during spring. Overall, Ouargla climate provides favorable conditions for palm cultivation and desert agriculture.

1-1-5- Agricultural Activity:

According to the latest available data from the National Office of Statistics of Algeria, the following is an overview of the agricultural activity in Ouargla Province based on the 2019 General Agricultural Census:

Arable Land: The arable land in Ouargla Province spans 136,312 hectares, representing 1.2% of the total arable land in Algeria.

1-1-5-1 Crops:

Dates: Ouargla Province is a major producer of dates in Algeria. There are a total of 5,435,221 productive palm trees in the province, which yielded 121,623 tons of dates during the 2018-2019 season.

Cereals: Cereal crops in the province include durum wheat (17,200 tons), soft wheat (1,000 tons), and barley (2,500 tons).

Vegetables: Vegetables are cultivated on an area of 3,044 hectares, with a total production of 101,155 tons

1-2- Water Resources in the Province:

Ouargla Province, like other provinces in Algeria, has two types of water sources: surface water and groundwater.

1-2-1- Surface Water: Due to the desert climate characteristic of Ouargla Province, as mentioned earlier, with hot summers and cold winters, surface water resources are scarce. The sandy dunes are permeable, causing some water to flow from higher areas to lower ones, resulting in erosion. The water collects in various depressions, sebkhas (salt lakes), and water bodies with high salinity, as well as in wadis (valleys) such as Wadi N'sa and Wadi Mia.

1-2-2- Groundwater: The province heavily relies on groundwater resources as the primary water sources in the region. Ouargla has three aquifer layers, divided by depth:

1-2-2-1- The first layer, called the free layer or shallow water layer: This layer's depth ranges from 1 to 8 meters. It is fed by agricultural irrigation water, sanitary water, surface runoff from rainfall, water from depressions, and the phenomenon of water rising.

1-2-2-2- The second layer, known as the final complex layer: This layer extends over an area of 350,000 square kilometers and comprises two types of strata:

a-The Mio-Pliocene layer**:** Its depth ranges from 50 to 200 meters. It is a sandy layer used for oasis agricultural irrigation, with a thickness of up to 100 meters in Ouargla. The water temperature in this layer ranges from 3 to 25 degrees Celsius.

b- The Senonian layer**:** This layer was discovered during the Senonian era, and its depth exceeds 200 meters. It is a limestone layer used for daily consumption, with its depth decreasing as you move southward. The length of its sheet is 30 km.

1-2-2-3- The last layer is the Continental Intercalary layer: This layer consists of a mixture of coarse sand and sandstone, sandwiched between dolomite and limestone layers. Its depth exceeds 1,000 meters, reaching 1,058 meters in Ouargla. It contains Alpine waters, characterized by high temperatures of up to 57 degrees Celsius, low salinity, and suitability for daily consumption, drinking water, and agricultural irrigation. It comprises three sheets:

- The first sheet, the uppermost, consists of clay, sand, and sandstone, with a thickness ranging from 100 to 150 meters, dating back to the Lower Cretaceous.

-The second sheet comprises clay, limestone, and dolomite clay, representing the middle portion of the layer, with a thickness ranging from 20 to 30 meters in the south, and in the north, it includes a dolomite layer.

-The third sheet is the lower part of the Alpine layer, consisting of red clay with a thickness ranging from 100 to 200 meters.

Regarding water exploitation in the area, the exploitable volume is estimated at 02.381 billion cubic meters per year. Another study estimates the exploitable volume in Ouargla Province at 01.03491 billion cubic meters per year, distributed as follows:

1-2-3- Drinking water: 145.54 million cubic meters/year, or 14.07%

Irrigation water: 879.34 million cubic meters/year, or 85.01%

Industrial and other purpose water: 9.3096 million cubic meters/year, or 0.9%

This extraction is sourced from approximately 1,060 wells.

Concerning potable water in the province, it relies on exploiting a group of wells to extract water using dedicated pumps, tapping into the Final Complex and Continental Intercalary layers because the latter has water with lower salinity and fewer chemical pollutants. After extraction, this water is directly transported to desalination plants for treatment and disinfection using sterilizing agents, including "Javel", which helps eliminate various bacteria.

Chapter II:

Drinking water treatment

2-1-Introduction :

The drinking water in the Ouargla region is a vital source of life and plays a fundamental role in the health and well-being of the local communities. Important steps have been taken to ensure the quality of drinking water in the area. The local authorities implement advanced water treatment techniques to guarantee the safety and purity of the water that reaches homes.

The drinking water in Ouargla is characterized by its high-quality standards, undergoing meticulous purification and treatment processes to ensure it is free from any pollutants or impurities. The local authorities adhere to international drinking water standards, providing peace of mind for the local residents.

2-2-Characteristics of waters:

Currently, nine (09) desalination plants for brackish water have been installed. Each plant is located within an existing hydraulic complex. The nine (09) existing hydraulic complexes are supplied from boreholes, and the water produced has a salinity of approximately 3 g/l.

The goal of these plants is to improve the quality of drinking water and reduce salinity to a value below 0.5 g/l. The physicochemical parameters conform to the recommendations of the World Health Organization (WHO). The nine (09) plants will be able to process 70,500 m3/day to provide 75% treated water (Table II.1).

2-2-1-Marine Waters:

Seawater is a complex solution containing all the elements essential for life (calcium, silicon, carbon, nitrogen, phosphorus, trace elements), organic matter (content ranging from 0.5 to 2mg), and naturally dissolved gases present in the atmosphere. Seawater is slightly alkaline, with a pH ranging from 7.5 to 8.4. The most important characteristic of seawater is its salinity, where, its overall content of salts (sodium and magnesium chlorides, sulfates, carbonates). The average salinity of seawater in the world's oceans and seas is 35 g/L. This salinity may vary in the case of enclosed seas (in Atallah, 2014).

2-2-2-Brackish Water:

Brackish water is non-potable saline water with a salinity lower than that of seawater. Most brackish waters contain between 1 and 10 g of salts per liter. They may be surface waters, but more often they are groundwater that has become saline by dissolving various salts present in the soils they have passed through.

Their composition depends on the nature of the soils traversed and the rate of flow through these soils. The main dissolved salts are: $CaCO_3$, $CaSO_4$, $MgCO_3$, and NaCl (in Atallah, 2014).

2-2-3-Demineralized Water:

It is known that consuming water with low mineral content has a negative effect on homeostatic mechanisms. Homeostasis is the tendency of an organism to maintain its various constants within normal ranges (homeostasis ensures, for example, the maintenance of temperature, blood flow, blood pressure, pH, body fluid volumes, composition of the internal environment, etc.). Experiments on animals have repeatedly shown that the intake of demineralized water leads to increases in diuresis, additional cellular fluid volume, a decrease in red blood cell volume, and some other hematocrit changes. A German study proved that if distilled water is ingested, the intestine must add electrolytes to this water, drawing them from the body's reserves. Ingestion of distilled water leads to a dilution of the electrolytes dissolved in the body's water. Inadequate redistribution of body water can compromise the function of vital organs. In the past, acute health problems were reported in mountain climbers who had prepared their drinks with snow that did not have enough necessary ions. A more severe turn of such a condition coupled with brain edema, seizures, and metabolic acidosis was reported in children whose drinks were prepared with distilled water or bottled water containing very few minerals (in Atallah, 2014).

2-3-Presentation of the Ifri-gara-Ouargla Demineralization Plant:

2-3-1-Geographic Location:

The Ifri-gara-Ouargla demineralization plant is located in the Sillis region. It is situated within the Ifri-gara complex, which spans an area of 1683 m^2 (Fig II-1).

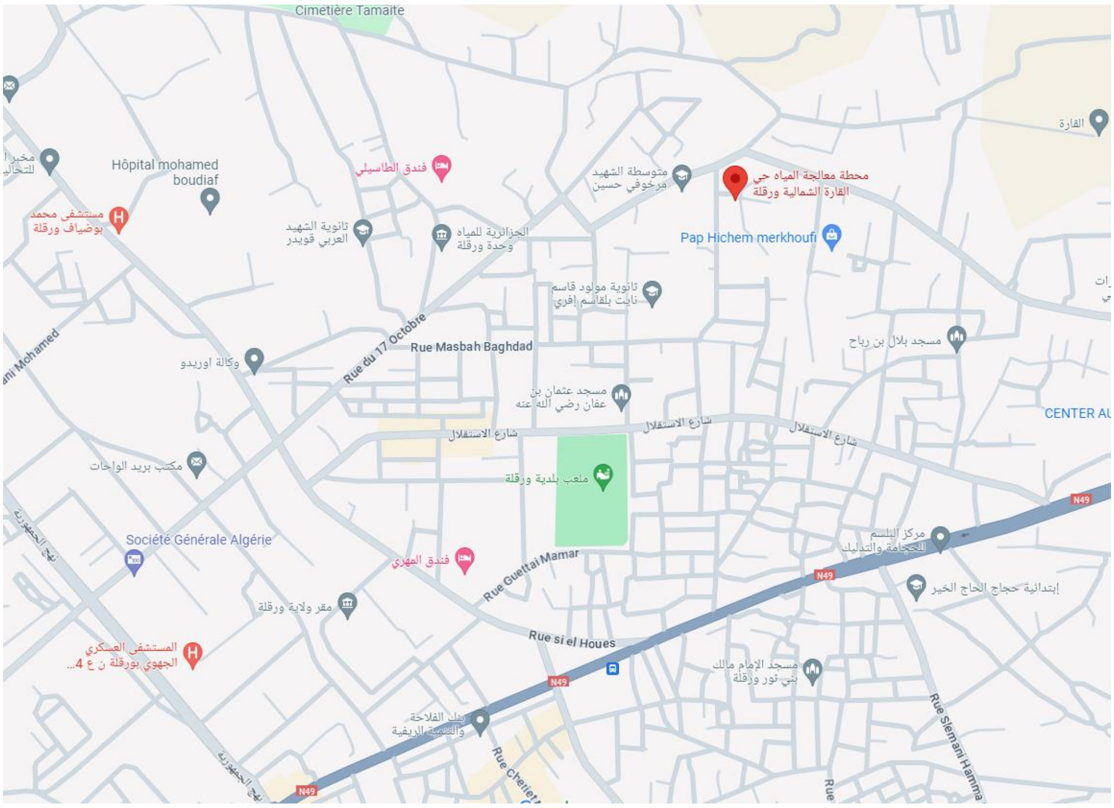


Figure II-1 : Geographic Location of the Ifri-gara-Ouargla Plant

The plant aims to reduce water salinity to meet national and international drinking water standards and thus reduce and eliminate the scaling phenomenon in networks. This plant has a treatment capacity of 10,500 m3/day.

2-3-2-Treatment Process:

The main components of the water treatment chain are

-Raw water basin;

-Preparation and dosing of calcium hypochlorite;

-Preparation of water for sand filtration;

-Sand filter feed pumps;

-Sand filter;

-Filtered water basin;

-Low-pressure feed pump;

-Dechlorination of filtered water;

-Cartridge filters;

-High-pressure feed pump;

-Reverse osmosis unit;

-Osmosis water basin;

Potabilization of osmosis water by disinfection.

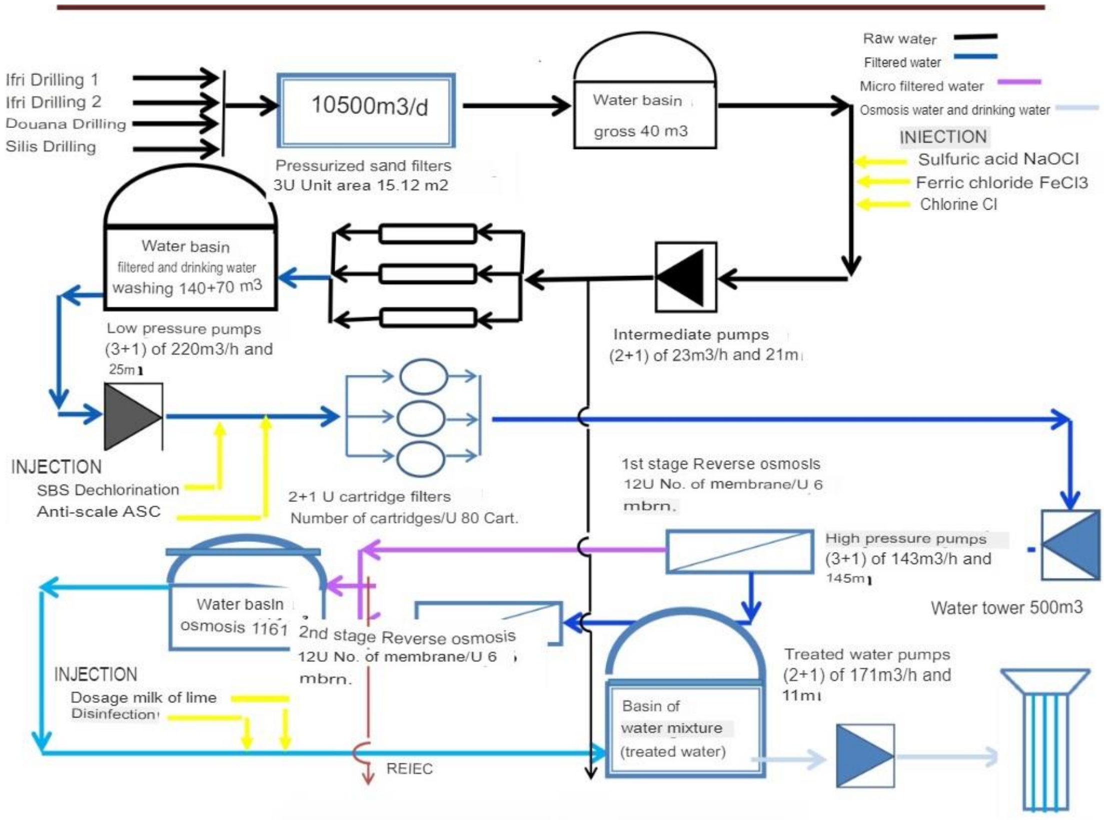


Figure II-1: block diagram of the ifri station (ADE-Ouargla 2010)

2-3-3- Auxiliary positions

In addition, the following auxiliary units are planned for operation in the art regions of the treatment plant:

- Water rinsing station for sand filters;

- Membrane cleaning station;

- Wastewater pumping station;

- Chemical preparation and dosing station; - Service water station.

2-3-4- Process Description:

2-3-4-1-Transferring water from the source to the desalination station:

Before commencing the desalination process, water is pumped from the 4 forage into the desalination plant. This step is crucial for transferring water from its source to the facility where the desalination process can be initiated, as illustrated in the (figure II-3) **.**

Figure II-3 : Injection tips

2-3-4-2-Raw Water Preparation:

Raw water is disinfected downstream of the sand filters using calcium hypochlorite. Continuous dosing is planned. To enable control of the chlorine dosing rate, a free chlorine meter is mounted on the main conduit.

To optimize water filtration, dosing of sulfuric acid (H_2SO_4) and ferric chloride is performed. The injection points are located upstream of the sand filters.

The dosing station consists of a reservoir equipped with air dryers located outside the chemical dosing room for safety reasons, two chemical dosing pumps, and other instruments necessary for automatic operation. Sulfuric acid is dosed proportionally to the operating flow rate (ADE-Ouargla, 2010).

Sulfuric acid (H2SO4) improves coagulation and prevents the formation of calcium carbonate. The dosing of magnesium carbonate reduces pH and prevents the deposition of tartar on the membranes.

Ferric chloride (coagulant) allows for more effective trapping of suspended matter and colloids. The coagulant is dosed upstream of the sand filters to improve filtration. The Fer (III) ion modifies the surface charge, causing the aggregation of colloids, which are then more easily trapped in the filter media. The injection points are located upstream of the sand filters (ADE-Ouargla, 2010).

Figure II-4: Injection tips

2-3-4-3-Low-Pressure Feed Pumps:

Three (2+1) 9600m3/day pumps provide low-pressure feed to the sand filters (fig. II-5).

Figure II-5 : Low-Pressure Feed Pumps

2-3-4-4-Sand Filter:

Bi-layer sand filter (against suspended solids) and 3 units with a unitary surface area of 15.12 m2.

Sand filtration is one of the most widely used water treatment processes.

The filtration step separates the continuous phase (liquid) and the dispersed phase (solid). It captures the finest suspended solids, down to a diameter of 10 microns. Compared to sedimentation, the cut-off threshold is finer.

Water passes through a porous filtering medium under pressure, providing the suspension with the necessary energy to traverse the porous medium.

There are several types of filtering media. Among the most well-known are fine sand, which offers an excellent price-performance ratio, anthracite, useful for filtering larger particles, or activated carbon, which combines adsorption and sedimentation to better capture suspended solids. In each of these processes, the sedimentation of suspended solids occurs through various mechanisms: inertia, centrifugal force, mutual attraction of masses or electrostatic particles, or magnetic effect. Sand filters can thus filter particles with a diameter smaller than the interstices of the filtering medium.

Finally, there are different types of filtration speeds. Slow sand filters with a superficial hydraulic load have average flow velocities between 0.10 and 0.30 m/h. They have the advantage of not requiring strict control, but on the other hand, they require a significant ground surface area. Costs can be quite high, and there is sometimes a risk of algae development within the filtering medium. Rapid filters, with gravitational or pressure flow, have average flow velocities between 2.5 and 20 m/h. Thanks to the supported loads (up to 20 m), these filters do not promote the appearance of algae or negative pressure zones in the lower part of the filtering medium. However, a slight risk of particle breakthrough remains with this process (in Belgaid, 2015).

Figure II-6 : Sand Filter Units

2-3-4-5-Filtered Water Reservoir:

Filtered water is transferred by a low-pressure feed pump and stored in a 200 m3 capacity reservoir equipped with a level measurement probe and a humidity control system (ADE-Ouargla, 2010).

2-3-4-6-Low-Pressure Feed Pumps:

Four (3+1) low-pressure feed pumps with a capacity of 8784 m3/day supply cartridge filters with filtered water.

2-3-4-7-Cartridge Filters:

Four (3+1) units; 80 cartridges in each filter

To prevent the passage of large particles or fine sand into the membrane system, a disposable cartridge filter system is provided. The cartridges are made of polypropylene filament in a helical winding with a nominal retention threshold of 5 microns.

Downstream of the microfilters, measurement points for certain operational parameters such as redox potential, pH, conductivity, turbidity, and temperature are provided.

After starting up the demineralization unit, and in the event that the water quality is outside the required operating conditions for the membranes, a discharge valve installed downstream of the microfilter can be opened to divert the water to the reject line until the required conditions are restored.

Figure II-7 : Cartridge Units

2-3-4-8-High-Pressure Feed Pumps:

Four (3+1) high-pressure feed pumps to the reverse osmosis unit (8784 m3/day). This unit can be of various types such as segmented, chamber part, and others

Figure II-8 : High pressure feed pumps

2-3-4-9-Reverse Osmosis:

Reverse osmosis (Fig II-9) is a liquid-phase separation process by permeability through semi-selective membranes under the influence of a pressure gradient. Semi-selective membranes allow for the transfer of certain materials between two separated environments, prohibiting others, or more generally, favoring certain transfers over others (in Mellal, 2011).

2-3-4-9-1-Principle:

The reverse osmosis process involves separating dissolved substances from a pressurized saline solution by forcing it to diffuse through a membrane. In practice, the feed water is pumped into a sealed tank where it is pressurized against the membrane. As a fraction of the water diffuses through the membrane, the salt concentration in the remaining fraction increases. At the same time, some of this feed water is rejected without diffusing through the membrane. Without this regulatory discharge, the pressurized feedwater would continue to increase its salt concentration, leading to issues such as salt precipitation and increased osmotic pressure across the membrane (in Meziane, 2014).

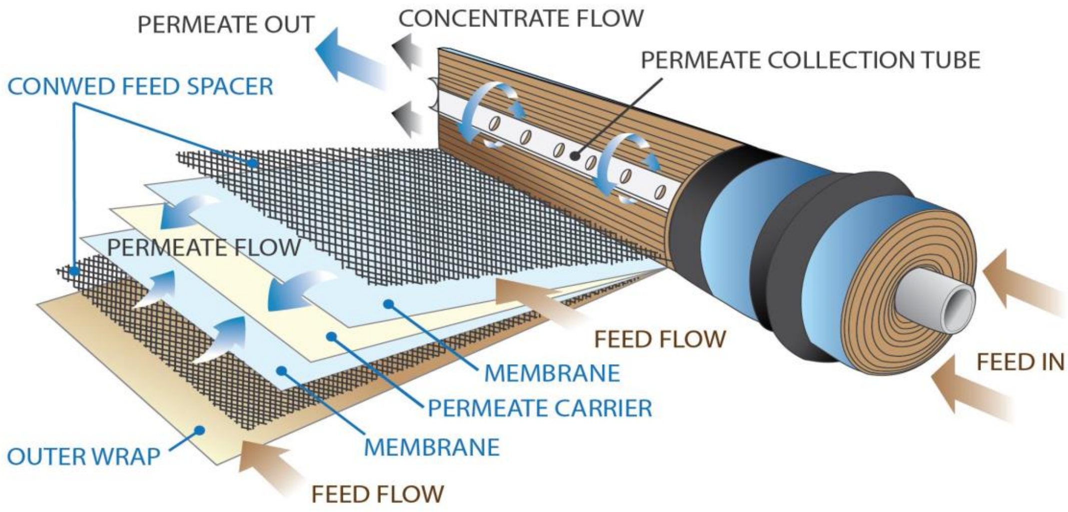


Figure II-9 : Schematic Diagram of a Water Treatment Process by Reverse Osmosis

2-3-4-9-2-Osmotic Pressure:

Osmosis is the transfer of solvent through a membrane due to a concentration gradient. If we consider a system with two compartments separated by a semi-selective membrane and containing two solutions of different concentrations, osmosis results in a water flow directed from the dilute solution to the concentrated solution. If pressure is applied to the concentrated solution, the amount of water transferred by osmosis will decrease. With sufficient pressure, the water flow will even cancel out, and this pressure is known as the osmotic pressure P (assuming the dilute solution is pure water). If the pressure exceeds the osmotic pressure, a water flow will occur in the opposite direction of the osmotic flow (Fig II-10): This is the phenomenon of reverse osmosis (in Meziane, 2014).

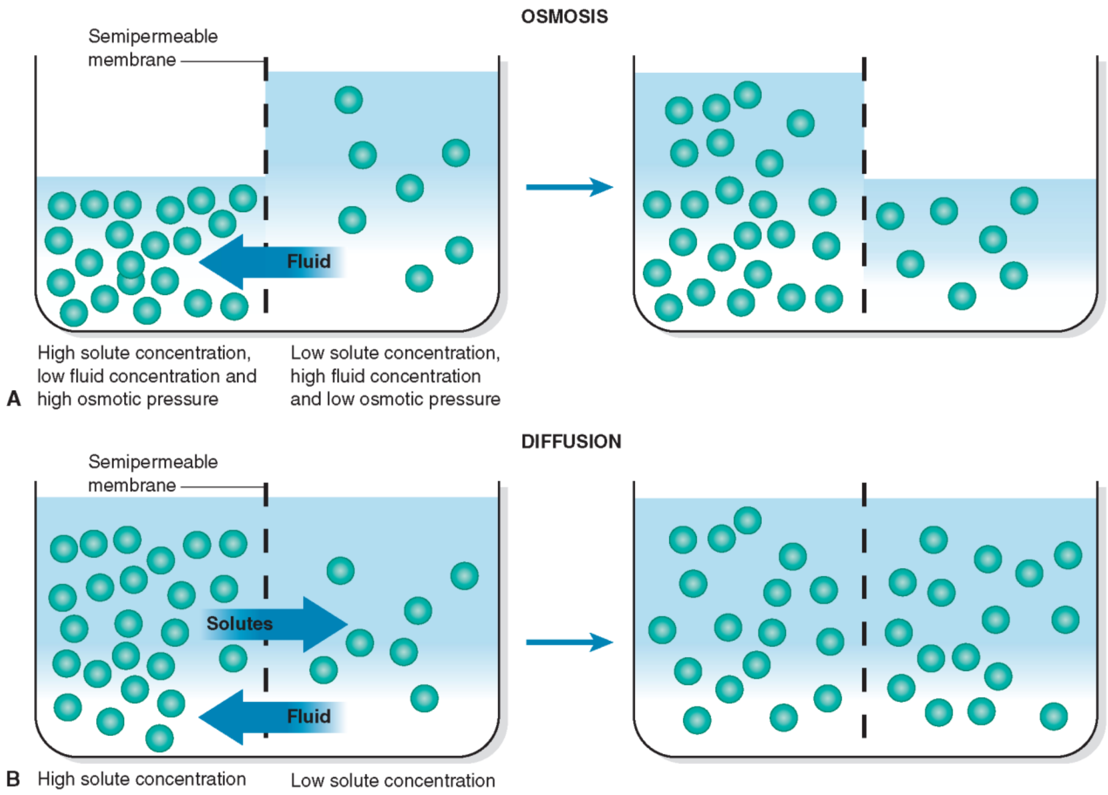


Figure II-10 : Osmotic Pressure of Electrolytes

2-3-4-9-3-Reverse Osmosis Membranes:

The membranes are semi-permeable, allowing water to pass through while retaining more than 90% of the dissolved salts and organic matter (Fig. II-11). They also retain all colloidal matter. They are defined by their propensity for fouling. The salt passage of the membranes is the parameter indicating the mineralization leakage from the saline water to the desalinated water. A membrane that retains 96% of the salinity of water has a salt passage of 4% (in Meziane, 2014).

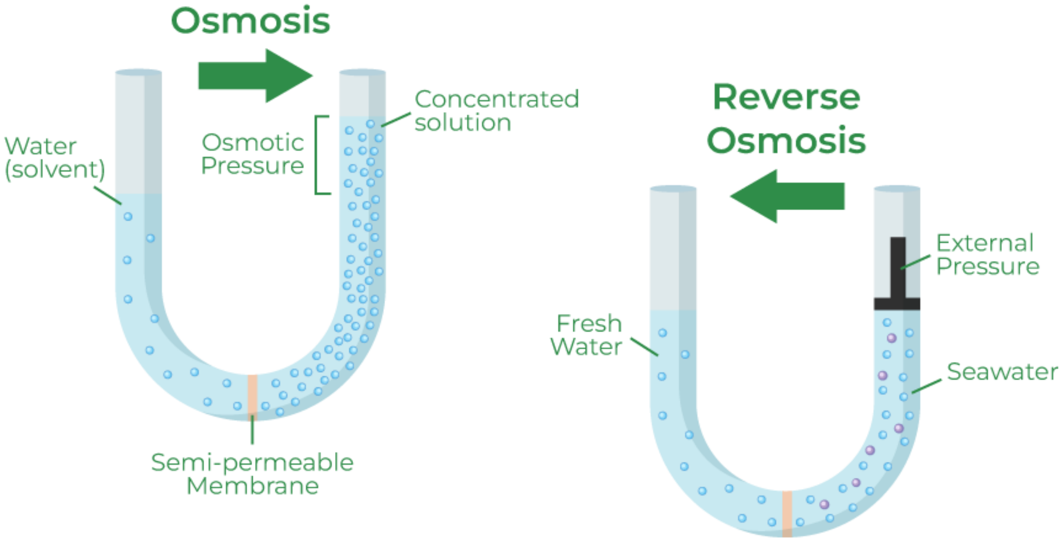


Figure II-11 : Demineralization Technique by Osmosis

2-3-4-9-4-Reverse Osmosis Unit:

For the IFRI GARA plant, the configuration of the reverse osmosis system is as follows:

The treatment is carried out on a train of osmosis. Each train consists of two passes: the first-stage reverse osmosis unit comprises 12 units, each unit containing 6 membranes, the second-stage reverse osmosis unit comprises 12 units, each unit comprising 6 membranes. Downstream of the cartridge filters, the pre-treated water is pressurized by a high-pressure pump to feed the dedicated reverse osmosis train (ADE-Ouargla, 2010) (Fig. II-12).

2-3-4-9-5-Demineralized Water Reservoir:

It is intended to hold the demineralized water produced by reverse osmosis. This desalinated water is also used to rinse the reverse osmosis membranes in case of fouling (basin volume is 116 m3).

2-3-4-9-6-Potabilization of Osmosed Water by Disinfection:

It is necessary to ensure a disinfection step to prevent any biological contamination and development. In this context, there are several methods for water disinfection, but the most commonly used is chlorination using a sodium hypochlorite solution (bleach). Chlorination destroys pathogenic organisms present in the water and protects it from subsequent contamination during transport or storage. Using one of the pumps, the treated water is pumped into the storage reservoir, but the reservoirs are a favored point for the sedimentation of deposits and, therefore, a risk zone. Their cleaning must be frequent. This operation is carried out periodically every 15 days using bleach (in Guerd et al. 2007).

Finally, before the water exits, its pH must be measured, and it must be treated with a low concentration of bleach (0.2 mg/l). The Sanitary Prevention Directorate has required the chlorination of the produced water before distribution.

Figure II-12 : reverse osmosis line

2-4-Physicochemical Analysis Results:

To determine the physicochemical characteristics of the waters in the Ifri-gara plant after each treatment step, two campaigns were carried out for three types of water: raw water, osmosed water, and outlet water.

2-4-1-pH:

The pH of natural waters is linked to the nature of the terrain traversed. In general, highly calcareous waters have a high pH, while waters from soils poor in limestone or siliceous have a pH close to 7 or lower (in Guerd et al. 2007).

pH is one of the most important parameters of water quality. The pH value (7.7) of the raw water meets national standards (6.5 to 8.5), compared to values of 6.9 and 7.8 for osmosed water and outlet water, respectively (Table II.2).

2-4-2-Electrical Conductivity:

Measuring electrical conductivity provides a rapid but very approximate assessment of the overall mineralization of water and allows for monitoring its evolution (in Guerd et al. 2007).

Raw water exhibits very high conductivity (3.7 mS/cm), exceeding standards, while osmosed water shows very low conductivity (0.2 mS/cm), and outlet water conductivity is within acceptable limits (1.7 mS/cm) (Table II.1).

2-4-3-Overall Mineralization:

- **Calcium (Ca):** Calcium is generally the dominant element in potable waters. Its content varies mainly according to the nature of the traversed terrain and is extremely widespread in nature, particularly in limestone rocks in the form of carbonate (in Guerd et al. 2007). The levels are below the standards (Table II.2).
- **Magnesium (Mg):** Magnesium is one of the most abundant elements in nature, and its content depends on the composition of the encountered sedimentary rocks. The levels are within the norms for raw water (160 mg/l) but show very low values compared to the standards for osmosed water and outlet water (Table II.2).
- **Sodium (Na) : Potassium (K); Chloride (Cl), and Sulfate (SO4):** The levels of these ions are very high (507; 38; 980; and 880 mg/l, respectively) in raw water, very low in osmosed water (42; 2.5; 95; and 11 mg/l, respectively), and within the norms for outlet waters (275; 12; 463; and 320 mg/l, respectively) (Table II.2).
- **Iron (Fe):** The results obtained show very low levels compared to the standards (Table II.1).
- **Fluoride (F):** The levels are within the norms for raw water (1.3 mg/l) but show very high values for outlet water (4 mg/l) (Table II.2).

Table II.1: Results of Physicochemical Analyses of Waters (March 2024) :

Parameter	untreated water	osmosed	Outlet water	Algerian Standard
	mg/l			
Ca^{++}	132	3	92	200
Mg^{++}	160	0,6	70	150
Na^{+}	507	42	45.5	250
K^{+}	38	2,5	11	15
Cl^{-}	980	95	481	600
SO42-	880	11	312	400
CO32-	0	0	0	/
HCO^{3-}	170	8	190	/
Fe^{2+}	0,03	0	0	0,3 (OMS)
F^{-}	1,35	0	4	1 (OMS)
PH	7,7	6,9	7,8	6,5 – 8,5
°Temperature C	24	17	22	25
electrical conductivity (µs/cm)	3770	227	1700	2500
TAC (F°)	14	0,6	156	/
TH (F°)	143	0,9	52	/

2-5-Chemical Facies of Waters:

According to Schoeller-Berkaloff, the waters are of passable quality and have a chlorinated-sodic facies with a sulfate dominance.

Chlorinated-sodic and potassic for raw and osmosed water;

Hyperchlorinated-sodic for outlet water.

The chemical facies of raw waters result from the gypsum nature of the aquifer. For osmosed water, the change in chemical facies is due to the nature of the membranes, which retain ions (Ca+2, Mg+2, Cl-, SO4-2, Na+, K+) more than ions (HCO3- and CO32-). The sulfate-chlorinated-sodic and calcic facies of the outlet waters are due to the chlorination process.

2-6-Potability of Waters:

In this section, we will examine the chemical quality of the waters by comparing them to Algerian potability standards. After demineralization, the water becomes potable and of good quality. (Table II.2)

Table II.2: Potability of Water:

Paramètre	pH	Cond (mS/cm)	Ca^{+2} (mg/l)	Mg^{+2}	Na^{+}	K^{+}	Cl^{-}	SO4-2	Remarque
Norme Alg	6,5–8,5	2,5	200	150	250	15	600	400	Potable
Outlet water	7,8	1,7	92	70	45,5	11	481	312	Potable

2-7- Conclusion:

Water desalination in our region is achieved through the process of reverse osmosis. This process results in highly demineralized water due to the selectivity of the reverse osmosis membrane, which achieves a high retention rate of up to 70% for all salts.

Chapter III:

Wastewater treatment

3-1-Introduction:

Managing wastewater in Ouargla Province, located in the heart of the Algerian desert, is a pressing challenge given the arid climate and limited water resources. Wastewater, or sewage water, results from various human activities including domestic, industrial, and agricultural use, and it carries pollutants that can pose risks to the environment and public health. In Ouargla, the Said otba Treatment Plant is making concerted efforts to treat this water and sustainably manage its water resources

3-2-Main types of water pollution:

a. Physical pollution: This type of pollution is caused by physical agents, including any solid element carried by water.

b. Chemical pollution: Chemical products that pollute water come from fertilizers and phytosanitary products used, such as insecticides and pesticides. These products can be carried by runoff water, polluting groundwater. Chemical fertilizers are transported into lakes, leading to water degradation.

c. Organic pollution: Organic pollution constitutes the most significant part and mainly comprises biodegradable compounds, hydrocarbons, and detergents.

d. Agricultural pollution: The excessive use of chemical fertilizers and pesticides in agriculture and livestock farming results in the presence of excessive amounts of nitrogen and phosphorus. Pesticides pose a significant problem for the environment.

e. Microbiological pollution: This type of pollution occurs when certain types of microorganisms capable of proliferating in water exist. A large number of microorganisms can multiply in water, which serves as a natural habitat or a simple means of transportation for these microbes.

The main pathogenic organisms that multiply in water include bacteria, viruses, parasites, and fungi…

3-3-Origin of the waters entering the Saïd Otba wastewater treatment plant:

a. Domestic wastewater: It originates from various domestic uses of water, residential establishments, and services, mainly carrying organic pollution produced mainly by human metabolism and household activities;

b. Household wastewater: Contains suspended solids (soil, sand, waste, vegetation, animals, more or less emulsified grease, etc.) and dissolved substances (mineral salts and discharged organic matter) (in Rahmani 2015).

c. Sewage waters: Contain mineral substances and constitute the bulk of pollution. They consist of kitchen, bathroom, and toilet waters (in Rahmani 2015);

d. **Urban and agricultural:** drainage waters.

3-4-Presentation of the wastewater treatment plant (STEP):

3-4-1-Geographical Location:

The Ouargla wastewater treatment plant is located in the SaïdOtba region, north of the RN 49 road.

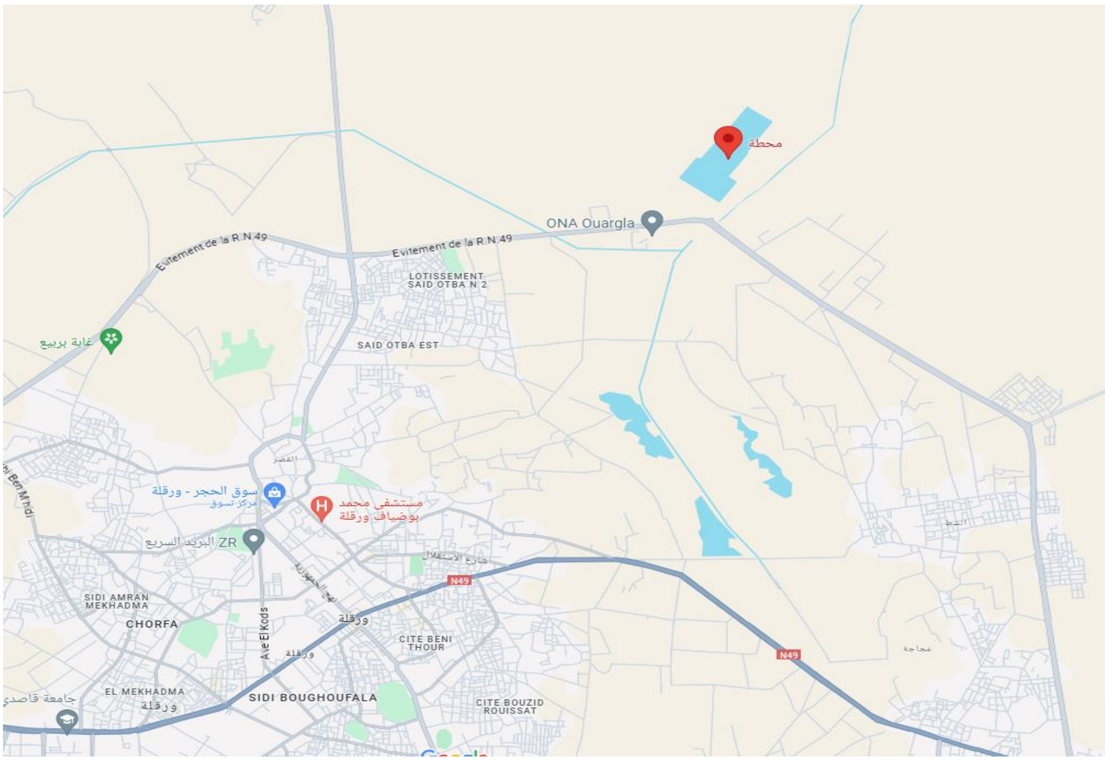


Figure III-1 : Geographical location of the STEP

3-4-2-Wastewater Treatment Objectives:

Eliminate nuisances and contamination risks in urbanized areas -

Protect the receiving environment-

Eliminate the risk of groundwater contamination-

Maintain the possibility of reusing treated effluents-

3-4-3-Operation Mode of the STEP:

This plant uses an aerated lagoon system, and the treatment process consists of the following stages:

-Pretreatment

-Primary treatment stage using aerated lagoons

-Secondary treatment stage using aerated lagoons

-Tertiary treatment stage using polishing lagoons

-Sludge drying beds

The wastewater treatment plant operates based on extensive biological treatment processes through aerated lagoons. It comprises six treatment basins in which the biodegradable load of the effluent is degraded by bacterial action. Downstream of the aeration lagoons are two settling lagoons, also called polishing lagoons, whose role is to reduce the levels of pollutants that are poorly or not eliminated to prevent interference with the proper functioning of the treatment plant by bulky or hardly biodegradable materials. It also limits the frequency of lagoon desludging.

3-4-3-1-The wastewater to be treated arrives at the plant through five pumping stations:

Refoulement 01: DN 600 mm pipeline from the Chott hydraulic node pumping station;

Refoulement 02: DN 315 mm pipeline from the SidiKhouiled pumping station;

Refoulement 03: DN 400 mm pipeline from the new Caserne/Hôpital pumping station;

Refoulement 04: DN 500 mm pipeline from the Douane pumping station;

Refoulement 05: DN 700 mm pipeline from the N'Goussa road pumping station

These pipes will flow into a degassing manhole. The latter provides natural oxygenation of the raw water. This operation evacuates the H2S that could form in the refoulement pipes.

From the degassing manhole, the raw waters flow into a channel that groups together the grating and de-sanding installations.

A Venturi channel will be placed at the outlet of the pretreatment structures to measure the inlet flow rate.

Figure III-2 : Schematic of the STEP

3-4-3-2-Pretreatment and primary treatment:

Pretreatment aims to eliminate the coarsest elements that may hinder subsequent treatments and damage equipment.

3-4-3-2-1-Pretreatment includes:

Grating: Sewage passes through a grid whose bars are more or less spaced, retaining the most bulky materials. The system includes a set of two automatic graters (25 mm bar spacing) arranged in parallel. A backup channel equipped with a static grid (40 mm bar spacing) arranged in parallel will allow to completely bypass all pretreatments in case of shutdown of the automatic graters. The rejects from all the graters are conveyed by a screw conveyor to a waste bin.

3-4-3-2-2-Desanding: Retaining sandy particles helps to prevent overloads in the following steps of treatment, accumulation of sand in the subsequent stages of treatment, and abrasion of mechanical equipment. Desanding will be achieved through three parallel channels, each 2 m wide and 23 m long. Each structure will be equipped with a scraper bridge that brings the settled sand into a pit at the end of each channel. A pump will extract the sand to a sand classifier. This classifier is a separator in which sand particles sediment and are extracted from the bottom by an Archimedes screw, while the water is recovered at the top after passing through a siphon partition. The extracted sand is then stored in a bin.

3-4-3-3-Distribution structure: Located at the head of the station downstream of the pretreatment structures, it distributes the sewage to the six lagoons of the first aerated stage. This distribution is ensured by six identical weir overflows, 1.50 m wide, equipped with stop logs to allow any lagoon to be taken out of service if needed.

3-4-3-4-Secondary treatment:

Following these pretreatments, the waters to be treated undergo a treatment system of aerated lagooning.

Aerated lagooning is a biological purification technique by free culture with artificial oxygen supply.

The process consists of two aeration stages and a finishing stage.

3-4-3-4-1-Aeration lagoon: The effluents are distributed between the six first-stage lagoons through a distributor. In the aeration stage, oxygenation is provided by a surface aerator, and this mechanical aeration promotes the development of bacteria that degrade organic matter and assimilate nutrients.

3-4-3-4-2-Settling lagoon: The waters being treated transit by gravity from the aerated lagoons of the first stage to the aerated lagoons of the second stage (settling lagoons), which consist of three lagoons. This is the physical separation stage of treated water and biological sludge, which is formed after a slow aggregation of suspended matter (microorganism clusters and trapped particles).

3-4-3-4-3-Sludge removal: The two-stage lagoons must be regularly desludged to prevent odors and degradation of treatment by sludge removal. In practice, desludging the lagoon becomes necessary when the volume occupied by the sludge approaches 25% of the total volume of the lagoon. During the actual sludge extraction, the sludge mixes with water being treated, resulting in a decrease in the dryness of the sludge to be spread on the beds to 80 g/l

In addition, it is practically difficult to extract more than 80% of the sludge from a lagoon with each desludging operation. Therefore, a desludging frequency of approximately once every 3 years is recommended for the lagoons.

3-4-3-5-Supplementary treatment - Finishing lagoon:

The waters exiting the second-stage aerated lagoons are directed towards three finishing lagoons, where the influents are purified to 80%. A portion of this treated water will be used for restricted irrigation. At the inlet and outlet, a Venturi channel associated with an ultrasonic probe to measure the water height upstream will allow for continuous measurement of flow rates.

3-4-3-5-1-Sludge treatment:

The transport of sludge from the bottom of the lagoons to the drying beds will be achieved using flexible conduits. The sludge increases in dryness due to natural evaporation coupled with a drainage system. This system promotes the evacuation of most of the water through simple drying. The water will be evacuated at the head of the wastewater treatment plant via a pumping station. After this drying process, the sludge is transported to its final destination, either landfill or spreading on crops as an interesting organic amendment

3-5-Physico-Chemical Analyses:

In all sewage treatment plants, it is necessary to perform analyses of the raw and treated water to determine various physico-chemical and bacteriological parameters. This helps assess the pollution level at each treatment stage and the pollution removal efficiency, providing a good evaluation of the sewage treatment plant's purification performance.

In this study, we aim to monitor the following parameters: temperature (°C), pH, EC (electrical conductivity), salinity, BOD_5 (biochemical oxygen demand), COD (chemical oxygen demand), DO (dissolved oxygen), SS (suspended solids), NO_2^-, NO_3^-, and PO_4^{-3}. Samples were collected at the pretreatment structures (at the plant's entrance) and the outlet (final settling tank.(

The analysis of physico-chemical parameters was carried out in the plant's laboratory.

3-5-1-Materials and Methods:

3-5-1-1-Suspended solids (MES):

The objective of this analysis is to determine the concentration of suspended solids in sewage.

3-5-1-1-1-Principle:

The water sample is filtered, and the weight of the retained solids is determined by measuring the difference in weight (Fig. III-3 and III-4)

Figure III-3 : Vacuum Filtration Device

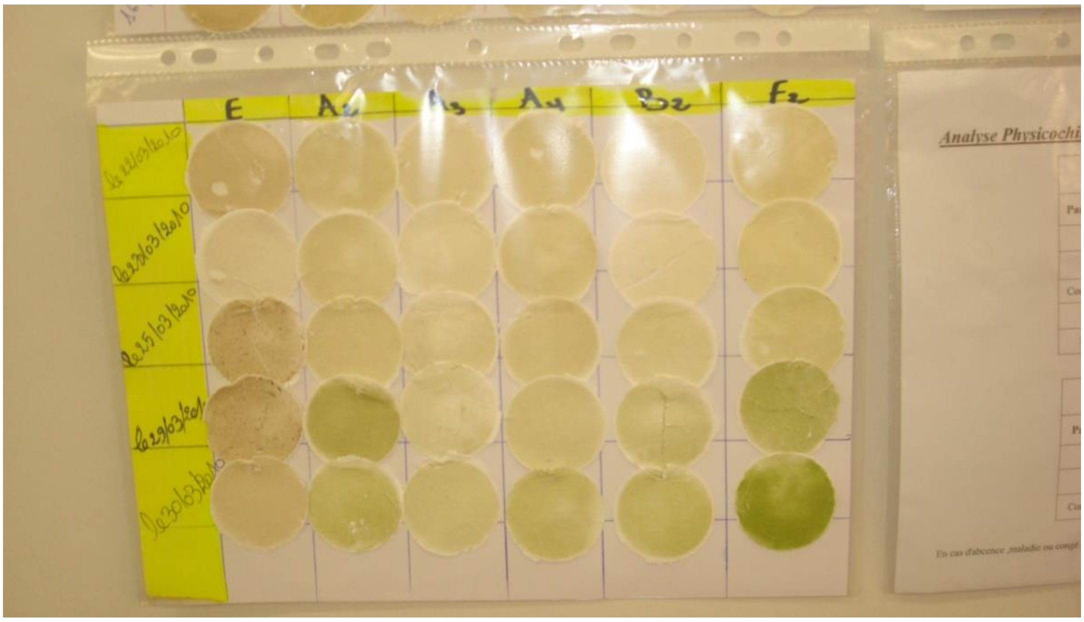


Figure III-4 : Suspended Solids

3-5-1-2-Chemical Oxygen Demand (COD) :

COD provides information on the proper functioning of the aeration basins and helps estimate the sampling volume for BOD_5 tests (Table III-1)

Table III-1 : Sample Volume Based on COD

Charge	COD (mg/l)	Sample Volume (ml)	Factor
Very Low	o-40	432	1
Low	0-80	365	2
Medium	0-200	250	5
More than Medium	0-400	164	10
Slightly High	0-800	97	20
High	0-2000	43.5	50
Very High	0-4000	22.7	100

3-5-1-2-1-Principle:

COD involves the chemical oxidation of reducing substances in the water sample using an excess of potassium dichromate (K2Cr2O7) in an acidified medium of sulfuric acid (H2SO2), along with silver sulfate (Ag2SO4) and mercury sulfate (HgSO4.(

3-5-1-2-2-Reagents:

LCK 314 reagents (range: 15 to 150 mg/l) for low concentrations.

LCK 114 reagents (range: 150 to 1000 mg/l) for high concentrations

Figure III-5 COD Reagents

Figure III-7 Spectrophotometer

Figure III-6 COD Reacto

3-5-1-3-Biochemical Oxygen Demand (BOD_5):

3-5-1-3-1-Principle:

The water sample is placed in a thermostated enclosure and incubated. The mass of dissolved oxygen required by microorganisms for the degradation of biodegradable organic matter in the presence of air for five days is measured. The microorganisms present consume the dissolved oxygen, which is continuously replaced by the oxygen from the air contained in the flask, creating a decrease in pressure above the sample. This pressure drop is recorded by an OXI TOP.(

BOD_5 (mg/l) = Reading × Factor

Figure III-8 BOD meter

3-5-1-4-Electrical Conductivity and Temperature:

3-5-1-4-1-Principle:

Electrical conductivity is a cumulative parameter that indicates the concentration of ions in a solution. The higher the concentration of salts, acids, or bases in a solution, the higher its conductivity. The unit of conductivity is µS/cm. We used the electrochemical resistance method to measure conductivity, employing a handheld conductimeter (Conductimeter 3 m cable TetraCon325-3 with integrated temperature probe).

3-5-1-4-2-Apparatus:

- Handheld conductimeter (Conductimeter 3 m cable TetraCon325-3 with integrated temperature probe)(

Distilled water dispenser-

3mol/l KCl solution for calibration-

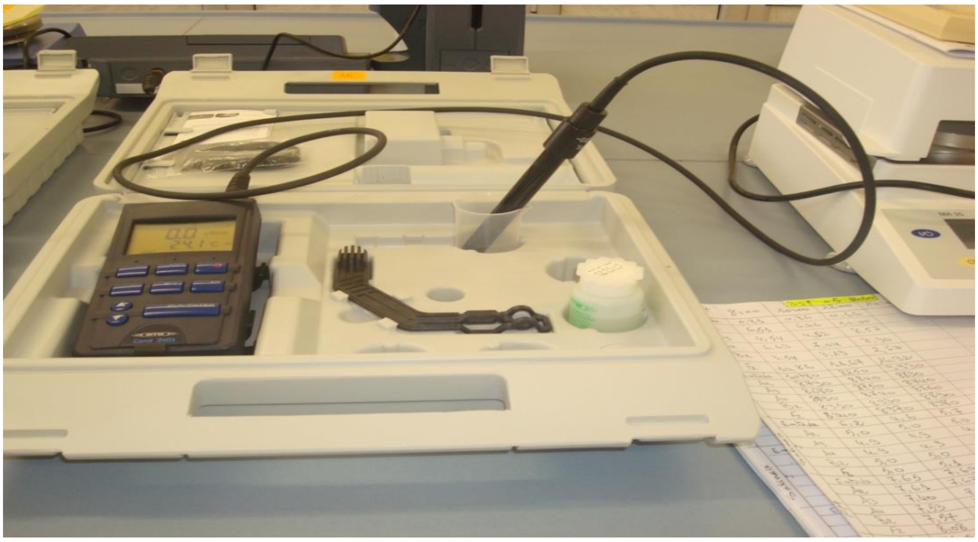
3-5-1-4-3-Procedure:

Check the calibration of the device.

Immerse the electrode in the solution to be analyzed.

Read the EC and temperature values.

Rinse the electrode thoroughly after each use and store it in distilled water



Conductimeter Figure III-9

3-5-1-5-pH:

The pH measurement was performed using a portable pH meter, WTW 340 I /Set, with a Sen Tix 41-3 electrode

FigureIII-10 : pH Meter

3-5-1-6-Dissolved Oxygen:

3-5-1-6-1-Principle:

The actual concentration of oxygen depends on temperature, air pressure, and oxygen consumption due to microbiological processes. We used a handheld oxymeter, Oxi. 340i, to determine the oxygen concentration in the water samples

Figure III-11: Oxymeter

3-6-Conclusion:

he results obtained indicate a significant difference in pollution levels between treated and raw water, confirming the effectiveness of the aerated lagoon process in wastewater treatment. The efficiency of this process makes it a promising solution for addressing water contamination, given the available resources in the region.

Chapter IV: The effectiveness and importance of these techniques

4-1-The Importance and Effectiveness of Drinking Water and Wastewater Treatment Techniques:

Drinking water and wastewater treatment techniques are of paramount importance and exhibit high effectiveness in safeguarding human health and preserving the environment. The following discussion delves into the significance and efficacy of these techniques:

4-1-1-Drinking Water Treatment Techniques:

4-1-1-1-Pollutant Removal: Drinking water treatment techniques aim to eliminate harmful contaminants, such as bacteria, parasites, and toxic chemicals. Filtration processes, including sand or activated carbon filtration, are employed to remove large particles and organic compounds. Chemical disinfection, through the addition of chlorine or ozone, is utilized to kill bacteria and germs

4-1-1-2-Quality Improvement: Treatment techniques enhance the quality of drinking water by reducing the levels of pollutants and sediments. This ensures that the water reaching households is safe, clean, and compliant with water quality standards

4-1-1-3-Disease Prevention: Drinking water treatment plays a critical role in preventing waterborne diseases. By removing harmful bacteria and viruses, the risk of waterborne illnesses, such as cholera and typhoid, is significantly reduced

4-1-1-4-Human Health: Ensuring access to safe and clean drinking water for communities is vital for maintaining human health. Contaminated drinking water can cause severe illnesses, especially among children, the elderly, and vulnerable groups

4-1-1-5-Economic Development: Economic development relies on the availability of clean and safe water. By guaranteeing the quality of drinking water, industries and businesses can thrive, fostering economic growth and social stability

4-1-1-6-Environmental Sustainability: Drinking water treatment contributes to environmental preservation. By removing contaminants before releasing water into the environment, aquatic ecosystems and wildlife are protected from pollution.

4-1-2-Wastewater Treatment Techniques:

4-1-2-1-Pollution Treatment: Wastewater treatment techniques aim to eliminate pollutants and nutrients before discharging water into the environment. Common processes include primary treatment, which removes large particles, biological treatment utilizing microorganisms to break down organic pollutants, and tertiary treatment to eliminate any remaining contaminants

4-1-2-2-Environmental Protection: Without proper treatment, wastewater can inflict significant harm on the environment. Pollutants in untreated wastewater can contaminate water bodies, kill aquatic life, and degrade ecosystems

4-1-2-3-Reusage: Wastewater treatment techniques can provide treated water suitable for various purposes, such as irrigation and industrial processes. This reduces the demand for freshwater, promoting sustainable water resource management

4-1-2-4-Preservation of Water Resources: Efficient wastewater treatment helps conserve our limited water resources. It ensures the availability of water for future generations and alleviates pressure on freshwater sources

4-1-2-5-Regulatory Compliance: Wastewater treatment techniques are crucial for communities to comply with environmental regulations and standards. Discharging untreated wastewater can lead to fines and negative repercussions for companies and institutions

4-1-2-6-Disease Prevention: Wastewater can harbor pathogens and harmful bacteria. Effective treatment mitigates the risk of waterborne disease transmission, thereby safeguarding community health

finally, drinking water and wastewater treatment techniques hold paramount importance and demonstrate high effectiveness in protecting human health and the environment. By ensuring the quality of drinking water and efficiently treating wastewater, we can enhance public health and sustain our precious water resources for future generations

4-2-Evaluation of Drinking Water and Wastewater Treatment Techniques:

4-2-1-Treatment Effectiveness:

-4-2-1-1-Pollutant Removal: Drinking water and wastewater treatment techniques are highly effective in removing harmful contaminants, including bacteria, chemicals, and nutrients. This ensures the provision of safe drinking water free from hazardous pollutants.

-4-2-1-2-Quality Improvement: Treatment techniques enhance water quality by reducing levels of sediments, suspended solids, and organic compounds. This results in improved taste and odor, making the water more acceptable to users.

-**4-2-1-3-Compliance with Standards**: Treatment processes adhere to governmental standards and regulations regarding water quality. This guarantees that treated water meets the guidelines set for potable water and wastewater discharge.

4-2-2-Environmental Sustainability:

-**4-2-2-1-Protection of Water Resources:** Treatment techniques contribute to the protection of water resources by reducing pollution and recycling water. This aids in preserving groundwater reserves and surface water sources for future generations.

-**4-2-2-2-Pollution Reduction:** Treatment techniques eliminate harmful pollutants from wastewater before it is released into water bodies. This mitigates environmental pollution and safeguards aquatic ecosystems and wildlife.

-**4-2-2-3-Reusage:** Modern treatment techniques offer recycled water that can be utilized for various purposes, such as irrigation and industrial cleaning. This reduces the demand for freshwater, promoting sustainable resource management.

4-2-3-Economic Efficiency:

-**4-2-3-1-Cost Savings:** Efficient treatment techniques can be more cost effective in the long run. By reducing chemical and energy usage, communities and industries may save on costs associated with water treatment.

-**4-2-3-2-Infrastructure Improvement**: Advanced treatment techniques can enhance water infrastructure, decreasing the need for frequent maintenance and improving the efficiency of water distribution and wastewater collection systems.

-**4-2-3-3-Job Creation:** The development and implementation of advanced treatment techniques require a skilled workforce, generating job opportunities in engineering, scientific research, and water management sectors.

4-2-4-Resilience and Adaptability:

-**4-2-4-1-Adaptability to Changes:** Modern treatment techniques exhibit greater flexibility in adapting to variations in water quality and quantity. For instance, reverse osmosis technologies can adjust to different levels of water salinity.

-**4-2-4-2-Emergency Response:** Mobile and adaptable treatment solutions can provide safe drinking water in emergency situations, such as natural disasters, aiding affected communities.

-**4-2-4-3-Climate Change Response**: With the increasing impact of climate change, innovative treatment techniques enable communities to adapt to changing conditions, such as rising water salinity or extreme weather events.

4-2-5-Limitations and Challenges:

-**4-2-5-1-Initial Cost**: Some advanced treatment techniques may carry a higher initial investment cost. However, this can be offset by long-term savings and improved water quality.

-**4-2-5-2-Existing Infrastructure**: Implementing advanced treatment techniques may require upgraded infrastructure, posing a challenge in regions with limited infrastructure or financial resources.

-**4-2-5-3-Maintenance and Expertise**: Certain treatment techniques necessitate regular maintenance and technical expertise to function effectively. This could be a hurdle in remote areas or regions with restricted resources.

In conclusion, the evaluation of drinking water and wastewater treatment techniques highlights their effectiveness, environmental sustainability, and economic efficiency. By embracing innovative treatment technologies, communities can enhance water quality and ensure the protection of water resources for future generations. However, it is imperative to consider limitations and challenges to ensure successful implementation and universal access to safe and clean water.

General conclusion:

Treating water and managing its resources effectively is one of the fundamental pillars of our modern civilization. Efficiently treating wastewater and providing safe drinking water are critical indicators of societal progress and development. As we conclude our extensive scientific discussion on this vital topic, we can derive the following insights and recommendations to promote the sustainability of our water resources and ensure a brighter future for generations to come.

We have reached some important conclusions and recommendations in this context:

First and foremost, we must recognize that water is a finite natural resource, and it is imperative that we adopt sustainable practices for its management and protection. Excessive water usage and pollution resulting from human activities pose significant threats to the integrity of our aquatic systems, adversely affecting public health and the environment. Therefore, we should embrace the principle of 'prevention is better than cure' by implementing stringent policies to prevent pollution and safeguard water sources. This includes strict regulation of industrial and agricultural practices, along with educating communities about the importance of water conservation and efficient usage.

Secondly, with increasing water demand and global climate change, investing in innovative water treatment technologies is imperative. We have already witnessed remarkable advancements in this field, including the application of nanotechnology and advanced biological treatment processes. However, further research and development are necessary to enhance the efficiency of these technologies and make them more economically sustainable. Additionally, exploring integrated solutions that combine conventional and innovative water treatment techniques is essential to cater to the specific needs of diverse regions.

Thirdly, promoting the reuse and recycling of treated wastewater is a sustainable practice that should be encouraged and developed. By redirecting treated water for non-potable purposes, such as irrigation and industrial processes, we can alleviate the pressure on freshwater sources and improve our overall water usage efficiency. This requires the implementation of rigorous water quality monitoring systems and the safe management of recycled water to ensure no harm is caused to public health.

Fourthly, collaboration and partnership are indispensable in addressing water-related issues. Water transcends geographical boundaries, and thus, efforts to manage it sustainably must be collaborative and transboundary. This entails cooperation among governments, international organizations, local communities, and scientists to formulate shared policies and strategies for protecting our transboundary water resources. Moreover, public-private partnerships can leverage expertise and financing to enhance and improve water infrastructure.

Fifthly, education and awareness play a pivotal role in ensuring the sustainable use of water. It is essential to educate individuals about the significance of water conservation and efficient water usage in their daily lives. Promoting awareness of water-related issues, such as water scarcity, pollution, and climate change, can motivate individuals to adopt more sustainable practices. Additionally, integrating water-related education into school curricula will ensure that future generations comprehend the value of this precious resource.

Lastly, we must acknowledge that treating wastewater and providing safe drinking water is a shared responsibility. By working collectively and committing to this cause, we can ensure access to clean and safe drinking water for all and protect our environment from the detrimental effects of improper water management. As responsible stewards of our water resources, it is our duty to leave a legacy of clean and sustainable water for future generations.

In conclusion, treating wastewater and providing safe drinking water are fundamental pillars for building a healthy and sustainable future. Through the adoption of sustainable practices and prudent management of our water resources, we can meet the needs of our current and future societies. It is a collective responsibility, and by working together, we can aspire to achieve efficient and sustainable wastewater and drinking water treatment, leaving a positive impact on our planet for generations to come.

BIBLIOGRAPHICAL REFERENCES

Alkama, A., & Kuper, M. (2019). Water Scarcity and Population Growth in the .Arab Region: Challenges and Opportunities. Water, 11(1), 121

El-Fadel, M., & El-Fadel, A. (2017). Water scarcity, population growth, and water reuse in the Middle East. Current Opinion in Environmental Sustainability, 28, .103-110

Ouargla Province: Population Statistics. (2023, June 16). Retrieved from /https://www.worldometers.info/population/algeria/ouargla

Climate of Ouargla Province. (n.d.). Retrieved from https://en.wikipedia.org/wiki/Ouargla_Province#Climate

Arable Land in Ouargla Province. (n.d.). Retrieved from /https://www.ons.dz/index.php/fr

Date Palm Production in Ouargla Province. (n.d.). Retrieved from /https://www.ons.dz/index.php/fr

Cereal Production in Algeria. (2022). Retrieved from https://www.fao.org/3/cb992en/CB992EN.pdf

Vegetable Production in Algeria. (2021, June). Retrieved from https://www.fao.org/3/ca4350en/CA4350EN.pdf

ADE-Ouargla 2010: Technical data sheet for the project "Study, realization, operation, and maintenance assistance for nine water demineralization stations ".in Ouargla

ATALLAH A, 2014: "Desalination process and physicochemical quality of water desalinated by the Honaine sea water desalination plant." Master's thesis in .Agronomics. Univ, Tlemcen

BELGAID Dalila 2015: Comparative study on the aging of reverse osmosis membranes used in industrial sites. Master's thesis in Process Engineering. Univ, .Chlef

BELLAOUEUR A, 2008: Hydrogeological study of groundwater in the Ouargla region, subject to the rise of water from the phreatic layer, and palliative .solutions. Master's thesis in Hydrogeology. Univ, Batna, Algeria

BENAISSA 2013: "Study on the reverse osmosis process for the desalination of .slightly brackish waters." Master's thesis in Hydraulics. Univ, Ouargla

BEN ALI T & SOUALAH B. 2014: Geological and sedimentological study of the Gara Mio-Pliocene in the East of Oued M'y (Ouargla). Engineering thesis in Geology. .Univ, Ouargla

BENMOUAFFEKI D. 2011: Study of the spatio-temporal variability of salinity in sandy environments. Case of the palm grove of Ouargla University. Engineering .thesis in Saharan Agronomy. Univ, Ouargla

BEN SAADIA & GHEBBACHE, 2014: "Qualitative study of drinking water boreholes in the Oued Righ valley: Variation of fluoride content as a function of .piezometry." Master's thesis in Hydraulics. Univ, Ouargla

DAHOU A & BREK A, 2013: Aerated lagoon in the arid zone, purification performance in the Ouargla region. Master's thesis in Environmental Engineering. .Univ, Ouargla

DJIDEL M, 2008: Mineral and organic pollution of the superficial water table of the Ouargla basin. PhD thesis in Hydrogeology, University of Baji Mokhtar, .Annaba

GUERD H & MESGHOUNI A, 2007: Performance of the Ouargla region water .desalination plant. Master's thesis in Biology. Univ, Ouargla

HOUGA A & SOLTANA A, 2014: Contribution to the valorization of local potentials in aggregates of the Ouargla region by geotechnical methods. Engineering thesis .in Geology. Univ, Ouargla

MAAMRI D & LOUAZEN A, 2013: Quality of groundwater in the Ouargla basin. .Engineering thesis. Univ, Ouargla

MELLAL 2011: "Contribution to the study of a reverse osmosis desalination plant, case of the Ain Béniane plant, Algiers." Master's thesis in Agronomics. Univ, .Annaba

MEZANE S, 2014: "Defluoridation of drinking water in Ouargla city by precipitation and reverse osmosis." Engineering thesis in Hydraulics. Univ, .Ouargla

RAHMANI A. 2015: Purification of wastewater in the N'Goussa region (Ouargla) by vegetation, purification performance. Master's thesis in Environmental .Engineering

UNESCO. 1972: Study of Water Resources in the Northern Sahara, Report on the .results of Project REG-100, UNESCO, Paris

ZARROUKI A, 2013: Management of water resources in the Ouargla basin. Master's thesis in Hydrogeology. Univ, Ouargla