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THEME

Attempt to detect antibiotic pollution in El-
Oued wastewater: The Kouinine WWTP Case.

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الإهداء

إلى أولئك الذين كانوا السبب بعد الله في كل ما وصلت إليه، إلى من منحوني حبهم دون شرط، واحتملوا ضعفي، وآمنوا بي حين شككت بنفسي...

إلى أمي

يا نبع الحنان يا دفيء الأيام وصوت الدعاء الذي لم يخفت يوماً... إلى أبي

يا من تعلمت منك الصبر والشهامة ومعنى أن أكون قوياً رغم كل ما أواجه... أهديكما هذا العمل، امتناناً لما قدمتماه، وفاءً لجميلكما الذي لا يُرد.

إلى إخوتي وأخواتي

أنتم أوتاري التي تعزف الأمل، وضلوعي التي تحميني... بكم تكتمل عائلتي وبحبكم تزهو روحي. إلى صديقتي الغاليتين

وإلى أولئك الذين أحببناهم بكل صدق

الذين سكنوا أرواحنا دون موعد إلى من جمعنا بهم محبة لا يفسدها غياب ولا تمحوها الأيام... وإلى من رحلوا عن هذه الدنيا

أرواحكم لا تزال تنبض في ذاكرتنا في تفاصيل إيماننا في دعائنا الذي لا ينقطع... رحمكم الله بقدر ما أوجعنا رحيلكم وجعل الجنة مثواكم ومأواكم لن ننساكم وستظلون جزءاً من كل إنجاز نحققه وكل لحظة فرح نعيشها.
إلى الجميع

أهدي هذا العمل عربون شكر ووفاء وذكرى لا تُنسى.

شيماء

الإهداء

من زرعاً في حبِّ التعلّم، وسانداني دعماً ودعاءً في كل خطوة إلى والديّ
الحبيبين

أنتم النور الذي أثار دربي، والظلّ الذي احتميت به في كل منعطف...لكما أهدي ثمرة جهدي، ونجاحي الذي
لولاكما لما كان له وجود.

إلى عائلتي الكريمة
إلى من كانوا الحضن الدافئ، والدافع الصامت، والملاذ الأمن شكراً لصبركم، لحبكم، وإيمانكم الدائم بي.
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كان لحضوركم أثرٌ لا يُفاس بالكلمات...في صمتكم دعم، وفي وجودكم طمأنينة كنتيم السند في
لحظات التوتر، والبسمة في لحظات التعب أهديكم هذه المذكرة اعترافاً بدوركم الذي لا يُنسى. إلى أساتذتي الأجلاء

لكل من منحني من علمه، ووقته، وتوجيهه لكم مني كل التقدير والاحترام، فأنتم منارات هذا الطريق.

أولئك الذين ساعدوني بصمت، خلف الكواليس، دون أن يسعوا لظهور أو مقابل زملاء، موظفون، أو أصدقاء... أنتم
جزء من هذا النجاح، وإن لم تُذكر أسماؤكم.

إلى كل من لمس هذا العمل بصبر أو ابتسامه أو كلمة طيبة...

أهديكم هذه المذكرة بكل فخر وامتنان.

عفاف

شكر و عرفان

قال الله تعالى:

{وَقُلْ رَبِّ زِدْنِي عِلْمًا}

[114سورة طه، الآية]

بمشاعر يملؤها التقدير والاحترام، نتقدم بأسمى عبارات الشكر والعرفان إلى كل من ساهم من قريب أو من بعيد في إنجاز هذا العمل المتواضع، الذي ما كان له أن يكتمل لولا توفيق الله عز وجل أولاً، ثم بدعم ومساندة مجموعة من الأشخاص الذين نكنّ لهم كل الامتنان والتقدير.

وفي مقدمتهم، نتوجه بخالص الشكر والتقدير إلى الأساتذة الفاضلة باشي أم الخير، لما قدمته لنا من دعم علمي وتوجيهات سديدة طيلة فترة إعداد هذه المذكرة. لقد كانت نعم المرشدة والمشرفة، لم تبخل علينا بعلمها الغزير ولا بخبرتها، ورافقتنا خطوة بخطوة في مسار هذا البحث، فكان لحرصها واهتمامها بالغ الأثر في إخراجها بهذا الشكل. و نشكر ايضاً الاساتذة الافاضل للجنة المناقشة لقبولهم مناقشة هذا العمل الدكتورة سراي عائشة كرئيس اللجنة و الدكتورة العابد سمية كمنافش.

كما نخص بالشكر إدارة وعمال محطة كوينين ONA، على ما أبدوه من تعاون وتسهيلات خلال فترة الدراسة الميدانية، حيث وفروا لنا المعلومات والظروف الملائمة للقيام بأبحاثنا التطبيقية، فكان لذلك بالغ الأثر في إثراء الجانب العملي من بحثنا.

ولا يفوتنا أن نعرب عن امتناننا العميق لكل الأساتذة الذين درّسونا خلال مسيرتنا الجامعية، وساهموا في تكويننا العلمي والمعرفي، وكذلك إلى كل من ساندنا ووقف إلى جانبنا من زملاء، أصدقاء، وأفراد العائلة الذين كانوا لنا سنداً ودافعاً لمواصلة هذا المشوار.

وفي الختام، نسأل الله أن يوفقنا في تقديم هذا العمل بما ينفع، ويكون إضافة في ميدان البحث العلمي وخدمة المجتمع.

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تجربة الكشف عن التلوث بالمضادات الحيوية في المياه المستعملة (حالة محطة تطهير المياه المستعملة بكوينين الوادي)

الملخص:

تهدف هذه المذكرة إلى دراسة وجود بقايا المضادات الحيوية في المياه المستعملة المعالجة على مستوى محطة
التصفية في كوينين (ولاية الوادي، الجزائر). تندرج هذه الدراسة في سياق القلق المتزايد بشأن تلوث المياه
بالمضادات الحيوية، والذي يمثل تهديداً بيئياً وصحياً.

لهذا الغرض، تم أخذ عينات من المياه قبل وبعد المعالجة في المحطة.

لتحليل وجود المضادات الحيوية، تم استخدام تقنية الكروماتوغرافيا السائلة عالية الأداء (HPLC)، بالإضافة إلى خصائص أخرى مثل درجة
حرارة الماء، الرقم الهيدروجيني، التوصيل الكهربائي، الأوكسجين الكيميائي المطلوب (DCO)، والأوكسجين البيوكيميائي المطلوب خلال 5
أيام (DBO5)، وذلك للتحقق من تأثيرها على النسبة المئوية للمضادات الحيوية. تركزت دراستنا على بعض المضادات الحيوية
الشائعة الاستخدام، مثل:

(Azithromycin, Trimethoprim, Cefalexin)

وفقاً لنتائجنا، تم الكشف عن آثار لبعض المضادات الحيوية في المياه المعالجة بنسبة مئوية متذبذبة تتراوح ما بين (2.01% الي 81.40% خلال
الشهرين جانفي وافريل)، مما يدل على أن محطات التصفية التقليدية لا تتمكن من إزالة هذه المركبات بالكامل.

تختلف مستويات المضادات الحيوية المكتشفة حسب نوع المركب، الموسم ومرحلة المعالجة.

وجود هذه البقايا قد يشكل خطراً بيئياً، خاصة على الحياة المائية، ويساهم في ظهور مقاومة المضادات الحيوية في البيئة.

الكلمات المفتاحية: المضادات الحيوية، التلوث، مياه الصرف الصحي، محطة التصفية (كوينين)

Attempt to Detect Antibiotic Pollution in Wastewater (Case of the Kouinine-El Oued Wastewater Treatment Plant)

Summary:

This thesis aims to study the presence and residues of antibiotics in treated wastewater at the Kouinine wastewater treatment plant (El Oued Province, Algeria). This study falls within the context of growing concern about water pollution by antibiotics, which poses both environmental and health threats.

For this purpose, water samples were collected before and after treatment at the plant.

To analyze the presence of antibiotics, High-Performance Liquid Chromatography (HPLC) was used, in addition to measuring other parameters such as water temperature, pH, electrical conductivity, Chemical Oxygen Demand (COD), and Biochemical Oxygen Demand over 5 days (BOD5), in order to assess their effect on the percentage of antibiotics. Our study focused on some commonly used antibiotics, such as Azithromycin, Trimethoprim, and Cefalexin.

According to our results, traces of some antibiotics were detected in the treated water with fluctuating percentages ranging from 2.01% to 81.40% during the months of January and April, indicating that conventional treatment plants are not capable of completely removing these compounds.

The levels of antibiotics detected vary depending on the type of compound, the season, and the treatment stage.

The presence of these residues may pose an environmental risk, particularly to aquatic life, and may contribute to the emergence of antibiotic resistance in the environment.

Keywords: Antibiotics, Pollution, Wastewater, Kouinine Plant.

Éssai de detection de la pollution antibiotique dans les eaux usées (cas de la station d'épuration des eaux usées de Kouinine, Eloued)

Résumé:

Ce mémoire a pour objectif d'étudier la présence des résidus d'antibiotiques dans les eaux usées traitées au niveau de la station d'épuration de Kouinine (wilaya d'El Oued, Algérie). Cette étude s'inscrit dans le contexte d'une préoccupation croissante concernant la pollution de l'eau par les antibiotiques, qui représente une menace à la fois environnementale et sanitaire.

À cet effet, des échantillons d'eau ont été prélevés avant et après le traitement à la station.

Pour analyser la présence des antibiotiques, la technique de chromatographie liquide à haute performance (HPLC) a été utilisée, en plus de la mesure d'autres paramètres tels que la température de l'eau, le pH, la conductivité électrique, la Demande Chimique en Oxygène (DCO) et la Demande Biochimique en Oxygène sur 5 jours (DBO5), afin de vérifier leur effet sur la concentration des antibiotiques. Notre étude s'est concentrée sur certains antibiotiques couramment utilisés, tels que : Azithromycine, Triméthoprim, Céfalexine.

Selon nos résultats, des traces de certains antibiotiques ont été détectées dans les eaux traitées, avec des pourcentages fluctuants allant de 2,01 % à 81,40 % au cours des mois de janvier et avril, ce qui indique que les stations d'épuration conventionnelles ne parviennent pas à éliminer complètement ces composés.

Les niveaux des antibiotiques détectés varient selon le type de composé, la saison et l'étape du traitement.

La présence de ces résidus peut constituer un risque environnemental, en particulier pour la vie aquatique, et contribuer à l'émergence de résistances aux antibiotiques dans l'environnement.

Mots-clés : Antibiotiques, pollution, eaux usées, station de Kouinine.

Introduction

Introduction

Introduction

Environmental pollution is one of the most prominent global challenges facing humanity today, with wastewater containing antibiotics contributing significantly to this crisis. Antibiotics are widely used in medical and agricultural fields, and a substantial amount of these compounds reaches water sources without adequate treatment, leading to water pollution and the emergence of drug-resistant microorganisms. Therefore, research on wastewater treatment plants, such as the one in Kouinine, is essential to understand this problem and work toward its mitigation **(Kümmerer, 2009; Michael et al., 2013)**.

This study aims to evaluate the effectiveness of the Kouinine wastewater treatment plant in removing antibiotic residues, analyze the impact of these pollutants on the environment and human health, and propose advanced treatment technologies to reduce the spread of antibiotics and the resulting bacterial resistance. This objective is based on research emphasizing the importance of improving wastewater treatment to reduce pharmaceutical pollutants and combat antibiotic resistance **(Kümmerer, 2009)**.

The presence of antibiotics in water disrupts microbial ecosystems and negatively affects aquatic organisms. Moreover, the persistence of these compounds in the environment leads to their accumulation and increases the risk of developing antibiotic resistance, which threatens treatment efficacy and poses a health risk to humans through transmission via contaminated water and food **(Martínez, 2009; WHO, 2014)**.

Solutions include improving treatment technologies such as ozonation, activated carbon, UV/hydrogen peroxide treatment, and nanofiltration. Continuous monitoring, public awareness, and stricter regulations on antibiotic use in agriculture and healthcare are essential steps to reduce the concentration and spread of these compounds in the environment **(Ventola, 2015; Fatta-Kassinos et al., 2011)**.

At the Kouinine plant, conventional water treatment processes have shown insufficient ability to completely eliminate antibiotic residues. Therefore, upgrading treatment stages and implementing advanced techniques are recommended to enhance removal efficiency and reduce environmental risks. Regular monitoring and public-

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private partnerships are also fundamental to the success of these efforts (**Michael et al., 2013; Nam et al., 2014**).

Sources of pollution are diverse, including improper disposal of medications, hospital effluents, agricultural activities, and pharmaceutical industries. Addressing these sources requires raising public awareness, establishing programs to collect unused drugs, improving pre-treatment in hospitals, and enforcing strict agricultural regulations. These measures can significantly reduce the amount of antibiotics released into the environment (**Larsson, 2014; Manyi-Loh et al., 2018**).

Enhanced oversight of agricultural and industrial activities is crucial to preventing environmental pollution. Promoting organic farming, monitoring emissions, and raising awareness among stakeholders aim to reduce the antibiotic load entering treatment plants and natural water bodies (**Berendonk et al., 2015; Bound & Voulvoulis, 2005**).

In the future, there is an urgent need for in-depth research to better understand the environmental and health impacts of antibiotic residues and to develop innovative and sustainable treatment technologies. Such research will support the formulation of effective policies to combat antibiotic resistance and enhance collaboration between scientific and industrial sectors to protect public and environmental health (**Li et al., 2018; Pruden et al., 2013**).

In this context, this study was initiated at the wastewater treatment plant in Kouinine, located in El Oued Province. The general objective of this study is to assess the presence of antibiotics and antibiotic-resistant bacteria in the treated wastewater at this plant.

Specifically, the study aims to:

Study the extent of the contamination of wastewater with antibiotics the Kouinine plant.

The first and second chapters contain a bibliographic synthesis that includes general information about wastewater and details about antibiotics.

The third and fourth chapters are dedicated to presenting the study area, as well as the wastewater treatment plant addressed in our research.

Introduction

Finally, the fifth chapter is devoted to presenting the analyses conducted and their discussion.

Chapter I:

General Information About Wastewater

1-Definition of Wastewater

Water pollution extends as an unfavorable or harmful modification of the Physicochemical or biological properties, produced directly or indirectly by human activities, making it unfit for its intended use established.

Wastewater also includes rainwater and its pollutant load, they generate all kinds of pollution and nuisance in the receiving environment (**Dugnolle,1980; Glanic et al., 1989**)

"Wastewater is any water that has been adversely affected in quality by anthropogenic influence. It comprises liquid waste discharged by households, commercial properties, industry, and agriculture, and can contain various contaminants such as chemicals, nutrients, and microorganisms" (**Hammer & Hammer Jr, 2012**).

2-Origin of Wastewater

2-1- Domestic Wastewater

Domestic wastewater includes household water and sewage, and mainly carries organic pollution (carbohydrates, lipids, proteins) but also mineral matter (chlorides, phosphates, sulfates) (**Vaillant,1974; Mettahri, 2012**).

Household water originates from bathrooms and kitchens and is loaded with biodegradable organic matter (carbohydrates, lipids, proteins), detergents containing sulfur or phosphorus, grease, solvents. Wastewater comes from toilets (urine and fecal matter) and is loaded with various organic hydrocarbon materials, nitrogenous, phosphate compounds and fecal germs (**Rejsek, 2002; Baumont et al., 2004**) .

2-2- Industrial Wastewater

Unlike domestic wastewater, industrial effluents have a more specific composition and their characteristics, in particular the quality and pollution rate, are directly linked to the type of industry considered. Industrial wastewater is also cooling water, washing or rinsing water for machines or various products and raw materials. In addition to

organic, nitrogenous or phosphorous materials, they are loaded with various organic and metallic chemical substances. Depending on their origin, they may also contain chemical substances used during manufacturing processes (fats, hydrocarbons, acids, bases, metals, and radioactive materials) (Baumont *et al.*, 2004; Mettahri, 2012).

Before being discharged into the collection networks, industrial wastewater must undergo pre-treatment. They can be mixed with domestic water if they no longer pose a danger to the collection networks and do not disrupt the operation of treatment plants (Mettahri, 2012).

2-3 -Rainwater

Rainwater, or stormwater, becomes wastewater when it flows over surfaces and collects pollutants before entering drainage or combined sewer systems. In combined sewer systems, rainwater is treated along with sewage, which can lead to overflows during heavy rainfall (Qasim, 1998).

2-4- Agricultural Water

Agricultural water is water from cultivated land loaded with fertilizers. It leads , through runoff, to an enrichment in nitrogenous or phosphate materials of the most superficial water tables, watercourses and reservoirs (Mettahri, 2012).

2-5- Parasitic Water

Parasitic water is typically considered as unwanted water that enters sewer systems unintentionally. it includes infiltration (groundwater seeping through cracks in pipes) and inflow (surface water entering through manholes, roof drains, etc.). this increases treatment costs and can overload sewer systems (Davis,2010) .

3-Wastewater Components

3-1- Chemical Components

3-1-1- Ammonia (NH₃)

Formed from the breakdown of organic nitrogen in wastewater; toxic to aquatic organisms (Metcalf & Eddy,2003).

3-1-2 - Nitrates (NO₃⁻)

They result from nitrification processes or agricultural runoff and contribute to eutrophication (Tchobanoglous *et al.*,2003).

3-1-3- Phosphates (PO₄³⁻)

Originate from detergents and fertilizers; cause excessive algal growth (Spellman *et al.*, 2013).

3-1-4 - Heavy Metals (Such as Lead, Mercury)

Toxic elements from industrial sources; harmful even at low concentrations (Fu &Wang, 2011).

3-1 -5 - Chlorine Compounds

Used for disinfection; may form carcinogenic by-products like trihalomethanes (White *et al.*, 2010).

3-1 -6 - Organic Compounds (Oils, Fats, Solvents)

Decrease dissolved oxygen during biodegradation, affecting aquatic life (Sawyer *et al.*, 2003).

3-1-7 -Pharmaceutical Residues and Pesticides

These are Trace compounds that affecting microbial life and contributing to resistance (Kümmerer *et al.*, 2008)

3-2- Biological Components**3-2-1- Bacteria (e.g., Escherichia coli, Salmonella)**

Pathogens indicating fecal contamination; cause waterborne diseases (**Bitton et al., 2011**).

3-2-2- Viruses (e.g., Enteroviruses, Hepatitis A)

Infectious agents transmitted through contaminated water (**Bosch et al., 1998**).

3-2-3- Protozoa (e.g., Giardia, Cryptosporidium)

Resistant to chlorine; cause severe gastrointestinal illness (**Craun et al., 2006**).

3-2-4- Helminths

Parasitic worms found in untreated wastewater, especially in developing areas (**Mara & Feachem, 1999**).

3-2-5- Algae

Grow due to high nutrient content (nitrogen and phosphorus); may release toxins (**Carmichael et al., 2001**).

3-2-6- Fungi

Can be present in humid or organic-rich wastewater environments (**Gadd et al., 2004**).

3-2-7- Other Microorganisms (Such as Antibiotic-Resistant Bacteria)

Emerge from medical and domestic sources; raise public health concerns (**Rizzo et al., 2013**).

4-Wastewater Treatment Processes

4-1- Pretreatment

Pretreatments allow the removal of the coarsest solid elements by physical processes such as sedimentation, flotation and screening and to prepare the effluent for subsequent biological treatment (**Attab, 2011**).

The successive treatments (screening, grit removal and oil removal) are illustrated in (**Figure 01**).

4-1-1- Screening

Purpose: to remove large waste such as branches, fabrics, bottles, etc.

Description: wastewater passes through metal screens with specific opening (e.g.,2.5cm) that traps large solid materials.

Result: Protects pumps and equipment from clogging or damage.

4-1-2- Sand Removal (Desanding)

Result: Prevents pump and pipe corrosion and increases the efficiency of biological treatment (**Tchobanoglous et al., 2003**).

4-1-3- Oil and Grease Removal

Objective: Remove lighter materials such as oils and greases that floats.

Description: Water is gently agitated in separation basins where oils and greases float to the surface and are removed by scraping.

Result: Prevents pipe blockages and improves biological treatment efficiency (**Spellman,2013**).

4-1-4- Transition to Biological or Physicochemical Treatment

Objective: To prepare the pre-treated water for the primary stage of removing dissolved and organic contaminants.

Description: After pre-treatment, the water is directed to stages such as biological (bacteria) or physicochemical (chemicals, sedimentation, filtration) treatment.

Result: Removal of organic matter, nitrogen, phosphorus, and heavy metals (**Libes ,2010**).

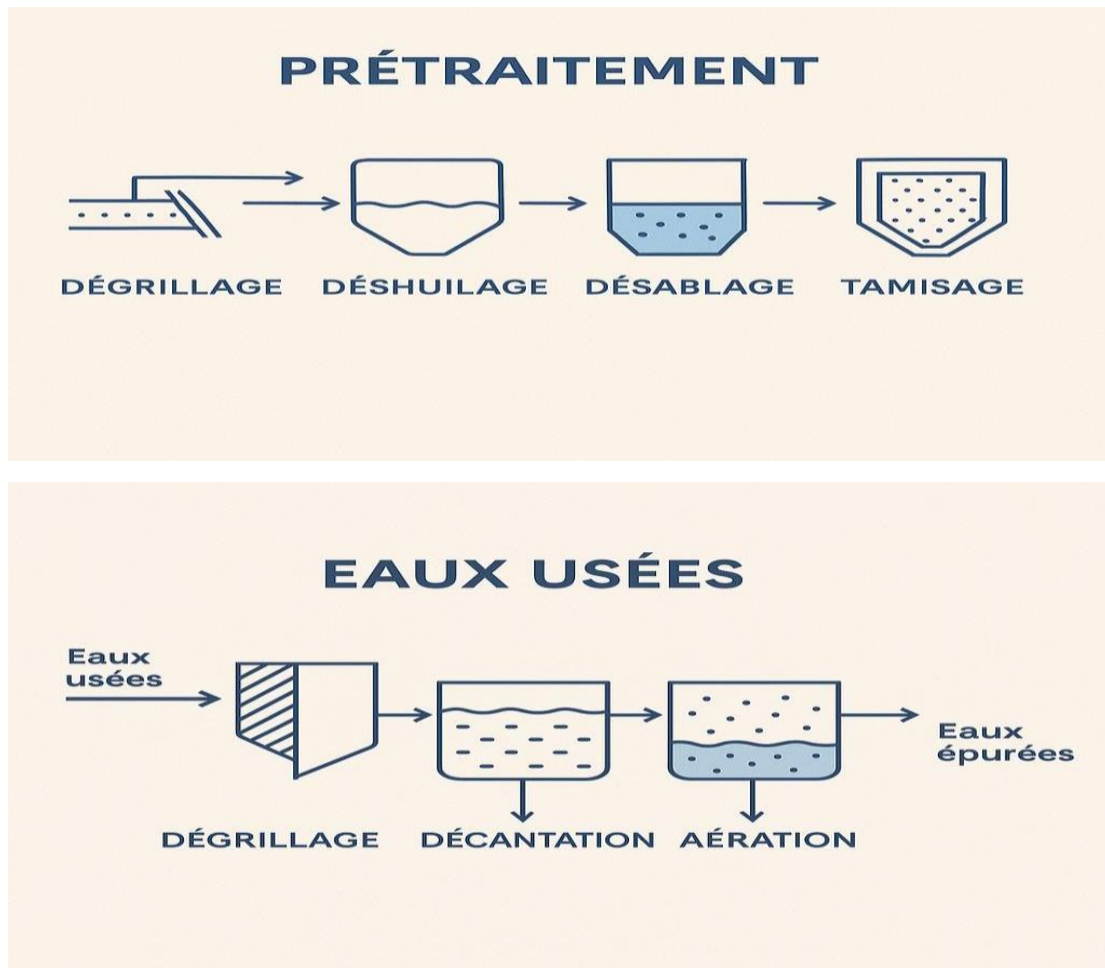


Figure 01: Preprocessing steps (**Libes, 2010**).

4-2- Primary Treatment

Primary treatment is the first stage in wastewater treatment. Its goal is to remove settleable solids, oils, greases, and some suspended materials. It is a preparatory step before biological treatment (**Metcalf & Eddy, 2014**).

4-2-1- Primary Sedimentation

This process takes place in specially designed tanks called Primary Settling Tanks (usually circular or rectangular) Wastewater is slowly fed into these tanks, allowing heavier particles to settle at the bottom by gravity. The typical retention time in the tank is 1.5 to 2.5 hours to allow effective sedimentation (**Tchobanoglous et al., 2003**).

4-2-2- Coagulation and Flocculation to Enhance Sedimentation

When particles are too fine to settle naturally, chemical coagulants and flocculants are used to enhance sedimentation.

Commonly used chemicals:

Aluminum sulfate ($\text{Al}_2(\text{SO}_4)_3$)

Ferric chloride (Fe Cl_3)

Ferrous chloride (Fe Cl_2)

Organic polymers (Polyelectrolytes)

These chemicals neutralize the electrical charge on colloidal particles, causing them to clump into larger, heavier aggregates called (flocs) which settle more easily (**Koller et al., 2004; Davis & Masten, 2009**)

4-2-3- Removal Efficiency

Primary treatment can achieve the following removal rates:

60–70% of Total Suspended Solids (TSS)

30–35% of Demand Chemical Oxygen (DCO) 25–

30% of Demand Biological Oxygen (DBO_5)

This significantly reduces the load on the following biological treatment stage (**Metcalf & Eddy, 2014**).

4-2-4- Formation of Primary Sludge

The settled solids at the bottom of the tank form primary sludge, which:

_Contains 2–5% solids

_It Rich in biodegradable organic matter

_Represents a valuable source for biogas production when anaerobically digested

_It is transferred to digestion tanks or drying beds for further treatment, as shown (Figure 02) (Tchobanoglous et al., 2003; Spellman,2013).

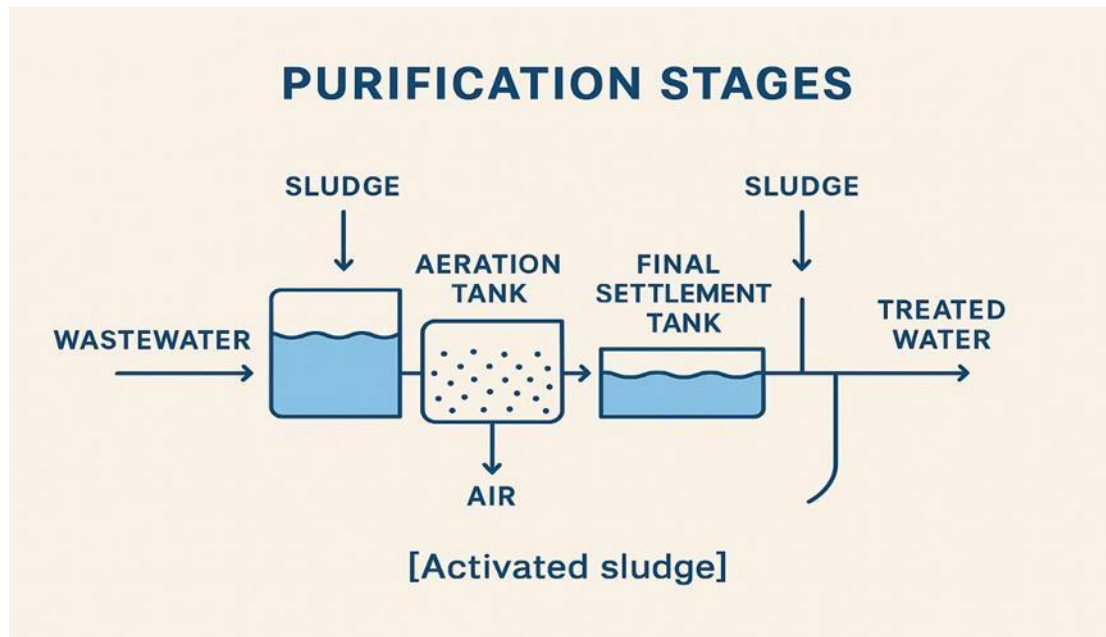


Figure 02 : Purification stages (Tekfi, 2006).

Chapter II :

Antibiotics

I - History of Antibiotics

The history of antibiotics began in 1928 when Alexander Fleming, a Scottish bacteriologist, discovered that a mold (*Penicillium notatum*) could kill surrounding bacteria in a petri dish. Although his discovery was groundbreaking, it went largely unnoticed for over a decade (Fleming, 1928).

It wasn't until the early 1940s that Dr. Howard Florey and his team at the University of Oxford managed to extract, purify, and mass-produce penicillin, turning it into the first true antibiotic. This medical breakthrough transformed the treatment of bacterial infections and marked the beginning of the antibiotic era, saving countless lives during World War II and beyond (Lax, 2004).

1- Definitions of Antibiotics

Antibiotics are molecules that stop the growth of microorganisms, whether bacteria or fungi, and kill them directly, antibiotics that prevent bacteria from growing and reduce bacterial numbers. Some antibiotics may exhibit bacteriostatic activity under some conditions and bactericidal activity under others, where sufficient destruction of one or more cell structures or pathways occurs to induce a bactericidal response. Antibiotics are "against life" agents that may be natural or man-made products of synthetic chemicals, designed to selectively disrupt important processes in bacterial cells (Walsh, 2012).

In the broadest sense, an antibiotic is a chemotherapeutic agent that prevents or eliminates the growth of microorganisms, such as bacteria, fungi or protozoa. Often used are chemotherapies or antimicrobials, for example, antimicrobials can also be effective against viruses. The term "chemotherapy" refers to compounds used to treat diseases that kill cells, especially microorganisms or cancer cells. The term antibiotic originally referred to any agent that has biological activity against living organisms; however, it also refers to substances with antibacterial, antifungal or antiparasitic activity. There are currently about 250 different chemical entities registered for use in medicine and veterinary medicine (Kümmerer et al., 2003)

Today, any substances with anti-bacterial, antifungal or anti-parasitic activities are called Antibiotic, which scientifically refers to any agent with biological activity

against the living Organisms. Antibiotics have no toxicity effect on Their host and are used to treat infectious diseases in humans, animals and plants. In other words, all the compounds with natural origin, which can Affect the cell life, are called antibiotic. Generally, Antibiotics affect four major components and (**Jones et al., 2001**).

2-Examples of Antibiotics

Some of the most commonly used antibiotics in hospitals

2-1- Flagyl (Metronidazole)

Use: An antibiotic and antiprotozoal agent effective against anaerobic bacteria and protozoa such as *Entamoeba histolytica* and *Giardia lamblia*.

Mechanism: Inhibits microbial DNA synthesis.

2-2- Clamoxyl (Amoxicillin)

Use: A broad-spectrum penicillin used to treat upper respiratory infections, otitis media, and urinary tract infections.

Mechanism: Inhibits bacterial cell wall synthesis by binding to penicillin-binding proteins (PBPs).

2-3- Augmentin (Amoxicillin + Clavulanic Acid)

Use: Treats infections caused by beta-lactamase-producing bacteria that are resistant to amoxicillin alone.

Mechanism: Clavulanic acid inhibits beta-lactamase enzymes, protecting amoxicillin from degradation.

2-4- Orapen (Phenoxymethylpenicillin)

Use: Effective against *Streptococcus* infections such as strep throat and for the prevention of rheumatic fever.

Mechanism: Inhibits bacterial cell wall synthesis.

2-5- Cloracef (Cefaclor)

Use: A second-generation cephalosporin used to treat upper respiratory, urinary tract, and skin infections.

Mechanism: Inhibits bacterial cell wall synthesis.

2-6- Cefazolin

Use: An injectable antibiotic used preoperatively to prevent infections, and for skin or bone infections.

Mechanism: Inhibits bacterial cell wall synthesis.

2-7- Meprenal (likely Sulfamethoxazole + Trimethoprim – confirm actual composition)

Use: A combination antibiotic used for urinary tract infections, respiratory infections, and some gastrointestinal infections.

Mechanism: Inhibits bacterial folic acid synthesis (SMX inhibits dihydropteroate synthase; TMP inhibits dihydrofolate reductase).

2-8- Gentamicin (40 mg & 80 mg)

Use: An aminoglycoside used for severe infections such as sepsis and hospital-acquired infections.

Mechanism: Binds to the 30S ribosomal subunit, inhibiting bacterial protein synthesis (**Brunton & Knollmann, 2018; Katzung, 2021**)

3-Use of Antibiotics

3-1- Uses of Antibiotics in Medicine

- Treatment of Bacterial Infections: Antibiotics are used to treat bacterial infections such as strep throat, pneumonia, and urinary tract infections.

Examples of antibiotics: Penicillin, Amoxicillin, and Ciprofloxacin **(Walsh, 2003)**.

- Prevention of Infections After Surgeries: Antibiotics are given before major surgeries to prevent bacterial infections, especially in heart surgeries and organ transplants **(Who,2023)**.
- Treatment of Sexually Transmitted Diseases (STDs): Antibiotics like Azithromycin and Ceftriaxone are used to treat gonorrhea and chlamydia **(Chamber, 2006)**.
- Controlling Infections in Hospitals: Antibiotics are used to combat hospital-acquired infections, such as Methicillin-resistant Staphylococcus aureus (MRSA) **(Walsh,2003)**.
- Treatment for Immunocompromised Patients:
Patients with chronic diseases such as cancer or HIV are given antibiotics to prevent infections **(Who,2023)**.
- Uses in Dentistry: Antibiotics like Amoxicillin are used to treat gum infections and dental abscesses **(Chambers, 2006)**.

3-2- Uses of Antibiotics in Industry

- Food Production and Agriculture: Antibiotics are used in livestock and poultry farming to protect animals from infections and enhance growth rates, such as Tetracycline and Penicillin **(Kümmerer, 2009)**.
- Pharmaceutical and Cosmetic Industries: Some antibiotics are used in the production of ointments and creams to treat acne and skin infections **(Who,2023)**.

- Biotechnology Industry: Antibiotics are used in scientific research and genetic engineering to isolate beneficial bacteria and eliminate unwanted ones **(Walsh, 2003)**.
- Antibiotic Production: Antibiotics are produced by fungi and bacteria in specialized manufacturing facilities **(Kümmerer, 2009)**.
- Food Preservation and Spoilage Prevention: Some antibiotics, such as Nisin, are used as natural preservatives to prevent bacterial growth in food products **(Chambers,2006)**.

4-Sources of antibiotic contamination

In general, there are two main ways for antibiotics to enter the environment:

4-1- Agricultural and industrial activities

Many studies have been conducted on the presence of antibiotics in the environment and their effects on nature so far. Researchers have found through their examination of hospital wastewater that some substances such as antitumor agents, antibiotics and organic halogen compounds are often removed from the inlet of the sewage filter without any analysis. As a result, the mentioned chemical compounds can cause pollution of the natural environment due to the biological imbalances they can cause. Emmanuel et al. suggested that hospital wastewater and municipal wastewater have the highest and lowest concentrations, respective, as shown in the **(Figure 03)** **(Broszat et al., 2014)**.

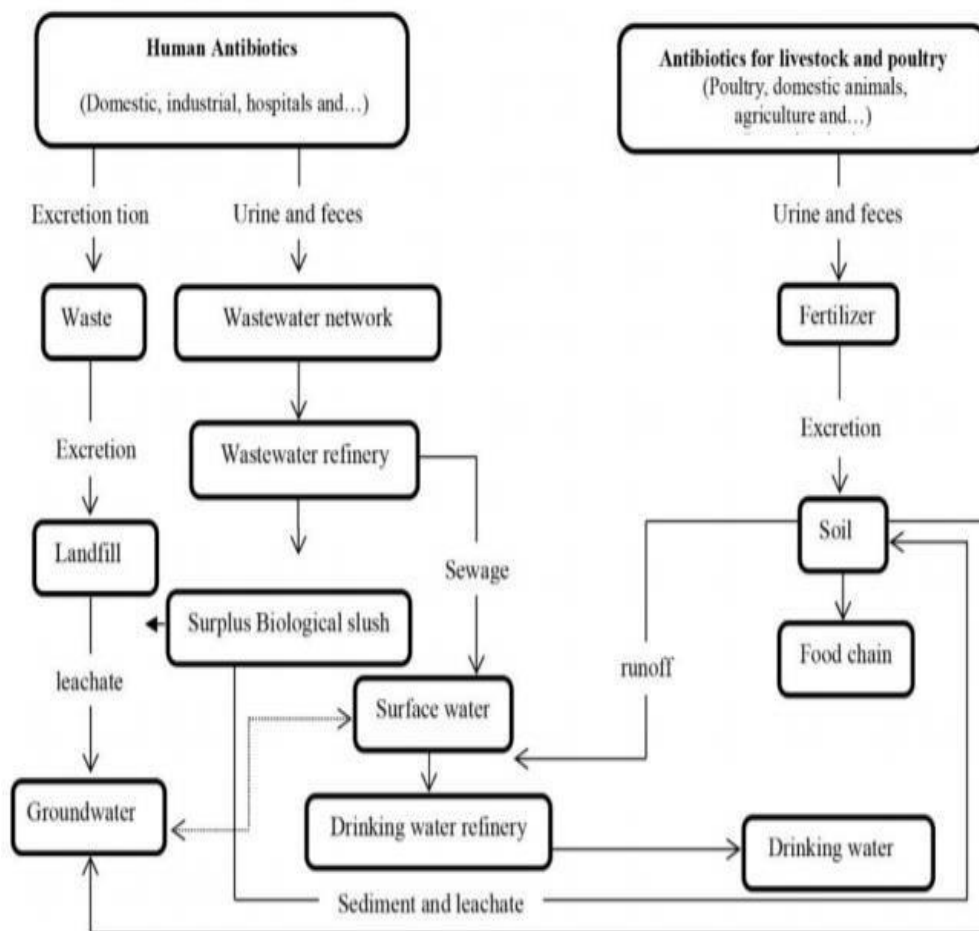


Figure 03: The main routes and sources of contamination of human and animal antibiotic (Kümmerer, 2008; Heberer,2002).

Industrially: During the past decades, there has been little attention paid to the wastes resulting from the manufacture of pharmaceutical compounds; however, in some Asian countries, high concentrations (up to several milligrams per liter) of pharmaceutical compounds have recently been reported in the outputs of these industries. Even in developed countries, the antibiotic manufacturing industries have a significant impact on the total concentration of these compounds, distributed in the outputs of wastewater treatment plants (Alizadeh & Amin, 2006; Mutiyar & Mittal, 2014; Jones-Lepp, 2014).

4-2- Human and Veterinary Wast

-By excretion and entering the sewage network and then surface or groundwater or soil, and in fact after taking different drugs, different proportions of them exit the body without any change, and the amount of any antibiotic in the human body depends on its chemical composition as well as its action in the body (**Farzadkia et al.,2014**).

-By disposing of expired and unused antibiotics that may be transmitted through health services, sewage or household waste. In such cases, antibiotics are transferred to landfills. In fact, the quantities of medicines disposed of all depend on the patient's habits as well as the quantity of medicines prescribed by doctors.

Veterinary: Animal antibiotics are used in different ways to prevent or treat animal diseases. They are given as animal feed or as a growth supplement. In fact, in some countries, small amounts of antibiotics are used in animal feed in order to improve product quality and produce lean meat and high amounts of protein (**Awad et al., 2014**).

5-Impact of Antibiotics on the Environment

5-1- Impact on Ecosystems and Water

The human body cells react to antibiotics in very low systemic levels. As a result, their existence in drinking water or food can increase the levels of these compounds in body. These compounds can reach the body tissues and cause different responses from body. It can be said that there is still insufficient information available about the possible effect of small amounts or low concentrations of antibiotics on human body (**Mutiyar& Mittal, 2014**).

Nonetheless, even low concentrations can act as a vaccine for bacteria and make them resistant to the antibiotics used in the treatment of diseases. The bacteria resistance can happen due to the existence of antibiotics in hospitals and health centers wastewater, swage, soil etc (**Awad et al., 2014**).

Moreover, on barren fields, the wastewater containing antibiotic, bacteria and resistant bacteria would be used for irrigation and also the excess sludge is used as fertilizer. As a result, the resistant bacteria directly enter the food chain. The concentrations less than the required rate for diseases treatment have a significant role

in bacteria resistance, which can even transmit to the bacteria genetics. Studies have shown that the chronic effects of antibiotics are more than their acute (**Gechalke et al.,2014**).

5-2- Bacterial Resistance to Antibiotics

5-2-1- Antibiotic Resistance

Antibiotic resistance specifically refers to bacteria becoming resistant to antibiotics (**Tedros, 2022**).

5-2-2- Antimicrobial Resistance (AMR)

AMR is the ability of bacteria, viruses, fungi and parasites to resist the effects of antimicrobial Medicines that kill susceptible organisms or keep them from growing antimicrobial resistance predates the use of antimicrobials in human medicine and many Bacteria, viruses, fungi and parasites are intrinsically resistant to some antimicrobials. Microorganisms can also acquire resistance by being exposed to antimicrobials. Infection with antimicrobial-resistant pathogens makes infections harder to treat and increases the risk of disease spread, severe illness and death (**Tedros,2022**).

Chapter III:

Presentation of The Study Region

I-Presentation of the Study Region

1- Description of the Study Area (EL Oued State)

This field study was conducted in one of the Algerian regions located in the southeast of Algeria called Oued Souf, as shown in the **(Figure 04)**. The state of Oued Souf is considered one of the states of southern Algeria, as it is located in the northeastern part of the desert. The area of the city is 40 square kilometers. The state of El Oued currently includes 30 municipalities divided into 12 districts, has 44,586 km² and a population of 647,548 people (census 2008). It is known as the city of a thousand domes and domes and is also known as the capital of golden sands. The region is characterized by the abundance of sand in the form of dunes **(Zobeidi,2018)**.

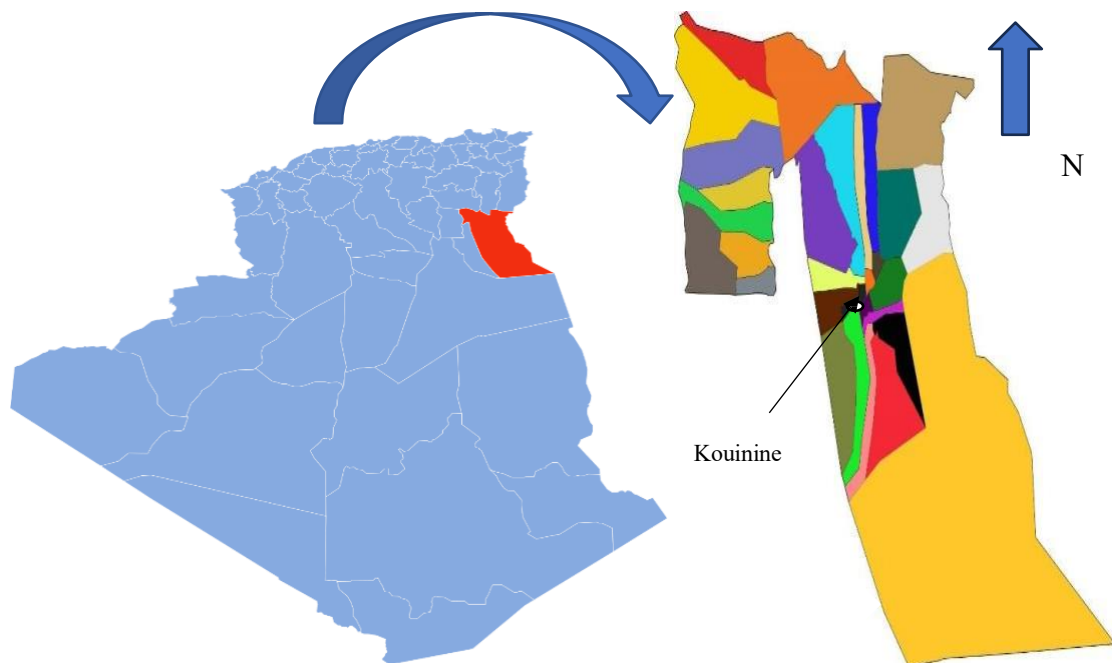


Figure 04: The geographical location of El Oued province (kouinine) **(Ouadi,2025)**.

1-1- Astronomical Location

The city of El Oued is located at:

Latitude :33° and 30' degrees north of the equator.

Longitude: 6° and 44' degrees east of the Greenwich line.

The city was promoted to a state in 1984, includes 12 districts and 30 municipalities and was divided into two regions, Oued Righ and Oued Souf (**Zobeidi ,2018**).

1-2- Geographical Location

El Oued is located in the southeast of Algeria, bordered by:

-To the north, the states of Tebessa, Khenchela and Biskra.

-To the south, the state of Ouargla.

-To the east, the Republic of Tunisia.

-To the west, Djelfa, Ouargla and Biskra(**Zobeidi, 2018**).

2-Description of the Wastewater Treatment Plant (Kouinine)

2-1- Astronomical Location

Located at latitude 31° and 24' North and longitude 6 east.

2-2- Geographical Location

The wastewater treatment plant in El Oued, affiliated to the municipality of Kouinine, is located in the north of the state of El Oued, El Oued district on National Road No. 03. Linking the city of El Oued and the city of Biskra, as shown in the (**Figure 05**).

This station covers an area of 47 hectares, its design was based on a total estimate of 246,300 inhabitants with a flow of 33,904 m³ today and treats approximately 15,000 m³ daily. The station started operating in 2009 and is located in the city of Kouinine. The source of wastewater coming to the station is from 4 municipalities: El Oued Rabbah, Kouinine and El Bayada. This municipality was chosen to host this project

because it is lower than the rest of the other municipalities and does not require a large amount of energy to reach the water.

Currently, dedicated to purifying part of the water used by the city of El Oued and reducing the phenomenon of rising water as well as the spread of epidemics in the city of El Oued Souf. The Quinine station, along with three stations located in the state, represents a sewage network length estimated at 750 km and a total connection rate of about 76%

(Zaghdi, 2017).

The water discharged by the S.T.E.P company and the water from the station is drained to Shatt Haloufa, 47 km away



Figure 05: Location of the wastewater treatment plant in the El Oued (**Maps google,2020**).

3-Climate Characteristics of the Region

This region a very hot climate (**Table 01**) shows the average climate data for 2019 for the valley region:

Table 01: Climate data for 2019 for the valley region

The months	Temperature (°C)	Humidity (%)	Rainfall (mm)	Wind (km/h)
January	10,4	55,4	00	11,2
February	12,5	44,5	00	11,9
March	16,9	47	11,17	11,5
April	21,5	43,5	31,23	14,28
May	24,9	37,8	9,66	12,9
Joan	32,2	25,1	00	13,6
July	35,7	25,7	00	12,9
August	35,1	30,7	00	12,9
September	30,8	42,4	10,93	12
October	24	84,2	3,05	9,5
November	15,7	53,7	8,38	12,2
December	13,9	56,3	1,02	9,5

(O.N.M. EL-OUED.2019)

.Temperature : This region experiences very cold winters, with the lowest temperature recorded in January at approximately 10.4°C. In contrast, summer temperatures rise significantly, reaching a peak of 35.7°C in July.

Humidity :The area is characterized by relatively high humidity, reaching 56.3% in December. However, humidity levels drop during the summer due to intense evaporation and warm winds.

Rainfall: The highest recorded rainfall occurred in April, with a total of 31.23 mm.

Wind: Strong winds are commonly observed during the spring season. The region is known for the "Sirocco" winds, which are hot and dry and are locally referred to as "Chihili."

Table 02: Specific indicators for the basins of the wadi station (ONA,2025).

	Level A	Level B	Level F
Number of basins	3aeration tanks	3 aeration tanks	3 finishing basins
Size of each basin	73892 m3	61789 m3	34671 m3
Depth of each basin	3,5m	2,5m	1,5m
Dwell time	6 days	4 days	2 days
Number of pumps	13 pump	6 pumps	Not provided

(ONA,2025).

Chapter IV:
Materials and Methods

I- Procedures for Water Level Measurement and Sample Collection

1-Measurement of Inflow and Outflow Water Volume Using a Flow Meter

To measure the inflow of water, the device is installed on the channel that directs the water to the required level, placed after the sand separator in a longitudinal position. To measure the outflow of water at the station, it is installed in the basin where the treated water collects, also placed longitudinally. This basin is located at the pumping station inside the (STEP EL-OUED) facility, as shown in the **(Figure 06)**,



Figure 06: Image of the inlet and outlet water meter (Débit meter) (ONA,2023).

2- Sampling preleveur

The process of taking a sample from the watercourse is an important and essential process to reach correct analytical results that accurately express the true values of the elements measured inside the watercourse, so any change in the physical or chemical properties of the water must be avoided when taking the sample. It is preferable to use bottles with sanded nozzles and tightly closed with glass or plastic stoppers. The bottles are cleaned before use with a concentrated solution of potassium permanganate and then with sulfuric acid. They are then washed with normal water until the acidity disappears from the washing water and are washed again with distilled water several times. However, the process of washing the bottle three times with the water to be

calibrated is necessary when obtaining the sample. The bottles are closed well without allowing air bubbles to remain inside them(**AL-Haik,2017**).

At the valley station: The sample is automatically taken by a 24-hour sampling system to place it in the form of a mixture located directly after the velocity channel. The system works manually for fresh samples daily, the first for the incoming water and the second for the treated water, as shown in the (**Figure 07**).



Figure 07: Image representing samples at the valley station (preleveur) , (**ONA,2023**).

II- Wastewater Treatment Using Aerated Lagoons (Lagunage Aéré)

1- Definition of Treatment by Aerated Lagoon

It is one of the methods used in wastewater treatment, which relies as a basic principle on the slow flow and flow of water. Treatment in these Lagoon is carried out in a natural way that depends on an integrated joint activity carried out by algae and bacteria in the presence of sunlight and some elements present in wastewater. The biodegradable charge of liquid waste is destroyed by bacteria, and at least part of this treatment is carried out aerobically thanks to the contribution of dissolved oxygen in the water through aeration. There is no recycling of bacteria, as shown in the (**Figure 08**), (**AL-Rifai,2014**).

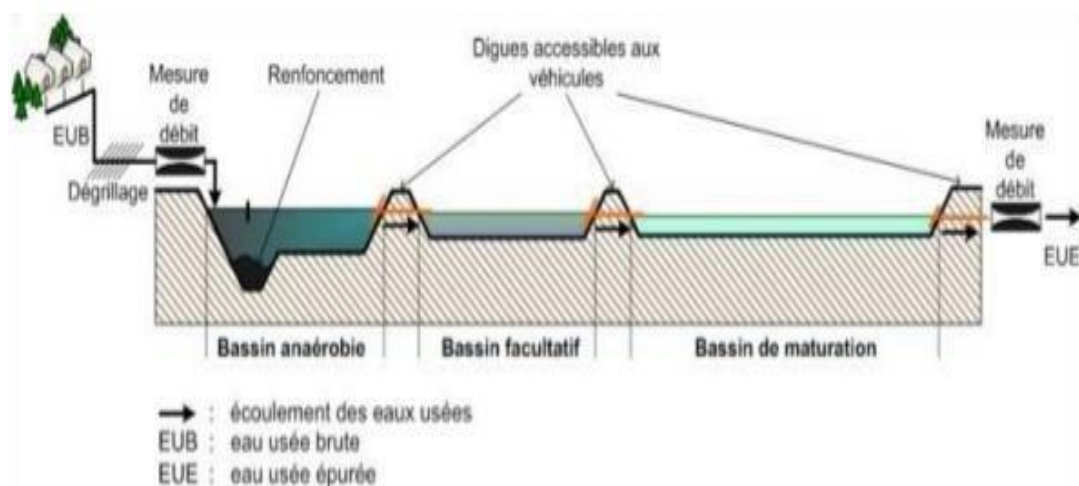


Figure 08: A diagram showing the treatment process(ENSEEIHT, 2020).

2- Types of Aerated Tanks

2-1- Arobic Aerated Tanks

In this type of pond, a constant oxygen concentration is maintained throughout the entire pond. The depth typically ranges from 2.4 to 2.8 meters, ensuring uniform distribution of both oxygen and suspended solids within the pond.

2-2- Aerated Facultative Ponds

In this type of pond, oxygen is maintained only in the upper layer, while the heavier suspended inert materials and non-biodegradable organic matter settle to the bottom, where they undergo anaerobic decomposition.

3- Wastewater Treatment Stages (STEP EL-OUED)

3-1- Primary Treatment of Wastewater (Physical Treatment)

It is the first stage that wastewater goes through, where water flows from the channels to the gas drainage rooms, which are rooms that are smoothed from the top and have a pipe that pours upwards and is shaped like a chimney, it is the first place where water enters every 8 minutes.

3-1-1- Screening (Dégrillage)

This stage consists of two chambers: one equipped with the main screen to filter particles from the main wastewater stream, and a secondary chamber that serves as a backup in case of emergencies. The screening unit is positioned before the wastewater collection basin, where the water flows through screens of various sizes. Any object wider than 2 cm is retained by the screen.

After screening, the screen is cleaned mechanically using an automated cleaning arm connected to a specialized sensor that detects debris. The collected waste is then moved by a loader into a horizontally extended, half-square-shaped container along the length of the screen, using a shaftless horizontal conveyor. These residues are ultimately gathered in a dedicated container.

This step aims to homogenize the water flow, especially since the station sometimes receives large volumes of water at once. , as shown in the **(Figure 9)**.



Figure 9: Sieve (ONA,2023)

3-1-2- Sand Removal (Dessablage)

Sand is removed through three channels, each equipped with a scraper bridge that pushes the settled sand toward a pit located at the end of the channel. A pump is used to extract the sand and transfer it to a sand classifier. This classifier acts as a separator where sand particles settle at the bottom and are discharged by an upward helical

motion with circular agitation. In this process, the sand is separated and discharged, while the water is recovered at the top of the unit.

The extracted sand is collected in a dedicated bucket. It is worth noting that the station is not equipped with an oil removal system, and the water flows directly into the fast channel for daily flow measurement, as shown in the **(Figure 10)**.



Figure 10: Sand removal (ONA,2023)

3-1-3-Distributor

The distributor is located at the top of the station, following the physical treatment stages. Its function is to evenly distribute the wastewater across the lagoons on the first level. It is also equipped with control barriers that allow any lagoon to be isolated and taken out of service when necessary., as shown in the **(Figure 11)**.



Figure 11: Distributor (ONA,2023).

3-2- Biological Treatment

Treatment is done by aerated basins.

3-2-1- First Aerated Basins (A1-A2-A3)

Biological treatment of wastewater is carried out in these basins, and this method is considered a fundamental step to ensure effective results in reducing both biological and chemical pollution. It relies on the activation of microorganisms, specifically aerobic bacteria, which are stimulated through the aeration process using 13 air pumps in each basin. These bacteria digest the organic matter after its breakdown, with part of the material being directed to the subsequent aeration basins. The water remains in these basins for about 6 days, and the treatment efficiency in basins A ranges between 70% and 80%. , as shown in the **(Figure 12)**.



Figure 12: Aerated basins in the first stage (A1.A2.A3). (ONA,2023).

The second complex (RP2): It collects the water coming out of the primary treatment. It contains 3 pumps to control the distribution of water according to the flow to the second aerated basins (B1-B2-B3), as shown in the **(Figure 13)**.



Figure 13: Complex (RP2). (ONA,2023).

3-2-2- Second Aerated Basins (B1-B2-B3)

The biological treatment of wastewater continues in the second aerated basins (B1-B2-B3), where microorganisms, specifically aerobic bacteria, are activated through aeration using six air pumps in each basin. The biological treatment process proceeds until completion in these basins, where the water remains for 4 days. The treatment efficiency in the B basins ranges from 20% to 30%, as shown in the **(Figure 14)**.



Figure 14: Aeration pumps inside the basins (ONA,2023).

The third complex (RP3)

In it, the water coming out of the primary treatment is collected, it contains 3 pumps to control the distribution of water according to the flow to the second aerated basins (F1-F2-F3).

3-2-3- Final Basins (F1-F2-F3)

These basins serve the same purpose as basins A and B, but they primarily help improve the quality of biologically treated water, as the dissolved materials remain in these basins. The water stays in these basins for about 3 days, where only sedimentation occurs without the use of pumps. Afterward, the treated water flows towards the pumping station and settles in the Chott Hloufa area, which was chosen because of its lower elevation, allowing the water to flow without pumping and preventing any backflow. The soil in this area can absorb the water without causing any negative environmental impact.

3-3- Removal of Sludge Deposited in Biological Treatment Basins

Sludge is the solid or semi-solid material that results from the physical, chemical, or biological treatment processes of wastewater. It primarily consists of organic and inorganic substances that are separated from the water during treatment and represents a key aspect that must be properly managed in wastewater treatment plants (Metcalf & Eddy,2014).

For the sludge that accumulates in the first and second basins, its depth is measured every three months. When it reaches a depth between 80 cm and 1 meter, it must be removed, as it poses a risk to the water quality in the basin. This sludge can be visually observed, often indicated by the appearance of bubbles on the water surface. This removal process is typically carried out every 9 to 10 years.

The sludge is removed using a manually operated scraper device, which includes a pump connected to a channel that transfers the sludge to drying beds. Before starting, the basin is completely closed off—no water enters or exits—then the pump is activated to transfer the sludge. Once the water appears clear in that section of the basin, it indicates that the sludge has been successfully removed from that area, and the device is then moved to another corner of the same basin using the control system. The complete cleaning of a single basin takes approximately one week.

3-4- Sludge Drying Beds

Sludge drying beds are one of the filtration methods used in sludge treatment. The system consists of 14 beds arranged in two rows, with 7 beds in each row. Each bed is composed of sequential layers of coarse gravel, fine gravel, and sand, along with outlets specifically designed for sludge discharge.

To remove sludge from wastewater basins in treatment plants, it is essential to conduct thorough analyses of both raw and treated water. These analyses help identify various physical and chemical characteristics, enabling the assessment of pollution levels at each stage of the treatment process and evaluating the efficiency of pollutant removal. This allows for an accurate estimation of the wastewater treatment plant's overall performance in water purification.



Figure 15: Sludge drying family.

At the National Sanitation Office in El Oued, we conducted laboratory work that included a variety of tests on both influent and effluent water, as outlined below:

- pH
- Dissolved Oxygen (OD)
- Temperature (°C)
- Electrical Conductivity (CE) †Salinity
- Chemical Oxygen Demand (DCO)
- Biochemical Oxygen Demand (DBO₅)
- Suspendant (MES)

III– Measured Physicochemical Parameters

1- Measurement of pH

1-1- Definition of pH

It is a measure of the acidity or alkalinity of an aqueous solution, and is expressed as a pH number between 0 and 14. Values less than 7 indicate an acidic medium, values between 7 indicate a basic medium, while a value of 7 means that the solution is above neutral (**Skoog et al., 2013**).

The pH is measured by a pH meter (EUTECH INSTRUMENT 510), as shown in the (**Figure 16**).



Figure 16: pH level (EUTECH INSTRUMENT 510) (ONA,2023)

Procedure:

- Set up the device and turn it on.
- Wash the electrode with distilled water, then wipe it.
- Take 100 ml of the sample and put it inside the Becher cup.
- Place a magnetic electrode inside the Becher cup with a weak movement.
- Insert the device electrode inside the Becher cup and leave it until it stabilizes.
- Read the result on the device

2- Temperature (°C) and Dissolved Oxygen Measurement

2-1- Definition Temperature (°T)

Temperature is a measure of the thermal energy of a substance or environment, influencing physical and chemical reactions in water and ecosystems (**Brown et al., 2017**).

2-2- Definition Dissolved Oxygen (O₂ Dissous)

Dissolved oxygen is the amount of free oxygen available in water, essential for aquatic life, as shown in the (Figure 17) (Wetzel,2001).

Dissolved oxygen and temperature are measured with the same Oxymeter Hach HQ30.

Proceduer:

- Set up and turn on the device.
- Wash the electrode with distilled water and then wipe it with filter paper.
- Take 100 ml of the sample and place it inside the Becher cup.
- Place a magnetic electrode inside the Becher cup.
- Read the value from the device when it stabilizes.
- The device reads dissolved oxygen in (mg/l).
- The device reads the temperature in (°C).



Figure 17: Oxy-meter (ONA,2023)

3- Measurement Electrical Conductivity (CE)

3-1-Definition Electrical Conductivity

Electrical conductivity (CE) measures a solution's ability to conduct electricity, indicating ion concentration in water, as shown in the **(Figure 18)** (Sawye *et al.*,2003).

The conductivity is measured by the WTW Terminal 70 device.

Procedure

- Set up the device and turn it on.
- Wash the electrode with distilled water.
- Take 100 ml of the sample and put it inside the Becher cup.
- Place a magnetic electrode inside the Becher cup on a weak movement.
- Insert the device electrode inside the Becher cup.
- Adjust the mode in the cond meter and press AR then RUN and take the recorded conductivity value.
- Read the result on the device in (ms/cm)



Figure 18: Conductivity meter (ONA,2023).

4-Determination of Suspended Materials (MES).

4-1- Definition Suspended Matter (MES – Matières En Suspension)

MES represents solid particles suspended in water, affecting turbidity and water quality (Metcalf & Eddy, 2014).

There are two methods for measuring suspended materials.

The first method: The filtration method is used when the water has low suspended materials.

The second method: The centrifugation method is used when the water has a high density of suspended materials.

Materials and tools used:

- _ Filter paper
- Becher
- Analytical balance
- Distilled water
- Vacuum filtration device
- Desiccant (Etuve) at (105°C)
- _ Moisture absorption device (dissiccateur).

4-2- Method of Work

4-2-1- Filtration Method

- Wet the filter paper with distilled water and place it inside the incubator at (105°C) for a few minutes.
- We take out the filter paper and leave it to cool inside the dehumidifier.
- Weigh the empty filter paper using the analytical balance and record its weight (M_0).
- We connect the vacuum filtration device.

- We put 100 ml of the water to be filtered in the Becher and filter it through the vacuum device.
- We put the filter paper in the desiccant at (105C°) for two hours.
- We put the filter paper in the dissicateur for 15 minutes.
- Weigh the filter paper using the analytical balance and record its weight(M₁).

Calculating the result: The amount of suspended materials MES calculates the ratio between the difference in weight and volume of the sample used

Based on the following relationship and given in (mg/l)

$$\text{MES (mg/l)} = (M_1 - M_0) / V$$

MES: Concentration of suspended materials (mg/l).

M₀: Weight of the empty filter paper in (mg).

M₁: Weight of the filter paper after use (mg).

V: Volume of water used in (L).



Figure 19 : Vacuum filtration device (ONA,2023). **Figure 20:** Affectionate Perennial (ONA,2023).



Figure 21: Distortion (ONA,2023). Figure 22: Analytical balance (ONA,2023).

4-2-2- Centrifugation Method:

- We take 100 ml of the sample and put it inside a 100 ml container.
- We subject them to centrifugation for 20 minutes until we get the precipitate.
- We remove the suspended water, then wash the precipitate with distilled water, then subject it to centrifugation again for 20 minutes.
- We weigh a clean crucible and record its weight (M_0).
- We pour the precipitate into the crucible, then place it inside the incubator (Etuve) at a temperature of (105°C).
- We take the crucible out of the incubator and let it cool away from moisture inside the dessiccateur.
- We weigh the crucible with the dry precipitate and record its weight (M_1).

Calculating the result: The MES concentration is calculated from the following

$$MES=(M_1-M_0)\times 100/V$$

MES: Concentration of suspended materials (mg/l).

M_0 : Weight of the crucible before use in (mg).

M_1 : Weight of the crucible with the sediment after use (mg).

V: Volume of water used in (ml).

5- Determination of Chemical Oxygen Demand DCO

5-1- Definition Chemical Oxygen Demand (DCO – Demande Chimique en Oxygène)

DCO measures the amount of oxygen required to chemically oxidize organic and inorganic matter in water (Stumm & Morgan, 1996).

5-2- Equipment Materials Used

_ Spectro photometer HACH DR 3900 device We use

_ Thermo reactor

_ Pipette

_ Becher cup

_ Distilled water.

_ In our measurement of DCO

_ We used a capsule containing the commercial reagent (LCK114).

Procedure

- Shake the tube well to mix the precipitated materials.
- Take 2 ml of the sample using a pipette and pour it on the inner wall of the tube (capsule) that contains the reactant so that the capsule is at an angle.
- Close the tube tightly and shake it well.
- Heat the tube for two hours at a temperature of (148°C) inside the Thermo reactor.
- Remove the tube from the Thermo reactor and let it cool on a stand for 15 minutes.
- After 15 minutes, shake the tube well.
- After cooling, place the tube inside the HACH DR 3900 spectrophotometer.
- Read the DCO value from the device in mg/l (Spectrophotometer), as shown in the (Figure 23).



Figure 23: Spectrophotometer (ONA,2023)

6-Determination of Biochemical Oxygen Demand (DBO₅)

6-1- Definition Biochemical Oxygen Demand (DBO₅ - Demande Biologique en Oxygène sur 5 jours)

DBO₅ measures the oxygen needed by microorganisms to decompose organic matter over five days, as shown in the (Figure 24) (Figure 25) (Davis & Masten, 2013).

The amount of DBO₅ was determined using the DBO-meter device using the manometric method.

Tools and materials used:

- _Magnetic shaker
- _DBO (MF120) manometric pressure measuring device
- _500 ml light-proof incubation bottles with an inner and outer cover
- _ Incubator
- Forceps
- Becher beaker

- Calibration flask
- NaOH (sodium hydroxide).

6-2- Method of Work

- We adjust the device according to the sample taken.

Table (03): Coefficient of variation of DBO₅ values according to the size of the sample used

Gamme mg/l	40-0	80-0	200-0	400-0	800-0	2000-0
V (ml)	432	365	250	164	97	43,5
Facteur	1	2	5	10	20	50

(ONA,2025)

Influent Water:

The required sample volume for analysis is measured using a graduated flask. A volume of 164 ml of influent water is taken and poured into a dark incubation bottle to prevent photosynthesis.

A magnetic stir bar is placed inside the bottle.

Three drops of the inhibitor (1-alkyle-2-thio-urea, C₄H₈N₂S) are added to inhibit nitrogenous compounds, as they oxidize in the presence of oxygen.

A plastic holder is placed inside the bottle, and two NaOH pellets are added using forceps.

The bottle is initially loosely sealed.

The bottles are then placed in a dedicated refrigerator on a shaker at 20°C and left for 30 minutes to reach equilibrium. Afterward, the bottles are tightly sealed.

Readings are taken daily for five days, and the final result is multiplied by a correction factor.

Effluent Water:

The required sample volume for analysis is measured using a graduated flask. A volume of 432 ml of effluent water is taken and poured into a dark incubation bottle to prevent photosynthesis.

A magnetic stir bar is placed inside the bottle.

Nine drops of the inhibitor (C₄H₈N₂S) are added to the sample.

A plastic holder is placed inside the bottle, and two NaOH pellets are added using forceps.

The bottle is initially loosely sealed.

The bottles are placed in a refrigerator on a shaker at 20°C and left for 30 minutes to stabilize. They are then tightly sealed.

Readings are taken daily for five days, and the final result is multiplied by a correction factor.



Figure 24: Bottles used to measure (DBO₅) (ONA,2023)



Figure 25: The incubator (ONA,2023)

7- Antibiotics

Antibiotics are substances used to eliminate or inhibit the growth of bacteria and are considered one of the most important discoveries in modern medicine. To measure the concentration of these antibiotics in water or environmental samples, a UV-Vis Spectrophotometer is used, which relies on measuring light absorption. As shown in the following image.

To analyze antibiotics in wastewater, it is essential to use sensitive and accurate extraction and analytical methods to detect these compounds at potentially low concentrations. The extraction and analytical techniques used in our work are as follows:

7-1- Extraction Techniques

Antibiotics in wastewater are often extracted using methods that concentrate the compounds and eliminate interferences.

Solid Phase Extraction (SPE):

This method is widely used to concentrate antibiotics prior to analysis. It involves passing the sample through a cartridge containing antibiotic-specific adsorbent material, allowing their separation from other water components.

7-2- Analytical Techniques

Once the antibiotics have been extracted, sensitive analytical methods are required to identify and quantify these compounds.

High-Performance Liquid Chromatography-Mass Spectrometry (HPLC-MS/MS):

This method is highly sensitive and allows the detection of antibiotics at very low concentrations. It is particularly suitable for antibiotics, as it offers high specificity and can quantify multiple compounds simultaneously.

In summary, the combination of SPE-HPLC-MS/MS or SPE-UPLC-MS/MS is among the most effective for analyzing antibiotics in wastewater, due to its sensitivity and ability to handle complex samples.

***The equation for determining the antibiotic recovery rate:**

$$\mathbf{R\% = \frac{X_i - X_f}{X_i} \times 100}$$

R: Purification yield.

X_i: Concentration of media present in the wastewater entering the basin (mg/l).

X_f: Concentration of media present in the wastewater coming out of the basin (mg/l).

Chapter V:

Results and Discussions

I-Results and Discussions of the Analyzed Parameters

1-Physical and Chemicals Parameters

1-1- Hydrogen Potential (pH)

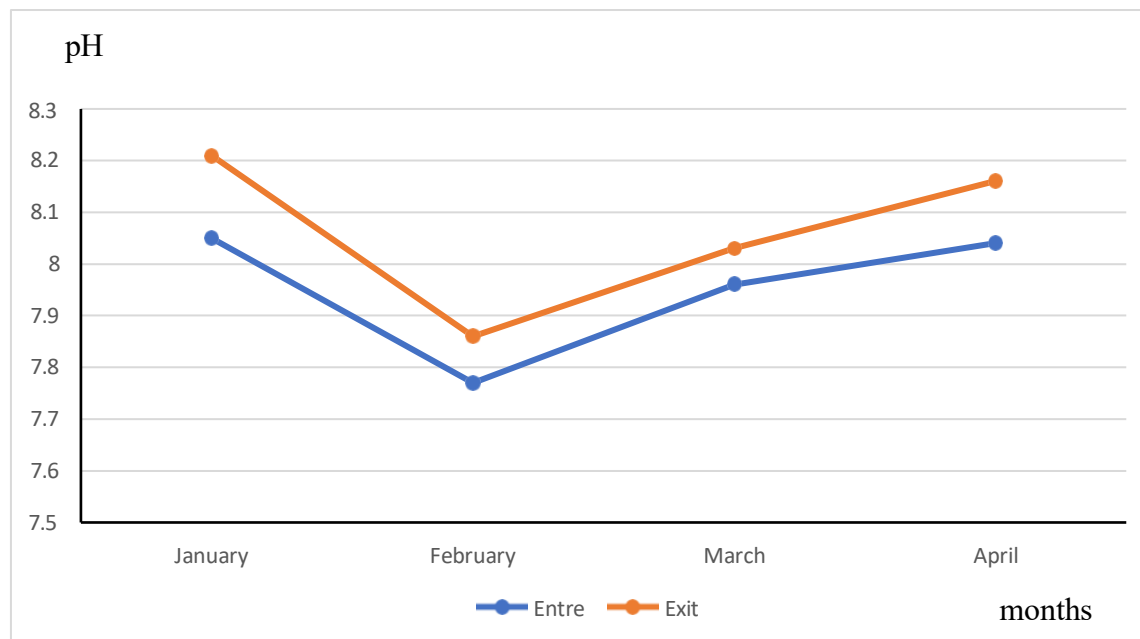


Figure 26: Monitoring pH level

The graph shows changes in the **pH** level over several months at the Kouinine wastewater treatment plant, located in El Oued Province, Algeria.

The blue line represents the **pH** values at the plant inlet, while the red line reflects those at the outlet after treatment.

The **pH** values at the inlet ranged between 8.5 and 7.8, while the outlet values ranged between 8.2 and 7.9. Both lines show slight fluctuations, with a gradual increase over time, indicating relative stability in the acid-base balance of the wastewater as shown in the (Figure 26).

FAO Standards (2023): For irrigation purposes, **FAO** recommends a **pH** range between 6.5 and 8.4, to prevent soil degradation and ensure crop health (FAO & IWMI, 2023).

WHO Guidelines (2006): The World Health Organization sets the acceptable pH range for wastewater between 6.5 and 8.5 to maintain water quality and avoid corrosion or scaling in distribution systems (WHO, 2006).

Algerian Standards (Official Gazette JORA, 2006): According to national regulations, the pH of treated domestic wastewater discharged into the environment must be between 6.5 and 8.5 (JORA, 2006).

The recorded pH values for both the inlet and outlet at the Kouinine plant remain within the permissible ranges defined by **FAO, WHO, and Algerian standards**. This indicates that the treatment process maintains a stable pH environment, contributing to the safety of the discharged water for agricultural and environmental uses. Continued monitoring is essential to ensure sustained compliance and to detect any deviations that could affect treatment efficiency or environmental safety.

1-2- Temperature T(C°)

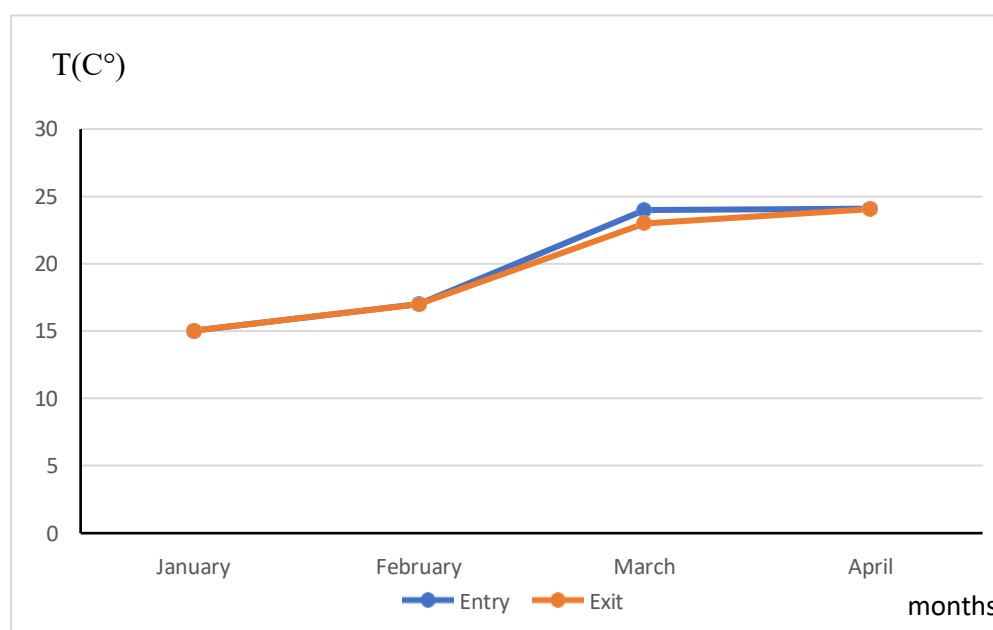


Figure 27: Monitoring Temperature T(C°)

The monitoring of temperature values for wastewater at the Kouinine treatment plant, from January to April 2025, showed that inlet temperatures ranged from 15.03°C to 24.09°C, as shown in the (Figure 27). While outlet temperatures were very similar, ranging from 15.03°C to 24.05°C. This indicates a relative thermal stability throughout

the treatment process, with minimal variation between inflow and outflow temperatures.

According to **FAO** standards, the recommended maximum temperature for treated wastewater intended for agricultural reuse should not exceed 30°C to avoid harmful impacts on crops and soil microorganisms (**FAO,2023**).

The **WHO** guidelines suggest an optimal discharge temperature range between 20°C and 35°C for treated wastewater to minimize environmental stress (**WHO,2006**).

As per **JORA** (Official Algerian Gazette) regulations, the maximum allowed temperature for discharged treated wastewater is 30°C (**JORA,2006**).

Comparing the recorded temperatures with these standards, it is clear that all measured values are well within the permissible limits, indicating good operational control and compliance with both national and international standards.

The minimal difference observed between inlet and outlet temperatures (typically around 0.02°C) can be attributed to the nature of biological treatment processes, as well as minor environmental effects such as evaporation or heat loss to the surrounding environment, without causing any significant thermal impact.

Maintaining the treated wastewater temperature within the acceptable range is crucial for ensuring the biological stability of the effluent and its safe reuse for irrigation purposes. The observed stability in temperature suggests an efficient treatment process and minimal environmental risk upon discharge.

1-3- Electrical Conductivity (EC)

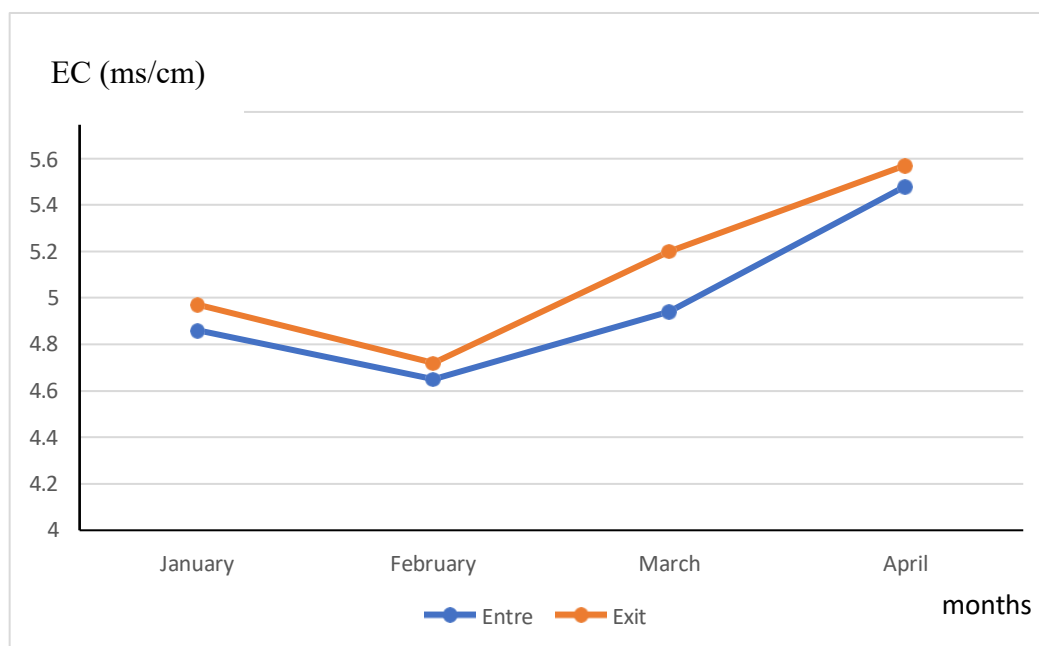


Figure 28: Monitoring Electrical Conductivity (EC)

The monitoring of electrical conductivity (**EC**), as shown in the (**Figure 28**). Values over the selected period reveals a variation in measurements for both inlet and outlet water samples. The recorded **EC** values ranged between 4.65 and 5.48 mS/cm for the inlet and between 4.72 and 5.58 mS/cm for the outlet samples. These values indicate that the wastewater exhibits noticeable electrical conductivity, which is typical for treated effluent containing dissolved ionic substances, such as salts and minerals.

A slight decrease in electrical conductivity (**EC**) values was observed at the beginning of the monitoring period, followed by a gradual increase over time. Notably, the **EC** values at the outlet consistently remained close to, or slightly higher than, those at the inlet. This suggests that the treatment process had a limited effect on reducing the total dissolved salts in the wastewater. The slight increase in **EC** values after treatment may be attributed to factors such as the dissolution of certain minerals within the treatment system or concentration effects due to evaporation, both of which contribute to the persistence or accumulation of salts in the treated effluent. These observations highlight the need to enhance treatment strategies to ensure the suitability of the treated water for safe environmental discharge or reuse in irrigation.

When compared to international and national standards:

According to **FAO** guidelines, the acceptable electrical conductivity range for irrigation water generally falls below 0.3_ 0.7mS/cm. Higher conductivity values may cause soil salinity issues, adversely affecting plant growth. Based on the data collected, some of the recorded values, particularly during the later monitoring stages, exceed the **FAO's** recommended limit for safe irrigation use (**FAO,2023**).

The **WHO** standards (Decree concerning wastewater reuse and discharge) also set quality limits for treated wastewater, typically emphasizing the control of salinity for agricultural reuse. While lower recorded **EC** values meet these criteria, the higher readings observed later in the study period might limit the treated wastewater's suitability for direct irrigation without dilution or additional treatment (**WHO,2006**).

As per the **JORA** regulations concerning the discharge of treated wastewater, electrical conductivity is not always explicitly regulated unless the wastewater is intended for reuse. However, maintaining lower **EC** values is generally encouraged to protect soil and water resources (**JORA,2006**).

Based on the monitored data, the treated wastewater's electrical conductivity shows moderate to high levels. While some values comply with international and national recommendations, others exceed the permissible limits for irrigation purposes. This variability highlights the need for continuous monitoring and, if necessary, additional treatment measures to lower salinity before reuse, ensuring the long-term sustainability of treated wastewater in agricultural applications.

1-4- Suspended Solids (SS)

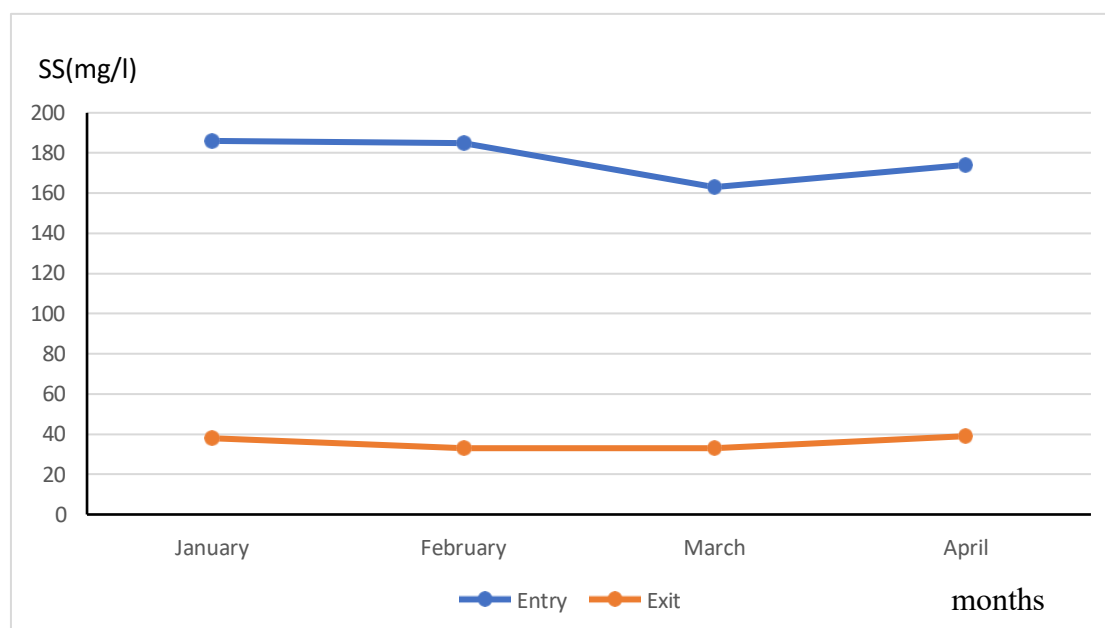


Figure 29: Suspended Solids (SS)

The monitoring of suspended solids (SS), as shown in the (Figure 29). Concentrations during the selected period reveals notable variations between the inlet and outlet water samples. The recorded concentrations ranged from approximately 163 to 186 mg/L for the inlet and between 33 and 39 mg/L for the outlet. These findings indicate that the raw wastewater carries a significant load of suspended particles, typical of untreated or partially treated effluents containing organic and inorganic matter.

Throughout the monitoring period, a consistent reduction in suspended solids was observed following the treatment process. However, outlet concentrations remained relatively elevated compared to established international and national standards, despite the reduction. This outcome suggests that the treatment system moderately improved water quality by removing a portion of the suspended solids, although the efficiency varied across different months.

When compared to current international and national standards:

According to **FAO** guidelines (**FAO & IWMI, 2023**), the maximum recommended concentration of suspended solids for irrigation purposes, particularly for sensitive crops, should not exceed 30 mg/L. Higher concentrations may lead to clogging of irrigation systems and deteriorate soil permeability. Based on the monitored data, most

outlet values exceeded this threshold, posing potential risks for direct agricultural reuse without further treatment or filtration.

The World Health Organization (**WHO, 2006**) recommends that the suspended solids in treated wastewater should be below 20 mg/L to avoid clogging or corrosion in sewer systems, as well as to prevent negative impacts on the efficiency of treatment plants and the surrounding environment. However, the analysis results of the treated wastewater samples show a significant exceedance of this limit, confirming their unsuitability for discharge or reuse without further advanced treatment stages.

Regarding national regulations, the Algerian wastewater discharge standards (**JORA, 2006**) stipulate a maximum suspended solids concentration of 30 mg/L for treated wastewater intended for agricultural reuse or environmental discharge. The outlet values documented during the monitoring period exceed this threshold, indicating that the treated effluent, in its current state, does not fully comply with Algerian reuse regulations.

Based on the analyzed data, the treated wastewater shows a partial improvement in suspended solids removal but remains above acceptable thresholds for irrigation and reuse. This underscores the necessity of implementing additional treatment processes, such as enhanced sedimentation, filtration, or membrane technologies, to achieve compliance with both international and national water quality standards and to ensure the safe reuse of treated effluent in agriculture.

1-5 -Biochemical Oxygen Demand (BOD₅)

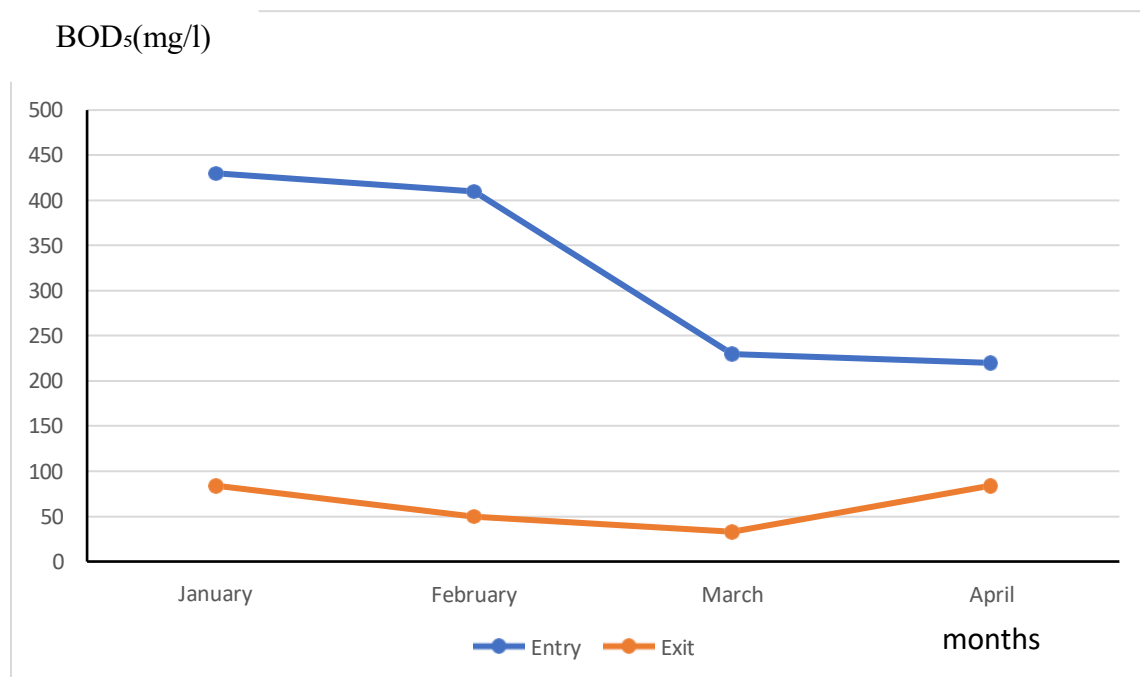


Figure 30: Biochemical Oxygen Demand (BOD₅)

The variations in Biochemical Oxygen Demand (**BOD₅**) concentrations during the study period, as shown in the(**Figure 30**), show a noticeable gradual decrease at the inlet point (Entry), with values dropping from approximately 430 mg/L to around 220 mg/L over time. This decrease indicates a reduction in the amount of biodegradable organic matter in the raw water entering the treatment plant.

By monitoring the temporal changes, it was observed that the highest BOD₅ (Biochemical Oxygen Demand) concentration was recorded in January, reaching approximately 430 mg/L at the inlet, indicating a high presence of organic pollutants in the water at the beginning of the study. In February and March, the values began to gradually decrease to around 230mg/L, reflecting a slight improvement in the quality of the raw water. By April, the concentrations continued to decline and stabilized at around 220 mg/L, suggesting a relative improvement in water quality before treatment.

At the outlet point (Exit), lower **BOD₅** values were recorded throughout the study. In January and February, concentrations ranged between 50 and 84 mg/L. As the study progressed into March and April, Values fluctuated between 33 and 84 mg/L.

Despite this improvement, the outlet **BOD₅** concentrations remained above the maximum permissible limits set by international and national standards.

The Food and Agriculture Organization (**FAO, 2023**) recommends that **BOD₅** concentrations in treated wastewater intended for agricultural irrigation should not exceed 30 mg/L.

The World Health Organization (**WHO, 2006**) specifies an acceptable range of 20–30 mg/L depending on the type of reuse or environmental discharge.

Nationally, Executive Decree No. 23-120 of the Algerian Official Gazette (**JORA, 2006**) establishes a maximum limit of 30 mg/L for the discharge of treated water into the natural environment.

Based on these results, it is evident that the treatment plant under study does not fully comply with the required standards. Therefore, it is recommended to improve treatment processes, either by adding a tertiary treatment stage or by enhancing the efficiency of the current treatment stages, to better protect the environment and public health, and to achieve higher quality standards for treated water.

1-6- Chemical Oxygen Demand (COD)

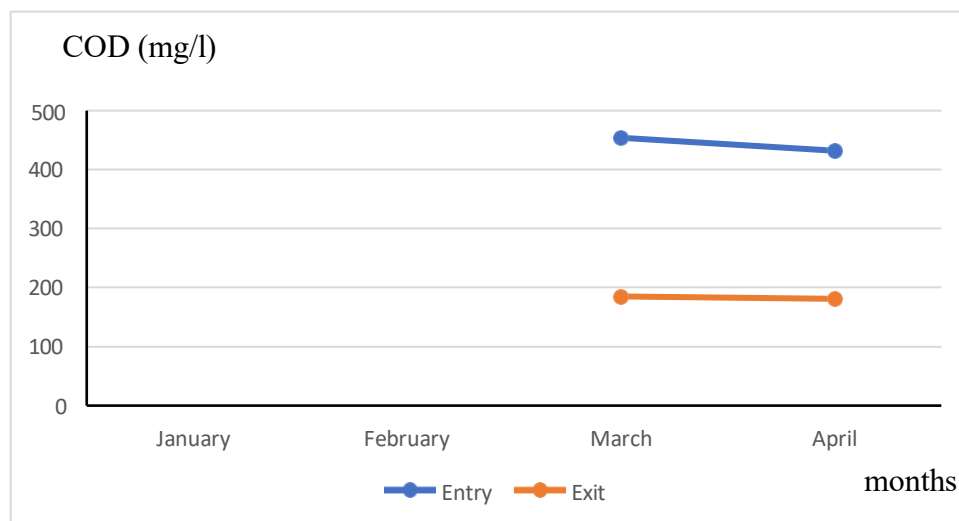


Figure 31: Chemical Oxygen Demand (COD)

The graph shows changes in the Chemical Oxygen Demand (**COD**), as shown in the (**Figure 31**). Concentration in mg/L over several months at the Kouinine wastewater treatment plant, located in El Oued Province, Algeria. It is important to note that the **COD** measuring device was not available during the initial months, leading to missing data for that period. Actual measurements began later after the device was put into operation.

The blue line shows **COD** values at the plant inlet, where a slight gradual increase is observed in March, followed by a slight decrease in April. This is due to the higher amount of organic pollutants in March.

The red line shows **COD** values at the outlet, which tend to decrease, indicating that the treatment is relatively effective in reducing oxidizable organic matter.

FAO Standards (2023): According to the **FAO** guidelines for water use in irrigation, **COD** levels exceeding 100 mg/L may negatively affect soil structure and plant health (**FAO & IWMI, 2023**).

WHO Guidelines (2006): The World Health Organization recommends that the Chemical Oxygen Demand (**COD**) in treated wastewater should be below 90 mg/L in order to reduce environmental pollution and ensure the safe discharge or reuse of the effluent. However, the analyzed samples showed **COD** values exceeding this limit, indicating inadequate treatment and potential environmental risks (**WHO, 2006**).

Algerian Standards (Official Gazette JORA, 2006): As per the 2006 updates, the maximum permissible **COD** value in treated wastewater discharged into the natural environment must not exceed 120 mg/L for wastewater.

The data indicate that **COD** levels in the influent at the Kouinine plant are relatively high, signaling significant organic pollution. However, the noticeable decrease at the outlet reflects a reasonably effective treatment process. Still, some outlet values during certain months exceed the legal limits, which necessitates technical improvements and strict periodic monitoring. Compliance with **FAO**, **WHO**, and **JORA** standards remains essential to ensure environmental protection and public health.

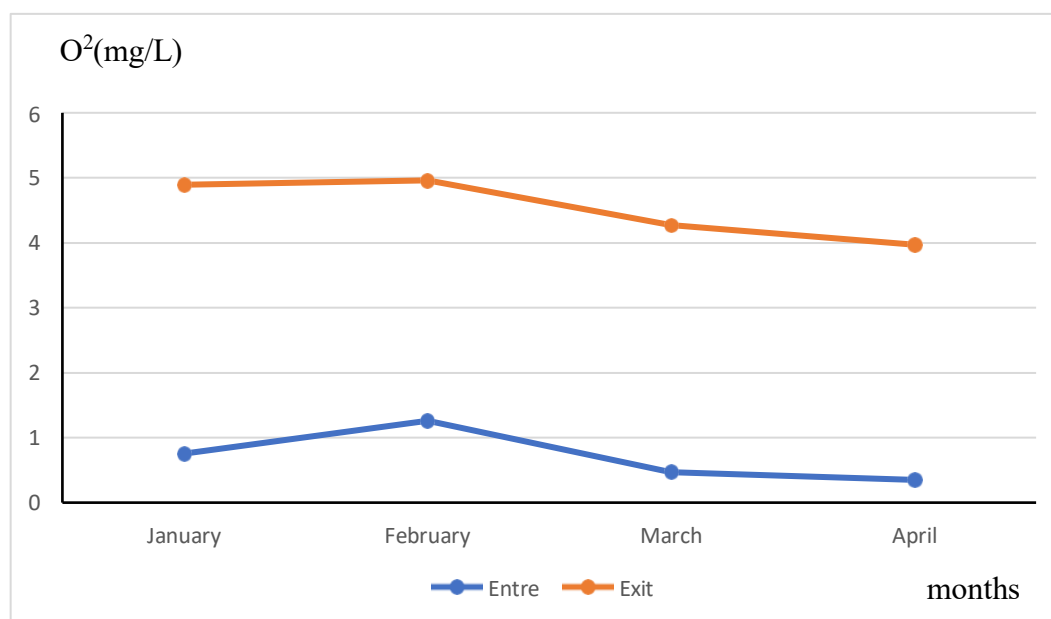
1-7-Dissolved Oxygen (DO)

Figure 32: Dissolved Oxygen (DO)

This curve shows changes in dissolved oxygen (**DO**), as shown in the (**Figure 32**). concentration in mg/L over several months at the Kouinine wastewater treatment plant. The chart displays two lines:

The blue line represents **DO** values at the plant inlet. The levels are relatively low with slight variations, indicating low aeration or the presence of a high amount of organic materials.

The red line represents **DO** values at the outlet, showing relatively stable and higher levels than the inlet, which reflects an improvement in water quality after treatment due to aeration and biological.

FAO Standards (2023): **DO** levels below 3 mg/L are considered unsuitable for irrigation, as they negatively affect beneficial microorganisms in the soil (**FAO,2023**).

WHO Guidelines (2006): Recommend that water should contain at least 5 mg/L of dissolved oxygen to ensure environmental and public health quality (**WHA,2006**).

Algerian Standards Official Gazette (**JORA, 2006**): State that the **DO** concentration in treated wastewater discharged into the natural environment must not be less than 4 mg/L.

The data show that **DO** levels at the inlet are relatively low, indicating a large amount of pollution or weak aeration. On the other hand, the outlet values show clear improvement, although in some months they are close to the minimum acceptable limit. It is recommended to improve the aeration system and carry out regular technical monitoring to ensure effective treatment and compliance with environmental and health standards.

1-8- Antibiotics (ATB)

ATB (ng/l)

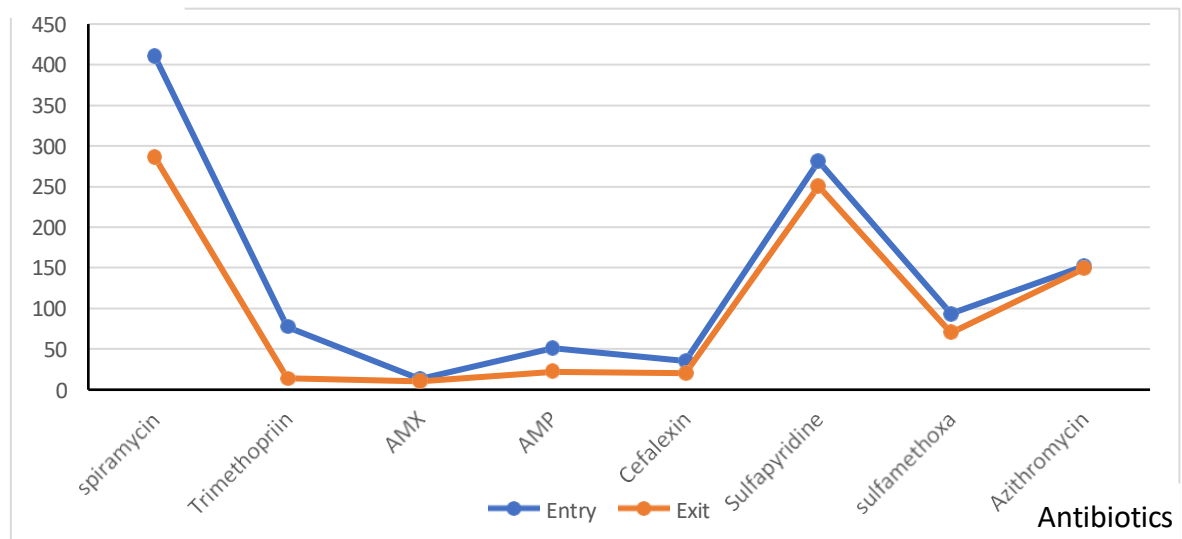


Figure 33: The percentage of antibiotics in wastewater for the month of January

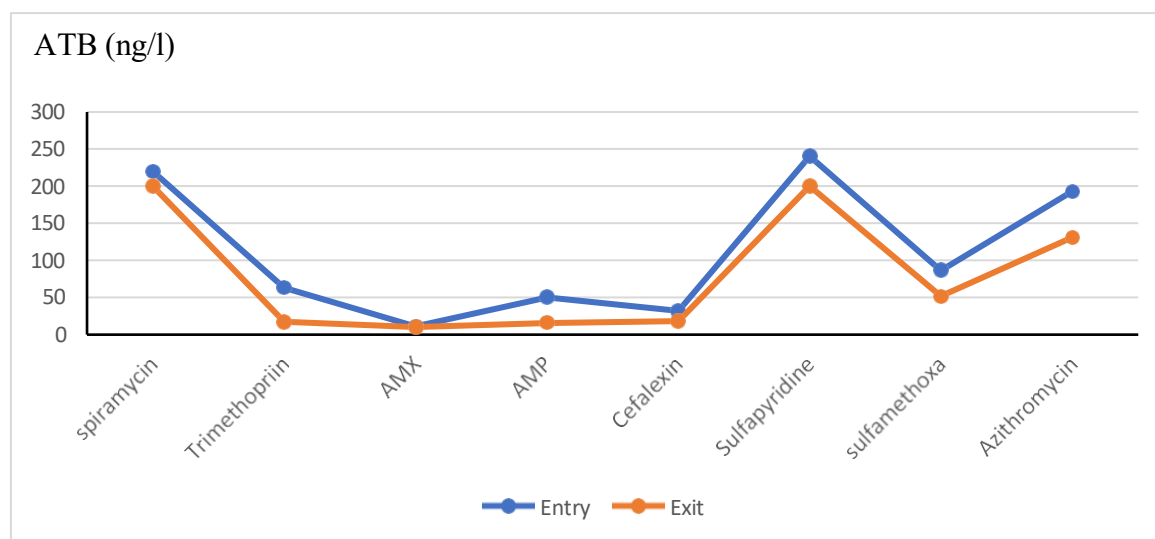


Figure 34: The percentage of antibiotics in wastewater for the month of April

The data for January indicate that the majority of antibiotics exhibit significantly higher concentrations in the influent (Entry) than in the effluent (Exit) of the wastewater treatment plant, reflecting partial removal efficiency. For instance, spiramycin and trimethoprim appear at high levels in the influent and decrease notably after treatment. In contrast, antibiotics such as sulfamethoxa (short for sulfamethoxazole) and azithromycin persist at elevated levels in the effluent, suggesting low biodegradability and resistance to conventional treatment processes. Their persistence may be attributed to high chemical stability and low sorption potential, limiting microbial degradation as shown in the **(Figure 33)**.

In April, a general decline in antibiotic concentrations is observed in both influent and effluent compared to January, possibly due to reduced antibiotic usage or improved treatment performance under lower biological oxygen demand (**BOD**) conditions. Despite this, antibiotics like sulfamethoxa and azithromycin still appear in considerable amounts in the effluent, confirming their persistence (**Kümmerer, 2009**). On the other hand, amoxicillin (AMX) and ampicillin (AMP) demonstrate greater reductions, indicating higher susceptibility to biological degradation as shown in the **(Figure 34)**.

The analysis of antibiotic concentration curves in the Kouinine wastewater treatment plant revealed a clear correlation with various physicochemical parameters monitored during the study period. The recorded temperatures, ranging between 17°C and 24°C, likely enhanced microbial activity within the treatment basins, facilitating the partial degradation of certain biodegradable antibiotics, such as amoxicillin (Metcalf & Eddy, 2014). Furthermore, the pH values, which remained within a mildly alkaline range (7.8 to 8.2), may have contributed to the breakdown of antibiotics sensitive to alkaline conditions, such as tetracyclines.

Electrical conductivity (EC), which exceeded 9 mS/cm in some months, suggests a high concentration of dissolved salts and ions, potentially affecting the sorption and mobility of antibiotic compounds. Additionally, suspended solids (SS) levels remained above permissible limits at the outlet, despite showing improvement compared to the inlet. This indicates that a portion of the antibiotics may have been adsorbed onto particulate matter, limiting their removal during conventional treatment.

The elevated values of Biochemical Oxygen Demand (BOD₅) and Chemical Oxygen Demand (COD) at the outlet further reflect a high organic load, which includes complex and persistent pharmaceutical compounds that resist biological degradation. In some months, Dissolved Oxygen (DO) levels approached the minimum acceptable thresholds, potentially limiting the performance of aerobic microbial communities responsible for the degradation of such pollutants.

Overall, the continued presence of antibiotics in the treated effluent highlights the limitations of conventional treatment processes in effectively eliminating pharmaceutical residues. Therefore, it is recommended to integrate advanced treatment technologies, such as ozonation or membrane filtration, to enhance water quality and safeguard aquatic ecosystems from the long-term impacts of antibiotic contamination.

When comparing the concentrations of antibiotics in the effluent after treatment during January and April with the reference values provided by the Trace Organics Laboratory of Central Pollution Control Board, Delhi.

It is observed that Spiramycin decreased from 286.19 ng/L to 199.94 ng/L, yet remains significantly above the reference value (51 ng/L).

Azithromycin also dropped from 149.05 ng/L to 130.99 ng/L, still exceeding the reference limit (30 ng/L).

In contrast, AMX remained nearly stable (from 10.27 to 10.22 ng/L), well below the reference value (80 ng/L),

while AMP decreased from 22.3 to 15.68 ng/L (below the reference of 45 ng/L).

Cefalexin also declined slightly from 20 to 18 ng/L, far below its reference value (130 ng/L).

These results indicate a relative improvement in April compared to January in terms of reducing most antibiotic concentrations in the treated effluent. This could be attributed to better treatment plant performance, lower antibiotic consumption, or favorable climatic conditions. However, the persistent exceedance of Spiramycin and Azithromycin above the reference levels highlights their resistance to conventional treatment and the limited efficiency of the system in removing these compounds.

***Antibiotic efficacy:**

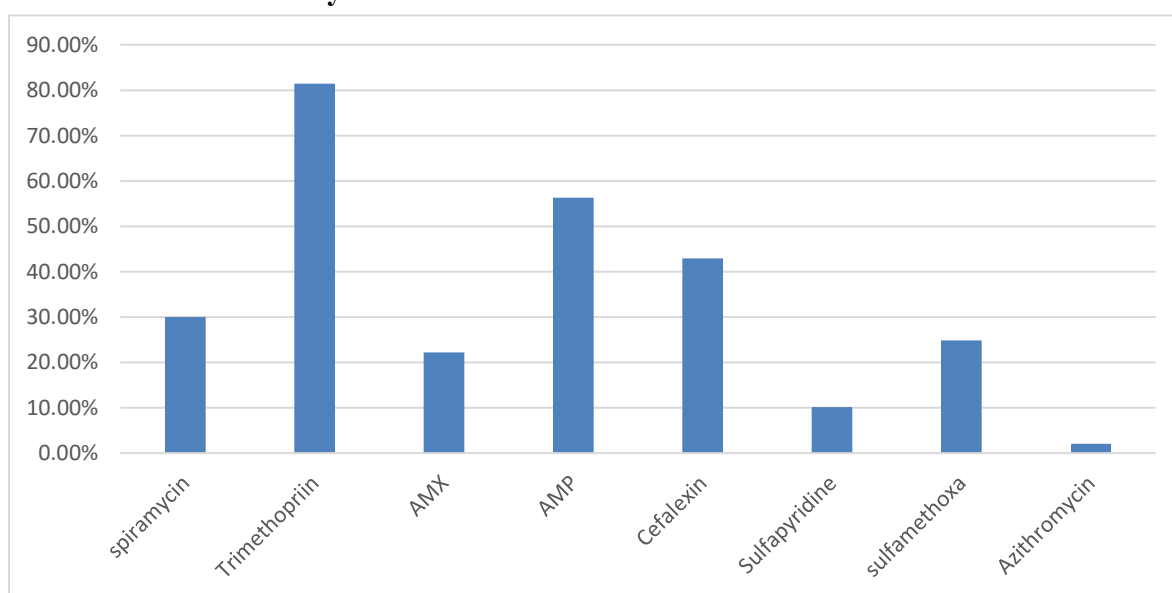


Figure 35: Antibiotic yield for January

The attached curve represents the efficiency rate of the wastewater treatment plant in removing a range of antibiotics during the month of January. A clear variation in

removal rates between the different substances can be observed, reflecting the plant's varying ability to treat these compounds depending on their chemical and physical properties as shown in the (Figure 35).

Highest removal rates:

Trimethoprim and AMP (Ampicillin) showed high removal rates (around 55–80%), indicating a high efficiency of the plant in eliminating these compounds.

Lowest removal rates:

Azithromycin and Sulfadiazine showed low removal rates (less than 10%), suggesting that these substances are more resistant to treatment processes and may persist in the effluent, posing an environmental risk.

Moderate removal rates:

Cefalexin, Sulfamethoxazole, AMX (Amoxicillin), and Spiramycin had moderate removal rates (20–40%). These values indicate average efficiency and may require improvements in the treatment system to better target these compounds.

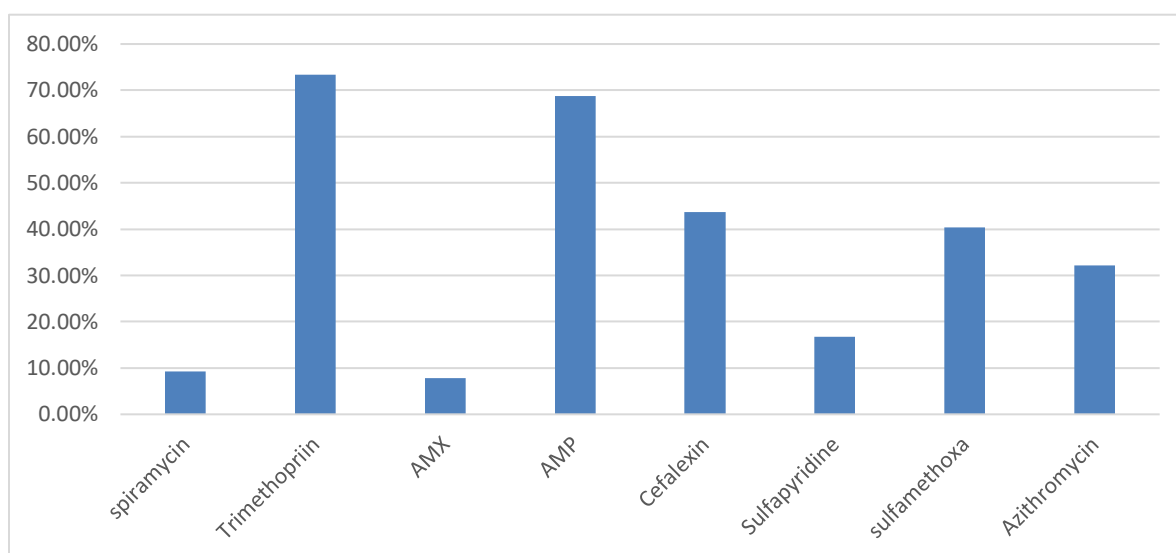


Figure 36: Antibiotic yield for April

The curve illustrates the removal efficiency of the wastewater treatment plant for several antibiotics during the month of April. A significant variation in removal percentages is observed, reflecting the plant's varying effectiveness depending on the type of antibiotic as shown in the **(Figure 36)**.

Highest removal rates:

Trimethoprim and AMP (Ampicillin) showed high removal rates, reaching up to approximately 75%. These values indicate that the plant is highly effective in eliminating these two antibiotics.

Lowest removal rates:

Spiramycin and Amoxicillin (AMX) showed low removal efficiency (around 10%). This low percentage suggests that:

These two compounds are resistant to conventional treatment processes.

They may leave the plant without sufficient removal, posing an environmental risk.

Advanced treatment technologies (such as oxidation or UV treatment) may be required to eliminate them effectively.

Moderate removal rates:

Cefalexin, Sulfamethoxazole, Sulfapyridine, and Azithromycin showed moderate removal efficiencies, ranging between 20% and 40%. This indicates partial effectiveness of the plant for these compounds and highlights the need for improvement.

This work aims to attempt the detection of antibiotic pollution in wastewater at the Kouinine wastewater treatment plant in El-Oued. The study was conducted through the collection and analysis of water samples from different stages of the treatment process, with comparisons made to previous studies such as *Pharmaceutical Products in the Environment: Sources, Effects and Risks* ((Narváez et al., 2012)) and *Présence et devenir des médicaments dans les eaux usées urbaines, une analyse bibliographique* (Alighardashi et al., 2008). The results revealed traces of antibiotics in the water, indicating that the treatment plant does not completely eliminate these pollutants. The study highlights the necessity of monitoring these compounds due to their potential

environmental and health impacts, especially with the increasing issue of bacterial resistance to antibiotics

Conclusion

Conclusion

Conclusion

This study aimed to assess the presence of antibiotic pollutants in wastewater treated at the Kouinine-El Oued wastewater treatment plant. By combining sampling, physicochemical analyses, and interpretation of the results, the study highlights a growing environmental concern: the persistence of drug residues (antibiotics) in treated water.

The results obtained, although preliminary, suggest that conventional treatment techniques may not be sufficient to eliminate all traces of these emerging contaminants. Such contamination endangers biodiversity as well as the ecological functions of ecosystems essential to human well-being and livelihoods. The measured antibiotic concentrations are of concern, particularly for spiramycine and trimethopriin, identified as potentially problematic compounds in wastewater discharges. This underscores the urgent need for more advanced treatment technologies and regular monitoring programs, particularly in areas where wastewater is reused for agricultural or environmental purposes.

The study also highlights the importance of collaboration between environmental researchers, public health authorities, and policymakers to mitigate the potential risks of antibiotic contamination of water.

In conclusion, this work provides a solid foundation for further in-depth studies in the region, particularly on so-called resistant bacteria that harm biodiversity and humans.

These results also call for the adoption of effective management strategies to preserve the environment and human health.

***Recommendations:**

- Regular Monitoring of Antibiotics in Wastewater.
- Implementation of Advanced Treatment Techniques.
- Environmental Risk Assessment.
- Public Awareness and Education Campaigns.
- Promotion of Green Pharmacy and Eco-friendly Antibiotics.

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Appendices

Appendices

1. FAO

2023 FAO Guidelines for the Quality of Treated Water Used in Agriculture:

Parameter	Sybol	Unit	Recommended Limit
Temperature	T	C°	≤30
PH	PH	_	8.4_6.5
Electrical Conductivity	CE	ms/cm	0.3_0.7
Chemical Oxygen Demand	DCO	mg/l	≤100
Biochemical Oxygen Demand (5days)	DBO ₅	mg/l	≤30
Suspended Solids	SS	mg/l	≤30
Dissolved Oxygen	OD	mg/l	≥3

(FAO,2023)

These values represent general recommendations from the Food and Agriculture Organization and may vary depending on the crop type, soil conditions and local environmental factors.

2.WHO

Based on the WHO (World Health Organization) guidelines for treated wastewater quality (2006) in agricultural use:

Parameter	Sybol	Unit	Recommended Limit
Temperature	T	C°	20_33
PH	PH	_	6.5_8.5
Electrical Conductivity	CE	ms/cm	_
Chemical Oxygen Demand	DCO	mg/l	≤90
Biochemical Oxygen Demand (5days)	DBO ₅	mg/l	20_30
Suspended Solids	SS	mg/l	≤20
Dissolved Oxygen	OD	mg/l	≥5

(WHO,2006)

Appendices

3.JORS

Here is a table showing the main physical and chemical parameters of treated water quality according to Algerian official standards (JORA) from the year 2006, based on available documents:

Parameter	Sybol	Unit	Recommended Limit
Temperature	T	C°	≤30
PH	PH	–	6.5_8.5
Electrical Conductivity	CE	ms/cm	–
Demand Chemical Oxygen	DCO	mg/l	≤120
Demand Biochemical Oxygen (5days)	DBO ₅	mg/l	≤30
Suspended Solids	SS	mg/l	≤30
Dissolved Oxygen	OD	mg/l	≥4

(JORS,2006)

4-Central Pollution Control Board. (2017).

ATB	Reference Value (ng/l)
AMX	80
AMP	45
Cefalexin	130
Azithromycin	30
spiramycine	51