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University Abdelhamid Ibn Badis Mostaganem
جامعة عبد الحميد بن باديس مستغانم

Faculty of Sciences and Technology
كلية العلوم و التكنولوجيا
Department of Process Engineering
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FOR THE ACADEMIC MASTER'S DEGREE

Streem **: Process Engineering**

Option**: Environmental Process Engineering**

TOPIC

Assessment of wastewater pollution indicators before and after treatment at the Mostaganem Wastewater Treatment Plant

Presented by:

1- Elmeddah Leyla

2- Agboubi Ghania

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Chair: Ms. ABDLLI ISLAM Safia	*MAA*	*University of Mostaganem*
Examiner: Ms. BENYAKHOU Nabila	*MAA*	*University of Mostaganem*
Rapporteur: Ms. KHELLADI Malika	*MAA*	*University of Mostaganem*

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Dedication

First of all, I would like to thank GOD for giving me the strength and courage to complete this modest work.

I would like to dedicate this humble work to: My dear mother ZOHRA and my beloved father AHMED; my precious sister. ; A special dedication to you: Mrs KHELLADI

To my partner: AGBOUBI GHANIA

My best friends.

To all my friends from childhood and throughout my school and university years.

To my whole family, to all those who love me and whom I love.

ELMEDDAH LEYLA

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First of all, I would like to thank GOD for giving me the strength and courage to complete this modest work.

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To my sisters: BOUCHRA; DOUAA; OUMAIMA

To my partner ELMEDDAH LEYLA

To my best friends.

To all those who love me and whom I love.

AGBOUBI GHANIA

ملخص:

أدى التطور الصناعي المتسارع وارتفاع مستوى معيشة السكان إلى زيادة هائلة في تدفقات مياه الصرف الصحي، مما أفقد المجاري المائية والبيئة قدرتها الطبيعية على التنقية الذاتية، ودفع الباحثين نحو ابتكار تقنيات حديثة لمعالجة هذه الملوثات السائلة. ونظراً لأن مياه الصرف غير المعالجة تحمل خطورة بيئية وصحية جسيمة تمنع الاستفادة منها، فقد بات نقلها وتصفيتها ضرورة حتمية، حيث تبرز محطات المعالجة كأحد أهم الحلول الاستراتيجية للحفاظ على الثروة المائية، كونها لا تكتفي بالتخلص الآمن من السموم بل تحولها إلى مورد مائي بديل وثمين لمواجهة الجفاف ونقص المياه، وهو ما يلزم السلطات المحلية بإدراج هذا المصدر غير التقليدي في خطط التنمية وتطوير المنشآت الحالية. وفي هذا الإطار، يأتي هذا العمل لتقييم كفاءة أداء محطة تصفية مياه الصرف الصحي لولاية مستغانم التي تعتمد على تكنولوجيا "الحمأة المنشطة"، وذلك من خلال مراقبة سير محطة تطهيرالمياه المستعملة وتحليل التغيرات التي تطرأ على مختلف المؤشرات الفيزيوكيميائية والبيولوجية للمياه بين مرحلتي ما قبل المعالجة وما بعدها.

الكلمات المفتاحية :الصرف الحي, محطة تطهير المياه المستعملة بمستغانم , الحمأة المنشطة

RÉSUMÉ :

Le développement industriel accéléré et l'amélioration du niveau de vie de la population ont entraîné une augmentation massive des flux d'eaux usées. Cela a dépassé la capacité d'auto-épuration naturelle des cours d'eau et de l'environnement, incitant les chercheurs à développer des technologies modernes pour traiter ces effluents liquides. Étant donné que les eaux usées non traitées présentent de graves risques environnementaux et sanitaires qui limitent leur réutilisation sécurisée, leur acheminement et leur épuration sont devenus une nécessité impérative. Dans ce contexte, les stations d'épuration apparaissent comme l'une des solutions stratégiques les plus cruciales pour préserver les ressources hydriques. En effet, elles ne se contentent pas d'éliminer les toxines de manière sûre, mais les transforment également en une ressource en eau alternative et précieuse pour faire face à la sécheresse et à la pénurie d'eau. Cela oblige les autorités locales à intégrer cette ressource non conventionnelle dans leurs plans de développement et à moderniser les installations existantes. C'est dans ce cadre que s'inscrit ce travail, qui vise à évaluer l'efficacité des performances de la station d'épuration des eaux usées (STEP) de la wilaya de Mostaganem, basée sur la technologie des "boues activées", et ce, à travers le suivi du fonctionnement de la station et l'analyse des variations des différents paramètres physico-chimiques et biologiques de l'eau entre les étapes de prétraitement et de post-traitement.

Mots-clés : Eaux usées, STEP de Mostaganem, Boues activées.

ABSTACT :

Accelerated industrial development and the rising standard of living of the population have led to a massive increase in wastewater flows. This has exceeded the natural self-purification capacity of waterways and the environment, driving researchers to develop modern technologies for treating these liquid effluents. Given that untreated wastewater poses severe environmental and health risks that restrict its safe reuse, its conveyance and treatment have become an imperative necessity. In this context, wastewater treatment plants emerge as one of the most critical strategic solutions for preserving water resources. Indeed, they do not merely dispose of toxins safely, but also transform them into a valuable alternative water resource to counter drought and water scarcity. This obliges local authorities to incorporate this non-conventional resource into their development plans and to upgrade existing facilities. Within this framework, this work aims to evaluate the performance efficiency of the wastewater treatment plant (WWTP) in the Wilaya of Mostaganem, which relies on the "activated sludge" technology, by monitoring the plant's operation and analyzing the variations in various physicochemical and biological water parameters between the pre-treatment and post-treatment stages.

Keywords: Wastewater, Mostaganem WWTP, Activated sludge.

TABLE OF CONTENTS:

LIST OF TABLES:

LIST OF FIGURES

List of abbreviations:

SS (Suspended Solids)

VSS (Volatile Suspended Solids)

DSM (Dry Mineral Matter)

DM (Dry Matter)

MM (Mineral Matter)

BOD (Biological Oxygen Demand)

BOD_5 (Biological Oxygen Demand after 5 days)

COD (Chemical Oxygen Demand)

TOC (Total Organic Carbon)

OC (Organic Carbon)

TKN (Total Kjeldahl Nitrogen)

TP (Total Phosphorus)

pH (Hydrogen Ion Concentration)

EC (Electrical Conductivity)

SV_{30} (Sludge Volume after 30 minutes)

IM / IVB / SVI (Mohlman Index / Sludge Volume Index)

WWTP (Wastewater Treatment Plant)

ONA (National Sanitation Office)

PE / E-H (Population Equivalent)

MBBR (Moving Bed Biofilm Reactor)

DN 1000 (Nominal Diameter 1000)

RN8 / RN02 (National Road)

TA1 / TA2 (Aeration Tank)

RW (Raw Water)

TW (Treated Water)

O_2: Molecular oxygen (dissolved oxygen)

CO_2: Carbon dioxide

CH_4: Methane (gas produced during anaerobic digestion).

N_2: Nitrogen gas (end product of denitrification)

SO_2: Sulphuric dioxide.

$N\text{-}NH_4^+$: Ammoniacal nitrogen (ammonium ion).

$N\text{-}NO_2^-$: Nitrogen in the form of nitrite ions

$N\text{-}NO_3^-$: Nitrogen in the form of nitrate ions

P: Elemental phosphorus.

PO_4^{3-}: Orthophosphate ions

NaOH: Sodium hydroxide (soda tablets used to trap CO_2 in BOD_5 measurements).

H_2SO_4: Sulphuric acid (reaction medium for COD)

Ag_2SO_4: Silver sulphite (used as a catalyst or indicator)

$Fe\ (SO_4)$: Iron sulphite (dephosphatation reagent)

$Al_2\ (SO_4)$: Aluminium sulphite (coagulant for dephosphatation)

$FeCl_3$: Iron chloride / Ferric chloride

$FeCl\ (SO_4)$: Iron chlorosulphate

$Ca\ (OH)_2$: Slaked lime (calcium hydroxide).

GT: Total bacteria.

CT: Total coliforms.

CF: Faecal coliforms (thermotolerant, indicators of faecal contamination).

SF: Faecal streptococci.

E. coli: Escherichia coli (specific bacterium indicating faecal contamination)

CSR: Sulphite-reducing Clostridia

DNA / RNA: Deoxyribonucleic acid / Ribonucleic acid (genetic material targeted by UV-C disinfection)

mg/L or mg.L^{-1}: Milligram per litre (concentration)

mg O_2/L: Milligrams of oxygen per litre (concentration of oxygen demand BOD/COD).

µS/cm: Micro-Siemens per centimeter (unit of measurement for electrical conductivity)

µm: Micrometre or micron (size of microorganisms).

mL / L: Millilitre / Litre

G/L: Gram per litre.

m^3/d: Cubic metre per day (unit of daily flow rate for a treatment plant)

m^3/h: Cubic metre per hour (unit of hourly flow rate)

Kg/d: Kilogram per day (unit expressing daily pollution load)

KW: Kilowatt (unit of power for mechanical equipment)

nm: Nanometre (wavelength of germicidal UV-C radiation).

DA: Algerian Dinar (project costs)

kg BOD_5/kg VSS.d: Kilogram of BOD_5 per kilogram of volatile suspended solids per day (unit of the mass load Cm).

Introduction:

Introduction:

General:

People use water every day for many purposes, such as washing and cooking, particularly in the evening, which leads to increased water pollution.

This practice has led to the pollution of seawater, oceans and groundwater. This wastewater is harmful to human health, causing infectious diseases and skin conditions, and affecting fish stocks – all direct consequences of the discharge of untreated wastewater.

Water pollution has harmful consequences for human life and, in particular, for fish, due to its discharge into the sea and river valleys. More generally, all living organisms are affected. Environmental scientists are studying this phenomenon in order to build wastewater treatment plants and to reuse or discharge treated water into the sea without consequences or obstacles. Why is wastewater treatment vital for the environment and Algerian agriculture?

The aim of these studies is to analyse the methods used by the National Sanitation Office (ONA).

In a centralized treatment system, wastewater is transported to a treatment plant via a sewerage network. The implementation of a traditional process in this type of plant relies on a series of successive systems, designed to progressively remove the various pollutants present in the water. Biological treatment is often the central element of the purification process. This stage reduces pollutants, particularly some of the contaminants, through the action of microorganisms. The treatment plant then produces two main outputs: treated water and sludge.

Sludge is mainly generated at two key stages of the treatment process. Primary sludge results from the settling of suspended solids contained in the water as soon as it arrives at the plant. Secondary sludge, on the other hand, is produced by the proliferation of microorganisms during biological treatment. All these operations aim to treat the water sufficiently to preserve the quality of the natural environment into which it is discharged. Consequently, the effluent poses no risk to public health. We will now examine the following points:

-Chapter I: General information on domestic wastewater and its effects on the environment.

-Chapter II: Several water distribution plants are located in Algeria.

-Chapter III: describes the Mostaganem wastewater treatment plant and the procedures used in the treatment of domestic wastewater.

-Chapter IV: The protocol, methodology and tools used at the Mostaganem wastewater treatment plant.

-Chapter V: The final results obtained from physical and biological treatment.

CHAPTRE I

Overview of domestic wastewater and its impact on the environment

Definition of wastewater

Wastewater refers to water that has been used for domestic, industrial or agricultural purposes.

I.1 Characteristics of wastewater

There are four types, which are:

I.1.1 Storm water

It may contain various pollutants, such as oils, hydrocarbons, tyre wear particles and heavy metals, mainly carried by runoff from roofs and roads. This water, which contains pollutants, contributes to the deterioration of water quality [3].

I.1.2 Industrial wastewater

This refers to wastewater resulting from non-domestic water use. This definition applies to industrial wastewater; it may also include other craft and commercial activities. Its composition is extremely varied. This water can be toxic to humans and animals. Cooling water is water used to clean equipment, vehicles and machinery, as well as general cooling systems, facilities, raw materials and semi-finished or finished products [3].

I.1.3 Domestic wastewater

Domestic wastewater can come from toilets, washbasins, dishwashers, washing machines, baths and showers. Dry toilets produce significantly less wastewater than flush toilets. The source of the wastewater determines its characteristics; it may therefore contain various combinations of chemical substances and biological contaminants. Domestic wastewater is treated as waste.

I.1.4 Agricultural water

Agricultural water is a major source of water pollution and the primary cause of diffuse pollution. Agriculture generates runoff from cultivated fields, rich in nitrates and phosphates in ionic form or when the soil's retention capacity and the plants' absorption capacity exceed. This process enriches shallow groundwater, as well as watercourses and reservoirs, with nitrogen and phosphate compounds [3].

I.2 Composition of wastewater

The table below shows the Algerian standards for urban wastewater.

Table I.1: Characteristics of urban wastewater in Algeria [2]

Parameters	**Values**
pH	**7.5–8.5**
Dry residue (mg/L)	1000–2000
Total suspended solids (mg/L)	150–500
BOD_5 (mg O_2/L)	100–400
COD (mg O_2/L)	300–1000
TOC (mg/L)	100–300
NTK (mg/L)	30–100
N-NH_4^+ (mg/L)	20–80
N-NO_2^- (mg/L)	**>1**
N-NO_3^- (mg/L)	**>1**
P (mg/L)	10–25
Detergents (mg/L)	6–13

I.3 Water pollution

I.3.1 Definition of pollution

Wastewater contains various pollutants or harmful substances, and its treatment aims to biodegrade, reduce and eliminate them.

Before implementing measures to combat the contamination of water resources, it is essential to carry out a specific study on the categorization of pollutants. Several types of pollution are identified in wastewater [4].

I.3.2 Different types of pollution

A) Physical pollution

Generally refers to the presence of solid or liquid particles in the environment that impair the quality of the air, water or soil. These particles can originate from various sources, such as industrial activities, vehicle emissions, or plastic waste. Physical pollution is often visible to the naked eye, which makes it easier to identify but not necessarily to manage [39].

B) Chemical pollution

It stems from chemical discharges originating mainly from industry, the domestic sector and agriculture.

It can be organic (hydrocarbons, pesticides, detergents) or inorganic (heavy metals, cyanide, nitrogen, phosphorus…), [5].

- **Organic pollution**

This refers to discharges rich in fermentable (biodegradable) organic substances, which are generated by the food and agri-food sectors (dairies, abattoirs, sugar refineries, etc.), as well as by domestic waste (human excrement, fats, etc.).The primary effect of this pollution is the consumption of dissolved oxygen in these waters [5].

- **Hydrocarbons**

These are substances that have a low solubility in water (with a lower density than water) and are difficult to biodegrade. They originate from the oil and transport sectors.

On the surface, they form a film that blocks gas exchange with the atmosphere [5].

- **Pesticides**

These are products used in agriculture; their harmful effects are associated with the following characteristics: accumulation in food chains caused by persistence and chemical stability, and a disruption of the natural balance [5].

C) Microbiological pollution

Microbiological contamination refers to the presence of viruses, bacteria, parasites such as various protozoa, or worms known as helminthes (often in the form of eggs), and also includes other microorganisms. Some of these may present varying degrees of pathogenicity to humans and animals [6].

➢ Bacteria

Bacteria are simple single-celled organisms without a nucleus. They measure between 0.1 and 10 µm. According to Asano (1998), the average number of bacteria in faeces is approximately10^{12}bacteria per gram. Urban wastewater contains approximately10^{6}to10^{7}bacteria per 100 mL, of which$10^{5}$are Proteus and Enterobacteria, $10^{3}$to 10^{4} are Streptococci, and$10^{2}$to$10^{3}$are Clostridia. Salmonellae are frequently found, some of which cause typhoid, paratyphoid and various intestinal disorders. Microorganisms are frequently used as indicators of faecal contamination, such as thermo tolerant coliforms [5], to assess the relative quality of water.

➢ Protozoa

Protozoa are single-celled organisms with a nucleus, more sophisticated and larger in size than bacteria. The majority of pathogenic protozoa behave as parasites.
During their life cycle, some protozoa develop a resistant form known as a cyst. This form is generally capable of withstanding wastewater treatment methods [5].

➢ Viruses

A virus is an infectious agent that cannot replicate outside a host cell.
It is smaller than a bacterium. To replicate, a virus needs a living cell. It cannot develop or replicate independently; it uses the cells of another living organism, such as an animal or a plant, to carry out its development in its place. A virus consists of genetic material, either DNA or RNA, which is protected by a protein shell known as the capsid membrane.

➢ Helminthes

Helminthes are multicellular parasitic worms that inhabit the bodies of humans and animals. The best-known ones are mainly found in the digestive tract, but they can also colonize blood or lung tissue.

I.4 Sources of pollution

Table I-2: Types of source and their origin, with pollutants and type of discharge

Type of source	**Main origin**	**Examples of activities**	**Main pollutants**	**Type of discharge**
Domestic	Homes and urban areas	Domestic wastewater, toilet water, laundry water, kitchen water	Organic matter, suspended solids (SS), nitrogen, phosphorus, microorganisms	Point source (sewerage network)
Industrial	Industrial activities	Waste from factories, refineries, chemical and extractive industries	Heavy metals, hydrocarbons, solvents, other toxic substances	Generally point source
Agricultural	Agricultural and livestock farming activities	From fertilizers, pesticides, animal manure and runoff	Nitrates, phosphates, pesticides, organic matter	Diffuse
Natural	Natural phenomenon n	Erosion, organic decomposition n, saline intrusion	Sediments, mineral salts, organic matter	Diffuse

I.5 Water pollution parameters

I.5.1 Physical and chemical parameters

- **Temperature**

Assessing water temperature is fundamental, as it impacts various crucial factors such as the solubility of salts and gases, as well as biological processes [3].

- **Turbidity**

Turbidity refers to the opacity of a cloudy environment. It describes the reduction in the clarity of a liquid caused by the presence of undissolved substances. In water, it is attributed to the presence of fine suspended particles (SSP) such as clay, silt residues, grains, etc. A small fraction of turbidity may also be attributed to colloidal substances of organic or mineral origin. The units used to indicate turbidity are derived from ASTM standard l, which considers the following three units to be equivalent [7].

- **Conductivity**

The quality of water is determined, in particular, by measuring its electrical conductivity (EC). This demonstrates the water's ability to conduct an electric current, which is closely linked to the overall concentration of dissolved ions (minerals). The unit of measurement for conductivity is µS/cm.

The total mineralization of water can be assessed by measuring its conductivity [3].

- **Suspended solids (SS)**

The analysis of the suspended solids (SS) content in effluent is a fundamental element. SS is an important indicator of wastewater pollution. Its concentration indicates the presence of solid particles that have not dissolved, generally associated with organic or inorganic pollutants. It is essential to determine the level of suspended solids in order to properly size treatment systems, such as settling and filtration tanks [3].

- **Settleable solids**

Settleable solids refer to the fraction of suspended solids (SS) that can settle naturally under the effect of gravity when the water is left to stand for a certain period of time.

This parameter is essential in assessing wastewater quality, as it allows for an evaluation of its behavior during the settling stages and plays a key role in the design and efficiency of water treatment processes.

- **Volatile suspended solids (VSS)**

Volatile suspended solids (VSS) constitute the organic fraction of total suspended solids (TSS). These TSS are obtained by calcination at 105°C, followed by a second calcination at 525°C for two hours. The difference in weight between the solid sample matter calcined at 105°C and that at 525°C represents the loss of matter during calcination, which corresponds to the VSS concentration (mg/L) in water [7].

- **Total dry matter (TDM)**

These represent the product of complete water evaporation, i.e. the dry residue comprising both suspended substances and soluble substances such as chlorides, phosphates, etc. [7].

- **Dissolved oxygen**

The crucial parameter for assessing water quality is the presence of dissolved oxygen. This is a measure of the concentration of molecular oxygen (O_2) dissolved in the water. In wastewater treatment plants, monitoring the dissolvedO_2 level is crucial to ensuring the effectiveness of biological processes [3].

- **pH**

The pH criterion is essentially the main indicator used to assess water quality and condition. It determines the ability of nutrients and metals to dissolve in water, a factor that impacts aquatic biodiversity. It is a key factor in identifying the source of the water [3].

- **Chemical Oxygen Demand (COD)**

Represents oxygen consumption in ($_{mg}O_2$/L) during an oxidation reaction carried out with potassium dichromate, in a heated sulphuric acid medium and under the action of a catalyst, affecting all materials capable of being oxidized (mineral salts capable of being oxidized as well as the majority of organic matter) [8].

- **Biological oxygen demand (BOD)**

This parameter aims to quantify the total amount of oxygen used by biochemical reactions during the oxidation of organic substances contained in a sample by microorganisms [7].

- **Biological oxygen demand (BOD_5)**

The amount of oxygen consumed (expressed in mg $_{o2}$/L) under experimental conditions (incubation at 20 °C in the dark for a period of 5 days) to ensure the microbial biological oxidation of organic matter classified as biodegradable [8].

- **Biodegradability**

Biodegradability refers to the ability of an effluent to be broken down or oxidized by microorganisms that contribute to biological water purification processes. A K factor is used to express this, where $K = DCO/BOD_5$: If K is less than 1.5, this suggests that the oxdisable substances consist mainly of highly biodegradable materials. If K is between 1.5 and 2.5, this means that the oxidisable substances have average biodegradability.

This indicates that the oxidisable compounds have moderate biodegradability. If K is between 2.5 And 3, the oxidisable substances have low biodegradability. If K exceeds 3, the oxidisable components are not biodegradable. A high K value indicates the presence in the water of elements that inhibit bacterial growth, such as: metal salts, cleaning agents, phenols, hydrocarbons, etc. The choice of treatment process depends on the value of the K coefficient. If the effluent is biodegradable, biological treatment is carried out; otherwise, physico-chemical treatment is applied [7]

- **Total Organic Carbon (TOC)**

Total organic carbon (TOC) is used to measure carbon in its organic form (CO). CO derived from organic matter is measured by catalytic thermal oxidation at temperatures ranging from 800 to 1000 °C, or by an oxidation method using ultraviolet light, or through low-temperature chemical oxidation (a combination of persulphate and UV radiation), before proceeding to assess the total amount of CO_2produced.

This is a rapid method that can often be satisfactorily correlated with COD values [6].

- **Nitrogen**

Water may contain nitrogen compounds in two forms: organic and inorganic. Organic nitrogen encompasses various substances such as proteins, polypeptides, amino acids and urea, which are usually present in small quantities. In contrast, inorganic nitrogen, which consists mainly of ammonia (NH_4^{+}), nitrate compounds (NO_3^{-}) and nitrite compounds (NO_2^{-}), accounts for the largest proportion of total nitrogen [3].

I.6.3 Microbiological parameters

The study of the bacterial status of water requires the identification and collection of the following microorganisms: total bacteria (TB), total coliforms (TC) and faecal coliforms (FC), faecal streptococci (FS), Escherichia coli (E. coli) and sulphite-reducing Clostridia (SRCC) [9].

Faecal coliforms (referred to as thermotolerant) are a group of bacteria used to indicate faecal contamination. These organisms belong to the Enterobacteriaceaes family**.** They are Gram-negative, oxidase-negative, aerobic or facultative anaerobic bacteria, capable of growing and fermenting lactose whilst producing gas, acid and aldehyde. They are often considered excellent indicators of faecal contamination and are cultured at 44°C [5].

CHAPTRE II:

Sludge Treatment Plants Established in Algeria (WWTPs)

II.1. Activated sludge wastewater treatment plants in Algeria (WWTPs):

II.1.1. TIZI-OUZOU plant: To assess the treatment performance of the Tizi-Ouzou WWTP, located in eastern Algeria, a characterization of the wastewater treated using activated sludge was carried out.

The reduction in organic pollution was estimated through physical (temperature, pH and suspended solids), chemical (nitrates) and biological (BOD_5) analyses, carried out before and after treatment at the plant. The results show satisfactory treatment performance. The reduction in TSS, COD and $BOD_5$is approximately: 38.601 mg.$^{L^{-1}}$; 41.53 mg.L^{-1}; 180 mg.L^{-1} [10].

II.1.2. SKIKDA Wastewater Treatment Plant:

The SKIKDA wastewater treatment plant: The Skikda wastewater treatment plant forms part of the wilaya's environmental protection infrastructure. The construction phase was completed on 11 December 2011, and operations commenced on the same day for a period of two years. This facility, covering an area of 11 hectares, treats wastewater from the towns of Skikda. This wastewater is mainly conveyed via a DN 1000 collector, fed by pumping stations managed by the National Sanitation Office (ONA). The WWTP is designed to meet the needs of a population of **328,183 inhabitants** by **2025**, corresponding to a pollution load of **286,161 P.E.** and a daily flow of **46,000 m³/day** [11].

II.1.3. the BARAKI wastewater treatment plant (Algiers):

The treatment plant is located at the Sidi-Rzine junction (to the right of the RN8).

The BARAKI wastewater treatment plant has a capacity of 900,000 population equivalents and a theoretical capacity of 147,000 m³/day. This plant is responsible for treating wastewater from the municipalities of Greater Algiers. First commissioned in 1989, it remained inactive for a long period until its recent refurbishment. Following the commissioning of the second phase in 2015 (900,000 P.E.), the plant doubled its capacity, now reaching 1.8 million p.e. A third phase of 900,000 P.E. is currently under consideration (implementation of tertiary treatment) [12].

II.1.4. the Tlemcen plant:

The Tlemcen wastewater treatment plant is a low-load activated sludge plant (Cm < 0.2 kg BOD_5/kg DM.day). It has a capacity of 150,000 population equivalents and an average daily flow. With a capacity of 30,000 m³/day, this plant was inaugurated in November 2005 and is currently managed by the National Sanitation Office (ONA). It manages, via a combined sewer system, the urban wastewater of the city of Tlemcen. The treatment process selected for the water sector includes coarse and fine mechanical screening, grit and oil removal, an aeration tank with nitrification and denitrification, followed by a clarifier and finally disinfection of the treated water [7].

II.1.5. the Ain-Defla plant:

The Ain-Defla wastewater treatment plant is located in the north of the Ain-Defla province, 145 km south-west of the Algerian capital. It has been operational since April 2007, and the treatment process used is 'low-load activated sludge'. It has a capacity of 50,000 population equivalents and a nominal flow of 12,900 m^3/day. This Wastewater Treatment Plant (WWTP) was designed to treat domestic wastewater from the town of Ain Defla and ensure the protection of the Oued Cheliff, which serves as the final discharge point (ONA, 2013) [13].

II.1.6. the Tiaret plant:

The Tiaret WWTP is located in the municipality of Ain Bouchakif, 6 km from the city of Tiaret. The plant covers an area of 9.47 hectares. It has a treatment capacity of 39,000 P.E., equivalent to 38,000 cubic metres of treated wastewater per day [14].

II.1.7. the Medea plant:

The plant is situated near the Oued Lhammar, 10 km from the province of Medea. It came into operation in 2007 and is operated by the ONA. The capacity of this WWTP is 26,000 $^{m^3}$per days; it treats a load of 195,000 Population Equivalents (PE) [15].

II.1.8. the Ain Témouchent plant:

The recently built Ain Témouchent wastewater treatment plant is located on the northern side of the town.

It is bounded to the east by the town's police station, to the south by the RN02 national road (towards Oran), to the north by the Sarrane wadi and to the west by residential areas. It has been operational since 2013 under the ONA. This plant manages the treatment of wastewater from the town of Ain Témouchent. It is designed to handle a volume of 10,920 m^3 /day, which corresponds to 72,800 residents served (or 82,000 population equivalents) by 2015, with the potential for expansion to serve 90,000 residents (or 119,000 population equivalents) by 2030 [16].

II.2. Types of activated sludge WWTPs:

Table II.1: Operational characteristics of the different types of activated sludge WWTPs

Type of plant	Mass load (kg BOD_5/kg DM.day$^-$)	Retention time (sludge age)	Aeration	Sludge production	Treatment efficiency
Low-load plants (extended aeration)	0.05 – 0.15	Long (15–30 days)	High and continuos	Low	Very high (90–95% BOD_5)
Stations with medium load	0.2–0.4	Medium (8–15 days)	Moderate	Medium	High (85–90% BOD_5)
High-load stations	0.4–1	Short (3–8 days)	Intense but short	Significant	Good (70–85% BOD_5)

II.3. Technical configuration of the WWTP type:

II.3.1. the plant head (pre-treatment):

II.3.1.1. Screening:

In the field of water engineering, screening refers to a pre-treatment stage designed to capture coarse debris prior to more detailed or biological treatments. It is a fundamental process in urban or industrial wastewater treatment plants, often categorized as mechanical ‘screening’.

Different types of screening and how they work:

The technical report on pre-treatment. ‘Simple or motorized screening’ refers to a mechanism where water passes through metal grids that retain heavy debris (plastics, fabrics, wood, etc.). In basic screening, the grids are cleaned manually using a rake or a pitchfork. In a motorized screening system, an automatic device (combs, rakes) regulary removes unwanted material from screen 1. These systems protect the pumps, pipes and downstream biological or physico-chemical stages [17].

Its position in the treatment chain: Screening is situated upstream of the treatment chain; it reduces the risks of clogging, mechanical wear and malfunction, whilst limiting the quantity of raw material to be treated subsequently. Screenings must subsequently be removed and treated (compaction, loading into skips, controlled disposal) [17].

II.3.1.2. Sand removal:

Sand removal is a method designed to remove sand and mineral particles of various shapes present in the effluent. The purpose of this operation is to protect pipes and pumps from corrosion, whilst preventing blockages in the pipes caused by the accumulation of deposits during treatment. The sand trap operates by passing water through a settling chamber at a speed of approximately 0.3 m/s, which facilitates the settling of a large proportion of the sand [18].

Depending on their mode of operation, there are two types of sand removal tanks: longitudinal and circular sand separators [18].

II.3.1.3. Oil removal:

The aim of degreasing is to remove grease from the wastewater, as this can hinder the effectiveness of subsequent biological treatment processes. The degreasing process is carried out by flotation. The introduction of air at the bottom of the structure facilitates the rise of fatty matter to the surface. The grease is scraped from the surface and then stored prior to disposal [17].

II.4. Primary treatment:

This generally consists of sedimentation, which facilitates subsequent biological or chemical treatments by removing a portion of the suspended solids. The effectiveness of the treatment depends on the retention time and the rise velocity (which contrasts with sedimentation). Primary settling, with a rise rate of 1.2 m/h, is capable of removing between 40 and 60% of suspended solids, which corresponds to the removal of 10 to 30% of viruses, between 50 and 90% of helminthes and less than 50% of protozoan cysts [17],
using physical or physico-chemical methods designed for the advanced settling of suspended solids in water. A distinction is made between:

II.4.1. Physical (static) settling

Suspended particles, which are generally rich in organic matter (70 to 90%) and have a density slightly greater than that of water, will naturally separate in a primary clarifier within one to two hours. The water thus treated will overflow, and the solid suspended matter that has settled at the bottom of the tank (primary sludge) will be extracted and sent to the sludge treatment facilities [17].

II.4.2. Physico-chemical sedimentation

the performance of the settling process can thus be improved by adding chemicals (such as Aluminum sulphite, ferric chloride, etc.) Which neutralize charged particles, thereby increasing the likelihood of collision between particles (coagulation-flocculation), as well as the subsequent formation of easily settable flocs? This stage removes 90% of colloidal substances [17].

II.5. Biological treatment:

Biological wastewater treatment is an environmentally friendly and effective method aimed at purifying water using natural processes. This technique aims to convert suspended and dissolved organic pollutants into biomass and emitted gases (such as CO_2, CH_4, N_2 and SO_2), which can be separated from the water during treatment.
These gases can subsequently be removed from the treated water, thereby ensuring purer and less

contaminated water. Furthermore, the process is designed to break down pollutants dissolved in the effluent through the action of microorganisms. These microorganisms then utilize these materials for their survival and reproduction, using the pollutants as nutrient sources [20].

It is essential to understand what the acronym MBBR stands for. It stands for Moving Bed Biofilm Reactor. It is a biological treatment method using a modular system based on attached cultures. Thus, we will break down this process in the same way as our digestive system, to act gradually on the water to be treated. These stages include:

-The denitrification process,

-carbon removal [20].

II.5.1. Extensive methods:

There are two methods, which are:

II.5.1.1. Constructed wetlands

a) Natural lagooning:

Treatment is carried out via a long retention time in several watertight tanks arranged in sequence. The most common configuration generally comprises three tanks. However, the use of a configuration comprising 4 or even 6 tanks ensures more thorough disinfection. Photosynthesis is the fundamental process on which natural lagooning is based. The upper layer of water in the basins is exposed to light. This encourages the growth of algae, which generate the oxygen essential for the proliferation and survival of aerobic bacteria. The decomposition of organic matter is carried out by the bacteria.

Algae can reproduce thanks to the carbon dioxide produced by the bacteria, as well as the mineral salts present in the wastewater. We therefore observe the proliferation of two interdependent populations: bacteria and planktonic algae, also known as ‘microphysics. This cycle is self-sustaining as long as the system has a supply of solar energy and organic matter [21].

b) Aerated lagooning:

In aerated lagooning, oxygenation is provided mechanically by a surface aerator or by air injection. This principle differs from activated sludge only in the absence of a continuous sludge recycling or extraction system. The energy consumed by the two methods is comparable at equivalent capacity (1.8 to 2 kW/kg BOD_5removed) [21].

II.5.2. Intensive methods:

They are defined by two methods:

II.5.2.1. Bacterial filters (fixed-bed system):

A bacterial bed, also known as a bacterial culture bed or trickling filter, is a biological wastewater treatment process based on a fixed culture of microorganisms. These form a biological film on a porous granular support – such as pozzolan or plastic materials – which is periodically irrigated with the pre-settled effluent. Air circulation, whether natural or assisted by forced ventilation, ensures an aerobic environment conducive to the assimilation of the organic load, regulated in particular by the biochemical oxygen demand (BOD [28]).

II.5.2.2. Fixed-bed culture (biological disc):

Fixed-bed culture using biological discs relies on rotating discs partially submerged in the settled effluent, which act as supports for bacterial biofilms. The slow rotation of these discs alternately exposes the biofilm to water and air, thereby ensuring effective aerobic treatment thanks to a considerable exchange surface area. More compact than conventional bacterial beds, this process is effectively used to improve effluent quality, despite historical mechanical constraints [25].

II.5.2.3. Activated sludge process

All current wastewater treatment technologies result in the indirect production of sludge. The increase in the number of treatment plants within urban areas and the introduction of increasingly stringent environmental regulations are therefore leading to a rise in sludge production.

Due to environmental constraints and the associated costs, sludge treatment has now become as essential a necessity as wastewater treatment [28].

a) Sludge management:

Wastewater treatment inevitably generates residues in the form of sludge, resulting from the removal of pollutants. An efficient treatment plant effectively transfers pollution from the water into this sludge, which consists mainly of suspended solids, organic matter, nitrogen, phosphorus and other contaminants. Without regular removal of sludge from sedimentation tanks, aeration tanks and clarifiers, gradual accumulation compromises the operation of the facilities.

b) Sources of municipal sludge

- Primary sludge: Resulting from the primary settling of wastewater, this sludge traps the densest suspended solids by natural gravity. It consists mainly of inert solid residues and raw organic matter, such as fats and mineral sediments [30].
- Biological sludge: Originating from secondary treatment (activated sludge), this sludge results from microbial growth in aeration tanks, where it breaks down dissolved organic pollutants. Consisting mainly of bacterial biomass and metabolic by-products, it has a high content of volatile organic matter.

c) Properties of sludge:

Urban sewage sludge is characterized by a very high moisture content (generally over 95%), a high proportion of volatile organic matter (between 40 and 70% of its dry weight), and a significant nutrient content, particularly nitrogen (2–5%) and phosphorus (1–3%). Their composition varies depending on their origin (primary, physico-chemical or biological), with initial dry matter contents generally ranging from 1 to 10%. These characteristics determine the methods used for their treatment, stabilization and recovery.

- Sludge dryness: Dryness refers to the proportion of dry matter, expressed as a percentage of total weight, following the partial or total removal of water.

It characterizes the physical condition of the sludge: fluid (less than 6%), paste-like (between 6% and 30%) or dry (more than 85% after heat drying). High dry matter content facilitates storage, transport and recovery (composting or incineration), despite the significant energy costs of the dewatering and drying processes.

- Dry Matter (DM) Content
  we refer to sludge with a dry matter (DM) concentration of 20 g/L. It is generally accepted that one litre of sludge weighs approximately one kilogram (1,000 grams).
  Thus, there are 20 g of solids in one litre of sludge, or 1,000 g of sludge.
- Volatile suspended solids (VSS) content**:** Volatile suspended solids (VSS), which represent the volatile organic fraction of suspended solids (SS), refer to the biodegradable portion of the dry solids present in sludge, determined by calcination at 550 °C following prior drying at 105 °C. This index illustrates the consistency of the sludge: high percentages (generally between 40–70% for municipal sludge) indicate a high content of readily fermentable organic compounds, which are conducive to mechanization but may generate odours and rapid decomposition. In biological sludge, VOS predominate (60–80%), in contrast to primary sludge, which is more mineral in composition (30–50%) [28].

C. 4. Operational settings for activated sludge plants

- **Sludge age:** This is the ratio of the mass of sludge in the aeration tank to the daily quantity of sludge removed from the plant [4]. The average length of time that microorganisms remain in the biological treatment system is also known as sludge age, or solids retention time (SRT). It is the ratio of the total mass of sludge in the reactor to the mass of sludge removed each day.
- **Mass load (Cm):** The mass load corresponds to the quantity of BOD_5 applied daily per kilogram of volatile suspended solids (VSS) present in the system. It has several significant effects on the overall performance of the plant, on the VSS content of the sludge, and on the age of the bacterial culture [29].
- **Mohlman Index**: The Mohlman Index (MI), also known as the Sludge Volume Index (SVI), is used to assess the ability of activated sludge to settle in wastewater treatment plants. It is the volume (in milliliters) occupied by one gram of suspended solids (SS) after 30 minutes of static settling in a one-litre test tube [23]**.**

II.5.3. Factors influencing activated sludge tanks:

Several factors determine the efficiency of anaerobic digestion:

- **Temperature**: Temperature directly influences the metabolic activity of microorganisms in the aeration tanks of activated sludge systems.

The ideal range, between 20 and 30 °C, promotes optimal performance of heterotrophic and nitrifying bacteria in the breakdown of BOD and nitrogen.

- **pH:**

Secondary treatment tolerates a pH range of 5 to 9, with an ideal bacterial zone between 6 and 8.

- **Retention time**

The sludge retention time is determined by the operational capacity of the digester. It is measured in kilograms of VSS (volatile suspended solids) of sludge introduced per day, and also in cubic metres, whilst taking into account the temperature of the sludge mass [17].

II.6. the secondary clarifier:

The sludge separation process takes place in a secondary clarifier. The separation of treated water and sludge occurs through gravitational settling. The settled sludge is recovered and returned to the aeration tank. To maintain a stable biomass level, the excess biomass produced is generally discharged at the outlet of the clarifier. Before disposal, this biological sludge may undergo reduction and/or stabilization processes. Section 1 deals in depth with the secondary clarifier [18].

II.7. Tertiary treatment:

It is the tertiary treatment that aims to remove stubborn and persistent pollutants following the primary and secondary stages of wastewater treatment.
It employs techniques such as denitrification, dephosphatisation, fine filtration, adsorption and disinfection (via UV, Ozonation or chlorination), thereby ensuring compliance with strict environmental criteria for the discharge or reuse of effluent.

II.7.1. Phosphate removal

the application of biological or physico-chemical treatments significantly enhances the agricultural ‘value’ of the sludge, whose phosphorus concentration is three times higher than that of sludge from a conventional treatment plant.

The physico-chemical approach involves the chemical removal of phosphates by adding a reagent, resulting in the formation of a complex precipitate that is insoluble. This method is particularly suitable for small-scale facilities [23].
Metal salts and/or lime are mainly used as reagents.
Fe $(_{SO_4})$: iron sulphite, Al_2 $(_{SO_4})$: aluminum sulphite, $FeCl_3$: ferric chloride, FeCl $(_{SO_4})$: ferric chlorosulphate, Ca $(OH)_2$: lime.
The methods used are divided into three groups depending on where the reagent is introduced into the system:
- Primary precipitation
- Real-time precipitation (activated sludge)
- Tertiary precipitation [22].

II.7.2 Removal of nitrogenous substances:

In order to comply with discharge standards in sensitive areas, it is necessary to adopt supplementary or tertiary treatments. Nitrogen removal is generally carried out by biological processes such as nitrification-denitrification, or by ion exchange [12].

II.7. 2.1. Assimilation:

Assimilation refers to the cellular synthesis of bacteria during the removal of carbon-based pollution by biological treatment, a process that mobilizes nitrogen.

When microorganisms cease their biological activity, the lysis of bacterial membranes releases hydrolyzed organic matter rich in carbon and nitrogen – the predominant components. It is mainly heterotrophic biomass that generates these mineral elements, the quantities of which are proportional to its concentration [30].

II.7. 2.2. Nitrification:

This involves the oxidation of ammonia into nitrite, then into nitrate by nitrifying bacteria. Ammonia is toxic to aquatic life. Nitrifying bacteria are autotrophic, meaning they assimilate the carbon necessary for their growth from CO_2in the air. Consequently, their growth is much slower than that of heterotrophs. Before nitrification can take place, a wastewater treatment plant must first remove organic compounds [24].

II.7. 2.3. Denitrification:

Denitrification refers to the biological conversion of nitrates into nitrogen by bacteria. *Pseudomonas stutzeri* was selected to represent a denitrifying population in a wastewater treatment process. The process takes place in two stages: the conversion of nitrates (NO_3^-) to nitrites, followed by the conversion of nitrites (NO_2^+) to nitrogen (N_2). The study focused on the kinetics of nitrate reduction and the simultaneous reduction of nitrates and [25].

II.7. 3. Disinfection:

In addition to conventional disinfection techniques used in traditional treatment, such as chlorination or UV exposure, more rigorous approaches, such as membrane disinfection, advanced chlorination or irradiation with high-intensity UV light may prove essential to ensure the effective removal of pathogens and microorganisms [23].

II.7. 4. Ozone:

Ozone is generated by passing an electric current through oxygen. It interacts with reducing mineral compounds, organic matter and microorganisms. It facilitates the removal of 90% of color, reduces COD by 20%, and helps to revitalize the environment. This eliminates bacteria, viruses and protozoa. It is the only method that is truly effective against viruses.

II.7.5. Ultraviolet treatment:

UV systems eliminate microorganisms, such as bacteria, viruses and parasites capable of triggering epidemics, by rendering them inactive.

Within the vast spectrum of electromagnetic radiation, the effectiveness of

, the use of UV-C rays (200 to 280 nm) to neutralize these microorganisms has been proven. These rays damage nucleic acids (DNA or RNA) and halt the reproduction of these organisms.

The germicidal efficacy of UV systems is influenced by various parameters: the quality and flow rate of the water to be treated, as well as the amount of UV radiation applied. The amount depends on the UV intensity produced by the system and the duration of exposure within the reactor [22].

II.7.6 Filtration:

The use of more advanced filtration technologies, such as microfiltration or ultrafiltration, offers the possibility of removing suspended particles, organic matter and certain chemical pollutants from treated wastewater [23].

The use of semi-permeable membranes for the separation of salts and molecules represents an alternative solution for the disposal of effluents from meat processing, where the treated water is intended for reuse. Various membrane purification techniques, such as nanofiltration (NF) and reverse osmosis (RO), achieve separation rates exceeding 90% for the removal of salts, organic substances and infectious agents. One of the issues to consider in membrane-based processes is membrane fouling during wastewater treatment, given that an appropriate protocol for pre-treatment, maintenance and membrane replacement is essential to ensure the process's effectiveness [23].

II.8. Sludge treatment:

Sludge treatment is a crucial process in wastewater treatment plants, aimed at reducing sludge volume, stabilizing its fermentable organic fraction and facilitating its recovery for use in agriculture or energy production [32].

II.8.1. Sludge thickening:

Thickening is the initial stage in the densification of sludge from wastewater treatment plants, increasing its dry matter content from 1–4% to 6–10%. It utilizes gravitational (static settling) or mechanical (flotation, centrifugation) processes, effectively preparing the

Subsequent stages of stabilization and dewatering. This operation reduces the volumes to be managed, improves economic performance and limits the risks of residual pollution [26].

II.8.1.1. Thickening by settling (static thickening)

Static thickening is based on a simple principle: allowing sludge to settle naturally under the force of gravity. This is known as piston settling, as the sludge gradually sinks to the bottom of the tank, forming a compact mass. This process is aided by a slow-rotating rake. By gently agitating the sludge, it allows the particles to rub against one another, which promotes the flow of water trapped between them and the release of trapped gases. As a result, the sludge settles more effectively and its volume is significantly reduced.

II.8.1.2. Dynamic thickening

Unlike the static method, dynamic thickening uses an active mechanism to accelerate the separation of water and solids. Concentration is achieved by applying mechanical energy.

The main processes include:

- Flotation
- Dewatering or filtration;
- Centrifugation.

It is not unusual to use both methods together in the same plant to maximize the concentration of the final mixture. Depending on the constraints of the downstream process, it is often beneficial to remove coarse, filamentous and fibrous materials. It is at this stage of thickening that screening, de-gritting, screen press and similar equipment may be employed [26].

- ✓ **Thickening by flotation**

In this process, the aim is to cause solid particles to rise to the surface rather than allowing them to settle. To achieve this, fine air bubbles are injected, which attach themselves to the sludge particles. By adhering to them, these bubbles reduce their bulk density, causing them to rise. The rate of ascent depends on the flow conditions (particularly in laminar flow) and can be described by Stokes' law. Once at the surface, the thickened sludge is recovered, whilst the clarified water remains below [20].

- ✓ **Thickening by dewatering:**

Various pieces of equipment can be used (drums, filter bags, dewatering screens). However, the dewatering screen stands out for its combination of ease of use and reliability. This equipment, which operates continuously, is positioned directly at the outlet of the fresh sludge feed pump. The horizontal field of fine screens, constantly scraped by rubber blades, receives the sludge that has been flocculated with a synthetic polymer and then dispersed. e sludge accumulation gradually increases as it moves along the screen field, and the adjustment is ideal when the sludge contains no free water at the end of the run [20].

- ✓ **Centrifugal thickening:**

Sludge thickening by centrifugation is an effective technique, although it involves a significant financial investment as well as relatively high operating costs. Despite this, it remains widely used due to its performance and operational advantages. As the system is fully enclosed, odour emissions are greatly reduced, which improves operating conditions. Furthermore, its compact footprint is a major advantage in plants where space is limited.

The operating principle is based on accelerated settling driven by centrifugal force. Under the effect of high-speed rotation, the denser solid particles are flung outwards, whilst the liquid phase is separated. This mechanism generally achieves a higher degree of thickening than that obtained by flotation [20].

a) Sludge stabilization:

The aim of stabilization is to prevent further fermentation of the sludge, which could cause unpleasant odours. At the same time, the level of pathogens is reduced to varying degrees depending on the type of treatment applied [27].

b) Dewatering:

Following the thickening processes, the sludge is often subjected to mechanical dewatering, which helps to increase its dry matter content, which can range from 16 to 35% [26].

Once this stage is complete, various thermal treatments can be carried out depending on the objectives; These may aim either to refine the drying process in order to further minimize the sludge's water content, or to induce partial or complete oxidation of the organic matter, as occurs during combustion, gasification, thermalizes or pyrolysis, without causing major changes to the mineral fraction. In certain situations, a more intense heating pro s applied to convert the mineral fraction of the sludge and induce changes in its mineralogical composition [26].

c) Sludge incineration:

Regardless of the system used, it is generally very difficult to dispose of this sludge. Sludge removed by dredging or other means from septic tanks is odorless and can be easily left to settle or dry on the ground; it does not decompose and takes on the appearance of spongy peat within a few days. However, this is not the case for sludge from separators or decanters that has not undergone septic fermentation. This sludge gives off a strong odour, is extremely putrid and may be hazardous to handle. It is crucial to remove them as quickly as possible using mechanical methods and to dispose of them on site before they have had time to ferment [28].

To prevent the fermentation of sludge from wastewater treatment, it is recommended that it be disposed of promptly. One of the most effective methods, both from a health and economic perspective, is to incinerate it in furnaces specifically designed for waste combustion, similar to those used for household waste. Several types of incinerator have been developed, notably the Horsfall system, which allows sludge to be burned with very low fuel consumption [28].

The equipment also allows the heat produced during combustion to be recovered to generate steam, electricity or compressed air, which can be used to power pumps, lighting

Generators and other machinery in wastewater treatment plants. The solid residues from this combustion form slag that can be reused in various applications, notably for maintaining bacterial beds or for manufacturing building materials such as bricks and slabs [28].

Conclusion:

In conclusion, this chapter suggests that activated sludge technology constitutes an optimal and sustainable solution for the removal of organic matter thanks to its microbiological activity. However, the success of the process remains dependent on precise control of operational parameters such as temperature, dissolved oxygen and pH. A thorough theoretical understanding of these mechanisms paves the way for the analysis of the laboratory results presented in the following chapter.

CHAPTRE III

The Mostaganem Wastewater Treatment Plant

III.1. Description of the Mostaganem Wastewater Treatment Plant:

The treatment plant is situated to the west of the town of Mostaganem, between Salamander and Sablette, bordered to the north by the Mediterranean Sea. It came into operation in March 2017.
The Mostaganem wastewater treatment plant is designed to treat a volume of 56,000 m^3 of wastewater per day from the town's various discharge points, namely Stidia, Hassi Mamache, Ouréah, Mazagran, Mostaganem, Khair-Eddine, Sayada and Ain Boudinar, serving a population of 35,000, with the potential for expansion until 2030.
The plant is a biological, activated sludge plant with a medium load.
The plant's main objectives are to collect and treat domestic wastewater, primarily with a view to conserving resources, protecting seawater and recycling waste.

The plant operates fully automatically 24 hours a day, 7 days a week, with a full team working 8 hours a day, 5 days a week.

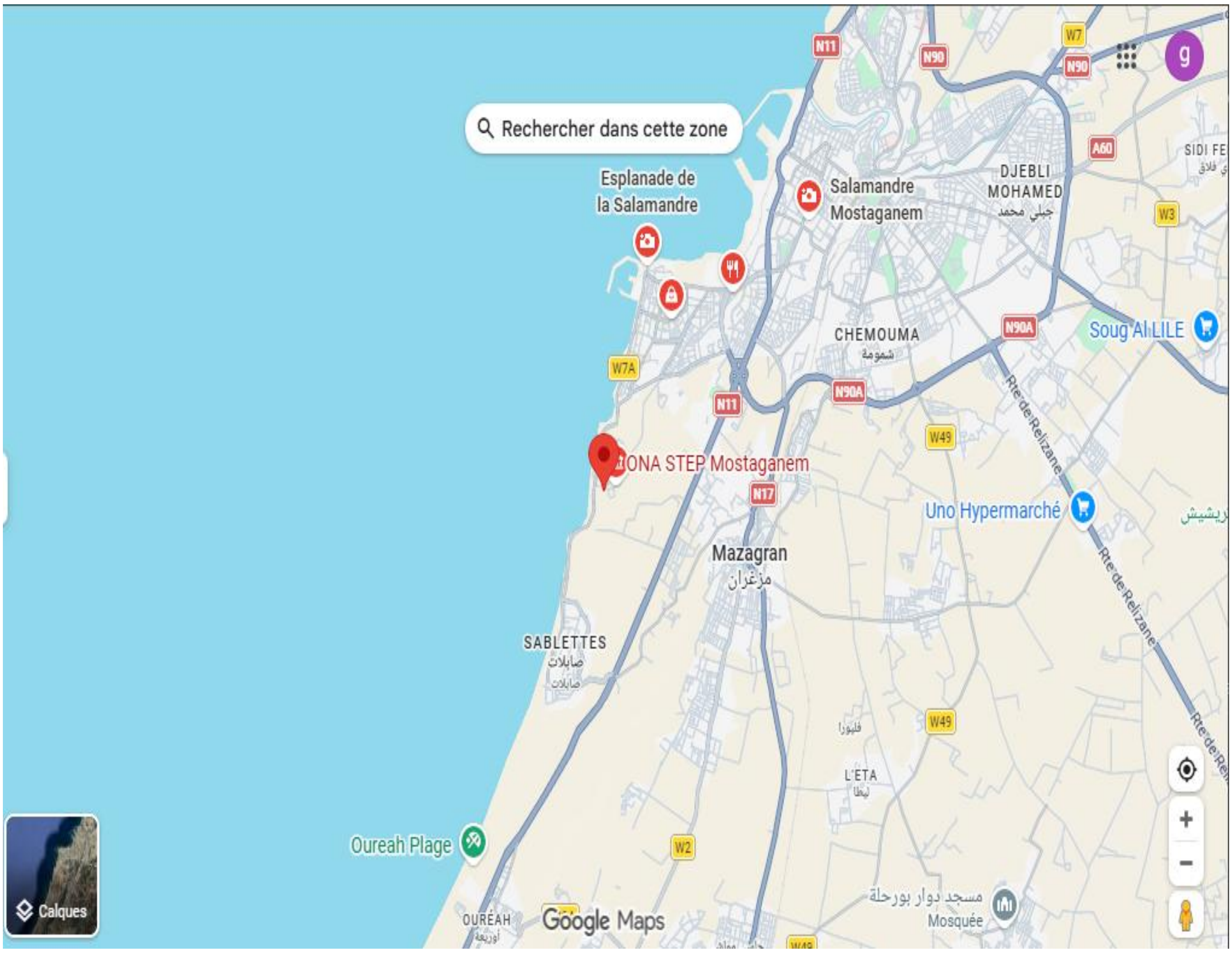


Figure III.01: Map showing the location of the Mostaganem WWTP

Table III.1. Technical specifications of the Mostaganem wastewater treatment plant:

Cost	540 million DA
Start date of Works	Novembre 2014
Commissioning date	March 2017
Contracter	STULZPLANAQUA/ETUHPMENANI/BUTEC (Germany, Algeria, Lebanon)
Principale	Medium-load biological treatment with aerobic sludge stabilization
Discharge standards	COD <= 90 mg_{O_2}/L; SS <= 30 mg/L; BOD_5<= 30 mg/L

Table III.2. Capacity of the Mostaganem wastewater treatment plant:

Timeframe	to 2030
Population	350,000 E-H
Daily flow	56,000 m^3/day
Type of water	Domestic
Average dry season flow	2,334 m^3 /day
Peak dry flow	3,735 m^3/day
Maximum flow rate, permitted during rainfall	5,600 m^3/day

III.2. Necessity and objective of wastewater treatment:

Wastewater treatment is now essential for health, economic and legal reasons, and to protect the environment.

For these reasons, humans have developed treatment methods aimed at removing dissolved and suspended organic matter, as well as reducing or eliminating microbes, particularly pathogenic microorganisms [3].

III.3. Principle of wastewater treatment:

Wastewater treatment follows the same principle as natural purification. The aim is to remove pollutants and return water to the natural environment which, although not pure, poses the least possible risk. Treatment methods therefore essentially consist of separation techniques, whether physical, chemical or biological, accompanied by the necessary modifications to facilitate this separation [16].

Figure III.02: Satellite view of the WWTP (Google Earth)

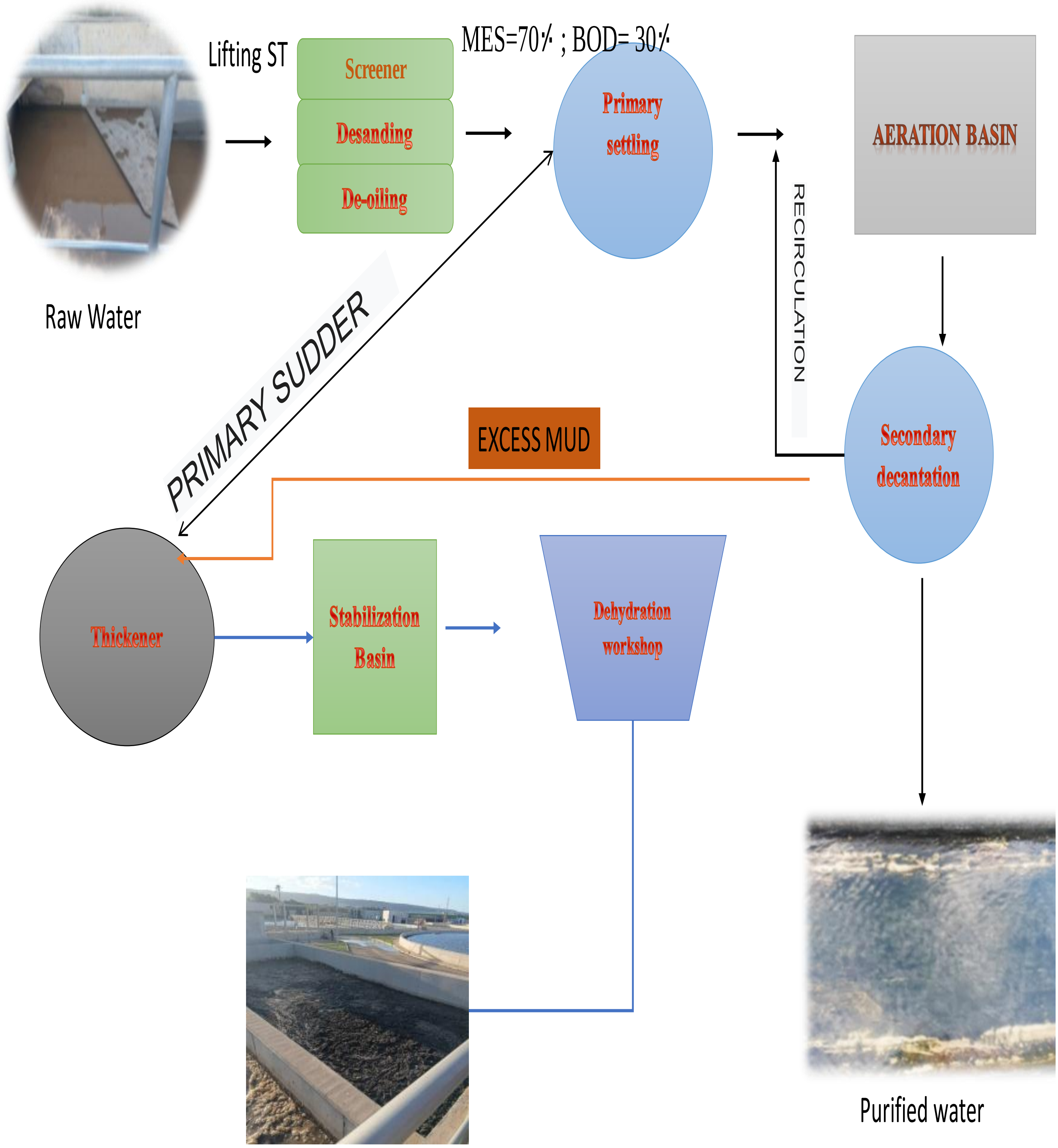


Figure III.03: Complete treatment process at the Mostaganem WWTP

III.4. Wastewater treatment processes

III.4.1. Pre-treatment:

- **Storm water overflow:**

This facility allows for the supply of water via gravity flow [31] at a maximum flow rate of 2, 334m³/h, and any excess (in the event of withdrawal) will be discharged into the storm water basin, which has a diameter of 80 m.

.

Figure III.04: Storm overflow

- **Screening:**

Removal of bulky waste by a coarse screen. It is a vertical bar screen,

With a flow velocity through the channel and across the screen of 0.3–0.8 m/s and 0.5–1 m/s

Respectively. A fine screening flow rate of 5,600 m^3/h, with a power rating of 1.5 kW.

Table III.3: Dimensions of the coarse and fine screening

	Coarse	Fine
Spacing	40	8
thickness	10	5
Channel width	1.5	2
Angle	90°	90°

-

Figure III.05: Coarse screen

- **Sand removal and oil removal**

- Sand removal:

The pre-treatment is designed to remove:

-coarse solids;

-particles >1 cm;

-sand.

The purpose of desanding is to remove heavy inorganic materials, which settle easily, from wastewater in order to prevent damage to mechanical equipment or sedimentation in downstream installations [28].

- Oil removal:

The objective of oil removal is to remove water from oils to prevent any disruption to the operation of treatment facilities. These substances, which have a density of less than 1, float to the surface and are then skimmed off [3].

Table III.3: Characteristics of the desalted/de-oiler

Parameters	Value
Length (m)	50
Width of the desanding channel (m)	3
Useful water Head (m)	4
Surface area (m^2)	150
Total unit volume (m^3)	5600
Minimum residence time (min)	6

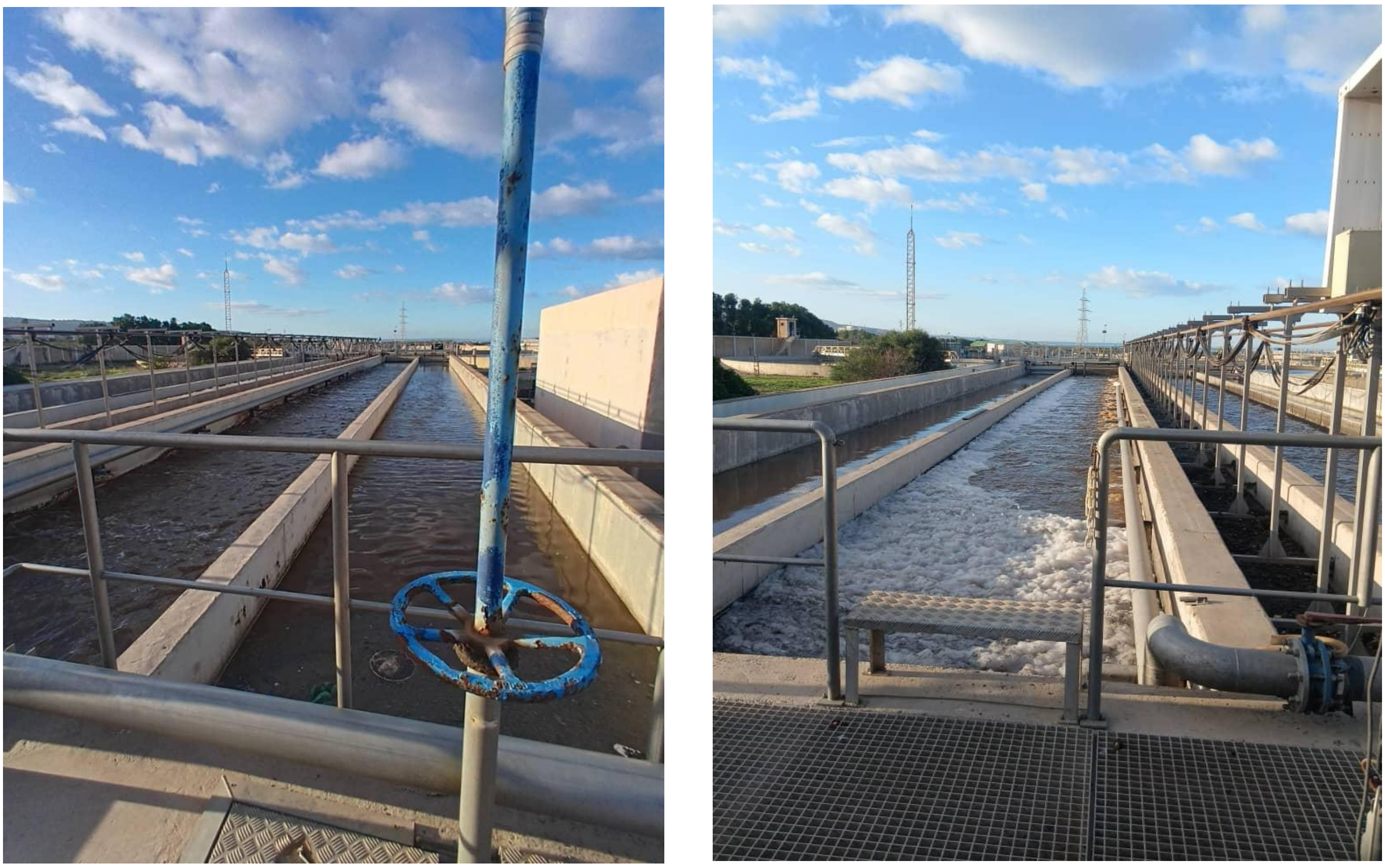


Figure III.06: Desanding and De-oiling

III.4.2. Primary treatment:

This involves sedimentation, usually without prior chemical coagulation, aimed at removing organic matter that can be separated by sedimentation [4].

- **Primary settling tank:**

Circular in shape, its total volume is3,267 m^3, with a diameter of 46 m. The effective water depth is 2.6 m, and the surface area is2490 m².

Figure III.06: Primary clarifier

III.4.3. Secondary treatment (Biological treatment):

Biological reactors, known as 'tanks', are places where organic matter is transformed by anaerobic microorganisms. These tanks form a fundamental component of the 'activated sludge' process [33].

- **The aeration tank:**

A treatment tank equipped with a device for injecting air or oxygen into the water, with the aim of facilitating the aerobic degradation of organic matter [33].

Table III.04: Characteristics of the aeration tank

Number of storms	2	
Basin dimensions	Length	50.3 m
	width	34.2 m
	Height	3.9 m
	volume	13'600 m^3
Average length of stay	4 hours	
Age of sludge	5 days	

Figure III.07: Biological tank (Aeration tank)

- **Secondary clarifiers:**

Used in activated sludge treatment plants to separate treated water from biomass. The sludge settles at the bottom of the tank and is collected by a scraper. The supernatant, or treated effluent, is discharged into the natural environment [34].

Table IV III.5: Dimensions of the clarifier

Diameter (m)	46
Height (m)	2.82
Volume (m^3)	3735
Number of clarifiers	2

Figure III.08: Secondary clarifiers

- **Chlorine disinfection:**

It can be used to inactivate most microorganisms [2]. The disinfection tank has a volume of 1,867 m^3, is 55 m long, 22 m wide and 1.8 m high.

Figure III.09: Disinfection tank

III.4.4. Sludge treatment:

Sludge treatment comprises the following main stages:

- Thickening,
- Stabilization,
- Dehydration.

The aim of all these operations is to remove the pollutants contained in the sludge and reduce its volume with a view to subsequent recovery or disposal. The various techniques are summarized as follows:

- **Sludge thickening:**

Thickening is the first stage of sludge treatment. It serves to increase the volume of
, using little energy. Two thickening techniques are possible [36].
The thickener has a capacity of 2,155m³/day, with a depth of 54 m and a diameter of 30 m
And a power rating of 0.45 kW.

Table III.6: Sludge flow rates and concentrations

	Primary sludge	concentration	Biological sludge	concentration	Mixed sludge	concentration
Pre-thickening	735 m^3/day	20 kg $_{SS}$/m^3	1’420 m^3/day	8.8 kg $_{SS}$/m^3	2’155 m^3/day	12.6 kg $_{SS}$/m^3
After thickening	294 m^3/day	50 kg $_{SS}$/m^3	625 m^3/day	20 kg $_{SS}$/m^3	919 m^3/day	29.6 kg $_{SS}$/m^3

- **Sludge stabilisation Treatment:**

Dehydration is the second stage in reducing the volume of thickened sludge

To reduce their fermentable organic load or pathogenic microorganisms [37].

Figure III.10: Stabilization tank

III.4.5. Sludge conditioning:

The aim of sludge conditioning is to reduce the volume to be treated by removing the liquids present in the sludge, thereby transforming it into a more solid form [37]. Conditioning processes help to optimize the efficiency of the sludge dewatering process.

➢ Dehydration:

The principle of sludge dewatering is to reduce the water content of the sludge, generally to between 80% and 90%. This helps to reduce the volume of the sludge, thereby making its management and disposal easier [38].

Figure III.11: Dewatering section

Figure III.12: Storage of dewatered sludge

III.4.6. Sludge disposal:

Once treated, sludge can be put to beneficial uses, such as agricultural land application or compost production. If it cannot be reused, it can be disposed of appropriately [38].

CHAPTER IV

MATERIALS AND METHODS

IV.1. Introductory overview:

To identify the specific parameters required to assess the level of pollution at each stage of the treatment process, a series of analyses was carried out as part of this study.

Samples were taken at the inlet (raw water) and outlet (treated water) of the wastewater treatment plant. We took the following parameters into account: pH, temperature, suspended solids (SS), biochemical oxygen demand (BOD_5); chemical oxygen demand (COD), as well as total nitrogen and ammonia nitrogen. Further tests were also carried out to verify the operational parameters of the process during this period.

Sampling included the following elements: mass load, volume load, sludge concentration in the aeration tank, sludge age and water retention time in the aeration tank.

Figure IV. 01: Mostaganem WWTP laboratory

Table IV.01. Pollutant load of raw wastewater

Parametre	Load		concentration	
COD	47 250	kg/day	843.8	mg/L
BOD_5	19 600	kg/day	350.0	mg/L
SS	24 500	kg/day	437.5	mg/L
NTK	3500	kg/day	62.5	mg/L
TOTAL P	880	kg/day	15.7	mg/L

Table IV.02. Quality of treated water and removal efficiency

Parametre	Unit	Concentration	Minimum removal efficiency in ٪
COD	mg/L	≤90	≥80
BOD5	mg/L	≤30	≥90
SS	mg/L	≤30	≥90

IV.1.4. the purpose of the analyses:

Analysing wastewater parameters makes it possible to verify that the objectives of the water treatment process are being met:

- To protect the ecological health of the receiving environment
- To protect the public health of populations coming into contact with Effluents
- To correctly size a wastewater treatment plant (WWTP),
- To monitor the effectiveness of the treatments applied,
- To reduce the environmental impact of discharges

IV.2. Physico-chemical analysis:

- **Temperature:**

Objective

The objective of this procedure is to monitor the effectiveness of the treatment and control biological processes.

• The Principle:

This involves using a sensor (thermometer or probe) that detects changes in water temperature and converts them into a measurable value.

✓ **Experimental procedure:**

- Switch on the digital thermometer and check that it is working properly

- Immerse the probe in the water without touching the sides

-Wait a few seconds until the reading stabilises

- Note down the temperature displayed.

NOTE:

Rinse the probe after each measurement

Figure IV.02: Thermometer

➢ Hydrogen ion concentration (pH):

objective:

To determine the acidity or alkalinity of the water in order to monitor quality and efficiency at every stage of the treatment process.

• The principle:

pH measurement relies on a probe (glass and reference electrodes) that detects the concentration of H^+ ions in the water.

✓ Experimental procedure:

-Take approximately 100 ml of water to be analysed

-Set the stirrer to low speed

-Immerse the electrode in the beaker

-Allow the solution to stabilise for a moment with the stirrer on low speed, and then record the pH

Figure IV .03: pH metre

➢ Conductivity:

Objective:

To assess the amount of dissolved mineral salts in the water.

• The Principle:

This is based on the use of a probe that applies an electric current to the water and measures its ability to conduct it.

✓ Experimental procedure:

-take approximately 100 ml of water to be analysed

-dip the electrode into the beaker

-allow it to stabilise for a moment, and then record the conductivity value

.

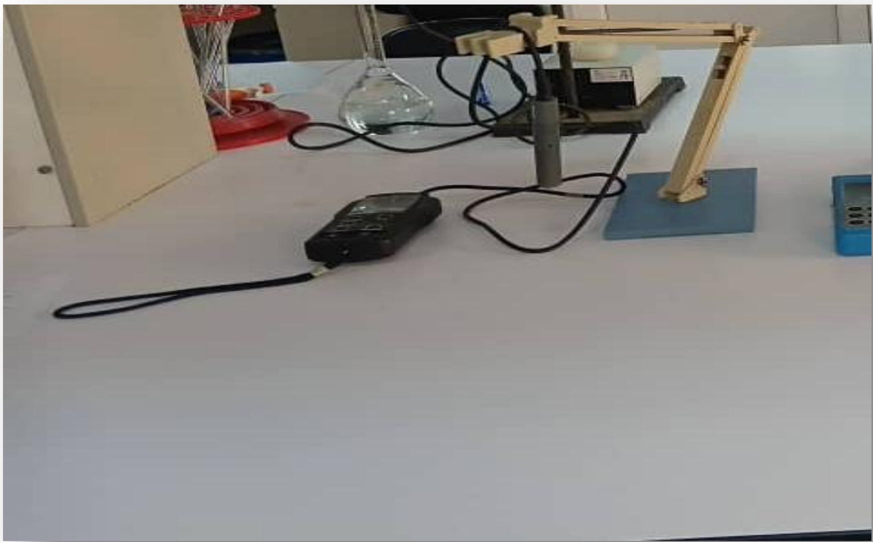


Figure IV.04: Conductivity meter

➢ Dissolved oxygen:

Objective:

To monitor water quality and check whether it contains sufficient oxygen to support aquatic life (particularly microorganisms) in the ponds.

• The Principle:

This is based on the use of an (electrochemical) probe that detects the amount of oxygen present.

✓ Experimental procedure:

- to approximately 100 ml of water for analysis,

-Place the electrode in the beaker.

-Allow the reading to stabilise, and then record the dissolved oxygen value

Figure IV.05: The Oximeter

➢ Chemical oxygen demand (COD):

Objective:

The aim of this protocol is to define the procedure for measuring chemical oxygen demand (COD).

. •The Principle:

The sample is heated for 2 hours in the presence of an oxidising agent (potassium dichromate). Ox disable organic compounds react with the dichromate ion to form green chromate ions.

• Apparatus:

• Reflux apparatus; this consists of a tube topped with a condenser

• Heating block

• Graduated burette

• REAGENTS:

Sulphuric acid (H_2SO_4)

Silver sulphate (Ag_2SO_4)

✓ Experimental procedure:

- Place 10 ml of sample in a test tube and add 5 ml of potassium dichromate,

- Add 15 ml of the sulphuric acid–silver sulphate mixture and a pinch of boiling regulator,

- Place the samples in a mineraliser at 150°C, wait 2 hours and make up to 100 ml with distilled water.

- Add a few drops of Ag_2SO_4 colour indicator,

- Titrate with Mohr’s salt until a colour change occurs (brick red).

NOTE:

WHEN THE COLOUR CHANGES, WE IMMEDIATELY TAKE THE VOLUME.

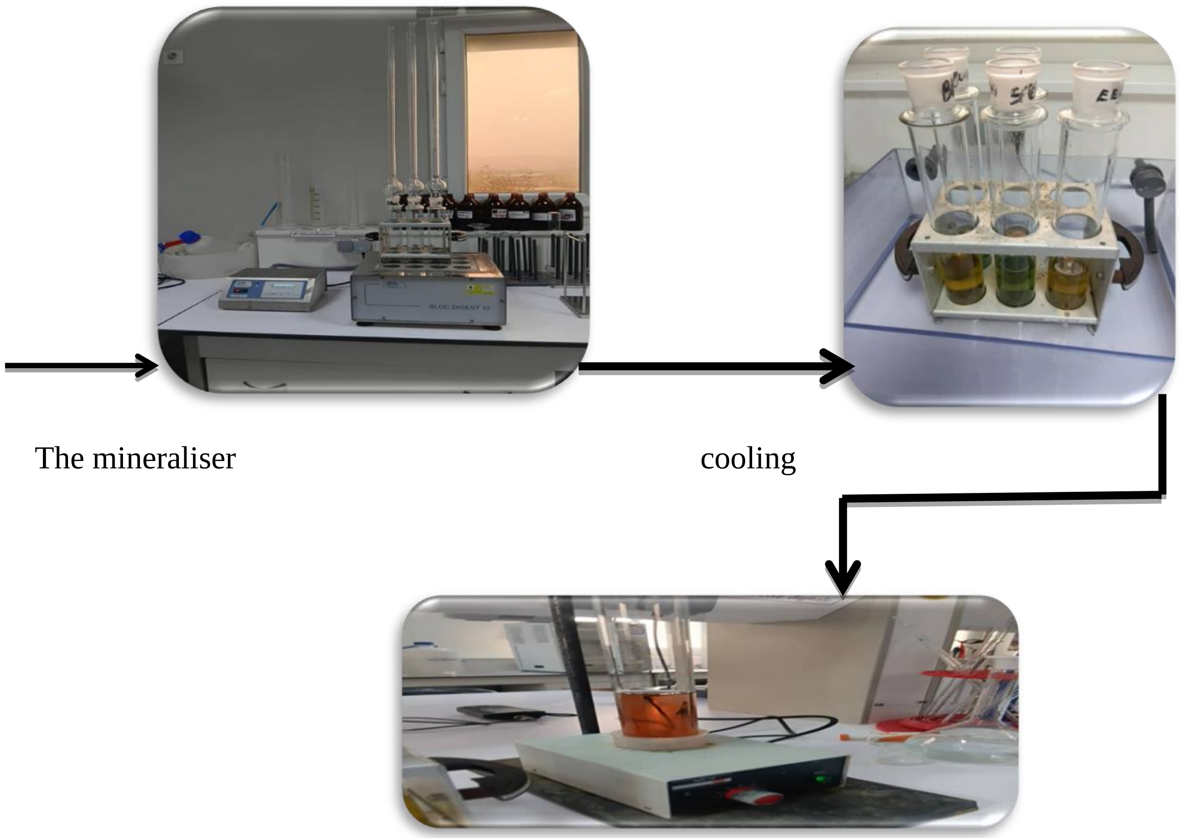
Presentation of results:

$$\textbf{Control} = \textbf{(2.4 / titration voltage)} \times \textbf{8000}$$

$$COD = (B_{BLANC} - V_{TITRAGE})/V_{ECHENT}) * CONTROL$$

- **Title verification:**

(90 ml of 4 M sulphuric acid) + 10 ml of potassium dichromate



➢ **Figure IV.06:** Steps for determining chemical oxygen demand (COD)

➢ Determining biochemical oxygen demand(BOD_5):

objective:

BOD_5 is used to assess the biodegradable organic pollutant load in water.

• The principle:

It is based on measuring the amount of dissolved oxygen consumed by microorganisms to break down the biodegradable organic matter present in the water, over a period of 5 days at 20°C, in the dark.

✓ Equipment:

-BOD5 Sensor bottle.

-Incubator

• REAGENTS:

Sodium hydroxide (NaOH) tablets.

✓ Experimental procedure:

-Rinse the 3 BOD5 bottles with the sample water,

-Add the sample volume to the bottles

♣ Add a denitrification inhibitor for treated water (to prevent algae growth),

-Place magnetic stir bars in the bottles,

-Insert the rubber funnel into the bottle neck,

-Place 4 sodium hydroxide (NaOH) tablets into the rubber cup using tweezers

-Place the bottles in a BOD5 incubator at 20°C for 5 days,

-Read the recorded BOD5 values after 5 days.

➢ Suspended solids (SS):

Objective:

To quantify the solid particles suspended (not dissolved) in water.

• The Principle:

This involves separating the suspended solid particles from the water using a centrifuge and filtration, then drying and weighing them to determine their quantity.

✓ Equipment:

-Precision electronic balance (STATORIUS, CP, 224S, OCE).

-Vacuum filters (BUCHNER).

-Drying oven (MEMMERT).

- The determination of suspended solids in water is carried out using a centrifuge:

✓ Experimental procedure:

❖ Using a centrifuge:

- Measure the weight of the empty capsule m0,

- Fill four tubes (40 ml of sample in each),

- Place the tubes in the centrifuge for 20 minutes,

- Measure the weight of the empty capsules.

- After 20 minutes, remove the tubes,

- Fill the capsules with a specific volume of water and measure the weight of the filled capsule,

- Place the capsules in an oven at 105°C for 8 hours and allow to cool in the desiccator

Then weigh the m2 capsule

-Place the capsules in a muffle furnace at 505°C, and then leave them to cool in the desiccator and measure the weight of the capsule per cubic metre,

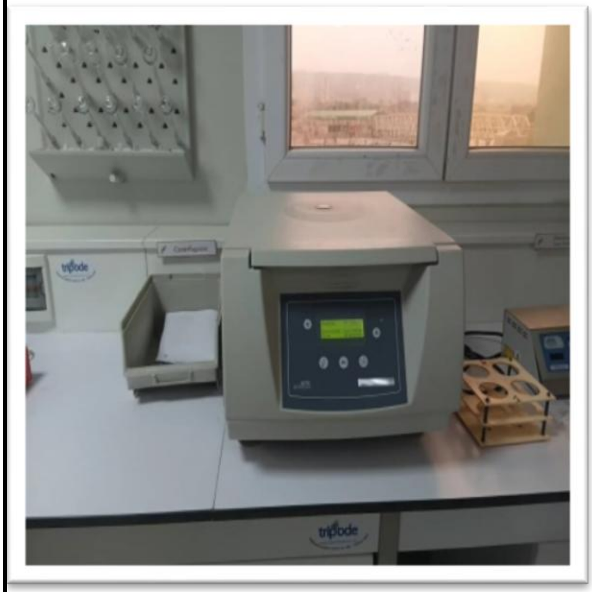


Figure IV.07: Centrifuge

Figure IV.08: The tubes

- **By filtration:**

- Weigh the filter (m0),

- Prepare and rinse the filters with distilled water to remove any dust, and then dry them

At 105°C for at least one hour,

- Allow them to cool in the desiccator, and then proceed with the filtration,

- Place the filter (smooth side down) on the filter holder,

- Shake the sample bottle,

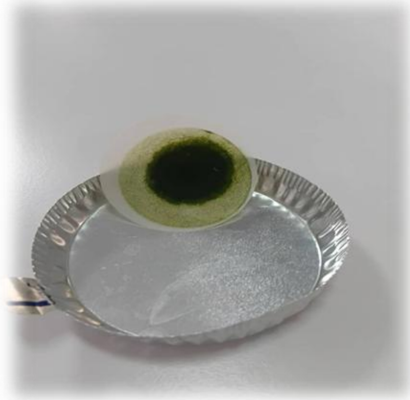
- Pour a suitable volume of the sample into the graduated cylinder, then filter,

- Release the vacuum when the filter paper is almost dry,

-Carefully remove the filter paper using flat-ended forceps,

-Place the filter on a drying stand (cap) and place it in an oven at 105°C for 2 hours,

-Place in the desiccator to cool and measure the new mass m1



Filtration

Cooling

➢ **Figure IV. 09:** Steps involved in determining suspended solids (SS)

➢ Reporting of results:

✓ The concentration of suspended solids in the water (mg/l) is given by the expression

SS (mg/l)= 1000*(m1- m0)/V

SS: suspended solids (mg/l)

. m0 = mass of the filter disc before use (mg)

m1 = mass of the filter disc after use (mg)

V = volume of the sample

➢ Settleable solids:

Objective:

To monitor settleable solids in water in order to assess the effectiveness of sedimentation.

✓ Experimental procedure:

- Fill the 1000 mL conical flasks with the sample (raw water and treated water),

- Leave to settle for 2 hours,

- Record the volume,

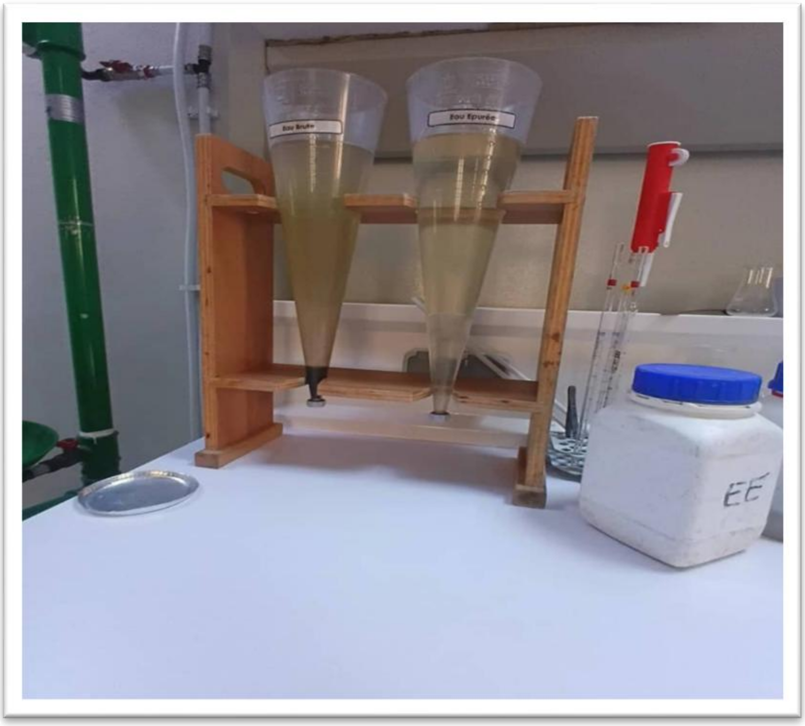


Figure IV.10: The idiots

➢ V30:

Objective:

To measure the volume of settled sludge after 30 minutes of sedimentation, in order to assess the sludge's settling capacity and monitor its concentration in the biological tanks.

✓ Experimental procedure:

-Place 1000 mL of sample from each tank (BA1, BA2) into a graduated cylinder,

- Leave for half an hour,

- Record the V30 value (mL/L).

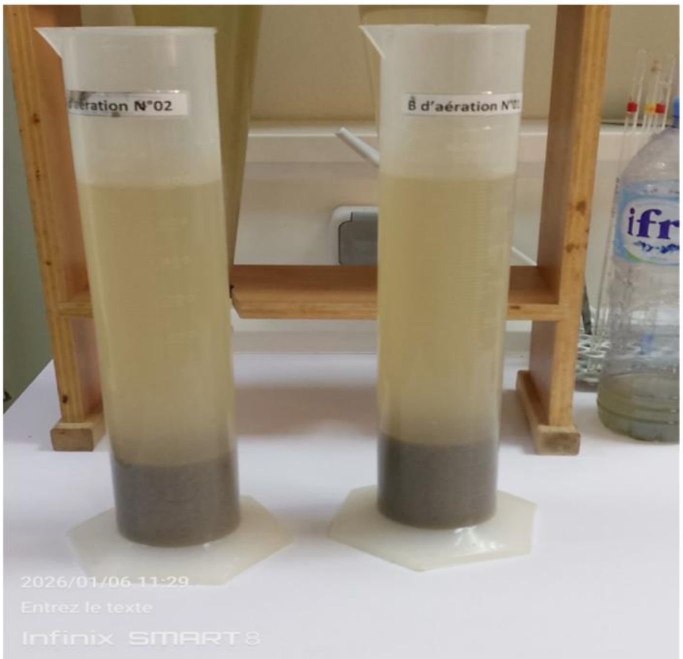


Figure IV.11: the V30

➢ Mohlman index:

Objective:

To monitor the condition of the sludge (proper settling or bulking) and ensure the biological treatment process is functioning correctly.

✓ After dilution, allow the sludge to settle for 15 minutes, and then take a sample.

Reporting of results:

IM = V30/ SS

IB = V30 /SS (dilution factor)

NOTE:

-SLUDGE INDEX EXPRESSED IN MG/L
-WE USE WATER FROM THE CLARIFIER FOR DILUTION.

➢ Dry matter and dry volatile matter:

Objective:

To determine the total amount of dry matter (DM) present in a sample after drying at 105°C. This method also allows the measurement of dry volatile matter (DVM), which corresponds to the organic fraction removed by calcination at 550°C.

• The principle:

This involves drying the sample at 105°C to remove water and determine the dry matter (DM). The residue is then heated to 550°C in a furnace to burn off the organic matter; the loss in mass corresponds to the dry volatile matter (DVM), whilst the remaining residue represents the mineral matter.

✓ Apparatus:

-Muffle furnace

-Glass desiccator

✓ Experimental procedure:

- Weigh the empty capsules (m0), then fill the capsules with a certain volume of water to be analysed and weigh the filled capsule (m1),

- Place the capsules in an oven at 105°C for 8 hours and allow cooling in the Desiccator, and then measuring the weight of the capsule m2,

- Place the capsules in a muffle furnace at 505 °C, then allow to cool in the

Desiccator and measure the weight of the capsule m3.

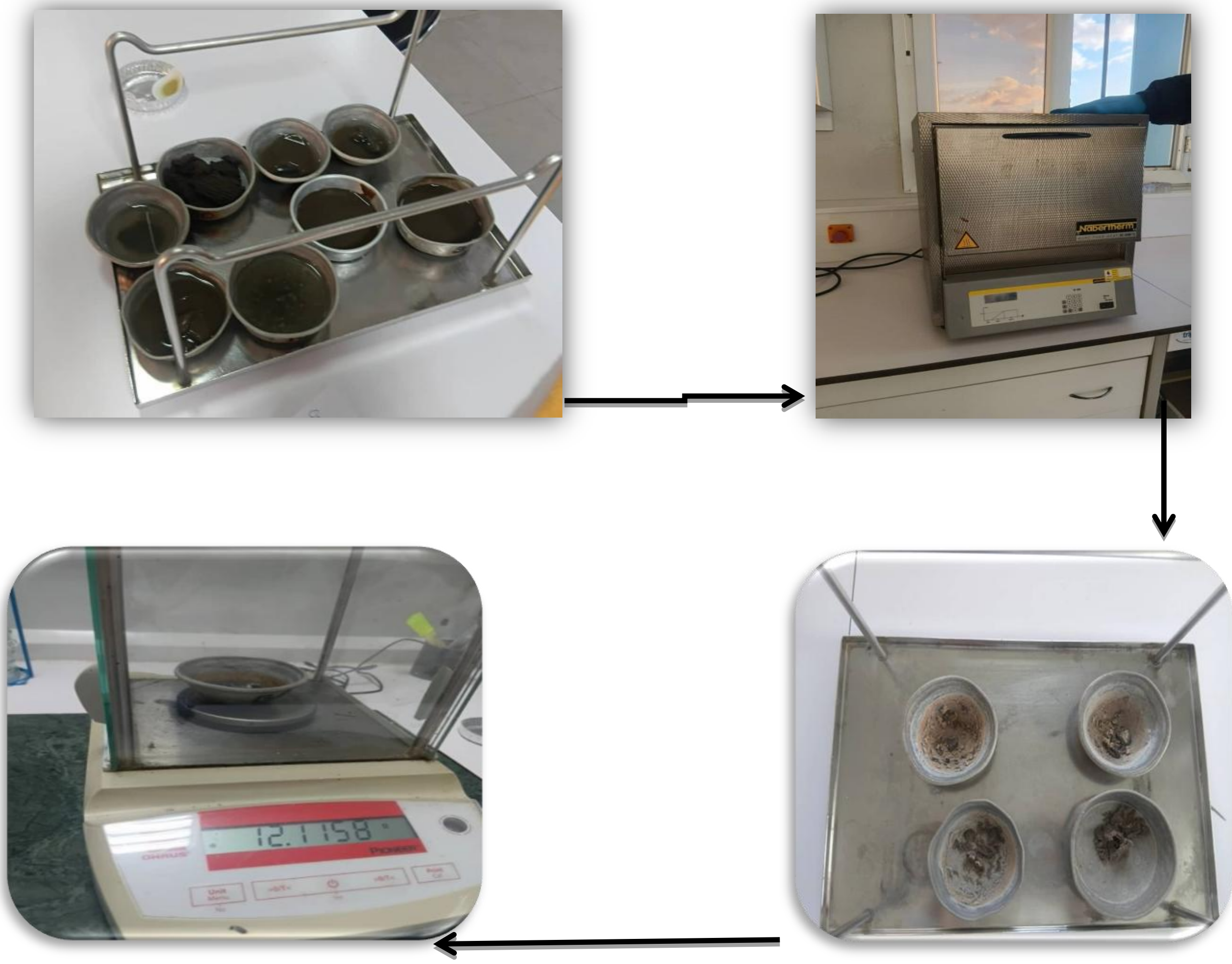
Reporting of results:

$$MS=\frac{m2-m0}{m1-m0}*1000\left(\frac{g}{l}\right)$$

$$\text{Drought } (\%) =\frac{m2-m0}{m1-m0}*100$$

$$\text{VDM } (\%) =\frac{m2-m3}{m2-m0}*100$$

VDM (g/L)=DM-MM



Measures masses

- Figure IV.12: Steps for determining dry matter and dry volatile matter

Determination of ammonium (NH_4+):

Objective:

To determine the concentration of ammonium in water (raw and treated) in order to assess the level of nitrogen pollution.

•The Principle:

In an alkaline medium, ammonium (NH_4+) reacts with Nessler's reagent to form a yellow to brown coloured compound. The intensity of the colour is proportional to the ammonium concentration and is measured using a spectrophotometer.

Apparatus:

Spectrophotometer

Micropipette

• Reagents:

Nessler's reagent

Stabiliser

Alcohol

Distilled water (for blank and dilution)

Experimental procedure:

-Prepare 3 flasks: EB (raw water), EE (treated water), and Blank;

-Add the sample to EB and EE, and distilled water to the Blank;

-Add to each flask:

- 3 drops of stabiliser
- 3 drops of alcohol

-Add 1 mL of Nessler's reagent to each flask

-Mix the solution thoroughly

-Allow a reaction time of approximately 1 minute

-Measure the absorbance using the spectrophotometer.

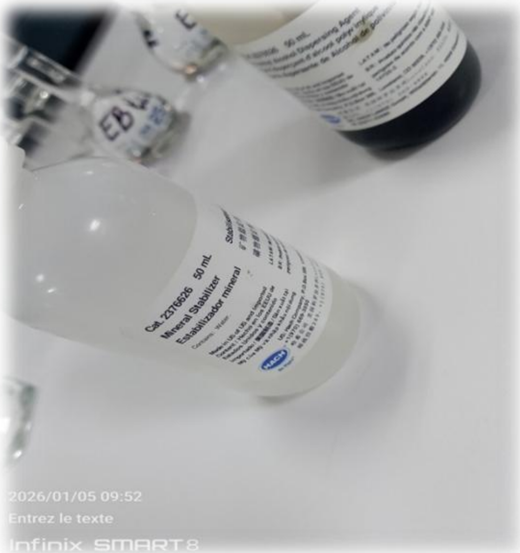


Figure IV.13: Stabiliser

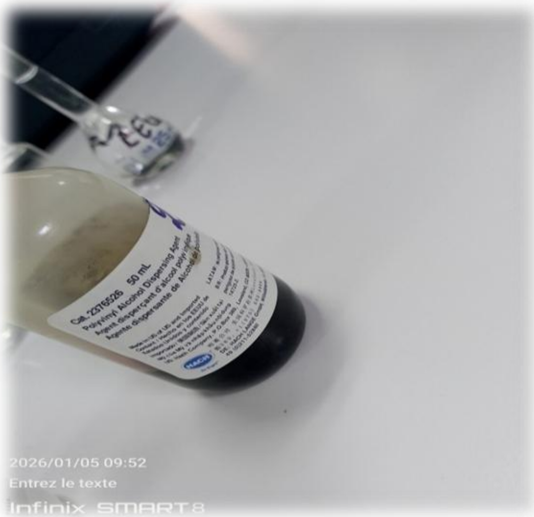


Figure IV.14: Alcohol

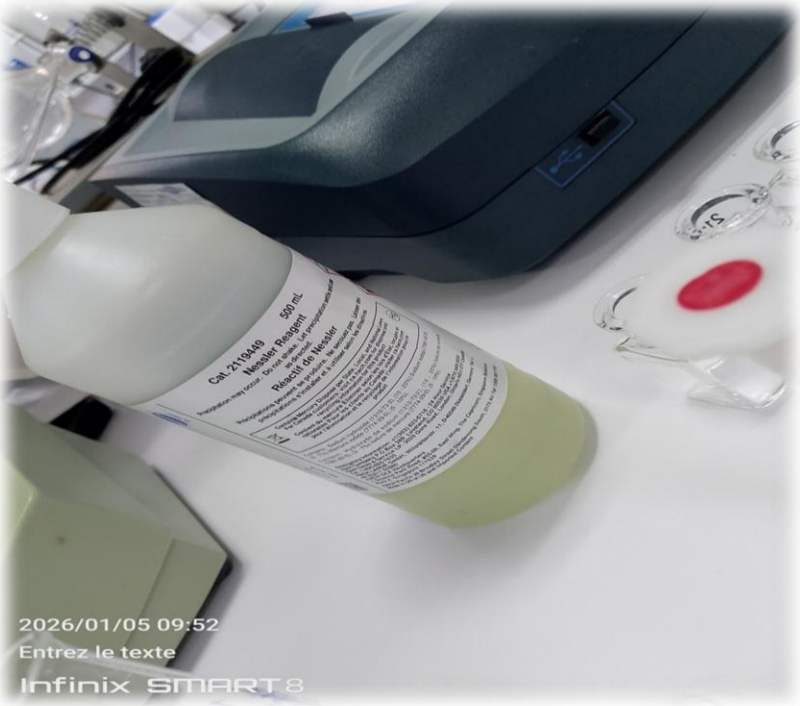


Figure IV.15: Nessler

- **Determination of nitrates (NO_3^-):**
- **Objective:**

To remove nitrogenous and mineral compounds

- **Reagents:**

Nitrate reagent (Nitrover 3)

✓ **Experimental procedure:**

-Prepare two tubes: EB and EE

-For EE: prepare a dilution (2 mL of sample + 18 mL of distilled water)

-For EB: use the sample directly

-Add the nitrate reagent to each tube

-Mix thoroughly, shaking for 1 minute

-Allow a reaction time of approximately 20 minutes

-Take a reading using the spectrophotometer

Reporting of results:

$$Y = x*(14/62)$$

X = spectral value;
y = nitrate value

Figure IV.16: spectrophotometer

Figure IV.17: the samples

➢ Determination of nitrites (NO_2^-):

• The Principle:

In an acidic solution, nitrites react with primary and aromatic amines to form ionium salts. These, when combined with aromatic compounds containing an amino group or a hydroxyl group, form an intensely coloured

• Reagents:

Nitrite reagent (often based on sulphanilamide).

✓ Experimental procedure:

- Prepare the tubes: EB, EE and blank

- Add the sample to EB and EE and distilled water to the blank

- Add the nitrite reagent to each tube

- Mix thoroughly

- Allow a reaction time of approximately 10 minutes

NOTE :

The more intense the pink colour, the more it indicates a high concentration of nitrite

For each analysis, clean the outside of the cuvette thoroughly and place it in the spectrophotometer

Table IV.03: Nitrification inhibitor dosages relative to BOD_5 volumes:

BOD_5 volume (ml)	Nitrification inhibitor dosage
432	0.23
365	0.19
250	0.13
164	0.087
97	0.05
43.5	0.023

- **Determination of orthophosphates (PO_4^{3-}):**
- **Objective:**

To measure the concentration of orthophosphates in water in order to assess the risk of eutrophication.

- **The Principle:**

Orthophosphates react with the reagents to form a blue-coloured complex.

- **Apparatus:**

Spectrophotometer

Micropipette

• **Reagents:**

Molybdate reagent (ammonium molybdate)

✓ **Experimental procedure:**

-Take a 10 mL sample (EB and EE)

-Add the corresponding reagents Results and Discussion

-Shake to homogenise for 30 seconds

-Observe the appearance of a blue colour

-Allow a reaction time of approximately 2 minutes

-Measure using the spectrophotometer

NOTE:

The absence of a blue colour indicates a low concentration of orthophosphates

CHAPTRE V

Results and Discussion

V.1Introduction:

This chapter presents and analyses the results obtained from the various analyses carried out on raw and treated water, in order to assess the effectiveness of the treatment and verify that the water quality complies with current standards.

Figure V.01: Color difference between raw and treated water.

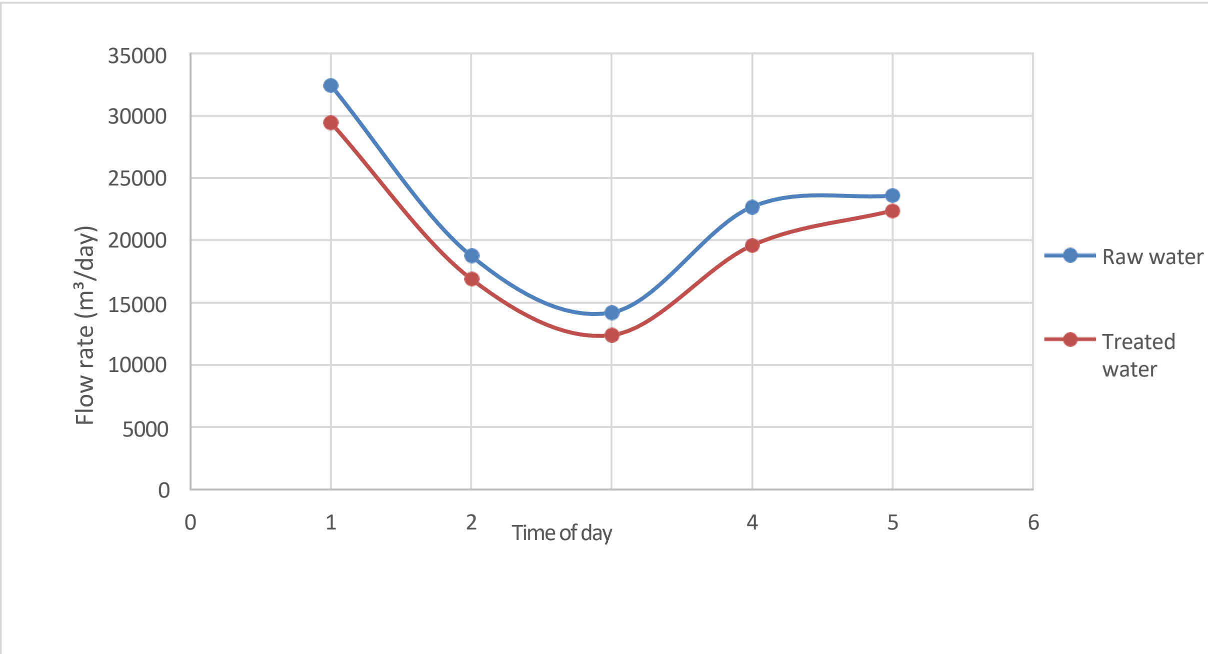


Figure V.02: Graph showing the daily flow rate of raw and treated water

- The average daily flow rates for raw water vary between 32,435 and 23'585 m^3/day, whilst the average values recorded for treated water are between 29,440 and 22,375 m^3/day, in accordance with the standard of 56'000m^3/day.

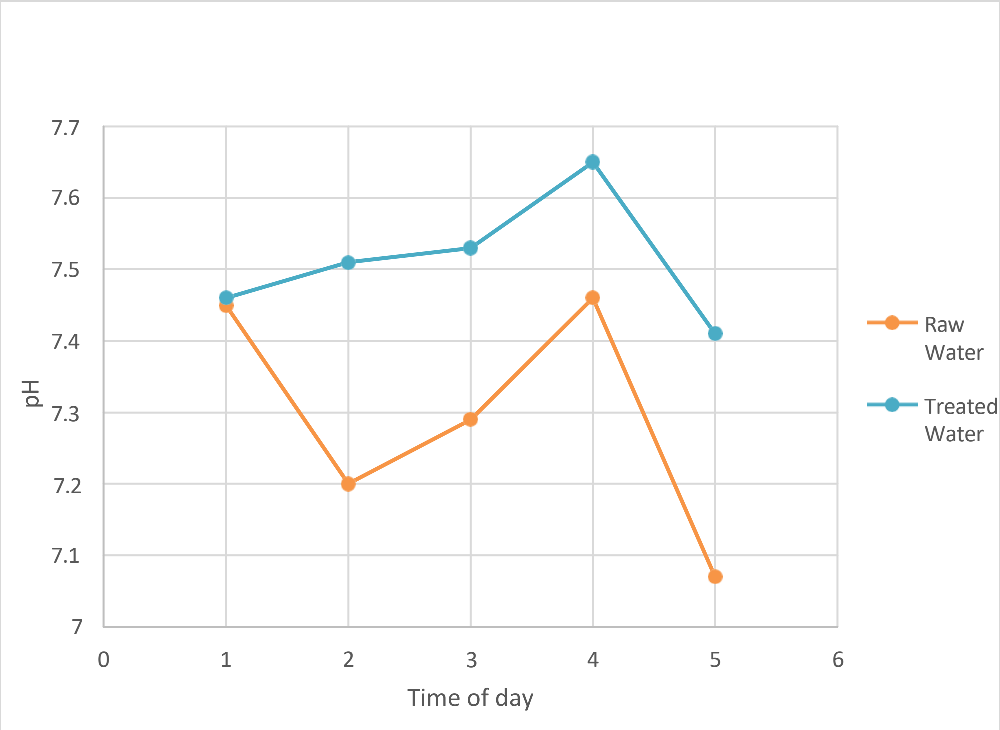


Figure V.03: Graph showing the pH of raw and treated water

The daily average values for raw water range from 7.43 to 7.07, which indicates the influence of urban effluents.

- The daily average pH of treated water measured is between 7.46 and 7.41; as it falls within the standard range of 6.50 to 8.50, we observe that there is a slight difference between the pH of treated water and that of raw water, which can be considered negligible.

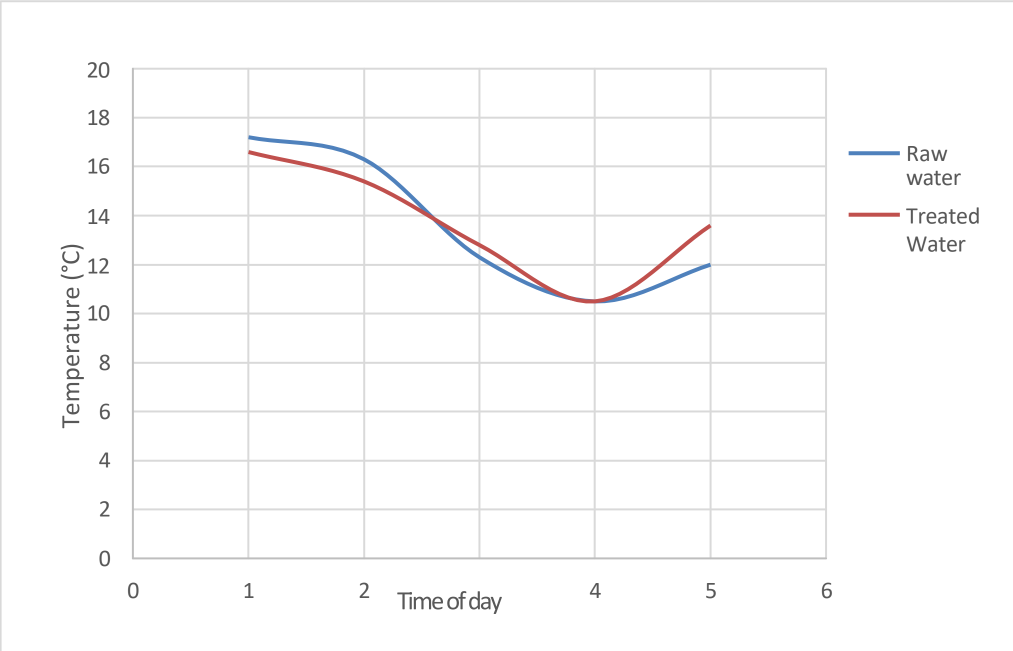


Figure V.04: Graph showing the temperature of raw and treated water

-The temperature values for treated water range from 16.6 to 13.6 °C.

-The temperatures recorded at the plant inlet are between 17.2 and 12 °C.

-Weather conditions influence the various values, but they are favorable as they remain below the standard of 30°C.

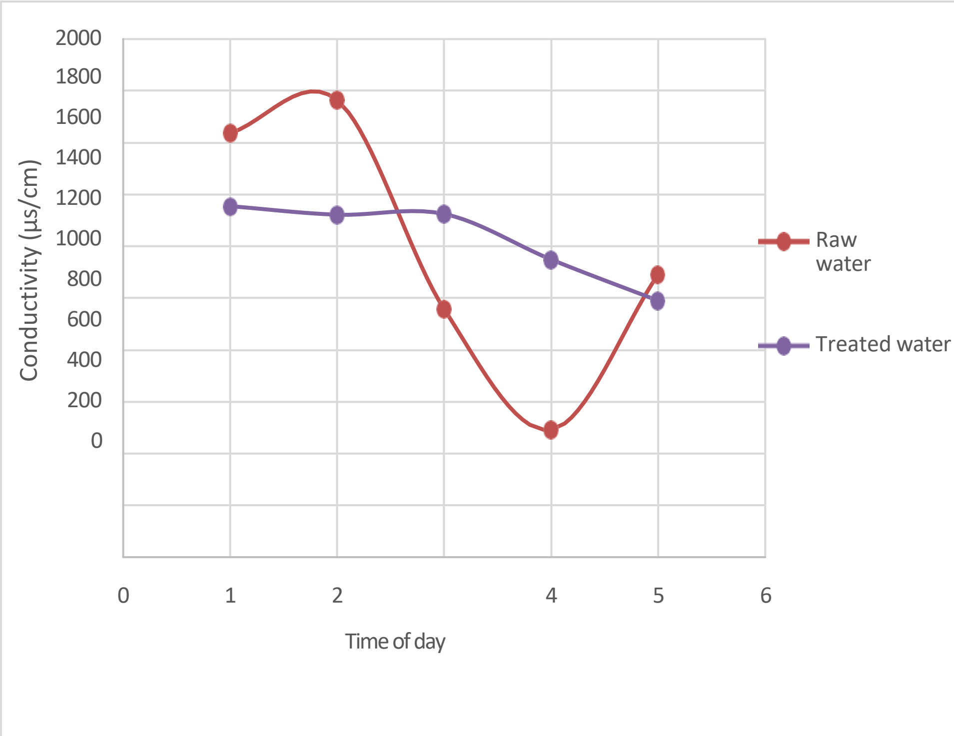


Figure V.05: Graph showing the conductivity of raw and treated water

- Conductivity complies with the standard in two cases: it remains within the acceptable limits for treated water according to the standard of 3000 us/cm^3

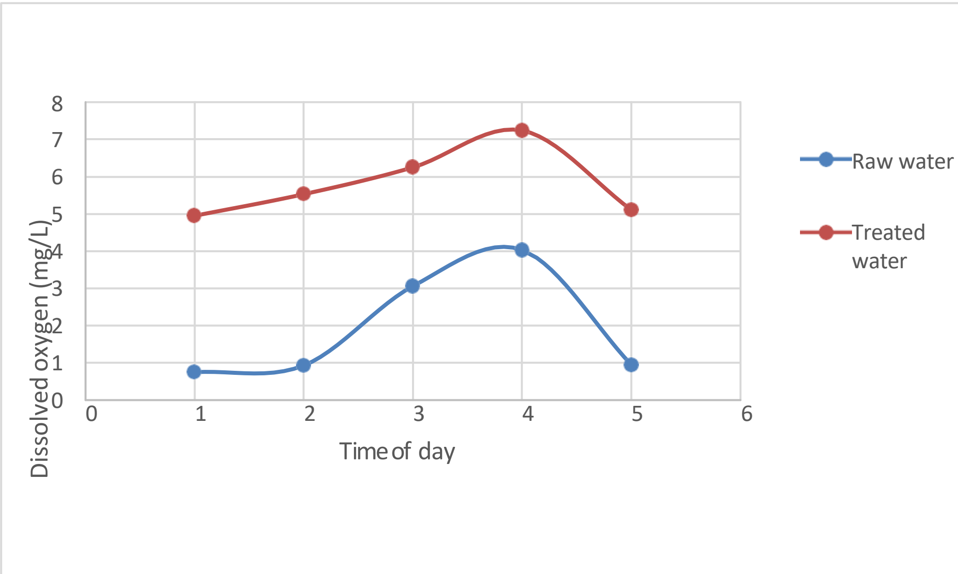


Figure V.06: Graph showing the dissolved oxygen content (mg/L) of raw and treated water

- The daily average dissolved oxygen values in raw water vary between 0.75 and 0.95 mg/L, a level that complies with the standard of less than 1 mg/L, whilst the daily average values recorded in treated water are between 4.95 and 5.11 mg/L; These results indicate that the natural discharge of treated water is favorable for aquatic life in terms of the necessary level of dissolved oxygen in the water. (O_{2RW}>1) ($O_{2\ tw}$ to 9)

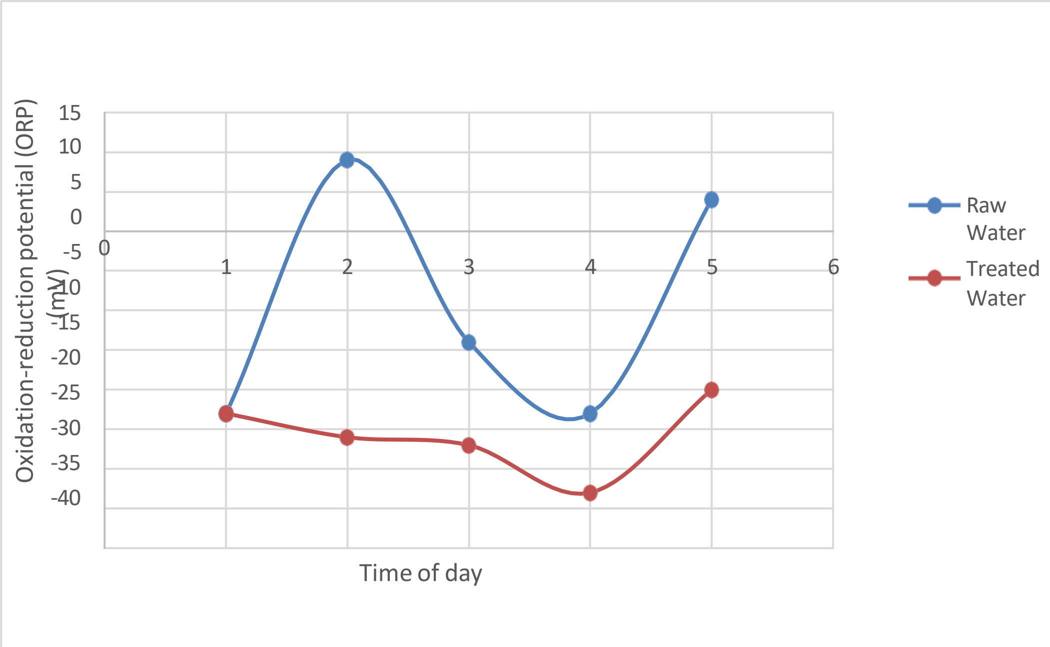


Figure V.07: Graph showing the oxidation-reduction potential of raw and treated water

- Negative values (-33 mV to -14 mV): Treated water with a negative redox potential indicates that it is in a state of anoxia (lack of oxygen).

  This indicates that biological treatment is incomplete or that the water is fermenting

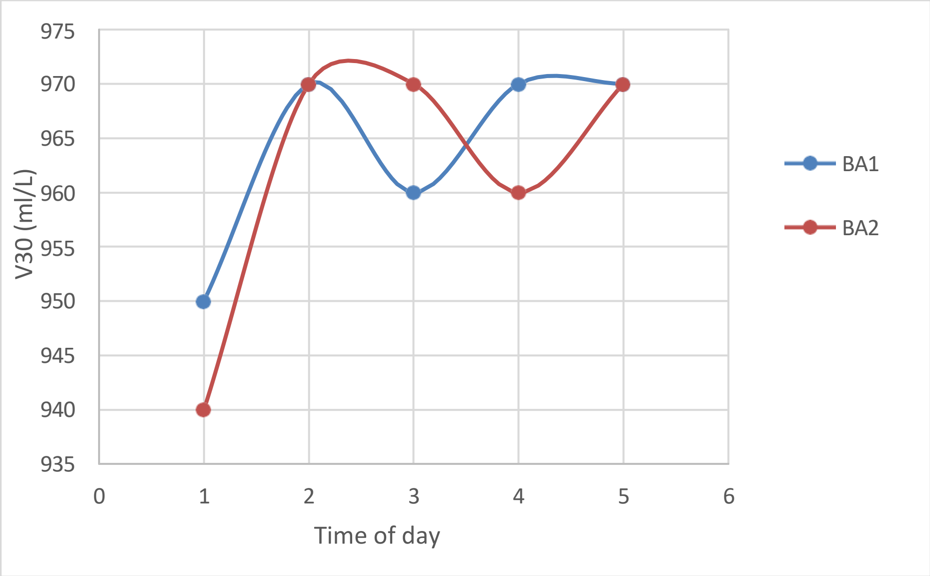


Figure V.08: Graph showing the volume over 30 minutes in the two tanks

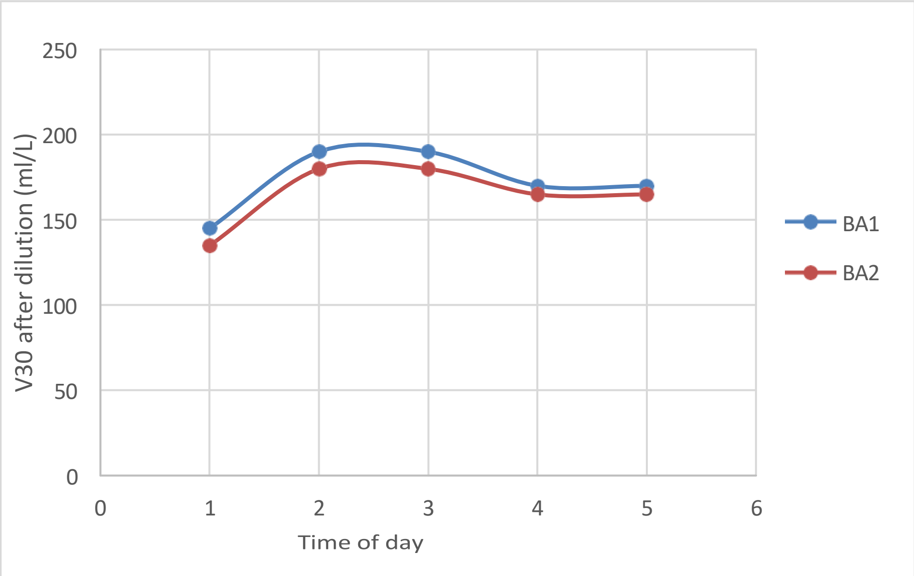


Figure V.09: Graph showing the volume over 30 minutes for the two tanks after dilution

- Before dilution: the SV30 is higher, as the sludge is more concentrated and occupies a sedimentation volume.
- After dilution: the SV30 decreases, as the sludge concentration is reduced, resulting in a lower settled volume after 30 minutes.

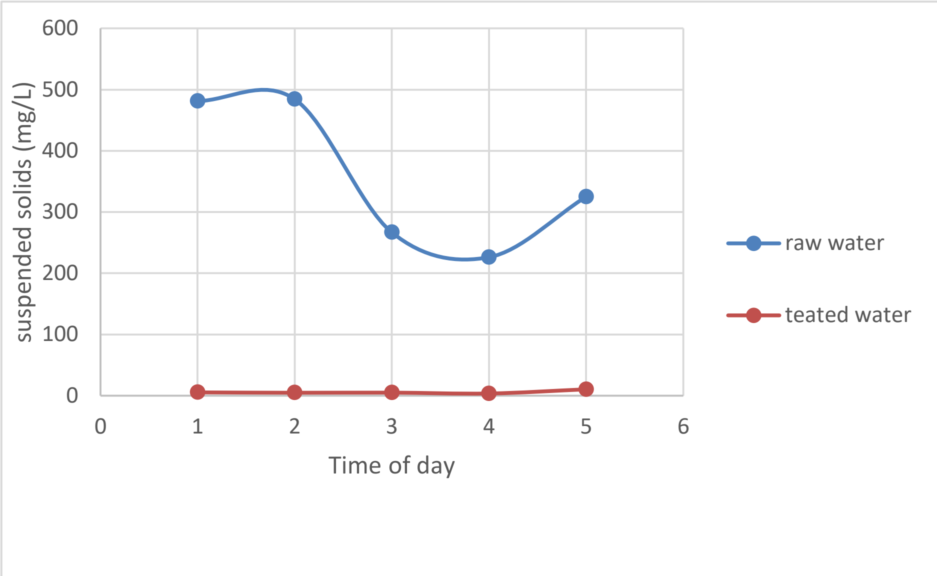


Figure V.10*:* Graph showing settleable solids in raw and treated water.

Adecrease in raw water, whilst the value remains stable in treated water

- This trend indicates a reduction in the load of settleable solids at the inlet, whilst the treatment remains stable and effective

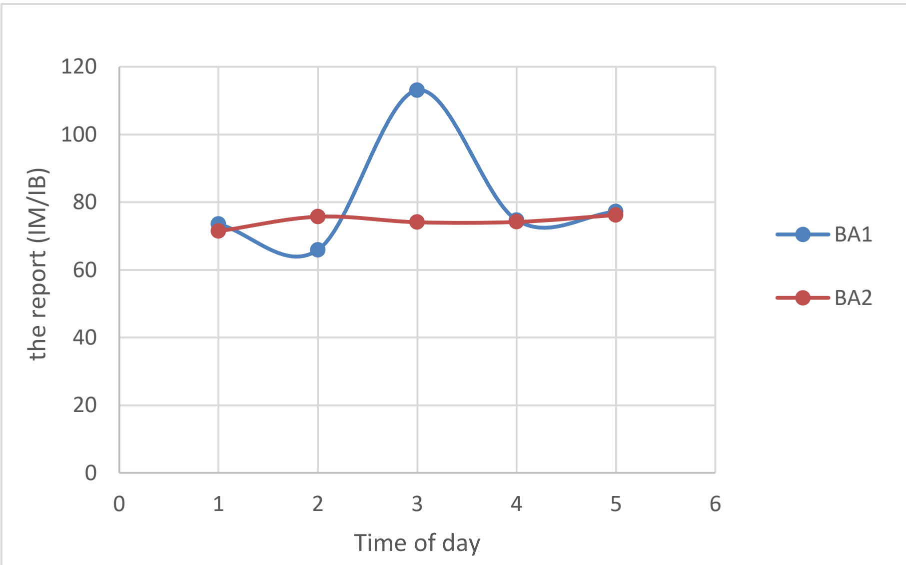


Figure V.11*:* Graph showing the ratio (IM/IB) in the two aeration tanks

- All values fall within the optimal operating range (50 to 150 mg/L). Except on the third day**.**

Results	**Reference values**
IB < 120 mg/L	Very good settling
120<Ib<150 mg/L	Good settling
150<Ib<200 mg/L	Moderate settling, but caution is advised when Ib > 150 mg/L
Ib > 200 mg/L	The sludge presents significant difficulties in settling; the sludge is filamentous.

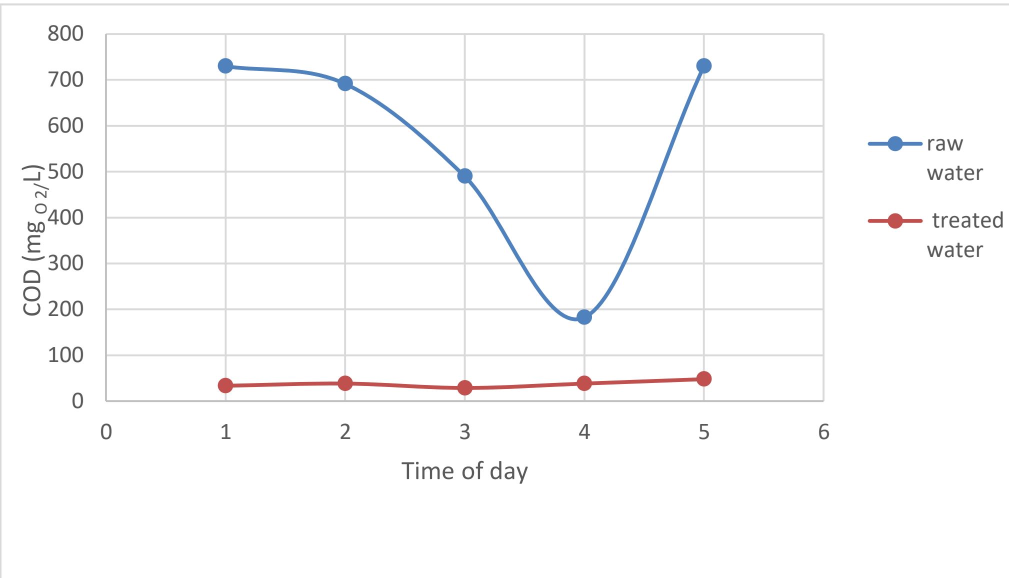


Figure V.12: Graph showing the chemical oxygen demand of raw and treated water

With a maximum value of 48 mg/L at the outlet, the treated water is fully compliant with Algerian regulations. It is even well below the permitted limit.

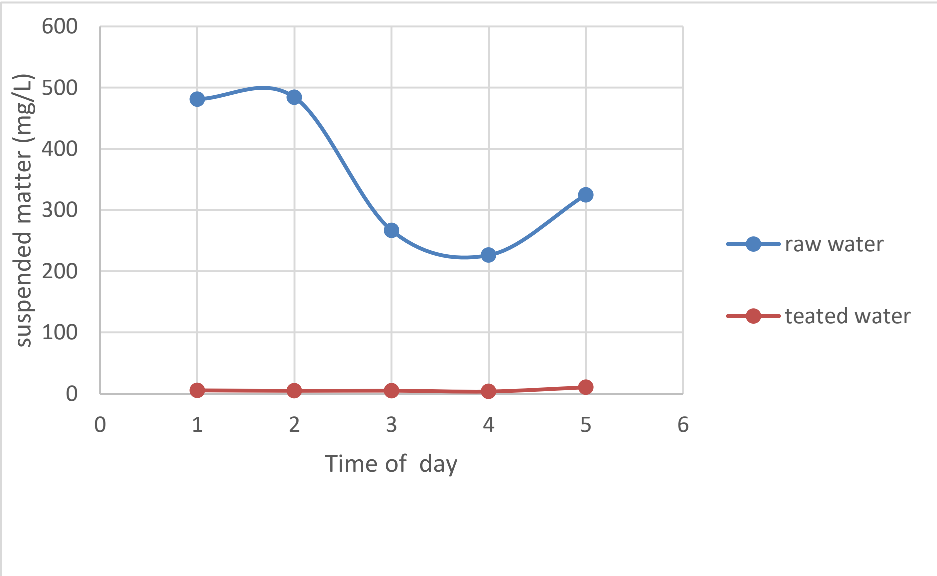


Figure V.13: Graph showing suspended matter (mg $_{O2}$/L) in raw and treated water

- It is clear to see this huge difference between the values obtained for treated and raw water; the latter vary between 481.25 mg/L and 325 mg/L, whilst treated water is between 5.4 mg/L and 10.44 mg/L; in all cases, they are below the standard (30 mg/L).

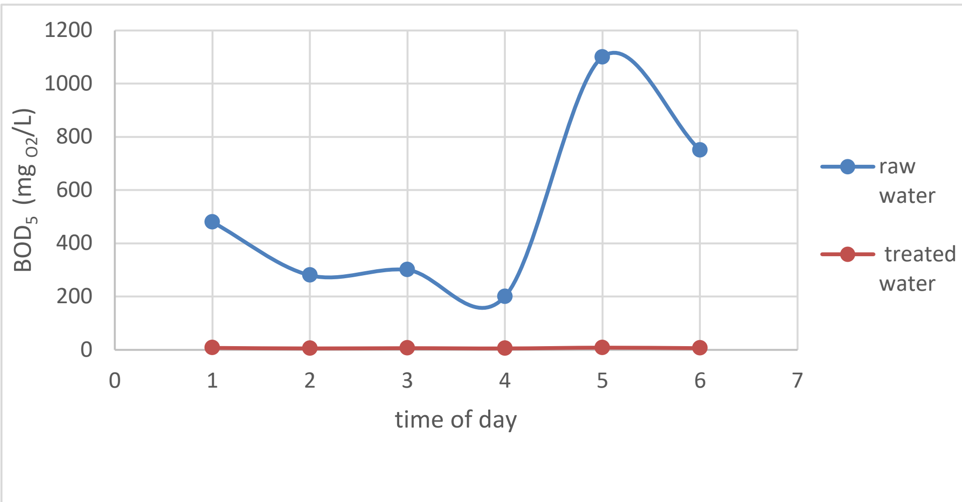


Figure V.14: Graph showing the biological oxygen demand of raw and treated water

The recordedBOD_5 values for raw water range from 480 mg/L to 750 mg/L, whilst those for treated water range from 7 mg/L to 6 mg/L.

The last two days' readings for raw water exceed the standards (350.0mg/L).

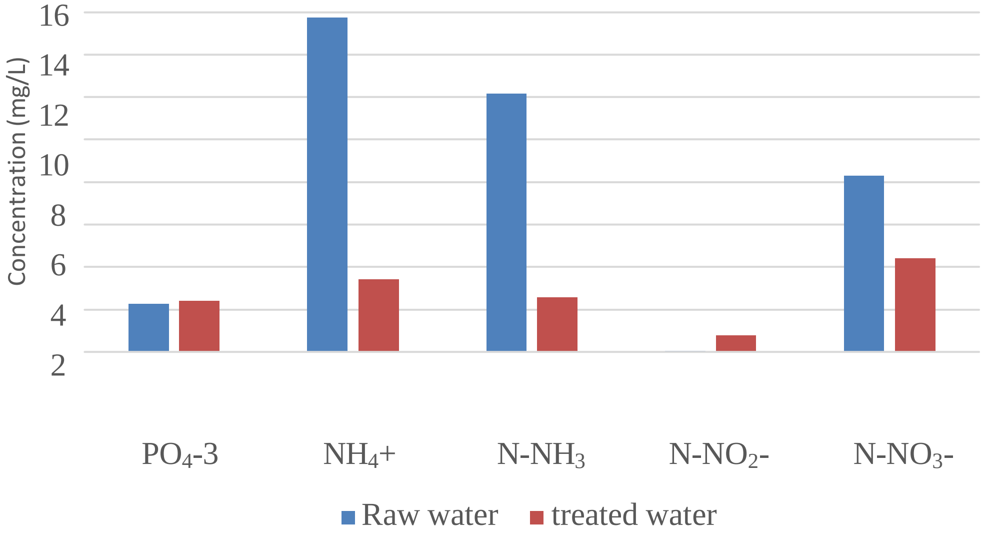


Figure V.15: Graph showing nutrient concentrations in raw and treated water

- PO_4^{3-} : The result of 2.4 mg/L is slightly above the ideal standard. This indicates that the current biological treatment is not effectively removing phosphorus.
- NH_4^{+} : the discharge complies with standards for the protection of aquatic fauna against ammonia toxicity
- N-NH_3 : Complies with the standard
- N-NO_2^{-} : A slight increase is noted in the treated water (0.78 mg/L) compared to the raw water. The discharge limit is set at 1 mg/L. The discharge is compliant, although the increase indicates incomplete nitrification.
- N-NO_3^{-} : The results are very satisfactory.

IV.2 General Discussion of the results:

The various analyses carried out on samples of raw and treated water have made it possible to assess the behavior of certain parameters describing the organoleptic and physico-chemical quality, as well as the pollution parameters of the water discharged into the environment.

• Analysis of the organoleptic quality of the water from the WWTP (MOSTAGANEM) revealed that discharge standards for daily parameters (color and odour) were met.

• All results obtained for the physico-chemical parameters (pH, temperature, suspended solids and conductivity) show compliance with discharge standards.

- The results for average weekly parameters such as BOD_5 and COD

Allow us to assess the quality of the biological treatment, which complies with standards,

• Pollution parameters, also known as eutrophying substances (NO_2^-, NO_3^-, PO_4^{3-}) are above the standard.

• The dissolved oxygen (O_2) level in the treated water is certainly acceptable for the continued survival of the Mostaganem salamander.

CONCLUSION

CONCLUSION:

Water is a major strategic resource at the heart of global economic development. Indispensable to human survival as well as to wealth creation, it represents a precious asset whose sustainable use is essential on a global scale.

Algeria, and more specifically its western region, has made significant progress in the field of water treatment. However, environmental protection in the face of untreated discharges remains a priority issue. With this in mind, the reuse of treated water for the irrigation of neighboring agricultural areas stands out as the most viable solution for conserving this precious resource.

Our work focuses on the operation of the Mostaganem wastewater treatment plant. It aims to describe the treatment processes implemented, as well as the physico-chemical analysis methods used to characterize water quality before it enters the plant and after treatment.

The results obtained demonstrate satisfactory treatment efficiency, particularly for the removal of suspended solids (SS). Analyses of BOD_5, COD, ammonia nitrogen and dissolved oxygen confirm performance in line with effluent discharge standards.

Conversely, the treatment of eutrophying substances, such as nitrites and phosphorus, proves to be insufficient. The concentrations measured at the plant outlet exceed regulatory thresholds, indicating incomplete removal of these nutrients.

"In light of our results, the following options are being considered:

- ✓ Improve treatment efficiency through tertiary treatment to reduce the nutrient load, thereby preventing the risk of eutrophication when the water is reused.
- ✓ Establish a protocol for continuous monitoring of treated water quality to validate its safety prior to any use for irrigation."

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