PAN-AFRICAN UNIVERSITY
INSTITUTE FOR WATER AND ENERGY SCIENCES
(including CLIMATE CHANGE)

Master Dissertation

Submitted in partial fulfillment of the requirements for the Master degree in

Water Policy

Presented by

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Water Quality Indices as Important Tools for Water Quality Assessment in WWTP:
The case of the waste water treatment plan of Ain El Hout Tlemcen

Defended on 04/09/2019 Before the Following Committee:

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ACADEMIC YEAR: 2018-2019

DECLARATION

I, **RAHMOUN Sihem** hereby declare that this thesis represents my personal work, realized to the best of my knowledge. I also declare that all information, material and results from other works presented here, have been fully cited and referenced in accordance with the academic rules and ethics.

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Sihem

CERTIFICATION

This thesis has been submitted with my approval as the supervisor

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ACKNOWLEDGEMENTS

Thanks to God, the Almighty this work has been realized. This research has been a success due to the cooperative effort from many people and organizations. I would like to express my deepest gratitude to:

My supervisor Pr NADIA BADR and my co-supervisor Dr ABDELBAKI CHERIFA for their availability, advices and supports throughout the completion of this work;

The Pan African University Institute of Water and Energy Sciences Including Climate Change (PAUWES), the Director and his team and the guest lecturers;

The Wastewater Treatment Plant of Ain El Hout (Tlemcen) for the internship opportunity;

The Environmental Sciences Department of the Faculty of Sciences at the University of Alexandria, Egypt;

DEDICATION

I dedicate this work to my Father and Mother (ILIES RAHMOUN and FATIMA ZOHRA CHIALI). Their guidance, encouragement, affections, sacrifices, and prayers gave me the strength to achieve this success and honour.

My sister Sarah RAHMOUN and my little brother Hassen Moulay RAHMOUN for their supports.

My family and friends for their support and kindness.

My colleagues and friends as well as all those who have not been mentioned.

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LISTE OF ABBREVIATIONS AND ACRONYMS

BOD_5	Biological oxygen demand
COD	Chemical oxygen demand
DO	Dissolved oxygen
EC_w	Electrical conductivity
FAO	Food and agriculture organization
IPCC	Intergovernmental Panel on Climate Change
MENA	Middle East and North Africa
NO	Nitric oxide
TSM	Total suspended matters
WHO	World Health Organization
WWTP	Wastewater treatment plant
WQI	Water Quality Indice

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ABSTRACT

The scarcity of conventional water resources represents for Algeria, because of its Mediterranean climate arid to semi-arid, a major concern. The global water potential of Algeria does not exceed 13.2 billion m3 of water, which offers an annual volume of 412 m3 to each citizen. Considering the vulnerability of available water resources to the impact of climate change, population growth as well as socio-economic factors, a situation of severe water scarcity occurs, which hinders the development of the country. This project seeks to study the feasibility of reusing the treated domestic wastewater for agricultural purposes as an adaptation measure to climate change. The area under investigation is Tlemcen Town, an arid region located in North Western Algeria. Climate studies have shown that climate change through the drought that has occurred in the past decades has affected the whole of the country and more particularly the North Western region. This has been characterized by a negative impact on available water resources as well as on the agricultural productivity. In Algeria, agricultural irrigation is the primary water-consuming sector followed by domestic and industrial sectors. It is therefore imperative to rationalize the use of conventional water resources. The reuse of treated wastewater represents the alternative for the preservation of the available water resources and the promotion of the agricultural sector. The present study is intented to calculate water quality index (WQI) of an urban wastwater treatment plan, in Ain El Hout in Tlemcen town , in order to ascertain the quality of water used in agriculture, to detect the major problems in WWTP, to analyze the water quality parameters in discharged effluents and to assess the water quality indices for the effluents discharged from WWTP. There are several ways to assess the quality of water as deemed fit for irrigation. Water quality index, indicating the water quality in terms of index number, offers a useful representation of overall quality of water use, as well as in pollution abatement programmes and in water quality management. A number of parameters affect the usability of water for a particular purpose. In this study the water quality index will be electrical conductivity, total suspended solids, dissolved oxygen, biological oxygen determined on the basis of various physic-chemical parameters like

Temperature, pH, demand, Chemical Oxygen Demand, Phosphates, nitrate, Ammonium Nitrogen and Nitrite

Key Words: Water reuse, Climate change, Adaptation, Agriculture, WQI.

RÉSUMÉ

La rareté des ressources en eaux conventionnelles représente pour l'Algérie, en raison de son climat méditerranéen aride à semi-aride, une préoccupation majeure. Le potentiel hydrique mondial de l'Algérie ne dépasse pas 13,2 milliards de m3 d'eau, soit un volume annuel de 412 m3 pour chaque citoyen. Compte tenu de la vulnérabilité des ressources en eau disponibles à l'impact du changement climatique, de la croissance démographique ainsi que des facteurs socio-économiques, une grave pénurie d'eau se produit, qui entrave le développement du pays. Ce projet vise à étudier la possibilité de réutiliser les eaux usées domestiques traitées à des fins agricoles en tant que mesure d'adaptation au changement climatique. La région sous enquête est la ville de Tlemcen, une région aride située au nord-ouest de l'Algérie. Des études climatiques ont montré que le changement climatique provoqué par la sécheresse des dernières décennies avait affecté l'ensemble du pays et plus particulièrement la région Nord-Ouest. Cela s'est caractérisé par un impact négatif sur les ressources en eau disponibles ainsi que sur la productivité agricole. En Algérie, l'irrigation agricole est le principal secteur consommateur d'eau, suivie des secteurs domestique et industriel. Il est donc impératif de rationaliser l'utilisation des ressources en eau conventionnelles. La réutilisation des eaux usées traitées représente une alternative pour la préservation des ressources en eau disponibles et la promotion du secteur agricole. La présente étude vise à calculer l'indice de qualité de l'eau d'un plan de traitement des eaux usées urbaines, à Ain El Hout, dans la ville de Tlemcen, afin de déterminer la qualité de l'eau utilisée en agriculture, de détecter les principaux problèmes de la STEP, d'analyser les paramètres de qualité de l'eau dans les effluents rejetés et d'évaluer les indices de la qualité de l'eau des effluents rejetés de la STEP. Il existe plusieurs manières d'évaluer la qualité de l'eau jugée apte à l'irrigation. L'indice de qualité de l'eau, qui indique la qualité de l'eau en termes d'indice, offre une représentation utile de la qualité globale de l'utilisation de l'eau, ainsi que des programmes de réduction de la pollution et de gestion de la qualité de l'eau. Un certain nombre de paramètres affectent la facilité d'utilisation de l'eau dans un but particulier. Dans cette étude, l'indice de qualité de l'eau sera déterminé sur la base de divers paramètres physico-chimiques tels que la température, le pH, la conductivité électrique, le total des solides en suspension, l'oxygène dissous, la demande biologique en oxygène, la demande chimique en oxygène, les phosphates, les nitrates, l'azote ammoniacal et le nitrite.

Mots-clés: réutilisation de l'eau, changement climatique, adaptation, agriculture, WQI.

1 INTRODUCTION

1.1 Background

Water is essential for life. However, millions of people around the world are experiencing water shortages and struggling daily to find drinking water covering their basic needs. Millions of children still die each year from preventable diseases transmitted by water. Water-related natural disasters, such as floods, tropical storms and tidal waves, are causing great loss of life and suffering. Too often, drought strikes some of the poorest countries in the world, aggravating hunger and malnutrition. (Kofi Annan, 2005). The water shortage situation has the potential to develop into a global water crisis. Reliance on surface water bodies alone seems to be insufficient to respond to this rising demand, while heavy extraction of ground water can lead to negative long term effects such as land subsidence. Recycle and reuse of water, therefore, has emerged into an urgent environmental and social issue. (Toze, 2006)

Higher temperatures and decreased precipitation are likely to generate decreased water supplies and increased water demand. Therefore, the need for the exploitation of additional water resources will be a necessity. The Middle East and North Africa (MENA) region is the driest and the most water scarce region of the World. With an average of 6.3% of the world's population, the region contains only 1.4% of the world's renewable fresh water (Roudi-Fahimi, Creel and De Souza, 2002). Overall water resources management, problems are obviously perceivable in MENA region. Aquifers are over pumped, water quality is being deteriorated, water supply and irrigation services are sometimes rationed. Consequently, human health, the environment and agricultural productivity are impacted. Population growth is a dominant challenge in the MENA region. The population has doubled in the three decades since 1980. In 2015, the total number of people living in the MENA countries was 493 million (Keulertz et al., 2016). It is estimated that in 2050, the total number of people living in the MENA countries will be 730 million (United Nations, 2015). This is therefore one of the fastest-growing regions in the world, and this growth will put immense pressure on natural resources and the environment (Keulertz et al., 2016). By 2050, per capita water availability is likely to be reduced by almost 40% (Terink, Immerzeel and Droogers, 2013). Over 60% of the region's population lives in areas with high or very high surface water stress, compared with the world global average of about 35% (World Bank, 2011).In the last three decades, the region has experienced increasing water stress, regarding water scarcity and the degradation of the water quality. This is due to some factors such as sea intrusion to surface and ground waters as well as pollution arising from land use activities such as industrial and agricultural activities. More than half of the wastewater collected in the Middle East and North Africa is returned to the environment untreated, resulting in both health hazards and wasted water resources (World Bank, 2011).

According to FAO (2006) more than two-thirds of the 360 km3 average total annual renewable water resources in MENA come from surface resources (rainfall, rivers, springs and lakes). The average water availability per capita in the MENA region is estimated to 1,200 m3/cap/yr against the world average of 7,000 m3/cap/yr (Philippe Marin, 2014). This value is far below the water security threshold of 1,700 m3/cap/yr of renewable water (Brown, Matlock and Ph, 2011). It is noting that MENA region has the highest per capita rates of freshwater withdrawal in the world (804 m3/yr) and currently exploits over 75% of its renewable water resources. Because of expanding population and rapid economic growth, the per capita water availability is expected to reduce in the coming decades. By the year 2050, two-thirds of MENA countries could have less than 200 m3 of renewable water resources per capita per year (EcoMENA, 2018).

The Middle East and North Africa (MENA) being an arid and water scarce region, is vulnerable to the climate change impacts on its water resources. Some areas are affected by more frequent droughts while in other areas, there are rising sea levels. According to (World Bank, 2007), most of the MENA region's countries cannot meet their current water demand, and the situation is to get worse because of climate change and population increase. Climate change coupled with demographic growth will profoundly affect the availability and quality of water resources in the MENA region (Conway, 1996). If climate change affects weather and precipitations patterns as predicted, the MENA region could experience more frequent and severe droughts and floods. As a direct consequence of climate change, and given the current rapid trends of population increases, FAO projections show that Algeria, Egypt, Morocco, Syria and Tunisia are expected to experience severe water shortages by 2050, and only Iraq is expected to be in a relatively better situation (FAO, 2002). Drought can have both direct and indirect impacts in North Africa, and can act as a risk multiplier, destabilizing populations, and amplifying inequalities in access to water services and water resources, and reinforcing perceptions of marginalization (World Bank, 2017). Water shortage in the MENA region will be significant in the next decades and that about 20% can be attributed to climate change and 80% to the increase in demand, population growth and fast economic development (Immerzeel et al., 2011). Agriculture plays a significant role in the economies of the majority of the countries in the MENA region. However, agricultural potential will be limited due to the decrease in water availability that leading to a competition between different water uses.

1.2 Problem Statement

In Algeria, at the area under investigation, the vulnerability of available water resources is affected by several problems such as climate change, increasing population growth, surface and groundwater pollution, and the over exploitation of fresh water resource. These make the country exposed to water scarcity at the local and regional level. These problems, if not properly managed are likely to decelerate the country's economic growth. Algeria is among the most populous country in the Maghreb. Although, the population is irregularly distributed over the country. In January 2017, Algeria's population was 41.3 million Official statistics predicted Algeria's population to expand to 42.2 million by next January and swell to 51 million by 2030. Algeria has added almost 1 million inhabitants each year over the past three years, causing its population to grow at an average of 2.2% per year as released by the state-run National Statistics Office stated. This has led to a great increase in the demand for water supply (World Data Info, 2018). Water pollution in Algeria is also a considerable problem. Underground and surface water resources are polluted by uncontrolled and untreated municipal wastewater, discharge of untreated effluents from industries. Uncontrolled discharges of nitrates and phosphates from agricultural runoff is considered as a major source of pollution to surface waters. Moreover, about 75% of the urban population is connected to a sewage network, but most wastewater treatment plants are out of service, so untreated sewage is being discharged into natural water bodies (Wang, Lee and Melching, 2015). About 200 million m3 per year of untreated industrial wastewater is discharged into the environment (Wang, Lee and Melching, 2015). In addition, through the increasing urbanization, cities have become major contributors to water pollution in Algeria. In coastal zones, groundwater quality is altered due to marine intrusion. Therefore, this degradation reduces the amount of water intended for consumption. Groundwater resources in Algeria are being overexploited. In most of the cases, a great number of wells and boreholes are being drilled without previous authorization from the authorities. However, the number of illegal wells or boreholes is estimated at several thousand across the country (Wang, Lee and Melching, 2015).The water resources of Algeria have been negatively impacted by the climate change through the drought that occurred for several decades. During the last 25 years, the country has experienced a severe drought, which has affected the country's rainfall by causing important deficit. In the whole of the country, the pluviometric deficit have been evaluated to nearly 30% (Messahel and Council, 2007). The drought had also a negative impact on the modes of flow of the surface water, the level of filling the reserves and the underground waters (Messahel and Council, 2007). From 2000 to 2002, the pluviometric deficits have reached around 50 to 60% in the Centre and Eastern areas of the country (Messahel and Council, 2007). Moreover, the drought had also a negative impact on the socioeconomic activities of the country. Renewable water resources (surface water and groundwater) were estimated at around 16.5 billion m3 for an average year on the basis of climatic series from before the 1980s (Hamiche, Stambouli and Flazi, 2015). This estimate was revised down to around 12.2 billion m3 taking into account the droughts experienced by Algeria since the 1980's, with a decrease in water resources of around 25% (Hamiche, Stambouli and Flazi, 2015). Therefore, water availability dropped to under 447 m3/cap/yr in 2012, which is significantly below the "scarcity threshold" of 1,000 m3 per year set by the UNDP (Hamiche, Stambouli and Flazi, 2015).

1.3 Justification

In recent years, climate change has been documented in many locations throughout the world (Moonen et al. 2002), but never in Algeria until now. Algeria, however, is the largest country in both Africa and the Mediterranean basin, which are amongst the most vulnerable areas to climate change (Niang et al. 2014), Due to its geographical position and climatic characteristics, Algeria is highly vulnerable to climate change. Even a small rise in temperature would lead to various socio-economic problems that hinder the development of the country. The models predict that rainfall events are less frequent but more intense, while droughts are more common and longer (Sahnounea, Belhamela, Zelmatb, Kerbachic, 2013). It also indicate that rainfall could decrease by more than 20% by 2050, which would result in even greater worsening water shortages in different basins of Algeria (Hamiche, Stambouli and Flazi, 2015). The spatial and temporal distribution of rainfall will also change. The analysis of climate data from 1931 to 1990 in northern Algeria reveals a rise in temperature of 0.5 °C would reach an increase of 1 °C by 2020. A temperature rise of 2 °C is expected by 2050. The decrease of water resources, , encroaching desert, and specialy declining agricultural yields because In this country , agricultural irrigation is the primary water consuming sector followed by the domestic and industrial sectors. Water allocated for irrigation has dropped from 80% in 1960 to around 60% in 2002 (Wang, Lee and Melching, 2015). Currently, agriculture is facing more and more serious problems in irrigation. Water intended for this purpose is almost rare and the application of adequate solution is essential adapt to climate change. IPCC (Intergovernmental Panel on Climate Change) defines climate change adaptation as “an adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities”. Wastewater should no longer be considered as a problem, but rather as a solution to the challenges faced by water resources in Algeria, due to the climate change.

To meet all the water needs of the country and to reserve good quality water for drinking water, one of the solutions would be to use marginal quality water in agriculture treated wastewater is one of the promising alternatives, which has drawn great interest over the last two decades, especially in arid and semi-arid regions where water sources are limited. The wastewater is a readily available and reliable source, and its treatment and recycling would reduce the extensive amount of water extracted from the natural environment (Toze, 2006). The potential use of the treated wastewater can be varied significantly, depending upon the degree of treatment and quality for public acceptance. Advances in the treatment made it possible to use wastewater from irrigation purposes to public water supply

1.4 Objectives

1.4.1 General Objective

Waste Water Treatment plants (WWTP) are considered as fundamental tools for the protection of natural environment. They have the objectives of reducing the flow of pollutants to open aquatic areas. Controlling the operation of a WWTP is often difficult because of the disturbances that can occur and are difficult to characterize and predict. A WWTP must be able to operate satisfactorily during critical emergency situations, service shutdowns and power outages that make the management of the wastewater plant difficult. It is therefore necessary to ensure permanently the proper functioning of the wastewater treatment plant toward the objectives assigned to it. To answer this question, an analysis of failure modes and their effects on WWTP discharges. To represent water quality in a lucid way, different water quality indices for water quality assessment are used which aim at giving a single value to the water quality of a source reducing great amount of parameters into a simpler expression and enabling easy interpretation of monitoring data. Analysis is performed on data to identify the main problems at the WWTP which penalize its operation and limit its reliability. At this case, preventive and corrective actions will be proposed. Therefore, the main objective of this project is to assess the performance of the WWTP with respect to the removal of chemical pollutants and evaluate the quality of the water produced from it through comparison with the required standards using different water quality indices, then Propose the different processes for applying water policy instuments.

1.4.2 The specific objectives are :

1. Detection of major problems in WWTP
2. Analyze the water quality parameters in discharged effluents
3. Assess the water quality indices for the effluents discharged from WWTP
4. Propose the different processes for applying water policy instuments

1.5 Research Questions

In order to assess the specific objectives specified above, our study examines the following questions:

a) What is the physico-chemical quality of the treated wastewater from the WWTP of Ain El Houtz?

This question intends to assess the different physico-chemical water quality parameters of the treated wastewater. The assessment of these parameters was based on the analyses carried out within the laboratory of the plant.

b) What are the hazardous material existing in the wastewater from the WWTP of Ain El Houtz?

This question consisted in identifying the different Hazardous material that can exist in the wastewater before and after treatment.

c) What is the water quality indices to detect the pollution level ?

This question highlights the indices that must be used to know the real level of pollution of the treated wastewater so it can be used in irrigation based on the recommendations of water quality for irrigation.

1.6 Scope and Limitations of the Study

There are other products resulting from the wastewater treatment plant such as the sludge produced from the treatment process. This sludge can also be valuable through the use in agriculture. However, our study is only focused on the quality of water before and after treatment.

2 LITERATURE REVIEW

The need for sustainability in the management of water resources is becoming day-by-day more necessary due to their levels of contamination and the frequency of shortages. Indeed, the environment is repeatedly experiencing highly stressing phenomena related to deficient or nonexistent wastewater and waste treatment plants, compromising the accessibility to water and sanitation with the resulting health troubles. The goal of environmental sustainability should be pursued to reduce all discharge dilution phenomena, maximize treated wastewater reuse and by-products recovery. The treatment technologies should be efficient and reliable, with low costs for construction, management and maintenance that support self-sufficiency and acceptance by stakeholders and the general public. Developments in wastewater treatment processes enhance a plant's ability to improve effluent quality; ensure the robustness and reliability of equipment and aim for high automation and low maintenance.

2.1 Overview of Wastewater Reuse for agriculture

In regions suffering from water scarcity, wastewater is no longer considered as waste to be disposed but as an integral part of potential water resources. The use of wastewater in agriculture started in Australia, France, Germany, India, the United Kingdom and the United States of America in the latter part of the 19th century and in Mexico in 1904 (WHO, 1989). It is used for irrigation in treated and untreated forms, varying by geographic and economic context, although with the majority in untreated form in developing countries (Pay et al., 2010). The untreated wastewater is frequently used for urban or peri-urban agriculture, which comprises approximately 11% of all irrigated croplands globally (Thebo et al., 2014).

Reuse of treated wastewater for the irrigation of crops and urban green spaces such as parks and golfs courses has significantly expanded in Australia, Latin America, North Africa, Spain, other Mediterranean countries and the United States of America (WHO, 1989). In some countries such as Israel, Jordan, Peru, and Saudi Arabia, it is government policy to reuse all wastewater from sewage treatment plants mainly for crop irrigation (WHO, 1989). It has been shown that during the 1990s, in many part around the world expanded interests in wastewater reuse occurred for reliable water supplies in agriculture (Asano and Levine, 1996).

There are only a few countries in Africa such as South Africa, Tunisia or Namibia which planned to construct wastewater treatment plants in order to produce a safe effluent (Bahri, Drechsel and Brissaud, 2012). In Botswana, at the Glen Valley Irrigation Scheme treated effluent is used to grow vegetables under 203 ha of farmland for supply to supermarkets in Gaborone (Monyamane, 2011). In the Middle East and North Africa (MENA) region, Tunisia was among the first Mediterranean countries equipped with wastewater treatment facilities, which have elaborated and implemented a national reuse policy for many years (Asano and Levine, 1996). The Ministry of Agriculture in Egypt promoted the restricted reuse of treated wastewater for cultivation of non-food crops such as timber trees and green belts in the desert to fix sand dunes (Guasch et al., 2010).

Algeria is presently looking at improving water availability by adopting a new water resources policy and new alternatives that enable to ease the crisis. Treated wastewater represents a promising alternative that is not only constantly available but also increasingly available, with the development of cities, tourism and industry. In the agricultural sector, reuse of wastewater is a technique that adds to the value of the water resources while it protects the environment (Bahri, 2003). According to the National Sanitation Office (2013) the quantities of water treated and reused in agricultural irrigation, reached in 2013 a volume of 19 million m3 for the irrigation of 12,000 ha.

DJEMIL et al., (1990) have demonstrated that the treated wastewater produced from the wastewater treatment plant of BARAKI in Algiers is acceptable as water for irrigation. A study conducted by Djedi (2006) stated that the use of treated wastewater from the Ibn Ziad wastewater treatment plant to irrigate urban tree species, have shown a faster growth and development of these tree species, and can be used safely for irrigation. The research done by Aissa (2013) concluded that the wastewater treatment plant of Chlef can be used for irrigation, especially in arboriculture. However, an additional treatment of the wastewater with chlorine disinfection can expand this practice to other types of crops in particular vegetable crops.

With the rehabilitation of the old WWTPs and the construction of new plants, several irrigation projects from treated wastewater are being studied or already realized. The current program aim to increase the number of WWTPs from 146 with an installed wastewater treatment capacity of 550 million m3/yr to 216 WWTPs by 2020 with a capacity of 1200 million m3/yr of treated wastewater. It is planned to irrigate 100,000 ha from these new resources (Karef, 2017b). According to Karef (2017) the programs in progress are:

a. Hennaya project in Tlemcen from a WWTP, for the irrigation of an area of 912 ha (arboriculture and fodder).

b. Boumerdes project: Two private farmers irrigate 89 ha of arboriculture from treated wastewater from Boumerdes WWTP.

c. Dahmouni (wilaya of Tiaret) Project on an area of 1214 ha. d. Irrigation from the WWTP of the city of Bordj Bou Arreridj on an area of 350 ha.

e. Irrigation from the Hamma Bouziane WWTP in Constantine covering an area of 327 ha.

f. Irrigation from the WWTP of Oran on an area of 8100 ha.

g. Irrigation at the downstream part of the WWTP of Medea city on an area of 255 ha.

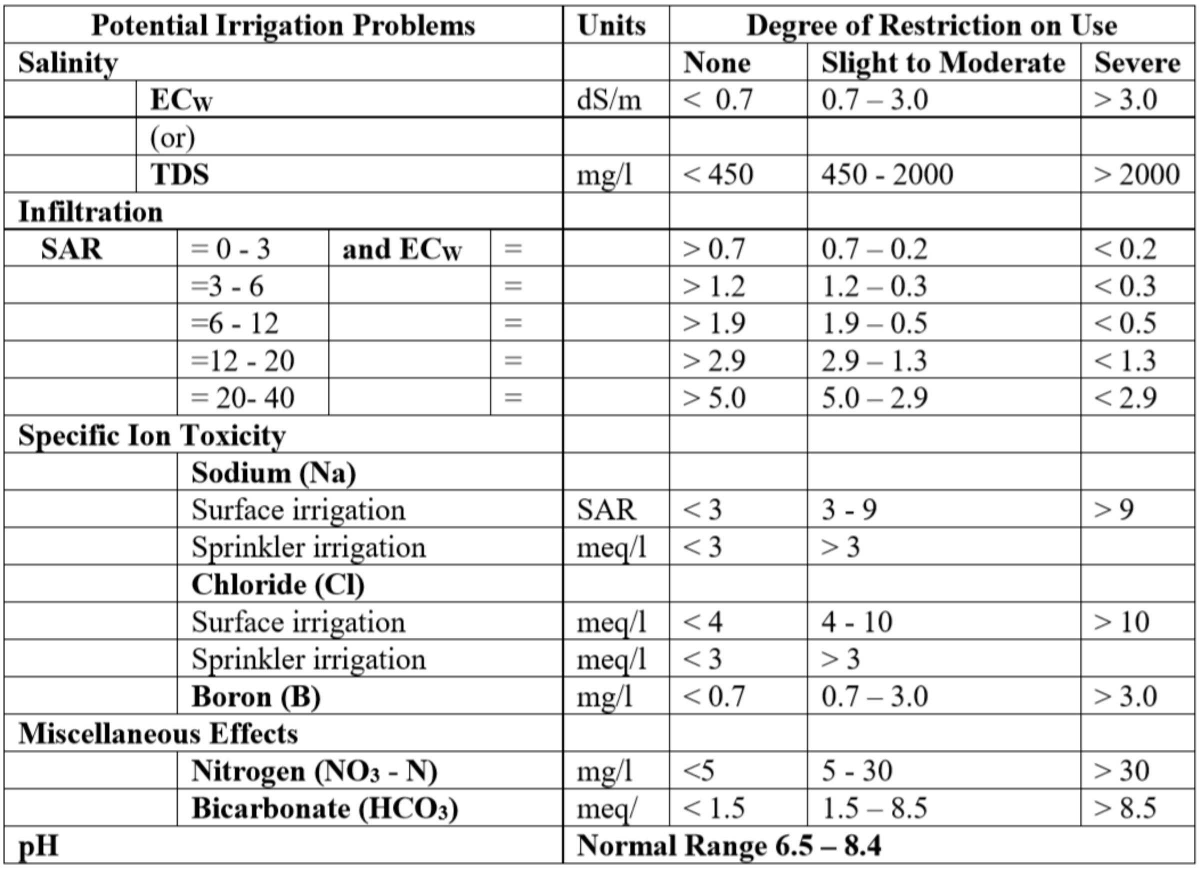
h. Irrigation from the WWTP of Saida on an area of 330 ha.

The number of wastewater treatment plants operated by the National Sanitation Office is estimated at 146 plants in 2018 (National Sanitation Office Report, 2018). During February 2018, a volume of 1.5 million m3 of treated wastewater by seventeen wastewater treatment plants has been used to irrigate 11,062 ha of agricultural land, which represents a re-use rate of 40% (National Sanitation Office Report, 2018).

2.2 Standards for wastewater reuse for agriculture

At the global level, there is no common regulation regarding the reuse of wastewater in agriculture. This is due to the diversity of the climate, geology and geography, soil and crop type, but also to the economic context, the political and social situation of the country. However, some governments and organizations have already established reuse standards such as the World Health Organization (WHO), Food and agriculture organization (FAO). Most developing countries have formulated their wastewater reuse standards based on recommendations set by one of the above-mentioned organizations. Algeria has published in this framework a ministerial decree establishing the National standards of the use of treated wastewater for agricultural purposes.

Table 2.1 : FAO Guidelines for the interpretations of water quality for irrigation



Potential Irrigation Problems				Units	Degree of Restriction on Use		
Salinity					**None**	**Slight to Moderate**	**Severe**
	EC_w			dS/m	< 0.7	0.7 – 3.0	> 3.0
	(or)						
	TDS			mg/l	< 450	450 - 2000	> 2000
Infiltration							
SAR	= 0 - 3	**and EC_w**	=		> 0.7	0.7 – 0.2	< 0.2
	=3 - 6		=		> 1.2	1.2 – 0.3	< 0.3
	=6 - 12		=		> 1.9	1.9 – 0.5	< 0.5
	=12 - 20		=		> 2.9	2.9 – 1.3	< 1.3
	= 20- 40		=		> 5.0	5.0 – 2.9	< 2.9
Specific Ion Toxicity							
	Sodium (Na)						
	Surface irrigation			SAR	< 3	3 - 9	> 9
	Sprinkler irrigation			meq/l	< 3	> 3	
	Chloride (Cl)						
	Surface irrigation			meq/l	< 4	4 - 10	> 10
	Sprinkler irrigation			meq/l	< 3	> 3	
	Boron (B)			mg/l	< 0.7	0.7 – 3.0	> 3.0
Miscellaneous Effects							
	Nitrogen (NO_3 - N)			mg/l	<5	5 - 30	> 30
	Bicarbonate (HCO_3)			meq/	< 1.5	1.5 – 8.5	> 8.5
pH				**Normal Range 6.5 – 8.4**			

Table 2.2 FAO Laboratory determinations needed to evaluate common irrigation water quality problems

Water parameter	**Symbol**	**Unit**	**Usual range in irrigation water**	
SALINITY				
Salt Content				
Electrical Conductivity	EC_w	dS/m	0 – 3	dS/m
(or)				
Total Dissolved Salts	TDS	mg/l	0 – 2000	mg/l
Cations and Anions				
Calcium	Ca^{++}	meq/l	0 – 20	meq/l
Magnesium	Mg^{++}	meq/l	0 – 5	meq/l
Sodium	Na^{+}	meq/l	0 – 40	meq/l
Carbonate	$CO^{--}{}_3$	meq/l	0 – .1	meq/l
Bicarbonate	HCO_3^-	meq/l	0 – 10	meq/l
Chloride	Cl^-	meq/l	0 – 30	meq/l
Sulphate	SO_4^{--}	meq/l	0 – 20	meq/l
NUTRIENTS				
Nitrate-Nitrogen	NO_3-N	mg/l	0 – 10	mg/l
Ammonium-Nitrogen	NH_4-N	mg/l	0 – 5	mg/l
Phosphate-Phosphorus	PO_4-P	mg/l	0 – 2	mg/l
Potassium	K^+	mg/l	0 – 2	mg/l
MISCELLANEOUS				

Boron	B	mg/l	0 – 2	mg/l
Acid/Basicity	pH	1–14	6.0 – 8.5	
Sodium Adsorption Ratio	SAR	(meq/l)	0 – 15	

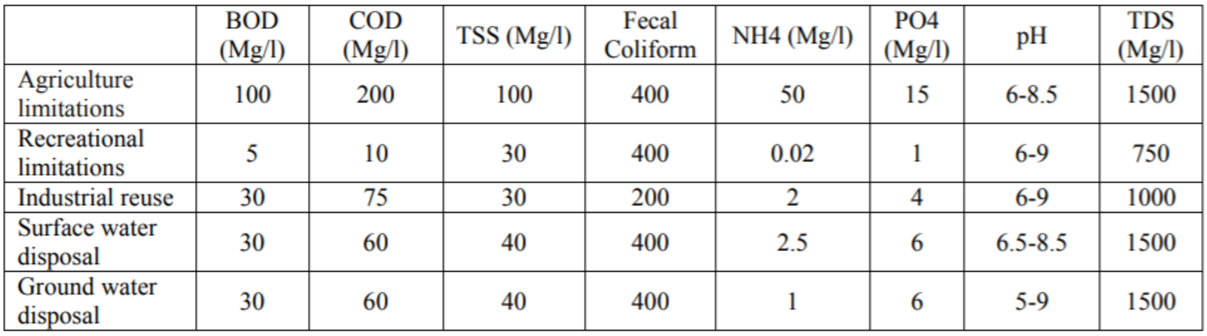
Source: (Ayers and Westcot, 1985)

2.3 Water quality index :

Water constitutes the most important element of body. Water quality index is a dimensionless number that depends on the combination of chemical, physical, and microbiological parameters. The index could be of great help for management and decision makers while planning for water resources. In particular, for comparing effluent quality level achieved by different wastewater treatment sequences (Mudyia, 2012). Generally, water quality indices consist of sub-index scores assigned to each parameter by comparing its measurement with a parameter specific rating curve, optionally weighted and combined into the final index (Yagow and Shanholtz, 1996). In order to carry out an accurate analysis of the resources, it is essential to consider and analyze the values assumed by the individual variables which influence quality (Verlicchi et al., 2011).

Various studies evaluated water quality indices considering different quality parameters. Bhagava (1985) suggested grouping of water quality parameters for potable purpose and evaluated a water quality index for drinking water supplies. A water quality index (WQI) summarizes large amounts of water quality data into simple terms (e.g., excellent, good, bad, etc.) for reporting to managers and the public in a consistent manner (Hulya, 2009).

Table 2.3: Reuse and Disposal limitations of treated effluent



	BOD (Mg/l)	COD (Mg/l)	TSS (Mg/l)	Fecal Coliform	NH4 (Mg/l)	PO4 (Mg/l)	pH	TDS (Mg/l)
Agriculture limitations	100	200	100	400	50	15	6-8.5	1500
Recreational limitations	5	10	30	400	0.02	1	6-9	750
Industrial reuse	30	75	30	200	2	4	6-9	1000
Surface water disposal	30	60	40	400	2.5	6	6.5-8.5	1500
Ground water disposal	30	60	40	400	1	6	5-9	1500

Legally, discharging or reusing the effluent, must meet all the quality standards. A great number of chemical, physical, and microbiological pollutants should be analyzed, which is a complicated and time consuming job. Additionally, in almost all countries, the tendency is to fix limits of concentrations in water for reuse purposes for many quality parameters without identifying the most appropriate treatments. An effluent quality index which is able to rapidly evaluate the quality of the waste water of municipal treatment plant for reuse purposes, is a very significant tool for decision makers to compare different treatment processes and planning for future. To achieve these goals in this study, a water quality index (WQI) is defined and applied in municipal waste water treatment plant in Tlemcen, Algeria. to define a new method for categorizing effluent regarding the reuse purposes.

3 STUDY AREA

3.1 Presentation of Ain El hout in Tlemcen

The area under investigation is the region of Ain El Hout in Tlemcen. Tlemcen is located in the North Western part of Algeria, a hundred kilometers from the Moroccan border. It is limited by: 1) The Mediterranean Sea to the North; 2) The city of Naama to the South; 3) Morocco to the West and 4) The cities Sidi-Bel-Abbes and Ain Temouchent to the east. The region is extended over an area of 9 017,69 km^2 (Ministry of Finances, 2016).The population of Tlemcen region is estimated to 949 132 inhabitants in 2015 (Ministry of Finances, 2016).

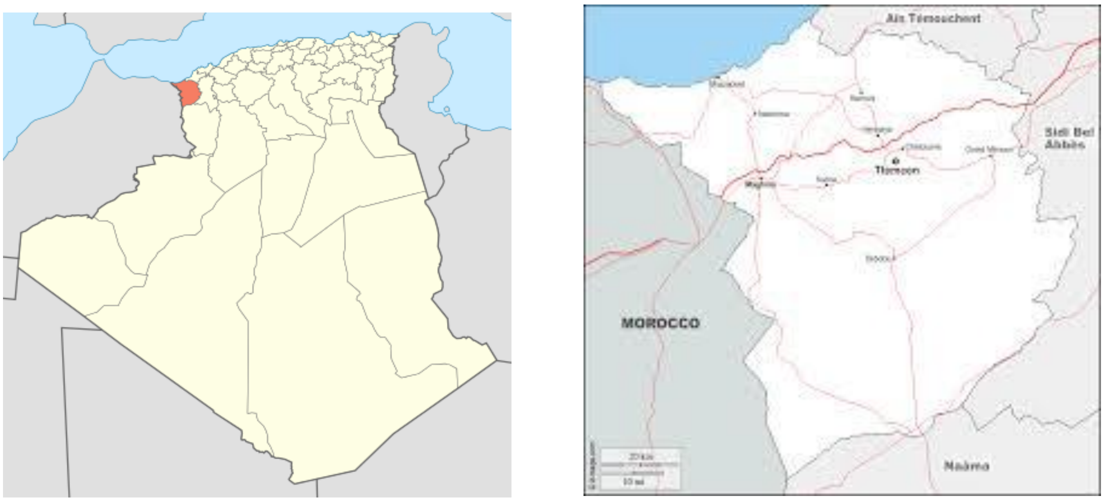


Figure 3.1 Geographical location of Tlemcen

3.2 Situation of the Water Resources of Tlemcen :

The hydrographic network of Tlemcen includes the watersheds of wadi Sidi Djelloul, wadi Hallouf, wadi Sassel, wadi Tafna wadi Malah, wadi Sidi Besbes, wadi Senane, wadi Ouzert and wadi Sidi Baroudi. Wadi Tafna is the most important watershed by its flowrate. It has its source in Morocco at Oued Mouileh (high Tafna) and flows into the Mediterranean Sea to Rachgoun.

Tlemcen is part of the Oranie-Chott Chergui Hydrographic region, which covers the 11 regions of the Western part of the country. This hydrographic region has been the subject of a Regional Plan for the use of water resources, developed in 2004 by the German Technical

Cooperation Agency (GTZ). The agency carried out a general assessment of the water resources and water needs during 2003 for all combined sectors.

From the analysis carried out as part of this plan throughout the region, the following observations have been made:

a. The available surface water and groundwater resources are estimated to be around 517 x 106 m3/yr. With withdrawals estimated to 312 x 106 m3/yr, the exploitation of groundwater has reached its limits and even exceeds natural potential, due to the realization of a large number of illegal drilling.

b. Agriculture is the most important sector in terms of water demand in the region of Oranie-Chott Chergui. The theoretical demand for agricultural water was estimated to be around 491 x 106 m3/yr and about 443 x 106 m3/yr for drinking and industrial water demand, namely, a total theoretical requirement of 934 x 106 m3/yr.

c. The huge deficit found for the Oranie hydrographic region led to drastic limitations of the use of available water resources, whether for drinking water or water for irrigation.

d. The general conclusion of the plan is that the overall deficit in the region could reach 830 x 106 m3/yr by 2020, with a total demand of 1,603 x 106 m3/yr.

3.3 Climate Study

The drought that has occurred in Algeria over past decades had affected the whole of the country and more particularly its North-Western part (Medejerab and Henia, 2011). Tlemcen is a part of the North Western Oran coastal river basin characterized by a semi-arid climate. The average annual rainfall varies from 249 to 389 mm/yr with an average monthly temperature varying from 12 to 26.6 °C (Baghli and Bouanani, 2013). According to Taibi (2012) climate change has led to determinate some impacts and consequences on the river basin: a very strong drought felt over the past decades. The impact of this drought is reflected by a rainfall deficit of 16 to 38% within the river basin.

Sebaibi (201 3) carried out a climatic study in Tlemcen .The National Office of Meteorology in Zenata, a municipality of Tlemcen provided the climatological data. The results of his research are the following:

3.3.1 Precipitations

Over a period of 38 years (1975 to 2013), the monthly variations of precipitations represented in the table below reveal the maximum values in February and November with respective monthly averages values of 46 mm and 52 mm. The minimum values corresponds to the months of July and August with respective monthly averages values of 2 mm and 4 mm.

Table 3.1 : Average monthly precipitations from Zenata, Tlemcen (1975-2013)

Months	J	F	M	A	M	J	J	A	S	O	N	D
Monthly precipitation (mm)	44	46	44	39	29	6	2	4	16	28	52	38

3.3.2 Temperatures

Average temperatures recorded during the period from 1976 to 2013, shows a maximum of 26.9°C in August, which remains the hottest month of the year. The minimum of the average temperatures 10.3°C is recorded in the month of January. The average annual temperature is 17.6°C. As for extreme temperatures, the minimum of monthly averages of minimum temperatures is recorded in January with a value of 4.6°C and 35°C is the maximum of monthly averages recorded in August.

Table 3.2 : Distribution of average monthly minimum and maximum temperatures at the Zenata station (1976 to 2013)

Months	J	F	M	A	M	J	J	A	S	O	N	D	Average
Tmin (°C)	4.6	5.4	7	9.4	11.4	15	18	18,9	15.4	11.3	8	9.6	11
Tmax (°C)	16	17	18.6	22	25.8	29.6	32.5	35	30	25.8	20.5	17.3	24.3
T aver (°C)	10.3	11.2	12.8	15.7	18.6	22.3	25.2	26.9	22.7	18.5	14.2	13.4	17.6

3.4 Bioclimatic syntheses

According to the study carried out by (Abdelhak, 2015) the synthesis of climate data (Precipitations and Temperatures), classify the climate to better understand the distribution and the behavior of different plant and animal associations. Several indices are used to establish this synthesis, though, for the area of study, the aridity index of De Martonne (1926) and the precipitation quotient of Emberger (1955) have been considered.

3.4.1 The Aridity index of De Martonne (1926)

The index of aridity noted I, is a quantitative indicator of the degree of aridity of a region. To calculate it, we use the following relationship (I.1):

$$\mathrm{I} = \frac{\mathrm{P}}{\mathrm{T} + 10} \qquad (\mathrm{I}.1)$$

Where:

I: Index of De Martonne;

P: Average annual precipitation (mm);

T: Average annual temperature (° C);

The table below shows the different climate classifications of the index of De Martonne

Table 3.3 : Climate classifications of the index of De Martonne (Mokhtari et al., 2013)

Value of I	Type of climate	Irrigation
I≤5	Desert	Essential
5<I≤10	Very dry	Essential
10<I≤20	Dry	Often essential
20<I≤30	Relatively wet	Sometimes useful
I>30	Wet	Useless

Over a period of 19 years (1976 to 2013), the index of De Martonne gives a value of 12.6 (P = 348 mm and T = 17.6°C from tables 2.1 and 2.2). Following this result, it can be concluded that the study area Tlemcen is characterized by a dry climate where irrigation is often essential.

3.4.2 The precipitation quotient of Emberger

Among the bioclimatic indices used in the Mediterranean, we can distinguish the Emberger bioclimatic index Q. The following equation (I.2) gives the expression of Q as a function of precipitation and temperature (Abdelhak, 2015):

$$\mathrm{Q} = 2000 \times \frac{\mathrm{P}}{\mathrm{M}^2 - \mathrm{m}^2} \qquad (\mathrm{I.2})$$

Where;

Q: Precipitation coefficient of Emberger;

P: Average annual precipitation (mm);

M: Average of the maximum temperatures of the hottest month (° K);

m: average of the minimum temperatures of the coldest month (° K).

In our case:

$$\left.\begin{array}{l} \mathrm{P} = 348\ \mathrm{mm} \\ \mathrm{M} = 35 + 273 = 308\ ^\circ\mathrm{K} \\ \mathrm{m} = 4.6 + 273 = 277.6\ ^\circ\mathrm{K} \end{array}\right\} \Rightarrow \mathrm{Q} = 39$$

According to the Emberger bioclimatic diagram below, our study, area is classified in the arid bioclimatic stage.

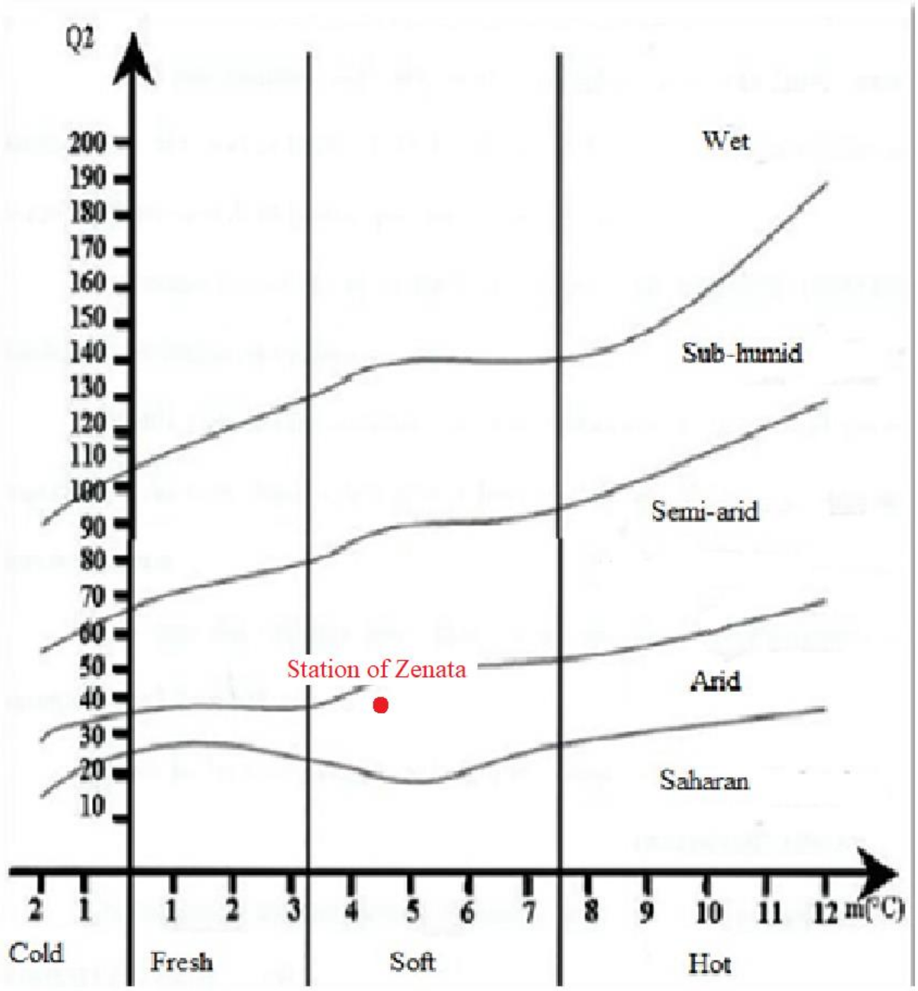


Figure 3.2: Position of the sation of Zenata on the bioclimatic diagram of Emerger

Therefore, considering the vulnerability of this region to the impact of climate change, the state of aridity of the region and given the fact that agriculture is the main water-consuming sector, the reuse of the treated wastewater from the WWTP of Tlemcen for agriculture would be an adaptation measure to climate change, leading to a better water resources management of the region .

4 WASTEWATER TREATMENT PLANT OF AIN EL HOUT (TLEMCEN)

The wastewater treatment plant of the city of Tlemcen is located north of the capital "Tlemcen Ville", west of Chetouane "Daïra" on the Route of Ain El Hout designed for a population of 150 000 eq / hab of a capacity of 30,000 m3 / d, it was carried out by the Hydrotreatment Company commissioned on November 05, 2005, which is currently managed and operated by the National Office for Sanitation.

Figure 4.1: Geographical location of the WWTP

The treatment plant in the city of Tlemcen is activated sludge type low load. In the biological treatment of effluents, aerobic processes are generally used whereby bacteria cause direct oxidation of organic matter from wastewater from dissolved oxygen in the water.

Figure 4.2: Panoramic image of the WWTP

Description of the Operating Process of the Treatment Plant

The WWTP is equipped with two parts of treatment: one for the treatment of wastewater and the other for the treatment of sludge.

4.1 Description of the Treatment Processes of the Wastewater

4.1.1 The storm weir

The domestic wastewater and rainwater from the city of Tlemcen are conveyed gravitationally by a collector of 1250 mm diameter up to the existing look which will be replaced by a storm weir. From the storm weir the wastewater will be transported gravitationally towards the treatment plant by a pipe made of concrete. During the rainy period, the exceeded wastewater to the inflow rate to be treated will be deviated laterally through a channel towards the wadi of Ain El Hout .

Figure 4.3: The storm weir

4.1.2 Pre-Treatment

The pre-treatment involves the mechanical and physical treatment processes of the wastewater. In the WWTP of Ain El Hout, we have the following processes

4.1.2.1 Screening

At this level, large solid wastes such as rags, plastics, wood, tires, cans …are removed. It includes the following equipments:

- **The Mobile Vertical Emergency Bar Screen**

Before the coarse mechanical bar screen, there is a vertical translation barrier to use only during the maintenance period of the coarse mechanical bar screen. The mobile vertical bar screen is made of galvanized steel with a width of 1850 mm and a height of 1000 mm. The thickness of the bars is 15 mm and the spacing between the bars is 50 mm with an Inclination: 70%

Figure 4.4: The Mobile Vertical Emergency Bar Screen

- **Coarse Mechanical Bar Screen**

A vertical coarse mechanical bar screen used for the pretreatment. It works automatically following the increase of the upstream level of the wastewater with the following characteristics: width 1000 mm, spacing between the bars 20 mm, thickness of the bars 30 x12 mm. It aims to eliminate all solid pollutants of significant size to prevent the clogging of the sand trap and the cells of the fine bar screens. At this level, solid wastes, which are greater or equal to 20 mm, are removed. Then, the solid wastes recovered are taken over by a steel screw conveyor and evacuated to avoid the diffusion of bad smells.

Figure 4.5: The coarse mechanical bar screen

4.1.2.2 Sand, Grease and Oil Removal

It involves the physical treatment process of the wastewater. The pretreated wastewater contains a significant amount of sands, grease and oils, which may hinder or slow down the operation of downstream structures. During this step of pretreatment, two equipments (sand trap and de-greaser) are installed for sand, grease and oil removal. These two equipments have a volume of 120 m^3 each, a width of 4 m, a height of 9 m, and a length of 26 m. To obtain the elimination of inert elements of small particle size, we use a mechanized sand trap in which the air is blown through a compressor, to avoid the fermentation of the wastewater to be treated. Oils and floating bodies are transported to the surface in the lateral zone of tranquilization. Sand grease and oil are recovered by the means of a motorized moving bridge equipped with a bottom scraper for sands. Floating elements and oils are evacuated by the means of a scraper in two storage basins with a capacity of 20 m^3 each incorporated in the downstream side of the sand trap. The sand decanted in the bottom of the basin is scraped into the pit located at the entrance of the sand trap. A pump recovers intermittently the sands by pushing them back into a washing device. The retention time for an average flow rate is of 25 minutes, thanks to which a separation efficiency of 98.5% is obtained for particle sizes ranging between 0.12 and 0.16 mm.

Figure 4.6: The sand, Grease and Oil removal units

4.1.3 **Secondary Treatment**: Biological Treatment

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The pretreated water flows into a compartment where a volume of recirculated sludge from the second clarifier is added. In this compartment, recycled sludge from the clarifier is pumped in liquid form and mixed with the pre-treated water. Then, the water that has been mixed with recirculated sludge flows through the distribution channel with the aerated liquor before entering into the denitrification basin.

The station has four units of aeration basins, at each unit there are two separate basins

4.1.3.1 Nitrification and Denitrification

The purpose of the nitrification process is the transformation by biological oxidation ammoniacal forms of nitrogen present in the wastewater, in origin about 60 % of all in the form of nitrates. Biological denitrification can be defined as a process through which microorganisms reduce nitrate ions and nitrogen gas (N_2), nitrous oxide (N_2O) ions to nitric oxide (NO). Biological denitrification can be considered as the most widely system used for the removal of nitrogen in urban wastewater treatment plants. Bacterial strains capable of developing biological denitrification are called heterotrophs, because they can metabolize the complex organic substrate using for the oxidation of its different compounds molecular oxygen (when available) or oxygen present in the nitrate. Under the conditions of anoxia, specific bacteria reduce nitrates by a mechanism in which nitrate and nitrites dissolved in water replace oxygen for cellular respiration. The process of nitrate dissimilation occurs through a series of complex reactions of enzyme catalysis in two stages: In the first stage, the nitrates are reduced to nitrites, in the second step, nitrites are reduced to nitrogen gas (N_2).

In the wastewater treatment plant of Ain El Hout, there are four denitrification basins with the following characteristics: - Volume 725 m3, Length 187.56 m, Width 8.5 m, - Height of concrete 5.6 m and Height of water 4,9 m

Figure 4.7: Nitrification and Denitrification Basins

4.1.3.2 Aeration Basins

The basin has a rectangular shape, is supplied with denitrified water aeration in the basin is carried out using slow speed surface aerator; each basin is equipped with three aerators. This favorable environment causes the development of bacteria that by physicochemical action retain the organic pollution is feed, at each basin there is a dissolved oxygen sensor to ensure the automatic triggering of aeration in case of failure of the concentration of the latter, each aeration basin has the following dimensions: Volume: 4723 m3, Length: 55.5 m, Width: 18.5 m , Depth of water: 4.6 m and Concrete height: 5.6m.

The Water coming out from the denitrification basins overflows the separation wall, which acts as a weir to achieve uniform movement across the width of the basin. On the bottom of the basin is installed a network of membrane-type air diffusers having a porosity of 60 µ. With the use of the porous system based on elastic material, the air diffusers do not present any risk of clogging.

Figure 4.8: Aeration Basins

The water after passing through all these steps then flows to the secondary clarifiers.

4.1.3.3 Secondary Clarifier

The WWTP of Ain El Hout is equipped with two circular secondary clarifiers with peripheral traction each have a diameter of 46 m, surface of 1661 m² and a water depth of 4 m. The clarifiers are equipped with a bottom scraper, a central deflector for radial distribution, a superficial blade for the evacuation of the scum towards the scums box connected to a well, a mobile pump ensures the evacuation of these scums with oils and greases.

Figure 4.9: A secondary clarifier

According to the laboratory staff of the plant, preliminary studies carried out before the construction of the WWTP, have shown that the wastewater from Ain El Hout contain a high concentration of phosphorus (more than 40 mg/ l) , compared to European wastewater (maximum 20 mg / l). However, some analyzes carried out by the laboratory of the plant have shown that the treated wastewater from the clarifiers contain a high amount of phosphorous remains. For this reason, the water coming out of the clarifiers must undergo a tertiary treatment.

4.1.4 Tertiary Treatment

The water coming out of the clarifiers is directed to a distributor well to be subjected to phosphorus precipitation treatment by a dosage of the ferric chloride, mixed at the well through a quick stirrer, separated into three lines and each directed to the clarifloculator for the precipitation of phosphorus in the form of chemical sludge. The chemical sludge is evacuated to the thickener by submerged pumps installed at the chemical sludge wel

4.1.4.1 The Clariflocculators

Two circular clariflocculators with peripheral traction and a slow-type agitator, having each a diameter of 46 m and a total height of 4 m are installed for the precipitation of phosphorus with the ferric chloride. Then the amount of phosphorous will decrease while chemical a sludge is formed. This sludge will be evacuated to the sludge thickener by submerged pumps installed inside the clariflocculators.

Figure 4.10: A clariflocculator

After all these treatment processes, the water will undergo a disinfection treatment for the elimination of pathogenic microorganisms.

4.1.4.2 The Disinfection Basin

The wastewater treatment plant of Ain El Hout is equipped with a disinfection basin with the The total volume is estimated to 700 m^3. The installed dosing capacity and 40 Kg of chlorine per hour. The reagent used for disinfection is the sodium hypochlorite (NaCLO). The expected contact time is 43 minutes for the average daily inflow rate and 14 minutes for peak inflow rate during rainy period. However, the chlorine disinfection treatment is suspended in the WWTP. This is justified by the unavailability of the chemical (sodium hypochlorite) in the plant.

Figure 4.11: The disinfection basin

Then, the treated wastewater will flow through a canal to be discharged in the Oued of Ain El Hout.

4.2 Description of the Treatment Processes of the Sludge

The treatment processes of the sludge are comprised of the following steps:

4.2.1 Recycling and Disposal of the Exceeded Sludge

During this step, the activated sludge is subtracted from the bottom of the clarifier, returned back to the top of the biological treatment, in order to regenerate it and to maintain a substantially constant concentration in purifying microorganisms. A submerged pump and another one in reserve, placed in a well, provide this recycling operation. Each pump have the following characteristics: The unitary flowrate is equal to 455 m^3/hr and the manometric height is equal to 5.0 m.

In the same well, there are two other pumps, of which one in reserve, for the evacuation of exceeded sludge towards the thickener. The characteristics of these pumps are: The flow rate is equal to 30 m^3/hr, the total manometric height is equal to 5.0 m. The maximum concentration of sludge extracted from the clarifier is approximately 0.8%.

In each recycling line, a flow meter is placed to allow the possibility to adapt the recycling flowrate according to the flowrate of the wastewater entering in the WWTP.

4.2.2 Thickening of Biological and Chemical Sludge

This treatment is the first stage of a significant reduction of the volume of the sludge from the biological and chemical treatment of the wastewater. The exceeded sludge is directed to a circular thickener with a diameter of 16 m, and the total height is 4.5m. Mechanization is applied in a scraping and slow stirring system to facilitate the sludge slippage to the central pit from which they are extracted and to allow the release of interstitial water and gases contained in the sludge.

Figure 4.12: Transport of sludge by Recirculation screw

- *Sludge Dewatering*

Dehydration is the second step in reducing the volume of the sludge in order to bring them to the solid state. In the wastewater treatment plant of Ain El Hout, the dehydration is done through drying beds .

4.2.2.1 Mud thickener:

Figure 4.13: Sludge thickener

After biological treatment, the sludge is the main residue of the Ain El Houtz wastewater treatment plant. It is first directed to the thickener, which has a circular shape made of reinforced concrete 14 m in diameter and a useful height of 4 m, the bottom of the basin to a slope of 1/10.

4.2.2.2 *Drying Beds*

The thickening mud is taken by pumping and discharged to the drying beds. Sludge drying is carried out in open air in areas of areas 30 m long and 15 m wide. There are 14 drying beds made of concrete equipped with a perforated drainage pipe, to allow the evacuation of filtered water to the entrance of the station

Figure 4.14: Drying beds

The drying time in the plant is normally about 4-6 weeks, however, it can reach 3 to 4 months during unfavorable weather conditions.

5 MATERIAL AND METHODS

In order to assess the quality of the treated wastewater from the WWTP of Ain El Hout (Tlemcen), a series of analyzes on the water quality parameters were carried out. Sampling of the treated wastewater has been done using automatic samplers. Some analyzes were carried out in the laboratory of the plant. The physico-chemical parameters that are usually analyzed in the laboratory are: Temperature, pH, Electrical conductivity, Total dissolved salts (TDS), Total suspended matter (TSM), Dissolved oxygen (DO), Biological oxygen demand (BOD_5), Chemical oxygen demand (COD), Phosphates (PO_4^{3-}). Nitrate-nitrogen (NO_3-N), Ammonium nitrogen (N-NH_4^+). The laboratory of the plant does not have equipments to carry out the analyzes for microbiological and heavy metals parameters. However, two water samples of the treated wastewater were taken on 21st June 2018.

5.1 Temperature

Among the physical parameters that characterize different environments, water temperature is one of the most important environmental characteristics, which determine, to a considerable extend, the trend of change in its quality. In the WWTP of Ain El Hout, the temperature is measured using a thermometric probe, which is soaked carefully in the water sample. Then, the reading of the value is done after the stabilization of the thermometer.

5.2 pH

It expresses the acidity or basicity of water. The pH value of water is determined by the concentrations of H^+ ion and OH^- ion. Water with a pH of 7 has equal concentrations of H^+ ion and OH^- ion and is considered to be a neutral solution. If a solution is acidic (pH less than7), the concentration of H^+ ion is greater than the concentration of OH^- ion. If a solution is basic (pH greater than 7), the concentration of H^+ ion is less than the concentration of OH^- ion. In the WWTP of Ain El Hout, the measurement of the pH is based on the use of a WTW brand pH meter.

Figure 5.1 : pH meter.

5.3 Electrical Conductivity

Conductivity is the measure of the capacity of a water to conduct an electric current. Expressed in micro Siemens per centimeter, its value varies according to the temperature. It is measured at 20 ° C and related to the concentration of total dissolved salts. In the WWTP of Ain El Hout, the conductivity is measured using a HANNA brand conductivity meter.

Figure 5.2: Electrical conductivity measurement

5.4 Total Suspended Matters (TSM)

Total suspended matters are composed of organic and mineral fine particles, insoluble and are the source of the turbidity of water. They limit the penetration of light into the water, decrease the dissolved oxygen content, and harm the development of aquatic life. The materials and experimental procedure used to determine the total suspended matters in the laboratory are explained below:

- Vacuum pumps
- Filtration unit
- Micro fiberglass filters
- Stove
- Desiccator
- Analytical balance
- Pliers

5.4.1 Experimental Procedure

a. The filter is washed in the vacuum filtration unit by passing distilled water, then placed in the stove at a temperature of 103 to 105 °C, during 2 hours. It will then be kept in a desiccator and weighed.
b. After that, the filter is placed in the funnel of the filtration device, and connected to a vacuum suction device.
c. A sample volume of the treated wastewater is filtered in a few seconds.
d. We carefully remove the filter from the funnel using flat-ended pliers. It is then weighed using the analytical balance.
e. Then the filter is dried at about 105 °C, cooled, and finally weighed to get the suspended matter results.

The following formula is used to obtain the results:

$$\mathbf{TSS\ (mg/l) = (M2-M1)*1000/V}$$

Where:

TSM: Total suspended matters (mg/l)

M2: Mass of the filter after drying (mg)

M1: Mass of the empty filter, before filtration (mg)

V: Volume of the water sample filtered (ml)

Figure 5.3 : Total suspended matters measurement

5.5 Dissolved Oxygen (DO)

Figure 5.4: Dissolved oxygen measurement

The amount of oxygen gas dissolved in water (DO) is important for the survival of most aquatic organisms as it provides them with oxygen to carry out cellular respiration. In the WWTP of Ain El Hout, dissolved oxygen is measured using a HANNA brand oximeter. The oximeter probes are placed in the water sample. The reading of the value is done after the stabilization of the oximeter.

5.6 Biological Oxygen Demand (BOD_5)

The concentration of organic matter in wastewater is measured by the biological oxygen demand (BOD) value. BOD measures the amount of dissolved oxygen the microorganisms require to oxidase or decompose the organic matter present in the wastewater. In the laboratory, the amount of oxygen is expressed under the conditions of the test (incubation for 5 days at 20 °C in the darkness).

5.6.1 Principle

The measurement of the BOD_5 is based on the measurement of the pressure in a closed system where microorganisms consume oxygen in the sample and generate carbon dioxide (CO_2) emissions. The carbon dioxide CO_2 is absorbed with sodium hydroxide (NaOH), and negative pressure is created then measured directly by the transmitter. The transmitter transforms the pressure value directly to the BOD_5 (mg /l). With sample volumes, we regulate the amount of available oxygen which can make a complete determination of BOD at different concentrations and with different volumes.

5.6.2 Materials and Reagents

For the BOD system, we have:

- Measuring heads (BOD sensors)
- Measuring bulbs brown
- Magnetic stirrers
- Pliers
- Rubber carcass for the necks of the bulbs
- Sodium hydroxide (NaOH) lenses
- Thermostatic incubator with constant temperature at 20 degree Celsius
- Inhibitor of nitrification.
- Containers and pipettes of several sizes

- Distilled water
- Calibration tablet for system controls VELP: D (+) glucose $C_6H_{12}O_6$ and L-glutamic acid $C_5H_9NO_4$.

5.6.3 Experimental Procedure

a. A sample volume corresponding to the desired BOD to be obtained is selected.
b. We clean the bulbs with distilled water to lighten them, then with the sample of the treated water.
c. Add a quantity of the homogenized sample.
d. Agitate each bulb with a magnetic stirrer.
e. Put on the neck of the bulb a rubber carcass. Inside, add with the pliers the lenses of NaOH. Then fill with the treated water up to the limit without exceeding.
f. The bulbs are placed in an incubator for the measurement of BOD_5.The incubator is set to zero value and starts working for five days at 20°C. The result of the value will be displayed directly on the device.

Figure 5.5: Biological oxygen demand measurement

5.7 Chemical Oxygen Demand (COD)

Chemical oxygen demand represents the quantity of oxygen required to chemically stabilize the carbonaceous organic matter using strong oxidizing agents under acidic conditions. The method used to determine the COD in the laboratory of Ain Temouchent is described below:

5.7.1 Principle

The test consists of a chemical oxidation of the organic matter by a strong oxidant (acid) at high temperature and by the potassium dichromate ($K_2Cr_2O_7$).Oxidizable substances react with a sulfuric acid (H_2SO_4) solution and potassium dichromates in the presence of silver sulphates (Ag_2SO_4) as a catalyst. The presence of chloride is masked with mercury sulfate ($HgSO_4$). We measure the decrease of the yellow coloring of Cr^{6+}. The result is expressed in mg O_2 /l (milliliter ppm O_2).

5.7.2 Materials and Reagents

The following material are used:

- COD measurement kits
- Distilled water (dissolution cleaning).
- Digester HACH COD REACTOR
- Spectrophotometer DR 2000
- Gradette support
- Graduated pipette 2 ml
- Pipette aspirator 2 ml

5.7.3 Experimental Procedure

a. We select the COD program: this program heats the vat for 2 hours at 150 °C. During the cooling phase, four sound signals indicate that the vats have been cooled to a temperature of 120°C.

b. The vats are prepared by mixing the kit contents to have a homogeneous solution and 2 ml of water sample are pipetted carefully.

c. The thermostat heats up to the set temperature. Two sound signals indicate that the required temperature has been reached.

d. Then the vats are placed in a heating block HACH COD REACTOR , while closing the protective cover. We put the vats in the conventional COD digester during two hours at 150 °C.
e. We remove the hot vat and invert carefully twice.
f. The vat is cooled at room temperature in the vat support.
g. Finally, we clean the outside part of the vat and measure it with a HACH brand spectrophotometer.

Figure 5.6:Chemical oxygen demand measurement

5.8 Phosphates (PO_4^{3-})

Phosphorous is a macronutrient essential to all plants and microorganisms growth. Phosphorous concentration determines the level of eutrophication phenomena. Total phosphorous exist in organic (combined with organic matter) and inorganic (orthophosphates and polyphosphates) forms. Agricultural wastes fertilizers contain high levels of phosphates that enter the water through runoff and erosion. Phosphorus in the form of phosphate (PO_4^{3-}) is an essential plant nutrient and is a major component of most fertilizers.

5.8.1 Principle

Phosphate ions react in acidic solution with molybdate ions to give an antimony molybdate phosphorus complex. The ascorbic acid to phosphorus-molybdenum blue reduces this.

5.8.2 Materials and Reagents

- Measuring kit HACH DR 2000
- Distilled water.
- HACH DR 2000 spectrophotometer.
- Graduated pipette 2 ml.
- Aspirators pipette 2 ml.

5.8.3 Experimental procedure

a. Enter a stored program number for reactive phosphorus powder pillow
b. Press 490 READ/ENTER, the display will show: DIAL nm TO 890
c. Press: READ/ENTER the display will show: mg/l PO_4^{-3} PV or mg/l P PV
d. Fill a sample cell with 25 mL of sample
e. Add the contents of one PhosVer3 phosphate Powder Pillow to the sample cell (the prepared sample). Swirl immediately to mix.
f. Press: SHIFT TIMER, A 2-minute reaction will begin.
g. Fill another sample cell (the blank) with 25 mL of sample. Place it into the cell holder
h. Whene the timer beeps, this display will show: ml/l P PV, Press ZERO the display will show: WAIT, then 0.00 mg/l PO_4^{-3} PV or 0.00 mg/l P PV.
i. Place the prepared sample into the cell holder. Close the light shield.
j. Press: READ/ENTER the display will show: WAIT the results in mg/L P will be display.

NOTE: for conversion of Phosphorus:

- mg/l PO_4^{-3} PV = mg/l P* 3.07
- mg/l P_2O_5 =mg/l P* 2.25
- mg/l P_2O_5 =mg/l PO_4^{-3} 0.75

Figure 5.7: Phosphates measurement

5.9 Nitrites (N-NO_2^-)

Nitrite (NO_2^-) is the degrardation of Nitarates and it toxic to human health.

5.9.1 Principle

Nitrite reacts with p-aminophenylmercaptoacetic acid in the presence of hydrochloric acid to form a diazonium cation, which is subsequently coupled with N-(1-naphthyl) ethylenediamine dihydrochloride in acidic medium to form a stable bluish violet azo dye.

5.9.2 Materials and Reagents

- Measuring kit HACH DR 2000
- Distilled water.
- HACH DR 2000 spectrophotometer.
- Graduated pipette 2 ml.
- Aspirators pipette 2 ml.

5.9.3 Experimental Procedure

1. Enter a stored program number for reactive of Nitrate small concentration.
2. Press 351 READ/ENTER, the display will show: DIAL nm TO 507
3. Press: READ/ENTER the display will show: mg/l NNO_2^-
4. Fill a sample cell with 25 mL of sample

5. Add the contents of one NitriVer3 phosphate Powder Pillow to the sample cell (the prepared sample). Swirl immediately to mix.
6. Press: SHIFT TIMER, A 15 minute reaction will begin.
7. When the timer beeps, this display will show: mg/l NNO_2^-, Fill another sample cell (the blank) with 25 mL of sample. Place it into the cell holder
8. Press ZERO, the display will show: WAIT, then 0.00 mg/l N NO_2^- L
9. Place the prepared sample into the cell holder. Close the light shield.
10. Press: READ/ENTER the display will show: WAIT the results will be display.

5.10 Nitrates Nitrogen (NO_3-N)

Nitrogen is a macronutrient essential for plants and microorganism's growth. Nitrate-nitrogen is the final product in the oxidation of ammonia produced in the first stage of the decomposition of nitrogen. Nitrates are non-hazardous inorganic compounds but when degraded to nitrite (NO_2^-) becomes very toxic to human health.

5.10.1 Principle

In a sulfuric acid solution and phosphoric, nitrates react with the dimethylphenol to give nitro-dimethyl phenol.

5.10.2 Materials and Reagents

- Measuring kit HACH DR 2000
- Distilled water.
- HACH DR 2000 spectrophotometer.
- Graduated pipette 2 ml.
- Aspirators pipette 2 ml.

5.10.3 Experimental Procedure

1. Enter a stored program number for reactive of Nitrate small concentration.
2. Press 351 READ/ENTER, the display will show: DIAL nm TO 507
3. Press: READ/ENTER the display will show: mg/l N-NO_3^-
4. Fill a sample cell with 30 mL of sample
5. Add the contents of one Nitrate Ver6 phosphate Powder Pillow to the sample cell (the prepared sample). Swirl immediately to mix.

6. Press: SHIFT TIMER, A 3-minute reaction will begin.
7. When the timer beeps press: SHIFT TIMER a second period of reaction of 2 min will begin to allow cadmium to be settle
8. When the timer beeps fill another sample cell (the blank) with 25 mL of sample
9. Add to it one Powder Pillow of Nitrit Ver3
10. Press: SHIFT TIMER, A 10-minute reaction will begin.
11. When the timer beeps, this display will show: mg/l NO_3^-, Fill another sample cell (the blank) with 25 mL of sample. Place it into the cell holder
12. Press ZERO
13. Place the prepared sample into the cell holder. Close the light shield.
14. Press: READ/ENTER the display will show: WAIT the results will be display.

Figure 5.8: Nitrates nitrogen measurement

5.11 Ammonium Nitrogen N-NH_4^+

Nitrogen from wastewater is in organic and inorganic forms. Inorganic forms are immediately available to the plant while microorganisms must mineralize organic forms. The mineral forms of nitrogen are ammonium and nitrate.

5.11.1 Principle

In the presence of sodium acting as a catalyst and at a pH value of about 12.6, the ammonium ions react with hypochlorous and salicylic ions to give a blue color.

5.11.2 Materials and Reagents

- Nitrite measurement kit
- Distilled water.
- Spectrophotometer HACH DR 2000.
- Graduated pipette 2ml.
- Aspirator pipette 2ml.

5.11.3 Experimental Procedure

1. Enter the stored program number for Ammonia Nitrogen (NH_3-N), Press: 380 READ/ENTER, the display will show : DIAL nm 425
2. Press: READ/ENTER the display will show: mg/l N NH_3 Ness
3. Fill a sample cell with 25 mL of sample
4. Fill another 25 mL mixing graduated cylinder with demineralized (the bank)
5. Add three drops of Mineral Stabilizer to each cylinder. Invert several times to mix. ADD three drops of polyvinyl Alcohol Dispersing Agent to each cylinder.
6. Pipet 1.0 mL of Nessler Reagent into each cylinder. Stopper. Invert several time to mix.
7. Press: SHIFT TIMER, 1 minute reaction will begin.
8. Pour each solution into respective blank and prepared sample cells.
9. When the timer beeps, the display will show: mg/l N NH_3 Ness Place the blank into the cell holder. Close the light Shield.
10. Press ZERO the display will show: WAIT, then 0.00mg/l N NH_3 Ness

11. Place the prepared sample into the cell holder. Close the light shield.
12. Press: READ/ENTER, the display will show WAIT then the result will be displayed

6 RESULTS AND DISCUSSIONS

To evaluate the feasibility of reusing the treated wastewater from the WWTP of Ain El Hout for agricultural purposes, physico-chemical analyzes were performed on the wastewater before and after the treatment in order to assess its quality and level of response to the requirements and standards established for irrigation. Results obtained from analyzes carried out on the wastewater are interpreted and compared to some existing recommendations and norms (Algerian, FAO and WHO). The results include the following parameters usually measured in the plant for the year 2016: Temperature, PH, Total dissolved salts (TDS), Total suspended matter (TSM), Dissolved oxygen (DO), Biological oxygen demand (BOD5), Chemical oxygen demand (COD), Phosphates (PO43-), Nitrate-nitrogen (NO3-N) and Ammonium nitrogen (N-NH4+). The experimental results are presented (Table 6.1 and 6.2).

6.1 Physico-Chemical Parameters

Table 6.1: Physico-Chemical Parameters variation of wastewater before and after the treatment

Month	T°c		EC (µS/cm)		PH		TSM (mg/l)		DO (mg/l)		BOD (mg/l)		COD (mg/l)	
	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After
January	8.33	7.01	1 323	994	7.51	7.42	372.45	14.11	4	8.6	360.45	15.76	514.2	31.60
February	7.98	6.47	1024	982	7.69	7.48	407.83	13.35	4	8.72	196.00	22.08	549.50	38.00
March	12.25	12.05	1354	947	7.61	7.58	334.57	14.00	4.25	8.25	247.20	19.52	491.60	40.20
April	12.43	11.87	1322	975	7.64	7.62	286.05	33.95	4.17	7.17	254.88	21.23	445.25	38.75
May	20.75	19.48	1302	970	7.67	7.51	377.14	16.81	4.35	7.35	261.75	20.38	501.25	37.50
June	23.32	24.53	1322	803	7.64	7.53	353.68	19.05	4.55	6.55	407.25	24.13	607.50	48.00
July	24.25	27.32	1423	935	7.98	7.77	373.56	12.33	4.45	6.45	367.50	18.13	677.00	43.00
August	24.85	26.36	1420	973	7.84	7.65	330.43	19.13	4.31	5.31	416.80	23.56	607.80	52.60
September	22.96	22.80	1094	942	7.46	7.69	325.36	17.91	4.3	5.3	371.25	20.73	464.75	40.50
October	21.93	20.85	1276	912	7.55	7.67	214.62	16.59	4	7	347.00	17.40	441.50	35.25

November	9.13	10.41	1023	873	7.51	7.60	212.94	13.28	4.42	8.42	269.75	13.88	484.00	16.75
December	7.36	8.0	1078	972	7.67	7.60	300.05	11.62	4	7	309.40	19.90	514.00	27.60
Medium	**17.02**	**17.2**	**1230**	**939**	**7.648**	**7.593**	**324.1**	**15.26**	**4.233**	**6.88**	**317.4**	**19.73**	**524.9**	**37.48**

6.1.1 Temperature

6.1.1.1 Results

The obtained results showed that the absolute values of temperature for the water before treatment varies between a minimum of 7.36 °C in December and a maximum of 24.85°C in August , and between 6.47°C in February and 27°C in july after treatment (Table 6.1 and Fig 6.1)

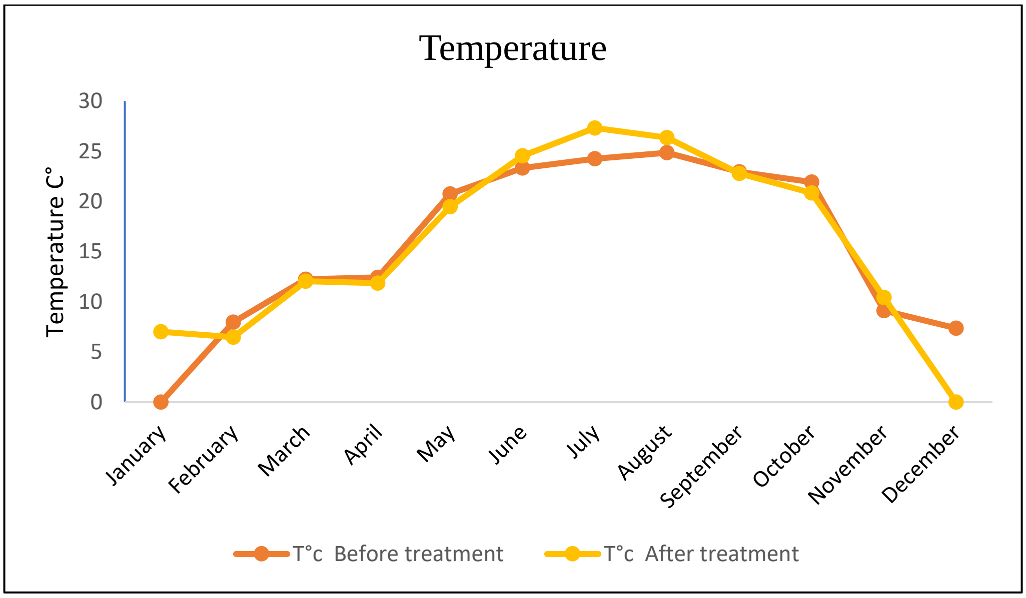


Figure 6.1: Monthly variations of Temperature values for waste water before and after treatments

6.1.1.2 Discussion

Water temperature has impacts on water chemistry and biological life. Moreover, the level of chemical reactions increases at higher temperature. The change in temperature influences the amount of oxygen that can be dissolved in water as well as rate of photosynthesis by algae and other aquatic plants. As temperature decreases, the amount of oxygen that will dissolve in water increases. Increased water temperature can cause an increase in the photosynthetic rate of aquatic plants and algae, which can lead to increased plant growth and algal blooms that harm the local ecosystems (Johnson, R.L, Holman, S, Holmquist, 1999). Moreover, temperature also affects the sensitivity of organisms to toxins, parasites and diseases.

In the present study, a comparison was made to assess the temperature status of the water before and after treatment for the year 2016. According to Fig 6.1, we observe that the variation of the temperature was followed the difference in the Air temperature by increasing values in Summer season and decreasing in winter.

6.1.2 Electrical Conductivity (EC)

6.1.2.1 Results

The obtained results showed that the absolute values of electrical conductivity for the waste water before treatment varies between a minimum of 1023 µS/cm in November and a maximum of 1423 µS/cm in July and between 803 µS/cm in June and 994 µS/cm in January after treatment (Table 6.1 and Fig 6.2)

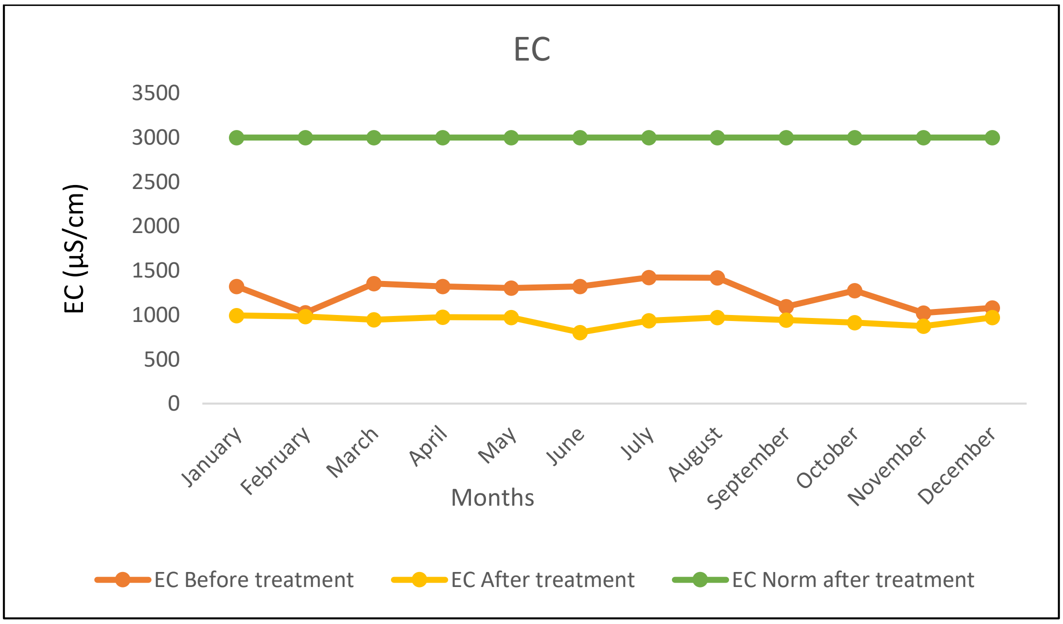


Figure 6.2: monthly variation of EC for the wastewater before and after treatment

6.1.2.2 Discussion

Pure water has a very low, but not quite zero, electrical conductivity. This conductivity provides a probe into fundamental properties of water, including the electrochemical mobility of the hydrogen and hydroxide ions. Conductivity is a parameter is a general indicator of water quality, especially a function of the amount of dissolved salt, and can be used to monitor processes in the wastewater treatment that causes changes in total salt concentration and thus changes the conductivity (Levlin, 2006). In wastewater treatment the main processes that reduces conductivity are biological nutrient removal (Aguado et al. 2006, Maurer och Gujer, 1995). The most influential water quality guideline on crop productivity is the water salinity hazard as measured by electrical conductivity (Tak et al., 2010). Sources of salinity include urban and rural run-off containing salt, fertilizers and organic matter. The composition of salt in water varies according to the source and properties of the constituent's chemical compounds. This may include calcium (Ca2+), magnesium (Mg2+), sodium (Na+), potassium (K+), chlorides (Cl-), sulphates (SO42-) and bicarbonates (HCO3-) salts. In the case of the WWTP of Ain El Hout, according to the Fig 6.2 the recorded values are below the Algerian standard (3000 µS/cm) whish means that the water can be used for irrigation.

6.1.3 pH

6.1.3.1 Results

The absolute values of pH for the wastewater before treatment vary between a minimum of 7.44 in February and a maximum of 7.69 in August. However, after treatment the values vary between a minimum of 7.42 in January and a maximum of 7.69 in September (Table 6.1 and Fig 6.3)

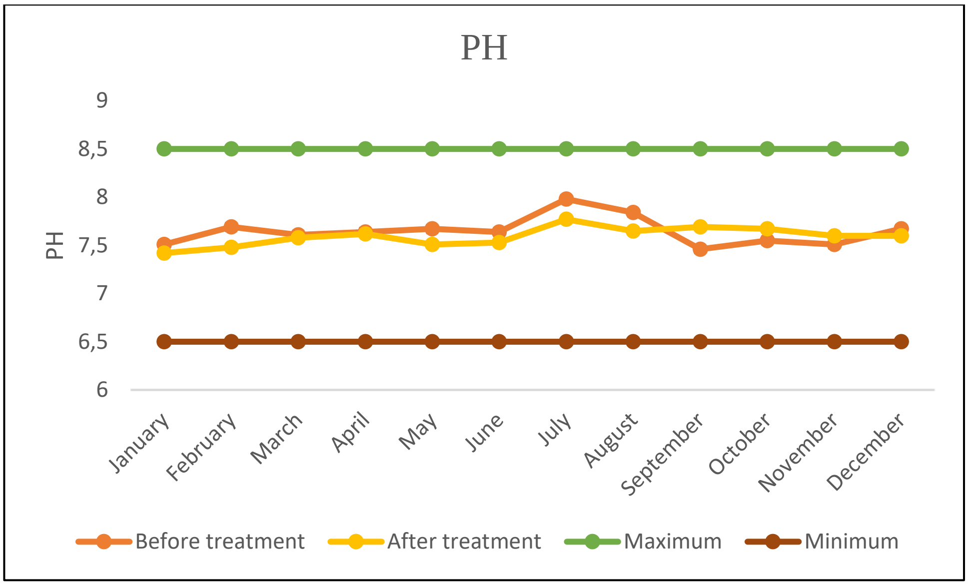


Figure 6.3: monthly variation of pH for the wastewater before and after treatment

6.1.3.2 Discussion

The pH is a reflection of many biological and chemical processes occurring in the aquatic environment (Sreenivasan, 1974). Major among these are photosynthetic activities of aquatic plants, respiration of aquatic organisms, decomposition of organic matter, precipitation, dissolution and oxidation-reduction reactions taking place in the aquatic environment. The pH plays an important role in many aquatic life processes. Living organisms are dependent on and sensitive to pH. It is not only a measure of the potential pollutant but is also related initially to concentration of many other substances, particularly the weakly dissociated acids and bases.

The acidity or basicity of irrigation water is expressed as pH (< 7.0 acidic; > 7.0 basic). High pH's above 8.5 are often caused by high bicarbonate (HCO_3^-) and carbonate (CO_3^{2-}) concentrations, known as alkalinity. Calcium and magnesium ions become insoluble due to high carbonates and bicarbonates and sodium remain the dominant ion in solution (Tak et al., 2010). According to the Algerian standards, the normal pH for irrigation water ranges from 6.5 to 8.5 (Table 2.1).

From the observations made in Fig 6.3, the variation of pH values throughout the year under investigation was in the range of the standard values set by the Algerian Government for treated wastewater intended for irrigation (6.5 to 8.5) with a limited seasonal variation. The relatively high pH value recorded in the warm months (July and August) might be attributed mainly to the rise in temperature during summer (Hutchinson and Stokes, 1975). Welch (1952) found that shallow areas had relatively high pH in summer seasons due to the loss of CO2 because of evaporation and precipitation of monocarbonates. Generally, this water does not represent any risks neither for soil nor for crops. However, The long-time use of irrigation water with low or high pH values can be dangerous for crops production (Bortolini, Maucieri and Borin, 2018).

6.1.4 Total Suspended Matters (TSM)

6.1.4.1 Results

The absolute values of total suspended matters from the WWTP of Ain El Hout vary between a minimum of 212.94mg/l in November and a maximum of 407.83 mg/l in February for non treated water and between a minimum of 11.62 mg/l in December and maximum of 33.95mg/l in April for treated water (Table 6.1 and Fig 6.4).

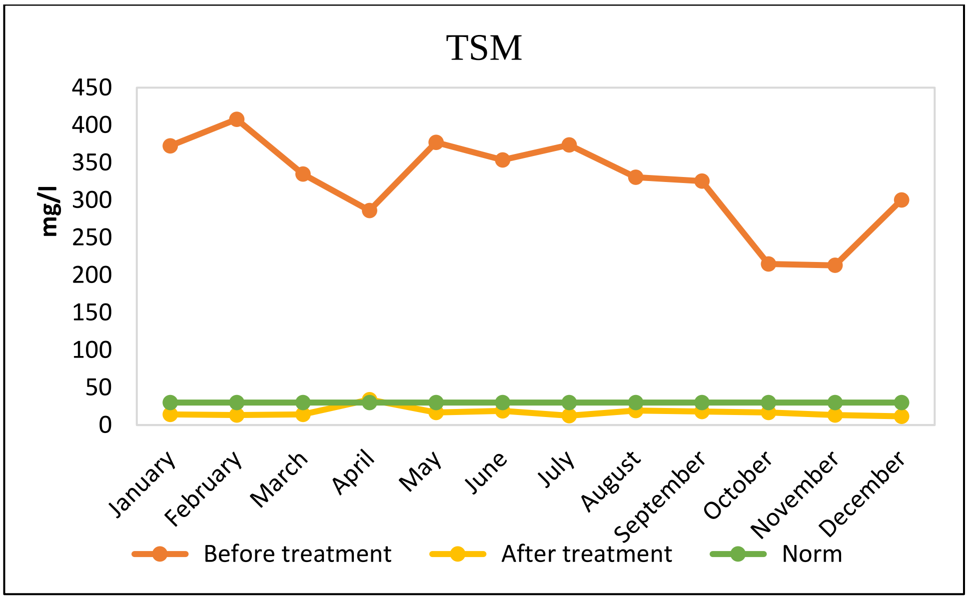


Figure 6.4: monthly variation of TSM for the wastewater before and after treatment

6.1.4.2 Discussion

Suspended matters consist mainly of inorganic and organic fractions. The inorganic particles are composed of lithogenic clay, slit, sand and particles resulted from chemical processes, such as precipitation of calcium carbonate or formation of colloidal hydroxides (Harris, 1972). Organic materials play a vital role in marine ecology. They provide an essential part of the energy, food vitamins and other requirements for bacteria, plants and animals (Ryther and Menzel, 1965). According to Zeitschel (1970) suspended matter consists of lithogenic clay, silt, sand…etc., and biogenic parts including phytoplankton, zooplankton and detritus.

The monthly variation of the total suspended solids before treatment showed a maximum value of 407,83 mg/l in February and a minimum of 212,94mg/l in November this might be related to the biological processes, quantity and quality of wastewater discharged to the plant. Except in Apri, for treated waste water, TSM values recorded were below the limit value set by the Algerian government for treated wastewater for irrigation (30mg/l). However, the maximum value of TSM in April was 33.95 which was slightly higher than the Algerian norm. This could be explain by a functional problem in the WWTP of Ain El Hout.

6.1.5 Dissolved Oxygen (DO)

6.1.5.1 Results

The absolute values of dissolved oxygen before treatment varies between a minimum of 4 mg/l in January, February, October and December and a maximum of 4.55 mg/l in June. After treatment, it varies between a minimum of 5.3 in September and a maximum of 8.72 in February (Table 6.1 and Fig 6.5)

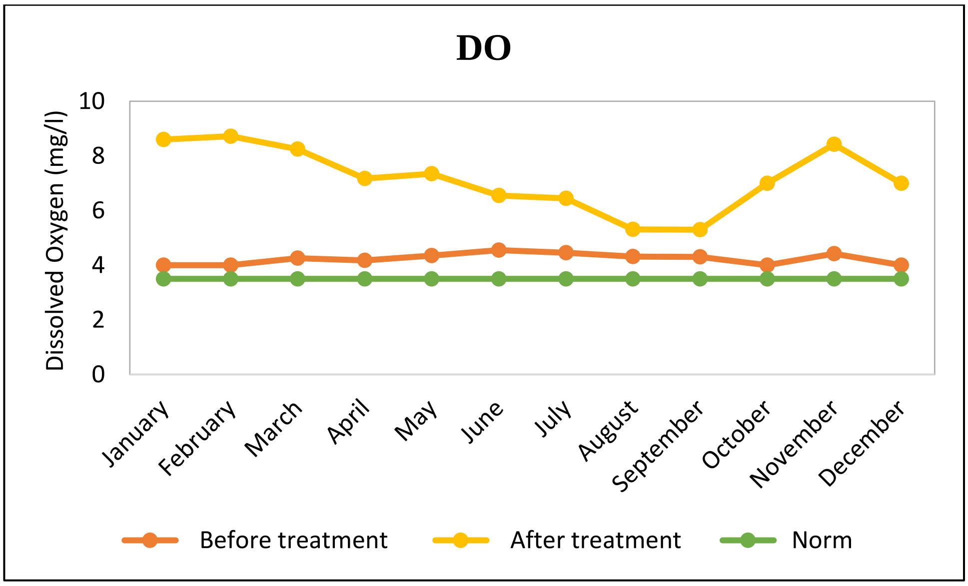


Figure 6.5: monthly variation of DO for the wastewater before and after treatment

6.1.5.2 Discussion

Dissolved oxygen is necessary in aquatic systems for the survival and growth of many aquatic organisms and is used as an indicator of the health of surface-water bodies (Lewis, 2006). Most of the chemical and biological reactions in groundwater and surface water depend directly or indirectly on the amount of available oxygen. The oxygen content of water depends on a number of physical, chemical, biological and microbiological processes. Moreover, The oxygen concentration is an important indicator of pollution of a water body, indicating its biological state, the predominant processes occurring in it, the destruction of organic substances and the intensity of self-purification. If oxygen levels are high, the pollution levels in the water are low and vice versa in which the the body of water is not in optimal health (Mccaffrey, 1997). It is also defined in biological treatment as the relative measure of oxygen dissolved in wastewater available to sustain life, including living bacteria (Water Technologie, 2013).

In the present study, an assessment of the dissolved oxygen status for the treated wastewater from the WWTP of Ain El Hout has been carried out throughout the year 2016. From the Fig 5.4, it was noticed that DO recorded high concentration in winter season. Increased aeration derived from the blooming of active winds play an important role in increasing dissolved oxygen in the surface water. However, a minimum value of DO was recorded in August and September may be due to higher temperature that increases evaporation process and the high load of agricultural and sewage wastes, contain high load of organic matter that consume large amount of DO mostly in the surface layer. For a diversified warm-water biota, the optimum concentration of dissolved oxygen should be at least 3.5 ml/l. For a cold-water biota, dissolved oxygen concentration at or near saturation values are desirable for healthy growth. The minimum level should not be lower than 4.2 mg/l (Grundy, 1971). Boner and Furland (1982) emphasized that dissolved oxygen values can be of 3.5 mg/l on a daily average, but never less than 2.8mg/l.

6.1.6 Biological Oxygen Demand (BOD5)

6.1.6.1 Results

The absolute values of biological oxygen demand (BOD5) for the wastewater before treatment in WWTP of Ain El Hout varied between a minimum of 247.20 mg/l in March and a maximum of 416.80 mg/l in August. However, after treatment it vary between a minimum of 15.76 mg/l in January and a maximum of 24.13 in June. (Table 6.1 and Fig 6.6).

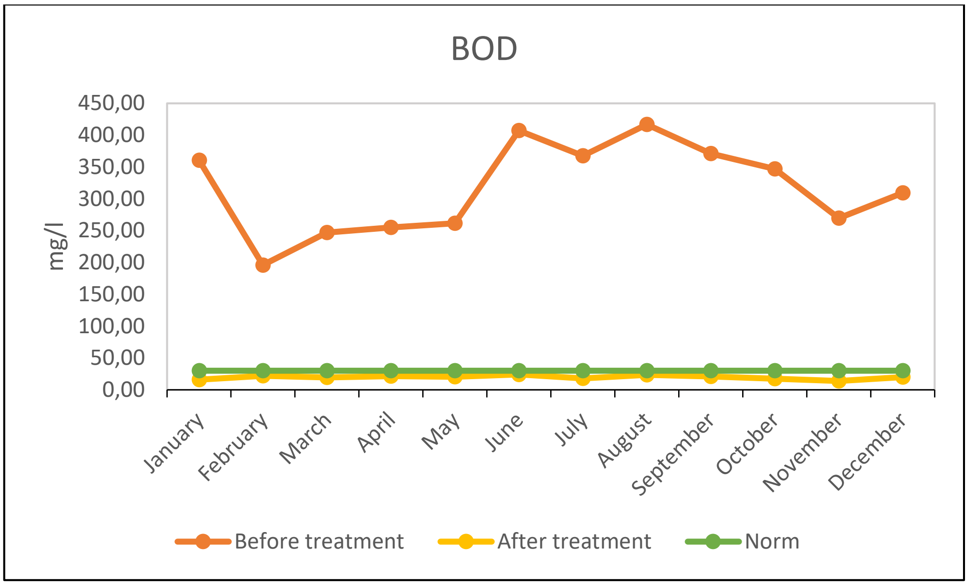


Figure 6.6: monthly variation of BOD for the wastewater before and after treatment

6.1.6.2 Disscution

BOD is a parameter defined as the amount of oxygen, divided by the volume of the system, taken up through the respiratory activity of microorganisms growing on the organic compounds present in the sample (e.g. water or sludge) when incubated at a specified temperature (usually 20°C) for a fixed period (usually 5 days, BOD5). This parameter was adopted by the American Public Health Association Standard Methods Committee in 1936 as a reference indicator to evaluate the biodegradation of chemicals and hazardous substances. It is a measure of that organic pollution of water which can be degraded biologically. In practice, it is usually expressed in milligrams O2 per litre (Nagel et al., 1992), which associated with the biodegradable fraction of carbonaceous organic compound.

Determining BOD values after five days (BOD5) has been adopted as a compromise between a short test-period and the detection of a practically complete biological breakdown of organic materials. With domestic effluents, at 20 °C a complete degradation (= 100 % BOD) is achieved only after 20 days (BOD20); however, after only 5 days, 70 % of the biologically convertible substances are broken down (Hütter, 1994).

The biological capacity of a sewage treatment plant can be tested by comparing the BOD value of a known, control solution with the BOD derived from a microbiosphere being present in the treatment plant. In general, the following assertions may be made:

- a high BOD indicates a high content of easily degradable, organic material in the sample
- a low BOD indicates a low volume of organic materials, substances which are difficult to break down or other measuring problems

In this study, a comparison was made to evaluate the BOD status of the water from the WWTP of Ain El Hout before and after treatment of water for the year 2016 in order to qualify of treatment inside the plant. As noticed in Fig 6.6, the monthly variations of BOD5 after the treatment is below the norm value set by the Algerian government for irrigation water (30mg/l). In terms of biodegradable organic pollution, the treated wastewater does not present any risk and can be used for irrigation, which also proof that the WWTP clean the water correctly and respect the norm.

6.1.7 Chemical Oxygen Demand (COD)

6.1.7.1 Results

The absolute values of chemical oxygen demand (COD) for the wastewater before the treatment varies between a minimum of 441.50mg/l in October and a maximum of 677.00 mg/l in July and after the treatment it varies between a minimum of 27.60 in December and a maximum of 52.00 in August (Table 6.1 and Fig 6.7).

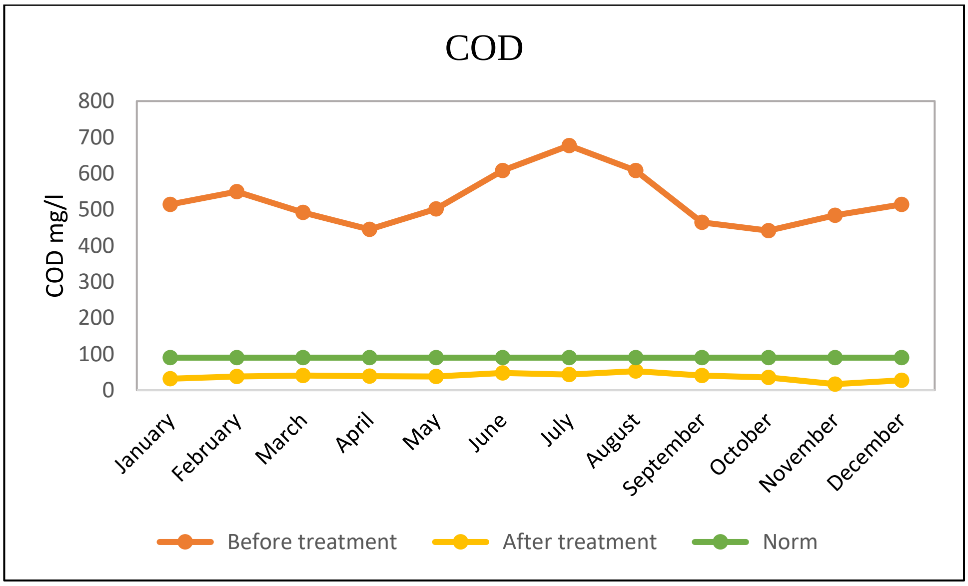


Figure 6.7: monthly variation of COD for the wastewater before and after treatment

6.1.7.2 Disscution

COD is defined as the amount of dissolved oxygen to oxidize and stabilize a sample when organic or inorganic matter of sample solution is responsive by a strong chemical oxidant. The COD value indicates the mass of oxygen consumed per liter of solution and expressed in milligrams per liter (mg/L). The higher COD values, the higher the amount of pollution in the water sample. Generally, COD is considered one of the important quality control parameter of an effluent in wastewater treatment facility (Wu et al., 2011)

In comparison with the BOD test, COD test has some advantages including the fact that it takes only two to three hours. Due to this, it can be used for operational control to give a convenient characterization of the water quality of any aquatic environment. Many hydrocarbons are readily oxidized by chemical methods and sparingly oxidized biochemically (Pheleps, 1944).

In this study, the COD values of the wastewater before and after treatment (Fig 5.7) showed irregular variation throughout the period of investigation. Before and after treatment, the COD values are higher in summer season with the maximum temperature value 27°C. According to the reaseach done by Azeez (2009), she found that the removal efficiency of BOD and COD decreases in temperature higher than 30°C (optimum temperature) because the activity of microorganism becomes lower after this temperature which means ability to remove pollutants decreases. According to the figure , it was observe that the COD variation of the water is below the limited value set by the Algerian government for water intended for irrigation (90mg/l).

6.2 Nutrient salts:

Table 6.2: Nutrient salts variation of wastewater before and after the treatment

Month	NH_4^+ (mg/l)		$N-NO_2$ (mg/l)		$N-NO_3$ (mg/l)		PO_4 (mg/l)	
	Before	After	Before	After	Before	After	Before	After
January	39.25	3.82	0.45	0.21	3.79	1.40	6.7	4.4
February	37.10	2.80	0.75	0.21	4.93	1.35	7.2	5.4

March	41.99	2.18	0.63	0.17	2.82	1.26	6.5	4.42
April	44.83	1.56	0.22	0.05	3.37	2.60	10.5	6.45
May	46.04	2.09	0.12	0.07	2.90	1.31	11.2	6.1
June	41.92	3.45	0.15	0.09	1.23	0.78	6.5	4.5
July	49.89	3.97	0.17	0.08	0.93	0.50	4.5	2.95
August	45.54	4.97	0.13	0.10	0.85	0.46	7.6	4.55
September	35.57	2.48	0.12	0.07	0.83	0.55	5.4	3.1
October	39.91	1.89	0.20	0.07	2.54	1.00	4	2
November	40.71	2.12	0.23	0.10	1.32	0.69	3	1.68
December	45.57	3.58	0.49	0.18	1.92	1.00	7	4

6.2.1 Phosphates (PO_4^{3-})

6.2.1.1 Results

Before the treatment, the absolute values of PO_4^{3-} for the waste water from the WWTP of Ain El Hout vary between a minimum of 3.0 mg/l in November and a maximum of 11.2 mg/l in May, while after treatment a minimum of 1.68 mg/l and a maximum of 6.45 were recorded in November and April, respectively (Table 6.2 and Fig 6.8).

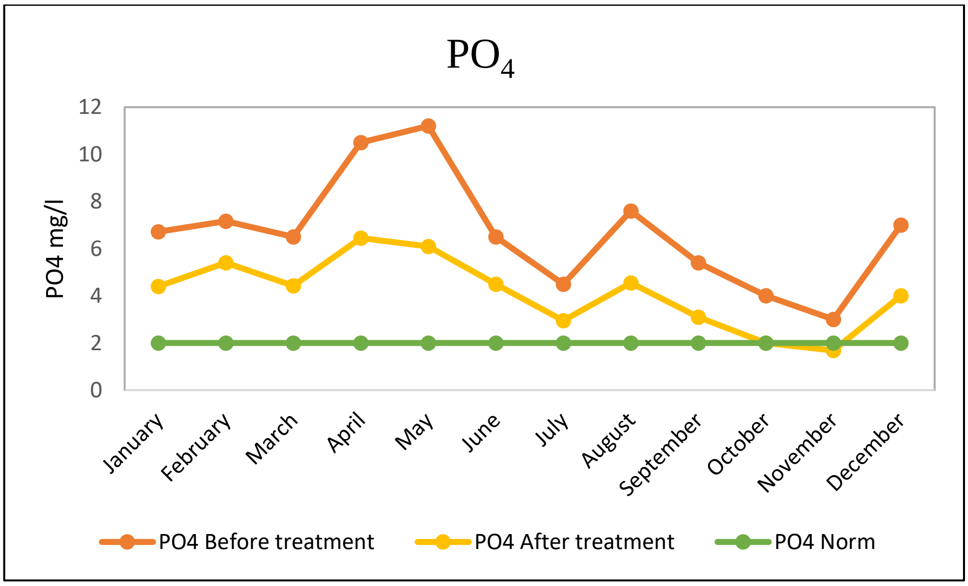


Figure 6.8: monthly variation of PO4 for the wastewater before and after treatment

6.2.1.2 Discussion

Phosphorus is a naturally occurring nutrient found in soil and rocks that is required by all living organisms. It is one of the most important nutrient elements in aquatic environment and usually used as an index of eutrophication phenomena. High levels of phosphates in aquatic environments can fuel algal growth, resulting in algal blooms that can potentially lead to eutrophication as the thick algal mats block out sunlight causing the algal cells to die off. It has a double existence as nutrient element and sometimes as a pollutant (Johnson, R.L, Holman, S, Holmquist, 1999). Phosphorus in the form of phosphate (PO43-) is a major component of most fertilizers. Although all forms of nitrogen and phosphorous can be assimilated by most species of plants, nitrate, ammonium and orthophosphate are usually used preferentially (Krom, Kress and Brenner, 1991). Run-off and sewage discharges are important contributors of phosphorous to surface waters (EPA, 2001).

Unfortunatly, the effectiveness of phosphorus removal during wastewater treatment can vary, depending on the available equipment and the treatment methods used. Only wastewater treatment plants that employ specialised phosphorus removal techniques will normally be able to remove phosphorus to the desired levels. (Andrew Miley, 2018)

During the study, an evaluation of the phosphate status for the wastewater from the WWTP of Ain El houtt has been carried out. From Fig 6.8, we observe that the variation of the phosphates throughout the years under investigation is not uniform. The minimum value before and after treatment are seen in November since the irrigation is not high in this periode time comparing to the spring periode. The maximum value after treatment was recorded in April and May and the annual mean for 2016 were 4.12mg/l, which is too high than the limited phosphate standard set by FAO and the limited value set by the Algerian government for irrigation water (2 mg/l). This is probably resulted from the extensive discharge from sewage, the surrounding agricultural areas during this season and also specially a malfunction of WWTP.

6.2.2 Nitrite- Nitrogen (N-NO_2)

6.2.2.1 Results

The absolute values of Nitrite for the treated wastewater from the WWTP of Ain El Hout varies between a minimum of 0.12mg/l in September and a maximum of 0.75 mg/l in February before the treatment, and a minimum of 0.05mg/l in April and a maximum of 0.21mg/l in January and February (Table 6.2 and Fig 6.9).

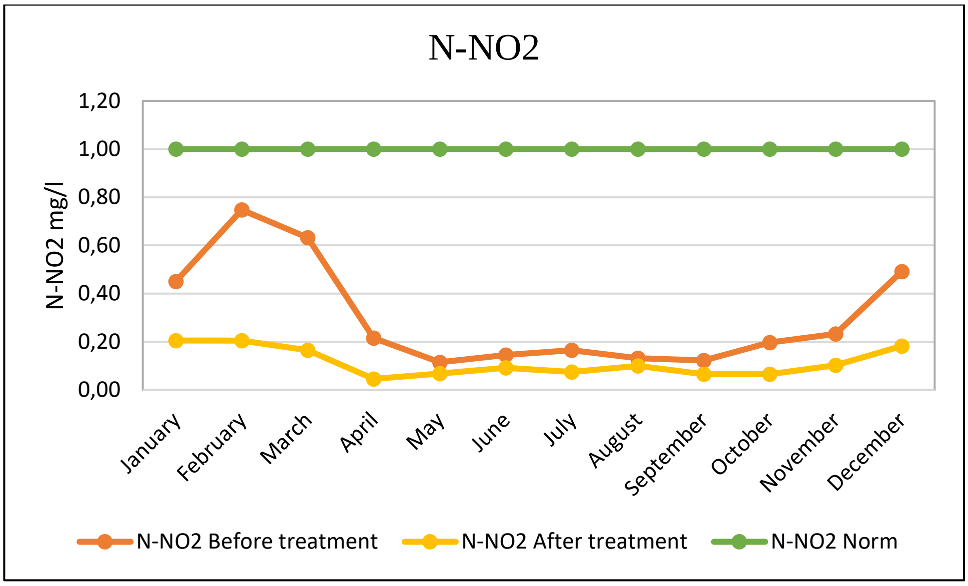


Figure 6.9: monthly variation of N-NO_2 for the wastewater before and after treatment

6.2.2.2 Disscution

Nitrification is a microbial process by which reduced nitrogen compounds (primarily ammonia) are sequentially oxidized to nitrite and nitrate.

The nitrification process is primarily accomplished by two groups of autotrophic nitrifying bacteria that can build organic molecules using energy obtained from inorganic sources, in this case ammonia or nitrite. In the first step of nitrification, ammonia-oxidizing bacteria oxidize ammonia to nitrite according to equation (1).

$$NH_3 + O_2 \rightarrow NO_2 - + 3H+ + 2e- \ (1)$$

In the second step of the process, nitrite-oxidizing bacteria oxidize nitrite to nitrate according to equation (2).

$$NO_2 - + H_2O \rightarrow NO^{3-} + 2H+ +2e- \ (2)$$

Nitrobacter is the most frequently identified genus associated with this second step, although other genera, including Nitrospina, Nitrococcus, and Nitrospira can also autotrophically oxidize nitrite (Watson et al. 1981).

In the present study, we assess the nitrite status of the wastewater from the WWTP of Ain El Hout before and after treatment and According to Fig 5.9, the nitrite is higher in winter than in summer this due to the high rate of rainfall in the wastewater and other sources of nitrogen that can include agricultural runoff from fertilization and livestock wastes (Sawyer and McCarty, 1978). Fortunately, the nitrIte variation of the water recorded during the study period is below the limited value set by the Algerian government for irrigation water (1 mg/l).

6.2.3 Nitrate Nitrogen (NO_3-N)

6.2.4 Results

The absolute values of nitrate-nitrogen for the wastewater before treatment were varies between a minimum of 0.50mg/l in July and a maximum of 4.93 mg/l in February, while after the treatment the values varied between a minimum of 0.46 in August and a maximum of 2.60 in April (Table 6.2 and Fig 6.10)

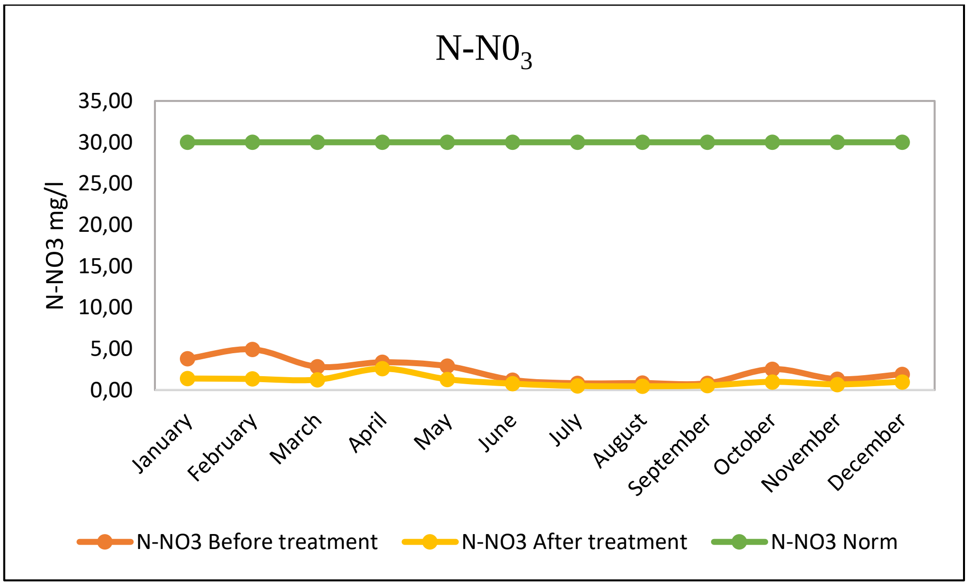


Figure 6.10: monthly variation of N-NO_3 for the wastewater before and after treatment

6.2.4.1 Disscusion

Nitrogen is one of the biologically important elements in the aquatic environments where Nitrate is the final oxidation product of nitrogen compound in natural waters (Riley and Chester, 1971). It is generally considered as the only thermodynamically stable oxidation species of nitrogen in the presence of oxygen in aquatic environment (Sillen, 1961). For plants, however, nitrates are an essential source of nitrogen and in many cases appears to be the major limiting nutrient for phytoplankton growth. Usually, the nitrate ion exists at higher concentrations than ammonium in irrigation water. Natural soil nitrogen or added fertilizers are the usual sources, but nitrogen in the irrigation water has much the same effect as soil-applied fertilizer nitrogen and an excess will cause problems, just as too much fertilizer would (Tak et al., 2010).

In the present study, we assess the nitrate status of the treated wastewater from the WWTP of Ain El Hout for the the year 2016. According to Fig 5.10, It was obvious that the maximum nitrate concentrations were recorded during winter season. This can be attributed to the high rate of rainfall associated with high fresh water discharges and high concentration of nutrient salts washed from agricultural areas. Moreover, decreasing temperature during winter may help in increasing solubility of dissolved oxygen in water. In contrast, the low value appeared in summer seasons may be due to the increase in nitrate uptake by phytoplankton blooms developed during warm seasons leading to increase denitrification process (Zentara and Kamykowski, 1977 ; EPA, 2001). This image is most probably due to biological activities that took place in the area under investigation. Fortunately, the nitrate variation of the water recorded during the study period is below the limited value set by the Algerian government for irrigation water (30 mg/l). This result can be attributed to the performance of nitrification-denitrification bacteria during biological treatment.

6.2.5 Ammonium Nitrogen (NH_4^+-N)

6.2.5.1 Results

The absolute values of ammonium nitrogen for the wastewater from the WWTP of Ain El Hout varies between a minimum of 35.57 mg/l in Speptember and a maximum of 49.89 mg/l in July before the treatment and a minimum of 1.56 mg/l in April and maximum of 4.97 in August after the treatment, (Table 6.2 and Fig 6.11).

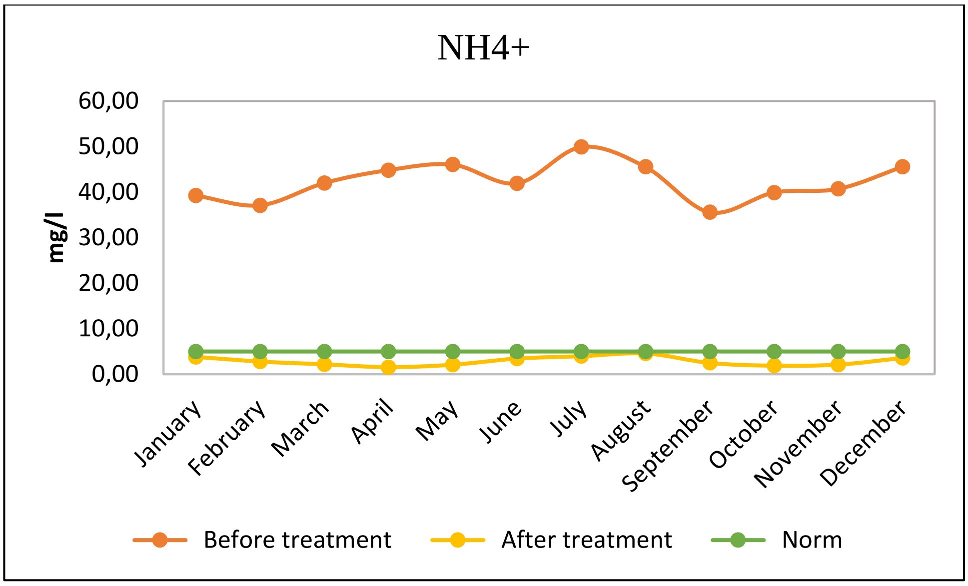


Figure 6.11: monthly variation of NH4+ for the wastewater before and after treatment

6.2.5.2 Disscution :

Ammonium nitrogen is a form of mineral nitrogen essential in the biological development of aquatic ecosystems. Ammonia is the first inorganic product in the regeneration of organic nitrogenous materials. It is also considered as a chief nitrogenous excretory product of many aquatic organisms, especially zooplankton. It may be used as a good indicator for the degree of pollution. Ammonia exists in solution in the form of the ion (NH4+) and in a free form, not ionized (NH3) according to the following dynamic equilibrium (Sperling, 2008):

$$NH_3 + H^+ \leftrightarrow NH_4^+$$

Ammonium ion NH4+ is frequently found at low levels in water compared to nitrate and organic nitrogen. It is the predominant form in the pH range of most natural waters and less toxic to fish and aquatic life as compared to NH_3. As the pH increases above 8, the ammonia fraction begins to increase rapidly. In the rare situation that a natural water pH exceeds reaches 9, ammonia and ammonium ion would be nearly equal (Wall, 2013). According to Wafar et al. (1986) Ammonium ion has been recognized as an important alternative nitrogen source for various aquatic plants and in most environments may be assimilated in preference to nitrate.

In the present study, the ammonium -nitrogen concentrations for the treated wastewater from the WWTP of Ain El Hout, recorded the maximum seasonal value in summer season, contrary to the nitrate values, while the minimum value appeared during spring season. It is worth noting that the relative concentration of ionized and unionized ammonia in a given ammonia solution are principally a function of pH, temperature and ionic strength of the aqueous solution (Eisler, 1987). The equilibrium between NH3 and NH4+ is also affected by temperature. At any given pH, more toxic ammonia is present in warmer water than in cooler water (Hargreaves J. A., 2004). According to Toot-levy (2017), Ammonia's toxicity is temperature and pH dependent. In other word, as temperature increases, organisms are more sensitive to ammonia. As noticed from Fig 5.11 , the ammonium variation of the water recorded during the study period is below the limited value set by the FAO for irrigation water (5 mg/l).

7 WATER QUALITY INDEX (WQI)

7.1 Introduction :

Water quality is used to characterize the condition, including the chemical, physical and biological properties of the water, generally according to suitability for a particular purpose (Sargaonkar et al, 2003.). Changes in physical and chemical properties of water quality are affected by anthropogenic factors (REZA et al ,2010). The combined interactive natural processes such as hydrological conditions, climate and topography, precipitation and flow inputs, size of basin area, erosion events, weathering of crustal materials and bedrock geology , have great influence on water quality characteristics (GLINSKA-LEWCZUK, et al, 2006)(KASIROVA, S et al , 2010).

It is very difficult to assess the water quality in large samples that each parameter has a different concentration (ALMEIDA et al, 2007). In such cases, Water Quality Index (WQI) is a very utility and effective method used for determining the suitability of water quality for various purposes. Furthermore, it is a very handy tool for giving the information on the water quality (ASADI et al, 2007 ; BUCHANAN et al, 2009.)

Water quality index provides a single number that expresses overall water quality at a certain location and time, based on several water quality parameters. The objective of WQI is to turn complex water quality data into information that is understandable and usable by the public. A single number cannot tell the whole story of water quality; there are many other water quality parameters that are not included in the index. However, a water quality index based on some very important parameters can provide a simple indicator of water quality. In general, water quality indices incorporate data from multiple water quality parameters into a mathematical equation that rates the health of a waterbody with number (Yogendra and Puttaiah, 2008). For calculating the WQI in the present study, 10 parameters namely pH, TSM, EC, DO, BOD, COD, PO_4, NO_2, NO_3 and NH_4 have been considered in order to study the quality of the treated water coming from the WWTP of Ain El Hout. The WQI has been calculated by using the standards of water quality recommended by the World Health Organisation (WHO) and the Algerian standard for treated waste water used in irrigation . The weighted arithmetic index method has been used for the calculation of WQI of the treated wastewater. (Yogendra and Puttaiah, 2008)

The quality rating or sub index (q_n) was calculated using the following expression

$$\mathbf{q_n = 100[V_n - V_{io}] / [S_n - V_{io}]}$$

where:

n: water quality parameters and quality rating or subindex (**q_n**) corresponding to **n^{th}** parameter is a number reflecting the relative value of this parameter in the polluted water (with respect to its standard permissible value)

q_n =Quality rating for the **n^{th}** Water quality parameter

V_n=Estimated value of the **n^{th}** parameter at a given sampling station.
Sn =Standard permissible value of the **n^{th}** parameter.
V_{io} = Ideal value of **n^{th}** parameter in pure water. (i.e., 0 for all other parameters except the parameter pH and Dissolved oxygen equal to 7.0 and 14.6 mg/L respectively.

Unit weight was calculated by a value inversely proportional to the recommended standard value **Sn** of the corresponding parameter.

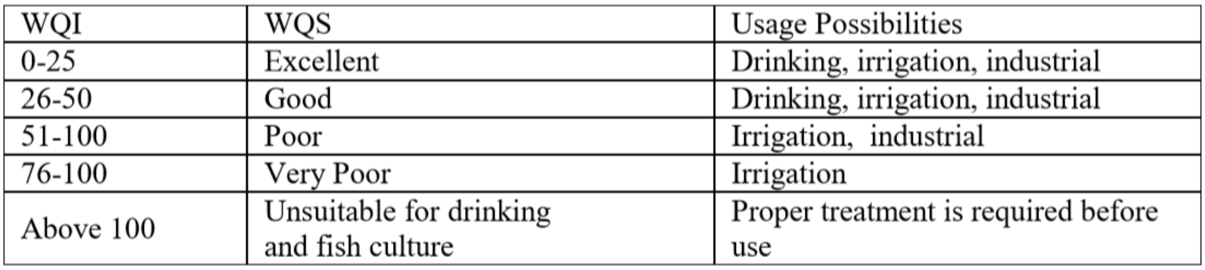
$$\mathbf{Wn = K / Sn}$$

Wn= unit weight for the **n^{th}** parameters.
Sn= Standard value for **n^{th}** parameters
K= Constant for proportionality.

The overall Water Quality Index was calculated by aggregating the quality rating with the unit weight linearly.

$$\mathbf{WQI = \sum q_n\, Wn / \sum Wn}$$

Table 7.1: Possible uses and WQS corresponding to WQI values



WQI	WQS	Usage Possibilities
0-25	Excellent	Drinking, irrigation, industrial
26-50	Good	Drinking, irrigation, industrial
51-100	Poor	Irrigation, industrial
76-100	Very Poor	Irrigation
Above 100	Unsuitable for drinking and fish culture	Proper treatment is required before use

Table 7.2: Mean concentration of the phyco-chemical parameters of WWTP of Ain El Hout during the year 2016

Parameters	**Symbol**	**Unit**	**Average of the year 2016**
PH	Ph	Ph	7.59
Total Suspended Matters	TSM	mg.L-1	16.84
Electrical Conductivity	EC	µS/cm	939.9
Dissolved Oxygen	DO	mg.L-1	6.88
Biochemical Oxygen Demand	BOD	mg.L-1	19.73
Chemical Oxygen Demand	COD	mg.L-1	37.48
Orthophosphates	O-PO_4	mg.L-1	4.13
Nitrite Nitrogen	NO_2N	mg.L-1	0.11
Nitrate Nitrogen	NO_3N	mg.L-1	1.07
Ammonium Nitrogen	NH_4N	mg.L-1	4.45

7.2 Calculations of the WQI

7.2.1 WQI using WHO standards :

Table 7.3: Calculations of the WQI using the WHO standards

Parameters	**Symbol**	**Unit**	**WHO Standard (Si)**	**Vn**	**Wn**	**Qn**	**Wn*Qn**
PH	Ph	Ph	8.5	7.59	0.11	39.33	4.63
Total Suspended Matters	TSM	mg.L-1	500	16.48	0.002	3.36	0.007
Electrical Conductivity	EC	**µS/cm**	300	939.8	0.003	313	1.04
Dissolved Oxygen	DO	mg.L-1	6	6.88	0.17	89.76	14.96

Biochemical Oxygen Demand	BOD	mg.L-1	3	19.73	0.33	657.66	219.22
Chemical Oxygen Demand	COD	mg.L-1	5.5	37.48	0.18	681.45	123.9
Orthophosphates	PO4-P	mg.L-1	5	4.12	0.2	284	56.8
Nitrite Nitrogen	NO2-N	mg.L-1	3	0.11	0.33	3.66	1.22
Nitrate Nitrogen	NO3-N	mg.L-1	50	1.07	0.02	2.14	0.043
Ammonium Nitrogen	NH4-N	mg.L-1	1.5	2.87	0.67	191.33	127.5
					2.025		**549.37**

WQI= ∑Wn*Qn/ ∑Wn

WQI=271

7.2.2 WQI calculated using Algerian standard

Table 7.4: Calculations of the WQI using the Algerian standards

Parameters	**Symbol**	**Unit**	**Algerian Standard(Si)**	**Vn**	**Wn**	**Qn**	**Wn*Qn**
PH	pH	Ph	6.5-8.5	7.59	0.13	118	15.34
Total Suspended Matters	TSM	mg.L-1	30	16.48	0.03	54.93	1.64
Electrical Conductivity	EC	µS/cm	3000	939.8	0.003	313.26	0.93
Dissolved Oxygen	DO	mg.L-1	3.5	6.88	0.28	69.54	19.45
Biochemical Oxygen Demand	BOD	mg.L-1	30	19.73	0.03	65.76	1.97
Chemical Oxygen Demand	COD	mg.L-1	90	37.48	0.01	41.64	0.41
Orthophosphates	PO4-P	mg.L-1	2	4.12	0.50	206	103
Nitrite Nitrogen	NO2-N	mg.L-1	1	0.11	1	11	11
Nitrate Nitrogen	NO3-N	mg.L-1	30	1.07	0.03	3.56	0.1
Ammonium Nitrogen	NH4-N	mg.L-1	5	2.87	0.2	57.4	11.48
					2.213		**165.32**

WQI= ∑Wn*Qn/ ∑Wn

WQI= 74.70

7.3 Discussion :

The water samples from the WWTP of Ain El Hout were analysed for 10 physicochemical parameters by following the established procedures. These parameters were used to study the quality of the treated wastewater by using WQI principle.

The Water Quality Index obtained from the WWTP for the year 2016 is 271 according to WHO standard and 74.70 according to the Algerians standard. This indicates a poor quality of water and unsuitability for using in irrigation or for drinking purpuses (Table). In general, the results at sampling sites for treated waste waters indicated that the values of some parameters such as Chemical Oxygen Demand (COD), Biochemical Oxygen Demand (BOD), Dissolved Oxygen, and Total Hardness are beyond of permissible limits prescribed by WHO for drinking water standards (WHO, 2012). These parameters have the greatest effect on the WQI scores (Table 6.3). BOD shows the extent of pollutant in the water body, and is the amount of dissolved oxygen needed for the biochemical decomposition of organic compounds and the oxidation of some inorganic materials (Kumar et al, 2015). COD is a measure of water quality used to measure the amount of biologically active substances, such as bacteria, as well as the amount of biologically inactive organic matter in the water (Khuhawari et al, 2009). Theoretically, if COD value in water is higher, then the water is considered polluted water (Amneera, 2013). The important reason for this is because of the fact that industrial wastes and domestic wastes are released into the drainage area of Ain El Hout without any filtering process. The high values of BOD may be indicative of fecal and organic waste contamination from human and animal sources, which restricts the use of water for drinking and domestic purposes. An increase in BOD causes a potential health threat to the people, using the water with high BOD for drinking water. High COD can result from leaching of chemically degradable organic and inorganic waste matter coming from intensive populated surrounding area (ŞENER, 2017).

On the other hand, The WQI calculated using Algerian standard (Table 6.4) indicated that the water is in poor quality but acceptable for irrigation and industrial use. This is due to the fact that the irrigation water should has slightly high concentrations of organic substances. Hence, the water outgoing from WWTP of Ain El Hout are used for the irrigation of different land in Henaya in Tlemcen. Moreover, the results in this research indicated that the PO4 concentration is high compared to the Algerian standard but it does not affect the WQI.

8 ALGERIAN POLICY RELATED TO THE USE OF TREATED WASTEWATER

8.1 Introduction

Algeria has enriched its national water policy by adapting it to all mutations born from changes as well climate change, issues, and social and economic needs as well as a perception of the real cost of water and the economical consequences. Since 1996, Algeria has embarked on a new water policy, know the "Integrated Water Resources Management" to guarantee their valorisation and sustainability. This new policy is based on a set of institutional reforms and new instruments that are Basin Agencies and Basin Committees.

This new policy has 5 principles which are:

1. **Uniqueness of the resource**: Unit management at the scale of the Hydrographic Basin. This management will be provided by Hydrographic Basin Agencies.
2. **Concertation:** This consultation is done through the basin committees river.
3. **Economy**: This economy will be done by the fight against the leaks and the waste of the water with objectives based on systematic counting and rehabilitation of networks as well as by raising the awareness of users about the use of this resource.
4. **Ecology**: Water is a rare resource and a collective good to protect against any form of pollution.
5. **Universality:** Water is the business of all users.

To offset regional deficits in conventional water, Algeria is committed to mobilization and valorisation of unconventional waters. By unconventional waters means (article 4 of the law of 4 August 2005 in Appendix X), seawater, urban wastewater, southern brackish and high plateaus and waters of any origin injected into aquifer systems by the technique of artificial recharge. In the face of insufficient resources Conventional waters (groundwater and surface water), the use of unconventional waters, including desalination of seawater and recycling of wastewater, was an unavoidable necessity. unconventional waters of all kinds in order to increase water potential, is enshrined in article 2 of the law of 4 August 2005 on water (Appendix 1). It is even one of the objectives of the integrated management of water resources to ensure safety in terms of water availability in the face of the scarcity of resources in front of a phenomenon of climate change.

However, Algeria has improved really well in the field of sea water desalinisation by constructing many desalinisation plans. Unfortunately, in the field of treatment of wastewater the number of WWTP is still not enough, and a lot of wastewater is thrown into the sea. The government must understand the importance of reusing water specially in country like Algeria and its impact in social, environmental and economic field

8.2 Social

Although the reuse of treated wastewater has been applied and well accepted since several decades in rural and urban areas of some developing countries because of demographic growth, it has always raised socio-cultural issues (Al Khateeb, 2001). Therefore, a variation in beliefs, customs and values can influence the cultural acceptability of this new source of water. Public support is an issue determining in water management projects, especially in countries where water resources available and abundant (Marsalek et al., 2002), hence the importance of designing a communication and awareness system for the people involved in this reuse (Marsalek et al., 2002).

Public health is also an important issue to consider, as many risks have been identified during the reuse of wastewater for irrigation, especially when waters do not comply with the established reuse standards, the objectives of which are the protection of human health. Wastewater contains several pathogenic microorganisms that could end up in the final effluent that will be reused to irrigate crops intended for human consumption. Some risks have an impact in the short term, depending on the frequency, type and duration of contact between the environment, humans and animals, and a long-term impact that increases with continued use of wastewater (Toze, 2005). And for this reason, the Algerian government created the Executive Decree No. 05-12 corresponding to 4 August 2005 relating to water, Artical n°130:“The use of raw wastewater for irrigation is prohibited”.

In addition, the reuse of treated wastewater has shown several advantages. In fact, irrigation by these waters has increased the harvest of vegetables in people poor people cannot afford to buy fish and meat. As a result, this increase has had a positive impact on the diet of the population and the income farmers (Agunwamba, 2001).

At the institutional level, the reuse of wastewater would push officials to improve environmental regulation and adopt new management policies water to protect the environment and public health from uncontrolled uses of raw wastewater.

8.3 Environmental

In addition to providing a dependable, locally- controlled water supply, water recycling provides tremendous environmental benefits.

By their load in different types of pollutants, the wastewater discharged directly into the natural environment constitute a risk to natural resources and the environment. Nevertheless, once properly treated, wastewater could be a source of water for sectors known for their high-water consumption, such as agriculture.

In arid and semi-arid regions, variations in rainfall accompanied by successive periods of drought generate long-term impacts on the water availability for farmers (Khouri et al., 1994). For that, from a point of quantitative view, wastewater is a source of water that is always available since clean water consumption does not stop. In fact, the treated wastewater can ensure balancing the natural water cycle and preserving resources by reducing harmful discharges in the natural environment (Bouchet, 2008).

In fact, the recycling of treated wastewater would generate a large amount of water which would be available for the agricultural sector. In 2005, the city of Milan, Italy, was able to irrigate 22,000 hectares of market gardening thanks to a wastewater reuse plant having a capacity of 345,000 m3/ j (Lazarova and Brissaud, 2007). In the same light, In 2000, the Spanish Government adopted a plan aimed at recycling water used for the irrigation of the golf courses (300 golf courses), to this is added 408 million m3 already reused in the field of the environment (Lazarova and Brissaud, 2007).

Indeed, this wastewater recycling approach would encourage construction pollution treatment infrastructure, which would have a positive impact on the long-term receiver medium. In addition, the construction of these infrastructures would limit the construction of water reservoirs and dams, which would minimize the negative impacts of these major hydraulic developments on the environment. These are important both for increasing soil fertility and structure and for Agricultural Productivity (OMAFRA, 2009). This would replace, in part, the use of mineral fertilizers.

To insure that treated wastewater is not dangerous for agriculture uses the Algerian government has created Decree No. 05-12 corresponding to 4 August 2005 relating to water, Art. 119. - Any spill in a public network sanitation or in a water treatment plant other than domestic use is subject to authorization prerequisite for the administration of resources in water. This spill may be subject to an obligation pre-treatment if, in the raw state, these waters waste can affect the proper functioning of the network public sanitation or sewage treatment plant. (Algerian Official Journal, 2005)

And the Law No. 03-10 on the Protection of the Environment Executive Decree No. 06-141 of 19/04/2006 defining the limits of industrial liquid effluent discharge values : The purpose of this order, pursuant to the provisions of Article 10 of Law No. 03-10, to define the limits of the discharge of industrial effluents values. (Algerian Official Journal, 2006)

By providing an additional source of water, water recycling can help us find ways to decrease the diversion of water from sensitive ecosystems. Other benefits include decreasing waste water discharges and reducing and preventing pollution. Recycled water can also be used to create or enhance wetlands and riparian habitats.

8.4 Economic

Algeria's water sector reform is currently characterized by a gradual liberalization of the price of water. However, this trend can have detrimental effects on the standard of living of the majority of Algerian households in general and poor households in particular. This interaction requires a more global vision to ensure effective water management knowing that water is the resource that defines the limits of sustainable development.

Water is a limiting factor in the development of agriculture; scarcity is understood in terms of water stress and irregularity of the resource, two factors likely to increase with climate change. Face the challenge of ensuring the coverage of water needs for agriculture in Algeria , an active political mobilization of water resources has been implemented , as well as new management tools is the reuse of wastewater in agriculture .

Clean wastewater could have an impact positive economic impact on farmers. As a result of the high demand for water in the area agricultural water, the transfer of treated water to agricultural fields would reduce the negative effects caused by the use of clean water in irrigation. In fact, irrigation can have affect the economy of poor farmers, especially where equal access to land and water is absent, in addition to the high costs of transfer and pumping works agricultural water (FAO, 2005). Therefore, the treated water could reduce all these and make irrigation cheaper and within the reach of local farmers. would allow them to invest their money in crop diversification and move towards high value-added and more sustainable agriculture. It would also increase the value irrigated land, ensuring significant economic benefits for farmers. Even those responsible for sanitation and water treatment could benefit from the sale price of treated water and by-products instead of rejecting it directly in the natural environment (Lazarova and Brissaud, 2007).

On the other hand, agriculture is also known for its high fertilizer consumption chemicals and minerals whose main purpose is to increase the crop. Currently, the Fertilizer market is experiencing a price hike that began in 2007 with the increase fertilizer demand in some Asian countries, such as China and India, and in of South America because of several factors, mainly: growth economic change in consumption patterns, increased production animal husbandry and forage production (Triferto, 2008). To this is added the manufacture of biofuels. This increase in fertilizer prices could have an impact on profitability of farmers, adding to that the costs of using fresh water. For this reason, replacing fertilizers with a cheaper source of nutrients, such as treated wastewater, is seen as a promising solution. This source, rich in phosphorus, nitrogen, potassium and macronutrients essential for plant growth, could be play the same role as fertilizer, depending on the concentration of these elements in the water, the type of cultivation and soil fertility level (Janssen et al., 2005). As a result, reuse of treated wastewater could limit and even eliminate the use of fertilizers in irrigation by reducing all expenses involved in this use.

In Algeria three important point regarding the use of treated waste water in agriculture were fixed in the Executive Decree n ° 07/149 of the 20/05/2007: fixing the terms of concession of use of the purified waste water for irrigation purposes and the specifications relating thereto.

1. Interdepartmental Order Fixing Specifications for Purified Wastewater Used for Purposes irrigation
2. Interministerial Order fixing the list of crops that can be irrigated with wastewater Clean
3. Interministerial Decree fixing the list of qualified laboratories of analyzes of the quality of treated wastewater used for irrigation purposes.

In Algeria, the presence of specific discharge standards for water reuse used in agriculture (Executive Decree No. 93-160 of 10 July 1993 and Decree Executive No 06-141 of 19 April 2006) and the presence of texts regulations laying down the rules for the reuse of waste water and the list of crops and the conditions for their irrigation by treated wastewater (Executive Decree No 07-149 of May 20, 2007 and the inter-ministerial decree of January 2, 2012) constitute a promotion of projects for the reuse of treated wastewater.

The definition of integrated water resources management formulated by the Global Water Partnership is now an authority. It states that "the integrated water resources management is a process that encourages the implementation of value and coordinated management of water, land and associated resources, in order to maximize the resulting economic and social well-being of a equitably, without compromising the sustainability of vital ecosystems " (WWAP, 2009).

The leaders, public and private, have decisions to make regarding reuse of wastewater in agriculture. They are faced with the need to exploit increasing quantities, in order to respond to requests always bigger. Integrated management of treated wastewater in Algeria, now institutionally recognized as a model of partnership public-private, is the best approach for development and management effective and sustainable clean wastewater, in the face of water demands in increase.

9 CONCLUSION AND RECOMMENDATIONS

9.1 Conclusion

This work allowed to evaluate the physico-chemical quality of the treated wastewater from the WWTP of Ain El Hout in Tlemcen. The study focused on the interpretation of the physico-chemical data of the year 2016. Following the obtained results, we can conclude that the quality of the treated wastewater is satisfactory for the reuse in irrigation. The treatment process of the plant is effective to produce a water that meets the reuse standards, since it is equipped with a tertiary treatment units. The physico-chemical analyzes of the treated wastewater have shown in most of the cases the values below the recommended WHO, FAO and Algerian standards of water quality for irrigation.

Concerning the WQI method, this method is very useful for evaluation and management of water quality. In this study we reveal the quality of the treated water of the WWTP of Ain El Hout in Tlemcen by using both the WHO standards and the Algerian standards in the calculation of WQI, and we can conclude that the WQI change depend on these standards and the standards depend on the use of the outgoing water. Water used for drinking and treated water used for irrigation must not have the same standards because if it the case the result will mistaken or incorrect.

Finally, despite the rather simple principle of water reuse , the implementation of such projects, for its part, is much more complex because of the multitude of areas affected, including water resources management, sanitation, environment , health, economy, etc. Another complexity lies in the fact that the implementation of projects must take into account the purification facilities already in place. The technical feasibility of each project should therefore be assessed on a case-by-case basis. Also, in some areas, residences are sometimes not served by the municipal sanitation system. It might therefore be interesting in these cases, rather to think about the establishment of autonomous purification systems. This aspect would require a deepening of knowledge beyond those presented in this essay, since this avenue includes very different issues. The benefits, would remain similar and would lead Algeria to better management of wastewater, water resources and the environment.

9.2 Recommendations

From the conclusion drown, the following recommendations are suggested:

1. Operation of the chlorine disinfection treatment and the optimization of the chlorine dosage the contact time could lead to the reuse for non-restrictive irrigation, namely the cultivation of vegetable crops.
2. Provide an optimized treatment for phosphorus removal to meet the recommended standards could prevent potential pollution problems of the soils and the environment.
3. The design of an irrigation network fed by the treated wastewater would be a real application of the results obtained from this work.
4. Develop an informational database and opening it for researchers and scientist
5. Using the WQI calculation to know the quality of water easily

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Appendix 1:

OFFICIAL JOURNAL OF THE ALGERIAN REPUBLIC N ° 60

Law n ° 05-12 of 28 Joumada Ethania 1426

corresponding to 4 August 2005 relating to water.

TITLE I

PRELIMINARY PROVISIONS

Art. 2. - The objectives assigned to the use, themanagement and sustainable development of water resources aim to ensure:

- water supply through mobilization and the distribution of water in sufficient quantity and quality required to meet the needs of the population and livestock watering and to cover demand from agriculture, industry and other economic and social activities that use water;

- the preservation of public health and the protection of water resources and aquatic environments against the risks of pollution through the collection and domestic and industrial wastewater treatment as well as rainwater and runoff in the urban areas;

- research and evaluation of water resources surface and underground as well as the monitoring of their quantitative and qualitative status;

- the valorization of unconventional waters all kinds to increase water potential;

- Flood control through regulatory actions surface water flows to mitigate harmful effects of floods and protect people and goods in urban areas and other areas flood.

TITLE II

THE LEGAL SYSTEM OF RESOURCES IN WATER AND INFRASTRUCTURE HYDRAULIC

Chapter 1

From the natural hydraulic public domain

Section 1

Consistency of the public domain natural hydraulics

Art. 4. - Under this Act, are part of the natural hydraulic public domain:

- groundwater, including recognized waters as spring waters, natural mineral waters and waters by the simple fact of the observation of their existence or their discovery, particularly as a result of excavation work or reconnaissance drilling any nature made by any natural person or moral, public or private law;

- the surface waters consisting of wadis, lakes, ponds, sebkhas and chotts as well as the grounds and vegetations included in their limits;

- the alluviums and landings that form,naturally in the wadi beds;

- unconventional water resources consisting of:

* desalinated seawater and brackish water demineralized for the purpose of public utility;

* wastewater purified and used for the purpose of utility public;

* waters of any origin injected into the systems aquifers by the artificial recharge technique.