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TREATED AND WASTEWATER QUALITY CHARACTERIZATION OF SIDI MAROUANE WWTP IN MILA PROVINCE, ALGERIA: SUITABILITY AND REUSE FOR IRRIGATION

This study aims to evaluate the quality of wastewater treated by Mila's activated sludge process, assessing its potential for agricultural reuse. Effective wastewater treatment is essential to mitigate health risks associated with the use of surface and groundwater resources. Reusing treated wastewater for irrigation is a key objective, especially in arid and semiarid regions where water scarcity is prevalent. The research adheres to Algerian regulations, which currently restrict the reuse of urban effluent. We conducted comprehensive analyses of several critical parameters, including in situ measurements of temperature and pH using multi-parameter field probes. Laboratory analyses were performed to determine levels of suspended matter (SM), biochemical oxygen demand (BOD_5), chemical oxygen demand (COD), nitrates (NO_3), nitrites (NO_2), ammonium (NH_4), and total nitrogen (TN) using spectrophotometric and conventional techniques. To assess the irrigation suitability of the treated wastewater, we evaluated electrical conductivity (EC), sodium percentage (Na%), sodium absorption ratio (SAR), residual sodium carbonate (RSC), permeability index (PI), magnesium ratio (MR), and Kelley ratio (KR). Our findings, derived from field visits and observations of the purification processes, indicate that the treated effluents generally comply with quality standards for key pollutants, particularly BOD_5, COD, and SM. The treated water meets the regulatory requirements for discharge into the receiving environment. Additionally, the evaluated parameters, including the average SAR value, which falls within acceptable limits, indicate that the treated wastewater is suitable for agricultural irrigation. Overall results showed no alkalinities, magnesium, or bicarbonate dangers associated with using Sidi Marouane WWPT's purified water for agriculture, indicating that the treated wastewater is suitable for agricultural irrigation.

Key words: *parameters, evaluation, standards, activated sludge, urban effluent, irrigation suitability, indices, wastewaters reuse.*

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Introduction. Algeria faces increasing threats to its water resources due to pollution from urban and industrial sewage discharges, which contain various pollutants and pathogenic microorganisms, threatening the quality of the environment [1- 2]. Wastewater, derived from residential, industrial, and other sources, necessitates treatment to eliminate harmful contaminants that pose a threat to the environment and human health [3]. Population growth and urbanization have increased demand for natural resources, including water, posing challenges in wastewater management, necessitating effective treatment to preserve water resources and prevent environmental degradation [4]. The efficient design and operation of treatment plants require the accurate characterization of wastewater before treatment [5]. Parameters like chemical oxygen demand, biological oxygen demand, nitrogen, phosphorus, and solids per capita are crucial for designing wastewater collection systems and controlling water resource pollution, estimating pollution load, and assessing urban or industrial wastewater flows [6].

Wastewater treatment aims to protect human health and prevent environmental damage by properly disposing of domestic and industrial wastewater, with a significant purpose of recycling water for irrigation in limited water resources [7]. Wastewater treatment plants (WWTPs) play a crucial role in urban water infrastructure, but they face increasing stringent requirements in effluent quality, energy consumption, and resource recycling [8-9]. Mathematical models are utilized to predict WWTP efficiency and develop operational strategies by quantitatively linking influent parameters to effluent water quality [10].

Algeria's potential for reusing treated wastewater for agricultural purposes has significantly increased from 20 million m^3 in 2014 to 40 million m^3 in 2019, with 26 WWTPs involved in treated wastewater reuse, irrigating over 13,000 hectares of agricultural land. Key projects include Chelghoum Laïd, Ouargla, Saïda, Tiaret, Chlef, Sétif, Médéa, Sidi Bel Abbès, and Ain Defla. The ONA/ONID is preparing an action plan to explore the potential of reusing treated wastewater for large-scale irrigation across five national hydrographic basins [11-12].

The preservation and reuse of wastewater is a significant global challenge in agricultural irrigation, as untreated wastewater can cause soil damage, agricultural production issues, and saline intrusion in groundwater, posing significant challenges [13]. US farmers are exploring the integration of total water Supply in agriculture to address expanding water shortages, particularly in regions supplied by the Colorado River [53]. As water scarcity worsens, the need for sustainable water sources becomes urgent, with reclaimed wastewater emerging as a safe alternative to standard water supplies [54].

In Algeria, many WWTPs, particularly older ones, suffer from reputational issues due to technical sophistication, management deficiencies, and insufficient operational funding, leading to disuse [14]. Algeria's significant WWTP, Sidi Merouane plant in Mila city, uses activated sludge treatment and is part of the Beni Haroun dam's protection facilities. However, many older WWTPs face reputational issues due to technical sophistication, management deficiencies, and insufficient funding, leading to disuse [14].

Various treatment methods, including biological, physicochemical, and membrane-based techniques, are used to mitigate harmful effects of these substances [15-16]. AquaMeld is a revolutionary method for recycling agricultural and industrial effluent in rivers and lakes [48]. Cleanup and environmental restoration also demand major investment. These cumulative costs emphasize the critical need for adequate wastewater treatment as an environmental and economic imperative [49].

The study evaluates the physicochemical quality of wastewater from Sidi Marouane to identify anomalies, enhance treated water value, and assess irrigation suitability using various water quality indices.

Materials and Methods. The study of water quality and composition is essential for assessing the health of water bodies and their surrounding environments [18 -19]. In this research, the quality of influent and effluent water from each treatment plant was evaluated by measuring various physicochemical parameters. These included electrical conductivity (EC), pH, temperature (T), chemical oxygen demand (COD), biochemical oxygen demand over five days (BOD_5), suspended matter (SM), total nitrogen (NT), nitrate (NO_3), nitrite (NO_2), ammonium (NH_4), phosphate (PO_4), dissolved oxygen (OD), and flow rate. These parameters were monitored monthly, covering both hot and cold periods, across different aerated lagoon stages and between the influent and effluent.

Characterization protocols

Samples were collected using sterile glass vials with a capacity of 1500 ml. Sampling was consistently performed at the same time of day and at the water surface, twice monthly during both the cold and hot periods. For each sample, in situ measurements of temperature and pH were taken using a multi-parameter field device. These parameters are highly sensitive to environmental conditions and may alter during storage and transport to the laboratory [19]. For other parameters, samples were collected using a specialized sampler and stored in sterile glass bottles. These were transported in an icebox to ensure preservation, with analysis conducted within a maximum of 8 hours if the distance between the sampling site and the laboratory required it. Laboratory analyses were performed according to standard and spectrophotometric methods (Table 1).

Table 1

Water quality parameters and their analytical method

Parameters	Instruments/Apparatus
pH	pH/Temperature
EC, TDS	Conductivity/TDS/Salinity meter Portable
SM	Filtration
Mg, Ca	Titration with 0.05 N EDTA
Na, K	Flame Photometer
Chloride Cl	Titration using 0.014 N $AgNO_3$ (Argentiometric)
Carbonates CO_3, Bicarbonate HCO_3	Titration with 0.01 N H_2SO_4
Ammoniac, NH_3	Spectrophotometer
Nitrate NO_3	Spectrophotometer
Sulfate SO_4	Spectrophotometer
Phosphate PO_4	Spectrophotometer
BOD, COD, DO	OD meter
TN	Spectrophotometer

Presentation of the study area

Sidi Merouane is one of the thirty-two communes of Mila city in Algeria; it is located 14 km northeast of Mila city. The wastewater treatment plant of Sidi Merouane has a treatment capacity of 20.657 m^3/day, 137.000 inhabitant's equivalent, and water produced by the plant was discharged into the basin of Bni Haroune dam, which is located nearby (MWR 2014)**.** Its surface area is 8 hectares, on the southern side of the Beni Haroune dam. The plant treats wastewater from the agglomerations of Sidi Merouane, Grarem Gouga and Mila (Fig. 1).

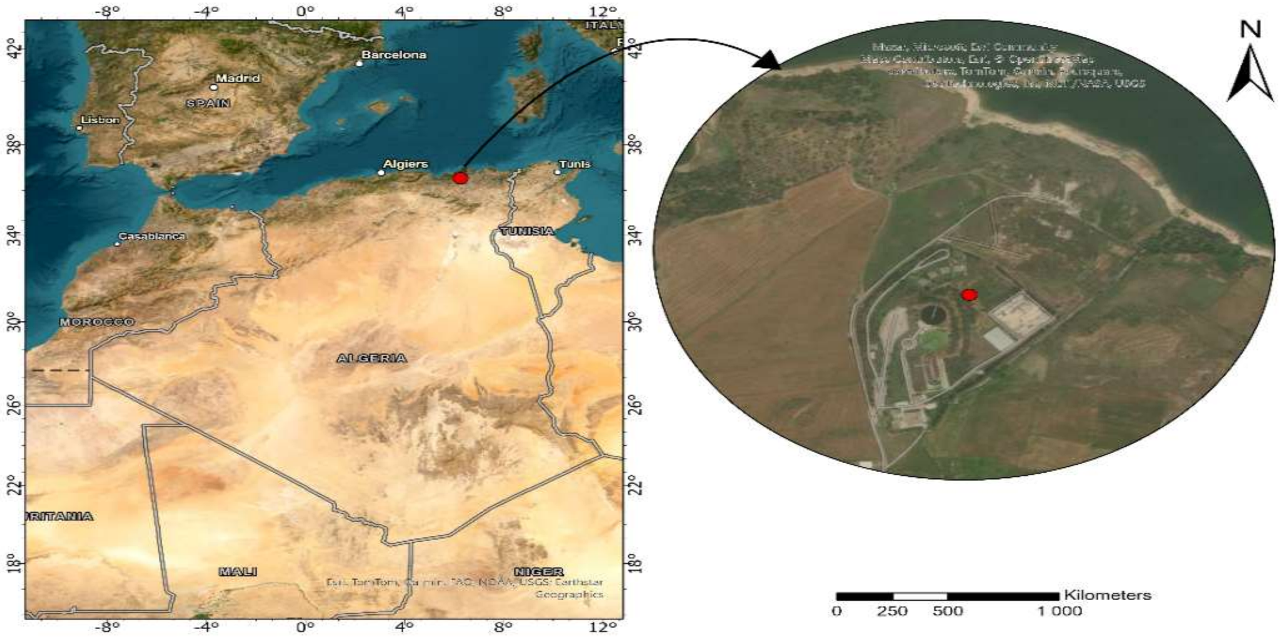

Fig 1. Map of Sidi Merouane WWTP location (Mila, Algeria) (Own edition using ArcGIS Software)

Characteristics of WWTP

The National Sanitation Office (2014) manages the plant. It was commissioned on 01 August 2009, with a nominal capacity of 137,000 EqH (2015 horizon) and an installed flow of 20,657 m^3/d. The wastewater entering the plant is domestic water arriving from 07 lift stations. The treatment method used in the WWTP is low load activated sludge with nitrogen and phosphorus treatment. This wastewater pollution treatment aims to protect the Bni Haroune dam [11].

This wastewater treatment plant was built to mitigate the pollution of the lake of the Beni Haroun dam, particularly at the level of the lake of the dam, which receives the waters of the Rhumel wadi and Endja wadi. The wastewater treatment plant of Sidi Merouane, the first of a series of three planned in this watershed, was delivered in 2009 by NSO, the project owner. It was built by GCB (a Sonatrach subsidiary specializing in civil engineering and construction) under the leadership of a project manager who was responsible for the proper execution of work, and OTV (a French company responsible for the equipment). Once treated, the water produced by the plant will be discharged into the nearby dam basin. The quality discharged will comply with international standards, i.e. less than 30 mg/l for BOD, less than 30 mg/l for MES, less than 90 mg/l for COD, less than or equal to 10 mg/l for nitrogen and 50 to 80 % (depending on season) for total phosphorus [17].

Irrigation Water Quality Indices

To assess the quality of treated water for irrigation, five indices were created using physicochemical data from the treated water samples. These indices include the Sodium Adsorption Ratio (SAR), Sodium Percentage (Na%), Magnesium Absorption Index (MAR), Percent Soluble Sodium (SSP), Sodium Carbonate Residue (RSC), and Total Dissolved Solids (TDS).

The Sodium Adsorption Ratio (SAR) is particularly significant, as high SAR levels can reduce soil permeability and make it harder, rendering it impermeable and unsuitable for plant growth. The SAR is determined using the ratios of sodium, calcium, and magnesium, all measured in mg/l. The calculations for these indices are performed using specific equations (1 to 6) [21-23].

$$SAR = \frac{Na^+}{\sqrt{\frac{Ca^{2+}+Mg^{2+}}{2}}} \quad (1)$$

$$Na\% = \frac{Na^+ + K^+}{\sqrt{Ca^{2+} + Mg^{2+} + Na^+ + K^+}} \cdot 100\% \quad (2)$$

$$MAR = \frac{Mg^{2+}}{Ca^{2+}+Mg^{2+}} \cdot 100\% \quad (3)$$

$$SSP = \frac{Na}{Ca^{2+}+Mg^{2+}+Na^+} \quad (4)$$

$$RSC = (CO_3^{2-} + HCO_3^{-}) - (Ca^{2+} + Ca^{2+}) \quad (5)$$

TDS – the Sum of Major anions *(6)*

Statistical analyses

For the analysis of statistical data, we calculated means (avg) for the various parameters studied they were carried out using the SPSS software, to compare differences between months and to evaluate if there were any significant variations in the treated water in the end of WWTP.

Results and Discussion. In this part, we will discuss the results of our work and the detailed interpretations of the physicochemical analysis of the wastewater of Mila city determined from the daily samples taken in cold period and hot period.

Quality aspect of treated and wastewater

The Sidi Merouane WWTP's secondary treatment efficiency is monitored through parameter analysis, indicating a degree of agreement with optimal discharge standards (Table 2).

Table 2

Summary of results of the physicochemical analysis of the water of Sidi Merouane WWTP in cold period and hot period

Parameters	Norms	Wastewater		Treated water	
		Cold period	Hot period	Cold period	Hot period
T (° C)	25	14.94	17.15	15.28	18.16
EC (µS/cm)	2000	1988.90	1990.26	1529.52	1533.79
pH	$6.5 \leq pH \leq 8.5$	8.03	7.80	7.57	7.51
Ox D (mg/l)	5	4.06	2.34	6.00	4.29
BOD_5 (mg O_2/l)	30	243.57	268.33	3.93	2.83
COD (mg/l)	90	496.44	529.71	22.13	21.27
SM (mg/l)	30	459.88	427.10	6.17	4.63
NO_3 (mg/l)	1	3.30	1.80	1.00	1.30
NO_2 (mg/l)	1	5.40	5.60	0.13	0.32
NH_4 (mg/l)	0.5	70.00	29.20	0.67	0.39
PO_4 (mg/l)	2	6.50	5.40	3.08	1.68
TN (mg/l)	25	79.00	81.00	11.20	2.90

Temperature variations in wastewater treatment plants significantly impact the growth of microorganism colonies [20]. At the WWTP inlet, the average water temperature is 14.94 °C in the cold period and 17.15 °C in the hot period. At the outlet, the average temperature is 15.28 °C in the cold period and 18.16 °C in the hot period (Table 2). These values are below the Algerian standards for urban liquid waste (30 °C). Temperature influences the metabolism and growth of aquatic organisms, particularly microscopic ones, by promoting the development of mesophilic bacteria that enhance organic pollutants degradation through oxidation and mineralization [24 -25], and is therefore directly linked to the rate of organic matter degradation [20].

Climate variations in Algeria affect water temperatures at stations, allowing bacteria growth and organic matter degradation. No significant temperature changes between WWTP inlet and outlet [19].

Conductivity is a crucial measure for wastewater quality control, indicating the mineralization of water and the salinity level of raw water entering a WWTP. The raw water has higher conductivity than the treated water, with averages of 1988.90 µS/cm in the cold period and 1990.26 µS/cm in the hot period, compared to 1529.52 µS/cm in the cold period and 1533.79 µS/cm in the hot period (Table 2). These values are within the standards for discharge to irrigation (2000 µS/cm), according to JORA [26-27].

pH is a crucial water quality parameter that measures acidity, alkalinity, or basicity, and should be closely monitored during treatment operations [27]. The pH values of the wastewater in both seasons are almost neutral, with 8.03 and 7.57 in the cold period and between 7.80 and 7.51 in the hot period (Table 2). These values remain within the Algerian discharge standards ($6.5 < pH < 8.5$).

Oxygen is crucial for aerobic aquatic life respiration and organic matter oxidation, also known as self-purification. At the WWTP inlet, dissolved oxygen has average monthly values of 4.06 mg/l in the cold period and 2.34 mg/l in the hot period. In treated water, dissolved oxygen increases, with average values of 6.00 mg/l in the cold period and 4.29 mg/l in the hot period (Table 2).These values meet the Algerian standards for discharge (5 mg/l). This increase in oxygen concentration indicates improved water quality, which benefits most aquatic organisms [28].

Biochemical oxygen demand (BOD_5) measures the oxygen needed for microbial degradation of organic matter in wastewater, measured over a five-day incubation period at 20°C in the dark [28-29]. The BOD_5 values at the WWTP inlet vary between 243.57 and 268.33 mg O_2/l in the cold and hot periods (Table 2), respectively. At the outlet, BOD_5 shows a significant decrease, with values below the optimal limit for discharge (3.93 and 2.83 mg O_2/l in the cold and hot periods, respectively). According to JORA, the limit for irrigation is 30 mg O_2/l, and the same standard applies for discharge to the natural environment [30].

Most suspended matter (SM) in wastewater is biodegradable [31]. This is reflected in the significant reduction in SM from raw to treated water. In raw wastewater, SM values are 459.88 mg/l and 427.10 mg/l in the cold and hot periods, respectively. At the WWTP outlet, values drop to 6.17 mg/l in the cold period and 4.63 mg/l in the hot period (Table 2), remaining below the WHO [24] and Algerian discharge standards (30 mg/l). The WWTP effectively operates by significantly degrading SM in treatment ponds and eliminating a significant portion through sedimentation in settling tanks.

Chemical oxygen demand (COD) measures the concentration of organic or mineral matter, dissolved or in suspension, in water. In treated water, COD values (Table 2) are 22.13 mg/l in the cold period and 21.27 mg/l in the hot period, significantly lower than the COD values of raw wastewater (496.44 mg/l in the cold period and 529.71 mg/l in the hot period). The treatment process enriches water with oxygen, primarily through aerators in activation basins, enabling the chemical degradation of organic matter [30-32], which falls below the Algerian discharge standard (120 mg/l), the Official Journal of the European Community standard (125 mg/l), and WHO standards (<90 mg/l).

The treated wastewater contains ammonium and nitrite concentrations below Algerian standards. Nitrate levels are below Algerian standards. Total nitrogen concentrations are higher in influent water than treated water, with maximum values at the inlet and outlet, but not exceeding Algerian standards.

The predominant form of nitrogen discharged by the Sidi Merouane WWTP is ammonium (NH_4) [33]. Ammonium concentrations can cause dissolved O_2 consumption during oxidation, while low or zero nitrate concentrations indicate nitrification in aeration tanks, which requires adequate pH and dissolved oxygen conditions [35]. Oxygen is essential for nitrification, but its concentration in aeration tanks is limited (around 0.4 mg/l), hindering nitrifying bacteria growth [36]. Dissolved oxygen levels directly affect COD abatement efficiency, with depletion leading to higher COD values and lower abatement rates.

The study found high nitrogen removal rates, likely due to aerobic processes maintaining sufficient nitrifying bacteria concentrations in the aerobic part of the channel, supported by an anoxic zone upstream of biological treatment [35].

Phosphate (PO_4) in treated water can cause eutrophication, water quality deterioration [37], and promote algae growth [38], leading to water body colonization and increased eutrophication in marine waters [39- 40].

Description of WWTP performance

The high BOD_5 abatement efficiency is due to the growth of purifying bacteria, while a decrease in bacterial activity results in lower efficiency, consistent with the Maghnia WWTP's 94.94% rate [17-40]. Dissolved oxygen levels directly influence COD abatement efficiency ((Table 3), with depletion resulting in higher COD values and lower abatement rates [19-41]. This trend aligns with observations from Mascara city [42].

BOD and COD are crucial indicators of organic contamination in water and wastewater, affecting aquatic life and wastewater treatment facilities. Low concentrations support aquatic life, while high levels deplete dissolved oxygen, affecting aquatic ecosystems [7]. The biodegradability of wastewater, such as that from slaughterhouses, is evident when examining this ratio, suggesting that biological treatment is suitable [43-44]. High-suspended matter concentrations in treated water (Table 3 and 4) are primarily due to algae presence, lagoon aging, and sludge accumulation, indicating the need for cleaning operations [19].

Table 3

European wastewater discharge standards [28]

Parameters	Concentration	Minimum performance
BOD_5	25 mg/l	80 %
COD	125 mg/l	75 %
SM	35 mg/l	90 %
NTK	10-15 mg/l	70 %
PT	1-2 mg/l	80 %

Table 4

Performance of WWTP

Parameters	Performance (%)	
	Cold period	Hot period
SM	98.61	98.96
BOD_5	98.28	98.94
COD	95.31	96.05

Comparison of principal ions

Compared to treated sewage water in the hot period (Fig 2), the concentration of major ions is significantly higher in the cold period, except for Cl, Mg, and SO_4. In the study region, Na, Mg, and Ca are the predominant cations, while SO_4 and Cl are the main anions in treated water during both periods. The cation chemistry is primarily governed by sodium ions, followed by calcium, magnesium, and potassium (Na > Ca > Mg > K) [23-45].

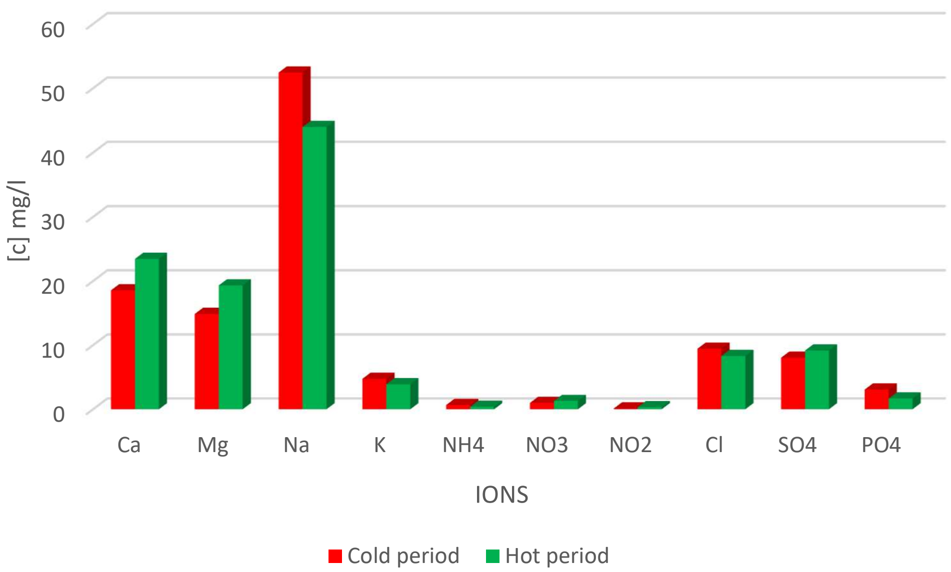

Fig 2. Evaluation of the average concentrations of major ions in treated water (Own edition)

Irrigation suitability

In relation to quality control tests performed on treated water used for irrigation in this area. In order to evaluate quality of this water, we analyzed all the salinity-related variables during study period (Table 5).

Agriculturally useful nutrients such as nitrogen, phosphorus, and potassium could be also recovered and reused [50-51].

Table 5

Classification of various irrigation indices

Index	Range	Water Category	Results and Number of Samples (%)	
			Cold period	Hot period
SAR	**<10**	Excellent	0	9.5 (100 %)
	10-18	Good	12.87 (100 %)	0
	18-26	Doubtful or fairly poor	0	0
	>26	Unsuitable	0	0
Na%	**< 20**	Excellent	0	0
	20-40	Good	0	0
	40-60	Permissible	0	52.82 (100 %)
	60-80	Doubtful	63.11 (100 %)	0
	>80	Unsuitable	0	0
MAR	**< 50**	Good	44.48 (100 %)	45.17 (100 %)
	>50	Unsuitable	0	0
SSP	**< 50**	Safe	0	0
	>50	Unsafe	61.07 (100 %)	50.70 (100 %)
RSC	**< 1.25**	Safe	-33.43 (100 %)	-42.77 (100 %)
	1.25-2.5	Marginal	0	0
	>2.5	Safe	0	0
TDS	**<1000**	Non-saline	109.92 (100 %)	110.14 (100 %)
	>1000	Saline	0	0

The water is thus not in danger of becoming alkaline and may be utilized for irrigation, according to the average SAR value, which is still in excellent category (hot period) to good category (cold period), as well as the other parameters, including MAR, Na %, SSP, RSC, and TDS (Table 5). Overall results showed in Table 5 that there are no alkalinity, magnesium, or bicarbonate dangers associated with using Sidi Marouane WWPT's purified water for agriculture [43–46]. The use of groundwater would not rise if treated wastewaters are used for irrigation on these farms. Instead, the amount of conventional and filtered water available for irrigation would decrease due to lower costs [47]. Recovering and reusing agricultural nutrients like nitrogen, phosphorus, and potassium through treated water reuse for irrigation can contribute significantly to a circular economy and sustainable development [52-53].

Conclusion. Wastewater treatment using the activated sludge process is a continuously operating system where microorganisms are brought into contact with wastewater containing organic matter and oxygen, which is injected to provide the bacteria with this essential element for their respiratory needs. The aim of this study is to evaluate the efficiency and purification performance of the Sidi Merouane wastewater treatment plant, which utilizes an activated sludge system.

The experimental results demonstrate that the Sidi Merouane WWTP generally produces satisfactory outcomes, adhering to Algerian standards and WHO guidelines in terms of BOD_5, COD, SM, and NT, thereby indicating the effective operation of this facility. During the monitoring period, the Sidi Merouane WWTP achieved notable purification yields, with COD and BOD_5 abatement rates exceeding 98% and SM reduction close to 96%. These results confirm the purification efficiency of the WWTP and its reliability in water treatment, with the treated water quality meeting the required criteria for discharge into the receiving environment. Moreover, the average SAR value remains within the acceptable range, alongside other parameters such as MAR, Na%, SSP, RSC, and TDS, indicating that the purified water is suitable for agricultural irrigation in hot period.

However, the challenges facing wastewater treatment facilities, both in urban and rural areas, include inadequate coverage, poor operational states, design flaws, lack of expertise, corruption, insufficient funding, overloaded capacities, and inadequate compliance monitoring. These issues are prevalent in both developed and developing countries. To protect the environment and public health, especially for those who rely on surface water as a primary water source, it is imperative to enforce water and environmental regulations. Treated wastewater reuse for irrigation can reduce irrigation water imbalances, particularly in water-scarce areas, while also increasing or maintaining food output by expanding irrigated agriculture, and enhancing global food and water security. Additionally, exploring technical solutions to enhance wastewater treatment standards is essential to facilitate safe water recovery. Consideration of the microbiological quality of treated resources, as required by national regulations, is also crucial. Comprehensive regulations and strategies for risk management are critical to ensuring the smooth operation and long-term viability of TW reuse systems, as well as environmental and public health and societal acceptance.

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Data availability statement. Data cannot be made publicly available; readers should contact the corresponding author for details.

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Резюме

Заоуі Л., Аббачі С, Фекраче Ф., Кахіт Ф.З., Хеліфі В., Бенселгуб А., Сахер Е., Соліман А.М. **Характеристика якості очищених та стічних вод Сіді Маруанських очисних споруд у провінції Міла, Алжир: придатність та повторне використання для іригації.**

Це дослідження має на меті оцінити якість стічних вод з міста Міла, очищених за допомогою процесу активного мулу, оцінивши їх потенціал для повторного використання в сільському господарстві. Ефективне очищення стічних вод має важливе значення для пом'якшення ризиків для здоров'я, пов'язаних з використанням ресурсів поверхневих і підземних вод. Повторне використання очищених стічних вод для зрошення є ключовою метою, особливо в посушливих і напівпосушливих регіонах, де поширений дефіцит води. Дослідження дотримуються законів Алжиру, які наразі обмежують повторне використання міських стоків. Ми провели комплексний аналіз кількох критичних параметрів, включаючи вимірювання температури та pH in situ за допомогою багатопараметричних польових зондів. Були проведені лабораторні аналізи для визначення рівнів завислих речовин (ЗР), біохімічного споживання кисню (БСК$_5$*), хімічного споживання кисню (ХСК), нітратів (*NO_3*), нітритів (*NO_2*), амонію (*NH_4*) і загального азоту (ЗN) за допомогою спектрофотометричних та звичайних методів. Щоб оцінити придатність очищених стічних вод для зрошення, ми оцінили електропровідність (EC), відсоток натрію (Na%), коефіцієнт поглинання натрію (SAR), залишковий карбонат натрію (RSC), індекс проникності (PI), коефіцієнт магнію (MR) і коефіцієнт Келлі (KR). Наші висновки, отримані під час візитів на місця та спостережень за процесами очищення, вказують на те, що очищені стоки загалом відповідають стандартам якості щодо основних забруднювачів, зокрема БСК*$_5$*, ХСК та ЗР. Очищена вода відповідає нормативним вимогам щодо скидання в приймаюче середовище. Крім того, оцінені параметри, включаючи середнє значення SAR, знаходяться в допустимих межах. Загальні результати показали відсутність небезпеки лужності, магнію чи бікарбонату, пов'язаної з використанням очищеної води Сіді Маруанських очисних споруд для сільського господарства, що вказує на те, що очищена стічна вода придатна для сільськогосподарського зрошення.*

Ключові слова: *параметри, оцінка, стандарти, активний мул, міські стоки, придатність до поливу, індекси, повторне використання стічних вод.*