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Assessment of wastewater and estimation of the designer's population equivalent

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Abstract

The precise characterization of urban wastewater is a crucial factor for the correct selection and sizing of the suitable treatment system. This study aims to assess and justify the urban effluents released by the primary town of the commune, Draa Ben Khedda. The analysis of physicochemical parameters reveals elevated and variable concentrations of biological oxygen demand and chemical oxygen demand, with values ranging from 4% to 3.88 times and 1.80% to 2.43 times above the standards for discharge into a sewerage system or treatment facility, signifying an unacceptable discharge. The estimated daily pollution output per capita deviates from the reference values employed. The computed average ratios for suspended matter, ammonium, and orthophosphorus are 28.29, 5.40, and 3.49 g/IE/d, respectively, representing reductions of 59.59, 61.43, and 12.75% compared to the reference standards of 70, 14, and 4 g/IE/d. The computed BOD5 and COD ratios were 119.95 and 154.70 g/IE/d, respectively, exceeding the reference standards of 60 and 120 g/IE/d by 99.95 and 28.92%, respectively.

Keywords: characterization, ratios, Discharge standards, Eutrophication

1. Introduction

Water pollution is a major environmental issue that affects aquatic ecosystems, human health, and the global economy (Boulal *et al.*, 2020; Amiri *et al.*, 2022; Sikkander et Ramachandran, 2022; Ruzi *et al.*, 2023; Muoghalu *et al.*, 2023; Ribarova *et al.*, 2024). Good wastewater management is critical for maintaining a sustainable environment and ensuring the health and safety of the entire population, but financial and economic constraints continue to be major challenges in developing countries (Farheen *et al.*, 2021; Shukla *et al.*, 2021; Sharma *et al.*, 2022; Justin *et al.*, 2022). Algeria currently has 240 wastewater treatment plants serving a population of 46 million. The volume of wastewater discharged is estimated to be 3 million m3/day, with less than 50% treated. In Algeria, the construction of wastewater treatment plants has been heavily influenced by European and American standards, which have a direct impact on technological choices, wastewater treatment methods, construction costs, and project economics.

However, the application of these standards, which were originally designed for different socioeconomic and climatic contexts, has influenced stage selection and treatment basin size. Indeed, the adoption of these standards has resulted in the implementation of wastewater treatment processes that typically end with a clarification stage but do not incorporate specific phosphorus and nitrogen removal processes. Similarly, wastewater management projects are frequently overlooked in terms of project development and budget allocation (Chabi et Hammar, 2019; Moondra *et al.*, 2021; Aroua-Berkat et Aroua, 2022). Algerian WWTPs are sometimes unsuitable for local variations in urban discharges, especially in agri-food-influenced regions like Tizi-Ouzou wilaya. However, depending on the actual discharge characterization, specific treatments for phosphorus elimination are required, as phosphorus is a limiting factor for the quality of receiving environments.

This parameter is especially important in the wilaya of Tizi Ouzou, where receiving waters are heavily polluted by the discharge of poorly treated or even untreated domestic and urban wastewater, which is frequently laden with nutrients like nitrogen and phosphorus. The lack of adequate treatment for these elements promotes eutrophication in aquatic environments, resulting in ecological imbalances and water quality degradation (Metahri, 2012). This situation highlights the critical need to tailor treatment processes to local conditions. Furthermore, a precise assessment of wastewater quality parameters would be extremely useful in determining the best treatment system size and configuration. Thus, this study aims to propose a regulatory strategy based on the actual values of pollution parameters expressed in inhabitant equivalents per day for our urban discharges.

2. Materials And Methods

Presentation of the study area

Draa Ben Khedda is located 11 km west of Tizi-Ouzou and approximately 90 km east of Algiers. It covers an area of 172.23 km^2 (Figure 1).

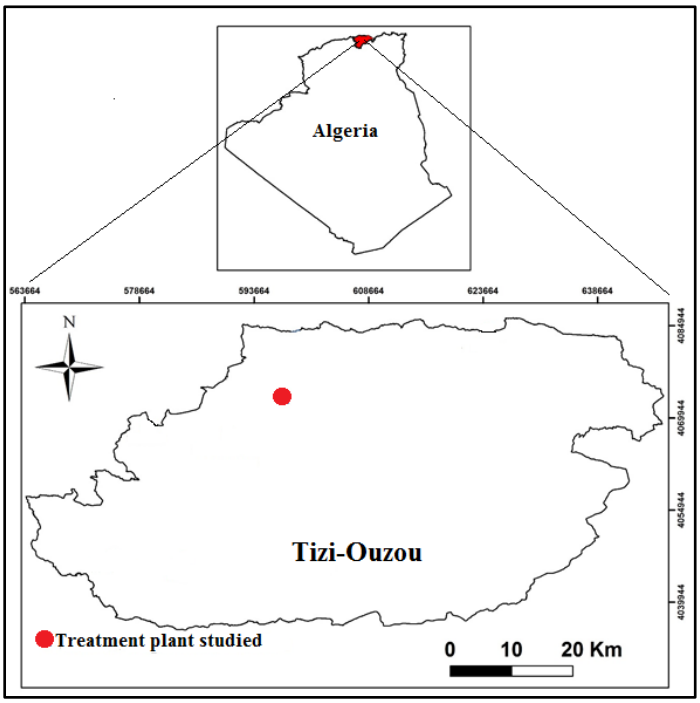


Figure 1: Commune of Draa Ben Khedda.

Sewerage system and wastewater discharge

The commune of Draa Ben Khedda has 34,674 inhabitants, 96.14% of whom are connected to the 66.68 km linear sewerage network. The public service is managed by the Algerian National Sanitation Office. Table 1 depicts the current status of the sewer network.

Table 1: State of the sewerage network in the commune of Draa Ben Khedda.

Area	Population	CR (%)	LSN (Km)	VWD (m^3/d)	POD	VWT (m^3/d)
Chief town	27 345	98	32.923	3 858.92	WWTP	950
Mouldiouene village	3 075	96	4.84	377.86	ST. Oued	160
Mouldiouene area	2 050	96	11.8	251.90	Oued	106.66
Ain Faci	1 409	96	9.8	162.36	SB. ST. Oued	106.66
Bourima	240	94	0.568	27.06	ST. Oued	8.54
Boubakour village	411	100	0.45	49.32	ST. Oued	13.65
Fali village	144	93	0.3	16.01	ST. Oued	10.55

CR: Connection Rate, LSN: Linear Sewerage Network, VWD: Volume of Wastewater Discharged, POD: Place of Discharge, VWT: Volume of Wastewater Treated, SB: Settling Basin, ST: Septic Tank

Sampling and analysis methods

Over the course of a year, hydrogen potential (pH), temperature (T°), suspended solids (TSS), five-day biological oxygen demand (BOD5), chemical oxygen demand (COD), ammonium (NH_4^+), and orthophosphates (PO_4^{3-}) were all measured. Raw wastewater samples were collected once a month at the plant head and transported to the laboratory in a cooler (Rodier, 2009; FONASA, 2013). pH and T° were determined electrometrically using a Hanna pH meter (pH 211) and a Hanna Checktemp1 mini-thermometer (HI 98509). TSS was determined using the filtration method (Rice *et al.* 2012). BOD5 was determined using the manometric method in Oxitop flasks.

COD was determined by oxidizing sample organic matter at 150°C for 2 h in excess of potassium dichromate under test conditions in the presence of iron and ammonium sulfate as catalysts and measuring it with a Hach DR 2000 spectrophotometer. Then, NH_4^+ and PO_4^{3-} were measured using a colorimetric method and a Hach DR 2000 spectrophotometer. Ammonium was determined in the presence of ammoniacal salicylate and ammoniacal cyanurates, which produce a greenish hue. Absorbance is measured at a wavelength of 655 nm. Orthophosphates were determined in the presence of a PhosVer 3 reagent, which forms a blue complex with orthophosphate ions and is measured at 890 nm (Rodier, 2009).

3.Results And Discussion

Physicochemical characterization

Table 2 lists the monitoring of physicochemical parameters in the inlet effluents to the Draa Ben Khedda WWTP. The temperature analysis revealed significant variations ranging from 13.70 to 25.0°C, with an average of 19.61°C. This range provides an ideal environment for biological equilibrium and microbial multiplication (Hamaidi-Chergui *et al.*, 2016). Furthermore, maximum values were recorded in July, August, September, and October. Conversely, minimum values are recorded in January and February. This temperature difference demonstrates that water temperature is strongly correlated with air temperature; it is highest during dry seasons and lowest during wet seasons (Merghem *et al.*, 2016). The temperature values are below the Algerian standard for acceptable discharge into the public sewerage system or a wastewater treatment plant, which is approximately 30°C (JORA, 2009). Our findings are similar to those found in Mascara (Algeria) by Bouregba *et al.* in 2016. On the other hand, the mean temperature is lower than 21.94, 22.2, and 24.05°C found in Iraq by Al Saleh (2021), Tunisia by Ben Messaoud *et al.* (2021), and Sidi Bel Abbes by Chadli *et al.* (2022).

Hydrogen potential results show a minimum and maximum value of 6.71 and 7.66. They fall between 5.5 and 8.5 and are considered the upper and lower limits for discharge into the public sewage system or a wastewater treatment plant (JORA, 2009). Furthermore, the pH range obtained encourages the growth of organisms necessary for the biological degradation of organic pollution (Benyoucef, 2021). The average pH results are consistent with those reported by Bouregba *et al.* (2016) in Mascara, Basturk *et al.* (2020) in Turkey, and Ji *et al.* (2021) in Japan. Furthermore, the maximum value is comparable to the 7.606 found in Jordan by Qasaimeh and Al-Ghazawi (2020).

The suspended solids values obtained are variable, with a minimum of 128 mg/L and a maximum of 432 mg/L recorded in October and an average of 200.05 mg/L. The maximum value found remains below 600 mg/L, which is considered the standard for discharge into the public sewage system or a wastewater treatment plant established by the Algerian government in 2009. The variation in TSS reflects the range of contaminants emitted by various domestic and commercial sources. The exact composition of wastewater varies around the world, depending on a variety of factors, such as domestic water use and the level of commercial activity (UN WATER, 2017). The quality of the liquid effluent is tailored to the physical treatment at the WWTP. The average content found is comparable to those found in El Oued (194.65 mg/L) (Khechekhouche *et al.* 2020). However, it is lower than the concentrations found in Tissemsilt (Algeria) by Ferradji *et al.* (2023), India by Saravanakmar *et al.* (2019), and Indonesia by Rozari *et al.* (2020).

The extreme minimum and maximum values for biological oxygen demand range between 440 and 1940 mg/L, with an average of 850 mg/L. With the exception of August, the recorded values exceed 500 mg/L, which is the JORA (2009) standard for the discharge of non-domestic water into a sewerage system or WWTP. This increase is most likely due to urban effluents influenced by organic matter-laden discharges from a cheese factory and dairy connected to the public sewage network. These biodegradable discharges result in nutritional imbalances in the downstream plant's biomass, as well as organic load surges and network fermentations. Non-domestic effluent is a significant source of nuisance. They contribute to the premature deterioration of sewage systems and the failure of the WWTP, which primarily treats urban effluent (Aissaoui, 2023). Our findings are significantly higher than those reported in El Oued (280 to 390 mg/L) by Yahiaoui *et al.* in 2018, Boumerdès (309.60 mg/L) by Ait Baziz *et al.* in 2022, and Sidi Bel Abbes (514.91 mg/L) by Chadli *et al.* in 2022.

The chemical oxygen demand load varies considerably, ranging from 640 to 2,430 mg/L, with an average of 1,096.25 mg. The high COD values could be attributed to the discharge of urban wastewater and effluent from industrial units loaded with biodegradable and non-biodegradable organic matter upstream of the sewer system. The measured values are higher than those reported in Turkey by Basturk *et al.* (2020), Tissemsilt by Ferradji *et al.* (2023), and Japan by Ji *et al.* (2021). On the other hand, they are lower than the 1807.80 and 1322.50 mg/L measured in Poland by Zawadzka *et al.* (2021) and Sidi Bel Abbes by Chadli *et al.* (2022). The raw water has high ammonium concentrations, ranging from 21.20 to 46.20 mg/L, with an average of 38.28 mg/L. These concentrations show a range of pollution sources in the urban wastewater network, which can be attributed to both domestic and industrial activity. Effluent from the dairy industry discharged into the public sewerage system may contain high levels of ammonium due to cleaning residues, dairy products, and organic matter being degraded by microorganisms, which release ammonium in the process.

The average NH_4^+ value is lower than the ammonium levels found in wastewater from Chile (85.10 mg/L) by Andrés *et al.* in 2018 and China (42.50 mg/L) by Zhang *et al.* in 2021. On the other hand, our result is higher than the value found by Ng *et al.* (2021) in Malaysia, which is an average of 10 mg/L, as well as the values found by Ngoc *et al.* (2021) in Vietnam, which is 31 mg/L, and the average value found by Zawadzka *et al.* (2021) in Poland, which is 26.30 mg/L.

Orthophosphate levels were found to range between 17.46 and 28.96 mg/L, with an average of 24.75 mg/L. The high values are due to the high concentrations of laundry detergents and cleaning products in domestic wastewater, combined with discharges from the region's commercial, craft, and industrial activities. The recorded values are higher than those for raw water from STEPs in the wilaya of Tizi-Ouzou (Aissaoui, 2023) and those reported by Andés *et al.* (2018) in Chile. On the other hand, they are lower than the value found in Malaysia by Ng *et al.* (2021).

Table 2. Analytical results of raw effluent from the WWTP studied.

	Unit	Avg	Max	Min
T	°C	19.61	25.80	13.70
pH	-	7.08	7.66	6.71
TSS	mg/l	200.50	432.00	128.00
BOD5	mg/l	850.00	1940.00	440.00
COD	mg/l	1096.25	2430.00	640.00
NH_4^+	mg/l	38.28	46.20	21.20
PO_4^{3-}	mg/l	24.75	28.96	17.46

T: Temperature, pH: Potential of Hydrogen, TSS: Total Suspended Solids, BOD_5: Biochemical Oxygen Demand (5 days), COD: Chemical Oxygen Demand, NH_4^+: Ammonium Ion, PO_4^{3-}: Phosphate Ion, Avg: Average, Max: Maximum, Min: Minimum.

Multiple correlation analyses of the raw water physicochemical parameters revealed two positive relationships between variables (Table 3). A strong positive relationship (r = 0.97006) was found between BOD5 values and the COD variable, indicating that organic matter in raw effluent is primarily biodegradable. However, a positive relationship was found between BOD5 values and the variable PO_4^{3-} (r = 0.52836), indicating that phosphorus is an essential nutrient for microorganisms. A high phosphorus concentration in dairy wastewater can promote microbial growth, which can lead to an increase in BOD because these microorganisms consume oxygen to degrade the organic matter in the effluent. The remaining parameters have low linkage levels, indicating that there are no significant correlations between them.

Table 3: Correlation matrix between raw water physicochemical variables.

	TSS	BOD	COD	NH_4^+	PO_4^{3-}	T°	pH
TSS	1						
BOD	0.11362	1					
COD	0.040175	**0.97006**	1				
NH_4^+	0.18504	0.19353	0.28372	1			
PO_4^{3-}	0.38377	**0.52836**	0.39239	00094295	1		
T°	0.15724	-0.047272	-0.13773	-0.09984	0.44868	1	
pH	0.081547	0.28447	0.2471	0.11116	0.184	0.20035	1

Assessment of pollution levels

To assess the impact of discharges on the receiving environment, Table 4 summarizes the interpretation of the results of the key pollution indicators with the standards for discharge to a sewer system or treatment plant set by JORA in 2009, using signs. The + sign indicates that the values of the parameters studied exceed the appropriate standard. The - sign indicates that our results are acceptable and fall below the discharge standard. Table 3 shows a - sign for TSS, NH_4^+ and PO_4^{3-}, indicating that the values obtained during the study year were below the discharge standards established by JORA (2009).

The + sign, on the other hand, is used for BOD all year except in August and for COD except in January, July, August, and November. The effluent load in terms of BOD and COD is high and irregular, ranging from 4% to 3.88 times and 1.80% to 2.43 times the discharge standard. This increase has the potential to degrade the sewage works and result in ineffective treatment of certain non-domestic pollutants that pass through the treatment plant basins. The WWTP is malfunctioning, with the py-pass reaching 85.15%, or an average of 418.70 hours per month. In fact, this wastewater pollutes the receiving waters in the wilaya of Tizi-Ouzou, posing a significant threat to the environment and human health.

Table 4: Interpretation of results in relation to Algerian discharge standards.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
TSS	-	-	-	-	-	-	-	-	-	-	-	-
BOD	+	+	+	+	+	+	+	-	+	+	+	+
COD	-	+	+	+	+	+	-	-	+	+	-	+

NH_4^+	-	-	-	-	-	-	-	-	-	-	-	-
PO_4^{3-}	-	-	-	-	-	-	-	-	-	-	-	-

Designers' estimate of the equivalent inhabitant

Population equivalent represents the average amount of pollution discharged per day by each inhabitant. Figure 2 illustrates the actual daily inhabitant-equivalent production of raw urban effluent from the Draa Ben Khedda region. To obtain a true estimate of pollution in inhabitant equivalent per day, we used the actual daily flow rates and connected population shown in Table 1.

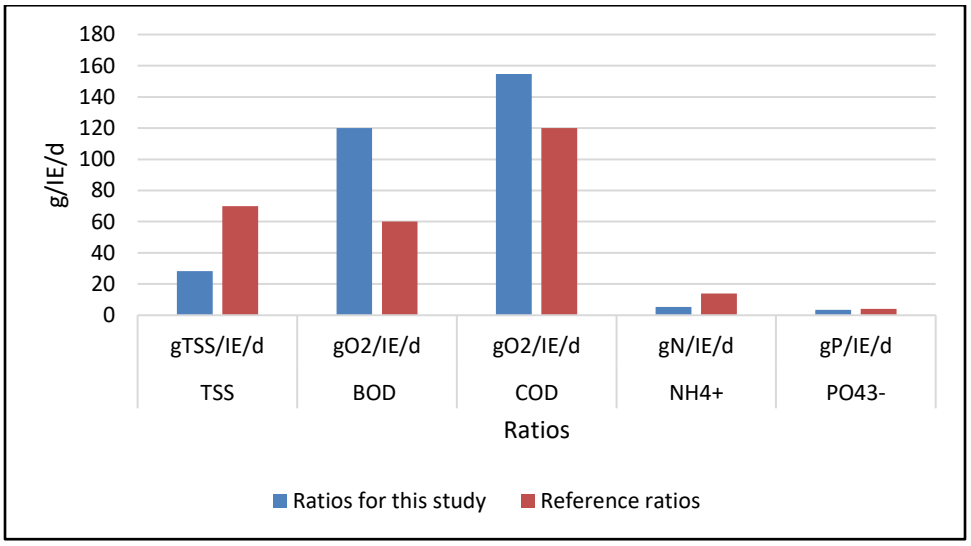


Figure 2: Pollution ratios in g/IE/d for the Draa Ben Khedda region.

The average daily per capita production of TSS is 28.29 g/IE/d, representing a 59.59% decrease from the average daily per capita discharge standard of 70 g/IE. The estimated daily per capita ammonia nitrogen production ranged between 2.99 and 6.52 g/IE/d. The maximum value is 53.43% lower than the reference value of 14 g/IE/d. These values reflect a different reality in terms of daily discharge, which is determined by the lifestyles of the connected populations.

The estimated values for biological oxygen demand range from 62.09 to 273.77 g/IE/d, with an average of 119.95 g/IE/d. This average is 99.92% higher than the reference value for average daily discharge per individual, which is 60 g/IE/day. Regarding chemical oxygen demand, the calculated pollution ratio ranges from 90.32 to 342.92 g/IE/d, with an average of 154.70 g/IE/d, which is 28.92% higher than the reference value of 120 g/IE/d. The daily per capita orthophosphate discharge ranges between 2.46 and 4.09 g/IE/d, with an average of 3.49 g/IE/d. The maximum value is 2.25% above the reference value of 4 g/IE/d.

The development of urbanization can explain these increases, as well as the prevalence of agri-food activity and the study area's unitary wastewater collection network. The large volumes of agri-food industrial effluent from the dairy connected to the public sewage system are most likely contaminated with biodegradable and non-biodegradable organic matter, as well as white water from washing and hygiene operations containing detergents and disinfectants. However, these discharges are a significant source of nuisance, causing fermentation in the networks. They also contribute to the early deterioration of sanitation infrastructure and the failure of wastewater treatment plants (Sukmana *et al., 2025*; Obayomi *et al.*, 2026).

4. Conclusion

The findings of this study demonstrate that the effluent possesses elevated levels of organic matter and phosphorus. BOD5 and COD concentrations typically surpass the recommended threshold values for discharge into sewage systems and treatment facilities. The daily productivity ratios determined for the study area indicate a discrepancy from the reference values. The results indicate that the daily pollution rate per capita is closely associated with the lifestyle of the affected populations, the extent of urbanization, the nature of the wastewater collection system, and the influence of industrial effluents.

To further develop these conclusions, it is essential to conduct a comprehensive study of wastewater within the collection network, emphasizing both quantitative and qualitative dimensions, to precisely assess the origin, quality, and volume of daily pollution produced. To mitigate the effects of industrial effluents, it is advisable to enhance effluent treatment processes and conduct routine discharge inspections to ensure adherence to prevailing regulations.

References

1. Aissaoui, D. (2023). Caractérisation des effluents domestiques et optimisation de l'épuration biologique. Cas des STEP de la région de Tizi-Ouzou (Doctoral dissertation, UNIVERSITÉ MOULOUD MAMMERI DE TIZI-OUZOU).
2. Al Saleh, H. A. (2021). Wastewater pollutants modeling using artificial neural networks. Journal of Ecological Engineering, 22(7), 35-45.
3. Amiri, K., Bekkari, N. E., Débbakh, A. E., Chaib, W., & Kherifi, W. (2022). The efficiency of household sewage treatment by Wastewater garden technique in arid regions, case of WWG of Temacine, Algeria. Journal Algérien des Régions Arides, 14(2), 18-31.
4. Andrés, E., Araya, F., Vera, I., Pozo, G., & Vidal, G. (2018). Phosphate removal using zeolite in treatment wetlands under different oxidation-reduction potentials. Ecological Engineering, 117, 18-27.
5. Aroua-berkat, S., & Aroua, N. (2022). Opportunities and challenges for wastewater reuse in Algeria. Larhyss Journal, 19(4), 35-45.
6. Basturk, I., Varank, G., Murat Hocaoglu, S., & Yazici Guvenc, S. (2021). Medical laboratory wastewater treatment by electro-fenton process: Modeling and optimization using central composite design. Water Environment Research, 93(3), 393-408.
7. Ben Messaoud, R., Lachaal, F., Leduc, C., & Mlayah, A. (2021). Discharge of treated wastewater: hydrodynamic and hydrogeochemical impacts on the Kairouan plain aquifer (Central Tunisia). Environmental Earth Sciences, 80(10), 381.
8. Benyoucef, A. (2021). Traitement des eaux usées par la phytoépuration (Doctoral dissertation, Larbi Ben M'hidi Oum El Bouaghi).
9. Boulal, A., Kalloum, S., Bekouche, H., & Boulahya, K. (2020). Microbiological treatment of domestic wastewater with Moringa oleifera seeds from the city of Adrar-Algeria. Fascicula Biologie, 27(2), 209-214.
10. Bouregba, N., Benmimoun, Y., Meddah, B., Tilmatine, A., & Ouldmoumna, A. (2016). Ozonation of wastewater in Algeria by dielectric barrier discharge. Desalination and Water Treatment, 57(4), 1824-1835.
11. Chabi, M. et Hammar, Y. (2019). Modélisation de la dépense énergétique dans une station d'épuration à boues activées : cas de la station de Souk Ahras. Rév. Sci. Technol, 25 (1), 144-154.
12. CHADLI A., BENHASSEINI H., FERTOUT MOURI N., & AGUIAR H. (2022). La réutilisation des eaux usées, une alternative durable pour la gestion des ressources en eau de la ville de Sidi Bel Abbes (Algérie). Revue Geo-Eco-Trop N° 46 Tome 2, pp. 301-313.
13. Farheen, K. S., Reyes, N. J., & Kim, L. H. (2021). Constructed wetlands in treating domestic and industrial wastewater in India: A review. Journal of Wetlands Research, 23(3), 242-251.
14. Ferradji, F. Z., Hamouche, N. E. I., & Badis, A. (2023). Production of Biogas at Wastewater Treatment Plant in Algeria: Case Study From W. Tissemsilt. Algerian Journal of Renewable Energy and Sustainable Development, 5(2), 144-149.
15. Fondation Nationale de la Sante. 2013. Manuel pratique d'analyse de l'eau, 4eéd., Brasilia, 146 p
16. HAMAIDI-CHERGUI F., ZOUBIRI A.F., HAMAIDI M.S., DEBIB A., KAIS H. (2016). Evaluation de l'efficacité de la station d'épuration de Médéa (Algérie). Larhyss Journal, (26), 113-128.
17. Ji, J., Chen, Y., Hu, Y., Ohtsu, A., Ni, J., Li, Y., ... & Li, Y. Y. (2021). One-year operation of a 20-L submerged anaerobic membrane bioreactor for real domestic wastewater treatment at room temperature: Pursuing the optimal HRT and sustainable flux. Science of the Total Environment, 775, 145799.
18. JORA. (2009). Journal Officiel de la République Algérienne N° 36. Décret exécutif n° 09-209 du 17 Joumada Ethania 1430 correspondant au 11 juin 2009 fixant les modalités d'octroi de l'autorisation de déversement des eaux usées autres que domestiques dans un réseau public d'assainissement ou dans une station d'épuration.
19. Justin, L. D., Olukanni, D. O., & Babaremu, K. O. (2022). Performance assessment of local aquatic macrophytes for domestic wastewater treatment in Nigerian communities: A review. Heliyon, 8(8).
20. Khechekhouche, A., Bouchmel, F., Kaddour, Z., Salim, K., & Miloudi, A. (2020). Performance of a wastewater treatment plant in south-eastern Algeria. International Journal of Energetica, 5(2), 47-51.
21. Metahri, M. S. (2012). Elimination simultanée de la pollution azotée et phosphatée des eaux usées traitées par des procédés mixtes : cas de la STEP est de la ville de Tizi Ouzou (Doctoral dissertation, Université Mouloud Mammeri).
22. Moondra, N., Jariwala, N. D., & Christian, R. A. (2021). Role of phycoremediation in domestic wastewater treatment. Water Conservation and Management, 5(2), 66-70.
23. Muoghalu, C. C., Owusu, P. A., Lebu, S., Nakagiri, A., Semiyaga, S., Iorhemen, O. T., & Manga, M. (2023). Biochar as a novel technology for treatment of onsite domestic wastewater: A critical review. Frontiers in Environmental Science, 11, 1095920.
24. Ng, J. Y., Wong, D. L., Kutty, S. R. M., & Jagaba, A. H. (2021, May). Organic and nutrient removal for domestic wastewater treatment using bench-scale sequencing batch reactor. In AIP Conference Proceedings (Vol. 2339, No. 1, p. 020139). AIP Publishing LLC.
25. Ngoc, L. T. B., Tu, T. A., Hien, L. T. T., Linh, D. N., Tri, N., Duy, N. P. H., ... & Phuong, P. T. T. (2020). Simple approach for the rapid estimation of BOD5 in food processing wastewater. Environmental Science and Pollution Research, 27(16), 20554-20564.
26. Obayomi, O. V., Mustapha, L. S., Olawoyin, D. C., Oladoye, P. O., & Obayomi, K. S. (2026). Waste to wealth: Circular utilization of dairy waste for sustainability in agri-food industries. Sustainable Chemistry One World, 100217.

27. Ribarova, I., Vasilaki, V., & Katsou, E. (2024). Review of linear and circular approaches to on-site domestic wastewater treatment: Analysis of research achievements, trends and distance to target. Journal of Environmental Management, 367, 121951.
28. Rice, E. W., Bridgewater, L., & American Public Health Association (Eds.). (2012). Standard methods for the examination of water and wastewater (Vol. 10). Washington, DC: American public health association.
29. Rodier. 2009. L'Analyse de l'eau. 9e éd., Dunod, Paris, France, 1526 p.
30. Rozari, P. D., Krisnayanti, D. S., & Gaol, M. L. (2020, April). An investigation into the use of sand media planted with Thypa latifolia in constructed wetland ecotechnology in removing organic matter, suspended solids and nutrients from domestic wastewater. In AIP Conference Proceedings (Vol. 2229, No. 1, p. 030032). AIP Publishing LLC.
31. Ruzi, I. I., Ishak, A. R., Abdullah, M. A., Zain, N. N. M., Tualeka, A. R., & Aziz, M. Y. (2023). Assessment of heavy metal concentrations in Penang, Malaysia's wastewater treatment plants: a wastewater-based epidemiology approach. Trends in Sciences, 20(5), 6523-6523.
32. Saravanakumar, P., Gopalakrishnan, P., Sivakamidevi, M., & Archana, E. S. (2019). Domestic wastewater treatment using flyash as adsorbent. Int. J. Eng. Adv. Technol, 8, 1465-1468.
33. Sharma, M. K., Tyagi, V. K., Singh, N. K., Singh, S. P., & Kazmi, A. A. (2022). Sustainable technologies for on-site domestic wastewater treatment: a review with technical approach. Environment, Development and Sustainability, 1-52.
34. Shukla, R., Gupta, D., Singh, G., & Mishra, V. K. (2021). Performance of horizontal flow constructed wetland for secondary treatment of domestic wastewater in a remote tribal area of Central India. Sustainable Environment Research, 31, 1-10.
35. Sukmana, H., Rizwana, I., Dobozi, R., Al-Tayawi, A. N., Szabó, B. P., Özer, B., & Kertész, S. (2025). A review of various protein separation techniques and valorization of cheese whey and buttermilk. European Food Research and Technology, 251(12), 4263-4279.
36. Tandia, C. T. (2007). Contrôle et suivi de la qualité des eaux usées protocole de détermination des paramètres physicochimiques et bactériologiques (Control and Monitoring of Wastewater Quality Protocol for Determining Physical, Chemical and Bacteriological Parameters). Centre Régional Pour L'eau Potable Et L'assainissement A Faible Coût, Centre collaborant de l'OMS, Ouagadougou, Burkina Faso.
37. Water, U. N. (2017). Rapport mondial des Nations Unies sur la mise en valeur des ressources en eau 2017. Place de Fontenoy, 75352. Paris 07-SP.
38. Yahiaoui, K., Zoubeidi, A., Rouahna, N., & Ouakouak, A. (2018). Study of domestic wastewater treatment bymacrophyte plant in Arid Region of South-east Algeria (case of el oued region). Journal of Fundamental and Applied Sciences, 10(2).
39. Zawadzka, B., Siwiec, T., & Marzec, M. (2021). Effectiveness of dairy and domestic wastewater treatment and technological reliability of the wastewater treatment plant in michów, Poland. Journal of Ecological Engineering, 22(10), 141-151.
40. Zhang, J., Shao, Y., Liu, G., Qi, L., Wang, H., Xu, X., & Liu, S. (2021). Wastewater COD characterization: RBCOD and SBCOD characterization analysis methods. Scientific reports, 11(1), 691.