Egyptian Journal of Aquatic Biology & Fisheries
Zoology Department, Faculty of Science,
Ain Shams University, Cairo, Egypt.
ISSN 1110 – 6131
Vol. 28(4): 2223 – 2235 (2024)
www.ejabf.journals.ekb.eg

Physico-Chemical Assessment of the Surface Waters of Oued Seybouse-Annaba (North-East Algeria)

Naziha Amri[1]*, Saloua Nebbache[2], Fatiha Chalane[3], Sara Habbachi[1], Ibtissem Samai[4]

[1]Department of Biology, Faculty of Sciences, Applied Neuroendocrinology Laboratory. Badji Mokhtar University, Annaba, Algeria

[2]Department of Life and Natural Sciences. Faculty of Exact Sciences and Natural and Life Sciences. Research Laboratory for Bioactive Plant Molecules and Plant Improvement. Larbi Ben M'hidi University, Oum El Bouaghi, Algeria

[3]Department of Biology, Faculte of Sciences, Laboratory Research for Water Resources and Environment Dr. Moulay Tahar Saida University, Algeria

[4]Department of Biology, Faculty of Sciences, Laboratory Researches of Soil and Sustainable. Badji Mokhtar University, Annaba, Algeria

*Corresponding Author: naziha.amri@univ-annaba.dz

ARTICLE INFO

Article History:
Received: April 30, 2024
Accepted: Aug. 5, 2024
Online: Aug. 26, 2024

Keywords:
Pollution,
Oued Seybouse,
Discharges,
Physico-chemical analyses,
Environment

ABSTRACT

The Lower Seybouse Plain in northeastern Algeria is undergoing rapid and unregulated urban development, particularly in the industrial sector, resulting in asignificant environmental degradation. Thus, the current study aimed to assess the surface water quality of the Oued Seybouse (Annaba) and to investigate various water pollution parameters. In February 2023, three sampling points were examined in the Oued: Djoinou, Sidi Salem, and Bouhamra. The analysis focused on key physico-chemical parameters indicative of water pollution, including pH (hydrogen potential), electrical conductivity, biochemical oxygen demand (BOD_5), nitrates, nitrites, and chlorides. Increases were recorded in pH and electrical conductivity, along with elevated levels of nitrates, nitrites, and chlorides, as well as a rise in BOD_5, indicating the presence and biodegradability of organic matter in the wadi. These changes contribute to the contamination and rising pollution levels in the wadi, rendering the water increasingly unusable and in urgent need of biological, chemical, and physical treatment.

INTRODUCTION

Water is a natural resource that is essential for the survival of humans, animals, and plants. It is vital to life, making it both precious and indispensable, as life on Earth would not exist without it. Although water covers 71% of the Earth's surface, only a small fraction of the billions of gallons of water on our planet is fresh and usable by humans **(Moudallal, 1997; Samai *et al.*, 2022)**.

While this quantity is sufficient to meet humanity's future needs, the deterioration in water quality is making the proportion compatible with human use ever smaller

(Burek *et al.*, 2016). Water is second only to air in its importance for sustaining life on Earth. It exists in various forms, including surface water such as rivers, lakes, seas, and groundwater **(Jeng, 2007)**. As the source of life, water ensures the continuity of all species on our planet **(Jones *et al.*, 2021)**. It plays a crucial role in supporting productive human activities like agriculture, energy production, industry, sanitation, transport services, fisheries, and tourism **(UNEP, 2009)**. However, when polluted, water can become a source of disease **(Scalon *et al.*, 2005)**. Interestingly, paleontological data from studies on polar ice caps indicate that natural pollution has significantly increased over geological time at various levels. This offers hope for the potential restoration of initial conditions, which could benefit all ecosystem components on Earth, the only known living planet in the solar system **(Gaamoune, 2010)**.

Water pollution refers to the alteration of water's natural physical and chemical properties. It involves actions and processes that degrade water quality **(Zenati *et al.*, 2018)**. In recent years, global water quality has deteriorated significantly due to uncontrolled industrial discharges and the intensive use of chemical fertilizers in agriculture, which chemically alter water, rendering it unsuitable for various uses **(Rouabhia *et al.*, 2004; Rouabhia *et al.*, 2010)**. Numerous studies have investigated the diverse impacts of industrial and urban discharges on surface water quality and the contamination of continental aquatic ecosystems **(Walling *et al.*, 2001)**. The contamination of natural water sources by toxic pollutants poses a potential threat to future human activities **(Petrovic *et al.*, 2002)**.

Water is considered polluted when its quality no longer meets the standards for domestic, agricultural, or industrial use. Pollution of groundwater, rivers, or seas primarily results from urban, agricultural, and especially industrial discharges. Industry, which consumes a significant amount of water in the production process, is responsible for nearly half of all pollutant discharges in the natural environment **(Wear *et al.*, 2021)**. These discharges alter and sometimes destroy the nature of the receiving waters, leading to ecosystem imbalances, with potentially catastrophic and irreversible consequences for the environment **(Hafsi, 2017)**. Therefore, it is essential to address this issue by investing in wastewater treatment plants **(Raweh *et al.*, 2011)** to ensure public health protection. By discharging treated water into receiving environments under conditions that maintain or improve the quality of these environments, we can preserve the necessary biological balance and prevent or mitigate harmful effects reflecting on the environment and public health **(Derwich *et al.*, 2010)**.

Industrial pollution is a major concern in Algeria, as in all countries around the world, and particularly in the wilaya of Annaba, the subject of our study. In our study of surface water pollution in the Oued Seybouse, we assessed the physico-chemical parameters of these waters, by measuring physical parameters, such as pH and electrical conductivity and chemical parameters, such as nitrates, nitrites, chloride, ammonium and

BOD$_5$ biochemical demand. To hit this target, three samples were collected from the towns of Djoinou, Sidi Salem, and Bouhamra during February 2023.

MATERIALS AND METHODS

1. Site description

The Lower Seybouse Plain is located in northeastern Algeria, 600km east of Algiers, and belongs to the Annaba-Bouteldja aquifer system (Fig. 1).

Its natural limits are:

- To the north, the Mediterranean Sea;
- To the west, the Belelieta (287m) and Bouhamra (152m) massifs, which are separated from the main Edough massif (1008m);
- To the south, the eastern Numidian range (1411m);
- To the east, the eastern extension of the Annaba-Bouteldja aquifer system.

The geomorphology of the site is characterized by a flat topography over the entire plain, marked by significant inclinations at the edges of the plain, to the west and south, due to the anticline of the Edough, Belelieta metamorphic massif, and that of the Numidian chain **(Vila, 1980; Kerrouch & Chahlaoui, 2009)**.

This study region belongs to the Mediterranean climate, with rainy winters and dry summers, according to the Thomthwaite balance **(Chaoui *et al.*, 2013)**. The average annual precipitation is around 623.9mm, and the average temperature is 18.6 celsius.

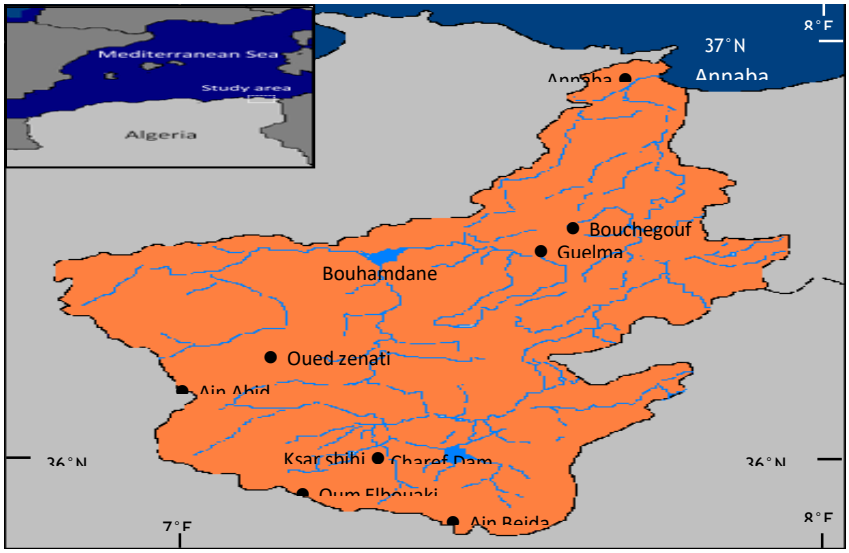

Fig. 1. Map of the Seybouse water shed showing the two dams built on Oued Charef and Oued Bouhamdane **(Aounallah *et al.*, 2022)**

2. Sampling and measurement of physico-chemical parameters

The experimental study consists of carrying out physico-chemical analyses of water from the Oued Seybouse, which flows through the city of Annaba. The water quality study comprises three stages: sampling, analysis, and interpretation.

In February 2023, sampling was conducted at the mouth of Oued Seybouse, which is one of the primary sources of continental input. The sampling points were selected based on the location of industrial zones. Additionally, we focused on the towns of Djoinou, Sidi Salem, and Bouhamra. Surface water samples were collected in three sterile bottles, which were rinsed three times with water, followed by examination to ensure they maintained the same water characteristics. The bottles were then filled to the brim with water to prevent any potential chemical reaction. After sealing, each bottle was carefully labeled and numbered with the date, contact details, and sampling number.

Before analysis, within 24 hours, the laboratory filtered, de-oiled, and acidified the samples with a few drops of nitric acid (HNO_3), and stored them at 4°C **(AFNOR, 1999)**, when necessary.

The measured parameters and their analysis methods implemented in the current study are detailed as follows:

- Hydrogen potential (pH) and conductivity (EC) were measured *in situ* using a portable multiparameter device in accordance with the respective protocols (ISO 10523:2008), (ISO 7888:1985), and (ISO 5814:2012).
- Biological oxygen demand (BOD_5) was determined using a BOD meter, following the guidelines of (ISO 5815-1:2003).
- Nitrates (NO_3^-) and nitrites (NO_2^-) were determined by a colorimetric assay using a spectrophotometer (UV/visible) in accordance with the protocols (ISO 7890-3:1988), (ISO 6777:1984), and (ISO 13395:1996).
- Chlorides (Cl^-) were measured by silver nitrate titration using chromate as an indicator (Mohr's method) according to the studies of **Rodier (2009)** and **Barour (2015)**.

3. Statistical analysis

All the results were analyzed using the statistical software Minitab version 10, using the Tukey test to analyze variance with a single classification criterion.

RESULTS AND DISCUSSION

Physico-chemical indicators of the water quality are often subject to spatiotemporal variations induced by anthropogenic activities that modify the characteristics of the water and affect its quality **(Kerrouch & Chahlaoui, 2009)**.

1. Hydrogen potential (pH)

Water pH measures the concentration of H^+ protons in water. It summarizes the stability of the equilibrium established between the different forms of carbonic acid and is linked to the buffer system developed by carbonates and bicarbonates **(El Blidi & Fekhaoui, 2000)**. The observed values indicate that the pH is slightly neutral to acidic in all Wadi Seybouse stations. This is due to the effect of acid discharges from factories, especially Fertial. The water is therefore polluted by acidic discharges (Fig. 2).

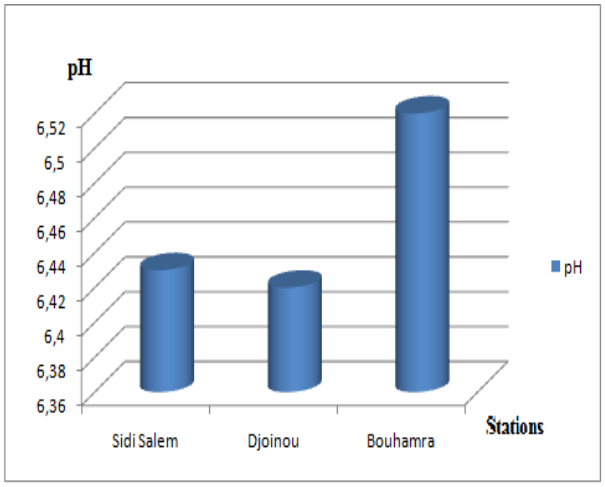

Fig. 2. Spatial variation of pH

2. Electrical conductivity (EC)

This parameter allows us to predict the state of chemical ions in water, as well as the direction of chemical reactions (oxidation or reduction). Conductivity measurement provides a good indication of the degree of mineralization of water, where each ion acts through its concentration and specific conductivity **(Rodier, 2009; Arouya, 2011)**. The average values recorded ranged from 2630 to 8100µS/ cm, showing variations in the excessive mineralization of the water in this wadi. This finding is ascribed to Fertial's industrial discharges (Fig. 3).

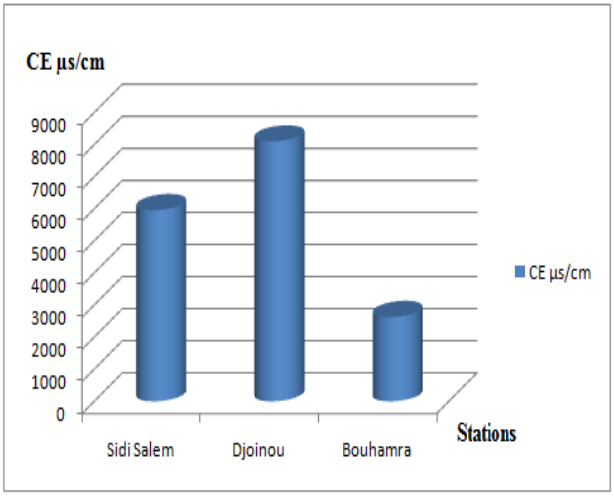

Fig. 3. Spatial variation of CE

3. Biochemical oxygen demand (*BOD_5*)

BOD_5 (biochemical oxygen demand) is the quantity of dissolved oxygen consumed by microorganisms in the dark at 20 Celsius for 5 days. It is used to assess biodegradable organic matter **(Makhoukh *et al.*, 2011)**. Fig. (4) shows an increase in the *BOD_5* content of Wadi Seybouse waters, with average *BOD_5* values ranging from 11.1 to 13.2mg/ l (Fig. 4). This increase is at its highest at the second station (Djoinou), where fertilizer inputs and domestic or industrial discharges are the main causes.

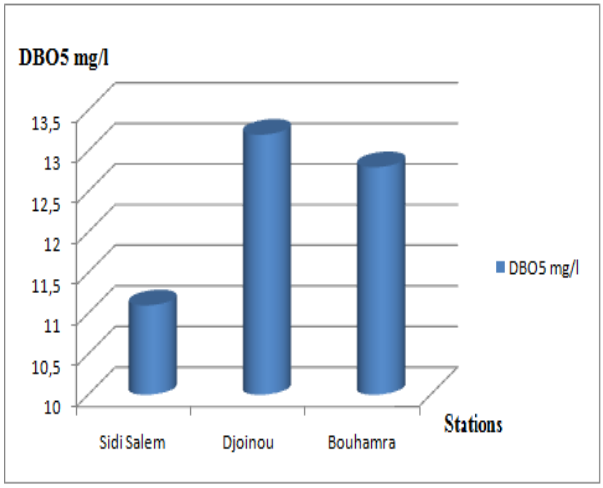

Fig. 4. Spatial variation of $\boldsymbol{BOD_5}$

4. Nitrates NO_3^-

Nitrates are the final stage in the oxidation of nitrogen and represent the most highly oxidized form of nitrogen present in water. Their concentrations in natural water range from 1 to 10mg/ l, while their levels in untreated wastewater are low **(Saadali *et al.*, 2015)**. The recorded values range from 39.17 to 59.1mg/ l (Fig. 5). The increase in nitrate levels in Oued Seybouse and its presence in surface waters are linked to the intensive use of fertilizers (chemical or organic). In a permeable watershed, diffuse discharges of agricultural origin are the primary cause **(Ruiz, 200)**.

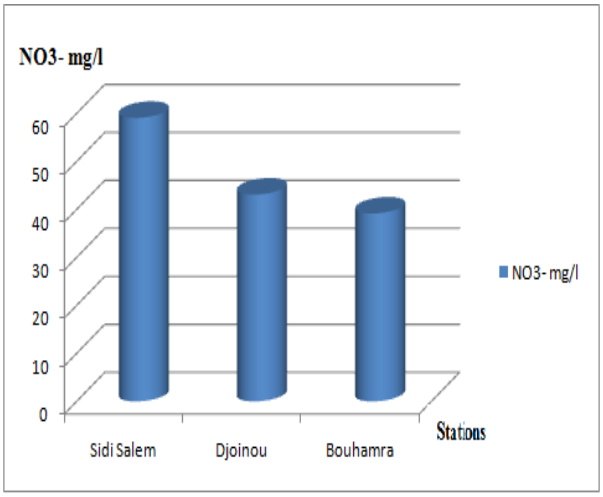

Fig. 5. Spatial variation of NO_3^-

5. Nitrites NO_2^-

Nitrites are considered a pollutant that is highly harmful to human and animal health (NO_2 levels become harmful when they exceed $0.5\ mg/l$) **(Seghir & Khérici, 2008)**. The results obtained show high nitrite levels, exceeding the standard $(0.5\ mg/l)$, which varies between $1.57\ mg/l$ and $1.91\ mg/l$ (Fig. 6). Therefore, it can be deduced that the waters of Wadi Seybouse are highly polluted with nitrites.

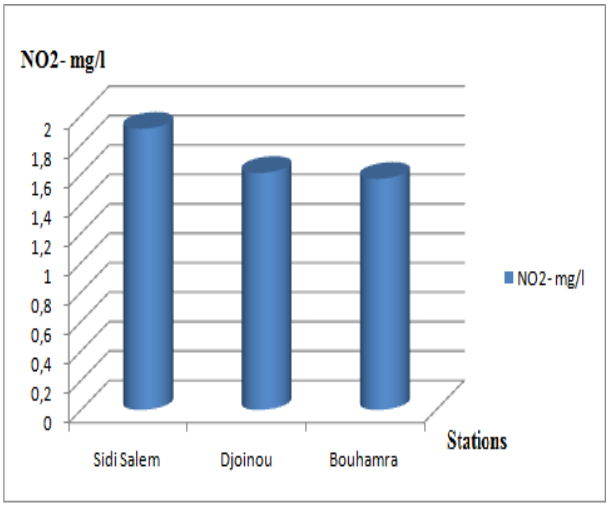

Fig. 6. Spatial variation of $\boldsymbol{NO_2^-}$

6. Chlorides (Cl^-)

Chlorides are important inorganic anions found in varying concentrations in natural waters, generally in the form of sodium $(NaCl)$ and potassium (KCl) salts. They are often used as an indicator of pollution. They influence the aquatic flora and fauna, as well as the plant growth **(Remi, 2010)**. Chloride ion concentrations in Oued Seybouse water ranged from $71.3\ mg/l$ to $81.9\ mg/l$ (Fig. 7), indicating that urban or industrial anthropogenic input is involved.

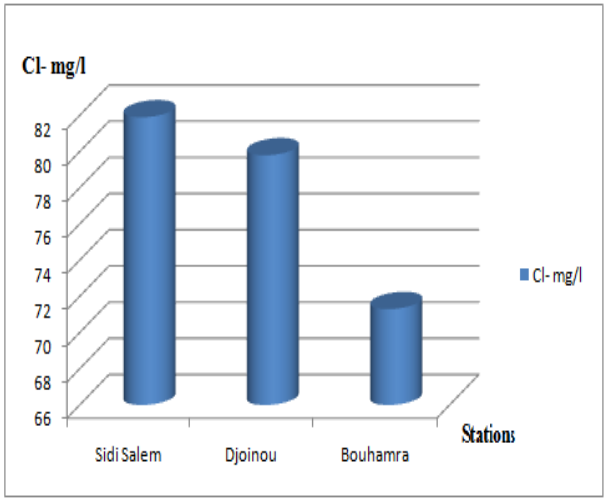

Fig. 7. Spatial variation of $\boldsymbol{Cl^-}$

7. Statistical analysis

7.1. Analysis of variance pH

Source	DL	SomCar adjust	CM adjust	Value of F	Value of *P*
Factor	1	89,468	89,4676	237,89	0,000
Error	16	6,017	0,3761		
Total	17	95,485			

7.2. Analysis of variance (CE ($\mu s/cm$).

Source	DL	SomCar adjust	CM adjust	Value of F	Value of *P*
Factor	1	129186738	129186738	46,03	0,000
Error	16	44901810	2806363		
Total	17	174088548			

7.3. Analysis of variance BOD_5 (mg/l)

Source	DL	SomCar adjust	CM adjust	Value of F	Value of *P*
Factor	1	480,50	480,500	578,92	0,000
Error	16	13,28	0,830		
Total	17	493,78			

7.4. Analysis of variance NO_3^- (mg/l).

Source	DL	SomCar adjust	CM adjust	Value of F	Value of *P*
Factor	1	9865,9	9865,91	261,52	0,000
Error	16	603,6	37,72		
Total	17	10469,5			

7.5. Analysis of variance NO_2^- (mg/l).

Source	DL	SomCar adjust	CM adjust	Value of F	Value of *P*
Factor	1	0,3961	0,3961	1,02	**0,327**
Error	16	6,1982	0,3874		
Total	17	6,5942			

7.6. Analysis of variance Cl^- (mg/l).

Source	DL	SomCar adjust	CM adjust	Value of F	Value of *P*
Factor	1	25741,8	25741,8	2125,01	0,000
Error	16	193,8	12,1		
Total	17	25935,6			

The single-criterion analysis of variance for the classification of physico-chemical water parameters for the three selected stations in Oued Seybouse showed a highly significant difference for pH, CE, BOD_5, NO_3^-, and Cl^-, $p = 0.000$. However, we did not detect any difference, with $p = 0.327$ for NO_2^-, between the different stations in Oued Seybouse.

CONCLUSION

The present study aimed to determine the degree of pollution in the Oued Seybouse (Annaba, Algeria), a major watercourse in northeastern Algeria. For this purpose, we conducted physico-chemical analyses of the Oued's surface waters.

The various physico-chemical parameters measured in February 2023 indicated a slightly acidic pH at Bouhamra and a basic pH at Djoinou and Sidi Salem, with high electrical conductivity, and a slight increase in biochemical oxygen demand (BOD_5). Our results also showed that the Oued Seybouse is highly charged with chloride, nitrate, and nitrite ions. A deterioration was observed in the surface water quality of the Oued Seybouse, particularly at stations subject to wastewater discharges from settlements in the Annaba Wilaya and its proximity to the industrial zone (Fertial). Consequently, these waters cannot be used for market gardening or irrigation as currently practiced. It is advisable to halt the direct discharge of urban and industrial effluents into the wadi by treating them before reaching the wadi and to continuously monitor the water quality.

To combat pollution, it is imperative to implement appropriate biological, chemical, and physical treatments for all discharges and to install wastewater treatment plants.

For a more comprehensive study, it would be advisable to:

- Extend the monitoring period.
- Sample additional sites.
- Measure other physical parameters, such as turbidity, color, and alkalinity.
- Include additional chemical measurements, such as dissolved oxygen (DO), suspended solids (SS), ammonia (NH_3), redox potential (ORP), phosphorus (P), and potassium (K).

REFERENCES

AFNOR. (1999). Water Quality, volumes 1–4, 6th edition. Paris, France. 2500p.

Aounallah, O.; Samai, I.; Nebbache, N.; Meghlaoui, Z. and Diaf, W. (2022) Evaluation of the physico-chemical characteristics of the waters of Oued Seybouse at the coast of Annaba (North-East Algeria). Asia Life Science., 12 (11): 1581-1595.

Arouya, K. (2011). Water pollution: impact of wastewater on the quality of surface water. European University Editions, Germany. 124 Pp.

Barour, A.B.E. (2015). Characterization of water and soil in the upper Medjerda valley. Doctoral thesis in science. Option: Plant Biology. Badji Mokhtar University, Annaba, Algeria.

Burek, P.; Satoh, Y.; Fischer, G.; Kahil, M.; Scherzer, A.; Tramberend, S.; Nava, L. F.; Wada, Y.; Eisner, S.; Flörke, M.; Hanasaki, N.; Magnuszewski, P.; Cosgrove, B. and Wiberg, D. (2016). Water Futures and Solution - Fast Track Initiative (Final Report). Environmental Science.

Chaoui, W.; Bousnoubra, H.; Benhamza, M. and Bouchami, T. (2013). Study of the water pollution of the Seybouse and Mellah wadis (Eastern Algerian Region), Rev. Sci. Technol., Synthese., 26 (1): 50-56.

Derwich, E.; Benaabidate, L.; Zian, A.; Sadki, O. and Belghity, D. (2010). Physico-chemical characterization of the waters of Haut Sebou's alluvial aquifer downstream of its confluence with Oued Fes. Larhyss Journal., 8 (1): 101-12.

El Blidi, S. and Fekhaoui, M. (2000). Hydrology and tide gauge dynamics of the Sebou estuary (Gharb, Morocco). Bull. Inst. Sci., 25 (1): 57-65.

Gaamoune, S. (2010). The role of algal biofilms in biological water treatments. Master's thesis in plant biology, University: Farhat Habbes, Sétif. Option: Valorization of plant resources.

Jeng, H. (2007). Encyclopedia of Cancer and Society. Ed. Graham Colditz.Los Angeles:Sage Publications Inc., 2: 695-697.

Jones, E.R.; Van Vliet, M. T.; Qadir, M. and Bierkens, M.F. (2021). Country-level and gridded estimates of wastewater production, collection, treatment and reuse. Earth System Science Data., 13(2): 237-254.

Hafsi, R. (2017). Contribution to the Study of Pollutant Flows in Hydro-Systems. Doctoral thesis. Kasdi Merbah University, Ouargla. 135 Pp.

Kerrouch, L. and Chahlaoui, A. (2009). Biomate*c* Echo., 03(6): 6-17.

Makhoukh, M.; Sbaa, M.; Berrahou, A. and Van. Clooster, M. (2011). Contribution to the physico-chemical study of the surface waters of the Moulouya wadi (eastern Morocco), Larhyss Journal., 9(12): 149–169.

Moudallal, S. (1997). Hydraulic resources in Lebanon. 1st ed., Dar El Fekr El Arabi (editor), Beirut, Lebanon, 62 pp.

Petrovic, M.; Solé, M.; López De Alda, M. J. and Barceló, D. (2002). Endocrine disruptors in sewage treatment plants, receiving river waters, and sediments: Integration of chemical analysis and biological effects on feral carp. Environmental Toxicology and Chemistry., 21(10) : 2146-2156.

Raweh, S.; Belghyti, D.; Al-Zaemey A.; El Guamri, Y. and Elkharrim, K. (2011). Qualphysico-chemical wastewater from the wastewater treatment plant in the city of S'anaa (Yemen). International Journal of Biological and Chemical Sciences, 12 (1), 1–10.

Remi, B. (2010). The water problem in Algeria. Larhyss Journal., 08 (1): 27-46.

Rodier, J. (2009). Water analysis: natural water, waste water, and sea water. 9th edition, Dunod Paris, 1573 Pp.

Rouabhia, A.; Baali, F.; Kherici, N. and Djabri, L. (2004). Drought., 15 (1): 47-52.

Rouabhia, A.E.K. and Djabri, L. (2010). Larhyss Journal., 08 (1): 55-67.

Ruiz, L. (2000). Transfers and transformations of nitrogen in watersheds: from leachable nitrogen to nitrate in rivers and groundwater. Rennes I.N.R.A. France, 150-151Pp.

Saadali, B.; Derradji, E.F.; Saboua, T.; Remita, R. and Zahi, F. (2015). Impact of the anthropogenic activity on the degradation of the environment and water's quality: El Kala National Park (North East of Algeria). Rev. Sci. Technol., Synthèse., 30: 66-75.

Samai, I.; Chouba, I.; Nebbache, S.; Amri, N. and Ksentini, H. (2022). Study of groundwater chemistry in the Lower Valley of Oued Bounamoussa (El Tarf- Algeria). Eco. Env. & Cons., 28 (1) :445-450.

Scalon, B.R.; Reedy, R.C.; Stonestrom, D.A.; Prudic, D.D.D.E.; Dennhy, K.F. (2005). Impact of land use and land cover change on groundwater recharge and quality in the South westernUS. Global Biol., 11: 1577-1593.

Seghir, K. and Khérici, N. (2008). Contribution to the Study of the Origin of Salinity in Alluvial Aquifer System in the Ain chabro-Hammamet (North-East ALGERIA). American Journal of Environmental Sciences., 4 (6): 708-716.

UNEP. (2009). Water Security and Ecosystem Services. The Critical Connection. A Contribution to the United Nations World Water Assessment Program (WWAP). Country done this study (Unit Nation Environmental Program (UNEP).

Walling, D.E.; Russell, M.A. and Webb, B.W. (2001). The Science of the Total Environment., 266 (1): 113- 123.

Vila, J.M. (1980). The Alpine chain of eastern Algeria and the Algerian-Tunisian borders, doctoral thesis, Pierre and Marie-Curie University Paris VI, 282-296 Pp.

Wear, S. L.; Acuña, V.; McDonald, R. and Font, C. (2021). Sewage pollution, declining ecosystem health, and cross-sector collaboration. Biological Conservation., 255(1): 109010.

Zenati, N.; Belhacene, N.; Rezak, A.; Zeghadnia, L.; Messadi, D. and Belkadi, D. (2018). Origin of the degradation of water quality in Oued Medjerda downstream. Souk Ahras region. International Journal of Environment and Water., 7 (2): 62-72.