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Water pollution of the Oued D'Hous River (Algeria) and its potential impact on fauna and flora

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Abstract Water plays a crucial role in all aspects of our lives, including the economy, food security, production, and politics, making it essential for sustainable development. Surface water pollution, which includes rivers, lakes, and oceans, is a significant environmental concern. Oued D'Hous, located in the Wilaya of Bouira in Algeria, is the subject of our research, which examines its hydrochemical pollution resulting from the discharge of domestic, industrial, and agricultural wastewater from the city. The evaluation of the physicochemical parameters reveals that the existing pollutant levels in Oued D'Hous have significantly increased, leading to a high degree of toxicity that threatens the area's flora and fauna. This pollution also limits the use of this resource by humans. We call upon the competent authorities to promptly limit the discharge of these hazardous effluents into Oued D'Hous to prevent further water contamination and reduce the risk of adverse health effects on the public, including those who use the wells located in the vicinity. In conclusion, immediate measures are necessary to mitigate the severe pollution of Oued D'Hous, and we urge the authorities to take action to address this pressing environmental concern.

Keywords: contamination, effluents, environment, pollutants, toxicity

1. Introduction

Water is an indispensable resource that sustains all living organisms, irrespective of their size, complexity, or habitat. It is a key factor in promoting the three pillars of sustainable development: the economy, social issues, and the environment. Therefore, water policies must prioritise meeting the needs of current and future generations from both an economic and broader human development perspective (Papaioannoua et al 2007).

Maintaining and improving water quality is particularly challenging in heavily urbanised areas, especially in developing countries. Pollution control at the source is often impractical, and waste collection and disposal systems are typically inadequate (Jain et al 2005). Waterborne diseases, which are primarily caused by animal or human waste, pose severe consequences, particularly in urban poor and developing regions. These diseases frequently spread via sewage and contaminate water sources, resulting in health hazards (Fischer 2000).

Point source pollution is mainly caused by untreated discharges and is commonly linked to industries, cities, farms, or livestock operations that emit various toxic chemicals harmful to wildlife and humans. Such pollution sources are identifiable and easier to control, but accidents can occur that cause sudden contamination, disrupting the river's ecosystem for a brief period. Accidents may result from a factory's altered production or the release of toxic waste (Arrignon 1998). Bravard and Petts (1993) argue that while catastrophic events can have severe consequences, less severe but frequent accidents can cause more significant long-term impacts, and it is essential to address such incidents.

Human activities significantly influence rivers and streams, although the severity and frequency of their effects vary regionally. According to Resh et al (1988), sewage, industrial effluents, deforestation, and dam construction are the most damaging activities to streams. In contrast, anthropisation, such as intensive agriculture or organic pollution, can lead to permanent changes in biotic communities. Environmental services, defined as an ecosystem's potential for human use, are significantly impacted by water quality degradation, thereby reducing their value to society (Walmsley 2002). For example, the services provided by rivers include hydrological cycles, water storage and conservation, self-purification, habitat for biodiversity, food production, recreation areas, and other cultural and non-commercial uses (Neal et al 2000).

Against this backdrop, our research aims to study the hydrochemical pollution of Oued D'Hous in the Wilaya of Bouira (Algeria), which receives domestic, industrial, and agricultural wastewater. We seek to assess the pollution's degree and intensity and its impact on living beings and the environment. Our study intends to highlight the urgency of the situation and urge the competent authorities to address

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the issue before the risk of water contamination in the surrounding wells escalates, endangering public health.

2. Material and Methods

The Oued D'Hous watershed is situated in the southeast of Algiers, specifically in the Wilaya of Bouira, between 36.344476° and 36.362603° N longitude and 30° and 60°45' E latitude (Figure 1). The basin covers an area of 842.5 km^2 and has an average altitude of 764.8 m (Hadjout and Benkhalata 1997; Khattab and Chemmam 2017).

The watershed of Oued D'Hous is bounded to the north by the Djurdjura massif, to the south by the Bibans mounts in Sour EL Ghouzlan, to the west by Cretaceous para-autochthonous hill formations, and to the east by the plateau of Bled El Madjen. The basin outlet (1501) flows into the Chemas dam (El Asnam) with Lambert coordinates X=626.380, Y=340.580, and Z=740 m (Hadjout and Benkhalata 1997; Khattab and Chemmam 2017).

2.1. Collection of water samples

Targeted sampling was employed to obtain water samples, which means that samples were collected from locations where contamination by pollutants is suspected (Mddepq 2008). Consequently, three monitoring points were established for monitoring the water quality of Oued D'Hous: one upstream (S1), one in the center (S2), and one downstream (S3) of the Oued. These points provide us with information on the quality of water and its discharge along the Oued D'Hous. To minimise the possibility of contamination (Zegaoula and Khellaf 2014), great care was taken to maintain the sampling and handling locations clean.

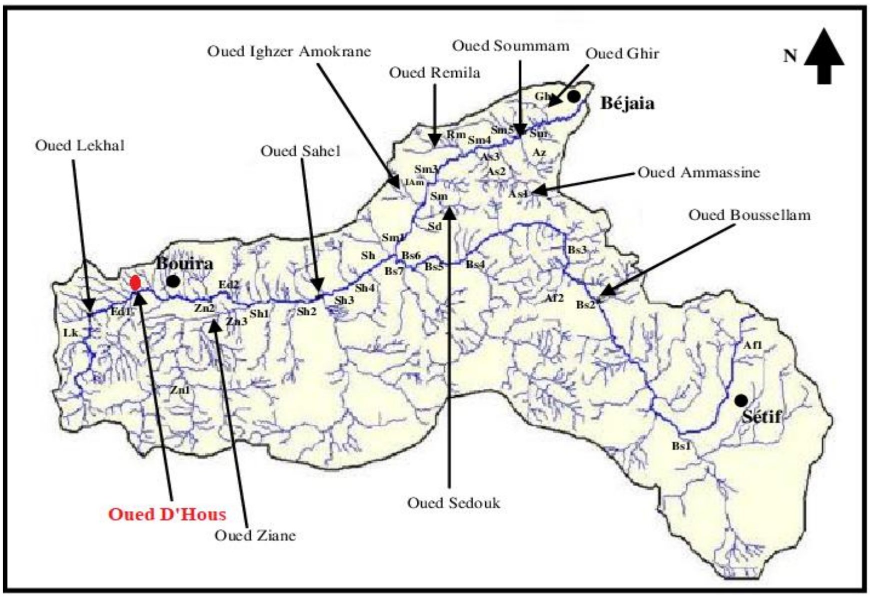

Figure1 Presentation of the study area.

The water sample collection campaigns were carried out from January 2021 to December 2021 (monthly sampling), and the sampling followed the standards for filtration (using a filter with a pore size of 0.45 µm), acidification (using 5 ml of HCl or HNO_{-3}), and preservation (at 4°C) (AFNOR 1986).

The physicochemical parameters of water samples were obtained through the following methods. Temperature (T °C) was measured using a field mercury thermometer left in the stream for five minutes. Hydrogen potential (pH) was measured using a pH meter. Electrical conductivity (EC) was measured using a conductivity meter. Dissolved oxygen (DO) was measured using the Winkler titration method. Biochemical oxygen demand (BOD_5) was measured using a BOD meter. Nitrate (NO_{-2}) was analysed using the colourimetric method (Rodier et al 1984). Nitrite (NO_{-3}) was analysed using the colourimetric method (AFNOR 1986). Chlorides (CL^-) and sodium (Na) were analysed using the volumetric method (AFNOR 1997). Ammonium (NH^+_4) was analysed using the colourimetric method (Rodier et al 1984). Suspended solids (SS) were determined by filtering a volume of water on a 0.45 µm cellulose filter, according to Rodier et al (1984). Fatty oils were extracted at pH 5 using a roller extractor with special decanting bulbs, according to Visvanathan (1996). Turbidity (TURB) was measured using a turbidimeter, with measurements given directly in Nephelometry Turbidity Unit (NTU) according to AFNOR (1997).

2.2. Statistical analysis

For this study, a total of six water samples were collected each month, taken at random from three points along the Oued D'Hous at the beginning, middle, and end of the month. The samples were then analysed for various physicochemical parameters. The results were analysed using Analysis of Variance (ANOVA) to determine if there were any significant differences between the different sampling points. The Tukey test was used as a post hoc analysis to investigate further any differences found. All statistical analyses were performed using the MINITAB 18 software.

3. Results and Discussion

3.1. Temperature (T °C)

The water temperature (Figure 2) indicates the amount of heat contained in a volume of water, not the heat intensity. The river's temperature is influenced by local factors such as topography, regional climate, sunshine duration, flow rate, and depth (McNeely et al 1980) and by hot discharges from power plants or factories that use water for cooling. This study's temperature peaked in August, which could impact the Oued's flora and fauna.

3.2 Hydrogen potential (pH)

The pH (Figure 3) is a chemical parameter that indicates the acidity or basicity of a substance. It results from the ionic composition of water and the presence of carbonates resulting from the exchange of carbon dioxide (CO_2) at the air-water interface and the dissolution of limestone (Aminot and Kérouel 2004). The pH of the study area is alkaline, especially in January, which could affect the organisms' functioning in this watercourse (both fauna and flora).

3.3. Electrical Conductivity (E.C.)

Electrical conductivity is a measure of the ability of an aqueous solution to conduct an electric current and is indicative of its overall mineral content. Soft water has low conductivity, whereas hard water has high conductivity (Brémaude et al 2006). As shown in Figure 4, the electrical conductivity of the river is consistently high throughout the year, indicating high salinity levels that can have negative impacts on the river's fauna and flora.

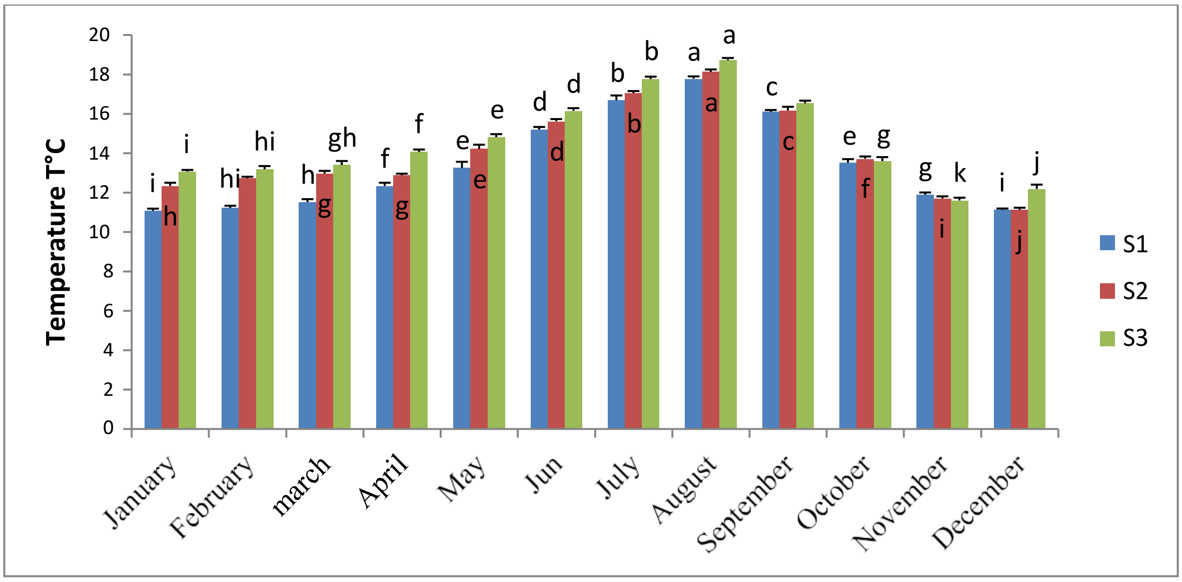

Figure 2 Temperature variation (mean±SD) for 12 months. Means that do not share the same letter are different ($P < 0.05$).

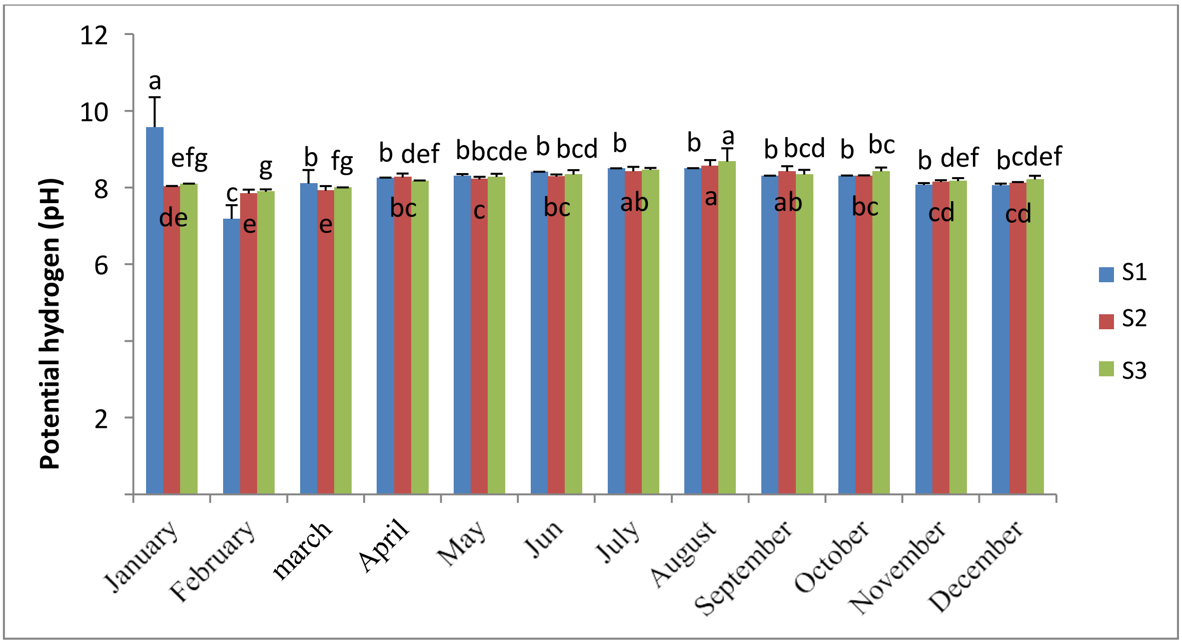

Figure 3 Potential hydrogen variation (mean±SD) for 12 months. Means that do not share the same letter are different ($P < 0.05$).

3.4. Dissolved Oxygen (DO)

Oxygen is one of the most important parameters for assessing water quality, and its concentration is an excellent indicator of the degree of pollution in water (Figure 5). It is one of the most sensitive pollution indicators and provides information on the degree of self-purification of a watercourse. The concentration of dissolved oxygen (DO) in water is an essential factor influencing most chemical and biological processes in aquatic environments (Rodier et al 1984; Brahimi and Chafi 2014). The concentration of dissolved oxygen in the Oued is high, which may negatively impact its fauna and flora.

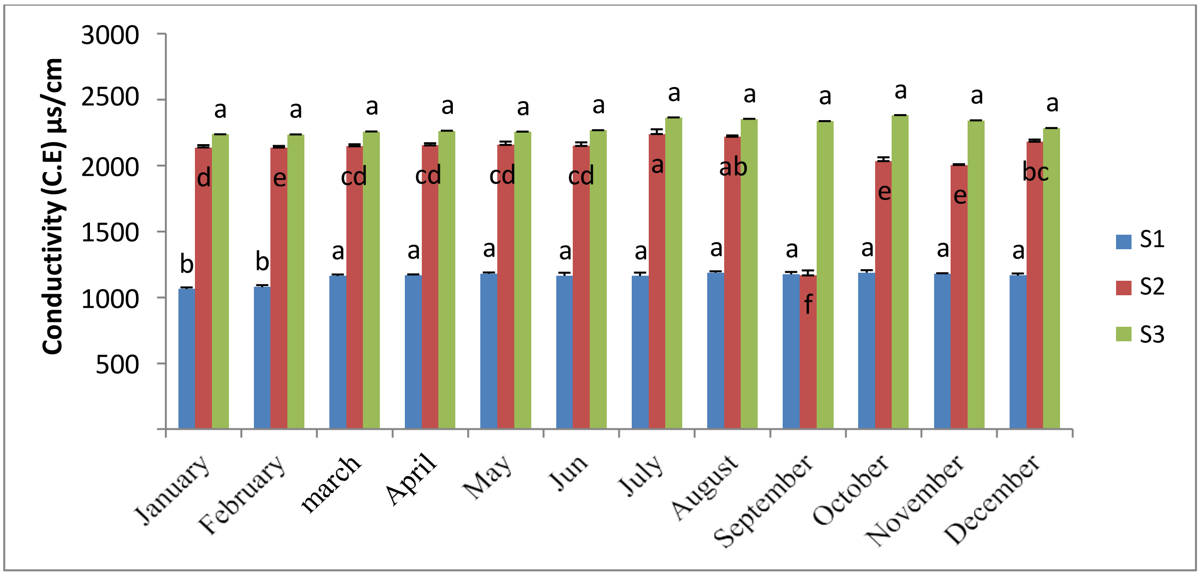

Figure 4 Conductivity variation (mean±SD) for 12 months. Means that do not share the same letter are different (*P* < 0.05).

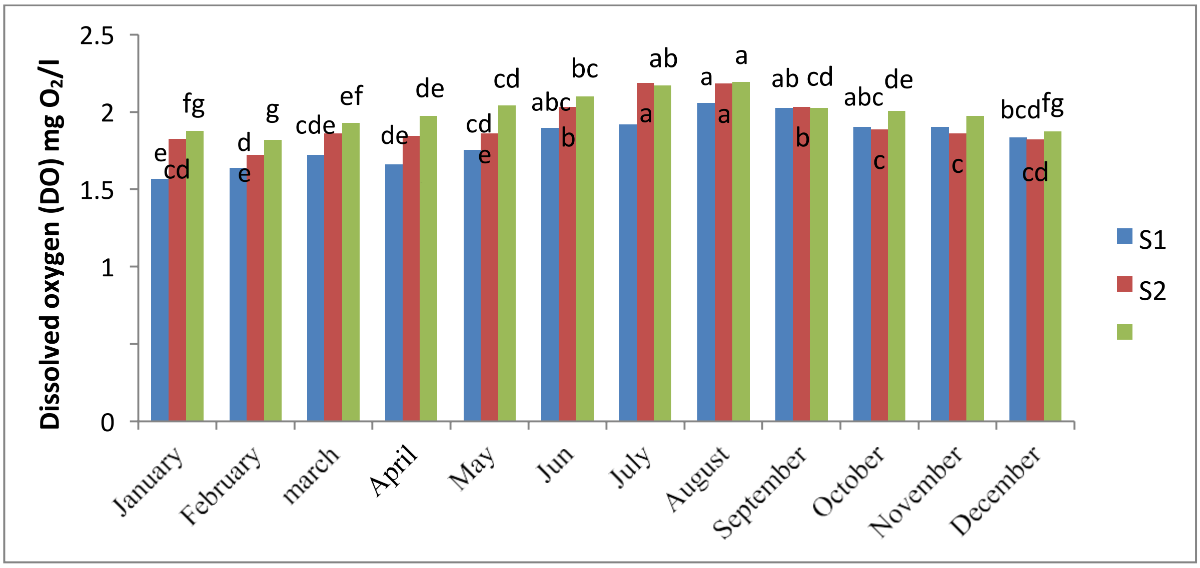

Figure 5 Dissolved oxygen (mean±SD) for 12 months. Means that do not share the same letter are different (*P* < 0.05).

3.5. Biochemical Oxygen Demand (BOD_5)

Biochemical Oxygen Demand (BOD) is the amount of oxygen required to degrade biodegradable organic matter in water using microorganisms over a period of five days at 20 °C. This is commonly referred to as BOD_5 and is frequently used to monitor urban effluents. It is expressed in mg O_2/l (Salghi 2015). As illustrated in Figure 6, the BOD_5 levels in the Oued remain high throughout the year, which may interfere with the role of microorganisms in the degradation of organic matter.

3.6. Nitrate (NO^-_3)

Nitrate occurs naturally in nature at concentrations of a few milligrams per liter of water because nitrate is a highly soluble pollutant and is the most oxidised form of nitrogen (Salamon, 2003). The values recorded were between 41 mg/l and 52 mg/l (Figure 7). The increase in nitrate levels in the waters of Oued D'Hous and its presence in surface waters are related to the intensive use of fertilisers (chemical or organic) (Chapman and Kimstach, 1996; Lgourna et al., 2014). Diffuse discharges of agricultural origin on a permeable watershed are mostly involved (Ruiz, 2000). Moreover, in this situation, the increase in nitrates is due to the excessive use of fertilisers and agricultural products in the plain that is located just near the Oued d'Hous (the cultivated plains that are located near this Oued). The high rate of nitrate destroys the fauna and flora of this Oued.

3.7. Nitrite (NO^-_2)

Nitrite (Figure 8) is a byproduct of the degradation of plant and animal waste in an aqueous environment, and its presence in water is often linked to a malfunction of the nitrogen cycle. Nitrite is highly toxic and quickly and naturally oxidises to nitrate ions (Melquiot 2003). High nitrite levels harm human and animal health, with NO^-_2 levels becoming harmful when exceeding 0.5 mg/l (Fekhaoui 1990). This oued is heavily loaded with nitrites, and this pollution poses a threat to the fauna and flora of the river.

3.8. Chloride (CL^-) and Sodium (Na^+)

The origin of these elements is mainly related to the dissolution of salt formations and the effect of marine salinity. The following equation can represent the dissolution of salt minerals: $NaCl = Na^+ + Cl^-$, as shown in Figures 9 and 10 (Debieche 2002).

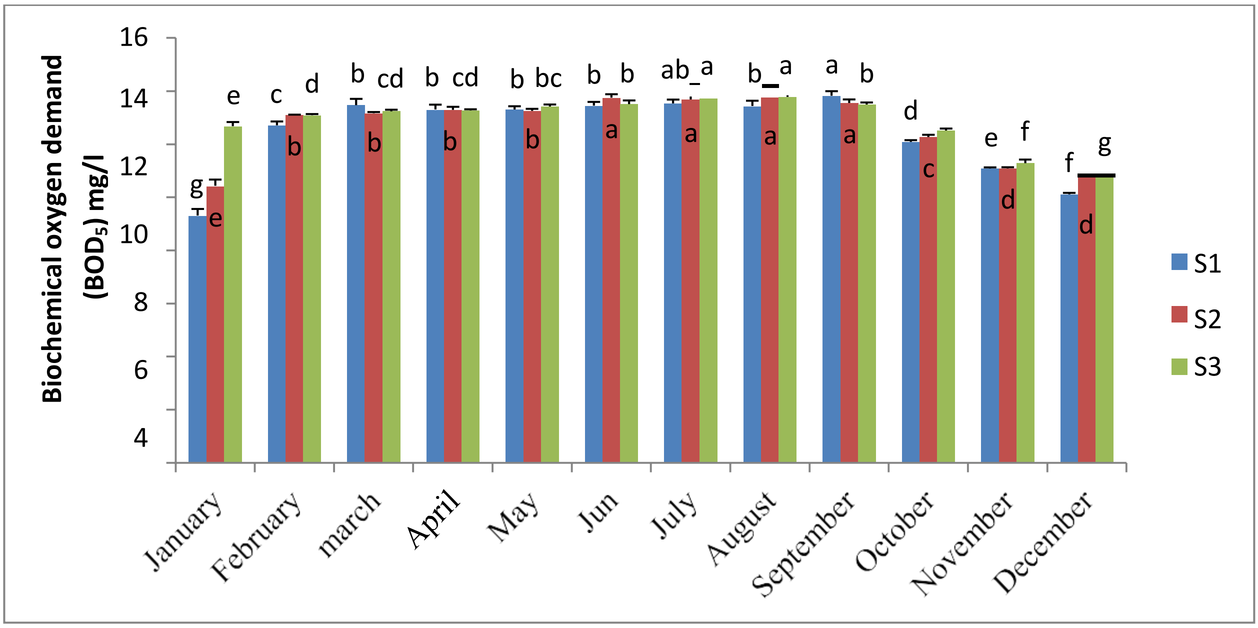

Figure 6 Biochemical oxygen demand variation (mean±SD) for 12 months. Means that do not share the same letter are different (*P* < 0.05).

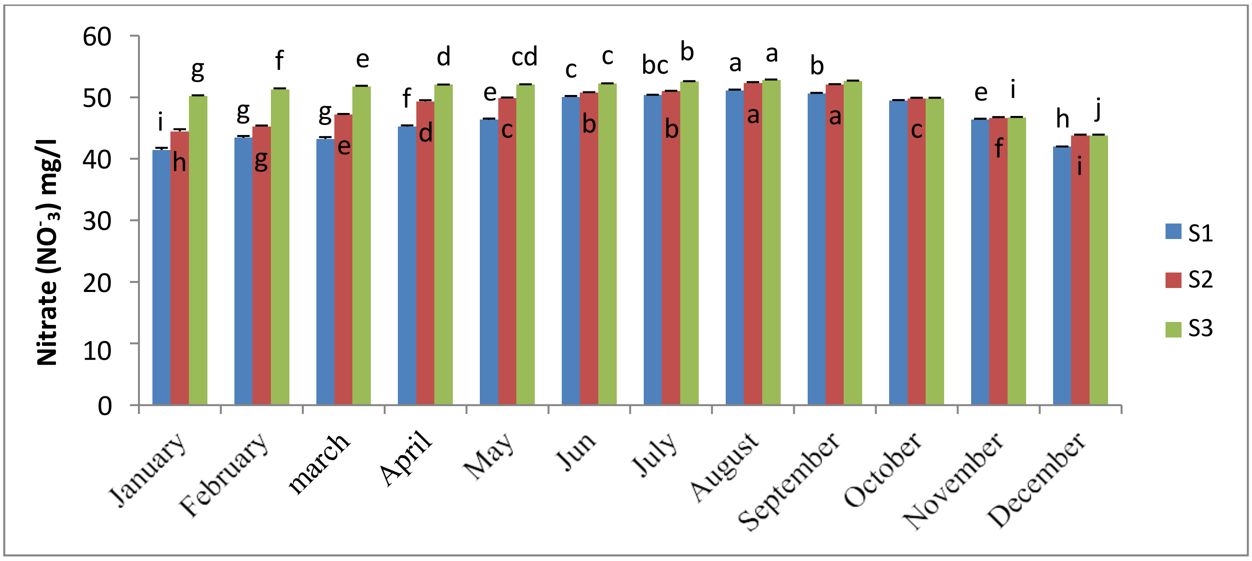

Figure 7 Nitrate (mean±SD) for 12 months. Means that do not share the same letter are different (*P* < 0.05).

3.9. Ammonium (NH^+_4)

The ammonium ion corresponds to the reduced form of nitrogen and is associated with the organic nitrogen characteristic of wastewater. It does not significantly affect human health as it is not in the toxic ionised form (NH^+_4). For aquatic organisms, ammonia is the most toxic form, and the balance between NH^+_4 and NH_3 depends on the water's pH, temperature, and oxygen levels. However, the presence of NH_3 in water is a sign of pollution (Debieche, 2002). As shown in Figure 11, Oued is heavily polluted with ammonium, adversely impacting the river's fauna and flora.

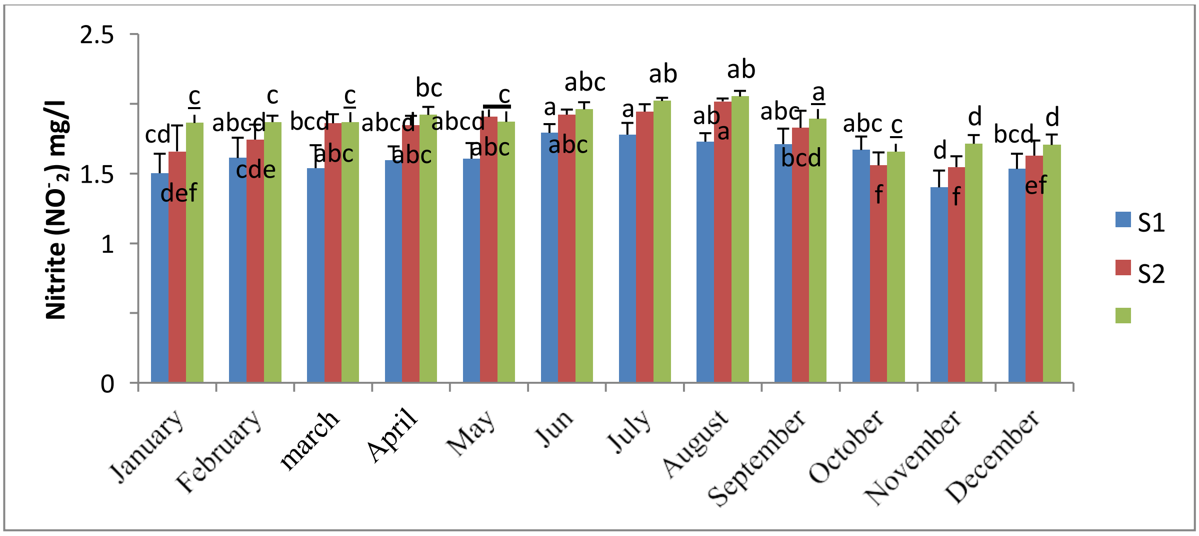

Figure 8 Nitrite (mean±SD) for 12 months. Means that do not share the same letter are different ($P < 0.05$).

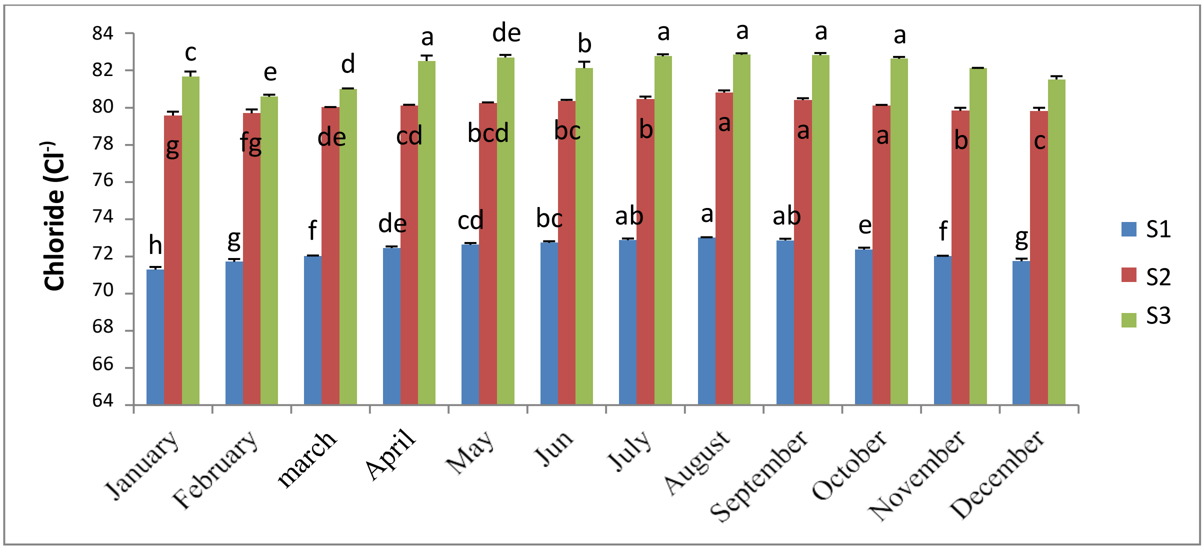

Figure 9 Chloride (mean±SD) for 12 months. Means that do not share the same letter are different ($P < 0.05$).

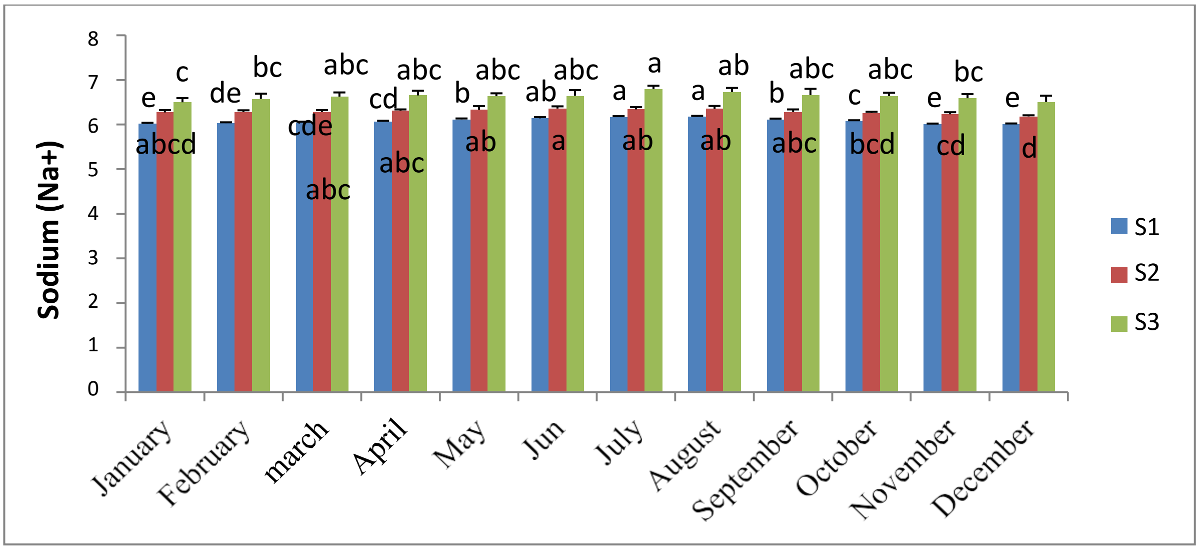

Figure 10 Sodium (mean±SD) for 12 months. Means that do not share the same letter are different ($P < 0.05$).

3.10. Suspended Solids (SS)

Suspended solids represent all the mineral and organic particles contained in water. They depend on various factors, such as the nature of the land, season, rainfall, water flow regime, and discharges (Rodier et al 1984). High levels of suspended solids can be considered a form of pollution and can also lead to water warming, reducing the habitat quality for cold-water organisms (Galvez-Cloutier et al 2009). TSS values in the three sites vary between 95 mg/l and 107 mg/l in Figure 12, exceeding the 20 mg/l norms (Légaré and Hébert 2000). The intensive agricultural and livestock activities on the outskirts of the Oued could explain the high concentrations in water. The presence of TSS in the discharges can significantly compromise the functioning of the sewerage system and cause nuisances such as sludge deposits and clogging of the receiving aquatic bottoms (Official Newspaper 2006). This Oued has a high rate of SS, and this enormous pollution can cause mortality in the fauna and flora of this river.

3.11. Turbidity (TURB)

Turbidity is a characteristic that expresses the degree of "cloudiness" of a liquid, opposite to transparency (Hazourli et al 2007). It is caused by the presence of suspended matter or substances in solution, such as mineral substances (sand, clay, or silt), organic matter (dead organic matter or decaying plants, suspended plankton), or other microscopic matter that obstructs the passage of light in water (Hazourli et al 2007; Rodier 1996). Turbidity is variable during all seasons, as shown in Figure 13, and it disturbs all the existing microorganisms.

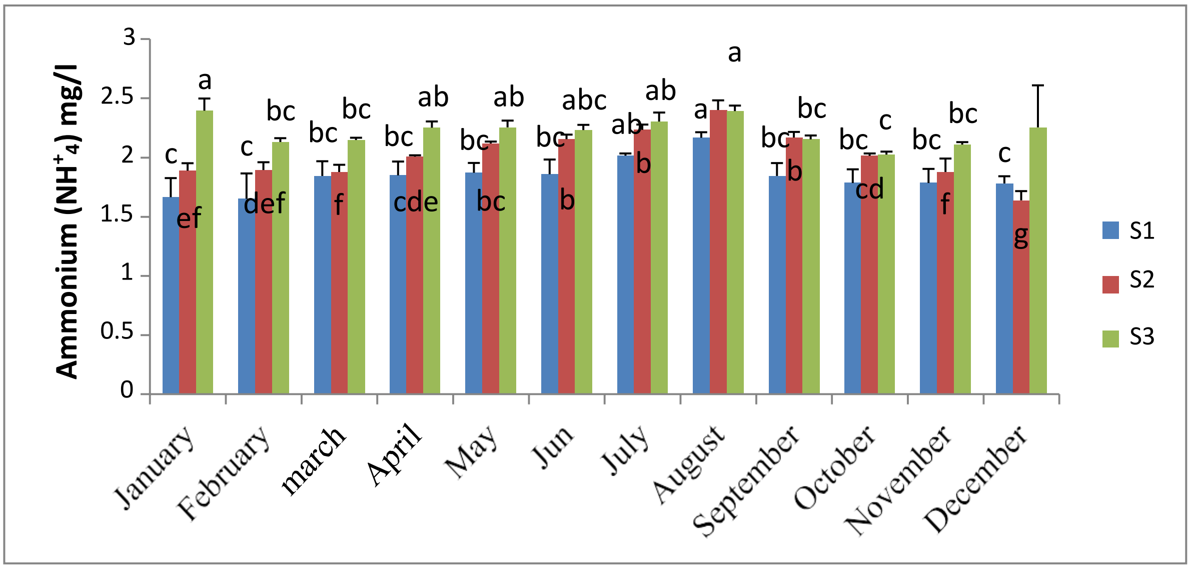

Figure 11 Ammonium (mean±SD) for 12 months. Means that do not share the same letter are different (*P* < 0.05).

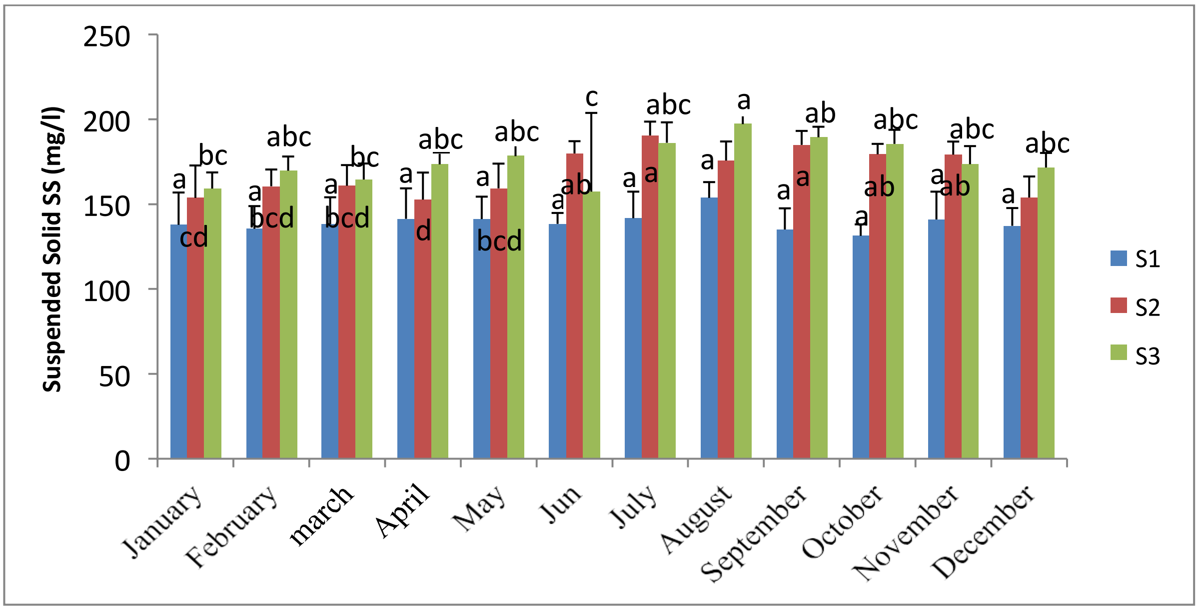

Figure 12 Suspended solid (mean±SD) for 12 months. Means that do not share the same letter are different (*P* < 0.05).

3.12. Fatty Oils

Oils and greases from pumping and compression equipment can contaminate liquid effluents generated downstream of mineral fertiliser manufacturing processes. A regular analysis is necessary before discharging wastewater into the natural environment (AFNOR 1986). The values of fatty oils varied between 90 mg/l and 118 mg/l in Figure 14 along the Oued, exceeding the standard of 40 mg/l (Official Newspaper 2006). This is due to industrial discharges from various factories, such as the detergent factory and the cement factory in Sour El Ghozlan (Algeria). Figure 14 shows significant pollution by fatty oils, which can lead to poisoning and even mortality of the fauna and flora in this Oued.

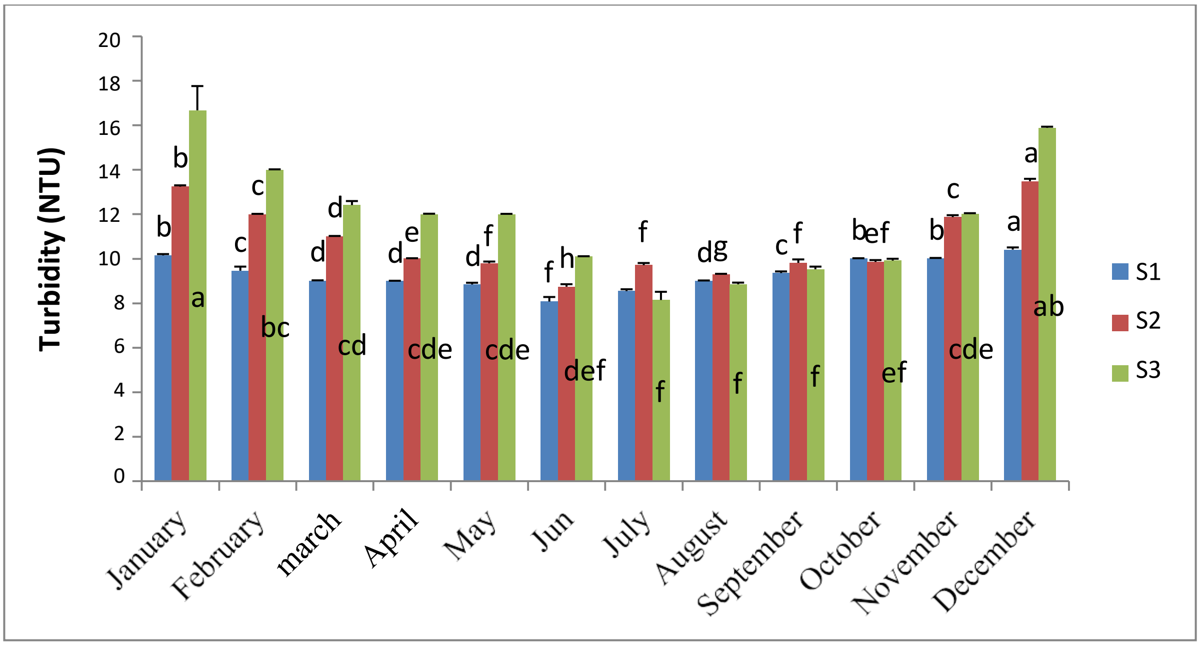

Figure 13 Turbidity (mean±SD) for 12 months. Means that do not share the same letter are different ($P < 0.05$).

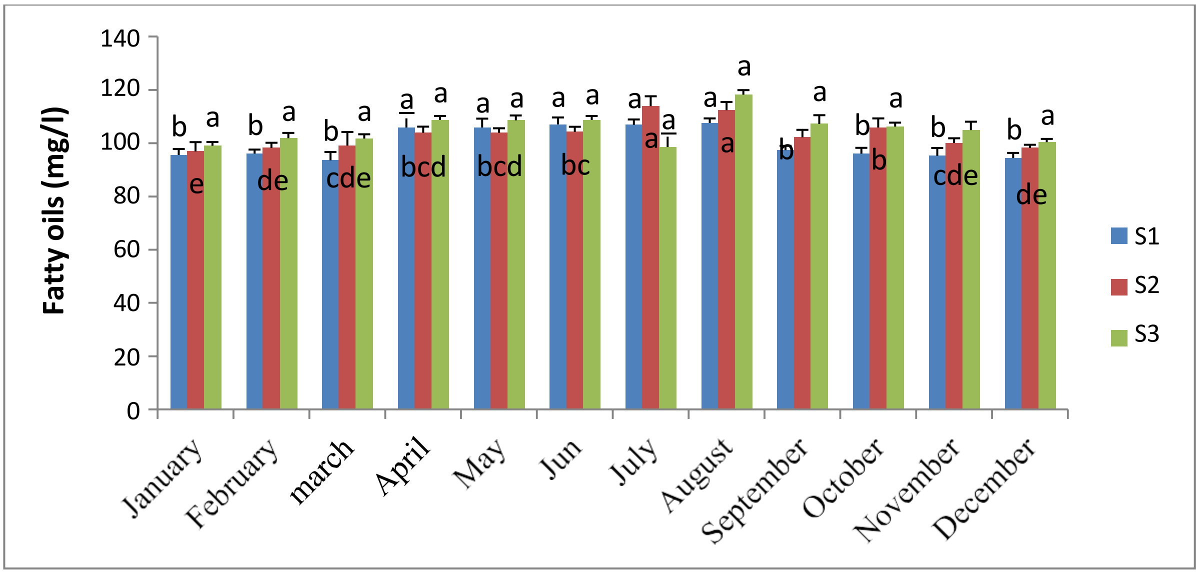

Figure 14 Fatty oils (mean±SD) for 12 months. Means that do not share the same letter are different ($P < 0.05$).

4. Conclusions

Pollutants and discharges have created a "hidden crisis" affecting water quality in rich and developing countries. This study aimed to assess the quality of surface waters in Oued D'Hous, Wilaya of Bouira (Algeria).

The study found that Oued D'Hous is facing pollution from multiple natural and anthropogenic sources, as it receives direct discharges from industry and urban areas. Agriculture is also widely practiced in the low valley of the Oued. Statistical analysis of the physicochemical parameters showed that the water quality changed with temperature, with consistently high levels observed in August and increasing turbidity in winter. The river was heavily loaded with nitrates, nitrites, chlorides and ammonium, with concentrations exceeding national and international standards.

To address this pollution, it is recommended to individually characterise the various wastewater produced by each industry and study the possibility of isolating the polluted water by installing pilot purification plants in each industrial factory. Sensitising farmers to reduce the excessive use of fertilisers and chemical fertilisers is also a major solution.

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Ethical considerations

Not applicable.

Conflict of interest

The authors declare that they have no competing interests.

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