Ukrainian Journal of Ecology

*Ukrainian Journal of Ecology,* 2021, 11(8), 28-34, doi: 10.15421/2021_264

*ORIGINAL ARTICLE*

# Impacts of urban discharges on the coastal environment and groundwater quality case: Coastal area of ecological interest Stidia (West Mostaganem-Algeria)

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***Received: 25.08.2021. Accepted: 04.10.2021.***

The coastal area of Stidia, located in the extreme west of the wilaya of Mostaganem, has a significant agricultural and forestry potential and a renowned dune belt, which is of considerable interest for ecology, agriculture and seaside tourism. Unfortunately, this area suffers considerable consequences in terms of pollution, especially during the summer season, due to urban discharges without prior treatment, which cause contamination of groundwater and vegetable crops, thus harming public health and the coastal environment. Indeed, on agricultural land near the beach there is a wild lagoon where urban wastewater flows, which unfortunately are considered a source of irrigation for farmers. To assess water pollution in this sensitive area, physicochemical analyzes were carried out from January to December 2019, on wastewater samples at discharge and the lagoon and on groundwater (4 wells located near the lagoon). The results of the measured parameters obtained show concentrations exceeding international standards, which revealed chemical pollution of the groundwater. This is confirmed by the high levels of Chlorides 625 mg/l, which explains the values of Electrical Conductivity that reach 2460 µs/cm. Nitrate levels reaching 65.4 mg/l, proving nitric pollution. A high organic load is reflected in high values of $BOD_5$ and COD values of up to 30 and 220 mg/$O_2$/l respectively, confirming the strong degradation of groundwater and the coastal environment that compromises any sustainable development. Furthermore, the degree of contamination differs from one site to another depending on the distance from the source of the pollution and the depth of the water table.

**Keywords:** Contamination, Groundwater, Wastewater, Coastal environment, Lagoon, Pollution, STIDIA, Mostaganem.

## Introduction

The coastal pollution ecosystem has become one of the major environmental problems. The factors responsible for it are constantly increasing and unbalancing, especially through human action (Taleb, 2013). The problem of this pollution is currently worsening and constitutes a danger for public health, due to the demographic growth and technological development of cities, more marked in coastal areas. Wastewater remains the main source of contamination of the coastal environment, and wastewater discharges along the coast have increased significantly in recent years and are often discharged directly into the natural environment without any prior treatment (Boutiba et al., 2003). Water pollution, which is one of the main ecological crises, is an alteration that makes its use dangerous and disturbs the aquatic ecosystem. It can concern surface water (rivers, water bodies) and/or groundwater (Mehanned et al., 2014).

Stidia is a coastal area with an agricultural, tourist and seaside vocation, which unfortunately suffers considerable consequences in terms of pollution, especially during the summer season, due to urban and industrial discharges without any prior treatment, and which are at the origin of a contamination of groundwater and market garden crops, which is detrimental to public health and damages the coastal environment (Taleb et al., 2015).

This study consists in elaborating a diagnosis of the situation and assessing the degree of pollution through physicochemical analyzes which were carried out from January to December 2019, on samples of wastewater discharged at the discharge, the lagoon, and on groundwater (4 wells located near the lagoon).

## Materials and Methods

### General presentation of the study area

The locality of Stidia is located 15 km to the extreme west of the wilaya of Mostaganem (geographical coordinates 35° 50’00» N and 0° 00' 00" E) where the Greenwich meridian passes (Fig. 1) and extends over a linear coastline of 14.5 km. The coastal zone is characterised by a substantial forest area (1,744 hectares), an important dune belt (409 hectares) that shelters the tussocks of *Retama Monosperma* (Figure 2), which must be protected to maintain the morpho-ecological balance, and the presence of the important wetland of Mactaa, classified in 2001 under the Ramsar Convention (DGF, 2011). This feature is of considerable interest for ecology, agriculture, and seaside tourism (Taleb et al., 2015).


**Fig. 1.** Geographic location of the study area, Stidia-Mostaganem (Realised by Taleb, 2021).

The climate of the region is semi-arid with a hot dry season from June to October and a cool rainy season from November to May; the hydrographic network is poor and groundwater is drastically reduced (ONM, 2012). The various deep or phreatic aquifers are threatened by the effects of overexploitation and the degradation of their water quality by various forms of anthropogenic or natural pollution. The water table is stored in ancient coastal sands,, covered by recent sands and exploited for agricultural purposes (ANAT, 2004).

Demographically, the commune of Stidia has experienced significant growth and urban development, with a population of 17226 inhabitants in 2018 (ONS, 2018). It receives a large flow of visitors, especially during the summer season. This has prompted the authorities to identify a tourist expansion zone (ZET) with a surface area of 48 hectares (ANAT, 2004).


**Fig. 2.** (**a**) Sand dunes covered with Retama monosperma; (**b**) Agricultural vocation.

The agricultural sector is considered one of the main vocations of the region. The useful agricultural area covers more than 2900 hectares in 2018 (Forestry Conservation, 2018). The different crops grown are market gardening, particularly tomatoes and watermelons, arboriculture, and viticulture. The commune has some small industrial facilities such as tyre manufacturing units, cosmetics, dairy products, and construction materials (Personal investigation in situ, 2019).

The volume of wastewater discharged was estimated in 2018 at 2340 $m^3$/day. The existing sewer network is undersized, not longer able to meet the demands of an ever-increasing population, causing overflows of wastewater pipes (Hydraulics Directorate, Mostaganem 2018).

Actually, there are two main destinations for wastewater discharges, the first coming from the agglomeration of Stidia is in the middle of nature near the agricultural lands, which constituted a large wastewater pond called Lagoon (Fig. 2). The second discharge to the sea comes from a few houses on the beach that are not connected to the sewer network. (Personal investigation in situ, 2019).

## Sampling sites

This study is based on the analysis of physicochemical parameters, pollution indicators on wastewater samples collected at discharge (R) and the lagoon (L) as well as at the groundwater level (4 wells located in the vicinity, Fig. 3 and 4.) during the period of January to December 2019, according to the techniques of water quality assessment (J. Rodier, 2010) and to the recommendations of the World Health Organization (WHO, 2004).

Some parameters were measured in situ such as temperature, pH, electrical conductivity and dissolved oxygen, respectively, using a thermometer, a hand-held pH meter type lutron (pH-206) Taiwan, a conductivity meter HANNA (HI-8733), Singapore with a margin of error of 2% and an oximeter WTW OX192 with an accuracy of 0.5 mg/l. The other parameters were determined in the laboratory.

Each month, a volume of 1.5 l was taken in polyethylene bottles for physicochemical analyzes from the outfall, the lagoon, and the 4 wells. Sample bottles were transported to the laboratory in a cooler at low temperature (4°C). The wells were numbered in ascending order according to their distance from the source of pollution. Well P1 is the closest to the lagoon (115 m), and well P4 is the furthest (360 m).

The statistical analysis of the results obtained is based on the comparison of the averages of the different parameters measured. We used the maxima and minima to evaluate the variations of these parameters for different sites and during well-defined periods (Derwich et al., 2010).


**Fig. 3.** Location of the study area and sampling sites (MK Taleb, 2021).

**Fig. 4.** (a) Wastewater discharge (R), (b) Wastewater lagoon (L).

## Results and Discussion

### Temperature

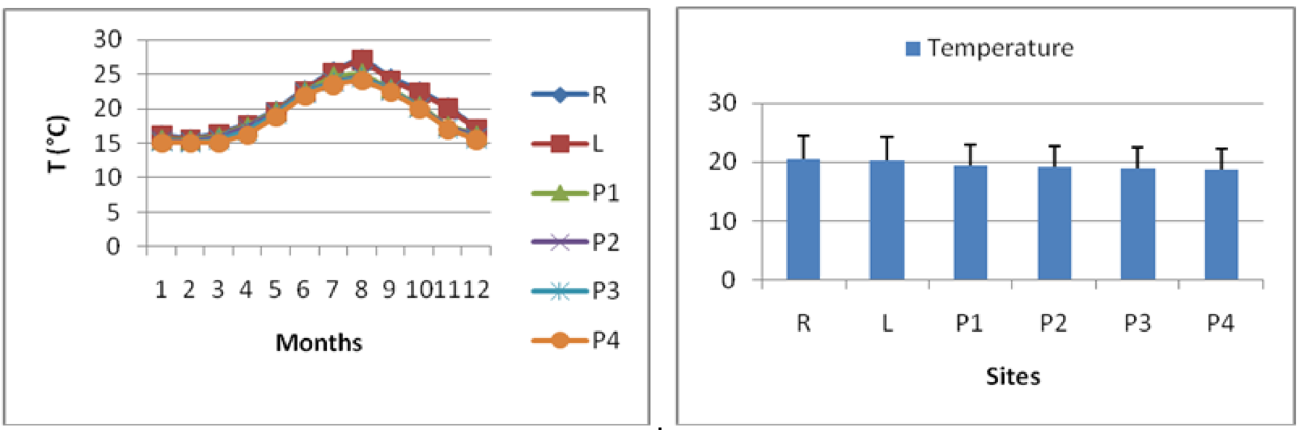


**Fig. 5.** Monthly and annual temperatures variations of wastewater discharges and groundwater.

The temperatures of the discharged wastewater vary between 15.5°C in winter and 27.3°C in summer in August. Groundwater temperatures vary between 15°C for well P4 in winter and 25.1°C for well P1 in summer (Fig. 5).

## Hydrogen ion concentration (pH)

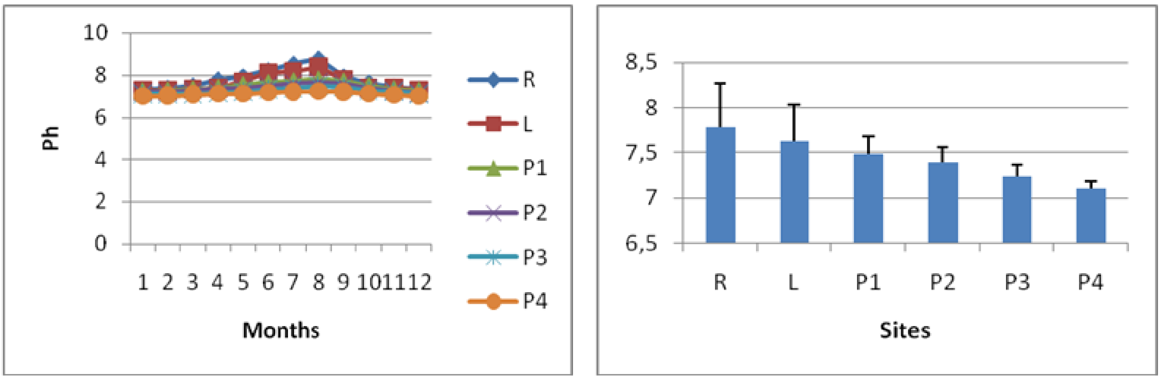


**Fig. 6.** Monthly and annual variations in the pH of wastewater discharged and groundwater.

The wastewater is characterized by an alkaline pH, between 7.9 downstream and 8.75; this is related to urban discharges, especially in summer (summer season). Groundwater is characterised by a relatively neutral pH, whose value is between the minimum 7.01 and the maximum 7.22 (well P4 being the furthest from the lagoon) throughout the year and between 7.24 and 7.54 (well P1) during the winter and fall seasons, reaching 7.8 in the summer, which is due to the proximity of the lagoon, a source of pollution (Fig. 6).

## Electrical Conductivity (EC) and Chlorides ($Cl^-$)

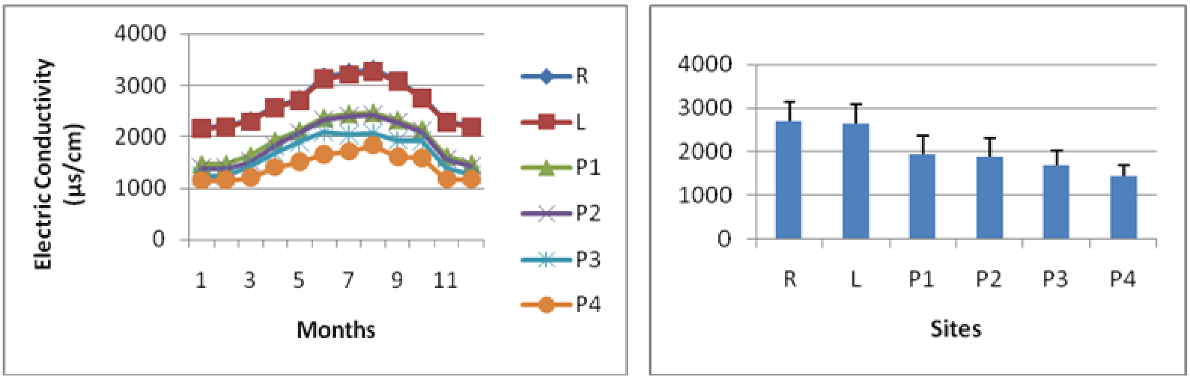


**Fig. 7.** Monthly and annual variations in the electrical conductivity of wastewater discharged and groundwater.

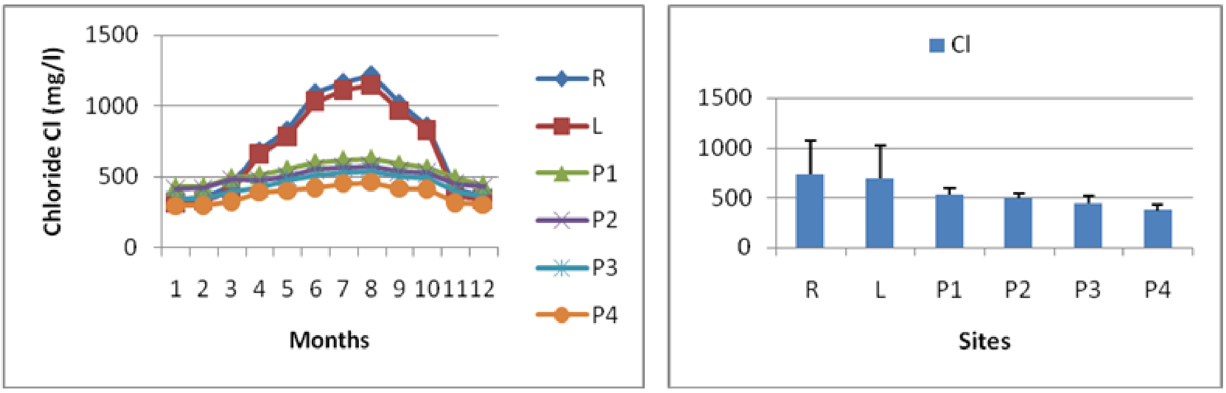


**Fig. 8.** Monthly and annual chloride levels in wastewater discharges and groundwater**.**

This study shows that these two parameters evolve in parallel. In fact, the electrical conductivity of the discharged wastewater increases from 2185 µs/cm in February to 3326 µs/cm in August. The same evolution is observed for chlorides, which vary between 342 mg/l in January and 1220 mg/l in August. For the majority of the months of the year, these levels correspond to a decrease in the discharge to the lagoon, linked either to decantation along the path of the wastewater flow with possible infiltration, or to a chemical transformation that prevents their detection (Bontoux, 1993).

The waters of the studied wells show variable electrical conductivities: a minimum of 1150 µs/cm was measured in well P4 being the furthest from the wastewater lagoon with a chloride concentration of 294.5 mg/l in January. Maximum values were recorded at well P1 which is the closest to the lagoon (2460 µs/cm in conductivity and 625 mg/l in chlorides) in August.

According to these two parameters, the algerian (JO, 2011) and international WHO standards allow us to classify these groundwaters as highly mineralised (brackish) waters in medium to poor classes. (Fig. 7 and 8).

## Orthophosphates $PO_4^{3-}$

The orthophosphate levels in the waters studied are low. They indicate a fairly low variation during the sampling period. The wastewater concentrations vary between 7 and 12.75 mg/l. These levels exceed standards throughout the year.

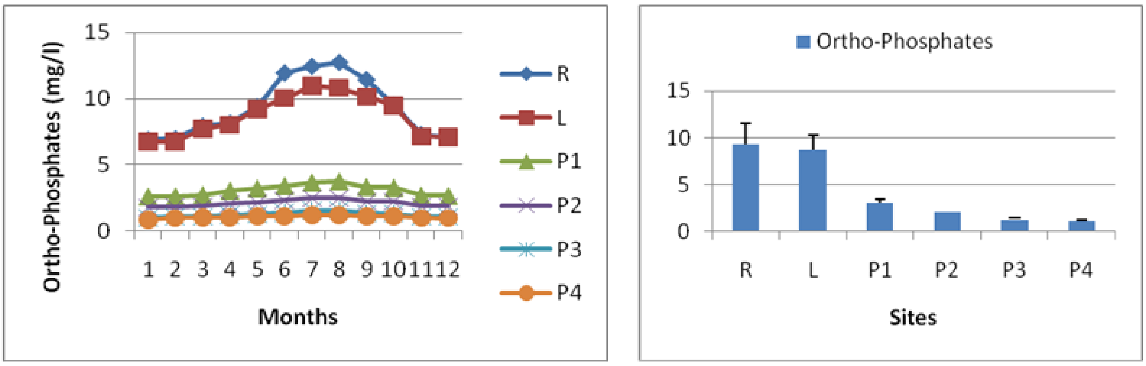


**Fig. 9.** Monthly and annual levels of orthophosphorus in discharged wastewater and groundwater.

In terms of groundwater, the levels vary between 2.6 and 3.8 mg/l (P1), being the closest to the source of pollution, and between 0.9 and 1.25 mg/l (P4). These values classify these waters as poor according to WHO guidelines. However, we observe a decreasing gradient away from the source of pollution (Fig. 9).

The phenomena involved in the contamination of well water by orthophosphates can be the application of fertilisers in excessive quantities and the discharge of wastewater into the natural environment (Butler et al., 1995), (Derwich et al., 2010).

## Nitrates ($NO_3^-$)

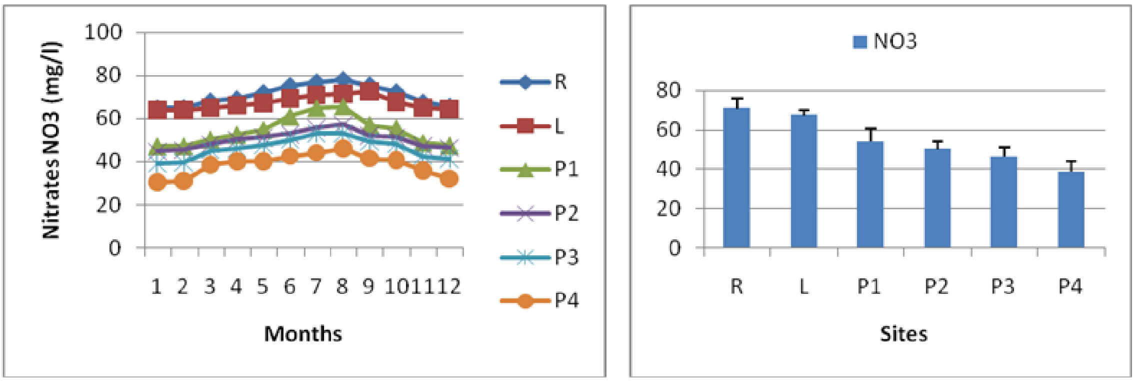


**Fig. 10.** Monthly and annual levels in discharged wastewater and groundwater.

Nitrate levels in the water of wells P1, P2 exceed the 50 mg/l suggested by the algerian and international WHO standards, indicating groundwater contamination (Fig. 10). This alteration of groundwater quality by nitrates could be attributed to wastewater which has not been subjected to any prior treatment and the shallow depth of the wells that facilitates contact between leached nitrates and groundwater (Brémond et al., 2005). These wells are the most vulnerable to infiltration, particularly the P1 well, which is the closest to the source of pollution, with a content of 65.4 mg/l.

**Nitrites ($NO_2^-$)**

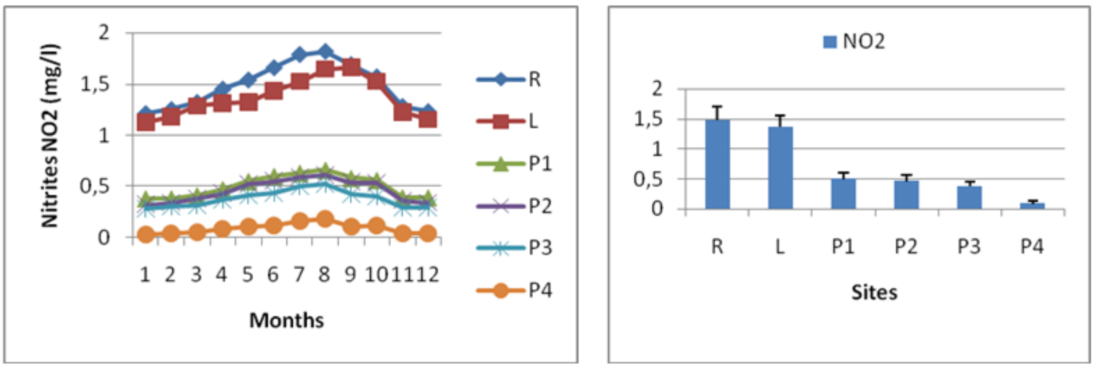


**Fig. 11.** Monthly and annual levels in discharged wastewater and groundwater.

The results obtained reveal that the majority of wells P1, P2 and P3 have nitrite contents that exceed the potability threshold of 0.1 mg/l set by WHO standards. With a high content that varies between 0.38 and 0.66 mg/l in P1 and a low content between 0.03 and 0.1 mg/l in P4, except in summer when it shows an increase to 0.18 mg/l. (Fig.11).

## Dissolved Oxygen (DO)

The dissolved oxygen content in wastewater is very low, around 1 mg $O_2$/l, which is normal for water loaded with organic matter whose degradation by microorganisms consumes oxygen. Groundwater has levels ranging from 2 to 4.09 mg/l (Fig. 12), and can therefore be classified as medium to poor quality according to algerian standards.

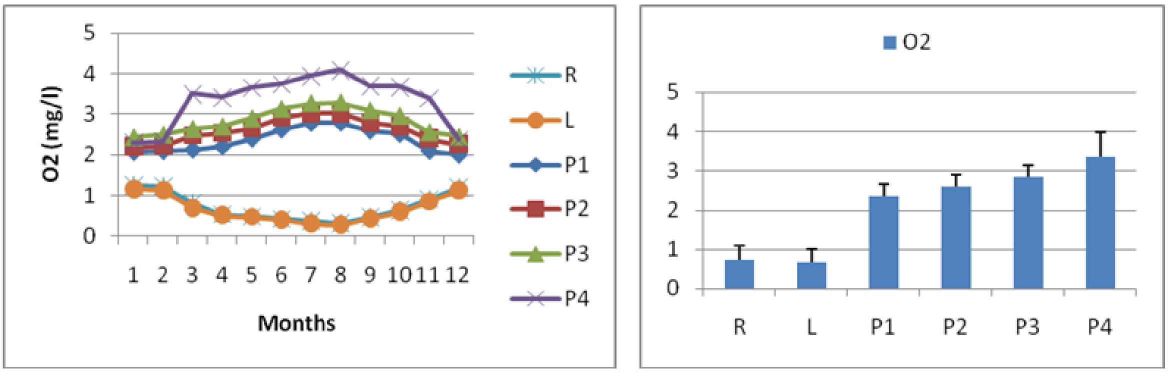


**Fig. 12.** Monthly and annualdissolved oxygen levels of discharged wastewater and groundwater.

The lowest content was measured at well P1, which is close to the source of pollution (Lagoon), the contribution of organic matter favours the development of microorganisms, which has an impact on the dissolved oxygen content.

## Biochemical Oxygen Demand ($BOD_5$)

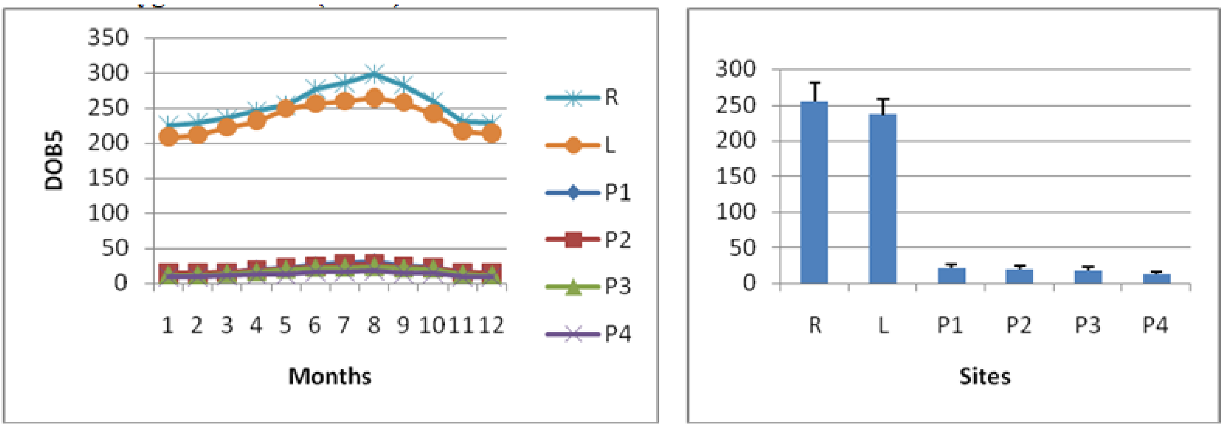


**Fig. 13.** Monthly and annual variations in $BOD_5$ of wastewater discharges and groundwater.

$BOD_5$ allows the assessment of the biodegradable organic matter present in water. The results obtained show significant concentrations of organic matter that vary between 225 mg/l in January and 298.5 mg/l in August (the hottest month) exceeding the wastewater standards for wastewater and between 15.4 mg/l in January and the maximum 30 mg/l in August for P1 closest to the source of pollution. A decrease in groundwater $BOD_5$ values is observed moving away from the pollution source (Lagoon) for wells P3 and P4 with a minimum of 9.4 mg/l at P4 (Fig.13).

## Chemical Oxygen Demand (COD)

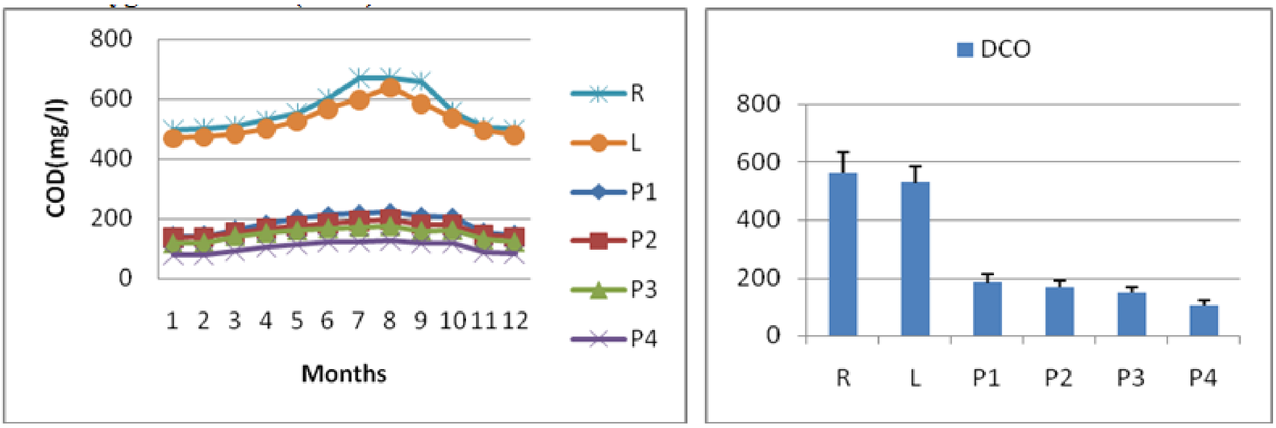


**Fig. 14.** Monthly and annual variations in COD of wastewater discharges and groundwater.

The COD represents the quantity of oxygen consumed by the chemically oxidisable matter contained in the water (Bontoux, 1993). Wastewater has values that exceed the standards, ranging from 497 mg/l in January to a maximum of 671 mg/l in August. (Fig. 14).

The COD values for all the wells studied exceed the value of 80 mg $O_2$/l set by the WHO. Similarly, the standard grid allows these waters to be classified as of very poor quality.

However, due to the same causes explained above, the high temperatures of the hottest months of the year and the increase in the number of summer visitors seem to significantly increase the $BOD_5$ and COD of groundwater, particularly in wells P1 and P2, which are close to the source of pollution (the lagoon).

## Conclusion and Recommendations

Our study has allowed us to assess the impact of wastewater on the quality of groundwater used by the local population as drinking water and on the contamination of several vegetable crops that may be harmful to public health.

The results obtained during this study show in their majority a relative contamination of groundwater by the raw wastewater according to an infiltration process, with maximum contents of 625 mg/l in chlorides with electrical conductivity reaching 2460 µs/cm. Nitrate levels reached 65.4 mg/l, indicating nitric pollution. A high organic load is reflected in high levels of $BOD_5$ and COD levels of up to 30 and 220 mg/$O_2$/l respectively, confirming the strong degradation of groundwater and the coastal environment.

Therefore, it is imperative to review the entire dimensioning of the urban wastewater drainage network in accordance with the current and projected housing expansion, as well as to proceed with the construction of a wastewater treatment plant to effectively and permanently treat the wastewater of the entire municipality in order to contribute to the protection of water resources and the environment.

## Aknowlegment

We would like to thank the director, the members of the hydraulic division of Mostaganem and all those who contributed to this work.

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**Citation:**

Taleb, M.K., Benaissa, N., Mouffok, S. (2021). Impacts of urban discharges on the coastal environment and groundwater quality case: Coastal area of ecological interest Stidia (West Mostaganem-Algeria). *Ukrainian Journal of Ecology* 11 (8), 28-34.