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Research Paper.

Nutrient level in Algerian coastal waters: Algiers, Bou-Ismail and Zemmouri bays

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Abstract

During sprint cruise (2013), numerous measurements of nutrient levels were conducted across the Algiers region (Algiers Bay, Bou-Ismail Bay and Zemmouri Bay) in order to assess the state of pollution by nutrient salts. Twelve stations were sampled along the Algiers coast using a NISKIN bottle. The nutrients (*e.g.*, nitrates NO_3^-, nitrites NO_2^-, ammonium NH_4^+, orthophosphate PO_4^{3-} and silicates SiO_2) were analyzed in the laboratory. the results show fluctuations with measured concentrations of nitrate (1.81-3.39 µmol/L), of nitrite (0.18-0.28 µmol/L), of ammonium (1.23-33.93 µmol/L), of orthophosphate (0.89-5.08µmol/L), and of silicate (2.55-7.64 µmol/L). The non-significant correlation between nitrate and phosphate data ($R^2 = 0.0366$) allows us to estimate an N/P ratio of -0.071.

Keywords
Nutrients;
Algiers coast;
Water pollution;
Eutrophication.

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1 Introduction

The Mediterranean is a sea subject to very high human pressure, chronically receiving wastewater from large urban and industrial units with a high pollution load. The various types of plastic waste from coastal dumps and ships can threaten coastal wildlife (Abd elguerfi, 2003).

Faced with these threats of pollution, mankind is mobilized to fight to preserve heritage, limit and study their effects by measuring physico-chemical and chemical parameters used as tracers in seawater, so they are a very important tool for the study of phenomena and processes taking place within the ocean. Like most Mediterranean coastal areas, the Algerian coast and coastline are experiencing serious environmental problems. The Algerian region is certainly one of the areas where the deterioration in the quality of coastal marine waters is most perceptible.

Knowledge of water quality and the monitoring of pollution levels in the coastal environment appear to be a priority for the preservation of the marine environment and its resources. This is the aim of this study. The present investigation concerns the waters of the Algiers coastline (Algiers Bay, Bou-Ismail Bay and Zemmouri Bay), which are subject to continental water discharges (wadis).

2 Materials and methods

2.1 Samples collection

In order to monitor the state and quality of sea water in the Algerian region (Bou-Ismail Bay, Algiers Bay and Zemmouri Bay), more specifically at the level of Oueds discharges, urban and industrial outfalls, we took several samples at stations that had been selected in advance; During a sea trip aboard the small boat El Awras (ENSSMAL) on May 20, 2013, we took samples at four stations (S1, S2, S3 and S4). In order to complete our study, eight (08) samples were entrusted by the CNRDPA. These samples were taken in our study area during March 2013 by CNRDPA researchers during a mission aboard the Grine vessel. These stations are as follows: S5 and S6 in Bou-Ismail Bay, S7 and S8 in Algiers Bay and S9, S10, S11, S12 in Zemmouri Bay (Figure 1).

2.2 Sea water sampling

Seawater was sampled using a 5-liter NISKIN bottle.

2.3 Analysis of nutritive elements

The nutrient (*e.g.*, nitrates NO_3^-, nitrites NO_2^-, ammonium NH_4^+, orthophosphate PO_4^{3-} and silicates SiO_2) were analyzed in the laboratory using the Aminot and Chaussepied (1983) method.

Figure 1. Location of stations in the study area

3 Results and discussion

In the following, we present the nutrient levels. Dissolved nutrient concentrations (NO_3^-, NO_2^-, NH_4^+, PO_4^{3-}, SiO_2) are presented in Table 1 and Figures 2 - 6.

3.1 Nitrates (NO_3^-)

Analysis of nitrate concentrations in the Algiers region reveals levels ranging from 1.81 to 3.39 µmol/l, with an average of 2.54±0.48 µmol/l (Figure 2). These values remain low compared with the nutrient content observed by Boulahdid (2003), which was 5.36±6.69µmol/l in Bou-Ismail Bay, due to the consumption period and low continental inputs (spring). The high levels observed, particularly at the surface near the mouth of Oued El-Harrach and the port of Dellys (station 07 and station 12), are linked to the high inflow of water during this period. The surface minimum is located off Zemmouri Bay (station 11), due to the dilution effect and the absence of coastal contribution, but the influence of Atlantic waters via the Algerian current should also be noted.

Table 1. Nutrient concentrations (µM) in the Algiers coastal seawater

Stations	Latitude	Longitude	NO_3^- (µM)	NO_2^- (µM)	NH_4^+ (µM)	PO_4^{3-} (µM)	SiO_2 (µM)
S1	36.7900°N	2.8700°E	2.18	ND	1.54	1.77	3.18
S2	36.7500°N	2.8200°E	2.06	ND	1.4	5.08	4.27
S3	36.7300°N	2.8100°E	2.35	ND	1.57	2.61	7.64
S4	36.8000°N	2.8900°E	2.67	ND	1.68	2.05	6.45
S5	36.8258°N	2.6570°E	2.71	ND	1.23	1.01	4.36
S6	36.8938°N	2.7720°E	2.24	ND	1.51	0.97	3.64
S7	36.7600°N	3.1740°E	3.38	0.24	2.33	1.29	2.55
S8	36.8364°N	3.1767°E	2.71	ND	1.51	0.89	5.36
S9	36.8646°N	3.6775°E	2.48	0.28	1.75	2.21	3.64
S10	36.8403°N	3.5091°E	2.46	0.20	33.93	4.00	4.82
S11	36.9498°N	3.7831°E	1.81	0.18	1.33	1.69	4.27
S12	36.9135°N	4.1133°E	3.39	ND	1.75	2.93	4.00
		Max	3.39	0.28	33.93	5.08	7.64
		Min	1.81	0.18	1.23	0.89	2.55
		Mean ± sd	2.54±0.48	0.08±0.11	4.29±9.34	2.21±1.28	4.52±1.41

3.2 Nitrites (NO_2^-)

Nitrite ion concentrations at the various stations in the study area are undetectable, with the exception of S07, S09, S10 and S11, where values vary between 0.18 and 0.28 µmol/l (Figure 3). These values are logical, as nitrite ions are intermediate forms, and their presence in the marine environment in significant quantities is generally due to the presence of a polluting source of nitrite.

3.3 Ammonium (NH_4^+)

Ammonium levels observed in spring 2013 (1.23-33.93 µmol/l) show little fluctuation over the study period, with the exception of the suspected high value at station S10 (Figure 4), contamination and/or poor sample preservation are thought to be responsible for this high concentration. The highest levels of ammonium in the various stations are found in particular at stations receiving inputs from the wadis, mainly El-Harrach, El-Hamiz and Mazafran, as well as the station near the port of El Djamila. These areas are generally enriched in ammonium by domestic and industrial wastewater discharges.

3.4 Orthophosphate (PO_4^{3-})

Phosphate concentrations range from 0.8 to 5.08 µmol/l, with an average of 0.54±0.58µmol/l, reflecting the variation from station to station (Figure 5). Fluctuations follow those observed for nitrates, *i.e.* a clear difference in concentration between consumption, regeneration and input periods. Station 2 (ilots Sidi Fredj) has the highest orthophosphate levels, linked to an inflow of wastewater laden with polyphosphate-rich detergent.

3.5 Silicates (SiO_2)

Silicate levels observed in March and May 2013 ranged from 2.55 to 7.64 µmol/L, with an average of 4.52±1.41 µmol/L (Figure 6). With the exception of station S7, where silicate levels are low, fluctuations are less significant and follow those observed for nitrates and phosphates, *i.e.* occasional enrichment opposite the mouths of the main wadis during periods of direct inflow, and depletion during periods of consumption and low inflow of continental water.

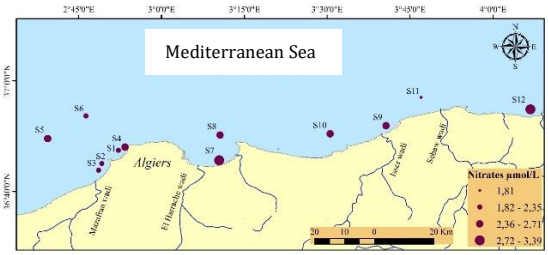

Figure 2. Spatial variation of NO_3^- concentrations

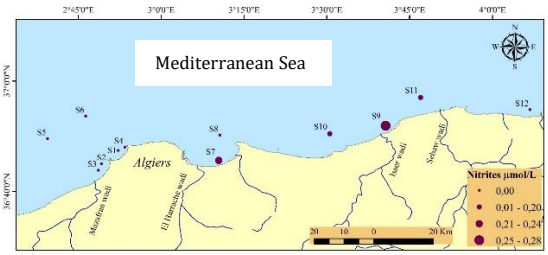

Figure 3. Spatial variation of NO_2^- concentrations

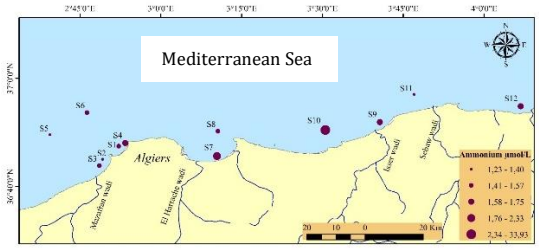

Figure 4. Spatial variation of NH_4^{3+} concentrations

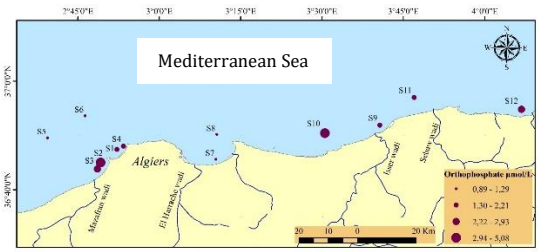

Figure 5. Spatial variation of PO_4^{3-} concentrations

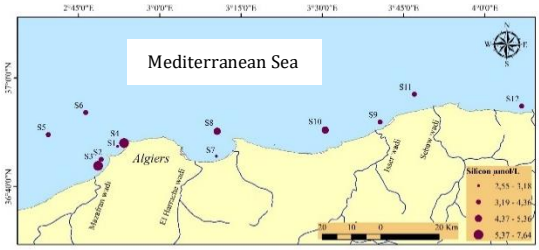

Figure 6. Spatial variation of SiO_2 concentrations

3.6 Nitrate/Phosphate diagram and N/P ratio

The Mediterranean ecosystem, in addition to its relative nutrient poverty, its waters are characterized by values of the Redfield N/P biochemical ratio different from those reported for the world ocean. Indeed, it is found with a rather high value of the order of N/P = 21 (Raimbault *et al.*, 1990; Benhalima *et al.*, 2014).

The nitrate-phosphate correlation diagram shows the nitrate/phosphate abundance ratio (N/P) characterizing the stocks of these two elements over the period studied (Figure 7). The value of the N/P ratio (-0.071) for the whole period indicates a scattered and insignificant distribution, and is well below the value generally accepted for Mediterranean waters (20-27) according to Gomez (2003) and for the world ocean 16 (Redfield *et al.*, 1963). The N/P ratio is unstable due to the influence of water inputs and the general circulation of water along the coast. Urban and agricultural activities are the main causes of the imbalance in the N/P ratio. It would appear that this general imbalance at all stations is more related to phosphate enrichment than to nitrate deficiency.

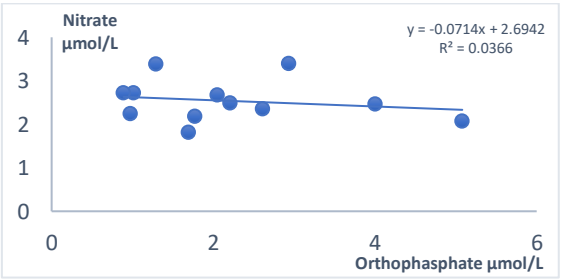

Figure 7. Nitrate-Phosphate diagram (during spring 2013)

4 Conclusion

The Algerian coastline appears to be a series of bays with different physical and chemical characteristics in relation to the importance of urban and agricultural inputs and activities:

The hydrological characteristics of the Algerian coastline are determined by the influence of offshore waters and continental waters, in particular the contributions of the main wadis (El-Harrach, Mazafra,

Isser and Sebaw), as well as meteorological conditions. The imprint of continental waters is marked by the varying degrees of surface desalination observed in front of wadi mouths and outfalls.

Analysis of the chemical substrate has highlighted the importance of exogenous inputs and upwelling of deep waters in enriching coastal waters with nutrient salts. This enrichment, particularly in phosphate, by wastewater from the Mazafran wadi, is causing a deterioration in the chemical quality of the water in Bou Ismail Bay. This is reflected in the permanent nature of the pronounced imbalance in the nitrate/phosphate ratio, which reaches very low levels at all stations. Nevertheless, water mixing and the influence of offshore waters keep concentrations of these two elements below those that could lead to eutrophication.

Following on from this state of pollution, it is important to emphasize that pollution assessment at any site requires continuous monitoring, which is only meaningful if it is complemented by an estimate of inputs and a reduction in pollutant discharges. In this respect, the sampling strategy needs to be improved to meet the specific needs of the site, and to provide additional information (study of wadi inputs and their effluents, currentology and more precise identification of the origin and source of pollutants).

- **Conflict interest**

The authors confirm that there are no known conflicts of interest associated with this publication and there has been no significant financial support for this work that could have influenced its outcome. Also, there are no funding was received for this work.

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