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Physico-Chemical Quality and Metallic Pollution Levels in Wastewater Discharges from Mostaganem (Algerian West Coasts).

Bensahla Talet Lotfi[a*], Mezdjri Lyamine[b], Bensahla Talet Ahmed[c], Mami Anas[d], & Kerfouf Ahmed[e].

[a]*University of Sidi Bel Abbès, Faculty of Nature Sciences and Life, Department of Biology BP 89, 22000, Sidi-Bel-Abbès, Algeria*

[b]*University of Skikda.Faculty of Sciences.Dpt of SNature Sciences and Life. Skikda21000. Algeria.*

[c]*University of Oran, Faculty of Nature Sciences and Life, Department of Biology BP 16 Es Sénia. ,31000, Algeria.* [d]*Laboratory of Applied Microbiology, Department of Biology, Faculty of Sciences, University of Oran, BP 16, Es-senia, 31100, Oran, Algeria.*

[e]*University of Sidi Bel Abbès, Faculty of Nature Sciences and Life, Department of Environment, BP 89, 22000, Sidi-Bel-Abbès, Algeria*

[a]**Email: btlotfi77@hotmail.fr*

[b]*Email: mezedjri.lyamine@gmail.com*

[c]*Email: ahmedbensahla@yahoo.fr*

[d]*Email: anas.mami@yahoo.fr*

[e]*Email: kerfoufahmed@yahoo.fr*

Abstract

The present study aimed to evaluate the physico-chemical quality (temperature, salinity, pH, O_2, and SS) of Mosatganem nearshore waters, and the level of metal contamination (Zn, Pb and Cd) in urban and industrial wastewaters of Mostaganem city. For this, a sampling program was carried out monthly during one year (December 2009-November 2010).

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* Corresponding author.

E-mail address: btlotfi77@hotmail.fr.

The temperature of the urban and industrial water discharged fluctuated between 18.5 and 17.5 ° C but didn't exceed the standard (30 ° C). In the sampling points, the mean values were near to 7.9 for urban discharges and near to 9.1 in industrial releases which is under the normative limits. Salinity of water samples collected at the two observation points was generally between 20 and 30 ‰, these values are lower than the salinity of the Mediterranean, which is around 37 ‰. Dissolved oxygen concentrations vary significantly from one season to the other in each site. The values obtained for the urban release and industrial releases of Mostaganem were respectively 2.90 mg/l and 2.28 mg/l. Concerning the suspended solids concentrations, the average concentration found for urban effluent of Mostaganem (33.8 mg/l) was lower than the norm, but six measures exceed it (maximum value of 50 mg/l in March 2010). The industrial release of Mostaganem is in accordance with the standard already set (mean: 29.2 mg / l; maximum: 33 mg/l in December 2010). Stations targeted during our study are considered as sensitive areas and BOD5 measured exceeds the normative level, especially in the case of urban release of the city. The mean levels of cadmium are over the normative values and the statistic test showed significant difference (t-test, $p<0.001$) between the industrial release (0.88 ± 0.35 mg/l) of Mostaganem and those recorded for urban discharges (0.21 ± 0.17). Also, significant difference was recorded during winter and spring compared to the rest of the year. Urban release of Mostaganem (0.92 ± 0.44 mg / l) is characterized by a significant (t-test, $p<0.001$) release of zinc in relation to industrial discharge (0.25 ± 0.23). The mean levels of lead have almost similar levels in urban discharges (0.22 ± 0.21 mg/ l) and industrial discharges (0.19 ± 0.20 mg / l) of Mostaganem city. Heavy metals concentrations found in waters analyzed are heterogeneous but do not exceed the normative values, except for cadmium, but this does not diminish the cumulative effect of these micropollutants through the food chain that could harm humans last link of this chain.

Keywords: wastewater; marine ecosystem; urban effluent; industrial effluent; metal pollution; heavy metals; west coast of Algeria; Mostaganem, Algeria.

1. Introduction

The aim of this work is to determine ranges and variations of potentially toxic trace metals (Cu, Hg, Cd and Pb) in water samples collected from various points of Algeria west costs (Mosatganem) and their impact on the environmental quality. In fact, rapid industrialization and the discharge of potentially toxic trace metals into the marine environment has become a serious problem [1]. Fast population growth, tourism and industrialization in Mosatganem area have led to an increase in metal pollutants in the sediments and water [2],[3] and the main sources of heavy metals are industrial and urban waste, harbor activities and wastewater discharges without treatment.

2. Sampling area

1) Description and localization

The study sites are located on a fringe of coast (Fig. 1), near the port of Mostaganem. This coastline is supplied by waters of Atlantic origin. Circulation appears very turbulent along the coast promoting the dispersion of potential pollution sources and allowing a relatively large development of the entire food chain [4]. At the level

of Oran coast, occurs an opposing current coming from a branch of the Atlantic current called the Algerian current [4] which presses this branch against the coast, allowing the movement of the fine fraction in the bottom and creating an extension of the great mud flat area to Mostaganem [5].The climate in this area is Mediterranean, hot summer and mild winter, with a pronounced dry season from mid-June to mid-September, while the months of October to December are the wettest. The distribution of rainfall between wet months of 2010 (295 mm rainfall, mean temperature of 18.7 ° C - ONM, 2010) showed a significant departure from average climatic conditions in western Algeria.

2) Sampling sites

Sample sites (Fig. 1) are represented by the main urban effluent of the city, coordinates 35 ° N and 04 ° 54'436 13'125 E, and the industrial effluent called GIPEC of coordinates 35 ° N and 00 ° 54'436 03'145 E. Several industrial units are located around this area, we can cite: the National Company of Cellulose and Paper (CELPAP), the National Sugar Company (ENASUCRE) located in the western part of the city and the Algerian Society of batteries (SAAC) manufacturing lead-batteries, located in the southeastern part of the city. In addition, Arzew industrial zone mainly specialized in petrochemical products is situated near our study area (30 km) which represents an important source of several pollutants (acids, bases, oils, heavy metals, hydrocarbons, hot water ...) [6].

Figure 1. Location of urban and industrial discharges of Mostaganem city (Algeria).

(**IR**: Industrial release; **UR**: Urban Release)

(Google earth, 2014 modified by Bensahla Talet L).

3) Material and Methods

Sample collection methods

The samples were collected from December 2009 to November 2010 at the rate of a monthly sample taken in the first week of each month. The samples were collected between 9h and 12h at depth between 30 and 50 cm according to guidelines of international organizations [10,11] Some parameters were measured in situ:

- The temperature with a thermometer laboratory,

- The pH with a pH meter with glass electrode type MA 5730,

- Salinity with a conductivity-salinometer WTW LF 191 (accuracy ± 0.01 PSU - PSU 1 = 1 gram of salt per kilogram of water),

- Dissolved oxygen with a WTW OXI92 oximeter (accuracy of about 0.5 mg / l),

Suspended solids (SS) were determined in the laboratory by weighing the retained during a filtration membrane particles (pore diameter ≈ 1 micron), after drying at 103-105 ° C.

For the determination of heavy metals concentrations, filtered water samples were analyzed using an Atomic Absorption Spectrophotometer with flame AAS (SOLAAR 929). The choice of elements (cadmium, lead, zinc) was based on our available technical and financial resources.

BOD5 or quantity of consumed oxygen in 5 days (20 ° C) by microorganisms ensuring the mineralization of organic matter present in water was obtained by means of the WTW OxiTop ® Control 12 [7].

3. Results and discussion

1) Physico-chemical parameters

The data collected during our study are summarized in Table 1

a. Temperature

The temperature of the urban and industrial water discharged fluctuated between 18.5 and 17.5 ° C but didn’t exceed the standard (30 ° C). The relatively high winter temperatures of urban discharges are related to the contributions of domestic waste water. Temperatures increase in summer particularly between June and August 2010, this increase in water temperature is in close relation to the air temperature (27 ° C in July and 26.2 ° C in August).

Table 1. Mean values of the measured parameters from December 2009 to November 2010 in the waters of urban and industrial discharges of Mostaganem.

	T (°C)	pH	Salinity (mg/l)	O_2 (mg/l)	MES (mg/l)	DBO_5 (mg O_2/l)	Cd (mg/l)	Pb (mg/l)	Zn (mg/l)
UR	18,5 (± 5,1)	7,93 (± 0,36)	25,8 (± 1,2)	2,90 (± 0,60)	33,8 (± 10,5)	80,3 (± 16,7)	0,21 (± 0,17)	0,22 (± 0,21)	0,92 (± 0,44)
IR	17,5 (± 5,0)	9,12 (± 1,95)	23,5 (± 3,0)	2,28 (± 0,85)	29,2 (± 3,1)	57,3 (± 21,4)	0,88 (± 1,35)	0,19 (± 0,20)	0,25 (± 0,23)
NL	30	6,5 - 8,5	-	-	35	35	0,20	0,50	3,0

T: temperature, **UR**: urban release, **IR**: industrial release, **NL**: normative limits, **-**: no standard set.

b. pH

In sea water, the pH values are around 8.2 to 8.3 while in the sampling points, the mean values were near to 7.9 for urban discharges (range: 7.2 to 8.4 in January and April 2010 respectively) and near to 9.1 in industrial releases (range: 6.8 to 12.6 in February and April 2010 respectively).

Compared to normative values (> 6.5 and <8.5), the industrial discharge of Mostaganem appears outside the norm, certainly because of strongly basic water discharges from the paper mill CELPAP (formerly SONIC) [8]

c. Salinity

The salinity of water samples collected at the two observation points was generally between 20 and 30 ‰. These values are lower than the salinity of the Mediterranean, which is around 37 ‰ while the highest values were observed in September for urban waste, and in July for the industrial discharges.

d. Dissolved Oxygen

Dissolved oxygen concentrations vary significantly from one month to the other in each site. The values obtained for the urban release of Mostaganem (6 values ≥ 3 mg/l, mean: 2.90 mg/l, 2.28 mg/l for industrial releases of Mostaganem). The decrease in the concentration of dissolved O_2 at the site of industrial releases of Mostaganem between March to June 2010 was in relation to the bacterial metabolism, which uses this element to degrade the abundant organic material at this station. Whereas, increased levels of oxygen in November at Urban release of Mostaganem, is probably due to water inflows following heavy precipitation during autumn.

e. Suspended solids (SS)

National standards (Executive Decree 06-141 of 19 April 2006 / JORADP / 23-04-2006) and international [9] set as limit for SS in liquid effluents (domestic, industrial and agricultural), a concentration of 35 mg / l.

The average concentration found for urban effluent of Mostaganem (33.8 mg/l) was lower than the norm, but six measures exceed it (maximum value of 50 mg/l in March 2010). The industrial release of Mostaganem is in accordance with the standard already set (average: 29.2 mg / l; maximum: 33 mg/l in December 2010).

Comparing our results with those of other previous work on Oran coasts a significant decrease in concentrations of SS is observed. Indeed, in June 1998, the measured values reached 1885 mg/l in the urban release of Oran city and 1650 mg/l at 5 m depth. The observed trend is the result of recent efforts made by the government in treating waste water.

f. Biological oxygen demand in 5 days (BOD5)

According to national standards, this parameter should not exceed 35 mg O_2/l in waste water while WHO recommends, as a limit, 25 mg O_2/l in normal coastal areas and 15 mg O_2/l in sensitive coastal areas [10]. Stations targeted during our study are considered as sensitive areas and BOD5 measured exceeds the normative level, especially in the case of urban release of the city.

2) Heavy metals (Cd, Pb and Zn)

a. Results of analyzes on urban effluents

The cadmium concentrations found ranged between 0.003±0.001 and 0.40±0.0001 mg/l (Fig. 2) and are superior to the normative limit (0.20 mg/l). Very low in December (0.03 mg/l), the concentration of this element is maintained between 0.34 and 0.40 mg/l from January to June 2010, and the values down to 0.04 and 0.05 mg/l in October and November 2010. With significant difference recorded during winter and spring compared to the rest of the year.

Lead concentrations are very low (from 0.02 to 0.06 mg/l) from December 2009 to March 2010 and from October to November 2010 (Fig. 2) and remain below the standard but between March to august the maximal values of lead are recorded reaching the normative values (0.50 mg/l). Zinc concentrations attained the maximal values in winter (1.6±0.0001 mg/l) and summer (0.9±0.0001 mg/l) (Fig. 2) and the lowest values were attained during spring with levels below the normative level (3 mg / l)

b. Results of analyzes on industrial effluent of Mostaganem

The difference between the maximum concentrations (3.2±0.1 mg/l in January 2009) and minimal one (0.004±0.001 mg/l in September 2009) for cadmium was highly significant compared to the other periods (ANOVA, $p<0.05$). Also, the measured (Fig. 3) values from January to March are particularly high (≥3 mg/l), but we have no information on their origin.

The highest concentrations of lead were measured in winter 2009 (0.51 mg/l) and are equal to the normative level (0.50 mg/l). The remaining seasons of the year (Fig. 3), the values are very low (≤0.03mg/l in December 2009 and July-November 2009).

Finally, zinc concentrations attained a maximum of 0.6±0.1 mg/l in summer (Fig. 3) whereas the lowest values ranged between 0.06±0.0011 and 0.24±0.001 mg/l for the remaining seasons.

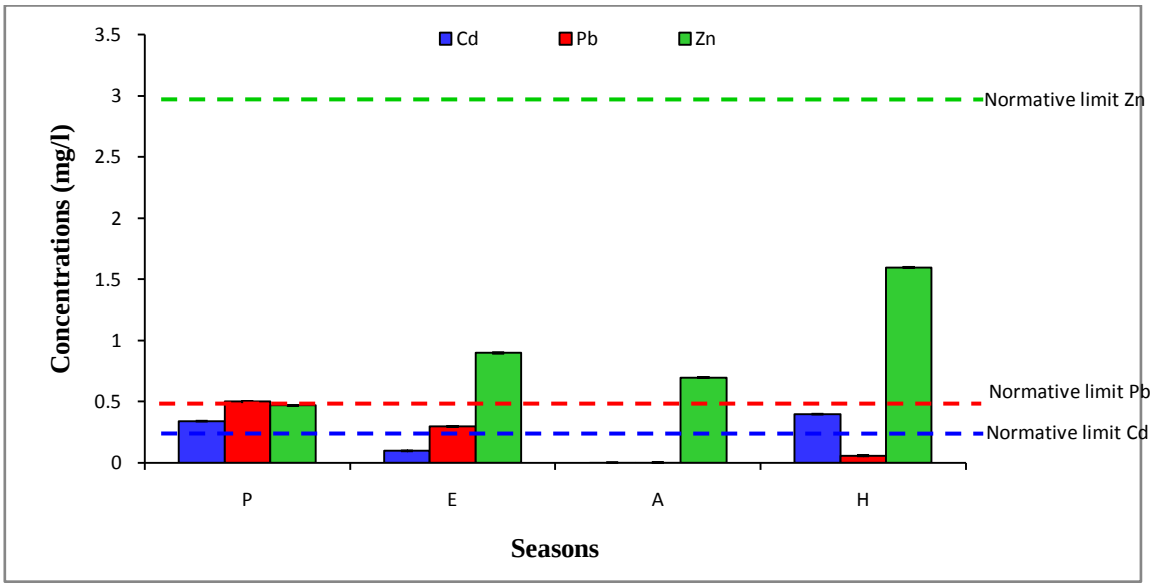

Figure 2. Concentrations of cadmium, lead and zinc in urban release (UR) of Mostaganem (April 2009 to March 2010).

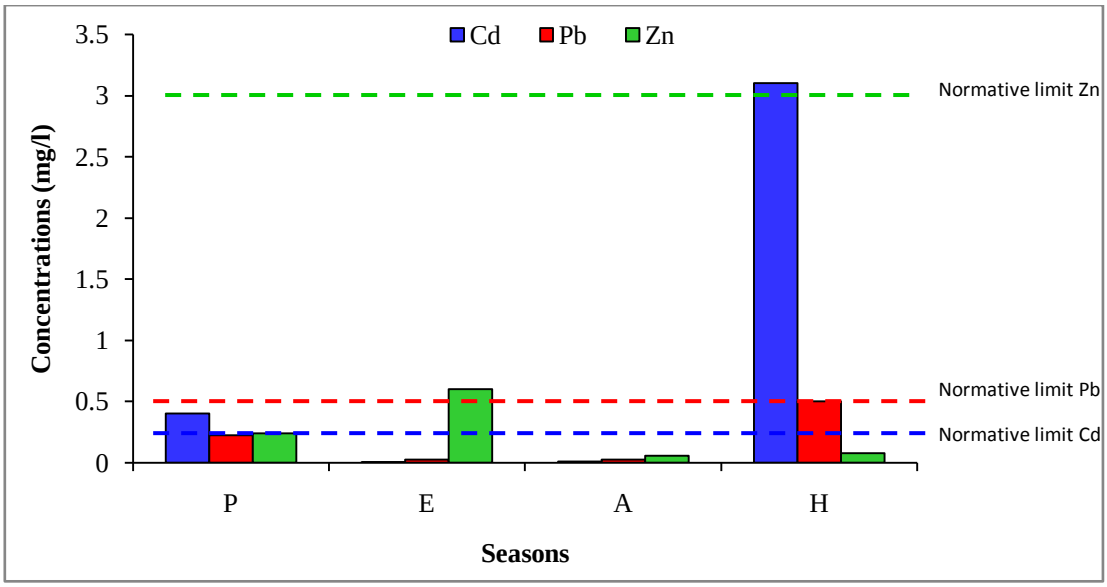

Figure 3. Concentrations of cadmium, lead and zinc in the industrial release (IR) of Mostaganem (April 2009 to March 2010).

In fact, recent works on the same area showed that, human activities in the region create significant wastewater discharges, causing the proliferation of algal flora composed of invasive species of Caulerpa [13], whereas the analysis of the composition of benthic and testing the quality of the larval development of the sea urchin

Paracentrotus lividus revealed and confirmed a satisfactory conditions in Stidia and Hadjadj sites, located west of the city of Mostaganem. However, the site of Kharouba near the industrial discharge seems to have early signs of degradation and disturbance of the environment [14].

Comparing our physico-chemical data obtained during our study to those obtained in a Oran bay [11], a close area to Mostaganem coastline (tab. 2)

Table 2. Mean values of the measured parameters from December 2009 to November 2010 in the waters of urban and industrial discharges of Mostaganem ad Oran bays.

	T (°C)	**pH**	**Salinity (mg/l)**	**O_2 (mg/l)**	**SS (mg/l)**	**DBO_5 (mgO_2/l)**	**Cd (mg/l)**	**Pb (mg/l)**	**Zn (mg/l)**
UR Mostaganem	18,5 (± 5,1)	7,93 (± 0,36)	25,8 (± 1,2)	2,90 (±0,60)	33,8 (±10,5)	80,3 (± 16,7)	0,21 (±0,17)	0,22 (±0,21)	0,92 (±0,44)
IR Mostaganem	17,5 (± 5,0)	9,12 (± 1,95)	23,5 (± 3,0)	2,28 (±0,85)	29,2 (± 3,1)	57,3 (± 21,4)	0,88 (±1,35)	0,19 (±0,20)	0,25 (±0,23)
UR Oran	21,3 (±5,8)	8,21 (±1,28)	24,3 (±2,8)	2,59 (±1,05)	47,3 (±18,7)	164 (± 38)	0,52 (±0,45)	0,23 (±0,22)	0,61 (±0,54)
NL	30	6,5-8,5	-	-	35	35	0,20	0,50	3,0

T: temperature, **UR**: urban release, **IR**: industrial release, **NL**: normative limits, **-**: no standard set, **SS**: suspended solids.

It appears that the two areas have quite similar values for water temperature, pH and dissolved oxygen, whereas suspended solids in Oran effluent are higher than those recorded in Mostaganem release, also for cadmium levels and concentrations of oxygen consumed (DBO5) reflecting the richness of this environment in organic matter and microorganisms. This is due to the fact that Oran population is two times larger than Mostaganem population producing more waste and rejecting different forms of pollutants in sea water.

4. Conclusion

The temperature varied between 18.5 and 17.5 ° C but didn't exceed the standard (30 ° C) urban discharges in winter contribute a lot to warm waste water whereas in summer air temperature had an effect on this parameter. The pH in urban release seem to be in the normative range but the industrial release exceed it

Salinity of water samples collected at the two observation points was generally lower than the salinity of the Mediterranean with values between 20 and 30 ‰. The poor values of dissolved oxygen found in urban an industrial releases of Motaganem reflect an important bacterial metabolism using the essential element while suspended solid evaluation indicated that only industrial wastewater are in agreement with national and international standards (35mg/l) and that urban waste waters exceeded this norms for BOD5. Heavy metals

concentrations found in waters analyzed are in some samples close to the national and international standards but in some water samples exceed the normative values which constitutes a real danger in the short and long term for the local population strongly consumer of seafood (fish, shellfish, seafood ...)

Related to seasons it seems that winter and spring records the highest values of heavy metals (Cd, Pb and Zn) compared to the remaining seasons in the urban and industrial wastewater released except for zinc; highest levels of this element are recorded during spring and summer in the industrial discharges.

The physico-chemical quality of coastal waters of Mostaganem analyzed during this study indicated that these waters are rich in organic matter and micropollutants (Cd, Pb and Zn) while they are poor in oxygen, which has serious consequences on the aquatic environment, resulting in an eutrophication phenomenon of the coastal waters. This preliminary finding will allow public authorities to take the necessary measures in order to protect the marine environment during the conception and installation of wastewater treatment systems in various urban and industrial areas in accordance with the national regulations governing the prevention and protection against coastal pollution (Art 45-46-46 / Chap. 4 / JORADP / 4 December 2005).

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