# Protection and enhancement of the coast of Mostaganem (Algeria): preliminary restoration study

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## ABSTRACT

The project aims to identify the quantifiable and permanent variables to assess the overall development of the marine ecosystem of Mostaganem. This identification is based on a methodological approach of dialogue, which is between the social sciences responsible for the identification and characterization of sustainable development in the particular context of Mostaganem marine ecosystem and marine scientists responsible for the representation and quantification of such knowledge. This question is to obtain operational elements for managers in charge of the sector. It therefore underpins the thinking and detailed position on the nature and operation of the system of sustainable management of the marine ecosystem in Mostaganem. The study area is a marine ecosystem known for its biodiversity and its sites of biological and ecological interest. This study provides results on the characterization of Mostaganem coast, diagnosis and analysis of environmentally sites bioecologique, tourism, and socio-economic challenges. This is due to human activities and tourism development alternatives for sustainable development with regard to physical balance and landscape quality of the site. This research used a baseline study and proposes solutions to development problems facing initiatives Mostaganem Marine ecosystem development.

**Keywords:** Marine ecosystem, Algeria, coast restoration, sustainable development, Cheliff Estuary

## PAPER

### 1. Introduction

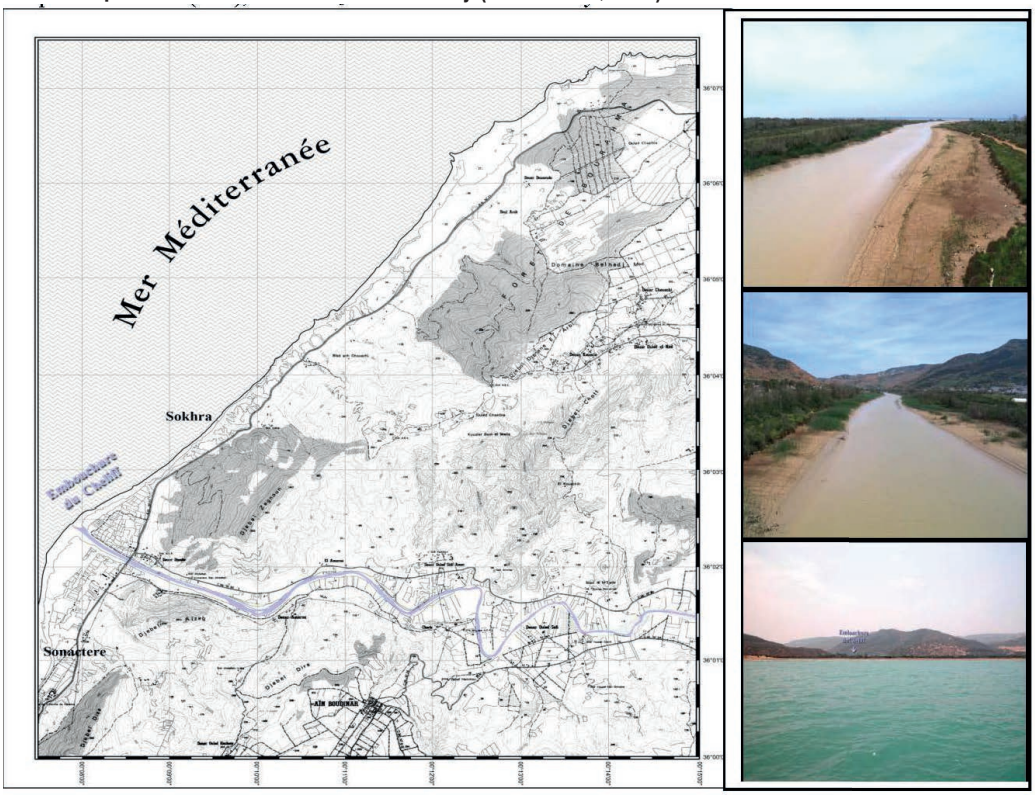
The Cheliff River (Fig. 01) is the largest River in Algeria; it's 700 km long with a flow rate of about 2700 m3/s (Bouzelboudjen & Mania, 1989; Gagneur & Kara, 2001; Al-Asadi et al., 2005, Kies et al., 2012; Kies & Kerfouf, 2014a). It passes through different wilayas like as Mostaganem, Relizan, Ain-Defla and Cheliff. The River of Cheliff is dynamic, extremely variable and plays crucial roles within the structure, the function and also the evolution of the marine coastal of water ecosystems of the bay of Mostaganem (Kies, 2015). Nutrient availability at Cheliff River controls the abundance and structure of phytoplanktonic populations at the bay of Mostaganem. Eutrophication problems are clearly identified in this body of water with micro invasive algae covering its surface at certain times of the year (Kies et al., 2012; Kies & Kerfouf, 2014a; Kies, 2015). Some work on the Cheliff River have indeed established direct links between pollution of the sea state and domestic and industrial wastewater discharges directly discharged into the Cheliff River without any treatment (Bouzelboudjen & Mania, 1989; Kies & Taibi, 2011; Kies et al., 2012; Kies & Kerfouf, 2014a,b; Kies, 2015).

Bay Mostaganem is located in the Algerian west coast. This bay receives urban and industrial discharges via the hydrodynamics of water, swells brewing phenomena and water circulation. Because of the intensification of effluent discharges and many leisure complex construction, the Bay of Mostaganem which was in the past a little disturbed natural environment, is about to turn into a real dump of urban waste. The objective of this study is to assess the physico-chemical quality of surface waters of this bay. Thus, a temporal and spatial study has tracked the seasonal changes in temperature, salinity, pH, dissolved oxygen, ammonium, nitrite, ortho phosphates, Suspended Mater (SM), of BOD5 and COD from January 2014 till December 2015.

### 2. Materials and methods

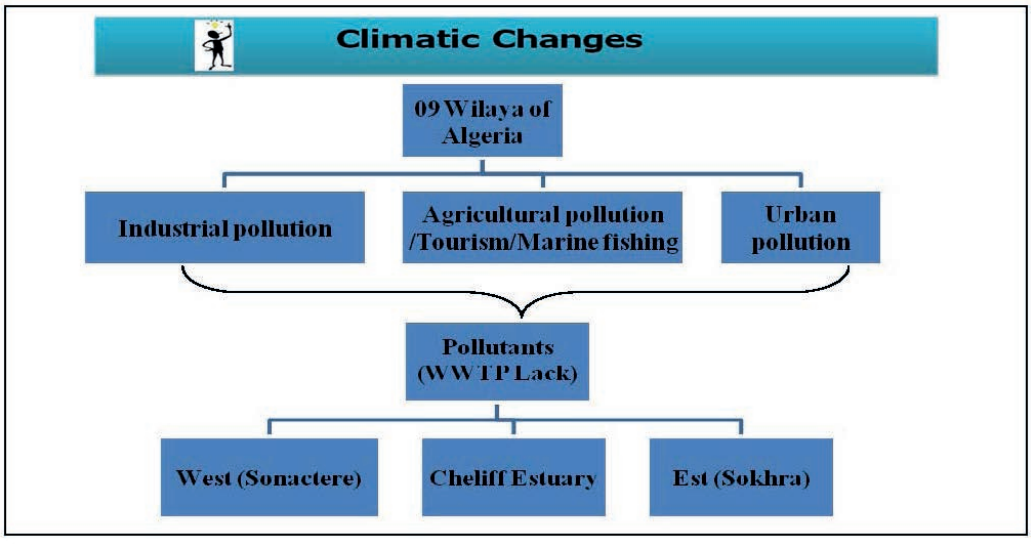
We selected two different stations. The first one "Station 1" located in the River of Cheliff (Sour and Sidi Belattar). The second "Station 2" was fixed on the bay of Mostaganem, which is divided in two regions, the Sokhra bay at the Est of Estuary of Cheliff River and Sonactere bay at the West of the same Estuary (Fig.01 & Fig. 02). Twenty four (24) samples were collected at each station during the studied period (from January 2014 until December 2015).

**Figure 1. - Mostaganem map with Cheliff River (colored in blue) and beaches of Sonactere and Sokhra, with the photos of Cheliff River and its estuary (Kies & Taibi, 2011)**




We used identification key for species determination (Bougis, 1974) and fomol solution (70%) for fixation of phytoplankton specimens. Algal taxa were identified using an inverted microscope at magnifications of x 400 (Vollenweider, 1971; Rodier, 1996).

**Figure 2. - General diagram of the behavior of pollutants in the Cheliff River, the Cheliff estuary and the Mediterranean Sea) (Kies et al. Present research)**




## 3. Results and discussion

### 3.1. Phytoplankton abundance

A total of 70 phytoplankton species were identified during our survey in the two stations. The dominant cluster is Chlorophyta (along the period of study particularly in summer time) followed by Chrysophyta cluster that proliferates in autumn season 2014. At Station 1 (Tab. 01), the maximum of Cyanophyta (blue-green algae) was recorded in May 2014, and the minimum in January 2015. At Station 2 (Tab. 01),

the maximum of blue-green algae was recorded in November 2014, and the minimum in February 2015.

Euglenophyta species were found at Station 1 (River of Cheliff), during the sampling period. A maximum was recorded in August 2014 and the minimum in January 2015. Euglena species were found too during the sampling period at Station 2 (Bay of Mostaganem) with value ranged between a maximum at July 2014 and a minimum at December 2015. The Green algae (Chlorophyta) were dominant at Station 1 than at Station 2 (with 42 and 38 species respectively). In May 2014, the maximum number of green algae was recorded at both stations. The minimum was recorded in January 2015 at Station 1 and in March 2015 at Station 2. The maximum number of diatoms (Bacillariophyta) was recorded in June 2015 at both stations. Low numbers of diatoms were found in November 2014 at Station 1 and in March 2014 at Station 2 during the sampling period. This phylum was found in five of ten occasions at Station 2. The Cheliff River was powerfully dominated by chlorophyll (Gagneur & Kara, 2001; Al-Asadi et al., 2005), whereas the bay of Mostaganem had equal proportions of diatoms (i.e.: *Nitzschia acicularis, Cyclotelle meneghiana*) and chlorophyte (i.e.: *Oocystis, Scenedesmus*).

**Table 1. - Seasonal distribution of microalgae in the two stations studied**

| Phyla | Station 1 | | Station 2 | | Genera dominated at 1 & 2 | Rare Algae At Sation 1 (Cheliff River) |
|---|---|---|---|---|---|---|
| | Max | Min | Max | Min | | |
| Chrysophyta | 06.2015 | 11.2014 | 06.2015 | 03.2014 | Nitzschia Navicula Cyclotelle Gyrosigma | Melosira granulata |
| Chlorophyta | 05.2014 | 01.2015 | 05.2014 | 03.2015 | Strombomonas Scenedesmus Oocystis Dictyococcus Tetraedron Coelastrum | Pediastrum Tetraedron Staurastrum Cosmarium Monoraphidium Chlamidomonas |
| Cyanophyta | 05.2014 | 01.2015 | 06.2015 | 01.2015 | Oscillatoria subsalsa Nostocopsis Microcystis | Oscillatoria tenuis |
| Euglenophyta | 08.2014 | 01.2015 | 07.2014 | 12.2015 | Euglena | Trachelomonas |

### 3.2. Connectivity between river and the sea

A follow-up in 2014-2015 of pollution indicators (temperature, pH, dissolved oxygen, ammonium, nitrite, ortho phosphates, BOD5, COD, and SM) in surface waters was carried out in order to estimate the quality physicochemical of the Bay of Mostaganem. The results revealed the existence of a water contamination by domestic and industrial wastewater from the urban area of the nine provinces of the country carried by the Cheliff River marked by significant spatial and temporal variation. By analyzing the graphs of the variables obtained from January 2014 till December 2015 (Fig.03), we have a tendency to notice for this era "of contact" that nutrients [NO2 (nitrites), NO3 (nitrates), NH4 (ammonia), Ptot (total phosphorus), SiO2 (silicates)] area unit terribly dependent parameters with Chlorophyll. a, that support a rise of OM (organic matter) described by the DBO5 (biological demand for oxygen), whereas parameters [OD (dissolved oxygen) and T° (temperature)] area unit associated with the supply of the suspended matter (SM) and to the turbidity (Turb). Since there is a consumption of the varied nutrients (N, P, Si) by the microflora species with nearly identical concentration. Therefore, there is a phytoplanktonic diversity for the period of connectivity between the watercourse and the ocean.

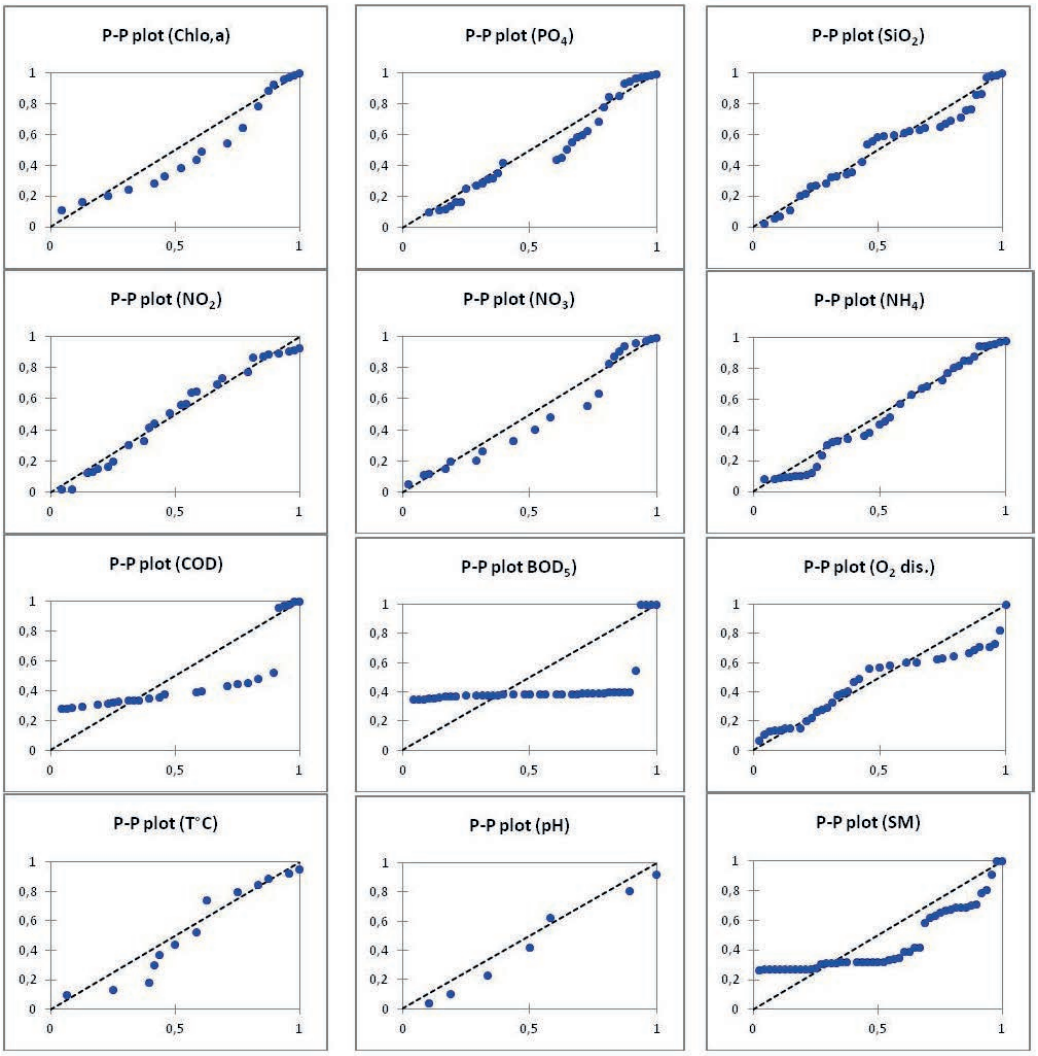
The discharge of wastewater into the environment may cause a rise in temperature. The temperature variations curves of the companies studied have the same evolution, with different amplitudes. The most significant differences are observed in February and April, and the lowest was in rainy season (Bouzelboudjen & Mania, 1989). This relative stability reflects thermal homogeneity of the waters of the bay (Kies et al., 2012; Kies, 2015; Elegbede et al., 2015). Most vital reactions are slowed or even stopped by a significant lowering of the temperature. In contrast, temperature increases can have effects to kill certain species, but also to promote the development of other species resulting ecological imbalance (Kies & Taibi, 2011; Kies et al., 2012; Kies & Kerfouf, 2014b; Bu et al., 2014; Kies, 2015). The pH of the

**Table 2 - Variations of Physical and Chemical Parameters**

| Descriptive Statistics | Obs. | Min | Max | Mean | SD | CV |
|---|---|---|---|---|---|---|
| T | 48 | 8 | 27 | 14,13 | 6,36 | 2,22 |
| pH | 48 | 7.4 | 7.9 | 7,70 | 0,18 | 43,43 |
| Dissolved oxygen | 48 | 3.9 | 9.1 | 7,54 | 1,71 | 4,40 |
| Suspended Matter (SM) | 48 | 34 | 26294 | 5 330,50 | 8 883,58 | 0,60 |
| SiO2 | 48 | 1.2 | 21.4 | 10,69 | 6,10 | 1,75 |
| COD | 48 | 10 | 170 | 67,38 | 61,00 | 1,10 |
| $BOD_5$ | 48 | 2.1 | 38.2 | 14,41 | 12,86 | 1,12 |
| COD/ $BOD_5$ | / | 3,22 | 4,45 | 4,26 | 4,51 | 0,98 |
| $NO_3$ | 48 | 4 | 21 | 10,63 | 5,07 | 2,10 |
| $NO_2$ | 48 | 0.13 | 4.8 | 1,14 | 1,53 | 0,74 |
| $NH_4$ | 48 | 0.22 | 11.1 | 4,41 | 4,89 | 0,90 |
| $PO_4$ | 48 | 0.03 | 2.06 | 0,88 | 0,75 | 1,17 |

water of Mostaganem bay is relatively alkaline. The seasonal average values are between 7.1 and 8.3 (Fig. 03).

**Figure 3 - Monthly changes of the physicochemical parameters during the periods of contact between the River (Chellif) and the sea (Mostaganem shallow water area) during 2013 and 2014**




This slight alkalinity shows the influence of sea water generally basic compared to those of continental origin. The highest pH values were observed in April, during the period of strong marine influence and the lowest in June and October, during the rains and floods. For dissolved oxygen, the average values of the dissolved oxygen content of the surface water of the Mostaganem bay fluctuate between 3.9 mg/l and 9.1 mg/l (Fig. 03 & Tab. 02). The lowest levels are obtained in February (Great dry season), related to the consumption of oxygen by the organic matter from wastewater traces. As for ammonium, nitrites

and orthophosphates, the high levels of these nutrients observed in the Bay of Mostaganem result of several phenomena whose discharges of domestic and industrial wastewater; ocean and River inputs; the "wash out" by chemical fertilizers rainwater spread on industrial plantations.According to (Kies & Taibi, 2011; Kies et al., 2012; Kies & Kerfouf, 2014b; Bu et al., 2014; Kies, 2015; Elegbede et al., 2015) the concentrations of nutrients in surface waters vary regularly under the influence of border areas ( watershed, streams, ocean ...). The discharge of the Cheliff River that is rich in nutrients to the sea of Mostaganem, could explain the high values of the NH4 +, observed in long dry season. The contents of $NH_4^+$, $NO_2^-$ and $PO_4^{3-}$ high, observed in the rainy season and floods, is explained by the massive arrival in the Bay of wastewater settlements, rainfall runoff, combined with water floods of the Cheliff River (Fig. 02-03 & Tab. 02), rich in nutrients (Kies et al., 2012; Kies, 2015). The pollution level in nutrients determined in this study is relatively high compared to the east side of Mostaganem rating compared to the estuary Cheliff; this classifies the Bay of Mostaganem and Cheliff River among eutrophic (Kies & Taibi, 2011; Kies et al., 2012; Kies & Kerfouf, 2014b; Kies, 2015).For parameters $BOD_5$, COD and SM in general, the water of the bay are heavily loaded with solid particles and matter in suspension. The highest values were obtained in February and April, during the long dry season and those in the lowest period of rains and floods. This could be explained by the fact that in rainy season, the water circulation becomes weak and suspended particles tend to settle. COD and BOD5 record the greatest values in February and April, during the long dry season, indicating organic contamination of the waters of the bay. The smallest values are obtained in periods of rains and floods.

To characterize the nature of the pollution and degradation of performance, the COD/BOD5 ratios were calculated (Tab. 02). According to (Kies et al., 2012) if the ratio COD/BOD5 is greater than 3, the effluent will be predominantly chemically biodegradable. This study shows that the reports COD/ BOD5 are between 3.22 and 4.45; which corresponds to industrial wastewater characteristics with difficult degradation. The descriptive statistics that include all biological and physico-chemical data are presented in Table 02. Between the different stations (Cheliff River, Cheliff Estuary and the Bay of Mostaganem) and different months, the density difference was such that it was necessary to use a logarithmic ordinate for the graph. Graphics univariate quantitative data composed of 48 rows and 16 columns which were rescale from 0 to 100.

**4. Conclusions**

The results of this study show that the realm close to the Cheliff watercourse would be representative of reference conditions of the Cheliff estuary and also the bay of Mostaganem for its restoration. The class Diatomophyceae and Conjugatophyceae are indicators of pollution with ammonia, but the Dinophyceae are indicator of intense mineralization of the medium. The physicochemical and hydrobiological analysis of samples from the watercourse, the ocean and also the estuary in periods of flooding showed that Cheliff watercourse pours important quantity of pollutants within the watercourse mouth area. Contaminated waters issued by nine wilayas of the country are fed by the Cheliff River to empty into the Bay of Mostaganem. The pollutants are urban, agricultural and industrial.

The study discovered the presence of nitrogenous substances, phosphorus and sulfur; suspended matter (organic and inorganic) is significant. Consistent with the scientific observation conducted between January 2014 and December 2015, detected pollutants have adverse effects on wildlife and on the marine life of the bay of Mostaganem, notably within the area of the mouth of Cheliff. Owing to the winds of the East and coastal ocean currents that result, polluted waters are moving in times of floods to the west coast and might sometimes reach the beach of Sablettes (December 2015 wherever precipitation reached 156.5 mm). The large quantities of solid particles found in the water prevent the penetration of daylight, for this, the development of the flora is reduced to a minimum in the area of the mouth as is confirmed by the observation during marine's immersion. Additionally, it is probable that the flora like Posidonia oceanica meadows cannot be established within the space of the study due to the robust horizontal currents and the nature of the substrate (sandy bottom mixed with clay). This vegetable poorness so involves a really low diversity of fauna.

Companies Wilayas upstream of the Cheliff River minimize production charges by rejecting waste that can makes damage in the Wilaya of Mostaganem (downstream). So the problem of pollution from Cheliff watercourse isn't a matter of "all or nothing" however rather a case of "more or less". This can be explained by the fact that the results of the pollution increase with the degree of contamination and also the price of non-pollution decreases with it. This work showed the influence of Cheliff watercourse on the marine ecosystem, as well as negative effects on the phytoplankton and plants life, that has a real disturbance on abundance.

**5. Recommendations**

The intervention of the authorities is essential to reduce pollution at the optimum level. To reach acceptable levels, they should be equipped with policy instruments such as the imposition of a solution on polluters and victims of pollution which minimize costs that they bear together. Each Wilaya upstream to increase its interest cost of abatement and the Wilaya downstream to increase the cost of the damage; the introduction of compulsory treatment of wastewater from urban and industrial activities before they are released into the environment; promotion of scientific knowledge through research and information; dissemination of scientific knowledge and environmental education; revision of standards relating to water pollution, taking

into account the concentration of the pollutant because the polluter can increase the amount of water that contains a polluting effluent that meets the standard, so they have consider the damage generated by the concentration of the pollutant per unit of time, not only the amount of the pollutant; establish a land use plan (and coastal) or physical planning; this instrument would, in relation to the possible establishment of new heavy and polluting industries, to prevent pollution of the coast of Mostaganem. It takes thorough foundation for economic demand and ecological data studies, namely climate change, the susceptibility of the soil and plant pollution, hydro-chemical, bio-chemical and hydro-biological. The economic argument should be directly related to the importance of the environment.

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