Review article :

Impact of the climate change on the West coast of Algeria: Gulf of Oran, Arzew and Mostaganem

Fatima Kies[1], Ahmed Kerfouf[2]

1- Department of the Environment and Earth, University of Milano Bicocca, Italy.

Author for correspondence, email: f.kies@campus.unimib.it

2- Department of Environmental Sciences, Faculty of Natural Sciences and Life, University Of Sidi Belabess, Algeria

Abstract

Different hydro climatic conditions at and above a continental shelf have significant effects on the ecology of the environment (temperature, nutrient richness and pelagic production). Indeed, bioclimatic changes defined clearly reflects the prevailing conditions imposed above the continental shelf. Based on contributions made to the sea (rainfall, temperature, wind ...) and those put together by the internal dynamics can be distinguished marine years that correspond to low enrichment in terms of any change in continental and marine conditions generally short and strong enrichment of years corresponding to eventful years and transformations of continental and marine conditions, strong shifts in time. Thus, a hot or cold but very fluctuating period influence the marine ecosystem and phytoplankton growth. Also, the impact of development on the coastal and marine environment is localized mainly in the coastal metropolitan areas characterized by high urbanization and concentration of activities.
Keywords: climate change; environmental variability; Ecosystem vulnerability; West coast of Algeria.

Résumé

Les différentes conditions hydro climatiques qui règnent sur et au-dessus d'un plateau continental ont de considérables effets sur l'écologie du milieu (température, richesse nutritive et production pélagique). En effet, l’évolution bioclimatique définie, reflète nettement les conditions dominantes imposées au-dessus du plateau continental. En fonction des apports apportés à la mer

(pluviométrie, température, vent…) et ceux remontés par la dynamique marine interne on peut distinguer des années à faible enrichissement qui correspondent à de maigres années en termes de toute variation des conditions continentales et marines, généralement de courte durée ainsi que des années à fort enrichissement qui correspondent à des années riches en événements et de transformations des conditions continentales et marines, de forts décalages dans le temps. Ainsi, une période froide ou chaude mais très fluctuante influencerait l'écosystème marin et le développement du phytoplancton. Aussi, l'impact des actions de développement sur le milieu littoral et marin est localisé essentiellement dans ces aires métropolitaines côtières, marquées par une forte urbanisation et une concentration des activités.
Mots-clés: changement climatique; variabilité de l'environnement; Vulnérabilité des écosystèmes; Côte ouest d'algérien.

Introduction

The coastal zone, or terrestrial, pelagic and benthic intertidal zones converge is a particularly fragile, sensitive and complex place subject to strong demographic and economic pressure (Person,1976, Prud Homme, 1980, Ramade, 1998, Ramade, 2000, Belhadj, 2001, Kies &Taibi, 2011). It is an evolution and variability of physico-chemical (Redfield et al. 1963, Nisbet & Verneaux. 1970, Aubert et al. 1973, Aminot & Chausspied, 1983, Aminot et al. 1985, Rodier. 1996, Sigg et al. 2000, Al-Asadi et al. 2005, Thieu, 2009, Kies et al. 2012) and biological (Redfield et al. 1963, Vollenweider. 1971, Bougie, 1974, Belin et al. 2001, Gagneur and Kara, 2001, Al-Asadi et al. 2005, Billen and Garnier. 2007, Kies et al. 2012) phenomena manifest themselves there. This natural diversity is the result of simultaneous changes in coastal morphology (rocky shores, sandy, mixed ...) of the hydrodynamics (Guibout, 1987, Aminot et al. 1994, Grimes et al. 2003, Kies and Taibi. 2011, Kies et al. 2012). of water bodies (currents, waves), the mechanisms of climate and the inputs of nutrients (Redfield et al. 1963, Belhadj, 2001, Grimes et al. 2003, Kies and Taibi. 2011, Kies et al. 2012).

Among the consequences of climate change on the marine coastal ecosystem of Western Algerian (Grimes et al. 2003, Kies et al. 2012); a fluctuation in the flow of rivers (Macta and Cheliff) located in Western Algeria that is directly related to the climate (Belhadj, 2001, Kies & Taibi, 2011); and leads to an increase in precipitation and thus the flow of rivers; which means the addition of organic matter (Aminot and Guillaud, 1990, Belhadj, 2001, Garnier et al. 2008, Kies & Taibi, 2011) by heavy flooding; change in the composition of macrobenthic communities (Belbachir, 2012, Kies et al. 2012) and the abundance of opportunistic species (Grimes et al. 2003, Belbachir, 2012); and finally a long-term impact on the abundance of their predators such as benthic and demersal fish (Darley, 1992, Grimes et al. 2003, Boubenia, 2011, Kies et al. 2012). We note the following consequences of the arrival of new large predators; mortalitées massive consequences of suspension; in this case, what is the future holds for nature underwater? (Darley, 1992, Grimes et al. 2003, Boubenia, 2011, Kies et al. 2012).

This research aims first to do a study on the coast of Western Algeria, and secondly to establish their spatial and temporal variation in climate in this region, including the Gulf of Oran, Arzew and finally Mostaganem by factors of ecological population structure analysis.

Characterization of the study area

The Gulf of Oran on the Algerian West coast between the Gulf of Arzew and Bay Andalusian is between Cape Needle East and Cape Falcon to the West (Fig. 1; Leclaire, 1972, Grimes et al. 2003). The Gulf of Oran is bathed by the waters of Atlantic origin. Traffic appears very turbulent along the Algerian Precontinent. Turbulence favors the dispersion of potential pollution sources and allows a relatively large development of the entire food chain (Millot, 1989).

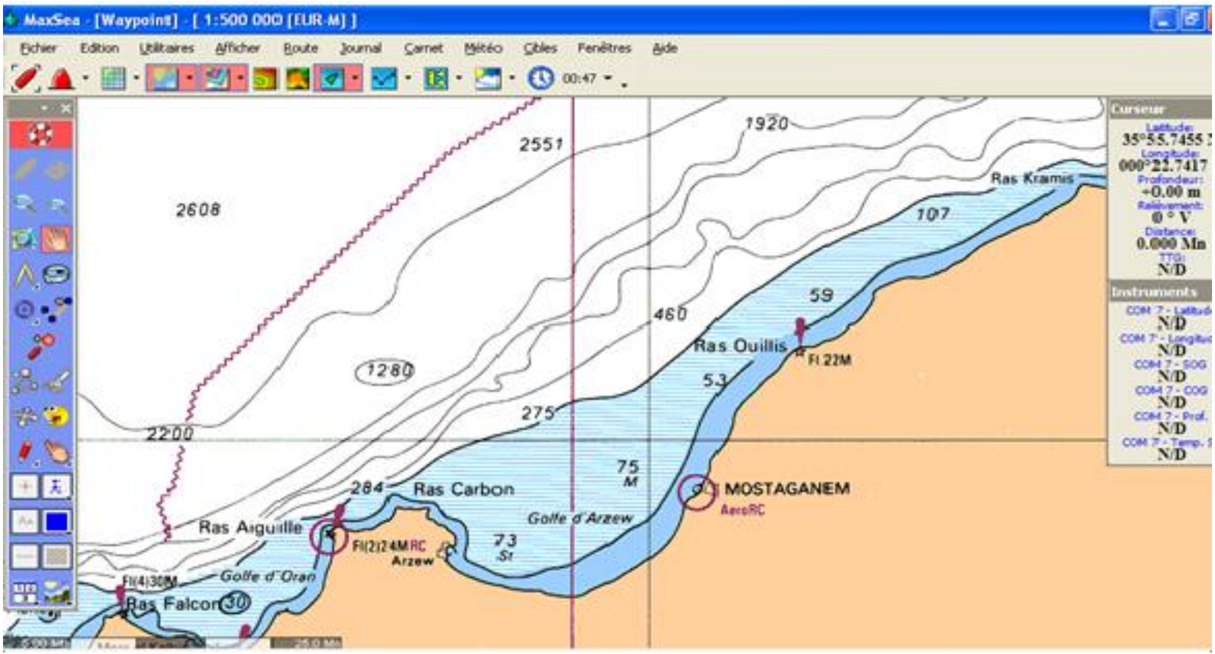

Fig. 1: Location map of the Algerian West coast: Arzew, Oranand Mostaganem (Boutiba et al., 2003, in Kies et al. 2012)

Mostaganem is bounded on the north by the Mediterranean Sea, to the West by the provinces of Oran and Mascara, to the East by the province of Cheliff and south by the Relizane city. It is characterized by a semi-arid climate in summer and mild in winter, with a variant rainfall between 350 mm on the plate and 400 mm on the foothills of Dahra (Belhadj, 2001, Belbachir, 2012, Kies et al. 2012). Mostaganem has a coast line extending over 124 km with a depth of thiscoastal area not exceeding three (3) kilometers and has an approximate area of 300 km^2 or 13% of the total area of the province Mostaganem. The submarine shelfis very wide both in length and breadth. Its underwater terrain consists of gentle slopes with sandy and clayey fonts and fonts isolated with rocky places (Belbachir, 2012, Kies et al. 2012). Given its location in the bay and its Arzew near Oran, ports Bethioua, Arzew and its industrial center, Mostaganem holds many opportunities for economic growth. It's an outlet for the other cities like Relizane, Tiaret and Mascara.

Space-time evolution of environmental climate

Surface winds: winds create horizontal movement (wave motion) that agitates the surface of the sea (forced waves) (Grimes et al. 2003, Kies & Taibi, 2011). They are the origin of certain ocean currents called "current pulse". These currents reach a speed whose value corresponds to 1 to 5% of the winds that generatethem (Kies & Taibi, 2011, Kies et al. 2012). They are influenced by coastal morphology (eg littoral drift whose direction is oblique to the coast) and the underwater terrain (Leclaire, 1972, Guibout, 1987, Gagneur & Kara, 2001, Grimes et al. 2003, Bouras & Boutiba, 2004, Bouras et al. 2006, Bouras, 2007, Kies and Taibi, 2011, Kies et al. 2012). Knowledge of management, power and frequency is important for the development of hydrodynamics (Guibout, 1987, Aminot et al. 1994, Grimes et al. 2003, Kies & Taibi, 2011, Kies et al. 2012). Wind is the basic element in temperate climates, such as the Algerian coast. Depending on its direction, it leads us either if breath of fresh air masses and unstable directions North-West (NW) and North-East (NE), or mild air masses and relatively humid s' heblows directions West (W) or East (E). Currents South-East (SE), and those of South-West (SW), are more or less dry and cold winters and hot and dry in summer (Grimes et al. 2003, Bouras & Boutiba, 2004, Bouras et al. 2006, Bouras, 2007, Kies and Taibi, 2011, Kies et al. 2012). By its strength (or speed), wind speeds turbulence in the lower layers and tends to reduce the temperature differences from one place to another.

Wind data available surface are obtained from meteorological records of Oran and Mostaganem cities (2012-2013). There is the existence of a strong seasonal signal in the winter and fall season defined, respectively, a maximum in March and October and a minimum in August. The annual signal appears and shows a less wind on dominance Oran than other stations and a net decrease of the wind speed side. A series recording, the wind varies between 100 and 175 Km/h in different directions. In the rest of the series, the wind varies between 0 and 90 km/h, with widely varying directions and sources. Note the presence of the hot wind (Sirroco) from the South. There are two distinct periods for winds on the Mostaganem coast; one runs from September to April with frequent cold winds West (W) ward direction (W) and North-West (NW), the other with hot winds or direction is East (E) in the North- East of the month from May to August (Kies et al. 2012).

Pluviometry: the average monthly rainfall, different weather stations (2012-2013) show maxima and minima of unequal amplitude, generating various reconfigurations and ecological responses of the entire coastal ecosystem. The main maximum rainfall in Oran is centered on the month of October to December and averaged 150 mm while the secondary maximum, centered on the months of January to April, do not exceed 60 mm on average. Minimum in July and August do not exceed 10 mm. This is perfectly consistent with the seasonal maximum temperatures. Indeed, when they cancel, precipitation increases and vice versa.

Temperature: it's a fundamental element in Oceanography. This factor control surface trade intensity and sea-atmosphere conditions widely and significantly ecology of marine and coastal systems (Ramade, 1998, Ramade, 2000, Bouras and Boutiba, 2004; Kies et al. 2012).

The surface temperature observations periods between 2012 to 2013 of Oran regions, Arzew and Mostaganem, primarily along the coast and over the Algerian continental shelf indicate the presence of strong seasonal fluctuations. A decrease in temperature from September to February there with a minimum value in December-January (T = 5-8° C) and an increase from March to June with a maximum recorded from July to August (T = 35-38° C).The average seasonal temperature variability along the coast and Oran plateau, shows absolute minimum (Fig 2). In addition, as the temperature at the surface and subsurface y increases from East to West. The various data (Guibout. 1987, Grimes et al. 2003) showed that the depth of the thermocline is lower in the East than in the West and it is the same with the amplitude of the seasonal variability. However, it can be noted a cooling period, particularly in winter, slightly greater (2 to 3 weeks). If we moved along the coast to Oran Mostaganem, we could note the similarities suddenly transform East of Mostaganem. It is conceivable that the meridians and vertical axes are taken respectively from South to North and depth to the surface, the coherent distribution emphasizes the near-simultaneity of ski (upwelling) sea level (Millot, 1989).

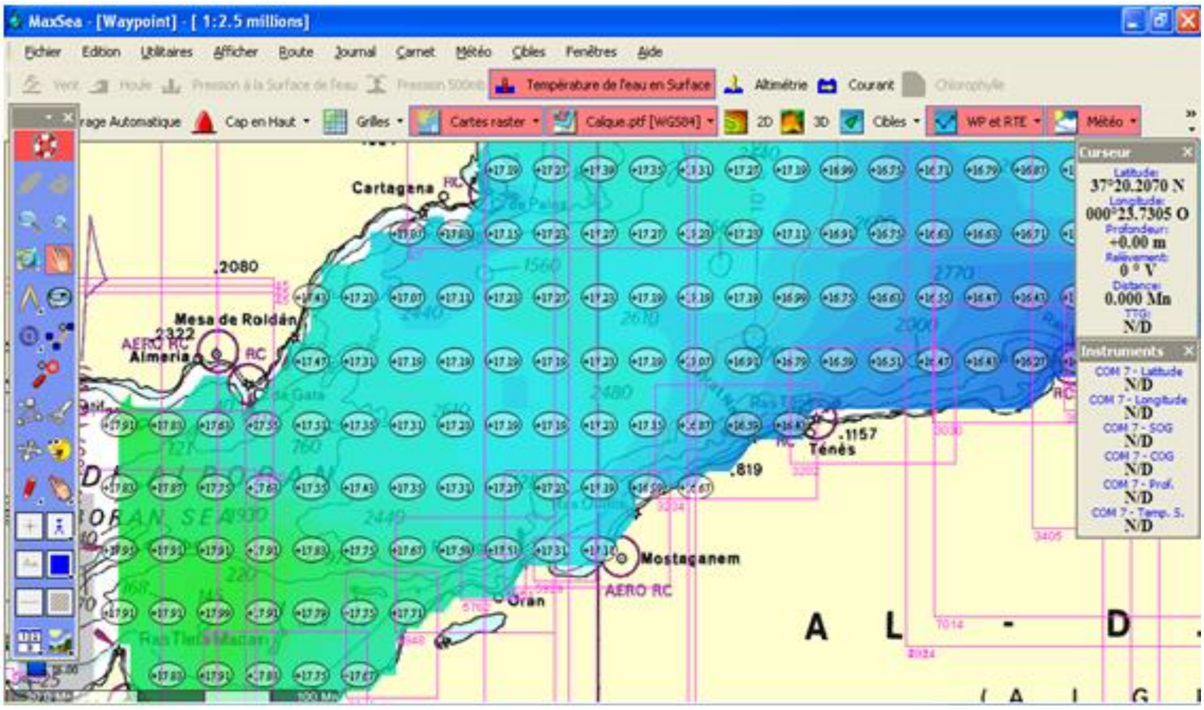

Fig. 2: Map of average temperatures (16-17° C in spring time) surface sea water of the wilaya: Oran and Mostaganem (Kies et al., 2012).

Salinity: as temperature, salinity is a very important physical parameter in Oceanography. It plays a vital role in the density and quality of water and its occupation, but also for determining the speed of the geostrophic current (Guibout, 1987, Grimes et al. 2003, Kies et al. 2012). Surface salinity in the vicinity of the coast (Oran station), has a relatively constant signal which is of the order of 36-38 %. These fluctuations are associated with changes in local rainfall and temperatures for which the maximum is in summer. Salinity decreases slightly winter summer period which corresponds to the maximum temperature. This seasonal trend is extrapolated to the entire ecosystem of the continental shelf and this modification differs from that of the temperature by a monthly increase of energy. This difference can be explained by the contribution of rivers Mactaa and Cheliff (Kies & Taibi, 2011, Kies et al. 2012), whose effects on variability are more important for surface salinity than for temperature. It should be noted that a better analysis of this energy requires records to a longer time scale (Grimes et al. 2003, Bouras & Boutiba, 2004). Changes in the level of the sea surface (elevation - reduction) are squared with changes in marine and coastal whole dynamic. Therefore, the average level is a better indicator of the occurrence of seasonal hot and cold periods (lifts and drops of water). The transformation of the average level during the year clearly reveals the presence of two minima recorded in July and August, and two maxima recorded from January to March. The absolute maximum is autumn, from October to November period, which simultaneously is the beginning of the rise, maximum rainfall and finally the maximum speed of the rivers and water such as Cheliff (Kies & Taibi, 2011, Kies et al. 2012) and Mactaa (Grimes et al. 2003, Kies et al. 2012).

Current variability: the current is maximum at the surface and decreases in depth; the normal current path off the Gulf of Arzew is oriented mainly towards the East (Grimes et al. 2003). The velocities off the latter are 30-40 km from the coast and 50 m depth, reaching 20 to 30 cm / sec to 300 m depth. This current creates a current flowing in against the direction of clock wise, its speed is very low, it is of 08 cm/s (Kies and Taibi. 2011, Kies et al. 2012); it can increase when winds North Atlantic and they are original and under the influence of the flow from the Strait of Gibraltar dominates the wide area Mostaganem, Arzew and Oran. It acquires the name of Algerian current, this current flows along the Algerian coast with a width of 50 km Within 1° E 36° 30' N character becomes apparent with the creation of cyclonic and anticyclonic eddies involving upwelling (Grimes et al. 2003, Kies & Taibi, 2011). These turbulent structures cause a significant mix of Mediterranean and Atlantic waters. The following figure shows the flow of dirty water of Atlantic origin (Modified Atlantic Water: MAW). The Algerian current (name introduced to emphasize the unstable nature of the flow of MAW along the Algerian coast) seems to generate vortices 100-200 Km likely to come then interact with him for months (Fig.3).

The current observations obtained on the longitude of Oran, were used to study the spatio-temporal variability of the intensity of the currents, the seasonal scale, the dynamics of continental shelf waters, the maxims of stream West dominate the surface, January to February and maxims current is observed when the current of the Gulf of Arzew tends to weaken (July, August and October). These various oceanographic parameters lead us to discuss the seasonal variations in oxygen content (Kies et al. 2012). Indeed, in the hot season, the oxygen dissolved in the waters of the Algerian continental shelf decreases rapidly from the surface to the depth (Leclaire, 1972). By cons, in the cold season, there is a strong homogenization across the water layer (Servain et al. 1982). In both cases, the content of O_2 varies with depth, which is consistent with a shallow upwelling. The seasonal distribution of dissolved oxygen is related to the thermal envelope, depth and rainfall, but also with the intensity of an ecosystem such as the Posidonia meadow (Belbachir, 2012). Moreover, this level of differences may reflect relatively biological activity. In addition, note well the role of sunlight in the photosynthetic process. Indeed, close to the coast (less than 50 m isobath), transparency of seawater decreases mainly with biological activity when the cold season is established. Moreover, sunshine defines well both the level of dissolved and the maximum zooplankton biomass oxygen. From West to East, the sun is stable and significant annual signal relative to the seasonal signal that is fully in line with changes in temperature (Bouras and Boutiba, 2004).

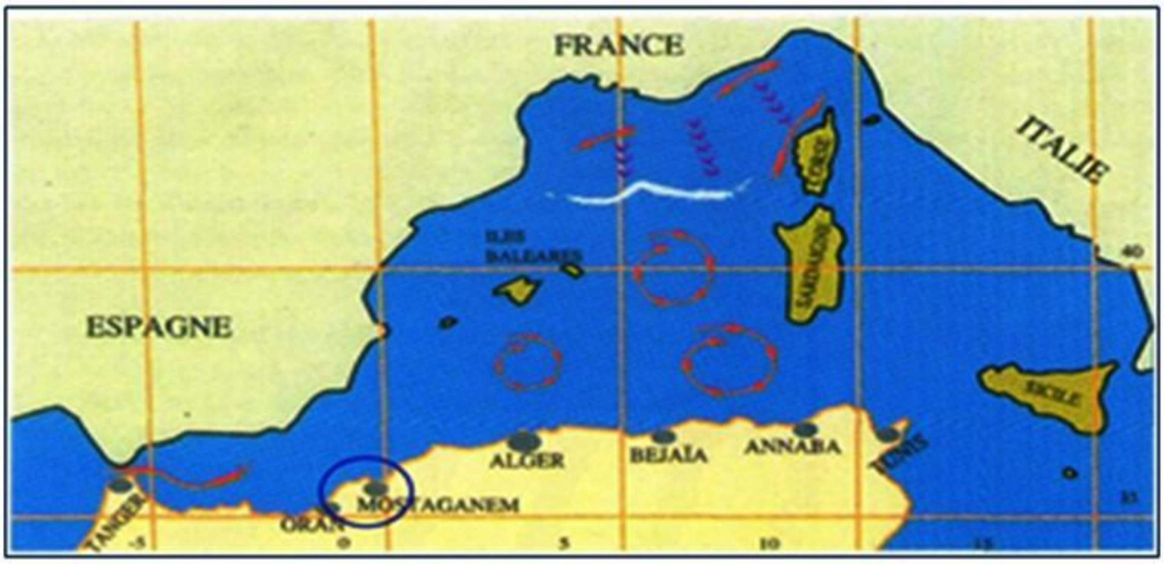

Fig. 3: Flow of sea water of Atlantic origin (red arrows) (from Millot, 1993: in Atlas of the Environment, 2002).

<u>Waves</u>: the sea surface usually has an indefinite following almost identical parallel ripples that spread substantially uniformly towards the shore. This set of undulations or waves is called heave. On the coast of Mostaganem, swells are an important ecological factor in the absence of permanent currents (Kies and Taibi, 2011, Kies et al. 2012). They are seasonal with 02 main directions; a direction of 30° W and direction NNE 20° to 40°. These waves occur during the winter and on average from August to October seconds.

Terrigenous inputs: the rivers and waters of the Algerian West coast certainly play a rewarding role in biological and Marine Dynamics (Kies and Taibi. 2011, Kies et al. 2012). Runoff convey solids or dissolved solids (organic or inorganic) and discharged directly to sea during this transport, vegetation cover determines the intensity of erosion. It is 10 to 15 times more severe than in savanna forest. Plants carpet usually burned or subjected to row crops, are much more susceptible to erosion than natural vegetation (Roose, 1981). Nevertheless, the solid fillers and Mactaa Cheliff (Kies and Taibi. 2011, Kies et al. 2012) are fairly constant and fairly proportional to flow which varies according to the season. So they have a very clear and distinct seasonality. Transport suspensions are less important. In addition, some substances can pass into solution when rivers mix with seawater and enrich it (Redfield et al. 1963, Kies and Taibi, 2011, Kies et al. 2012). It is therefore expected that the organic particles are immediately consumed by marine life. Soluble minerals to Mactaa are small and do not undergo large seasonal variations. Note that silica forms, from September to March, half of the load. Moreover, the contents of nutrients decrease as the volume of water increases passed for almost all elements except silica (Redfield et al. 1963, Conley et al. 1993, Kies and Taibi. 2011, Kies et al. 2012). The most sensitive to the effect of dilution factors are, among others, the nitrates, and organic materials. Ultimately, it appears that the soil deposits at the Algerian coast are qualitatively and relatively rewarding (nitrogen content) during floods (October-April). But it is likely that large floods they become dominant (September, October, November) due to the amount of silica rejected. According to various observations, silica would be exhausted in euphotic zone before nitrogen and phosphorus consumption in the planktonic diatom bloom rich (Conley et al. 1993, Kies and Taibi, 2011, Kies et al. 2012). Bouras and Boutiba (2006, 2007) reported that silica could become the first limiting nutrient salt after a bloom of diatoms (Redfield et al. 1963, Conley et al. 1993, Kies and Taibi. 2011, Kies et al. 2012). In addition, the flood rainy months could raise any limitation silica and enable strong development of diatoms. This would explain why zooplankton biomass indirectly months strong upwelling is related to both the intensity of cooling and flood volume.

Rivers of the West Algerian

Beside the Mactaa which is classified as a wetland of international importance signed in RAMSAR, River Cheliff is located in North West coast of Mostaganem, it is the longest river in Algeria; It's 700 km long with a flow rate of about 2700 m^3/s (Belhadj, 2001, Gagneur and Kara. 2001, Grimes et al. 2003, Al-Asadi et al. 2005, Kies and Taibi. 2011, Kies et al. 2012). It passes through different wilayas such as Mostaganem, Relizan, Ain-Defla and Cheliff. The River Cheliff is dynamic, highly variable and plays crucial roles in the structure, the function and the evolution of the coastal pelagic ecosystems of the bay of Mostaganem (Belhadj, 2001, Kies and Taibi, 2011, Kies et al. 2012). Nutrient availability (Armatrong and Butler. 1960, Redfield et al. 1963, Aminot et al. 1986, Aminot, 1988, Aminot and Guillaud. 1990, Gaujous and Aminot, 1990, Aminot et al. 1994, Aminot et al. 1998, Billen and Garnier, 2007, Garnier et al. 2010, Kies et al. 2012) at River Cheliff controls the abundance and structure of phytoplanktonic populations (Redfield et al. 1963, Bougis, 1974, Aminot et al. 1994, Garnier et al. 1995, Aminot et al. 1998, Belin and Raffin, 1998, Videau et al. 1998, Al-asadi and Randerson, 2006, Kies et al. 2012) at the bay of Mostaganem (Bougie, 1974, Ramade, 1998, Ramade. 2000, Kies and Taibi, 2011, Kies et al. 2012).

It is considered as a source of land-based pollution of coastal Mostaganem, due to the presence of several urban and industrial units discharge in gap stream (Redfield et al. 1963, Bougie, 1974, Kies and Taibi, 2011, Kies et al. 2012). The drainage basin is West ward during floods and East ward periods of drying up. The large population in the watershed Cheliff is estimated at more than 3.000.000 (three million), the estimated rate of rejected waste water affecting the quality of water is 72,000 m^3/d. The North-Eastern part of Cheliff was banned swimming because of pollution from the beach.

Consequences of climate change on west marine ecosystem of Algeria

Phytoplankton abundance: a total of 74 phytoplankton species were identified during our survey in the two stations; the first one is located at the bay of Mostaganem, the second one was in the Gulf of Oran. The dominant group is Chlorophyta (along the period of study especially in summer time) followed by Chrysophyta group which proliferates in autumn 2012 (Fig. 4). At Station 1, the maximum of Cyanophyta (blue-green algae) was recorded in May 2012, and the minimum in January 2013 (Table 1). At Station 2, the maximum of blue-green algae was recorded in November 2012, and the minimum in February 2013 (Table 1). Euglenophyta species were found at Station 1 (Bay of Mostaganem), during the sampling period. A maximum was recorded in August 2012 and the minimum in January 2013 (Table 1). *Euglena* species were found too during the sampling period at Station 2 (Gulf of Oran) with value ranged between a maximum at July 2012 and a minimum at December 2013 (Table 1). The Green algae (Chlorophyta) were dominant at Station 1 than at Station 2 (with 42 and 38 species respectively). In May 2012, the maximum number of green algae was recorded at both stations (Table 1). The minimum was recorded in January 2013 at Station 1 and in March 2013 at Station 2 (Table 1). The maximum number of diatoms (Bacillariophyta) was recorded in June 2013 at both stations (Table 1). Low numbers of diatoms were found in November 2012 at Station 1 and in March 2012 at Station 2 during the sampling period (Table 1). This phylum was found in five of 10 occasions at Station 2.

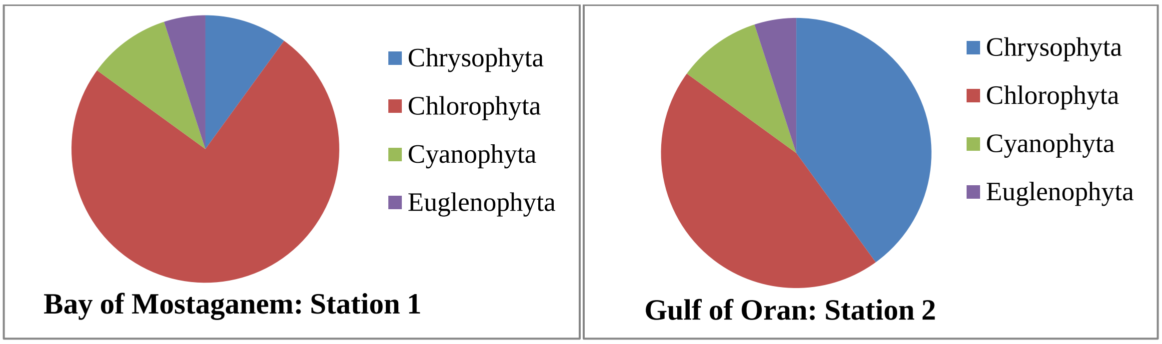

Fig. 4.Relative abundance of algal phyla during the studied period (2012-2013)

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

Phyla	Station 1		Station 2		Dominated Genera at stations 1&2	Rare algae species and Genera at station 1
	Max	Min	Max	Min		
Chrysophyta	06.2013	11.2012	06.2013	03.2012	*Nitzschia*	
					Navicula	*Melosira granulata*
					Cyclotelle	
					Gyrosigma	
Chlorophyta	05.2012	01.2013	05.2012	03.2013	*Strombomonas*	*Pediastrum*
					Scenedesmus	*Tetraedron*
					Oocystis	*Staurastrum*
					Dictyococcus	*Cosmarium*
					Tetrahedron	*Monoraphidium*
					Coelastrum	*Chlamidomonas*
Cyanophyta	05.2012	01.2013	06.2013	01.2013	*Oscillatoria subsalsa*	*Oscillatoriatenuis*
					Nostocopsis	
					Microcystis	
Euglenophyta	08.2012	01.2013	07.2012	12.2013	*Euglena*	*Trachelomonas*

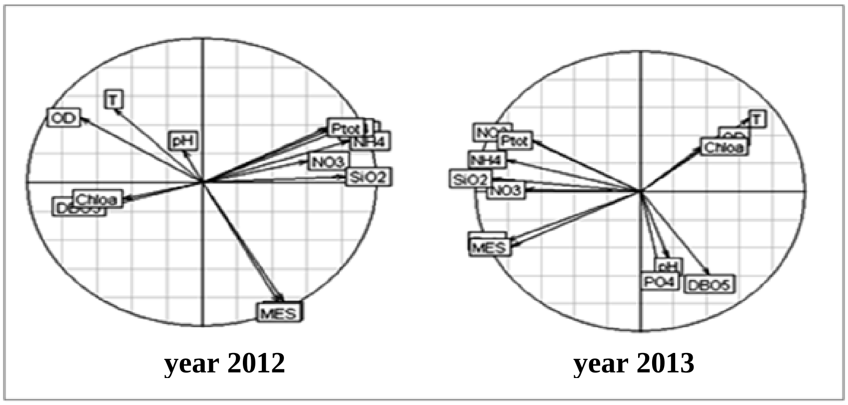

Fig. 5. Connectivity between River (Chellif) and the sea (Mostaganem shallow water area) during 2012 and 2013.

The bay of Mostaganemwas strongly dominated by Chlorophyll A (Redfield et al. 1963, Gagneur and Kara, 2001, Al-Asadi et al. 2005, Kies et al. 2012), whereas the Gulf of Oran had equal proportions of diatoms (i.e.: *Nitzschia acicularis*, *Cyclotelle meneghiana*) and green algae (i.e.: *Oocystis*, *Scenedesmus*).

Connectivity between River and the sea: by analyzing the circle of correlations of the variables obtained during the two year (2012 and 2013) (Fig.5) using R "Programming Environment for Data Analysis and Graphics" (Venables and Smith 2011), we notice for this period "of connectivity" that nutrients [NO_2 (nitrites), NO_3 (nitrates), NH_4 (ammonia), Ptot (total phosphorus), SiO_2 (silicates)] are very dependent parameters with Chloa (chlorophyl a), which support an increase of MO (organic matter) represented by the DBO_5 (biological demand for oxygen), while parameters [OD (dissolved oxygen) and T° (temperature)] are related to the availability of the suspended matter (MES) and to the turbidity (Turb). Since it is a consumption of the various nutrients (N, P, Si) by the phytoplankton species with almost the same concentration. Therefore, there is a phytoplanktonic diversity for the period of connectivity between the river and the sea.

Conclusion

The study and analysis of bioclimatic changes are essential for a better understanding of our environment. In addition, the results of our research finds that the annual patterns obtained are very similar and we can speak of relative regional originality. Two large units contrast sharply with a cold unit which extends from September to April, with a maximum intensity between December and February. This sequence, which can be likened to the cold season, is quite marked in Mostaganem and Oran. A hot unit which extends from May to August, but particularly marked in July and August. This period can be characterized by a cooling between Arzew and Mostaganem. This representation assigns overall seasonal cutting likely to be found across the Algerian coast. The strongest average annual accentuation of ascent is noted between Arzew and Mostaganem, while the lowest value is raised to the station of Oran. The other points of the Algerian West coast have average annual expressions comparable Terga and Maddagh. A trend we notice a gradual decrease in the activity of the reappearance of the cold season, which thus has a minimum intensity facing the West coast of Cape Falcon. Moreover, the thermal evolution defined clearly reflects the prevailing conditions imposed above the continental shelf. Indeed, based on inputs conveyed to the sea (rainfall, temperature, wind) and those put together by the internal dynamic marine, then we can distinguish year low enrichment that match lean years in terms of any change continental and marine conditions, generally of short duration and high enrichment of years corresponding to eventful years and transformations of continental and marine conditions, strong shifts in time. And a hot or cold but very fluctuating period influence the marine ecosystem and phytoplankton growth.

References

Al-Asadi, M. S., P.Randerson, and K. Benson-Evans, 2005. Phytoplankton population dynamics in three West Algerian rivers: III. The Tafna River and its tributary the Remshy River. Marina Mesopotamica Online 1: 37-57.

Al-Asadi, M., and Randerson P., 2006. Phytoplankton Population Dynamics in Three West Algerian Rivers: I – The River Cheliff and its Tributary, the River Mina. Marina Mesopotamica Online. Vol. 1, pp. 48-72.

Aminot, A., and M. Chausspied, 1983. Manuel des analyses chimiques en milieu marin, Centre National pour l’Exploitation des Océans (CNEXO).

Aminot, A., R. Keroual, and J-L. Mauvais, 1985. Les sels nutritifs en Baie de Seine. In: La Baie de Seine (Greco-Manche)- Université de Caen, IFREMER. Actes de Colloques, 4 : 289-296.

Aminot, A., R. Keroual, and J.L. Mauvais, 1986. Les éléments nutritifs en Baie de Seine, IFREMER, Actes de Collogues, 4 : 289-296.

Aminot, A., 1988. Le phosphore, ses dérives et leurs comportements dans le milieu naturel, Collogue de l’A.I.D.E, Dijon.

Aminot, A., and J-F. Guillaud, 1990. Apports en matière organique et en sels nutritifs par les stations d’épuration, IFREMER, Centre de Brest, Actes de Colloques, 11: 11-26.

Aminot, A., J.-F. Guillaud, and R. Kerouel, 1994. La baie de Seine : hydrologie, nutriments et chlorophylle (1978-1994). Editions IFREMER, Repères Océan 14. 148 p.

Aminot, A., J-F. Guillaud, F. Andrieux-Loyer, F. Keouel, and P. Cann, 1998. Apports de nutriments et développement phytoplanctonique en Baie de Seine. IFREMER, Acta Oceanologica, 21: 923-935.

Armatrong, F-J., and E-I.Butler, 1960. Les variations de la teneur des eaux en silicium dissous (en ug de SI par litre).

Aubert, M., B. Donnier, and M. Barrlli, 1973. Etude générale de la toxicité des pollutions chimiques. 161.

Belbachir, N. 2012. Contribution à l'étude écologique de l'herbier à *Posidoniaoceanica* (L.) Delile (1813) de la frange côtière de Mostaganem: Etat de santé et relation entre plante et échinoderme. Mémoire de Magister en Biologie, Faculté des Sciences de la Nature et de la Vie, Université de Mostaganem , Algérie.

Belhadj, M., 2001. Etude de la pollution des eaux du bassin de Cheliff et son impact sur l'environnement. Mémoire de Magister en Chimie de l'Environnement, Faculté des Sciences de l'ingénieur, Université de Mostaganem, Algérie.

Belin, C., and B. Raffin, 1998. Les espèces phytoplanctoniques toxiques et nuisibles sur le littoral français de 1984 à 1995, résultats du REPHY (réseau de surveillance du phytoplancton et des phycotoxines). Rapport Ifremer RST.DEL/MP-AO 98-16, 2 tomes. 283 p.

Belin, C., J-F. Guillaud, A. Lefebvre, M. Merceron, and P. Souchu, 2001. L'eutrophisation des eaux marines et saumâtres en Europe, en particulier en France. Rapport IFREMER DEL/EC/01.02, PP. 32 – 44.

Billen, G., and J. Garnier, 2007. River basin nutrient delivery to the coastal sea: assessing its potential to sustain new production of non-siliceous algae. Marine Chemistry 106: 148-160.

Boubenia, R., 2011. Analyse de la distribution spatiale des espèces démersales de la côte algérienne à partir des compagnes océanographiques, Mémoire de magister en Océanographie biologique et environnement marin, Faculté des Sciences de la Mer , Université de Beb El Zouar-Alger, Algérie.

Bougis, P., 1974. Ecologie du plancton marin. Le phytoplancton, Tome 1, Masson et Cie, Paris VI,

Bouras, D. 2007. Dynamique bioclimatique et morphologique de la zone côtière oranaise (Algérie Nord Occidental). Thèse de Doctorat de l'Université d'Oran, Algérie, 200p.

Bouras, D., A. Kerfouf, Z. Boutiba, K. Hussein Boumedienne, and S. Mouffok. 2006. Régime et aspect hydrographique de l'Algérie nord occidentale, CILEF, Hammamat, Tunisie, Mars.

Bouras, D., and Z. Boutiba. 2004. Ecologie discipline d'impact, Ed. 3 pommes, Oran, Algérie. 117p.

Conley, D.J, C.L. Schelske, and E.F Stoermer. 1993. Modification of the biogeochemical cycle of silica with eutrophication.Marine Ecology Progress Series 101: 179-192.

Darley, B., 1992. Poissons des côtes Algériennes. Institut National des Enseignements Scientifiques en Agronomie, Tizi-Ouzou, Algérie, Edition Office des Publications Universitaires, Alger.

Gagueur, J., and H. Kara, 2001. Limnology in Algeria. In: Wetzel, R. G. and Gopal, B. (eds), Limnology in Developing Countries, 3: 1-34.

Garnier J., G. Billen, and M. Coste, 1995. Seasonal succession of diatoms and chlorophyecae in the drainage network of the River Seine: observations and modelling. Limnology and Oceanography, 40: 750-765

Garnier, J., G. Billen, S. Even, H. Etcheber, and P. Servais, 2008. Organic matter dynamics and budgets in the maximum turbidity zone of the Seine Estuary (France). Estuarine, Coastal and Shelf Sciences: 77: 150-162,

Garnier, J., G. Billen, J. Némery, and M. Sebilo, 2010. Transformation of nutrients (N, P, Si) in the turbidity maximum zone of the Seine estuary and export to the sea. Estuarine, Coastal and Shelf Science, 90: 129-141,

Gaujous, J-F., and A. Aminot, 1990. Devenir des éléments nutritifs en zone littorale, IFREMER, Centre de Brest. Actes de Colloque, 11 : 27-34,

Grimes, S., Z. Boutiba, A. Boukalem, M. Bouderbala, B. Boudjellal, S. Boumaza, M. Boutiba, A. Guedioura, A. Hafferssas, F. Hemida, N. Kaidi, H. Khelifi, F. Kerzabi, A. Merzoug, A. Nouar, Sellali B., H. Sellali-Merabtine, R. Semroud, H. Seridi, M-Z.Taleb, and T. Touhria. 2003. Biodiversité Marine et Littorale Algérienne, Laboratoire Réseau de Surveillance Environnementale, Université d'Es Senia, Oran, ISBN N° 9961-9547-O-X.

Guibout, P. 1987. Atlas hydrologique de la Méditerranée, Lab. Océanographie physique, Muséum National d'Histoire Naturelle, Edit. IFREMER et SHOM, France. 150p.

Kies, F., and N.E. Taibi. 2011. Influences de l'Oued Chéliff sur l'écosystème marin dans la zone de l'embouchure – wilaya de Mostaganem, Editions Universitaires Européennes-EUE, ISBN: 978-613-1-58966-9, PP. 77-94.

Kies, F., K. Mezali and D. Soualili. 2012. Modélisation sous R de la pêcherie de Mostaganem et des flux de nutriments (N, P,Si) de l'Oued Chéliff (Algérie), Editions Universitaires Européennes-EUE , ISBN: 978-3-8381-8346-6.

Leclaire, L. 1972. La sédimentation holocène sur le versant méridional du bassin Algéro-Baléares (pré continent algérien), Mem. Muséum National d'Histoire Naturelle, Paris, France. 391p.

Millot, C. 1989. La circulation générale en Méditerranée occidentale: aperçu de nos connaissances et projets d'études, Annales de géographie, n° 549, XCVII, 498-515.

Nisbet, M., and J. Verneaux. 1970. Annales de limnologie. Composantes chimiques des eaux courantes. Discussion et proposition des classes en tant que bases d'interprétations des analyses chimiques, 1.6, Fasc. 2, 161-199.

Persson, P., 1976. La pollution des eaux continentales. Incidence sur les biocénoses aquatiques, Bordas, Paris.

Prud Homme, R., 1980. Le management de la nature des politiques contre la pollution, Bordas, Paris.

Ramade, F., 1998. Dictionnaire encyclopédique des Sciences de l'eau. Biogéochimie et Ecologie des eaux Continentales et Littorales, Ediscience International, Paris.

Ramade, F., 2000. Dictionnaire encyclopédique des pollutions. Les polluants. De l'environnement à l'homme, Ediscience International, Paris.

Redfield, A.C., B.H. Ketchum, and F.A. Richards. 1963. The influence of organisms on the composition of sea-water. In: Hill MN, editor. The sea. New York: John Wiley & Sons. p. 12–37.

Rodier, J., 1996. L'analyse de l'eau. Eaux naturelles. Eaux résiduaires. Eaux de mer, 8ème édition, Dunod, Paris.

Roose, E. 1981. Dynamique actuelle des sols ferralliques et ferrugineux tropicaux d'Afrique occidentale, Trav. Doc. ORSTOM, 130-569, Paris, France.

Servain, J., J. Picaut, and J. Merle. 1982. Evidence of remote forcing in the Atlantic Ocean. Journal of Physical Oceanography, 12: 129-135.

Sigg, L., P. Behra, and W. Stumm. 2000. Chimie des milieux aquatiques. Chimie des milieux naturels et des interfaces dans l'environnement, 3ème édition, Dunod, Paris.

Thieu, V., 2009. Modélisation spatialisée des flux de nutriments (N, P, Si) des bassins de la Seine, de la Somme et de l'Escaut: Impact sur l'eutrophisation de la Manche et de la Mer du Nord. Thèse de Doctorat, Université de Pierre et Marie Curie.

Venables, W.N., and D.M. Smith. 2011. The R development core team. An Introduction to R. Notes on R: A Programming Environment for Data Analysis and Graphics. Version 2.14.1 (2011-12-22).

Videau, C., M. Ryckaert, and S. L'helguen, 1998. Phytoplancton en Baie de Seine. Influence du panache fluvial sur la production primaire. Oceanologica Acta, 21 : 907-921.

Vollenweider, R.A. 1971. A Manual of Methods for Measuring Primary Production in Aquatic Environments. 2nd print. IBP Handbook No. 12, Blackwell Sci. Pub., Oxford and Edinburgh, 213 pp.