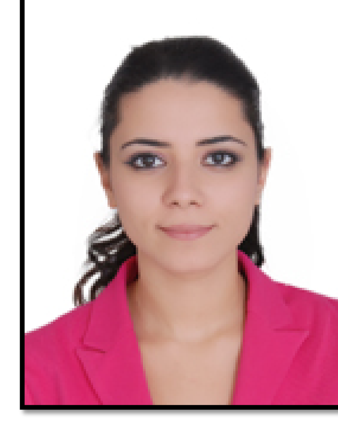

IMPACT OF ENVIRONMENTAL CHANGE ON THE DYNAMICS OF THE DINOFLAGELLATE POPULATION (VEGETATIVE FORM AND CYSTS.)

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INTRODUCTION

This study is part of the environmental monitoring, especially of the safety monitoring of the Moroccan coast (LSSR) by the INRH.

In this work we present the results of the palynological and phytoplankton analysis (vegetative cells and cysts contained in surface sediments), in the lagoon of Sidi Moussa between 2012 and 2013.

Basing on the distribution of dinoflagellates, this study aims to explain the repartition of the phytoplankton in the lagoon under various environmental pressures and thereby to define:

- the relationship between the physico-chemical parameters and this distribution ;
- the causes of the blooms of the species "*Peridinium quinquicorne*" and "*kryptoperidinium foliaceum*" ;
- the link between the cysts and the vegetative cells that may suggest that cysts can generate blooms;
- the environmental quality of this lagoon.

STUDY AREA

Figure.1. Geographical location of the Sidi Moussa lagoon.

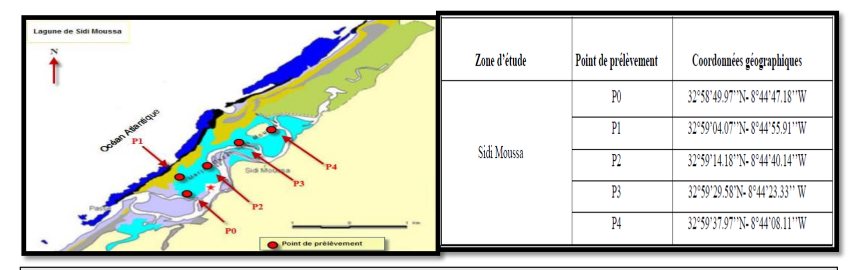


Figure.2. The geographical coordinates of the sampling points at the Sidi Moussa lagoon.

The lagoon of Sidi Moussa is located on the Atlantic coast of Morocco between the towns of El Jadida and Safi (Figure 1). Its geographical coordinates are between 32 ° 57 'and 32 ° 59' north latitude and between 8 ° 45 '8 ° 47' west longitude (El khalidi et al, 2011).

Physicochemical parameters

- The Chemical analyzes of different parameters were performed in the laboratory (chemistry) at the National Fisheries Research Institute (NHRI).
- These analyzes are performed on water samples (not fixed) taken in parallel with those intended for quantitative analysis of the phytoplankton population.

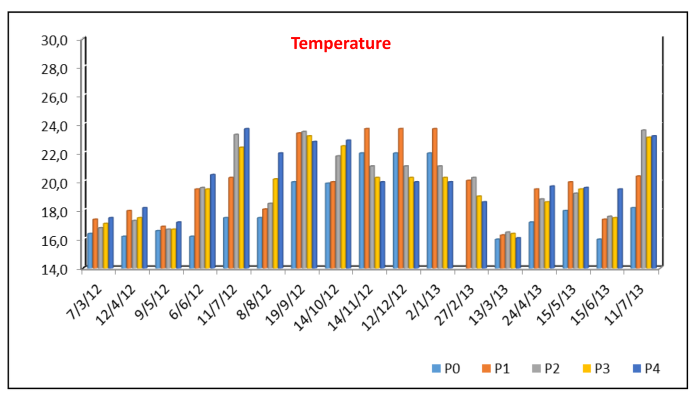


Figure 3 : Evolution of the temperature during the study period.

The minimum value of the recorded temperature is 16 ° C at P0,the maximum value is 22 ° C recorded during the summer of 2013 at the point3.

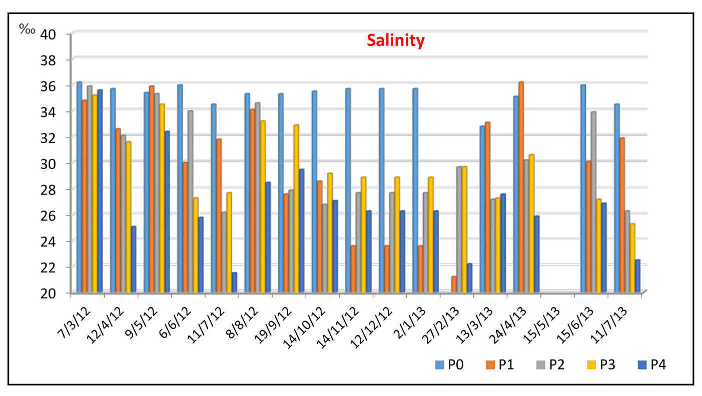


Figure 4 : Evolution of the salinity during the study period.

The salinity values follow a freshening gradient from downstream to upstream. The highest concentrations (36 ‰) are recorded at the point 0. Point 4 records the lowest values (29.3 ‰).

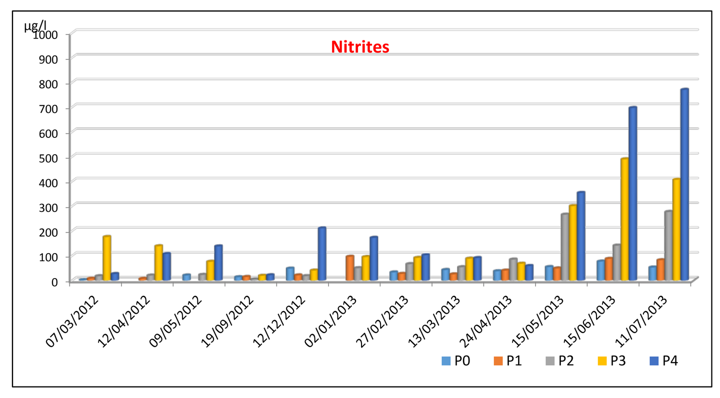


Figure 5 : nitrites measures during the study period.

The nitrate concentrations are low during the period of study until May where nitrite increase progressively up in July, the maximum values of 770.86 µg / l. These concentrations increase successively by going to coastal stations

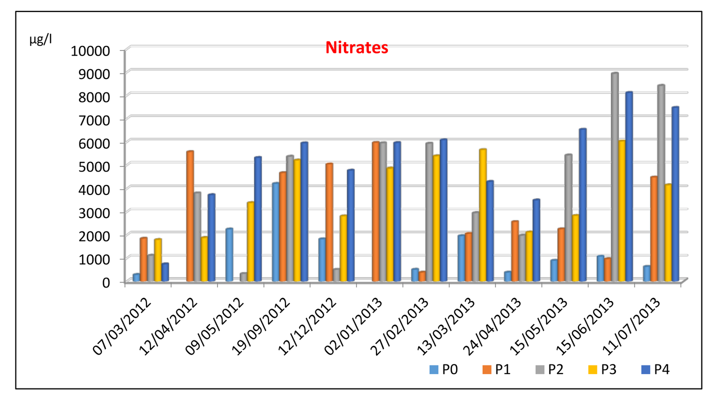


Figure 6 : nitrates measures during the study period.

During the study period, the concentrations of nitrates remain low at point 0 not exceeding 4216 µg / l.

in June, a considerable rise nitrates at stations observed (2, 3 and 4). This increase does not occur at station 0.

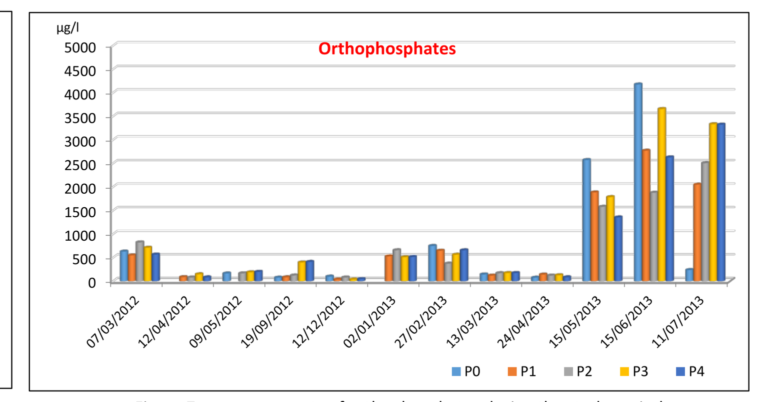
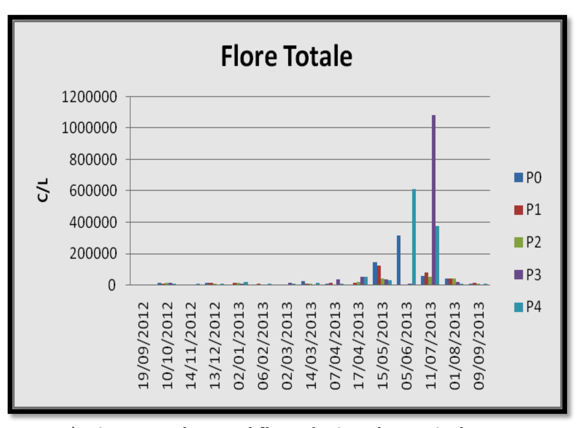


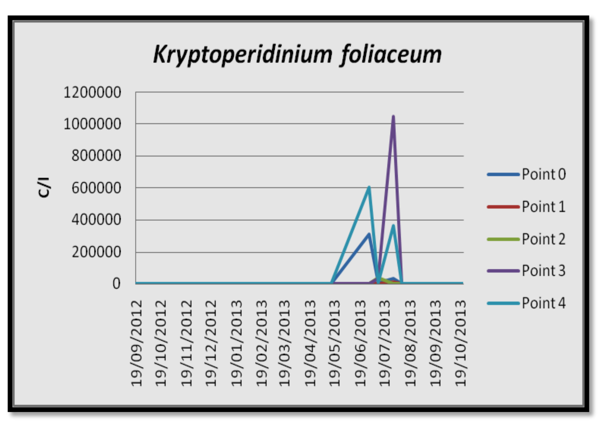
Figure 7 : measurements of orthophosphates during the study period.

The measured values of orthophosphate in the different sampling stations show minor changes in concentrations during the study period These concentrations increase progressively in the month of May to achieve, in June, the highest thresholds of 4177.19 g / l (point 4).

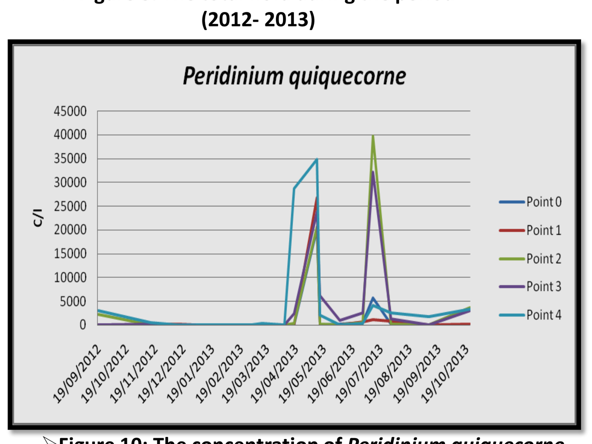
Dinoflagellates (vegetative form)



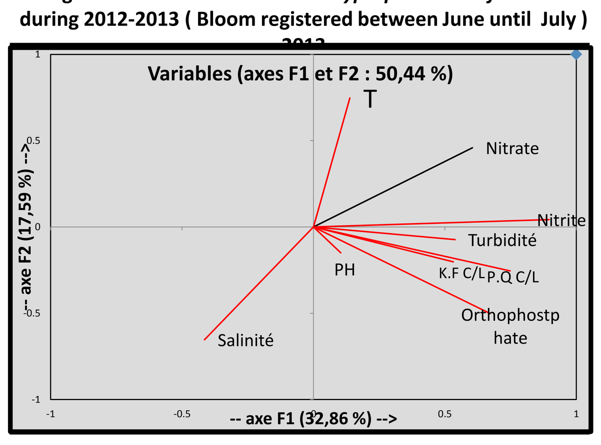
➢Figure 8: The total flora during the period (2012- 2013)



➢Figure 9: The concentration of *Kryptoperidinium foliaceum* during 2012-2013 (Bloom registered between June until July) 2013



➢Figure 10: The concentration of *Peridinium quiquecorne* during 2012 and 2013 (Bloom registered in May and July 2013)



➢Figure 11: Analysis of ACP

The phytoplankton qualitative analysis in samples from in the lagoon of Sidi Moussa during the study period (2012-2013), revealed the abundance of dinoflagellates and diatoms, on the Silicoflagellates group which are episodic .

Taxonomically, 59 taxa were identified 36 diatoms are represented mainly by : *Nitzghia sp, Thalassiosiera sp, Lauderia ,Chaetoceros sp, Navicula sp et Grammatophora marina.*

The 23 taxa of dinoflagellates listed in our samples are represented by genres : *Dinophysis sp, Alexandrium sp, Gymnodinium sp, Ceratium sp, et Protoperidium sp.*

The species of this genus dominating the dinoflagellates community with two massive blooms of two species: *Peridinium quiquecorne* et *Kryptoperidinium foliaceum.*

➢Bloom of *Perdinium quiquecorne*

The most important cellular abundance is saved months of May 2013 at point 4 at a rate of 42,320 cells / liter (Fig. 10). The minimum value was recorded (1.26 10^4C / l) near the pass at the point 0. A second proliferation of this species was recorded in July, with a maximum value of 3,2.$10^{5\ C}$ C/l, always at the bottom of the lagoon at the P3.

➢Bloom de *kryptoperidinium foliaceum*

While the cellular concentration *of Peridinium quinquecorne* decline in June, a massive proliferation of the species of dinoflagellates *kryptoperidinium foliaceum* was registered at the lagoon, with thresholds that exceeds 6.10^7C / l at the point 4 (Fig. 9). This proliferation was accompanied by a very good representation of genres : *Dinophysis sp* with concentrations that exceed 4.10^3 C / l, *Alexandrium sp* arriving at a threshold (1.10^2 C / l) with *Gymnodinium sp* (1.10^2 C / l) and the group , *Ceratium sp* (1.10^3 C / l).

These phytoplankton blooms appeared alternately in the Sidi Moussa lagoon during the period (May-July 2013).

The blooms of the species *Peridinium quinquecorne* were noted in several regions of the world: in China (Shen et al., 2001) , in Island (article journal), Golf of California (Ismael garate et al, 2007), North of Spain (Madariaga et al., 1989) , Golf of Mexico (Barón-Campis et al., 2005; Okolodkov et al. , 2007). some authors (Ismael Gárate-Lizárraga, 2008) have cited that the bloom *P.quinquecorne* always occur in the marine environment near the coast.

In Morocco it is the first time that this species proliferates in the lagoon of Sidi Moussa. This bloom has not been identified at points near the pass (0, 1 and 2), but it occurred at the bottom of the lagoon (points 3 and 4), so it's an autochton bloom with local cause.

Analysis of nutrient concentration curves (nitrite and orthophosphate) (fig5, 7) show very high values recorded between the months of May and July at points 3 and 4, where the species *P.quinquecorne* has proliferated. This proliferation may be related to the enrichment of environment by nitrate and orthophosphate, this is confirmed by statistical analysis (PCA) (Fig. 11) who shows a very good correlation between the elevated levels of nitrite and orthophosphate with increasing the cellular concentration of the species *P. quiquecorne*.

The same synthesis was developed by Shamsudin et al., (1996), who noted that the species *P. quiquecorne* prefers and proliferates in environments rich in nutrients.

Dinoflagellates (cysts)

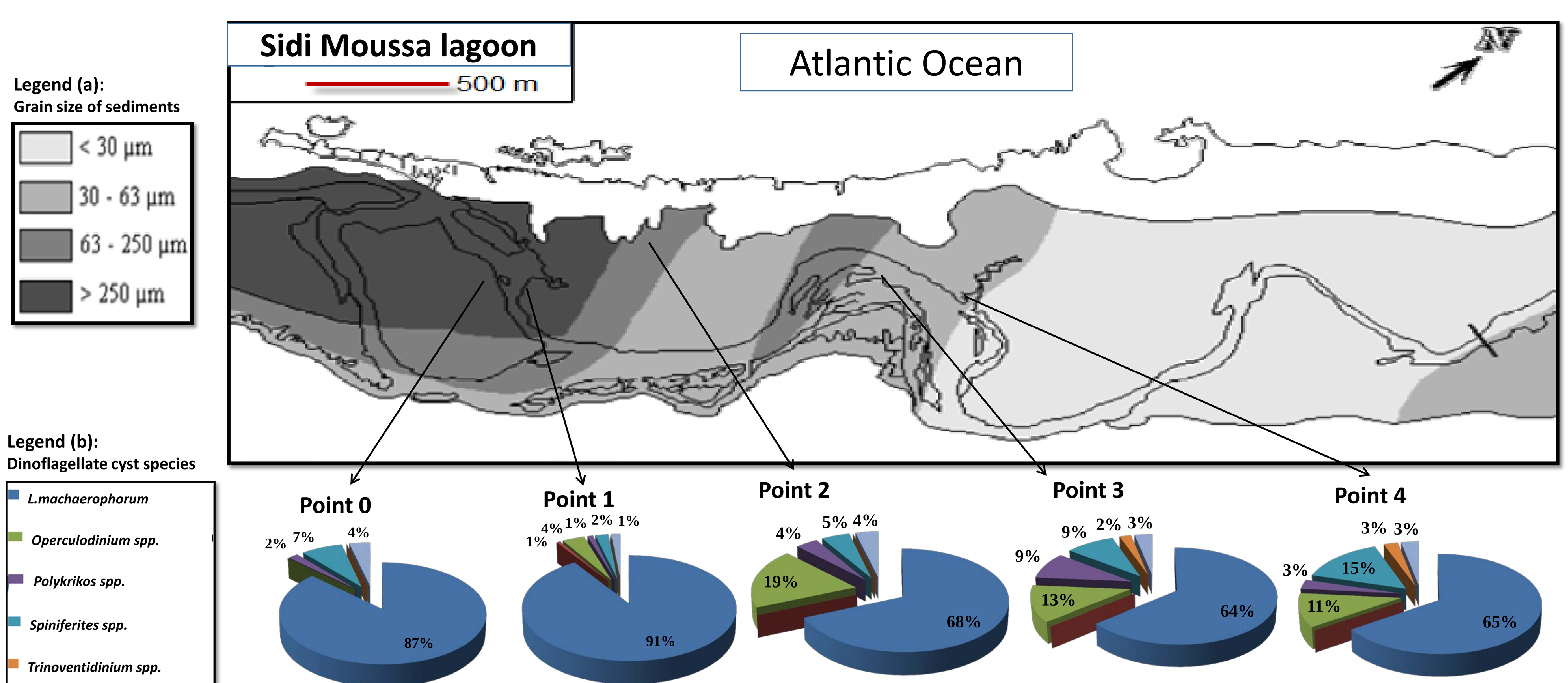
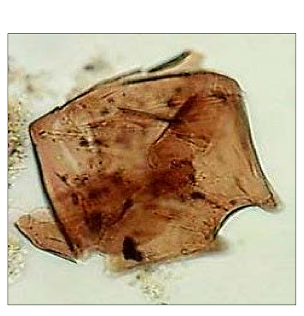


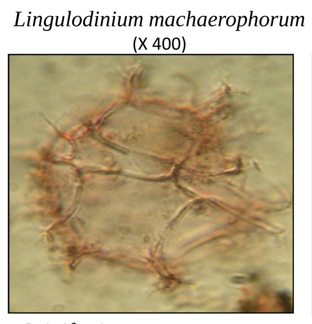
Figure 12: representation of the distribution of dinoflagellate cyst species in Sidi Moussa lagoon .

Lingulodinium machaerophorum (X 400)

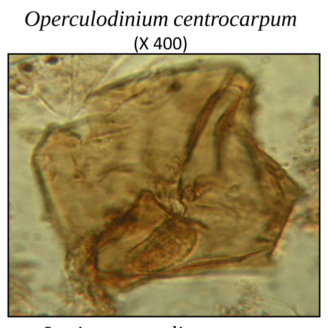
Operculodinium centrocarpum (X 400)



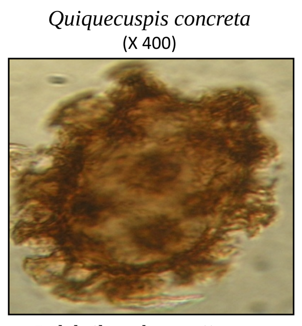
Quiquecuspis concreta (X 400)



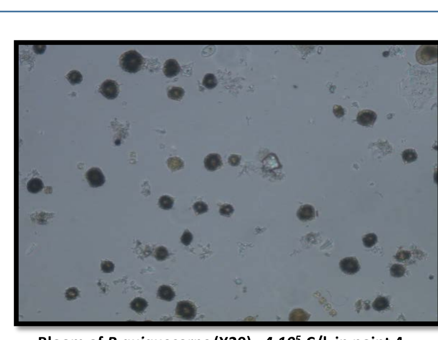
Spiniferties ramosus (X 400)



Leujencysta olivum (X 400)



Polykrikos shwartzii (X 400)



Bloom of *P.quiquecorne* (X20), *4.10⁵ C/l* in point 4, May 2013.

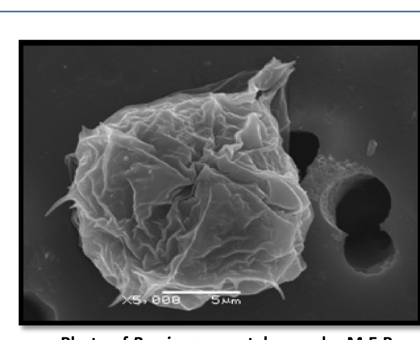
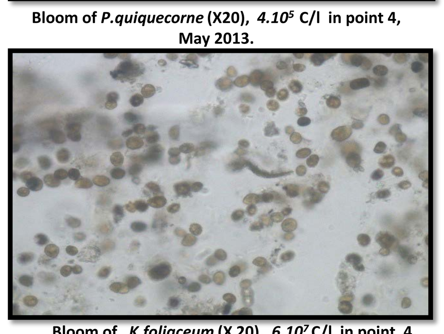


Photo of *P.quiquecorne* taken under M.E.B.



Bloom of *K.foliaceum* (X 20), *6.10⁷ C/l* in point 4, July 2013.

Presentation of the first apical plate of *K.foliaceum* species.

THE QUANTITATIVE STUDY

After palynological treatment of surface sediments, the organic content has yielded a modest richness of dinoflagellate cysts. The highest concentrations are noted in sites P3 (218 cysts) et P4 (218 cysts).

The particule size distribution (Fig. 12) of different facies shows that the silt fraction (less than 63um), is located at sites P3 and P4. The coarse fraction (greater than 250 µm) is marked at the P1 site, however P0 and P2 harbor the fractions between 63 µm and 250 microns. The levels of concentrations of dinoflagellate cysts, seems to have a relationship with sediment grain size.

In addition to low concentrations of dinoflagellate cysts in surface sediments, there is also a low species richness, it could be related to low salinity. Some researchers (Wall et *al*, 1977 ; Dale, 1996; Ellegaard, 2000; Mudie et *al*., 2001 ; Popeslova et *al*. 2004), also noted that oligohaline environments are characterized by low species diversity.

THE QUALITATIVE ANALYSIS

Cysts associations are dominated by the species *Lingulodinium machaerophorum* cyst species *Lingulodinium polyedrum*, to 90,47% in point 1, associated with this autotrophic species: *S.ramosus and O.centrocarpum* which are considered by ubiquist towords the temperature. They are found in a wide variety of marine environments neritic to oceanic (Marret & Zonnenveld, 2003).

These autotrophic species are accompanied by an association of heterotrophic cysts composed by : *Selenopemphix q*uanta (Bradford 1975), *Votadinium sp*, *Quinquecuspis concreta* (Reid 1977), *Trinovantedinium sp*, et *Lejeunecysta sp* .

Apart from the cyst *L.machaerophorum* , it was a dominance of heterotrophic cysts on autotrophic cysts. This dominance could be explained by eutrophication. Indeed in the port of Yokohama, this dominance has been interpreted as indication of the middle of eutrophication (Matsuoka 1999). It was also interpreted such as industrial pollution indicator in Norway (Sretre et al. 1997). The autotrophic / heterotrophic report can be used for the qualification of productivity, the signal upwelling, nutrient availability in the environment and the proximity of the continent (Wall et *al*, 1977, Bujak, 1984, Mudie, 1992, Harland et *al*. 1998, Dale, 1996, Mudie et Rochon, 2000 et Radi, 2008).

CONCLUSION

The study of dinoflagellate cysts from Lagoon Sidi Moussa (Morocco) is a premiere in the field considering the fact that it treats the vegetative and the encysted forms of this important group on phytoplankton simultaneously.

During the study period (2012-2013), two blooms were recorded at the bottom of the lagoon at sites 3 and 4, and the incriminated species were *Peridinium quinquicorne* and *kryptoperidinium foliaceum*.

In Morocco, the notable great Atlantic blooms, always concerned *Lingulodinium polyedrum*, that were responsible of Red tides in 1999 and 2006 in the lagoon of Oualidia.

The blooms of *L. polyedrum* are usually related to high levels of anthropogenic nutrients in the environment. At the lagoon of Sidi Moussa, it's the first time that these two species proliferate.

The present study demonstrated the relationship between the bloom and the environmental enrichment in Orthophosphates and nitrates. And the source of the contamination may be the industrial installations from Jorf Al Asfar of the phosphate, located 10 Km away from the lagoon.

The cysts that are the second part of this work, present modest concentrations, probably related to salinity (oligotrophic) and particle size of the lagoon. This low concentration is associated with an assemblage undiversified of dinoflagellate cyst.

Besides *L.machaerophorum* species, autotrophic cysts are dominated by heterotrophic ones. These are the signal of eutrophication of the lagoon environment.

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