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Taxonomic structure of benthic diatoms' communities in spring in six sites of Oued beht and Oued r'dom (Morocco)

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ABSTRACT

The present work is concerned with the determination of an inventory of diatoms of two rivers of Morocco, Oued Beht and Oued R'dom to the levels of two riverine cities Sidi Slimane and Sidi Kacem. The harvested spring algal flora is composed of 93 species and varieties of species belonging to 11 orders of which the most represented in families are the orders of the Naviculales and Cocconeidales. In total 16 families are identified, which are subdivided into 25 genera. The families of *Fragilaceae, Gomphonemataceae, Naviculaceae*, *Bacillariaceae, Achanthaceae* have two genera each. The genera specifically the more rich are Nitzschia, Navicula and Gomphonema. The taxonomic structure of diatomic communities varies significantly from upstream to downstream of the riverine cities studied, but the variation is clearer when one considers the abundance of species. The discharged industrial and urban wastewater at the level of each city, the activity of cleansing performance of the river and the variation of responses of species, or varieties of species, to different physico-chemical conditions along the course of water are the main causes. Results of the index of diversity of Shannon-Wiener are in agreement with this result and the calculated equitabilities in the stations of each river do not differ much from a station to another, because, when in a biotop the effectives of some species are declining, those of other species are increasing.

Keywords: Diatoms, Spring, Oued Beht, Oued R'dom, Morocco

INTRODUCTION

The diatoms constitute a group of unicellular algae very rich in species able to colonize wetlands sailors, continental brackish or fresh water. They are present in all ranges of water quality, ranging from free sources of pollution until the waters most degraded. But, according to the degree of this quality, the qualitative and quantitative structure of the diatomic communities is not the same (Lowe and Pan 1996, Kelly et *al*., 1998; Prygiel et *al*., 1999; Stevenson and Pan, 1999). So, bogs, waters limestones, brackish water, thermal waters, and polluted waters have of diatomic Populations quite systematically different (Nigorikawa, 1998; Brown-Beverly and Olive-John, 1995; Lobo et *al*., 2004; Rimet et *al*., 2004). In addition, the taxonomic structure of diatomic communities is very sensitive to the conditions of the environment. So, in a given biotope, the taxinomic structure of benthic diatoms allows the determination of the quality of the water of the environment; This operation is also possible by using the morphological characteristics of their test (Sanchez-Saavedra, 2006; Tapia, 2008). Many species of diatoms are therefore excellent biological indicators of the waters of their living environment including the degree of pollution of such waters, their salinity, their pH (Lowe and Pan 1996, Kelly et *al*., 1998; Prygiel et *al*., 1999; Stevenson and Pan, 1999).

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Moreover, by their great richness, their taxonomic diversity and the diversity of their living environment, diatoms have been exploited to develop indices to assess the biological quality of their biotope of life. In France for example, since the 1979, different diatomic indexes have been exploited including the index of Polluo-specific sensitivity (IPS). But, since 1999, an index is more efficient, the index diatomic biological or IBD, has been designed and developed by the Water Agencies in France and the Cemagref (Prygiel and Coste, 1999; AFNOR, 2000; AFNOR, 2003) to become the habitually used index in France and to be the standardized French method to evaluate biologically the quality the aquatic environments. However, although this index is considered as the French method standardized to approach the assessment of the biological quality of the aquatic environments, its reliability is lower in the case of the evaluation of the biological quality of the waters of other Country. As well, to have a better estimate of the organic quality of its own waters, each country or each ecological zone must seek its own IBD. However, any development of IBD the country begins first of all by the constitution of a data bank grouping the taxonomic structures of a large number of diatomic communities of the country and the respective ecological conditions to these communities.

It should be noted that in Morocco, the using of the French diatomic index to assess the quality of the water has been tried by Fawzi et al. (2001, 2002). But, until today, no Moroccan index has been developed for this objective. So, for the development of such index a constitution of a data bank of the ecology of species diatomics is, therefore, necessary (Yuzao et *al*., 1998; Nigorikawa, 1998; Lobo et *al*., 2004; Cunningam et *al*., 2005). As well, to contribute to the development of this objective, the present work is interested in the determination of an inventory of the Spring diatomic species in two rivers: Oued Beht and Oued R'dom.

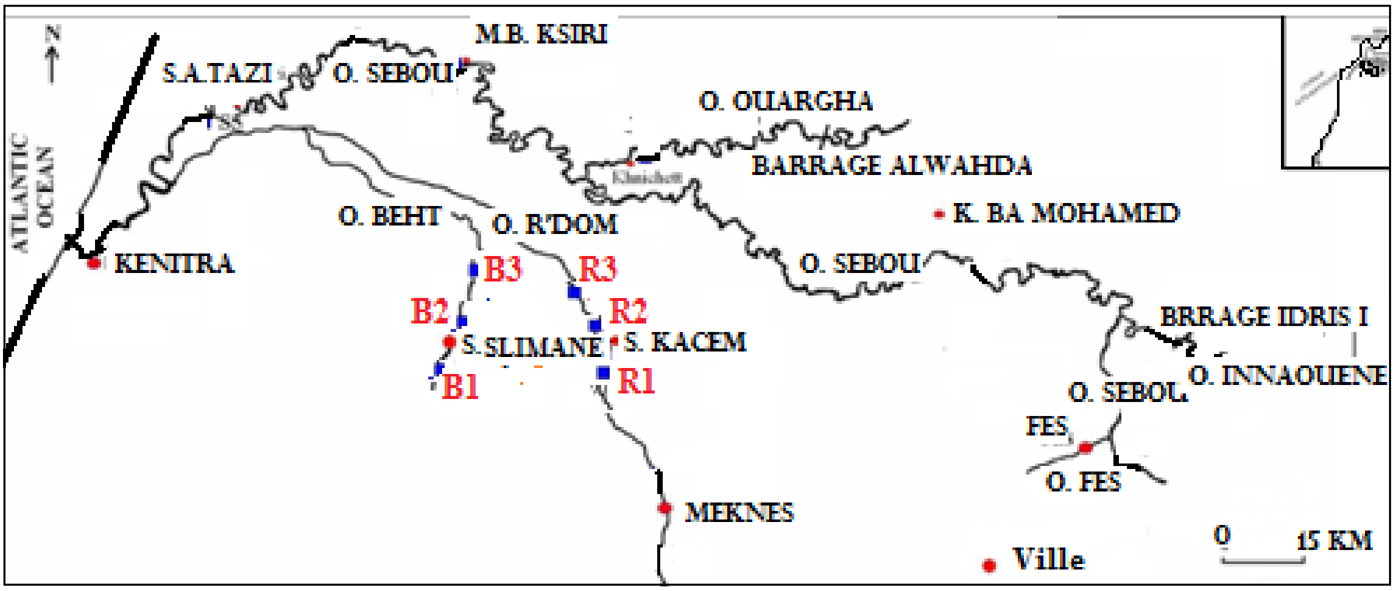
Materials and Methods

Sampling sites of the diatomic Flora Studied:

The watershed of Sebou covers two main plains of the country, the plain of Sais and the plain of Gharb; his watershed is known by a pollution of order organic and mineral caused by landfills urban and industrial of large urban agglomerations located on the borders of the rivers (Abdellaoui, 1990, Azzawi, 1999). It is subdivided into three parts: top Sebou, medium Sebou and low Sebou. This last part is crossed by Oued Beht and Oued R'dom that potentially are loaded by pollutants that come from human agglomerations and industrial facilities located at the level of many cities such as Meknes, Sidi Kacem, Khemisset, Sidi Slimane and Dar Gueddari (Fekhaoui et al., 1996). Oued R'dom, receives the urban wastewater and/or industrial of many human agglomerations such as the cities of Meknes and Sidi Kacem. Oued Beht crosses several cities and urban agglomerations such as Sidi Slimane and Sidi Yahia. Thus, for these two courses of water, the phenomenon of pollution constitutes a direct threat to the aquatic environment and indirectly for the living beings plants or animals. It is therefore of a capital interest to assess biodiversity to the levels of these two rivers. Thus, by the present work, we contribute to the determination of the specific structure of the diatom communities in three sites of Beht river (BI, B2 and B3) and three in sites of R'dOm river (R1, R2 and R3) (Figure-1). B1 is located upstream of Sidi Slimane, B2 exposed directly to releases of this same city and B3 to 6 km of B2. R1 is located upstream of S. Kacem, R2 exposed directly to releases of this same city, and R3 to 6 km downstream of the same city.

Method of sampling and systematic determination of harvested taxons:

Figure-1: Studied rivers and surveyed stations



Sampling techniques:

The sampling was conducted in May 2014. Its treatment and Its determination have been made following the methods granted by the Cemagrf :

- The upper face of one or several stones submerged in the fast part of the water stream is brushed and rinsed by the water of the river by a brush with large bristles of nylon on a surface of about 200 cm^2. Then, the whole of the rinça is collected in a bottle of 250 ml.
- In the absence of stones, various artificial substrates may be placed in each station. And then, after one month, we have proceeded in the same manner as previously.
- Fasten with 10 ml of formaldehyde to 10%, either directly in the field or as soon as the return to the laboratory.

Then, the sample is treated with the oxygenated water in order to destroy the organic matter present in the frustule which prevents a better determination of the species to the optical microscope. It is then treated with hydrochloric acid to eliminate the maximum of carbonates present.

The Determination of the species:

The systematic determination of the harvested taxa has been carried out on the basis of the work of Bourrelly (1968) and on various previous works including those of Fawzi et *al*. (2001, 2002).

Biological Diversity Evaluation of diatomics in the prospected sites: Specific richness, Diversity index of Shannon-Wiener and Equitability:

Evaluate the biological diversity of a site is a complex operation, but there are simple indicators of this biodiversity such as the number of species present, the number of individuals for each species, the relative abundance of each species in relation to the total number of individuals of the present species.

Specific richness

The specific richness (RS) (or diversity alpha, beta, or gamma) is a measure of the biodiversité of all or part of an ecosysteme; it designates the total number of espèces (of a given taxa) present in an environment.

RS = Sum of species living in a given biotope ; but often, it is used for a limited to species of a single group zoological

The idea behind this index is that the diversity of a community is similar to the amount of information in a code or message. It is calculated in the following way:

$$H' = -\sum (ni/N) \,.\, Log_2 (ni/N)$$

where pi is the proportion of individuals found in species i. For a well-sampled community, we can estimate this proportion as pi = **ni/N**, where **ni** is the number of individuals in species i and **N** is the total number of individuals in the community. Since by definition the "pi" will all be between zero and one, the natural log makes all of the terms of the summation negative, which is why we take the inverse of the sum.

Equitability:

The equitability constitutes a second fundamental dimension of diversity, (Ramade 1984). According to Dajoz (1995), It is the distribution of the number of individuals per species. It is the ratio between H' and the maximum diversity (Hmax) and, it is expressed as follows:

E= H' / Hmax

Hmax= Log_2 (S)

S = total number of species

RESULTS & DISCUSSION

We have identified 93 species and varieties of species belonging to 11 orders of which the most represented by families are the order of the Naviculales (5 families) and the order of the Cocconeidales (2 Families) (Table-1). The other orders do account that each family.

In total 17 families are identified, which are subdivided into 25 genera. The families of Fragilaceae, Gomphonemataceae, Naviculaceae, Bacillariaceae, Achnanthaceae have two genera each. Other families are represented by only one genus each.

The genera the richer in species are Nitzschia (18 species), Navicula (13 species), Gomphonema (13 species), Achnanthes (7 species), Cymbella (5 species), Amphora (4 species) and Cyclotella (4 species). The other genera have less than 4 species each. But, 13 genera have everyone a single species or varieties of species each such as Pseudostaurosira, Staurosira, Reimeria, Naviculadicta, Sellaphora, Pinnularia, Eolimna, Mayamaea, Hantschia, Platessa, Acanthidissa, Psammoyhidium and Stephanodiscatuse

Concerning the specific richness and the taxonomic structure of diatoms of each of the stations explored and we noted:

- B1:

In this Station, we have identified 59 species, sub-species, and varieties of species that are systematically belonging to 20 genera, 14 families, and 10 orders. As well, compared to the taxonomic structure total observed in the six stations explored, in the station B1, 6 systematic genera (Reimeria, Naviculadicta, Mayamaea, Achnanthidium, Psammothidium and Stephanodiscacus), two families (Achnanthidiaceae and Stephanodiscaceae) and 1 order (Stephanodiscales) are not represented by any species.

The genera Navicula and Nitzschia are the most represented in species and the most abundant species are *fragilaria ulna, gomphonema clavatum, gomphonema olivaceum var. Olivaceum, gomphonema pumilum, Cymbella affinis, amphora venata, Cyclotella radiosa, Cyclotella pediculus, craticula acomoda, achnanthes hauckiana var. Hauckiana and achnanthes minutissima var: Jackii.*

- B2:

In this second station of Beht, we have identified 51 species, sub-species and varieties of species that are systematically belonging to 19 genera, 15 families and 10 orders. As well, in relation to the taxonomic structure total observed in the six stations explored in the station B2, 6 genera systematic (Fragilaria, Pseudostaurosira, Staurosira, Eolimna, Hantzschia and Psammothidium), one family (Fragilariaceae) and 1 order (Fragilariales) has no species.

It should also be noted that Navicula, Nitzschia and Gomphonema are the genera most represented in species. Then, the most abundant species are: *Gomphonema productum*, Amphora *libyca*, *Amphora ovalis*, *Navicula cincta*, *Navicula cryptocephala*, *Pinnularia gibba* and *Achnanthes hauckiana* var. Hauckiana.

- B3:

In this station located 6 km downstream of B2, we have identified 44 species, sub-species and varieties of species that are systematically divided into 18 genera, 14 families and 9 orders. As well, compared to the taxonomic structure total observed in the six stations explored in the station B3, 7 systematic genera (Reimeria, Naviculadicta, Sellaphora, Mayamaea, Hantzschia Platessa and Stephanodiscacus), two families (Sellaphoraceae and Stephanodiscaceae) and 1 order (Stephanodiscales) are not represented by species. The genera Navicula and Nitzschia are the most represented in species. While, the most abundant species are: *Cymbella sinuata*, *Navicula cryptocephala*, *Navicula miniscus* var.miniscus, *Nitzschia sublinearis* and *Surirella* angusta.

- R1:

We have identified 53 species, sub-species and varieties which are systematically divided into 20 genera, 14 families and 10 orders. As well, compared to the taxonomic structure total observed in the six stations explored, in the station R1, 4 genera systematic (Naviculadicta, Mayamaea, Achnanthidium and Stephanodiscacus), 1 Family (Stephanodiscaceae) and order (Stephanodiscales) have no species. The genera Navicula and Nitzschia are the most represented in species. And, the most abundant species are: *Fragilaria capucina* var. Capucina, *Gomphonema parvulum* var. Parvulum, *Amphora ovalis*, *Cyclotella radiosa*, *Navicula cryptotenella*, *Navicula miniscus* var. Miniscus, *Nitzschia capitellata*, *Platessa conspicua* and *Cocconeis pediculus.*

- R2:

In this station, exposed to urban and industrial discharges of Oued R'dOM, we have identified 41 species, sub-species and varieties of species. These taxa are systematically belonging to 17 genera, 13 families and 9 orders. In relation to the taxonomic structure total observed in the Stations explored, 6 genera systematic (Pseudostaurosira, Staurosira, Cyclotella, Sellaphora, Eolimna and Achnanthidium), 2 families (Stephanodiscaceae and Sellaphoraceae) and 1 order (Stephanodiscales) are not represented by species. The genera Navicula, Nitzschia and Gomphonema are the most represented in species. While, the most abundant species are: *Fragilaria ulna, Gomphonema truncatum, Amphora pediculus, Navicula cryptocephala, Navicula cryptotenella and Achnanthes minutissima var: Jackii*.

- R3:

Located 6 km downstream from R2, the diatomic flora of this station is composed of 44 species, sub-species and varieties of species, which are systematically, distributed between16 genera, 12 families and 9 orders. As well, compared to the taxonomic structure total the algal flora identified in the three stations, 9 systematic genera (Cymbella, Thalassiosira, Naviculadicta, Sellaphora, Mayamaea, Hantzschia, Platessa, Psammothidium and Stephanodiscacus) 4 families (Cymbellaceae, Thalassiosiraceae, Sellaphoraceae and Stephanodiscaceae) and 2 Orders (Thalassiosirales and Stephanodiscales) have no species. Navicula, Nitzschia and Achnanthes are the genera represented in species. While the most abundant species are: *Gomphonema truncatum*, *Navicula capitatoradiata*, *Navicula cryptocephala*, *Navicula subminiscula*, *Nitzschia dissipata* var. Dissipata, *Amphora pediculus*, *Navicula cryptocephala*, *Achnanthes lanceolata* var: Lanceolata and *Cocconeis pediculus*.

Furthermore, both in Oued R"dom and Oued Beht, the Taxonomic wealth decreases slightly from upstream to downstream of the studied parts of the two courses of water. In addition, in Oued R'dom, this wealth is slightly higher in R1 than in R2 and R3, and It does not differ significantly between R2 and R3. Also, according to the stations explored in the same course of water and according to the stations explored in the two studied streams, the results show a clear difference in the abundance of species. In species, the richest genera are those of Navicula and Nitzschia in B1 and R1, Navicula and Nitzschia and Gomphonema in the Stations R2, and B2, Navicula and Nitzschia and Achnanthes in R3.

In addition, the diatomic flora harvested to the levels of the parties of the rivers studied is therefore taxonomically rich and diverse. This diversity differs from one station to another and it is so for the abundance of species. Concerning the explanation of this difference, it is known that the different species of diatoms respond differently in quantity and quality to the different environmental conditions of the biotope in particular to its degree of organic pollution and eutrophication, its richness in trophic elements and to other variables such as the physicochemical composition of the environment (Kobayasi and Mayama, 1982 ; Round, 1991 ; Van Dam et *al*., 1994 ;

Kelly and Whitton 1995 ; Biggs and Kilroy, 2000 ; Potapova and Charles, 2003 ; Lobo et *al*., 2004, 1996). Thus, according to the conditions offered by such or such biotope, certain species or groups of species, can prosper or avoid these conditions (Taurai and Tundisi, 2011 ; De Almeida, 2001). For examples, the conductivity and the chemical oxygen demand (COD) influence much the specific structure of diatomic communities of hydrosystèmes. Similarly, the diversity of structure of the gravel of the course of water could influence the structure of the diatomic communities. Indeed, many other authors (Roude, 1991 ; Patrick and Hendrickson ;1993 ; Potapova and Charles ; 2005 ; Fisher and Dunbar, 2007; Taurai and Tundisi, 2011) have indicated that the qualitative and quantitative composition of taxonomic communities of benthic diatoms varies according to the nature of the biotope substrate (sand, rock immergée or emergent macrophytes) because the species are better adapted to a substrate that other substrates. It should be noted that among the algal flora that we harvested, there are some species that tolerate an organic or metallic pollution; so they thrive in environments rich in organic material having a low rate of dissolved oxygen.

We quote some species of the genus Cyclotella, *Cyclotella meneghniama*, *Gomphonema parvulum*, *Nitzschia palea* and *Sellaphora pupula* (Round, 1991 ; Van Dam et *al*., 1994 ; Biggs and Kilroy, 2000; Potapova and Charles, 2003; Duong et al., 2006 ; Eirb and Tundisi, 2009). Similarly, N. Palea has been described as an abundant species of environment very polluted and eutrophic (Lange-Bertalot, 1979 ; Kobayasi and Mayama, 1982 ; Lobo et al., 1996). This last species and *Gomphonema parvulum* have been described by Kelly and Whitton (1995) such as species tolerant to eutrophication and resistant to heavy metal pollution.

According to Taurai and Tundisi (2011), and Beyene et *al*. (2009), some species that we have harvested in the prospected sites are resistant to pollution and can live even in the polluted environments, we include *Nitzschia palea*, *Cyclotella meneghiniana*, *Gomphonema parvulum* and *Sellaphora pupula*. However, among these taxa, *Nitzschia palea* is regarded as one of the best indicators of organic pollution Kawecka (1981), which also dominates in the waters which are very rich in nitrogen (Turoboyski, 1973 ; Schoeman, 1976) and which is usual in waters contaminated by discharges worn domestic (Besch And•et al., 1972 ; Kawecka, 1981). Similarly, according to Larras et *al*. (2014), *Nitzschia palea* is a common species which is resistant to organic pollution and to certain herbicides. For the species of the genus Cymbella, ecological conditions or favorite supported differ according to the authors. They are reported in waters rich in oxygen and mineralized little (Schoeman, 1976) ; it grows very well in the clean water (Kawecka, 1981) and in of oligotrophic waters (Cholnoky, 1970)

Furthermore, according to Van Dam and al. (1994), and Larras at al. (2014), many species belonging to the Fargilariales, Naviculales, Achnanthales and Cyclotellales do not resist all to a same degree of pollution by pesticides. Some are sensitive to herbicides and other can withstand an average pollution of the environment by herbicides. The presence and abundance of other species are associated with a high nutritional enrichment such as *Achnantidium minutissima*; other species can be considered as indicators taxa of the nutrient quantity of the biotope (Potapova and Charles, 2007). For *Achnanthes lanceolata*, it frequents waters which are not too rich in organic matter but rich in mineral substances (Backhaus, 1968a). Other species or varieties of species characterize of the watermarking a final phase of the self-purification of the water course (Butcher, 1947) or of oligotrophic waters (Schoeman, 1973) such as *Amphora veneta* and *Gomphonema angustatum*Other species have a wide ecological spectrum such as *Cymbella ventricosa* (Kawecka, 1981), *Navicula cryptocephala* (Archibald, 1971), *Cocconeis placentula* and *Gomphonema parvulum* that can live in polluted water or clean water (Kawecka 1981).

Furthermore, according to Larras (2014), the systematic relatedness of species belonging to the same taxonomic group may play as a factor of the determination of the degree of the ability to withstand the adverse action of an ecological factor of environment but the degree of this intervention is low.

In addition, in Oued Beht, as shown in table II, the diversity indices H' of the three stations explored B1, B2 and B3 do not show important differences. But for the stations which are situated upstream of the cities studied, B1 and R1, the specific wealth are higher than those of the stations that are located downstream.This low difference of H' of some explored stations could be explained by a large number of species identified in each of these stations and the low variance in the number of species or varieties of species according to th stations.

Table-2. H', Hmax and E noted to the levels of the stations explored

	Oued Beht			Oued R'dOM		
	B1	**B2**	**B3**	**R1**	**R2**	**R3**
H'	5,483	5,181	5,178	5.386	4,922	5.20
Hmax	5,883	5,601	5,459	5,700	5,358	5,459
E=H'/ Hmax	0,932	0.923	0,948	0.944	0,919	0.953

For the index of the equitability, remember that this index determines, either the approximation or the distance between H' and Hmax. This aspect is an indicator of the diversity, due to the approximation of diversity index of the value 1, or the remoteness de this value. The results show that for each of the streams studied values the equitability which are slightly more low have been noted in the stations that are more exposed to urban and industrial discharges of cities, either B2 for Oued Beht and R2 for Oued R'dom. Also, note that this low variation of the values of the equitability does not show the importance of the qualitative variation of the taxonomic structure of the stations explored.

Conclusion

The diatomic flora harvested is specifically rich but it digitally is poorly distributed among the genera, families, the orders and the sub-classes. For this systematic imbalance, the difference of ecological conditions required by each of the species and varieties of species seems to be the main cause. Indeed, it is known that for the diatoms, these are the physicochemical conditions preferred or required by the various taxa that determine the specific structure of diatomic communities. In the two streams studied, Navicula and Nitzschia are the genres that are spécifiquent very present in the Stations explored. However, the list of the species most abundant differs from one station to another. This could be explained by the ability of each taxon systematically to prefer, to bear, or to avoid some ecological conditions such prevailing in the environment. For each course of water from the rivers studied, the diversity indexes H' and the équitabilty “E” noted in the stations explored B1, B2 and B3 do not show important differences. The difference affects rather the richness in species and taxonomic structure in these stations.

Conflict of Interests

Authors declare that there is no conflict of interests regarding the publication of this paper.

References

1. **Abdellaoui A., 1990**. Contribution à l'étude de la pollution des cours d'eau marocains par les métaux lourds – Cas d'oued Boufekrane : Thèse de 3éme cycle, Univ. Moulay Ismail, Meknès, 258p.
2. **AFNOR, 2000.** Qualité de l'eau. Détermination de l'Indice Biologique diatomées NF T90-354, mai 2000, 63pp.
3. **AFNOR, 2003,** Guide de l'échantillonnage en routine et le prétraitement des Diatomées benthiques en rivière NF T90-357-1.
4. **Archibald R.E.M., 1971**. - Diatoms from the Vaal dam catchrnent area Transvaal, South Africa. Bot. Mar., 14,17-70.
5. **Azzaoui S., 1999.** Les métaux lourds dans le bassin versant du Sebou ; Géochimie, sources de pollution et impact sur la qualité des eaux de surface ; Thèse Doctorat, Univ. Ibn Tofaïl, Kénitra, Maroc 138 p.
6. **Backhaus D., 1968a.** Okologishe untersuchungen an den aufwuchsalgen der obersten donau und ihrer quellflusse. 3 : Die algenverteilung und ihre beziehungen zur milieuofferte. Arch. Hydrobiol., suppl. 34, 130-149.
7. **Besch, W.K., Richard M. et Cantin R., 1972.** Benthic diatoms as indicators of mining pollution in the North west Miramichi River System, New Brunswick, Canada. Int. Rev. Ces. Hydrobiol., 57, 39-74.
8. **Bere, T., & Tundisi, J. G., 2009.** Weighted average regression and calibration of conductivity and pH of benthic diatoms in streams influenced by urban pollution—Sao Carlos/SP Brazil. Acta Limnologica Brasiliensis, 21, 317–325.
9. **Bere, T. & Tundisi, J. G. (2010).** Epipsammic diatoms instreams influenced by urban pollution, São Carlos-SP, Brazil. Brazilian Journal of Biology, 70 (in press).
10. **Beyene A., Taffere A., Demeke K., Worku L., Helmut K., Ludwig T., (2009),** Comparative study of diatoms and macroinvertebrates as indicators of severe water pollution: Case study of the Kebena and Akaki rivers in Addis Ababa, Ethiopia. Ecological indicators 9 381–392
11. **Biggs, B. J. F., & Kilroy, C. (2000).** Stream periphyton monitoring manual. Christchurch: NIWA
12. **Bourrelly P., 1968.** Les algues d'eaux douces : algues jaunes et brunes. Editions N. Boubee & Cie. 441pp.
13. **Brown-Beverly J. et Olive-John H., 1995.** Ditom Communities in the Cuyahoga River (USA): Changes in Species Composition Between 1974 and 1992 Follwing Renovations in Wastewater Management. The Ohio Jornal of Science. Vol. 95 n° 3 : 254-260.
14. **Butcher R.W., 1947**. - Studies in the ecology of rivers. 7 : the algue of organically enriched waters.J Ecol., 35, 186-191.
15. **Cholnoky., 1970.** Bacillariophycées des marais du lac Bangweolo ; Bacillariophyceae trom the Bangueulu swamps. Explor. Hydrobiol. Bassin lac Bangweolo, lac Luapula, 5, 1, 5-71.
16. **Cunningam L., Snape I., Stark J. S. and Riddle M. J., 2005.** Bentic diatom community response to environmental variables and metal concentrations in a contaminated bay adjacent to Csey Station, Antartica. Marine pollution Bulletin. Vol. 50 n° 3 : 264-275.
17. **Daget, J. 1976.** Les modèles mathématiques en écologie. Masson, Paris. 172 p.
18. D**ajoz R. 1975.** Pércis d'Ecologie. Troisième édi., Dnod. 549p.
19. **De Almeida S. et Gil M.C., 2001-** Ecology of freshwater from the control region of Portugal. Cryptoamie, Algologie, vol. 22, n° 1, pp. 109-126.
20. **Duong T., Coste M., Feurtet-Mazel A., Dang D., Gold C., Park, Y., et al., 2006.** Impact of urban pollution from theHanoi Area on benthic diatom communities collected from the Red, Nhue and

Tolich Rivers (Vietnam). Hydro-biologia, 563, 201–216.

21. **Fawzi B., Loudiki M., Oubraim S., Sabour B. Chlaida M., 2002.** Impact of Wastewater Effluent on the Diatom Assemblages Structure of a Brackish Small Stream : Oued Hassar (Morocco). Limnologica, 32 (1) : 54-65
22. **Fawzi b., Chlaida M., Oubraim S., Loudiki M., Sabour B., Bouzidi A., 2001.** Application of some diatom indices to a Moroccan water course : Hassar stream. Journal of Water Sciences, 14(1) : 73-89
23. **Fekhaoui A, Bennasser L, Bouachrine M., 1996.** Utilisation d'un nouvel indice d'évaluation de la contamination métallique des sédiments: cas du bas Sebou (Maroc). Bllll, lnsl. Sei., Rabat, 1996, N° 20, p. 143-150
24. **Fisher J. & Dunbar M. J., 2007.** Towards a representative periphytic diatom sample. Hydrology and earth system, 11, 399–407
25. **Kawecka R, 1981.** Sessile algae in european mountain streams, 2: taxonomy and autecology. Acta Hydrobiol., 23, 17-46.
26. **Kelly M. G., Cazaubon A., Coring E., Dell'uomo A., Ector L., Goldsmith B., et al., 1998.** Recommendations for the routine sampling of diatoms for water quality assessments in Europe. Journal of Applied Phycology, 10, 215–224.
27. **Kelly MG, Penny CJ, Whitton BA, 1995.** Comparative performance of benthic diatom indices used to assess river water quality. Hydrobiologia 302 : 179-188.
28. **Kelly MG, Whitton BA, 1995.** The Trophic Diatom Index : a new index for monitoring eutrophication in rivers. J. appl. Phycol. 7: 433-444.
29. **Kobayasi H. & Mayama S., 1982**. Most pollution tolerant diatoms of severely polluted rivers in the vicinity of Tokyo. Japanese Journal of Phycology, 30, 188–196.
30. **Lange-Bertalot H., 1979.** Pollution tolerance of diatoms ascriteria for water quality estimation. Nova Hedwigia, 64,283–304.
31. **Larras F., Keck F., Montuelle B., Rimet F. & Bouchez A., 2014.** Linking Diatom Sensitivity to Herbicides to Phylogeny: A Step Forward for Biomonitoring? Environmental Science & Technology 48(3), 1921–1930.
32. **Lobo E. A., Callegaro V. L. M., Oliveira M. A., Salomoni S.E., Schuler S., & Asai K., 1996.** Pollution tolerant diatoms from lotic systems in the Jacui Basin, Rio Grandedo Sul, Brasil. Iheringia Série Botânica, 47,45–72.
33. **Lobo E. A., Callegar V. L. M., Hermany G. Gomez N. Ector L., 2004.** Review of the use microalgae in South America for Monitoring Rivers, with special reference to Diaoms. Vie Milieu, 54 (2-3) : 105-114.
34. **Lobo, E. A., Callegaro, V. L., Hermany, G., Bes, D., Wetzel, C.E., & Oliveira, M. A., 2004.** Use of epilithic diatoms asbioindicator from lotic systems in southern Brazil, with special emphasis on eutrophication. Acta LimnologicaBrasiliensis, 16,25–40
35. **Sateesh Pujari** and **Estari Mamidala** (2015). Anti-diabetic activity of Physagulin-F isolated from *Physalis angulata* fruits. *The Ame J Sci & Med Res,* 2015,1(1):53-60. doi:10.17812/ajsmr2015113.
36. **Lowe, R. L., & Pan, Y. (1996).** Benthic algal communities asbiological indicators. In R. J. Stevenson, M. L. Bothwell,& R. L. Lowe (Eds.), Algal ecology. Freshwater benthicecosystems (pp. 705–739). San Diego: Academic.
37. **Loez, C. R., & Topalian, M. L. (1999).** Use of algae formonitoring rivers in Argentina with a special emphasis for Reconquista River (region of Buenos Aires). In J.
38. **Nigorikawa A., 1998.** Water pollution from Ditom Assemblages and Water qualities at Ditches of Takada-Castle Ruins, Joetsu Cty, Niigata Prefecture, Central Japan. Basic Research on Environmental Education. Bulletin of Joetsu Univ. of Educ. Vol 17 n° 2: 619-636
39. **Patrick, R., & Hendrickson, J. (1993).** Factors to consider in interpreting diatom changes. Nova Hedwigia Beihelf, 106,361–377
40. **Potapova, M., & Charles, D. F. (2003).** Distribution of benthic diatoms in US rivers in relation to conductivity and ionic composition. Freshwater Biology, 48, 1311–1328.
41. **Potapova, M., & Charles, D. F., 2005.** Choice of Substrate inalgae-based water quality assessment. Journal of The North American Benthological Society, 24, 415–427.
42. **Potapova, M. & Charles, D.F. 2007.** Diatom metrcis for monitoring eutrophication in rivers of the United States. Ecological Indicators 7: 48-70.
43. **Prygiel, J., Whitton, B. A., & Bukowska,** J., 1999. Use ofalgae for monitoring rivers III. Douai: Agence de L'EauArtois-Picardie
44. **Prigiel J. & Coste M., 1999.** Progress in the use of diatoms for monitoring rivers in France. Use of algale for monitoring rivers III: 165-179.
45. **Ramade F., 1984.** Eléments d'Ecologie: Ecologie fondamentale. Me Graw-Hill, 397 p.
46. **Rimet F., Ector L., Cauchie H.-M. and Hoffman L., 2004.** Regional distribution of Diatom assemblages in the headwater streams of Luxembourg. Hydrobiologia 520 : 105-117.
47. **Round, F. E., 1991.** Diatoms in river water-monitor ingstudies. The Journal of Applied Psychology, 3,129–145.
48. **Sanchez-Saavedra, 2006 ;** Sanchez-Saavedra M. D. P., 2006. The effect of cold storage on cell variability and composition of two bentc diatoms. Aquacultural Engineering. Vol. 34, N° 2 : 131-136.
49. **Schoeman, (1973) Schoeman, F.R., 1973.** - A systematical and ecological study of the diatom flora of Lesotha with special reference to the water quality. Pretoria CSIR, 355 p.

50. **Schoeman, F. R., 1979.** Diatoms as indicators of water quality in the upper Hennops River. Journal of the LimnologicalSociety of Southern Africa, 5,73–78.
51. **Schoeman F.R., 1976**. Diatom indicator groups in the assessment of water qua1ity in the lukskei-Crocodile River System (Transvaal, Republic of South Africa). J Limnol. South. Africa., 2, 21-24.
52. **Stevenson R. J. & Pan Y., 1999.** Assessing environmental conditions in rivers and streams with diatoms. In E. F. Stoermer & J. P. Smol (Eds.), The diatoms: Applications for the environmental and earth sciences (pp. 11–40).Cambridge: Cambridge University Press
53. **Tapia P. M., 2008,** Diatoms as bioindicators of pollution in Mantaro River, Central Andes, Perou. International Journal of Environment and Health. Vol. 2 N° 1 : 82-91.
54. **Taurai Bere & José Galizia Tundisi, 2011.** The Effects of Substrate Type on Diatom-Based Multivariate Water Quality Assessment in a Tropical River (Monjolinho), São Carlos, SP, Brazil. Water Air and Soil Pollution 216(1):391-409 · March 2011
55. **Turoboyski L. (1973).** - The indicators organisms and their ecological variability. Acta Hydrobiol., 15, 259-274.
56. **Van Dam H., Mertens A., & Sinkeldam J., 1994.** A codedchecklist and ecological indicator values of freshwaterdiatoms from the Netherlands. Aquatic Ecology, 28, 117–133.
57. **Yuzao Q., Weijian H., Yumin L. and Liying W., 1998.** Evaluation of Water quality of the Pearl Assemblage Index (RPId). Journal of Tropical and Subtropical Botany, 6(5): 329-335.