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Evaluation of the organic pollution impact on freshwater diatoms in the northern Algerian river "Allala"

Evaluation de l'impact de la pollution organique sur les diatomées d'eau douce dans le nord de l'Algérie "Oued Allala"

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KEY WORDS
River, periphyton, diatom, index OPI, pollution.

Abstract In order to evaluate the impact of organic pollution on freshwater diatoms, water and periphyton were analyzed in Allala river during April and May 2015. Values of biological oxygen demand (BOD5), ammonium, nitrite and orthophosphate were used to calculate the organic pollution index (OPI). Identifying genera of periphyton diatoms were used to calculate the generic diatomic index (GDI).

Water and periphyton sampling was taken at the upstream and the downstream of the river.

During the two months of the study, the evaluation of the organic pollution index (OPI) indicated that the upstream site 1 located near an agricultural farmland is characterized by a high level of pollution. However the downstream site 2 that receives urban waste discharge is characterized by a much higher level of pollution.

The evaluation of the (GDI) showed that the site 1 is marked by an intermediate pollution while the site 2 is characterized by high pollution. Most prevalent diatoms genera in both sites are Nitzschia, Navicula and Hantzschia which are mostly resistant to pollution.

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MOTS CLES
Rivière, Périphyton, diatomée, indice IPO, pollution.

Résumé Afin d'évaluer l'impact de la pollution organique sur les diatomées d'eau douce, des échantillons d'eau et de périphyton ont été prélevés au niveau de la rivière Allala pendant les mois d'avril et de mai 2015. Les valeurs de la demande biologique d'oxygène (DBO5), d'ammonium, de nitrites et d'orthophosphates ont été utilisées pour calculer l'indice de pollution organique (IPO). Le périphyton a servi pour la récolte des diatomées et le calcul de l'indice diatomique générique (IDG).

L'échantillonnage de l'eau et du périphyton a été effectué en amont et en aval de la rivière. Au cours des deux mois de l'étude, l'évaluation de l'indice de pollution organique IPO a indiqué que le site amont (1), situé près des terres agricoles, est caractérisé par un niveau de pollution élevé. Le site (2) qui se situe en aval et reçoit des déchets urbains se caractérise par un niveau de pollution beaucoup plus élevé.

L'évaluation de l'indice diatomique IDG a montré que le site 1 est marqué par une pollution moyenne alors que le site 2 est caractérisé par une forte pollution. Les types de diatomées les plus répandues dans les deux sites sont Nitzschia, Navicula et Hantzschia, ils sont particulièrement résistants à la pollution.

1. Introduction

Rivers are very important natural sources, they have many utilities: they represent an effective source of potable and irrigation water, they represent hosts for biodiversity and recreational areas as well. However this natural resources is highly exposed to danger, it is very usually the final repository of urban, agricultural and industrial wastes.

The healthiness of an aquatic ecosystem depends on the biological characteristics of autochthonic communities [1], [2].

Diatoms are at the base of the food chain, they represent the major part of the phytoplankton. The quality of the aquatic ecosystem thus depends on the integrity of this group of microorganisms. Diatoms are susceptible organisms to organic pollution [3]. They are very sensitive to nitrogenous and phosphorus contaminations. They form a deep brown homogeneous gelatinous layer on the top of submerged stones [4].

Methods of environments quality assessment using living organism have appeared in European literature since the early of 20th century with the publication of a series of papers devoted all to the study of the quality of water in relation with urban discharges.

These studies were based on approaches that described ecological requirements of species to the organic pollution [5].

The study of diatoms can measure the impact of pollution on the river ecosystem. In this study, evaluation of organic pollution in Allala river was performed based on the organic pollution index (OPI) which was calculated by combining results of four chemical parameters of water (the BOD_5, ammonium, nitrite and orthophosphate concentrations).

To measure the impact of pollution, we have identified all diatoms genera that could be found on périphyton. The study of diatoms has allowed us to verify the effectiveness of the pollution by the Generic Diatomic Index (GDI).

2. Materials and methods

2.1 Sampling

Our study was carried out on Allala River; this latter crosses the coastal city of Ténès which is located in north-western of Algeria. The first sampling site 1 (upstream) is located at 6 km approximately from the city; this site is characterized by some agricultural activities. The second sampling site 2 (downstream) is located in the city of Ténès and receives a part of its urban discharges (Fig 1).

During April and May, two water samples have been collected from each site for the physicochemical analysis. Sampling of Periphyton has been done during May, which is a hot and relatively dried period.

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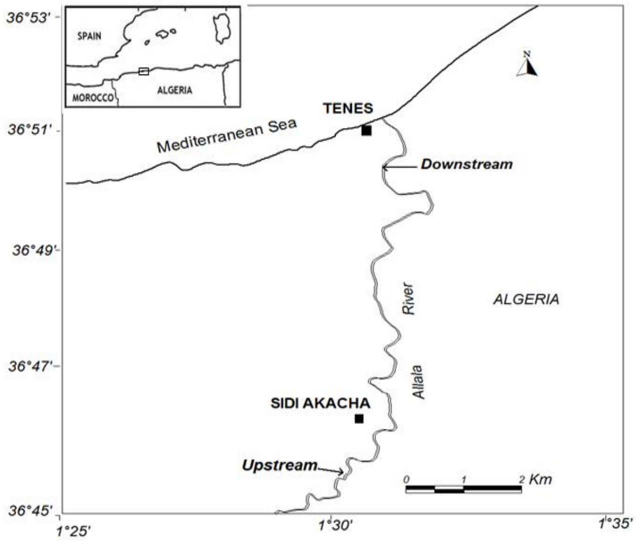

Fig. 1: Geographic localization of sampling sites

Source : Personal work

2.2 Organic pollution index OPI

The organic pollution index OPI was calculated as described by Leclercq and Maquet [6] (Cf. Tab. 1, 2 and 3) by analyzing the following parameters in water: BOD_5, ammonium, nitrite and orthophosphate according to the French standard methods [7].

Tab. 1: Classes of the Organic pollution index OPI

Parameters / Classes	BOD_5 Mg $0_2.l^{-1}$	NH^{+4} Mg $N.l^{-1}$	NO_2^- µg $N.l^{-1}$	PO_4^- µg $P.l^{-1}$
Class 5	< 2	< 0.1	5	.5
Class 4	2 - 5	0,1- 0.9	6-10	16-75
Class 3	5.1-10	1-2.4	11 - 50	76-250
Class 2	10.1-15	2.5- 6.0	51- 150	251-900
Class 1	> 15	> 6	> 150	> 900

Source : [6]

We must determine from these values, the corresponding class number for each parameter and then average them (Cf. Tab. 2).

2.3 Study of diatoms

The diatoms were recovered by brushing the upper face of the wet stones, onto a surface of about 100 cm².

The sample has subsequently been treated by hydrogen peroxide in order to remove all organic matter in such way to keep only the siliceous skeletons of diatoms.

Dentification of genera after microscopic observation has been performed using several books dedicated to key determination of micralgae [8], [9], [10], [11], [5].

Tab. 2: Average grade interpretation of OPI

Average class	Level of organic pollution
5,0 - 4,6	Zero
4,5 - 4,0	Low
3,9 - 3,0	Intermediate
2,9 - 2,0	High
1,9 - 1,0	Very high

Source : [6]

To calculate diatoms The Generic GDI index, we observed more than 400 diatoms [8]. The Index GDI was calculated using the following formula :

$$GDI = \sum_{j=1}^{n} A_j S_j V_j \Big/ \sum_{j=1}^{n} A_j V_j$$

S_j: Overall sensitivity value of the genus ranging from 1 for the most resistant to 5 for the most sensitive.

V_j: Ecological amplitude value of the genus: 1 = high, 2 = medium, 3 = low.

A_j: Abundance of the genus, expressed in percentage (%).

The average classes that determine the organic pollution level of GDI are presented in Table 3.

Tab. 3: Average grade interpretation of GDI

Average class	Level of organic pollution
IDG ≥ 4.5	Zero
4 < IDG > 4,5	Low
3,5 < IDG > 4	Moderate
3 < IDG > 3,5	Intermediate
2 < IDG > 3	High
1 < IDG > 2	Very high

Source :[6]

3. Results and discussion

3.1 Index OPI

In order to detect the responsible factor of pollution, the values of the four parameters (BOD_5, ammonium, nitrites and orthophosphate) used to calculate the OPI were compared with the French environmental norms [12] (Cf. Fig. 2, 3, 4 and 5).

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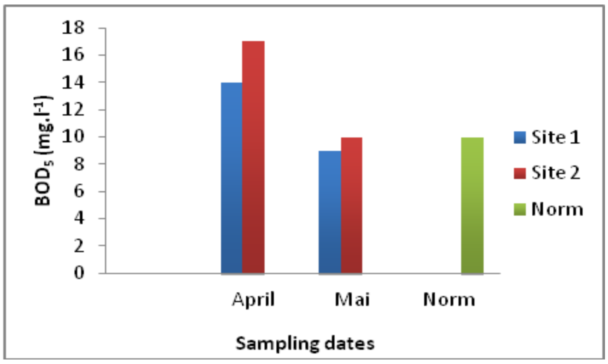

Fig. 2: Values of BOD5

Source : Personal work

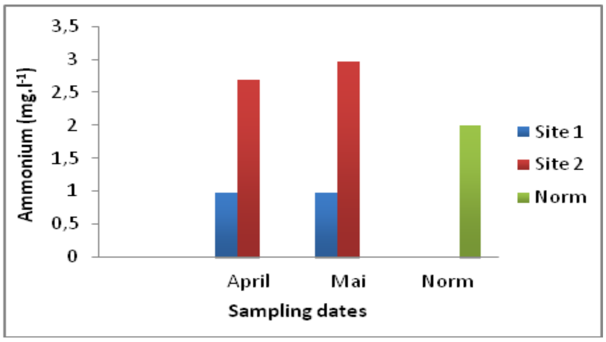

Fig. 3: Values of Ammonium

Source : Personal work

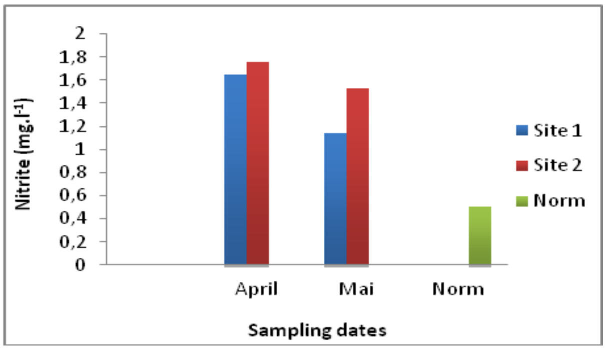

Fig. 4: Values of Nitrites

Source : Personal work

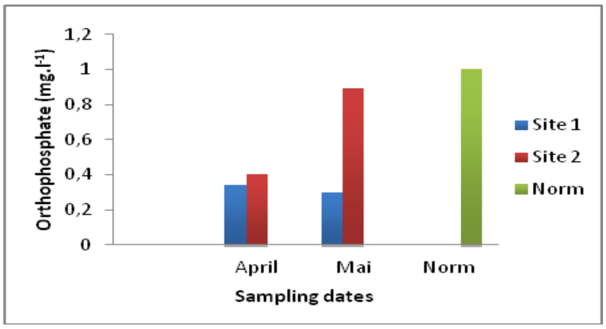

Fig. 5: Values of orthophosphates

Source : Personal work

The results obtained by calculating the organic pollution index OPI show that organic pollution is high in the site 1 and very high in the site 2 during April and May (Cf. Tab.4).

Tab. 4: Results of organic pollution index (OPI)

Sampling month	Sampling area	OPI	Quality of water
April	S1	2,25	High organic pollution
	S2	1,50	Very high organic pollution
Mai	S1	2	High organic pollution
	S2	1,75	Very high organic pollution

Source : Personal work

Orthophosphate analysis results showed that both sites have never known a high concentration of this parameter. The values of BOD_5 and ammonium recorded reveal that, during the two months, the concentrations of organic matter and ammonium are low in the site 1 and high in the site 2. For nitrites, high concentrations were recorded in both sites during the two months of the study.

In the site 1 Nitrite is ultimately the principal responsible of organic pollution; it might be generated by the rapid transformation of ammonium used as fertilizer. In fact, agricultural waste could also represent a potential source of organic pollution [13], [14].

In the site 2, BOD_5, ammonium and nitrites, are all responsible for the organic pollution detected, the origin of this pollution could be very likely due to the urban waste of the city of Ténès. In urban areas, effluents from domestic activities and plants are generally the principal sources of pollution [15].

Organic pollution recorded in the two sites is suitable for cyanobacteria proliferation which are able to secrete cyanotoxins, this latter might cause serious skin disorders in human in the case of direct contact with contaminated water [16], [17].

Excessive organic matter frequently brought to the site 2 can lead, at short-term, to a simplification of biocenoses; algae and plants can thus invade the entire background, therefore the most sensitive species may disappear [18].

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3.2 Study of diatoms

During May, analysis of periphyton sample from the upstream site 1 has shown the presence of 11 genera represented by 575 species. In the downstream site 2, we collected 9 genera represented by 408 species (Cf. Tab.5).

In site 1, the most abundant genera are: *Nitzschia* with a density of 36.87%, *Hantzschia* with 25.56% and *Navicula* with 10.95%. The overall sensitivity value S of three of them is 1, which means that they contain the most resistant species [8]. In the site 2, the most abundant types are the same as those found in the upstream site: *Nitzschia* with a density of 40.08%, *Navicula* with 15.35% and *Hantzschia* with 14.71%.

Tab. 5: Diatom genera collected in both sites and their percentage

Genera	A (upstream) (%)	A (downstream) (%)	S	V
Amphipleura	0.7	3.41	5	3
Cocconeis	2.08	1.7	4	1
Fragilaria	-	3.41	4	1
Gomphonema	3.3	-	3	2
Gyrosigma	3.13	-	4	3
Hantzachia	25.56	14.71	1	3
Melosira	4.34	-	3	1
Navicula	10.95	15.35	1	2
Nitzschia	36.87	40.08	1	1
Pinularia	4.52	-	4	3
Rhizoscoleneai	-	8.74	2	3
Stauroneis	4.52	-	5	2
Surirella	-	5.97	3	3
Syndra	4	6.86	3	1

Source : Personal work

S: overall sensitivity value
V: ecological amplitude value of the genera
A: abundance of genus**-:** absence

Our results show that diatomic diversity is higher in the site upstream than the downstream site. This difference is due to the changes in the level of pollution in both sites. Biodiversity is generally affected by the healthiness of the natural environment. In 2012 Rawat [19] reported that slightly polluted aquatic ecosystem is characterized by a rich biodiversity while a polluted aquatic ecosystem is characterized by a poor biodiversity.

In the site 1, the generic diatomic index (GDI) is equal to 3.25 which correspond to an intermediate level of pollution. This site is characterized by an OPI index that corresponds to a high organic pollution with a value of 2 (Cf. Tab. 6).

Tab. 6: Generic diatomic index (GDI) values

Sampling area	GDI	Quality
S1	3,25	Intermediate pollution
S2	2,94	High pollution

Source : Personal work

In the site 2, the generic diatomic index (GDI) is equal to 2.94 which reflect a high level of pollution. This site is characterized by an OPI index that corresponds to a very high organic pollution with a value of 1.75.

Comparing the values of the OPI and GDI in both sites, we can say that there is a lag of a class between the two indexes. When the OPI is high, the GDI is intermediate and when the OPI is very high, the GDI is high. The evaluation of the GDI would then have led to an overestimation of the water quality. This could be very likely due to the presence of some genera such as *Navicuia* or *Nitzschia* which contain a multitude of species that could be able to cover the full range of sensitivity to pollution [20]. However, we believe that the result of GDI has led to an acceptable rating.

The use of this index for the preliminary assessment of biological quality of rivers remains interesting and very useful. Also, chemical analyzes of water are not always enough since they are subjected to daily fluctuations and could change from hour to another [3]. Low frequency rate of water sampling could thus lead to a misdetection of the pollution.

4. Conclusion

Excessive amounts of nitrites, ammonium and organic matter (estimated by BOD_5) in the river water are the main cause of organic pollution. Upstream the river, the pollution would originate from agricultural activities. Downstream, it would rather be due to urban waste discharge.Our study showed that the composition of diatomic population is mainly dominated by genera resistant to pollution (*Nitzschia*, *Hantzschia* and *Navicul*). The most sensitive genera tend to disappear.

The GDI index gives a satisfactory image of the biological quality of river water. The evaluation of the GDI is fast and simple, it seems thus to be effective in preliminary assessment of the biological quality of rivers.

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