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Organic Pollution Assessment and Biological Quality of the River Oued Rhiou (Algeria)

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Abstract:

Organic pollution index OPI and biological river macrophyte index BRMI were evaluated in Oued Rhiou river. During the months of April, May and June 2014, results of biological oxygen demandBOD_5, ammonium, nitrite and orthophosphate were used to calculate OPI. BMRI was calculated during June 2014, a vegetation development period of helophytes, hydrophytes and algae recoveries. During the three months of April, May and June, OPI evaluation reveals that sites S2 and S3, which receive anthropogenic releases are marked by a strong level of organic pollution. Site S1, which receives no effluent is characterized by a medium level of organic pollution. During June, the BRMI index indicates a strong trophic level in both S2 and S3 sites, cons, it shows a mean trophic level in S1 site.

Keywords: Organic pollution, river ; Oued Rhiou ; index OPI ; index BRMI ; macrophyte.

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1. Introduction

Located in western Algeria, Oued Rhiou river filled many ecological functions, such as biodiversity protection, groundwater supply and irrigation water. In this context, this river preservation turns an ecological and socio-economic issue of major interest.

Surface waters quality evaluation in Algeria is usually practiced by physicochemical measurements and biological indicators assessment are rarely performed. However, indicator species used to assess closely ecosystems biological quality, as some species are more or less resistant to pollutants than others [1-13]. In fact, biological monitoring and physicochemical monitoring rivers are considered as complementary tools [10].

To assess organic pollution and biological quality of Oued Rhiou river receiving domestic and industrial discharges from Oued Rhiou town, we evaluated a share of organic pollution index OPI, and secondly biological river macrophytes index BRMI. OPI index is based on four physicochemical parameters (BOD_5, ammonium, nitrite and orthophosphate), it has been developed by [9]. BRMI index is based on a comprehensive survey of visible aquatic plants to the naked eye (helophytes, hydrophytes and algae) with estimated recoveries. It essentially reflects trophic increased level related to organic pollution. BRMI is a French NF T90-395 standard (2003)[5].

2. Study Area

Our work was conducted between April and June 2014 at Oued Rhiou river near the town of Oud Rhiou (35°58’00.79’’ N 0°54’59.56’’ E). Three sites S1, S2 and S3 were selected according to their proximity and remoteness to the effluents (Figure 1). Main characteristics of S1, S2 and S3 sites are summarized in Table 1.

Fig.1: Representative map of the study area (Google Earth, 2014)

Table 1: Sampling sites characteristics

Sites	Location	Average width	Average depth	Speed average current
Site S1	Upstream of the river (50 m near the dam Gargar)	1.5 m	0.40 m	0.7 m/s
Site S2	500 m after small urban effluents	1.8 m	0.35 m	0.6m/s
Site S3	300 m after points urban and industrial discharges	2 m	0.30 m	0.5 m/s

3. Materials and methods

3.1. Water analyses

Temperature measurements, pH, electric conductivity and oxygen below were performed *"in situ"* using a multi-parameter model WTW 340i. BOD_5 was analyzed by manometry, ammonium, orthophosphate and nitrite were analyzed spectrophotometrically [14].

3.2. Organic pollution index OPI

OPI index was developed by dividing the values of four parameters, BOD_5, ammonium, nitrite and orthophosphate into five classes (Tabel. 2). Depending on the analysis results, it is determined to which class each of the parameters is analyzed and then averaged (Table. 3) [9].

Table 2: Organic pollution index OPI classes limits

	DBO_5 mgO_2/l	NH_4^+ mg N /l	NO_2^- µg N/l	PO_4^- µg P/l
Class 5	<2	<0,1	≤5	≤15
Class 4	2-5	0,1-0,9	6-10	16-75
Class 3	5,1-10	1,0-2,4	11-50	76-250
Class 2	10,1-15	2,5-6,0	51-150	251-900
Class 1	>15	>6	>150	>900

Table 3: Average grade interpretation

Average class	Level of organic pollution
5,0 – 4,6	Zero
4,5 – 4,0	Low
3,9 – 3,0	Moderate
2,9 – 2,0	High
1,9 – 1,0	Veryhigh

3.3. Biological river macrophytes index BRMI

BRMI index *"in situ"*determination is based on stands macrophytic observation. Taxa identification and plant list establishment allows to BRMI calculation. Aquatic taxa included in the biological river macrophyte index are 208. BRMI determining must be performed during vegetation development and performed on sections of 50 to 100 meters long [14].

IBMR is calculated as follows: $BRMI = \Sigma (Ei \times Ki \times CSi) / \Sigma (Ei \times Ki)$

Ei : stenoecie coefficient (i taxon adaptability) (1 to 3)

Ki: i taxon abundance coefficient in studied site (1 to 5)

CSi: i taxon affinity coefficient for trophic conditions (0 to 20)

Results are interpreted using a BRMI gate of 5 water trophic levels (Table 4).

Table 4. BRMI index levels interpretation

BRMI	BRMI≤ 8	8< BRMI≤10	10< BRMI≤12	12< BRMI≤14	BRMI>14
Trophic level	Very high	High	Moderate	Low	Very low

4. Results and Discussion

4.1. Water analyses

For a detailed results analysis, we plotted histograms determining physicochemical parameters variation of water in the three studied sites.

4.1.1. Temperature

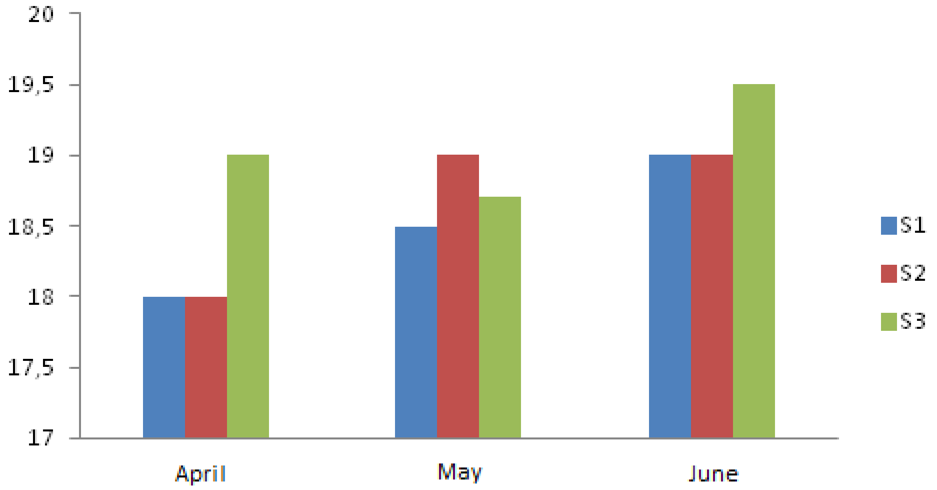

Fig. 2: Temperature variation

Recorded results show that April temperature is between 18 and 19 ° C, 18.5 and 19 ° C for May and between 19 and 19.5 months for June. These temperature variations follow those of region climate and do not reflect thermal pollution.

4.1.2. pH

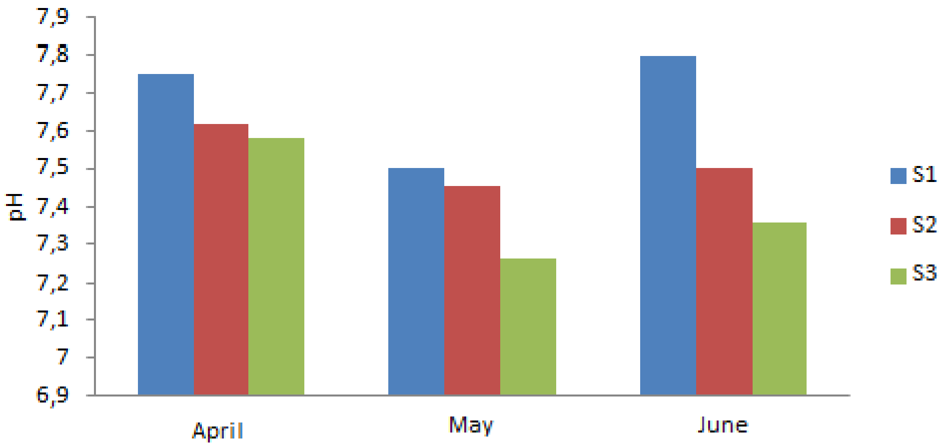

Fig. 3:pH variation

pH water measures protons H^+ concentration in water. It summarizes balance stability between different forms of carbonic acid and it is also linked to the buffer system developed by carbonates and bicarbonate [4].

pH of Oued Rhiou river varies between 7.58 and 7.75 in April, 7.26 and 7.5 in May and 7.36 and 7.8 in June, it is relatively stable and a neutral site to another. This is due to carbonates presence that can buffer the water flowing into the river.

4.1.3. Electrical conductivity

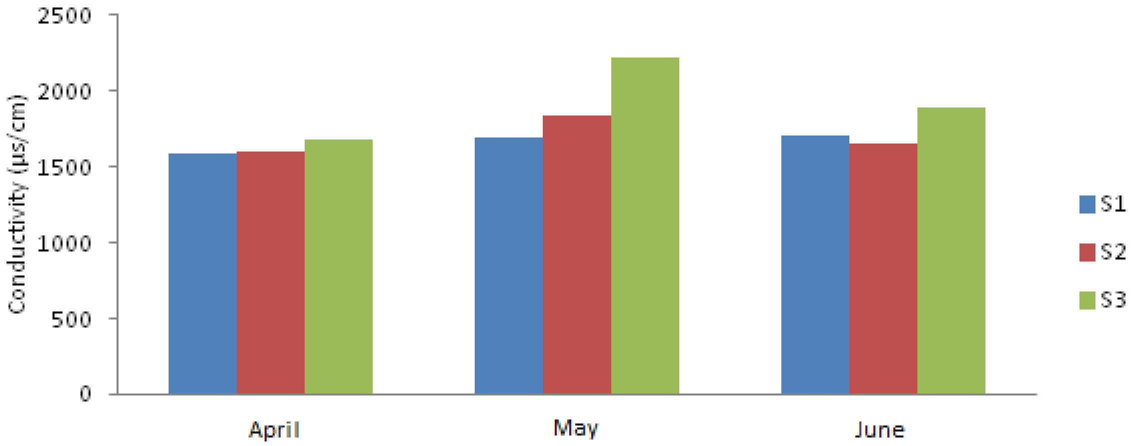

Fig. 4: Change in electrical conductivity

According to our results, the maximum conductivity was recorded in station 3, during the month of May (2225 microseconds / cm). The minimum conductivity was recorded in station 1 during the month of April (1585 microseconds / cm). Conductivity increase during the warm period may be due partly to the the river low flow which leads to higher minerals concentrations and to strong atmospheric evaporation [8]. By against, the minimum values recorded during the rainy season could be attributed to rainfall which result in a phenomenon of water dilution.

4.1.4. Dissolved oxygen O_2

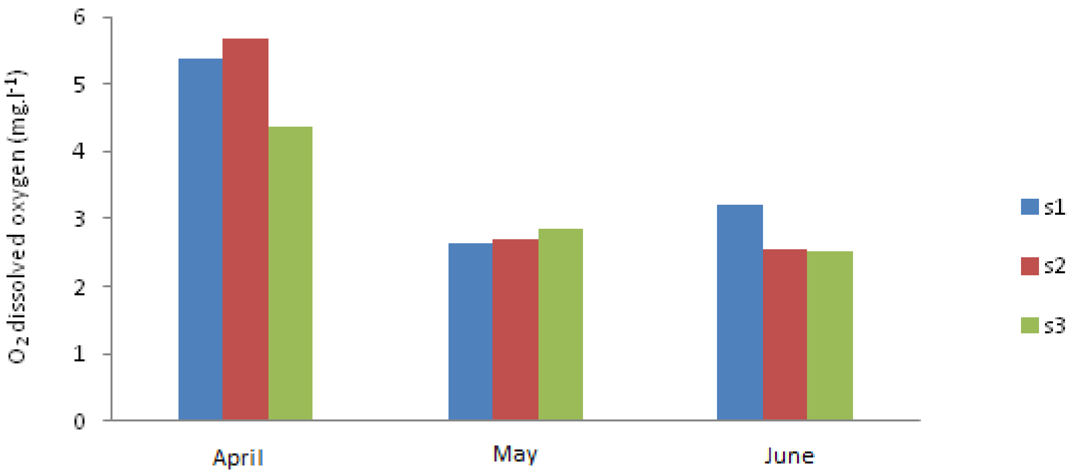

Fig. 5: Change in dissolved oxygen levels

Oxygen varies between 2.53 and 5.69 $mg.l^{-1}$. Water flow of the river is causing brewing water and therefore oxygen dilution in water. Additional oxygen is provided by aquatic plants producing oxygen during the day. In general, for the three sites, the oxygen content decreases during the warm period, as more water is heated, less oxygen is soluble (perez océanographie [11].

4.1.5. Orthophosphates PO_4^-

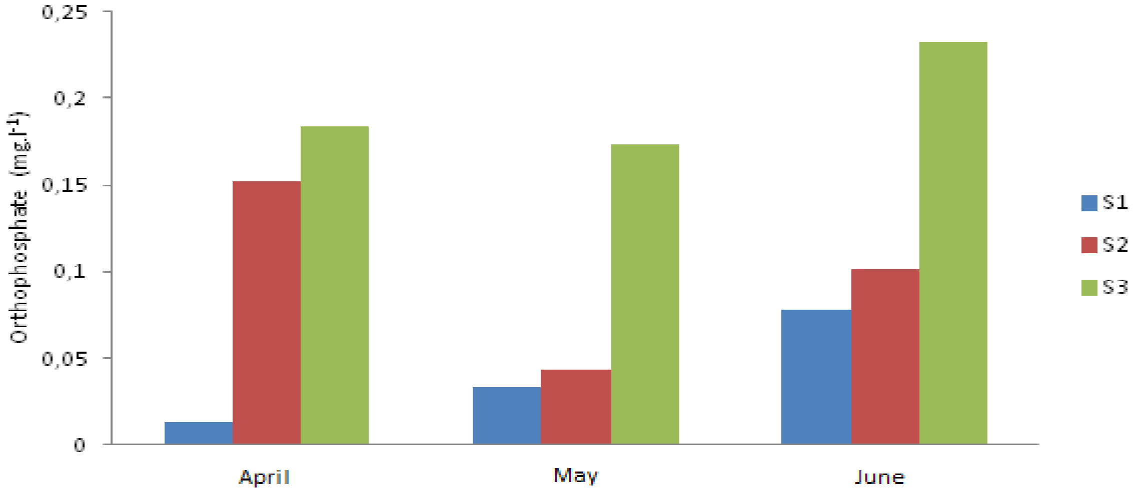

Fig. 6: Change inorthophosphates (PO_4^-)levels

Orthophosphate lowest concentrations characterize the S1 site that does not receive municipal wastewater discharges. The highest levels were recorded in S2 and S3 sites. Waste water discharges loaded with organic matter received at these sites would be responsable of these high levels.

Regarding the increase recorded at S1 site during June, concentrations are due to the increase in temperature during this month. In fact, organic phosphorus can be converted to orthophosphate by photo-oxidation in ultraviolet [14].

4.1.6. Biological oxygen demand BOD_5

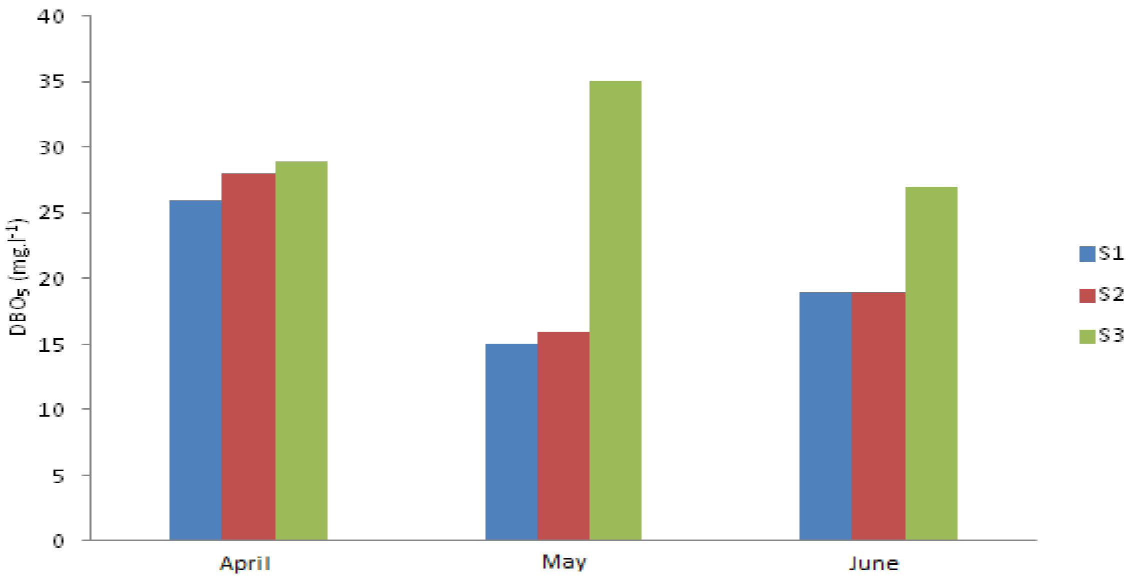

Fig. 7: Change in BOD_5 levels

BOD_5 gives an estimate of anthropogenic amount and natural biodegradable organic matter [12]. In the riverOuedRhiou, the highest values BOD_5 were recorded in S3 site, this is due to large amounts of waste water rich in organic matter from urban and industrial facilities.

4.1.7. Ammonium NH^{+4}

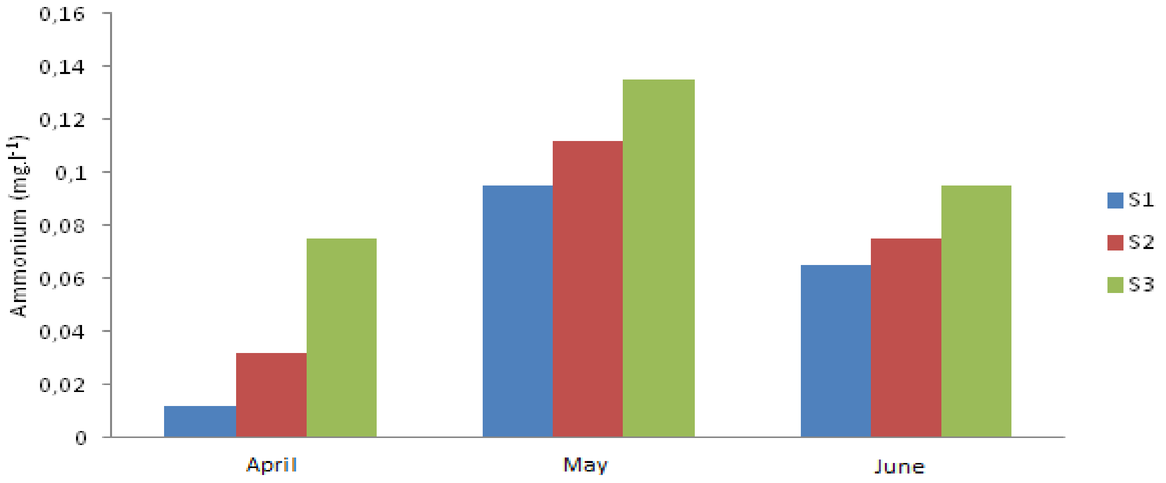

Fig. 8: Change in ammonium (NH^{+}) levels

Concentrations found in the river are low, ranging from 0.012 to 0.065 $mg.l^{-1}$ in S1 site, between 0.032 and 0.112 $mg.l^{-1}$ in S2 site and between 0.0751 and 0.135 $mg.l^{-1}$ in S3 site. During the three months, the highest values were recorded in S2 and S3 sites receiving waste water loaded with organic nitrogenous material.

During May, ammonium excess is observed in the three sites of the river. This can be caused by a nitrogen fertilizers contribution. Oued Rhiou region is known for growing watermelon starts to be picked from June.

4.1.8. Nitrite NO_2^-

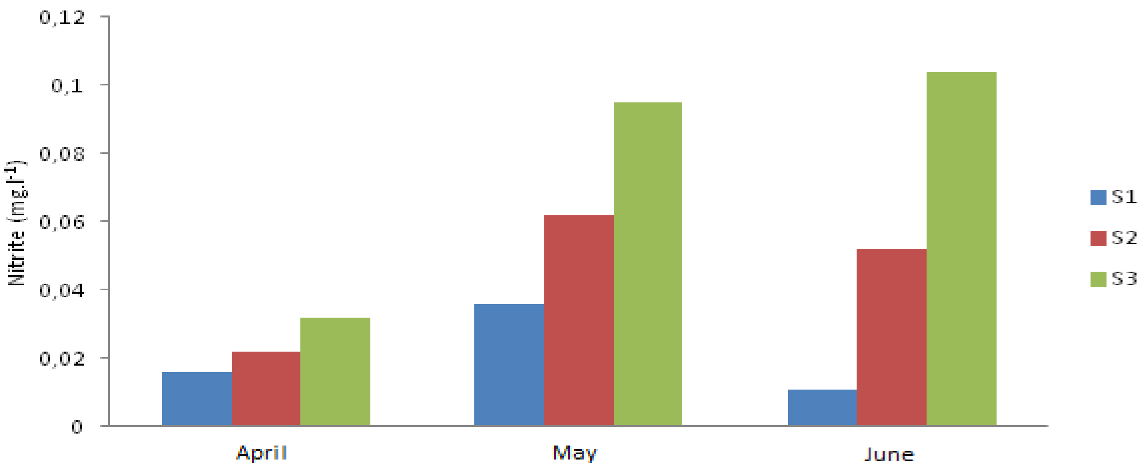

Fig.9: Variation of nitrite (NO_2^-) levels

The highest values are observed in S3 site, maximum value reported during June is 0.0104 $mg.l^{-1}$. Nitrites come either from incomplete ammonium ions oxidation, or a nitrate reduction [14]. Generally, nitrite concentrations are consistent with those of ammonium.

4.2. Organic pollution index OPI

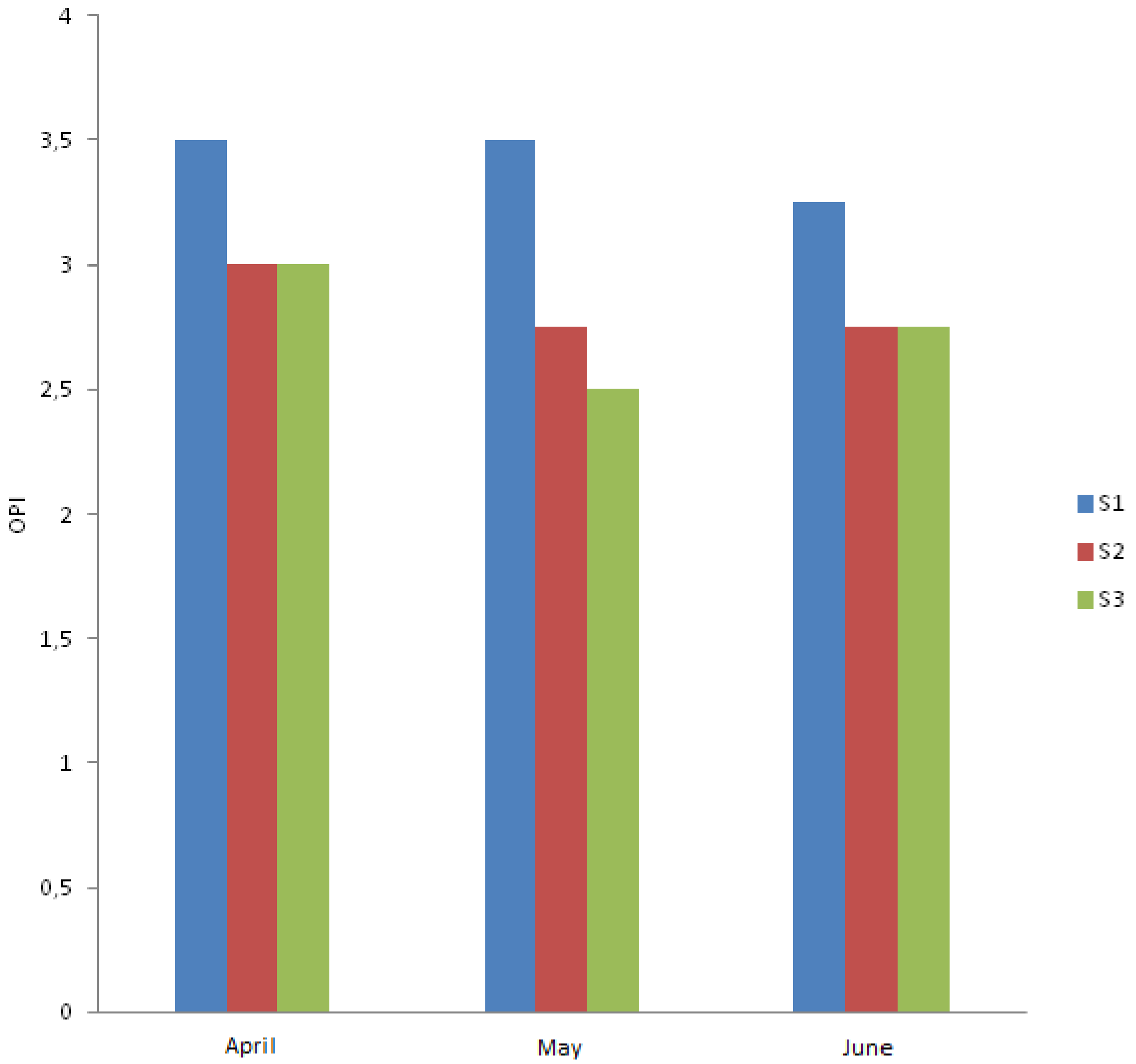

Fig.10: OPI variation in the three sites

Our results show that the S1 site is characterized by an OPI index that varies between 3.25 and 3.5 for three months, this indicates a moderate level of organic pollution. In S2 site, the index indicates a moderate level of organic pollution during the month of April (3.00) and a OPI strong during the month of May (2.75) and June (2.75).

In S3 site, the organic pollution level is moderate during the month of April (3.00) and becomes stronger during the month of May (2.5) June (2.75). During the warm period, represented by the months of May and June, the OPI indexes show that the organic pollution level in Oued Rhiou river increases from upstream to downstream.

4.3. Biological river macrophytes index BRMI

BRMI index application was conducted at three sites in Oued Rhiou during June. Macrophytes distribution results in the study sites are summarized in Table 4.

Table 4**:** Macrophytes distribution and indexes

Species name	Site S1 Ki	Site S2 Ki	Site S3 Ki	Csi	Ei
Iris pseudacorus	4	4	5	10	1
Polygonum hydropiper	3	4	4	8	2
Phragmites australis	4	4	4	9	2
Alisma plantago-aquatica	2	-	-	8	2
Nasturtium officinale	3	3	3	11	1
Juncus bulbosus	3	3	2	16	3
Spirogyra sp.	3	3	3	10	1
Cladophora sp.	-	3	3	6	1
Chara globularis	3	-	-	13	1
Catabrosa aquatica	3	3	3	11	2
Berula erecta	3	-	-	14	2
Polygonum amphibium	2	-	-	9	2

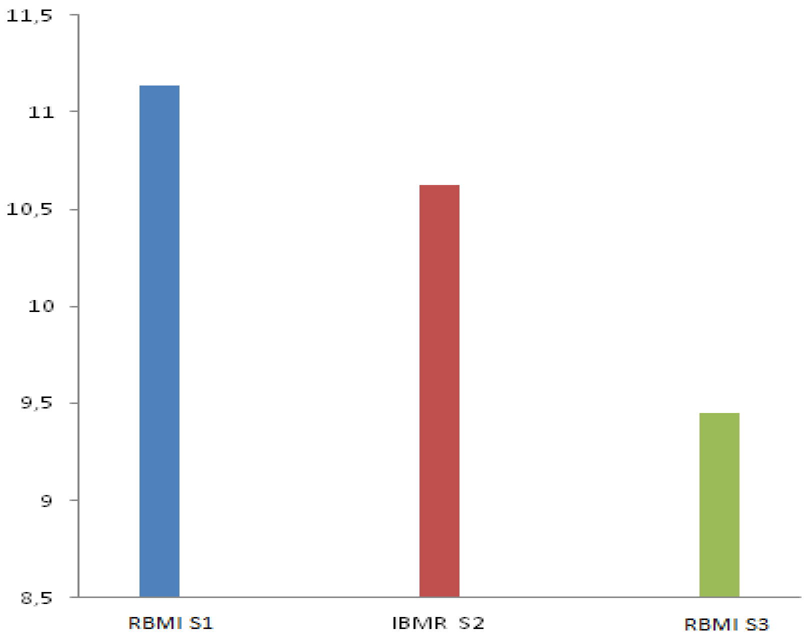

Fig. 11: RBMI index variation in the three sites

BRMI index is equal to 11.14 in S1 site and 10.62 in S2 site. Both sites are characterized by a mean trophic level. However, S1 site biodiversity study revealed the *Chara globularis* presence. This alga is abundant in hard alkaline water (pH > 7), rich in calcium [6] stoneworts being indicative of good chemical water quality [3].

S3 site is marked by an BRMI index equal to 9.45 corresponding to a high trophic level. A high BRMI index reflects organic pollution of water courses. S3 site is also marked by a strong OPI index of 2.75. This pollution type can cause significant disruption to the river ecosystem. In fact, it is very favorable to proliferation of cyanobacteria producing toxins. Agricultural crops irrigation of with water contaminated by toxins could lead to a cyanotoxins internal accumulation [2]. However, macrophytes respiration in water densely colonized by vegetation, can cause a critical dissolved oxygen reduction during the night [7]. Macrophytes excessive proliferation in S3 site can be considered as a degradation sign of the river Oued Rhiou ecosystem.

5. Conclusion

Our work showed that the river Oued Rhiou ecosystem is degraded, especially at S3 site that receive significant amounts of urban and industrial effluents. This important river, both for nature balance and population well-being of Oued Rhiou town, must have a specific strategy for better preservation.

At the end of this work, we recommend that together each hot season, OPI and BRMI indexes evaluation to assess the impact of organic pollution on the river. Other evidences must be evaluated to quantify chemical pollution and judge biological impacts on this ecosystem.

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