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Aquatics Macroinvertebrate Diversity and Bio-Assessment of the Quality of the Middle Wadi Oum Er-Rbia (Morocco)

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ABSTRACT

The Oum Er Rbia river in Morocco is particularly threatened by lack of appropriate management. It is in this context, this study of the biological diversity of benthic macroinvertebrates in the middle zone of Oum Er Rbia river and the evaluation of the biological quality of water at this level, during a campaign carried out in April 2018. The results show that the stations upstream of the two sources of agricultural and industrial pollution represented by the stations (S1, S3, S4, S5 and S6), the biodiversity is important and the water is of good quality. So that the discharge of wastewater from the city of Kasba Tadla (S2) and Dar Ouled Zaidouh correspond to the station S7 has caused a reduction in diversity and a degradation of water quality of Oum Er Rbia river. We also noted a significant improvement in water quality away from Dar Ouled Zaidouh by 5 km from sources of pollution, which demonstrates the purifying power of the water of the Oum Er Rbia river.

Keywords: Oum Er Rbia river, benthic macrofauna, biological quality, taxonomic richness.

INTRODUCTION

Running and standing waters has always played an important role in the development of agricultural, industrial and domestic activities. However, those resources are not always protected from different sources of disturbance and dysfunction (Hbaiz et al., 2022a; Ihsane et al., 2022). The preservation of surface water quality has become a major issue given the uses of this resource (drinking water production, irrigation, recreation) and also the biological and ecological services that these environments provide (Kettab, 2003; Rezouki et al., 2021).

Faunistic, ecological studies are of paramount importance in understanding the functioning and management of natural systems and, on the other hand, in assessing the ecological health of hydrosystems (Abbou and Fahde, 2017; Babaci and Moussai, 2020).

Macroinvertebrates are good bioindicators due to their sedentary nature, high diversity and variable tolerance to pollution and habitat degradation, and reflect particularly well the ecological status of the stream by reacting very quickly to changes occurring in their environment (Hbaiz et al., 2022; Mboye et al., 2020; Rezouki et al., 2021).

The Oum Er Rbia Wadi originates in the Middle Atlas at an altitude of 1800 m and a length of 550 km, crosses the Middle Atlas range, the Tadla plain and the coastal Meseta and flows into the Atlantic Ocean about 16 km from the city of El Jadida (Oum Er Rbia River Basin Agency). The biological richness of this stream is not yet well studied despite work conducted downstream of the Wadi by (Bitar et al., 2013). Biological assessment consists in analyzing the settlement structure of living organisms (biological indicators) such as microorganisms, plants or animals. This method provides a more reliable assessment of the biological quality of the environment (Beauger and Lair, 2014). Thus, the concept of ecosystem integrity or health requires the simultaneous consideration of chemical, physical and biological parameters (Wu et al., 2020).

One of the animals exploited in the biological assessment of the environment is the benthic macroinvertebrates, characterized by their diversity and sensitivity to pollution and habitat degradation (Fierro et al., 2017), and reflect particularly well the ecological status of the stream by responding very quickly to changes occurring in their environment. Thus, many indices have been developed based on the variation of the specific structure of the benthic macroinvertebrate population. We mention the Belgian Biological Index (IBB) and the Standardized Global Biological Index (IBGN).

Our research work consists in the study of the biological diversity of the benthic macrofauna and the evaluation of the biological quality of the waters of the river Oum Er-Rbia at the level of the plain of Kasba Tadla (Morocco).

MATERIAL AND STUDY METHODOLOGY

Presentation of the study area

The Oum Er-Rbia river basin is located in west-central Morocco, at 31°19′33″–33°22′21″ N lat. and 5°8′55″–8°22′53″ W Long. and covering an area of 48,070 km^2. Annual rainfall in the Oum Er-Rbia basin varies between 1100 mm on the Middle Atlas and 300 mm in the downstream area of the river, with an average of 550 mm (Tahiri, 2013). It is concentrated from October to April with a maximum between December and February. Lionello et al., 2006 Three rivers are distinguished: upper, middle and lower.

Our research is limited to the middle river (Figure 1) which crosses the phosphate plateau and the Tadla plains. This watercourse has tributaries with more or less regular flow (El Abid river, Lakhdar and Tassaout river) and temporary (Derna and Day river).

Choix des stations

Our study covers eight stations, and is based on the identification of pollution sources in the study area. (Figure 2, Table 1).

Sampling of benthic macroinvertebrates

Benthic macroinvertebrate samples are collected during the month of April 2018 at eight stations shown in Figure 2 and Table 1. Fauna sampling was performed by a turbid net in still water and by a 300 µm Surber net with one square foot of bottom surface (1/10 m^2) in running water. The

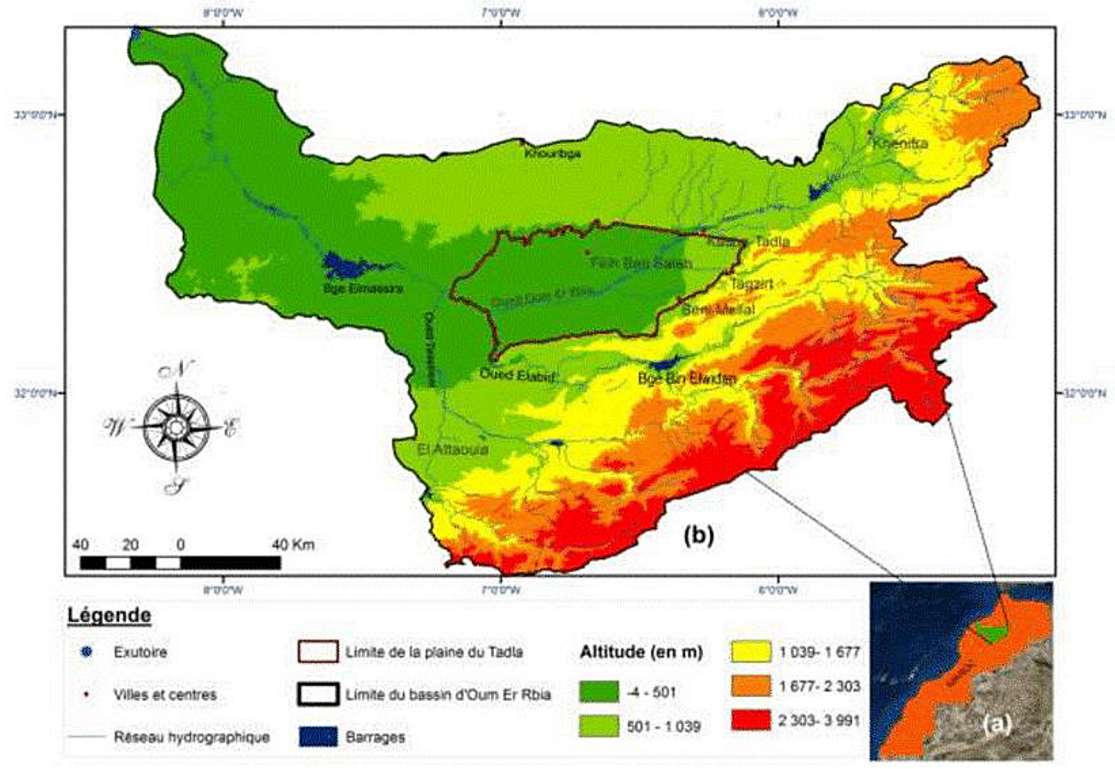

Figure 1. Geographical location of the Oum Er-Rbia watershed on the map of Morocco (a) and its elevation map in the form of the digital terrain model (DTM) with the location of the Tadla Plain (b) (Zaitouni and Ibouh, 2016)

Table 1. Descriptions of sampling sites

Sampling	Station Name and Address	Geographical coordinates		Human pressure
		Latitude N	Longitude W	
S1	Située en amont de la ville de kasba Tadla	32°35′38.9″	6°14′06.3″	Agricultural
S2	Située dans la zone qui reçoit les eaux usées de la ville de kasba Tadla	32°35′35.2″	6°16′13.9″	Urbain
S3	Située à 5 Km de la ville de Kasba Tadla	32°35′20.9″	6°18′30.9″	urbain /agricultural
S4	Situées en amont du village «Ouled Said Loued»	32°33′02.6″	6°22′36.8″	Activités agricole
S5	Situées en aval du village «Ouled Said Loued»	32°32′08.7″	6°24′01.0″	Activité agricole
S6	Située en amont de Dar Ouled Zaidouh	32°19′32.3″	6°53′08.7″	Activité agricole
S7	Située au niveau de Dar Ouled Zaidouh	32°18′48.7″	6°54′49.9″	Activité industriel/ urbain
S8	Située à 5 Km de Dar Ouled Zaidouh	32°18′12.7″	6°59′42.9″	Activité agricole

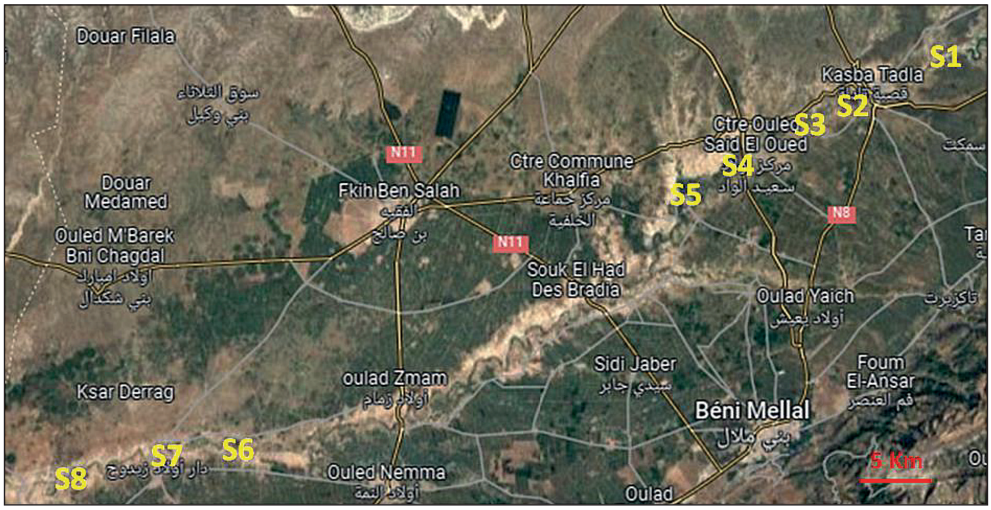

Figure 2. Location of water sampling stations of Oum Er Rbia river

collected samples were fixed directly with 10% formalin.

The determination of benthic macroinvertebrates was carried out with reference to the work of (Gagnon and Pedneau, 2006; Moisan, 2010; Tachet, 2010; Wichard et al., 2002). The taxonomic unit chosen for the different faunal groups is the family, the genus or the species.

Method of quantitative and qualitative study of benthic macroinvertebrates

The quantitative study of benthic macroinvertebrates is based on the calculation of the Specific Richness S and the Frequency of Occurrence F of a taxon is the ratio between the number of samples (Pa) of a site where the taxon is present by the total number (P) of samples.

$$F = \frac{Pa}{P} \times 10 \qquad (1)$$

- Four groups are thus defined (Dajoz, 2000):
- Very frequent taxa ($80 \leq F \leq 100\%$)
- Frequent taxa ($50 \leq F < 80\%$)
- Fairly frequent taxa ($20 \leq F < 50\%$)
- Rare taxa ($5 \leq F < 20\%$)
- Incidental taxa ($F < 5\%$): absent.

To estimate the biological quality of the waters of the middle Oum Er Rbia river, we based ourselves on the calculation of two biotic indices:

– The index of (Shannon and Weaver, 1949):

$$H' = -\sum_{i=1}^{s} (pi)(\log 2\ pi) \qquad (2)$$

where: pi – relative abundance of a taxon;
pi – ni/N with ni: number of individuals of species i and N: total number of individuals.

Table 2. Principle of determination of the Belgian biological index (Touzin, 2008)

Fauna groups ranked in order of decreasing sensitivity to pollution		Biotic index as a function of the total number of systematic units present				
	Number of SUs in the faunal group	0–1	2–5	6–10	11–15	≥ 16
Plecoptera	≥ 2	-	7	8	9	10
	1	5	6	7	8	9
Trichoptera à foureau	≥ 2	-	6	7	8	9
	1	5	5	6	7	8
Ancylidae et Ephemeroptera sauf heptageniidae	≥ 3	-	5	6	7	8
	≤ 2	3	4	5	6	7
Aphelocheirus (hemiptera) Odonata Gammaridae (Crustacéa) Mollusca sauf sphaeridae	≥ 1	3	4	5	6	7
Asellus (isoptera) Hirudinae Sphaeridae Hemiptera sauf Aphelochéirus	≥ 1	2	3	4	5	-
Tubificidae Chironomidae thumini-plumosus	≥ 1	1	2	3	-	-
Eristalinae/Syrphidae	≥ 1	0	1	1	-	-

The Shannon and Weaver index provides information on faunal diversity, based on the relative abundance of the various taxa.

- The Belgian Biological Index (BBI), (Table 2 and 3) which combines a quantitative measure of diversity with a qualitative measure based on the presence or absence of pollutant-sensitive macroinvertebrates (De Pauw and Vanhooren, 1983).

Table 3. Classification of waters according to the IBB. (De Pauw and Vanhooren, 1983)

Classes	Index	Pollution level
I	10–9	Little or no pollution
II	8–7	Little polluted
III	6–5	Polluted, critical situation
IV	4–3	Very polluted
V	2–0	Excessively polluted

RESULTS AND DISCUSSION

Faunal inventory

The establishment of the faunistic inventory of benthic macroinvertebrates of the eight stations during the sampling campaign, allowed us to evaluate the Shannon and Weaver diversity index (H') and the Belgian biological index (BBI). Table 4 shows the results obtained.

Diversity of benthic macroinvertebrates

Frequency of occurrence (F)

The frequency of occurrence of families and genera of aquatic macroinvertebrates of the Oum Er-Rbia Wadi: On a total of 30 families collected in the Wadi, only two families of insects: Physa acuta, Lumbricus sp, are very frequent with (80 ≤ F ≤ 100%), 6 families of insects are frequent with a frequency of occurrence > 50% including the family of Aescnidae, Achaetae, Hydropsychidae sp, Chironomus sp, Calopterygidae, Beatidae, Lymnaeidae, while the families of Plecoptera, Potamanthus, Margaritana sp, Perla, Lestidae, Rhithrogina, Platycnemididae, Gammarus sp, Blephroceridae, Pisidium sp, Notonectidae, Ptychoptera contaminata, Cordulegastridae are quite frequent with a frequency of occurrence (20 ≤ F < 50%). Rare taxa are represented by Unio sp, Rhagionidae, Culicidae larva, Melanopsis costellata, Dryopidae, Oligoneuriellidae, Anodonta sp, with an occurrence factor (5 ≤ F < 20%). Table 4 represents the different signs of frequency of occurrence of the families collected in Oum Er-Rbia river.

Specific richness

The specific richness is more important in stations S1 (16), S4 (17) and S6 (16) which are

Table 4. Faunal inventory and values of H' and IBB determined in the study stations

Stations / Taxons	S1	S2	S3	S4	S5	S6	S7	S8	Frequency of occurrence
Plécoptère	2			1		1			++
Perla (Perlidae)	2			1		1			++
Hydropsychidae sp (Trichoptères)	1		2	3	2	1			+++
Aescnidae (Odonates)	3			2		2		2	+++
Calopterygidae (Odonates)	4	2	1		2			1	+++
Platycnemididae (odonates)			1			2	1		
Cordulegastridae (Odonates)			2					1	++
Lestidae (Odonates)	3					4	2		++
Rhithrogina (Heptageniidae Ephémeroptères)	2			1	2	1			++
Beatis sp (Ephéméroptères)	2			2	1	2			+++
Ecdyonurus (Éphéméroptères)	2			2		1			
Oligoneuriellidae (Éphéméroptères)					1				+
Potamanthus (Éphéméroptères)	1			2		3			++
Larve de culicidae (Diptères)								1	+
Blephroceridae (Diptères)			3	1				2	++
Chironomus sp (Diptères)		2	3		2		4	3	+++
Rhagionidae (Diptères)			2						+
Achaetae		1		1			2	1	+++
Lumbricus sp (Oligochètes)	4	3	3	2	3	5	1	2	++++
Notonectidae (Hétéroptères)	5			2		2			++
Dryopidae (Coléoptères)			2						+
Gammarus sp (crustacés)	2			2		1			++
Margaritana sp (Crustacés)			2	1		2			++
Melanopsis costellata (Gastéropodes)					2				+
Physa acuta (Gastéropodes)	23	6		13	10	8	6	10	++++
Lymnaeidae (Gastéropodes)			11	8		5	2		+++
Pisidium sp (Bivalves)	3			1	2				++
Anodonta sp (Bivalves)	2								+
Unio sp (Bivalves)								1	+
Ptychoptera contaminata (Diptères)		1	1					2	++
Total	61	15	33	45	27	41	18	26	
Nb of taxa	16	6	12	17	14	16	7	11	
H'	2.26	1.59	2.02	2.27	2.01	2.51	1.71	1.9	
IBB	10	5	8	10	8	10	5	6	

Note: + : F ≥ 5% (rare taxa); ++ : F ≥ 25% (fairly frequent taxa); +++ : F ≥ 50% (frequent taxa); ++++ : F ≥ 80% (very frequent taxa)

far from any source of pollution. Discharges of domestic waste in S2 and industrial waste in S7 have caused a drop in species richness, which reflects a degradation of water quality. In the same sense, the low taxonomic richness found in arid and semi-arid indifferent bioclimatic regions like the one considered in this study (Boutin, 2010; Sellam et al., 2017) can be explained by unstable environmental conditions.

Biological diversity

The diversity of benthic macroinvertebrates in the waters of the Oum Er-Rbia is illustrated by the evolution of the Shannon-Weaver index, shown in Figure 3.

The graph shows that the value of H' varies from one station to another, the high diversity is observed at stations S1, S3, S4, S5 and S6 where H' exceeds the value 2. This can be explained by the presence of favorable conditions for the

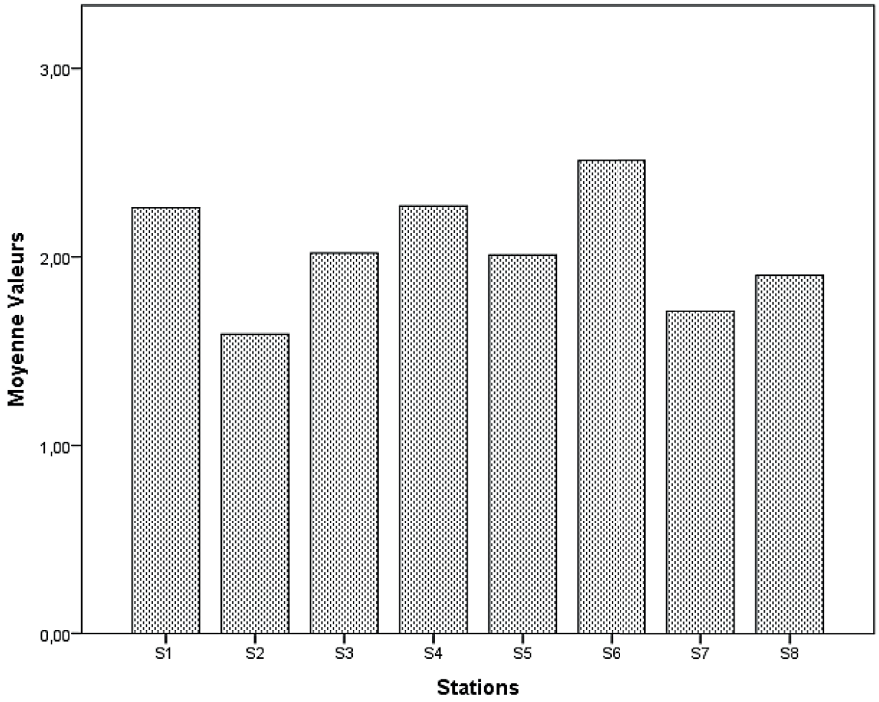

Figure 3. Spatial evolution of the Shannon-Weaver index (H') during the sampling period in the waters of Oum Er-Rbia

Table 5. Biological quality of Oum Er Rbia waters in the Tadla plain

Station	Valeur de l'IBB	Classe	Niveau de pollution
S1, S4 and S6	10	I	Low or no pollution
S3, S5	8	II	Low pollution
S2, S7 and S8	6-5	III	Polluted, critical situation

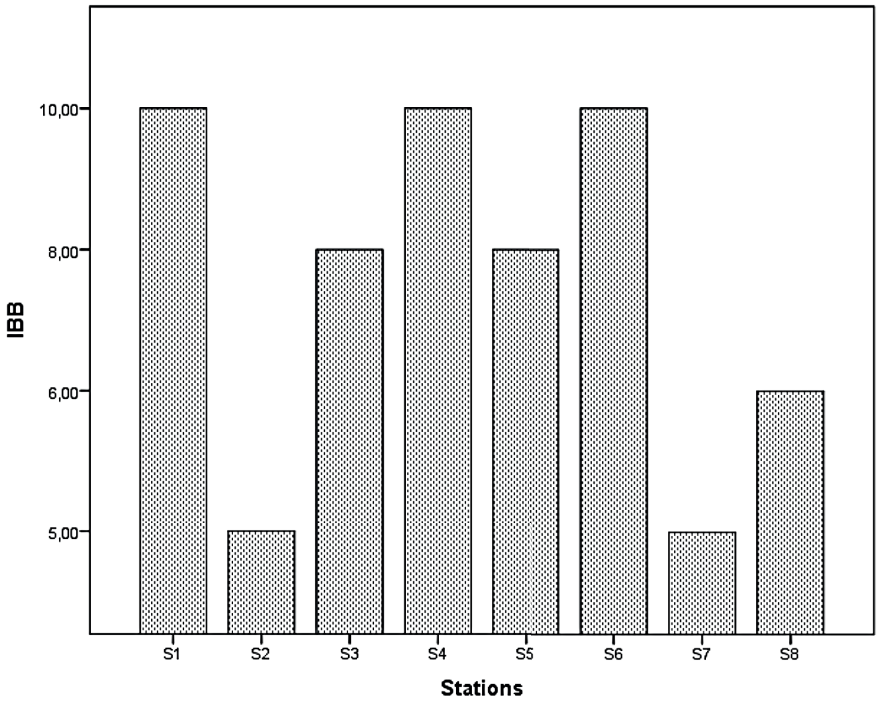

Figure 4. Spatial evolution of the Belgian Biological Index (BBI) during the sampling period in the waters of Oum Er Rbia

development of the majority of macroinvertebrates during this period, and by the absence of pollution sources (Belala and Saheb, 2022). The low values of H' are recorded at stations S2 and S7 (Table 1), these results are attributed to wastewater discharges from the city of Tadla, as well as domestic discharges from other villages neighboring Oum Er-rbia (Dar Ouled Zaidouh) could, without doubt, contribute significantly to the distribution and diversity of this stream.of domestic and industrial waste in these study areas (Karrouch et al., 2018).

Biological water quality

Water quality is assessed by determining the Belgian Biological Index. Figure 4 shows the spatial evolution of this index.

The results represented in Figure 4 and Table 4 show that the values of the IBB vary from station to station, and referring to Table 3 which represents the classification of the waters according to the values of the IBB, we determined the class of water and the level of pollution for each station (Table 5).

Thus, the index approach adopted in our research allowed us to assess the biological quality of the water of Oum Er-Rbia river and to indicate the impact of raw sewage discharges on the distribution of benthic macroinvertebrate populations (Lair and Reyes-Marchant, 2000).

The study stations where the biological quality of the water is polluted are characterized by low taxonomic richness and biological diversity, suggesting that pollution negatively affects the distribution and diversity of the aquatic fauna of this river.

CONCLUSION

The Oum Er Rbia basin is of great importance for agriculture in Morocco, however in recent decades, the scarcity of rainfall and pollution of the main river of the basin have a negative impact on the profitability of agricultural land. Our work aims to contribute to the evaluation of the biological quality of the waters of Oum Er Rbia at the level of the plain of Tadla, The methodology of the study followed consists in carrying out benthic macro-invertebrate sampling in eight stations, and in exploiting the data to calculate the diversity index of Shannon-Weaver and the Belgian biological quality index. The results show that upstream of the two pollution sources, biodiversity is important and water quality is good. While wastewater discharges cause a drop in diversity and a degradation of water quality. There is also a clear improvement in water quality away from the sources of pollution, which attests to the purifying power of the water of the Wadi Oum Er Rbia.

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