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EVOLUTION OF THE PHYSICO-CHEMICAL AND BIOLOGICAL QUALITY OF THE WATERS OF DRADER RIVER (MOROCCO)

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Abstract

The objective of this study is to assess the diversity of benthic macroinvertebrates. And the Physic-chemical and biological quality of the waters of Oued Drader. The main watercourse of the Drader-Souier basin. It is located in northwest Morocco. The results show the physicochemical parameters reveal that the upper course is not polluted. While the middle and lower parts show a high concentration of nitrates during certain periods of the year. This temporary pollution is explained by the contamination of the water of the river by the residues of the chemical fertilizers spread in the catchment area. The values of the organic pollution parameters also show a gradual deterioration from upstream to downstream of water quality. The calculated values of the Chemical Water Quality Index show that, along the river. The water is of good quality during the winter period. Which corresponds to the period of heavy rainfall. For other times of the year. The water becomes polluted. The decrease in flow and the concentration of certain pollutants under the effect of water evaporation are the main causes. The Shannon and Weaver index (H') shows that during the two sampling periods. The diversity of benthic macro-invertebrates is high during spring and early summer, and low during the winter period. And the highest values of the BWI show that in spring and at the beginning of summer upstream and downstream. The waters are of good quality compared to the average river. This difference could be a consequence of the clayey nature of the substrate of the middle part of the river. Note also that the comparative study of the results of the two study campaigns showed results showed only a slight difference that can be attributed to annual variations in climatic conditions.

Keywords: Oued Drader, Water, Physic-chemistry, Macro-invertebrates.

INTRODUCTION

In Morocco, the quantities of fresh water are constantly decreasing. Repeated droughts and increasing demands for water are the main causes. It is therefore imperative to protect

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against any possible pollution and to monitor the quality of the waters in the reserves of this vital substance. This assessment makes it possible to determine the impact of pollutants on the health of ecosystems. In addition, the evaluation of the quality of a hydrosystem could be carried out either by physico-chemical way, or by biological way. However, to optimize this evaluation it must combine the two methods [1]. The notion of ecosystem integrity or health therefore requires simultaneous consideration of chemical, physical and biological parameters [2]. It should be noted that the physico-chemical approach compares the values of the physico-chemical parameters measured with those of the accepted standards, whereas the biological approach consists of analyzing the structure of the populations of certain groups of species or systematic taxa, mainly the macro-invertebrates of the environment. Benthic macro-invertebrates are good examples [3]. Indeed, through their sedentary lifestyle, their great diversity and the difference in species to withstand pollution. This zoological group provides an appreciation of the quality of the environment [4]. Our research out was carried in the Drader-Soueir basin in the North West of Morocco, it aims to study the evolution of the physico-chemical and biological quality of the water of Oued Drader over two periods (2016/2017 and 2018/ 2019).

MATERIAL AND METHODS

1-Study site

The Drader-Soueir watershed (Figure 1), located in the northwest of Morocco, covers an area of 621 km^2. Crossed by two rivers, this basin is known for various agricultural and forestry activities, in particular the production of eucalyptus. Precipitation and groundwater are the main sources of its water supply. The overall surface water supply of the Drader-Soueir basin is 50 Mm^3 including resurgences and returns from irrigation. Nearly 70% of this contribution joins the Merja Zerga by the Oued Drader [5]. This study site opens into the Merja Zerga. In addition, the upper course of Oued Drader in a North-South direction is temporary. While the middle and lower courses in an East-West direction are permanent and benefit from spills from resurgences of the Dhar El Hadechi aquifer on its right bank and El Fahis on the left bank [6]. The Drader plain has a relatively large dowsing complex. The springs in the Drader downstream valley total an average low water flow of 180 l/s (i.e. nearly 5.6 Mm^3) for an observed overall minimum flow of 50 l/s (1.6 Mm^3) [7].

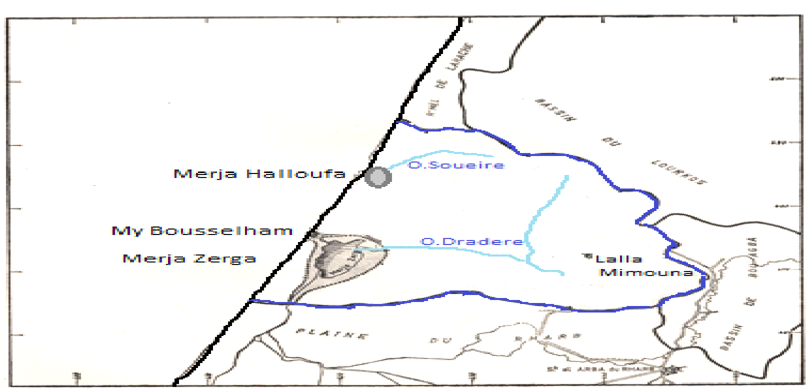

Figure 1: Region of study

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2. Sampling and analytical techniques

Prospected stations were chosen to assess the spatiotemporal evolution of the physico-chemical characteristics of the water and the structure of the population of benthic macro-invertebrates (Table. 1). Station 1 (34°.929' N; - 6°.109' W) is located upstream of Oued Drader (Dr El Mellah) at an altitude of 63 m. Station 2 (34°.84' N; - 6°.118' W) is located at Dr L'Anabsa at an altitude of 14 m, at the confluence of the upper course and the middle course of Oued Drader. Station 3 (34°.856' N; -6°.242' W) is located downstream of the river, just before arriving at the Merja zerga lagoon at an altitude of 10 m.

Table 1: Description of the stations studied and their biotic and abiotic characteristics.

Stations	Lenght (m))	Depth (m)	Speed (m/s)	Bottom substrate (Abiotic Habitat)	Aquatic vegetation (Biotic Habitat)	Comments and rationale
S1	12	0.3	00.00 – 0.2	- Pebbles with gravel and sand - Silts and vases. clay.	- Less dense hydrophytes (macrophytes)- Filamentous algae	- Located upstream (El Mellah). - Reference site. little affected by anthropogenic nuisances.
S2	7	1.2	0.3	- Silts and vases. clay	- Hydrophytes of the herbaceous and shrub layer.	- Located at the confluence of the tributaries coming from the water table with the main watercourse (Dr.Anabsa
S3	13	0.7	0.07	- Sand silt and mud. clay	- Hydrophytes. including macrophytes and mosses. - Dead wood	- Located downstream (Merja Zerga). - Estimate the quality of the water arriving at Lake My Bousselham.

Physico-chemical measured parameters

Water samples are taken bimonthly for two periods respectively from April 2016 to February 2017 and from April 2018 to February 2019 at three stations. As indicated by Rodier (2016) [8]. The water sampled was packaged in opaque bottles and kept cold until arrival at the laboratory. It should be noted that the upper watercourse is temporary, which explains the August and October values are missing.

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Physical parameters

Three physical parameters (water temperature, pH and conductivity) were measured on site with a HACH type multi-parameter, model HQ40d.

Chemical parameters

Ten other chemical parameters were evaluated namely calcium, magnesium, carbonates, nitrates, ammonium, orthophosphates, BOD5, COD suspended matter and dissolved oxygen (DO). Dissolved oxygen is measured in situ by the HACH-type multi-parameter, model HQ40d.

For the other parameters, the analysis methods are those recommended by the standards of Rodier (2016) [8].

Calculation of the Water Quality Index (WQI)

The index (IQE) used makes it possible to classify the quality of the water by referring to international standards or Moroccan standards of nine physicochemical parameters (pH, DO, CE, T°C, $SO_4{}^{2-}$, BOD5, $PO_4{}^{3-}$, $N\text{-}NH_4^+$ and $N\text{-}NO_3^-$). This index has been used for this purpose by many authors including [9], [10]. Moreover, in this approach, a numerical value called relative weight (Wi), specific to each physico-chemical parameter, is calculated (Table. 3) according to the following formula:

$W_i = \frac{k}{Si}$ …..(1)

Where: k: proportionality constant and can also be calculated using the following equation:

$$k = 1/\sum_{i=1}^{n}\left(\frac{1}{Si}\right) \dots (2)$$

n: number of parameters

Si: maximum value of the Moroccan standard for surface waters [11] of each parameter in mg/L except for pH, T°C and electrical conductivity [11]. The quality assessment scale (Qi) is calculated for each parameter by dividing the concentration by the standard of the said parameter and multiplying the whole by 100 as in the following formula:

$Q_i = \left(\frac{Ci}{Si}\right) \times 100$ ……………. (3)

Qi: quality assessment scale for each parameter. Ci: the concentration of each parameter in mg/L. Finally, the overall water quality index is calculated by the following equation:

$$IQE = \sum_{i=1}^{n} Qi\ X\ wi / \sum_{i=1}^{n} Wi \dots\dots (4)$$

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Table 2: Classification and possible use of water according to the WQI [12], [13].

IQE class	Type of water	Possible use
0 – 25	Excellent quality	Drinking water, irrigation and industry
>25 – 50	Good quality	Drinking water, irrigation and industry
>50 – 75	Bad quality	Irrigation and industry
>75 – 100	Very bad quality	Irrigation
>100	Non-drinkable water	Appropriate treatment required before use

Table 3: Weight of physico-chemical parameters and Moroccan surface water quality standard [11].

Parameters	Moroccan standards	S_i (standard maximum value. Morocco)	$1/S_i$	W_i
pH	6.5 – 9.2	9	0.111	0.031
T(°C)	20 - 30	30	0.033	0.009
Cond (µs/cm)	750 - 2700	2700	0.000	0.000
O_2 diss (mg/l)	3 - 5	5	0.200	0.056
NH_4^+(mg/l)	0.1 – 0.5	0.5	2.000	0.560
NO_3^-(mg/l)	<50	50	0.020	0.006
SO_4^{2-}(mg/l)	100 -250	250	0.004	0.001
PO_4^{3-}(mg/l)	0.2 - 1	1	1.000	0.280
DBO5 (mg/l)	3 - 5	5	0.200	0.056
			3.569	
		$K=1/\sum(\frac{1}{Si})$	0.280	

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Sampling of benthic macro-invertebrates

Benthic macro-invertebrate samples are taken with the same frequency as water sampling for physico-chemical analysis. At each station, habitats are sampled by stirring up sediment or vegetation. Deep areas are sampled using artificial substrates. Sampling device: Net attached on 2 sides collecting the animals dislodged upstream with the foot, similar to a mini-seine ("Kick-net") or a kick-net ("hand-net"). The level of determination of the harvested fauna is the family or the genus. Thereby, in our sampling, we followed the protocol [14] indicated to evaluate the Belgian Biological Index (BBI).

Benthic macroinvertebrate samples were taken in calm water using a kick net and in running water using a 300 µm Surber net with one square foot of bottom surface (1/10 m^2). The collected samples are directly fixed with 10% formalin. The determination of benthic macro-invertebrates was carried out in the laboratory using binocular loupes and microscopes, referring to the work of Gagnon et al. (2006) [15], Moisan. J. (2010) [4] . The taxonomic unit retained is the family for the different faunal groups.

3. Method for the quantitative and qualitative study of benthic macro-invertebrates

To determine the biological quality of the waters of Oued Drader, we based ourselves on the determination of two biotic indices [16]:

- H'= $-\sum_{i=1}^{s}(\mathrm{pi})(\log 2\ \mathrm{pi}) \ldots\ldots (5)$

p_i = the relative abundance of a taxon; $p_i = n_i/N$ with n_i: number of individuals of species i and N: the total number. The Shannon and Weaver index provides information on faunal diversity, based on the relative abundance of the various taxa.

- The Belgian Biological Index (BBI), which combines a quantitative measure of diversity with a qualitative measure based on the presence or absence of pollution-sensitive macro-invertebrates [17].

RESULTATS ET DISCUSSION

The Results of the physico-chemical analysis of Drader wadi waters during the 2016/2017 period shown in the Table 4& 5.

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Table 4: Results of the physico-chemical analysis of Drader wadi waters during the 2016/2017 period.

	pH	Teau (°C)	C E (µS/cm)	Ca (mg/L)	Mg (mg/L)	$CaCO_3$ (mg/L)	SO_4^{2-} (mg/L)	NO_3^- (mg/L)	NH_4^+ (mg/L)	PO_4 (mg/L)	DBO5 (mg/L)	DCO (mg/L)	MES (mg/L)	D O (mg/L)
S1 Av	7.56	19.3	1356	11.60	1.46	39.04	228	10.91	1.13	0.3	2	4	4.4	11.45
S1 Ju	7.59	23.7	1486	12.45	1.57	42.58	155	13.54	1.2	0.44	2	3.6	2.6	11.35
S1Ao	-	-	-	-	-	-	-	-	-	-	-	-	-	-
S1 Oc	-	-	-	-	-	-	-	-	-	-	-	-	-	-
S1De	7.7	12.4	682	68	10.3	143	63	8.3	0.16	0.3	6	13	9	11.26
S1Fe	7.53	16.9	1160	190	29	100	179	8	<0.1	<0.20	4.2	12.6	35.7	11.4
S2AV	7.61	17.1	1161	117.60	12.64	290.36	125	28.40	1.67	0.46	3	3.7	5.6	11.25
S2 Ju	7.65	21.2	1244	124.5	1.85	42.58	129	13.54	1.2	0.44	2	3.5	4.7	11.19
S2Ao	7.79	23.9	1325	146	17	181	110	90	1.4	0.8	5	8	5.8	9.22
S2 Oc	7.94	20.7	1356	170	9.6	172	70	163	1.65	0.7	5	9	6.4	9.17
S2De	7.78	13.1	550	100	3.4	191	45	73	<0.1	0.3	4	7	6	9.47
S2Fe	7.57	16.8	1114	78	4.7	218.44	53	45	<0.1	0.28	7	21	44	8.79
S3Av	7.51	19.2	1242	153.6	9.23	270.84	76	30.38	1.71	0.42	5	13	11	7.14
S3Ju	7.54	24.2	1269	164.4	10.56	286.24	74	36.48	1.81	0.47	4	12.6	10.25	8.06
S3Ao	7.73	25.1	1325	118	19.2	258	78	29.2	1.8	0.7	7	11.4	10.45	5.96
S3Oc	7.68	20.8	1261	125	24	276	62	9.9	1.49	0.7	8	12.6	10.5	5.78
S3De	7.62	11.7	2093	180	33.4	331	74	30	0.19	0.3	12	34	29	8.69
S3Fe	7.61	14.2	1240	174	52	330	64	35.2	<0.1	<0.2	4	14.3	19	8.1

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Table 5: Results of the physico-chemical analysis of Drader wadi waters during the 2018/2019 period

	pH	Teau (°C)	C E (µS/cm)	Ca (mg/L)	Mg (mg/L)	$CaCO_3$ (mg/L)	SO_4^{2-} (mg/L)	NO_3^- (mg/L)	NH_4^+ (mg/L)	PO_4 (mg/L)	DBO5 (mg/L)	DCO (mg/L)	MES (mg/L)	D O (mg/L)
S1 Av	7.42	19.6	1410	10.8	1.65	43.51	196	7.12	1.24	0.41	3.5	7	5.6	10.25
S1 Ju	7.51	23.4	1452	14.5	2.83	40.69	135	12.03	1.36	0.37	2.8	6.5	3	10.56
S1Ao	-	-	-	-	-	-		-	-	-	-	-	-	-
S1 Oc	-	-	-	-	-	-		-	-	-	-	-	-	-
S1De	7.73	13	722	75.7	9.34	155.24	81	8.24	0.14	0.2	7	16	15.5	9.77
S1Fe	7.68	15.9	1096	144.6	31.2	117.11	169	7.68	0.13	<0.20	5	11.5	19	9.88
S2AV	7.5	17.6	1144	120	16.77	278.65	113	33.41	1.42	0.41	3	7	7	10.85
S2 Ju	7.59	22	1290	110.6	2.54	45.22	130	18.32	0.96	0.32	3.3	8	7.5	10.66
S2Ao	7.82	23.7	1415	128.5	11.44	184.2	121	78.25	1.28	0.62	4.5	9	12	8.84
S2 Oc	7.76	21.2	1366	145	11.32	169	82	146	1.82	0.53	6	13	8	9.44
S2De	7.8	14.8	648	92	4.61	223.4	57	61.22	0.1	0.26	5	14	10	9.68
S2Fe	7.64	16.5	1205	69.7	5.19	257.88	64	37	<0.1	0.31	5.5	17	37	8.67
S3Av	7.48	20	1260	133.4	10.47	256.22	87	26.77	1.35	0.51	4.5	12	14	8.05
S3Ju	7.52	23.8	1320	155	14.63	271.33	71	31.44	1.84	0.44	4	13.5	13	8
S3Ao	7.74	25.4	1386	134.2	18.55	249	93	28.11	1.62	0.48	6	14	11.8	7.1
S3Oc	7.68	20.6	1179	141	19.38	255.89	89	12	1.08	0.68	7	15	12	6.88
S3De	7.71	13	1877	168.4	28.66	346	78	22.14	0.1	0.26	13	29.5	26	8.3
S3Fe	7.65	1.6	1203	182.6	46.12	321.4	103	33.54	<0.1	<0.2	7	13.5	14	8.55

1. COMPARATIVE STUDY OF THE PHYSICOCHEMICAL PARAMETERS OF THE WATERS OF OUED DRADER

1.1 pH

In the two study campaigns, the pH did not vary remarkably. It oscillates between 7.42 recorded in April 2018 in station 1 and 7.94 measured in October 2016 in station 2. This slight alkalinity of the waters can be attributed to the marly nature of the substrate [18]. The stability of the water resources of Oued Drader and the low variation in flow contribute to the stability of the pH.

1.2. Water temperature

For both campaigns, the water temperature is higher during the summer period and lower during the winter period. This seasonal difference in water temperature is attributed to intra-

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annual variation in climate. The small variations between the temperature values of the two campaigns are the result of the inter-annual variation of the climate.

1.3. Electrical Conductivity

For the two study campaigns, the electrical conductivity is variable depending on the stations. The lowest values (550 µs/cm in 2016 and 722 µs/cm in 2018 were recorded in S1). While the highest values (2093 µs/cm in 2016 and 1877 µs/cm in 2018) were recorded in S3. Note that all these values are lower than the Moroccan surface water standard set at 2700 µs/cm [11].

1.4. Carbonates. Calcium and Magnesium

For the two study companions, the carbonate content varies temporally and spatially. The lowest (39.04 mg/L in 2016 and 40.69 mg/L in 2018) were recorded upstream of the river (S1). The highest values (331 mg/L in December in S3 and 346 mg/L in December 2018 in S3). These variations can be explained by the variation of the intensity of the erosion of the substrate and the variation of the flow of the river.

For calcium concentrations, the values recorded are low upstream in April (11.60 mg/L in 2016 and 10.8 mg/L in 2018). The highest values (180 mg/L in December 2016 in S3 and 182.6 mg/L in February 2019 in S3). These variations can be attributed to the marly nature and the richness of the soils of the Drader-Soueir basin in calcium and the abundance of water.

The magnesium content in the waters of Oued Drader varies from upstream to downstream and according to the time of year. These variations can be explained by the nature of the substrate and the climate. This last factor is at the origin of the differences observed between the two sampling campaigns.

1.5. Sulphates

Recorded sulphate concentrations in both companions are below Moroccan standards (250 mg/L). Overall, these levels decrease from upstream to downstream with differences observed between the two sampling periods. These results can be explained by the variations in climatic conditions which influence the erosion of the substrate and the dilution of the substance in water.

1.6. Nitrates

Upstream of Oued Drader, for both sampling periods, nitrate concentrations are well below Moroccan and international standards (50 mg/L). This can be explained by low agricultural activity. On the other hand, at station 2, values were recorded which far exceed the standards accepted in August (90 mg/L in 2016 and 78.25 mg/L in 2018), in October (163 mg/L in 2016 and 146 mg/L in 2018) and in December (73 mg/L in 2016 and 61.22 mg/L in 2018). This increase in nitrate levels in water can be attributed to the leaching of fertilizers used intensively in agricultural soils located in the Drader-Soueir basin and the northern part of the Sebou basin.

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Downstream of the river nitrate levels are high but remain below 50 mg/L. These results can be explained by the large volume of water and therefore the dilution effect.

1.7. Ammonium and orthophosphates

During the two sampling periods, the concentration of the ammonium ion is lower than the accepted standards (0.5 mg/L) during the winter season. While it is much higher than the standards during the other seasons of the year. These results can be explained by the amendment of the soil by nitrogenous fertilizers and by the seasonal variation of the water flow.

The orthophosphate levels are lower than Moroccan standards in the waters of Oued Drader, attesting to the absence of orthophosphate pollution.

1.8. Organic pollution parameters

1.8.1. Biochemical oxygen demand (BOD5)

During both sampling periods, the BOD5 values measured at the three stations are low, they do not exceed the accepted standard (25 mg/L). This indicates the absence of organic pollution of the waters of Oued Drader. However, there is a slight increase in BOD5 from upstream to downstream, attesting to a slight deterioration in the quality of the river water. The values measured between April 2018 and February 2019 and those recorded between April 2016 and February 2017 show a slight and variable difference that is difficult to interpret.

1.8.2. Chemical oxygen demand (COD)

The results show that during the two sampling periods, the chemical oxygen demand is low during the summer period compared to the winter period, with higher values downstream of Oued Drader. These differences result from the abundance of organic matter and decomposers in the water. We also note that the COD measured during the second sampling campaign is generally higher than that recorded during the first campaign, which can be explained by the abundance of precipitation and therefore of suspended matter during this period. However, all the COD values recorded are below the accepted standards [11].

1.8.3. Suspended matter (SS)

The results show that the SS levels are low upstream of the river for the two study periods. These concentrations increase downstream. The highest values are recorded during the months of December and February. This increase in suspended solids is attributed to the effect of precipitation on the vegetation and on the substrate and to the transport of these suspended solids from upstream to downstream of the river.

1.8.4. Dissolved oxygen (DO)

It is noted that during the two sampling periods the O_2 content dissolved in the water is higher upstream of Oued Drader, and it gradually decreases downstream indicating a slight deterioration in water quality. The values recorded also show a higher rate of dissolved O_2 during the winter period, which can be explained by the low temperature which favors the dissolution of oxygen, and by increased water agitation as a result of increased water flow in

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winters. Furthermore, the comparison of data recorded during the two periods shows sometimes significant differences attributed to climatic conditions.

2. WATER QUALITY ASSESSMENT VIA WQI

The water quality index values show in Table 6.

Table 6: Values of the WQI index and quality class of the surface waters of Oued Drader during the two sampling campaigns.

Station	WQI 2016/2017	Water quality	WQI 2018/2019	Water quality
S1 Av	153.42	Non-drinkable water	169.06	Non-drinkable water
S1 Ju	165.22	Non-drinkable water	181.13	Non-drinkable water
S1Ao	-	-	-	-
S1 Oc	-	-	-	-
S1De	50.31	Good water	43.24	Good water
S1Fe	37.31	Good water	40.10	Good water
S2AV	219	Non-drinkable water	189.58	Non-drinkable water
S2 Ju	42.03	Good water	135.65	Non-drinkable water
S2Ao	58.53	Bad water	180.05	Non-drinkable water
S2 Oc	225.61	Non-drinkable water	240.46	Non-drinkable water
S2De	38.65	Good water	39.92	Good water
S2Fe	40.39	Good water	39.34	Good water
S3Av	224	Non-drinkable water	42.45	Good water
S3Ju	233.17	Non-drinkable water	235.51	Non-drinkable water
S3Ao	225.71	Non-drinkable water	213.35	Non-drinkable water
S3Oc	188.52	Non-drinkable water	153.94	Non-drinkable water
S3De	56.21	Bad water	45.83	Good water
S3Fe	33.92	Good water	37.77	Good water

For the three stations, the waters are of good quality during the winter period, characterized by heavy rainfall. While for other times of the year, the water becomes undrinkable, testifying to an intense degradation of its quality which can be explained by the decrease in flow and the concentration of certain pollutants such as nitrates from agricultural activity [18].

3. Spatiotemporal evolution of the benthic fauna of the waters of Oued Drader

The development of faunal inventories of benthic macro-invertebrates at the three stations enabled us to determine, for the two study companions, the Shannon and Weaver diversity

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index (H') and the Belgian biological index (BBI). Tables 7and 8 combine the results obtained.

Table 7: Fauna inventory and values of H' and BBI recorded upstream and downstream of Oued Drader during the 2016/2017 period.

Station	S1						S2						S3					
Samples	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
Taxa																		
Cl. INSECTA																		
O.Plecoptera																		
Leuctridae	2						1						2					
Perlidae	3	1																
O.Trichoptera																		
Leptoceridae	3	1												1				1
Odontoceridae	1					1	2						1					
O.Odonata																		
Lestidae	1	2				1	2	1	2			1	2	1	1			1
Libellulidae	4	3				2	2	1	1			3	3	2	3	2	1	2
O.Heteroptera																		
Notonectidae	1	3				1		1										
Gerridae	3	1					1		1					3	2			
Hydroptilidae													2					
O.Coleoptera																		
Gyrinidae	1						1	2					1	2				
Dytiscidae	6	3				2	4	4					3	1				
Elmidae	3	2					1	2					2	2	1			1
Sphaeridiidae	1							1					2	1		1		
O.Ephemeroptera																		
Baetidae	9	6				3	3	5		1			5	4				
Heptageniidae	1													1				
Caenidae	1																	
O.Dipteria																		
Thaumaleidae	1																	
Empididae	2	1						1					2					
Tipulidae	2	1						1					2	1		1		
Chironomidae	6	3				2	5	7				3	6	8	6			4
Cl. GASTEROPODI																		
O.Prosobranchia																		
Physidae	12	6			3	6												
Lymnaeidae	6	8			4	7	11	10	10	6	5	7	39	31	34	32	19	26
Planorbidae		1											2	3	2			2
Cl. BIVALVE																		
O.Eulamellibranchia																		
Syphridae													2	3	3	2	1	2
Cl. CRUSTACE																		

Gammaridae	1	2		1	2	1		1				1		1		1
Cl. OLIGOCHETES																
O.prosopora																
Tubificidae (Tubifex)		2				1						1	2	1		
Lumbricidae	3	4	2	4	2	3	3	4	1	2	5	6	8	6	3	5
Cl. Arachnid																
O.Hydracarina																
Hydrachnidae	5	6			2	3	2	1			3	2	5	2		
Total	78	57	9	30	39	44	19	13	6	16	85	74	66	48	24	49
Nb of taxons	24	19	3	11	14	16	6	5	2	5	18	19	11	9	4	11
H’	2.07	2.4	1.06	2.31	2.3	2.27	1.39	0.94	0.44	1.4	1.2	2.09	1.69	0.93	0.5	1.75
BBI	10	8	4	7	8	8	5	5	4	4	10	8	6	5	4	7

H’: Diversity index of Shannon and Weaver. BBI: Belgium Biotic Index

Table 8: Fauna inventory and values of H' and BBI recorded upstream and downstream of Oued Drader during the 2018/2019 period.

Station	**S1**						**S2**						**S3**					
Samples	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
Taxa																		
Cl. INSECTA																		
O.Plecoptera																		
Leuctridae	3	2											1					
Perlidae	2																	
O.Trichoptera																		
Leptoceridae	2	1				1							2	2				1
Odontoceridae		1				2	1											
O.Odonata																		
Lestidae	2	2				1	2		1			2	2	3	1			1
Libellulidae	5	4				4	3	2	3			4	5	6	5	3	1	4
O.Heteroptera																		
Notonectidae	3	2				2	1	2	1				2					
Gerridae	4	2							1					2	1			
O.Coleoptera																		
Gyrinidae	1						1	2					2	1	1			
Dytiscidae	7	3				2	3	3	2				4	2				2
Elmidae	3	1						1					2	2		1		2
Sphaeridiidae	2				1		1	1					3	1	2	1		
O.Ephemeroptera																		
Baetidae	8	6				4	4	5		1			6	3				
Heptageniidae	2													1				
O.Dipteria																		
Thaumaleidae	2																	
Empididae	2	2											1		2			

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Tipulidae	4	3					2	1	1				3	2		2		
Chironomidae	5	4			3	1	4	6	3			2	8	9	8			3
Cl. GASTEROPODI																		
O.Prosobranchia																		
Physidae	15	9			4	5		3	5	5		2	6	11	12	9	6	10
Lymnaeidae	10	7			6	4	14	8	12	8	7	14	43	28	30	35	23	29
Planorbidae		1											2					1
Cl. BIVALVE																		
O.Eulamellibranchia																		
Syrphidae	3	2						2					3	4	5	3	1	3
Cl. CRUSTACE																		
Gammaridae	1						1	1		1				2	1	1		2
Cl. OLIGOCHETES																		
O.prosopora																		
Tubificidae (Tubifex)	2	4			3			2					2	2	3	4		
Lumbricidae	4	2			2	3	2	4	3	3	1	2	4	5	6	5	2	4
Cl. Arachnid																		
O.Hydracarina																		
Hydrachnidia	10	7					3	4	3	2			4	3	4	3		
Total	100	65			19	29	42	47	35	20	8	26	105	89	81	67	33	62
Nb of taxons	24	20			6	11	14	16	11	6	2	6	20	19	14	11	5	12
H'	2.12	2.25	-	-	1.66	2.25	2.25	2.36	1.79	1.52	0.37	0.72	1.75	2.19	1.74	1.68	0.96	2.4
BBI	10	10			4	8	7	7	6	5	4	5	9	9	6	6	4	7

H': Diversity index of Shannon and Weaver. BBI: Belgium Biotic Index

3.1. Diversity of benthic macro-invertebrates in the waters of the Drader

The evolution of the diversity of benthic macro-invertebrates from the two sampling periods is shown in Figure 2.

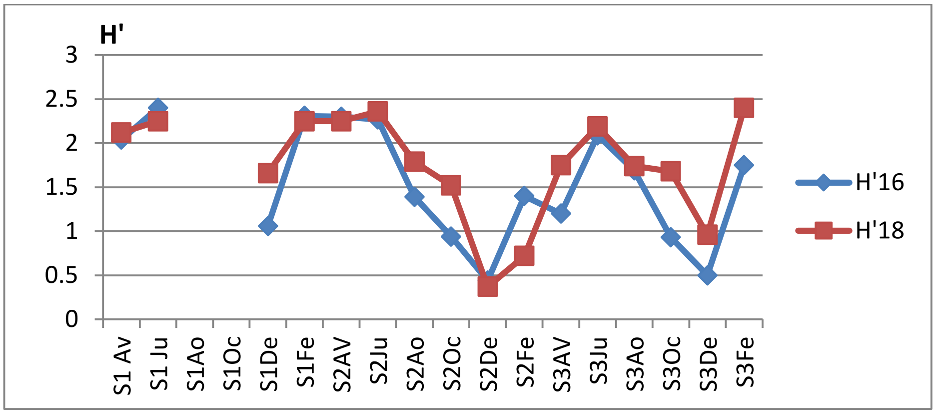

Figure 2: Spatiotemporal evolution of the Shannon index (H') during the two sampling periods of benthic macro-invertebrates in the waters of Oued Drader.

This evolution shows that the diversity is high during spring and summer and low in winter. Favorable climatic conditions (rainfall and temperature) and water quality promote the spring and summer diversity of macro-invertebrates. Also, the graph shows that the evolution of H' during the two sampling periods is similar. The slight differences can be attributed to the inter-annual difference in climatic conditions between the two years of study.

3.2 Evaluation of the biological quality of the waters of Oued Drader

Figure 3 represents the evolution of the Belgian biological index (BBI) that was determined to assess the quality of the water of Oued Drader during the two study periods.

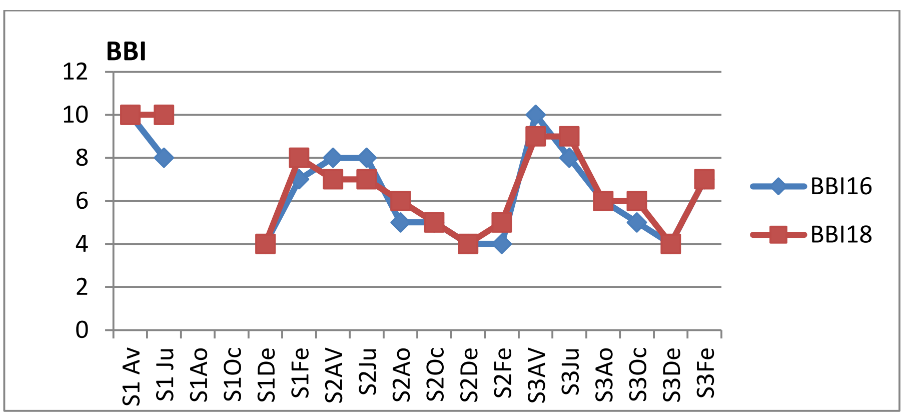

Figure 3: Spatiotemporal evolution of the Belgian biological index (BBI) during the two sampling periods of benthic macro-invertebrates in the waters of Oued Drader

The obtained curves show that, for the two periods, the water quality varies from one season to another. The highest BBI values recorded in spring and early summer, indicate that the waters of the wadi studied are not polluted during these periods [14]. The low BBI values recorded in the other seasons attest to a deterioration in the quality of the water which could be attributed to the effect of the rains on the surrounding environment and on the substrate.

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Similarly, low winter temperatures do not favor the reproduction of benthic macro-invertebrates.

Conclusion

The monitoring of physico-chemical parameters reveals that the upper course does not show environmental pollution. While the middle and lower rivers experience during certain periods of the year high concentrations of nitrates sometimes exceeding the standard accepted for the middle course. This can be explained by the use of fertilizers in agricultural activity. Similarly, the evaluation of organic pollution parameters showed a slight degradation of the water quality of Oued Drader from upstream to downstream. The calculation of the IQE shows that, for the three stations, the water is of good quality during the winter period, a period characterized by abundant rainfall. While for other times of the year. The water becomes undrinkable testifying to an intense degradation of its quality. The decrease in flow and the concentration of certain pollutants such as nitrates from agricultural activity could be causes. In addition, the Shannon index and the Belgian biological index showed a significant diversity of macro-invertebrates and good water quality during spring. Unlike, during the winter period. The values of the two indices fall due to the deterioration of climatic conditions which become unfavorable to the development of benthic macro-invertebrates.

References

[1] F. A. El-Gohary, S. I. Abo-Elela, S. A. Shehata, and H. M. El-Kamah, “Physico-Chemical-Biological Treatment of Municipal Wastewater,” *Water Sci. Technol.*, vol. 24, no. 7, pp. 285–292, 1991.

[2] B. Genin, C. Chauvin, and F. Ménard, *Cours d’eau et indices biologiques: pollution, méthodes, IBGN*. Educagri éditions, 2003.

[3] F. B. Gonçalves and M. S. de Menezes, “A comparative analysis of biotic indices that use macroinvertebrates to assess water quality in a coastal river of Paraná state, southern Brazil,” *Biota Neotropica*, vol. 11, no. 4, pp. 27–36, 2011.

[4] J. Moisan, *Guide d’identification des principaux macroinvertébrés benthiques d’eau douce du Québec, 2010: surveillance volontaire des cours d’eau peu profonds*. Développement durable, environnement et parcs Québec, 2010.

[5] A. Benhoussa, “Caractérisation des habitats et microdistribution de l’avifaune de la zone humide de Merja Zerga (Maroc),” *These Doc D’État Univ. Mohamed V Rabat*, 2000.

[6] H. Aguedai, F. Lahlou, and B. El Mansouri, “Hanaa Aguedai—Intrusion Zones Identification in the Mnasra Aquifer (Morocco) Using the Seawater Intrusion Models and the Geophysics Data,” in *Geospatial Technology*, Springer, pp. 51–68, 2020.

[7] Agence du bassin hydrolique de Sebou (ABHS), 2017. "Nappe Dradère soueir".

https://www.abhsebou.ma/presentation-du-bassin/eaux-souterraines/nappe-de-dradere-soueir/

[8] J. Rodier, B. Legube, and N. Merlet, *L’analyse de l’eau-10e éd.* Dunod, 2016.

[9] A. Talhaoui, A. El Hmaidi, H. Jaddi, H. Ousmana, and I. Manssouri, “Calcul de L’Indice de Qualité de l’Eau (IQE) pour l’évaluation de la qualité physico-chimique des eaux superficielles de L’Oued Moulouya (NE, Maroc),” *Eur. Sci. J. ESJ*, vol. 16, no. 2, 2020.

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DOI 10.17605/OSF.IO/3CFZ8

[10] S. M. Yidana and A. Yidana, "Assessing water quality using water quality index and multivariate analysis," *Environ. Earth Sci.*, vol. 59, no. 7, pp. 1461–1473, 2010.

[11] N. M. "Normes Marocaine de qualité des eaux," *Bull Off*, no. 5062, 2002.

[12] D. N. Aher, V. D. Kele, K. D. Malwade, and M. D. Shelke, "Lake Water Quality Indexing To Identify Suitable Sites For Household Utility: A Case Study Jambhulwadi Lake; Pune (MS)," *Int. J. Eng. Res. Appl.*, vol. 6, no. 5, pp. 16–21, 2016.

[13] R. M. Brown, N. I. McClelland, R. A. Deininger, and M. F. O'Connor, "A water quality index—crashing the psychological barrier," in *Indicators of environmental quality*, Springer, 1972, pp. 173–182.

[14] N. De Pauw and G. Vanhooren, "Method for biological quality assessment of watercourses in Belgium," *Hydrobiologia*, vol. 100, no. 1, pp. 153–168, 1983.

[15] E. Gagnon and J. Pedneau, "Surveillance Volontaire (SurVol) Benthos, guide du volontaire, programme de surveillance volontaire des petits cours d'eau," *CVRB Qué. Can.*, vol. 25, 2006.

[16] C. E. Shannon, "A mathematical theory of communication," *Bell Syst. Tech. J.*, vol. 27, no. 3, pp. 379–423, 1948.

[17] D. Touzin and M. Roy, "Utilisation des macroinvertébrés benthiques pour évaluer la dégradation de la qualité de l'eau des rivières au Québec," *Fac. Sci. L'agriculture L'alimentation Univ. Laval Quebec Can. 40p*, 2008.

[18] Ş. Şener, E. Şener, and A. Davraz, "Evaluation of water quality using water quality index (WQI) method and GIS in Aksu River (SW-Turkey)," *Sci. Total Environ.*, vol. 584, pp. 131–144, 2017.