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DIVERSITY OF BENTHIC MACROINVERTEBRATES AND STREAMS QUALITY IN THE NATIONAL PARK OF BELEZMA (NORTHERN-EAST, ALGERIA)

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Abstract

In North Africa, the studies of streams quality are incomplete, especially in arid environments which are very fragile. This work is intended to highlight the knowledge of the health status of the streams in the Belezma National Park (Biosphere Reserve) through a multi-parametric approach based on benthic macroinvertebrates ecology. We have prospected in April 2015 four temporary rivers (Wadis: W. Hamla, W. Chaaba, W. Bouilef and W. El Ma) and evaluated the biodiversity of benthic macroinvertebrates in relation to a set of environmental factors: 12 physicochemical water parameters, global habitat characteristics and degree of human pressure. The water flow velocity is generally very low to medium. The habitats are dominated by coarse substratum and rocks (5-90%), sand and gravel are poorly represented while plants habitats are completely absent. The water pH was between 7.29 and 8.50, nitrates (0 - 0.76) and nitrites (0.1

- 0.4). The water was slightly salted (0.20% and 0.30%) and generally clear (turbidity: 2.8 to 22 NTU). We identified a total of 28 taxa of benthic macroinvertebrates divided into 3 phylums, 4 classes, 11 orders and 22 families. Among the insect class, which was the most dominant taxa, the most abundant groups are Diptera (36.85%), Trichoptera (20.92%) and Ephemeroptera (16.73%). The highest biodiversity (total richness: 22 taxa; Shannon index: 2.84) was noted in W. Chaaba, which is located in the integral zone of the protected area. The evaluated biotic index of water quality ''IBGN'' shows that hydro-biological quality of the water in the 4 studied streams was generally as ''average'' (IBGN score between 9 and 10). It would be urgent to set up a biomonitoring program in order to control the disturbances issue to high pollution in this protected area.

Keywords

Macroinvertebrates, Water quality, Multi-parametric analysis, Belezma National Park, Algeria

1. Introduction

Waters are very unevenly distributed on the planet surface: 97% of the total volume accumulates in the oceans, 2% on continents, 0.6% solid phase in polar ice sheets and glaciers, finally, a very small part in the gas phase in the atmosphere (Ghislain, 2006).

Limnology can be defined as the science of continental waters and living organisms. Nowadays, limnology is concerned with all inland waters, whether soft or brackish, stagnant (lakes, ponds ...), current (streams, rivers ...) or underground (groundwater, underground rivers ...) and related flora and fauna organisms; it examines all the interactions between the characteristics of the habitat and these organisms (Dussart, 1966).

Among the applications of limnology studies, the biological quality evaluation of streams can be carried out by several conventional approach methods (biochemical, toxicological, biocenotic …) and updated such as biocenotic studies and more precisely those based on benthic macroinvertebrates known as bioindicators (Angelier, 2000; Couceiro et al., 2012; Greaber et al., 2017). According to the application of biological indexes, the species counting in rivers, for example, allow to conclude on the pollution degree. Changes in land use such as agricultural intensification and human pressure can severely alter their composition and biodiversity (Tonkin & Death, 2012). By their presence or absence, their behavior or their disappearance, their sensitivity and wide range of disturbance types, macroinvertebrates can inform about the water quality (Rodier, 2000; Gabriels et al., 2010).

This knowledge is necessary to successfully assess the modalities of how macroinvertebrate communities vary along the gradients of natural and anthropogenic disturbance. Also, nowadays, environmental legislation for the monitoring, management and protection of freshwater ecosystems is based on biological indicators to assess the health of these ecosystems (Stoddard et al, 2008; Dos Santos et al, 2011). National and regional organizations water stream monitoring provides a large mass of specific data to biological and physicochemical communities of the associated environment (Paulsen et al, 2008; Mondy et al, 2012).

The first limnology research in North Africa dates back to the 19th century, with the work of Gauthier on the continental waters fauna of Algeria and Tunisia and Vaillant on the benthic fauna in North Africa (Lounaci, 2005). Ecology research of invertebrates in Algeria's continental aquatic ecosystems where uncommon and incomplete until the 1980s. It was only after the 1980s that several works were carried out in different country parts (Gagneur et al., 1986 ; Lounaci, 1987; Ait Mouloud, 1988; Arab, 1989 ; Samraoui & Menai, 1999; Samraoui & Corbet, 2000a-b; Lounaci-Daoudi, 1996; Thomas, 1998; Mebarki, 2001; Zerguine et al., 2009; Zouggaghe, 2010; Yasri et al., (2013); Moubayed-Breil & Lounaci, 2013; Sellam et al., 2016; Sellam et al., 2017).

In the Mediterranean basin, streams are characterized by an irregular hydrological flows and sudden fluctuations due to rough and violent precipitation. The annual flow is marked by a maximum in spring and autumn and a low level of severe water in summer. There is thus a wide range of variability in environmental conditions, linked not only to floods and droughts, but also to increasing human pressure (Giudicelli et al., 1985).

This work was undertaken in the purpose to enrich the bioecological knowledge and environmental assessment with several objectives:

- Characterize the habitat types and the physicochemical water quality in the streams ‘’Wadis’’ of the Belezma National Park ‘’BNP’’ (Northern-East, Algeria), through a multitude of parameters measured in situ and in vitro,
- Enrich the taxonomic knowledge of benthic macroinvertebrates in the Wadis of the BNP,
- Highlight the biological quality and health status of the BNP waters through a multi-parameter approach combining, at the same time: physicochemical water characteristics, environments characteristics with the population abundance of macroinvertebrates.

The results of this pioneering study will contribute to the knowledge enrichment on the biodiversity of aquatic invertebrates of the BNP which is shortly known; and will contribute to

guide the conservation and management programs of species and spaces in the protected area of the BNP.

2. Materials And Methods

2.1 General Description Of The Study Area And Sampling Stations

The Belezma National Park (BNP) (35° 32' 40"; 35° 37' 46" N, 5° 55' 10"; 6° 10' 45" E) is a protected area, recently designated as a Biosphere Reserve (MAB: Man and Biosphere). It occupies 26,250 ha, dominated by Atlas cedar forests (*Cedrus atlantica* Manetti). The BNP is located in the arid bioclimatic stage with cold winters (PNB, 2015).

Our study involved four temporary streams designated in this study by Wadis (W): W. Hamla, W. Chaaba, W. Bouilef and W. El Ma. On each of these streams, we explored three stations (S) in upstream, middle stream and downstream (Table 1).

Table 1: *General characteristics of the stations sampled in four Wadis of the Belezma National Park (Batna, Algeria)*

Wadis	Station	Altitude (m)	Width (m)	Slope (%)	Depth (cm)	Land occupation
Hamla	1	1411	10	10	15	Forest
	2	1316	10	5	15	Forest
	3	1136	10	15	10	Urban
Chaaba	1	1345	10	10	20	Forest
	2	1303	8	5	25	Forest
	3	1277	6	5	25	Agriculture
Bouilef	1	1075	4	5	25	Forest
	2	1043	3	15	30	Forest
	3	1039	4	10	30	Urban
El Ma	1	1440	10	10	15	Forest
	2	1183	6	10	20	Agriculture
	3	1045	8	10	15	Agriculture

The streams exploration and the benthic macroinvertebrates sampling were carried out in April 2015, the most favorable period for the development of aquatic fauna, following the precipitation received between December and March. Beyond this period, the Wadis dry up until they completely dry out from May to June.

2.2 Characterization of the Environment and Physicochemical Water Parameters

For each of the sampled stations, we noted the altitude (m), the geographical coordinates (latitude, longitude) using a GPS (Garmin, Oregon 650). The water flow velocity is

measured at the surface of the axial course by means of a float released in drift over a known space (Haouchine, 2011). Water flow is classified according to the Berg scale (Haouchine, 2011): very slow speed: less than 0.1 m/s; slow speed: from 0.1 to 0.25 m/s; average speed: from 0.25 to 0.50 m/s; fast speed: from 0.50 to 1 m/s; very fast speed: higher than 1 m/s. A flow scale is used in this work: (1) very slow speed; (2) slow speed; (3) average speed and (4) fast speed.

The habitat types available for benthic macro-invertebrate are described through the substrate type present in the Wadi bed and the recovery rate of each habitat is estimated. We considered four habitat types: (i) sand (< 2 mm); (ii) stones (2-25 mm); (iii) coarse substratum (> 25 mm; < 250 mm) and (iiii) rocks (> 250 mm) (Tachet et al., 2014). The nature of the main pressure factor is described through land occupation characterizing the adjacent land to the sampled stations. We noticed: forest, agriculture and urban (Table 1).

Overall, 12 physicochemical parameters of the water were analyzed: temperature (T) in °C, pH, turbidity (NTU: Nephrometric Turbidity Unit) and electrical conductivity (Cond. µs), measured *in-situ.* Water samples are collected, immediately placed in a cooler and sent to the laboratory for analysis. The measured parameters are (AFNOR, 2005): Salinity (%), Nitrates (NO_3^- in mg/l), Nitrites (NO_2^- in mg/l), dissolved Oxygen (O_2 in mg/l), total dissolved solids (TDS in mg/l), Chlorine (Cl^- in mg/l), complete alkalimetric titer (TAC in mg/l) and Sulfates (SO_4^{2-} in mg/l).

2.3 Benthic Macroinvertebrates Sampling

The sampling of benthic macroinvertebrates in sand and stones habitats was carried out using a Surber of 1/20 m^2. Also, we lift the coarse substratum and rocks and wash them at the entrance of the mesh size 500µm, the equivalent of 1/20 m^2. Once the sampling is complete, the Surber is washed and emptied into a labeled container on which we note the sampling station number, date and environmental characteristics of the station (see below). The collected macroinvertebrates samples are then preserved within 10% formalin (Touron-Poncet et al., 2014).

2.4 Data Analysis

In order to characterize population structure and organization of the sampled benthic macroinvertebrates, we calculated several ecological and diversity parameters:

- Total specific richness (S): is the number of species (or taxa) contracted at least once in the considered samples (Magurran, 2004).

- Shannon diversity index: symbolized by H' and given by the following formula (Magurran, 2004): $H' = -\sum Pi \log_2 Pi$; where: Pi represents the individuals number (n_i) of i species in relation to the total number of counted individuals (N): $Pi = n_i / N$. When all the individuals belong to the same species, the index of diversity is equal to 0 (Magurran, 2004).
- Abundance (%) of different macroinvertebrates families was calculated by the percentage of the individual's number of the considered taxa to the total number of individuals.
- Global Standardized Biological Index (IBGN): this index assesses the hydrobiological water quality at a given point, through the composition of the benthic macroinvertebrates population (AFNOR, 2005). Thus, the IBGN index constitutes synthetic information expressing the water stream capacity to the benthic macroinvertebrates development from all causes. It allows an objective classification of the biogenic qualities of sites belonging to different systems, natural, modified, artificial or variously degraded (Verneaux & Coll, 1982).

Once the sorting of the macroinvertebrates is done in the laboratory and the faunistic list established, we will determine (Table 2): The taxonomic variety of the sample (∑t), that is the total number of identified taxa, regardless of the individuals number found by taxon. The faunistic Indicator Group (I.G) is the most "polluo-sensitive" that is to say the indicator taxon having a significant presence on the station (at least 3 or 10 individuals according to taxa) and having the highest possible index. The IBGN is then calculated from a double-input analysis table: on the abscissae of taxonomic classes (class quality 1 to 14) and on the ordinate, the IG, arranged in descending order (index 9 to 1) of pollution sensitivity.

Table 2: *Grid assessment for water quality (AFNOR, 1992)*
IBGN: Global Standardized Biological Index

IBGN	≥ 17	13-16	9-12	5-8	4
Class quality	1A	1B	2	3	HC*
Matching colour	Blue	Green	Yellow	Orange	Red
Hydrobiological quality	Very good	Good	Medium	Poor	Bad
HC*: Out of class					

3. Results

3.1 Flow Velocity And Habitats Description Of The BNP Wadis

The water velocity is generally very slow to average speed (1 to 3). Only station 1 of W. Chaaba has a fast speed (Table 3).

The listed habitats are dominated by coarse substratum with area coverage ranging from 5 to 90 %. (With an average of 33.75 % for the 12 stations) and rocks (21.25 %), with Habitats with fine and coarse substratum are poorly represented. In the station 2 of W. Hamla and the station 1 of W. Chaaba, stones dominate (Table 3).

Table 3: *Water velocity and area percentages of the main habitats of the studied wadis in Belezma National Park (Batna, Algeria)*
(1: very slow speed; 2: slow speed; 3: average speed and 4: fast speed)

	W. Hamla			W. Chaaba			W. Bouilef			W. El Ma		
Station	1	2	3	1	2	3	1	2	3	1	2	3
Flow velocity	1	2	2	4	3	2	3	2	1	3	2	1
Sand (%)	0	0	0	0	70	25	0	25	70	35	15	0
Stone (%)	45	95	5	90	0	0	50	0	0	0	15	0
Coarse substratum (%)	10	5	90	5	15	30	20	65	20	35	40	70
Rocks (%)	45	0	5	5	15	45	30	10	10	30	30	30

3.2 Physicochemical Quality Of Water In The Wadis Of Belezma National Park

Generally, the 12 physicochemical parameters of water of the four explored Wadis vary from one water stream to another and from one station to another. The pH varies from 7.29 to 8.50 while nitrates and nitrites appear only by traces. The degree of salinity varies from 0.2 mg / l to 0.3 mg / l. The Sulphate (103.93 mg / l) and nitrate (0.4 mg / l) values are the highest in station 3 of W. Hamla. Nitrates are of low levels, ranging from 0.21 mg / l to 0.76 mg / l, sometimes with a total absence of nitrates in several stations: W1S3, W3S1, W3S2, W3S3, W4S2 and W4S3 (Table 4).

Table 4: *Physicochemical characteristics of the water in the studied Wadis of the Belezma National Park (Batna, Algeria)*

Wadi	W. Hamla			W. Chaaba			W. Bouilef			W. El Ma		
Station	1	2	3	1	2	3	1	2	3	1	2	3
T (°C)	7.8	8.08	8.07	14.7	15	14.7	25.6	22.7	24.5	11.7	18.8	15.7
pH	8.12	8.09	8.50	8.11	8.04	8.04	7.46	7.50	7.51	7.40	7.29	7.30
Conductivity (µs/cm)	603	602	819	605	572	672	813	747	725	700	590	651

TDS (mg/l)	291	290	395	291	276	325	392	360	349	338	284	314
Salinity (%)	0.20	0.20	0.30	0.20	0.20	0.30	0.30	0.30	0.30	0.30	0.20	0.20
Turbidity (NTU)	2.80	2.80	5.66	4.13	4.53	5.45	9.11	3.97	5.29	6.08	22.00	7.12
TAC (°F)	26.10	25.03	27.20	26.20	23.80	24.50	24.00	19.30	18.60	33.60	28.40	35.00
[Cl^-] (mg/l)	1.00	1.00	1.00	0.50	0.40	0.40	0.90	1.00	1.00	0.50	0.50	0.60
[$SO4^{--}$] (mg/l)	68.89	60.83	103.93	73.94	70.09	94.35	36.61	33.28	36.76	10.41	12.41	5.91
[$NO3^-$] (mg/l)	0.21	0.49	0.00	0.22	0.50	0.32	0.00	0.00	0.00	0.76	0.00	0.00
[$NO2^-$] (mg/l)	0.02	0.03	0.04	0.02	0.02	0.03	0.01	0.01	0.01	0.01	0.01	0.02
O_2 (mg/l)	2.41	2.34	2.34	1.99	1.99	2.38	2.60	2.54	2.64	2.54	2.08	2.02

3.3 Benthic Macroinvertebrates Diversity In Streams Of The Belezma National Park

The inventory of benthic macroinvertebrates identified in the four explored wadis of NPB covers a total of 28 genus/species, divided into 3 phylums, 4 classes, 11 orders and 22 families (Table 5).

Table 5: *Systematic list of benthic macroinvertebrate identified in the explored Wadis of Belezma National Park (Batna, Algeria) (und : undefined taxa)*

Phylum	**Class**	**Order**	**Family**	**Genus/ Species**
Annelida	Clitellata	Oligochaeta	Lumbriculidae	Lumbriculidae und.
		Hirudinida	Hirudidae	*Hirudo medicinalis*
Mollusca	Gastropoda	Pulmonata	Lymnaeidae	*Lymnaea sp*
	Bivalvia	Veneroida	Sphaeriidae	*Pisidium sp*
Arhropoda	Crustacea	Amphipoda	Gammaridae	*Gammarus sp*
	Insecta	Ephemeroptera	Ameletidae	*Ameletus inopinatus*
			Baetidae	*Acentrella sp*
			Caenidae	*Caenis sp*
			Heptageniidae	*Ecdyonurus sp*
				Epeorus sp
				Heptagenia sp

			Leptophlebiidae	*Leptophlebia sp*
		Plecoptera	Capniidae	*Capnioneura sp*
		Heteroptera	Gerridae	*Gerris lacustris*
		Coleoptera	Hydrophilidae	*Hydrophilus sp*
			Scirtidae	*Hydrocyphon sp*
				Cyphon sp
		Trichoptera	Brachycentridae	*Brachycentrus sp*
			Hydropsychidae	*Hydropsyche sp*
				Cheumatopsyche sp
		Diptera	Chaoboridae	*Chaoborus sp*
			Chironomidae	*Chironomus sp*
				Podonominae und
			Simuliidae	Simuliidae und
			Limoniidae	Limoniidae und
			Stratiomyidae	Stratiomyidae und
			Dixidae	*Dixa sp*
			Thaumaleidae	Thaumaleidae und

3.4 Population Abundance and Biodiversity Assessment

In the streams of the NPB, Diptera (36.85%), Trichoptera (20.92%) and Ephemeroptera (16.73%) are the most represented orders in terms of numbers. Bivalvia and Pulmonata are the least represented groups with very small percentages (0.2% for each) (Figure 1).

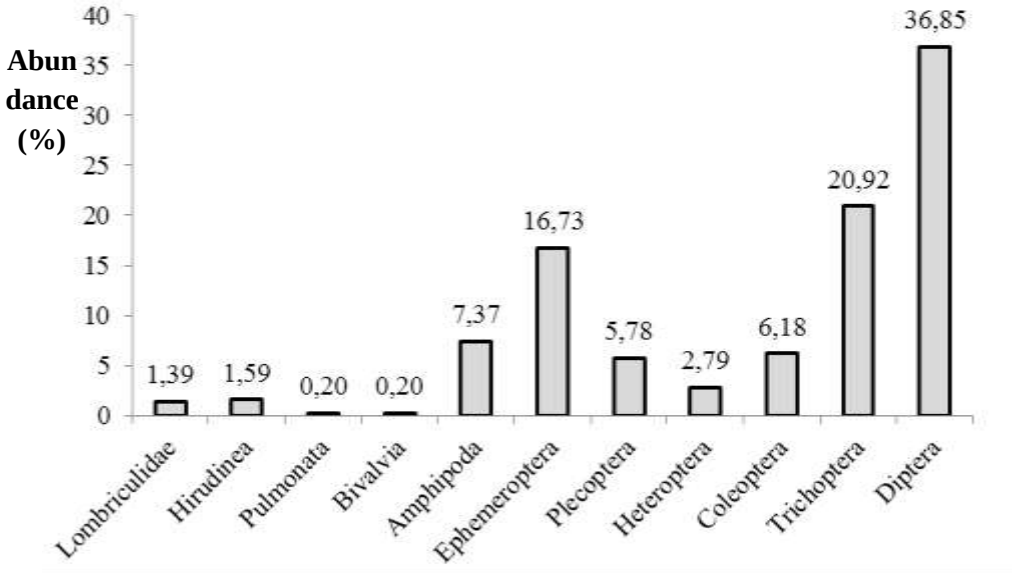

Figure 1: *Abundances of the various orders of the benthic macroinvertebrates recorded globally in BNP.*

The highest individuals total number is noted in W. El Ma (198 individuals). Although, the individuals total number of W. Chaaba is only 125 individuals (3rd position after W. El Ma and W. Bouilef), the total richness (22 taxa) and the Shannon index (H'= 2.84) are the highest (Table 6).

Table 6: *Structure and diversity parameters calculated for the stands of the benthic macroinvertebrates of the watercourses of the Belezma National Park (Batna, Algeria)*

Parameters/Index	W. Hamla	W. Chaaba	W. Bouilef	W. El Ma
Individuals total number (N)	21	125	158	198
Total richness (S)	5	22	16	11
Shannon index (H')	1,31	2,84	2,13	1,36

3.5 Evaluation of the standardized global biological index (IBGN)

The hydrobiological quality of the water in the four studied Wadis is qualified as medium (IBGN between 9 and 10, Class quality 2), combining a low taxonomic variety (∑t between 5 and 8 taxa), which would entail a limitation of the IBGN value. The indicator group (IG) is amount 5 for W. El Ma and 8 for W. Hamla, W. Chaaba and W. Bouilef (Table 7).

Table 7: *Assessment grid of the water quality of the 4 studied wadis in the Belezma National Park (Batna, Algeria). IBGN: Global Standardized Biological Index*

Wadis	Taxonomic variety (∑t)	IG	IBGN value	Class quality	Water Quality
Wadi Hamla	5	8	9	2	Medium
Wadi Chaaba	8	8	10	2	Medium
Wadi Bouilef	8	8	10	2	Medium
Wadi El Ma	7	5	9	2	Medium

4. Discussion

The low flow velocity of streams in the BNP are mainly due to the relief and slopes of the region, as well as to the arid environment characterized by precipitation that becomes increasingly weak and unpredictable as early as the spring. On another hand, our sampling carried out in April, coinciding with the beginning of the fall in precipitation and the rise of temperatures in the region, should accelerate the phenomenon of drying. Indeed, the distribution of the stations according to the altitude and the nature of the substrate show heterogeneity of the substrate within the altitudinal scales. According to Angelier (2000), it is possible to characterize streams environments by their physical factors such as altitude, slope, bed width, current

velocity, substrate and temperature regularly from the upstream to downstream, as well as the water chemical factors.

Physicochemical water analyzes has shown that the pH represents a large variation. However, the pH values are generally in a range of alkalinity, due in most part to the buffering effect of the lands crossed by the studied Wadis and which are mostly of limestone nature. The pH values and the conductivity of the four Wadis reveal that the water is mainly soft at alkaline pH. According to Decamps (1971), the calcareous rocks are leached, which makes water very rich in calcium. It forms calcium carbonate which neutralizes everything from acidic soils and helps to maintain the water pH in an alkaline level.

The degree of salinity of the studied stations indicates that the rivers are from fresh to very low saline. The degree of salinity makes it possible to classify the water according to the following categories: freshwater (< 0.5 g/l); freshwater to brackish water (0.5 à 5 g/l); brackish to salt water (18 à 30 g/l) and salt water (> 30 g/l) (Hecker et al., 1996).

The recorded turbidity values indicate that the four studied streams are of clear water. Turbidity is representative of the transparency of water. This transparency can be affected by the presence of suspended particles and colloidal matter in water (silt, clay, organic matter …) (Dussart, 1992).

As regards nitrates and nitrites, our data show that the nitrous nitrogen content is very low. The maximum concentration of 0.4 mg / l was noted in the W. Hamla. In fact, nitrites represent the intermediate form and the result of the oxidation of the organic nitrogenous substances (Dussart, 1992). The presence of nitrites in water may be due to incomplete oxidation of nitrogen compounds (organic nitrogen or ammonia). It corresponds to an intermediate stage and its concentration is generally less than 1.0 mg/l (Rejsek, 2002). Some authors have shown that nitrates are related to the rainfall regime (Ben Rejeb-Jenhani, 1989; Turki, 2002).

Moreover, the benthic macroinvertebrates identification shows that the study area, by its relief and its topography, offers a greater or less diversity of habitats allowing hosting a rich fauna of benthic macroinvertebrates. In the majority of cases, the identification of this fauna is pushed to the family and the genus, demonstrating a singularity of this fauna compared to that known in the Algerian humid regions. Only three species are determined up to the species: *Hirudo medicinalis*, *Aneletus inopinatus* and *Gerris lacustris.*

The Diptera and Ephemeroptera orders contain the highest numbers of families. Most other orders are rated only by one or two families. The large presence of Diptera and

Ephemeroptera shows the ability of these species to withstand the widely varying environmental conditions, while other taxa are apparently less tolerant. Moreover, it is useful to point out that the present inventory, although partial and carried out in a short period of time, represents an enrichment of the knowledge on the macroinvertebrates of the NPB, since the majorities of the identified taxa are reported for the first time. This would enrich the known biodiversity of this protected area (man and biosphere reserve). Stadies of Bouzidi & Giudicelli (1994); Gagneur & Aliane (1991); Boumaiza (1994); Lounaci et al. (2000); Berrahou et al. (2001) ; have highlighted the low diversification of benthic macroinvertebrate populations in the continental ecosystems of North Africa. Indeed, most of the families and genera identified in this region are poor in species, while in European river systems these taxa have a wide variety of specific. Thus, the relative weakness of this diversity would be related to the lower temperatures in Europe and the high precipitation. In addition, variations in the biodiversity of aquatic invertebrates are mainly due to the station's environmental characteristics, such as substrate nature, current velocity, water temperature (Hynes, 1971, Lavandier, 1979) and water chemicals characteristics (Gagneur & Thomas, 1988). Among the four studied streams, W. Chaaba represents the highest biodiversity parameters, reflecting a fairly good diversity of its benthic macroinvertebrates communities. It should be noted that the Diptera larvae and Ephemeroptera are the most abundant. It appears that W. Chaaba would be the most protected from climatic hazards (due to altitude and relief) and human pressure (absent in the studied stations). This Wadi, located in the integral zone of the Park, contains actually a richer diversity that deserves to be better explored and protected. Stations with low specific wealth deserve to be monitored in order to identify and control the disruptive factors of these Wadis and their invertebrate populations.

The assessment of the biological quality of the studied streams through the calculation of IBGN showed that the water quality is overall medium. Indeed, the benthic macro-invertebrate families present in abundance in these Wadis are not very demanding, with regard to the water quality and the environment, they belong to more or less polluo-resistant groups such as Ephemeroptera (Haouchine, 2011). The proximity of the road or dwellings to some sampled stations would expose them to the continued influence of point releases from villages and neighboring farms. However, the resulting degradation is limited because it achieves a class of medium quality and not poor or bad. Therefore, the streams of the BNP have a medium hydrobiological quality which is acceptable, but which deserves to be monitored. Permanent monitoring of certain sources of pollution would certainly contribute to having good quality

water, especially in mountain areas and particularly, those experiencing disturbing anthropogenic activities. In the prospects for conservation and management of species and spaces, we recommend to the BNP managers to set up a monitoring program for the streams of the Park, in particular to enrich knowledge on the biodiversity of benthic macroinvertebrates and to assess the water quality and habitats, as a result of natural and anthropogenic changes.

5. Conclusion

The benthic macroinvertebrates populations and their ecology in inland water ecosystems of North Africa, particularly in arid environments, are rare and limited to humid bioclimatic areas. This is owing to the fact that these regions are lacking of basic knowledge about biomonitoring compared, for instance, to other regions of the world (Touron-Poncet et al., 2014). To this purpose, it would be important to develop research on taxonomy, diversity and life traits of this fauna group.

Our study showed that benthic macroinvertebrates communities in arid regions of Algeria are rich biodiversity despite the climatic constraints like irregular and unpredictable flow of streams. Otherwise, in the protected area of the Belezma national park, it would be urgent to preserve the streams from disturbances, particularly the W. Hamla, which is subjected to more or less pollution, especially in downstream. On the other hand, W. Chaaba, with its great diversity, deserves special protection and depth surveys that would consolidate research, not only on the biodiversity of benthic macroinvertebrates, but also on aquatic fauna in general.

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