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Taxonomic diversity of benthic macroinvertebrates and bio-evaluation of water quality of Grou River (Morocco) through the use of the standardized global biological index (IBGN)

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Abstract

The Grou River, located in the central Moroccan plateau, seems particularly threatened due to the lack of proper management. It is in this framework that this study was carried out in the region of Rabat, Morocco. It is purposed to examine the structure and taxonomic diversity of benthic macroinvertebrates, and to assess the biological quality of the waters in this river in order to solve the threat mentioned above. The fauna studied was collected monthly between December 2014 and November 2015. In the study, 9409 individuals identified belong to 33 Families and 40 taxa corresponding to 4 faunal phyla (Annelidae, Platyhelminthes, Mollusks and Arthropods). The values of the Global Standardized Biological Index (IBGN) classified the waters of the Grou River at the level of station S_1 in the middle category, at the station S_2 in the mediocre category and at both stations S_3 and S_4 in the good category. The results obtained in this study reveal an alarming situation regarding the quality of waters in the Grou River, especially at the S_2 station located immediately followingthe confluence zone with the wastewater of the rural commune of JmaaMoulblad. In order to solve this problem, we recommend a plan for the sustainable management of the Grou River watershed and the construction of a wastewater treatment plant in the rural community of JmaaMoulblad.

1. Introduction

Running and stagnant waters have always played a major role in the development of agricultural, industrial and domestic activities. However, these resources have not always been immune to the various sources of disturbance and dysfunction. The water quality of a hydrosystem is assessed through the concentrations of the various substances and elements it contains, their quantities and their effects on the functioning of aquatic ecosystems and human health. These chemical elements may be either of natural origin or of anthropogenic origin (deriving from human presence (wastewater) or from industrial and agricultural activities (nitrates, heavy metals, pesticides)[1,2]. The monitoring of physicochemical parameters and the bacteriological status of water are now the most common methods used to assess the quality of surface water in Morocco. These approaches have shown their utility but also their limitations [3].

It this context, this study aimed to evaluate the ecological quality of the waters of the Grou River, using benthic macroinvertebrates as bioindicators. The latter have been the subject of several hydrobiological studies [4-10].

The number and the spatio-temporal distribution of these organisms will allow us to calculate the standardized global biological index (IBGN) [11] which will serve us later to categorize the waters of Grou River. Indeed, macroinvertebrates are good bioindicators because of their sedentariness, their great diversity and their variable tolerance to pollution and habitat degradation [12]. They reflect in a particular way the ecological status of the river in reacting very quickly to changes in their environment.

This study was carried out in the downstream part of Grou River (region of Rabat), which is a relatively seasonal watercourse, about 75 km long, before flowing into the Sidi Mohammed ben Abdallah SMBA dam (which plays a very important role in the production of drinking water for about ¼ of the Moroccan population between Casablanca and Kenitra). This in order to determine both the ecological state of the waters and to fill the gap of the interference of the macroinvertebrates of this river by a reference faunistic inventory. Despite the various studies carried out in this watershed, this type of study has never been carried out yet.

2. Material and Methods

2.1 Study site and sampling stations

This study was carried out in the downstream part of the Grou River, between the rural commune of JmaaMoulblad and the SMBA dam. The waters of the river are used for livestock drinking, drinking water production, bathing and other activities of the local population. This river plays a very important role in the region despite the threats it undergoes. Indeed, during its flow towards the dam it receives the wastewater from the rural commune of JamaaMoulblad, the contributions of small runoffs, especially in winter, coming from the mountains and agricultural lands threatening its quality.

In order to assess the quality of these waters, four sampling stations were chosen on the bed of the river. Taking into account a number of criteria such as accessibility, direction of flow, sources of pollution, etc. (Figure 1).

- Station S_1: located furthest upstream, it was chosen as a reference point.
- Station S_2: located downstream immediately after the confluence zone of sewage discharged by the rural commune of JmaaMoulblad and the waters of the Grou River.
- Station S_3: located 35 km from station S_2, where the water crosses a more or less sufficient distance to the implementation of the phenomenon of self-purification to improve the quality of the water.
- Station S_4: is located 30 km from station S_3, just downstream from the river in contact with the waters of the SMBA dam. It informs us about the quality of the waters that will eventually be used for the production of drinking water.

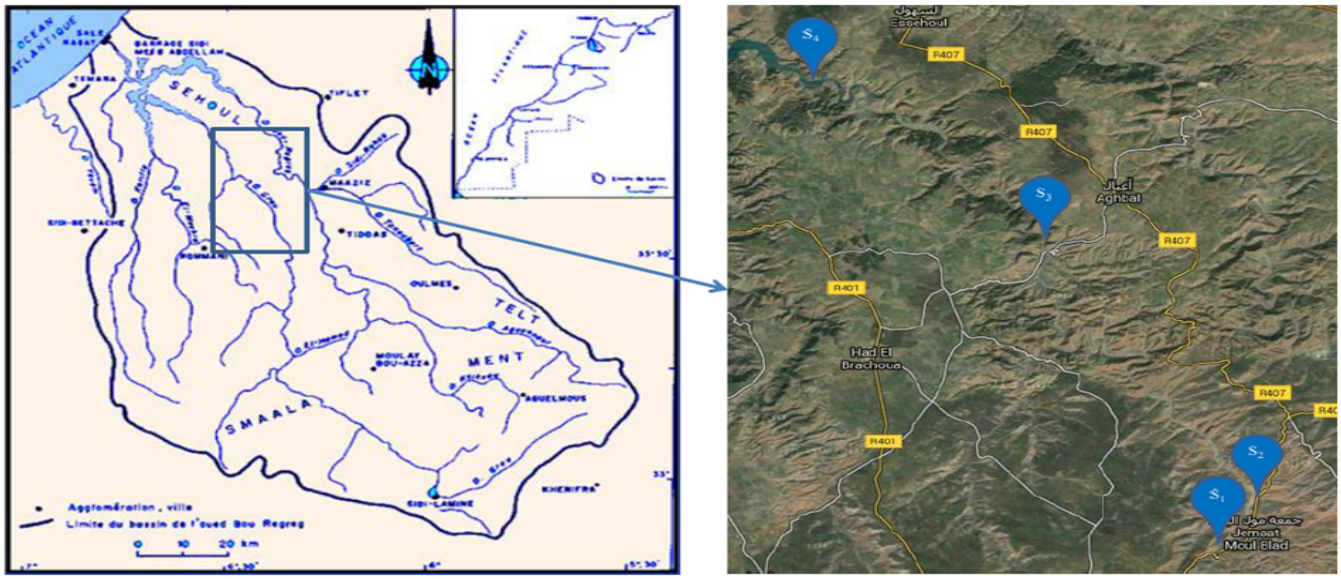


Figure 1: Location of the study site (Source: QNINBA 1988 Slightly modified, Google Map, 2015)

2.2 Sampling and analysis

2.2.1 Sampling technique

The biological potential is limited by the quality of the physical habitat forming the framework on which the biological communities develop [13].

The IBGN is station established. The station is defined as the stretch of stream which length is substantially equal to 10 times the width of the wet bed at the time of sampling [11]. For a station, sampling of the benthic fauna consists of 8 samples. All these samples must give an idea of the diversity of habitats and bring together the greatest faunistic diversity of this station. In our study, macroinvertebrates harvests were carried out between November 2014 and December 2015 on a monthly basis, in 4 stations (S_1, S_2, S_3 and S_4), using a Surber net for lotic facies, and a disturbed net for the lentic facies.

2.2.2 Pre-sort and preserve samples

The collected samples are deposited in a white basin with water to facilitate their mobility as well as their capture and also to eliminate the coarsest elements (vases, stones, pebbles, fragments of wood and leaves of the plants). Pre-sorting is a very important operation indeed, it makes it possible to limit the risks of deterioration of the fauna and to reduce the volume of sample to be fixed. The captured organisms are transferred into plastic containers containing 10% formalin to fix those [14]. At the place of sampling, the date, the number and the characteristics of the station are recorded with each sampling. After each sample has been retained, it is returned to the laboratory for sorting, determination and analysis.

2.2.3 Sorting and determination

This step consists in extracting the fauna from the substrate contained in the sample. It is carried out in the laboratory where samples stored in station-labeled containers are rinsed abundantly with clear water over a series of mesh sieves of decreasing size (5 to 0.2 mm) in order to eliminate as much as possible the substrate small remaining and coarse elements (gravel, plants, leaves ...) [7-9]. The contents of the sieves are then poured into a basin and then transferred to 50 cc beakers. Sorting, counting and determination begin under the binocular lens. The organisms are handled gently, using fine pliers in petri dishes. After this operation, these organisms are transferred to containers containing 10% formalin. The taxonomic unit retained in this work is the genus with the exception of certain macroinvertebrates which are determined up to the species, because of the difficulties of determination which they presented for us. To do this we have referred to websites, identification keys, books and collections [12-15].

2.2.4 The Standardized Global Biological Index (IBGN)

The Standardized Global Biological Index (I.B.G.N) provides a quantitative estimate over the whole medium, using macroinvertebrates fauna as an integral compartment in the medium [16]. It responds to different perturbations, but it is particularly sensitive to organic pollution of water.

The IBGN is based on the analysis table (Table 1) [11] comprising the 9 indicator faunistic groups on the ordinate and the 14 taxonomic variety classes on the abscissa.

Table 1: Value of the IBGN according to the nature and the taxonomic variety of the macrofauna - (AFNOR, 1992)

Variety class		14	13	12	11	10	9	8	7	6	5	4	3	2	1
Taxon Indicators	Σt GI	> 50	49 45	44 41	40 37	36 33	32 29	28 25	24 21	20 17	16 13	12 10	9 7	6 4	3 1
Chloroperlidae Perlidae PerlodidaeTaeniopterygidae	9	20	20	20	19	18	17	16	15	14	13	12	11	10	9
Capniidae BrachycentridaeOdontoceridae Philopotamidae	8	20	20	19	18	17	16	15	14	13	12	11	10	9	8
Leuctridae Glossosomatidae BeraeidaeGoeridae Leptophlebiidae	7	20	19	18	17	16	15	14	13	12	11	10	9	8	7
Nemouridae Lepidostomatidae Sericostomatidae Ephemeridae	6	19	18	17	16	15	14	13	12	11	10	9	8	7	6
Hydroptilidae Heptageniidae Polymitarcidae Potamanthidae	5	18	17	16	15	14	13	12	11	10	9	8	7	6	5
Leptoceridae Polycentropodidae Psychomyidae Rhyacophilidae	4	17	16	15	14	13	12	11	10	9	8	7	6	5	4
Limnephilidae (1) Hydropsychidae Ephemerellidae(1) Aphelocheiridae	3	16	15	14	13	12	11	10	9	8	7	6	5	4	3
Baetidae (1) Caenidae (1) Elmidae (1) Gammaridae (1) Mollusques	2	15	14	13	12	11	10	9	8	7	6	5	4	3	2
Chironomidae (1) Asellidae (1) Achètes Oligochètes (1)	1	14	13	12	11	10	9	8	7	6	5	4	3	2	1
(1) Taxa represented by at least 10 individuals - Others by at least 3 individuals.															

We shall determine successively:

- The taxonomic variety of the sample (Σt), equal to the total number of taxa harvested even though they are represented by only one individual. This number is confronted with the classes on the x-axis of the table.

- The faunistic indicator group (GI), taking into account only the taxon indicators represented in the sample by 3 individuals or 10 individuals according to the taxa.
  Determination of (GI) is carried out by prospecting the columns of the table from top to bottom (GI 9 to GI 1) and stopping the examination at the first significant presence ($n \geq 3$ individuals or $n \geq 10$ individuals) of a taxon of the repertoire on the ordinate of the table.

We deduce IBGN from the table from its ordinate (GI) and its abscissa (Σt).
This same note IBGN can also be calculated by the following relation:

IBGN = GI + variety class - 1, with I.B.G.N. ≤ 20

In the absence of significant indicator taxa (n <3 or 10 individuals), note IBGN is equal to 0.

3. Results and discussion

3.1 Benthic Community Structure

The aim of this census is essentially to establish an inventory as complete as possible of the different taxa that may be encountered in the waters of this aquatic system and thus enrich the list of Moroccan biodiversity.

3.1.1. Inventory of macroinvertebrates

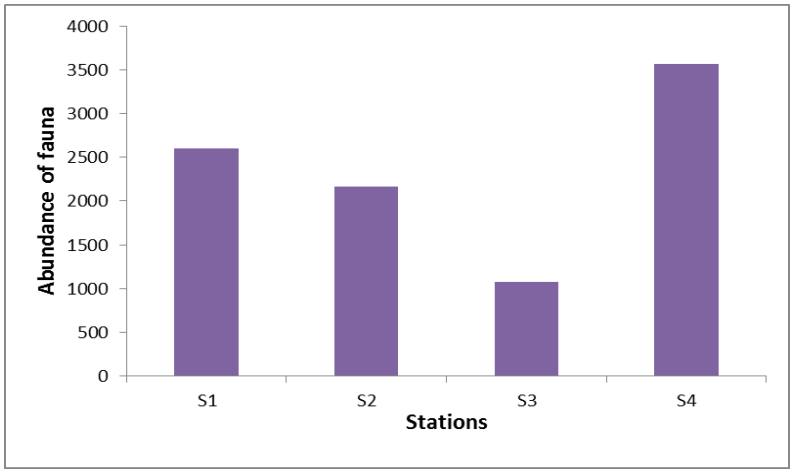
The faunistic inventory established (Table 2), groups the distribution of stands in the different sampling stations.

3.1.2. Global analysis of benthic fauna

A total of 9409 individuals, divided into 4 faunal phyla (Annelida, Platyhelminthes, Molluska and Arthropoda) belonging to 33 families and 40 taxa (Table 3), were identified in the present faunistic study during the 12 sampling campaigns.
Given that the census year experienced a great deal of precipitation, which increased water levels and velocities, factors influencing habitat stability and the spatial and temporal distribution of existing macroinvertebrates [17]. Most of the fauna was harvested between April and July.

3.1.3. Abundance of benthicfauna

The abundance fluctuates depending on stations and varies between 1080 and 3564 individuals (Figure 2). These spatial variations could be attributed to the various influences that the environment undergoes and also to the nature of the different habitats. Indeed, a disturbed watercourse can create unfavorable conditions for certain (polluo-sensitives) organisms, leaving room for other more tolerant (polluo-resistants) organisms.



Figures 2: Distribution of the total fauna in the waters of the studied stations

The analysis of the entire stand collected during the study period shows that insects are numerically the most inventoried and represent the highest percentage at the Grou River level (74.4%) followed by the Platyhelminthes (10.6%), Annelida (8.3%), Crustacea (5.5%) and Molluska, the lowest group (1.1%) (Figure 3).
For comparison, the stands recorded in the downstream part of the Grou River are less diversified compared to the fauna of all the waters of the large Bouregreg River watershed and with other rivers, such as those of the Sebou River [18], Moulouya River [19,20,21,22] and the Boufekrane River [5,9,23]. This could be related to the natural and/or anthropogenic factors influencing this watercourse. Abiotic factors can influence the distribution of benthic macroinvertebrates, including altitude, current velocity, water transparency, substrate type, substrate heterogeneity, macrophyte abundance, and width from the river. While anthropogenic factors such as domestic discharges and the discharge of wastewater into the rural commune of JmaaMoulblad in the Grou River could

undoubtedly contribute considerably to the installation of special conditions that are generally unfavorable to the presence of a very diversified stand, characteristic of this river.

Table 2 : List of macro invertebrate taxa collected at sampling sites during the study period

Phylum (subphylum)	Class (sub class)	Order	Family	Genus	Species
Annelida	Clitellata (Oligocheata)	Haplotaxida	Lumbricidae	*Eiseniella*	*Eiseniellatetraedra* (Savigny, 1826)
	Hirudinea	Rhynchobdellida	Glossiphoniidae	*Helobdella*	*Helobdellastagnalis* (Linnaeus, 1758)
Platyhelminthes	Turbellaria	Tricladida	Dugesiidae	*Dugesia*	*Dugesiasp*
Molluska	Bivalvia	Veneroida	Corbiculidae	*Corbicula*	
	Gastropoda	Pulmonata	Limnaeidae	*Lymnaea*	*Lymnaeasp*
			Physidae	*Physa*	*Physasp*
Arthropoda (Antennata)	Maxillopoda	Cyclopoida	Cyclopidae		
	Malacostraca	Amphipoda	Gammaridae	*Gammarus*	*Gammaruslocusta* (Linnaeus, 1758)
		Decapoda	Potamonidae	*Potamon*	*Potamonsp*
(Hexapoda)	Insecta	Plecoptera	Perlodidae	*Perlodes*	
	Insecta	Plecoptera	Taeniopterygidae		
	Insecta	Trichoptera	Lepidostomatidae	*Lasiocephala*	*Lasiocephalabasalis* (Kolenti , 1848)
	Insecta	Trichoptera	Hydropsychidae	*Hydropsyche*	*Hydropsychesp*
	Insecta	Heteroptera	Corixidae	*Micronecta*	*Micronectascholtzi* (Fieber, 1860)
	Insecta	Heteroptera	Nepidae	*Nepa*	
	Insecta	Heteroptera	Gerridae	*Gerris*	*Gerris sp*
	Insecta	Coleoptera	Curculionidae		
	Insecta	Coleoptera	Gyrinidae	*Dineutus*	
	Insecta	Coleoptera	Hydrophilidae	*Hydrochara*	*Hydrocharasp*
	Insecta	Coleoptera	Hydrophilidae	*Coelostoma*	*Coelostomasp*
	Insecta	Coleoptera	Staphylinidae	*Paederidus*	*Paederidusruficollis* (Fabricius, 1777)
	Insecta	Ephemeroptera	Baetidae	*Baetis*	*Baetissp*
	Insecta	Ephemeroptera	Caenidae	*Brachycerus*	*Brachycerusharrisella*
	Insecta	Ephemeroptera	Leptophlebiidae	*Choroterpes*	*Choroterpespicteti (Eaton, 1871)*
	Insecta	Ephemeroptera	Leptophlebiidae	*Lepegenia*	*Lepegenialineata(Peters, Peters & Edmunds, 1978)*
	Insecta	Ephemeroptera	Ameletidae	*Ameletus*	*Ameletusinopinatus (Eaton, 1887)*
	Insecta	Diptera	Empididae		
	Insecta	Diptera	Chironomidae	*Corynoneura*	*Corynoneurasp*
	Insecta	Diptera	(Tanypodinae)		
	Insecta	Diptera	Culicidae	*Aedes*	
	Insecta	Diptera	Rhagionidae		
	Insecta	Diptera	Simuliidae	*Simulium*	*Simuliumsp*
	Insecta	Diptera	Simuliidae	*Simulium*	*Simuliumneornatipes (Dumbleton, 1969)*
	Insecta	Diptera	Simuliidae	*Austrosimulium*	
	Insecta	Diptera	Stratiomyidae		
	Insecta	Diptera	Sciaridae	*Bradysia*	
	Insecta	Odonata	Gomphidae		
	Insecta	Odonata	Libellulidae	*Brachythemis*	*Brachythemisleucosticta (Burmeister, 1839)*

3.1.4. Qualitative and quantitative analysis of benthic fauna

The upstream station S_1 has a fairly balanced structure with an annual abundance of 2597 individuals. The stations S_2, S_3 and S_4, which are more agitated and rich in organic matter, are affected directly by the wastewater

of the rural commune of JmaaMoulblad at the station S_2 and in confluence with the waters of the SMBA dam rich in organic matter of the station S_4, have an unbalanced structure with annual abundances varying between 2168 individuals in S_2, 1080 individuals in S_3 and 3564 individuals in S_4, with proliferation of Oligochaetes, Chironomidaes and Simuliidaes which support organic pollution. As already noted by [24], the phenomenon of the anthropization of the River, could be at the origin of a disappearance of the polluo-sensitive taxa and the proliferation of the polluo-tolerant groups such as Chironomidae.

Table 3 : Number of Families and Genus by Zoological Group

Zoological Group	Number of families	Number of genus
Annelida	2	2
Platyhelmintes	1	1
Molluska	3	3
Crustacea	3	3
Plecoptera	2	3
Trichoptera	2	3
Heteroptera	3	3
Coleoptera	4	5
Ephemeroptera	4	5
Diptera	7	10
Odonata	2	2
Total	**33**	**40**

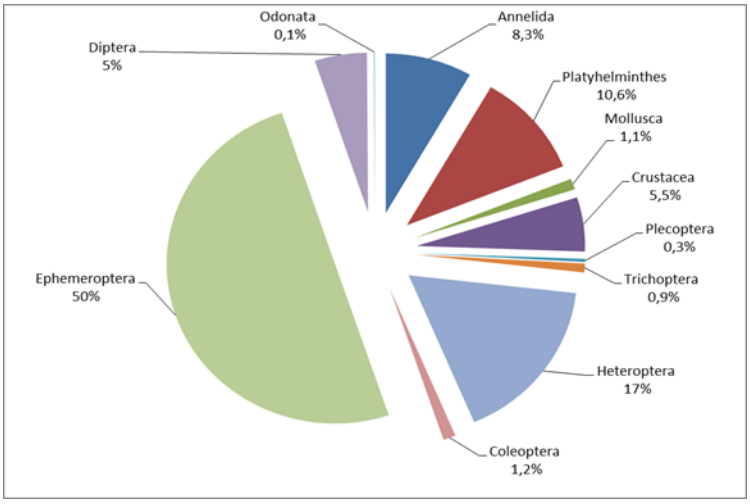


Figure 3: Abundance of the total fauna in the waters of the studied sites

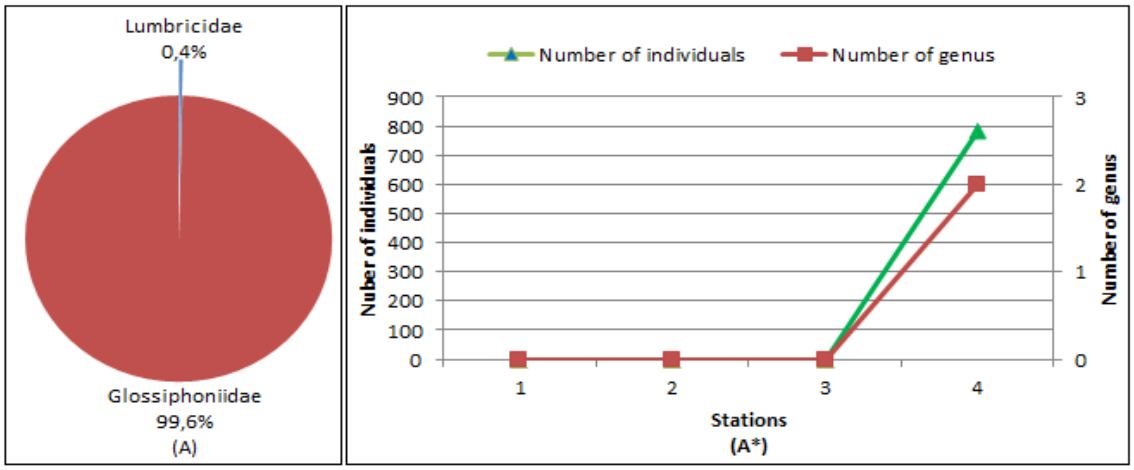


Figure 4: Abundance (A) and longitudinal distribution (A*) of the Annelids in the Grou River.

Annelids

According to our results, annelids are represented in the Grou River by 783 individuals, representing 8.3% of the harvested fauna. They belong to two families: Lumbricidae and Glossiphoniidae (Figure 4A). In this group

of organisms, Glossiphoniidae are dominant with 780 individuals of *Helobdellastagnalis* (99.6% of Annelids), corresponding to 8.29% of the total fauna harvested. Lumbricidae are poorly represented and contain only 3 individuals of *Eiseniella* (0.4% of Annelids) forming 0.01% of the stand.
Figure 4A* shows the longitudinal development of Annelids along the Grou River. It shows that these invertebrates develop favorably in the S_4 station located downstream of the River, zone of confluence of the waters of the River and the SMBA dam rich in organic matter. This result is probably related to the presence of organic matter, factors favorable to the proliferation of these organisms. In this station, the *Helobdellastagnalis* are the most dominant, with a maximum peak at station S_4.

Mollusks

According to the literature, mollusks are never abundant in continental aquatic environments. The calcium content, the nature of the substrate, the nature of the vegetation and the litter, and the speed of the current are the dominant factors on the proliferation and distribution of mollusks in continental waters [4,9,24]. In the Grou River, Mollusks are represented by only 104 individuals (1.1% of the total fauna harvested) belonging to 3 families and 3 genusthat have been collected: Corbiculidae (*Corbicula*), Limnaeidae (*Lymnaeasp*) and Physidae (*Physasp*). Physidae are dominant and have 60 individuals (58% of mollusks) and are represented by a single genus *Physa*. The other families, Limnaeidae (*Lymnaeasp*) and Corbiculidae (*Corbicula*) are less dominant, accounting for 27% and 15% respectively (Figure 5A).
The longitudinal distribution of the mollusks (Figure 5A*) shows that their proliferation appears to be greater only in the S_4 station, downstream of the River, the confluence zone of the river waters and the SMBN dam, rich in organic matter by the phenomenon of eutrophication and where the speed of the current seemed low, conditions favorable to the proliferation of mollusks.

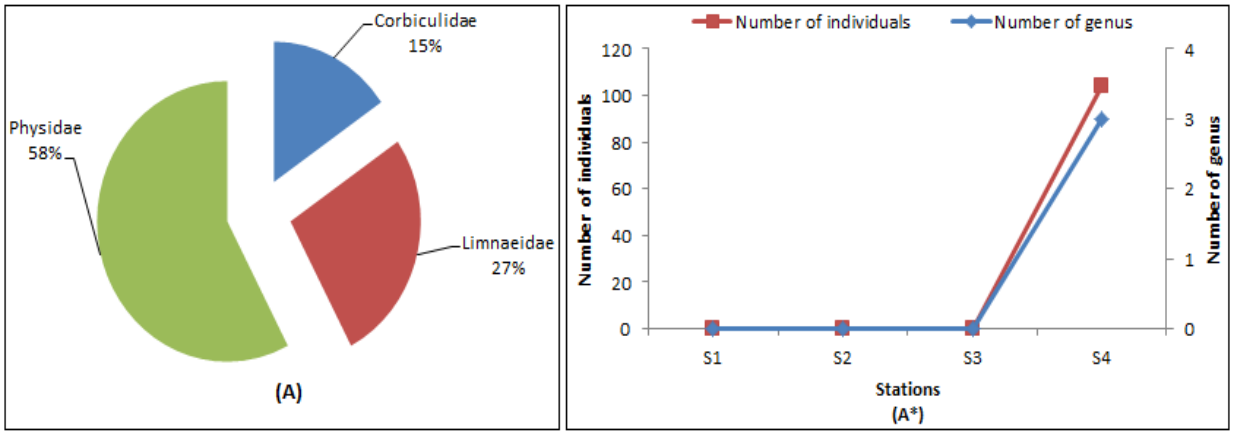


Figure 5: Abundance (A) and longitudinal distribution (A*) of Mollusks in the Grou River.

Crustaceans

Crustaceans are represented by 517 individuals, or 5.5% of the total fauna harvested. They are represented by 3 families: Gammaridae, Cyclopidae and Potamonidae. The Gammaridae are dominant and have 509 individuals (98% of the crustaceans) and are represented by a single genus *Gammarus*. The other families, Cyclopidae and Potamonidae, are of very small numerical importance (Figure 6A).

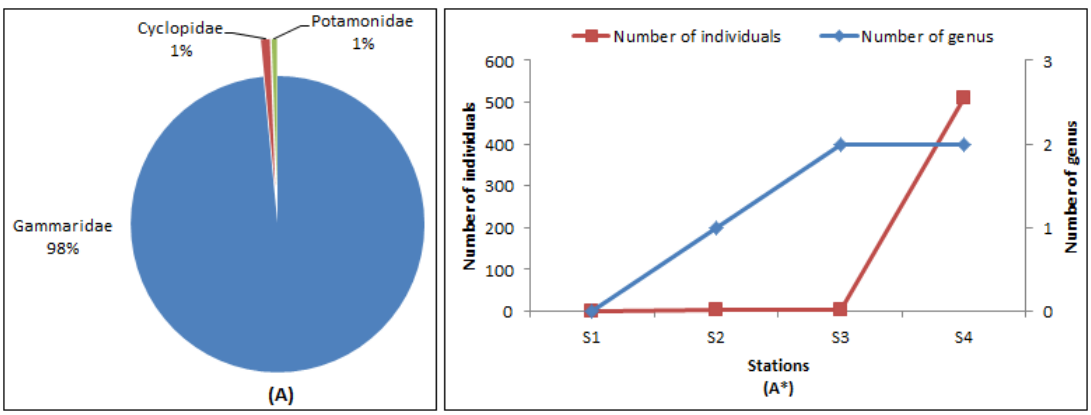


Figure 6: Abundance (A) and longitudinal distribution (A*) of Crustaceans in Grou River.

Figure 6A* represents the longitudinal development of crustaceans along the river. It shows that these invertebrates develop favorably in stations located downstream of river S_1, S_3 and S_4, especially in station S_4, zone of confluence of the waters of the River and the SMBA dam. This result is probably related to the presence of organic matter, which is a favorable factor to the proliferation of these organisms.

Diptera

The Diptera encountered in Grou River represent 5% of the total fauna harvested, represented by 472 individuals. They are composed of 7 families which abundance differs from one family to another: Chironomidae (92%), Simuliidae (3.4%), Sciaridae (2.6%), Rhagionidae (0.6%), Empididae (0.6%), Culicidae (0.4%) and Stratiomyidae (0.4%). These organisms are represented by different families (Figure 7A), in which Chironomidae are by far the most abundant and are widespread in the S_1 which is the highest station.

The longitudinal distribution of the Diptera (Figure 7A*) shows that they are present in all stations but with unequal proportions. The stations S_1 and S_3 contain more Diptera than the stations S_2 and S_4. Indeed, according to [25], the elements of this group of insects possess not only a wide altitudinal distribution, but also a great capacity to colonize various polluted or unpolluted biotopes. The taxonomic richness in Diptera is more diversified downstream than upstream, we have inventoried 7 genus in the station S_3 located downstream of the River. The latter result can be explained by the fact that in the downstream areas of watercourses the importance and taxonomic diversity of Diptera are related to relatively high water temperatures, relatively high current velocity and the presence of organic substances, favorable factors to the proliferation of those organisms.

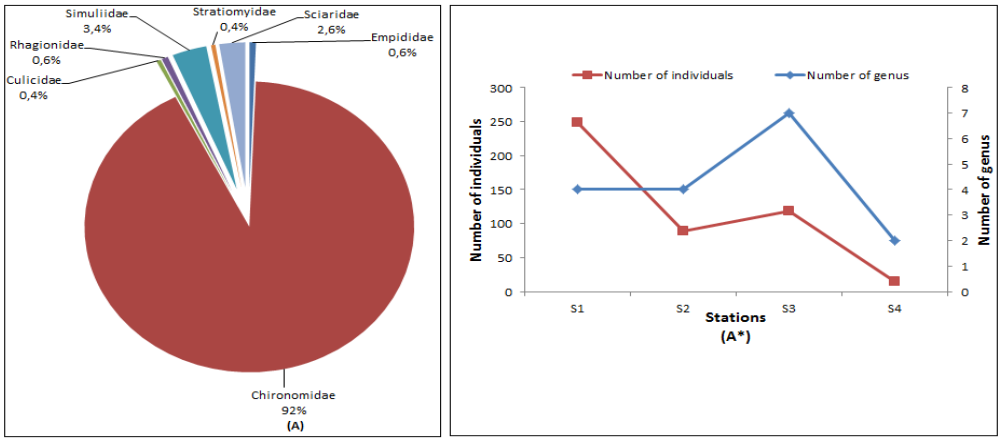


Figure 7: Abundance (A) and longitudinal distribution (A*) of the Diptera in the Grou River.

Plecoptera

Plecoptera are a very interesting group of aquatic insects especially for biogeographic studies because of their age [26] and for ecological studies, thanks to the level of knowledge that exists on their systematics and phylogeny [27].Recent hydrobiological studies [4,28,29,30] have shown the poor diversty of the populations of the Plecoptera in the lotic ecosystems of North Africa. Indeed, most families and genus are poor in species. On the other hand, these taxa have a great specific variety in European rivers. The significant decline in this diversity is due to higher temperatures compared to Europe.

Plecoptera harvested in this study are represented in very small proportions compared to Ephemeroptera, Heteroptera and Diptera. Indeed, the prospecting of all the stations allowed us to harvest only 30 individuals (Figure 8A), or 0.3% of the total fauna, at station S_1 (5 Individuals), station S_3 (11 Individuals) and station S_4(14 Individuals) upstream and downstream from the River. These invertebrates are distributed irregularly in two families: Perlodidae in (S_1 and S_3) and Taeniopterygidae in S_4, its polluo-sensitive organisms are absent in station S_2 which receives directly the domestic discharges from the rural commune of JmaaMoulblad. Indeed, [24,31] have shown that waters with a daily high temperature average are the poorest in Plecoptera, as well as waters subjected to organic pollution, even if in a low quantity. This group appeared to beparticularly sensitive.

The longitudinal distribution (Figure 8A*) of the Plecoptera appears to be related to water quality, they are present in the waters of the stations (S_1, S_3 and S_4) far from domestic wastes, while they are absent in the station S_2 located in the confluence zone of sewage and waters of the River. Most often, the Plecoptera are well known for their polluo-sensitivity to environments affected by any disturbance [7]. This could be explained in part by the absence of these invertebrates in the S_2 station directly exposed to the wastewater discharges of the rural commune of JmaaMoulblad which influence the quality of the water in this segment of the River.

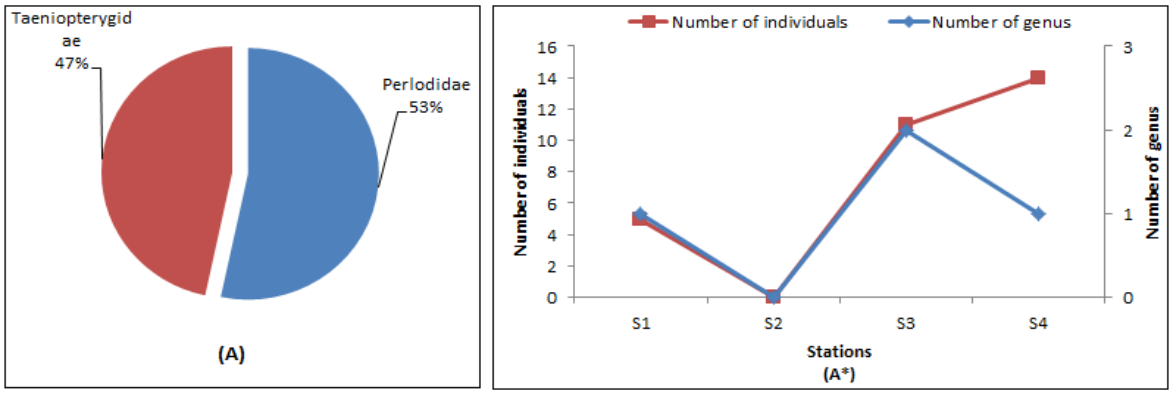


Figure 8: Abundance (A) and longitudinal distribution (A*) of the Plecoptera in the Grou River.

Coleoptera

The Coleoptera are a very diverse and ecologically very heterogeneous group that can adapt to any type of biotope. They are sometimes difficult to apprehend due to the alternance of aquatic and terrestrial phases. Some families have some representatives of which only the larval stage is aquatic (Helodidae, Sphaeridiidae) or only the adult phase is so (Hydraenidae) while others are strictly aquatic (Dryopidae, Elmidae, Hydrochidae) [32,33]. They are the only holometabolous insects to be presented both in the imaginary form and in the larval form in aquatic environments. They colonize various habitats (springs, streams of springs, torrents, rivers with moderately current water and rivers with quasi-stagnant water and rich in vegetation).

In the present study, the Coleoptera were represented only by 112 individuals (1.2% of the total fauna harvested) belonging to 4 families. Gyrinidae, Hydrophilidae, Curculionidae and Staphylinidae.Gyrinidae are dominant with 78 individuals (70% of Coleoptera), followed by Hydrophilidae with 25 individuals (22% of Coleoptera). Other families, Curculionidae and Staphylinidae are weakly represented with 5 individuals (4.5% of Coleoptera) and 4 individuals (3.5% of Coleoptera) (Figure 9A).

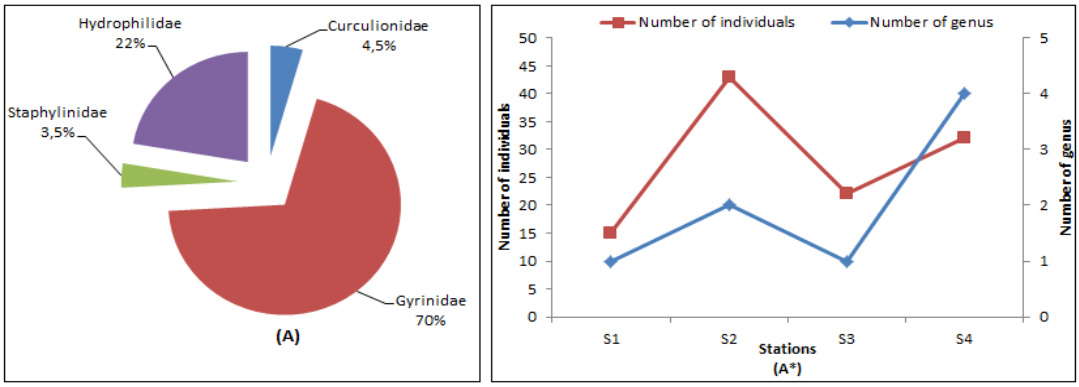


Figure 9: Abundance (A) and longitudinal distribution (A*) of the Coleoptera in the Grou River.

The analysis of the longitudinal distribution of the Coleoptera along the Grou River (Figure 9A*) is due to the presence of these invertebrates in all stations in a large population in station S_2, with relatively equal numbers in the stations (S_3 and S_4) and finally with a low number in station S_1. The taxonomic richness of the Coleoptera stations is reflected, as a whole, by a relatively high S_4 richness which decreases towards the upstream of the River, marking a decrease in the S_3 wealth, followed by a S_2 rise and then a another decrease in the number of genus in S_1. This richness could be explained by the fact that the biotopes of the station S_4 offer a wide variety of ecological atmosphere favorable to the proliferation of Coleoptera. The station S_4wich is a zone of confluence of the waters of the River and of the SMBA dam contribute favorably to the proliferation of the fauna. According to [25,34,35], submerged vegetation, fine-grained substrate, water temperature and trophic potential are the most influential factors affecting the elements of this group of insects.

Ephemeroptera

Ephemeroptera are hemimetabolic insects that present a single winged stage in the insect class (subimago) that precedes the imaginal stage. Their complete larval development lasts on average ten to twenty days depending on the temperature of the water. It usually consists of 15 to 25 moults. Ephemeropterous larvae are abundant in running water. They often occupy the main biotopes, torrents, streams and rivers and constitute the first rank of aquatic insects.

Ephemeroptera are the largest faunal group represented in the benthic fauna harvested in this work. They are represented by 4709 individuals (50% of the fauna harvested) divided into 5 genus belonging to 4 families: Leptophlebiidae (*Choroterpes* and *Lepegenia*), Baetidae (*Baetis*), Ameletidae (*Ameletus*) and Caenidae (*Brachycerus*) (Figure 10A). The most abundant family is Leptophlebiidae (*Choroterpes* and *Lepegenia*), with 2890 individuals (61.4% of total Ephemeroptera catches), followed by the Baetidae (*Baetis*), which represent 1459 individuals (31% Ephemeroptera). As for Ameletidae (*Ameletus*) and Caenidae (*Brachycerus*), they are weakly represented in terms of numerical abundance. These families represented respectively 346 and 14 individuals (respectively 7.3% and 0.3% of this stand). Figure 10A* shows the longitudinal distribution of the Ephemeroptera along the Grou River. The distribution in individuals in the different stations studied shows a decrease in the number of individuals from upstream to downstream. It shows that these invertebrates develop favorably at stations upstream (S_1 and S_2) and downstream (S_3 and S_4). This result is probably related to altitude. This explains their decreases in number, while going from the stations upstream to the downstream stations characterized by low altitudes, thus offering conditions weakly favorable to the development of its organisms. This finding is consistent with other work on other rivers [36].

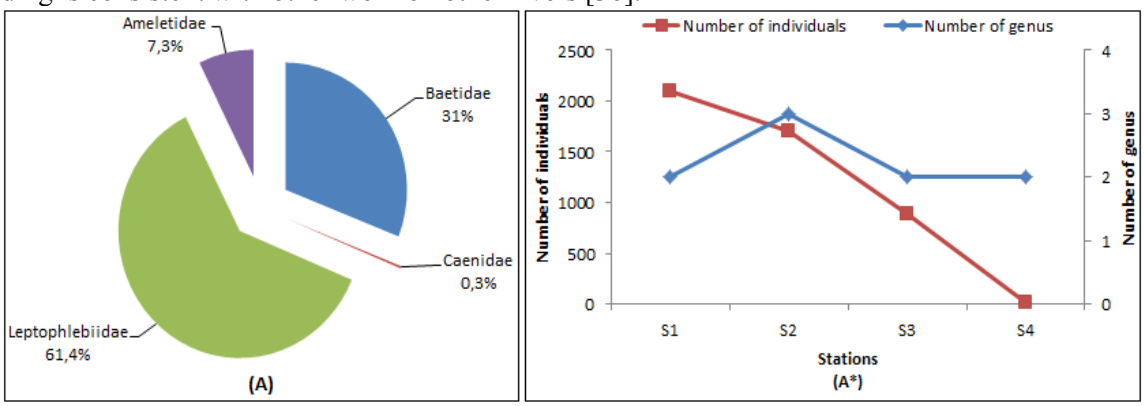


Figure 10: Abundance (A) and longitudinal distribution (A*) of Ephemeroptera in Grou River.

Heteroptera

Aquatic Heteroptera occur almost every season. In the adult state, they hibernate and resume their activity as soon as the temperature softened. Each species has its own ecological requirements. According to [36], they inhabit various biotopes of the aquatic environments: marshes, ponds, streams and rivers; they are observed above all on the banks of rivers.

According to our results, the harvested fauna of the Heteroptera counts 1586 individuals (17% of the total fauna inventoried), divided into 3 genus belonging to 3 families. The Corixidae (*Micronecta*) are the most represented by 1438 individuals (90.7% of the Heteroptera), followed by the other families which are weakly represented first by the Gerridae (*Gerris*) by 146 individuals (9.2% of the Heteroptera) and Nepidae (*Nepa*) with 2 individuals (0.1% of the Heteroptera) (Figure 11A).

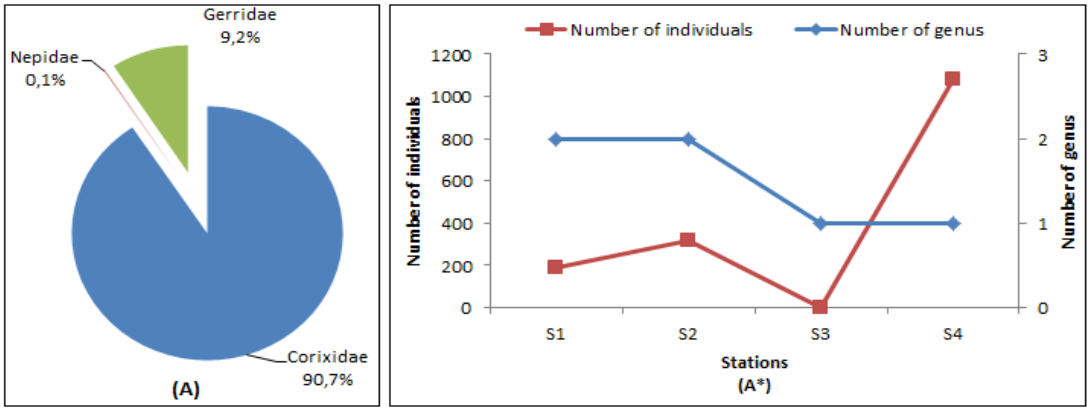


Figure 11: Abundance (A) and longitudinal distribution (A*) of the Heteroptera in Grou River.

The distribution of Heteroptera in the Grou River (Figure 11A*) reveals the existence of these invertebrates in all stations with varying proportions. Indeed, the number of individuals harvested in the last station S_4 is greater than that in the upstream stations. Contrary to the number of genus inventoried which is between 2 in (S_1 and S_2) and 1 in downstream (S_3 and S_4). Since the Corixidae form 90.7% of the collected Heteroptera, this can be explained by the nature of the habitats as demonstrated by [37].

Trichoptera

The Trichoptera harvested in this study are represented in a very small proportion of the total stand. Indeed, the prospecting of all the stations allowed us to harvest only 85 individuals (0.9% of the total fauna). They are divided into 2 genus belonging to 2 families: the Hydropsychidae (*Hydropsyche*) represented by 74 individuals (87% of the Trichoptera) and the Lepidostomatidae (*Lasiocephala*) represented by 11 individuals (13% of the Trichoptera) (Figure 12A).

The longitudinal distribution of the Trichoptera throughout the Grou River (Figure 12A*) results in an abundance in the stations (S_1 and S_3), then at the station S_2 and weakly at the station S_4 located downstream of the River. This result can be explained by the quality of the water and the low resistance of these invertebrates to pollution. Indeed, the elements of this group of insects are considered by many authors, as slightly polluo-resistant and very able to recolonize a substrate largely deserted by the fragile species [7], because the larvae of the genus *Hydropsyche* constitutes a frequent, often abundant element of the benthos of running water [38].

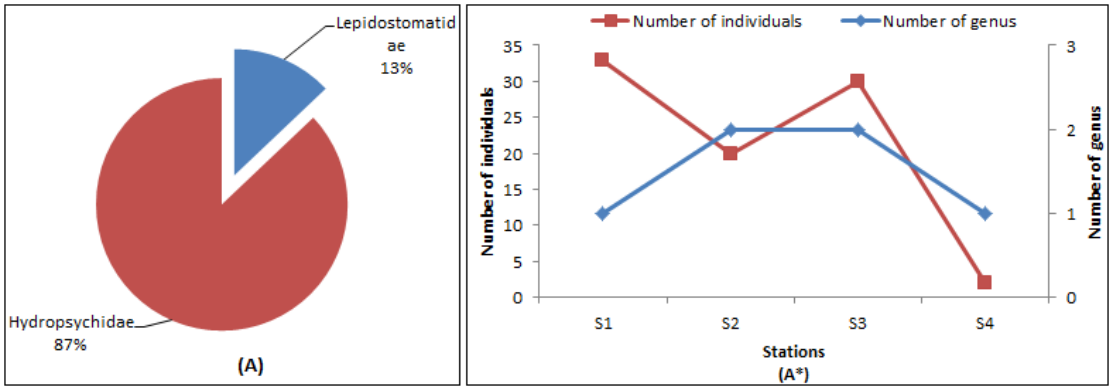


Figure 12: Abundance (A) and longitudinal distribution (A*) of Trichoptera in Grou River.

Odonata

The Odonata harvested in the present study are represented in very small proportions compared to the Ephemeroptera, the Heteroptera and the Diptera. Indeed, the prospecting of all the stations allowed us to harvest only 10 individuals (Figure 13A), is 0.1% of the total fauna, at station S_1 (4 Individuals), station S_3 (2 Individuals) and station S_4 (4 Individuals). These invertebrates are divided into two families: Libellulidae (6 Individuals) and Gomphidae (4 Individuals).

The longitudinal distribution (Figure 13A*) of the Odonata seems to be related to the quality of the water, they are present in all the stations with the exception of the station S_2 (zone of confluence of the River waters and the wastewater of the rural commune JmaaMoulblad). This last result confirms our observations which goes in the same direction and results in the absence of relatively polluo-sensitive organisms in station S_2 exposed directly to anthropogenic disturbances.

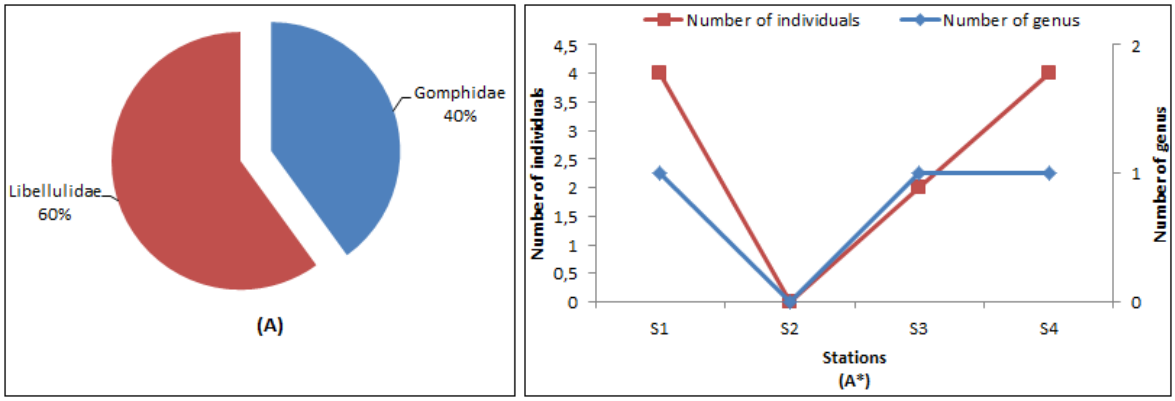


Figure 13: Abundance (A) and longitudinal distribution (A*) of the Odonata in the Grou River.

Platyhelminthes

The Platyhelminthes encountered in the Grou River represent 10.6% of the total fauna harvested. With a population of 1001 individuals belonging to the same family Dugesiidae (*Dugesia*). Their longitudinal distribution shows that these organisms are present only in the S_4 station located downstream of the River (Figure 14A*), the confluence zone of the River waters and the SMBA dam rich in mineral salts and organic

matter. The latter result confirms our observations that go in the same direction as its polluo-resistant organisms characterizing media rich in mineral salts and organic matter and where the speed of current seems slowed down. This finding is consistent with [11].

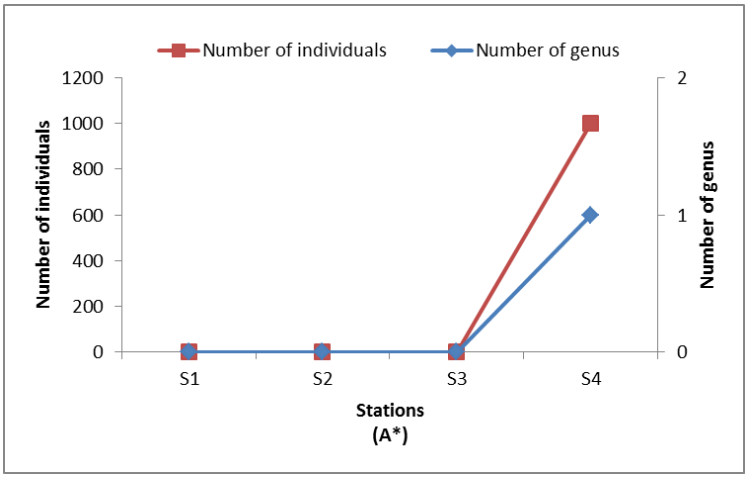


Figure 14: Longitudinal distribution (A*) of the Platyhelminthes in the Grou River.

3.2 Analysis of the stand structure by calculation of the Global Standardized Biological Index (IBGN)

Methods of analysis and assessment of the ecological quality of an aquatic environment are numerous. The choice of a method will depend on the studied problem in question.

In our study, in order to assess the biological quality of the waters of the Grou River, we selected among these methods the one based on the calculation of the Global Standardized Biological Index (IBGN); Which is a standardized method used in applied ecology to determine the biological quality of a watercourse.

The principle is based on benthic macrofauna taken directly from the field, according to a standardized sampling protocol taking into account the different types of habitats [11]. It is also based on the presence or absence of certain taxa called Bioindicators[15]. Indeed, the organisms inhabiting watercourses are particularly sensitive to changes in the environment in which they grow. Any disturbance affects their environment thus induces changes in the composition of stands, for example the disappearance of certain species or the proliferation of others. Benthic macroinvertebrates have this ability. Some groups of macroinvertebrates such as worms are thus not very sensitive to disturbances; they are called "polluo-tolerant", unlike others such as so-called "polluo-sensitive" Plecoptera [11]. Note that macroinvertebrates have the advantage of being more often environment-dependent, rapidly responding to stress and constituting one of the first links in the food chain of rivers [39].

The analysis of the ecological quality of a watercourse is a complementary approach to the physico-chemical analysis of water and sediments. Indeed, while the physicochemical approach characterizes the origin of disturbances and informs about the nature of the pollutants, the ecological approach identifies the disturbances by their effects on the habitats and the animal and plant communities in place.

The IBGN is a diagnostic tool among others; it helps to interpret all the information collected on the medium studied and provides a qualitative estimate of the environment as the whole. This method applies to running water sites which depth does not exceed one meter on the majority of the station.

Table 4 summarizes the results of the hydrobiological analyzes (Total Variety (VT), Variety Class (CV), Indicator Group (GI) and IBGN value).

According to its results, the quality of the waters of the Grou River undergoes very important variations. We note that the value of the IBGN at the upstream station S_1 is 12, whereas a sharp drop of this value to 6 is observed at the station S_2. This can be explained by the degradation of water quality at the S_2 station located downstream of the domestic and wastewater discharges of the rural commune of JmaaMoulblad. Then, there is an increase in the values of the IBGN at the level of the two downstream stations S_3 and S_4, with respectively 13 and 14. This could be explained by the phenomenon of self-purification of the water, which is a natural biological process by which the water cleans itself. This natural purification is the work of organisms living in the aquatic environment: macroinvertebrates, bacteria, algae, which allow water to return to its original quality. This self-purification also depends on the nature and quantity of the pollutants. If the amount of pollutants released is too large, it would require a very large number of organisms or a long distance for water to restore its quality. This is the reason why we can explain the increase in the value of the IBGN at the stations S_3 and S_4. Since the station S_3 is situated at 35 km from the station S_2, this distance is sufficient for the implementation of this natural phenomenon, the same for the station S_4 located at 30 km from the station S_3. These results allow us

to classify the waters of the Grou River at the level of station S_1 in the category of medium quality water, at station S_2 in the category of poor quality water and at stations S_3 and S_4 in the category of good quality water.
With the increasing population growth in recent years and the increase in urban areas, the rate of anthropogenic pollution will increase, which will increasingly affect the quality of water in the Grou River to a degree at which the phenomenon of self-purification will not allow improving the quality of the water. As a result, the water quality of the SMBA dam, that supplies drinking water for ¼ of the Moroccan population (between Casablanca and Kenitra), which waters are at 35% provided by the Grou River will be strongly affected.
If the conservation and protection measures are not ready at the level of the watershed of the Grou River, more than a quarter of the Moroccan population will undergo a water pollution threat. It is therefore urgent to put in place a sustainable development and management plan aimed at protecting and exploiting water resources against any risk of pollution and degradation and the prevention of any activity likely to affect the quality of water, taking into account the human potential, which is a key factor in the success of this operation. The construction of a sewage treatment plant in the rural community of JmaaMoulblad has become a short-term obligation.

Table 4: Mean values of the standardized global biological index at the stations of the Grou River.

Index	Stations			
	S_1	S_2	S_3	S_4
VT	11	12	13	19
CV	4	4	5	6
GI	9	3	9	9
IBGN	12	6	13	14
Water quality	Medium	Poor	Good	Good
Mapcolour	Yellow	Orange	Green	Green
Pollution	Moderate	Heavy	Low	Low

Conclusion :
At the end of this study, it is noted that Grou River harbors a large community of benthic macroinvertebrates, characterized by a taxonomic diversity that varies according to the nature of the habitats and the degree of water pollution.
The benthic population showed that Ephemeroptera are the largest faunal group followed by the Heteroptera, Platyhelminthes, Annelids, Crustacea and Diptera which are moderately represented, while Coleoptera, Molluska, Trichoptera, Plecoptera and Odonata are only a small fraction of the fauna harvested. The most numerically counted families are the Leptophlebiidae followed by the Baetidae, the Corixidae and the Dugesiidae.
The specific wealth of the River depends on the ecological conditions at each station; It is all the higher as the biotope is heterogeneous and less influenced by anthropogenic activities. Thus, the downstream part of the Grou River, the subject of this study, shows that it is poor in fauna compared to other rivers [5,9,40].
The study of the hydrobiological quality of the Grou River by the method of the global standardized biological index (IBGN) showed a heterogeneity of the quality of the water. These results show a marked degradation at station S_2, influenced directly by the effect of anthropogenic impacts (domestic and wastewater effluent) in the rural commune of JmaaMoulblad, where the value of the IBGN drops from 12 at station S_1 located at the entrance of the rural commune to 6 at station S_2, thus showing the passage from the category of water of average quality to the category of water of poor quality.
Thereafter, there is an increase in the value of the IBGN at the level of the two downstream stations S_3 and S_4, respectively to 13 and 14, showing the passage this time from the category of water of poor quality to the category of good quality water. This could be explained by the phenomenon of self-purification of water, which is a natural biological process by which water cleans itself. Possibly, with population growth, which has been booming in recent years and the increase in urban areas, the rate of anthropogenic pollution will increase and this natural phenomenon will have no effect.
As a result, certain protection and recovery measures should be taken in order to preserve and improve the ecological status of the waters of the Grou River through the implementation of a sustainable management and management plan. It is also essential to sensitize the population of the region by means of information so that it can become aware of the importance of water and its quality. The construction of a wastewater treatment plant in the rural commune of JmaaMoulblad and the establishment of a regulation in force to prohibit the illegal removal of sand from the River has become an urgent obligation.

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