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Bioassessment of Beht's river in Morocco through the GBI-CSN index

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Abstract: This study is a contribution to the biological assessment and monitoring of Beht's River quality in Morocco during 2014- 2015 using the standard Global Biological Index of Control and Surveillance Networks (GBI-CSN). Twelve to fourteen sampling stations were chosen to determine impacts of human activities such as agriculture and urban waste management on the biological quality of hydro-systems in the studied area. The results obtained by calculation of the biological index in different stations sampled show the degradation of the quality from the upstream water bodies (Index of Ras Al Ma station: 17/20) to downstream (Index of Dar Elgueddari station: 3/20) of Beht watershed. This deterioration in the quality of the water bodies can be explained by the increase in anthropogenic activity such as the extraction of alluvial materials, intensive arboriculture, and the presence of an uncontrolled public dump downstream of the province of Ifrane as well as the installation of hydroelectric dams that perturb the flow regime of rivers.

Key words*:* River "Beht", Bioassessment, macroinvertebrates, anthropogenic activity.

1. INTRODUCTION

Renewable fresh water represents a small fraction of the world's water but is of extreme importance for life in terrestrial and aquatic systems[1-3]. This resource is indeed answering all needs of Humanity on Earth and is considered the fundamental element to foundation of all vital domains such as agriculture and industry[3.4]. However, water resources are strongly reached and negatively affected by

the grater increase of human action that led to the damage of natural systems and a worldwide fading biodiversity[5-7].

Since 1992, pollution had been a major societal concern and a parameter to include to every water policy of all countries (Agenda 21). Thus, every watershed agency was called into its management program of water resources to detect, prevent and oppose irreversible changes that face every natural system nowadays[8,9]. In Morocco, water management program is based essentially on a surveillance system that includes physicochemical and microbiological parameters which lead to know the status of water resources within the time of water sampling and could detect various causes of pollution[10]. Yet water quality is a function joining several parameters influencing it[11]. It can be determined by the mineral composition of bedrocks, the influence of atmospheric processes of evapotranspiration and wind deposition, hydrological and climatic factors that lead to cessation of water flow, biological processes of aquatic environment and organic composition or nutrient related to soil[3,11]. Then, natural water is composed of dissolved substances such as salts and minerals necessary for the survival of the various bio-organisms that depend on it and other particles [11]. Therefor a good assessment of water resources requires a full surveillance of aquatic environments state, goal that can be achieved using biological practices[9].

In fact, biological assessment or bioassessment is an evaluation of the state of a water body based on the study of living organisms present in it such us macroinvertebrates, macrophyts and fish. It involves methods called biological indexes that gather a quantitative measurement of biodiversity to a qualitative measure that depend on the presence or the absence of sensitive taxa towards pollution[12,13]. These methods lead to complete conclusions concerning the state of an aquatic environment and also allow the better knowledge of biodiversity of natural environment[12,-14].

Then, this paper is a work based on the use of the standard Global Biological Index of Control and Surveillance Networks (GBI-CSN) using freshwater benthic macroinvertebrates. Its identification and index calculation allows determining the global state of Beht watershed in Morocco.

2. METHODOLOGY

2.1. Study environment*:* Beht watershed is located in the northwest of Morocco and occupies about 4500Km^2 at the southwest part of Sebou watershed. It is limited to the North by the plain of Gharb and the upland of Meknes, to the South by Oum-Erbia watershed, on the West by Bouregreg watershed and in the East by the Middle Atlas moutains. Its limits enroll between meridians 5° and 6° west and parallels 33° to 34° north. Therefor this watershed enjoys a Mediterranean climate[15, 16] (**figure 1**). From a geological point of view this basin is installed on several geological structures and domains[16, 17].

This river is an important tributary of Sebou River. It originates from Azrou area where several oueds of this region joins such as Tigirgra and Ifrane, then it feeds while crossing the central upland by water coming from numerous oueds like: Bou Achouch, Kharouba, Ouchket, El Kell, Berrajline, D'Kor and Chébi[16, 18]. Finaly it receives before joining Sebou the water of R'Dom River [19].

2.2. Sampling stations*:* 12 stations were visited during periods of Mai-June 2014 and 2015, with the addition of 2 stations in 2015 (stations 6 and 7) in order to sample the macrofauna of the river. **Table 1** is presenting coordinates of all stations and **figure 1** is locating all 14 stations in Beht watershed. Location of sampling stations in Beht watershed by coordinates; stations from 1 to 7 are located in the

upstream of Beht. Stations: 8, 9, 10 and 11represent the Midstream of Beht. The last 3 stations are situated on the downstream of Beht.

Table 1: Stations coordinates

Station number	Station	Oued	Coordinates	
			X	Y
1	Ras El Ma	Tigrigra	523314	318561
2	Ben Smim	Ben Smim	505775	317240
3	Sidi Elmokhfi	Tigrigra	507676	311800
4	Ain Leuh	Ain leuh	495358	305279
5	Adarouch	Adarouch	487 796	315 183
6	Amghas	Amghas	495 540	308 987
7	aval Had oued Ifrane	Ifrane	491369	299775
8	Ouljet sultane	Beht	452250	338050
9	Khémisset (1)	Beht	450816	364815
10	Khémisset (2)	Beht	450300	369150
11	Dar Bel Amri	Beht	447720	439970
12	Sidi slimane	Beht	449350	415180
13	Dar El Gueddari (1)	Beht	436175	424152
14	Dar El Gueddari (2)	Beht	435592	424510

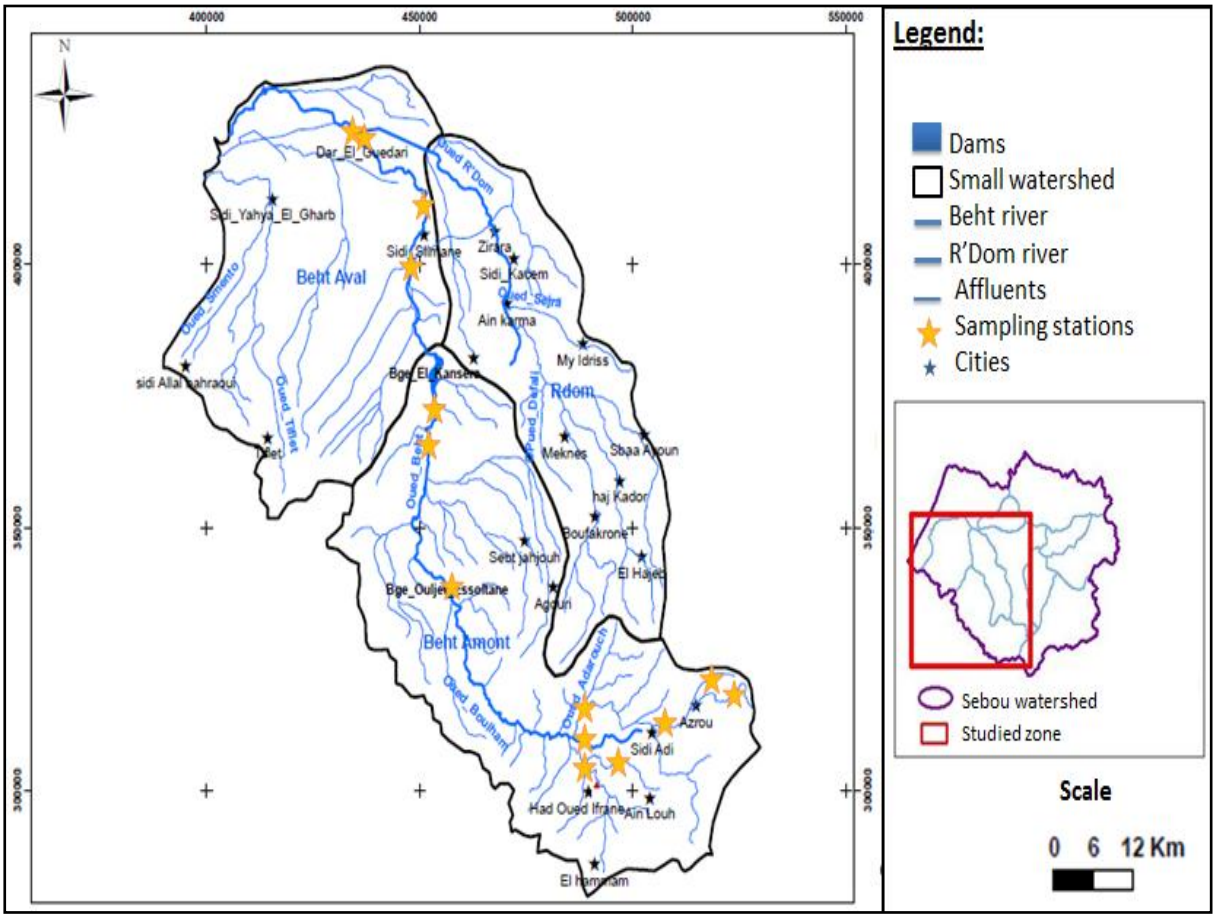

Figure 1: Presentation of the studied zone and sampling stations

2.3. Biological sampling*:* GBI-CSN is a biological index based on the study of benthic macro invertebrates living within the water body. It involves surveying the types and numbers of organisms present in the water and comparing the results to established benchmarks of biological health. Samplings were done following the strict protocol of this index published under the standard XP T90-333 of the French national organization for standardization (AFNOR) [20] in 2009.

This protocol is performed in three main steps:

- First stage: 12 takings of benthic macrofauna were achieved in various biotic or abiotic substrata existing in a station, using surber and troubleau according to the accessibility of the different substrata;
- Second stage: samples fixed and preserved in alcohol (70°) are sorted out in the laboratory then determined to family level using a binocular magnifying glass and determination guides;
- Third stage: index calculation using a double-entry table, which join quantitative (number of identified families in one station) to qualitative measurement (represented by a group of families listed according to their level of sensitivity towards pollution) (**table 2).** As result, a note is assigned to the station by crossing the double entries on table 1. This note refers to a range of quality (**table 3).**

The obtained results are manipulated with the software geographic information system "Arc-GIS 10" in order to present a bioassessment map.

Table 2: Index calculation[21]

Classe de variété		14	13	12	11	10	9	8	7	6	5	4	3	2	1
Nbr de familles		≥50	40-45	44-41	40-37	36-33	32-29	28-25	24-21	20-17	16-13	12-10	9-7	6-4	≤3
Taxons indicateurs (polluo- sensibilité) ↓															
Chloroperlidae -Perlidae Perlodidae - Taeniopterygidae	9	20	20	20	19	18	17	16	15	14	13	12	11	10	9
Capniidae- Brachycentridae Odontoceridae- Philopotamidae	8	20	20	19	18	17	16	15	14	13	12	11	10	9	8
Leuctridae - Glossosomatidae Beraeidae – Goeridae -Leptophelbidae	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- Ephemerellidae Hydropsychidae - Aphelocheiridae	3	16	15	14	13	12	11	10	9	8	7	6	5	4	3
Baetidae - Caenidae Elmidae – Gammaridae - Mollusques	2	15	14	13	12	11	10	9	8	7	6	5	4	3	2
Chironomidae - Asellidae Achètes - Oligochètes	1	14	13	12	11	10	9	8	7	6	5	4	3	3	1

Table 3. *Range of biological quality*[21]

	>= 17	16 – 13	12 – 9	8 – 5	<=4
Quality	excelent	good	average	poor	bad
Color	blue	green	yellow	orange	red

3. RESULTS

The biological approach using benthic macro invertebrates is showing an alteration of biological health of water bodies located downstream of urban agglomerations in Beht watershed. It's indeed the case of stations 3, 5, 7, 10, 12, 13 and 14 positioned in downstream of domestic discharges of small towns or cities (Had oued Ifrane, Sidi Elmokhfi, Khémisset, Sidi Slimane and Dar Elgueddari). These stations are also situated in an agricultural area and there for influenced by agricultural wastes. Water bodies 4 and 8 situated far from the grate human disturbance are presenting poor biological quality. This result can be attributed to the negative effect of another type of human intervention in lotic systems which are the installation of hydroelectric dams in streams or furthermore the extraction of alluvial materials needed for dams construction, as a practice damaging benthic macroinvertebrates assemblages and not allowing their proper installation. Other stations far from human activity and disturbing mass attendance are credited with good and very good biological qualities (**table 4 and figure 2**).There is no much difference between the biological results of the two campaigns, except for two stations 3 and 12. The health status of the third station has become good in 2015. This quality improvement can be explained by the work achievement of the national road N°8 rehabilitation. As for the station Sidi Slimane the biological quality has changed from poor to bad.

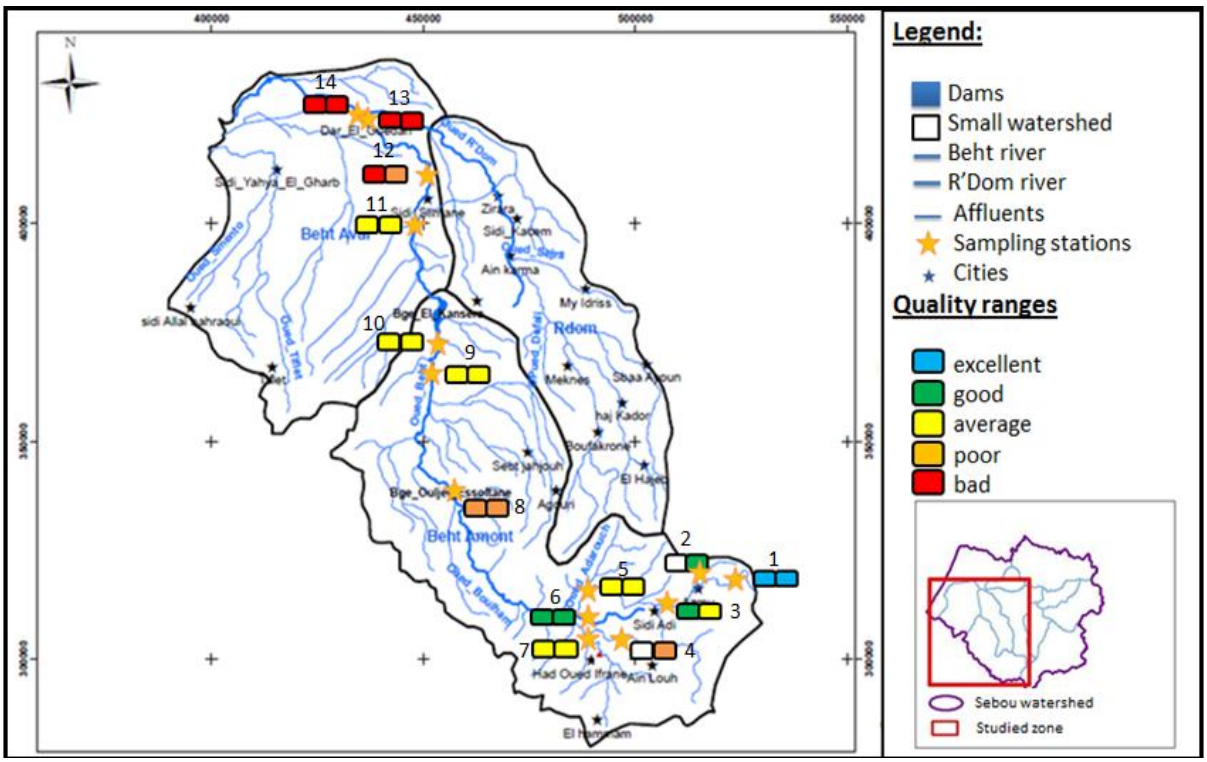

Figure 2: Bioassessment quality map

Table 4: Index calculation

Station	Campaign I 2014 (C I)				Campaign II 2015 (C II)			
	Taxa diversity	Indicator group	Note	Stations quality	Taxa diversity	Indicator group	Note	Stations quality
1	30	9	17/20	excellent	31	9	17/20	excellent
2	-	-	-	-	24	9	15/20	good
3	20	7	12/20	average	21	7	13/20	good
4	-	-	-	-	17	3	8/20	poor
5	19	5	10/20	average	21	5	11/20	average
6	23	7	13/20	good	27	7	14/20	good
7	16	5	9/20	average	16	5	9/20	average
8	12	5	8/20	poor	12	5	8/20	poor
9	17	5	10/20	average	17	5	10/20	average
10	16	5	9/20	average	16	5	9/20	average
11	18	5	10/20	average	18	5	10/20	average
12	11	2	5/20	poor	9	2	4/20	bad
13	7	2	4/20	bad	7	2	4/20	bad
14	6	2	3/20	bad	6	2	3/20	bad

4. DISCUSSION

The choice and positioning of the various benthic macrofauna sampling stations was carried out in order to determine the impact of human activities on the health status of lotic systems and their biological diversity (in this case their richness in benthic macrofauna). Macrozoobenthic communities are very sensitive to environmental variability[22] and their diversity and abundance in a given lotic system can provide important information on the quality of this environment[23]. Negative disturbing effects of pollution on the quality of running water ecosystems demonstrated by the biological approach of this work have been cited in numerous works in the world, among which in Morocco the works of some authors[24-25-27]. However, the health status of a water body depends also on a number of parameters considered as a natural stress, for example the climate and the type of the parent bedrock. Thus the effects of these last factors are intensified by the phenomenon of Human-induced pollution and other activities related to watershed management policy in lotic systems[3,11]. All these combined factors change the aquatic environment and lead to the decline of associated biodiversity.

5. CONCLUSION

This study is a biological assessment and monitoring of the quality of the Beht basin in Morocco using the global biological index of control and monitoring networks based on the study of benthic

macroinvertebrates assemblages in freshwater as an effective instrument in applied ecology. Two surveys of macroinvertebrates sampling were carried out on our watershed with 12 to 14 sampling points during 2014 and 2015. The analysis of the IBG-RCS index scores shows an upstream-downstream degradation of the health status of lotic systems. These results can be explained by the combination of natural and / or anthropogenic stressors parameters, including pollution with domestic and agricultural wastes.

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