



The Bougara dam's water quality assessment using macroinvertebrates benthic indices. Avaliação da qualidade da água da barragem de Bougara utilizando índices bênticos de macroinvertebrados.

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Abstract

The benthic macroinvertebrate communities along with the physicochemical variables in Bougara dam waters (Nahr Ouassel river) downstream of a dam North-western of Algeria, were recorded from three sampling sites during January to May 2022. All the physicochemical parameters were highest in the first station (temperature, pH, conductivity, BOD and COD) while they were slightly lower in the second station and low in the third station. A total of 13 species, belonging to 10 families of 7 orders of benthic macroinvertebrates were recorded. With a great domination of insects. The maximum density of benthic fauna was recorded from the site nearest to the dam exit. These results were confirmed by the benthic indices of macroinvertebrates where the recommendations are to clean the first highly polluted station and to keep monitoring the other remaining stations moderately polluted.

Keywords: Fresh water. Dam. Biotic indices. BOD. COD. Algeria.

Resumo

As comunidades de macroinvertebrados bentônicos, juntamente com as variáveis físico-químicas nas águas da barragem de Bougara (rio Nahr Ouassel) a jusante de uma barragem a noroeste da Argélia, foram registradas em três locais de amostragem durante janeiro a maio de 2022. Todos os parâmetros físico-químicos foram mais elevados na primeira estação. (temperatura, pH, condutividade, BOD e COD), enquanto foram ligeiramente inferiores na segunda estação e baixos na terceira estação. Foram registradas um total de 13 espécies, pertencentes a 10 famílias de 7 ordens de macroinvertebrados bentônicos. Com grande domínio de insetos. A densidade máxima da fauna bentônica foi registrada no local mais próximo da saída da barragem. Estes resultados foram confirmados pelos índices bentônicos de macroinvertebrados onde as recomendações são limpar a primeira estação altamente poluída e continuar monitorando as demais estações moderadamente poluídas.

Palavras-chave: Água doce. Barragem. Índices bióticos. BOD. COD. Argélia.

Introduction

Fresh water is the main natural resource necessary to maintain life processes on Earth (CARONE et al., 2009). The deterioration of water quality impact on biodiversity has been observed in many countries (HARDING et al., 2005).

On a larger scale, Mediterranean rivers and water bodies are marked by seasonal drought leading to low flows or even drying up completely in summer combined with climate change and increased water demand (BARCELÓ & SABATER, 2010; LOBANOVA et al., 2017).

Anthropogenic activities wastewater is responsible of highly increased levels of pollution in most of rivers and dams in developing countries, causing a major threatening factor for water quality (ARIMORO & IKOMI, 2008; ARIMORO & OSAKWE, 2006).

Biological methods are used to determine anthropogenic and natural effects on water resources, biota perceive changes on spatiotemporal level (WEIGEL & ROBERTSON, 2007). Moreover, they are time and costs saving compared with physicochemical methods (BODE et al., 1991).

Macroinvertebrates are known to be sensitive to environmental changes that makes them good indicators of water quality. Their diversity and biological indices are often applied in attempts to measure river pollution. Score-based biological indicators are one of the biological monitoring methods most commonly used to synthesize large amounts of data from environmental monitoring. (GILLER & MALMQVIST, 1998).

These indices, taxa are assigned scores up to the family or genus level, based on their tolerance to organic pollution, assigning the highest or lowest score (ARMITAGE et al., 1983).

The past recent decades have known a highly significant development in river biological monitoring, by being more effective and relatively less expensive, using multifactorial approaches for identifying contaminants and pollutants (BAPTISTA et al., 2007; ILIOPOULOU-GEORGUDAKI et al., 2003) water quality degradation and its impact on biodiversity have been carried out in many countries (HARDING et al., 2005). Moreover, several studies have focused on the use of benthic invertebrates for biological monitoring and the impacts of pollutants on macroinvertebrate populations (FERREIRA et al., 2004; MANDAVILLE, 2002; SCHÄFER et al., 2007).

The aim of this study is to establish a list of the macroinvertebrates tolerant/sensitive species in the dam of Bougara in order to assess the quality of its water through biotic indices.

Materials and methods

The Bougara dam is located on Oued Nahr Ouassel in the Wilaya of Tissemsilt, upstream of the village of Bougara. The reservoir is mainly in the Wilaya of Tissemsilt. The aquatic ecosystem is subdivided into two parts, the first is a swamp with an area of 433.6 ha north of the Bougara dam with a depth of 45 cm and 2 m.

The second covered lake part represents 80% of the aquatic ecosystem with a depth which exceeds 2 m under the limnic system, approximately 223 ha and is less than 2 meters under the coastal system over a little over 121 ha (MEZIANE et al., 2022) (Figure 1).

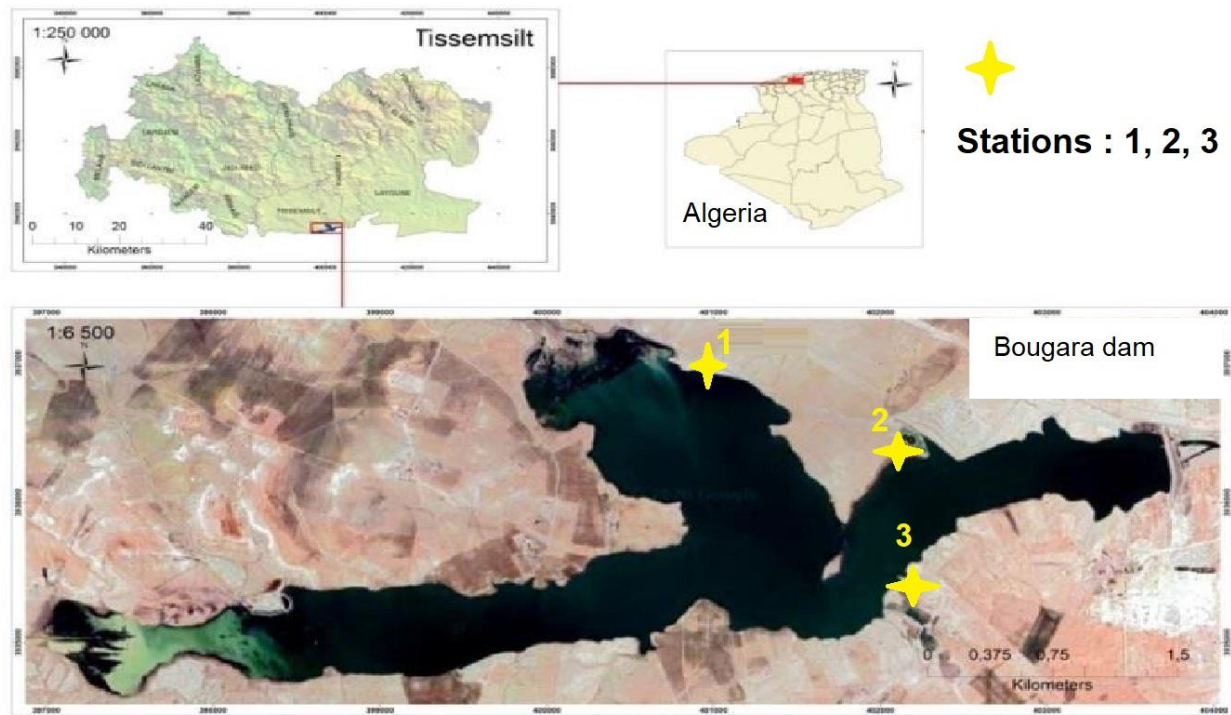


Figure 1 - Study area localization slightly modified (MEZIANE et al., 2022).

Physico-chemical analysis

The water samples were collected in prerinsed clean one liter polythene bottle having double stopper facility to its full capacity without entrapping air bubbles inside it. When the water samples from all the stations were received, systematic analysis of the water samples was undertaken.

For analysis of samples, methods followed were of (APHA, 1998). Temperature, pH and turbidity were measured by multimeter (CRISON MM 40), BOD and COD was measured by titration method.

Species determination

We carried out the analysis and counting of the individuals of each taxon, which allowed us to constitute a list of species from the three stations. Then the specimens are preserved in ethanol. Animal species are identified according to the determination of the different groups and using a binocular magnifying glass referring to the *Atlas des macro-invertébrés des eaux douces de l'île de la réunion* (FORCELLINI et al., 2015).

The biotic index

The biotic index used was developed by William M. Beck, Jr (BECK, 1955) in response to the need for a simple biological measure of stream pollution. This method is based on the classification of selected aquatic invertebrates into categories based on their response to organic pollution (sewage and other demanding wastes) (Table 1):

Class I – sensitive to pollution; Class II - moderately tolerant; Class III - pollution tolerant.

Since the class III is already tolerant, it will not figure in the formula. So, the formula developed was:

$$2 (\text{n class I}) + (\text{n class II}) = \text{Biotic index.}$$

Where (n) is the number of species.

Table 1 - Biotic indices standard values.

Biotic index values	Water quality rating
≥ 10	Clean up streams
3-9	Moderate pollution
0-2	Highly polluted

Results and discussion

The results of the physicochemical parameters are shown in Table 2.

Table 2 - Physicochemical parameters of the three stations of Bougara dam.

Parameters	Station 1	Station 2	Station 3
Temperature °C	26.1	24.9	25
pH	9.09	8.21	8.22
Conductivity (µS/cm)	2880	2190	1180
BOD Mg/l	10.4	11	10;3
COD Mg/l	9	9.8	9.3

Temperature was stable all along the station, slightly lower in the second station because of the amount of water is higher making the temperature cooler than the other two stations. The first station has shown the maximum value of pH compared to the other stations values. The pH is more basic and starts decreasing in value along the dam to come close to neutrality at the exit of the dam, this could be explained by the gaining in in the amount of water which more important, the concentrations are dissolved in higher amounts of water.

The high values of conductivity, BOD and COD in the first station its position being in the downstream, charged with high number of organic pollutants to be oxidized along the runaway of water to the dam exit.

An exhaustive list of the inventoried species of the Bougara Dam is represented in Table 3.

Microinvertebrates are small organisms that play an important role in aquatic ecosystems, particularly in benthic environments. Dissolved oxygen levels, pH, and temperature can all have a substantial impact on their distribution and community (OJEDA-RIVERA et al., 2022; YAO, 2016).

Varied responses may occur to different microinvertebrate taxa due to dam induced changes in environmental condition, some species are more tolerant than the others (ALLAN & FLECKER, 1993). Changes in water quality can have a considerable impact on microinvertebrates, which have developed tolerance mechanisms to cope. Odonata, Mollusca, Decapoda, Hemiptera, Ephemeroptera, and Coleoptera have evolved to adapt to changing water quality, habitat, and flow. Similarly, Hemiptera and Decapoda have been classed as resistant invertebrates that respond solely to some of the water quality variables, demonstrating their ability to tolerate specific environmental changes (BANDA et al., 2023).

The macroinvertebrate indices indicated the first station is the location with the poorest water quality waters, and indices values decreased from station to the other when nearest to the dam exit.

This dam's waters are used for irrigation of the surrounding areas. Although, the affect might not be instantly observed on irrigated cultures, the effect of polluted waters is accumulated in crops.

Table 3 - List of inventoried species in the study area and benthic indices.

Class	Family	Order	Taxa	Sites		
				S1	S2	S3
Insecta	Hydrophilidae	Coleoptera	<i>Coelostoma orbiculare</i>	+++		
		Coleoptera	<i>Laccobius mascarensis</i>	++		+++
	Hydraenidae	Coleoptera	<i>Hydraena borbonica</i>	++		+++
		Coleoptera	<i>Sicilicula borbonica</i>		++	
	Gyrinidae	Coleoptera	<i>Dineutus aereus</i>	++		
	Dytiscidae	Coleoptera	<i>Bidessus sp</i>		++	
	Chironomidae	Diptera	<i>Orthoclaadiinae sp</i>	++		
	Philopotamidae	Trichoptera	<i>Chimarra bettinae</i>		+++	+++
	Dryopidae	Doleoptera	<i>Dryopidae sp</i>		+++	+++
	Libellulidae	Odonata	<i>Crocothemis sp</i>	+++		
Gastropoda	Planorbidae	Basommatophora	<i>Helisoma duryi</i>		++	
			<i>Afrogyrus rodriguezensis</i>			++
Hirudinae	Glossiphoniidae	Rhynchobdellida	<i>Helobdella enropaea</i>		++	++
Biotic indices				14	9	5

++ moderately present, +++ highly present.

Macroinvertebrates unique presence or absence pattern with a specific level of water quality can be defined as an indicator of the health and condition of an aquatic system. Researchers by comparison have successfully determined taxa-specific indicators of water pollution. For instance, pollution sensitive species such as Coleoptera and Trichoptera have been found in streams that are clean and have good quality (AZMI et al., 2018); Odonata, Basommatophora and Rhynchobdellida indicate moderate water quality (ABDEL GAWAD, 2019). It has been found that insects are most dominant in polluted water bodies to their capacity to tolerate pollution (RAFIA & ASHOK, 2014). Taxa richness decreases significantly with the increase of organic pollutants, this latter affects the distribution of macroinvertebrates giving results to non-uniform groups due to high organic pollution (XU et al., 2014).

In summertime, day/night high temperature fluctuations, penetration of and the variant concentrations of organic matter make the low flows lessen the dilution capacity of chemical discharges. Activities like discharge of untreated animal wastes from slaughter houses, livestock and fish farms, untreated sewage, wood wastes cause diversity of stresses to benthic macroinvertebrates

are key components of lotic ecosystems (ARIMORO & OSAKWE, 2006; BOIX et al., 2010; RUEDA et al., 2002) .

Community composition at a given point can indicate the water quality because the sensitivity and tolerance towards pollution is shown by the different members of the fauna present in that particular point (ROY et al., 2003).

Conclusion

Benthic macroinvertebrate communities as well as physicochemical variables in the waters of the Bougara Dam (Nahr Ouassel river) downstream of a dam in northwestern Algeria, recorded from three sampling sites. All physicochemical parameters were highest at the first station (temperature, pH, conductivity, BOD and COD) while they were slightly lower at the second station and low at the third station indicating severe and moderate pollution, respectively. Benthic macroinvertebrates have been recorded with great dominance of insects. The maximum density of benthic fauna was recorded from the location closest to the dam outlet, these results were confirmed by macroinvertebrate benthic indices calculated.

We recommend an urgent to clean the first heavily contaminated station and continue monitoring the other moderately contaminated stations.

Interest conflicts

There was no conflict of interest of the authors.

Authors' contribution

Maamar Benchohra - original idea, field work, reading and interpretation of works and writing; Maamar Benchohra, Hichem Berrabah and Nouar Belgacem - writing and corrections; Hocine Fadlallah Rabah - guidance, corrections and revision of the text; Baya Bnina - data collection and organization.

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