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Biodiversity indices and nutrient load assessment in Ishmi River, Albania, during 2012-2013

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Abstract: Ishmi River basin is located in the central part of Albania crossing inhabited, industrial and agriculture areas. These activities have a direct impact on the aquatic ecosystem and water quality. The catchment area of Ishmi River consists of several tributaries, including the Lana, Tirana, and Tërkuza Rivers which join to create the Gjola Tributary; close to the River Delta, Zezë and Gjola Rivers together with Droja spring join into Ishmi River which flows into Adriatic Sea (Eftimi, 1989). Taking into consideration the River catchment area, its hydrological characteristics and recent rural and urban development's and industrial activities, we have monitored and analysed the water quality by assessing the biodiversity indices of benthic bio indicators and nutrient load in three monitoring stations along the River during 2012 – 2013. Benthic macro invertebrates are sampled seasonally according to Water Framework Directive (WFD) requirements and the Shannon and Simpson Indices were calculated; while nutrient load for each of the water samples was assessed according to Standard Methods for Examination of Water and Wastewater, APHA, 1998. The study results indicate that the nutrients content as $P\text{-}PO_4^{3-}$, $N\text{-}NO_3^-$, $N\text{-}NH_4^-$, $N\text{-}NO_2^-$, increases due to the high organic pollution load and it causes the decrease of benthic invertebrate taxa and variation of Biodiversity Indices.

Key words: Shannon Index, Simpson Index, nutrient load, water quality

1. INTRODUCTION

Being a candidate to EU membership and a costal country Albania has to handle important issues related to water quality and management. The implementation of the Water Framework Directive (WFD) in Albania is an opportunity to improve water quality according to European Standards and Practices. In the present study we have assessed the water quality of Ishmi River, by analysing nutrient load and benthic invertebrates' biodiversity variances at three monitoring stations along the River. The relation between benthic invertebrates' number of individuals and their relative abundance and nutrient load is presented as well. A variable macro benthic community, being able to adapt better to climate changes and water quality, is a good indicator of the environmental status.

2. METHODS AND MATERIALS

2.1 Sampling

Sampling was undertaken seasonally, on daily expeditions, in order to sample at each of the monitoring stations within the same day and weather conditions during 2012-2013. At each monitoring station three samples are taken randomly. Benthic invertebrates were collected from the river bottom (40 – 60 cm) with a kick – net (500 μ) in order to gain sufficient samples from larger depths of water. The net is held upright on the stream bed by one individual, while the stream bottom upstream of the net is physically disrupted by a second individual. Kicking and turning over rocks and logs with the feet and hands dislodges organisms which are washed into the net by the current (Barbour et al., 1999; Bode et al., 1995, 1997; Cardoso et al., 2005; Downing and Rigler, 1984; Voeiz et al., 2001; Pollard, 1981). The samples were collected from areas of differing current speed. All benthic macro invertebrates are kept in 95% ETOH. Before mailing to the Laboratory, the jars are completely filled with alcohol to reduce damage to the specimen and labelled. Each label consists on name of the station, no. of the sample and date of sampling.

2.2 Sorting

Sorting consists on disaggregating the invertebrate taxa from the substrate, assessing the abundance of each groups found in the respective samples (Braukman, 2000; Haase et al., 2004). Sorting has been carried out at using a stereomicroscope (OPTIKA zoom stereo microscopes SZM – Led 2).

Each of the invertebrate present in the sample is counted and stored in alcohol 95% in separate plastic tubes, which are labelled with the data on the period, site or monitoring station. Each of the above phases is exercised for each replicate separately, for respective sampling sites and monitoring stations. The substrate disaggregation is realised carefully using the stereo microscope.

2.3 Species identification

For the identification of benthic invertebrates different publications are used: Wallace and Wallace (2003), Edington and Hildrew (2005), Hickin (1967), Macan (1994), Hynes H.B.N (1993), Tachet et al. (1980), Cao et al. (1997), Parker and Salansky (1998) and Campaioli et al. (1994).

2.4 Biodiversity indices calculation

Shannon & Simpson Indices are diversity indices that provide important information on the commonness and rarity of species within the community. The diversity quantifying is an important tool for understanding the community structure (Magurran, 2004):

2.4.1 Shannon Index Calculation

$$H = -\sum_{i=1}^{S} p_i \ln p_i \tag{1}$$

H = Shannon Index

P_i = proportion of S made up of the i^{th} species

S = total number of species in the community/ richness

$\sum$ = Sum from 1st individual to S individual

Equitability (evenness) (E_H) can be calculated by dividing H by $H_{\max}$ (here: $H_{\max}$ = ln$S$). Equitability assumes a value between 0 and 1 with 1 being complete evenness.

2.4.2 Simpson Index Calculation

Simpson Index calculation comprises a simple mathematical measure that characterizes species diversity in a community. Simpson's index is based on the probability of any two individuals drawn at random from an infinitely large community belonging to the same species: $D = \Sigma\ p_i^2$ where pi is the proportion of individuals found in species i.

Simpson Index calculation for a finite community:

$$D = \Sigma [n_i (n_i - 1)/N (N - 1)] \quad (2)$$

2.6 Chemical analyses

Nutrient load assessment of the water samples has been carried out at the Laboratory of Analytical Chemistry, Faculty of Natural Sciences, Tirana, Albania. The water samples are taken seasonally during 2013, using 0,5 L sterilized bottles, closed hermetically. Each bottle has been labelled with the date and monitoring station name. The bottle is opened and closed within water, in order to avoid air presence. Measurement of nitrites and nitrates have been carried out using UV-VIS Spectrophotometer; while for the assessment of total phosphorus has been used the Spectrophotometer UV-VIS Pay-Unicam SP-5 (for the measurements at 880 nm wave length). Water samples storage, pre-treatment and chemical analyses have been executed according to Standard Methods for Examination of Water and Wastewater (APHA, 1998).

3. RESULTS AND DISCUSSION

3.1 Biodiversity Indicess assessment in Ishmi River

Increase of Shannon Index and Equitability values show the increase of the heterogeneity or richness of macroinvertebrates' community; decrease of Shannon Index value reflects the poorness and homogeneity of benthic invertebrates' community (Magurran, 2004).

D - Simpson Index is considered as measure of dominance, so increase of its value (in equitability basis) is an indicator of species diversity decrease (Magurran, 2004).

Table 1. Shannon & Simpson Indices in Ishmi River, Albania, per each monitoring station during 2012 – 2013; Water quality classification per each monitoring station in Ishmi River based on P-PO_4^{3-} and N-NH_4^+ according to UNECE classification

Monitoring stations	H – Shannon Index	E (Shannon Equitability)	D – Simpson Index	P-PO_4^{3-} μg/L	UNECE	N-NH_4^+ mg/L	UNECE
Lanës/Rinas Bridge	1.928232236	0.838361842	0.181606901	333.4	V	4.94	IV
Zezë/Fushë-Krujë	0.899912379	0.391266252	0.59602767	114.7	IV	2.84	IV
Gjuricaj/Sukth	1.001172789	0.526933047	0.532999376	360.3	V	7.22	V

Biodiversity Indices have slight differences from one monitoring station to another along the River (Table 1); H decreases from the first monitoring station to the second reflecting poorness of the community diversity. The decrease of taxa is a consequence of water pollution at the monitoring stations; the increase of H value at the 3rd monitoring stations shows an increase of identified taxa. However the identified taxa are of a higher tolerance toward pollution compared to the 2nd monitoring station, while the density per taxa is lower than at 2nd monitoring station. Water pollution increases from the first monitoring station to the River delta, where the pollution concentration is higher compared to the upper parts of the river basin/catchment area. Monitoring stations are located at different sites along the river basin: at Lana/Rinas Bridge and Zezë/Fushë-Krujë i.e. in the medium section of River basin, while the 3rd monitoring station Gjurica/Sukth is close to the River Delta. The location of the monitoring sites justifies the obtained results, i.e. the dominance of *Olighocheta* taxa (with a tolerance value toward pollution 8; Mandaville, 2002; Lenat, 1998) at the 3rd monitoring station; while in the samples of 2nd monitoring station the dominant taxa is *Chironomidae* (with a tolerance value toward pollution 6; Mandaville, 2002).

Simpson Index value increases from the 1st to the 2nd monitoring station and decreases from the 2nd to the 3rd monitoring station reflecting the same result as Shannon Index.

3.2 Nutrient load and water quality in Ishmi River

The nutrient load in Ishmi River/ selected monitoring stations is been assessed and is as follows:
The nutrient load in the water samples of each of the monitoring stations reflects an overview of eutrophic waters, which are characterized by low levels of dissolved oxygen and decrease of benthic invertebrates and other living species in the ecosystem (Cullaj et al., 2004; Minnesota Pollution Control Agency, 2005). Based on the mean values of P-$PO_4^{3-}$and N-NH_4^+ in all monitoring stations the water is classified as highly polluted belonging to the IV and V water quality class; the aforementioned classification indicates a bad quality of water and high pollution level (Table 1).

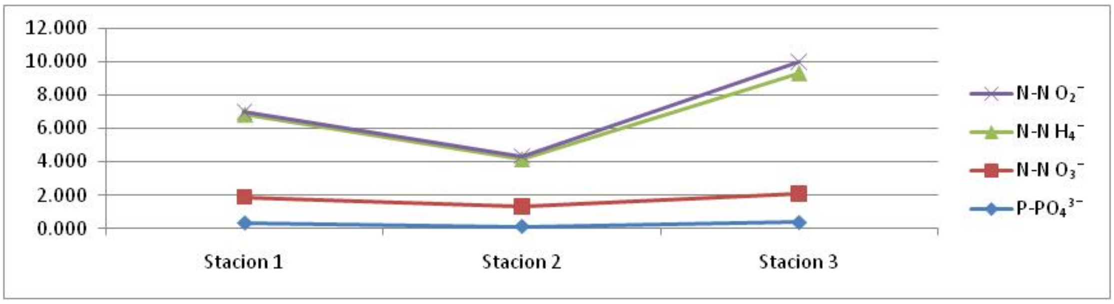

Figure 1. Nutrient load variances in three monitoring stations of Ishmi River, Albania during 2012 – 2013

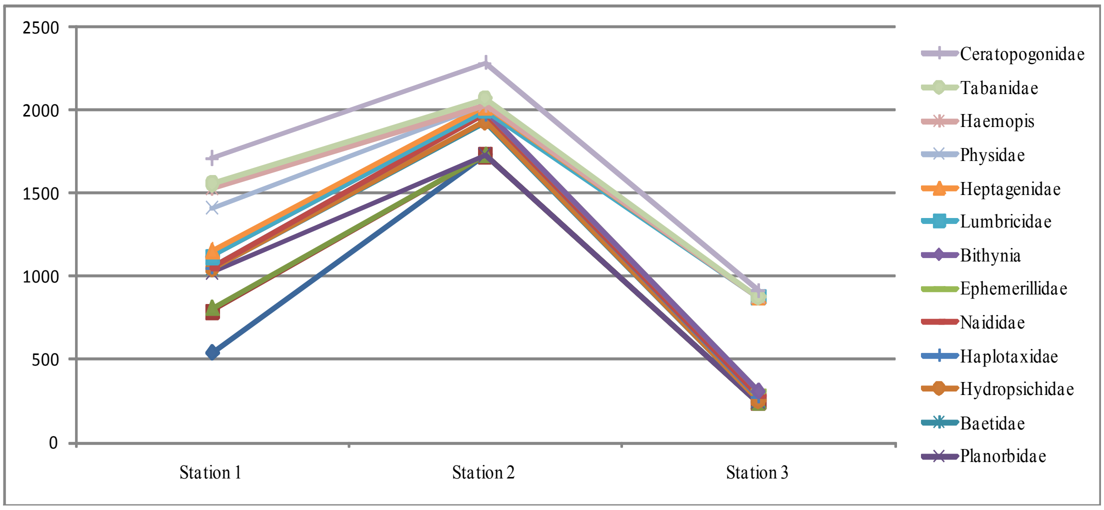

Figure 2. Benthic invertebrate individuals' variances per each monitoring station in Ishmi River, Albania during 2012 – 2013

Figures 1 and 2 present the decrease of the benthic invertebrates according to the considerable increase of the nutrient load into the water. It is noted that in the 2nd monitoring station (Zezë/Fushë-Krujë) the mean value of the nutrients decreases slightly, showing a slight improvement of water quality compared to the other monitoring stations. The slight decrease of nutrient load at the 2nd monitoring station has been accompanied by the increase of mean number of macro invertebrate individuals in this monitoring station. High level of nutrient load and high density of benthos tolerant invertebrates in the monitoring stations reflect a high level of water pollution of Ishmi River (Table 1; UNCE; EPA-USA; Miho et al., 2005; Cullaj et al., 2004).

4. CONCLUSIONS

1. H decreases from the first monitoring station to the second reflecting the poorness of the community diversity. The decrease of taxa is a consequence of water pollution within the

monitoring stations;

2. Taxa identified in the 3rd monitoring station are of higher tolerance toward water pollution compared to the 2nd monitoring station, while the density per taxa is lower than the 2nd monitoring station.
3. Invertebrate taxa density increase in the 3rd monitoring station justifies the slight increase of H value from the 2nd to the 3rd monitoring station.
4. Simpson Index value increases from the 1st to the 2nd monitoring station and decreases from the 2nd to the 3rd monitoring station reflecting the same result as Shannon Index.
5. High level of nutrient load (Fig. 1) and high density of benthos tolerant invertebrates in the monitoring stations (Fig. 2) reflect a high level of water pollution in Ishmi River (Table 1; UNCE; EPA-USA; Miho et al., 2005; Cullaj et al., 2004).

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