# IBI INDEX APPLICATION IN ASSESSMENT OF THE ECOLOGICAL STATUS OF LAKE OHRID TRIBUTARIES

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## SUMMARY

The importance of Lake Ohrid tributaries is in the fact that they contribute with approximately 50% in the overall water balance of this aquatic ecosystem. Likewise, they represent important habitats, hence positively affecting the maintenance of the general biodiversity of the lake`s watershed, especially the macroinvertebrates biodiversity.

The subject of this research was to assess whether these water bodies, bearing their importance in mind, have already been affected by the anthropogenic influence and in which manner these changes have been reflected in the macrozoobenthos community structure. Thus, by implementation of the results obtained for the Irish Biotic Index (IBI), an assessment of the ecological status of the tributaries, according to the EU Water Framework Directive, has been done for the first time. The results indicated to a lower ecological status in most of the sampling sites than the required “good” ecological status by the WFD. In fact, the inflows of the rivers have been assessed with moderate to bad ecological status (in fall) for River Sateska and bad for rivers Koselska and Cherava in both fall and spring.

**Key Words:** tributaries, Lake Ohrid, ecological status, benthic fauna.

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## 1. INTRODUCTION

The use of community structure of freshwater organisms for bio-monitoring can be traced back to the pioneering work of two German scientists, R. Kolkwitz and M. Marsson, in the early 1900s. Their publication on saprobity (degree of pollution) led to the development of indicator organisms. Today, indicators are much sought after as magic bullets to summarize a wide variety of states – from biological health to economics.

There are compelling reasons for the apparent popularity of freshwater macroinvertebrates in current bio-monitoring practice (Rosenberg et al., 1997): they are ubiquitous; they are species rich so the large number of species produce a range of responses; they are relatively sedentary; they are long-lived, which allows temporal changes in abundance and age structure to be followed, and they integrate conditions temporally, so like any biotic group, they provide evidence of conditions over long periods of time.

The use of benthic macroinvertebrates as environmental indicators is based on their ability to respond to a variety of environmental variables such as sediment quality, water quality, hydrological conditions, shading and biological factors (Armitage et al., 1983; Rosenberg & Resh 1993; Chessman 1995; Bonada et al. 2006). Furthermore, benthic invertebrates play an essential role in key processes within aquatic ecosystems (food chain dynamics, productivity, nutrient cycling and decomposition: Reice & Wohlenberg 1993 creating an important link between primary producers, detrital deposits and higher trophic levels in aquatic food webs (Brinkhurst 1974, Stoffels et al 2005). Consequently, benthic macroinvertebrates have become the most commonly used biological indicators in freshwater ecosystems (Resh & Jackson 1993).

The Water Framework Directive (2000/60/EC) (WFD) requires establishment of bio-monitoring programmes and reaching good ecological status for European aquatic ecosystems. It is based on more holistic approach of functioning and structure of aquatic ecosystems taking into consideration 5 biological quality elements: fish, phytoplankton, macrophytes, phytobenthos and benthic macroinvertebrates (Irvine et al. 2002; Heiskanen et al. 2004).

Assessing the ecological status of the water bodies in the watershed of Lake Ohrid, based on the WFD requirements have only recently started. The research has been limited to the littoral region of the Lake Ohrid (Loshkoska, 2015; Schneider et al., 2014; Trajanovska et al., 2014). Unlike the lake, very little attention has been given to the community structure inhabiting the Lake watershed, i.e. tributaries in general. Thus, until this research, the ecological status of the tributaries has never been a subject of research.

The primary goal in this study was to assess the ecological status of the tributaries as important contributors in the water balance for the Lake and habitats for the benthic fauna. In that context, some attributes of the benthic communities structure such as density and diversity and their seasonal and spatial variations as well as the impacting factors have been investigated.

## 2. MATERIAL AND METHODS

The research has been completed within one-year period duration, in 2014. Following the natural laws and life cycle of macrozoobenthos, the sampling dynamics was twice during the year: in spring and in autumn.
The sampling sites selection have been done taking into consideration the differences in the level of anthropogenic pressure and the bottom heterogeneity.
The samples from River Sateska have been collected from three sites along the river: Upper Course, in the upper flow; Middle Course in the middle flow and Inflow close to the inflow into the Lake. Only one site, the inflow of the rivers into the Lake, has been sampled for the rivers Koselska and Cherava (Fig. 1.).


*Figure 1. The sampling sites*

***Kick and sweep method*** (ISO: EN 27828:1994 AQEM/STAR-lakes: Cheshmedjiev et al. 2011 ) was used during the sampling on the tributaries on sandy, gravely and mixed bottom covered by macrophytic vegetation. The kick net was D-shaped, with a metal frame holding a mesh bag of 400-

mm size (Fig. 2.). The standard kicking time interval was 5 minutes. In order to calculate the qualitative composition of the sampled area, a metal rectangular square (1m$^2$ square) was set on the bottom where the sampling was taking part. This sampling type has been used on all sampling sites. The depth point was varying between 0.3-0.6 m. The samples have been sieved, preserved with 70% ethanol and transported to the Laboratory for further examination.

*Figure 2. Kick and sweep-D-shaped net*

Next, the determination has been done using the following keys: Lukin 1976, Sapkarev 1964, Radoman 1983; 1985, Kerovec 1986, Polinski (1929), Snegarova (1954), Radoman (1959), Hubendick (1960, 1970), Hadzisce (1974), Krstanovski (1994) etc.
Finally, the Irish Biotic Index-IBI (modified Biotic Index) was used to assess the ecological status of the sampling sites. The Biotic Index was developed by EPA using QRS (Q-value) based scheme and successfully applied in the river monitoring programs under WFD. The Q-value of a sampling site is assigned to one of five ecological classes from 5-1, indicating class status ranged from bad to high (Waterstatusireland.irish-surge-forecast.ie, 2016)

## 3. RESULTS AND DISCUSSION

Table 1 shows the benthic community structure, i.e. density and diversity of the macrozoobenthos from the sampling localities in the tributaries of Lake Ohrid. 51 species have been registered in both seasons from 6 systematic groups: Oligochaeta, Hirudina, Gastropoda, Isopoda, Amphipoda and Insecta. 72 % of the total diversity belongs to the group of Insecta. The diversity of the other 5 classes, with an exclusion of Isopoda, is almost evenly distributed and ranges within the boundaries from 6-8% (Fig. 3.). This high portion of Insecta diversity of the macrozoobenthos in the rivers distorts the common patterns about the diversity in the Lake where Insecta are insignificant little present, but Gastropoda apparently predominates.

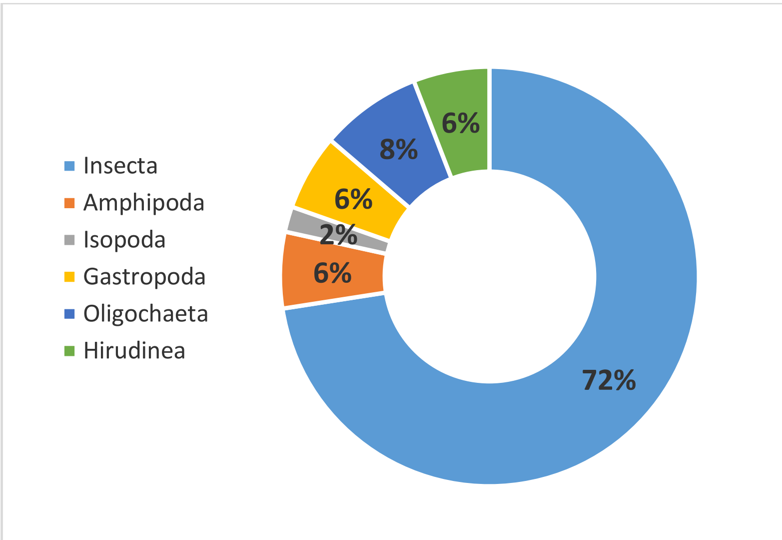


*Figure 2. Classes contribution in the general diversity*

*Table 1. Density and diversity of the macrozoobenthos in the tributaries of Lake Ohrid*

| | R.Sateska Upper | | R.Sateska Middle | | R. Sateska Inflow | | R.Koselska | | R.Cerava | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Species** | **Spring** | **Fall** | **Spring** | **Fall** | **Spring** | **Fall** | **Spring** | **Fall** | **Spring** | **Fall** |
| *Aeshna grandis* Linnaeus, 1758 | | | | | | | | | 1 | |
| *Ancylus fluviatilis* O.F. Muller, 1774 | 1 | 2 | | 1 | | | | | | |
| *Aphelocherius aestivalis* Fabricius, 1794 | | | 2 | | 1 | | | | | |
| *Asellus aquaticus* Linnaeus, 1758 | | | | | | | | 1 | | |
| *Atheryx sp.* | 3 | | 3 | | | | | | | |
| *Baetis vernus* Curtis, 1834 | 32 | 39 | 4 | 30 | | | 8 | | | 4 |
| *Baetis rhodani* Curtis, 1834 | | | | 3 | | | | 3 | | |
| *Baetis scambus* Curtis, 1834 | | | | 7 | | | | | | |
| *Bezzia sp.* | 1 | | | | | | | | | |
| *Caenis macrura* Stephens, 1835 | | | | | | | 1 | | | |
| *Chironomus sp.* | 1 | | 24 | | | | | | 64 | |
| *Chironomus plumosus* Linnaeus, 1758 | | 13 | | 3 | | 4 | 10 | 18 | | |
| *Coenagrion sp.* | | | | | | | | | 1 | |
| *Corixa sp.* | | | | | | 1 | | | | |
| *Criodrilus lacuum* Hoffmeister, 1845 | | 1 | | | | | | | | |
| *Dytiscus sp.* | | | | 1 | | | | | | |
| *Ecdyonurus venosus* Bürmeister, 1839 | 4 | 5 | | 14 | 3 | | | | | |
| *Epeorus sp.* | 4 | 8 | | | | | | | | |
| *Ephemera danica* Müller, 1764 | 17 | 33 | | 94 | 38 | 29 | 1 | | | 7 |
| *Ephemerella sp.* | 6 | | | | | | | | | |
| *Erpobdella octoculata* Linnaeus, 1758 | | | 4 | 4 | 3 | | 2 | 3 | | |
| *Gammarus balcanicus* Schäferna, 1922 | 36 | 47 | | 27 | | | | | | |
| *Gammarus roeseli* Gervais, 1835 | | | 64 | 170 | 83 | 375 | | | | 7 |
| *Gammarus ochridensis* Schäferna, 1926 | | | | | | | | | | 8 |
| *Glossiphonia complanata* Linnaeus, 1758 | 1 | | | | 1 | | | | | |
| *Goera sp.* | | | | 2 | | 1 | | | | |
| *Gomphus vulgatissimus* Linnaeus, 1758 | | | 2 | | 1 | 2 | | | | |
| *Haemopis sanguisuga* Linnaeus, 1758 | | | | | | | | | 2 | |
| *Hermetia sp.* | | | | | | | 1 | | | |
| *Hydrophilus sp.* | | | | | | | | | 2 | |
| *Hydropsyche sp.* | 1 | | | | | | | | | |
| *Isoperla sp.* | 1 | 3 | | 3 | | | | | | |
| *Leptocerus sp.* | 49 | 49 | | 111 | 12 | 1 | | | | |
| *Leptophlebia sp.* | | | | | | 6 | | | | |
| *Leuctra sp.* | | | | 2 | 1 | | | | | |
| *Limnephilus sp.* | | | 4 | 2 | 3 | | | | | |
| *Limnius sp.* | | | 4 | 1 | 1 | | | | | |
| *Limnodrilus hoffmeisteri* Claparède, 1862 | | | | | | | 1 | | | |
| *Lymnaea stagnalis* Linnaeus, 1758 | | | | | | | | 3 | | |
| *Ormosia sp.* | | | | 1 | | | 1 | | | |
| *Perla marginata* Panzer, 1799 | 14 | 21 | | | | | | | | |
| *Platanbus sp.* | | | | | | | | | 2 | |
| *Potamothrix hammoniensis* Michaelsen, 1901 | | 1 | | 1 | | | | 8 | | |
| *Rhithrogena sp.* | 23 | | | | | | | | | |
| *Rhyacophila sp.* | | 16 | | | | | | | | |
| *Sericostoma sp.* | 6 | | | 16 | 1 | 3 | | 1 | | 5 |
| *Silo sp.* | 3 | | | | | | | | | |
| *Stylodrilus sp.* | | | | | | | 7 | | | |
| *Tabanus sp.* | 1 | | 1 | 4 | | | | | | |
| *Theodoxus fluviatilis* Linnaeus, 1758 | | | 3 | | | | | | | |
| *Tipula sp.* | | 4 | | | | | | | 2 | |

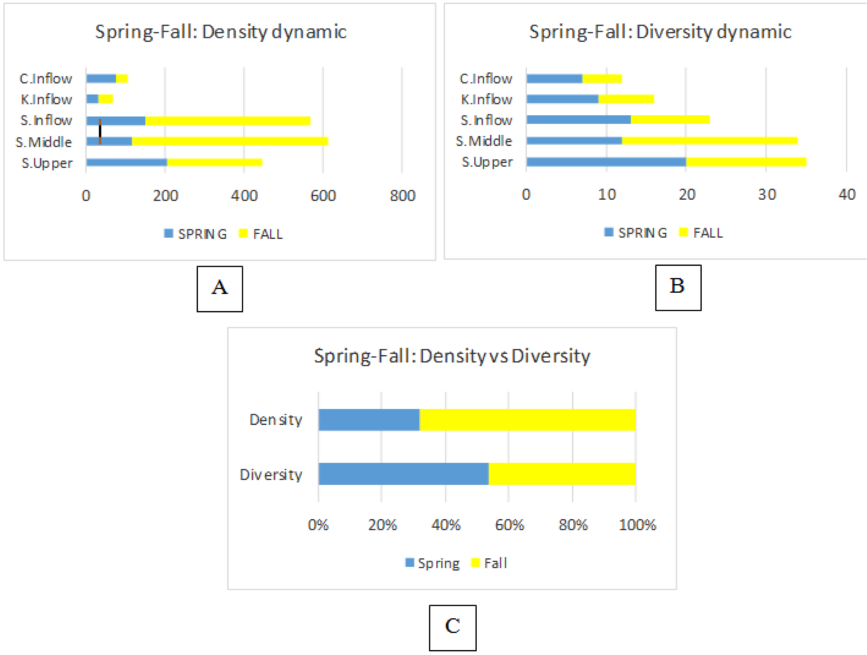


*Figure 4 (A-C): Density and diversity variations in spring and fall: A-density dynamic; B-diversity dynamic; C-Density vs. Diversity dynamic*

Figure 4 depicts the variation in the density and diversity of the general macrozoobenthos in spring and fall season. Thus, the diversity, with an exclusion in the sampling site Sateska Middle (S.Middle) is higher in spring than in fall. But if we analyze the density trend in both seasons, it is obvious that the density significantly increases during the fall period. Seasonal variability of the benthic community structure and productivity is high because many species of the benthic macro invertebrates have annual (or shorter) life cycles, which culminate in an adult phase during the open water period. Having in mind that over 70 % of the species are from the class of Insecta, diversity decreasing is expected phenomenon. In fact, during the late spring and early summer period, most of the aquatic species develop from larvae to imagoes leaving the water environment. This enable the immature ones, or the ones producing second generation, developing under "optimal" conditions: higher food availability as a result of the increased level of organic sedimentation and lowered competition for food.

Both density and diversity besides the seasonal dynamics are even more prone to changes resulting from sediments characteristics (spatial distribution) and anthropogenic impact or due to synergy of both of them. This is best evidenced along the river course of River Sateska, where the

samples have been taken from three different sampling points with different sediment traits and level of anthropogenic impact. In fact, as it can be seen from the Figure 5, the density and diversity have an irregular trend, whereby they are highest in the upper course (S.Upper-Spring) then they decrease in the middle and again increases in the inflow. The highest density and diversity which coincide with the upper course is due to the absence of any visible anthropogenic influence, i.e. this site could be considered as a reference site.
The decrease in the density and diversity in the middle course is due to the increased anthropogenic impact represented by agricultural activities and the alteration of the natural meandering river bad into straightforward canal. This river in 1962 was diverted into the Lake (Jordanoski et al., 2007) and ever since it flows through both agricultural and urban areas and carries a very high load of waste water, sewage waste, nutrients such as phosphorous and nitrogen, but most of all it loads the Lake with huge sediment amount. The load of phosphorus coming from the River Sateska might be about the same as that coming from the sewerage of Pogradec (Watzin et al., 2002). Finally, the increasing of the density in the inflow in comparison with the upper course, especially in the fall period is due to the faunal exchange between the Lake and the river.

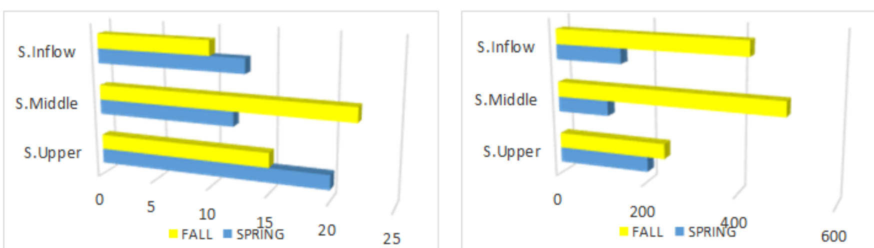


*Figure 5 (A-B): Diversity and Density variations along river Sateska: A-diversity dynamic; B-density dynamic.*

In fact, many benthic faunal elements from the littoral of the Lake penetrate into the lower course of the river thus increasing the overall density of the macrozoobenthos (Trajanovski et al., 2015). This is not a case with the diversity, which is significantly lower than the upper and middle course especially in the fall, as a result of absence of many Insecta representatives as it has already been explained above: most of the Insecta larvae have become imagoes and left the water environment.
In fall, the conditions in regards to the density differs concerning the middle course, where the highest densities have been recorded. The explanation behind this phenomenon is in the decreased water level and turbulence

altogether with higher input of organic load from the aquatic and neighboring terrestrial vegetation. These enabled conditions for optimal development of the population of the *Gammarus roeselii*, as a representative of the scrapers/shredders functional feeding group (Mayer et al., 2009). This species comprises 34 % of the total community density.

In the two other rivers, the variations of the density and diversity are also prone to seasonal changes but the community structure is very poor, i.e. both the diversity and the density are significantly lower than the sampling sites in River Sateska. This could be explained by an increased anthropogenic impact which has been reflected in the deteriorated trophic state of the water and habitat change (Matzinger et al, 2006; Veljanoska Sarafiloska, 2002; Trajanovski et al., 2015).

Furthermore, the community structure, i.e. metrics has been used in assessment of the ecological status of the tributaries of Lake Ohrid. IBI index values from 1-5 have been extrapolated in the scale referring the ecological status within the boundaries from high to very bad status.

The term 'ecological status' is defined in the WFD as: "…*an expression of the quality of the structure and functioning of aquatic ecosystems associated with surface waters, classified in accordance with Annex V*" (WFD 2000-Article 2.21, 2000). This implies that classification systems should reflect changes taking place in the structure of the biological communities and in the overall ecosystem functioning as response to anthropogenic pressures.

Table 2 shows the IBI values and their interpretations about the ecological status of all researched sites by assigning one of the five ecological classes ranging from high to bed.

*Table 2. Seasonal variations in the ecological status of the sampling sites*

| | S.Upper | S.Middle | S.Inflow | K.Inflow | C.Inflow |
|---|---|---|---|---|---|
| SPRING | 5 | 3 | 3 | 2 | 2 |
| FALL | 5 | 3 | 2 | 2 | 2 |

As it can be seen and already been explained by the community structure, the ecological status of the tributaries varies in the boundaries high to bad. High ecological status has been registered in the upper course in river Sateska, in both seasons, where no visible changes or any anthropogenic influence has been observed. That is why this site could be considered as reference site.

Going down the course of the River Sateska, the anthropogenic influence increases, which results in decreasing of the ecological status. Hence, in the middle course in both seasons the ecological status has been assessed as moderate. During the spring seasons, the ecological status of the Inflow is also moderate, but in fall, due to the lower water level and increased agricultural activities, the water quality deteriorate which is reflected on the ecological status, i.e. the ecological status changes from moderate to bad. In the two other rivers, the ecological status stayed unchanged throughout both seasons, i.e. it has been assessed as bad ecological status. Both rivers have been known as major contributors for pollution of the littoral of the Lake, loading it with sediments, organic waste, phosphorous and nitrogen (Veljanoska Sarafiloska et al., 2008). More precisely, River Koselska from the village of Kosel to its inflow passes through populated areas and represents recipient of the waste domestic waters from the households and sediments from the agricultural areas which contribute to deterioration of the River's water quality. Similarly, the River Cherava which rises in Albania, on the way beside accepting the domestic waste and sewage waters, due to the erosive character of the ground, it becomes one of the main donors of erosive material into the Lake.

## 4. CONCLUSIONS

As represented above, the ecological status of the sampling sites varies in the boundaries from high to bad based on the values of IBI index. The high ecological status was record in the upper course of River Sateska in both seasons. Unlike, the ecological status deteriorates going down the river course, first to moderate than to bad, which is in correlation to the level of the anthropogenic impact: changes of the river bed, altered habitats and season as shown in the Inflow of River Sateska.

The macrozoobenthos community structure in the sampling sites seemed affected by the seasonal changes of the factors in the water medium (either physical or chemical), but more to the spatial changes as result of the anthropogenic factor. As shown above, the seasonal changes affect and "promote" the lower density and diversity of the benthic communities.

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