Benthic Macroinvertebrates

Aquatic macroinvertebrates have been successfully used worldwide to assess the biological integrity of freshwater ecosystems and are considered to be a good reflection of a river's prevalent environmental water quality. This is because invertebrate communities respond relatively quickly to localized conditions in a river, especially water quality, though their existence also depends on habitat diversity. They are common, have a wide range of sensitivities, and have a suitable life-cycle duration that indicate short- to medium-term impacts of water quality (Scherman and others 2006).

This part of the paper illustrates and compares the benthic macroinvertebrate composition in the littoral and profundal zones of Lake Biwa (Figure 1). In the littoral zone, macroinverbrates were collected by taking sediments from 2 sites in the sampling area using a Surber net sampler (30 x 30 cm, 475 um mesh). Bigger rocks within the 30 x 30 cm sampling site were washed in a pail and sediments were then dragged into the net. Collected sediments were then rinsed to separate the macroinvertebrates. On the other hand, in the profundal zone, sediments were collected through an Ekman grab sampler (15 x 15 cm). The collected sediments were rinsed through a 475 um mesh net to finally collect the benthic macroinvertebrates. The benthic macroinvertebrates from both sites were then sorted and identified up to the family level.

Figure 1. Littoral and profundal zone sampling areas.

Littoral Zone. In the littoral zone, the benthic macroinvertebrates were dominated by organisms coming from Phylum Arthropoda, followed by organisms from Annelida, Platyhelminthes, and Mollusca (Figure 2). Order Diptera and Trichoptera had the most number of arthropod species in the area (Figure 3). The 2012 data on macroinvertebrate diversity in the same sampling station is also presented in Figures 4 and 5 to illustrate presenting community compositions using abundance and biomass data, respectively.

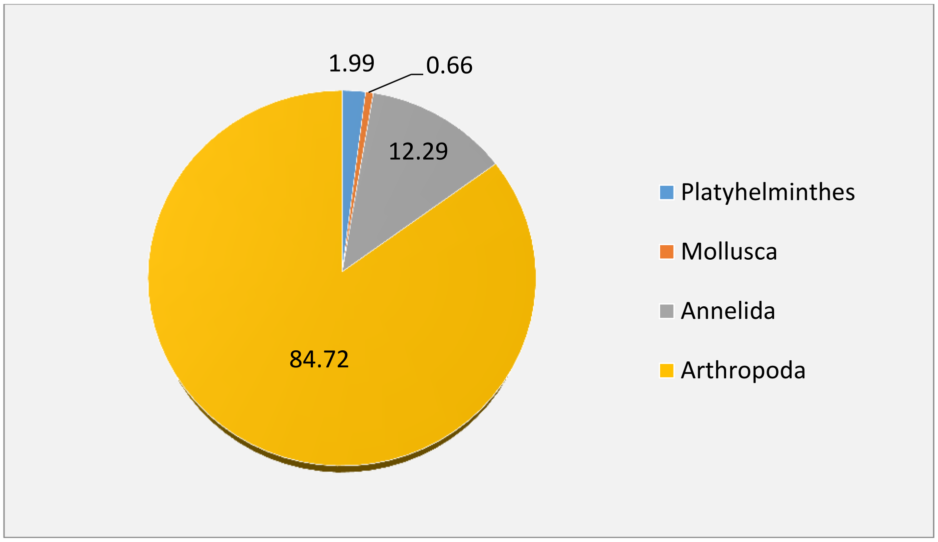

Figure 2. Groups of organisms in the littoral zone based on percent abundance per m^2.

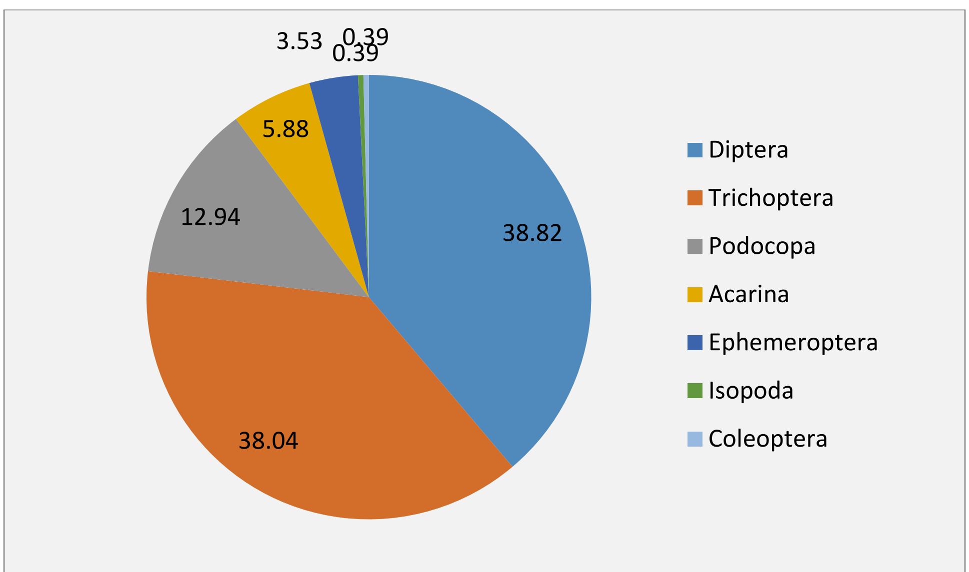

Figure 3. Percent abundance of insect orders in the littoral zone per m^2.

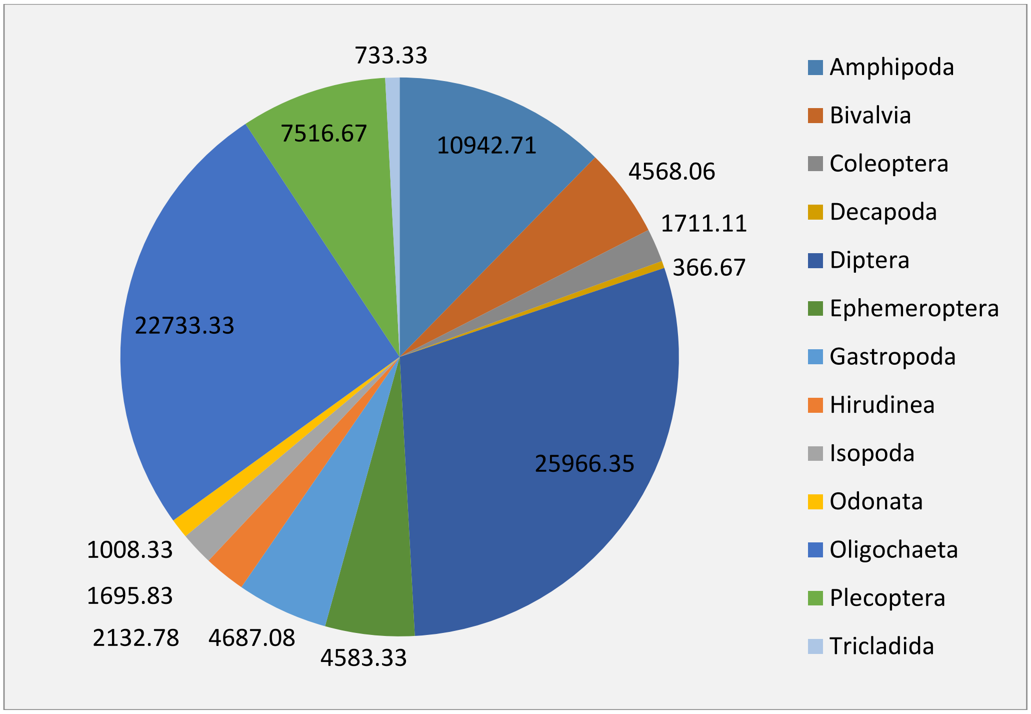

Figure 4. Macroinvertebrate species composition in the littoral zone (per m^2) based on abundance.

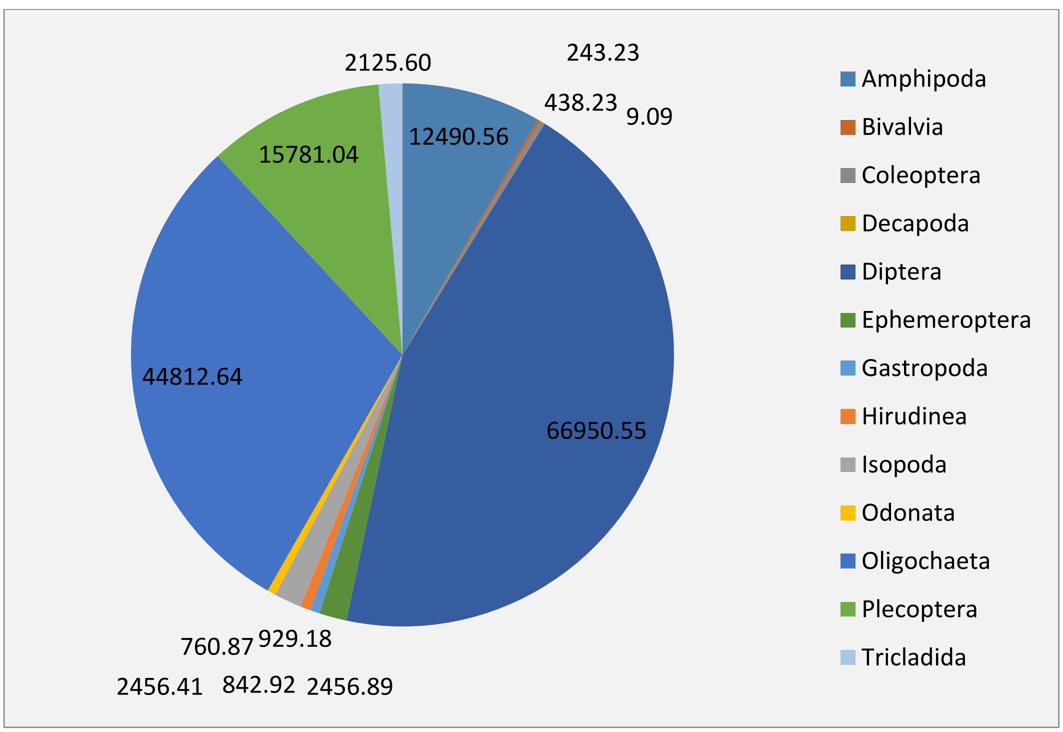

Figure 5. Biomass-based community composition (mg per m^2) of macroinvertebrates in the littoral zone.

Profundal Zone. In this year's sampling, only four macroinvertebrate species were observed in the sediment sample from the profundal zone: *Asellus hilgendorfii, Branchiura sowerbyi, Tubifex tubifex,* and *Bothrioneurum vejdovskyanum.* For the same purpose as Figures 4 and 5, Figures 6 and 7 are presented below.

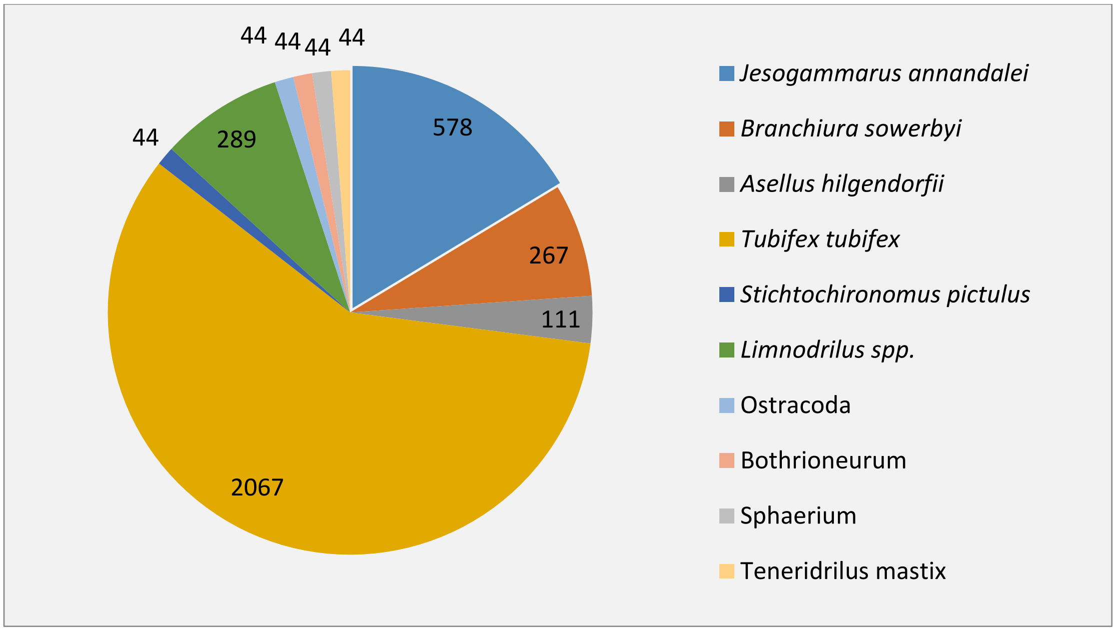

Figure 6. Macroinvertebrate species composition in the profundal zone based on abundance per m^2

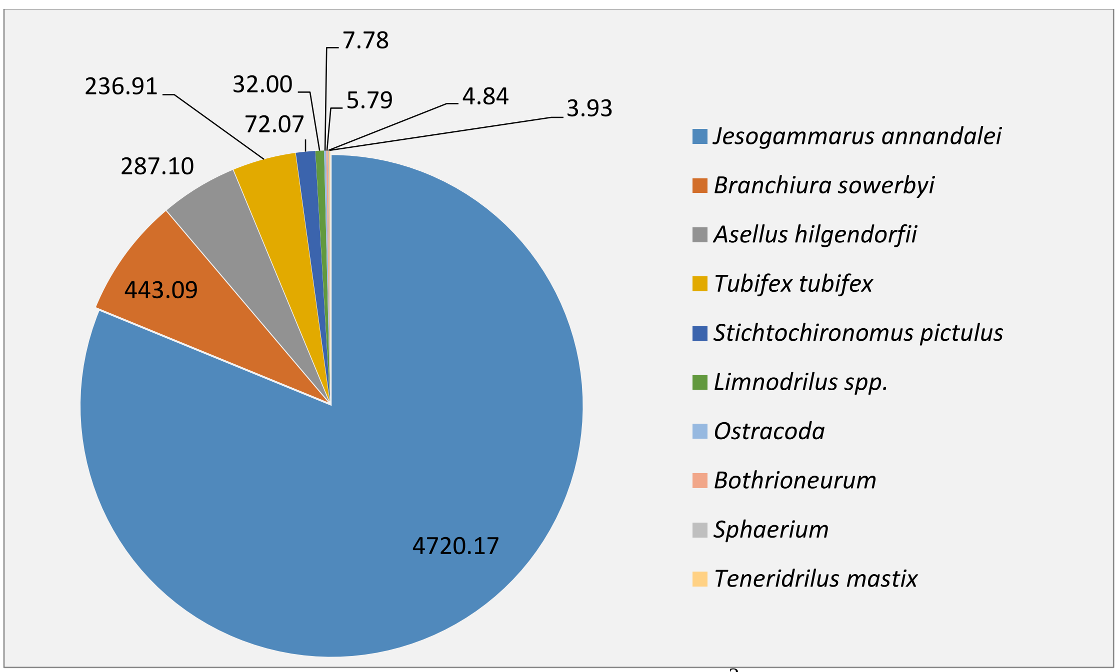

Figure 7. Biomass-based community composition (mg/m^2) of macroinvertebrates in the profundal zone.

Differences in community composition. Substratum type, water trophic status, and hydro-period are the three factors that mainly influence benthic macroinvertebrate composition in aquatic environments (Kownacki and others 2000). Other essential factors are oxygen level and depth (Santos and Henry, 2001). On the other hand, interspecific trophic interactions like competition and predation and the type of food resources define the distribution of macroinvertebrate species. Local community composition of macroinvertebrates can also be affected by the complexity and number of different habitats in an aquatic environment. Generally, environments with less stress and more available shelter against predators and disturbances will have greater diversity of macroinvertebrates (as cited in Shimabukuro and Henry 2011). Taking these given factors into consideration, it can be hypothesized that habitat heterogeneity (from the presence of different substrates) in the littoral zone might have caused the diversity of benthic macroinvertebrates in the area. In the profundal zone, only annelids were found in this year's sampling while some crustaceans and bivalves were recorded from last year's sampling.

The differences in community composition of macroinvertebrates in the two sampling areas can also be explained by analyzing to which feeding groups the macroinvertebrates present in the areas, belong to. As cited by Osmond (1995), there are four feeding groups of macroinvertebrates: shredders, filter-collectors, grazers, and predators:

> *Shredders such as stoneflies (Plecoptera) feed on plant material and some animal material, which is generally dead, and break it into smaller particles through their feeding and digestive process. Collectors, such as caddisflies (Trichoptera) and blackflies (Diptera), feed on this fine particle material which they filter from the water. Grazers, such as snails and beetles, feed on algae and other plant material living on rocks and on plant surfaces. Predators such as dobsonflies (Megaloptera) or dragonflies (Odonata) feed on other macroinvertebrates.*

It can be seen from the results that filter-collectors (Diptera, Trichoptera, Podocopa, and Ephemeroptera) are most dominant in the littoral zone. High density of dissolved organic matter and planktons might have caused this dominance. On the other hand, in the profundal zone, annelids might have dominated because the sediment in the profundal zone is rich in organic matter and is oxygen deprived. Habitats with organic pollution and low dissolved oxygen levels are preferred by some aquatic worms. They usually feed on detritus, algae, and diatoms in the substrate (as cited in Osmond and others 1995).

Primary Productivity of Planktonic and Epilithic Algae

Only the data on the primary productivity of epilithic algae can be compared with historical data since this year's data on the primary productivity of planktonic algae were erroneous. Figure 8 shows the net primary productivity of epilithic algae as computed in year 1963, 2001, (Nozaki 2002) and 2013. It can be observed that the net primary productivity of epilithic algae started low in the 60s, then increased through the years and decreased again in the recent year. This trend also reflects the trophic condition of the lake in the given years. Nozaki (2001) concluded that the sharp increase in the net primary productivity of the epilithic algae in the 90s was due to the development of filamentous algae in the lake which might have been caused by eutrophication. The decrease in the productivity from 2001 to 2013 could mean the transition of the lake from being eutrophic to mesotrophic or oligotrophic.

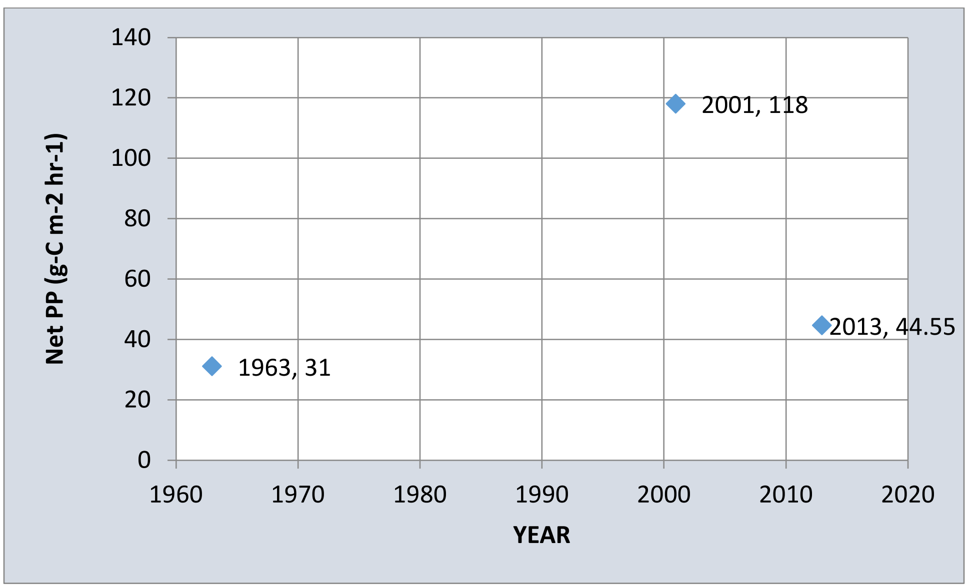

Figure 8. Net primary productivity of epilithic algae from 1963 to 2013.

Literature Cited

Kownacki, A., Galas, J., Duminicka, E., & Mielewczyk, S. (2000). Invertebrate communities in permanent and temporary high mountain lakes (Tatra Mts). *Annales de Limnologie* , 181-188.

Nozaki, K. (2001). Abrupt change in primary productivity in a littoral zone of Lake Biwa with the development of a filamentous green-algal community. *Freshwater Biology* , 587-602.

Nozaki, K. (2002). Characteristics of primary production in the littoral zone of lake. *Japanese Journal of Limnology* , 225-231.

Osmond, D., Line, D., Gale, J., Gannon, R., Knott, C., Bartenhagen, K., et al. (1995). *WATERSHEDSS* . Retrieved November 10, 2013, from Water, Soil and Hydro-Environmental Decision Support System: http://h2osparc.wq.ncsu.edu.

Santos, C., & Henry, R. (2001). Composição, distribuição e abundância de Chironomidae (Diptera, Insecta) na Represa de Jurumirim (rio Paranapanema, SP). *Acta Limnologica Brasiliensia* , 99-115.

Scherman, P., Reynhardt, D., Cawe, S., Gordon, A., Weeks, D., Kinya, J., et al. (2006). *Eastern cape river health programme technical report: mthatha river monitoring, 2004 - 2006.* Eastern Cape: Coastal & Environmental Services.

Shimabukuro, E., & Henry, R. (2011). Controlling factors of benthic macroinvertebrates distribution in a small tropical pond, lateral to the Paranapanema River (São Paulo, Brazil). *Acta Limnologica Brasiliensia* , 154-163.