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# Benthic macroinvertebrates and their relation with water quality: A case study of Beresa River, Amhara Regional State, North Showa Ethiopia

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**Abstract**
Beresa reservoir has been exposed to industries and anthropogenic activities from local people in past years. In order to assess the water quality status of the reservoir, the macro invertebrate community (species composition) and their relative abundance was examined during the study period, between April and May 2016. Totally, 111 individual macroinvertebrate organisms were collected from the sites of the river. These organisms were from seven families, four orders, and one phylum Species belonging to different families were identified including Corixidae, Chironomidae (blood red) and Chironomidae (pale) were the most dominant in terms of species richness and abundance. Benthic macro invertebrate communities were less diverse compared to many Ethiopian rivers. The lower abundance and diversity of macro invertebrate could be due to poor ecological status of the river. The dominance of macroinvertebrate community indicated the lower water quality of the river. Such species dominate polluted water with poor oxygen concentration as they have some special adaptation mechanism that helps them to survive in such conditions. Samples with H-FBI values of 0-2 are considered clean, 2-4 slightly enriched, 4-7 enriched, and 7-10 polluted. Therefore, the HFBI value of River Beresa was 8.17 during the study time which lie in the range between 7 and 10. The most probable cause for the pollution of Beresa River could be wastes which are being released from Debre Berhan University and Debre Birhan Textile factory. In addition, other anthropogenic activities around the river could significantly pollute the river.

**Keywords:** Beresa River, biological quality element, macro invertebrates, water quality

## Introduction

Many countries have a long history of using macroinvertebrates to monitor the ecological status of river ecosystems (Hellawell, 1986) [8]. There are several ways to assess water quality in lotic (flowing waters such as streams) and lentic (still waters such as lakes) water bodies; the most common methods focus on Physical and chemical (i.e., physicochemical) properties, such as the level of dissolved Oxygen, mercury, and water clarity. Physicochemical parameters, which provide snapshots of the condition of a water body, do not provide the integrative measure of overall health of a stream and can, at times, inadequately identify impaired waters (United States Environmental Protection Agency, USEPA, 2005) [22]. Instead, biological measures provide an integrated, comprehensive assessment of the health of a water body over time (Karr, 1999) [12]. These biological indicators, also called bio criteria, use measures of the biological community including lower trophic level organisms, such as algae or benthic macroinvertebrates, as well as upper trophic level species, such as fish.

Biological monitoring (also called bio-monitoring or bio-assessment) is defined as an evaluation of the condition a water body using biological surveys and other direct measurements of the resident biota in surface waters (Engel and Voshell 2002) [7]. Biological monitoring can be done with any living organisms (biological indicators) but benthic macroinvertebrate, fish, and peryphyton (algal) assemblages are used more often, in that order (Engel and Voshell 2002) [7]. These biological indicators describing the condition and threats to fresh water ecosystems are required to measure progress in halting the rapid decline in fresh water species (Revenga *et al.* 2005) [18]. Tolerance of bio-indicator organism usually has its limit, therefore the presence or absence and its health state can determine some of the chemical and physical components in the environment without the complex measurement and laboratory work (Kopciuch *et al.* 2004) [11]. Changes in benthic macroinvertebrates community with water pollution have many been documented and measured using different aspects including biomass, species density and species composition (Yong *et al.* 1997) [26].

Invertrebrate communities are good indicator of water quality (Resh 1995) [20] since fresh water macroinvertebrate species vary in their sensitivity to organic pollution (Rosenberg & Resh 1993) [19]. These freshwater benthic macroinvertebrates include representatives of many insect orders, as well as crustaceans, gastropods, bivalves and oligochaetes (Allan, 1995 [1]; Merritt *et al.*, 2008 [15]; Thorp and Covich, 2001) [21]. Benthic macroinvertebrates are highly suitable for monitoring the ecological condition and identifying the natural and human impacts to rivers (Barbour 2008 [3]; Korte *et al.* 2010 [13].

The study of river benthic macroinvertebrates for biological monitoring techniques has been widely reported and described in the literature (Washington, 1984 [24]; Metcalfe, 1989 [16]; Rosenberg and Resh, 1993 [19]; Mandaville, 2002) [14]. Iliopoulou-Georgudaki *et al.* (2003) [10] showed that the use of macroinvertebrates as bioindicators for the assessment of water quality has more advantages than those based on diatoms, fishes, riparian and aquatic vegetation. Benthic macroinvertebrates are often the taxa group of choice for biotic indices in river environments as they are found throughout the length of the river, have limited mobility and a relatively long lifespan.

Recently, the need in river ecosystem monitoring is capturing great attention by many environmentalists (WFD, 2000) [25]. In Ethiopia the quality and quantity of both surface and ground water have been anthropogenically and naturally affected for the past half century. It is attributed to rapid urbanization, industrialization and population increase with a lack of environmental planning and waste disposal facilities. Prior to devising well defined strategies for managing Ethiopian aquatic ecosystem, it is imperative to know the current status using appropriate and integrated methods. Hence, the purpose of this study was to present an overall view of the macroinvertebrate communities along the middle section of the Beresa River, and determine the biological water quality based on benthic macroinvertebrate communities.

## Materials and Methods

### Description of Study Area

The study was conducted in Debre Birhan town, near Debre Birhan University. The town is located in North Showa zone in Amhara Regional State which is located 130 km far from Addis Ababa and 659 km far from the capital city of Amhara Regional State, Bahir Dar. It is located 090 45' North latitude and 36 0 31' East longitudes and also found on the plateaus of central Ethiopia high land at average elevation of between 2800 and 2845 meter above sea level (fig 1). It receives 695 and 721 ml annual average of rainfall and has average temperature of 6-200 c. recently; the probability of Beresa River to become severely impacted by industries as the number of industries is increasing.

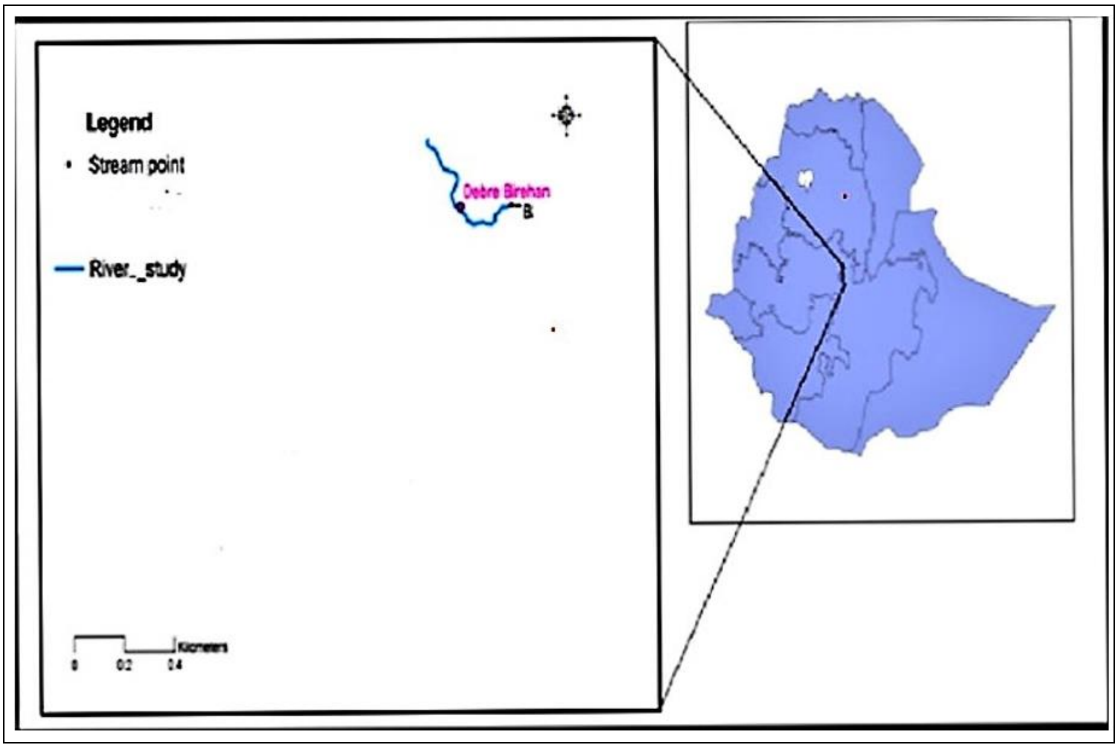


**Fig 1:** Map of the Study River and sites.

### Sampling Techniques, Sample Size and Methods of Data Collection

### Field Work

The Beresa River was visited during the dry season, between April and May 2007 E.C. During this time different type of benthic macroinvertebrate groups of species were collected from different sites of the river. 100m length of river section was selected for sampling in each site. Surber net sampler, with 0.5 mm mesh size, was used to sample macro invertebrate following (Barbour *et al.*, 1999) [2]. The samples were preserved using 4% formalin *in situ* and were taken to laboratory for identification and counting.

### Laboratory work

Sorting, identification and counting of macroinvertebrates was done using dissecting compound microscope and hand lens. All the macroinvertebrates will be identified to family level, using standard keys (Dudgeon 1999 [6]; Nesemann *et al*. 2007) [17]. Additionally all collected benthic macroinvertebrate communities will be grouped into sub groups based on their pollution tolerance and abundance by using the above literature keys

### Data Analysis

The diversity and abundance were summarized using percentage with excel spreadsheet. And the water quality of the river was evaluated using Hilsonhoff Biotic Family Index (H-BFI) as it summarizes the overall pollution tolerances of the taxa and used to detect organic pollution following Hilsenhoff (1988) [9] as shown below.

$$\text{H-BFI} = \Sigma\,(xi*ti)/\,(n),$$

Where:-
Xi= number of individual with in a taxon
Ti= tolerance value of a taxon (given in Bouchard 2012)
N= total number of organisms in the sample

## Results and Discussion

### Benthic Macroinvertebrate Composition and Abundace of River Beresa

Totally, 111 individual macroinvertebrate organisms were collected from the sites of the river. These organisms were from seven families, four orders, and one phylum (Table 1). Corixidae was the most abundant species followed by Chironomid (blood midge), Chironomidae (pale), Sphaeridae, Ancylidae, Bactiscidae and Flatworm respectively (Table 2). On the other side Flatworm, Bactiscidae and Ancylidae were very rare and they cumulatively constituted less than 6.3% of the total population.

**Table 1:** List of macro invertebrate identified during the study time

| Family | Order |
|---|---|
| Corixidae | Hemiptera |
| Chironomidae (blood red) | Diptera |
| Chironomidae (pale) | Diptera |
| Sphaeridae | Gastropods (Bivalve) |
| Ancylidae | Gastropod (snails) |
| Bactiscidae | Ephemeroptera |
| Flatworm | Platylmalithes (phylum) |

**Table 2:** Abundance and percentage composition of the macro invertebrates

| Family | Abundance |
|---|---|
| Corixidae | 70 |
| Chironomidae(blood red) | 16 |
| Chironomidae(pale) | 12 |
| Sphaeridae | 6 |
| Ancylidae | 3 |
| Bactiscidae | 2 |
| Flatworm | 2 |

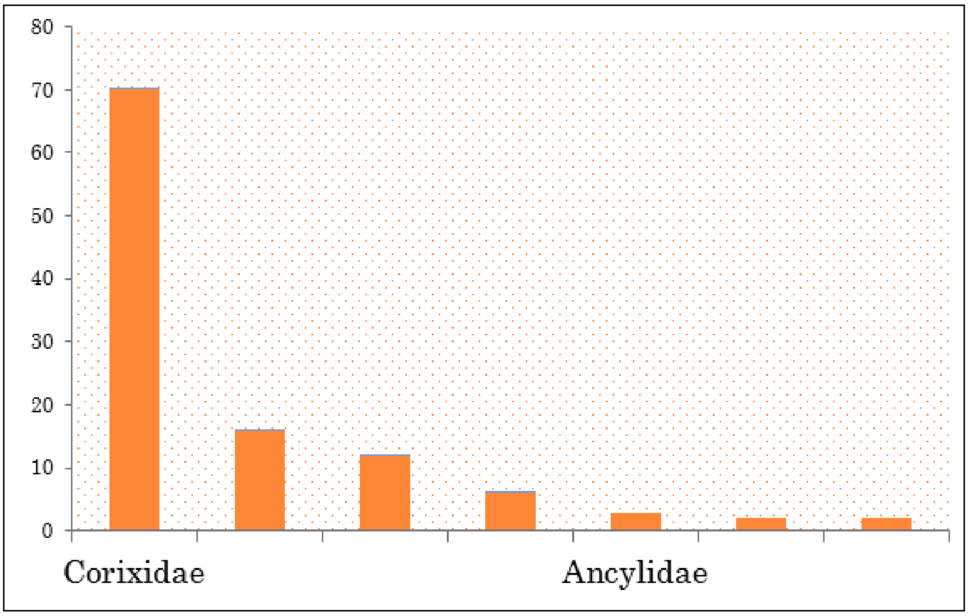


**Fig 2:** Relative abundance of major macro invertebrates in the reservoir.

**Table 3:** Hilsenh off benthic family index calculation

| Family | Order | Abun. (xi) | (ti) | Tv*xi | HBFI |
|---|---|---|---|---|---|
| Corixidae | Hemiptera | 70 | 9 | 630 | 907/111 = 8.17 |
| Chironomidae (red) | Diptera | 16 | 8 | 128 | |
| Chironomidae (pale) | Dipetera | 12 | 6 | 72 | |
| Sphaeridae | Gastropods | 6 | 7 | 42 | |
| Ancylidae | Gastropoda | 3 | 7 | 21 | |
| Bactiscidae | Ephemeroptera | 2 | 3 | 6 | |
| Flatworm | Platyhelminthes | 2 | 4 | 8 | |
| | | 111 | | 907 | |

In most case, physical and chemical means have been used to monitor rivers but these methods are very demanding in terms of cost and time. Because of this reason, the use of biological multi-metric index in river ecosystem monitoring has attracting the attention of many scientists and macroinvertebrates are the most commonly used among biological quality element (BQE) in monitoring studies. Benthic macro invertebrate communities were less diverse compared to many Ethiopian rivers. For example, Baye Sitotaw (2006) [4] was able to sample 25 families from River Chacha and 17 families from River Akaki. The lower abundance and diversity of macro invertebrate could be due to poor ecological status of the river. It is because the diversity of macro invertebrate is lower in ecologically impaired habitat (Bouchard, 2012) [5]. The other probable reason for lower abundance of macro invertebrate could be lower sampling effort in this study compared to other studies. Majority of the families identified in this study had higher tolerance value, more particularly Corixidae and Chironomidae.

It is a well-known that human population, agricultural activities, urbanization and industrial development are growing at a rapid rate globally. As a consequence, most ecosystems are adversely degraded and the anthropogenic changes at the catchment and local scales that affect habitat and water quality often have a direct influence on resident aquatic assemblages. It could be one indication for lower water quality of the river. Such species dominate polluted water with poor oxygen concentration as they have some special adaptation mechanism that helps them to survive in such conditions. These taxa are known to be resistant to low oxygen levels because they have high concentrations of hemoglobin (Vinogradov, 2001) [23], HBFI value of the river was very high (8.17) during the study time. This high value seems to come from higher abundance (dominance) of more tolerant families with high tolerance value, particularly Corixidae and Chironomidae, The HBFI value ranges from 0 to 10 (Hilsenhoff, 1988) [9]. Samples with H-FBI values of 0-2 are considered clean, 2-4 slightly enriched, 4-7 enriched, and 7-10 polluted. Therefore, the HFBI value of River Beresa lies in the range between 7 and 10, it was higher than the value of most Ethiopian rivers included in the study of Baye Sitotaw (2006)[4] except for River Akaki. The most probable cause for the pollution of Beresa River could be wastes which are being released from Debre Berhan University and Debre Birhan Textile factory. In addition, other anthropogenic activities around the river could significantly enrich the river.

## Conclusion and Recommendations

Based on the results of this study, it is possible to conclude that the water quality of River Beresa is poor and most probably it is polluted due to anthropogenic effects. The macro invertebrate community is also sparsely diverse and dominated by highly tolerant species which confirmed the poor status of the river. As the water quality of this river is poor and seems to be polluted, it could pose different health and related problems. Although the HBFI value indicated the lower water quality status of the river, the status should also be studied using other metrics as well in the future to support or refute our study.

Based on this study, some particular points which need greater attentions of the concerned governmental, non-governmental and other agencies are recommended as follows.

The result of this study should be communicated to the local people, administrators of Debre Berhan University and Textile Industry to raise the awareness regarding the status of the river**.**

The administrators of the town must stop the direct flow of waste water which comes from the factory and university. In addition to this, they should construct artificial wetland and grow plants such as papyrus which used to purify the water by absorbing organic matter and unwanted particles during runoff.

The society has the responsibility to prevent the pollution of this river by avoiding washing clothes and watering animals in the river.

Furthermore, the farmers should do not spray chemicals such as pesticides and herbicides at agricultural site and local people should not dispose solid wastes and toilet wastes from their household.

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