

# **Benthic Macroinvertebrates as Indicators of Organic Pollution in Upstream Batena River, Hossana, Central Ethiopia**

## **Abstract**

Benthic macro invertebrates are insects and other organism without a back bone that can be seen without magnification and that live in the bottom of all water bodies. They are bio monitor species in determining the water quality in fresh water and other aquatic ecosystems as they are indicator of environmental change of aquatic ecosystem and fresh water ecosystem. The aim of this study was to assess Organic pollution by using benthic macro invertebrate as indicator in upstream parts of Batena River and implication to the water quality of the river. Benthic Macro invertebrates were collected using Scrubber net and sieve with mesh size of 1mm. A total of 57 individual within 4 families belong to 4 orders and one class was identified during the study period. Most dominant group was Hemiptera 29(50.8%), Diptera 14 for Chironomidae (Red) (24.56%) and for Diptera family chironomidae (Pale) (19.3%). Sphendiea, Psephyendiea and class of Turbilaria accounts the same percentage (1.75%) and their total abundance was also similar. The pollution level of the river was assessed using Hillsenhoff Family Biotic Index (HFBI) and the value was 7.96. Over all study showed that the river is polluted and have poor water quality as result of diverse Organic pollutant agents. Therefore, the local people and administration of the river should work hard to prevent further deterioration of the river quality by raising public awareness, prevention of waste disposal and treat the waste water before discharging it directly to the river.

Key words: Bio monitors, Macro invertebrates, Organic pollution, Poor water quality,

## **1. Introduction**

### **1.1. Background**

“Benthic macro invertebrates are organisms in aquatic environment without back bone that live on or inside the deposit at the bottom of water. The distribution of these macro invertebrates’

fauna is determined by several factors, such as physical nature of substratum, depth and nutritive content, degree of stability and oxygen content of the water body”, (Sharma *et al.*, 2013).

“Macro invertebrates are used as indicator of environmental condition especially, in evaluating the impacts of specific pollutant in the aquatic environments because of their limited mobility, long life period, their sensitivity to change in their environment and tolerance of some contamination” (Barbose *et al.*, 2001).

“In Ethiopia the quality and quantity of water have been anthropogenically and naturally affected for the past half a century especially in the central parts of the country including the capital city of Addis Ababa. It is attributed to rapid urbanization, industrialization and population increase with a lack of environmental planning and waste disposal facilities. For instance organic pollution affects organism living in river and stream by lowering the availability of oxygen in water” (Freezer Eshetu, 2010).

“Organic pollution occurs when large quantities of organic compounds, which act as substrates for microorganisms, are released into watercourse. During the decomposition process the dissolved oxygen in the receiving water may be used up at a greater rate than it can be replenished, causing oxygen depletion and having severe consequences for the stream biota. Organic pollution affects the organism living in a river and stream by lowering the available oxygen in the water. It is imperative to know the current status of Ethiopian aquatic water resource using appropriate and integrated methods physical and chemical as well as physico-chemical parameter has been used as water quality indicator for many years in many countries”, (Valentine, *et al.*, 2011). “However, scientist are turning their attention to use of biological quality element (BQE) in monitoring studies because the traditional methods are quite expensive and required well trained expertise” (Valentine *et al.*, 2011).

Biological monitoring is effective tools to assess the ecological quality of water course chemical monitoring also very important to understand water quality but, it is expensive in terms of equipment and time. Monitoring the change of water quality in stream and river can be performed through assessment based on biological indicator of pollution is well developed in north hemisphere (Metcalf, 1989).

## 1.2. Statement of the Problem

“Water pollution is a pressing problem in developing countries, particularly, where there is high population growth, great development demands, high waste production without well-developed waste treatment technologies, and lack of comprehensive environmental policies and water quality monitoring system and standards” (James, 2005). “As the society relies on streams, rivers, and lakes as a source of water supply for development activities (irrigation, industrial production, etc) and for recreational purposes, it has become essential to have methods of assessment of water quality that can be easily communicated to the public and resource planners(United Nations/World Water Assessment Program” (UN/WWAP, 2003).

“Unlike developed nations where stringent regulation has been in effect to restrict the discharge of untreated waste water into rivers and streams, there is no such provision in developing countries. In Ethiopia, many rivers and streams are heavily polluted as they flow through major cities and towns” (Dejene Hailu, *et al.*, 1997; Tamiru Alemayehu, 2001). “However, the extent of damage caused to these natural resources has not yet been assessed using biological indicators that reflect aggregated impact of the past and present pollution. Lack of scientific criteria to monitor water quality that is applicable for Ethiopia is one of the main problems. Regardless of the abundance of water resources such as rivers and lakes, Ethiopia is categorized with nations that will face economic water scarcity by the year 2025 which indicate the urgent need of water resource management and at the same time appropriate water quality monitoring tool” (Harding *et al.*,2005).

“Recently, the ability to use benthic macro invertebrates to evaluate present and past conditions of water quality and environmental changes has been recognized worldwide” (Harding *et al.*, 2005). “However, there is no research conducted to evaluate benthic macro invertebrates as a surface water quality monitoring tool in Hossana in particular”. [20] Studies on Macro invertebrates are at their infancy stage and are not well developed as a river water quality monitoring tool to support decision making. Therefore, this research work was expected to fill this gap.

### **1.3. Significance of the study**

“Though river pollution is a common problem, there is no well-developed water quality monitoring tool in Ethiopia in general and in Hossana in particular. Therefore, the results of the study will be used by Environmental Authorities, Ministry of Water Resource, Ministry of Health, organizations and researchers involved in water resource protection and development for regulatory measures and further research. The public at large will be also benefited from the application of bio indicators by concerned authorities”. [20]

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## **1.4. Objectives of the Study**

### **1.4.1. General Objective**

- To assess Benthic Macroinvertebrates as Indicators of Organic Pollution in Upstream Batena River, Central Ethiopia.

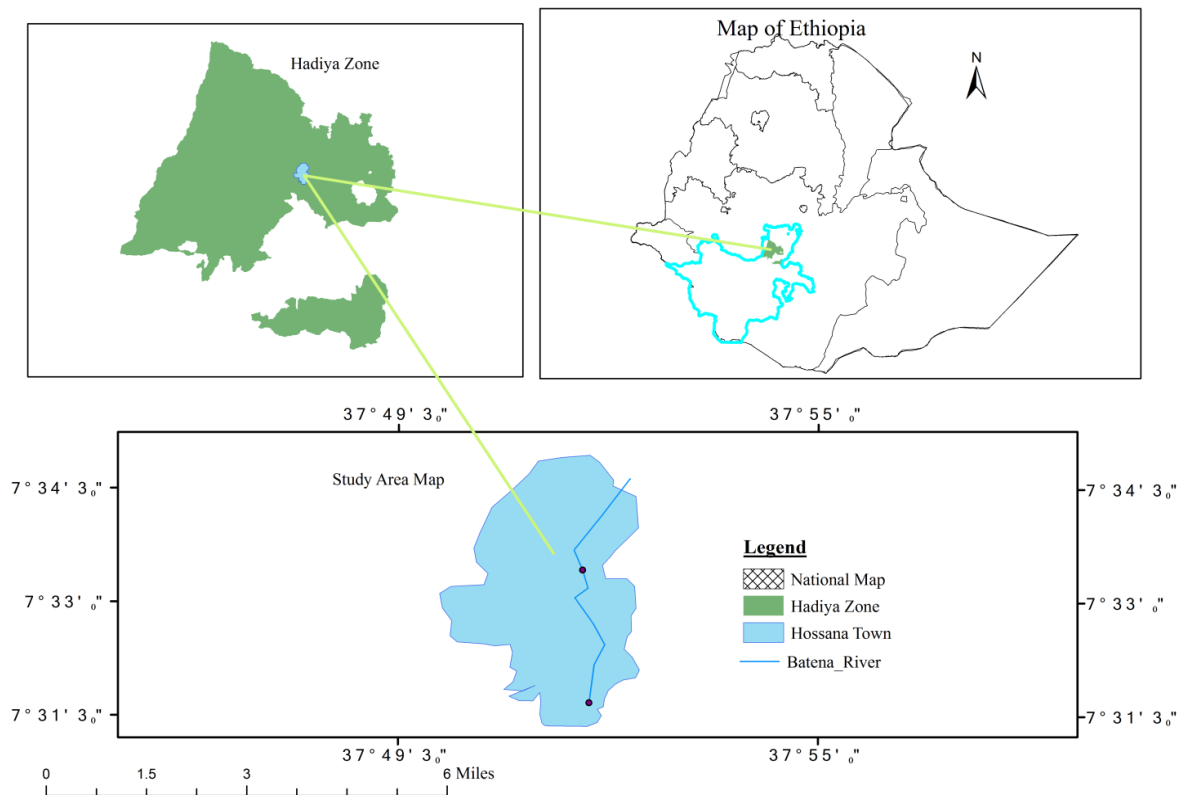
### **1.4.2. Specific Objective**

- To determine the level of organic pollution in river Batena Using Hillisenhoff family biotic index.
- To distinguish the effective methods of identifying the quality of water in Batena river.
- To familiarize the role of benthic macro invertebrate in the control of organic pollution of water.

## **2. Methodology**

### **2.1. Description of study area**

This study was conducted in Ambicho kebele around Hossana Town in upstream of Batena River. The town of Hossana is located 37° 51'E latitude and 7° 33'N longitude, 232km from Addis Ababa. Hossana is located in the former southern Nations Nationalities and Peoples Region; currently known as Central Ethiopia and elevated 2177m above sea level. The detail map of the study site is indicated in Fig 1. The sample site of our Research was established on upstream parts of Batena River which is found near Wachemo University.



**Fig 1. Map of the study area.**

### 2.1.1. Site Selection

When sampling, Processes affecting water quality and their influence should be taken into account and sites are selected. “Selection of sampling sites requires consideration of the objectives and some knowledge of the geography of the water-course system. A final decision on the precise location of a sampling station can be made only after a field investigation” (Bartram and Balance, 1996). “Based on the reference condition approach an attempt was made to choose arrays of reference sites characterizing the biological condition of the river tried to be chosen. The other impaired sites were chosen based on the degree of human disturbance physical change of the water proximity to point source pollutants and accessibility”. [20]

## 2.2. Fieldwork

### 2.2.1. Macro Invertebrates Sampling Techniques

The study site was visited during the period or season, between February to May 2015 E.C when heavy rain is not occurred for heavy rain can disturb the benthic macro invertebrates population and erode them. During this time different types of benthic macro invertebrate groups were

collected from different site of the upstream parts of the river. Benthic macro invertebrate were collected by using sieve and standard scrubber sampler with mesh size 1mm (Barbour *et al*, 1999). The samples were taken to laboratory by jar and preserved by 5% of formalin. The samples were collected more than one time from the site. Identification and counting were taken following Baye Sitotaw literature key(2006) and bouchard key(2012).

### **2.3. Laboratory work**

Sorting, identification and counting of benthic macro invertebrate was done in laboratory by using Microscope and hand lens. Additionally all collected benthic macro invertebrates communities grouped in to sub group based on their characteristics such as pollution tolerance and abundance by using the Bouchard key (2012) which shows predicted tolerance value of benthic macro vertebrates.

## **3. Data Analysis**

### **3.1 Family biotic index (FBI)**

The FBI is an average of tolerance values of all the macro invertebrates families in a sample(Hilsenhoff, 1988). FBI was calculated by multiplying the number in each family by the tolerance value for that family, summing the products, and dividing by the total macro invertebrates in the sample. The family-level tolerance values ranging from 0 (very intolerant) to 10 (highly tolerant) based on their tolerance to organic pollution. The FBI was then used to evaluate the water quality of each sampling site by comparing with the standard used to rate the water quality status .The diversity and abundance of all collected sample of benthic macro invertebrates communities were summarized using percentage with Excel spread sheet. The Data was analyzed by using Hillsenhoff family biotic index (HFBI) (1988).The organic pollutionof water of the river was evaluated using formula of the following:

$$\text{HFBI} = \frac{\sum Xi \times ai}{N} \quad \text{Where}$$

$Xi$  = number of individual with in a taxon

$ai$  = tolerance value of a taxon (given in Bouchad,2012). $N$  = total number of organisms in the sample .

## 4. RESULT

### 4.1 Abundance and composition of Benthic Macro invertebrates in upstream parts of Batena River

Totally, fifty seven (57) individual macro invertebrate organisms were collected from the upstream site of Batena River during the study time. These organisms were from five families and one class, four orders and one class (Table 1), Corixidae was the most about species followed by chironomidae (blood red), chironomidae (Pale), Sphaeridae, Pheophenidae and class Turbilaria Respectively (Table 2). Corixedae have largest percentage (50.8%) of macro invertebrates composition during the study period (Fig.1). On the other side spheridae, Pheplemidae and Turbilaria were very rare and they cumulatively constituted (1.75%) from the total population but the Chironomidae (red) and chironomidae (Pale) has percentage of (24.56%) and 19.3% respectively.

**Table 1. List of macro invertebrates identified during the study time**

| Family                    | Order                  |
|---------------------------|------------------------|
| Corixedee                 | Hemiptera              |
| Chironomidae (Blood read) | Diptera                |
| Chironomidae (Pale)       | Diptera                |
| Sphaeridae                | Gastropodste (Bivalve) |
| Pheophenidae              | Coleoptera (Battles)   |
| Turbilaria                |                        |

**Table 2. Abundance and percentage of macro invertebrates**

| Family                  | Abundance | percentage |
|-------------------------|-----------|------------|
| Corixedee               | 29        | 50.80%     |
| Chironomidae (bloodred) | 14        | 24.56%     |
| Chironomidae (Pale)     | 11        | 19.3%      |
| Sphaeridae              | 1         | 1.75%      |

|             |   |       |
|-------------|---|-------|
| Turbilaria  | 1 | 1.75% |
| Pheplemidae | 1 | 1.75% |

#### 4.2. Hillsenhoff benthic family index calculation

The benthic macro invertebrates communities identified during this study had a wider range of tolerance value (Table 3). For example, families such as Corixidae(9), Chironomidae(red blood) (8), Chironomidae(pale) (6), Sphaeridae (7), Phephenidae (4) and class Turbilaria (4) higher tolerance value which indicated that these families are tolerant species where psephenidae (4) and Turbilaria class (4) had lower tolerance value that indicated their sensitiveness to pollution. HFBI of upstream parts Batena River was 7.96 during the study time. The tolerance value or each species and HBFI of the river was shown in (table, 3).

**Table 3 Hillsenhoff Family Biotic Index of the upstream of Batena Rivers**

| Family                   | Order                | Abundance (xi) | Tolerance value (TV) | TV*xi | HBFI                                |
|--------------------------|----------------------|----------------|----------------------|-------|-------------------------------------|
| Corixidae                | Hemiptera            | 29             | 9                    | 261   | HBFI=<br>$\frac{454}{57}$<br>= 7.96 |
| Chironomidae (red blood) | Diptera              | 14             | 8                    | 112   |                                     |
| Chironomidae(Pale )      | Diptera              | 11             | 6                    | 66    |                                     |
| Sphaeridae               | Gastropoda (Bivalve) | 1              | 7                    | 7     |                                     |
| Psephenidae              | Coleoptera (Bettle)  | 1              | 4                    | 4     |                                     |
| Turbilaria               |                      | 1              | 4                    | 4     |                                     |
|                          |                      | 57             |                      | 454   |                                     |



Figure 2. Photos during collection of benthic macro invertebrates

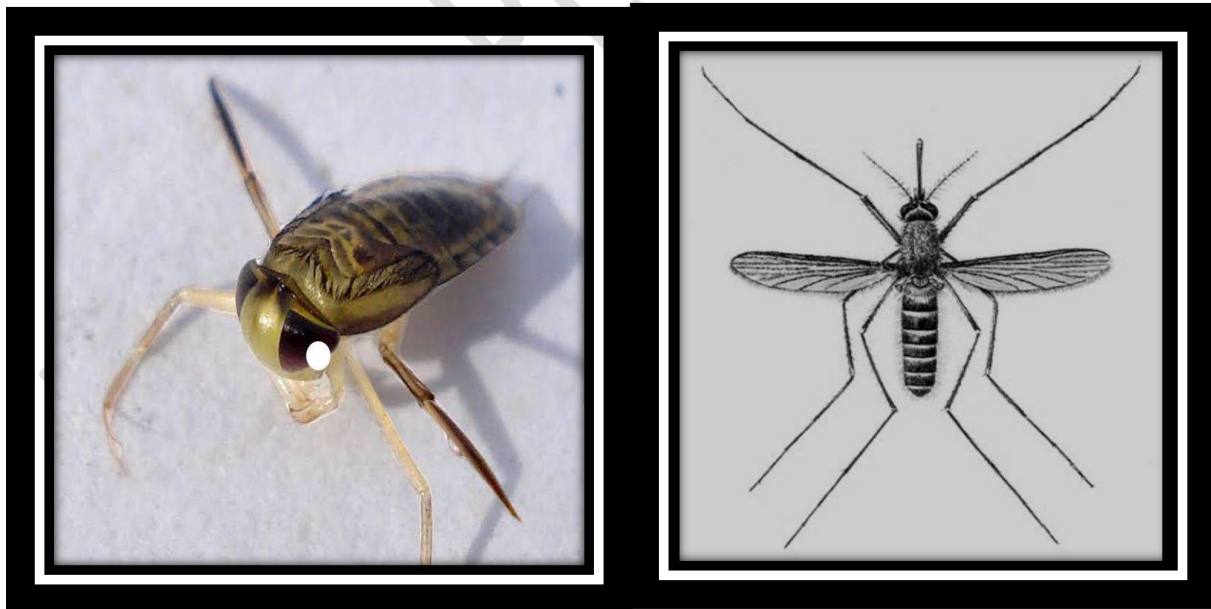


Fig 3. Corixidae(Hemiptera)Fig 4. Chironomidae (pale) \_Diptera



Fig 5. Chironomidae(red pale)\_ Diptera. Fig 6. Sphaeridae(Bivalve).



Fig 6.Psephenidae(Coleoptera) Fig 8. Turbilaria

## 5. DISCUSSION

Benthic macro invertebrate communities were less diverse in terms of number of families compared to many Ethiopian rivers. For example Baye Sitotaw, (2006) was able to sample 25 families from River chacha and 17 families from River Akaki. A total of 57 individual, 4 families, one class, and 4 order of macro invertebrate were collected From the Batena River. Among them the dominant organisms belongs to order Hemiptera, family Corixidae which accounts 50.8%. This group of organism is mostly found in very clean water and very sensitive to organic pollution. The leading Benthic macro invertebrate chironomidae family (red ) accounts 24.5% which is order Diptera and chironomidae (Pale) accounts 19% which they differ by tolerance value but they found in the same orders. Family sphaeridae, family phephricea and class Turbilaria were account the same percentage which accounts 1.75%.

The lower abundance and diversity of macro invertebrates of the upstream part of Batena could be due to poor ecological status. The majority of families identified in this study had higher tolerance value, more particularly family Corixidae and chironomidae family (red). It indicated the presence of organic pollution in the river.

HBFI value of the River was high (7.96) during the study time. This high value seems to come from higher abundance of more families with high tolerance value particularly Corixidae and chironomidae. The HBFI Value range from 0 to 10 (Hillsenhoff, 1988). According to this index, sample with HBFI values of 0 – 2 are considered clean, 2 – 4 highly enriched, 4 – 7 enriched and 7 – 10 polluted.

Therefore, the HFBI Value of upstream parts of Batena River lies in the range between 7 and 10, which showed the water is in poor condition or polluted. It was higher than the value of most Ethiopian rivers included in the study of Baye Sitotaw (2006). The cause of the high pollutant of river upstream parts of Batena River could be wastes that being released from Wachemo University and which are located at the vicinity of the river. In addition, other anthropogenic activities around the river such as washing clothes excrete from cattle and other solid sewages from local people could highly enrich the upstream of river and affect the ecology of the river in general.

## **7. Conclusion and Recommendations**

### **7.1. Conclusion**

Based on the result of this study, it is possible to conclude that the upstream parts of Batena River were dominated by order Hemiptera, family Corixidae which was 50.8% of total abundance. The water quality of upstream parts of Batena River is poor and mostly it is polluted due to anthropogenic effects such as, involvements of human and cattle waste that leads accumulation of organic matters.

The diversity of macro invertebrates is sparsely dispersed and dominated by high tolerant species which confirmed the poor status of the river. As the water quality at this river is poor and seems to be polluted, it could pose different health and related problems if it is used for drinking and other use and unless it is appropriately treated.

### **7.2. Recommendations**

Based on the finding of the study, the following recommendations are suggested to reduce the organic pollution of Batena River:

- The result of this study should be communicated to the local people, administration of Wachemo University and to give awareness regarding the status of river.
- The administrator of the town must stop the flow or release of waste water which comes from university and they should build artificial wetland and grow plants used to purify the water by absorbing organic matter and unwanted particles during run off.
- The society has responsibility to prevent the pollution of this river by avoiding washing clothes and watering animals in the river as farmer should do not spray chemical such as pesticide and herbicides at agricultural site, and local people should not dispose solid wastes and toilet wastes from their household.

## 8. REFERENCES

1. Barbose, F.R, Cavisto, M. andGalden, N. (2001).The diversityof the macroinvertebrate as an indicator of water quality and ecosystem health.Ac case study for Brazil, *Aquatic Ecosystem Health and Managements*. 4:51-59.
2. Barbour, M.T., strimbling, J.B. and karr, J.R. (1995).Mutimetric approach for establishing bio criteria and measuring biological condition. In: Biological assessment and criteria. Tools for water resource planning and decision making, PP 63-76 (Davis, W.s. and Simon, T.P.ed.)CRCLLC press.BockRafon, Florida.
3. Barbour, M.T., strimbling, J.B. and karr, J.R. (1995).Mutimetric approach for establishing bio criteria and measuring biological condition. In: Biological assessment and criteria. Tools for water resource planning and decision making, PP 63-76 (Davis, W.s. and Simon, T.P.ed.)CRCLLC press.BockRafon, Florida.
4. Barbour, M.T, Gerristen, J., synder, B.D. and sribing, J.B. (1999). Rapid bio assessment protocols for use in stream and Wadeable Rivers: periphyton, benthic micro invertebrate and fish, second edition. EPA 841-B.199-202, U.S. Environmental protection agency, office of water, Washington, D.C.
5. Bartram, J. and Balance, R. eds. (1996). Water quality monitoring-A practical guide to the design and implementation of freshwater quality studies and monitoring programmes. NEP/WHO.
6. Baye Sitotaw, (2006).Assessment of benthic macro invertebrate structure in its Relation to environmental degradation in same Ethiopian Rivers, M.Sc. thesis, school of graduate studies, A.A Univ. 130pp.
7. Bode, R.W. and Novak, M.A. (1995). Development of bio criteria for rivers and streams in New York State.New York state department of environmental conservation. Albany, N.Y.
8. Bouchard, R.W. Jr (2012). Guide to aquatic macro invertebrate of the upper Midwest. Water resource center, university of Minnesota, St.paul, MN.
9. Dejene Hailu and WorkuLegesse, (1997). Pollution status of Awetu stream as it crosses Jimma town, *Bulletin of JIHS*, 7 (2):79-85.

10. Freezer Eshetu. (2010). Physic-chemical Population pattern in Akaki River Basin ,Addis Ababa, Ethiopia, MSc, Stockholm university, Sweden.
11. Harding W.R., Archibald, C.G.M. and Taylor, J.C. (2005). The relevance of diatoms for water quality assessment in South Africa: A position paper. *Water SA* 31(1):41-46. URL: <http://www.wrc.org.za>.
12. James R.K. (2005). The economic approach to environmental natural resources, 3rd ed., p.516-534.
13. Hillsenhoff, W.L, (1988). Rapid field assessment of organic pollution with a family level biotic index. *J. North Am. Benthol. SoC.* 7 (1):65-68.
14. Morse, T.C. Bac, Y. J. Munkhjargal, G.Sangpraidob, N, N, N, N. Tanide, K, Tatyana, S.V. Wang. B. Yang, L. L. and Yule, C.M. (2007). Fresh water bio monitoring with micro invertebrate in east aria. *Frontier in Ecology environment*, 1:33-42.
15. Rosenberg, D.M. and Resh, V.H. (eds). Fresh waterBiomonitoring and benthic macroinvertebrates. Chapman and Hall, New York: 159-194
16. Sharma, k.ksamitachowdhary.(2011). Macroinvertebrate assemblage as biological indicator of pollution in a central Himabyan River. *International journal of biodiversity and conservation* 3:167-175.
17. Sharma, S.Sudha, D.andDave, V, (2013). Macro-invertebrate community diversity in relation to water quality status of Kunda River, *discovery publication*, 3:40-46.
18. TamiruAlemayehu, Dagnachew Legesse and Tenalem Ayenew (2005). Hydrogeology, waterquality and the degree of groundwater vulnerability to pollution in Addis Ababa.UNEP/UNESCO.
19. Valentine, R.L. Minshall, K.W. Commins, JR. Sedell and CE, crushing. (2011). “The river continuum concept.”
20. Wassie TA. Comparative study of macro invertebrates and diatoms as bioindicators of river water quality in Addis Ababa (Doctoral dissertation, MSc thesis, Addis Ababa University, Addis Ababa, Ethiopia).

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