

# Assessment of the Water Quality of Chole River, Ethiopia Using Benthic Macroinvertebrates and Selected Physicochemical Parameters

Alemayehu N. Emana<sup>1\*</sup> and Misganaw E. Dubie<sup>2</sup>

<sup>1</sup>Department of Biology, Ambo University, PO Box 19, Ambo, Ethiopia; <sup>2</sup>Stand for the Vulnerable Organization (SVO), PO Box 1176, Addis Ababa, Ethiopia

## ABSTRACT

The water quality of Chole River was assessed based on in situ measurements and laboratory analyses of water and benthic macroinvertebrates samples collected for three rounds from January - April, 2017 once every two months from three sites coded S1, S2 and S3 using standard procedures. Laboratory analyses of benthic macroinvertebrates samples yielded 5712 specimens belonging to 26 families and 9 Orders. Percentage of sensitive taxa (Ephemeroptera, Plecoptera and Trichoptera) (%EPT), Shannon diversity ( $H'$ ), ETHbios score, Average Score Per Taxon and family richness decreased with increasing level of impacts from S1 through S3 to S2 in contrast to percentage of the tolerant Chironomidae (%Chiro.), percentage of dominant taxon (%DT) and Hilsonhoff's Family Biotic Index (H-FBI). Mean %EPT was maximum at S1 (77.7%), followed by S3 (16.4%) and lowest at S2 (9.3%) whereas red Chironomidae dominated at S2 (84.6%) and S3 (91.8%). Family richness was maximum at S1 (25) and minimum at S2 (22). The lowest dissolved oxygen ( $4.29 \pm 1.85$  mg/l) and maximum total phosphorus ( $6.09 \pm 0.09$ ) were determined at S2 indicating organic and detergent pollutions, respectively. Electrical conductivity ( $609 \pm 169$ ), Ammonium Nitrogen ( $0.091 \pm 0.067$  mg/l), Nitrate nitrogen ( $\text{NO}_3\text{-N}$ ) and ( $2.02 \pm 0.141$  mg/l) picked at S3 and remained relatively higher at S2. The heavy solid and liquid wastes loaded from Ambo University campus at S2 and common stressors at S3 including solid waste disposal, cattle watering, bathing, washing clothes and car washing might be responsible for the spatial variation in benthic macroinvertebrates indices/metrics and physicochemical parameters which indicated deterioration in the water quality of Chole River at downstream sites.

**Keywords:** Biomonitoring; Ethiopia; macroinvertebrates; Physicochemical parameters; Water Quality

## INTRODUCTION

Currently, environmental pollution in general and pollution of flowing waters in particular has become a key focus of concern all over the world. Despite humanity's reliance on flowing water rapid urbanization, industrialization and the expansion of agriculture have severely degraded the quality of rivers worldwide, diminishing their ability to provide valuable ecosystem services and driving species to extinction. Moreover, rivers in underdeveloped and developing countries are widely used as waste disposal sites for domestic and industrial wastes. Growing anthropogenic influences on lotic environments has captured public interest because of the consequent problems associated with deterioration of water quality [1].

Anthropogenic activities may alter the physical, chemical, or biological processes associated with water resources and thus modify the resident community. Though physicochemical and

bacteriological measurements commonly form the basis of river monitoring, they cannot reflect the integration of numerous environmental factors for their instantaneous nature. Because they focus on living organisms whose very existence represents the integration of conditions around them biological evaluations can diagnose chemical, physical, and biological impacts as well as their cumulative effects. The use of biological methods is based on the straightforward premise that living organisms are the ultimate indicators of environmental quality. When water no longer supports living things it will no longer support human affairs. Biomonitoring is a useful complementary approach to physicochemical monitoring and has proved invaluable in tracking water quality trends over time. Together physicochemical and biological methods constitute the basis to a correct assessment of the quality of running waters.

Amongst aquatic organisms, benthic macroinvertebrates have proved to be excellent indicators for the quality of freshwater stream

**Correspondence to:** Alemayehu N. Emana, Department of Biology, Ambo University, PO Box 19, Ambo, Ethiopia, E-mail: EmanANA@gmail.com

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habitats. They are widely used as bio-indicator in wadeable waters because they have generally limited mobility, quite easy to sample, well established sampling techniques, and there is a diversity of forms that ensures a wide range of sensitivities to changes in water quality. The use of macroinvertebrates as indicators of environmental change in Ethiopia dates back to the 1980s; with a renewed interest in recent years following the advent of multimetric assessment methods [2]

Chole River has long been used for a variety of purposes including source of public water supply, small scale irrigation, bathing, washing and livestock watering. Nevertheless, poor agricultural practices, overgrazing, deforestation, effluent discharge and unregulated solid waste disposal which are generally widespread in the country remain serious problems in the catchment of Chole River with a potential of degrading its water quality. However, so far there is no research conducted on water quality of the river despite the multiple stressors prevalent in its catchment. This study was conducted to assess the water quality of Chole River based on benthic macroinvertebrates indicators and selected physicochemical parameters.

## MATERIALS AND METHODS

### Description of the study area

Figure 1 is one of the tributaries of Guder River located in the central highland of Ethiopia which originates near Wonchi Crater Lake and flows through Guder town about 127 Kms west of the capital, Addis Ababa. It is perennial and situated at 08057'397"-08058'657"N, 037045'589"-037045'975"E and an elevation of 1947-2818 meter above sea level and constitutes important source of water for various development activities in Toke-kutaye district (Toke-kutayeworeda Agricultural and Rural Development Office, 2016). The main rainy months in the area range between June and September peaking in July and August. The dry months extend from October to May with some intermittent rain from February to April. The minimum and maximum air temperature ranged between 10 and 29 °C. The hottest months in the district range between March and May; while October to December constitutes the coldest months. Teff, maize, wheat, and barley are the major crops produced in the area (Figure 1).

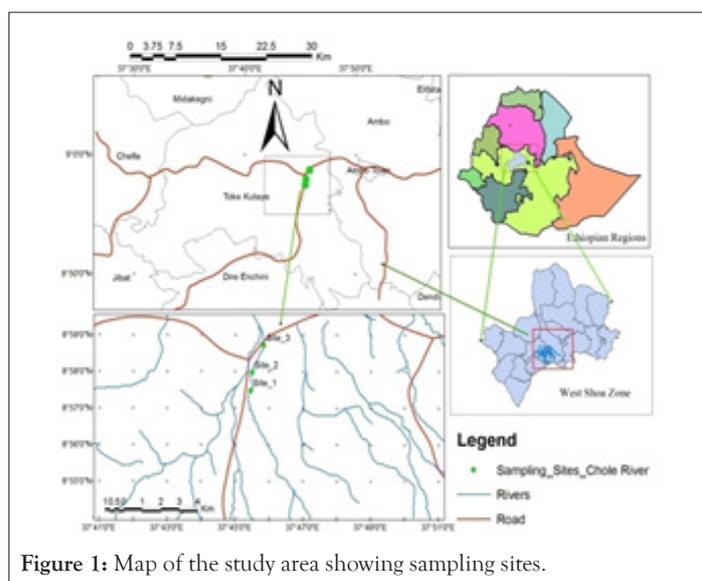


Figure 1: Map of the study area showing sampling sites.

### Selection of sampling sites

Three sampling sites coded Site 1 (S1), Site 2 (S2) and Site 3 (S3) were

selected along the river based on the rapid bio assessment protocol considering vegetation cover, habitat types, substrate structure, agricultural activities, waste disposal, washing cloth, grazing and animal watering. Site 1 is located upstream with remnant riparian vegetation, some agricultural activities and sand mining. Site 2 was without vegetation cover except scattered eucalyptus trees along the river bank. It was receiving heavy solid and liquid wastes generated at Ambo University Guder campus; and experiencing sand mining, grazing, cattle watering, washing clothes and bathing. Waste dumping, car washing, grazing, cattle watering and cloth washing were the common human activities noted at S3 [3].

### In situ measurements, water sampling and analysis of physico-chemical parameters

Water quality parameters such as temperature, pH, dissolved oxygen and conductivity were measured at the sampling sites in situ using a portable multi-parameter probe before sampling the macroinvertebrates. Altitude, longitude and latitude were measured using global positioning system (GPS) at the sites. Composite water samples were collected in 2L polyethylene bottles between 9 AM to 12 AM, stored in icebox and transported to Chemistry Department Laboratory of Ambo University. In the laboratory, Nitrate (NO<sub>3</sub>-N), Ammonia+Ammonium-Nitrogen and Total phosphorus (TP) were determined by Phenoldisulphonic Acid method using double beam UV-Spectrophotometer (ELICO SL-160), using Spectrophotometer (ELICO SL-160) after distillation following Phenate method and by Ascorbic Acid Spectrophotometric method after digestion, respectively (APHA, 1998).

### Macroinvertebrates sampling and identification

Benthic macroinvertebrate samples were collected using a standard hand net with frame width of 25\*25 cm<sup>2</sup> and mesh size 500µm. A composite sample comprising 20 sampling units was taken from different habitat types. A sampling unit was a sample collected by positioning the net and disturbing the substrate in a quadratic area that equals the frame area of the net. Sampling began at the downstream end of the reach and proceeded upstream against the current. Megalithic stones were sampled by brushing their surfaces approximately equal to the size of the sampling net. Macrolithal stones were picked by hand and their surfaces were brushed to dislodge clingers and sessile organisms. Before preservation, quick identification of major taxa was performed on site as a quality assurance and samples were then preserved in 4% formalin in the field [4].

The preserved macroinvertebrate samples were transported and processed in the laboratory after carefully copying all information from the sample containers to the sample log sheet. A complete sample was passed through a set of sieves (2000, 1000, 500 and 250 µm mesh size) in order to remove formalin and separate size classes of macroinvertebrates groups under tap water. Macroinvertebrates trapped in the coarse fraction of the sieve were identified using naked eyes while organisms trapped in the smaller fraction of the sieve were identified with the help of dissecting microscope. Identification was performed to family level using South African Aquatic Invertebrates Identification key.

## RESULTS AND DISCUSSIONS

### Distribution and abundance of benthic macroinvertebrates

A total of 5712 specimens of macroinvertebrates belonging to 26

Families and 9 Orders i. e. Diptera (3540), Trichoptera (935), Ephemeroptera (439), Oligochaeta (295), Bivalva (231), Gastropoda (188), Coleoptera (43), Hemiptera (22) and Odonata (19) were collected from the sampling sites along Chole River. Distribution and abundance of the benthic macroinvertebrates varied among the sampling sites. Family richness was maximum at S1 (25) and minimum at S2 (22) in contrast to abundance which was highest at S2 (2772) and lowest at S1 (1032). The %(EPT) decreased from S1 (77.7%) through S3 (16.4%) to S2 (9.3%) with only a few numbers of Ephemeroptera and Trichoptera occurring at the lower reaches of S2 in contrast to %(Chiro.) which increased from S1 (12%) through S3 (46%) to S2 (74%).

H-FBI for the entire samples was 6.3 and increased from S1 (4.4) through S3 (7.1) to S2 (7.3). The minimum Shannon diversity index and evenness were recorded at S2 with maximum values determined at S3. ETHbios score decreased from S1 (95) through S3 (92) to S2 (81) and similar trend was noted in ETHbios-ASPT .

### Physicochemical Parameters

The mean values and ranges of the physicochemical parameters determined at the sampling sites are given. The temperature at the sampling sites along Chole River ranged from 14.5 to 27.5 whereas pH ranged from 8.15 to 8.91. The lowest and highest levels of mean dissolved oxygen were recorded at S2 ( $4.29 \pm 1.85$  mg/l) and S1 ( $7.18 \pm 0.91$  mg/l), respectively. Maximum and minimum conductivity were recorded at S3 ( $609 \pm 169$ ) and S1 ( $496 \pm 160$ ), respectively. Maximum values of both nitrate-nitrogen ( $2.02 \pm 0.14$  mg/L) and total phosphorus ( $6.09 \pm 0.09$ ) were determined at S3.

## DISCUSSIONS

### Distribution and abundance of benthic macroinvertebrates

The spatial variation in distribution and abundance of benthic macroinvertebrates in Chole River appeared to be related to conditions of the habitats, influences of human induced pollutants and agricultural practices, as well as sensitivity/tolerance of the benthic fauna and in agreement with a report from Greater Akaki River by Solomon Akalu (2011). The conflicting trends in family richness and abundance noted at S1 and S2 are in accordance with the accepted view that as the upper part of river becomes pristine most fauna can inhabit it and there will be high competition, and can thus support fewer invertebrates than a site that is slightly impacted. also reported that mild pollution has a tendency to increase total abundance which is in agreement with the present finding.

The decrease in the percentage of sensitive taxa (%EPT) at S2 might be attributed to increased urbanization, effluent discharge from university campus and unregulated solid waste disposal. Previous reports (e. g., indicated positive correlation between %EPT and stream water quality which is in accordance with the present finding. The increase in % Chiro. from S1 through S3 to S2 might indicate increased organic matter load and nutrient enrichment and supported with the accepted view that tolerant species become abundant in degraded streams and rivers [5-7].

H-FBI indicated good, poor and very poor water quality at S1, S3 and S2, respectively. The H-FBI for the entire samples indicated substantial pollution and poor water quality which is in line

with. Shannon diversity index and evenness indicated maximum deterioration at S2 since diversity is positively correlated with water quality [] reported low diversity of sensitive taxa in impacted streams which is in accordance with the present result. The maximum diversity index determined at S3 might be explained by the mild pollution which agrees well with. ETHbios score and ASPT also indicated good water quality at S1 and deterioration at downstream sites mainly S2. Overall, the benthic macroinvertebrates indices/ metrics determined varied among the sampling sites at Chole River in response to local stressors indicating increased water quality degradation at downstream sites.

## CONCLUSIONS

The distribution and abundance of benthic macroinvertebrates and the physicochemical parameters determined varied among the sampling sites in response to local stressors. The indices/metrics and parameters determined indicated water quality deterioration at downstream sites mainly S2 with possible adverse effect on the valuable ecosystem services of the river and public health. Responsible authorities should take urgent ameliorative measures to stop further deterioration and restore the water quality of Chole River. Attempts to protect further deterioration and restore water quality of the river should involve regulating the waste water discharged to the river without treatment, promoting effective watershed management and introducing integrated solid waste management.

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## REFERENCES

1. Aschalew Lakew. Applicability of bioassessment methods using benthic macroinvertebrates to evaluate the ecological status of highland streams and rivers in Ethiopia Msc thesis , UNESCO-IHE Delft, The Netherlands 2007.
2. Aschalew Lakew. Development of biological monitoring systems using benthic invertebrates to assess the ecological status of central and southeast highland rivers of Ethiopia. PhD Thesis, University of Natural Resources and Life Sciences at Vienna, Austria: 163 pp. 2014.
3. Aschalew Lakew (2015a). Assessing Anthropogenic impacts using benthic macroinvertebrates as bio-indicator in central highland streams of Ethiopia. *Ethiop.J.Env. Stud.& Man.*, 8(1):45-26.
4. Aschalew Lakew and Moog, O. (2015a). A multimetric index based on benthic macroinvertebrates for assessing the ecological status of streams and rivers in central and southeast highlands of Ethiopia. *Hydrobiologia.* 751:229 -242.
5. Bae, J. Y., Kil, K. H. and Bae, S. K. (2005). Benthic Macroinvertebrates for uses in stream Biomonitoring and Restoration. *KSCE J.Civ. Eng.*, 9(1):55-65.
6. Barbour, M.T., Gerritsen, J., Snyder, B.D. and Stribling, J.B. (1999). *Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates and Fish*, 2nd edn. EPA 841-B-99-002. U.S. Environmental Protection Agency, Office of Water, Washington, DC.

7. BayeSitotaw (2006). Macroinvertebrates assemblage structure in relation to environmental degradation in some Ethiopian rivers. M.Sc. Thesis, School of Graduate Studies. Addis Ababa University, Addis Ababa.
8. BirenehAbay (2007). Assessment of Downstream pollution profiles of Awassa Textile Factory Effluent along Tikurwuha River Using physico-chemical and Macroinvertebrate Indicators, Ethiopia.
9. Chapman, D. and Kimstach, V. (1996). Selection of Water Quality Variables. In; Water Quality Assessments. A guide to the use of biota, sediments and water in environmental monitoring, pp. 243-318 (Ed. Chapman, D.), Cambridge.
10. Environmental Protection Authority (EPA) (2003). Guideline Ambient Environment Standard
11. for Ethiopia, 101pp. Prepared by Environmental Protection Authority in collaboration with
12. the United Nations Industrial Development Organization, Addis Ababa.
13. Gerber, AM, Gabriel JM (2002). Institute for water quality studies department of water Affairs and Forestry version 2, April 2002.