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Macro Invertebrate Communities in the spring and Stream Sites of Upper Awash River at Chilimo, Ethiopia

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Abstract

The aim of this study was to determine the abundance, distribution, composition and diversity of benthic macro invertebrate community at the different spring and stream habitats of upper Awash River at Chilimo, Dendi district, Ethiopia. Monthly benthic macro invertebrate samples were collected from the five selected stations between February 2016 and April 2016. Benthic fauna were collected from the pool and riffle habitats using standard net 25 cm x 25 cm respectively. Benthic macro invertebrates were identified and their abundance, distribution, composition and diversity were reported in relation to presence of natural forest vegetation covers and anthropogenic impact. The abundance of the fauna was high in station II and the lowest at station IV. The number of families of benthic fauna was high at stations III (23) and V (28) than the other sites. Ephemeroptera was the most abundant group at all sampling stations especially at station IV ranging between 400 and 592 No/m^2. The EPT index value 78.29% was recorded from the less impacted station II. The highest Hilsenhoff Family Biotic index (H-FBI = 3.75) was noticed at station V. Dissolved oxygen varied between 6.39 mg/l in station I and 8.62 mg/l in station V. Relatively higher values of PH, temperature, electrical conductivity and BOD were observed in station V which is highly impacted by human activities.

Keywords: *Biotic index; Richness; Insecta; Pool; Riffle;*

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Introduction

Springs and streams are the most important freshwater resources for the people residing in the highlands of Ethiopia. The River Awash originates from the Chilimo forest, at elevations ranging from 2000 to 3200 m a.s.l. The study area is lying between latitude 40028'-E and 40059'-E and longitudes 9099'N and 10003'N. There are many springs that supply water to the streams which join together to form the head water of Awash river found inside the state protected forest dominated by trees such as *Junipers procera, Podocarpus falcatus, Prunus africana, Olea europaea subspecies cuspidata, Hagenia abyssinica, Apodytes dimidiata, Ficus spp., Erythrina brucei*, and *Croton* *macrosytachus* [21]. In recent years, however, the increased population growth, industrialization, land use modification, removal of riparian vegetation and poor implementation of environmental regulations have resulted in the degradation of the water quality [34,4] of the major rivers in Ethiopia. The level of degradation of lotic systems are assessed by physico-chemical and biological methods. The macro benthic macro invertebrates (BMI) are often the taxa group of choice for bio monitoring in streams and rivers as they are ubiquitous, sensitive to several anthropogenic pressures such as water pollution and hydro-morphological alterations [8,7]. Each macro invertebrate has particular requirements with respect to the physical, chemical and biological conditions of its habitat.

Changes in these conditions can result in the reduction in taxa richness and change in community structure. Among biotic factors, presence or absence of aquatic vegetation, predation and competition also limit the distribution of benthic macro organisms causing variation in community composition [12]. Water level or depth fluctuation also affect indirectly by influencing the appearance and growth patterns of aquatic vegetation [16,10]. The studies conducted in Ethiopia demonstrated that benthic macro invertebrates are effective tools for evaluating the ecological status of lotic systems [22,3]. The springs and streams in the Chilimo forest are utilized by the local community for rearing cattle, growing food crops and several domestic purposes. No attempt has been made to study the nature of the water and benthic fauna of upper Awash River spring and stream habitats and the present study is the first report on the environmental status of the this part of the river.

Materials and Methods

Five sampling stations [Figure 1] were selected based on topographic features, nature of bottom substratum habitat structure, exposure to vegetation cover and various human activities, following the rapid bio assessment protocol criteria [7] besides considering the major human activities in the spring and stream proper and the surrounding areas as stressors.

Station 1- Warabo spring- located at the origin of Warabo stream and where human activity is less

Station 2- Arera spring - at the origin of the Arera stream with less human intervention

Station 3- Awash1 located downstream after the confluence of the Warabo and Arera streams with high human activities

Station 4- Dabo spring- located at the origin of Dabo stream and less human activities

Station 5- located downstream of Dabo stream where much human activities and with no vegetation canopy

The spring stations 1 and 2 were surrounded by natural forest and shrubs and there was large quantity of dry and partially decomposed leaves accumulated on the soil. At station 3 there is forest and riparian vegetation with human intervention. Station 4 has sparse vegetation on the buffer zone alone the stream. At station 5 human intervention in the form of washing, watering cattle and other activities.

Sampling of macro invertebrates

For the collection of macro invertebrates Multi-Habitat Sampling (MHS) scheme [23] using a standard hand net with frame width of 25*25 cm^2 and mesh size 500 µm. A composite sample consisting of 20 sampling units were taken from all habitat types each with a share of at least 5% habitat coverage. Samplings were done starting from the downstream end of the reach and proceeds 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. After every 3 sampling, the net was rinsed by running clean stream water to avoid clogging which could interfere in obtaining an appropriate sample. Samples were initially preserved in 4% formalin in the field and after final identification preserved in 70% alcohol.

Physico-chemical parameters

Water quality parameters such as temperature, pH, dissolved oxygen and conductivity were measured in-situ using a portable multi-parameter probe before sampling the macro invertebrates. Water samples collected were in 2L polyethylene bottles for the analysis of Total phosphorus (TP), Nitrate (NO3), Ammonia (NH4) and five day biochemical oxygen demand (BOD) following standard methods [2].

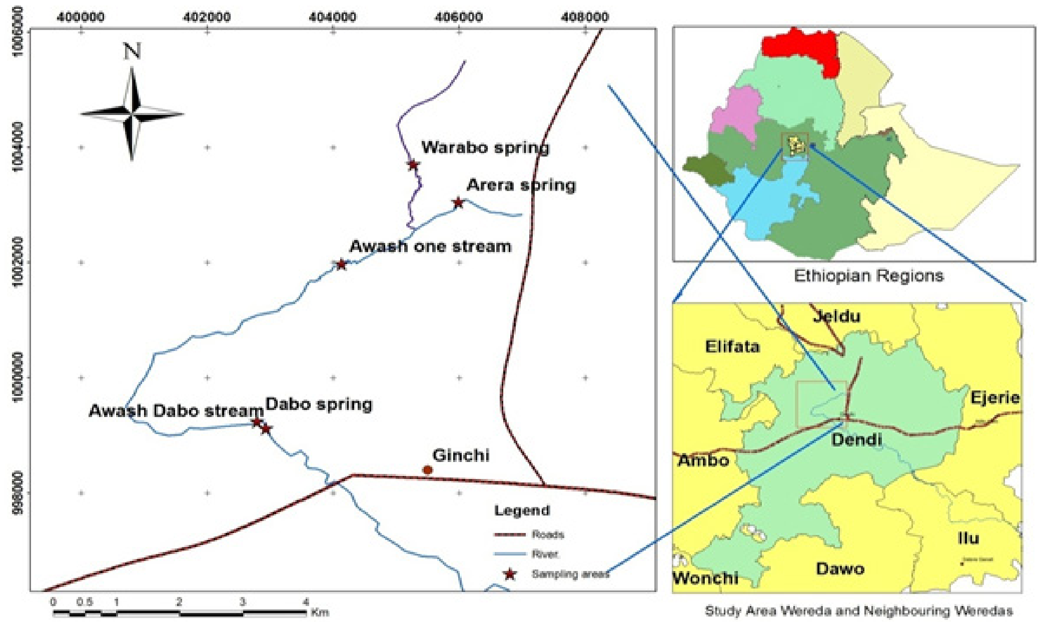

Figure 1: *Location of the study sites.*

The preserved macro invertebrate samples were passed through a set of sieves (5000, 3000, 2000, 1000 and 500 µm mesh size) in order to separate size classes [3]. When density of some organisms was high, sub sampling was applied according to (Barbour., *et al.* 1999). Identification of the organisms was performed based on the South African aquatic invertebrate's identification key [17]. Benthic macro invertebrate indices (BMI) such as Hilsenhoff Family-Level Biotic Index (H-FBI), Margalef Family-Level richness index, Percentage of EPT index, Percent of Chironomidae, Percentage of dominant taxa, ETHbios [26,4,5] and Average Score Per Taxon (ASPT) were calculated.

Results

Composition and abundance of invertebrate families

During the study period, a total of one subclass (Oligochaeta), 10 orders and 37 families of macro invertebrates were identified from the five stations [Table 1]. The nymph and larval stages of the insects identified belongs to 33 families, while Gastropoda and Oligochaeta were the non-insect macro invertebrates representing 4 families. There were 7 orders of the class Insecta namely Plecoptera, Ephemeroptera, Odonata, Hemiptera, Trichoptera, Coleoptera and Diptera collected from the study sites.

In the Warabo spring (St I) 13 families of macro invertebrates were identified from the pool and riffle part [Table 1]. At this station two families of gastropods, Planariidae and Planorbidae were found. The insect groups represented are Plecoptera, with one family (Perlidae), Ephemeroptera, two families (Baetidae and Caenidae), Odonata two families (Aeshnidae and Libellulidae), Hemiptera one family (Coroxidae), Coleoptera with three families (Gyrinidae, Elmidae and Dytiscidae) and Diptera with two families (Tipulidae and Chironomidae).

In the riffle section two families of Tricoptera, (Hydropschidae and Ecnomidae), two families of Coleoptera (Gyrinidae and Elmidae) and three Diptera families (Tipulidae, Simulidae and Chironomidae) were observed. Among the insect families Baetidae was numerically abundant followed by Caenidae. At station II (Arera Spring) pool and riffle habitats showed 11 and 12 families of invertebrates. In the pool habitat Baetidae and Caenidae were dominant whereas in the riffle section Simulidae members were abundant.

At station III the pool habitat showed 12 and riffle part 21 families. The Gastropoda was represented with two families (Planariidae and Planirbidae). The insect families recorded were Perlidae (Plecoptera), Baetidae and Caenidae (Ephemeroptera), Coenagrionidae (Odonata), Coroxidae (Hemiptera) Gyrinidae and Elmidae (Coleoptera), as well as Psychodidae, Simulidae and Chironomidae (Diptera).

Sub class/Order	Family/Taxa	Site 1	Site 2	Site 3	Site 4	Site 5
		Ind/m^2	Ind/m^2	Ind/m^2	Ind/m^2	Ind/m^2
Turbellaria	Planariidae	539	419	63	2	6
Gastropoda	Physidae		3		6	177
	Planorbidae	148		11	6	269
Oligochaeta	Oligochaeta		4			
Plecoptera	Perlidae	41		64		
Ephemeroptera	Baetidae	965	917	992	11	407
	Caenidae	420	303	439	3	92
	Heptageniidae			1		8
Odonata	Aeshnidae	2		6		14
	Libellulidae	2		1	7	18
	Coenagrionidae			4	5	18
	Calopterygidae					15
Hemiptera	Gerridae		6		2	18
	Notonectidae					26
	Corixidae	81	57	17	3	
	Nepidae					1
Trichoptera	Hydropsychidae	24	4	51	3	927
	Philopotamidae			1		3
	Lepidostomatidae	2		5		
	Ecnomidae	5				
	Leptoceridae			1		
	Sericostomatidae					13
Coleoptera	Gyrinidae	40	3	2	8	73
	Elmidae	6		8	1	
	Hydrophilidae			2		
	Psephenidae				6	32
	Dytiscidae	37		2	5	79
Diptera	Tipulidae	196	280	170		6
	Psychodidae		9	1	1	7
	Simuliidae	11	1022	56		
	Chironomidae	78	66	277	91	117
	Ceratapogonidae			4		
	Muscidae				1	3
	Tabanidae			1		18
Lepidoptera	Pyralidae					2

Table 1: *Taxa identified from the five sampling sites.*

The gastropod families, Planariidae and Physidae were found of which Planariidae. In the riffle site 21 families of insects were observed with more representatives the orders Trichoptera, Coleptera and Diptera.

In Dabo spring (station IV), pool site three families (Planariidae, Physidae and Planorbidae) of gastropods and 8 families of insects were present. A total of 12 families were found in the riffle. The number of insect families belonging to the order Ephemeroptera and Diptera were reduced. In Awash Dabo stream (station V) the pool habitat showed the presence of 19 families of invertebrates of which 16 were insect families. The family Baetidae was the most dominant at all stations the highest percentage followed by Caenidae and Simulidae among the insect families.

Numerical abundance of major orders of class Insecta

The benthic macro invertebrate population density showed marked variations in the riffle and pool sections within each sampling sites [Table2]. There were members of the class Insecta occurred in the samples falls under 7 orders. The different life stages of these insects were observed in all the sampling sites. The population density of the order Plecoptera was the least ranging from (0.95% to 3.81%) when present.

Order	StationI		StationII		Station III		StationIV		StationV	
	pool	Riffle	pool	Riffle	pool	Riffle	pool	Riffle	pool	Riffle
	%	%.	%.	%	%	%	%	%	%	%
Plecoptera	0.95	3.34			3.81	2.14				
Ephemeroptera	75	70.51	86.28	21.19	71.42	67.08	18.2	6.98	21.98	28.13
Odonata	0.32				0.4	0.54	20.5	4.44	13.92	0.79
Hemipetra	6.46	2.09	6.06	0.18	1.49	0.14	6.81	1.59	11.72	0.06
Trichoptera		3.03	2.37	22.18		4.51	2.27	1.27	9.89	59.43
Coleoptera	7.76	0.8		0.16	1.32	0.74	29.6	5.4	31.78	4.4
Diptera	9.49	20.22	5.29	56.29	21.54	24.84	22.7	80.32	10.71	7.19

Table 2: *Percentage composition (mean) of insect orders at the five stations.*

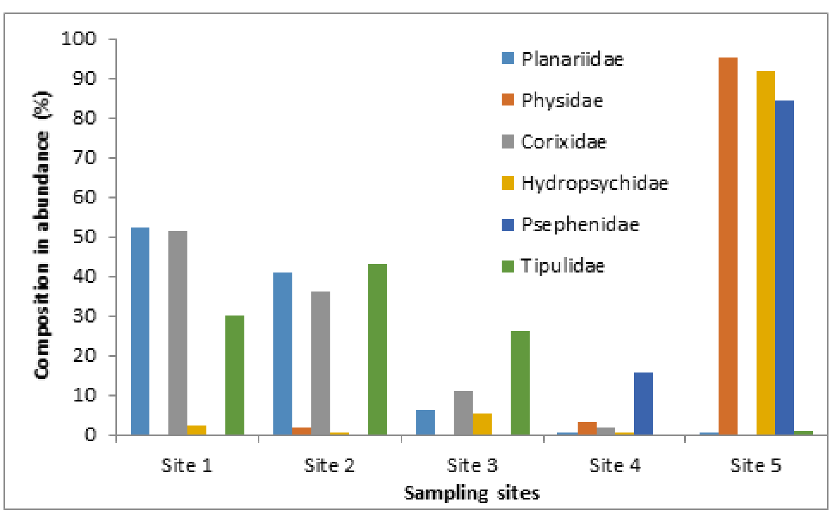

Figure 2: *Distribution of selected indicators at the sites (in % of total ind./m²).*

The orders Ephemeroptera, Diptera and Hemiptera were found throughout the study period at all stations and habitat types [Table 2]. Ephemeroptera was highly significant in terms of their percentage composition at stations I, II, III and V. The highest 86.28% was found in the pool at station II. The order Coleptera was more abundant in the pools of stations IV (29.6%) and V (31.78%) while their number was very less in other stations. The percentage composition of the Order Odonata was high at station IV (20.5%) and V (13.92%) pool sites and order Tricoptera at station V (59.43%) and II (22.18%) riffle section. The families of insects Corixidae, Planariidae and Tipulidae decrease dramatically with increasing anthropogenic influence, while the beetles Psephenidae, the caddisfly family Hydropsychidae and the snails Physidae showed increasing densities (Station V).

The Hilsenhoff family biotic index is a weighed measure of individuals in a population. During the period of study the number of individuals in family (family richness) showed considerable variation between the different habitats [Table 3]. Station IV had relatively higher H –FBI index (5.76) followed by station III (4.96), station II (3.99), station V (3.75) and station I (3.2).

Metrics	Station I	Station II	Station III	Station IV	Station V
Taxa richness	17	13	23	17	25
Abundance(individuals/m^2	2597	3093	2179	161	2349
Hilsenhoff Family Biotic Index (H-FBI)	3.2	3.99	4.96	5.76	3.75
% EPT	56.1	39.6	71.3	10.6	61.1
% Chironomidae	3	2.1	12.7	56.5	4.9
ETHbios	80	57	120	68	102
ASPT (ETHbios)	6.7	5.2	6.3	4.53	4.86

Table 3: *Biotic indices calculated from sampling sites.*

The Percentage of Ephemeroptera, Plecoptera, Trichoptera index (% EPT) was maximum at station III (71.3%) and lowest at station IV (10.6%) indicating the level impact of human interventions. The percentage of Chironomidae was very high at station IV (56.5%) followed by station III (12.7%).In the other sites the population of chironomids was very much reduced.

The results on the ETHbios index indicated that Station III had the highest sensitivity score (120) followed by station V (102).The lowest score was obtained for station II (57). The ASPT value was comparatively high for station I (6.67) and III (6.31) and least for station IV (4.53).

Environmental parameters

The water quality parameters measured (mean) in the field and laboratory during the sampling period from February to April are presented in [Table 4].The mean atmospheric temperature was high (21.07 ± 1.81°C and 21.02 ± 0.43°C) at stations I and V. The water temperature was in general less than the atmospheric temperature. However, the temperature recoded at station IV was (22.73 ± 2.05°C) high and the lowest (18.7 ± 1.35°C) were recorded at station II (Arera spring). The pH of water at all stations was alkaline in nature ranging from 8.1 ± 0.45 at Dabo spring and 8.53 ± 0.08 at Station V. There was very little variation in pH at stations II and III. The lowest mean dissolved oxygen value (6.32 ± 0.4 mg/l) was observed at Awash I stream and the highest (8.62 ± 0.28 mg/l) at station IV.

The dissolved oxygen saturation was comparatively low at Awash I stream (93.92 ± 5.95%) and maximum (128.6 ± 0.89%) at Dabo spring. The highest dissolved oxygen concentration (DO) was observed at station V (8.62 ± 0.28) and the lowest dissolved oxygen concentration (DO) was observed at station III (6.32 ± 0.4). The electrical conductivity of water was a useful indicator of its salinity or total salt content. The maximum conductivity value (561.19 ± 4.01) was observed at station IV and the minimum (175.45 ± 4.87) at Station II. The biological oxygen demand of the water was carried out for 5 days incubation .The highest BOD5 level of the water (4.91 ± 0.04) was recorded at station V and the least value (0.51 ± 0.03) for station III.

Parameters	Site 1	Site 2	Site 3	Site 4	Site 5
Temperature (^oC)	19.23 ± 0.93	18.7 ± 1.35	19.7 ± 1.37	22.73 ± 2.05	19.4 ± 0.52
pH	8.38 ± 0.15	8.51 ± 0.34	8.52 ± 0.1	8.1 ± 0.45	8.53 ± 0.08
Dissolved Oxygen (mg/l)	6.39 ± 0.18	7.37 ± 0.39	6.32 ± 0.4	8.04 ± 0.06	8.62 ± 0.28
Dissolved oxygen (%)	98.86 ± 2.71	104.17 ± 5.49	93.92 ± 5.95	128.6 ± 0.89	121.55 ± 3.95
Conductivity (μS/cm)	175.45 ± 4.87	230.74 ± 12.43	281.9 ± 25.78	561.19 ± 4.01	348.33 ± 37.1
BOD5(mg/l)	0.91 ± 0.03	1.26 ± 0.07	0.51 ± 0.03	4.91 ± 0.04	1.52 ± 0.05
NH_4-N(mg/l)	0.49 ± 0.21	0.21 ± 0.07	0.35 ± 0.07	0.35 ± 0.21	0.14 ± 0
NO_3-N(mg/l)	0.77 ± 0.07	0.7 ± 0.14	0.56 ± 0.28	5.09 ± 0.16	0.21 ± 0.07
Total Phosphorus(mg/l)	0.03 ± 0.01	0.05 ± 0.02	0.03 ± 0.01	0.03 ± 0.01	0.04 ± 0.02

Table 4: *Mean and standard deviation of environmental parameters in the five sampling sites.*

The ammonia nitrogen (NH4+N) content was high (0.49 ± 0.21 mg/l) at station I (Warabo spring) and lowest (0.14 ± 0 mg/l) at Station V (Awash Dabo stream). The nitrate nitrogen (NO3-N) in the water was very high at station IV (5.09 ± 0.16 mg/l) and low at station V (0.21 ± 0.07 mg/l).The total phosphorus concentration in the water varied from (0.03 ± 0.01 to 0.05 ± 0.02) in the study sites. However, the variations are not significant. The slightly highest value was observed from Station II (0.05 ± 0.02) and the lowest value from stations I, III and IV.

Discussion

The benthic fauna in the spring and stream habitats of upper Awash River showed significant variations in the abundance and composition in the selected study sites during the sampling months. In general, pool habitats showed less population density and family richness than riffle. In the riffle section microlithal, mesolithal and macrolithal habitat combined with organic habitats such as plant roots and fallen leaves were dominant which facilitates the suitable substratum for the macro benthos to inhabit. In the pool section the stream bed is dominated by sand and mud habitats where few taxa with special adaption features can survive. Station II had the highest abundance of benthic macro invertebrates followed by station I. The factors that influence the macro benthos include environmental variables, anthropogenic impact, habitat condition, tolerance value of the benthic macro invertebrates and climatic factors. Further, human activities such as cattle watering, washing, domestic waste disposal, agricultural activities could also affects the species composition and abundance of benthos in the rivers and streams [4,5]. Unexpected rain accompanied with short term flooding would may cause drifting of benthic macro invertebrates and only those taxa having ability to attach with different stone type may survive best.

Dissolved oxygen is one of the most important factors determining the quality of spring and stream water. An area with concentrated plant growth had significantly higher levels of dissolved oxygen to support aquatic fauna [15,32] stated that variation in species composition, abundance and diversity of benthic macro invertebrates are significantly related with dissolved oxygen. In general the oxygen content was high at all stations and did not showed wide fluctuation between the sampling months. The dissolved oxygen in the water at all the sampling stations was > 5 mg/l and in the required level for functioning of biological communities [11]. This could be the reason for the richness of the benthic fauna especially in station I and II spring site, where it was a natural forest cover and comparatively less human interventions. Generally, a high DO is an indicator of high state of purity of water and low DO is an indicator of pollution. The observed values in this part of Awash River is higher than the highly impacted sites of Modjo River (6.1 ± 4.01 mg/L) [9] and Great Akaki river (3.1 ± 2.4 mg/l) [14].

Temperature was an important physical property of water because it regulates the amount of dissolved oxygen, the rate of decomposition of organic matter, photosynthesis and ionization of ammonia [13]. Natural variation in water temperatures mainly occur in response to seasonal and regional climate. The temperatures recorded at all stations were found to be within a range of WHO (1995) guideline values (12-25^{0}C) for fresh water bodies. During this study, the mean water temperatures of the five stations of the study site were between (18.7 ± 1.35 and 22.73 ± 2.05) respectively, these variations are in conformity with the earlier guidelines of WHO [31]. Therefore, the maximum mean water temperature recorded at station IV (22.73 ± 2.05) may be influenced by the absence of forest cover and the least mean value recorded at station II (18.7 ± 1.35) is related to the presence of a natural forest cover and had a channel canopy of riparian vegetation. The PH values of all of the study stations were within the permissible range for natural water (6.0-8.5). The pH value recorded in all stations meet the EPA (2003) standards for surface water (6.0-9.0). Conductivity was a numerical expression of the ability of an aqueous solution to carry electric current. This ability depends on the presence of ions, their total concentration, mobility, valence, relative concentration and temperature.

According to [11], the electrical conductivity in fresh water range between 10-1000 μs/cm for surface waters. The values observed at all stations were lower than the values (910.2 + 186.6 μS/cm) [9] from River Modjo. Conductivity of the water can be influenced largely by geology since it was highly influenced by mineral salts. Increase in conductivity possibly occurs as additional wastes containing ions that enter the stream. In general, the electrical conductivity was increased from less impacted area to more impacted area and inversely decreased from station V to station I.

The conductivity of station IV (561.19 ± 4.01) was the highest, shows that electric conductivity increases with increase in anthropogenic impact or human activities. This might be due to domestic sewage rich in nutrients enriches the electrolytes from nearby areas or mineralization of sediment. Generally, a high DO was an indicator of high state of purity of water and low DO was an indicator of pollution. Conversely, a high BOD indicates that the water is polluted; whereas a low BOD indicates high water quality [1]. The average BOD5 value was found high at Dabo spring and Awash Dabo stream where human activities were more. Biological Oxygen demand values can be affected by respiration of algae in the sample presence of nitrifying bacteria and toxic substances in the sample that affect the microbial activity. The consequences of high BOD5 were the same as those for low dissolved oxygen: aquatic organisms become stressed, suffocate, and die [3].

In most natural waters, phosphorus ranges from 0.005 to 0.02 mg/L. Concentration as low as 0.001 mg/L may be found in some pristine waters and as high as 200 mg/L in some enclosed saline waters [11]. The phosphorous concentrations recorded in springs and streams of upper Awash Chilimo site were higher than concentrations in most natural waters (0.005 to 0.02 mg/l. Small amount of phosphate (to the level of 0.01 mg/L) can have measurable effect on aquatic communities [29]. According to [24] the phosphate mean values recorded at Guder River (0.85 ± 0.08) was above the concentration in natural waters (0.005 to 0.02 mg/l). The high level of phosphorus may be due to the weathering of rocks and the influence of land drainage from the agricultural plots situated on the sides of the sampling stations. Also the value of PO4 was found to negatively influence the Plecoptera population at Stations III and IV.

The nitrate-nitrogen (NO3-N) concentrations recorded during the sampling periods in all stations were below the maximum limit (5 mg/l) for the fresh water aquatic organisms to survive and that cause adverse effects on aquatic system [11]. Concentration of NO3-N at station IV alone was above this standard value; however it was not enough to limit the survival and growth of benthic organisms, since the highest species diversity was observed at this station. It was inferred that this high value could be due to the mixing of domestic wastes and land drainage from the surrounding areas. A nitrate level over 5 mg/L in natural waters normally indicates human intervention in the form of fertilizers, livestock, urban runoff, septic tanks, and waste water discharges. In general, nitrates are less toxic to human than ammonia or nitrite however at high levels nitrate will become toxic especially to infants [11].

Although physico-chemical parameters measured in the present study reflect the condition of the water bodies at the time of sampling, all parameters did not show degradation of environmental condition to affect the benthic community structure. However slightly high BOD_5 and conductivity in site IV may be due to the presence of significant organic matter in the water column coming from the nearest farmland or in stream activities unlike other upstream springs flowing through Chilimo forest. This is also confirmed by the absence of sensitive taxa such as Perlidae and Heptagenidae and low abundance of moderately sensitive taxa such as Baetidae, Caenidae and Elmidae at this site. A higher benthic macro invertebrate taxa diversity was recorded in stream sites (III and V) than spring sites (Station I, II & IV) irrespective of the human activities. This could be explained in terms of low water volume in spring sites and reduced microhabitat availability to host diverse BMI.

Benthic macro invertebrate metrics/indices indicate sign of water degradation at site IV (Dabo spring) compared to other study sites. Low percent of EPT (Ephemeroptera, Plecoptera and Trichoptera) and dominance of chironomidae indicates the presence of organic matter degradation in the spring substrates. Therefore, site IV may require immediate management option such as buffer zone development and minimizing in-stream activities. Although the benthic invertebrate family richness is low at site I and II (springs) abundance of sensitive taxa composition, low Chironomidae abundance and lower H-FBI were observed. This indicates the availability of good ecological conditions with limited micro-habitat diversity which hinders a higher taxa richness. Intensive irrigation, watering of domestic cattle, washing clothes, agriculture activities done nearby areas and flooding were the major factors in determining the abundance, diversity and distribution of benthic macro invertebrates. The extent of this problem was high in station IV and station V, while less in station I, station II and station III. The extraction of water for irrigation was high at station I which decreases the water level.

The reaction of selected taxa to various kinds of environmental stress in the study sites indicated that Corixidae, Planariidae and Tipulidae are sensitive to habitat-characteristics like shading and the associated leave-packs while Hydropsychidae and Physidae gain advantages from higher organic load and the grazer family Psephenidae feeds on periphyton and need high input of radiation. The percentage of dominant taxa (%DT) was increasing from more impacted station V to the least impacted station II, similarly the percentage of Ephemeroptera, Plecoptera and Trichoptera (%EPT) increased from more impacted station to least impacted stations. Conversely, the percentage of Chironomidae (%Chiro) decreased from more impacted station to the least impacted stations. Hilsenhoff-Family Biotic Index (H-FBI) more in the least impacted station decreased towards the more impacted station where agricultural activities were intensively done nearby areas.

Vegetation pattern was the main factor determining the spatial distribution of benthic macro invertebrates [27]. This could be the reason for high numerical density of fauna at spring sites with dense vegetation than the streams.

ETHbios and ASPT values used to classify the water quality based on the benthic faunal group abundance. A high score value of the macro invertebrate indicator taxon indicate high sensitivity to stressors and taxon with low scores indicate high tolerance to stressors [3]. Based on the two indices it was concluded that water quality is of moderate class due to and significant ecological disturbances and hence low level of degradation of the environment.

The large abundance of Chironomidae at stations III and IV is an indication of organic pollution and nutrient enrichment. Chironomidae are good indicator of severe point source pollution [30]. A sample in which greater than 50% Chironomidae suggests eutrophic condition with decreasing in water quality [33]. The abundance of tolerant Chironomidae in stream sites indicates the presence of organic matter which favors some tolerant taxa groups. This finding agrees with the accepted view that tolerant species become abundant in degraded streams and rivers [6,19]. So the present results points that there is water quality degradation in the stream sites but not severe. The percentage of EPT taxa also supports the view that low percentage is indication of increase in human intervention and presence of pollutants since families such as Heptageniidae and Perlidae are sensitive to low oxygen concentrations [28,5]. Organisms in the EPT orders were qualified as indicators of good water quality. The higher the EPT taxa index, the cleaner the stream [25].

At station IV and station V there were less percentage of EPT indicating the low water quality. The H-FBI value result ranges from 3.20 (St I) to 5.76 (St V). The H-FBI values were significantly lower at the reference site and higher at downstream of the study areas. High values of H-FBI were indicative of organic pollution while low values were indicative of clear water [18]. Moderately tolerant species such as Baetidae, Caenidae, Hydropsychidae and Planariidae were numerically dominant in less impaired spring sites and streams which might be because of the availability of nutrient from the catchment at a level to enhance somewhat sensitive taxa diversity. Highly sensitive taxa such as Perlidae was collected only from one spring and one stream flowing through dense forest with good water and habitat quality. This shows agricultural and in-stream activities will lead to extinction of highly sensitive taxa and enhance the abundance and diversity of moderately sensitive and tolerant BMI in both spring and stream sites. Both physico-chemical and biological parameters considered in the present study revealed that springs and streams inside the Chilimo forest have good water quality and undisturbed ecological condition than the downstream stations.

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References

1. Ademoroti CMA. "The effect of pH on purification". *Effl. Reat.Wat. Jornal* 20.11 (1980): 541- 549.
2. APHA. "Standard Methods for the Examination of Water and Wastewater. 20th Edition". American Public Health Association (1998):
3. 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* (2014): 163.
4. Aschalew Lakew and Moog O. "A multimetric index based on benthic macro invertebrates for assessing the ecological status of streams and rivers in central and southeast highlands of Ethiopia". *Hydrobiologia* 751.1 (2015): 229-242.
5. Aschalew Lakew and Moog O. "Benthic macro invertebrates based new biotic score "ETHbios" for assessing ecological conditions of highland streams and rivers in Ethiopia". *Limnologica* 52 (2015): 11-19.
6. Barbour., *et al*. "Biological Criteria: Technical Guidance for Streams and Small Rivers". (1996):
7. Barbour MT., *et al.* "Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macro invertebrates and Fish, 2nd edn". *Environmental Protection Agency* (1999):
8. Bartram J and Balance R. "Water Quality Monitoring: A Practical Guide to the Design and Implementation of Fresh Water Quality Studies and Monitoring Programmes". *United Nations Environment Programme* (1996): 400.
9. Baye Sitotaw. "Macro invertebrate assemblage structure in relation to land use types and Pollution in some Ethiopian rivers". *Addis Ababa University* (2006):
10. Bogut I., *et al*. "Benthic macro invertebrates associated with four species of macrophytes". *Biologia* 62.5 (2007): 600-606.
11. Chapman D and KimstachV. "Selection of Water Quality Variables. In; Water Quality Assessments. A guide to the use of biota, sediments and water in environmental monitoring". (1996): 243-318.
12. Cochrane SJ., *et al*. "Benthic fauna in the Northern Barents Sea. Norwegian Ministry of Environment". (1998): 33.
13. Colt JE and Tomasson JR. "Hatchery water supply and treatment. Fish Hatchery Management". *American Fisheries Society* (2001): 91-186.
14. Deshu Mamo. "An Assessment of Downstream Pollution Profile of Sebeta River and its Surrounding. MSc. Thesis". *Addis Ababa University* (2004):
15. Findlay EG., *et al*. "Multi-Scale control on Water Quality Effects of submerged Aquatic vegetation in the Tidal Fresh water Hudson River". *Ecosystem* 9.1 (2006): 84-96.
16. Furey C., *et al*. "Littoral benthic macro invertebrates under contrasting drawdown in a reservoir and a natural lake". *Journal of the North American Benthological Society* 25.1 (2006): 19-31.
17. Gerber A and Gabriel MJM. "Institute for water quality studies. Department of water Affairs and Forestry". (2002):
18. Hilsenhoff WL. "Rapid field assessment of organic pollution with a family-level biotic index". *Journal of the North American Benthological Society* 7.1 (1988): 65-68.
19. Karr JR and Chu EW. "Restoring life in running waters". *Better biological monitoring* (1999): 220.
20. Margalef R. "Information theory in ecology". *General systems* 3 (1958): 36-71.
21. Melaku Bekele. "Forest Property Right, the role of the state and institutional exigency: The Ethiopian experience". *Doctoral Thesis* 409 (2003): 227.
22. Mereta S., *et al.* "Development of a multimetric index based on benthic macro invertebrates for the assessment of natural wetlands in Southwest Ethiopia". *Ecological Indicators* 29 (2013): 510-521.
23. Moog O and Sharma S. "Guidance for pre-classifying the ecological status of HKH Rivers". *Deliverable 7b for ASSESS-HKH, European Commission* 27 (2005):

24. Mulugeta Tilahun. "Study on Abundance and Distribution of benthic macro invertebrates in River Guder, Ethiopia". *Thesis Submitted to the Department of Biology* (2012):
25. Perry JB. "Biotic indices of stream macro invertebrates for fun and (educational) profit". *Tested studies for laboratory Teaching* 26 (2005): 281-294.
26. Rosenberg DM and VR Resh. "Introduction to freshwater bio monitoring and benthic macro invertebrates". *Freshwater Bio monitoring and Benthic Macro invertebrates* (1993): 1-9.
27. Scheffer M., *et al.* "Distribution of macro invertebrates in a ditch in relation to vegetation". *Fresh water Biology* 14.4 (1984): 367-370.
28. Thorn JH and Covich AP. "Ecology and Classification of North American fresh water invertebrates". *Academic press Inc* (1991):
29. (USEPA) United State Environmental Protection. "Agency Monitoring and Assessing Wate Quality". (2006): 10.
30. Weigel BM., *et al*. "Macro invertebrate based index of biotic integrity for protection of streams in west-central Mexico". *Journal of the North American Benthological Society* 21.4 (2002): 686-700.
31. WHO. "Water supply and Sanitation operation and maintenance of urban water supply and sanitation systems: A guide for manager". *WHO Bulletin* 63.2 (1995): 273.
32. William J and McClintock N. "Dissolved oxygen concentration and diversity of benthic macro invertebrates in an artificially destratified Lake". *Hydrobiologia* 57.2 (1977): 163-160.
33. Yandor K. "Rapid Bio assessment of Benthic Macro invertebrate illustrates water quality in small order urban streams in a North Carolina Piedmont City". (1998):
34. Zinabu GM and Elias D. "Water resources and fisheries management in the Ethiopian rift valley lakes". *Ethiopian Journal of Science* 12.2 (1989): 95-109.