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THE IMPACT OF WATER QUALITY DETERIORATION ON MACROINVERTEBRATE COMMUNITIES IN THE LAKE TANA, NORTHWESTERN ETHIOPIA: ANALYSIS USING TOLERANCE LEVEL APPROACH

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ABSTRACT:

Lake Tana is a biodiversity reservoir and freshwater supplier that contribut significantly to the economy of Ethiopia and downstream recipient countries (Sudan and Egypt). Due to human activities, water quality and biodiversity of the lake was threatened. Some of the most significant contributors to the lake pollution include domestic sewage, agricultural inputs and outputs, industrial inputs and outputs, silt from the agricultural activity, etc in the catchement. To asses the impact of antropogenic activities of Lake Tana, macroinvertabrates were analysed in dry and wet seasons at 11 sampling sites. In the analysis, litratures indicated that the presence of more Odonata, Coleptera and Hemipteran larvae is the indication of water quality deterioration due pollution. From the collected organisms total numbers of tolerant individuals were 303 (48.2 %) and Facultative individuals were 243 (38.7 %) while intolerant individual organisms were 80 (12.7 %). Most of the taxa (48.2 %) had tolerance scores ranging from 7 to 10. In general, all the sampling stations show the degradation of water quality and thus needs for mitigation measures and management options to save Lake Tana.

KEY WORDS: *Macroinvertebrates; Tolerance; Lake Tana;*

Deterioration; Diversity.

INTRODUCTION:

Currently, Lake Tana faces huge ecological pressure because of different services and products it renders to the surrounding community and even downstream countries, such as Sudan and Egypt (Teshale *et al.*, 2001). Lake Tana feeds the Blue Nile, which in turn, provides about two-thirds of the water supply to the Sudan and Egypt through the Nile system. It also provides some of the water supply for Bahir Dar, and is significant water supply for the rural population around the lake (Howell and Allan, 1994). The quality of the lake water is also being increasingly affected by pollution from point and non-point sources in the region. Pollution is a danger to aquatic macroinvertebrates. Aquatic life is in danger with anthropogenic activities. Anthropogenic activities and high pollution have effect on water bodies and the total environment (Couceiro *et al.*, 2010).

Macroinveratbrates do not respond to all forms of pollution. Some types of macroinverabrates are known to be sensitive to a specific environmental factor such as temperature, dissolved oxygen or nutrient status and others. Due to limited mobility, the presence or absence of invertebrate families reflects conditions at a site over time (Roque, 2013). Macroinvertabrates are sensitive indicators of environmental changes of past as well as present conditions in aquatic ecosystems because they express long-term aswell as short term changes in water and habitat quality (Marius *et al.*, 2014). Macroinvertebrates serve as sensitive early warning indicators of impacts that makes macroinvertebrates attractive water quality tool to predict human influences on aquatic systems (Sanz *et al.*, 2014).

Due to human activities today surface water show a significant degree of pollution in Ethiopia. The rain washes much of the surface pollutants into the surface waters during wet seasons but in the dry seasons the flow towards reciving waters is minimal (Temesgen, 2009).

Lake Tana has suffered much from pollution resulting from silt deposition, organic and inorganic chemicals load from the catchment and it has been invaded by water hyacinth (*Echhornia crassipes)*. Both of these factors have severely affected the ecosystem of Lake Tana (Habiba, 2010). As a result of deterioration of the ecosystem, the water quality and biodiversity of Lake Tana degraded. Thus, to restore and maintain the biological integrity of the Lake Tana should be monitored (Baye, 2006). So, the macroinvertebrates tolerance level analysis and the biological communities can provide an ideal indicator response serving as a pertinent measure for water quality goals and resource use of Lake Tana. Hence, analysis of Lake Tana water quality using macroinveretbrates tolerance approach is of great importance to meet the ecosystem function goals and requirements. Therfore, this study aims to analyse the impact of anthropogenic activities on the water quality of Lake Tana, Northwestern Ethiopia using tolerance level of macroinvertebrates.

MATERIALS AND METHODS:

The study was conducted in Lake Tana located between 37 ^{0} 00'-37^{0} 20' East Longitude and 11^{0} 37'-12^{0}00' North Latitude (Shimelis *et al*., 2011). It is situated in the north-western highlands of Ethiopia in the Tana sub basin with a watershed of 16,500 km^{2}, of which about 20% is covered by the lake water (Dessalegn *et al.*, 2013; Stave *et al*., 2017). The Tana sub-basin is found in the Amhara Regional State, bordering West Gojam, North Gondar and South Gondar (Gebremedhin *et al.*, 2013). It is the largest lake in Ethiopia accounting for 50% of the total inland water (Mohammed *et al*, 2011). There are 37 islands in the lake, many of which are with ancient churches that form the craddle of the Ethiopian Orthodox Church and with colonies of birds. In their churches and monasteries beautiful old scriptures and scrolls are kept (Misganaw and Getu, 2016).

Lake Tana forms the head waters of the Blue Nile which contributes more than 80% of the water of the Nile River (Gizachew *et al*., 2015). Lake Tana is rich in biodiversity with many endemic species and the trophy level is based on macroinvertebrate community structure (Shimelis *et al*., 2011).

This study was conducted in five study areas; two urban areas are Bahir Dar study area and Gorgora study area. Bahir Dar study area is expected to be highly impacted and Gorgora town minimally impacted. The other category is two agricultural areas, Megech study area that was expected to be highly impacted and Tana Kirkos study area expected to be minimally impacted and Ambobahir study area is a reference site with less impacted and used for comparison of impacted areas with less impacted areas. Sampling areas are in the region bounded by latitudes 11°35'42.24''N to 12°16'51.68''N and by longitudes 37°19'23.14''E to37°29'37.31''E (GPS coordinates) (Figure 1).

Sampling sites:

For this study, samples were taken from Lake Tana in Bahir Dar study area sampling sites of Kuriftu, Tana Transport and Tana Hotel; Gorgora study area sampling sites: Gorgora hotel, Gorgora Transport and Debresina; Tana Kirkos study area sampling sites were Tana kirkos and Gumara; Megech study area sampling sites, Megech inlet and Megech east and Ambobahir study area a reference site with a sampling site Ambobahir. Samples were collected two times at each site seasonally at wet season and dry season.

Samples were taken at regular intervals seasonally in wet and dry seasons and 11 sampling points were determined in Lake Tana at five study areas to determine regional and seasonal variation in different sites (APHA, 2005).

Sample Collection:

Macroinvertebrates were collected to provide a quantitative and qualitative description of the community composition of Lake Tana at all sampling sites in the wet and dry seasons for one year used for comparison based on macroinvertebrates field guide (Gerber and Gabriel, 2002; Bouchard, 2004; Javier *et al.*, 2011). Macroinvertebrate samples were collected by using a standard aquatic Scoop net and identified using macroinvertebrates field guide.

The collected macroinvertebrates tolerance was valued based on Hisenhoff tolerance value to each sampling sites (the reference and impacted sites). Percent Composition of macroInvertebrates and family Tolerance values was analysed by using Excel spreadsheet, 2007

RESULT AND DISCUSSION:

Macroinvertebrates Tolerance

Benthic macroinvertebrate species are differentially sensitive to many biotic and abiotic factors in their environment. Consequently, macroinvertebrate community structure has commonly been used as an indicator of the condition of an aquatic system called tolerance (Mandaville, 2002). Such organisms have specific requirements in physical and chemical conditions. Changes in presence/absence, numbers, morphology, physiology or behaviour of these organisms can indicate the physical and/or chemical conditions outside their preferred limits. Presence of numerous (abundant) families of highly tolerant organisms usually indicates poor water quality (Jake *et al.*, 2012). Seasonal variability highly affects community structure and productivity because many species of macroinvertebrates have annual (or shorter) life cycles, which culminate in an adult phase during the open-water period. Thus, the presence of mature larvae, pupae or adults (the life stages most useful for taxonomic work) may be short-lived and easily missed if seasonal development rates differ from year to year. In this regard, mid-summer survey dates are chosen (Mandaville, 2002). The study area result is justified by this literature (Appendix 1, 2 and 3).

According to Bouchard (2004) macroinvertebrates used to evaluate water quality are often given a number to represent their tolerance or intolerance to pollution; lower numbers represent intolerance while higher numbers represent increased tolerance. In this regard, values of 0 to 3 are considered indicative of a low tolerance to stress (impairment), value of 4 to 6 a moderate tolerance and values of 7 to 10 a high tolerance (Appendix 2). The pollution tolerance values might be based on only one or a few types of impacts (Hilsonhoff, 1988; Bouchard, 2004). Tolerance values of the macroinvertebrates in Appendix1of the study area is shown in Appendix 2. Therefore, we can evaluate the water quality of the study area based on the tolerance values of the organisms.

The less number of individuals presence of EPT taxa (Ephemeroptera, Plecopetra and Trichoptera) in most of the impacted sites showed indication of water and habitat quality impairment as indicated by Aura *et al.* (2010). At the same time those Ephemeroptera groups found in the study area were with tolerance value 4 and 5 (that shows moderate water quality). The taxa that were found in the impacted sites were in the category of tolerance value more than 4 (water quality moderate to bad, many of the impacted sites were within the category of moderate while the Megech study area (sampling sites) were in the category of worst (Appendix 1).

Plecoptera (stone fly) was represented by two families, Capniidae (nine individuals) only found at S_0 in the wet season and Perlidae found at S_0 (one individual), S_1 (two individuals), S_3 (three individuals) and S_8 (three individuals) in the dry season and at S_4 (three individuals) in the wet season but absent in the other sites (Appendix 1). These families are sensitive as represented by Hilsonhoff tolerance value of one. This showed more credence to the perturbed nature of many of the sampling sites. It has been also reported that plecoptera are very sensitive aquatic insect groups (Blanca *et al.*, 2014). Coleoptera was represented by six families (taxa). The presences of some species of dytiscidae have been reported to indicate moderate water quality with 5 tolerance values as it was studied by Patrick *et al.* (2014). From this, the highest representation of Coleoptera families' composition and their tolerance value rated in the moderate water quality in the study area showed gross pollution effect on Lake Tana.

The more direct evidence to pollution in the study area was the fact that all families of diptera collected were pollution tolerant; especially pollution tolerant family Chironomidae, the most abundant were recorded in site S_2 during the wet season and S_9, S_1, S_2 and S_3 during the dry seasons, with decreasing rate. In view of this, this group can be used as pollution tolerant order owing to the fact that they were highly abundant and represented of this study area (Appendix 2 and 3).

Total numbers of tolerant individuals were 303 (48.2%) and intermediate or facultative individuals were 243 (38.7%) while intolerant individual organisms were 80 (12.7%). Most of the taxa (48.2%) had tolerance scores ranging from 7 to 10, while 38.7% of taxa had intermediate/ Facultative tolerance scores between 4 and 6 and 12.7% taxa had tolerance scores of less than 4 (Appendix 3). This showed that Lake Tana is polluted including the reference site.

The less abundance of intolerant EPT taxa (Ephemeroptera, Plecopetra and Trichoptera) in impacted sites showed that there is indication of water and habitat quality impairment or degradation (Marius *et al.*, 2014). However, in this study the reference site taxa richness is proportional with the summation of impacted sites that showed impairment at the reference site (13 taxa and 20 taxa in the wet season and 24 taxa and 32 taxa in the dry season respectively). Seasonal variations are important in macroinvertebrate community composition. This was the realty in the study area. The dry season composition was more than the wet season. Consequently, the period of sampling might affect the evaluation of sampling sites as indicated by Tanya *et al*., (2014).

The family Baetidae (mayfly) taxon collected in this study is moderately tolerant. This family is known to increase with moderate pollution as reported by Tanya *et al*., (2014). Therefore, the low scores at the impacted sites could indicate highly impaired ecological condition (at S_5, S_6 and S_7). Higher percent mayflies at the reference sites indicated moderate pollution known by moderately tolerant. Chironomidae is among the tolerant families of dipteran taxa being more tolerant (Amanuel, 2011).

Higher scores of percentage tolerant organisms at the reference site testify the presence of few tolerant organisms. The impacted sites scores show higher proportion of tolerant organisms, which in turn testify higher ecological impairment since percent tolerant organisms tend to increase with perturbation (Barbour *et al*., 2002; Amanuel, 2011).

CONCLUSION:

Lake Tana was found to be polluted and suffered from anthropogenic activities. The survival of the lake has become impossible mainly due to rapid population growth and anthropogenic destruction. Lake Tana has also had its share of destruction due to pollution from nearby industries, agricultural activities and sewage inflow from residential areas (Urban and rural). The Lake and its surrounding areas are fragile ecosystems that face increasing threats from water abstraction of anthropogenic activities.

This study has highlighted the various macroinvertabrate tolerance of Lake Tana. Seasonal variations in water quality were also observed. The current study has revealed that there was an undesirable impact on the macroinverabrates of Lake Tana as a result of the discharge of untreated waste from the catchment municipalities, industries and Agricultural activities.

In this study the taxa that were found in the impacted sites were in the category of tolerance value more than 4 (water quality moderate to bad, many of the impacted sites were within the category of moderate while the Megech study area (sampling sites) were in the category of worst. This showed that Lake Tana is polluted including the reference site. Higher scores of percentage tolerant organisms at the reference site testify the presence of few tolerant organisms. The impacted sites scores show higher proportion of tolerant organisms, which in turn testify higher ecological impairment since percent tolerant organisms tend to increase with perturbation. The results indicate the need for immediate actions to improve the environmental conditions and achieve the “Good” ecological potential of Lake Tana.

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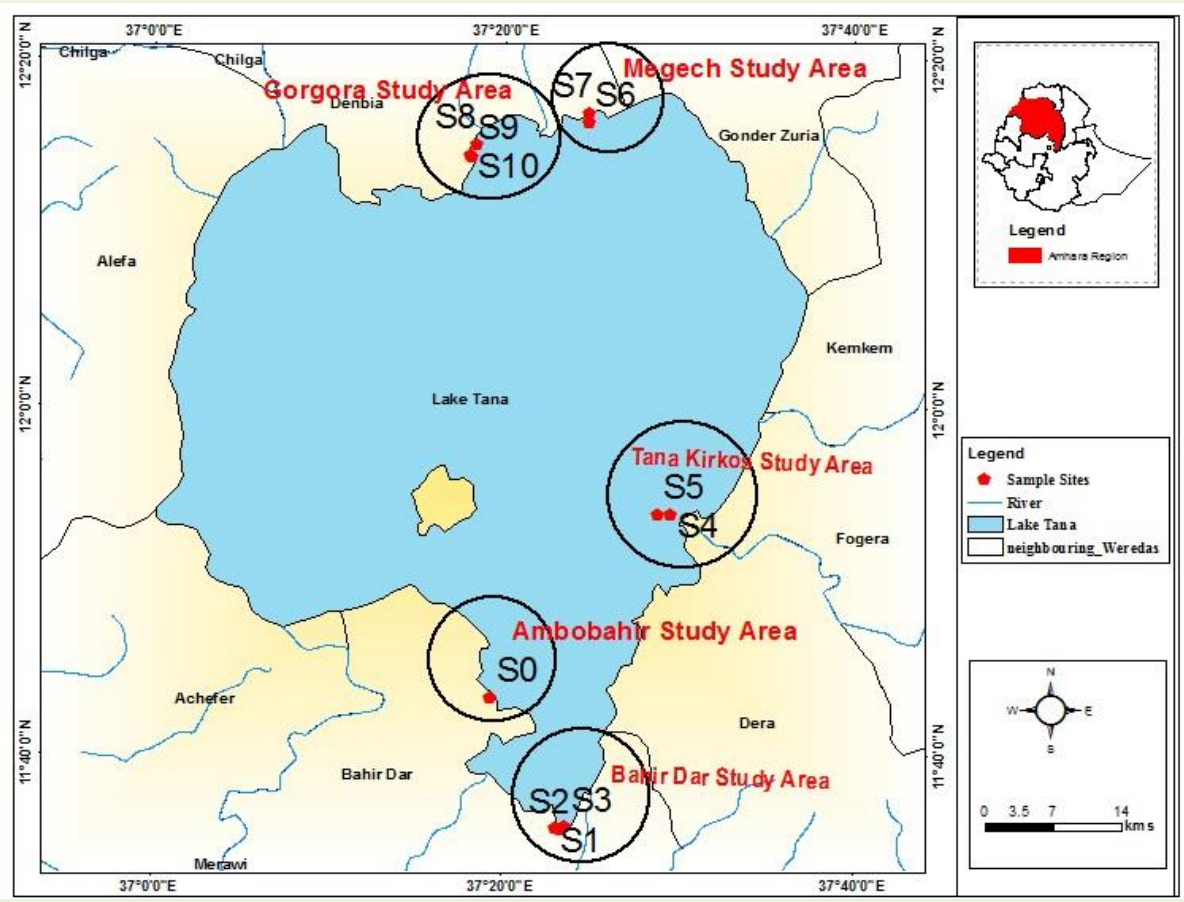

Figure 1. Map of Lake Tana showing study areas (Source: The researcher Coordinate Data

Appendix 1: Macroinvertabrate parameters of 11 sites in wet and dry season of Lake Tana water

Taxa	Ambobahir		Bahir Dar Study area (S.A)						Tana Kirkos S.A				Megech S.A				Gorgora S. A					
Families	**Wet**	**Dry**	**Wet**	**Dry**	**Wet**	**Dry**	**Wet**	**Dry**	**Wet**	**Dry**	**Wet**	**Dry**	**Wet**	**Dry**	**Wet**	**Dry**	**Wet**	**Dry**	**Wet**	**Dry**	**Wet**	**Dry**
	S_0	**S_0**	**S_1**	**S_1**	**S_2**	**S_2**	**S_3**	**S_3**	**S_4**	**S_4**	**S_5**	**S_5**	**S_6**	**S_6**	**S_7**	**S_7**	**S_8**	**S_8**	**S_9**	**S_9**	**S_{10}**	**S_{10}**
Ephemeroptera/Mayflies																						
Baetidae	1	16	0	1	0	17	0	2	2	0	0	0	0	0	0	0	0	2	0	0	2	0
Caenidae	1	1	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Heptageniidae	0	2	0	0	2	0	5	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Plecopetra/Stoneflies																						
Perlidae	0	1	0	2	0	0	0	3	3	0	0	0	0	0	0	0	0	3	0	0	0	0
Capniidae	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trichoptera/Caddisflies																						
Hydropsychidae	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Arachinida/Water mites																						
Hydracarina	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Odonata/Damselflies																						
Aeshinidae	0	3	0	2	0	2	0	5	5	0	0	0	0	0	0	0	5	0	0	0	0	0
Calopterygidae	8	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coenogrionidae	42	22	4	0	20	0	9	3	1	0	0	0	0	0	0	0	0	1	3	1	0	1
Gomphidae	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lestidae	3	1	0	1	0	0	0	2	0	0	0	0	0	0	0	0	0	1	0	0	0	2
Coleoptera/Beetles																						
Dytiscidae	1	1	0	2	13	0	10	2	0	0	0	0	0	0	0	2	6	0	12	23	9	0
Elimidae	0	1	0	2	0	0	0	0	0	0	0	0	4	0	0	0	0	1	0	3	0	0
Gyrinidae	2	1	11	0	0	0	2	1	7	0	0	0	0	0	0	3	0	11	0	0	1	0
Haliplidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0
Hydrophilidae	0	1	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Psephenidae	4	1	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	2	2
Diptera/Two winged or"True flies"																						

Ceratopogonidae	2	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chironomidae	0	0	0	3	12	1	0	1	0	0	0	0	0	0	0	0	0	0	0	6	0	0
Culicidae	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	1	0	1	0	0
Muscidae	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Psychodidae	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Simuliidae	0	0	0	0	0	1	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tabanidae	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tipulidae	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hemiptera/Water or true bugs																						
Belostomatidae	0	8	0	0	8	0	0	0	4	0	0	0	0	0	0	0	0	27	0	0	0	0
Corixidae	0	3	0	0	9	0	0	0	0	0	0	0	0	0	0	0	0	0	9	2	8	10
Gerridae	1	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	5	0	0	2
Hydrometridae	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Naucoridae	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0
Nepidae	0	1	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Notenoctidae	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	16	2	6	0
Pleidae	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Velidae	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Mollusca/Snails																						
Physidae	0	0	1	0	2	0	2	0	0	0	0	0	0	0	0	0	3	0	2	4	0	3
Planorbidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Corbiculidae	0	0	0	1	0	0	0	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Taxa	13	24	3	12	6	8	7	16	7	0	0	0	2	1	0	2	5	12	6	10	6	10
Total Abundance	61	90	16	19	64	29	32	60	23	0	0	0	6	2	0	5	17	55	47	48	28	27
Total Individual Organisms																						629

Appendix 2: Tolerance values of macroinvertebrate families collected at all sites of Lake Tana *as cited by Sisay (2017)*

Order	Family	Tolerance	Reference
Coleoptera (Beetles)	Dytiscidae (Predaceous Diving Beetles)	5	Bode *et al*. (1996)
	Elimidae (Riffle Beetles)	5	Hauer & Lamberti (1996) Bouchard *et al (* 2004)
	Gyrinidae (Whirligig Beetles)	4	Bode *et al*. (1996)
	Haliplidae (Crawling Water Beetles)	5	Hilsenhoff (1988) Bode *et al*. (1996)
	Hydrophilidae (Water Scavenger Beetles)	5	Hilsenhoff (1988) Bode *et al*. (2002)
	Psephenidae (Water penny beetles)	4	Hauer & Lamberti (1996)
Diptera (Two winged or''True flies'')	Ceratopogonidae (Biting Midges)	6	Hilsenhoff (1988) Bouchard *et al.* (2004)
	Chironomidae (Blood-red, including pink)	8	Hilsenhoff (1988)
	Chironomidae (Non-Biting)	6,1,2,4	Bode *et al*. (1996)
	Culicidae (mosquitoes)	8	Hilsenhoff (1988)
	Muscidae (House Flies)	6	Hilsenhoff (1988)
	Psychodidae (Moth Flies)	10	Hilsenhoff (1988) Hauer & Lamberti (1996)
	Simuliidae(black flies)	6	Hilsenhoff (1988) Hauer & Lamberti (1996)
	Tabanidae (Horse Flies, Deer Flies)	6	Hilsenhoff (1988) Hauer & Lamberti (1996)
	Tipulidae (Crane flies)	3	Hauer & Lamberti (1996)
Ephemeroptera (Mayflies)	Baetidae (Small Minnow Mayflies)	4	Hilsenhoff (1988) Hauer & Lamberti (1996)
	Caenidae (small square –gill Mayflies)	7	Hilsenhoff (1988) Bouchard *et al*. (2004)
	Heptageniidae (Flathead Mayflies)	4	Hilsenhoff (1988) Hauer & Lamberti (1996)
Hemiptera (Water or true bugs)	Belostomatidae	10	Bode *et al*. (1999)
	Corixidae (water boatmen)	9	Hilsenhoff (1988)
	Gerridae (water Striders)	8	Hilsenhoff (1988)
	Hydrometridae (Marsh treaders)	5	Barbour *et al*. (1999)
	Naucoridae (Creeping Water Bugs)	5	Barbour *et al*. (1999)
	Nepidae (Water scorpion)	8	Barbour *et al*. (1999)
	Notenoctidae (back swimmers)	2	Tanya *et al*. (2014)
	Pleidae (Pigmy backswimmers)	Undetermined	Barbour *et al*. (1999)
	Velidae (Broab-Shouldered Water Striders)	6	Barbour *et al*. (1999)
Mollusca (Snails)	Physidae	8	Barbour *et al*. (1999)

	Planorbidae	6	Hilsenhoff (1988)
	Corbiculidae (basket clams)	8	Bode *et al*. (1996)
Odonata (Damselflies &Dragonflies)	Aeshinidae (Darner Dragonflies)	3	Hilsenhoff (1988) Hauer & Lamberti (1996)
	Calopterygidae (Broad-Winged Damselflies)	5	Hilsenhoff (1988) Hauer & Lamberti (1996)
	Coenogrionidae (Narrow-Winged Damselflies)	9	Hilsenhoff (1988) Hauer & Lamberti (1996)
	Cordulegastridae (Spke-Tail Dragonflies)	3	Hilsenhoff (1988) Bouchard *et al*. (2004)
	Gomphidae (Club-Tail Dragonflies)	1	Hilsenhoff (1988) Hauer & Lamberti (1996)
	Lestidae (Damselflies)	9	Hauer & Lamberti (1996)
Plecopetra (Stoneflies)	Perlidae (Common Stoneflies)	1	Hilsenhoff (1988)
	Capniidae (Small Winter Stoneflies)	1	Hauer & Lamberti (1996)
Trichoptera (Caddisflies)	Hydropsychidae (Common Net -Spinner Caddisflies)	4	Hilsenhoff (1988)
Lepidoptera	Hydracarina (Water mites)		

Appendix 3: Composition of macroInvertebrates and family Tolerance values collected at all sites of Lake Tana

Order	Family	Tolerance	No. of Individuals	% of Compos -ition
Coleoptera (Beetles)	Dytiscidae (Predaceous Diving Beetles)	5	81	12.9
	Elimidae (Riffle Beetles)	5	11	1.8
	Gyrinidae (Whirligig Beetles)	4	39	6.2
	Haliplidae (Crawling Water Beetles)	5	5	0.8
	Hydrophilidae (Water Scavenger Beetles)	5	6	1
	Psephenidae (Water penny beetles)	4	11	1.8
Diptera (Two winged or''True flies'')	Ceratopogonidae (Biting Midges)	6	4	0.6
	Chironomidae ((Non-Biting, Blood-red, including pink)	8	23	3.7
	Culicidae (mosquitoes)	8	4	0.6
	Muscidae (House Flies)	6	2	0.3
	Psychodidae (Moth Flies)	10	3	0.5
	Simuliidae(black flies)	6	5	0.8
	Tabanidae (Horse Flies, Deer Flies)	6	2	0.3
	Tipulidae (Crane flies)	3	2	0.3
Ephemeroptera (Mayflies)	Baetidae (Small Minnow Mayflies)	4	43	6.8

	Caenidae (small square –gill Mayflies)	7	7	1.1
	Heptageniidae (Flathead Mayflies)	4	10	1.6
Hemiptera (Water or true bugs)	Belostomatidae	10	47	7.5
	Corixidae (water boatmen)	9	41	6.5
	Gerridae (water Striders)	8	10	1.6
	Hydrometridae (Marsh treaders)	5	2	0.3
	Naucoridae (Creeping Water Bugs)	5	4	0.6
	Nepidae (Water scorpion)	8	3	0.5
	Notenoctidae (back swimmers)	2	27	4.3
	Pleidae (Pigmy backswimmers)	---------	1	0.2
	Velidae (Broab-Shouldered Water Striders)	6	6	1
Mollusca (Snails)	Physidae	8	17	2.7
	Planorbidae	6	1	0.2
	Corbiculidae (basket clams)	8	31	4.9
Odonata (Damselflies &Dragonflies)	Aeshinidae (Darner Dragonflies)	3	29	4.6
	Calopterygidae (Broad-Winged Damselflies)	5	9	1.4
	Coenogrionidae (Narrow-Winged Damselflies)	9	107	17
	Gomphidae (Club-Tail Dragonflies)	1	1	0.2
	Lestidae (Damselflies)	9	10	1.6
Plecopetra (Stoneflies)	Perlidae (Common Stoneflies)	1	12	1.9
	Capniidae (Small Winter Stoneflies)	1	9	1.4
Trichoptera (Caddisflies)	Hydropsychidae (Common Net -Spinner Caddisflies)	4	2	0.3
Lepidoptera	Hydracarina (Water mites)		2	0.3