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Spatio - temporal distribution and diversity of macro - invertebrates in Lake Chivero.

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Abstract

The study was carried out in Lake Chivero Zimbabwe. The aim of the study was to determine Spatio -temporal distribution and diversity of macro-invertebrates in Lake Chivero .The variables that were being observed were species abundance, species diversity and species distribution. Macroinvertebrates play a key role in the transfer of energy to higher trophic levels, and can constitute the highest proportion in aquatic system. The results indicated differences in species abundances and diversity between sites sampled. Taken together, the results indicated differences in species abundances and diversity between sites sampled in November 2017 to March 2018 once a month on six different sites. The distribution and abundances of macroinvertebrates in lake Chivero showed high abundances of tolerant species, based on the observed results, it is possible to conclude that the Lake is polluted since there is high abundances of tolerant species on sites sampled with the exception of Psephenidae, Moreover Gomidae abundances did not differ at any of the sites (ANOVA: $F_{3,16}$ = 2.545, p = 0.105). All the other species differed significantly at the different sites. Abundances of Choronomidae differed significantly at the different site (ANOVA: $F_{3,16}$ = 26.241, p < 0.001) with abundances different at almost every site (Post-hoc Tukey: p < 0.05 for all comparisons) with the exception of Site A and Site C (Post hoc Tukey: p = 0.984). On species diversity Site E (fig 4.2) had high species diversity with H= (7,2), site B with H= (4,1) <site C with H= (1,3), site D with H= (6,5) site F with H=(3,7).

Keywords: Spatio -temporal distribution, diversity of macro-invertebrates, abundance.

1.0 Introduction

1.1 Background

Stream health assessments using macroinvertebrates are based on the assumed relationships between stream health and the pollution tolerances or habitat preferences of invertebrates. Water is essential to all forms of life and makes up 50-97% of the weight of all plants and animals and about 70% of human body (Allan, 1995). Water is also a vital resource for agriculture, manufacturing, transportation and many other human activities. Despite its importance, water is the most poorly managed resource in the world (Chutter, 1998).

The distribution of benthic macroinvertebrates is largely related to environmental factors (Richards et al. 1993, Tate & Heiny 1995, Benbow et al. 2003), and their communities change both spatially and temporally (Hynes 1970, Townsend & Hildrew 1994).

The distributional pattern of aquatic organisms results from interaction among geomorphology of the stream bed (Wallace & Webster, 1996), land-use (Resh et al., 1988), substrate type (Buss et al., 2004), hydraulic conditions (Statzner et al., 1988), water temperature (Merritt & Cummins, 1996; Townsend et al., 1997) and biological interactions. Jowett (1997) suggests that the generic term "habitat" should be used to describe the physical and chemical components of the stream, which provide the ideal environment for biota colonization. Brown & Brussock (1991) emphasize that despite the obvious differences in water flow, depth and slope between pools and riffles, other less obvious factors (like substrate composition) may also have pervasive influence on their suitability as habitats for macroinvertebrate species. Factors like the size of the particles (coarse or fine), conditions of refuges and the frequency, severity and intensity of disturbances are also critical for macroinvertebrate colonization.

Chemical water tests are limited because they only tell us what's in the water at the specific moment the sample is collected. They don't give an indication of what was in the water an hour ago, yesterday or last week. Every day, macroinvertebrates are surrounded by water and any pollutants that may be in the water. If pollutants were in the water last week or yesterday, the quantity and diversity of macroinvertebrates present would reflect this in the water quality.

Different types of macroinvertebrates have different requirements to survive. Some require cooler temperatures, relatively high dissolved oxygen levels or certain habitats. Other macroinvertebrates may be able to survive in less-than-ideal conditions where there are low dissolved oxygen levels or more sediment or where the water temperature is warmer.Again, there aren't any "bad" macroinvertebrates, but the population present may indicate that there are bad stream conditions in which only the "strong" can survive.

Water quality is closely linked to water use and to the state of economic development (Chapman, Jackson and Krebs, 1996). Ground and surface waters can be contaminated by several sources. In urban areas, the careless disposal of industrial effluents and other wastes may contribute greatly to the poor quality of water (Mathuthu, Mwanga. and Simoro, 1997). Most of the water bodies in the areas of the developing world are the end points of effluents discharged from industries (Mathuthu et al., 1997). Rivers are sources of water for people worldwide and are known to reflect both the climatic and physical characteristics of their catchments . The quantity and quality of clean freshwater depends on the conditions in the river. The ecological health of a river can be expressed in terms of its biological attributes and physico-chemical properties. These components can indicate degradation, transformation and/or improvement.

Competition, in general, is a basic tenet of modern ecology and population biology which tries to explain community and species composition in terrestrial and aquatic ecosystems. Every species has its own functional adaptations and different species have varying relative importance to particular ecological processes. Changes in time, space, and abundances of one species can result in unpredicted responses by other species as they attempt to compensate functionally for changes in the new species (Covich et al. 1999). Pratt and Cairns (1992) stated, "Loss of species may ultimately mean that, for certain conditions, no species in a particular functional category is available. The community and, therefore, the ecosystem are placed into severe disequilibrium because of the loss of one functional group.

Water pollution is a major problem in the global context (Moyo and Worster, 1997). The problem of water pollution is being experienced by both developing and developed countries (Moyo and Worster, 1997). Sewage disposal is of major concern in most urban areas of Zimbabwe. Wastewater from industries and sewage spillages from burst pipes around the country are released into streams and rivers which finally discharge into dams around the cities of Zimbabwe (Moyo and Worster, 1997). With the hard economic situation in the country, most of the trade waste effluents are released into the environment untreated or partially treated (Moyo and Worster, 1997).

Macroinvertebrates are often given a ranking according to how well or badly they tolerate living in water of bad quality and as a result the better the water quality the greater the number of animals that will be present. The tolerance levels are mainly based on organic pollution, such as sewage, high loads of leaf matter, dog feces, or agricultural run-off, which cause lowered oxygen levels. The tolerance levels of the macroinvertebrates groups may vary with other forms of pollution such as toxic metals, pesticides and sediment inputs. Within the group, tolerances of individual species may vary (Arimoro, Iwegbue. and Enemudo, 2008). Most studies on water quality in

Zimbabwe have been concerned with assessing the physio-chemical parameters of water (Mathuthu et al., 1997; Moyo and Worster, 1997, Magadza, 2003, Ndebele, 2009).

(Souleymane & Jean, 2014)Benthic macroinvertebrates, in particular, are used to assess the biological integrity of riverine ecosystems and are considered to be a good reflection of a river's prevalent water quality. They are often the taxa group of choice for biotic indices as they are visible to the naked eye, found throughout the length of the river, easy to collect and identify, have limited mobility and have relatively rapid life cycles. In addition, benthic macroinvertebrate families vary in their degree of sensitivity to organic and inorganic pollution . Thus, their presence or absence can be used to make inferences about pollution levels.

This study investigates the Spatio -temporal distribution and diversity of macro-invertebrates in Lake Chivero Zimbabwe with the objective of pollution mapping. , we establish the Spatio -temporal distribution and diversity of macro-invertebrates in Lake Chivero dam, Zimbabwe. Results of this study extend our knowledge of the role of macroinvertebrates in aquatic ecosystems and may be used to make informed predictions of the changes on the shoreline benthic macro invertebrate of macro invertebrates in lake Chivero.

1.2 Problem statement

The impact of water pollution on human health and ecosystems due to anthropogenic activities is largely known(Moyo and Worster, 1997) . Several studies have been conducted to determine the levels of pollutants (Mathuthu et al., 1997; Moyo and Worster, 1997, Magadza, 2003, Ndebele, 2009) in water bodies and the disturbance they cause in aquatic life . However, little is known on the use of GIS and remote sensing to map the spatial-temporal variation of macro-invertebrates . Thus this study will apply geospatial technologies to map the distribution of macro-invertebrates in Lake Chivero, Zimbabwe.

Water samples are the ground truth, the researcher will use macro-invertebrates as bio-indicators for pollutants. It is known that some thrive in pollution while others prefer clean waters, so the researcher is going to do spot mapping to see the cleaner point's vs pollutant concentrated areas.

1.3 Objectives

1.3.1 Main objective:

To model the spatio -temporal distribution and diversity map of macro-invertebrates in lake Chivero.

1.3.2 Specific objective

- to determine the species diversity of macroinvertebrates in Lake Chivero.
- to determine the spatial distribution of selected macro invertebrates in Lake Chivero.
- to determine the temporal distribution of selected macro invertebrates in Lake Chivero.

1.4 Research questions

1. What is the macro invertebrate community diversity at different sites ?
2. What is the distribution and abundance of macro invertebrates species at different sites ?
3. What factors explain the distribution of macro invertebrates in the Lake

1.5 Research hypotheses

H_0: There is no significant difference in the distribution, abundance and diversity of macro invertebrates in the sites sampled.

H_1: There is a significance difference in the distribution, abundance and diversity of macro invertebrates in the sites sampled.

1.6 Justification

Streams, rivers, wetlands and lakes are home for many small animals called macro-invertebrates. These animals live in the water for all or part of their lives, so their survival is related to the water quality. Macro-invertebrates live in many different places in a water body. Some live on the water's surface, some in the water itself, others in the sediment or on the bottom or on submerged rocks, logs, and leaf litter. Each type of habitat provides a surface or spaces on or within which macro-invertebrates can live. Macro-invertebrates are sensitive to different chemical and physical conditions. If there is a change in the water quality, perhaps because of a pollutant entering the water, or a change in the flow downstream of a dam, then the macroinvertebrate community may also change.(Barbero et al., 2013) Macroinvertebrates are sampled in water bodies because they are useful biological indicators of change in the aquatic systems. Therefore, the richness of macro-invertebrate community composition in a water body can be used to provide an estimate of water body health.

There are on-going studies to determine the ecology of these species and as such no studies to our knowledge have been conducted in Lake Chivero ,Zimbabwe to determine the spatio-temporal distribution of macro invertebrates , this study intends to fill that information gap. This project will help to sustainably manage the aquatic ecosystem in Lake Chivero since the spatio-temporal distribution and diversity of macro invertebrates in Lake Chivero will be known and academically used for further studies,

1.7 Assumptions

- The sampling method will not disturb the distribution of macro invertebrates.
- The sample is representative of the wider macro invertebrate population.
- Sampling effort and duration is standardized across all sample sites.
- Sampling collects individuals located within the sampling frame, not those that enter by drifting from upstream.

Definition of terms

Aquaculture is defined as the active cultivation (maintenance or production) of marine or freshwater aquatic organisms (plants and animals under controlled conditions.

Water quality refers to the physical, chemical biological and organoleptic (taste related)

Properties of water.

Species introduction is the placement of a species by humans into an ecosystem or community

1.8 Scope of the study

This investigation was conducted to determine the spatio-temporal distribution and diversity of macroinvertebrates in lake Chivero during the period of November 2017 to March 2018 once a month respectively . The study is a sample statistic for shoreline benthic macro invertebrates found in the range of 10 meters from the margin of the lake anything beyond that range was not included.

1.9 Limitations

The study was only done in the rainy season such that some macro invertebrates that are active in the non-rainy season were not sampled. Identification of the benthic macro invertebrates was done at order level due to lack of expertise and this underestimates true diversity because order level is too broad.

1.9.1 Study Area

This study was carried out in Lake Chivero, a man-made lake that was created in 1956 and is located about 37 km southwest of the city of Harare, Zimbabwe (Fig. 1). Lake Chivero experiences two major seasons: namely, a hot, wet summer (from November to April) and a cool, dry winter (from May to August) with a hot, dry transitional minor season (from September to October). Sampling during this study only considered one season (from November to April) .

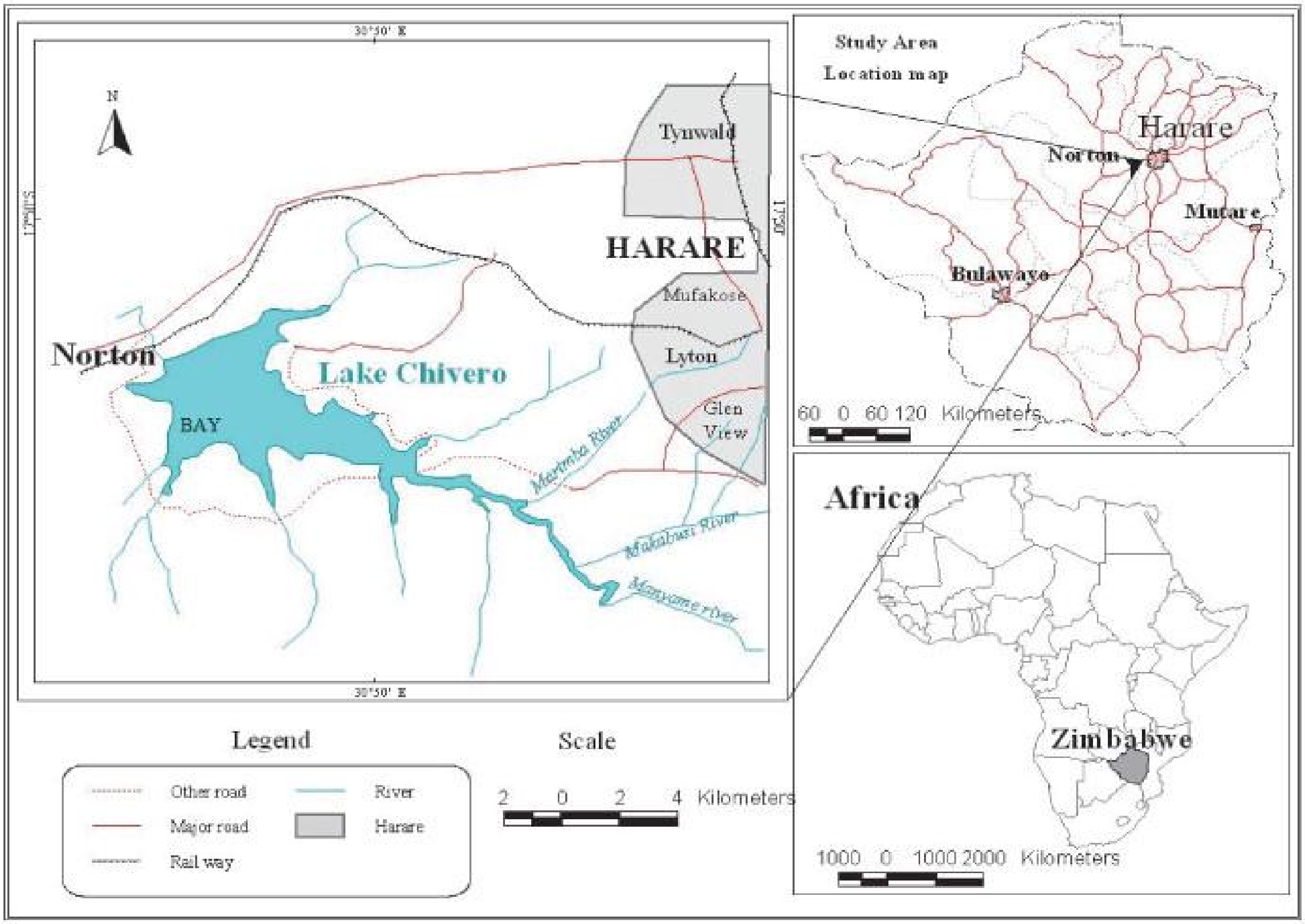


Figure 1 Map of Lake Chivero showing the location of the body where the study was carried out

1.9.2 Climate

The vegetation around Lake Chivero consists of a mosaic of broad leaved deciduous woodland, bush land thickets, and open grassland. *Brachystegia speciformis* and *Julbernadia globiflora* dominate the woodland, whereas the bush land is dominated by *Terminalia Sericea*. Open grassland areas are dominated by *Hyparrhenia filipendula* and *Hyperthelia dissoluta* (Vincent and Thomas 1960). The soils are two main types, dark reddish-brown, heavy textured, fertile soils from the basement complex and medium grained light granite soils (Vincent and Thomas 1960). The vegetation is almost entirely miombo woodland. The original woodland particularly on the north bank was cleared for tobacco farming in the past but has been regenerating over the past years until recent years when settlements due to the land reform resurfaced. Interspersed among the woodlands are many large wooded anthills and areas of grassland. The Lake margins have many patches of reed *Phragmites.* The waters of the lake have been invaded by several weeds including the non-native *Eichornia crassipes* and also *Pistia*, *Myrophyllum*, *Lagarosiphon*, *Azolla* and green algae. High nitrogen levels have contributed to the flourishing of water weeds.

1.9.3 Aquatic fauna

Phytoplankton is fairly abundant in the lake hence the most common genera that were found are *Anacystis*, *Anabaena*, *Novicula*, *Nietzschia*, *Melosira*, and *Staurotus* (Geoffrey, 1976). Zooplankton are also abundant and include the more common genera of *Diaptamus*, *Diaphanosoma*, *Bosmina*, *Mesocyclops*, *Daphnia*, and *Ceriodaphnia* (Bruce 1976). However (Geoffrey, 1976) is of the view that the fish fauna of the Lake was modified by the introduction of several exotic species. These include *Micropterus salmoides*, *Barbus holubi*, *Serranochromis robustus*, *Engraulicypris brevianalis*, *Oreochromis macrochir*, and *Mormyrus longirostris.* However, species indigenous to the lake include *Oreochromis mossambicus, Clarias gariepinus, Tilapia rendalli, Labeo cylindricus, Barbus paludinosis, Barbus trimaculatus, Barbus lineamaitus, Beirabarbus radiates*, and the eels, *Anguilla nebulosa labiata*, and *Anguilla mossambicus* (Mangwaya, 1997).

Reptiles such as the Nile crocodile (*Crocodylus niloticus*), clawless otter (*Aonxy capensis*), and terrapin (*Malaclemys terrapin*) are present in fair numbers. The avifauna includes a wide range of water birds along the lakeshore fish eating birds can be found that include Heron (*Ardea cinerea*) egret (*Egretta sacra*), fish eagle (*Haelietus vocifer)* and kingfisher (*Alcedo atthis*) (Mangwaya, 1997).

2.0 Review of Literature

2.1 Benthic Macro invertebrates

Aquatic macroinvertebrates are an important part of the food chain, especially for fish. Many feed on algae and bacteria, which are on the lower end of the food chain. Some shred and eat leaves and other organic matter that enters the water. Because of their abundance and position in the aquatic food chain, benthos plays a critical role in the natural flow of energy and nutrients. As benthos die, they decay, leaving behind nutrients that are reused by aquatic plants and other animals in the food chain . Unlike fish, benthos cannot move around as much, so they are less able to escape the effects of sediment and other pollutants that diminish water quality. Therefore, benthos can give reliable information on stream and lake water quality. Their long life cycles allow studies conducted by aquatic ecologists to determine any decline in environmental quality. Macro invertebrates constitute a heterogeneous assemblage of animal phyla and consequently it is probable that some members will respond to whatever stresses are placed upon them (Hellawell, 1986). Biomonitoring is the use of the biological responses to assess changes in environment. Therefore, macroinvertebrates are most frequently used as indicator species. Cairns & Pratt (1993) conclude that biological surveillance of communities, with special emphasis on characterising taxonomic richness and composition, is perhaps the most sensitive tool now available for quickly and accurately detecting alterations in aquatic ecosystems.

Macroinvertebrates communities are important as the trophic base for all classes of vertebrates such as fish, birds, reptiles, and mammals. Even though they are a critical component in the stream community, providing energy for the food web, they are often overlooked for their value as we focus on larger species. Macroinvertebrates are thought to be the most widespread and essential food source for stream fishes (Alley, 1982). They are essential to juvenile species such as Smallmouth Bass found in Ozark streams High abundances of macroinvertebrates food supplies are also important to waterfowl and passerine birds (Jackson and Fisher 1986; Gray 1993). Aquatic macroinvertebrates continue to be widely studied because of their unique diversity and ubiquity in streams and rivers worldwide (Covich *et al*. 1999).

It is estimated that macroinvertebrates in various functional feeding groups break down 20-73% of organic matter in riparian headwater streams (Covich et al. 1999). Each species within a macroinvertebrates community plays an important role in the aquatic ecosystem. For example, Wallace and Webster (1996) showed that predatory benthic macroinvertebrates accounted for 25-36% of total benthic production in first and second order fishless freshwater streams. To paraphrase Wilson (1987), invertebrates don't need us, but we need them. If they disappear, so does everything that benefits from them such as all the fishes, birds, amphibians and mammals that depend on their existence.

These organisms have provided water quality assessment programs with valuable insights for more than 100 years (Cairns and Pratt 1993). In aquatic systems these communities are among the most widely used component for bio monitoring activities by government agencies, private consulting firms, and citizen scientists.Amakye (2001) have monitored the seasonal as well as depth wise distribution of macro-invertebrates in the sediments of lake Volta at Yeji area and noticed the highest density of macroinvertebrates between the shore and depths of 8-10 metres. According to these authors, Chironominae were found 10 abundant whereas Orthocladinae and Ephemeroptera were less in the sediments compared to the formative years of the lake. The changes in the composition and diversity of benthos were due to increasing anthropogenic influences on the lake because changing chemical composition of the lake water Efitre *et al.* (2001) have studied the spatial and temporal distribution of macro-invertebrates in Nabugabo lake, Uganda with a focus on habitat associations and seen that the total absence of bivalves and crustaceans; and less abundance (1.8%) of gastropods. The dominant taxa includes ephemeropterans (77.7%), dipterans (11.1%); and annelids (5.4%), odonates (2.8%) and tricopterans (1.3%) have smaller contributions to the benthic assemblage. Gong and Xie (2001) have identified the 33 taxa belonging to Mollusca, Oligochaeta and Arthropoda in lake Donghu-China and seen low species diversity in highly eutrophic region measured in terms of species number, diversity index and k-dominant curves. Mir and Yousuf (2002) have recorded the Eighteen taxa (18) of macrozoobenthic organisms, belonging to Annelida, Mollusca and Arthropoda, during the course of a year in the Dal lake, Kashmir and noted a marked variations in the spatial distribution of various taxa, which was influenced by the texture of the sediment as well as by the macrophytic community structure. According to Singh et al. (2002), the number of Oligochaetes increased from 238 to 18527 indv. /m 2 in Bisar sarovar indicates that this pond's water always exists form mildly polluted to heavily polluted condition and with the 11 rise of temperature the pollution level goes up but water of the Kendui tank becomes mildly polluted only during summer season. These authors also observed that an increase in the decaying matter during summer enhances the growth of Oligochaeta. According to Mir and Yousuf (2003) the nature of the sediment influenced the population dynamics of the oligochaetes of Dal lake, Kashmir includes Limnodrilus hoffmeister, Tubifex tubifex, Branchura sowerbyii, Aelosoma sp. and Nais sp. which thrive in sediments rich in organic nutrients, since oligochaetes are the dominant among all.

3. Materials and Methods

3.1 Materials

- Global Positioning System (GPS) – the GPS was used to record loc stats of the sampled sites
- Microscope – this was used for easy observation of macroinvertebrates identification.
- Human resources – the researcher was accompanied by at least two assistants to help in data capturing .
- Recording sheets – were used to record the location statistics data and macro invertabrates sampled .

3.2 Experimental design

This assessment was conducted to determine the spatio-temporal distribution and diversity of macro invertebrates in Lake Chivero during the period of November 2017 to March 2018 once a month . The study was a sample for shoreline benthic macro invertebrates found in the range of 10 meters from the margin of the lake anything beyond that range was not included. The variables that were being observed were species abundance, distribution and species diversity. A multi- stage sampling technique was used whereby both systematic and random sampling was included in data collection procedures. Firstly, the shoreline of west side was divided into 100m × 10m plots. Six plots were sampled, Random sampling was done whereby the first 100m × 10m plot was randomly selected to have a starting plot. 10m x 10m quadrat was thrown randomly at 3 different position in each plot to reduce bias. All the macro invertebrate species found in the quadrat were identified, counted and recorded. The recorded species were used to calculate species diversity and species abundance.

3.3 Data collection

Scoop net was used to collect macro invertebrates. All the data was recorded on a data collection sheet for analysis.

3.4 Macro invertebrates sampling

At each site, sampling was done using a square-framed (0.25 by 0.25 m) hand net with a 500 µm mesh and a detachable sample collection bottle was used to keep the sampled macroinvertebrates. Macro invertebrates were disturbed using the scoop net technique.

A disk was thrown in the quadrant for random sampling in each quadrant. 3 samples of macro invertebrates were collected. When the disk was thrown a drum , was placed and a scope net was used to mix everything that was within that drum for two minutes, the collected sample was placed in a sorting tray for identification of macro invertebrates. The collected macro invertebrates where then placed in plastic containers and then preserved with 70% alcohol for later identification in the laboratory following the studies which were used by Gabriel and Gerber (2002) up to family level.

Fig 3.3 showing pictures of macro invertebrates sampled in the tray and identification in the laboratory by the researcher.

3.5 Data Analysis

Statistical Package for the Social Sciences (SPSS) was used for all univariate analyses. A nested analysis of variance (ANOVA) was used to test the effect of spatial and temporal variables on the abundance. Post hoc tukey tests were employed to assess differences within sites in instances where ANOVA identified significant differences. The assumptions required for applying parametric statistical testing to data were tested using a one sample Shapiro Wilk test(for data normality) and a Levine's test was (for equality of variances). Where required, data were transformed (log x +1) to meet the assumptions necessary for parametric testing. QGIS was also used to note the tolerant and intolerant spatial and temporal distribution.

For each sampling site, the mean number of invertebrate taxa present per sample was calculated. For the more common taxa, the mean abundance of individuals in each site were also calculated to look for specific effects on particular invertebrate groups. To examine effects on community diversity, the Shannon–Wiener index was used separately for each site using the formula H'= ∑pilnpi, were H' is the Shannon Index of diversity, pi =proportion abundances of species and ln is the natural log (Mehta *et al*, 2008).

4. Results and Discussion

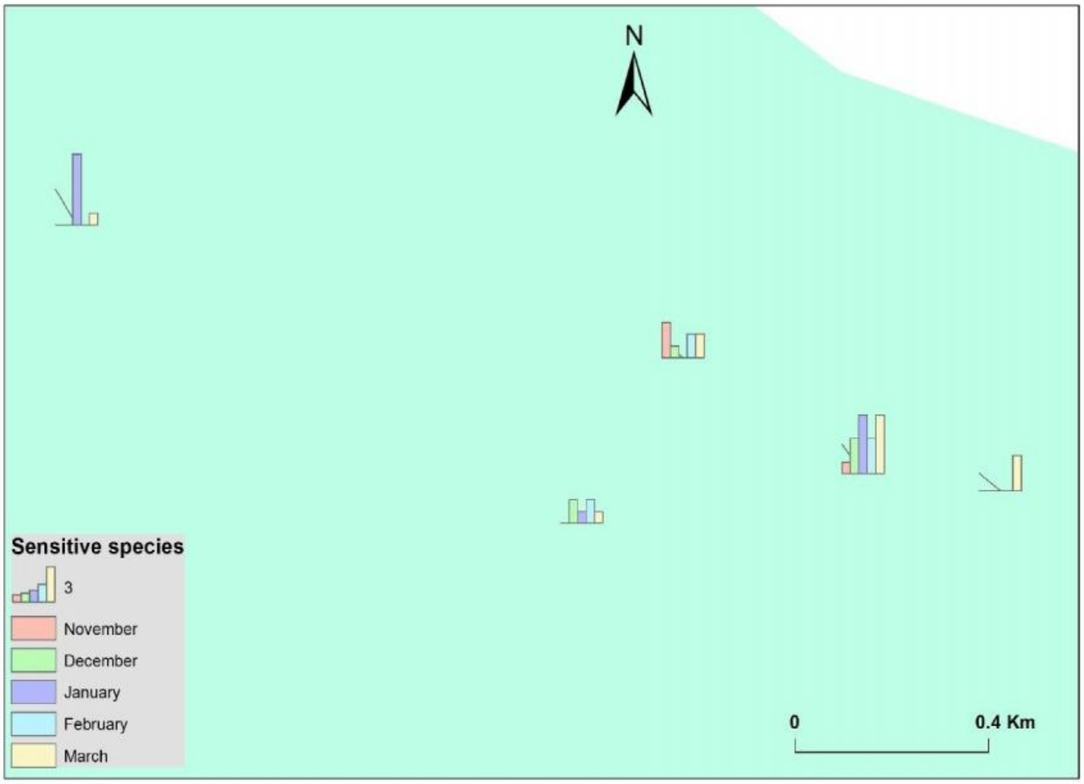
Psephenidae abundances did not differ at any of the sites (ANOVA: $F_{3,16} = 2.545$, $p = 0.105$). All the other species differed significantly at the different sites (table 1). Abundances of baitidae differed significantly at the different site (ANOVA: $F_{3,16} = 26.241$, $p < 0.001$) with abundances different at almost every site (Fig 3a; Post-hoc Tukey: $p < 0.05$ for all comparisons) with the exception of site B and site C (Fig 3a; Post hoc Tukey: $p = 0.984$).

Table 4.1: Summary statistics of analysis of variance (ANOVA) testing the effects of site on the abundance of macroinvertebrates in Lake Chivero. F = test statistic, P = significance level. * denotes significant differences (P < 0.05).

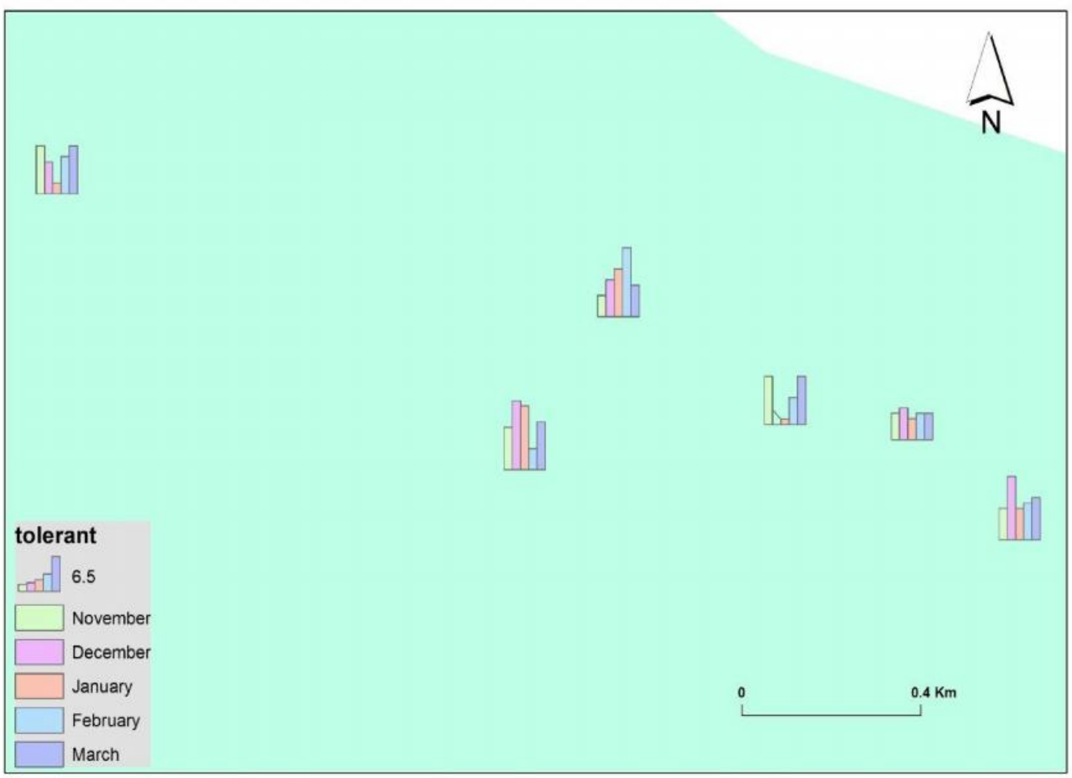
Response Variable	Factor	*F*	*P*
Chironomidae	Site	10.004	.001*
Psephenidae	Site	2.544	.105
Gomphidae	Site	8.524	.003*
Caenidae	Site	21.167	.001*
Hydrophilidae	Site	4.360	.027*
Baitidae	Site	7.455	.004*
Caratopogonidae	Site	24.967	.001*
Dystscidae	Site	20.231	.001*
Gyrinidae	Site	8.42	.003*
Chrysolimidae	Site	10.201	.001*
Velidae	Site	4.236	.027*
Syphidae	Site	21.123	.001*
Bulinidae	Site	12.132	.001*
Naucoridae	Site	4.326	.026*
Belostomatidae	Site	20.141	.001*
Nepidae	Site	9.541	.004*
gerridae	Site	10.103	.001*
herdidae	Site	7.123	.0.05*
Elmidae	Site	11.333	.001*

Chironomidae abundances differed at the different sites (ANOVA: $F_{3,16}$ = 10.004, p = 0.001). Differences were observed between Site A and Site D (Post-hoc Tukey: p = 0.010), Site B and Site C (p = 0.001), Site A and Site D (p = 0.04) and Site E and Site F (p = 0.001). For nematoda abundances, Naucoridae differed from all the other sites only (Post-hoc Tukey: p<0.05). For caenidae abundances, Site F differed from all the other sites (Post-hoc Tukey: p<0.05). No other differences between sites was observed. Abundances of Elmidae were only significantly different between Site A and Site C (Post-hoc Tukey: p = 0.023). Abundances of baitidaes differed between Site B and Site F and between Site E and Site F (Post-hoc Tukey: p < 0.05 for both comparisons).Differences in coengrinidae abundances were observed between most sites (Post-hoc Tukey: p < 0.05) with the exception of Site F and Site C(p=1) Site A and Site D (p=0,989).). For nematoda abundances, Naucoridae differed from all the other sites only (Post-hoc Tukey: p<0.05)For Belostomatidae abundances, Site C differed from all the other sites (Post-hoc Tukey: p<0.05) and no other differences between sites was observed. For herdidae abundances, Site D differed from all the other sites (Post-hoc Tukey: p<0.05) and no other differences between sites was observed For Bulinidae abundances, Site A differed from all the other sites (Post-hoc Tukey: p<0.05) and no other differences between sites was observed For Caratopogonidae abundances, Site F differed from all the other sites (Post-hoc Tukey: p<0.05) and no other differences between sites was observed For Gomphidae abundances, Site C differed from all the other sites (Post-hoc Tukey: p<0.05) and no other differences between sites was observed.

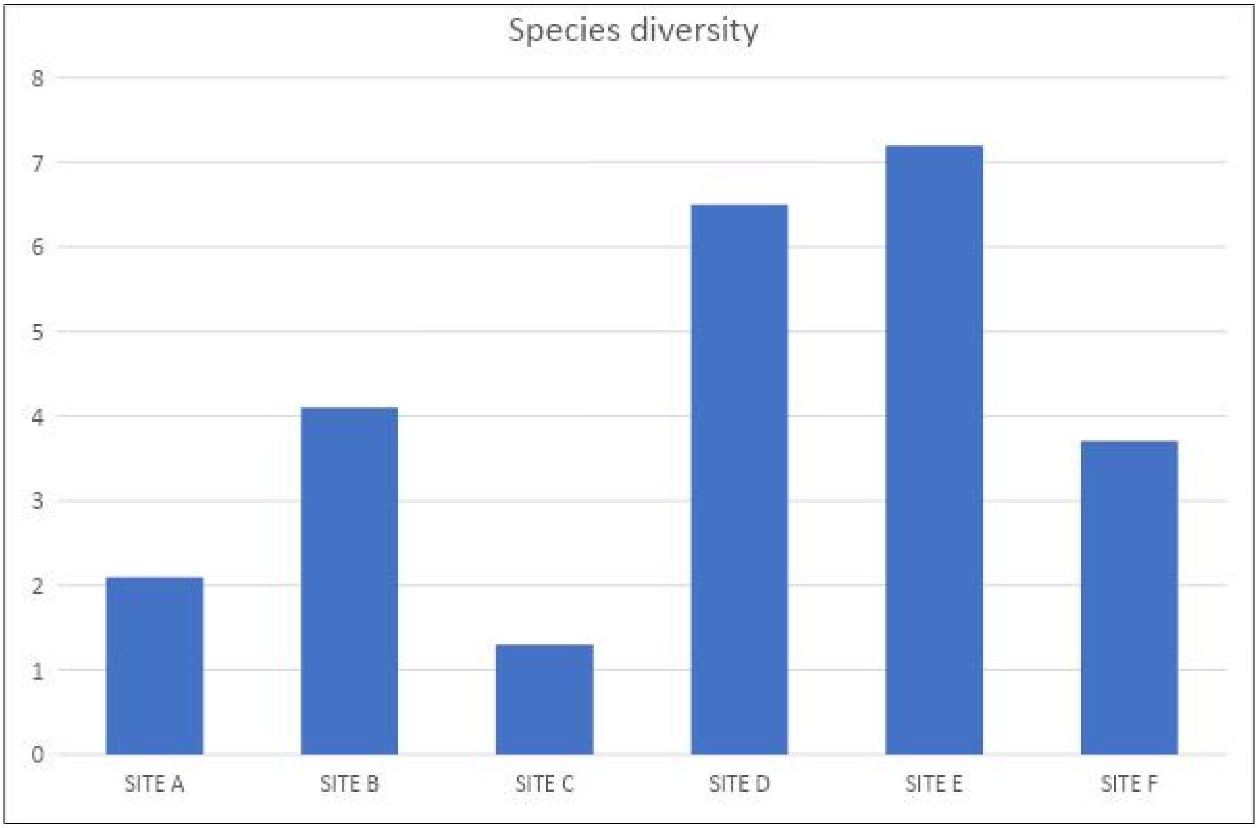
The hypotheses that, there is no significant difference in the distribution, abundance and diversity of macro invertebrates in the sites sampled was not supported by the results, hence rejecting the null hypothesis.



Map showing sensitive macroinvertebrates species distribution



Map showing tolerant macroinvertebrates species distribution



On species diversity Site E (fig 4.2) had high species diversity with H= (7,2), site B with H= (4,1) <site C with H= (1,3) ,site D with H= (6,5) site F with H=(3,7).

5. Conclusion and Recommendations

5.1 Conclusion

Quantum GIS and SPSS software's made it possible for the formulation of the map showing the spatial and temporal distribution of macro invertebrates and significance differences of species respectively. Taken together, the results indicated differences in species abundances and diversity between sites sampled. The distribution and abundances of macroinvertebrates in lake Chivero shows high abundances of tolerant species , based on the results from the sampled data ,it is possible to conclude that the Lake is polluted since there is high abundances of tolerant species on sites sampled with the exception of Psephenidae.

5.2 Recommendations

The study recommends constant monitoring and researches of macro invertebrate's abundances and distribution in Lake Chivero from Lake Chivero Fisheries Research Centre. The ministry of environment water and climate should consider enforcing policies that restricts industries to pollute a water body. ZPWMA management effort should also be channeled towards finding other ways through further researches that promote Integrated Water Resources Management in Lake Chivero.

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References

Barbero, M. D., Oberto, A. M. & Gualdoni, C. M. (2013) Spatial and Temporal Patterns of Macroinvertebrates in Drift and on Substrate of a Mountain Stream (Cordoba, Central Argentina). [Online], 25 (4), pp. 375–386. Available from: <http://dx.doi.org/10.1590/S2179-975X2013000400003> [Accessed 28 April 2018].

Souleymane, S. & Jean, K. T. (2014) Spatial-Temporal Dynamics of Population Structure for Macro Invertebrates Families in a Continuum Dam - Effluent - River in Irrigated System . Volta Basin (Burkina Faso). 2 (May), pp. 203–214.

Allert, A.L., J.F. Fairchild, R.J. DiStefano, C.J. Schmitt, W.G. Brumbaugh, and J.M. Besser. 2009. Ecological effects of lead mining on Ozark streams: In-situ toxicity to woodland crayfish (Orconectes hylas). *Ecotoxicology and Environmental Safety* 72:1207-1219.

Alley, T.R. 1982. Competition theory, evolution, and the concept of the ecological niche. *Acta Biotheoretica* 31: 165-179.

Austin, C. M., Jones, C. and Wingfield, M. (2009). *Cherax quadricarinatus*. IUCN Red List of Threatened Species. Version 2011.1: www.iucnredlist.org.

Barton, S.D., and S.L. Powers. 2010. Life history aspects of the Cherokee Darter, *Etheostoma scotti* (Actinopterygii: Percidae,) as imperiled species in Northern Georgia. *Southeastern Naturalist* 9:687-698.

Becker, G.C. 1983. The fishes of Wisconsin. University of Wisconsin Press. Madison. xii+1052.

Belle, C. C. and Yeo, D. C .J. (2010). New observations of the exotic australian red-claw crayfish, *Cherax quadricarinatus* (von martens, 1868) (crustacea: decapoda: parastactidae) in Singapore. *Nature in Singapore*, **3**: 99–102

Brown, B.L. and R.L. Lawson. 2010. Habitat heterogeneity and activity of an omnivorous ecosystem engineer control stream community dynamics. *Ecology* 91: 1799-1810.

Bortolini, J. L., Alvarez F. and Rodriguez-Almaraz, G. (2007). On the presence of the Australian red claw crayfish, *Cherax quadricarinatus*, in Mexico. *Biological Invasions*, **9 (5)**: 615–620

Bowater R.O, Wingfield M, Fisk A, Conodon K.M.L, Reid A, Prior H and Kulpa E.C (2002), A parvo-like virus cultured in redclaw crayfish *Cherax quadricarinatus* from Queensland, Australia. Dis aquat organ 50: 70-86

Bronseth T and Folstad I (1997) "The effects of parasites on courtship dance in threespine sticklebacks: More than meets the eye?"*Canadian Journal of Zoology*, **75**:589–594.

Brown, P.B. (1995) Physiological adaptations in the gastrointestinal tract of crayfish. Am. Zool., 35, 20–27.

Burkholder JM, Glasgow HB and Hobbs CW (1995) "Fish kills linked to a toxic ambush-predator dinoflagellate: distribution and environmental conditions" *Marine Ecology Progress Series*.

Bush A. O, LaffertyK. D, LotzJ. M and ShostakA. W (1997),Parasitology meets ecology on its own terms: Margolis et al. revisited. Journal of Parasitology 83: 575–583.

Calvo- Ugarteburu G and McQuaid C.D (1998), Parasitism and introduced species: epidemiology of trematodes in the intertidal mussels Perna perna and Mytilus galloprovincials.

Capelli, G. M., and B. L. Munjal. 1982. Aggressive interactions and resource competition in relation to species displacement among crayfish of the genus Orconectes. *Journal of Crustacean Biology* 2:486-492.

Covich, A. P., M. A. Palmer, and T. A. Crowl. 1999. The role of benthic invertebrate species in freshwater ecosystems: zoobenthic species influence energy flows and nutrient cycling. *BioScience* 49(2):119-127

Charlebois, P.M. Invading crayfish in a Michigan stream: direct and indrirect effects on periphyton and macroinvertebrates. 1996. *Journal of the North American Benthological Society* 15 (4): 551-563 de Moor, I. and Bruton M. N. (1988). Atlas of alien and translocated indigenous aquatic animals in southern Africa. South African National Scientific Programmes Report 144. Foundation for Research Development, South Africa.

Dorn, N.J. and Wojdak, J.M. The role of omnivorous crayfish in littoral communities. 2004. *Oecologia* 140 (1): 150 - 159.

DiStefano, R. J., M. E. Litvan, and P. T. Horner. 2009. The bait industry as a potential vector for alien crayfish introductions: problem recognition by fisheries agencies and a Missouri evaluation. *Fisheries* 34:586-597.

Edgerton B.F (1999), Diseases of the redclaw crayfish. Aquaculture magazine 25 (6):2

Edgerton B.F, Webb. R, Anderson I.G and Kulpa E.C (2000), Description of a presumptive hepatopancreatic reovirus and a putative gill parvovirus, in the freshwater crayfish *Cherax quadricarinatus*. Dis Aquat Organ.

Efron Band Tibshirani R (1993),An introduction to the bootstrap. Chapman & Hall, London, U.K., 436 p.

Enayat S.A.R (2011), "A review of some ecto-and endo protozoan parasites infecting Sarotherodon Galilaeus and Tilapia Zillii from Damietta Branch of River Nile, Egypt," Journal of American Science, vol. 7, no. 3, 2011.

Figueiredo, M. S. R. B., Kricker, J. A. and Anderson A. J. (2001). Digestive enzyme activities in the alimentary tract of redclaw crayfish, *Cherax quadricarinatus* (Decapoda: Parastacidae). *Journal of Crustacean Biology*, **21**:334-344.

Food and Agriculture Organisation FAO (2003), Information on fisheries management in the Republic of Zimbabwe. Organisation ofUnited Nations.

Garza de Yta A, Davis D.A, Rouse D.B, Saoud I.P and Ghanawi J (2011), Effects of stargrass hay supplementation on growth and survival of redclaw, N. Am. J. Aquacult. 73, 484-488.

Gherardi, F. 2006. Crayfish invading Europe: the case study of *Procambarus clarkii*. *Marine and Freshwater Behavior and Physiology* 39:175-91.

Hauck A.K, Marshall M.R, Li J.K.K and Lee R.A (2001), A new finding and range extension of bacilliform virus in the freshwater redclaw crayfish in Utah, USA. *Journal of aquatic animal health* 13: 158-162

Helfman G, Collette B and Facey D (1997),The Diversity of Fishes. Blackwell Publishing, pp 95-96, ISBN 0-86542-256-7

Holden M and Reed W (1972), West African Fresh Water Fish, Longman, London, UK.

Janzen, D. H., 1988. Guanacaste Park: Tropical ecological and biocultural restoration. In: J. Cairns, Jr. (ed.),Rehabilitating Damaged Ecosystems, pp. 143-192. CRC Press, Boca Raton, Florida.

Jones C (2005), *Cherax quadricarinatus* (redclaw crayfish) CAB International, Wallingford, UK. http://www.cabi.org

Jones, D.S. and Morgan, G.J. (1994). A field guide to crustaceans of Australian waters. Reed/Western Australian Museum.216 pp.

Jones, C.M. (1990) The Biology and Aquaculture Potential of the Tropical Freshwater Crayfish Cherax quadricarinatus. Queensland Department of Primary Industries Information Series

Lodge, D. M., C. A. Taylor, D. M. Holdich, and J. Skurdal. 2000. Nonindigenous crayfishes threaten North American freshwater biodiversity: lessons from Europe. Fisheries 25:7-20.

Lowe S., M. Browne, S. Boudjelas, and M. De Poorter. 2000. 100 of the world's worst invasive alien species: a selection from the Global Invasive Species Database. Aukland, New Zealand: Invasive Species Specialist Group. 12 pp.

Pratt, J. R., and J. Cairns Jr. 1992. Ecological Risks Associated with the Extinction of Species. Pages 93-117 *in* J. Cairns Jr., B. R. Neiderlehner, and D. R. Orvos, editors. *Predicting Ecosystem Risk*. Princeton, NJ: Princeton Scientific Publishing.

Sala, O.E., F. S. Chapin, III, J. J. Armesto, R. Berlow, J. Bloomfield, R. Dirzo, E. Huber-Sanwald, L. F.Huenneke, R. B. Jackson, A. Kinzig, R. Leemans, D. Lodge, H. A. Mooney, M. Oesterheld, N. L. Poff, M. T. Sykes, B. H. Walker, M. Walker, and D. H. Wall. 2000. Global biodiversity scenarios for the year 2100. *Science* 287:1770-1774.

Semple, G. P., Rouse, D. B. and McLain, K. R. (1995). *C. destructor, C. tenuimanus, C. quadricarinatus* (Decapoda: Parastacidae): A comparative review of biological traits relating to aquaculture potential. *Freshwater Crayfish* **8**: 495- 503.

Wilson, E. O. 1992. *The Diversity of Life*. New York. W. W. Norton and Company. 440 pp.

Wingfield, M.J. (2000). An overview of production techniques practiced in the Australian crayfish farming industry (acquired December 7, 2002).

Wingfield, M. (2002). An Overview of the Australian freshwater crayfish farming industry. *Freshwater Crayfish* **13**: 177- 184.

Xue, X. M., Anderson, A. J., Richardson, N. A., Anderson A. J., Xue, G. P. and MatherP.B. (1999). Characterisation of cellulase activity in the digestive system of the red claw crayfish (*Cherax quadricarinatus*). *Aquaculture*, **180**(3/4): 373-386.

Zimmerman, H. G. (2003). Invasive alien species in southern Africa: national reports and directory of resources: Global Invasive Species Programme. Cape Town, South Africa.

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