MAKERERE UNIVERSITY

COLLEGE OF NATURAL SCIENCES

THE DISTRIBUTION AND DIVERSITY OF MACROBENTHIC INVERTEBRATES IN KIWUNYA STREAM, KAMPALA.

BY

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JUNE , 2018

DECLARATION

I, **KAINZA WINNIE WANENDEYA** declare that this dissertation has not been submitted to any other university or another institution of learning for the award of any degree or other courses

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DEDICATION

I dedicate this book to my entire family. My dear aunts, Nambozo Harriet, Nadunga Beatrice and Neumbe Babra, my mother, siblings, my best friend Catherine Nalukwago as well as to my late Father Mr. Wanendeya Jackson and to my grandparents Jessica and Francis Wadada.

ABBREVIATIONS AND ACRONYMS

^0C	-	Degrees centigrade
D O	-	Dissolved Oxygen
G	-	grams
M	-	molar
M/s	-	meters per second
Mg/l	-	milligrams per liter
pH	-	Potential of hydrogen
Ppt	-	parts per million
Spp	-	species

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ABSTRACT

This study was carried out with a general objective of establishing the diversity and distribution of macrobenthic invertebrates in Kiwunya Stream located in Kampala District which has constantly been subjected to higher levels of pollution mainly due to the anthropogenic activities carried out by the communities living along this stream. This work involved measurements of the different physico-chemical water parameters like temperature, pH, flow velocity, dissolved oxygen, water depth, phosphates and nitrate levels at three sites, that is upstream, midstream and downstream. These parameters were later related to the distribution and diversity of the macrobenthic invertebrates found at the different sites of sampling. The study showed that water temperatures increased from upstream to downstream, the pH range was 7.0-75, the stream was shallow having a depth that increased on average from 6.8cm upstream,7.6 cm midstream and 18.8 cm downstream. The dissolved oxygen levels were highest upstream and lowest downstream, the flow velocity was highest upstream (0.39m/s), midstream (0.24m/s) and lowest downstream (0.18m/s). Phosphate and nitrate levels were highest upstream and these decreased as one proceeded to the downstream. The study revealed three phyla of macrobenthic invertebrates present in the different sampled sites of the stream and these include Mollusca, Annelida and Arthropoda with the midstream having the highest Shannon wiener diversity index(H`) of 7.34 and the downstream having the lowest diversity(H`) of 4.69. However, the downstream had the highest number of individuals, followed by the midstream and then the upstream with the lowest number of individuals.

CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND

Streams are important fresh water resources characterized by a continual downstream movement of water containing dissolved and suspended particles. These render support to macro and micro aquatic organisms including invertebrates which are well adapted to the lotic environment. They also serve as a source of water for domestic usage as well as acting as most suitable media for disposal of industrial and domestic wastes. Until recently, pollution of water bodies was not serious a problem because populations were small. However, the increasing population and urbanization has got a tremendous effect on the stream ecosystem structure. Urban streams have continuously been subjected to additional gross amounts of domestic sewage, industrial effluent, and excessive water runoff from car parkings and streets, pesticides among other forms of pollution. Urban stream ecology research has repeatedly established decline in the assemblage, richness, diversity and biotic integrity of algae, invertebrates and fishes with increasing urbanization (Paul and Meyer 2001).

Macrobenthic invertebrates are fauna that live at the bottom of a water body often retained by mesh sizes of 500µm pore sieve. They include a heterogeneous assemblage of organisms belonging to phyla such as Arthropoda, Annelida, Mollusca and many others. These organisms play a vital role in the circulation and recirculation of nutrients in aquatic environments. They constitute the link between the unavailable nutrients in detritus and useful protein materials in fish. The density of aquatic macrobenthic invertebrate species and communities is controlled by a variety of environmental factors such as habitat characteristics (Hynes 1970; Peeters and

Gardeniers 1998), sediment quality (Chapman and Lewis, 1976), sediment grain size (Tolkamp 1980) and by biological factors such as competition and predation (Kohler *et al*., 1992). Stream flow, nature of substratum and organic pollution generally regulates the species composition and dominance of different taxa in various stretches of rivers (Negi and Singh 1990; Bhat *et al*., 2011) and thus macrobenthic invertebrates constitute the most popular and commonly used group of freshwater organisms in assessing water quality (Rosenberg and Resh 1993). Macrobenthic invertebrates are used as indicators of pollution because invertebrate communities change in response to changes in physico-chemical factors and available habitats (Sharma and Chowdhary, 2011). Often the greater the density of these organisms, the greater the degree of organic pollution. The lower species diversity index generally shows more pollution in a water body and so tolerance to pollution is very essential in understanding the distribution of benthic fauna in a stream community. Realizing the importance of macrobenthic invertebrates, several workers have attempted to study their diversity in aquatic ecosystems in lotic water bodies. The current study focused on the distribution and diversity of macrobenthic invertebrates in an urban stream of Kiwunya in Kampala.

1.2 PROBLEM STATEMENT

As urban populations continue to grow, stress imparted upon the urban streams concurrently increases due to anthropogenic activities carried out by the people especially those involved in agricultural activities, disposal of domestic and industrial wastes, excess water runoff from streets, parking lots, roof tops, and pesticide usage among others. Data on water quality of urban streams is scarce. Information on macrobenthic invertebrate distribution and diversity in Kiwunya Stream is limited and yet these organisms are bio indicators of water quality. Changes in the quality of water can affect both human health (water borne diseases) and aquatic life.

The current study therefore focused on the distribution and diversity of macrobenthic invertebrates in Kiwunya Stream located in Kampala district.

1.3 SIGNIFICANCE OF THE STUDY

Data provided from this study about the distribution and diversity of macrobenthic invertebrates can be used to estimate the extent of human impact on the ecological integrity of Kiwunya Stream. The results obtained will also help in determining if the stream poses a health risk to the surrounding community since some macro invertebrates are vectors of diseases.

1.4 OBJECTIVES

1.4.1 General objective

To assess the distribution and diversity of macrobenthic invertebrates in Kiwunya Stream and relate it to water quality.

1.4.2 Specific objectives

1. To determine whether physico-chemical parameters of water influence the distribution and diversity of macrobenthic invertebrates in Kiwunya Stream.
2. To study the variations in water physico-chemical parameters in the selected sites along Kiwunya Stream.

1.5 HYPOTHESES

1. The distribution and diversity of macrobenthic invertebrates is independent of the water physico-chemical parameters.
2. The physico-chemical parameters of water are independent of the site selected along Kiwunya Stream.

CHAPTER TWO

LITERATURE REVIEW

2.1 Urban streams

Urban streams are intimately connected to their landscapes through drainage networks resulting in excessive storm water runoff (from roofs, streets, and parking lots), lower groundwater levels and increased loads of many kinds of urban pollutants such as pathogens, heavy metals and nutrients. This leads to water quality problems like dissolved oxygen deficits, toxics, sediment as well as damage of riparian areas, civil infrastructure and aquatic habitats and communities resulting into the urban stream syndrome. This "urban stream syndrome" presents a challenge for managers seeking to minimize degradation of streams so that these are available to people in both a recreational and ecosystem services context. Headwater streams are critical sites for organic matter processing and nutrient cycling and they are vital for maintaining the health of whole river network (Bengtsson, 1998). According to Clarke *et al*., (2008), the headwater streams are named as nutrient poor, less productive areas and macro-benthos in these areas provides a greater contribution to the secondary productivity in the streams. River continuum concept (RCC) is one of the conceptual models to describe river ecosystems and integrity of abiotic and biotic environment (Vannote *et al*., 1980). This concept is based on streams that originate in forested regions and integrates the geomorphological features of streams with the composition and function of the biological communities (Leprieur *et al*., 2009). Stream discharge is also an important character of stream ecology because it interacts with the gradient and substrate to determine the types of habitats present, the shape of the channel and the composition of the stream bottom (Dai and Trenberth, 2002). Kampala is a city in Uganda composed of commercial, residential communication routes and industrial areas. It is the garbage, sewage and industrial effluent generated from the activities of resident that make water pollution an issue of concern to public health and integrity of the security of the future water supply to Kampala city (Matagi, 1993)

2.2 Water monitoring practices in Uganda

According to Otim (2005), very few institutes in Uganda are engaged in regular water monitoring and more so they mostly use physico-chemical means. Some of these institutes include National Fisheries Resources Research Institute, National Water and Sewerage Corporation and some research and academic institutes. Biological monitoring has not been implemented due to lack of funds to carry out research on water monitoring method development in Uganda (MWE, 2012). Owing to the fact that most laboratories in the country have inadequate reagents, equipment and experts (Matagi, 2002) to carry out physico-chemical tests, there is justifiable and urgent need to develop capacity in implementing biological monitoring, which is a cost effective and yet a more reliable water monitoring method.

2.3 Macrobenthic invertebrate and their distribution

Macrobenthic invertebrates are organisms that live on the bottom substrates of aquatic habitats and are larger than 1 mm (Shen and Shi, 2003). The organisms include sponges, nematodes, annelids, mollusks, cnidarian, echinoderms, ascidians, and arthropods among others. Macro benthic invertebrates produce a wide range of valuable ecosystem services. In freshwater ecosystems, they can be good indicators of water quality (Weigel *et al*., 2002; Cristina *et al.*, 2009; Simone and Rui, 2010). Furthermore, they can improve water quality, sustain commercial fisheries and they support general ecosystem functioning that can provide people with leisure and recreational opportunities and inspiration for artistic expression (Shen and Shi, 2003). Biodiversity and distribution of macrobenthic invertebrates are influenced by water temperature, salinity, primary productivity by plants, depth, sediment type, and physical disturbance (Coles and McCain, 1990). Changes in macrobenthic community biodiversity and relative spatial distribution can influence primary (productivity of autotrophs such as plants) and secondary production (productivity of heterotrophs such as animals).

2.4 Macrobenthic invertebrates as bio indicators

Benthic macro-invertebrate species are differentially sensitive to many biotic and abiotic factors in their environment (Mandaville, 2002). Relative abundance and diversity of their communities have commonly been used as an indicator of the condition of an aquatic system (Mandaville 2002; Azrina *et al.,* 2005). Therefore, freshwater macrobenthic invertebrates can be commonly used as ecological indicators of aquatic ecosystems. Their populations depend on the condition of the environment such as water quality, organic matter content, soil texture, sediment particles and the ability to construct permanent burrows in the substratum (Dahanayaka and Wijeyaratne, 2006). Biological monitoring or its chemical contents is important in determining the health of an aquatic ecosystem. Physico-chemical monitoring of a water body is known to be insufficient to fully characterize its status or reliably detect adverse impacts (Mandaville, 2002). The technique of using macrobenthic invertebrates as bio-indicators is a cost effective method widely used in North America and Europe but they are not used as bio indicators in pollution studies in Uganda due to the lack of expertise and information on macrobenthic invertebrate populations. In recent years, interest in this area has grown tremendously as evidenced by several books devoted entirely to the subject**.** Invertebrates have been used in numerous biological-monitoring methods. The most widely used are based on tolerance values for specific taxa, which normally range from very intolerant to very tolerant according to the ability of a taxa to inhabit streams differing in water quality**.** The invertebrate communities of streams provide a more sensitive index of realistic changing conditions than chemical and microbiological data, which only indicate short-term alterations (Hynes 1960; 1965; Brinkhurst 1965). Therefore, benthic invertebrates have been widely used as bio indicators of aquatic impacts related to stream pollution (Tsui and McCart, 1981).

CHAPTER THREE

MATERIALS AND METHODS

3.1 Study area

Kiwunya Stream is one of the main tributaries of Lubigi Wetland. Lubigi is part of the complex network of rivers and streams draining into Lake Victoria. Kiwunya Stream is located between latitudes 0º20'N-0º21'N and longitudes 32º33'E-32º34'E in Kampala, Uganda. It originates from the valley, which is at the foothills of Kasubi, Kawaala and Makerere. The stream is 1.5meters wide and its depth varies with seasonality, being deeper in the rainy seasons. Eucalyptus trees, grasses and herbs characterize the vegetation area along the stream. The mean annual rainfall of about 1475mm with a bimodal distribution and it is received on an average of 166 days per year. There are two rainy seasons occurring from March through May and from September through November and the dry season is from December to February and June to August. The daily mean maximum and minimum air temperatures are 12.7ºC and 25.5ºC respectively. The mean annual temperature is 22ºC with a maximum of 26.8ºC and a minimum of 11.9ºC. The soils are predominantly red, well drained consisting of sandy loam and sandy clay loams.

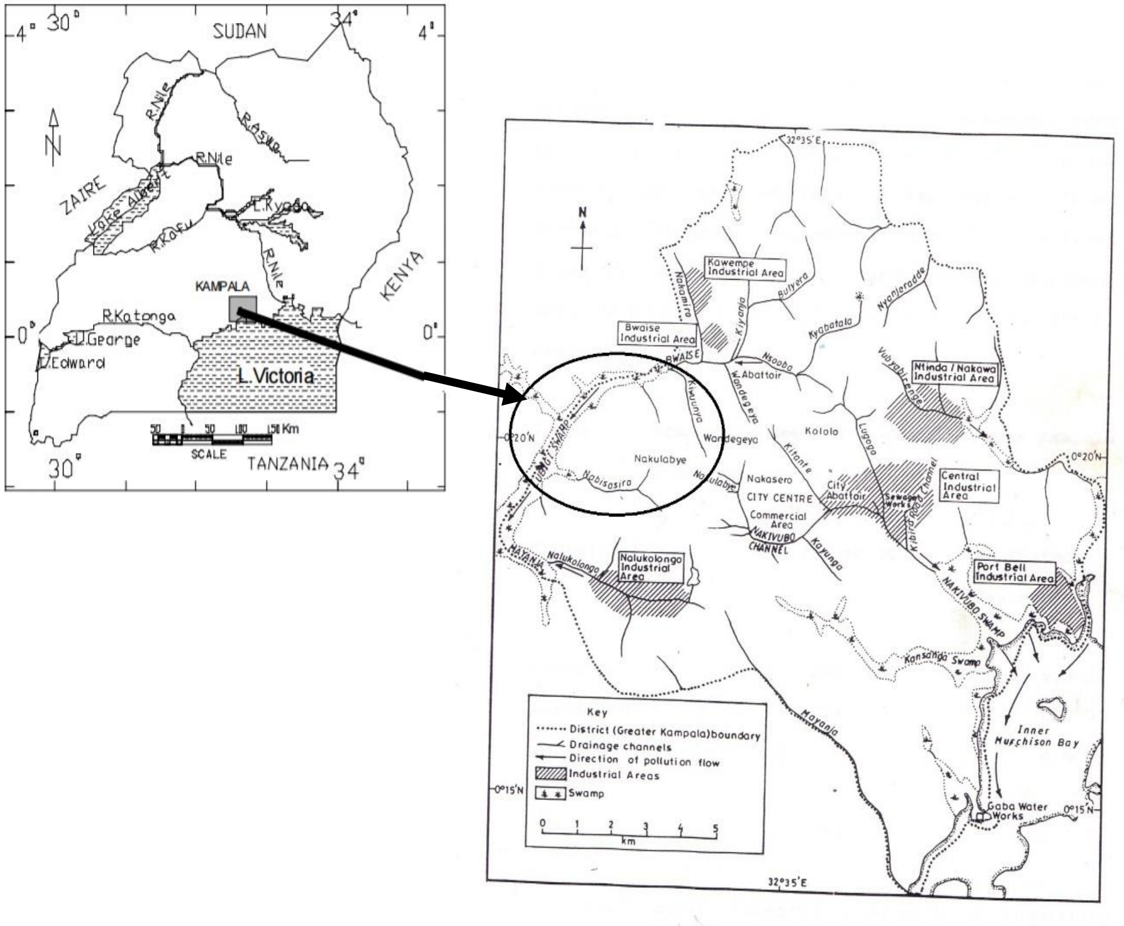

Figure 1: Map of Uganda showing location of Kampala district(left)

Figure 2: Kampala district map showing the location of Kiwunya Stream(right)

Table 1: selected sites in Kiwunya Stream Selected sites in Kiwunya Stream

Site	Site description	Distance from residents
Upstream	located in Kiwunya, surrounded by grass and shallow	10m
Midstream	located in Kikoni, 2km away from upstream densely populated	4m
Downstream	Located in Namungona, 2km away from the midstream surrounded by gardens and with a relatively low population	7m

3.2 Data collections

Data collection generally covered a multidisciplinary approach which involved determination of physical, chemical, hydrological and biological parameters. Water samples were obtained using plastic water sample bottles since the stream was shallow was and these samples later taken to the laboratory for analysis on the day of sampling.

Three sampling sites were selected for data collection that is upstream, midstream and downstream. Three samples were taken from each site of the stream. Area sampled was determined by random method. The suitability of the sites sampled also depended on the nature of human activity occurring in the vicinity of the site as well as the location.

Table 2: Parameters sampled in the study

METHOD	PARAMETER	UNITS
Physical	Temperature pH	^{0}C ……
Chemical	Nitrates Phosphates Dissolved oxygen(D.O)	mg/l mg/l mg/l
Hydrological	Flow velocity	m/s
Biological	Macrobenthic invertebrates	Shannon wiener diversity index(H´)

3.3. PHYSICAL PARAMETERS

3.3.1 Temperature

The temperature of water in the stream was measured using a laboratory mercury glass thermometer readable to 0.1^{0}C. Temperature influences the solubility of gases in water. Higher temperatures raise the rate of biochemical reactions which consequently leads to increase in the growth rates of individuals as well as the population of the macrobenthic organisms. The essence of measuring temperatures in this study was to find out its influence on the distribution if the benthic fauna.

3.3.2 pH

The water pH was measured using a pH probe which was inserted in the water and a reading taken from its screen. pH is a measure of the concentration of the hydrogen ions in water. It was measured because it relates in several ways to water quality parameters since aqueous chemical equilibrium involves hydrogen and hydroxyl ions. It is also known to affect the nutrient availability and toxicity of ammonia compounds in water.

3.3.4 Depth

The stream depth was measured using a wooden meter rule which was directly inserted into the water and the measurement recorded down there and then at the different sites of the stream.

3.4 CHEMICAL PARAMETERS

3.4.1 Nitrates

These were measured using the U.V spectrophotometer method. This involved collection of water samples which were treated with a standard solution of potassium nitrate

3.4.2 Phosphates

These were also measured by the U.V spectrophotometer method. Here the water samples collected were treated with chemical reagents like Ammonium molybdate and Stannous chloride. A 20mg/l of stock phosphate solution was also made.

Standard solutions were made from the provided stock standard solution and a 5point calibration curve with concentrations ranging from 0 to 5mg/l Phosphate (including blank) was prepared.

The standard solutions, the blank and the water samples were then treated according to their color development procedure.

Here, each water sample was placed in an Erlenmeyer flask 25ml. 1.0ml (with a pipet) of ammonium molybdate solution added into the flask and swirled to mix. Next, two drops of stannous chloride solution were added and mixed by swirling. A blue color developed about two minutes indicating presence of phosphates in the water sample. The wavelength of the spectrophotometer was then set to 650nm.and the blank was used to set the absorbance to zero and then the absorbance of the blue sample was taken and a plot of absorbance versus concentration made to obtain concentration of phosphates in the water samples.

3.4.3 Dissolved oxygen

The dissolved oxygen concentration in water was measured using the Winkler method. Three Water samples from each site were collected in D.O bottles and fixed with concentrated Sulphuric acid and Azide solution in the field. These were taken to the laboratory for titration. In the laboratory 200ml of the fixed sample was titrated with a standard solution of sodium thiosulphate of 0.2M in the burette using starch indicator. The volume of thiosulphate used in titration was equal to the amount of dissolved oxygen in the sample. Dissolved oxygen concentration was measured because it an indicator of organic pollution.

3.5 BIOLOGICAL PARAMETERS

3.5.1 Macrobenthic invertebrates

Three sampling sites were selected to obtain mud samples containing macrobenthic invertebrates using aquatic scoop net at the upstream, mid-stream and downstream. Three samples were taken from each site. Area sampled was determined by random method. The mud was washed and sieved through a sieve of mesh size 250µm. The macrobenthic invertebrates were picked from the sieve using forceps and transferred to specimen labelled plastic bottles containing 5% formalin for preservation. In the laboratory, the macrobenthic invertebrates were identified under a light microscope. The fauna was then classified using standard keys.

3.6 HYDROLOGICAL PARAMETERS

3.6.1 Flow velocity

The flow velocity of the water was measured using the float method. A Piece of full scarp paper of average weight 60g was made to float on the water and time it took to travel three meters was denoted and the flow velocity was then calculated as distance covered/time taken. The relevance of this parameter is that it is important in the distribution of macrobenthic invertebrates within the stream.

3.7 DATA ANALYSIS

3.7.1 Diversity index of data collected on macrobenthic invertebrates

Data obtained about macrobenthic invertebrates was subjected to Shannon wiener index of general diversity to find out the diversity of fauna in the stream. Here the number of individuals of a species (n_i) in each sample was divided by the total number of individuals in the sample(N) and the fraction (Pi) was then multiplied by its natural log (InPi). This procedure was repeated for all the different species found in the sample and the total sum of the products of individuals was then used to obtain the value of the diversity index.

$H' = (\Sigma Pi * InPi)$

$= e^{(\Sigma Pi * InPi)}$

Where:s

H' = Shannon wiener index

N=Total number of individuals

n_i=Number of individuals of a species

Pi=Proportion of species in a category

3.7.2 Standard errors and means of water physico-chemical parameters.

The obtained values of water physico-chemical parameters were subjected to One-way ANOVA using R- Software version 3.4.3 to analyze the means of the different parameters of water in the samples at their different sites as well as to their standard errors and deviations and their F values obtained at an Alpha level of 0.05.

3.7.3 Distribution and percentage abundance of macrobenthic invertebrates

The distribution and abundances of the different species of macro benthos along the stream (up-stream, midstream and downstream) was established using Microsoft windows excel to draw bar graphs and a pie chart showing distribution and percentage abundance of benthic macroinvertebrates respectively.

3.7.4 Relationship between water quality parameters and distribution of macrobenthic invertebrates

Correlation analysis was used to evaluate the relationship between water physico-chemical parameters and distribution of macrobenthic invertebrates.

Data was then summarized in graphs, table, text.

CHAPTER FOUR

RESULTS

Table 3: Water physico-chemical parameters at the study sites of Kiwunya Stream

PARAMETER	SITE	NO OF SAMPLES	MEAN VALUES	STANDARD ERROR	P(0.05)	P(0.001)	F
pH	Upstream	3	7.5	0	<	<	7.86
	midstream	3	7	0	<	<	
	downstream	3	7	0	<	<	
Dissolved Oxygen	Upstream	3	6.6	0.2	<	<	8.41
	midstream	3	5.9	0.1	<	<	
	downstream	3	4.9	0.46	<	<	
Depth	Upstream	3	6.8	2.09	<	<	20.72
	midstream	3	7.6	0.88	<	<	
	downstream	3	18.8	1.17	<	<	
Phosphate	Upstream	3	3.61	0.1	<	>	1.89
	midstream	3	3.25	0.29	<	>	
	downstream	3	1.76	1.2	<	>	
Nitrates	Upstream	3	17.12	0.53	<	<	22.86
	midstream	3	10.98	0.55	<	<	
	downstream	3	11.41	0.97	<	<	
Flow velocity	Upstream	3	0.39	0.02	<	<	31.12
	midstream	3	0.24	0.017	<	<	
	downstream	3	0.18	0.017	<	<	
Temperature	Upstream	3	23.83	0.44	<	<	45.6
	midstream	3	26.83	0.44	<	<	
	downstream	3	28.83	0.17	<	<	

Variations in water physico-chemical parameters were significant in all the three sites with $F_{(2,6)}$ = (45.6, 7.86,20.72,22.86,8.41,31.12) for temperature, pH, depth, nitrates, D.O and flow velocity respectively ($P<0.001$). However, variation in phosphate levels was not significant in all three sites at $F_{(2,6)} = 1.89$ ($P>0.001$)

Table 4 :The overall diversity of macrobenthic invertebrates in study sites of Kiwunya Stream.

	upstream	midstream	Downstream
Number of taxa	3	3	3
Number of individuals	83	228	346
Shannon-wiener index(H')	5.92	7.34	4.69

Shannon wiener general diversity index(H') which measures the relative importance of each taxon collected was highest in the midstream (7.34) compared to upstream (5.92) and downstream (4.69). However, the highest number of organisms was observed downstream and the lowest number upstream. Downstream had the lowest diversity because of its low oxygen concentration that can only be tolerated by a few species of macrobenthic invertebrates. The midstream had the highest diversity because of its relatively high levels of oxygen, the physical nature of the substratum and the surrounding vegetation that support a variety of benthic fauna.

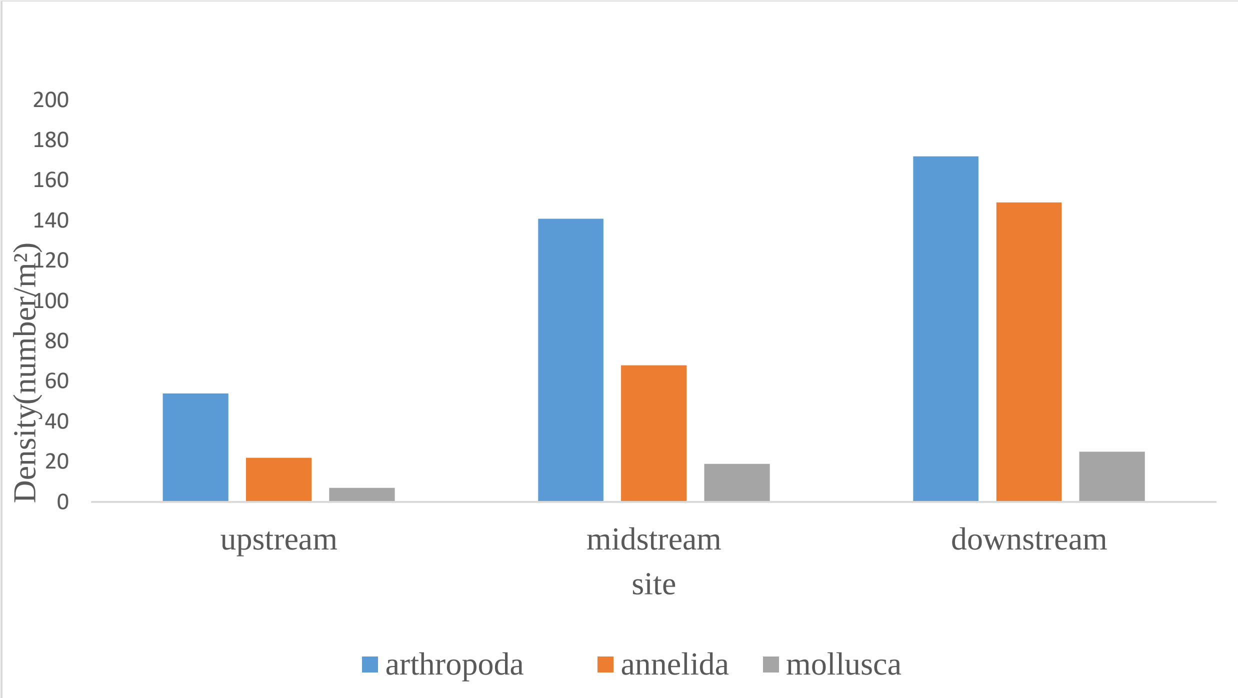

Figure 3: The distribution of the different macrobenthic invertebrate taxa at the different sites of Kiwunya Stream

The phyla Arthropoda and Annelida were the most dominant through all the three sites selected probably due to their high tolerance to lower oxygen levels and the presence of habitats like the vegetation around the stream and the physical nature of the substratum which supports survival of these organisms. Mollusca had the lowest density because these do not tolerate high levels of pollution which was evident in the stream.

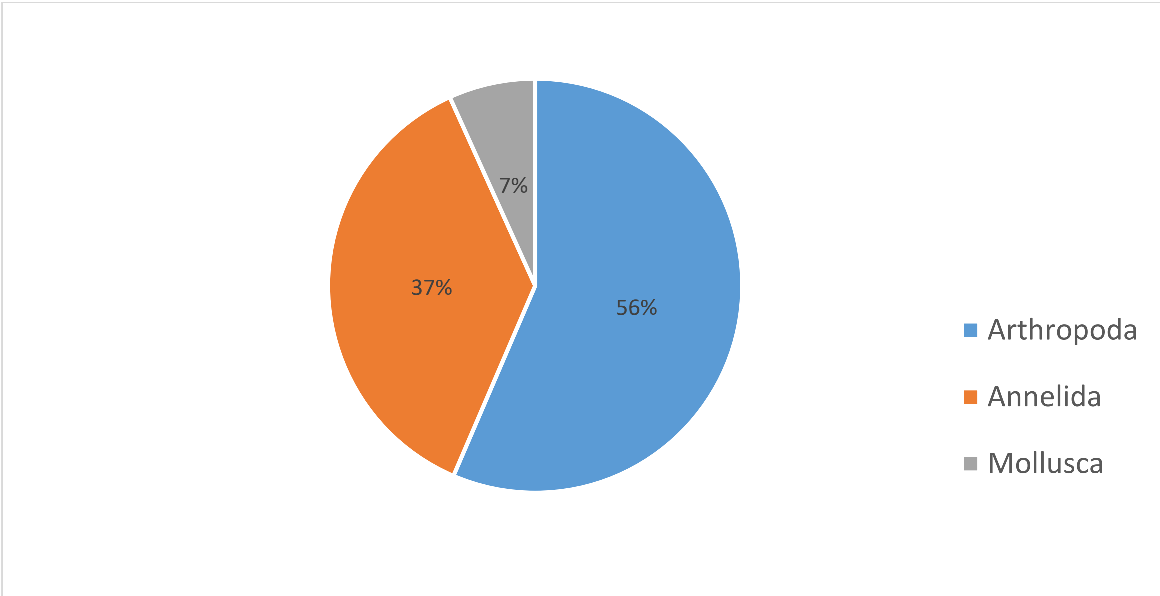

Figure 4: Percentage abundance of major faunal groups

The highest percentage of the benthic fauna found was Arthropoda accounting for over 56% of the total number of macrobenthic fauna found in the stream and the lowest being the Mollusca accounting for 7% of the entire population of macrobenthic invertebrates collected.

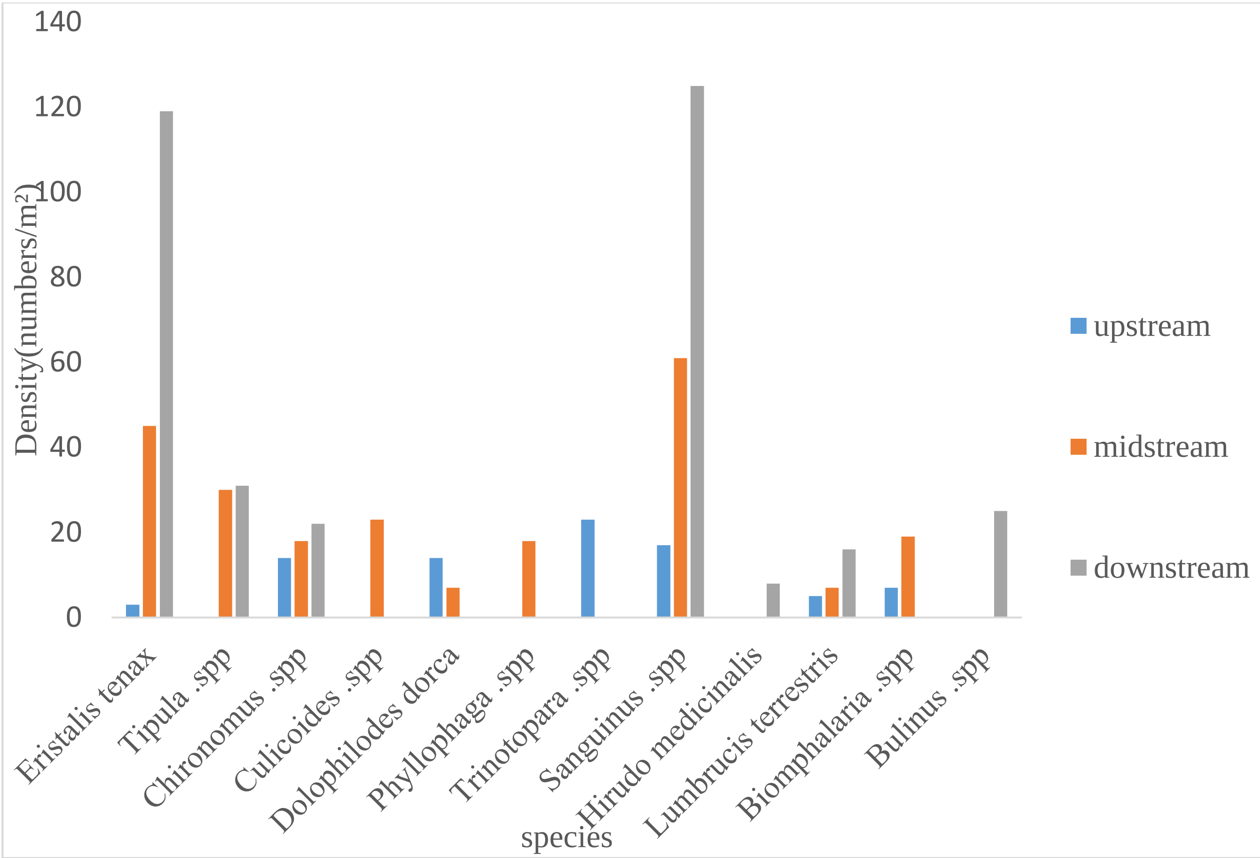

Figure 5: Relative abundances and distribution of macrobenthic invertebrates at the different sites of Kiwunya Stream

The downstream was mostly dominated by *Eristalis tenax* and *Sanguinus.spp*. Their high numbers in the downstream are attributed to their ability to tolerate living in environments with low dissolved oxygen concentration and these are seen to be in low concentrations in the upstream. The upstream mostly occupied by *Trinotopara.spp* and the midstream dominated by the *Sanguinus.spp*, *Eristalis tenax*, *Tipula.spp*, *Chironomus.spp and Culicoides.spp.*

Table 5: Pairwise correlation analysis for the relationship between number of organisms obtained in a site and water parameter

	number	sites	species	temp°C	PH	DO mg/l	depth (cm)
number	1.0000						
	108						
sites	0.2927*	1.0000					
	0.0021						
	108	108					
Species	0.1541	0.0000	1.0000				
	0.1113	1.0000					
	108	108	108				
Temp°C	0.2705*	0.9623*	0.0000	1.0000			
	0.0046	0.0000	1.0000				
	108	108	108	108			
PH	-0.2621*	-0.8660*	-0.0000	-0.8889*	1.0000		
	0.0061	0.0000	1.0000	0.0000			
	108	108	108	108	108		
D.O mgl	-0.2753*	-0.8533*	0.0000	-0.7327*	0.6916*	1.0000	
	0.0039	0.0000	1.0000	0.0000	0.0000		
	108	108	108	108	108	108	
Depth cm	-0.2010*	-0.5902*	-0.0000	-0.4685*	0.3514*	0.6840*	1.0000
	0.0370	0.0000	1.0000	0.0000	0.0002	0.0000	
	108	108	108	108	108	108	108
Flowvelocity	-0.2674*	-0.9259*	0.0000	-0.8993*	0.9188*	0.7727*	0.4984*
	0.0051	0.0000	1.0000	0.0000	0.0000	0.0000	0.0000
	108	108	108	108	108	108	108
Phosphatesmg/l	-0.1194	-0.5866*	0.0000	-0.5466*	0.4055*	0.5505*	0.4864*
	0.2184	0.0000	1.0000	0.0000	0.0000	0.0000	0.0000
	108	108	108	108	108	108	108
Nitratesmg/l	-0.2418*	-0.7831*	-0.0000	-0.7671*	0.9384*	0.7697*	0.3638*
	0.0117	0.0000	1.0000	0.0000	0.0000	0.0000	0.0001
	108	108	108	108	108	108	108

The number of organisms obtained was significantly associated with the site of sample collection (p=0.0021), Temperature (p=0.0046), PH (p=0.0061), D.O (p=0.0039), Depth (0.0370), Flow velocity (0.0051) and Nitrates (0.0117).

CHAPTER FIVE

DISCUSSION

The results revealed three taxonomic groups of macrobenthic invertebrates collected in Kiwunya Stream at the different sites. These include Arthropoda, Mollusca and Annelida. The highest percentage of organisms belonged to Arthropoda (56%) represented by *Eristalis tenax, Tipula.spp, Chironomus.spp, Culicoides.spp, Dolophilodes dorca, Phyllophaga.spp, Trinotopara.spp* followed by Annelida (37%) represented *Sanguinus.spp, Hirudo medicinalis, lumbrucis terrestris* and the Mollusca having the lowest percentage (7%) represented by *Biomphalaria.spp, Bulinus.spp.* Benthic macroinvertebrates are known to be stable over a wide range of environmental fluctuations (May, 1981). Most of the changes that occur in streams are as a result of natural or anthropogenic activities and those often impose stress upon these ecosystems. Kiwunya Stream is one of the urban streams that experience anthropogenic disturbances since it is surrounded mostly by residents. The impacts of anthropogenic activities on streams have been described in details by Kasangaki *et al*., (2006) and these are common to urban streams.

The Shannon wiener general diversity index(H´) was highest in the midstream which could have been as a result of the better environmental conditions compared to the downstream and upstream as well as due to the drainage channels that drain into the midstream. This observation concurs with the results obtained from the water physico-chemical parameters, that show that the water within the midstream was relatively less polluted and more macrobenthic invertebrate fauna of the different species could tolerate this environment compared to upstream and downstream. The downstream had the highest number of organisms (346) and the lowest diversity dominated mostly by the *Eristalis tenax* and *Sanguinus.spp* due to their ability to tolerate areas with very low dissolved oxygen and areas with high organic matter content. This explains why their numbers are lowest in the upstream and relatively low in the midstream. Generally, the low numbers (83) of the macro benthic fauna in the upstream was probably attributed to the high flow velocity of water at this site thus some of the organisms could be washed towards the midstream increasing the numbers (228). Organic loading indicated by low dissolved oxygen at the downstream is attributed to the input of disposal organic matter from the effluent. The high numbers of *Eristalis tenax* and the presence *Chironomus.spp* is confirmation of the low oxygen levels in the water body.

The physico-chemical parameter results in Kiwunya Stream comforms with previous works that they are crucial factors governing the distribution of benthic macroinvertebrates. pH of the stream ranging between 7.0-7.5 shows a neutral to slight alkaline conditions all through the stream indicating that water was less polluted. pH values in the sampling sites showed no significant difference. Life cycles and densities of most benthic invertebrates is dependent on temperature and any alterations of the stream average temperatures by few degrees could alter the flora and fauna of a river (Jackson *et al.*,1989). The very high temperatures downstream (28.83^{o}C) is probably due to the decomposition of nitrates producing heat at that site. Dissolved oxygen values showed a decrease from upstream to downstream with the lowest being at the downstream probably due to the high organic matter load and the low flow velocity. Phosphate levels were highest upstream (3.64mg/l) and midstream (3.25mg/l) because of the agricultural activities in the surrounding areas as well as anthropogenic activities like washing clothes that take place within the stream.

CHAPTER SIX

CONCLUSION AND RECOMMENDATION

6.1 CONCLUSION

In conclusion, throughout the course of my study on the diversity and distribution of the benthic macroinvertebrates in Kiwunya Stream, it shows that there is significant difference in the fauna found at the different sites of the stream. Also the variations in water physico-chemical parameters were significant in all the three sites for temperature, pH, depth, nitrates, D.O and flow velocity ($P<0.001$). However, variation in phosphate levels was not significant in all three sites ($P>0.001$). The results indicate the high numbers of *Eristalis tenax and Sanguinus.spp* in the downstream and midstream while showing low numbers of these upstream indicating the high levels of pollution at these sites as compared to upstream. Also generally the low numbers of *Biomphilaria.spp* and the *Bulinus.spp* species in the stream indicate organic pollution in this environment of which these organisms are less tolerant. The midstream had the highest diversity of organisms since the conditions in this environment are fair enough for the survival of the different species of the benthic fauna and the downstream had the lowest diversity indicating this environment was not suitable enough for most benthic organisms to survive.

It is also therefore noted that the diversity and distribution of benthic macroinvertebrates can be influenced by many factors; among them the natural anthropogenic disturbances, organic matter content in sediments, water temperatures, dissolved oxygen, nitrate levels, flow velocity among others. Most of the changes that occur in streams are of natural or anthropogenic origin and they often impose stress on these ecosystems. Kiwunya Stream is one of the streams which experience anthropogenic disturbances. Benthic macroinvertebrates are good indicators of ecosystems and these change as the ecosystems changes.

6.2 RECOMMENDATIONS

Environmental Education to the communities should be taken into account to create awareness on the impact of pollution through human activities on the stream ecology. An effective environmental policy among the poor needs to have an element of economic incentive, for them to be supportive and compliant in ensuring the proper use of the stream. Further studies need to be carried out on Kiwunya Stream considering more water physico-chemical parameters and with better equipment in order to establish trends on the ecological integrity of this stream as this impacts both human and residential aquatic life which inhabit the stream.

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