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MACROINVERTEBRATES AS INDICATORS OF ECOSYSTEM HEALTH AND DISTURBANCE, A CASE STUDY OF OKUTA SEASONAL STREAM, KISOKO SUB-COUNTY

BY

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A PROJECT REPORT SUBMITTED TO THE DEPARTMENT OF BIOLOGY IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE AWARD OF BACHELOR OF SCIENCE AND EDUCATION DEGREE OF BUSITEMA UNIVERSITY

SUBMISSION DATE: ……

APPROVAL

This research report has been submitted for examination with the approval of my supervisor **Mr Wamboga Emma**

Signed..... Date.....22nd/10/2024

DECLARATION

I Kiplimo Joshua declare that this research is my own original work and all the contents presented are original with the exception of the references and that this work has not been submitted for any award in any other University or institution of higher learning or publication.

Signature

.....

Date

05th/09/2024.....

DEDICATION

I dedicate this project report to my dear parents **Mrs. ROSE CHEMUTAI AND** my late father **ERIEZA MUKONGO MUGADI** for the love, care and support they have accorded me to see that I succeed in my academic endeavor.

ACKNOWLEDGEMENT

I wish to extend my sincere appreciation to my dear lecturers of biology department together with the laboratory technicians in Busitema University who have been of great help during the pursuit of my studies in the faculty of science and Education. Special thanks to my brothers and sisters who worked tirelessly to ensure that I completed my studies successfully more so my dear mummy Chemutai Rose, my siblings: Chemonges Eric (Tr. Kamet s.s), Chebet Nancy, Lakwey Sam Stephen, Kiprop Micheal, Chemutai Milcah and Chebet Sarah not forgetting Benna Chemutai (Daddy) and Chebet Faith (uncle)

I would also wish to extend my gratitude to my colleagues in the biology class more especially Kuloba Isaac, Wopala Kevin, Kibet Daniel, Mpango Ashiraf, Ssemakula Ashiraf and others for the unlimited support they rendered to me until I was able to submit my research report.

DEFINITION OF TERMS

1. USEPA- United States Environmental Protection Agency
2. EPT- Ephemeroptera, Plecoptera and Trichoptera
3. DO- Dissolved Oxygen
4. EC- Electrical Conductivity

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ABSTRACT

Aquatic macroinvertebrates perform an important role in response to a variety of environmental conditions of streams and may be used as bio-indicators for ecosystem health and disturbance(Sumudumali, *et al.,* 2021). In the past, biological communities like plankton, periphyton, microphytobenthos, macro benthos, aquatic macrophytes, fishes among others have been used for assessment of water quality of streams, but now the use of macroinvertebrates has become the most commonly used method because it is cheaper and takes less time in comparison with other methods and they can easily be seen with our naked eyes(Obubu, *et al.,* 2021). The study will involve sampling, pre-identification, identification of macroinvertebrates and finding out the abundance of macroinvertebrates of different taxonomic groups and carrying out physical chemical analysis of samples from the selected locations. The most common macroinvertebrates found in fresh water streams belong to the orders like Ephemeroptera, Diptera, Mollusca, Plecoptera, Heteroptera, Trichoptera, Odonata, oligochaetes among others(Mir, Arafat, & Bakhtiyar, et al., 2021). The purpose of this study was to assess the quality of Okuta seasonal stream using macroinvertebrates as indicators of ecosystem health and disturbance, three (3) sites were selected and from each site the physical chemical parameters including PH, temperature, electrical conductivity and dissolved oxygen the three sites were; forested area, rice growing site and animal rearing site. From the results obtained, forested area (site one) was found to have a more safer water quality as compared to the other two because it recorded a high value of dissolved oxygen of 1.28 and 1.27. Site two had the highest number of macroinvertebrates 11 all from one family Hirundinidae followed by site two with 9 and site three had the least (3). The macroinvertebrates which were collected from the three sites at Okuta seasonal stream include the following families: Canidae, Teleganodidae, Heptagenilidae, Baetidae, Platycnidae Hirundinidae and Dytiscidae. Sensitive species, such as certain mayflies, caddisflies, and stoneflies, thrive in clean water conditions, while tolerant species, such as some chironomids and oligochaetes can persist in more disturbed environments, absence of these groups of macroinvertebrates indicates less pollution in a water body

CHAPTER ONE: INTRODUCTION

1.1 BACKGROUND

Freshwater ecosystems are considered as the most endangered and threatened worldwide(*Akindele* et *al., 2023).* There is an urgent need for developing the most comprehensive methods possible for assessing the aquatic ecosystems health, and maintaining the goods and services of these ecosystems

Water pollution is a significant global problem that affects water bodies across the world, including oceans, rivers, lakes, and groundwater sources(Madhav et al., 2020). It is caused by various human activities, such as industrial discharges, agricultural runoff, improper waste management, and urbanization(*Akhtar, et al.,2021).* The consequences of water pollution are detrimental to both human health and the environment, water pollution poses a severe threat due to its sheer scale and impact*(Vasilachi, et al., 2021).* Pollutants discharged into the oceans can contaminate marine life, disrupt ecosystems, and lead to the formation of dead zones where oxygen levels are drastically reduced(Macko, 2018). This negatively affects global biodiversity and the sustainability of fisheries.

In Africa, like other continents, is facing the challenges of water pollution. Urbanization, industrialization, and agricultural practices have contributed to the contamination of rivers and lakes(du Plessis, *et al.,* 2019), reducing their water quality and availability. Moreover, limited access to safe drinking water exacerbates the problem, leading to various waterborne diseases and high mortality rates(Chan et al., 2021).

In Uganda, water pollution poses a significant problem, particularly in densely populated areas and industrial zones(Muhamya, *et al.,*, 2024). One of the major contributors is inadequate wastewater treatment, leading to untreated or partially treated effluents being discharged directly into water bodies(Tariq & Mushtaq, 2023). Additionally, agricultural practices, including the use of fertilizers and pesticides, contaminate water sources through runoff(Kaur & Sinha, 2019). The pollution of Lake Victoria, which is shared between Uganda and neighboring countries, is a concern due to its importance as a source of freshwater and livelihood for surrounding communities(Were Nakiyemba, *et al.*, et al.,2020).

In Eastern Uganda, water pollution is also a pressing issue. Many areas in this region rely on Lake Victoria and its tributaries as primary sources of water for domestic, agricultural, and industrial use(van Soesbergen, *et al.*,2019). Pollution from urban areas, including improper waste

disposal and inadequate sanitation systems, affects the quality of water in these water bodies(Edokpayi, *et al.,* 2017). Furthermore, industries and agricultural practices in the region release pollutants such as heavy metals, chemicals, and organic waste, contaminating the water supply and harming both aquatic life and the health of local communities(Chowdhary, *et al.,*2020).Efforts to combat water pollution in Eastern Uganda include implementing strict regulations on industrial waste disposal, promoting sustainable agricultural practices, and improving wastewater treatment systems(George, *et al.,*2020). Additionally, increased awareness and education about the importance of clean water and proper waste management are crucial for minimizing pollution levels(Debrah, *et al.,*2021). Collaborative efforts between governmental bodies, non-governmental organizations, and local communities are essential for addressing this multifaceted problem and ensuring access to clean and safe water for all(Hove et al., 2021). Both the anthropogenic influences such as urban, industrial, and agricultural activities increasing exploitation of water resources as well as natural processes, such as precipitation inputs, erosion, and weathering of crustal materials, degrade surface waters and damage their use for drinking, recreational, and other purposes(Khatri & Tyagi, 2015). Although several organisms contribute to the biodiversity of river ecosystems, aquatic, macro-invertebrates are among the most ubiquitous and diverse group of organisms in these systems because they play a central ecological role in nutrient cycling in these ecosystems(Vaidya, 2019). Benthic macroinvertebrates are the animals that lack a back-bone and generally are visible with the naked eyes(Sharma, *et al.,*2006). They live in the lower areas of the streams under rocks. They include larval forms of many common insects such as Dragon flies, Damsel flies and Crane flies(Merritt & Wallace, 2009).

1.2 Problem statement:

Lack of access to clean water is the problem in developing countries(Pandit & Kumar, 2015). There is an escalating pressure on the quantity and quality of freshwater resources in Uganda due to organic and inorganic pollution(Ndugga, 2021). The increasing rate of water pollution is as result of industrialization, greater demand for irrigation, livestock production, Agricultural activities like crop growing and application of artificial fertilizers(Schlink, *et al.,*2010). Therefore, a detailed investigation is required to determine the abundance, diversity and composition of macro invertebrate communities found in Okuta seasonal Stream. This study will also assess the impact of various disturbances, such as pollution, land-use changes, and habitat alterations, on macro invertebrate populations. The research aims to establish a reliable and

practical indicator system using macroinvertebrates, enabling effective monitoring and management of the Okuta Stream's ecosystem health and disturbances.

1.3 OBJECTIVES OF THE STUDY

1.3.1 General objective:

To assess the health status of the Okuta seasonal stream ecosystem in Kisoko sub-county, using macroinvertebrates as indicators of ecosystem health and disturbance.

1.3.2 Specific objectives:

1. To identify macro invertebrate taxa, present in the Okuta seasonal stream.
2. To determine the physical chemical parameters of the stream water.

1.4 Research questions

1. What are the most common macroinvertebrates present in Okuta seasonal stream?
2. What is the relationship between the water quality parameters and the abundance of macroinvertebrates in Okuta seasonal stream?
3. What is the overall water quality status of the Okuta seasonal stream based on the identified macroinvertebrates?

1.5 Hypothesis

1.5.1 Null hypothesis

There is no significant difference between macroinvertebrates as indicators of ecosystem health and disturbance

1.6 Significance of the study

This study was significant in the sense that it helped to assess the health and disturbances in ecosystems using macroinvertebrates as indicators. Understanding the health of an ecosystem is crucial for conservation efforts and sustainable management of natural resources. Macroinvertebrates, such as insects, mollusks, and crustaceans, are widely used as bio-indicators because of their sensitivity to changes in the environmental conditions. By studying the macro invertebrate community in Okuta stream in Kisoko Sub- County, researchers can gain a deeper understanding into the current state of the stream's ecosystem health and identify disturbances that may affect the overall ecological balance. This information can then be used to implement targeted conservation measures or address specific issues affecting the stream. The research can contribute to the preservation and restoration of the stream's ecosystem, thereby benefiting both the local community and the wider environment.

1.7 Study area

Okuta seasonal stream is located in Kisoko Sub County, which is a sub county within Tororo District. It is a significant water feature in this area, known for its seasonal variations in flow and water levels. The study area encompasses the entire length of the Okuta seasonal stream, including its upstream and downstream portions. It stretches for several kilometers, starting from its origin in the hilly areas of Kisoko Sub- County and flowing towards its confluence with a larger river or lake in the region. The physical characteristics of the study area include diverse landforms, varying elevations, and different types of vegetation along the stream. The stream passes through rural areas, including agricultural fields, settlements, and natural habitats. The study area also includes the inhabitants and communities situated along the Okuta seasonal stream. These communities rely on the stream for various activities such as domestic water supply, agriculture, fishing, and livestock watering. The stream plays a vital role in the socio-economic activities and livelihoods of the local population.

This research aimed at assessing various aspects of the Okuta seasonal stream, such as its hydrological characteristics, water quality, ecological health, and the impacts of human activities on the stream ecosystem. Okuta seasonal stream in Kisoko Sub- County, Tororo District presents a diverse and dynamic environment for research, offering valuable insights into the interactions between human activities and the natural resources of the area.

CHAPTER TWO: LITERATURE REVIEW

Water is an important resource to the existence of all living organisms, there is a high demand for water of high quality by human populations for domestic purposes and economic activities(Gössling et al., 2012). Aquatic environments are complex matrices that require careful use to ensure sustainable ecosystem functioning well into the future, also aquatic organisms require attention for their conservation(Frissell & Bayles, 1996).

Rivers and streams are the most important freshwater resources for man(Gleick, 2003). Unfortunately, river waters are being polluted by deliberate disposal of sewage, industrial waste and human activities, which affects their physical chemical characteristics and aquatic macroinvertebrates(Chakraborty & Chakraborty, 2021).

2.1 Bio-monitoring

Bio monitoring, or biological monitoring, is generally defined as "the systematic use of living organisms or their responses to determine the condition or changes of the environment(Conti, 2008). It involves carrying our regular surveillance of aquatic organisms in order to assess the continuing quality of the ecosystem(Bilotta & Brazier, 2008). Bio-monitoring is a critical tool used to assess the ecological health of aquatic ecosystems, particularly through the study of macroinvertebrate communities(Bo, Doretto, Laini, Bona, & Fenoglio, et al., 2017). These organisms, which include insects, crustaceans, mollusks, and worms, serve as indicators of environmental conditions due to their varying sensitivities to pollutants, habitat alterations, and other stressors(Sangwan et al.). Macroinvertebrates exhibit differing levels of tolerance to pollutants and habitat degradation(Xu, *et al.*,2014). Sensitive species, such as certain mayflies, caddisflies, and stoneflies, thrive in clean water conditions, while tolerant species, such as some chironomids and oligochaetes, can persist in more disturbed environments*(Deborde, et al., 2016).* The presence or absence of these groups can provide valuable information about water quality and habitat health(Diaz, *et al.*,2004). Unlike chemical monitoring, which provides a snapshot of water quality at a particular time, macroinvertebrate surveys reflect the cumulative effects of environmental conditions over time(Veríssimo, *et al.*,2013). They integrate the impacts of multiple stressors—such as chemical pollution, habitat alteration, and thermal changes—offering a more holistic view of ecological health. Bio-monitoring using macroinvertebrates is often more cost-effective than traditional chemical assessments(Ogidi, *et al.*, 2024). Collecting and identifying macroinvertebrates can be done relatively inexpensively and does not require

complex lab equipment(*Reed, et al.,2023).* Additionally, standard protocols and guidelines for macroinvertebrate sampling have been established, ensuring consistency and comparability across studies(Buss et al., 2015). Various techniques can be employed to collect macroinvertebrates, including kick-net sampling, D-frame netting, and hand-picking(Haubrock, *et al.*,2024). The choice of method often depends on the specific habitat type and study objectives(Rondinini & Chiozza, 2010). Sampling should be conducted at multiple sites to capture spatial variability within the ecosystem. After collection, macroinvertebrates are identified to the family or genus level, where possible(Chessman, *et al.,* 2007). Taxonomic identification is crucial, as different taxa exhibit varying levels of sensitivity to pollution. Accurate identification can often require the use of identification keys(Walter & Winterton, 2007). The data collected can be analyzed using various biotic indices, such as the Average Score Per Taxon (ASPT), and the Shannon-Wiener index of diversity*(Zeybek, et al., 2014).* These indices provide quantitative measures of community composition and health, allowing for comparisons across sites and time*(Hewitt, et al., 2005).* Bio-monitoring can identify impaired sites due to urban runoff, agricultural practices, or industrial discharges*(Dhananjayan, et al.,*. By establishing baseline conditions, it becomes easier to identify trends over time and evaluate the effectiveness of restoration efforts(Suding, 2011). Many regulatory frameworks require bio-monitoring as part of environmental assessments for permits or ongoing compliance(Ogidi et al., 2024). By employing macroinvertebrate surveys, agencies can ensure that aquatic ecosystems are protected and maintained*(Garda, et al.,, 2017).*

2.2 Macroinvertebrates and stream ecosystem assessments

Macroinvertebrates are all of those invertebrates that can be seen without the aid of a microscope or magnifying glass(Hauer & Resh, 2017). Benthic macroinvertebrates can serve as bio indicators and are the organisms more frequently used(Kenney, *et al.,*2009), They play a significant ecological role since they are an important link between energy inputs and their transfer to other trophic levels through the food web, and participate in the balance between heterotrophs(Hershey, *et al.,*2010).

The most common macroinvertebrates found in fresh water streams belong to the orders like Ephemeroptera, Diptera, Mollusca, Plecoptera, Heteroptera, Trichoptera, Odonata, oligochaetes among others. An important application of our ecological knowledge of stream macro invertebrate communities is the bio-assessments of stream ecosystem health(Kaboré et al., 2016).

Bio assessment protocols are based on the premise that biotic communities respond to changes in habitat and water quality resulting from anthropogenic disturbance and that such community responses are integrated indicators of the state of the biotic and abiotic variables representing stream health(Stribling, *et al.,* 2016) define bio assessments as "an evaluation of the condition of a waterbody using biological surveys and other direct measurements of the resident biota in surface water." Biological monitoring, as defined by includes "measuring and evaluating the condition of a living system, or biota. This process occurs over a long period of time in order to detect changes in living systems in water bodies and streams and help to identify the potential risks to human(Atazadeh, 2023), Thus bio assessments are individual evaluations of streams and long term bio-monitoring projects(Tiziano et al., 2017). Because macro invertebrates can be seen by our naked eyes and simple equipment used to sample them, they are commonly used in bio-monitoring assessments(Haldar, *et al.,* 2016). macroinvertebrates provide a more localized assessment of their response to stream conditions(*Pond, et al., 2017*). Additionally, they are abundant and less mobile than fish. Freshwater benthic macroinvertebrates include representatives of many insect orders, as well as crustaceans, gastropods, bivalves and oligochaetes(Bonada & Bogan, 2024). Macroinvertebrates are ecologically important in that they help in decomposition, nutrient recycling and play an important role in aquatic food webs as both consumers and prey(Demars, *et al.,* 2021).

The natural features of stream habitats can affect macroinvertebrate assemblage structure. These features include(Calapez, *et al.*,, 2021): the quality and quantity of food resources, habitat quality such as the physical structure of the stream bed, flow regime such as the frequency and intensity of storm-flow disturbance, water quality, biotic interactions, and the condition of the riparian zone affect macroinvertebrate assemblage and structure(Anderson e al., 2013). Agricultural and urban land-uses greatly alter both the physical and the chemical aspects of macroinvertebrate habitat, impacting the structure of macroinvertebrate communities(García–Girón et al., 2022)

2.3 P H

PH is the measure of the acidity or alkalinity of a solution which can be influenced by various biological and environmental factors(Boyd & Boyd, 2015). such as agricultural practices and industrial activities can increase the acidity of water bodies leading to negative impacts on aquatic life. Authors often highlight pH as an essential indicator of water quality, with specific ranges being optimal for different species(Kenney et al., 2009). For instance, most freshwater fish thrive in a pH range of 6.5 to 8.5(Alabaster & Lloyd, 2013). Research studies report how pH

affects nutrient availability, particularly for plants and phytoplankton(Jones, 1998). For example, the bioavailability of phosphorus is significantly influenced by pH, impacting primary production in aquatic ecosystems(Withers & Jarvie, 2008).

2.4 ELECTRICAL CONDUCTIVITY

Electrical Conductivity is the measure of the ability of a solution to attract electric current. In biomonitoring, high conductivity levels are associated with elevated levels of mineral ions such as sodium and calcium in water(Lu et al., 2015), changes in conductivity can also indicate changes in salinity, temperature or the presence of pollutants such as heavy metals. Many researchers discuss the use of electrical conductivity as a rapid method for assessing water quality(Gholizadeh, *et al.,* 2016). Increase in conductivity often indicate pollution due to higher concentrations of ions like nitrates and chlorides(Ntengwe, 2006). Conductivity has implications for aquatic life, as high levels can affect the survival and reproduction of sensitive species(Armstead, *et al.,*, 2016).

2.5 TEMPERATURE

Temperature is the measure of heat energy present in water. Changes in temperature can affect aquatic life by altering metabolic rates(Schulte, 2015), DO levels and other biological processes. Environmental changes such as climate change, land use activities are known to influence temperature in aquatic ecosystems thus affecting the survival and distribution of aquatic organisms. Research studies indicate that temperature affects metabolic rates in aquatic organisms. For instance, an increase in temperature generally leads to higher metabolic rates, which may increase oxygen demand, potentially creating hypoxic conditions(Diaz & Breitburg, 2009). Temperature influences the solubility of oxygen and other gases in water; warmer water holds less dissolved oxygen, which can affect aquatic life(Blumberg & Di Toro, 1990).

2.6 DISSOLVED OXYGEN

DO is the amount of oxygen in aquatic environments that is accessible to fish, invertebrates and all organisms in the water. Most aquatic organisms require oxygen to survive, fish for instance cannot survive for long in water with DO<5mg/l

The lower the DO in water is a sign of contamination and is an important factor in determining water quality, pollution control and treatment process, Oxygen is poorly soluble in water. In

aquatic environments, oxygen saturation is the ratio of the concentration of dissolved oxygen to the maximum amount of oxygen that will dissolve in that water body at the temperature and pressure which constitute stable equilibrium conditions. Many authors focus on the relationship between DO levels and aquatic ecosystem health. Low DO levels can lead to hypoxia, causing fish kills and biodiversity loss, Studies indicate that DO levels are influenced by temperature, salinity, and biological activity(Roman, *et al.*, 2019). For example, higher temperatures can lead to decreased oxygen solubility, exacerbating the effects of eutrophication(Jeppesen et al., 2010).

CHAPTER THREE: METHODOLOGY

3.1 Study site

The study was conducted in Okuta seasonal stream, Kisoko sub-county and measurements will be taken from three different sites with a distance of approximately 500m from one site to the next

This study included sampling of macroinvertebrates from different positions of Okuta seasonal stream and measurement of the physical chemical parameters,

Physical chemical parameters

PH

PH was measured directly on each point by getting the average of three points of the measurements using a multi-meter of the model HI991300 PH/EC/TDS meter Hanna instrument 02/ 2014 SN A0012217 made in Europe (Romania) HI128, The PH meter was partially immersed inside water and left for few minutes to stabilize and the readings were taken. This was done thrice at each site.

Temperature

Temperature was measured and recorded at every site in the field using multi meter HI991300 PH/EC/TDS meter Hanna instrument 02/ 2014 SN A0012217 made in Europe (Romania) HI128. This was done by immersing the meter in water and left for few minutes to stabilize and the readings were taken. Whereby three measurements were taken from each reach point and their average recorded

Electrical conductivity

Electrical conductivity was measured with the help of a conductivity meter HI991300 PH/EC/TDS meter Hanna instrument 02/ 2014 SN A0012217 made in Europe (Romania) HI128 by getting the average of three points at each site. This was done by immersing the electrical conductivity meter in water and left for few minutes to stabilize and the readings were taken.

Dissolved oxygen

Dissolved oxygen was measured using a multi meter of the model HI991300 PH/EC/TDS meter Hanna instrument 02/ 2014 SN A0012217 made in Europe (Romania) HI9146. The meter was partially immersed inside water and left for few minutes to stabilize and the readings were taken. The average for all the measurements which were taken from the three sites was determined and recorded.

Site description

The various habitat types that were encountered were defined as follows:

3.1.1 Site one

Glide - Slow moving water with a smooth, unbroken surface. Turbulence is low. Usually, shallow compared to other parts of the channel with aquatic vegetation growing beneath the water surface.

3.1.2 Site two

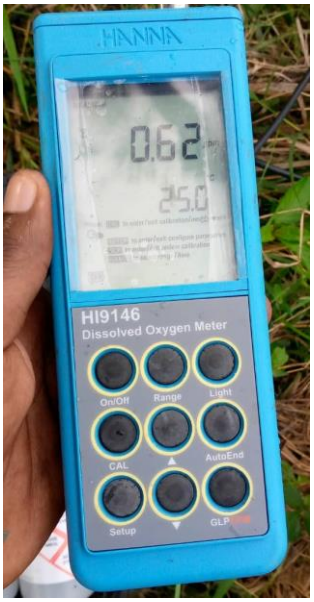
Run – Like glide but water is moving slightly faster. Turbulence is low, and the surface is without ripples that produce gurgling sounds. Runs may have small waves.

3.1.3 Site three

Pool - Still water with low velocity. Water surface is smooth and glassy.

3.2 Materials and reagents

P.H meter, temperature meter, electrical conductivity meter, Kick net, mineral bottle, 95% denatured ethanol, masking tape, and tray.



”





3.3 Benthic macroinvertebrate sampling

The macroinvertebrates were collected using the kick net method which will require standing upstream and kicking along the bottom of the stream in a zigzag pattern and were removed from the net use a pair of forceps and transferred into a 500ml polyethylene container with 95% ethanol preservative after 6 minutes of kicking and sweeping littoral macrophytes and marginal

vegetation. Macroinvertebrates will be identified to family level using identification guide, recorded their abundance and diversity will be noted

CHAPTER FOUR: RESULTS

Location and elevation on the Okuta catchment area:

SITE	SYMBOL	EASTING	NORTHING	ELEVATION
1	A1	0084294	36N0616643	1115M
2	A2	0080983	36N0619873	1136M
3	A3	0081245	36N0619621	1133M

4.1 Physical-Chemical parameters

The parameters were obtained at each site and the variations tabulated and graphically represented. The results showed variations among the three reach (see table 1.0), The lowest PH recorded in site one was 6.8 and the highest was 7.3 thus there was a decrease in neutrality in site one. site two and site three had a relatively neutral PH. The temperatures showed a significant increase with 28.7^0C at site one, 29.1^0C at site two and 27.7^0C at site three, the lowest temperature was recorded in site 3 (25.0^0C), see table 1.0. the highest Conductivity was recorded at site one (259.6**µs/cm**) while site three recorded the lowest Conductivity (227.2**µs/cm**).

Table 1.0 The table showing sampling sites and water parameters of Okuta seasonal stream, Tororo District

SITE	sampling station	pH	TEMP (ºC)	EC (µs/cm)	DO (ppm)
A1	1	7.5	25.5	227.2	1.28
	2	7.3	25.0	234.9	1.27
	3	7.1	27.7	234.4	0.89
A2	1	7.3	27.8	259.6	0.96
	2	6.8	28.7	243.0	0.40
	3	6.9	27.5	235.5	0.43

A3	1	7.6	29.1	243.0	0.82
	2	7.1	28.3	261.8	0.99
	3	7.5	27.8	248.2	0.89

Table 1; sampling sites and water paramenters of Okuta seasonal stream.

4.2 Macro invertebrates Diversity

The macro invertebrates were collected and their total numbers per each site noted. From the results, the families collected at site one was Canidae, Teleganodidae, Baetidae and Platycnidae, at site two the dominant family was Hirundinidae and it was the only family or macroinvertebrates collected at this site whereas at site three, only two families were collected Hirundinidae and Dytiscidae as shown in table 2. To compare their relative abundance, a graph was drawn for each site. Highest taxa richness was recorded at site one (5) and the lowest at site two (1). Of all the 7 macro invertebrate families collected at the three reaches, Hirundinidae was the most abundant with 50% of the total. see table 2.0.

Table showing the abundance of macroinvertebrates

FAMILY	**SITE 1 (forestry)**	**SITE 2 (rice growing site)**	**SITE 3 (cattle rearing site)**	**TOTAL**
Canidae	03	00	00	03
Teleganodidae	03	00	00	03
Heptagenilidae	01	00	00	01
Baetidae	01	00	00	01
Platycnidae	01	00	00	01
Hirundinidae	00	11	01	12
Dytiscidae	00	00	01	01

TOTAL	09	11	02	22

Table 2; Abundance of macroinvertebrates.

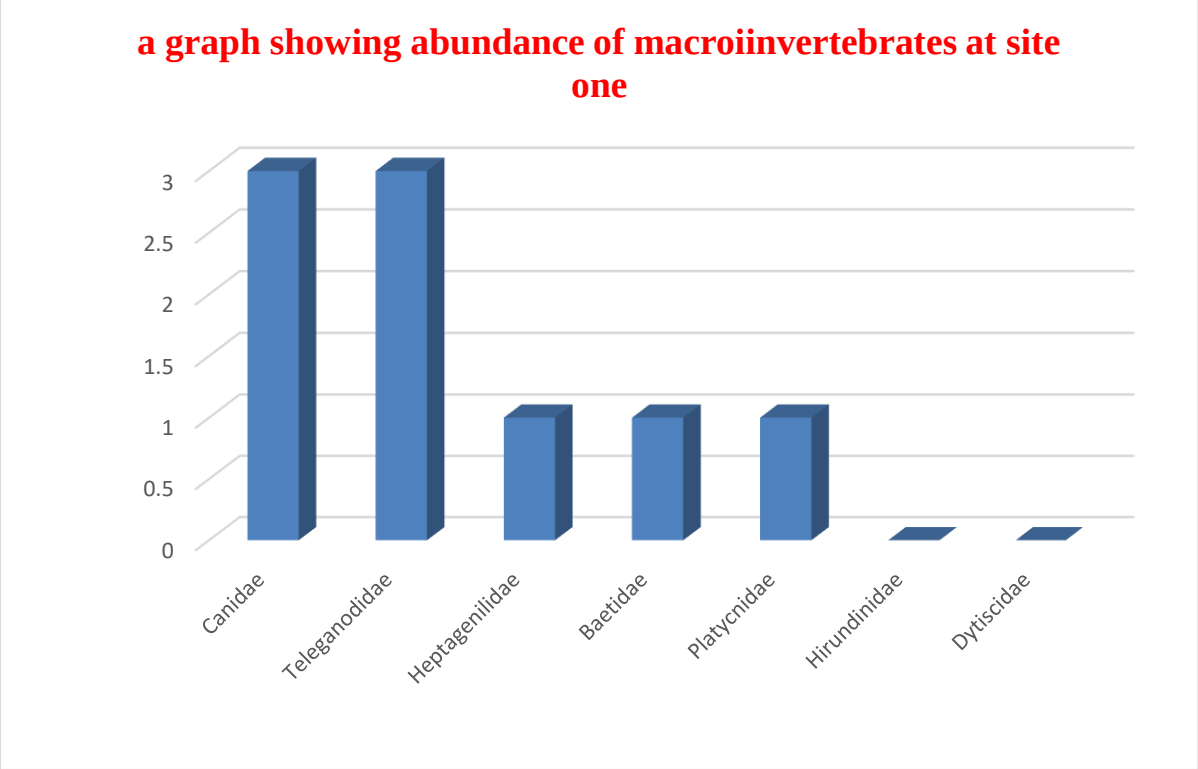


Figure 1 Abundance of macroinvertebrates at site one.

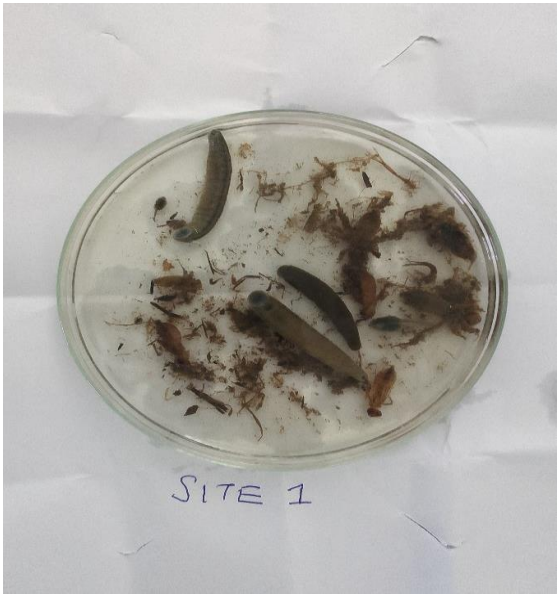


Figure 2 Site one macroinvertebrates

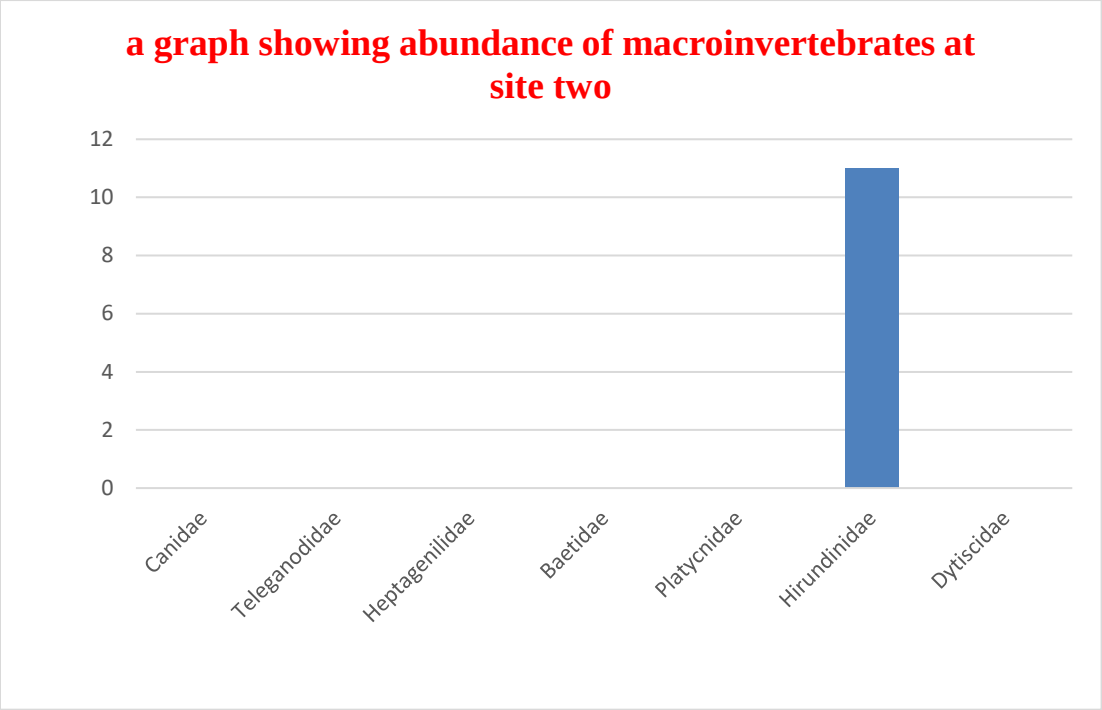


Figure 3 abundance of macroinvertebrates at site two.



Figure 4 Site two macroinvertebrates.

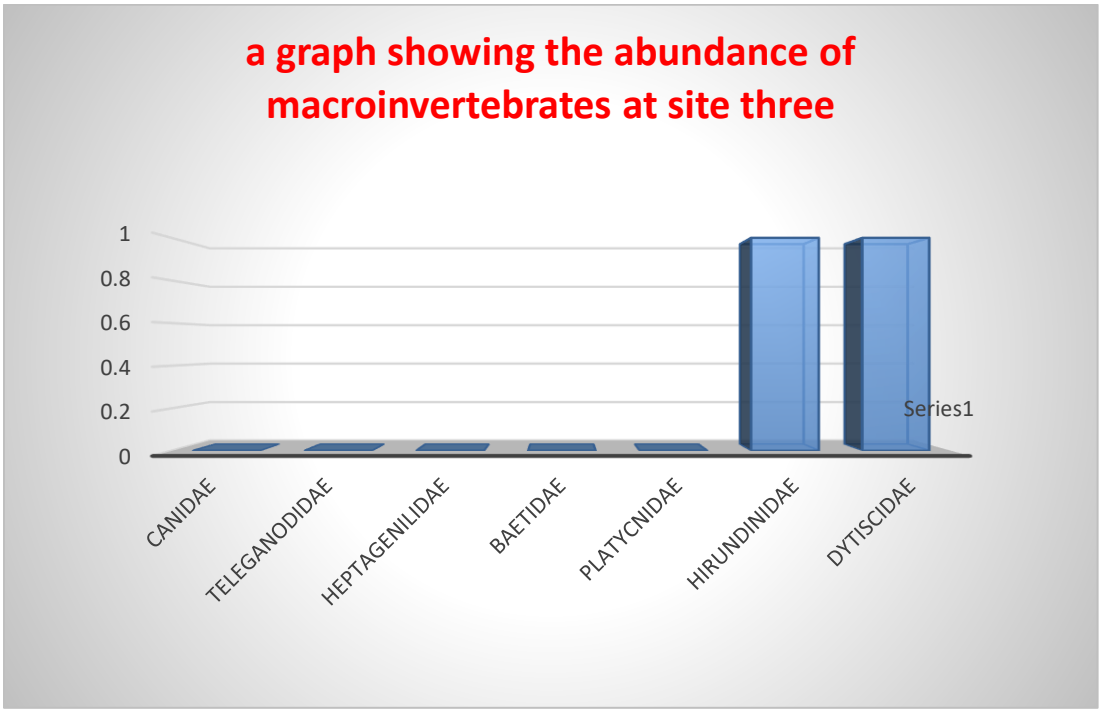


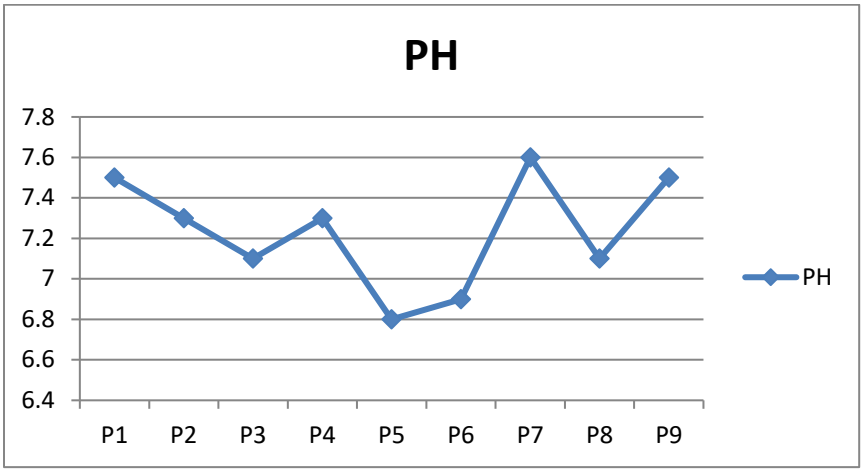
Figure 5Abundance of macroinvertebrates at site three.



Figure 6 Site three macro invertebrates.

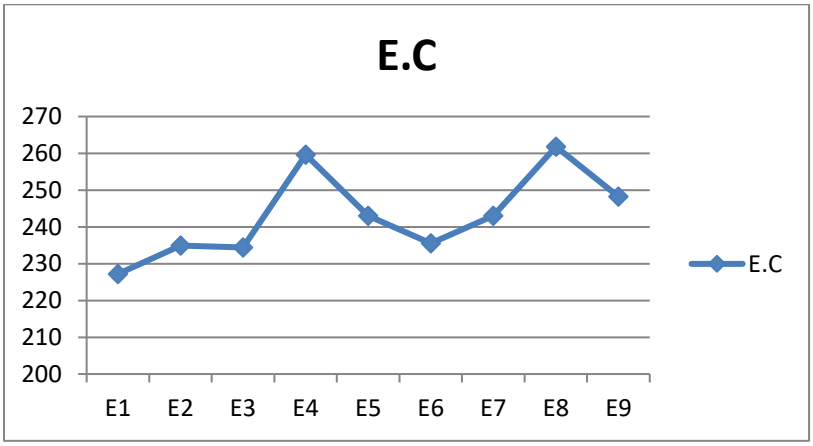
The variations in PH show the level of the quality of water at each site, below is the line graph showing variation of PH at each site

GRAPH SHOWING VARIATION OF PH AT EACH SITE



From the above graph, P1-P3 represent the PH measures taken from the site one, P4-P6 represent the pH measures taken from site two and P7-P9 represent pH measures taken from site three.

GRAPH SHOWING VARIATION OF ELECTRICAL CONDUCTIVITY



From the above graph, E1-E3 represent the EC measures taken from the site one, E4-E6 represent the EC measures taken from site two and E7-E9 represent EC measures taken from site three.

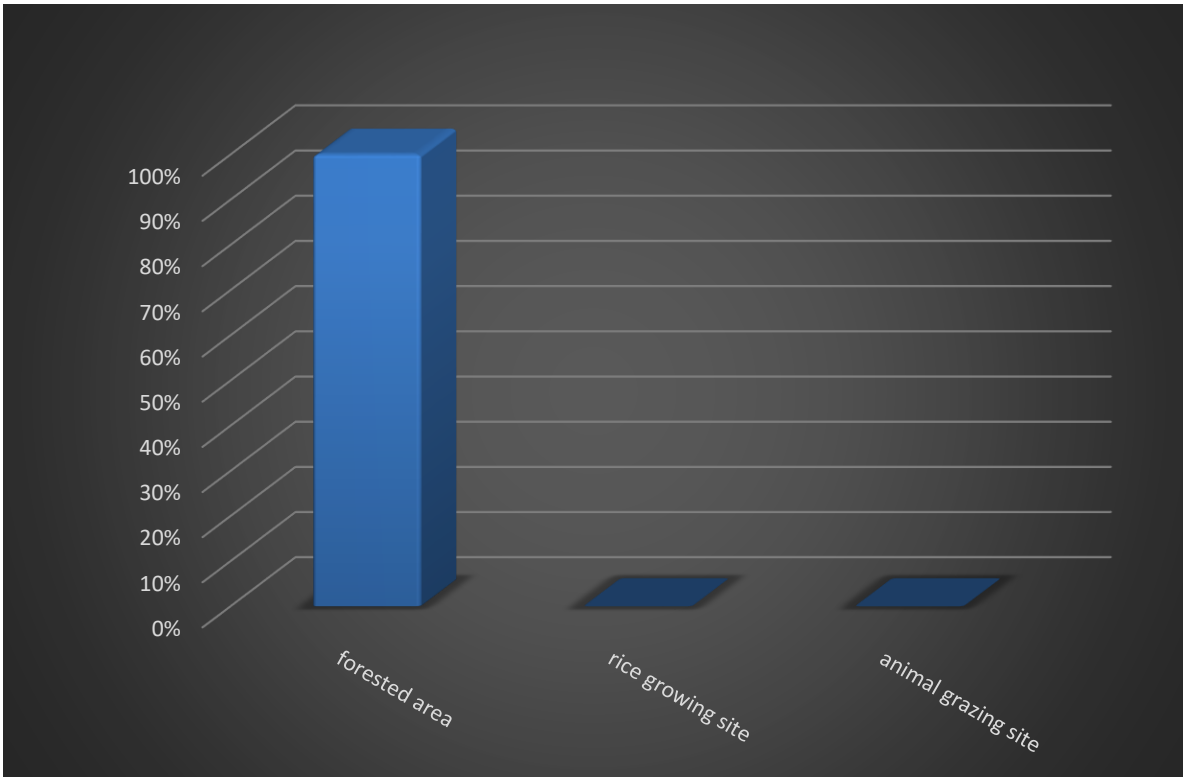


Figure 7 percentage of Ephemeroptera, Plecoptera and Trichoptera, (EPT) at each site.

a graph showing % EPT for every reach

CHAPTER FIVE

5.1 DISCUSSION OF RESULTS

From the results collected from the three different sites, there were variations as recorded in table 1.0, generally, there was an increase in temperature, the relatively low temperature at site one is attributed to the vegetation cover which prevent light rays from directly penetrating into the water whereas at site two, there was no vegetation cover and that is why an increase in temperature was noticed and so is site three. A shift of PH from neutrality to acidity was recorded in site two. "pH levels have a profound impact on macroinvertebrate distributions, with even slight changes potentially altering community structure(Tonkin, 2014)

Generally, there was an increase in the electrical conductivity downstream and this is due to human activities like agriculture. Site one is found to have the highest concentration of dissolved oxygen, this is because site one is near vegetation cover whereas there is a decrease in the concentration of dissolved oxygen in site two and site three because of the anthropogenic activities carried out which pollute the water. Electrical conductivity is an important factor influencing macroinvertebrate abundance and diversity, particularly in freshwater ecosystems. (Hamid, *et al.*, 2021)

A higher electrical conductivity indicates poor water quality. This is because electrical conductivity increases with increase in salinity and temperature

The macroinvertebrates which were collected from the three sites at Okuta seasonal stream include the following families: Canidae, Teleganodidae, Heptagenilidae, Baetidae, Platycnidae Hirundinidae and Dytiscidae. According to the results, site one had a high abundance of macro invertebrates with 5 families, site two had one while site three had two families collected. From the families collected the % EPT was the highest at site one with an 100% whereas site two and three have 0% EPT ratio.

Site one was dominated by highly sensitive Ephemeroptera Canidae, Teleganodidae and Baetidae. The presence of canids at agriculturally impacted areas is due to their adaptability to fine strata and slow current water. The presence of the Heptagenilidae in site one signified a good water quality as compared to site two and three

Studies have shown that leeches (Hirundinidae) contribute significantly to nutrient cycling and are indicators of water quality in freshwater ecosystems(Macova et al., 2009). "Leeches (Hirudinea) as indicators of water quality in freshwater habitats." Hydrobiological*(Adámek,*

Orendt, Wolfram, & Sychra, 2010). This research discusses the ecological role of leeches in maintaining ecosystem health. Canidae (Small Minnow Mayflies), The Canidae family is known for its diverse species, which are sensitive to environmental changes, making them excellent bioindicators of stream health*(Malakane, Addo-Bediako, & Kekana, 2020),* "The role of the Canidae in the assessment of stream condition." Freshwater Biology. This study highlights the use of Canidae in bioassessment protocols, noting their responsiveness to pollution(Carew, Miller, & Hoffmann, 2011). Baetidae (Baetid Mayflies). Baetids are among the most common and widespread mayflies, often dominating macroinvertebrate assemblages in lotic environments(Corbin & Goonan, 2010). "Survivorship of Baetis rhodani (Pictet) (Ephemeroptera: Baetidae) in a stream environment"(Corbin & Goonan, 2010). This research provides insights into the life cycle and ecological importance of Baetis species in freshwater ecosystems.

Research consistently shows that the diversity within macroinvertebrate families correlates with water quality and habitat stability(Tachamo-Shah et al., 2023). Factors such as pollution, sedimentation, and habitat modification can significantly affect these families. “Rapid assessment approaches to biomonitoring using benthic macroinvertebrates." In: Freshwater Biomonitoring and Benthic Macroinvertebrates(Resh & Jackson, 1993). This work discusses methodologies for assessing stream health using macroinvertebrate communities.

5.3 CONCLUSIONS AND RECOMMENDATIONS

From the results presented above, it can be concluded that site one is the least polluted due to vegetation cover as compared to site two and three where anthropogenic activities like rice growing and cattle rearing have interfered with water quality. Anthropogenic activities have a great impact on the abundance of macroinvertebrates.

5.4 RECOMMENDATIONS

I recommend that there should be regulation in human activities carried out along Okuta seasonal stream and trees should be planted along the river banks to avoid disturbance and ensure good water quality

CHAPTER SIX: REFERENCES

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APPENDICES



Figure 8 Sample site



Figure 9 kick netting.