COMPARING WATER QUALITY CONDITIONS AT SITES WITH DEFERENT LAND-USE BACKGROUNDS ALONG SEASONAL OKUTA STREAM IN KISOKO SUB-COUNTY, TORORO AS A PREREQUISITE FOR STREAM CONSERVATION

BY

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BU/UP/2021/3258

A RESEARCH PROJECT REPORT SUBMITTED TO THE DEPARTMENT OF BIOLOGY FACULTY OF SCIENCE AND EDUCATION IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF A BACHELORS DEGREE IN SCIENCE AND EDUCATION OF BUSITEMA UNIVERSITY

SEPTEMBER 2024

DECLARATION

I, Mpango Ashiraf, as a student, declare that this research report is my own work and it has not been submitted for any academic qualifications at any other university or institution.

Signature: ……[signature]……………………. Date: September, 17/2024……………………

Approval

This research report has been submitted for examination to the Department of Biology, Faculty of Science and Education, Busitema University, with approval of my supervisor.

Supervisor:

Signature.. Date September 17, 2024

DR. HANNINGTON OCHIENG

Approval

Dedication

I dedicate this research report to my beloved parents Mr. Mpango Malik and Ms. Mpango Fauza who have been financially supporting me and encouraging me emotionally, psychologically towards the completion of this research within the stipulated time.

ACKNOWLEDGEMENTS

Firstly, l would like to thank God for giving me the strength to carry out this project. I would also like to extend my sincere gratitude to my family especially my parents Mr. Mpango Malik and Ms. Mpango Fauza, my sisters Mpango Zudeda, Mpango Saluwa, and Nalubanga Shamimu and my brother Mpango Aramanzan for giving me both moral and financial assistance. Their patience and support are highly appreciated. I am greatly indebted to my supervisor Dr. Hannington Ochieng, and Mr. Olowo Moses, the laboratory technician, for their valuable guidance, encouragement and unwavering support during the course of this project. I would also like to thank all the staff of Biology Department for making my stay and study time worthwhile. Lastly, but not least, l would like to thank all my dear friends for their prayers and help in various aspects. God bless you all.

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LIST OF ABBREVIATIONS AND ACRONYMS

ANOVA Analysis of Variance

BASIN Better Assessment Science Integration Point and Non-point

BOD Biological Oxygen Demand

CV Coefficient of Variance

DO Dissolved Oxygen

DS Dissolved Solid

EC Electrical Conductivity

FCB Fecal Contamination

GIS Geographical Information System

NEMA National Environmental Management Authority

PH Negative logarithm of concentration of hydrogen ions

SS Suspended Solids

TDS Total Dissolved Solids

TEMP Temperature

TP Total Phosphorous

TUR Turbidity

WHO World Health Organization

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ABSTRACT

Water quality is a critical aspect of ecosystem health, particularly in areas where land use practices vary significantly. This study compared the impact of different land use practices—forestry, rice growing, and animal grazing—on the water quality of the seasonal OkutaStream in Kisoko Sub-County, Tororo. Water samples were collected from sites representing each land use type and analyzed for key water quality parameters, including temperature, pH, electrical conductivity, dissolved oxygen, turbidity, and depth. A one-way ANOVA revealed significant differences in these parameters across the land use types. Forestry areas were associated with the highest water quality, characterized by lower temperatures (23.9°C), higher dissolved oxygen levels (8.2 mg/L), and lower turbidity (225.9 NTU). Conversely, animal grazing areas exhibited poorer water quality, with higher temperatures (25.3°C), lower dissolved oxygen levels (5.2 mg/L), and elevated turbidity (399.6 NTU). Rice-growing areas had intermediate water quality characteristics. These findings underscore the influence of land use on water quality and highlight the need for sustainable land management practices to protect freshwater resources. Recommendations include promoting sustainable forestry practices, implementing buffer zones in grazing areas, adopting sustainable agricultural practices, and conducting regular water quality monitoring. This study contributes to the understanding of land use impacts on water quality and offers practical guidance for stream conservation in the region.

CHAPTER ONE: INTRODUCTION

1.1BACKGROUND

Interaction between land use and water quality are difficult to assess because of huge number of parameters and the complexity of the process involved(Tong and Chen 2002). In particular, vegetation, soil properties, intensity of land exploitation, and distribution of settlement seriously determines the run off process and transport of solid and solutes in catchments(Négrel, Merly et al. 2014). The concern over the impact of land use on stream water quality are not restricted only restricted to local(Lambin, Meyfroidt et al. 2014) and national level in temperate and tropical regions but also found worldwide in both developed and developing countries(Hossain 2017). These concerns result from continuous pollution problems relating to sources of water supply for drinking purposes, contact reaction and ecosystem health(Ritter 2002). Water quality problems are associated mainly with land based developments in agriculture, the impact of rapid urbanization encroachment on catchment protection zone and from other social and economic activities(Kibena, Nhapi et al. 2014). The adverse effect as a result of poor land use management practice tend to adversely impact on the catchment areas that protects surfaces and ground fresh water(Organization 2016). Degradation to water catchment area would impair sources of water supply from streams, rivers and lakes(Peters and Meybeck 2000).

Adverse effects of land use on the water quality threatens not only human water uses but their life supporting capacity and the integrity of the whole fresh water ecosystem which challenge future management of catchment areas(Falkenmark 2003). The adverseeffects arising from increasing water pollution have evidently attracted management attention and research interest in both developing and developed countries(Vardhan, Kumar et al. 2019). This challenge became the focus of research and studies worldwide. The importance of understanding water quality problems associated with land use effects is instrumental inhelping solve these problems(Lambin, Meyfroidt et al. 2014). This re-enforces the notion of how critical it is to understand the effect of land based development on our rivers and lakes, in order to consider appropriate and sustainable management of these activities(Newson 2008). Streams are a main source of water for human's domestic use, animal consumption and support aquatic biodiversity. NEMA (2004), emphasized that all natural aquatic resources in Uganda belonged to the government as this would enable it manage them well(Nakito 2018). Communities and individuals living around Okuta catchment area in Kisoko Sub-county, Tororo in Uganda extend up to the streambanks and use them to un controlled distribution of land usefor their activities such as agriculture, and forestry among others along the stream most of which seem to cause deterioration and impairment to the stream water quality evidenced by siltation and water color changes. Although some studies such as the one by (Wu, Zeng et al. 2021) in the river basin in Yangtze, (Gossweiler, Wesström et al. 2019) with in asemi-arid catchment in Bolivia have been conducted to assess the spatial and temporal trends of water quality levels in relation to different land usesno research has yet been carried out on Okuta seasonal stream , kisoko sub county Tororo district to show how different land uses are affecting the water quality levels over time and space yet the situation seems to be deteriorating with time more than ever before.

Therefore, this research will affirm that a sound understanding of the impacts of land uses on the water quality with its associate relationship, is the key component of managing catchment areas for the protection of water resources and ecosystem health not only in Okuta catchment area in Kisoko Sub-county, Tororo district but also catchment areas in Uganda as a whole.

1.2 PROBLEM STATEMENT

Man has the right to exploit the natural resource in order to be in position to sustain his/her life (Sangha 2018). Some of the natural resources include land, minerals, and water recourses among others. People of kisoko sub-county are using stream banks along Okuta seasonal stream for agriculture, forestry among others. This has led to deterioration of water quality of Okuta seasonal stream as evidenced by siltation and water color. This is due to the weak government policies about land use, lack of implementation of government policies about land use, and ignorance of the people of kisoko sub-county about the impact of land use on water quality. If the situation is not checked in time, the quality of water in this stream may reach the level which cannot sustain life of aquaticbiota and may end up upsetting the aquatic ecosystem with subsequent extinction of other species. The contaminated water in Okuta seasonal stream may end up in other water sources like rivers, lakes which man uses for drinking and other domestic uses ending up causing diseases like typhoid, diarrhea and others to man.

1.3 AIM OF THE STUDY

The aim of this study is to investigate the impact of different land uses along Okuta seasonal stream in Kisoko sub-county, Tororo district on the water quality to guide in developing mitigation measures and overall stream conservation.

1.4 OBJECTIVE OF THE STUDY

1.41 GENERAL OBJECTIVE

To establish the relationship between land uses along Okuta seasonal stream and its water quality

1.42 SPECIFIC OBJECTIVES

1. To determine water quality characteristics associated with rice growing along the banks of Okuta seasonal stream
2. To determine water quality characteristics associated with planted Eucalyptus sp. Forest along the banks of Okuta seasonal stream.
3. To determine water quality characteristics associated with livestock pasture areas along the banks of Okuta seasonal stream.
4. To compare the magnitude and extent of the influence of different land use practices on the stream.

1.5RESEARCH HYPOTHESIS

There is no significant deferent on the influence of land use on water quality.

1.6 SCOPE OF THE STUDY

The study focused on assessing water quality parameters in the Okuta seasonal stream under the influence of different land uses which include forestry, rice growing, and cattle grazing. It focused only on physical chemical properties of water at each site of every land use. Three sites on the Okuta seasonal stream at every land use were sampled that's the upper, lower, and middle of the stream for water quality testing and analysis. The following physicochemical water parameters were measured namely: temperature, electric conductivity (EC), total dissolved solids (TDS), dissolved oxygen (DO), turbidity, light penetration, and pH.These parameters provided overall view of health of a water body, since the characteristics of each of the above parameters show either direct or indirect type or occurrence of pollution which in turn may be a possible indicator of degradation of the stream which may end up affecting aquatic life: physical water parameter often relates to chemical parameters for example, the variation of pH can be attributed to the presence of chemical in water and would consequently threaten aquatic life since aquatic species adapt to specific range of PH and significant change in pH may threaten their life. This data was collected march, 2024.

1.7 SIGNIFICANCE OF THE STUDY

the availability and The findings of this study will contribute to the understanding of the impact of land use on Okuta seasonal stream water quality. This understanding is required to develop effective conservation strategies tailored to specific land uses around Okuta seasonal stream, Kisoko sub-county Tororo district. It will help the policy makers, to prioritize the actions that aim at conservation and implement proactive measures to prevent water contamination of water in Okuta seasonal stream. By this study, preserving or restoring water quality, it will not only protect the aquatic ecosystem and biodiversity but will also safe guard quality of water for domestic use.

CHAPTER TWO: LITERATURE REVIEW

2.1 Water quality

Water quality as the physical, chemical and biological characteristics of water that can be accepted for different purposes, it must not exceed permissible levels and standards set out by national governments and international organizations such as the WHO(Organization 2004). Examples of such standards include fecal coliform and Total coliform must not be detected in a 100mL of water sample(Shar, Kazi et al. 2007) (i.e. number of colony counts/100mL for both drinking and aesthetic standards; less than 1/100mL for WHO drinking water standards; and less than 260/100mL for aesthetic standards)(Ndugga 2021). Water quality standards and guidelines are set for the sole purpose of protecting water quality for human use, contact recreation uses and the ecological health of freshwater ecosystems(Organization 2003). Therefore, water quality can be defined as water that is suitable (given acceptable conditions) for a given use, such as, human drinking, stock water and recreational uses(Fulazzaky 2010).

2.2Sources of pollution

Sources of pollution of water are divided into point source and non-point source pollution. Point source pollution is referred to as pollution from a known point of discharge, or discharges of contaminants that originate from a fixed outlet and can be released into water bodies in pipes or drainage(Ritter 2002). For instance, a mole pipe of known location, which drains waste discharge from the industrial area, may be responsible for increasing the nutrient levels in the wetland stream system hence eutrophication problems(Manasa and Mehta 2020). While possible contaminants from a point source can be easily monitored by measuring discharge and pollutant from an identified discharge point, its impact can be manageable,compared to non-point sources of discharge(Lai, Yang et al. 2011). The problems associated with water quality contamination and pollution from a non-point source is that its origin cannot be guaranteed from a single source(Dosi and Zeitouni 2001), but rather a combination of sources of different natures, which are often difficult to identify at a fixed locale . These generally originate from urban and peril-urban runoffs, because of urban storm runoffs from agricultural and anthropogenic activities, which are often described as non-point discharges(Zong, Hu et al. 2021).Nevertheless, the management of non-point sources of pollution has become a challenge, since it originates from different unknown sources of anthropogenic activities(Wang, Wang et al. 2022). The same problem was experienced in the in the News land(Thompson-Saud and Wenger 2022), where non-point source pollution is an important environmental and water quality management problem.

2.3 Land use

Land use refers to the different ways that people are using the land, such as for farming or building houses(Chisholm 1979). The text explains that changes in land use happen because of many different factors like policies, economics, and human behavior(Briassoulis 2020).The increase number of agriculture activities like mixed cropping and livestock/cattle farming within the borders of the wetland threatens its ability to filter waste water flowing through it(Faiilagi 2015). This leads to contamination of streams. The increase in population together with commercial ventures utilizing water supply from the wetland has decreased its level causing negative impacts on aquatic plants and animals within this ecosystem(Hollis 1990).

Overall, unsustainable land use practices can be detrimental to our environment hence why we need better planning when it comes down to managing our lands effectively while ensuring sustainable development for future generations(Hollis 1990).

2.3 Relationship between land use and water quality

Land use and water resources are clearly linked(Weatherhead and Howden 2009). This inter-relatedness could explain their potential relationship, the effects of land use developments affect the water quality of freshwater resources of rivers, lakes and streams(Nielsen, Trolle et al. 2012). The realization of the risk involved and the detrimental effects of increasing concentrations of water pollutants, from both known and diffuse sources, marked an early attempt in the 1970s by the European Union to call for action to improve the quality of water resources(Stoate, Baldi et al. 2009).

According to studies carried out in the United States in order to establish the relationship between non-point sources, land use and stream nutrients level of watersheds showed that streams draining from agricultural watersheds obtained higher nutrient concentrations than streams draining from forested watersheds(Omernik 1977). Some of these studies have found that the type and intensity of land use have a strong influence on the receiving water quality(Tong and Chen 2002). Different land use types require a different intensity of land development, which could then determine how much it affects and influences the quality of water sources(Lambin, Rounsevell et al. 2000).

Previous studies have positively concluded on the impact of agriculture, with high deforestation causing soil erosion and contamination to receiving water bodies(Issaka and Ashraf 2017), (Wantzen and Mol 2013). Another study found that concentrations of nutrients (NO3-N, NH4-N, TP) were higher in urban and agricultural areas, as a result of higher inputs of waste into the river system(Ndugga 2021).

Since its early development in 1970s, researchers are continuing to study land use on water quality in different geographical regions around the world(Broussard and Turner 2009),(Osborne and Wiley 1988), in their study in the United States, have found that urbanization is a major factor controlling soluble reactive phosphorus, compared to agriculture. In regards to urbanization, the study of the Lia River basin in China, recorded high concentrations of TN, NH4-N, NO2-N and TP in urban land, which resulted in high nutrients discharge into the river, thus causing eutrophication problems(Qin, Xu et al. 2007). These various experiences show how the effects of land use practices on water quality can be sometimes misleading, without conducting more research on station-specific locations in different countries and regions around the world(Ndugga 2021). The results and outcomes of a study from specific country are not necessarily applicable to other countries with their local watershed settings and catchment characteristics varied climatic conditions(Ly, Metternicht et al. 2019). Therefore, the varied results of previous studies may depend on local topographical characteristics of watershed and catchment areas, soil conditions, types of land use development, and local climatic factors(Yu, Xu et al. 2016),which could differentiate the experiences of one country and region from others. Thus, in order to have a clear understanding of such land use impact on water quality, several approaches have to be tested for better management options(Glavan, Miličić et al. 2013) which hope to eventually assist restoring water quality in affected areas. Nonetheless, it can be concluded that changes in land use and land management practices are primarily responsible for the alteration of

receiving water quality(Riseng, Wiley et al. 2011).

2.4 Approaches to assess land use and water quality relationship

The management of land based pollution involves consideration of two main sources of pollution: point and nonpoint sources(Ramachandran, Ramachandran et al. 2014). The nature underlying these two causes can be very complex with regard to their respective causes. Therefore, in order to address such complexities and their nature of pollution, it requires several approaches, rather than having a one fit all approach. This has been signaled by (Faiilagi 2015), who stated the effect of land use on water quality is complicated, since such assessment involves complex biotic and abiotic interaction, especially in large drainage areas. This section provides a review of several approaches and methods that have been engaged by previous and recent studies to help understand the underlying factors affecting water quality, by considering the land use composition water catchment areas and other associated factors. The review would also assist with the identification of appropriate approach and methodology for the study. Such approach includes the use of catchment scale, compared to only a part of the catchment/ watershed; statistical analysis and modeling; and the wide use of technologies such as a geographical information system (RS), as being well advanced and useful management tools for water resources and land use management with in catchment areas.

2.41Catchment vs. sub-catchment approach

(Sliva and Williams 2001) studied land use relationship with the river water quality of an Ontario watershed in Canada using two different scale approach, where one is a 100m buffer zone and the other is a whole catchment approach. The results were compared between the two approaches over three season in which catchment land scape chacteristics appeared to have a slightly greater influence on water quality than the buffer zone. This can be explained as follows: a large drainage area would have more space for drainage more pollution into water sources, compared to the lesser scale of a 100m buffer zone. However, a recent study in (Ndugga 2021) which focused on the upper catchment/upland area of the Manyame river, found that both rural and urbanized part of the catchment were responsible for high degree of population (i.e. point and non-point) within the catchment area. His results indicate that an increase in settlement and agriculture activities had positive impact on water quality compared to forested land. Follow these results, a recommendation to consider a combined programme for point and non-point sources has been drawn up, as an outcome of their study. This could be an appropriate approach in case of the Manyame River, as this catchment area comprises a mix of land use including urbanization and agricultural activities. However, a holistic approach is needed for whole catchment area, where low land area s could be considered to generate some interesting results, based on lower reaches of the catchment river quality. This approach would see consideration of a ridge to reef approach that could help to identify problems facing all segments of the catchments of the catchment. Rather than just relying on upper catchment area. In consideration of water quality linkages to land use composition of the a catchment, the variation in water quality response (through measuring of physicochemical characteristics) can provide some insight on the different extents of impact and nature of association between land use and water quality(Namugize, Jewitt et al. 2018). The study of(Jordan, Weller et al. 2018) on the Rhode River located in the mid-Atlantic coastal plain of North America examined the effect of land use, by dividing watershed study area into two sub watersheds defined by dominant land use. The different in results were accounted for in the differences in land use and topography between the two sub watershed basins. Their results have shown a large seasonal variation was observed on all types of land use, due to differences in evapotranspiration rates. This could be advantage of considering a more holistic approach, such as a catchment scale or watershed scale, compared to only some portion of the catchment areas, especially in large catchment areas.

2.5 Physical chemical parameters

Water has different types of floating, dissolved, suspended and microbiological as well as bacteriological impurities. Some physical test should be performed for testing of its physical appearance such as temperature, color, turbidity, TDS and many others. While the chemical test should be performed for its BOD, COD, dissolved oxygen, alkalinity, hardness, and others characters.

2.51 Electrical conductivity

Conductivity is the measure of how well water can pass through an electrical current. Conductivity is not a pollutant itself, but serve as an indicator of the presence of pollutants. It's an indirect measure of the presence of inorganic dissolved solids such chloride, nitrate, sulfate and many others. The presence of these substances in water increases the conductivity of a body of water. Organic substances like oil, sugar and many others do not conduct electricity very well.

2.52 Dissolved oxygen

The concentration of dissolved oxygen in water is the mass of oxygen gas per liter of water. DO can be expressed in milligram per liter (mg/L) or parts per million (ppm). This is influenced by factors like temperature-oxygen is more dissolved in cold water, flow-oxygen concentration varies with the volume and velocity of water flow. Because more oxygen from the atmosphere enters faster flowing water, faster flowing water tends to be more rich than slower flowing, stagnant water.

2.53 pH

pH is an important chemical factor of aquatic life. Water that is too acidic or basic can disrupt biochemical reactions resulting in the harm or death of aquatic organism. pH is expressed as a scale of 1to 14. A solution with a pH less than 7 is considered acidic, a solution with a pH greater than 7 is considered basic. The pH scale is logarithmic, meaning that the strength of the acid or base has increased or decreased tenfold. Streams generally have pH ranging between 6 and 9. The presence of dissolved substances from bedrock, soil and other materials greatly affect the pH scale.

Changes in pH impact many aspect of water chemistry. For instance, as pH increases, smaller the concentration of ammonia is needed to reach a level that is toxic to fish. As pH decreases, metal concentration may increase because higher acidity increases the metal`s ability to be dissolved from the sediments into water.

2.54Total solids

Total solids are a measure of the suspended and dissolved solids in the body of water. It is related to both conductivity and turbidity. To measure Total suspended and dissolved solids, a sample of water is placed in a drying oven to evaporate the water, leaving only the solids. To measure dissolved solids, a sample is filtered before it is dried and weighed. To calculate the suspended solids, the weight of dissolved solids is subtracted from the total solids.

2.55 Temperature

Water temperature is the limiting factor for aquatic life for example temperature controls the rate of metabolic and reproductive activities, there by affecting life cycle. If water temperature increases, decrease or fluctuate too widely, metabolic activities may speed up, slow down, malfunction or stop altogether.

Usually the temperature variation in water is much less that in terrestrial environment. However, there are many factors that can influence water temperature can fluctuate seasonally, daily, and even hourly, especially in smaller sized bodies of water. Temperature is also influenced by the quantity and velocity of water flow. It is important to note that the sun has a small effect on the temperature of faster flowing water.

2.56 Turbidity

Turbidity is the measure of cloudiness of water. Cloudiness is caused by suspended solids (mainly soil particle) and plankton (microscopic plants and animals). Moderately low level of turbidity may indicate a healthy system, well-functioning system. However, higher levels of turbidity pose several problems for water systems. Turbidity blocks out the light needed by submerged aquatic vegetation. Turbidity can also raise surface water temperatures since suspended particles facilitate the absorption of heat from sun light.

CHAPTER THREE: RESEARCH METHODS AND MATERIALS

3.1 INTRODUCTION

This chapter presents a description of the approach for the research to gain information on the study problem. It consists of the research design, sample size, sampling methods, and data collection instruments and data analysis techniques

3.2 RESEARCH DESIGN

The study involved experimental and survey design. The Experimental design was employed in order to determine the physiochemical parameters of Okuta catchments, whereas the Survey design was used in acquiring data about the different land uses carried out in catchment and their impacts on water quality.

3.5 Visual habitat assessment

This method involved the use of naked eyes and therefore through this method was used to see the different land uses on the stream

3.3 SAMPLING

3.31 Selection of sampling sites

During this research, sampling stations was limited to three namely forestry station, rice growing and animal grazing station. The selection of field water sampling sites was made to ensure raw water samples was taken to analyze physical chemical water parameters. The three sampling sites at each station was identified on the basis of ensuring representative data at each station is taken. This was done by having them spaced out across each station of the catchment: upper catchment, mid catchment, and lower catchment. The local knowledge of the area based on my previous work experiences with in the area was used for validating the sampling sites on the ground for easy accessibility during sampling. Also the sampling sites was selected in locations which were free areas without obstruction so as to obtain the representative data of the overall water quality of the stream. This is because sites without obstruction are less influenced by local factors which can stew sampling result.

3.32 Selection of the physicochemical water parameters

The following physicochemical water parameters were measured from the three sampling stations that’s forestry station, rice growing station and animal grazing station namely:

temperature, electric conductivity (EC), total dissolved solids, dissolved oxygen, turbidity, light penetration, and pH.

3.4 Determination of physicochemical water quality in situ of Okuta catchment seasonal stream

The quality of water was measured in the three sampling sites that is to say forest, animal rearing site and rice growing sites and different parameters will be determined as follows

3.41 Electrical Conductivity, Temperature, Total Dissolved Solids and pH

In this research determined the temperature, PH, Total Dissolved Solids. This was done by reading directly on the combined H1991300 water proof pH, EC, TDS AND Temperature meter of Hanna type. The meter registers the values of EC in micro Siemen per centimeter, ppm of TDS as well as ^{o}C for temperature. The probe was immersed in the 500ml plastic bottle of water and stirred for few minutes and after the sample has stabilized the mode button was pressed and readings will be read. After that, the probe was rinsed on taking the reading on the reading from each sampled bottle for deferent parameters listed here. This was to avoid transfer of contamination from one sample to another.

3.42 Dissolved Oxygen

During this research, dissolved oxygen was recorded using D.O meter that was immersed in the water and the results were immediately displayed on the calibration LCD display.

3.43 Turbidity

During the research I determined Turbidity by the use of Turbidity meter type AL 450T – IR. Measurements which were done by pressing the ON key, rinsing out a clean vial four times with the sample to be measured. The vial was later filled with the sample so as to ensure that all outside surfaces are clean and dry, the vial was then being placed in the sample chamber and align correctly. Putting on the sample chamber cover (light shield). Read Key will be pressed to start measurement. NTU value will display on the LCD which was read and recorded.

3.5 Recording

This involved recording down all the data that was collected from the field later this data was organized and analyzed thoroughly

3.6 Data Processing and statistical Analysis

The data from the study was edited and tabulated in form tables, graphs, to make the data more meaningful. The analysis for this study included descriptive statistics and one-way ANOVA

3.71 Descriptive statistics

The descriptive statistics were performed in Minitab 16 statistical software to analyze the mean, min and max, and standard deviation of physical (pH, TEMP, TURB, DO, TDS, and EC

3.7 Limitations

There was a challenge of limited documentary review written on the Okuta seasonal stream because no research has been carried out on the stream for example historical and hydrological and water quality data.

The seasonal fluctuation of the stream may affect the reliability and validity of the data collected because sometimes the water levels reduce or increase too much and this may have impact on the data.

The researcher faced a challenge of negative attitudes of the people and some respondents as they may have bias on collecting water samples from the different land uses especially in the rice growing site and this almost affected data collection because some people thought that we had come take their land.

CHAPTER FOUR: RESULTS

4.1 Water quality characteristics of different land uses along Okuta seasonal stream

Table 1: Water quality characteristics of different land uses

Characteristic	Land Use	Sample Size (n)	Mean ± SD	Min	Max
Temperature (°C)	Animal Grazing	12	25.3 ± 0.6	24.30	25.90
	Forestry	12	23.9 ± 0.4	23.20	24.50
	Rice growing	12	24.6 ± 0.4	24.20	25.30
Ph	Animal Grazing	12	7.8 ± 0.4	7.40	8.60
	Forestry	12	7.2 ± 0.2	6.90	7.50
	Rice growing	12	6.9 ± 0.1	6.70	7.20
Electrical Conductivity (µS/cm)	Animal Grazing	12	226.1 ± 15.6	202.90	243.60
	Forestry	12	154.9 ± 28.0	123.80	204.10
	Rice growing	12	193.0 ± 26.4	150.20	232.30
Dissolved Oxygen (DO, mg/L)	Animal Grazing	12	5.2 ± 1.1	3.91	7.30
	Forestry	12	8.2 ± 0.7	7.38	9.38
	Rice growing	12	5.2 ± 1.0	4.01	7.01

Turbidity (NTU)	Animal Grazing	12	399.6 ± 20.8	373.00	435.00
	Forestry	12	225.9 ± 27.1	197.00	280.00
	Rice growing	12	333.0 ± 34.1	297.00	390.00
Depth (cm)	Animal Grazing	12	0.3 ± 0.1	0.20	0.43
	Forestry	12	0.5 ± 0.0	0.45	0.59
	Rice growing	12	0.4 ± 0.1	0.33	0.56

All parameters showed significant differences across the land use practices ($p<0.001$). Animal grazing areas had the highest temperature (25.3 °C), followed by rice-growing areas (24.6 °C), with forestry areas having the lowest temperature (23.9 °C). The pH was highest in animal grazing areas (7.8), followed by forestry areas (7.2), and lowest in rice-growing areas (6.9). The electrical conductivity also differed significantly across land uses ($p = 0.0000$). Animal grazing areas showed the highest mean conductivity (226.1 µS/cm), followed by rice-growing areas (193.0 µS/cm), with the lowest in forestry areas (154.9 µS/cm). Dissolved oxygen levels were significantly different ($p = 0.0000$). Forestry areas had the highest mean DO (8.2 mg/L), indicating better water quality, while both animal grazing and rice-growing areas had lower DO levels (5.2 mg/L). There were significant differences in turbidity ($p = 0.0000$). Animal grazing areas had the highest turbidity (399.6 NTU), followed by rice-growing areas (333.0 NTU), and the lowest in forestry areas (225.9 NTU). The depth of the stream also showed significant differences ($p = 0.0000$). Forestry areas had the greatest mean depth (0.5 cm), followed by rice-growing areas (0.4 cm), with the shallowest depths observed in animal grazing areas (0.3 cm) (Table 2).

Table 2: Statistical differences in Water quality characteristics

Characteristic	**Land Use**	**Frequency**	**Mean**	**p-value**
Temperature (°C)	Animal Grazing	12	25.3	**<0.001**
	Forestry	12	23.9	
	Rice growing	12	24.6	

pH	Animal Grazing	12	7.8	**<0.001**
	Forestry	12	7.2	
	Rice growing	12	6.9	
Electrical Conductivity (μS/cm)	Animal Grazing	12	226.1	**<0.001**
	Forestry	12	154.9	
	Rice growing	12	193.0	
Dissolved Oxygen (DO, mg/L)	Animal Grazing	12	5.2	**<0.001**
	Forestry	12	8.2	
	Rice growing	12	5.2	
Turbidity (NTU)	Animal Grazing	12	399.6	**<0.001**
	Forestry	12	225.9	
	Rice growing	12	333.0	
Depth (cm)	Animal Grazing	12	0.3	**<0.001**
	Forestry	12	0.5	
	Rice growing	12	0.4	

4.3 Relationship between water quality characteristics and land use

Temperature was highest in rice growing areas (26.3°C) and lowest in forestry (23.9°C). pH values were almost similar across all practices, hovering around 7.18-7.19. Electrical conductivity is slightly higher in animal grazing areas compared to rice growing and forestry. Dissolved oxygen levels are marginally higher in forestry (5.18 mg/L) and lowest in animal grazing (5.16 mg/L). Turbidity was significantly higher in animal grazing areas (~4.00 NTU) compared to rice growing (333 NTU) and forestry (1.26 NTU). Lastly, water depth was greatest in forestry and lowest in animal grazing areas (Figure 1).

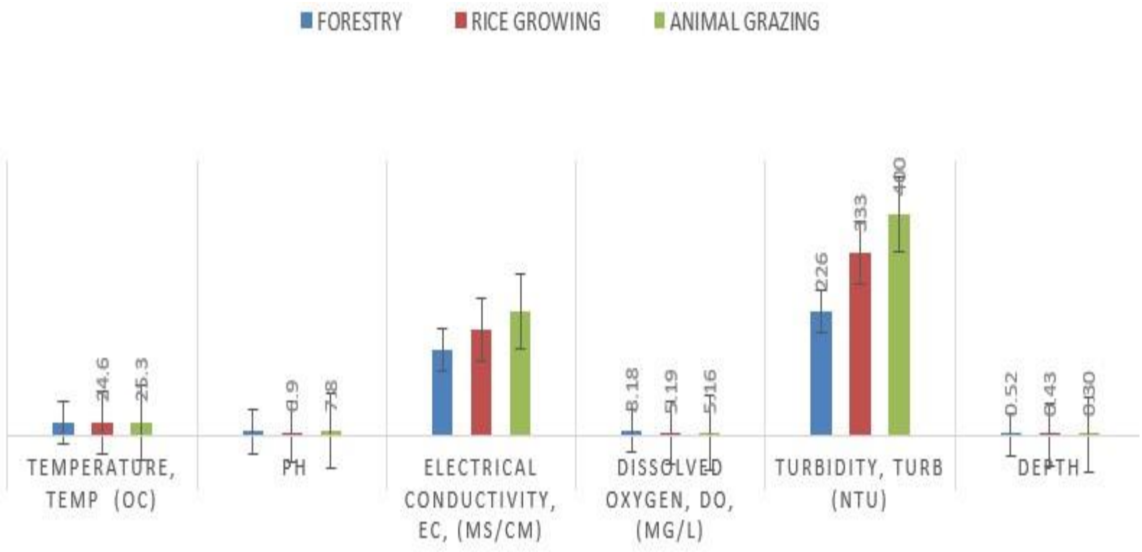

Figure 1: Variation of water parameters with different land use

CHAPTER FIVE: DISCUSSION

Water quality is a critical aspect of ecosystem health, particularly in areas where land use practices vary significantly. This study aimed to assess the impact of different land use practices—forestry, rice growing, and animal grazing—on water quality characteristics along the Okuta Seasonal Stream in Kisoko Sub-County, Tororo. By comparing key water quality parameters such as temperature, pH, electrical conductivity, dissolved oxygen, turbidity, and stream depth across these land uses, this research provides information on how human activities influence aquatic ecosystems and highlights the importance of sustainable land management. The findings of this study revealed significant differences in water quality characteristics across the different land use practices, reflecting the varying degrees of anthropogenic impact.

The study found that animal grazing areas had the highest mean water temperature, while forestry areas had the lowest. This is consistent with studies by (Smith et al., 2010), who noted that deforestation and reduced vegetation cover in grazing areas lead to increased water temperatures due to reduced shade and higher solar radiation. Conversely, (Jones and Phillips, 2008) found that forested areas typically exhibit lower water temperatures, which supports the buffering effect of tree cover on stream temperatures.

The pH levels were highest in animal grazing areas and lowest in rice-growing areas. This finding aligns with the findings of Brown et al. (2012), indicating that livestock activities can increase pH levels due to the runoff of alkaline substances, such as animal waste, into water bodies. However, (Gupta et al., 2015) reported lower pH levels in agricultural zones, particularly rice paddies, due to the acidic nature of fertilizers and soil amendments used in such areas, which aligns with the lower pH observed in rice-growing areas in this study.

Electrical conductivity was highest in animal grazing areas and lowest in forestry areas. Similar findings were reported by (Harris et al., 2011), who found elevated conductivity in grazing areas due to the runoff of salts and other ions from animal waste and disturbed soils. The lower conductivity in forested areas is consistent with the findings of (Meyer and Wallace, 2007), who noted that well-vegetated areas tend to have lower runoff and, consequently, lower levels of dissolved ions in streams.

Forestry areas had the highest dissolved oxygen levels, while both animal grazing and rice-growing areas had significantly lower levels. High DO levels in forested areas are supported by (Nelson et al., 2009), who found that dense vegetation promotes oxygenation through the photosynthesis of aquatic plants and reduced organic pollution. Conversely, lower DO levels in grazing and agricultural areas are often associated with higher levels of organic matter and nutrient loading, which increase microbial activity and oxygen consumption, as noted by (Wang and Yin, 2013).

Turbidity was significantly higher in animal grazing areas compared to forestry and rice-growing areas. This observation is consistent with (Williams et al., 2014), who reported that grazing activities lead to soil erosion and increased sediment load in streams, thereby increasing turbidity. Forestry practices, which generally involve less soil disturbance, were associated with the lowest turbidity, as also noted by (Peterson et al., 2010).

The stream depth was greatest in forestry areas and shallowest in animal grazing areas. This could be due to better soil infiltration and reduced surface runoff in forested areas, as suggested by (O'Connor and Bryant, 2012). In contrast, compacted soils and increased runoff in grazing areas, as noted by (Zhang et al., 2016), can lead to reduced stream depth.

Therefore, the significant differences observed across various water quality parameters highlight the critical role of land use in shaping aquatic ecosystems. Forestry practices appear to have the most beneficial effects on water quality, promoting lower temperatures, higher dissolved oxygen levels, and lower turbidity, all of which are conducive to healthy aquatic habitats. On the other hand, animal grazing is associated with higher temperatures, elevated turbidity, and reduced dissolved oxygen levels, which can negatively impact aquatic life.

These findings suggest that sustainable land management practices, particularly in agriculture and livestock rearing, are essential for conserving water quality. Implementing buffer zones, reducing soil disturbance, and managing runoff are strategies that could mitigate the negative impacts observed in grazing and rice-growing areas.

CHAPTER SIX: CONCLUSION AND RECOMMENDATIONS

7.1 Conclusion

This study has demonstrated that different land use practices; forestry, rice growing, and animal grazing significantly influence water quality in the Okuta Seasonal Stream in Kisoko Sub-County, Tororo. Forestry areas were associated with better water quality, evidenced by lower temperatures, higher dissolved oxygen levels, and reduced turbidity. In contrast, animal grazing areas showed poorer water quality, with higher temperatures, increased turbidity, and lower dissolved oxygen levels. These findings highlight the critical need for sustainable land management to protect water resources and ensure the health of aquatic ecosystems.

7.2 Recommendations

Promote Sustainable Forestry Practices: Given the positive impact of forestry on water quality, it is recommended that afforestation and reforestation initiatives be supported and expanded in the region. This will help maintain lower water temperatures, higher dissolved oxygen levels, and reduced sediment loads in streams.

Implement Buffer Zones in Grazing Areas: To mitigate the negative impacts of grazing on water quality, establishing buffer zones with vegetation around streams is recommended. These zones can help reduce runoff, lower turbidity, and improve overall water quality.

Sustainable Agricultural Practices: **Regular Monitoring of Water Quality**: Continuous monitoring of water quality in the Okuta Seasonal Stream is crucial to detect any changes over time and assess the effectiveness of implemented conservation strategies. Monitoring should include a broader range of pollutants, including pesticides and heavy metals, to provide a more comprehensive understanding of water quality.

Community Awareness and Education: Local communities should be educated on the impact of land use practices on water quality and trained in sustainable land management techniques. This will foster community involvement in conservation efforts and promote the adoption of best practices in land use.

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