# BINDURA UNIVERSITY OF SCIENCE EDUCATION

## DEPARTMENT OF NATURAL RESOURCES

# ASSESSMENT OF THE EFFECTS OF POLLUTION ON STREAM WATER QUALITY. A CASE STUDY OF NAKUPINGA RIVER, JULIASDALE, NYANGA.

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***A DISSERTATATION SUBMITTED IN PARTIAL FULFILMENT OF THE REQUREMENTS OF THE0BACHELORS OF SCIENCE HONOURS DEGREE IN NATURAL RESOURCES MANAGEMENT***

**2022**

**Date: DECEMBER 2022**

# DEDICATION

This work is dedicated to my mother for the guidance and love she has given me. Without her financial support and words of encouragement, this work would have been impossible. I express my deepest gratitude to my mother, who devoted all her abilities in ensuring my education and development.

# Acknowledgements

First and foremost, I would like to thank God for providing me with life, strength, and courage while carrying out this research. Following the accomplishment of this research project, a number of people came together to support me. Dr. Gotosa, my academic supervisor, deserves my heartfelt gratitude. Thank you for your advice, assistance, and time. I also want to thank Mr. Kamuto for taking the time to walk me through the SPSS software, which was completely new to me. I'd also like to thank the EMA laboratory personnel who analysed my water samples. I also want to thank my mother, brothers, and sister for their financial and moral support, as well as for providing me with the opportunity.

# ABSTRACT

Controlling wastewater discharge is currently the country's most difficult task, and disposing of contaminated water in streams is now prevalent. The drive of this study was to examine the effects of pollution on water quality. Three sampling exercises were carried out in July 2022. Water pH, biological oxygen requirement, electric conductivity, turbidity, and dissolved oxygen were five physiochemical and biological characteristics that were thoroughly examined. Escherichia coli and total coliforms were the biological parameters tested. Clean 500ml glass containers for Escherichia coli and total coliforms and 2 litre plastic polyethylene bottles for physicochemical characteristics were used to collect water samples from three sampling stations. Environmental Management Agency (EMA) Laboratory in Harare analyzed the samples. The T-Test was used to compare the mean differences of the physiochemical and biological parameters were calculated using three sample exercises, and the results were reported in the form of tables in Chapter 4 and the appendix section.

## LIST OF ACRONYMS

LEDCS- LEAST ECONOMICALLYY DEVELOPED COUNTIRES

MEDCS- MORE ECONOMICALLY DEVELOPED COUNTRIES

WHO- WORLD HEALTH ORGANISATION

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## CHAPTER ONE: INTRODUCTION

### 1.0 BACKGROUND TO THE STUDY.

Agreeing to Dube et al. (2014), river pollution is becoming a major global concern, affecting both less economically developed nations (LEDCs) and more economically developed countries (MEDCs) (MEDCs). Human activities induce wastewater discharge into rivers, which distorts the environment because the introduction or deletion of particular bacteria influences ecological processes. Water is a life-sustaining resource for humans. According to the UNESCO 2021 World Water Development Report, worldwide freshwater use has increased six fold in the last 100 years and has been expanding at a rate of roughly 1% per year since the 1980s. Water quality is facing serious issues as water demand rises. Industrialization, agricultural production, and urban life have all contributed to environmental deterioration and pollution, threatening vital water bodies (rivers and oceans) and, as a result, human health and long-term social development. Globally, an estimated 80% of industrial and local council wastewater is dumped into the ecosystem untreated, causing harm to human health and ecosystems. This ratio is larger in LDCs when sanitation and wastewater treatment facilities are severely insufficient. Water pollution can be caused mainly by industrialization due to the fact that the release toxic substances and volatile organic chemicals will be released into the rivers during industrial production. If these wastes are released into aquatic ecological systems without proper treatment, they will cause water fouling. According to (Chen et al, 2019) chromium, arsenic and cadmium are vital pollutants released in wastewater and industrial sector is the significant factor to harmful pollutants. In addition, water pollution is directly linked to agricultural and fish farming activities. Pesticides used during crop production, organic wastes from activities are significant causes of pollution. Stream water will be contaminated by agriculture b nitrates, phosphorous, soil sediments. Agriculture has severely damaged freshwater systems in areas that emerged from stratified societies and experienced the slow, autochthonous growth of specialised formal instruments of social control out of their needs for these institutions.

At least two million people around the globe succumbed annually from the effects of water pollution such as chronic diseases caused by poor sanitation and contaminated drinking water being the major cause of nearly 90% of deaths and disproportionately affecting children (United0Nations, 2016). It is critical to investigate the impact of water pollution on human health, particularly disease heterogeneity, and to emphasize the necessity of clean drinking water in achieving sustainable development goals.. Furthermore, according to Mustapha and Aris (2012) ), household wastewater pollution diminishes dissolved oxygen while increasing nutrients such as nitrogen and phosphorus, both of which are critical in the formation of algal blooms. Reduced oxygen levels in aquatic settings are lethal to species such as green-headed tilapia (Buka et al., 2014). This has been illustrated by hypereutrophication in Lake Chivero, where weeds such as water hyacinth (Eichhornia crassipes) and blue green algae (Anabaenopsis species) are sprouting as a result of sewage disposal. Water's chemical qualities can influence its aesthetic characteristics, such as how it looks, smells, and tastes, as well as its toxicity and whether or not it is safe to drink (Ogbonna, 2014).

## 1.1 PROBLEM STATEMENT

Households, sawmilling from lumber extraction, agricultural operations, and aquaculture (trout farming) are all extensively polluting the Nyakupinga River. Awkwardly, there is no consistent and up-to-date monitoring or information on the quality of domestic sewage effluent discharged into the river, as well as the quality of river water acceptable for human consumption (Ogbonna 2014). There have been numerous shortages of household items such as tapes and boreholes. Metallic pollutants and microbiological contamination are major concerns in many Zimbabwean water basins (UNEP, 2006) As sewage pipelines beneath the earth's surface deteriorate over time, splits and cracks form, resulting in seepage that contaminates groundwater (Robson 2016). Sewage leaks cause microbial growth. Charles et al., (2017) indicated that inappropriate dumping operations were a source of groundwater contamination, releasing heavy metals such as lead (Pb) and cadmium (Cd), posing health risks to the population that relies mostly on underground water. Another study discovered that septic tank leachate was a major source of stream water pollution (Ndoziya et al., 2019). In Zimbabwe, there is certainly adequate documentation on the impacts of water pollution on individuals and the ecosystem, but owing to a lack of cooperation from civilians, we tend to discover a high degree of ignorance among the majority of people and councils in effective River management. waste disposal, repairing of sewage systems to avoid stream water contamination to meet the SDG 6 which deals with clean water and sanitation.

## 1.2 MAIN OBJECTIVE

The general objective of the study was to assess the effects of wastewater discharge on Nyakupinga River water quality, in meeting the Environmental Management Agency effluent disposable standards and the suitability for irrigation and drininking

## 1.3 SPECIFIC OBJECTIVES

1. To investigate biological oxygen demand (BOD), dissolved oxygen (DO), electrical conductivity (EC), turbidity and pH levels at different points along Nyakupinga River.

2. To investigate the levels of *Escherichia* coli and total coliform bacteria of Nyakupinga River as affected by household waste water discharge.

3. To determine the suitability of Nyakupinga stream water for irrigation.
4. To determine the suitability of stream water for drinking as guided by WHO standards

## 1.4 RESEARCH QUESTIONS

- What are the main causes and sources of river pollution in town and how does it affect other communities or towns?
- How has river polluted affected the downstream communities?
- What are the strategies that has adopted in the past to solve the problem?
- How effective are/were they in aiming to achieve sustainable development?

## 1.5 JUSTIFICATION OF THE STUDY

Residential areas are getting closer to the river systems due to population growth in various places. Sickness and mortality rates are extremely high due to a lack of safe and clean water. Stream water is primarily used for drinking since people and some scholars states that a stream/river is capable of purifying itself and other household purposes. According to SDG number 6, clean water and sanitation by 2030 indicate that clean water is a requirement for human health.

The conclusion of this research may aid in the providing information which shall assist law makers in finding cures or methods that can be put in place to reduce contamination of the river system by toxic substances which pollute freshwater like wastewater, plastics, sewage effluent. This plays a big role in conserving a river as an ecosystem.

Moreover, the results of this project shall also aid in shedding light and paving way for municipal authorities and the save subcatchment in the need to rehabilitate settling ponds such that spillage and septics may be repaired properly if no longer functioning well. Lastly, the project shall assist in saving human life by reducing the spread of waterborne diseases such as cholera, diarrhoea, bilharzia thus meeting the Sustainable Development Goal 3 of Good Health and Well Being.

## 1.6 RESEARCH HYPOTHESIS

- Waste water discharge in Nyakupinga River alters the level of physiochemical parameters that is Biological Oxygen Demand, Dissolved Oxygen, Electrical Conductivity, turbidity, water pH.
- Sewage effluent in rivers increases the concentration of Escherichia coli and total coliform of Nyakupinga Stream Water

## 1.7 SCOPE OF THE STUDY

The surface water in the Canal as it enters the Nyakupinga area was the subject of the investigation. The influence of human activities on water quality was assessed. To assess the acceptability of the water for the different applications, the water quality was compared to commonly accepted criteria.

The study also compared water contamination results from collected water samples to previous data from the lower Save subcatchment

# CHAPTER 2: LITERATURE REVIEW

## 2.1 FRSHWATER AVAILABILITY ON GLOBAL SCALE

Acquiring an adequate freshwater supply (i.e., net of precipitation minus evapotranspiration) is vital for supporting human activities (e.g., agricultural productivity, industrial and household water usage) and environmental requirements (Gudmundsson et al 2017). Without clean water, education cannot be achieved, gender disparities increase, economic activity stagnates, and progress is hampered. According to the United Nations, water scarcity is both a natural and a man-made issue.. There is enough freshwater on the globe for all living things, including people, but because it is distributed unevenly, freshwater shortages become a global catastrophe because too much of it is squandered, contaminated, and unsustainable handled. There is a rise in the lack of consistent access to freshwater because over 2.2 billion people worldwide lack reliable access to adequately regulated drinking water. Water shortage in Africa is a hardship on women and girls, as well as a barrier to education and economic quality, because they are responsible for collecting water in 80% of families where water is not piped into houses (WHO and UNICEF 2017). Furthermore, water scarcity and contamination are hazardous to health and are the origins of preventable diseases. Contaminated water can increase the outbreak of diseases like diarrhoea, cholera, dysentery, and typhoid. Water contamination is predicted to kill 485,000 people per year, according to the WHO.

## 2.2 WATER QUALITY

Water quality refers to the chemical, physical, and biological characteristics of water in relation to all other hydrological0properties, often in terms of how well they are suited for a certain function (Mupedziswa, 2016). It has been shown that polluted rivers in the nation typically drain catchments with large metropolitan populations (Murwira et al, 2014). The quality of water supplies has recently been degrading at an concerning rate due to poor waste management and policy of ecosystem standards. Water scarcity is a major problem in Africa.

## 2.3 BIO PHYSIOCHEMICAL PARAMETERS

### 2.3.1 BIOLOGICAL OXYYGEN DEMAND

The amount of oxygen required for waste breakdown is referred to as biological oxygen demand, and it is an indirect waste measure (Mupedziswa 2006). The amount of oxygen consumed by microorganisms in decomposing organic material in wastewater is known as biological oxygen demand, and it is often stated as 5 days of oxidation of biodegradable organic matter by bacteria at 20 degrees Celsius (Science, 2014). BOD can deplete the oxygen in a body of water, creating odors and fish kills, according to Hudson (2010). It is concerned with dissolved oxygen measurement, which is utilised by microbes in the metabolic oxidation of organic materials. As a result, the introduction of domestic wastewater into streams lowers the concentration of biological oxygen demand. high grade re

### 2.3.2 DISSOLVED OXYGEN (DO)

The amount of oxygen dissolved in water is known as dissolved oxygen. DO enters a water body from the atmosphere and plant life, which creates oxygen in the water (Agriculture and Science, 2017). It is also more common in flowing streams than in stagnant waters, and its abundance is typically regulated by water body temperature, altitude, and seasons. The higher the water flow, the higher the dissolved oxygen content, and the lower the water flow, the lower the oxygen concentration, according to Owili (2003). Because oxidation of organic matter increases nutrients such as nitrogen and phosphorus, their quantity is substantially impacted by the discharge of untreated and partially treated sewage waste (Masere et al., 2010).

### 2.3.3 ELECTRICAL CONDUCTIVITY

The ability of water or any solution to conduct electricity is referred to as electrical conductivity, and it reflects the presence of dissolved salts. Its value is determined by ion concentration and degree of dissociation, as well as temperature and ion migration velocity in an electric field; consequently, as dissolved salt content increases, so does conductivity (Uqab et al., 2018). The plant's incapacity to compete for water with ions in the soil solution is the principal consequence of high EC0 on crop productivity; this is generally referred to as physiological drought in plants (Ibrahim, 2014). Even if the soil looks to be moist, the higher the EC, the less water available to plants.

### 2.3.4 NITRATES

In most circumstances, nitrogen and phosphorus coexist in water, and the two nutrients act together to induce algal bloom. Sewage, animal waste, and many industrial effluents include significant levels of nitrogen and phosphorus (Agnello, 2000). Nitrate concentration is linked to a number of human disorders, including hypertension, cancer, and birth abnormalities (Uqab et al., 2018). The high amounts of nitrates and ammonia in streams, according to Sharma (2014), are generated by heavy home waste and organic debris containing nitrogenous compounds, as well as industrial effluent that finds its way to surface streams. Reclaimed wastewater nutrients can aid crop growth, but they must be evaluated on a regular basis to avoid an uneven nutrient supply. Wastewater can be used to fertilize crops.

### 2.3.5 STREAM WATER pH

The acronym pH stands for potential hydrogen in water, and it represents the acidity and alkalinity of the water. The concentration of the hydrogen ion [H+] influences this (Mupedziswa, 2016). It is often measured using a pH scale ranging from 0-14, where 0-6 reflects the acidic nature of water, 7 is neutral, and 8 and above represents the alkalinity of water. Because most aquatic creatures are accustomed to an average pH and cannot resist rapid changes, pH is an important property in water bodies (Kaur and Singh, 2017). This characteristic is more important in irrigation water. Its depreciation causes trace metal availability to crops, and a pH of 6.5-8 is optimal for plants.

## 2.4 BIOLOGICAL PARAMETERS

### 2.4.1 *Escherichia coli*

This is one of the living organisms responsible for waterborne illness in humans. Because the bacteria is of faecal origin (Jean, 2015), the presence of E.coli suggests faecal contamination. Escherichia coli is mostly utilized as an indicator bacterium, and it is found in the intestines of warm-blooded animals such as humans (Shah, 2017). As a result, the presence of Escherichia coli in water samples implies the presence of faecal matter and, perhaps, pathogenic organisms of human origin (Version, 2016). The use of high-concentration E. coli irrigation water poses some health hazards, particularly when the water is used to cultivate leaf crops, which are sometimes ingested raw (Mwabi et al., 2012, Version, 2016). Streams that are polluted with home wastewater have the highest risk of containing E. coli, and such water may not be suitable for drinking in terms of human health.

### 2.4.2 TOTAL COLIFORM

Coliform bacteria is a member of facultative  aerobic bacteria which exist in most polluted surface water and its sources are human and animal wastes from leaching animal manure, improperly treated septic and sewage discharge, unavailability of land for proper disposal of human excreta directly into the river may be carrying out (Divya and Solomon, 2016) . Coliform bacteria cannot taste, smell or colour, so identification of the presence of bacteria is very difficult (Divya and Solomon, 2016). The existence of coliform bacteria in surface water has also been attributed to the discharge of wastewater in surface water bodies (Kacar and Gungor, 2010). Coliform bacteria also gives  an indication of the general level of the microbiological quality in water unlike  E coli which is the specific indicator of faecal contamination and is an indication of water quality (Version, 2016). The  concentration of these bacteria presents a danger in water  such that to use it for irrigation might be unadvisable.

# CHAPTER 3 METHODOLOGY

## 3.1 DESCRIPTION OF THE AREA

Nyanga is situated in one of the most scenic areas of Zimbabwe’s Eastern Highlands. Rolling green hills and perennial rivers transverse the 47000 hectare park. The region is characterised by wonderful mountain ranges, vast tea estates and cultivated forests which comprises of pine and Cyprus tree. In Nyanga the wet season is mostly cloudy, the dry season is clear and it is comfortable year round because of good climatic conditions which are conducive for human activities such as agriculture, apiculture and aquaculture which generates first hand income. The temperature is rarely above 25 degrees Celsius.

## 3.2 EXPERIMENTAL DESIGN

The design used was Randomised Block Designs (RBD) whereby the river was divided into three segments which are point A, upstream representing the control site, the point B where wastewater was discharged from the agricultural farms and a nearby trout farm and Point C where water samples were taken after the discharge into the stream. As replicates, two samples were collected once per week in one month resulting in six replicates from each site.

## 3.3 DATA COLLECTION

Two samples were drawn from each of the three points ( A,B and C). Samples were taken out on weekly basis for a month prior to the project requirements, A grab sampling technique was used whereby water samples were taken using 500ml glass bottles for parameter testing and comparing, and a 2 litre polythene plastic bottles for salts and nutrient testing. The samples were taken to Environmental Agency Laboratory in Rusape for testing.

## 3.4 ANALYTICAL PROCEDURES

A digital pH meter was used to measure pH, Electrical Conductivity (EC) was measured using Electrode SOP CM12 (EMA, 2007) in us/cm, Turbidity was measured using Nephlometric SOP CM39 (EMA, 2007), Nitrates were tested using Spectrophometric SOP CM23 (EMA, 2007), and Phosphorus was tested using Spectrophometric SOP CM28 (EMA, 2007). (EMA, 2007) Titrimetric SOP CM04 (EMA, 2007) was used to test calcium and magnesium, whereas Electrode SOP CM03 (EMA, 2007) was used to test biological oxygen demand (BOD), and Electrode SOP CM10 was used to test dissolved oxygen

## 3.5 POUR PLATE METHOD.

The number of colonies present in a liquid sample was counted using the pour plate method (Sagar et al., 2019). Before counting, the mixed culture of agar and distilled water was serially diluted with distilled water using a loop or pipette. In 1000 ml of decontaminated or disinfected water was suspended with 49.53 grams of dehydrated medium of agar and the medium was entirely heated before being autoclaved at 15 lbs of pressure for approximately 20 minutes to dissolve it.

A sterile pipette was used to place a predetermined volume of inoculum in the middle of a disinfected petri dish, typically 1 ml from a broth or sample. The petri dish containing molten agar was mixed with molten cooled agar (approximately 15 ml) thoroughly. After the agar had solidified, the plate was inverted and incubated at 37°C for 24–48 hours. McConkey agar was used for total coliforms to grow whilst Trybtone Bile X was used for *Escherichia Coli,*

Colonies grew on the surface and within the media after solidification. Each colony in each plate was counted using a magnifying colony counter. The CFU/ml equations were used to calculate the colony forming unit per millilitre (CFU/ml = **cfu x dilution factor x 1/aliquot**).

## 3.6 DATA ANALYSIS

Differences among means of microbiological contamination were evaluated by ANOVA in Statistical Packaging for Social Sciences (SPSS) Version 21 and one sample t – test was also used to judge against the quantities or concentrations of selected microbial variables of groundwater against the WHO international guidelines of drinking water quality (WHO, 2017). All test will be done at 0.05%.

# CHAPTER 4: DATA ANALYSIS

## EFFECTS OF POLLUTION ON PHYSIOCHEMICAL PARAMETERS IN WATER

### 4.1 BIOLOGICAL OXYGEN DEMAND and DISSOLVED OXYGEN

All sample locations measured biological oxygen demand. Because of the minimal changes and pollution from waste water and pollutants dumped into the river system, the BOD at the control was slightly lower. However, there was a significant increase in the amount of BOD in the river at points and C, respectively, due to an increase in water pollution caused by waste water from agricultural farms and aquaculture centers, which released water containing higher levels of nutrients from fish feed as well as fish excretions. The mean difference in BOD in the Nyakupinga River is shown in Appendix.

Electrical conductivity was not discovered at points B, C vs the control site, or point B versus point C ($p>0.05$), however raw sewer versus the control site, points A and B, reveal a significant difference (p0.05). Turbidity did not differ substantially across locations B and C when compared to the control site ($p>0.05$). In the meantime, there is a substantial difference between points B and C, as well as the control site and raw sewer (p0.05). illustrates the EC and turbidity's 17 mean and standard errors. 4.1.2 ELECTRICAL CONDUCTIVITY AND TURBIDITY

### 4.1.3 WATER pH

The table 4.1.3 above shows the statistical results of water pH levels in the Nyakupinga River

The mean change in water pH was slightly lower since the water samples were collected roughly 50 meters distant from a fish farm. Because of fish feed and fertilizers with higher alkaline concentrations, the average water pH is much lower than the regulation threshold, affecting the pH balance of the river system.

### 4.2 CONCENTRATION OF TOTAL COLIFORMS AND *Escherichia coli* COUNTS IN THE RIVER DUE TO WASTE WATER DISCHARGE.

The concentration of total coliform and *Escherichia coli* present in the stream water was tested at 3 points that is A, B AND C. Point A was the control point and 3 replicates were collected at each point . The control point was on the upstream where there was no or limited discharge of contaminated water in the river. Total coliforms were present at each point , as well as the control point A however the control point had too few to count. Except for the control well, *Escherichia coli* was recorded/noticed at every point according to the results in the stream water.

There was significance between total coliform concentrations between the wells adjacent to the cemetery. The results indicated lower significance different of total coliform concentration between these wells (appendix 1).

The concentration of total coliform in at point A was significantly lower than other points($P < 0.05$), there was no significance difference ($p > 0.05$) comparing point b and c to each other. The control point concentration of total coliform was significantly lower than other points. There was no significance difference ($p>0.05$) comparing point B and C to each other, the concentration of total coliform at point A was significantly lower compared with other points (B and C).

There was significance relation between *Escherichia coli* concentration between the points which were randomly selected in the river. The results indicated lower significance different of *Escherichia coli* concentration between the points. The concentration of *Escherichia coli* in the control poit was significantly lower higher than other points ($p < 0.05$), there was however no significance different ($p > 0.05$) comparing within well point B replicates and point C *Escherichia coli* concentration. Point A had significantly lower *Escherichia coli* concentration than point B ($p < 0.05$). The concentration of *Escherichia coli* in point A and point B was significantly lower than other points. There was no significance difference in *Escherichia coli* concentration ($p > 0.05$) comparing well point b and c to each other.

## 4.3 STREAM WATER QUALITY ACCORDING TO WHO (WORLD HEALTH 0RGANISATION) STANDARDS OF DRINKING WATER.

Table 4.3 shows the comparison of mean values and significance difference of total coliforms and Escherichia coli with WHO standards. The WHO standards guidelines for drinking water states that, total coliform and *Escherichia coli* concentration must be less than 1cfu/ml. All the 3 points were not compliant with WHO standards on total coliforms concentration. Total coliform mean concentration of the points ranged from 6.720±0.504cfu/ml to

3.630±0189cfu/ml. There was a lower significance different between the three points of total coliform concentration and WHO standards ($p<0.05$). Lowest total coliform mean concentration was in pointc which was significantly lower than WHO standards ($p<0.05$). Highest mean concentration was recorded in point A which was significantly lower than WHO standards.

*Escherichia coli* was detectedt at all points. *Escherichia coli* concentration at all points suppressed the WHO international standards of drinking water quality. There was a lower significance different between the three points of *Escherichia coli* concentration and WHO standards ($p<0.05$ *Escherichia coli* mean concentration of the points ranged from 5.020±0.020 cfu/ml to 1.590±0.270cfu/ml. Point A had lower mean concentration of *Escherichia coli* concentration which was significantly lower than WHO standards ($p < 0.05$).

# CHAPTER 5: DISCUSSIONS

## 5.1 EFFECTS OF WASTEWATER DISCHARGE ON PHYYSIOCHEMICAL PARAMETERS OF STREAMWATER

The results showed that the values of biological oxygen demand were substantially greater in April and May at sites A and B downstream, but dramatically reduced in June and July owing to water rationing, which reduces the quantity of wastewater entering the settling ponds and hence cuts the flow to the river. Nonetheless, the biological oxygen demand at the raw sewage site was high throughout all sampling months; the more the biological oxygen demand content, the more biodegradable chemicals were present in the wastewater, as mentioned by (Pitchammal et al, 2009; Subin and Husna, 2013).

Dissolved oxygen was relatively high at the control site in the first week due to the running water, and moderate at all sampling sites. This supports the findings of (Owili, 2003), who stated that the higher the water flow, the higher the dissolved oxygen concentration, and the lower the water flow, the lower the oxygen concentration. However, because of lesser velocity and the presence of high nitrogen and phosphorus levels in waste water, dissolved oxygen dropped in the control location, as reported by (Masere et al., 2012)

Due to an abundance of liquefied salts, which increases conductivity in water, electrical conductivity was high at raw sewer point, exceeding the red category of SI 6 of 2007 of EMA (Uqab et al., 2018). The electrical conductivity at the control sites, Point A and B, ranges within the sensitive to normal category of the SI 6 of 2007 EMA, which might be attributable to the dilution effect of the stream water to house wastewater.

Water pH levels increased during the dry season due to a scarcity of elements that influence the pH balance of the river system. However, a minor increase in pH levels was documented, particularly during the rainy season, due to increased harmful compounds brought from upstream, fertilisers used in agricultural farms, and fish feed, which contain substances that may impact water pH levels in the long run.

## 5.2 INVESTIGATION OF TOATL COLIFORMS COUNTS AND E. COLI CONCENTRATIONS FOUND IN THE NYAKUPINGA RIVER

Total coliforms concentration count were found at all water points in the river, as well as the control point (A), however control point had negligible concentrations, indicating that the water sources were polluted. However, the presence of coliform bacteria in water does not guarantee that drinking water will cause health hazards and major problems to agricultural use but their presence indicates potential contamination of water with disease causing bacteria (Bryan et al., 2016). The control point had few total coliforms concentrations.

In this study, the presents of total coliform concentration in every all wells closer to the cemetery were different from each other (Appendix 1). Similar study was undertaken in Seixas cemetery in Minho showed samples from water sources cited in central part of the cemetery containing higher concentration of bacteria than those away from the cemetery (Rodrigues 2003). The results also showed difference of *Escherichia coli* concentration between water points adjacent to the cemetery (Appendix 2) with wells w1, w2, w7, and w8 having small differences between the concentration levels of *Escherichia coli* . A study by Żychowski (2008) showed small differences between the numbers concentration of bacteria in water points situated within the graveyard or below their sites and their microbiological background.

# CHAPTER 6: CONCLUSIONS AND RECOMMENDATIONS

## 6.1 CONCLUSIONS

Results suggest that the pollution has the potential to damage surface water quality, according to the research. Higher levels of total coliform and *Escherichia coli* concentrations were detected at points which were used as sampling points and each well had mean concentration greater than 3.630cfu/ml for total coliforms and 1.590cfu/ml for *Escherichia coli*. The concentration of these microbiological variables suppressed WHO standards (2017) for drinking water quality (<1cfu/ml), thereby indicating that water from the water sources adjacent was unsuitable or safe for drinking but however total coliform and e. coli have no effect notable effects on agricultural use. The cemetery is also one of the most common anthropogenic sources of groundwater contamination that goes unnoticed by humans. This could result in disease outbreaks like cholera and typhoid, as well as an increase in child mortality.

## 6.2 RECOMMENDATIONS

Nyanga ZINWA and Save Subcatchment Area, as a water service provider for the town, must have a sufficient supply of water to all the locations in Nyanga and they must take part in creating awareness on ways to reduc pollution on stream water and surface water so that residents avoid using water that has been polluted because it could be harmful to their health in the long run. Furthermore, the use of water for drinking which consists of faecal concentrations in the river because it is against WHO regulations of drinking water.

REFERENCES

Bouwer H. (1978) Stream water Hydrology. McGraw-Hill Inc., New York.

Bryan S., William S. (2016). Drinking Water Programs: Coliform Bacteria in Drinking Water supplies

Castro D. L (2008) Geophysical and hydrogeological characterization of the Bom Jardim, cemetery Fortaleza. Rev. Bras. Geof. 26 (3) 251–271

Charles T, Tapiwa H (2017). Heavy Metal Contamination of Stream Water from an Unlined Landfill in Bulawayo, Zimbabwe. Journal of Health and Pollution. 7 (15) 18–27.

Dent B. B. (2000). Decay products in cemetery ground waters. Geology and Sustainable Development: Challenges for the Third Millennium. In: 31st International Geological Congress, Rio de Janeiro, August. Book of Abstracts (CD-Rom), IGC, Rio de Janeiro, pp. 6–17.

Dube Trevor, M. C. and S. Z. (2014). An Assessment of the Effect of Industrial and Sewage Effluent on Aquatic An Assessment of the Effect of Industrial and Sewage Effluent on Aquatic Invertebrates : A Case Study of A Southern Urban Stream , Zimbabwe. (May 2010), 3–8. https://doi.org/10.5539/jsd.v3n2p210

Elberg S.,Rice, E.,Karlin, R and Allen, M. (2000). Escherichia Coli: The best biological drinking water indicator for public health protection Society for Applied Microbiological Symposium Series 29:106S-116S.

Engelbrecht J. F. P. (1993) An assessment of health aspect on the impact of domestic and industrial waste disposal activities on groundwater resources. Water Research Commission, Pretoria.

Engelbrecht J. F. P. (1998) Groundwater Pollution from Cemeteries. Water Institute of South Africa. http://www.ewisa.co.za/literature/files/1998%20-%2017.pdf (accessed 31 March (2014).

Espindula J. C.(2004) Bacteriological and physico-chemical characterization of the unconfined aquifer of the cemetery Várzea – Recife. Dissertation, Universidade Federal de Pernambuco.

Environmental Protection Agency (2011). Parameters of water quality

Jonker C., Olivier J (2012). Mineral Contamination from Cemetery Soils: Case Study of Zandfontein Cemetery, South Africa. Int. J. Environ. Res.Public Health, 9: 511-520.

Józef Ż., Tomasz B (2014). Impact of cemeteries on groundwater contamination by bacteria and viruses – a review

Liddell, Henry G., Scott, Robert (1855). A Greek–English Lexicon at the Perseus Project

Lauren T (2021). Quasi-Experimental Design | Definition, Types & Examples Published on July 31, 2020 by Revised on October 20, 2021.

Migliorini R. B. (1994) Cemeteries as a Source of Pollution in Aquifers. The Study of Cemetery Vila Formosa in the Sedimentary Basin of São Paulo.

Nyemba, Anesu & Manzungu, Emmanuel & Masango, Sijabuliso & Musasiwa, Simon. (2010). The impact of water scarcity on environmental health in selected residential areas in Bulawayo City, Zimbabwe. Physics and Chemistry of the Earth, Parts A/B/C. pp. 823-827.

Ndoziya A. T, Hoko Z, Gumindoga W (2019). Assessment of the impact of pit latrines on groundwater contamination in hopley settlement, Harare, Zimbabwe. Journal of Water Sanitation and Hygiene for Development.

Patrick D. (2011). Groundwater pollution by sanitation, international hydrological programme.

Rodrigues L., Pacheco A. (2003) Groundwater contamination from cemeteries cases of study. In: International Symposium: Environment 2010: Situation and Perspectives for the European Union, Abstract Book CD-Rom Full Paper C01, University of Porto, Porto, pp. 1–6.

Robson S. N (2016). Department of Environmental Sciences: Assessing the impact of sewage leakages on groundwater quality in Dombotombo, Marondera

Sagar A (2019). Pour Plate Technique- Procedure, Advantages, Limitations

Silva F. C. B., Haberland N. T., Filho P. C. O. (2011) Cemeteries as a source of contamination of groundwater and watercourses. Annals of SIEPE II – Integration week teaching, research and extension, Book of Abstracts. UNICENTRO, Santa Cruz, pp. 1–4.

Silva L. M. (1995). The cemeteries as an environmental issue. National Seminar 'Cemeteries and Environment, pp. 1–8.

Shawn C. Y (2019). The Ohio State University, By Plant-Breading-Genomics, Introduction to Randomization and Layout

Trick J. K., Williams G. M., Noy D. J., Moore Y., Reeder S. (1999). Pollution Potential of Cemeteries: Impact of the 19th century Carter Gate Cemetery, Nottingham. Technical Report WE/99/4. British Geological Survey, Keyworth, Nottingham, pp. 1–34

Tenaillon, O., Skurnik, D., Picard, B. (2010). The population genetics of commensal Escherichia coli. Nat Rev Microbiol 8, pp. 207–217.

Üçisik A. S., Rushbrook P. (1988). The Impact of Cemeteries on the Environment and Public Health – an Introduction Briefing. Report nr E61937. WHO Regional Office for Europe, Copenhagen, pp. 1–11.

WHO (2008). Guidelines for Drinking water quality, Incorporating 1st and 2nd Addenda, Volume 1, Recommendations, 3rd. WHO: Geneva, Switzerland.

WHO. (2011). Guidelines for drinking water quality. Health Criteria and other Supporting Information 2nd. Ed. vol 20. Geneva.

WHO. (2006). Guideline for drinking water quality. Geneva.

WHO. (2017). Guidelines for drinking-water quality - 4th ed. WHO. (2017). Guideline for drinking water quality. Geneva

WWAP (2009). World Water Assessment Programme. The United Nations World Water Development Report 3.Water in a Changing World.

Yahuza T, Sunday P. Bo and Awever, T. (2013). Effects of sewage Pollution on water Quality of Samaru stream, Zaria, Nigeria pp 337.

## APPENDIX

## SPPS T-TEST OUTPUT

THE TABLE SHOWS THE STATISTICAL RESULTS OF BIOLOGICAL OXYGEN DEMAND AND DISSOLVED OXYGEN (4.1)

**One-Sample Statistics**

|  | N | Mean | Std. Deviation | Std. Error Mean |
|---|---|---|---|---|
| VAR00003 | 14 | 5.9929 | .62691 | .16755 |

**One-Sample Test**

|  | Test Value = 0 |  |  |  |  |  |
|---|---|---|---|---|---|---|
|  | t | df | Sig. (2-tailed) | Mean Difference | 95% Confidence Interval of the Difference |  |
|  |  |  |  |  | Lower | Upper |
| VAR00003 | 35.768 | 13 | .000 | 5.99286 | 5.6309 | 6.3548 |
|  |  |  |  |  |  |  |

## SPSS T-TEST OUTPUT 2

STATISTICAL RESULTS OF STREAM WATER pH (4.1.3)

**One-Sample Statistics**

|  | N | Mean | Std. Deviation | Std. Error Mean |
|---|---|---|---|---|
| VAR00002 | 4 | 5.0250 | 3.36192 | 1.68096 |

**One-Sample Test**

|  | Test Value = 0 |  |  |  |  |  |
|---|---|---|---|---|---|---|
|  | t | df | Sig. (2-tailed) | Mean Difference | 95% Confidence Interval of the Difference |  |
|  |  |  |  |  | Lower | Upper |

| | | | | | | |
|---|---|---|---|---|---|---|
| VAR00002 | 2.989 | 3 | .058 | 5.02500 | -.3246 | 10.3746 |

APPENDIX 2

## APPENDIX 4: RAW DATA FOR MICROBIOLOGICAL VARIABLES

### TOTAL COLIFORM CONCENTRATION (CFU/ML)

| Variety | A1 | A2 | B1 | B2 | B3 | C1 | C2 | C3 | Control |
|---|---|---|---|---|---|---|---|---|---|
| replicate1 | 6.48 | 5.67 | 4.95 | 4.67 | 4.41 | 4.50 | 3.96 | 3.78 | 1.5 |
| replicate2 | 7.30 | 4.98 | 3.89 | 4.30 | 4.98 | 4.36 | 3.75 | 3.70 | 1.0 |
| replicate3 | 6.38 | 5.36 | 4.56 | 4.53 | 4.20 | 4.45 | 3.20 | 3.42 | 1.3 |

### *Escherichia coli* CONCENTRATION (CFU/ML)

| variety | A1 | A2 | B1 | B2 | B3 | C1 | C2 | C3 | control |
|---|---|---|---|---|---|---|---|---|---|
| replicate1 | 5.04 | 3.96 | 3.69 | 4.50 | 3.42 | 3.15 | 2.43 | 1.90 | 0.00 |
| replicate2 | 5.00 | 4.02 | 3.61 | 4.78 | 3.33 | 3.02 | 2.40 | 1.40 | 0.00 |
| replicate3 | 5.02 | 3.88 | 3.50 | 4.46 | 3.00 | 2.98 | 2.36 | 1.47 | 0.00 |