

HEAVY METALS DETERMINATIO IN NASOLO RIVER BLANTYRE

CHANDIWIRA MAKWAKWA

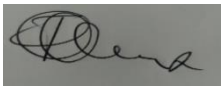
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JUNE, 2021

DISSERTATION APPROVED BY:

SUPERVISOR:

Mr. F Chauluka Signature: 

ASSESSOR:
Title, Initials, Name Signature: _____

DECLARATION

I Chandiwira Makwakwa declare that this research project represents my own work and that it has never been submitted to this institution or any other institution for any academic purpose. All sources of information have been appropriately acknowledged

Signature

Date 19 July 2021

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ABSTRACT

Heavy metals are metals with high densities and atomic weights. Heavy metal contamination in water systems is a severe concern all over the world, particularly in locations where anthropogenic pressures are considerable (Ochieng, 2007). In Malawi studies of heavy metals in our river systems is not an area of much interest, because it is thought that their concentrations do not exceed the recommended limits by MBS and WHO. In this context, a study was conducted to evaluate the amounts of heavy metals in the Nasolo river sediments, one of Blantyre's streams. The river is significant because it provides water for a variety of domestic purposes and serves as a habitat for aquatic organisms. This river also has a catchment with the Mudi River, from which Blantyre Water Board gets its raw water. The H_0 hypothesis was that the analyzed metals do not deviate considerably from the set standards. The study collected sediment samples from seven different locations, including the source, ndirande view, chioni bridge, paseli lodge, industrial area, and railway residences. With the exception of pH, samples were analyzed for heavy metal concentrations using atomic absorption spectrometry in the laboratory, and physical parameters such as TDS and EC were obtained on-site. Zn, Cd, Fe, Pb, and Cu were identified in the metal analysis. The findings were compared to the Malawi Bureau of Standards' (MBS, 2005) and World Health Organization's (WHO) drinking water quality standards. The average mean concentrations were, Zn(0.61mg/l), Cu(0.523mg/l), Pb(0.0342mg/l), Fe(1.796mg/l), and Cd(0.006mg/l). Cu, and Zn all fell within the MBS recommended range, however Cd, Pb and Fe did not. pH values, with the exception of TDS, were 6.2-8.0, EC (8.2-32.7 μS /cm), and TDS (389-494 mg/l), all of which were within the WHO and MBS recommended ranges. To better understand the level of pollution, contamination factor was calculated, Pb (0.0213), Fe(0.0189), Cd(1.1195E-5), Cu(0.0544) and Zn(0.0034).This indicates that nasolo river water is not highly polluted because CF values were all less than 1. The results also showed that the pairs of Zn and Pb, Cu and EC, Cd and Zn, Pb and Fe, TDS and Fe were highly correlated. This study will give a baseline that Blantyre city assembly and the department of environmental affairs work together to prevent further river system degradation.

Keywords: heavy metals, sediments, contamination factor, AAS, Nasolo river.

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ACRONYMS/ABBREVIATIONS

AAS…… Atomic Absorption Spectrometer

MBS……..Malawi Bureau of Standards

APHA…… American Public Health Association

ATSDR…….. Agency for Toxic Substances and Disease Registry

Mg/L…….Milligram per litre

µs/M…… Microseconds Per Metre

ICP-AES ……..Inductively Coupled Plasma- Atomic Emission Spectroscopy

SD…… Standard Deviation

CF……..Contamination Factor

USEPA……US Environmental Protection agency

WHO ……..World Health Organization

EC…… Electron Conductivity

TDS……..Total Dissolved Solids

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1.0. CHAPTER 1: GENERAL INTRODUCTION

1.1. Background information

Heavy metal pollution is a severe concern all around the world, particularly in locations where anthropogenic pressures are considerable (Chauhan et al., 2015). Heavy metals are poisonous, resistant to decomposition, and tend to build up in organisms and the environment (Effendi et al., 2016). Heavy metal concentrations in urban environments tend to be greater than background values, particularly in locations near large industrial complexes (Kumar et al., 2017), posing a threat to the environment, particularly soils and aquatic systems. Metal transmission across food chains can be high enough in damaged aquatic habitats to cause hazardous quantities in aquatic species' tissues (B. River, 2010).

Metal accumulation in organisms in the environment is strongly dependent on their availability for uptake by organisms, posing health risks to humans and wildlife alike (Saha, 2011). Heavy metals are known to cause cancer, damage to internal organs, and interference with critical organ systems in living creatures. Heavy metal exposure through the food chain poses a threat to organisms' health and well-being (Persson & Kayambazinthu, 2006). Heavy metals have been linked to decreased species variety and population densities of creatures in the environment, such as freshwater mussels in North America (Chernova et al., 2015). Although all heavy metals have the potential to create issues, exposure to lead, cadmium, mercury, and arsenic poses the greatest risk to human health (Y. River, 2014).

Heavy metals can be released into the environment as a result of industrial and domestic waste discharges, as well as agricultural and mining activities (Izah et al., 2017). According to Clements et al. (2000), mining activities contribute to severe heavy metal pollution of streams, such as that seen in the Rocky Mountains (USA). Heavy metal concentrations in rivers tend to be higher downstream due to agricultural activities, industrial effluents, and anthropogenic wastes (Article, 2009).In general, particles like as suspended matter and sediments are responsible for more than 90% of the heavy metal burden (Kumar et al., 2017). Heavy metals can generate hydrolysis species and complexes with inorganic ligands like chlorides and sulphates in soil solution. The relevance of hydrolysis species and inorganic complexes is determined by pH and metal and ligand concentrations (Shanbehzadeh et al., 2014). In urban environments, motor vehicles through emissions and tyre wear can also contribute to heavy metal pollution (Gashi et al., 2009). This is in addition to run-off from informal settlements and industries which can contribute significant levels of heavy metals in surface water bodies for instance a study done in India by Gaur et al. (2005), found that the River Gomti became highly polluted after passing through the city of Lucknow where it received industrial and domestic wastes through mainly drainage systems.

Several studies have been conducted in Malawi to determine heavy metal concentrations in diverse habitats, including soils, aquatic species, and aquatic environments such as streams,

rivers, lakes, and ponds, among others. Recent research by Sajidu et al, 2007, for example, found significant amounts of several heavy metals in the rivers of Blantyre, Malawi. Kaonga et al. (2008) looked at the amounts of Cd, Mn, and Pb in Blantyre City streams in another study. Apart from agricultural activity along their coasts, these streams pass through industrial zones and are frequently recipients of raw sewage as a result of faulty sewer connections. Cd levels were higher (0.07 to 0.111 mg/L) than previously measured (0.07 to 0.111 mg/L). However, Mn (n.d-0.626 mg/L) and Pb (0.011 to 0.23 mg/L) concentrations found in the same study were within the range of similar environments reported elsewhere. Even though this is true, data from such studies has been either scarce or insignificantly evaluated. To ensure sustainable management of water resources and the environment in general, it is critical to have a thorough understanding and evaluation of heavy metal emissions in Malawi.

By measuring heavy metals in sediments using a device called an atomic absorption spectrometer, this research will show the current condition of pollution in the Nasolo River, as well as contamination sources. The study will address a gap in the literature about heavy metals in our drinking water systems, especially in river water sources and utilities like Water Boards.

2.0. Problem statement

Malawi's second largest city, Blantyre, is located 311 kilometers southeast of the country's capital, Lilongwe. The city is around 220 square kilometers (sq. km) in size and sits at an elevation of about 1,150 meters (m) above sea level (Wash & Centres, 2018). It is the capital of Malawi's Southern Region as well as the Blantyre district. Among the major water and sanitation issues that Blantyre residents face are frequent water supply disruptions, sporadic solid waste collection, indiscriminate liquid waste disposal, and insufficient sewerage treatment, all of which lead to undesirable water sources from rivers within the city limits (M. Pritchard, 2007).

The Nasolo is one of Blantyre's most important rivers. It passes through a number of industrial and agricultural areas, including the makata, ntipe, and mpheta areas, to name a few, and flows into the mudi river in the downstream. The research was conducted in the Nasolo River as a result of the preliminary survey (site visit) which indicated that the nasolo river is under threat of severe degradation due to the anthropogenic activities happening along the river. It was also noted that there is scarcity of proved data on heavy metal analysis particularly in river sediments in Malawi, because much studies have focused on the physical and biological analysis. There was also interviews with the water quality department at the Blantyre Water Board revealed that the board does not delve into heavy metal treatment and this includes all water utilities in malawi, this was taken for a consideration because the catchment of mudi river and the nasolo river is primarily the same. The activities that happen along the nasolo

river includes numerous garbage disposals into the river, implying that heavy metals would precipitate into the river, increasing their natural background occurrence, posing a concern to people who use the river water for drinking and other domestic purposes. River investigations which were undertaken by Kuyeli and Masamba to assess the quality of the Nasolo River's water which looked at the temporal and spatial physicochemical water quality in urban streams in Blantyre and determined that the water in the Nasolo River was unsafe for drinking and contaminated before treatment, especially in terms of BOD and nutrients. Researchers discovered that many pit latrines are located near water sources such as rivers, affecting the physical, chemical, and biological water quality of river water in most urban settings, including the Nasolo River, in the study of, Effect of Sanitation Facilities, Domestic Solid Waste Disposal, and Hygiene Practices on Water Quality in Malawi's Urban Areas (Palamuleni, 2001). It was against this background that a study was to be done. This heavy metal research, which includes zinc, cadmium, iron, copper, and lead, is justified to provide a basis for sensitizing government entities that deal with the environment about the management of discharge into the environment, especially river systems since these rivers play a major role in the provision of raw water which is treated and distributed for various uses and also give a clue to water utilities such as Blantyre waterboard that its high time to start monitoring and treating of heavy metals in its operations.

2.1 Hypothesis

H_0 It is hypothesized in this study that heavy metal concentrations in nasolo river sediments do not deviate considerably from the MBS and WHO approved limits (WHO, 2008).

H_1 The levels of heavy metals would surpass worlds health organization(WHO,2008) and the Malawi bureau of standards(MBS,2005) approved limits.

3.0. Study objectives

3.1.0. Main objective

The research is to be conducted to assess heavy metals (iron, zinc, copper and cadmium) in Nasolo river sediments.

3.1.1. Specific Objectives

i. Find out concentration levels of heavy metal pollutants (Pb,Cu,Fe,Zn,Cd)
ii. Find out levels of the physical properties of water in nasolo river (pH,EC,TDS)
iii. Determine the effects of various polluting activities on the water of the Nasolo River.
iv. To see if there's a link between heavy metal levels in the river sediments and the three physical paramaters studied (pH, electrical conductivity, Total dissolved solids).

3.2. Research questions

The study answers the following questions

i. What are the concentrations of the selected heavy metals at different points along Nasolo river which includes copper, iron, cadmium, zinc and lead?
ii. What heavy metals are in abundance?
iii. How are pollution sources contributing to the presence of heavy metals in the river (dumping of industrial and domestic waste)
iv. Are the levels of selected heavy metals in the river comparable to their natural occurrences?

CHAPTER 2: LITERATURE REVIEW

2.0. Introduction

Heavy metals are released into the environment through a variety of processes, and they can be found in water, suspended particles, sediments, and biota. Lead, chromium, arsenic, cadmium, copper, and zinc are the heavy metals in water that cause the most environmental concern. Contamination by these heavy metals manifests itself in high concentrations in water, sediments, and aquatic creatures, and has negative consequences for the organism. This chapter covers heavy metals, their characteristics, impacts on plants, water, and humans, as well as heavy metal analysis methods.

2.0.1. Heavy metals

Heavy metals are primarily defined as metals with high densities and atomic weights (atomic numbers). Or Heavy metals are defined in metallurgy on the basis of densities, in physics on the basis of atomic number, and in chemistry on the basis of chemical behavior. In biochemistry, heavy metals are classified according to their ability to perform as Lewis' acid (electron pair acceptor) ions in aqueous solutions (Kamau, 2007). Iron (Fe), copper (Cu), tin (Sn), and other precious metals such as silver (Ag), gold (Au), and platinum (Pt) are examples of heavy metals. These were the first known metals (Petrosyan et al., 2019). Other heavy metals, including as iron, cobalt, and zinc, are also required nutrients; however, some are considerably less harmful, such as ruthenium, silver, and indium, and can be toxic in high doses or in their definite form. Then there are a few heavy metals that are extremely deadly, such as cadmium, mercury, and lead (Tole, 2003). Heavy metal contamination can be found in soil, water (rivers), and the atmosphere, among other places. Each heavy metal has a distinct composition, physical qualities, and chemical structure. Heavy metals, without a doubt, are both toxic and hazardous. They have negative consequences. Heavy metals must be handled with caution. Some heavy metals are less reactive, whereas others are extremely reactive (Linnik, 2000). These are thought to be toxic or highly destructive to the environment. Heavy metals mortify air, water, and soil quality and consequently cause health issues in plants, animals, people, etc. Some toxic elements are also regarded as beneficial, but only in small quantities for human health. These elements are vanadium, manganese, cupper, iron, zinc, strontium, selenium and molybdenum (Muiruri, 2013). A lack of these elements can be detrimental and raise the risk of heavy metal poisoning. Heavy metals hazardous or heavy metals consumption at a chronic level has dangerous consequences on the human body, and the effects are only visible after several years of exposure. Heavy metals are ordered in the following order based on their toxicity to live organisms: Hg > Cu > Zn > Ni > Pb > Cd > Cr > Sn > Fe > Mn > Al (Saeed, 2008)

2.1. Properties of heavy metals

Heavy metals have a number of characteristics, such being less reactive than lighter metals, being relatively scarce in the Earth crust, implying lower heavy metal concentrations, and so on and having a higher density than light metals, they are quite hard, thermal expansion of heavy metals is lower as compared to the light metals ,melting point of heavy metals varies from low to high whereas light metals have low melting point, tensile strength of heavy metals is mostly higher, they are extremely insoluble in sulphides and Heavy metals are often insoluble in hydroxides, heavy metals create colorful solutions in water, and heavy metals are micronutrients that must be consumed in small amounts (Salah et al., 2012).

2.2. Sources of heavy metals

Heavy metals in water and soil come from a variety of places, including atmospheric deposition, incorrect industrial solid and liquid waste disposal, mining activities, sewage, and pesticide and fertilizer use. These metals are primarily emitted into the environment as gas, soil, and dust through transportation, energy, metallurgy, and construction (Wepener V, 2001). Heavy metal reaches the air in the form of aerosol and eventually settles in the soil as a result of natural sedimentation and rainfall. Automobile transportation pollutes the environment with a lot of heavy metals. Irrigative sewage, sanitary sewage, chemical waste water, and industrial mining all introduce heavy metals into the land. Industries emit a large amount of hazardous chemicals, which are then discharged into a river or an open area. Also, for agricultural purposes, people increasingly utilize a lot of fertilizers and pesticides. The soil has been degraded as a result of the long-term excessive treatment. Inside fertilizers, heavy metals are the most commonly reported contaminant. Phosphoric fertilizers typically have a high concentration of harmful heavy metals, whereas nitrogen and potash fertilizers have a much lower concentration. Certain elements are detected in higher concentrations in vegetables planted near industrial plants and busy roads, as well as in crops exposed to municipal and agricultural wastewater. This could cause a disruption in the equilibrium of these elements, which would have a considerable impact on their bioavailability and interactions with other food items and metals (Muiruri, 2013). Heavy metals such as chrome from metallurgical, paint, and tanning industries, nickel mostly from steel industries and coal and liquid fuel combustion, and cadmium from metal smelters all have a substantial impact on environmental contamination, other causes of contamination with this element, according to the article, include grease used in automobiles and lead from paint, metallurgical, and glass industries.

2.3. Impact of heavy metal contamination on plants.

Soil conditions influence the dynamics of heavy metals in the soil, as well as their uptake by plants, and play an essential role in their bioavailability. A multitude of parameters, including soil type, pH, humidity, and micronutrient content, as well as crop harvesting time, influence the level and amount of heavy metals deposited in plants (Wepener V V. V., 2001). The acidic pH is the most critical element influencing the accelerated uptake of heavy metals by vegetation. In alkaline soils, heavy metal leaching and bioavailability to Organic debris can hinder metal uptake from the soil solution, and plants are limited. The following soil factors that affect metal solubility in the soil are modified to transport heavy metals in solid form. Metal mobility and bioavailability can be affected by the inclusion of organic and inorganic components. Plants growing in soils contaminated with heavy metals have lower growth, yield, and performance (Yousafzai, 2008). Due to changes in physiological and biological processes, plants growing in heavy metal-polluted soil show a reduction in growth. Lower yields occur from continued plant growth, which eventually leads to food poverty. Soil conditions have a range of effects on metal availability. The most important determinant of metal availability in soil is pH. The density and kind of charge in soil colloids, the degree of ligand complexation, and the relative surface area of the soil are all other features (Ochieng, 2007).

2.4. Impact of heavy metal contamination on water

Heavy metals release toxic chemicals, which are harmful to marine creatures. Heavy metals have a proclivity for bioaccumulation, making them harmful to all forms of life. The process of raising the concentration of any chemical in a living organism is referred to as "bioaccumulation." Increased water pollution causes the release of poisonous substances, pathogenic bacteria, and radioactivity, all of which require more oxygen to breakdown. Eutrophication, for example, is a state in which there is a lack of oxygen in a water body due to excessive algae growth due to pollution enrichment. It destroys all aquatic plants, tiny fish (who eat the aquatic plants), large fish (who eat the little fish), and humans. (B. River, 2010). Finally, the ecosystem is harmed. Water quality is worsening on a daily basis all across the planet.It is becoming less suited for any work, and it is absolutely unfit for drinking. However, some people have no choice but to filter the water before drinking it. Animals, on the other hand, have no knowledge if the water is fit for drinking or not, therefore after grazing, they go to the river, ponds, or small lakes to drink. They also absorb dangerous metals from the water. And over time, this toxic metal wreaks havoc on their bodies, making them sick and eventually killing them.

2.5. Impact of heavy metal contamination on human

Animals feed on heavy metal-poisoned vegetation and then drink the same water. Heavy metals contaminate the water where marine life breeds, and both metals build a mass in their tissue and milk. In a nutshell, every living entity is reliant on one another for survival. (Muiruri, 2013). When humans ingest these plants and animals, they also consume the poisonous compounds. Specific metals have different levels of toxicity. Toxicity is also determined by the amount of metals eaten. Cadmium is hazardous at low concentrations. It causes renal failure, bone abnormalities, osteoporosis, high blood pressure, and cardiac dysfunction in humans. Lead is extremely toxic and is primarily absorbed by ingestion of food and water, as well as breathing. Teratogenicity is one of the more dangerous side effects. Lead poisoning also causes hemoglobin production to stop, renal malfunction, and permanent harm to the central nervous system. The effects of zinc are similar to those of lead. Its high concentration causes anemia, diarrhea, bloody urine, vomiting, kidney failure, and anemia, among other things. Mercury is poisonous because it promotes spontaneous abortion and gastroesophageal reflux disease. Protein deficit causes a variety of health problems, including a decrease in chondroblast or osteoblastic activity (Tirkey A., 2012). Normal bone and cartilage growth and production are disrupted in this disorder, resulting in irreversible physical abnormalities in growing children and adults. As a result, it's critical to understand the precise amount of heavy metals present in coastal areas in order to protect both aquatic and terrestrial life. Terrestrial life's liver, kidneys, heart, and body connects are harmed. The liver and kidneys manufacture metallothionein, which cause toxicity that is extremely dangerous to human life. (Ogundiran & Afolabi, 2008).

2.6. Heavy metal analysis methods

Various methods and equipment are used to analyze heavy metals and trace elements in drinking water, sediment, soil, solid wastes, and a variety of other materials. Atomic Absorption Spectrometry (AAS) and Inductively Coupled Plasma-Mass Spectrometry are examples of instrumental analytical procedures (ICP-MS), Heavy metals are widely determined in environmental samples using inductively coupled plasma atomic emission spectrometry (ICP-AES) and inductively coupled plasma optical emission spectrometry (ICP-OES). When choosing a method and instrument for heavy metals and trace element analysis, several thoughts are taken into account. Sample type, sample processing, instrument sensitivity or detection limit, sample throughput, matrices or spectral interference, concentration range, robustness, regulatory constraints, time, and cost are some of these considerations. (APHA., 2005). On the one hand, atomic spectrometry equipment (such as Flame Atomic Absorption Spectrometry-FAAS or Graphite Furnace Atomic Absorption Spectrometry-GFAAS) are the most common and reliable methods for analyzing trace metals and metalloids in environmental samples. The ICP-MS and ICP-OES, on the other hand, are

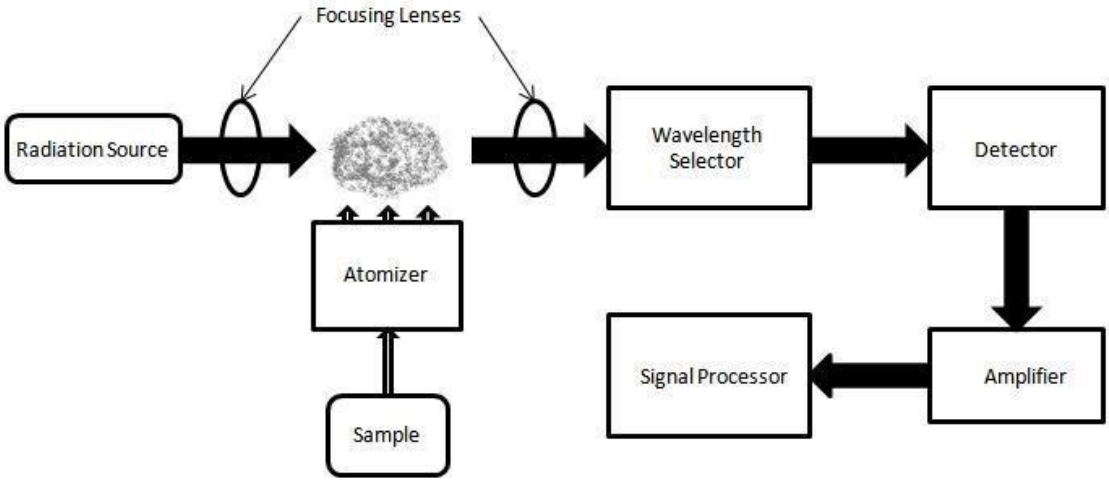
suitable for analyzing trace metal concentration in water and wastewater samples. The ICP-MS approach is preferred in circumstances when maximal detection is required. The ICP-OES is more durable, allowing it to analyze samples with greater total dissolved solids (TDS) levels with ease. Because of their low regulatory limit in drinking water, elements like lead (Pb) and arsenic (As) are well evaluated using ICP-MS. (Wepener V V. V., 2001). To ensure that metal ions are completely dissolved in liquid or leached from solid samples, acid digestion (acid or acid mixes) is frequently used. The choice of acids or acid mixtures is critical for achieving the best digestion results and minimizing (spectral) interferences, and this is depending on the analyte of interest to be examined, among other considerations. Flame (direct aspiration) AAS, a simple and rapid approach suited to a variety of environmental sample water, can easily analyze trace elements and metals in solution. The method is a combination of existing systems for water, wastewater, and solid waste management.(Mohamed et al., 2015). For acid digestion of sediments, sludges, and soils, the US-revised EPA's method 3050B (1996) is utilized. The technique specifies two procedures for preparing sediments, sludge, and soil samples for heavy metal and trace element analysis using FLAA or ICP-AES and GFAA or ICP-MS, correspondingly. Similarly, the US-EPA method 6020A (1998) describes the multi-elemental identification of analytes in environmental samples such as water and waste extracts or digests using ICP-MS (APHA., 2005).

2.7. Atomic absorption spectrometer (AAS)

This method uses absorption spectrometry to determine the concentration of an analyte in a sample. Beer Lambert's law is used to determine the connection between measured and analyte concentrations, and a standard with known analyte content is required. The process of turning a sample into atomic vapours is known as atomization. Because the atomization stage determines the precision and accuracy of this technology, the atomization technique must be carefully chosen. The two types of atomizers are continuous and discrete atomizers. Continuous atomizers continuously feed the sample into the atomizer, resulting in a spectral signal that is stable over time. Flame, inductively coupled argon plasma, and direct current argon plasma are examples of continuous atomization processes. A measured quantity of a sample is introduced as a plug of liquid or solid using discrete atomizers. In this situation, the spectral signal reaches a maximum and then drops to zero. One of the separate types is an electro thermal atomizer. The atoms then absorb wavelength-specific radiation from an external source. Heavy metal atoms absorb radiation of varying nanometer wavelengths from an external source, which is commonly a hollow cathode lamp (APHA., 2005).

This approach has been used to analyze elements in a variety of matrices, including soils, water, nuts, wine, and wine products. The components of AAS are shown schematically in the graphic below. The two types of radiation are a continuous source, which uses deuterium and mercury lamps, and a hollow lamp, which has an anode made of tungsten

wire or wink and a hollow cathode made of the element of interest or its own salt. A fuel and an oxidant are the key components of the flame atomization process. The flow rate and ratio of oxidant and fuel determine their temperatures, whereas the electro thermal atomizer is primarily formed of carbon rods. The free atoms are vaporized from the carbon atomizer into the optical light channel, where they are collected by a monochromator and presented to the detector as monochromatic radiation. Detectors receive the radiation from the monochromators and convert it to electrical signals. Photocells and photo multiplier tubes are two typical detectors.



SOURCE: (MWANGI JOHN MUIRURI, 2013)

Figure 1: Schematic diagram of AAS equipment a. Radiation source (Hollow cathode lamp)

a. source of radiation (Hollow cathode lamp)
   This is the source of the analytical light line for the element of interest, and it produces a steady and powerful beam of that analytical light line.
b. Atomiser (Flame)

The atomiser will shatter complexes and destroy analyte ions to form atoms of the element of interest.

c. A wavelength selector is a device that allows you to choose between different wavelengths (Monochromator)

A wavelength selector separates analytical line photons from dispersed light of the other wavelength as they travel through the flame. Only a thin line is impinged on the photomultiplier tube as a result of this.

d. Detector (Photomultiplier tube (PMT))

It determines the analytical line's intensity as it exits the monochromator. The PMT is the most widely used AAS detector.

Table 1:International and national drinking water standards for heavy metals.

Parameter (mg/L)	WHO (2011)	US-EPA (2012)		MBS (2005)
		MCL (P)		
	*			100 -200
		MCL (S)		
Fe3+	NA	NA	0.30	0.01-0.20
Cu2+	2.00	1.3	1.0	0.5-1.0
Zn2+	Nh	NA	5.0	3.0-5.0
Pb2+	0.01 (A, T)	0.015 (lead action level)	NA	0.01-0.05
Cd2+	0.003	0.005	NA	0.003-0.005

Maximum Contaminant Levels (MCLs) (P): Primary consequences, such as skin or tooth discolouration; (S): Cosmetic or aesthetic impacts, such as taste, odor, or color. Nh: At quantities found in drinking water, it is not a health hazard. *taste threshold value. NA: No data provided.

Instrument condition	Copper	Iron	Lead	Zinc	Cadmium
Lamp	Copper hollow cathode	Iron hollow cathode	Lead hollow cathode	Zinc hollow cathode	Cadmium hollow cathode
Slit	4mA	3mA	4mA	4mA	4Ma
Wavelength	324.7 nm	248.3 nm	283.3 nm	670.8 nm	228.8nm
Fuel	Acetylene	acetylene	Acetylene	acetylene	Acetylene
Oxidant	Air	air	Air	Air	Air
Type of the flame	Oxidizing	Oxidizing	Oxidizing	Oxidizing	Oxidizing

Table 2 Working condition for AAS instrument

Calculation of final metal concentration

FINAL CONCENTRATION (mg/l) = $\frac{Digested\ concentration\ (mg\ L{-}1)\ x\ Volume\ digested\ (L)}{SAMPLE\ WEIGHT\ (mg)}$ (APHA, 2005)

CHAPTER 3: MATERIALS AND METHODS

3.0. Introduction

The study area, data collection procedures in the field, sample collection, and processing are all covered in this chapter. The method for determining heavy metal concentrations in river sediments was also explained.

3.2. Study Area

3.2.1 Study Area Location

Blantyre district is located at 15°47'10"S 35°0'21"E, it is highly populated because of its inhabitants like ndirande. The research was carried out in ndirande. No one knows the precise size of the Ndirande slum in Malawi. The population should be well in excess of 200 thousand people. Ndirande is three kilometers from the center of Blantyre, Malawi's second largest city. Ndirande runs from Makata Road to the 1,800-meter-high Mount Ndirande's slopes. Halfway, you'll pass through Ndirande Ring road, the city's economic and manufacturing hub. Timber merchants, minibus repairers, taverns, take-away restaurants, and manufacturers of burglar bars, cooking stoves, and comfortable couches may be found on both sides. The Nasolo River, which runs through Ndirande, is where sediment samples are taken.

3.2: Research design

During the cold dry season (May 2021), river sediment samples were collected three times, totaling 21 samples from seven sampling points. The samples (sediments) were dried until no further weight change happened, wet digested, and atomic absorption spectroscopy was used to analyze for Pb, Zn, Fe, Cd, and Cu. Physical water characteristics like EC and TDS were measured onsite, whereas pH was assessed in the laboratory.

Data analysis

Excel was employed for data analysis as shown in the figure below:



Figure 2 data analysis flow

3.1. Setting/study site

The research was conducted on Nasolo River which runs through Ndirande area and makata area and feeds into mudi river in Blantyre. The map below shows the sampling points indicated by dots along the nasolo stream. The sampling points coordinates using a GPS machine shown in the appendix at each and every sampling point.

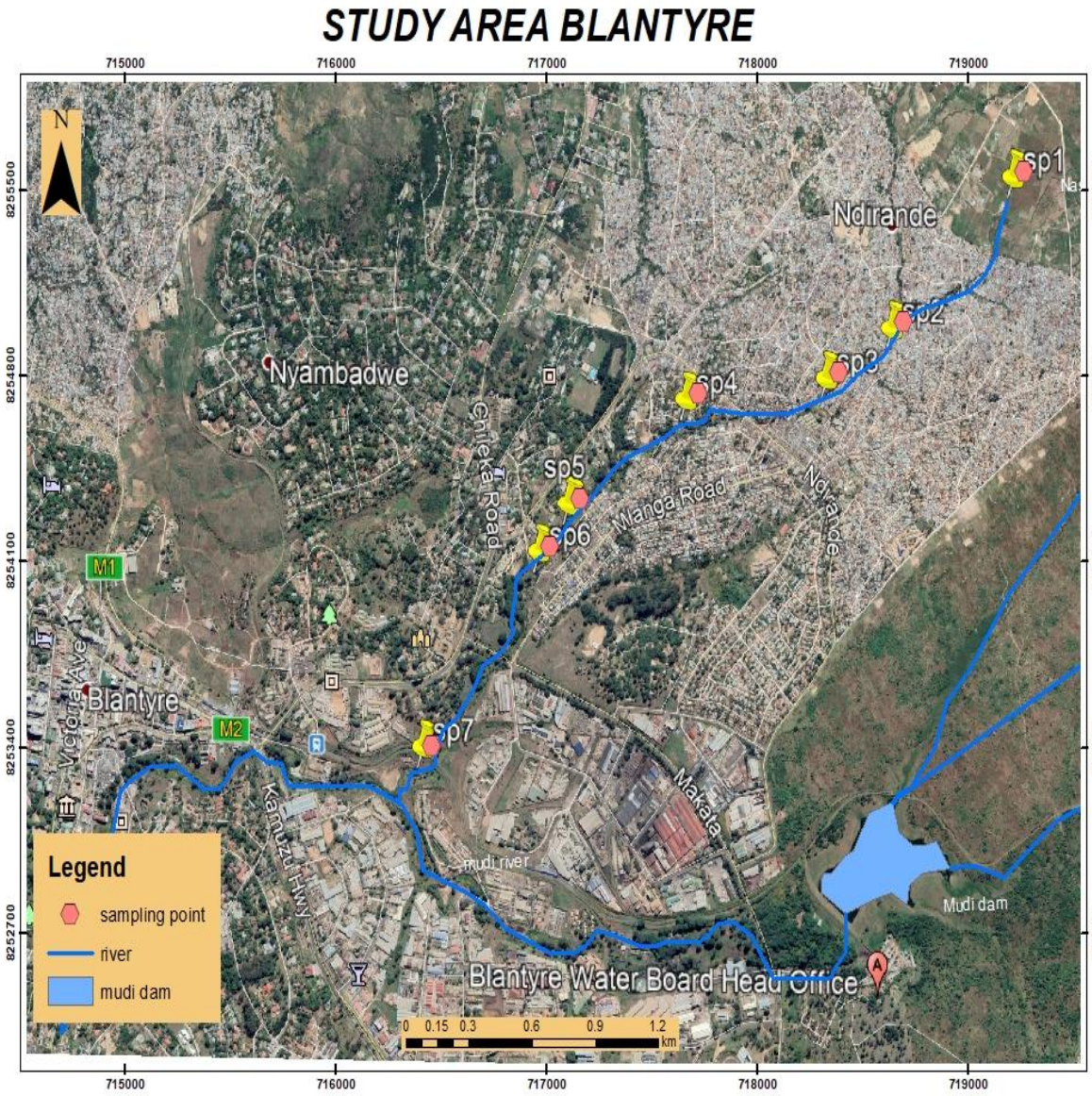


Figure 3: Study map of nasolo river sowing sampling points

Table 3: GPS coordinates for sampling points along Nasolo stream

Sampling point	EASTINGS(m)	NORTHING(m)
Source	719260.53	8255576.28
Ndirande view	718691.61	8255009.36
Chioni bridge	718380.77	8254818.19
Paseli lodge	717716.89	8254737.97
Church area	717154.07	8254737.97
Industrial site	717012.10	8254158.88
Railway houses	716449.90	8253410.32

Table 4: SAMPLING POINTS AND ITS SURROUNDING ACTIVITIES

SAMPLING POINT	SURROUNDING ACTIVITIES
SOURCE	Agricultural activities
NDIRANDE VIEW	Agricultural activities and residential area
CHIONI BRIDGE	Residential area, industrial effluent and dumping site
PASELI LODGE	Carpentry activities, market area, dumping site, and industrial effluent
CHURCH AREA	Agricultural activities, residential area and sand mining
INDUSTIAL AREA	Industrial effluent and dumping site
RAILWAY HOUSES	Farming and residential area

3.2. Study population

The research will have a total of 7 sampling sites, including the river's source, which will be sampled specifically because the nasolo river water is used for a variety of purposes by river residents.

3.3. Sampling and sample sizes

Grab sampling technique will be used to collect samples from the sampling points. Sediment samples was collected with an auger or PVC pipe of 5cm diameter which was pushed with pressure through the water to obtain sediment layer of 30g at a depth of approximately 16cm and was put in plastic bags at a temperature of 4 °C and taken to the laboratory for analysis. The Total Dissolved Solids and the Electron Conductivity was measured on site using the aquameter. Seven sampling points including the control which is the source was selected randomly along the river and sediment samples were collected in triplicates for heavy metal analysis at each sampling point. All this was done by following the use of the current American program health association (APHA) procedures document.

3.4. Sediment Samples Preparation.

21 sediment samples were obtained using a PVC pipe with a diameter of 5 cm that was pushed through the water under pressure to obtain a sediment layer at a depth of approximately 15cm. Some stones were removed, and the sediment samples were packaged in polythene bags and transferred to the lab, where they were dried at 105 oC until no more weight change occurred. Each sampling station's seven dried sediments were combined and homogenized with a pestle and mortar. Prior to digestion and heavy metal assessment, the homogenized samples were sieved and packaged in clean polythene bags.

The digestions of the triplicates were carried out according to the APHA guidelines. Wet digestion of sediments was performed, with less than 1g of dried sediment samples properly weighed using an electronic balance model aeAdAM. 18 mL concentrated HNO3 was added to a conical flask, which was then gradually heated on a hot mantle until dense brown vapors appeared. To remove the dark vapors and boost the nitric acid's dissolving power, hydrogen peroxide was added drop by drop. The sediment digestion was allowed to evaporate to around 5 ml. This was chilled and filtered (with Whatman No 42-filter paper) into a 25 ml clean and dry volumetric flask before being diluted with distilled water to the desired concentration. After that, the digested samples were separated into separate plastic bottles, labeled, and preserved for later analysis. Seven blanks were digested as pre-test samples for background correction, and each blank was tested for Pb, Cu, Fe, Zn, and Cd using an atomic absorption spectrophotometer.

3.5. Measurement of Electron Conductivity and Total dissolved Solids.

Except for pH, all physical parameters were determined on the field using the probe method. A portable Aquameter was used to measure temperature, electrical conductivity (EC), and TDS (Total Dissolved Solids).

3.5.1. pH Analysis

Weighing and transferring 5 g of air dried sediment into test tubes Each test tube was filled with 14 mL of water. After 30 minutes, the combinations were discarded. The pH of the supernatant solution was then measured using a pH meter after they were shaken by hand..

3.6. Contamination Factor (CF)

The contamination factor (CF) which gives an indication of the level of contamination, was computed for the sediments using the concentration of the heavy metals and their corresponding values in the world average shale reported in the World Health Organization which shows a concentration of selected heavy metals which include Cd, Pb, Zn, Fe, Cu, as 0.3, 20, 95, 46700 and 11.2mg/l respectively. The level of contamination of sediment by a metal is often expressed in terms of a contamination factor calculated as follows;
Contamination Factor (CF) = Metal content in the sediment/Background level of metal
Where CF < 1 refers to low contamination, 1 ≥ CF ≥ 3 means moderate contamination, 3 ≥ CF ≥ 6 indicates considerable contamination, and CF > 6 indicates very high contamination.

Table 8 : Contamination factor and level 0f contamination (HAKANSON 1980)

Contamination Factor (Cf) Level of Contamination	Level of Contamination
Cf < 1	Low contamination
1≤ Cf < 3	moderate contamination
3≤ Cf < 6	Considerable contamination
Cf > 6	very high contamination

CHAPTER 4: RESULTS AND DISCUSSION

4.0. Introduction

This chapter presents the findings of physical parameters and heavy metal concentrations in sediments. Discussions of results and comparison with other similar studies are also given in this chapter.

4.2 Physical Parameters

4.2.1. pH

The mean pH levels in the sediments recorded at different study sites showed moderate variations (Table 4). Nasolo river the mean pH was (7.17) and ranged from 6.2 – 8.0.

The recorded mean pH values in all the seven sampling points were within acceptable

range for water used for human (6.5 – 8.5) and livestock consumption (EPA, 1997; 2002). pH measurements indicate the acidity or alkalinity of water. The pH of water is very important because it affects the solubility and availability

of nutrients and their utilization by aquatic organisms. In general terms the pH was within the limits of the standard values (APHA, 1999) and WHO guideline of 6.0 – 8.5 for drinking water quality as shown in the graph below:

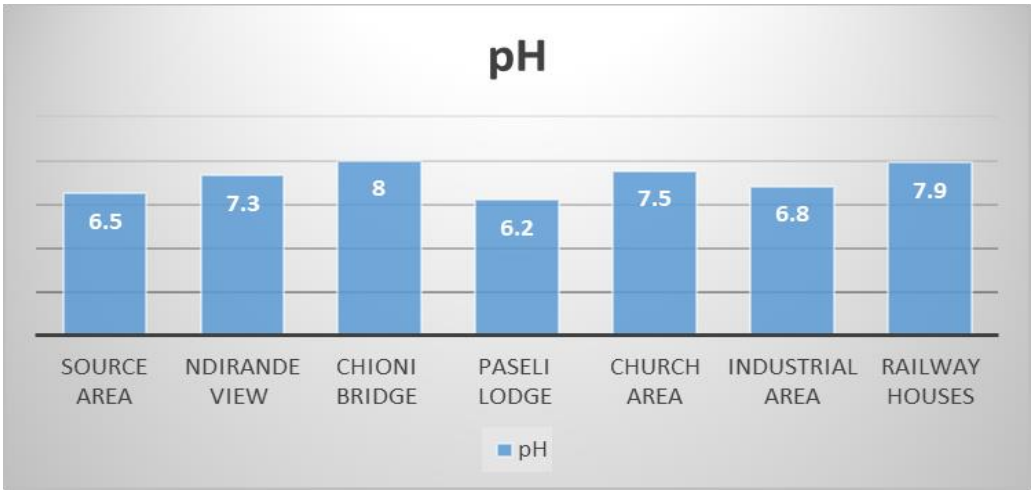


Figure 4: pH graph

The results obtained in this study are relatively similar to other physicochemical

characteristics of water studies carried out in Malawi Blantyre streams. Studies done by T.Mkandawire and others who were looking at the physical chemical and biological water quality in Blantyre shallow wells also revealed a range of Ph from 6.0-8.0.

4.2.2. EC

Conductivity is the measure of capacity of a substance or solution to conduct electric current and is used to determine the total dissolved solids in water. EC is a useful indicator of the mineralization in a water sample. The World Health Organization (WHO) limit for EC for drinking and potable water is 700 μS cm-1 (WHO, 2003). Based on this limit, the Nasolo river water is suitable for domestic use in relation to electrical conductivity recorded in this study. According to studies done by russel chidya and M. Wanda (2016), has pointed out to say health effects in human beings for consuming water with high EC may include disturbances of salt and water balance, adverse effect on certain mycocardic patients and individuals with high blood pressure.

The mean electrical conductivity levels during the study showed modest variations (Table 4.). The mean EC of Nasolo river from all the seven sampling points was (22.92857±9.9535 μS cm-1). The highest EC value was observed at industrial area and railway houses giving a value of (32.7 μS cm-1) and the lowest was at Ndirande view (8.2μS cm-1).

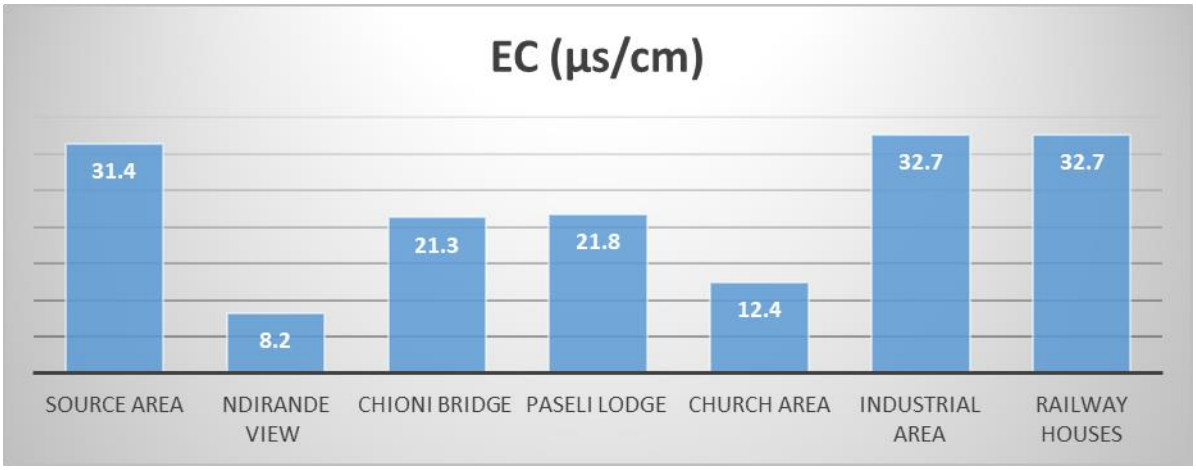


Figure 5: Electron conductivity graph

4.2.3 TDS

Mean TDS levels (mg/l) obtained during the study are shown in Table 4. The TDS levels measured at source was (389), Ndirande view (473), Chioni bridge (487), Paseli lodge (492), church area(491), industrial area(494) and railway houses(485). Generally, there were no wide variations in TDS levels recorded at different sampling points. The lowest TDS level observed was 389mg/l at the source while the highest value was 494mg/l at industrial area. TDS levels were not within thee recommended range of MBS and WHO making the water unfit for consumption.

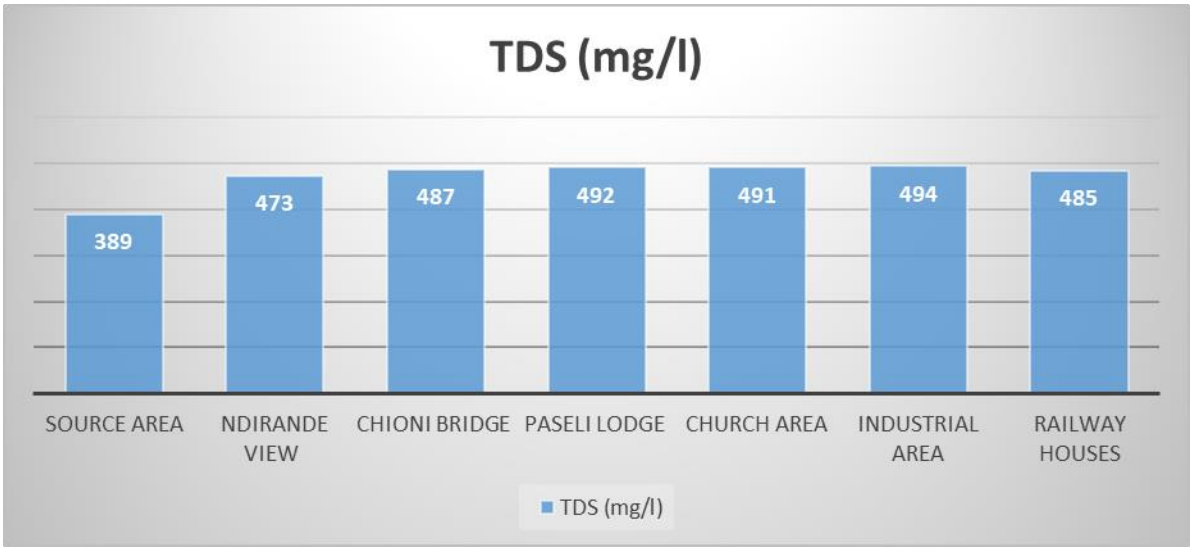


Figure 6: Total dissolved solids

4.3 Heavy Metal Concentrations in Sediments

4.3.1 Copper (Cu) Concentration (mg/l)

The mean Cu concentrations (mg/l) at the seven sampling points showed modest variations (Table 5). The mean Cu concentrations was(0.522857±0.454mg/l) recorded at source (0.10mg/l), ndirande view(0.02mg/l),chioni bridge(0.30mg/l), paseli lodge(0.56mg/l) church area(0.42mg/l), industrial area(1.19mg/l)and railway houses(1.07mg/l).The highest levels of Cu concentrations were recorded at the industrial area(1.19mg/l)

and the lowest at ndirande view (0.02mg/l) during the study. Copper can get into aquatic ecosystems from diverse sources for example, from Cu compounds used in fungicides, algicides, insecticides, wood preservatives, electroplating and azo dye manufacture. Also, from Cu compounds added in fertilizers and animal feeds as a nutrient to support plant and animal growth. The high Cu levels in Nasolo river could be attributed to agricultural and industrial effluent discharge activities in the catchment especially the use fertilizers, fungicides and insecticides. The mean levels of Cu in the study area were below the (WHO, 2011), standard values of 2mg/l and within the range of MBS 0.5-1.0 mg/l for drinking water purposes.

4.3.2 Zinc (Zn) Concentration (mg/l)

The mean Zn concentrations (mg/l) at the seven sampling points showed variations (Table 5). The mean Zn concentrations was (0.61±0.424) recorded at source (0.15mg/l), ndirande view(0.68mg/l),chioni bridge(0.33mg/l), paseli lodge(0.71mg/l) church area(01.43mg/l),

industrial area(0.30mg/l)and railway houses(10.67mg/l). The highest levels of Zn concentrations were recorded at the church area(1.43mg/l) and the lowest at the source (0.15mg/l) during the study. The source of Zn concentrations in sediments to nasolo river could be from Zn Carbonates used as pesticides. The results obtained on mean Zn concentration levels in all the sampling points did not exceed the range of MBS which is 3-5mg/l. However, sediments have the capacity to accumulate more heavy metals with time and remobilize them back to water and the food chain (WHO, 2011).

4.3.3 Lead (Pb) Concentration (mg/l)

The mean Pb concentration levels recorded in sediment in different sampling sites

during the study showed modest variations (Table 5). They ranged from 0.00-0.06mg/l

The mean Pb levels for the sampling sites was (0.034286±0.019), recorded at the source (0.00mg/l), ndirande viw(0.03mg/l), chioni bridge(0.04mg/l), paseli lodge(0.06mg/l), church area(0.05mg/l) industrial area(0.02mg/l) and railway houses(0.04mg/l). The sources of Pb in sediments include industrial wastes and from water pipes. Other likely sources of Pb are lead acid batteries, solder, alloys, cable sheathing, pigments, rust inhibitors, ammunition, glazes and plastic stabilizers (WHO, 2004). The consequences of excess lead in the human body range from low intelligent quotient in children and high blood pressure in adults. In addition lead can produce a damaging effect on the kidney,liver and nervous system, blood vessels and other tissues.

The levels of some Pb concentrations observed in Nasolo river ranges within the MBS standard of 0.01-0.05 and it has also registered a higher value at paseli lodge of 0.06mg/l which is outside the recommended value for WHO and MBS.

4.3.2 Cadmium (Cd) Concentration (mg/l)

At the seven sampling stations, the mean cadmium concentrations (mg/l) exhibited little variance (Table 5). The average Cd concentrations were (0.00640.001718) at the source (0.004mg/l), ndirande view (0.006mg/l), chioni bridge (0.005mg/l), paseli lodge (0.009mg/l), church area (0.008mg/l), industrial area (0.007mg/l), and railway houses (0.006mg/l). During the investigation, the highest Cd amounts were found near the paseli lodge (0.009 mg/l) and the lowest at the source (0.004 mg/l). The incineration of municipal garbage, such as plastics and nickel-cadmium batteries, could be the cause of Cd concentrations in sediments in the Nasolo River. The mean Cd concentration levels in all sampling points were found to be higher above the MBS range of 0.003-0.005 mg/l.

4.3.2 Iron (Fe) Concentration (mg/l)

During the investigation, the mean Fe content levels in sediment at several sampling sites exhibited only minor changes (Table 5). The concentrations ranged from 0.34 to 3.19 mg/l.

The mean Fe levels for the sampling locations were (1.7985711.034), with values of 0.34 mg/l at the source, 0.73 mg/l at Ndirande View, 1.45 mg/l at Chioni Bridge, 2.10 mg/l at Paseli Lodge, 2.00 mg/l at Church Area, 3.19 mg/l at Industrial Area, and 2.78 mg/l at Railway Houses. Rocks containing iron minerals, agricultural goods, and industrial waste disposal are all sources of Cd in sediments. The results obtained were above the recommended set values of MBS of 0.01-0.20mg/l.

The graph below shows the presence of heavy metals in the nasolo river sediments and their abundance and iron is dominating in all the seven sampling points while lead is the least.

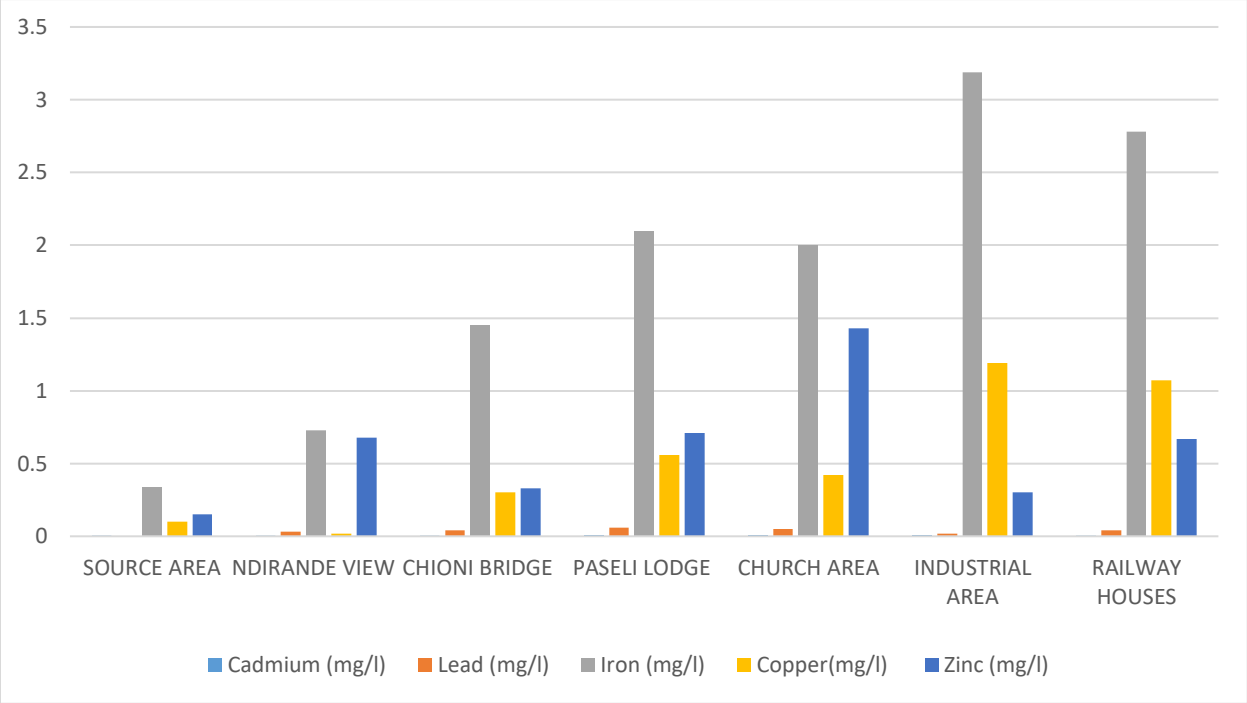


Figure 7: graph of selected heavy metal

4.3.3 Contamination factor results

The table below summarizes the contamination results heavy metals of nasolo river sediments correspondingly.

Table 5 calculated values for contamination factor (CF)

Heavy metal	Contamination factor=metal content /background concentration
Pb	0.0213
Zn	0.0034
Fe	0.0189
Cd	1.1195E-5
Cu	0.0544

Table 6: Mean physical parameters along the Nasolo River water

SAMPLING POINT	pH	EC (μs/cm)	TDS (mg/l)
Source area	6.5	31.4	389
Ndirande view	7.3	8.2	473
Chioni bridge	8.0	21.3	487
Paseli lodge	6.2	21.8	492
Church area	7.5	12.4	491
Industrial area	6.8	32.7	494
Railway houses	7.9	32.7	485
AVERAGE Mean±SD	7.171429 ±0.6921	22.92857 ±9.9535	473 ±37.687

Table 7: Average mean(mg/l) and Standard deviation

Sampling station	Cadmium (mg/l)	Lead (mg/l)	Iron (mg/l)	Copper(mg/l)	Zinc (mg/l)
SOURCE AREA	0.004	0.00	0.34	0.10	0.15
NDIRANDE VIEW	0.006	0.03	0.73	0.02	0.68
CHIONI BRIDGE	0.005	0.04	1.45	0.30	0.33
PASELI LODGE	0.009	0.06	2.10	0.56	0.71
CHURCH AREA	0.008	0.05	2.00	0.42	1.43
INDUSTRIAL AREA	0.007	0.02	3.19	1.19	0.30
RAILWAY HOUSES	0.006	0.04	2.78	1.07	0.67
AVERAGE Mean±SD	0.0064± 0.001718	0.034286 ±0.019	1.798571 ±1.034	0.522857 ±0.454	0.61 ±0.424

Correlation of results

The goal of the correlation analysis was to see or figure out what was going on between the variables. The basic purpose is to see if there is a substantial association between two factors.

Table 8: Correlation of results

	pH	*TDS (mg/l)*	*EC (µs/cm)*	*Pb (mg/l)*	*Fe (mg/l)*	*Cu (mg/l)*	*Zn (mg/l)*	*Cd (mg/l)*
pH	1							
TDS (mg/l)	0.3603	1						
EC (µs/cm)	-0.188	-0.2767	1					
Pb (mg/l)	0.2041	0.778	-0.433	1				
Fe (mg/l)	0.1221	0.7181	0.3993	0.399	1			
Cu(mg/l)	0.0612	0.5046	0.6301	0.1534	0.9532	1		
Zn (mg/l)	0.23	0.4758	-0.619	0.6747	0.19643	-0.028	1	
Cd (mg/l)	-0.296	0.6897	-0.2922	0.7667	0.5592	0.3505	0.6479	1

3.3.4. Conclusion

This chapter has discussed the parameters assessed in this study which includes the physical water parameters (pH,TDS,EC) and the the heavy metals analysed (Cd, Cu, Pb,Fe,Zn), contamination factor has also been calculated and correlation of the assessed results which has shown the relationship between this parameters

Therefore H_0 is rejected because some parameters are not within the range of the set standards of MBS AND WHO and these parameters are Cadmium, Iron and Total Dissolved Solids. H_0 is accepted in some parameters analysed like Ph, EC, Zn,Pb and Fe, which have not shown a great disparity to the set standards

CHAPTER 5: CONCLUSION AND RECOMMENDATION

5.0 Introduction

The study's precise aims was to determine the concentration of heavy metals in the nasolo river sediments in ndirande Blantyre. Site measurements and laboratory experiments were taken as said in the methodology chapter this was carried out to accomplish the research

objectives. The following paragraphs are detailed on the summary of the study with reference to the precise objectives.

5.0.1. Summary of the achieved aims

The thesis was conducted with an aim trying to bridge the literature that is available for heavy metal analysis particulary in river sediments, because these rivers provide water for various domestic uses and are a home of the aquatic organisms.

5.1. Specific objective 1: Find out concentration levels of heavy metal pollutants (Pb,Cu,Fe,Zn,Cd) in nasolo's river sediments. This objective was brought from the hypothesis that the concentration of heavy metals in the nasolo river sediments do not exceeds the set standards by the MBS and WHO.

5.2 Specific objective 2: Find out levels of the physical properties of water in nasolo river (pH,EC,TDS) and determine the effects of various polluting activities on the water of the Nasolo River.

5.3. Specific objective 3: Determine the effects of various polluting activities on the water of the Nasolo River.

5.4. Specific objective 4: To see if there's a link between heavy metal levels in the river sediments and the three physical parameters studied (pH, electrical conductivity, Total dissolved solids).

These objectives have been achieved through the paragraphs and indicated specific objectives in the brackets below:

5.0.2. Physical Parameter

Electrical conductivity and pH were within WHO drinking water requirements, but total dissolved solids were not under acceptable limits stipulated by the Malawi Bureau of Standards and the World Health Organization for drinking water. The high total dissolved solids levels in the water from the Nasolo River have led to the conclusion that it is not fit for home use without previous treatment. The high TDS level in the Nasolo River Catchment Area is a result of poor land use practices and other anthropogenic activities such as unregulated garbage disposal and agricultural operations. In this context Specific objective 2 is addressed.

5. 0.3. Heavy Metal Concentrations Sediments

Cu and Zn levels in the heavy metals tested were lower than the MBS and WHO recommended limits for drinking water, while Pb, Cd, and Fe levels were higher. As a result, it was determined that the water from the Nasolo River is unfit for human consumption. Heavy metal concentrations in sediments that above MBS and WHO guidelines indicate that

nasolo river water has significant levels of residential and garbage disposal, as well as poor agriculture practices in its catchment area. This discourses specific objective 1 and 4.

5.0.4. Contamination Factor

The results obtained for contamination factor has deduced that nasolo river is not highly contaminated. This is the case because all the contamination factor values are less than one this addresses specific objective 3

5.0.5. Management of nasolo river and recommendation

The Nasolo River is one of Blantyre's water sources, particularly for the Ndirande people. The river shares a watershed with the Mudi River and flows into it, where the raw water for Blantrye Water Boards is extracted. It also serves as a source of drinking and irrigation water for residents living along the Nasolo River's full length. Anthropogenic activities appear to be threatening the resource's long-term viability, necessitating effective monitoring and implementation of water resource management rules by the relevant authorities to ensure the Nasolo River's quality. To prevent contamination of this water, district assemblies should boost environmental sanitation education in communities along the river's edge. To minimize contamination of this water supply and subsequent transmission of water-related diseases, district assemblies should boost environmental sanitation education in communities along the bank.

5.0.6. The study limitations

Lack of AAS requirements such as hollow cathodes lamps for other metals such as arsenic and other heavy metals that was supposed to be incorporated in this study.

There were few reagents, which limited the number of heavy metals that could be investigated..

5.0.7. Further Research

Other heavy metals not addressed in this study will be investigated to determine their concentration levels in sediments and water.

It's also worth noting that a sociological study be conducted to determine the level of public awareness about the consequences of contamination from unmanaged waste disposal to users and natural resources in the Nasolo River area.

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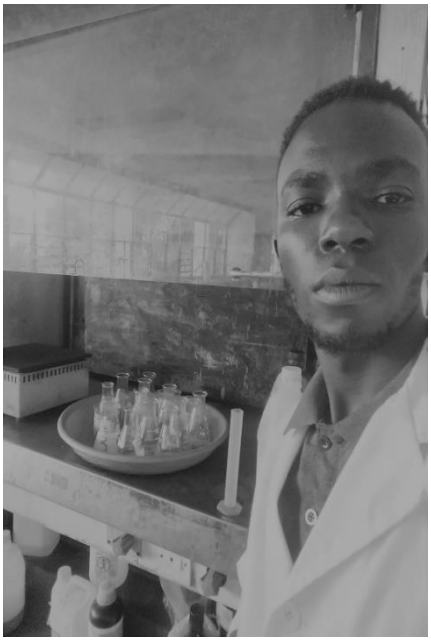
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APPENDICES A



Scienitist in the laboratory



samples ready for metal analysis

APPENDICES B



Domestic water use and waste dumping in Nasolo River.

APPENCICES C





GPS for coordinates taking and an image of toilets proximity to nasolo river