ASSESSMENT ON THE IMPACTS OF INDUSTRIAL EFFLUENTS TO THE WATER RESOURCES IN DAR ES SALAAM TANZANIA

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A DISSERTATION PRESENTED IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE DEGREE OF MASTER OF ARTS IN NATURAL RESOURCES ASSESSMENT AND MANAGEMENT

DEPARTMENT OF GEOGRAPHY

THE OPEN UNIVERSITY OF TANZANIA

2020

CERTIFICATION

The undersigned certifies that she has read and hereby recommends for acceptance by The Open University of Tanzania a dissertation entitled: **"Assessment on the Impacts of Industrial Effluents to the Water Resources in Dar es Salaam Tanzania"** in partial fulfillment of the requirements for the degree of Master of Arts in Natural Resources Assessment and Management of The Open University of Tanzania.

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Prof. Margreth S. Bushesha

(Supervisor)

.....

Date

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DECLARATION

I, **Angela Mwatujobe**, declare that, the work presented in this dissertation is original. It has never been presented to any other University or Institution. Where other people's works have been used, references have been provided. It is in this regard that I declare this work as originally mine. It is hereby presented in partial fulfillment of the requirement for the degree of Master of Arts in Natural Resources Assessment and Management of The Open University of Tanzania.

……..……

Signature

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Date

DEDICATION

I dedicate this work to my mothers' Glenna Nelly Chiligati and Gloria Mary Mwatujobe

ACKNOWLEGMENT

First of all, I thank the Almighty God who gave me strength and ability to complete this research study. During the course of this study and writing of the dissertation, a number of people assisted me in one way or another. It is not possible to mention all of them by names. However, I am deeply indebted to the following:

First and foremost, my heartfelt gratitude goes to Prof. Margreth S. Bushesha for her constructive criticisms and guidance. Her criticism and support were a source of inspiration that gave me courage to accomplish this work. More specifically, I also thank the Open University of Tanzania for providing me with a conducive learning environment. I am also grateful to all those who encouraged me to explore the complexities of industrial wastewater in particular, I acknowledge the valuable comments provided by Dr. Mushy Reguly, Dr. Haule Cosmas and Dr. Wawa Anna of the Open University of Tanzania. My sincere thanks also go to my colleagues in the Department of Geography at the Open University of Tanzania.

My sincere thanks also go to officials in Mikocheni industrial Area in Kinondoni District for their support and cooperation.

Finally, I would like to extend my gratitude to my beloved husband Jensen Mahavile, daughter Jeanelle Divine, sister Beatrice Mwatujobe and other members of my family for their constant support and for always being there for me. God bless them all.

ABSTRACT

The study examined the physical and chemical parameters of wastewater, their impacts to the surrounding community and challenges of wastewater management at Mikocheni industrial area, Dar es Salaam. It employed both quantitative and qualitative methods. 60 questionnaires were collected from respondents and 56 samples were collected from one point that most of wastewater from industries do discharge into. The findings have revealed that the industrial effluents contained physical and chemical parameters. The level of all physical parameters with COD and BOD_5 were not within the permissible limits for TBS standard for Municipal effluent discharge, hence contaminates nearby environmental resources. Further the findings indicated that there were myriads of challenges in wastewater treatment because of the poor effluents management systems of the industries. It was therefore, recommended that, Industries at the study area must have proper wastewater treatment facilities in their premises so as to safely discharge treated wastewater to the receiving bodies. There must be enforcement of rules and regulations by responsible authorities on wastewater discharge such authority as the National Environment Management Council (NEMC). Industrial owners who will fail to adhere to the environmental rules, their licenses need to be revoked, heavy metals should be handled well since their excess in environment may pose health side effects like cancer whereby the number of patients suffering from cancer increases daily also the study recommended that the local environmental committees should be involved in reducing effects of industrial effluents.

Keywords: Physical and chemical parameters, wastewater, wastewater management, Mikocheni industrial area Dar es Salaam

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

LIST OF ABBREVIATIONS

AAS	Atomic Absorption Spectrophotometer
BDL	Below Detectable Limit
BOD	Biological Oxygen Demand
Ca	Calcium
Cd	Cadmium
Cl	Chloride
COD	Chemical Oxygen Demand
Cr	Chromium
Cu	Copper
CW	Constructed Wetland
DAWASA	Dar es Salaam Water and Sewerage Authority
DO	Dissolved Oxygen
EC	Electrical Conductivity
EMA	Environmental Management Act
Fe	Iron
FOG	Fats, Oils and Grease
GEF	Global Environmental Fund
H	Height
KMC	Kinondoni Municipal Council
MBR	Membrane Bioreactor
mg/l	milligram per litre
Na	Sodium
NEMC	National Environment Management Council

NEP	National Environmental Policy
NWP	National Water Policy
Pb	Lead
PO4	Phosphate
Ppm	Particles per million
Qa	Actual Water Discharge
Qt	Theoretical Water Discharge
TBS	Tanzania Bureau of Standards
TDS	Total Dissolved Solids
TSS	Total Suspended Solids
UN	United Nations
UNEP	United Nations Environmental Program
UWSS	Urban Water Supply and Sanitation
WHO	World Health Organization
WSP	Waste Stabilization Pond
WW	Wastewater
Zn	Zinc

CHAPTER ONE

INTRODUCTION

1.1 Chapter Overview

This chapter defines the research problem. It presents the background of the research problem, statement of the research problem, research objectives, research questions, significance of the study and organization of the study.

1.2 Background to the Research Problem

Industrial wastewater management is a global problem. Industries use water in various production activities, such as in the production of goods, cleaning and cooling of machines, which at the end they become waste products. A lot of wastewater from industrial operations is from spills, leaks, products washing and cooling. Worldwide, it is estimated that around 80% of all wastewater is discharged into the world's waterways where it creates health, environmental and climate-related hazards. Industries are responsible for dumping 300-400 million tons of heavy metals, solvents, toxic sludge, and other wastes into waters each year (Wastewater Report, 2018). The total volume of wastewater generated in the US in 1996 was 32,175 million gallons per day. The study done by Visvanathan and Asano (2017) indicates that wastewater discharge into natural watercourses has caused surface and groundwater pollution, leaving water unsafe for potable use and impairing industrial use without major and costly treatment. It has been reported that, the total US water use by industrial sector is over 102 billion liters per day. China generated 57.2 billion tons of wastewater in 2008; municipal and industrial

wastewaters accounted for 58% and 42%, respectively. It is expected that total wastewater will continue growing due to rapid urbanization and industrialization, reaching 79 billion tons by 2020 while having inadequate wastewater treatment infrastructure (Zouboulis & Katsoyiannis, 2018: JLJ, 2010: Scheehle, 1996; Ogedengbe, 1998; Amamath, 1999).

A study done by Deng and Wheatley (2016) shows that in the last 10 years, the extent of wastewater treated in China has increased by 57%, the great amounts of sewage have threatened people's health as well the natural environment. In the last 10 years, the sewage treatment rate has improved, in December 2013, 99.1% of Chinese cities and 82.6% counties have sewage treatment plants. A study by Kayode, Lueth and Rene (2018) indicated that rapid population growth in Nigeria, as well as in many other developing countries, has resulted in an equally rapid increase in urbanization and these are generators of increased domestic and industrial wastewater. In addition to the already prevalent natural scarcity of freshwater in many such regions, the quality of the available water is also quickly deteriorating due to pollution.

Industrial discharges into rivers are one of the causes of irreversible degradation occurring in surface water systems and improper wastewater management has a very direct impact on the biological diversity of aquatic ecosystems and disrupts the integrity of the systems which support a wide range of sectors, from urban development to food production and industry (Kayode, Lueth & Rene, 2018).

On the other hand, the study done by Nasr (2012) in Cairo indicated that huge amounts of wastewater are generated from pasteurized liquid egg production. This kind of industry generates about 9.46 million cubic meters of wastewater per year all over the world, which contains high organic loads associated with egg losses. Untreated egg processing wastewater was discharged directly. All the studies show that there is a problem in industrial wastewater management.

Wastewater generated in developed countries has high levels of toxic substances compared to those generated in developing countries. Unfortunately, the generated industrial wastewater is often discharged without treatment to open watercourses, reducing the quality of larger volumes of water and sometimes infiltrating aquifers and contaminating groundwater resources. In fact, more than 70% of industrial wastes in developing countries are dumped untreated into waters (UN-Water, 2009). The increasing rates of industrial wastewater in developing countries are thought to be much higher than those of developed countries. The state of industrial wastewater generation and management in developing countries in general and Tanzania in particular, is marked by years of poor strategies of getting rid of the impacts of wastewater to the environment and human health (Nafees, Nawab & Shah, 2015).

According to the Tanzania Industrial Competitiveness Report 2012 by United Nations Industrial Development Organization (UNIDO), there has been steady growth of the industrial sector in Tanzania since 2000 after the government implemented economic reforms. Increased industrialization has had both positive impacts on livelihoods while in the same breath negatively impacted the environment

through unregulated release of wastewater (NEMC, 2015). In Tanzania, industries were established without adequate environmental attention. As a result, they have been operating without waste treatment facilities, some for more than 40 years. Some of the industries are located very close to water bodies such as oceans and rivers. The wastes from the industries are disposed of in inland rivers, depressions, pits, or on land. According to the study by Blacksmith Institute (2004 and 2005) these industries have turned the rivers into their effluents disposal points or channels contributing to the rivers' high toxins level. Industrial effluents have been reported to pollute rivers like Msimbazi in Dar es Salaam, Karanga in Moshi, Mwirongo in Mwanza, and Themi in Arusha (Kimati, 2011; TBS, 2005; Palela, 2002; Division of Environment, 1994; 1997 as cited by Mato, 2002). Few industries discharge raw effluents into sewers, which have resulted to malfunctioning of the municipal waste stabilisation ponds (Kayombo *et al*, 1998: Tumbo, 2008).

A number of industries have failed to manage wastewater they generate. There are several factors, which attributes to this problem including lack of national policies, legislation and institutional arrangements for effective and efficient wastewater management. Legislation has been in draft form for many years and Acts are passed without supporting regulations. As a result, there is no compliance and enforcement of wastewater management. In accordance with Lugwisha (2008), this has resulted to unregulated discharge of industrial effluents and significant environmental and public health threats and inadequate knowledge on the international legislation guiding wastewater management. This has contributed to industries rejecting the legislation's objectives and understanding its effects and outcomes. As a coping

strategy, Tanzania regulatory and administrative framework surrounding wastewater management is guided by international conventions, regional treaties, and national environmental policies and strategies cross-cutting and sector based. However, the international wastewater management legislation is not open and familiar to the Tanzanian industries and lacks clarity as it has not been translated into a simple language, including means to realize the objectives and outcomes, such as, how to meet national effluent standards and reduce pollution loads to the environment (Zouboulis & Katsoyiannis, 2018).

Aggravating the situation is the very limited experience on pollution control. Capacity of industries to manage wastewater has been focussing on waste pre-treatment prior to their discharge in the receiving bodies. The majority of industries have very limited experience of pollution control measures or of the institutional and legislative frameworks needed to make such measures effective (WHO/UNEP, 1997), because of inadequate training on waste management among the operators and contractors. The competency requirements are not clearly defined and there is no licensing regime in place, which result in lack of enforcement. Thus, systems are designed without heavy emphasis on enforcement (command and control) and without commensurate capability to effectively implement.

1.3 Statement of the Research Problem

Mikocheni is a home to several industries including food and beverages processing, iron and steel, tissue, paints, storage tanks and soaps making. These industries tend to discharge water through storm water channel that is close to their facilities. Tanzania

Country Environmental Analysis (2019) indicated that, water is often polluted by a variety of substances including toxic substances such as lead, arsenic, cyanide, and cadmium. Mwenda (2014) confirmed that industries at Mikocheni area discharge effluents some containing heavy metals like cadmium, lead, zinc and chromium which have effects on the environment. Several tools and initiatives including environmental auditing, Global Environmental Management Systems and Clean Technology to control industrial effluents have been developed by countries to oversee the management of environment. The National Environmental Management Council (NEMC) and the Environmental Protection Authority/Agency have been trying to control and reduce the effects of industrial effluents in waters resources. Despite the several efforts and strategies done worldwide and locally, industrial effluents have continued to be a serious problem posing negative impacts to environmental resources and escalating human health risks. However, the literature is quite on the impacts of industrial wastes on water resources in the country. This study therefore, was conducted to examine the impact of industrial effluents to the water resources in Tanzania with reference to Mikocheni Industrial Area in Dar es Salaam.

1.4 Research Objectives

1.4.1 General Objective

The general objective of the study was to assess the impacts of industrial effluents to the water resources in Dar es salaam Region.

1.4.2 Specific Objectives

The study intended to achieve the following specific objectives;

i) To examine the parameters of wastewater from Mikocheni industrial area, Dar es Salaam.

ii) To examine the effect of industrial effluents to water source at Mikocheni industrial area, Dar es salaam.

iii) To evaluate the challenges of wastewater management at Mikocheni industrial area, Dar es Salaam.

1.5 Research Questions

The following research questions guided the study;

i) What are the physical and chemical parameters of the wastewater from Mikocheni industrial area, Dar es Salaam?

ii) What are the effect of industrial effluents to the water source close to Mikocheni Industrial area?

iii) What are the challenges of wastewater management at Mikocheni industrial area, Dar es salaam?

1.6 Significance of the Study

It is hoped that this study will contribute to the existing body of knowledge. The study findings will assist responsible institutions in Tanzania to make informed decision on industrial wastewater discharged in the Indian Ocean originated from Mikocheni industrial area, Dar es Salaam. The study will further assist the industries to design desirable wastewater management practices which will minimise negative

impacts to the environment and human health especially one associated with heavy metals. The findings from this research will help policy makers, environmental consultants, environmental regulators, civil society organizations, development partners and other stakeholders to influence change to the industries to manage properly generated wastewater.

Further to that, the National Environmental Policy (1997) provides for use of clean technology, prevention and controlling of degradation of various resources including water which supports life systems, controlling of pollution though having treatment and recycling facilities, conduction of monitoring to such facilities and conduction of environmental impact assessment (EIA) as an essential element in industrial planning and development for taking account of potentially harmful activities on the environment. This study will therefore identify if the requirements of NEP are met and hence provide proper advice so as to meet said requirements and hence protect environment.

1.7 Scope of the Study

The study assessed the impacts of industrial effluents to the water resources in Dar es Salaam Region. Specifically, the study examined the parameters of wastewater from Mikocheni industrial area, Dar es salaam, examined the effect of industrial effluents to water source at Mikocheni industrial area, Dar es salaam and evaluated the challenges of wastewater management at Mikocheni industrial area, Dar es salaam. Data were collected from owners of the industries, industrial workers, environmental

consultants, environmental regulators and the community around the selected industries at Mikocheni industrial area, Dar es Salaam.

1.8 Limitations of the Study

In conducting this study, the researcher was limited by reluctance of some respondents especially the owners of the industries, industrial workers to provide information about the study under investigation also to collect samples from specific industries so as to get an insight of what is really generated from respective industries. However, the researcher managed to collect adequate information as she explained explicitly the aim of the study and assured the respondents on the confidentiality of their information. Moreover, the researcher was limited by not getting respondents on time because during data collection, respondents were busy with their daily activities. To solve this challenge, the researcher communicated with respondents prior to data collection sessions and they agreed on the suitable time for data collection. With regard to the challenge of sample collection from each specific industry the researcher managed to establish and collect samples from one point that almost all industrial effluents are discharged into.

1.9 Organization of the Study

The study is organized into five chapters. The first chapter introduces the study and provides the background and justification for the study, the second chapter reviews the relevant literature that builds the basis for the study. The third chapter presents the methodology that has been used in the study. Chapter four presents the findings and chapter five gives the conclusion and recommendations.

CHAPTER TWO

LITERATURE REVIEW

2.1 Chapter Overview

This chapter involves identifying and critically reading various works related to the research problem under investigation. The chapter includes; conceptual definitions, theoretical and empirical reviews leading to the derivation, research gap and conceptual framework.

2.2 Definition of Key Terms

2.2.1 Industrial Wastewater

Industrial wastewater is the aqueous discard that results from substances having been dissolved or suspended in water, typically during the use of water in an industrial manufacturing process or the cleaning activities that take place along with that process. Industrial wastewaters can have a high toxicity. While in developing countries these are often discharged into natural ecosystems without previous treatment, most developed nations employ water treatment plants using physical, biological, and chemical methods to clean the wastewater (Leonhauser & Birkenbeul, 2014).

2.2.2 Wastewater Management

Wastewater management describes the processes used for treating wastewater that is produced by industries as an undesirable by-product. After treatment, the treated

industrial wastewater (or effluent) may be reused or released to a sanitary sewer or to surface water in the environment (Nasr, 2012).

2.3 Physical and Chemical Parameters of Industrial Wastewater

2.3.1 Industrial Wastewater

Water is an important requirement in many industrial processes, such as, heating, cooling, production, cleaning and rinsing. Overall, some 5–20 per cent of total water usage goes to industry (WWAP, 2009), and industry generates a substantial proportion of total wastewater. If unregulated, industrial wastewater has the potential to be a highly toxic source of pollution. The vast array of complex organic compounds and heavy metals used in modern industrial processes, if released into the environment can cause both human health and environmental disasters. Industry has a corporate responsibility to take action to ensure discharged water is of an acceptable standard, and accept costs of any required clean up. The most cost-effective solutions usually focus on preventing contaminants from ever entering the wastewater stream or developing a closed system of water use (Corcoran *et al.* 2010).

Different industries use different amounts of water depending on the size of an industry and the nature and type of production, thus, generation of wastewater from industries tend to vary from one section to another. Industrial wastewater from different processing activities, usually contain a number of elements which when not well handled can threaten the quality of the endpoint of such generated wastewater. The study by Alturkmani (2006) showed that wastewaters may contain suspended, colloidal and dissolved (mineral and organic) solids. In addition, they may be either

excessively acidic or alkaline and may contain high or low concentrations of colored matter. These wastes may contain inert, organic or toxic materials and possibly pathogenic bacteria.

Furthermore, Alturkmani (2006) reported that several industries discharge heavy metals, but chromium is the most widely used and discharged to the environment from different sources. Many of the pollutants entering aquatic ecosystems such as mercury, lead, pesticides, and band herbicides are very toxic to living organisms. Also, Belay (2010) observed that industrial wastes are generated from different processes and the amount and toxicity of waste released varies with its own specific industrial processes. Tannery effluents are ranked as the highest pollutants among all industrial wastes. They are especially large contributors of chromium pollution. Belay (2010) explained that in India alone about 2000–3000 tons of chromium escapes into the environment annually from tannery industries, with chromium concentrations ranging between 2000 and 5000 mg/l in the aqueous effluent compared to the recommended permissible discharge limits of 2 mg/l.

Wastewater derived from food production has attributes that are very distinct from other industrial activities. In particular, food processing wastewater can be characterized as friendly in that it generally does not contain conventional toxic chemicals such as those listed under EPA's Toxic Release Inventory with a few exceptions, such as phenolics from the processing of some plant materials. However, food processing wastewaters can be subject to bacterial contamination, which represents a special issue for wastewater reuse. More generally, food processing

wastewaters are distinguished by their generally high Biological Oxygen Demand (BOD) concentrations, high levels of dissolved and/or suspended solids [including fats, oils, and grease (FOG)], nutrients such as ammonia and minerals e.g., salts.

2.3.2 Physical Parameter

2.3.2.1 Total Dissolved Solid (TDS)

Total Dissolved Solids (TDS) is a measure of the combined content of all inorganic and organic substances contained in a liquid in a molecular, suspended form. The principal application of TDS is in the study of water quality for wastewater treatment, although TDS is not generally considered a primary pollutant e.g. it is not associated with health effects which is used as an indicator of the presence of chemical contaminants (Harrison, 1992).

2.3.2.2 Colour

Colour in wastewater is due to the presence of decaying of vegetation, organic waste discharge and inorganic (metals ions Fe^{3+}). It is an important indicator of the type and the nature of the effluents in it. The colour of the wastewater is an indication that it contains contaminants of different materials and in varying concentrations. Some of these materials are chemical in nature. In such cases, the metallic ions present in these wastewaters impart different colours (APHA *et al*. 1992).

2.3.2.3 Electrical Conductivity (EC)

Conductivity refers to the measure of the ability of water to pass an electric current through it. All ionisable materials will contribute to conductivity, while materials

such as sugars, oils do not conduct, and thus conductivity is influenced by the presence of inorganic dissolved solids in water solution (Weast, 1978).

2.3.2.4 Total Suspended Solids (TSS)

Solids suspended in water may consist of inorganic or organic particles. Inorganic solids such as clay, silt and other soil constituents are common in running surface water as rivers and streams. Organic material such as plant fibers and biological solids as algal cells and bacteria are also common constituents of surface waters; because of the filtering capacity of the soil, and stagnation as in wells suspended material is a rare constituent of groundwater. Suspended solids are aesthetically displeasing and provide adsorption sites for chemical and biological agents. Suspended organic solids degrade biologically resulting in objectionable by-products of foul odors (Mara *et a.* 1998).

2.3.3 Chemical Parameters

2.3.3.1 The pH

Is the measure of acidity or alkalinity of the solution and it is expressed as a negative common logarithm of hydrogen ions concentration. It is measured by an instrument known as pH –meter. Measurement of pH is the one of the most important and frequently used test is water quality analysis. The pH influences the reaction rate and the equilibrium concentration of many compounds in water, so pH measurement and control is an important component of water purification (John, 1996).

2.3.3.2 Biological Oxygen Demand (BOD)

Biological Oxygen Demand can be defined as the amount of oxygen required by bacteria for decomposition of organic matter under aerobic condition. BOD determination is an empirical test in which laboratory procedures are used to determine the relative oxygen requirements of wastewaters, effluents and polluted waters. The test has its widest application in measuring waste loading to treatment plants and in evaluating the BOD removal efficiency of such treatment systems.

The test measures the oxygen utilized during a specified period for the biochemical degradation of organic material (Carboneous demand) and oxygen used to oxidize inorganic material such as sulphides and ferrous iron. It also may measure the oxygen used to oxidize reduced forms of Nitrogen (Nitrogenous demand) unless their oxidation is prevented by an inhibitor. The primary treatment takes place in the anaerobic pond, which is mainly designed for removing suspended solid and some of the soluble element of organic matter (BOD).

2.3.3.3 Chemical Oxygen Demand (COD)

Chemical Oxygen Demand is used as a measure of the oxygen equivalent to the organic matter content of a sample that is susceptible to oxidation by a strong chemical oxidant. Chemical oxygen demand is widely used in measuring the organic strength of domestic and industrial wastes. COD can be measured using spectrophometric method.

2.3.3.4 Heavy Metals (Lead, Cadmium, Zinc and Chromium)

Heavy metals as soluble ions are common contaminants of industrial wastewaters. Because of their toxicity they are typically removed prior to wastewater discharge. Heavy metals are naturally occurring elements, which under normal conditions are present at low concentrations in water. Weathering of rocks, soils and volcanic eruptions are among the natural sources of heavy metals in the environment. However, nowadays the anthropogenic contributions of heavy metal pollution to water, air and soil far surpass the natural sources. The main anthropogenic sources of heavy metal pollution include: mining, metal smelting, metallurgical industries and other metal-using industries, waste disposal, corrosion of metals in use, agriculture and forestry, fossil fuel combustion and sports and leisure activities (Mkumbo, 2012).

Zinc (Zn): Zinc is a transition metal with the following characteristics: period 4, group IIB, atomic number 30, atomic mass 65.4, density 7.14 g cm^{-3}, melting point 419.5^{o}C, and boiling point 906^{o}C. Zinc occurs naturally in soil (about 70mg kg^{-1} in crustal rocks) but Zn concentrations are rising unnaturally, due to anthropogenic additions. Most Zn is added during industrial activities, such as mining, coal, and waste combustion and steel processing. Many foodstuffs contain certain concentrations of Zn (Davies *et al*. 1988).

Zinc is one of the most common elements in the Earth's crust. It is found in the air, soil, and water and is present in all foods. In its pure elemental (or metallic) form, Zinc is a bluish-white, shiny metal. Powdered Zinc is explosive and may burst into

flames if stored in damp places. Common use for Zinc is to coat steel and iron as well as other metals to prevent rust and corrosion, which is called galvanization. Metallic Zinc is also mixed with other metals to form alloys such as brass and bronze. A Zinc and copper alloy is used to make pennies in the United States. Metallic Zinc is also used to make dry cell batteries (ATSDR, 2005). Elemental Zinc is a lustrous, blue-white to grey metal that is virtually insoluble in water (ATSDR, 1995).

Zinc enters the air, water, and soil as a result of both natural processes and human activities. Most Zinc enters the environment as the result of mining, purification of Zinc, Lead, and Cadmium ores, steel production, coal burning, and burning of wastes. These activities can increase Zinc levels in the atmosphere. Waste streams from Zinc and other metal manufacturing and Zinc chemical industries, domestic waste water, and run-off from soil containing Zinc can discharge Zinc into waterways. The level of Zinc in soil increases mainly from disposal of Zinc wastes from metal manufacturing industries and coal ash from electric utilities. Sludge and fertilizer also contribute to increased levels of Zinc in the soil (ATSDR, 2005).

Major sources of Zinc (Zn): The primary anthropogenic sources of Zinc in the environment are from metal smelters and mining activities (ATSDR, 1995). The production and use of Zinc in brass, bronze, die castings metal, alloys, rubbers, and paints may also lead to its release to the environment through various waste streams. Pure Zinc is usually produced by an electrolytic process in which Zinc oxide is leached from the roasted or calcined ore with sulfuric acid to form Zinc sulfate

solution which is electrolyzed in cells to deposit Zinc on cathodes. The primary application of Zinc in metallurgy is its use as a corrosion protector for iron and other metals (Lewis, 1997). In industries, Zinc is mainly found in paints, galvanization, batteries, smelting, fertilizers and pesticides, fossil fuel combustion, pigment, polymer stabilizers. Wastewater which comes from these industries is mainly polluted with zinc, since it is used in large quantities. One of the consequences is that rivers are depositing zinc-polluted sludge on their banks (WCE, 2012)

Lead (Pb): Lead is one of the heavy metals found in group IV period 6 of the periodic table. Having atomic number 24, atomic mass 52, density 11343Kg/m^3, melting point 327.46^{o}C, boiling point 1749^{o}C and its state at room temperature is Solid state. Lead is naturally present in all soils at low levels and not as a single element but in a combined form such as Pb $(NO_3)^2$, $PbSO_4$, PbS, and $PbCO_3$ when combined with Oxygen. The U.S Environmental Protection Agency established new standards for Lead in soils in 2001. The standards consider Lead to be a hazard to human health if there are greater than 400 ppm of Lead in bare soil in children's play areas or 1200 ppm average lead for bare soil in the rest of the yard. For the case of industries, lead is usually found in lead piping in the water distribution system and can be found in paints (as oxides, carbonates), solder, pool cue chalk (as Carbonate, furthermore, lead is the main ingredient in industries dealing with batteries making.

Generally, Lead is generated from various sources include Smelting, Battery Manufacture, Metal recovery, Crystal glass production, Pigment Manufacture, Ceramic and Paints industries. Organic compounds used in petroleum refining. With

these sources of Lead in Environment, effects that are associated with presence and accumulation of this heavy metal are such as Fatigue, Insomnia, Headache, Loss of appetite, Constipation, with increased exposure, Blue coloration of gum margins, abdominal cramps, weakening of muscles due to disturbance of peripheral nervous system (Rowland and Cooper, 1983).

Chromium: Chromium (Cr) is an environmental pollutant element and ranks seventh in abundance in the earth crust. The major contributors of Cr contamination are the leather tanning, electroplating, and stainless-steel industries (Dheri *et al*., 2007). Many investigations were conducted on phytoremediation of chromium contaminated soils (Mangkoedihardjo *et al.* 2008). Dheri *et al.* (2007), investigated comparative phytoremediation of chromium-contaminated soils by fenugreek, spinach, and raya. These results showed fenugreek, spinach, and raya are affective for phytoremediation of chromium contaminated soil. It is well known that chromium is toxic to human, animals and environment (soil, water, and plants) hence prior to its release, it needs high treatment in order to reduce or avoid such impacts. Hence chromium disposal needs to be well monitored so as to avoid its impacts to both human and environmental at large. To prevent the public health and environmental impact of tannery waste in general and chromium in particular the environmental regulation like effluent discharge limit has to be stringent (Belay, 2010).

Cadmium: Cadmium is a toxic metal occurring naturally in the environment and is considered as a pollutant emanating from industrial and agricultural sources.

Exposure of human population to cadmium from air, food and water may produce effects in organs such as kidney, liver, lung, and cardiovascular, immune and reproductive systems (Flowler, 2009). Cadmium is efficiently retained in the kidney (half-time of 10–30 years) and the concentration is proportional to that in urine (Thompson, 2008). Recent data indicate that adverse health effects of cadmium exposure may occur at lower exposure level than previously anticipated (Jarup, 2009). Exposure to Cadmium can cause a number of harmful health effects. Eating food or drinking water with high levels of Cadmium can severely irritate or bother your stomach and cause vomiting and diarrhea. Breathing high doses of cadmium can irritate and damage the lungs and can cause death (ATSDR, 1989).

Bai (2009) reported that Cadmium is a toxic heavy metal present in wastewaters from a variety of industries. Therefore, it is necessary to remove it before discharge into the environment. Different methods can be used for removing metals, including filtration, chemical precipitation, coagulation, solvent extraction, electrolysis, ion exchange, membrane process and adsorption.

2.4 The Impact of Industrial Effluents to the Surrounding Community

Olajumoke and Oluwagbemiga (2017) postulated that, industrial effluents are basically hazardous and as the name implies pose potential risk to human health and the environment if not properly addressed. Those who own, operate, or help manage industrial facility that deals with wastewater, it’s important to understand how wastewater treatment can play a significant role in the overall health of the industry, environment and the living creatures. This is an important part of the process to

consider, as ignoring it could earn the industry various fines or lawsuits and pose a potential threat to public health (SAMCO, 2016). The goal of wastewater management is to protect and maintain healthy rivers and oceans for the betterment of the surrounding community. Wastewater must be treated prior to discharge to receiving body whether it's to the ocean, river or lake so as to manage water appropriately so that it doesn't causes harm to the environment and living organisms at large by threatening public health, fisheries, wildlife habitat, recreation opportunities and ultimately, our quality of life (Sackey, 2001). In detail this focus on eliminating and/or reducing the harmful effects that may be caused by wastewater so as to attain the balance in water quality between the receiving bodies and the discharged water.

In both developed and developing countries the industrial activities have caused huge amount of untreated wastewater to carelessly release into freshwater streams. In Gulf regions, 80% of industrial effluents were directly discharged into rivers through various media (Islam *et al*., 2012). Similar observations were made in Nigeria and other developing countries. As there is an increase in industrial activities, the pollution stress was developed on the water bodies and resultant environmental and health problems rose in great extent. In many African states, there is a rapid increase in population, urbanization and industrialization which has altered aquatic diversity due to discharge of pollutant to water bodies (Rahib *et al*. 2013).

In the eastern African region, it is estimated that only 10% of the existing industries treat their wastewaters to any degree. Most of the agro-processing industries

discharge their industrial effluent without any form of treatment directly into immediate water bodies and open land. This discharge is affecting the health of the downstream communities not mentioning the threat to aquatic life in the region.

The uncontrolled disposal to the environment of municipal, industrial and agricultural liquid, solid, and gaseous wastes constitutes one of the most serious threats to the sustainability of human civilization by contaminating the water, land, and air and by contributing to global warming. With increasing population and economic growth, treatment and safe disposal of wastewater is essential to preserve public health and reduce intolerable levels of environmental degradation. In addition, adequate wastewater management is also required for preventing contamination of water bodies for the purpose of preserving the sources of clean water (Olajumoke and Oluwagbemiga, 2017).

2.4.1 Policies and Institutional Set Up for Waste Water Management

The Tanzanian political commitment for addressing management wastewater problems is expressed through the existence of respective policy and legal frameworks. Both the Environmental Management Act (EMA), 2004 and the Public Health Act, 2009 and the related regulation are used as enforcement tools to provide the mechanisms of removing the burden from the public. Urban Water and Sanitation Authorities are responsible for the collection, conveyance and treatment of waste water. More specifically, EMA, 2004 section 110, provides prohibition to discharge hazardous substances, chemicals, materials, oil etc into any waters or any other segment of the environment, also section 144 provide standards for effluents

discharge into water, furthermore, section 37 and 38 of the Public Health Act provides prohibition of pollution of water bodies and prohibition to dump waste respectively.

A person who violates guidelines or standards made by a local government authority on collection, transportation and disposal of sewage and sludge commits an offence and shall be liable on conviction to a fine not exceeding five million shillings or to imprisonment for a term not exceeding two years or to both (Env. Management Regulation, 2007). Also, in Environmental Management Act 2004, it states that "Every person living in Tanzania shall have a right to clean, safe and healthy environment". Part II section (5) sub.(2f) of EMA 2004 it direct the polluter to provide compensation for any victim of harm or omission and the cost of beneficial uses lost as a result of an activity that has caused harm to human health or the environment. The prescribe requirements for the operator of any plant (industry) or undertaking to undertake such works as it considers necessary for the treatment of effluent before it is finally discharged into water bodies (EMA 2004; section 144(c)).

On the other side, there are policies that provide details on the management of wastewater, this includes National Water Policy (2002), and it explains more on strategies of Water and wastewater management. Most existing industries were established without wastewater treatment facilities. In some instances, industrial wastewater contains toxic substances or biological process inhibitors. Industries shall establish pre-treatment facilities to treat their wastewater before discharging into public sewerage system. Urban Water Supply and Sanitation (UWSS) entities shall

conduct own regular chemical and bacteriological tests of the raw sewage to control toxic and offensive substances from being discharged into the treatment plants. Industries shall be required to use environmentally friendly raw materials with less toxic elements and adopt cleaner production technology (NWP, 2002). Also, National Environmental Standards Compendium (TZS 343:1989) industrial effluents can cause environmental pollution when they are not treated properly prior to exposure. Some of these effluents are toxic and can endanger directly the lives of people.

Institutionally, wastewater management is directly linked and regulated by Urban Water and Sanitation Authorities, which are responsible for the collection, conveyance and treatment of waste water. On the other hand, the Vice President's Office – Division of Environment, National Environment Management Council, Ministry of Health and Social Welfare and Prime Minister's Office – Regional Administration and Local Government are responsible for the formulation and enforcement of legislations and guidelines. These institutions provide guidelines but implementation of those guidelines has become a challenge hence poor management of wastewater from the main generators of such wastewater.

2.4.2 Industrial Wastewater Treatment Technologies

2.4.2.1 Wastewater Stabilization Ponds

This method is the most often used in the treatment of wastewater worldwide. In Tanzania and Dar es Salaam in particular this technology is also in use. They may be designed to be anaerobic, aerobic or facultative. Stabilization ponds provide

secondary biological treatment and are the most commonly used wastewater pond. Stabilization ponds are normally preceded by some form of primary treatment such as a primary clarifier to reduce the solids entering the pond. Normally, the required multiple ponds in series should have a detention times of 30 days plus. Average depths are three to five feet deep. All ponds must be constructed with impervious material such as clay or an artificial liner to prevent contamination of groundwater and surface water sources in the area.Dar es Salaam City has WSPs such as Vingunguti, Mabibo, University of Dar es Salaam and Mikocheni. All these receive WW from various activities including industries. The study by Mwakaboko *et al*. (2014) provides a proof of heavy metals such as Lead, Copper, Iron and Chromium contents in WW and sludge in the selected WSPs of Mabibo, Mikocheni, Vungunguti and UDSM.

2.4.2.2 Constructed Wetland

Constructed Wetlands (CW) is another option for wastewater treatment and it is used worldwide. This technology has helped to reduce the load that natural wetlands were carrying however they are still in use to treat wastewater though currently, CW is becoming more popular and effective for wastewater treatment.

Constructed wetland treatment systems are engineered systems that have been designed and constructed to utilize the natural process involving wetland vegetation, soil and their associated microbial assemblages to assist in treating wastewater. They are designed to imitate the same processes that occur in natural wetlands (Mayo *et al.* 2011).

Constructed wetlands can be built with a much greater degree of control, thus allowing the establishment of experimental treatment facilities with a well-defined composition of substrate, type of vegetation and flow pattern. In addition, constructed wetlands offer several additional advantages compared to natural wetlands, including site selection, flexibility in sizing and most importantly, control over the hydraulic pathways and retention time. The pollution in such systems is removed through a combination of physical, chemical and biological processes including sedimentation, precipitation, adsorption by soil particles, assimilation by plant tissue, and microbial transformation (Mayo *et al.* 2011). The study by Mashauri et al. (1999) has shown that, CW at University of Dar es Salaam has shown effectiveness in WW treatment for biological parameters rather than chemical parameters. Further, the study shown that, such CW has been placed to treat WW coming from the WSP located at the place (UDSM).

2.4.2.3 Fly ash and Cement Fixation

Fly ash and cement fixation is another process that helps in the reduction of heavy metals from industrial wastewater. A study by Weng and Huang (1994) has shown its effectiveness. Results show that the fly ash can be an effective metal adsorbent, at least for Zn (II) and Cd (II) in dilute industrial wastewaters. Fly ash adsorption capacities for Zn (II) and Cd (II) were 0.27 mg/g and 0.05 mg/g, respectively. A mortar specimen prepared with 10% metal-laden fly ash showed a 56-day strength, about the same or even greater than that of cement alone. Leachates from the fixed metal-laden fly ash, obtained by using both the ASTM and U.S. Environmental Protection Agency-extraction procedure (USEPA-EP) leaching tests, exhibit metal

concentrations lower than the drinking water standards. Compressive strength and leaching test results suggest that metal-laden fly ash can be considered for use in secondary construction materials.

2.4.2.4 Membrane Bioreactor

Membrane bioreactor (MBR) technology has been extensively employed for various industrial wastewater treatments due to its distinct advantages over conventional technologies. To provide present state and development trends of MBR technology used for industrial wastewater treatments. They present an overview of the most recent development of MBR technology for treatment of industrial wastewaters e.g., food processing, pulp and paper, textile, tannery, landfill leachate, pharmaceutical, oily and petrochemical wastewaters. Moreover, they discuss the operational characteristics, fouling characteristics, fouling control strategies, and costs of MBRs in industrial wastewater treatments. Based on the present information on MBR technology, the authors discuss further research aspects of MBRs in industrial wastewater treatments (Lin *et al*. 2011).

2.4.2.5 Global Industrial Wastewater Management

Industrial wastewater generation and management globally is increased with an increase in development. Volume of wastewater produced by industry and discharged directly remains difficult to access. Some countries do not have any data, some use different models, others perform occasional surveys (Sabic, 2005: EPA, 2018).

2.4.2.6 Industrial Wastewater Management in Tanzania

Studies in the country shows the fact that only few studies on industrial pollution have been done, it is important that more studies should be carried out to generate both baseline information as well as to follow trends on the impact of these wastes on the water quality. The majority of the studies carried out so far looked at pollution loads *per se* and noticeably few have examined the impact of pollutants on the natural or social environments. Some of these studies are mentioned here. The first one was conducted in Tanga where Munisi (1998) investigated the effects of waste discharges from a fertiliser factory on intertidal floral communities. Other studies were carried out in the waters fronting the Stone Town of Zanzibar where Bjork*et al* (1995) observed a reduction in coralline algae caused by sewage pollution from the municipality.

Johnstone and Suleiman (1998) reported increased community metabolism and gross production in the same area which they attributed to excess loading of nutrients through sewage discharge from the municipality. Machiwa (1999) examined the effects of sewage dumping on the levels and rate of mineralisation of organic carbon in sediments of a partly polluted mangrove stand in Maruhubi in Zanzibar. Kangwe (1999) studied the effects of mercury, lead and cadmium on calcification rates of the reefs building calcareous algae *Amphipora tribulis*. Other studies include that which looked at the impact of pollution on plankton biomass and composition at Kunduchi and the harbour area of Dar es Salaam (Lugenda, 1998) and port development in Tanzania and their impacts on marine environment (Shanmungam, 1981). Bryceson (1982) assessed the impact of effluent (domestic, industrial) disposal on the ecology

of Dar es Salaam coastal habitats. Chande (1994) identified and assessed the magnitude of activities that had an impact on the marine environment. Shunula and Ngoile (1989) assessed the consequences of human activities on the marine environment of Zanzibar.

2.5 Challenges of Industrial Waste Management

Water pollution due to industrial discharges is becoming a serious restrictive factor for sustainable development of any society. On weak economies of numerous transitions or other developing countries, water quality management is one of the heaviest burdens. Lack of basic data in planning and designing of wastewater systems and treatment mechanisms is a major challenge facing industrial wastewater management. Usually the main source data for planning are unrealistic and are based on theoretical calculations. Measured parameters of quantity and quality of wastewater are used in very few situations. Lack of practical experience is another challenge, visible in beginner mistakes with wastewater flow, pumping, inlet and outlet hydraulics, detention time, aeration and sludge treatment. Lack of knowledge is reflected in frequent copying of foreign solutions and old projects, without taking in account local situations and other important influences may hinder industrial wastewater management. Poor environmental policies and support from the environmental regulators and consultants may also affect the management of wastewater from industries (McIntosh & Pontius, 2017).

Conception of sewer system Construction of the sewers in the past was mainly purposed for as faster as possible drainage of all present waters to the nearest

recipient. With necessity of treating wastewaters this approach is completely changed. Low quality of sewer system is another challenge. The quality of the constructed sewers is very different from place to place, and also dependent as the time when it was constructed. Frequently the channels are not water-tight, and drainage of underground or storm water is a common problem. Poor maintenance of sewer system due to inferior economic situation in most of the industries is another big challenge to most of the industries (EPA, 2018).

2.6 Research Gap

In Dar es Salaam, Kondoro (1997) assessed heavy metal (Pb, Cd, Zn, Cu, Cr) distribution along Msimbazi River. Mwandya (1996) determined the concentrations of heavy metals Pb and Cd in the soft tissues of *Saccostrea cucullata* in Ocean Road beach and Msimbazi Creek. Other studies include that of Wekwe *et al* (1989) who assessed heavy metal content of several species of algae along the coast of Dar es Salaam. Heavy metal pollution was also studied by Machiwa (1992) who assessed anthropogenic input of Fe, Mn, Zn, Pb, Cr, Cd and organic carbon in Dar es Salaam coastal sediments. Machiwa (1992) also investigated the possibility of the occurrence of toxic materials (PCBs) and organic carbon and pathogenic microbes in the marine sediments off Dar es Salaam. In other studies, Lyantagaye (1996) invested the distribution of dissolved inorganic nutrients and dissolved oxygen in Mzinga Creek and Ocean Road coastal waters while Mamboya (1996) investigated.

2.7 Theories/ Models Related to the Study

This study was guided by waste management theory and deterministic theory of cause-effect relationships.

2.7.1 Waste Management Theory

Waste management theory is founded on the expectation that waste management is to prevent waste causing harm to human health and the environment. According to Hai, Yamamoto and Lee (2018), the practical values of waste management theory thus are giving answers to conceptual questions by explaining waste and concepts, providing a guide for choosing waste management options, providing a foundation for how and when to select and integrate waste management options, predicting the outcomes of the use of waste management actions, aiding legislation in how to prescribe activity for/upon waste.

McIntosh and Pontius (2017) revealed that when material is assigned the label of waste, it will be treated as such; consequently, despite its explicit wish of waste prevention, implicitly, legislation essentially amasses waste. The implication of the waste management theory is that industrial effluents are basically hazardous and as the name implies pose potential risk to human health and the environment if not properly addressed. In the context of this study, this theory was useful in examining the parameters of wastewater, examining the effect of industrial effluents to water source and evaluating the challenges of wastewater management at Mikocheni industrial area, Dar es salaam. Therefore, through this theory, the researcher achieved the main objective of the study.

2.7.2 The Deterministic Theory of Cause-Effect Relationships

The deterministic theory of cause-effect relationships states that knowing the cause – effect relationship is essential in decision making. Through this theory, people are able to quantify a specific water quality problem and thereby support rational management decisions. This can be done at different levels of complexity such as; first, loadings, these are preliminary decisions that can be taken with respect to reduction of loadings from a ranking of the size of actual pollution loadings to a particular receiving water body. The rationale is to assess where the greatest reduction in pollution can be obtained in relation to the costs involved (Mutamim, et al, 2012).

Second, mass balances whereby mass balances can be established using load estimates from pollution sources in combination with the water flow or residence time in the water body. The significance of the different loadings can be evaluated by comparing their magnitude to their contribution to the resulting concentration of the pollutant in the receiving waters. The significance of the different loadings for the pollution level of the receiving water body provides the rational basis for decisions on effective reduction of the pollution level in those waters. (Mutamim, et al, 2012). This theory was relevant to the study since it helped the researcher to understand how industrial waste water affects water sources at Mikocheni industrial area, Dar es salaam. Therefore, through this theory, the researcher achieved the main objective of the study.

2.8 Conceptual Framework

A conceptual framework is a structure which the researcher believes can best explain the natural progression of the phenomenon to be studied (Camp, 2001). In the figure below, industrial effluents is an independent variable; water resources is a dependent variable. In this case, water resources' quality depends on the presence or absence of industries. Thus, when industries are present, they discharge untreated effluents into water sources hence alter the quality of water. On the other hand, the absence of industries and their effluents at a certain place, will assure safety of water resources. For this case, presence of industries Mikocheni may lead to alteration of water quality though discharge of untreated effluents.

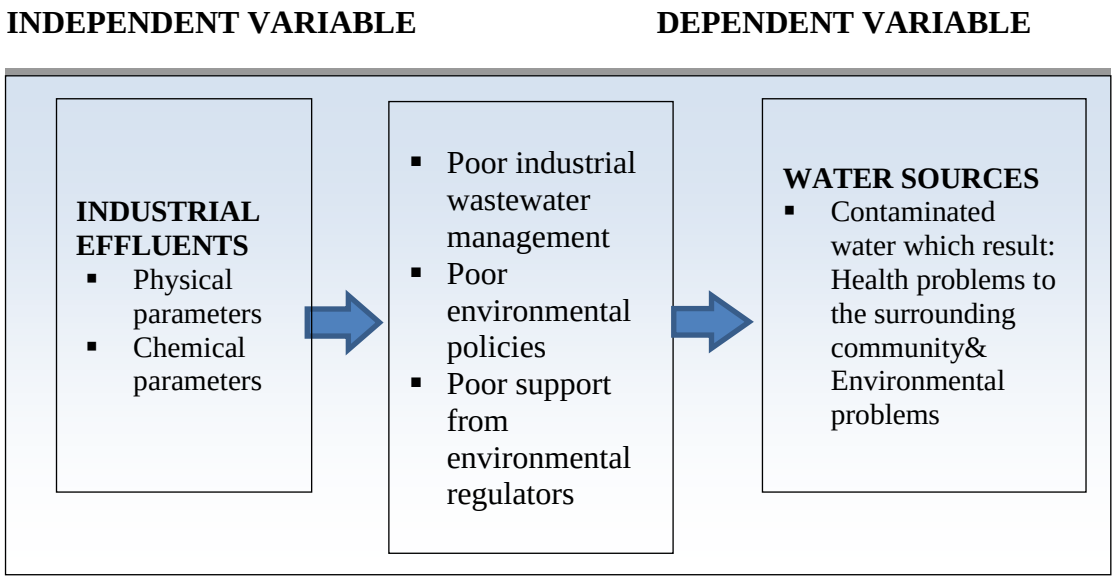

Figure 2.1: Conceptual framework

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Chapter Overview

This chapter provides the description of the research methodology which includes; description of the study area, research approach, research design, variables and measurement procedures, methods of data collection, data processing and analysis as well as ethical consideration.

3.2 Research Design

This study used the embedded experimental design. Embedded experimental design is a mixed method design which one data set provides a supportive secondary role in a study based primarily on the other data type (Kothari, 2004). The premises of this design are that single data set is not sufficient, that different questions need to be answered and that each type of question require different type of data. Embedded mixed method research are suitable in cases where single research components may not be sufficient to answer all research questions. This research design was appropriate because the researcher needed to embed a qualitative component within quantitative design as a case of experimental design. Therefore, the design helped the researcher to achieve the main objective of the study.

3.3 Description of the Study Area

The study was conducted in Mikocheni industrial area in Kinondoni Municipality, Dar es Salaam city (Map 3.1). The major industrial, commercial and administrative

centre of Tanzania making it the largest city, which hosts about 10% of the national population and contributes more than 70% of the Tanzania's Gross Domestic Product (GDP) (Census, 2012). The city is made-up of five municipalities of Kinondoni, Temeke, Kigamboni, Ubungo and Ilala (UN-HABITAT, 2009).

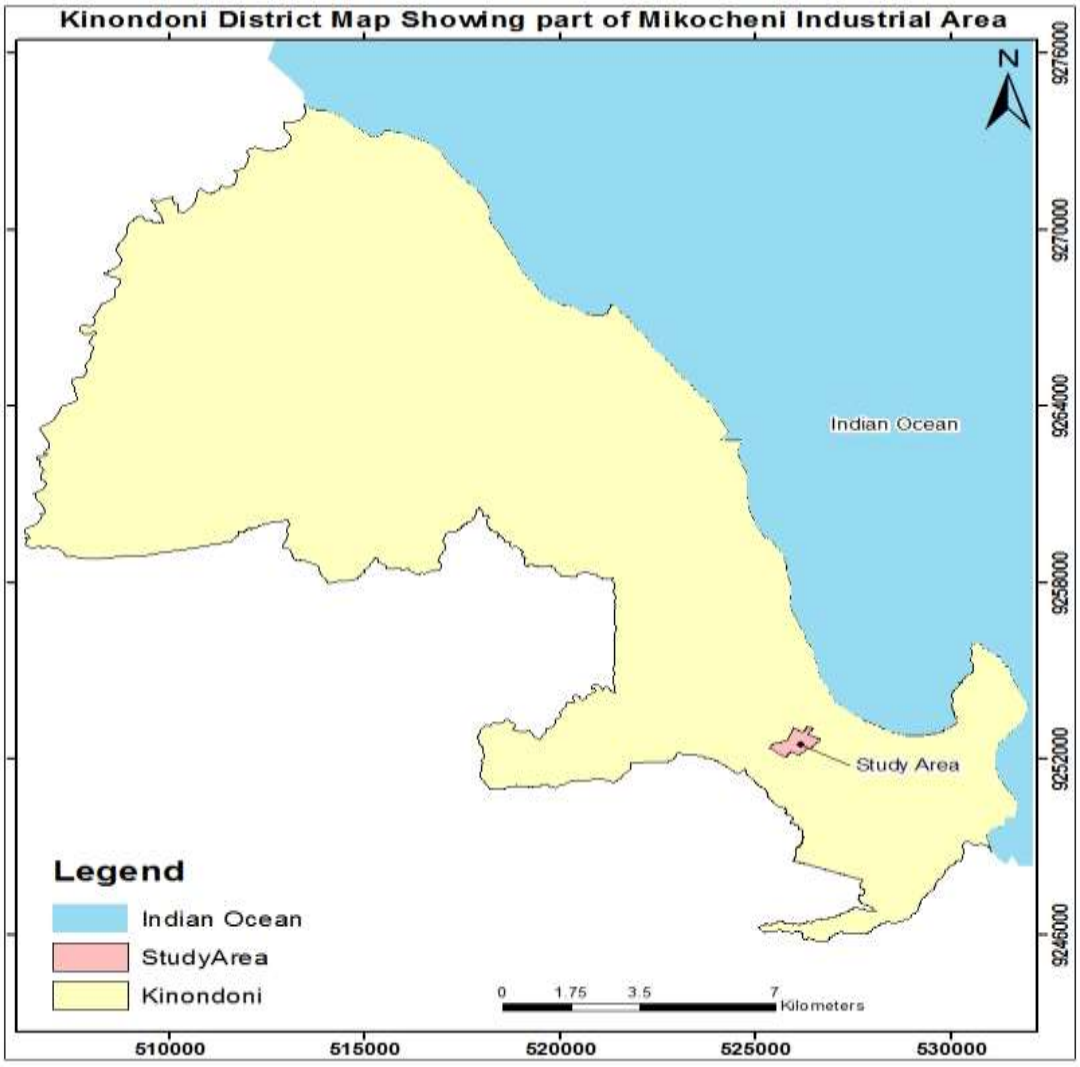

Figure 3.1: Dar es Salaam map showing the study area (Mikocheni Industrial Area)

Geographically, Kinondoni Municipality borders the Indian Ocean to the north-east, Ilala and Ubungo districts to the south, Ubungo, Bagamoyo and Kibaha districts to the west. The municipality covers about 531 km^2. As per 2012 Population and

Housing Census, Kinondoni is the most populated municipality/district in Tanzania. It has population of about 2,497,940 people with an annual growth rate of 4.3% per year (NBS, 2012). About 80% of the industries in the country are located in Dar es Salaam City, thus the city is perceived to experience numerous environmental challenges with special emphasis on effluents management from industrial agglomeration as compared to other regions.

Mikocheni was purposively chosen because it is a home of several industries including Kiboko Cold Galvanizing, Kiboko Precoated Sheets Limited, Shelys Pharmaceuticals Limited, Iron and Steel Co. Ltd, Tanpack, MMI Steel Mills Limited, Body Care Limited, East Africa Beverages Limited-Hakuna Matata Company. These industries manufacture different products (drugs/medicines, house paints, soft drinks, iron and steel, tissues, soaps, cooking oils), thus there is effluent diversity and associated management strategies. Therefore, the researcher believed that the area could provide all the necessary information about the impacts of industrial effluents.

3.4 Research Approach

Research approach is the plan showing a strategy of investigation aimed at obtaining relevant data that fulfills the research objectives and provision of answers to research questions. It is the framework within which the study is conceptualized in terms of theory, sampling, data collection techniques and the administration of data collection tools. This study employed the mixed research approach both quantitative and qualitative research approach. Quantitative approach is based on the measurement of quantity and amount. Quantitative approach is the mathematical method of

measuring and describing the observation of materials or characteristics (Kothari, 2004). Therefore, quantitative approach was used in this study because it enabled the researcher to collect numerical data from respondents regarding the wastewater management strategies in Mikocheni Industrial area. The collected data were quantitatively recorded.

Qualitative research approach in the other hand is a design which is flexible and it captures experiences of participants in their natural settings.

The qualitative research approach has its own characteristics: First, it is flexible to enable the researcher to consider the surprising of the field. Second, it is the approach which requires the researcher to collect information and present participant's own experience and not researchers perceptions, ideas, understanding and value judgments. Third, it is holistic, that it seeks to answer questions like; when, who, why, what and by who. Lastly, the design emphasizes the in depth study of phenomenon. Thus, it requires researchers to go down into mental modules of their participants (Patton, 2002).

The qualitative research approach was adopted due to its characteristics because the study intended to capture the respondent's experience on the the impact of industrial effluents to the water resources in Mikocheni Industrial area. Therefore, the mixed approach was suitable in this study as it ensured the provision of all necessary information about the topic under investigation.

3.5 Focus Population

Phrasisombath (2009) defines population of the study as the population to which a researcher wants to generalize the results of the study. Population involves a larger group of people, institution or thing that has one or more characteristics in common on which a study focuses. It consists of all cases of individuals or elements that fit a certain specification (Kothari 2004). The target population for this study included the owners of the industries, industrial workers, environmental consultants, environmental regulators and the community around the selected industries.

3.6 Sampling Design and Procedures

According to Sigh (2018) sampling helps a lot in research. It is one of the most important factors which determines the accuracy of the study. Sampling involves the selection of a number of study units from a defined study population. A researcher should take as big sample as possible. With a big sample, the researcher is confident that if another sample of the same size were selected, findings from the two samples would be similar to a high degree (Valenzuela & Shrivastava, 2011). The sample size for this study was 60 respondents where by 8 respondents were purposely taken due to their knowledge on the subject matter, of which 4 were industrial owners or their representatives, 2 environmental consultants, 2 environmental regulators, 40 industrial workers (operators, casual laborers, technician & engineers) from a total of 409 workers, 12 the community members from 122 households leaving close to the industrial area. The researcher believed that this number could provide enough information about the wastewater impacts in Mikocheni Industrial area. The researcher believed that this number could provide information about wastewater

impacts in Mikocheni Industrial area. With regard to effluents samples, a total of 56 samples were collected at a one point along a main drain where all industries discharge their effluents which later it joins Mlalakuwa river. The samples were collected for seven days, each day had eight samples and there established a three hours difference from one sample collection time to another hence 56 samples. The difference in hours for sample collection was selected to accommodate number of working and production shifts in industries. Preliminary study was conducted to identify operations of industries so as for a base for sample collection. A V-Notch weir (plate 3.1) was constructed at the main drain to allow proper sample collection.

Plate 3.1: Sample collection station

3.7 Sampling Techniques

In this study, purposive sampling techniques was used to select potential and information-rich cases individuals. It allowed the researcher to use cases that have the required information with respect to the objectives of the study (Sigh, 2018). It

was used to select the industrial owners or their representatives, environmental consultants, environmental regulators, industrial workers (technician & engineers) and the community around the selected industries. The researcher also collected the material samples at the main drain joint channel where effluents of all selected industries discharge for laboratory test so as to examine physical and chemical parameters of wastewater.

3.8 Wastewater Samples

Material samples were collected in the plastic bottles of different sizes ranging from 0.5 to 1.5 liters in order to serve for the kind of analysis needed for each sample. Samples were stored in a cool box from the site to the laboratory. Upon arrival in the laboratory the samples were preserved using concentrated H_2SO_4 (2ml per one liter of the sample) and were stored in the refrigerator while awaiting for analysis. The wastewater analysis included both physical and chemical parameters. The physical parameters included pH, alkalinity, color, electrical conductivity (EC), total suspended solids (TSS), and total dissolved solids (TDS). The chemical parameters that was analyzed included Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD) and heavy metals especially the Lead, Cadmium, Zinc and Chromium.

3.9 Variables and Measurement Procedures

Blerkom (2009), defined the term variable as a measurable characteristic that assumes different values among the subject. Variables may be either independent or dependent. This study had two variable, industrial effluents as independent variable

and water sources as dependent variable. Validity in the other hand refers to whether or not the test measures what it claims to measure. The validity of the instruments for data collection was done through expert review and pilot testing. Pilot study was done and correction or adjustments were made accordingly in relation to the topic under study. The results of the pilot study were not included in the final research findings. Reliability, on the other hand, is the degree or extent to which a test is consistent and stable in measuring whatever it is measuring. Reliability requires the administration of the same test to the same respondents twice with a short time interval after the first test. For the data collection tools, a correlation coefficient between the two sets of results were calculated. Only a reliability coefficient of 0.6 or 0.7 and above were accepted. The V notch weir was calibrated in order to get the value of coefficient of discharge, C_d which helped to determine the actual industrial wastewater discharged through the channel. The C_d was determined in accordance with equation (1);

$$Coeffientof\ discharge\ (C_d) = \frac{Actual\ discharge\ (Q_a)}{Theoretical\ discharge\ (Q_{th})} \qquad eq\ (1)$$

To obtain the actual discharge (Q_a), a fixed volume (V) of wastewater (10*l*) were collected over a period of time (t) using a 10l bucket. The time (t) to fill the bucket were recorded from a stop watch. The actual discharge of wastewater were from equation (2)

$$\frac{V}{t} \qquad eq\ (2)$$

The Theoretical discharge (Q_{th}) of wastewater was obtained from application of Bernoulli's Principle and wascalculated from equation (3)

$$Q_{th} = \frac{8}{15\sqrt{2g(H_t - H_O)}^{5/2} \tan\left(\frac{\theta}{2}\right)} \qquad eq(3)$$

Where Height (H_0) = 44.96m, Volume (V) = 15 litres, Angle θ= 60^0g= 9.81m/s^2

The discharge (Q) is the volume of water moving down a stream or river per unit of time; it is usually expressed in cubic meters per second (m^3/sec). Discharge is given by the following formula;

$$Q=C_d . Q_{th} \qquad \text{eq (iv)}$$

Table 3.1: Methods used for parameters examination

S/N	Parameters	Method to be used
1.	Temperature	In situ Temperature measurement
2.	Total Suspended Solid (TSS)	Gravimetric method
3	Electrical Conductivity (EC)	In situ Direct EC measurement using EC meter
4	Measure of Alkalinity/Acidity (pH)	In situ measurement using pH meter
5	Biological Oxygen Demand (BOD5)	Five days incubation BOD test
6	Chemical Oxygen Demand (COD)	Titrimetric method
7	Inorganic compounds	Atomic Absorption Spectrometer (AAS)

Source: Field Survey, 2019

3.10 Methods of Data Collection

3.10.1 Types of Data

Data refers to the facts, observations or experiences on which an argument or theory is constructed or tested. Data may be numerical, descriptive, aural or visual. Data

may be raw, abstracted or analyzed, experimental or observational Researchers, recognize two types of data: primary data and secondary data. Primary data are the information a researcher obtains from the field. Secondary data are the information researchers obtains from research articles, books or casual interviews (Fellous-Sigrist, 2015). This study included both primary and secondary data as helped to get enough information about the effects of industrial effluents on water sources in Mikocheni Industrial area.

3.10.2 Data Collection Techniques

Data collection techniques in this study included the closed ended questionnaires, interviews, observation and laboratory analysis of material samples. The questionnaire technique when used in collecting data can cover a large area and a large population. Information generated can be verified and crosschecked against the information collected using other methods. It is easy to manage and respondents usually give reliable information because they complete the questionnaires with utmost freedom from the pressure of the researcher (Kothari, 2004).

In this study, the questionnaire technique made data collection easy. While still in the field, the researcher was be able to detect gapes in the information collected. Indeed the information collected using the questionnaire method gave the researcher an opportunity to clarify issues and bridge information gapes while still in the field.

Interviewing is a face-to-face interaction between the researcher and respondents. Interviews are particularly useful for getting the story behind a participant’s

experiences. The interviewer can pursue in-depth information around the topic. Interviews may be useful as follow-up to certain respondents to questionnaires. It allows collecting bulk of information through social relationships and interactions. (Valenzuela & Shrivastava, 2011). In this study, interviewing enabled the researcher to personally interview respondents. Interviews allowed the development of positive social interactions and positive social relationships between the researcher and the respondents. These in turn facilitated data collection through enhanced cooperation.

Observation in the other hand is probably the most common and the simplest method of data collection. The direct observation helps the researcher to eliminate subjectivity from respondents' views (Kothari, 2004). This method involved taking photographs and observing the physical environment of wastewater streams so as to ensure that there was consistency of results obtained. Therefore, observing a phenomenon continuously, the researcher got well acquainted with the observed. The researcher was able know about the habits, likes, dislikes, problems, perception, different activities and so many other things hence can easily collect information about wastewater management strategies in Mikocheni Industrial area. Laboratory experiment was used to gather information about the physical and chemical parameters of wastewater discharged from the selected industries.

Laboratory analysis provided information about the content of wastewater discharged from the selected industries in Mikocheni area. Semi-supervised questionnaire were used to collect information from industrial workers wherethey agreed with the researcher on when to submit and the researcher kept pressure on them by first;

remaining put in the field and second; by chasing and reminding them according to time agreed.

In-depth interviews were used to capture additional information which supplemented laboratory analysis and secondary data as well. A set of pre-conceived questions were asked through face to face interviews. This was done to several factors such as owners of the industries, environmental consultants (DAWASA), environmental regulators (NEMC & VPO-DoE) and the community around the selected industries. The researcher believed that these groups of people could provide all the necessary information since they directly deal among other issues, with industrial wastewater by putting management ways such as establishment of standards for wastewater discharge, environmental impacts assessment, treatment and facilities for treatment, compliance and enforcement.

During the interview sessions, the researcher was jotting down the information given by the interviewees. To ensure the validly and reliability of the interviews the researchers sorted approval of what had been jotted down by reading it allowed to the interviewee and asking interviewees to make comments. The purpose of all this was to make the interview data are the research participants' own words and experiences about the impact of industrial effluents on waters sources in Mikocheni Industrial area. The researcher observed personally on how industries used water and their wastewater management strategies. Observational schedule was prepared so as to record the information on daily or weekly bases.

3.11 Data Processing and Analysis

Data from the laboratory were analyzed using descriptive statistics in the form of frequencies and percentages. Frequency statistics simply count the number of times that each variable occurs and represents its occurrences in percentages, such as the number of males and females within the sample. Measures of central tendency give one number that represents the entire set of scores, such as the mean. Data from the laboratory analysis was analyzed in percentages, graphs and charts. Data from the interview questions were analyzed content analysis.

3.12 Validity and Reliability

According to Blerkom (2009), validity refers to whether or not the test measures what it claims to measure. The validity of the instruments for data collection in this study was done through expert review and pilot testing. Pilot study was done and correction were made accordingly in relation to the topic under study. The results of the pilot study were not included in the final research findings. Reliability in the other hand is the degree or extent to which a test is consistent and stable in measuring whatever it is measuring. Reliability requires the administration of the same test to the same respondents twice with a short time interval after the first test. In this study, a correlation coefficient between the two sets of results were calculated. Only a reliability coefficient of 0.6 or 0.7 and above was accepted.

3.13 Ethical Consideration

Before data collection in the field, the researcher sought permission from the Open University of Tanzania. The permission letter was used to get the data collection

permission from the Dar es Salaam Regional Administrative Secretary and Kinondoni District Administrative Secretary who gave the researcher permission to collect data in a specified period of time. After the permission has been granted, the researcher was free to visit the selected industries in Mikocheni area for data collection. Other ethical consideration included confidentiality of the information collected and to allow freedom of respondents to participate in the study.

CHAPTER FOUR

FINDINGS AND DISCUSSION

4.1 Introduction

This chapter presents the findings of the study. These findings are according to the research objectives as well as research questions that guided the study. The findings presented in this chapter give information about demographic characteristics of respondents, the physical and chemical parameters of wastewater, the impact of industrial effluents to the surrounding community at Mikocheni industrial area and the challenges of wastewater management at Mikocheni industrial area, Dar es Salaam City. The thematic approach to presentation of findings was adopted in this study. The presentation therefore was according to themes. Quantitative data was analyzed by using the IBM Statistical Package for Social Science (SPSS) for window software package version 16.0. Frequencies were run to determine the percentage of responses for various items. Interview data was presented as narratives.

4.2 Respondents Characteristics

This study included in its sample people with varying backgrounds and characteristics. Tables 4.1, 4.2 and 4.3 presents the background information and characteristics of the sample.

Table 4.1: Gender, age and occupation of respondents

No. of Participants	**Participants gender**	**Frequency and Percent distribution.**	
		Frequency	**Percentage**
N=60	Male	41	68
	Female	19	32
Total		**60**	**100**

Source: Research data (2019)

Table 4.2: Age of respondents

No. of Participants	Participants age	Frequency and Percent distribution	
		Frequency	**Percentage**
N=60	Below 30	10	16
	Between 30-40	45	75
	Above 50	05	9
Total		**60**	**100**

Source: Research data (2019)

Table 4.3: Occupation of respondents

No. of Participants	Participants occupation	Frequency and Percent distribution.	
		Frequency	**Percentage**
N=60	Manager	02	04
	Supervisors	06	10
	Employees	40	66
	Community Member	12	20
Total		**60**	**100**

Source: Research data (2019

Results on respondent's composition by gender are shown in Table 4.1, 4.2 and 4.3 which indicates that there was variation in respondent's participation in the study. The findings in Table 4.1 shows that male respondents participated more than female respondents as they formed 68% of the total respondents. Female respondents formed only 32% of the total respondents. In terms of the age range as shown in Table 4.2, respondents with the age group between 30-40 participated more in this study than another age group as they formed 75% of the total respondents. This was followed by those with age group below 30 years as they formed 16%. Only 9% of respondents were aged above 50.

Findings in Table 4.3 also indicated that 66% of the total respondents who participated in this study were the industrial workers. This was followed by the

community members who formed 20%. About 10% of the total respondents were supervisors in industries. Only 4% were managers who were also represented the industrial owners.

4.3 Physical and Chemical Parameters of Wastewater to the Water Sources

The study sought to identify the industrial effluents to the water sources in Mikocheni industrial area, Dar es Salaam City. Respondents views on the industrial effluents wastewater were indicated by mean scores which were interpreted as follows: 1.00-1.49 = strongly disagree, 1.50-2.49 = disagree, 2.50-3.49 = agree and 3.50-4.00 = strongly agree.

Table 4.4: Respondents' views on physical and chemical parameters of wastewater from Mikocheni Industrial area

SN	Item	Mean Scores	Interpretation
1	In this area there are many industries	4.00	Strongly Agree
2	Industries in this area discharge waste water	3.51	Strongly Agree
3	Industries have environmental personnel	2.52	Agree
4	Owners of the industries are aware of the industrial effluents	2.53	Agree
5	Industries in this area discharge physical and chemical parameters	4.00	Strongly Agree
6	There are frequent visits of Environmental Authorities in this area	2.49	Disagree
7	Industries have mechanisms to preserve wastewater in tanks	2.48	Disagree
8	Chemical reduction is done at the effluent treatment tanks	2.31	Disagree
9	There is a challenge in wastewater management in this area	3.83	Strongly Agree
10	There are no policies for waste water management in this area	2.22	Disagree
	Overall Mean Score	**2.98**	**Agree**

Source: Field Research data (2019)

Findings in Table 4.2 revealed that respondents agreed that there were physical and chemical parameters from Mikocheni industrial area with the overall mean score of 3.0 which is within the agreement zone (2.50 - 3.49). This suggests that respondents agreed that industries emits physical and chemical parameters from industries to the water sources in the study area. The description of results for each item and their respective interview narratives have been interpreted and summarized below.

Specifically, Table 4.2 indicated that respondents strongly agreed that at Mikocheni industrial area there were many industries with the mean score of 4.00. This implied that, information about the effect industrial effluents on water sources was adequate due to the availability of many industries in the study area. Findings further revealed that industries in the study area discharged waste water with the mean score of 3.51. These findings give an expression that, there were evidences of wastewater discharged from the industries at Mikocheni Industrial area. Furthermore, findings from this study affirmed that industries at Mikocheni area discharged physical and chemical parameters with the mean score of 4.00. The findings in table 4.2 above on the presence of physical and chemical parameters in industrial wastewater was supported by the results from the laboratory test (see Table 4.5 and 4.6)

Table 4.5: Wastewater discharge from the selected site

SN	Time	H (cm)	$Q_{th}(m^3/s)$	l/s	Qa(l/s)	C_d
1.	1.67	57.73	0.01376	13.7644	8.98815	0.653
2.	1.53	58	0.0145	14.5035	9.77538	0.674
3.	1.6	58.19	0.01504	15.0376	9.39852	0.625
4.	1.42	58.1	0.01478	14.7832	10.5552	0.714
5.	1.7	58.2	0.01507	15.0661	8.84378	0.587
6.	1.06	60.34	0.02191	21.9114	14.0891	0.643
7.	0.93	60.34	0.02191	21.9114	16.1487	0.737
8.	1.14	60.5	0.02249	22.4858	13.1991	0.587
9.	1.07	60.17	0.02131	21.311	14.0226	0.658
10.	1.05	60.15	0.02124	21.241	14.2739	0.672
11.	1.32	60	0.02072	20.7205	11.3548	0.548
12.	1.08	59.7	0.0197	19.7026	13.91	0.706
13.	1.18	59.7	0.0197	19.7026	12.7082	0.645
14.	1.13	59.7	0.0197	19.7026	13.2993	0.675
15.	0.67	63.97	0.03722	37.2165	22.4788	0.604
16.	0.72	63.6	0.03543	35.4319	20.9757	0.592
17.	0.59	63.64	0.03562	35.6223	25.2562	0.709
18.	0.58	65.07	0.04284	42.8361	25.9159	0.605

Source: Field Research data (2019)

The physical parameters that were measured in the study were pH, Total Suspended solids and Turbidity so as to check for the baseline conditions of the wastewater pollution load. Moreover, the chemical parameters included the Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD) which were analyzed along with the physical parameter in the laboratory. The results are presented in the Table 4.6 below.

Table 4.6: Wastewater parameters' results

Parameter	**pH**	**TSS (mg/L)**	**Turbidity (NTU)**	**COD (mg/L)**	**BOD_5 (mg/L)**
Concentration/ Value	6.0	199	340	284	169
TBS standard	6.5-8.5	100	300	60	30

Source: Field Research data (2019)

Findings from laboratory as indicated in table 4.5 and 4.6 confirmed that the level of all physical parameters was not within the permissible limits for Tanzania Bureau of Standards (TBS) for Municipal effluent and majority were above the standards. For pH the average value was 6.0, which was outside the standard range of 6.0-8.5. This might be due to the raw materials such enzymes, lactic acid, benzoic acid and yeast which are mainly used by food industry. On the other hand, the concentration of suspended solids of 199mg/l was higher than the TBS standards of 100mg/L. The total suspended solids were generally higher during weekdays and low in weekends because of low manufacturing activities during weekends. In extending the argument, the higher concentration of suspended solids was recorded during afternoon period than evening because of the same reason. The variations of TSS are indicated in Figure 4.1.

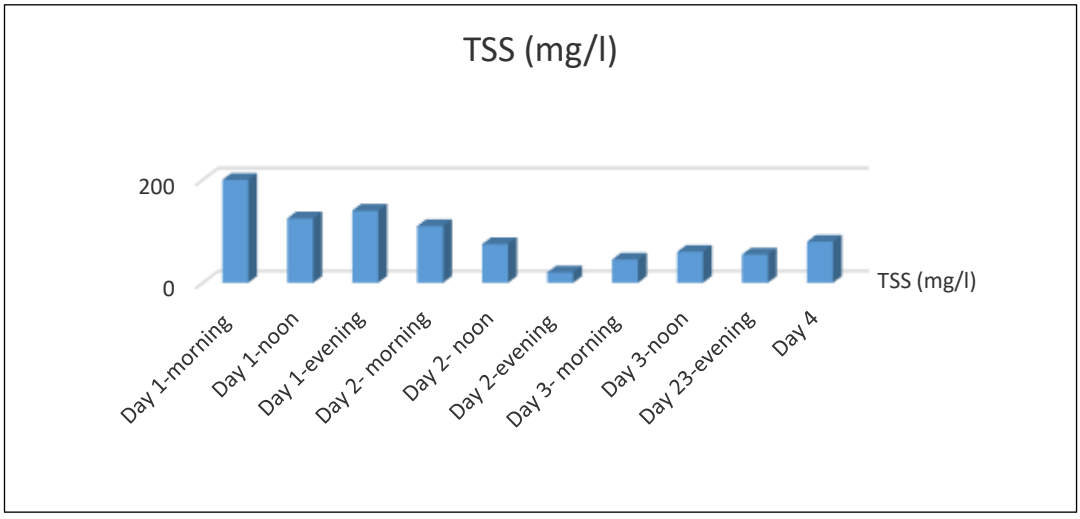

Figure 4.1: Variations in total suspended solids

Source: Research data (2019)

The findings from the laboratory further indicated that the turbidity was of high quantity as it formed 340 NTU which was not within the TBS standard of 300 NTU.

This indicates that the water stream is polluted and similar to TSS, the higher turbidity reading was recorded during the noon and evening while minimal reading was recorded during the morning. Similar justification also applies as in TSS. Findings further reported higher levels of BOD and COD which was 169 mg/L and 284 mg/L respectively. The higher values of biological oxygen demand are due to the presence of organic food remains wastes disposed by food processing industry after being processed in the factory, while for the COD the higher recordings were due to the discharge to the stream of various chemical compounds from the pharmaceutical industry of their end products and intermediate products along the way. This was evidenced by having high concentration of Lead and Zinc that exceeded the allowable level for TBS, Chromium has been observed below the standard for TBS however with day to day generation and discharge of effluents, they may pose accumulation of Cr in the environment. The figure their accumulation can presented to be below 4.2.

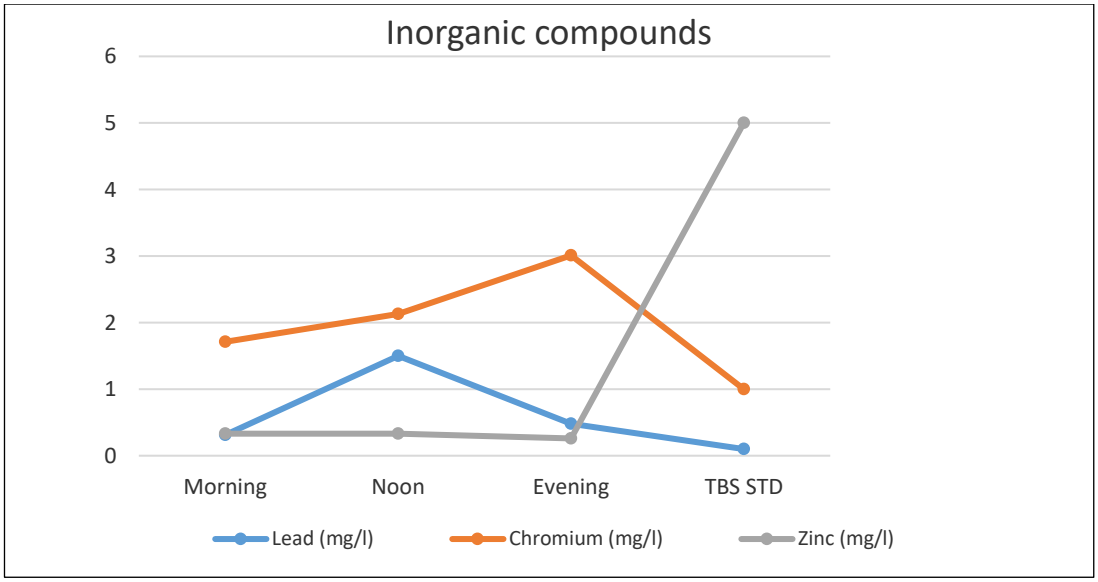

Figure 4.2: Inorganic compounds

In the interview, one of the respondents said:

> *There is no doubt that industries in this area discharge wastewater from industries because these industries have no proper means of preserving the wastewater from their industries. Just look at that pit of water there, first they are smelling badly and even the color of water tells us that that water is very dirty. This is very dangerous not only to the people around here but also to the environment.* Source: Mikocheni, 2019

Another interviewee said:

> *We do witness the industries in this area discharging these dirty waters. I'm a scientist to know what is there but im sure the water from industries are very dirty with dangerous chemicals. When you go close, they are stinking and they are totally dirty.* Source: Mikocheni, 2019

Plate 4.1: Wastewater with industrial effluents from Mikocheni Industrial area

Source: Research data (2019)

Findings in table 4.2 indicated that industries had environmental personnel and that owners of the industries were aware of the industrial effluents with the mean score of 2.5 and 2.53 respectively. These findings give an expression that, despite of the industrial effluents and their impact on water sources, the industries had

environmental personnel and also the owners of industries were aware of the industrial effluents. Findings also indicated that respondents disagreed that there were frequent visits of Environmental Authorities in the study area with the mean score of 2.49. This gives an implication that despite of the presence of environmental authorities, they rarely visited the study area.

In the interview, one of the respondents said;

> *These people dealing with environment are sometimes not serious because this place is leading in this city for producing dirty water but they don't come to visit frequently and when they come sometimes, they end up in the offices instead of seeing what is taking place. I sometimes feel the smell of corruption for these people.*
> Source: Mikocheni, 2019

One of the community members said;

> *When the Ministers visits the area is where those dealing with environment visit frequently in this area. This is the reason why these industries continue to pollute water sources in this area. If the situation continues like this, water sources will be more affected from the industrial effluents.* Source: Mikocheni, 2019

Findings also revealed that respondents disagreed that industries had mechanisms to preserve wastewater in tanks. They also disagreed that chemical reduction was done at the effluent treatment tanks with the mean score of 2.48 and 2.31 respectively. These views of respondents were influenced by the fact that at Mikocheni Industrial area, industrial effluents were evident with impact to the water's sources and the environment in general. Furthermore, findings revealed that there was a challenge in wastewater management in the study area with the mean score of 3.83. This means industries has not committed to reducing the industrial effluents that have impact to on water sources in the study area. However, respondents disagreed that there were no policies for waste water management in the study area with the mean score of

2.22. This gives a picture that policies on environmental issues in industries were there but were not well adhered by the industrial owners.

4.4 Impact of Industrial Effluents to the Surrounding Community at Mikocheni industrial area

The study sough to examine the impact of industrial effluents to the surrounding community at Mikocheni industrial area. Respondents views on the impact of industrial effluents to the surrounding community were indicated by mean scores which were interpreted as follows: 3.50-4.00 = strongly agree, 2.50-3.49 = agree, 1.50-2.49 = disagree and 1.00-1.49 = strongly disagree.

Table 4.7: Respondents' views on the impact of industrial effluents to the surrounding community at Mikocheni industrial area

SN	Item	Mean Scores	Interpretation
1	Industrial effluents are discharged in water sources in this area	4.00	Strongly Agree
2	People in this area use water that is contaminated with industrial effluents	3.31	Agree
3	People in this area are aware about the pollution of water sources	2.52	Agree
4	The surrounding community is affected from using the contaminated water	2.53	Agree
5	Industrial effluents are harmful to human health	3.48	Strongly Agree
6	Water quality in this area is questionable	3.00	Agree
7	The pollution of water sources may have effects on the life of other creatures	3.22	Agree
	Overall Mean Score	**3.15**	**Agree**

Source: Research data (2019)

Findings in Table 4.7 revealed that respondents agreed that the surrounding community were affected from the industrial effluents with the overall mean score of

3.15 which is within the agreement zone (2.50 - 3.49). This suggests that, there were effects witnessed by the community caused by the industrial effluents. The description of results for each item and their respective interview narratives have been interpreted and summarized below.

Specifically, table 4.5 above indicated that respondents strongly agreed that industrial effluents were discharged in water sources in the study area with the mean score of 4.00. This gives an impression that, waste water from industries were not well managed by industrial owners hence were discharged in water sources which in turn affected the community.

In the interview, one of the industrial worker said;

> *It is not that the industry has no system for wastewater but the problem is that the system are not working properly and some are small to hand the large volume of wastewater. This is what causes water to affect the surrounding community.* Source: Mikocheni, 2019

One of the community member said;

> *It is true that toxic water from the industries are just let in to our residents because those who own industries do not care about the community. We have been complaining for some years but the problem is still there however, nowadays some initiatives have stated being taken.* Source: Mikocheni, 2019

Furthermore, the findings revealed that people in the study area used water that was contaminated with industrial effluents, they were aware about the pollution of water sources and they agreed that surrounding community is affected from using the contaminated water with the mean score of 3.31, 2.52 and 2.53 respectively. The

implication of these results is that, the community was aware that their water sources were polluted by the industrial effluents and they still used the same water. The community also was aware that they were affected from the contaminated water. This is probably due to the fact that they had no other sources of water for their daily activities such as gardening.

One of the interviewees said;

> *The community here at Mikocheni uses this water for several purposes especially for their gardens. You see there are some vegetable gardens in this place and they use the same water that is contaminated that is the reason they are affected. I once tested the vegetable from this area, I felt something was wrong. I think some immediate measures need to be taken to rescuer this situation.* Source: Mikocheni, 2019

Findings in Table 4.7 above indicated that respondents strongly agreed that industrial effluents were harmful to human health with the mean score of 3.48. Further the findings indicated that water quality in the study area was questionable with the mean score of 3.00. Similarly they agreed that pollution of water sources had effects on the life of other creatures with the mean score of 3.22. The implication is that, industrial effluents were discharged in water sources and the contaminated water was harmful to both human and other creatures. This is supported by the laboratory results as indicated in table 4.4.

4.5 Challenges of Wastewater Management at Mikocheni Industrial Area

The study sough to examine the challenges of wastewater management at Mikocheni industrial area. Respondents views on this objective were indicated by mean scores

which were interpreted as follows: 3.50-4.00 = strongly agree, 2.50-3.49 = agree, 1.50-2.49 = disagree and 1.00-1.49 = strongly disagree.

Table 4.8: Respondents' views on the challenges of wastewater management at Mikocheni industrial area

SN	Item	Mean Scores	Interpretation
1	The is no awareness among the industrial owners on wastewater management	2.22	Disagree
2	The industries have poor infrastructure for sewage system	3.31	Agree
3	There is no mechanisms to reduce the effect of industrial effluents in this area	2.52	Agree
4	There are no strict environment laws to industrial owners for discharging chemicals in water sources	2.32	Disagree
5	There is no frequent environmental analysis in this area	3.21	Agree
6	The industries uses tanks to preserve and treat wastewater	2.51	Agree
7	The environmental committees in the study areas are not doing their job	3.22	Agree
	Overall Mean Score	**2.73**	**Agree**

Source: Field Research data (2019)

Findings in table 4.8 above revealed that respondents agreed that there are challenges of wastewater management at Mikocheni industrial area with the overall mean score of 2.73 which is within the agreement zone (2.50 - 3.49). This suggests that, there were variety of challenges in wastewater management at Mikocheni industrial area despite of all the effects of industrial effluents in water sources.

Specifically, the findings indicated that respondents disagreed that there was no awareness among the industrial owners on wastewater management with the mean score of 2.22. This means, respondents were sure that the industrial owners were

aware about the waste water management but they just ignored. Findings further indicated that respondents were in agreement that the industries had poor infrastructure for sewage system and that there were no mechanisms to reduce the effect of industrial effluents in the study area with the mean score of 3.31 and 2.52 respectively. The implication from these findings is that industries at Mikocheni area lacked the proper infrastructures for wastewater management and were no serious mechanism to solve the problem. The situation increase ganger to the water sources and the community in general. Further the finding revealed that respondents disagreed that there were no strict environment laws to industrial owners for discharging chemicals in water sources with the mean score of 2.32. This implies that, environmental laws and policies were there but the problem was on how to adhere to those laws.

Findings indicated that respondents agreed that industries used tanks to preserve and treat wastewater with the mean score of 2.51. This probably due to the fact that tanks helping to source the effect of industrial effluents to the waters sources and environment in general. Findings indicated that the environmental committees in the study areas were not doing their job properly with the mean score of 3.22. This affirms that, leaders from local area who were responsible for making sure environmental laws are adhered were not doing their work properly that is the reason the community were affected despite of the existence of the environmental committees in the study area (see Plates 4.2 and 4.3).

Plate 4.2: Wastewater treatment tank

Source: Research data (2019)

Plate 4.3: Wastewater separation tank

Source: Research data (2019).

In the interview, one of the responded said;

> *To me I sometimes not blame the industrial owners rather I blame those who constructed these industries…how can you construct and industry without proper wastewater systems? Those with industries here*

> *sometimes they just rent these buildings so no way they can do anything on industrial effluents.* Source: Mikocheni, 2019

Another interviewee said;

> *Here the problem is not the laws or policies, all are there and well stipulated but the problems the education and awareness to those e dealing with industries should be strengthened. Let me tell you, sometimes they discharge at night so no one can see until morning but seriously something should be done to rescue our waters sources and the community at large.* Source: Mikocheni, 2019

4.6 Discussion

Findings on the physical and chemical parameters of wastewater to the water sources indicated that, the industrial effluents at Mikocheni area had physical and chemical parameters such as lead, chromium and zinc as indicated in table 4.4. According to Matovu, (2010) the low pH levels are probably due to the effluents which contained organic waste. Moreover, in decomposition of organic wastes by bacteria, the Carbon dioxide tends to be released as the end product. This in turns reacts with water and forms the carbonic acid, which its presence in water streams increases the acidic level.

The total suspended solids occur in wastewater as the form of particulates which can be viewed through turbidity and color as it includes all particles suspended in water which are not able to pass through a filter. Moreover, suspended solids harbor the micro- organisms and important chemical anions and cations depending on the surface and characteristics of the element. It’s content in wastewater often enable to tell to what extent does water is polluted and it’s the pollutant load it carries. On the other hand, the concentration of suspended solids of 199mg/l was higher than TBS standards of 100mg/L. The total suspended solids were generally higher during

weekdays and low in weekends because of low manufacturing activities during weekends. In extending the argument, the higher concentration of suspended solids was recorded during afternoon period than evening because of the same reason. Results correlated with those of Haskoning and M-Konsult (1989), who observed that TSS from industrial effluents was 3,148 kg/day, which contributed to pollution of groundwater since they are discharged haphazardly without any treatment.

The turbidity of the high quantity which was 340 NTU and was not within the TBS standard which was 300 NTU. This indicates that the water stream is polluted and similar to TSS, the higher turbidity reading was recorded during the noon and evening while minimal reading was recorded during the morning. Similar justification also applies as in TSS. These results are in line with the results by Walakira (2011), in his findings, it was observed that turbidity from the selected sites among other results, were below the NEMA set standards of 300 NTU.

These are two chemical parameters are most important pollution determinants in the wastewater analysis and as they tell the pollution load in specific wastewater streams. COD determine the dissolved oxygen in the wastewater required to decompose all organic compounds present in wastewater while BOD_5 on the other hand determine the dissolved oxygen required by bacteria to decompose the biodegradable organic matter present in wastewater. In the study, wastewater laboratory findings reported higher levels of BOD and COD to which was 169 mg/L and 284 mg/L respectively.
The higher values of biological oxygen demand are due to the presence of organic food remains wastes disposed by food processing industry after being processed in

the factory, while for the COD the higher recordings were due to the discharge to the stream of various chemical compounds from the pharmaceutical industry of their end products and intermediate products along the way. In extending the arguments, on weekends especially Sunday to which most of the industries tend to stop production, small readings were recorded for both COD and BOD.

Furthermore, the study by Pandey and Gosh (2002) shows slight difference in the BOD generation from Indian industries, the BOD observations in their study was revealed to be very high in the total BOD was 876 mg/L and in their study, it was found Iron and Steel industries generated huge amount of BOD. Hence this made its concentration to be below detection limit, since the uses of cadmium chemical in many plastic industries decreases and replaced with nickel-metal hydride and lithium-iron batteries. Furthermore, although cadmium concentration level was below TBS standards, it was not a result of being well treated but the industry might be using low amount of such chemical, so industries must have treatment facilities in order to prevent when such chemical will be used in high amount (Morrow, 2010).

Findings indicated that the community was affected due to the industrial effluents at Mikocheni industrial area. Johnstone (2013) indicated that Industrial effluent control is of vital importance, particularly in developing countries where control is often very poor or non-existent. There is an old axiom which states that ‘good sewage treatment starts with good control of industrial effluents. Non-existent control could mean an inability to treat domestic sewage effectively.

The prime reasons for the control of industrial wastewaters are: to protect workers working within the sewerage system, to protect the fabric of the sewer and the fabric of any downstream treatment works, to prevent fires and explosions due to inflammable or explosive chemicals, to protect the environment where sewers eventually discharge to a watercourse or to the sea. This was supported by Tumbo (2008) who indicated that about 57 industries were surveyed and about 68% contributes both directly through discharging effluents some containing heavy metals like Cadmium, Lead, Zinc and Chromium from point sources or indirectly through non points sources. The effluents are discharged to open land and carried to the ocean through surface run off sand ultimately discharged to Indian Ocean.

Furthermore, findings on the challenges of wastewater management at Mikocheni industrial area indicated that there were myriads of challenges in wastewater treatment in the study area. About 59% of the industries in Tanzania have not installed wastewater treatment facilities. In Tanzania, both the Environmental Management Act (EMA), 2004 and the Public Health Act, 2009 and the related regulation are used as enforcement tools to provide the mechanisms of removing the burden from the public. Urban Water and Sanitation Authorities are responsible for the collection, conveyance and treatment of waste water. More specifically, EMA, 2004 section 110, provides prohibition to discharge hazardous substances, chemicals, materials, oil etc into any waters or any other segment of the environment, also section 144 provide standards for effluents discharge into water, furthermore, section 37 and 38 of the Public Health Act provides prohibition of pollution of water bodies and prohibition to dump waste respectively (Semboja, 2012).

4.7 Summary

Findings about the physical and chemical parameters of wastewater to the water sources at Mikocheni Industrial area revealed that affirmed that industries at Mikocheni area discharged physical and chemical parameters. The physical parameters that were measured in the study were pH, Total Suspended solids and Turbidity so as to check for the baseline conditions of the wastewater pollution load. Moreover, the chemical parameters included the Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD) which were analysed along with the physical parameter in the laboratory. Therefore, industries at Mikocheni area discharged physical and chemical parameters. Findings about the impact of industrial effluents to the surrounding community at Mikocheni industrial area found that industrial effluents were harmful to human health and environment at large. Further the findings indicated that water quality in the study area was questionable and that pollution of water sources had effects on the life of other creatures. Finally, findings about the challenges of wastewater management at Mikocheni industrial area found that there were various challenges of waste water management in the study area including; inadequate awareness among the industrial owners on wastewater management, the industries have poor infrastructure for sewage system, there is no mechanisms to reduce the effect of industrial effluents in this area, there is no frequent environmental analysis in this area, the industries uses tanks to preserve and treat wastewater and that the environmental committees in the study areas are not doing their responsibilities effectively.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter presents the conclusions, recommendations and areas for further researches.

5.2 Conclusions

On the basis of data presentation made in chapter four, the following conclusions were made from this study.

The study conclude that the industrial effluents contained physical and chemical parameter. The level of all physical parameters with COD and BOD_5 was not within the permissible limits for TBS standard for Municipal effluent discharge. This has been shown by the values of concentrations measured on each parameter such that, pH (6.0), TSS (199mg/L), Turbidity (340 NTU), COD (284 mg/L) and BOD_5 (169mg/L) while the TBS standards were (6.5-8.5), (100 mg/L), (300 NTU), (60mg/L) and (30mg/L) respectively. This indicated that, the wastewater stream is polluted and treatment is inefficient among the various industries that are located within the area.

Furthermore, level of Heavy metals on the analyzed industrial wastewater observed to be high than TZS 789:2003 standards for wastewater discharge except Cadmium which was Below Detection Limit (BDL). Heavy metals measured were Chromium,

Lead, Cadmium and Zinc and there results were as arranged Morning, Noon and Evening respectively;- Chromium (Cr) 1.71mg/L, 2.13mg/L and 3.01mg/L, this values were above allowable limits for discharging Chromium contaminated wastewater which is 0.1mg/L. Also Lead (Pb) were 0.31mg/L, 1.5mg/L and 0.48mg/L, Zinc (Zn) 0.33mg/L, 0.33mg/L and 0.26mg/L and the results of Cadmium (Cd) were Below Detection Limit approximately 0mg/L. The study also concluded that the community around Mikocheni area were affected by the industrial effluents because they used the contaminated water for several purposes including vegetable gardening. These contaminants in wastewater might results to diseases in human being, animals and plants as it pollutes water bodies. Dangerous Diseases like Cancer are the results heavy metals concentration in human or other living things bodies.

It was concluded that there were myriads of challenges in wastewater treatment because of the lack or inefficiency of treatment facilities of the industries. This has been evidenced as some industries use tanks for west water treatment which are not treatment facilities rather storage tanks. It was also concluded that, the local environmental committees were not active at the study area because despite of the effects of industrial effluents they were not reactive.

5.3 Recommendations

The recommendations made on the basis of the conclusions are as follows:

i) Industries at the study area must have proper wastewater treatment facilities in its premises in-order to discharge treated wastewater to the receiving bodies and affect water sources. This will help reduction of spread of diseases

to the society near those water bodies or streams. All wastewater treatment facilities constructed or installed by industries must be checked for its efficiency by the responsible authorities.

ii) There must be enforcement of rules and regulations by responsible authorities on wastewater discharge such authority like National Environmental Management Council (NEMC). Regulations like polluter pay principle should be enforced by the authorities' in-order to remake all impacts caused by such industry to the vegetation, animals living in water bodies, communities whom depend on those receiving water bodies for domestic uses and irrigation. Industrial owners who will fail to adhere to the environmental rules, their licenses need to be revoked.

iii) Heavy metals should be handled well since their excess in environment they had health side effects like cancer where number of patients suffering from cancer increases daily.

iv) The community surrounding Mikocheni area should be sensitized on the use of water that is contaminated to avoid getting related diseases such as cancer. Various means of education and should be given to the community to be aware of the effect of contaminated water.

v) There should be collaboration between the local environmental committees and the national environmental authorities in reducing the effects of industrial effluents in water sources.

vi) There must be reinforcement of Environmental Impact Assessment prior to establishment of industrial facilities and Environmental Audit for the case of ongoing industries. This will help in foreseeing various aspects that are most

likely to affect environmental resources including water of the proposed facilities but for the existing, will help to know how waste is managed including knowing facilities for treatment, their efficiency and capacity.

5.4 Recommendations for Further Studies

i) This study was conducted to examine the impacts of industrial effluents to the water resources in Tanzania with reference to Mikocheni Industrial Area in Dar es Salaam. Further studies can be done to examine the impact of industrial effluents to the water resources in Tanzania with reference to other industrial areas in Cities of Tanzania such as Mbeya, Mwanza, Arusha, Dodoma etc.

ii) This study focused to examine the impact of industrial effluents to the water resources in Tanzania with reference to Mikocheni Industrial Area in Dar es Salaam. Further research can be conducted specifically to examine the influence of city planning policies on waste water management at Mikocheni Industrial Area in Dar es Salaam.

iii) The study did not investigate on the effluents end point being the ocean, surface and ground water hence there is a need to conduct a further study to investigate on how the resources in such areas have been affected hence establish proper ways for ensuring marine, surface and ground water resources are safe to attain a healthier environment.

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APENDICES

APENDIX I: QUESTIONNAIRES

Dear Respondent, you have been selected to participate in a study entitled **"Impact of Industrial Effluents to The Water Resources. The Case of Mikocheni Industrial Area, Dar es Salaam Tanzania"** This study is conducted by Angela Mwatujobe from the Open University. Please provide true information to enable the accomplishment of this study. Responses you provide are for academic purposes only and will be treated with utmost confidentiality. Do not fill your name.

DEMOGRAPHIC INFORMATION: Please tick appropriate option

1. **What is your Gender?**

   ( ) Male ( ) Female

2. **What is your age?**

   ( ) Below 30 ( ) 30– 40 ( ) 41-50 ( ) above 51

3. **Your occupation is?**

   ( ) Industry owner ( ) Manager ( ) Supervisor ( ) ( ) Employee any other (Specify) ___

Please read carefully and tick correct option to describe your feelings about below aspects:

SM	**PHYSICAL AND CHEMICAL PARAMETERS OF WASTEWATER**	**Strongly Disagree**	**Disagree**	**Agree**	**Strongly Agree**
1	In this area there are many industries				
2	Industries in this area discharge waste water				
3	Industries have environmental personnel				
4	Owners of the industries are aware of the industrial effluents				

5	Industries in this area discharge physical and chemical parameters				
6	There are frequent visits of Environmental Authorities in this area				
7	Industries have mechanisms to preserve wastewater in tanks				
8	Chemical reduction is done at the effluent treatment tanks				
9	There is a challenge in wastewater management in this area				
10	There are no policies for waste water management in this area				
	IMPACT OF INDUSTRIAL EFFLUENTS TO THE SURROUNDING COMMUNITY	**Strongly Disagree**	**Disagree**	**Agree**	**Strongly Agree**
1	Industrial effluents are discharged in water sources in this area				
2	People in this area use water that is contaminated with industrial effluents				
3	People in this area are aware about the pollution of water sources				
4	The surrounding community is affected from using the contaminated water				
5	Industrial effluents are harmful to human health				
6	Water quality in this area is questionable				
7	The pollution of water sources may have effects on the life of other creatures				
	THE CHALLENGES OF WASTEWATER MANAGEMENT AT MIKOCHENI INDUSTRIAL AREA	**Strongly Disagree**	**Disagree**	**Agree**	**Strongly Agree**
1	The is no awareness among the industrial owners on wastewater management				
2	The industries have poor infrastructure for sewage system				
3	There is no mechanisms to reduce the effect of industrial effluents in this area				
4	There are no strict environment laws to industrial owners for discharging chemicals in water sources				
5	There is no frequent environmental analysis in this area				
6	The industries uses tanks to preserve and treat wastewater				
7	The environmental committees in the study areas are not doing their job				

Thank You Very Much

APENDIX II: INTERVIEW QUESTIONS

1. What is your opinion about the location of industries in this area?
2. Do you think industries in this area have any problem in the environment?Please mention all the environmental effects from the industrial effluents
3. Can you mention any physical or chemical parameters discharged from industries?
4. Is there effect in the water sources from the industrial effluents?
5. Do you think the owners of the industries are aware of the industrial effluents that affects water sources?
6. Do the surrounding community are aware of the industrial effluents that affect water sources?
7. Is there any health problem among the surrounding community from the used of contaminated water? Feel free to mention them
8. What is the role of the environmental authorities such as NEMC in reducing these water sources pollution?
9. Do the industries in this area have mechanisms for wastewater management?
10. Is there any challenges face in industrial wastewater management?
11. In your own views what do you think should be done to reduce effects of industrial effluents in the water sources in the area?