LEVELS OF INDUSTRIAL POLLUTANTS AND THEIR EFFECTS ON WATER RESOURCES AND LIVELIHOODS ALONG MSIMBAZI SUB CATCHMENT- DAR ES SALAAM, TANZANIA

BY

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DECLARATION

This thesis is my original work and has not been presented for a degree or any other award in any other university.

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DEDICATION

This work is dedicated to my beloved family. Thank you for your Prayers and tireless support.

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First of all, I am grateful to God who makes all my plans succeed according to his will and in whom all things are made possible.

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ABBREVIATIONS AND ACRONYMS

BIS	Basic Industry Strategy
BOD	Biochemical Oxygen Demand
Cd	Cadmium
CEP	Country Environment Profile
COD	Chemical Oxygen demand
Cr	Chromium
DAAD	Deutscher Akademscher Austausch Dienst (German Academic Exchange Service)
Dar	Dar es Salaam
DCC	Dar es Salaam City Council
DO	Dissolved Oxygen
DPSIR	Drivers, Pressure, State, Impact and Response
EC	Electrical Conductivity
EEA	European Environment Agency
EPA	Environmental Protection Authority/Agency
ETP	Effluent Treatment Plants
JICA	Japan International Cooperation Agency
NBS	National Bureau of Statistics
NEMC	National Environmental Management Council
NTU	Nephelometric Turbidity Unit
Pb	Lead
pH	Potentiality of Hydrogen
ppm	parts per millions
SIDP	Sustainable Industrial Development Policy

SPSS	Statistical Packages for Social Sciences
SWOT	Strengths, Weaknesses, Opportunities and Threats
TBS	Tanzania Bureau of Standards
TSS	Total Suspended Solids
UDSM	University of Dar es Salaam
UN	United Nations
UNIDO	United Nations Industrial Development Organization
URT	United Republic of Tanzania
WHO	World Health Organization
WWAP	World Water Assessment Program

ABSTRACT

Water is considered fundamental to development due to its contribution to economic growth and human welfare. Yet, most human activities such as agriculture, domestic and industrial pollute water resources. Industries use water in different processes and if not well managed, they pollute water bodies. The study assessed the levels of industrial pollutants and their effects on water resources and livelihoods along Msimbazi sub catchment. Specifically, the study determined the types and abundance of pollutants discharged by industries, levels of industrial pollutants and their effects on water resources and livelihoods. It also reviewed relevant aspects of the implementation of the relevant aspect of Tanzania National Industrial Policy on cleaner production and how they relate with industrial pollutants. Primary and secondary methods of data collection were used. Primary methods of data collection such as in *situ* measurements, laboratory analysis of water samples, structured questionnaires, interview guides as well as observation. Secondary data were collected from the National Bureau of Statistics (NBS). Different documentations were reviewed to compare data collected through primary methods. Data were analyzed using both quantitative and qualitative methods. The quantitative techniques included descriptive statistics such as cross-tabulation, frequencies, percentages and means which was done using Statistical Packages for Social Sciences (SPSS) software version 18.0 and Microsoft Excel 2007. Qualitative data was analyzed using Strengths, Weaknesses, Opportunities and Threats (SWOT) analysis. The results show that the types and abundance of pollutants discharged by industries along the sub catchment were higher and to some points exceeding the World Health Organization (WHO) and Tanzania Bureau of Standards (TBS) standards. Pollutants such as COD was found to be the highest at Vingunguti with the COD of 2451.57mg/l and Tabata 1 recorded 879.39mg/l. Turbidity was higher at Vingunguti with 674NTU and Kigogo 2 which had 357NTU exceeded the TBS and WHO acceptable levels. DO was exceeding the standards in stations like Vingunguti and Kigogo1 which had 0.00mg/l. DO was within the standards at upstream from the industries station. Chromium concentration was higher at Tabata 2 and Kigogo 2 and it was within the standards at the station upstream from the industries. Furthermore the results show that industrial pollutants was found to be affecting the water resources in terms of quality where the water quality parameters in some stations were exceeding the WHO and TBS permissible limits also livelihoods were found to be affected by the industrial pollutants in terms of health, agriculture and settlement. Moreover, the study found that industries are still discharging pollutants into the sub catchment despite the implementation of the Tanzania National Industrial Policy. The study recommends improvement of law enforcement in order to control industrial pollutants . Further; the authorities like NEMC should ensure that industries adopt efficient technology such as Effluent treatment Plants (ETP's) in order to minimize the effects of industrial pollutants into water resources and livelihoods. The findings will add to documentation on levels of industrial pollutants and their effects on water resources and on livelihoods along Msimbazi sub catchment which will be essential to community, water managers and other conservationists. In addition, the study provides practical recommendations on industrial policy implementations to the Ministry for Industry & Trade and NEMC

CHAPTER ONE: INTRODUCTION

1.1 Background to the Study

Water is considered a fundamental resource to development due to its contribution to economic growth and human welfare however; most human activities such as agriculture, domestic and industrial use pollute water resources. According to Wang (2005), industry is the direct user of water resources as well as the main sources of water pollution. Overall, some 5–20 per cent of total water usage goes to industry (WWAP, 2009), although this is not always the case in all the countries. Yet industries use water in different processes such as; heating, cooling, production and cleaning.

Egun (2010) identifies industrial effluents as one the chief sources of water pollution, including industrial wastes discharge from chemical industries, fossils fuel and nuclear power plants. According to Reza and Singh (2010) the main anthropogenic sources of heavy metal contamination are disposal of untreated and partially treated effluents into water bodies from different industries.

Worldwide, it is estimated that the industrial sector is responsible for dumping 300-400 million tons of heavy metal, solvents, toxic sludge, and other waste into water each year (Stockholm Water Front, 2010). Close to 70% of untreated industrial wastes in developing countries is discharged into water where they contaminate existing water supplies (UN-Water, 2009). Discharge of industrial waste into water often impacts negatively on water resources and livelihoods. According to Oluseyi (2011), industrial effluents also contain chemicals and heavy metals that are directly harmful to human health and indirectly affect human productivity. Industrial effluents also affects land productivity where crop production suffers from contaminated irrigation water from both surface sources and from ground water aquifers.

Against this backdrop are government mechanisms to promote cleaner production such as industrial policies that form key elements of a national framework and program (UNIDO, 2000). Because of inadequate land-use controls, industries are located adjacent to residential areas, including those along rivers. The resulting land and air pollution is sometimes exceeds minimum health and safety standards set by governments (Douglass, 1999; Hsiao *et al.*, 1999). In principal cities, land price increases, far outpacing both per capita income and minimum wage increases. The only land available to the poor is often severely environmentally degraded land that is located adjacent to polluting industries and/or along rivers (Douglass, 1999).

Industrial wastewater discharge is a serious problem in most developing countries, including Nigeria, Tanzania and the countries with middle economies. In Dar es Salaam, various industrial wastes and domestic effluents, including automobile garages and car wash discharge wastes into the streams that constitute Msimbazi sub catchment (Mwegoha and Kihampa, 2010). The consequences on water quality and livelihoods remain least documented; hence, the proposed study.

1.2 Statement of the Research Problem

Growth of industries is being witnessed in various cities and towns of Tanzania, with 80% of the industries located in the city of Dar es Salaam (CEP, 2006). Industries such as Oil, soap and detergents, FIDA, OK (footwear and rubber products industry), abattoir and steel manufacturing establishments discharge their raw wastes into the

Msimbazi sub catchment; which is an important source of water for industrial, domestic and agricultural uses for a dynamic population along the sub catchment. The discharge of raw wastes from industries could be affecting water quality and people's livelihoods along the sub catchment. Information on the dynamics between growth of industries and discharge of wastes into Msimbazi sub catchment is not adequately articulated. On the other hand, there is little known about the types and abundance of pollutants discharged by industries into the water system and their effects on the livelihoods along the sub catchment hence; the purpose of this research study.

1.3 Justification of the Study

This study assessed levels of industrial pollutants and their effects on water resource and livelihoods along Msimbazi sub catchment. The basis for conducting the study was guided by different reasons. Firstly, Msimbazi sub catchment flows across one-third of Dar es Salaam City and it is one of the densely populated areas of Dar es Salaam (Ak'habuhaya and Lodenius, 1988). Secondly, Msimbazi sub catchment is an important water source for residents of some areas of Dar es Salaam's poorest neighborhoods. Residents use the water for different purposes such as; for drinking, bathing, support for agriculture and industry. However, many industries continue to discharge wastes into the sub catchment, threatening most of its useful benefits, including irrigation (Mwegoha and Kihampa, 2010). There is limited current information about the types and abundance of pollutants discharged by industries into the water system, and their effects on people's livelihoods along the sub catchment. It is due to these reasons and the need to fill the gap of information that Msimbazi sub catchment was selected.

1.4 Research Questions

This study was guided by the following research questions:

i. What are the types and abundance of industrial pollutants discharged into Msimbazi sub catchment of Dar es Salaam?
ii. Are there any effects of industrial pollutants on water resources and livelihoods along Msimbazi sub catchment?
iii. How effective Tanzania National Industrial Policy?

1.5 Objectives of the Study

1.5.1 General Objective

To assess levels of industrial pollutants and their effects on water resources and livelihoods along Msimbazi sub catchment.

1.5.2 Specific Objectives

i. To determine the types and abundance of industrial pollutants discharged into Msimbazi sub catchment.
ii. To examine the effects of industrial waste discharge on water resources and livelihoods along Msimbazi sub catchment.
iii. To review the implementation of the relevant aspects of Tanzania National Industrial Policy on cleaner production and how it relates to industrial pollutants.

1.6 Significance and Anticipated Outputs

The study findings will contribute knowledge on the levels of industrial pollutants and their effects on water resources and livelihoods as future reference to studies in the water sector. Further, the study findings are significant to the local communities since they enhance their understanding about levels of industrial pollutants and their effects on water resources and livelihoods for better water management. The findings will also be shared with the Ministry for Industry & Trade and (NEMC) to help improve industrial policy implementation on water management. Also the results from the proposed research may result to research questions besides the issues addressed by the study.

1.7 Scope and Limitations of the Study

The study was conducted along Msimbazi sub catchment which originates 35 kilometres off the coast in Pugu forest, with the catchment area of approximately 260km^2 (Hobbelen, 2001). The research entailed analysis of water *in-situ* Potentiality of Hydrogen (pH), Dissolved Oxygen (DO), temperature, electrical conductivity and collected samples for laboratory analysis of Total Suspended Solids (TSS), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD) and turbidity as well as heavy metals (lead (Pb), cadmium (Cd) and chromium (Cr)) in order to determine types and the abundance of pollutants discharged. The study also reviewed the implementation of the relevant aspects of the Tanzania National Industrial Policy on clean production in relation to industrial pollutants. Lastly, the study assessed levels of industrial pollutants and their effects on water resources and the livelihoods along Msimbazi sub catchment. The study had anticipated facing one limitation, which was lack of awareness concerning levels of industrial pollutants and their effects on livelihoods among some respondents living along Msimbazi sub catchment. This limitation was ameliorated by taking water samples for laboratory analysis as well as doing literature review to validate the findings from the respondents.

1.8 Operational Definitions of the Terms and Concepts

1.8.1 Industrial Waste Discharge

Industrial waste discharge (IWD) refers to all wastewater from any producing, manufacturing, processing, institutional, governmental, commercial, restaurant, service, agricultural or other operation. Industrial waste discharge may also include cooling water and boiler blow down water (HRSD, 2012). Based on the study industrial pollutants refer to all wastes discharged into the sub catchment by the industries that are established along the Msimbazi sub catchment.

1.8.2 Water Pollution

Water pollution is commonly defined as any physical, chemical or biological change in water quality which adversely impacts on living organisms or which makes a water resource unsuitable for one or more of its beneficial uses (UNEP/WHO, 1988). Water pollution on this study means any physical, chemical or biological change in water quality which affects living organisms or makes water resource unsuitable for one or more of its beneficial use as the result of industrial waste discharge.

1.8.3 Sub Catchment

Sub catchment refers to an area of land within which all waters flow to a single river system. Natural and human systems such as rivers, bush land, farms, dams, homes, plants, animals and people can co-exist in a sub catchment. Sub catchment on this study is Msimbazi River of the Wami/Ruvu Basin, as which consists of the two main rivers of Wami and Ruvu, which drain into the Indian Ocean.

1.8.4 Livelihood

According to Chambers and Conway (1992) a livelihood comprises the capabilities, assets (including both material and social resources) and activities required for a means of living. Livelihood based on this study refers to health and activities that are carried out by residents living along Msimbazi sub catchment such as urban agriculture, sand mining, livestock keeping, residential houses /settlement, and small business.

1.8.5 Cleaner Production

According to UNEP, (1990), Cleaner Production is "the continuous application of an integrated preventative environmental strategy to processes, products and services to increase overall efficiency, and reduce risks for humans and the environment". Cleaner production for this study: means an industrial production that continuous apply technologies that reduce pollution from industries such as on site management including Effluent Treatment Plant (ETPs.)

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

This section reviews the relevant literature on levels of industrial pollutants and their effects on water resources and livelihoods. It is reviewed under the types and abundance of pollutants discharged by industries, effects of industrial pollutants on water resources and livelihoods and industrial Policy. Research gaps are identified in the field of industrial waste discharge on water resources and livelihoods. The chapter is organized around the specific objectives of the study. It also consists of the conceptual framework guiding the study.

2.2 The Types and Abundance of Pollutants Discharged by Industries

Industries vary considerably in terms of process, technology, size and nature of products generated. So are the types and abundance of the industrial wastes discharged (EPA, 2003), which differ from location to location depending upon the industries that generate the wastes, groundwater levels, and degree of separation between storm water and sanitary wastes. Agro-industries, chemical factories, breweries, soap and steel manufacturing establishments contribute directly or indirectly to the pollution of Msimbazi River (CEP, 2006). Industrial waste water has a wide range of pollutant concentrations; mainly: oil and grease, Total Suspended Solids (TSS), pH, and Biochemical Oxygen Demand (BOD) and the priority pollutant heavy metals (Environmental Protection Branch of Canada, 1996). According to Ekhaise and Anyasi (2005), industrial waste discharge include heavy metals, pesticides, polychlorinated biphenyls (PCBs), dioxins, poly-aromatic hydrocarbons (PAHs), petrochemicals, phenol compounds and microorganisms.

This study looked at the types and abundance of pollutants discharged by industries into Msimbazi sub catchment such as heavy metals (lead, cadmium and chromium), TSS, BOD, COD, turbidity as well as pH, DO, temperature and electrical conductivity.

Electrical Conductivity (EC) is a measure of the capability of a substance to conduct an electric current. It is an indirect measurement of the content of ions in the water. It relies upon the presence of ions, from their common concentration and the water temperature. High values of EC indicate the source of pollution in a particular water source (Durmishi *et al.* 2008). Conductivity is measured in terms of conductivity per unit length, and meters typically use the unit micro Siemens/cm (µS/cm).

Potentiality of Hydrogen (pH) refers to the measure of acidity or alkalinity. Pure water has a pH of 7, acidic solutions have lower pH values and alkaline solutions have higher values. The pH of a material ranges on a scale from 1-14, where pH 1-6 is acidic, pH 7 is neutral, and pH 8-14 is basic. Turbidity is an expression of the optical property that causes light to be scattered or absorbed rather than transmitted in straight lines through a water sample (Smith and Davies-Calley, 2001). Turbidity in water is resulted by the presence of suspended matter such as clay, silt, finely divided organic and inorganic matter, plankton, and other microscopic organisms.

Biochemical Oxygen Demand (BOD) is a chemical procedure for determining the amount of dissolved oxygen needed by aerobic biological organisms in a body of water to break down organic material present in a given water sample at certain temperature over a specific time period (Walakira, 2011). Chemical oxygen demand

(COD) is the amount of oxygen required to completely oxidize the organic matter in waste water by use of a strong oxidant and to convert it to carbon dioxide and water (Walakira, 2011). COD measurements are commonly made on samples of waste waters or of natural waters contaminated by domestic or industrial wastes. It allows for assessment of the pollution load of wastewater, including pollution by undesirable organic compounds. COD is one of the most important measures for effluent discharge standards. Dissolved Oxygen (DO) is an important pollution assessment parameter of the receiving water bodies (Vinod and Chopra, 2012). It's an important ecological parameter because the level of DO allows breathing of living organisms in water. It is a requirement for almost all forms of life. Aquatic animals, plants and most bacteria require it for respiration (getting energy from food), as well as for some chemical reactions.

2.3 Effects of Industrial pollutants on Water Resources and Livelihoods

2.3.1 Levels of industrial pollutants and their effects on Water Resources

Wang (2005) indicates that industry is not only the direct user of various resources and energies, but also the main sources of water pollution whereas; Drechsel *et al*. (2010), assert that untreated wastewater may contain a range of pathogens including bacteria, parasites, viruses, toxic chemicals such as heavy metals and organic chemicals from industry and other sources. Industrial waste discharge leads to physical and chemical stressors like changes of water quality, while biochemical oxygen demand (BOD) and the aesthetic appearance of the marine water may be affected by loss of clarity due to suspended solids in the discharge or by surface oil sheen (EPA, 2004).

Although the level of industrialization in Tanzania is relatively low, untreated industrial wastes causes significant levels of localized effects since industrial effluents are discharged untreated or partially treated into nearby water bodies (CEP, 2006). Further, CEP (2006) adds that about 80% of the industries in Tanzania, including agro-industries, chemical factories, breweries, soap and steel manufacturing establishments are located in the coastal city of Dar es Salaam. This causes numerous effects on water resources adjacent to the water sources where industrial effluents are discharged. In addition, Mato and Kaseva (1999) reported that more than 122 industries established in Dar es Salaam produce about 127 tons of hazardous wastes per day, which is about 40% of the total industrial solid waste production in Dar es Salaam. This study looked at the current status of industrial waste discharge along the sub catchment.

2.3.2 Levels of industrial pollutants and their effects on Livelihoods

Municipal sludge may contain high concentrations of heavy metals such as cadmium, lead, nickel and chromium. The presence of industrial wastewater results to the concentrations of metals 10 to 20 times higher (Chang *et al*., 1995). Toxicants from Industrial waste discharges may make areas unsuitable for recreation, may result in health complications if water is swallowed or may cause skin irritation (EPA, 2004). Human health effects potentially linked to exposure to these chemicals include: breast, prostate and testicular cancer; diminished semen quantity and quality; and impaired behavioral, mental, immune and thyroid function in children (WHO, 1999).

The health effects associated with use of contaminated water are serious although direct evidence of adverse health effects in humans is lacking (WHO, 1999).

According to WHO (1999), the effects of exposure to heavy metals like chromium include reproductive abnormalities and altered immune function. Population disruption potentially linked to exposure to these substances has been observed in amphibians, birds, fish, invertebrates, mammals, and reptiles (WHO, 1999). In some parts of China where irrigation using wastewater that is heavily polluted with industrial wastes has occurred for many years, health effects have been observed such as increased rates of liver and stomach cancer (Yuan, 1993). It is also likely that consumers of contaminated freshwater fish or shellfish might be exposed to these toxins (Chorus and Bartram, 1999). Prolonged exposure to heavy metals such as cadmium, copper, lead, nickel and zinc can cause deleterious health effects in humans such as kidney failure, mental depression and ulcer (Reilly, 1991).

Industrialization brings unintended and adverse effects to the natural resources and livelihoods among dwellers within the locality. Air, soil and water pollution from industrial sources frequently reduces agricultural yields and lowers health status. The impact of the effluents is so large that the water has become unfit for drinking and irrigation (Waziri, 2006). A vital aspect is water pollution, which can affect a river system for many kilometers downstream from the point of release of pollutants. (Oluseyi, 2011).

Industrial effluents also contain heavy metals that are directly harmful to human health and the ecosystem (Oluseyi, 2011). Apart from health effects, which indirectly affect human productivity, polluted water also affects land productivity where crop production suffers from contaminated irrigation water from both surface sources and from ground water aquifers (Oluseyi, 2011). This study concentrated on the effects of industrial waste discharged on water resources and livelihoods. It looked at the components like health, livelihood activities and access to resources by the people living along Msimbazi sub catchment.

2.4 Industrial Policy

Industrial policy forms a key element of a national framework and program to promote cleaner production which can influence significantly towards production with lower pollution potential, and the production efficiency of those industries which are established (UNIDO, 2000). There are two categories of policy measures that can influence the effect of industrial activity on the environment; one is industrial policies that indirectly affect the environment and the other is environmental policy which deliberately aims to protect the environment (UNIDO, 2000). Effective environmental policy and regulations have a potentially greater impact on industries than industrial policy itself because they attempt to directly address the environmental problems at the source and force industries to incorporate environmental costs (UNIDO, 2000).

In 1996 the Government of Tanzania launched the Sustainable Industrial Development Policy (SIDP) (1996-2020) to replace the Basic Industry Strategy (BIS) 1975-1995 (URT, 1996). SIDP's main mission is to contribute towards the achievement of the overall national long-term development goals as enshrined in the overall national vision, and to enhance sustainable development of the industrial sector. The main objectives of the policy are: human development; creation of employment opportunities; sustainable economic growth; environmental sustainability; and equitable development (URT, 1997). On the other hand the Industrial policy objectives with respect to environmental protection are the prevention, reduction, control and limitation of damage, and minimisation of the risk from the generation, management, transportation, handling and disposal of hazardous wastes, other wastes and emissions. In order to facilitate implementation of SIDP (1996-2020), the major institutions which are crucial actors in the process of industrialization include the government, the private sector and allied agencies that are appropriately structured to effectively play their respective roles.

The government promotes the continuous application of an integrated preventive environmental strategy to industrial processes, products and services. This strategy includes efficient use of raw materials and energy; elimination of toxic or dangerous material, as well as reduction of emissions and wastes at source as a key component (UNEP, 2002).

In view of policy, the government developed the capacity within its institutional machinery to support other initiatives designed to enhence application of cleaner production concept as an important complement to end-of-pipe pollution control. Cleaner production as a concept was introduced by UNEP's Industry and Environment Centre (UNEP IE) in 1989, and has since gained considerable ground worldwide. It focuses on preventing pollution rather than simply controlling it or cleaning it up after the event. This study reviewed the implementation of the relevant aspects of the Tanzania National Industrial Policy on cleaner production in relation to industrial waste discharge in order to see its strength weakness, opportunities and threats. The implementation of the relevant aspects of the Tanzania National Industrial Policy may be resulting to industrial waste discharge into water bodies hence the undertaking of the study.

2.5 Conceptual Framework

Studies on levels of industrial pollutants and their effects such as heavy metal have been done globally including India (Reza and Singh, 2010). The main anthropogenic source of heavy metals in the water systems is the discharge of untreated or partially treated wastes from different industries (Reza and Singh, 2010). Industrialization brings unintended and adverse effects to the natural resources (such as water) and livelihoods of dwellers within the locality (Oluseyi, 2011). The pollution might have direct influence on the environment (Ak'habuhaya and Lodenius, 1988). Wastes from industries can cause serious health risks (Salam, 2010) that can affect water resource in the area where it is discharged. On the other hand, the discharge of heavy metals into water bodies may affect human health especially when water is taken directly or indirectly through food chains.

A framework to guide the research questions to be asked and types of analyses to be conducted is hence necessary to ensure that the research considers the significant issues. It will also ensure that the research outcomes address the intended purpose of understanding how industrial waste discharge affects water resources and livelihoods. A Drivers, Pressure, State, Impacts and Response (DPSIR) framework was more widely adopted by the European Environmental Agency for environmental reporting (Figure 2.1). The framework addresses the relationship between "indicators" such as environmental pressure (the human activities leading to a stress), the states of the environment affected by e.g., physical, chemical and biological change in characteristics of water, and response can be in policies adopted to resolve the problem and achieve the intended goals.

This study has adopted the advanced DPSIR framework developed by Kristensen (2004). According to the modified DPSIR framework, there is a chain of causal links starting with "*driving forces*" (human activities) through "*pressures*" (emissions, waste) to "*states*" (physical, chemical and biological) and "*impacts*" on ecosystems, human health and functions, eventually leading to political "*responses*" (prioritization, target setting, indicators). Describing the causal chain from driving forces to impacts and responses is a complex task, and tends to be broken down into sub-tasks, for example, by considering the pressure-state relationship in figure 2.1 (Kristensen, 2004).

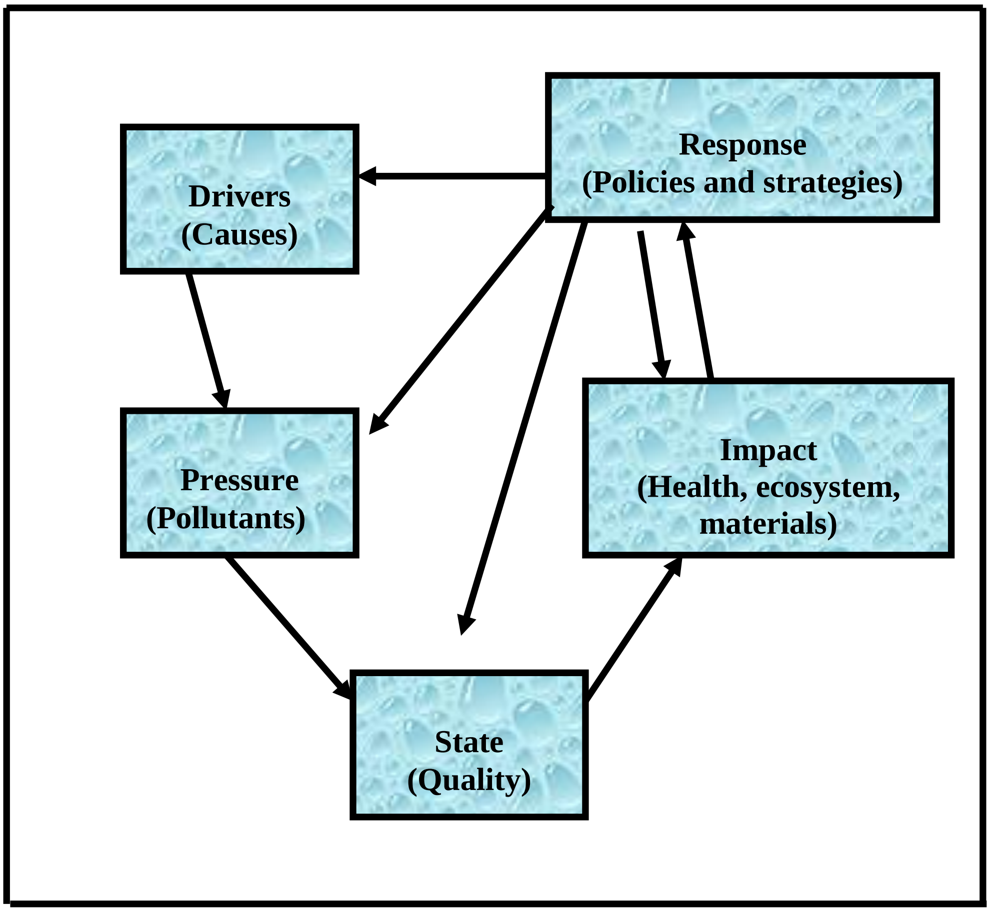


Figure 2.1: The DPSIR Assessment Framework

Source: (Adapted from Christensen, 2004).

The above DPSIR framework (figure 2.1) has been modified to (figure 2.2) which presents more suitable means for assessing effects of industrial waste discharge on water resources and livelihood along Msimbazi sub catchment. In the context of industrial pollutants wastes discharged by drivers such as industries caused pressure into the receiving water systems (Mwegoha and Kihampa, 2010).

In this study, it is assumed that industrial waste discharge is influenced by anthropogenic drivers such as industries. This driver among others has caused pollutant pressure on Msimbazi sub catchment such as heavy metals (Mwegoha and Kihampa, 2010). The state of the Msimbazi sub catchment includes reduced quality of water and other resources which make it unsuitable for livelihood. To reduce severity of the effects various mitigation measures can be taken, these include industrial waste treatment or management in the industrial sites and improved information.

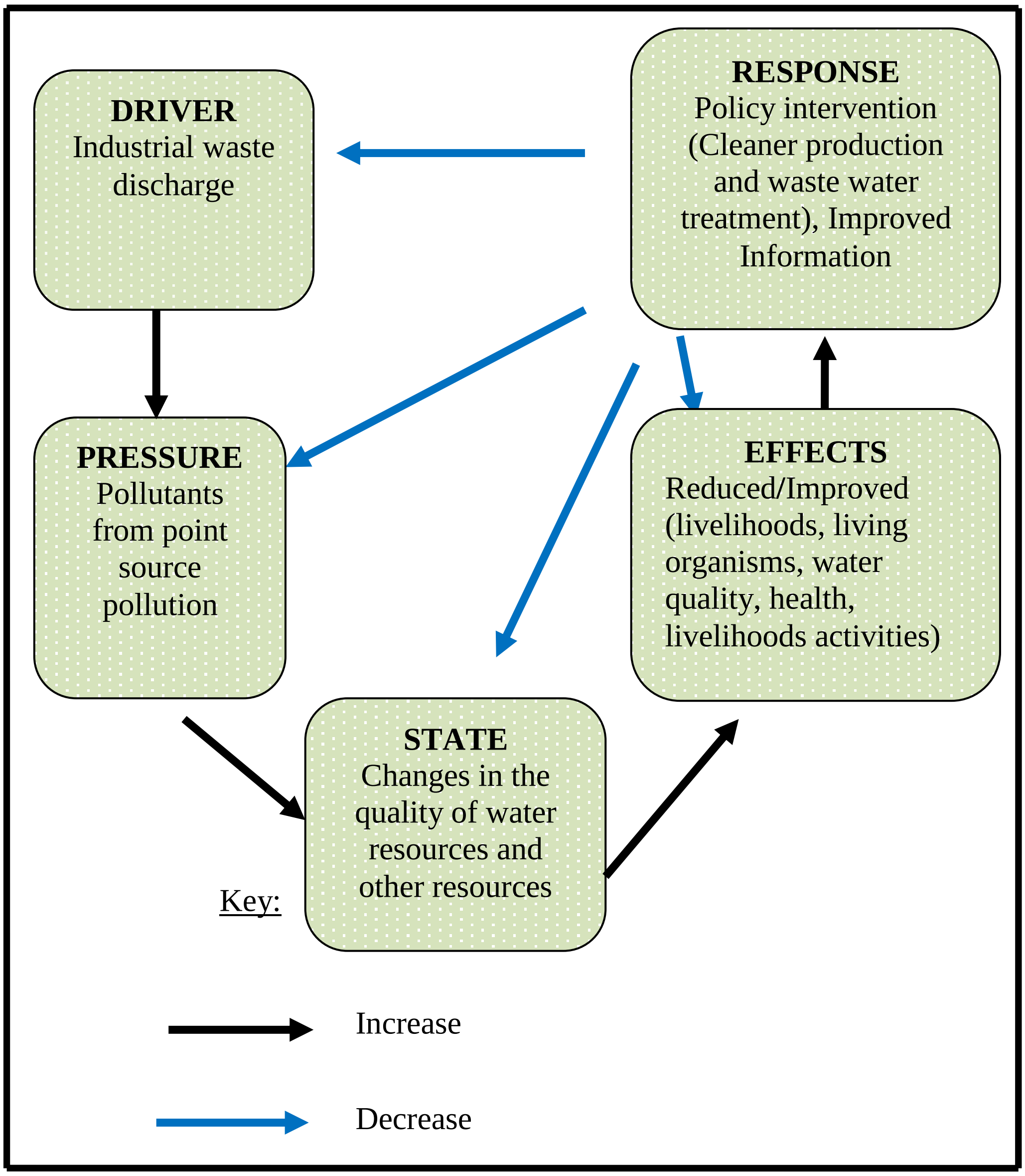


Figure 2.2: The Conceptual Framework for Effects of Industrial Pollutants on Water Resources and Livelihoods

Source: (Adopted and modified from Kristensen, 2004).

CHAPTER THREE: MATERIALS AND METHODS

3.1 Introduction

This study aimed at assessing the effects of industrial pollutants on water resources and livelihoods along Msimbazi sub catchment. This chapter builds up from the literature review in order to develop theoretical framework. Data was collected in the study area (Msimbazi sub catchment) to assess the achievement of the objectives of the study. Data analysis was done with the aim of understanding and filling the knowledge gaps concerning the effects of pollutants on water resources and livelihoods. Analyses were done to contribute on the existing knowledge for sustainable industrial waste management in future as well as make recommendations on policy matters for improvements.

3.2 Study Area

3.2.1 Administrative Units

The study area is located between latitudes 6°C and 7°C south of the Equator and between longitudes 39°C and. 39° C East of Greenwich (figure 3.1). The Msimbazi sub catchment fall under the Wami/Ruvu River basin and originates 35 kilometers off coast in Pugu forest, has an area of approximately 260 km^2 (Hobbelen, 2001). This sub catchment runs through the city of Dar es Salaam.

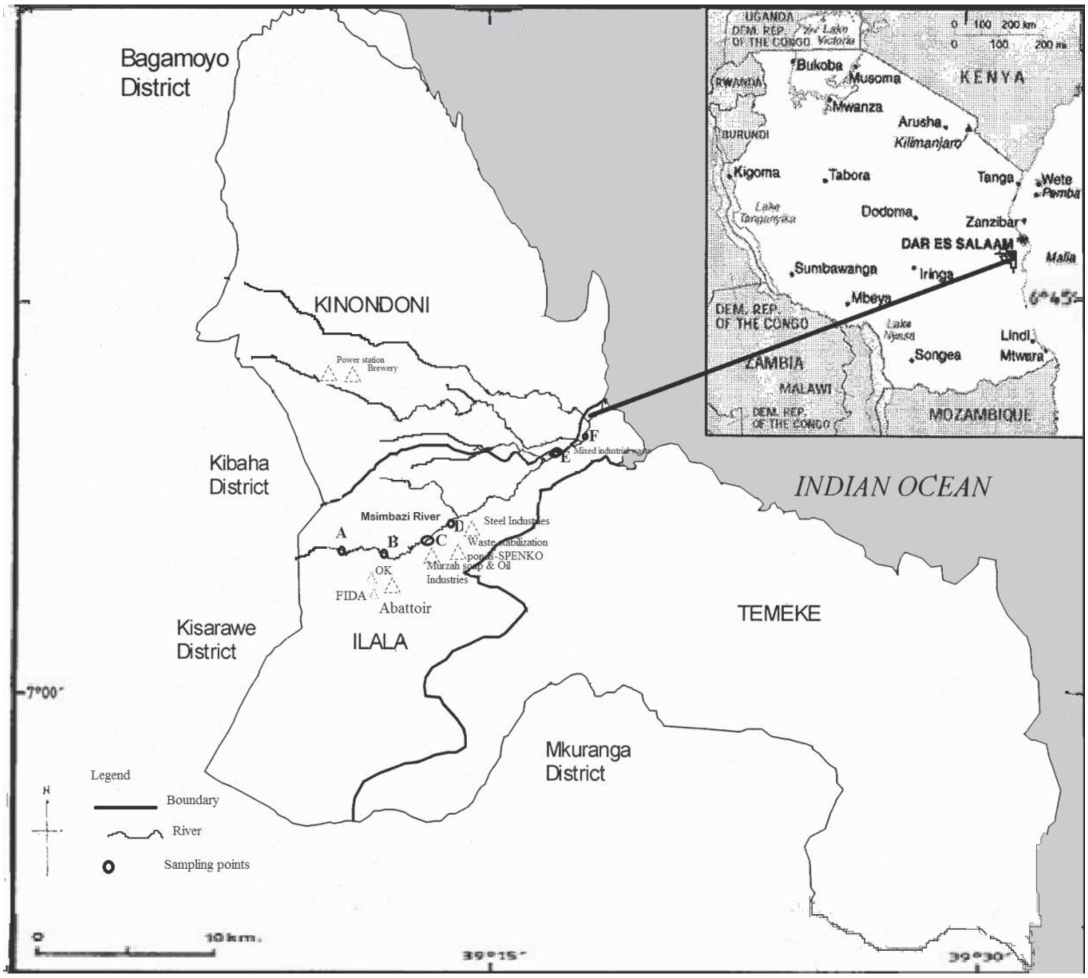


Figure 3.1: The Map of the Study Area

Source: (Survey and Mapping Division; Ministry of Housing and Human Settlements, 2008).

3.2.2 Climate

Msimbazi sub catchment experiences mainly a modified equatorial type of climate. It is generally hot and humid throughout the year with an average temperature of 29°C. The hottest season is October - March when temperatures rise up to 35°C. It is relatively cool between May and August, with temperature around 25°C. There are two main rain seasons: a short rain season October - December and a long rain season between March and May. The average rainfall is 1000 millimeters (lowest 800 millimeters and highest 1300 millimeters). Humidity is around 96% in the mornings and 67% in the afternoons. The climate is also influenced by the south-westerly monsoon winds from April - October and north-westerly monsoon winds between November and March. Msimbazi sub catchment cuts across different ecological zones existing across the city; such as upland zone comprising the hilly areas to west and north of the city, the middle plateau and the low lands zones (DCC, 2004; DCC and JICA, 2007). The rainfall data for the year 2012 are shown in table 3.1 and the data were collected during the month of May.

Table 3.1: Monthly Rainfall and Temperature for Dar es Salaam Station

Month	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**July**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Rainfall (millimeter)	32.0	36.4	49.9	263.5	109.6	9.7	3.7	19.2	15.8	0.8	124.0	66.8
Temperature (◦C)	32.4	33.3	33.3	32.2	31.3	31.2	31.0	31.4	31.5	32.6	32.4	33.4

Source: (*Tanzania Meteorological Agency*, 2012).

3.2.3 Population

Dar es Salaam City, which is a commercial capital and largest urban centre in Tanzania, has a projected population of 3.5 million, growing at an average rate of 4.3% per annum, with an estimated spatial expansion of 7% per year (2002 National Census). According to City Profile of Dar es Salaam (2004), Msimbazi sub catchment passes through Kinondoni and Ilala Districts of Dar es Salaam region that have a total population of 2,000,000 and the total number of 414,384 households; with Ilala District having 150,515 households and Kinondoni 263,869 households.

3.2.4 Soil and Vegetation

Msimbazi sub catchment soil ranges from deep poorly drained heavy clay soils to shallow drained medium textured stratified soils. It has soil mixed with alluvial deposited sand, and poorly drained silt clays enriched with organic matter (Kebede and Nicholls, 2010). The main natural vegetation in valley includes coastal shrubs, coastal swamps and mangrove trees (CEP, 2006). Other vegetations that are found in the area include; coconut trees, tree crops along the roads and vegetables, cereals, tubers and perennial crop such as sugarcane (CEP, 2006).The plate 3.1 shows the coconut trees, among the vegetations in the study area.

Plate 3.1: Coconut trees along Msimbazi Sub Catchment

Source: (*Field Survey*, 2012).

3.2.5 Current Land Use

Msimbazi sub catchment is characterized by a variety of land uses. The main land use in the sub catchment is human settlement, with a great majority of the population living in unplanned and informal settlements (UN-Habitat, 2009). Other land use activities include agriculture for green vegetables, industries SUKITA, Murzah soap and detergent limited, FIDA, OK (footwear and rubber product industry), Vingunguti Abattoir, Tanzania and China friendship Textile, Maxon industry (paper manufacturer), car washing, sand mining for construction, SPENKO (waste stabilization ponds) and settlements (Dar es Salaam master Plan, 1979). The Msimbazi sub catchment has water resources like river and groundwater which is highly saline. The types of livelihoods along the sub catchment include agriculture, livestock keeping, car wash, sand mining and small business. Below are plate number 3.2 and 3.3 showing current land use along Msimbazi sub catchment.

Plate 3.2: Land use along Msimbazi Sub Catchment (Sand mining & car washing)

Source: (*Field Survey*, 2012).

Plate 3.3: Vegetables, rice coconuts and settlements along Msimbazi Sub Catchment

Source: (*Field Survey*, 2012).

3.3 Sampling Methods and Procedures

3.3.1 Setting of Sampling Stations for Water Samples

The study was carried out along Msimbazi sub catchment, involving selection of sampling stations based on the objectives. The total numbers of six main sampling stations was planned in advance (figure 3.2). The waste water samples were obtained for a thorough investigation of water quality; were taken from the sampling stations along the sub catchment during the morning hours.

The stations of sampling points are as shown in the Figure 3.2. Station A was a point upstream from the industries before effluent from industries starts polluting the sub catchment and station F, downstream, is a point where waste water from various sources have already mixed.

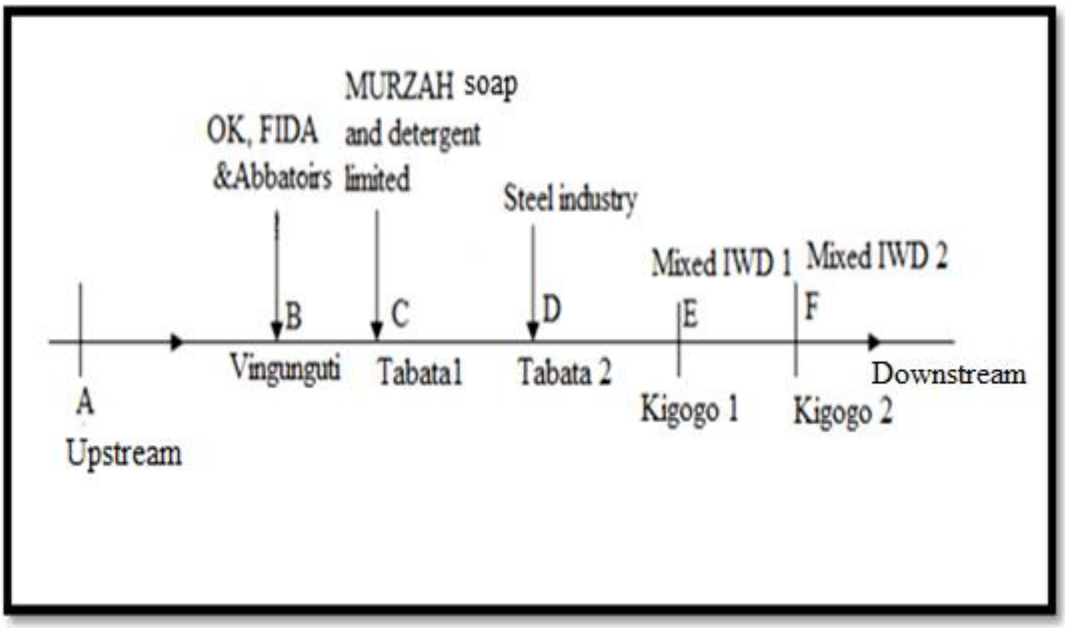


Figure 3.2: Schematic outline of Msimbazi Sub Catchment main Sampling Stations

Source: (*Field Survey*, 2012).

Table 3.2: Pollutants Generated by Selected Industries Along the Sub Catchment

INDUSTRY	**ACTIVITY**	**POLLUTANTS/NATURE OF EFFLUENT**
OK	Footwear and rubber products manufacturer	Toxic chemicals and chemical categories.
FIDA	Agriculture processors, wholesalers and exporters	Solid wastes, pH, BOD and Turbidity
Vingunguti Abattoir	Animal Slaughter area	Solid wastes, Turbidity, BOD
Murzah Industry	Soap and detergent producer	oil and grease, BOD, COD, synthetic detergents, pH, heavy metals (Nickel) and TSS, TDS, color, and pH.
St. Abri (steel Industry)	Metal fabrication	High Suspended Solids, High acid, Chromiam

Source: (*http://www.zoomtanzania.com*, 2012, *Kanu, and Achi*, 2011 *Egyptian Environmental Affairs Agency*, 2002)

3.3.2 Collection of Water Samples

All water samples for laboratory analysis were collected in sterilized and distilled plastic bottles. The samples were placed in a cool box and later transported to the laboratory for analysis.

The water samples for heavy metal estimations were collected in separate 1 litre plastic bottles and were preserved with 5 ml Nitric Acid per liter to prevent metal adsorption in the surface of the container.

Samples at (stations B, C and D), were taken at the points where industrial wastes are discharged into the sub catchment. The other remaining samples were taken along the other sections of the sub catchment i.e.; station A taken upstream from the industries while stations E and F were taken along the sub catchment where wastes had already mixed thoroughly. To ensure that samples were representative; three samples were taken at each main sampling station. Samples were taken at point where wastes were entering the sub catchment, mixing point and at the center of the stream. Sampling was performed in the months of May, during semi-dry season, when the river flow is lower; the level of dilution is modest. The waste water samples were obtained the following sampling stations:

3.3.2.1 Upstream from the industries (Sampling station A)

This station was strategically positioned to obtain water samples taken upstream before the industrial zone. At this point no significant effluent discharge into the sub catchment was noted, the water was used by the people for bathing, washing clothes, washing vegetables and for irrigation.

3.3.2.2 Vingunguti (Sampling station B)

Second category of water samples was taken at sampling station B (Vingunguti). This sampling point represented the beginning of effluent discharge into the river. The water flowing to this site was polluted due to industrial waste discharge such as the Vingunguti Abattoir, FIDA (Agriculture processors, wholesalers and exporters) and OK (footwear and rubber products industry) (footwear and rubber product industry).

3.3.2.3 Tabata 1 (Sampling station C)

The third categories of samples were obtained from station C (Tabata 1), before the bridge along the Msimbazi sub catchment. This location was selected as one of the areas where an industry such as Murzah soap and detergents industry, discharges the wastes along the sub catchment.

3.3.2.4 Tabata 2 (Sampling station D)

The fourth category of samples was taken at station D (Tabata 2) after the bridge along Msimbazi sub catchment. This sampling station depicts the area of waste discharge from industries such as steel industry.

3.3.2.5 Kigogo 1 (Sampling station E)

The fifth category of samples was taken at station E (Kigogo 1). This site was considered by the study as mixed industrial effluents. There was some livelihood activity carried out at this point such as sand mining activities.

3.3.2.6 Kigogo 2 (Sampling station F)

The sixth and the last category of samples were taken at station F (Kigogo 2) downstream of the Kigogo Bridge along the sub catchment. Water at this location is used for car washing.

3.3.3 Households' Samples

The household samples for the study were drawn using systematic sampling whereby a first house was selected randomly then after every two households a sample for the study was selected. The households were picked in relation to where water samples were taken at the distance of five hundred metres from both sides of the sub catchment.

The sample size of the study was based on the total number of households which was 414384 and was calculated using the following formula (Equation 1). The equation 1 is adopted from Glenn (1992) and is best placed for qualitative studies like the current study.

Equation1: $$n=\frac{N}{1+N\,(\alpha)^{2}} \qquad (1)$$

Where n = sample size, N = total number of households, α = margin of error set at 10%.

Using the above formula, the sample size was calculated as follows:

Equation 2: $$\text{Sample size} = \frac{414{,}384}{1+414{,}384(10\%)^{2}}$$

$$\approx 99.99 \qquad (2)$$

The formula gives almost equal to (≈) 99.99. Since there are not decimal in number of households the study sample size was approximated to 100 households.

3.4 Methods and Instruments of Data Collection

The study utilized both primary and secondary methods of data collection in obtaining the information on the types and abundance of pollutants discharged by industries, effects of industrial waste discharge on water resources and livelihood. Also on the implementation of relevant aspects of Tanzania National industrial Policy (SIDP) on cleaner production and its relation with industrial waste discharge along the Msimbazi sub catchment.

3.4.1 Primary Data Collection

The primary data were collected through *in situ* measurements, laboratory analysis, questionnaires, interview guide, observation as well as field photos.

3.4.1.1 *In Situ* Measurements and Laboratory Analysis

Primary data on the types and abundance of pollutants discharged by industries was generated through laboratory analysis of water samples obtained from the sub catchment as well as *in-situ* measurements. A total number of 18 water samples were collected. The water samples were analyzed for components such as temperature, Dissolved Oxygen (DO), Electrical Conductivity (EC), Total Suspended Solids (TSS) Turbidity as well as Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD). Inorganic components or heavy metals were also analyzed included chromium, lead and cadmium.

For determination of parameters equipments and instruments used included; for measures of temperature steel thermometer was used and the results were expressed in degrees centigrade (°C). Turbid meter was used for turbidity, the results were expresses in Nephelometric Turbidity Units (NTU); Conductivity meter was used for the EC measurement. pH meter was used for pH test. The electrode of the meter was rinsed with distilled water and buffer solution was used to calibrate the meter. TSS was analyzed by gravimetric method (filtration, weighing of residue), dissolved oxygen was measured using oxygen electrodes. COD was measured by Dichromate oxidation and titration with ferrous ammonium sulphate. BOD was analyzed through 5 days incubation at 20°C and measuring of initial and final dissolved oxygen. Lead, cadmium and chromium were measured using atomic absorption spectrometer (AAS). Chemical reagents were prepared as described by (UNEP GEMS, 2004).

3.4.1.2 Questionnaire Method

Data on levels of industrial pollutants and their effects in water resources and households along the sub catchment were collected using questionnaires that were personally administered (Appendix 1.0). Questionnaires were administered to the households to obtain information on levels of industrial pollutants and their effects on water resources and the livelihoods (urban agriculture, livestock keeping and people's health). Also observation and field photos methods were also employed.

3.4.1.3 Interview Method

Primary data on the implementation of relevant aspects of the Tanzania National Industrial Policy on cleaner production in relation to industrial waste discharge were collected using Interview Guide Method (Appendix 2.0 {I & II}). Thus, key informants from the Ministry for Industry & Trade and National Environmental Management Council were interviewed and the information collected supplemented with literature on relevant policy documents reviewed.

3.4.2 Secondary Data

Secondary data were collected from the National Bureau of Statistics (NBS) on the number of households for Kinondoni and Ilala districts through its 2002 National reports census.

3.5 Data Processing and Analysis

This study employed both qualitative and quantitative data analysis methods. The first step in data processing was editing and checking for errors completeness and relevance of the questionnaires responses, interviews, and observations, measurement of field results and laboratory analysis.

3.5.1 Qualitative Analysis

The qualitative analysis included the description of levels of industrial pollutants and their effects on water resources and livelihoods (urban agriculture, livestock keeping and health).Also it was used in analyzing the Strength, Weakness, Opportunities and Threats (SWOT) of the implementation of the relevant aspects of Tanzania National Industrial Policy. Data analysis was carried out using the SPSS version 18.0 software packages and Microsoft Excel 2007.

3.5.2 Quantitative Analysis

Quantitative analysis involved the laboratory analysis of sampled water for types and abundance of pollutants discharged by industries along the Msimbazi sub catchment. Thereafter, the findings were compared with the WHO and TBS standards for conformation. Moreover, other descriptive statistics such as; cross-tabulation, frequencies, percentages and mean will also be employed on such quantitative data. The analysis involved the use of SPSS software version 18.0 analyses and Microsoft Office Excel 2007.

Table 3.3: Summary of Research Methodology

Objectives	**Data required**	**Methods of data collection**	**Data Analysis**
To determine the types and abundance of industrial pollutants discharged into Msimbazi sub catchment.	Types of pollutants and their abundance	measurement Laboratory analysis Literature review	Quantitative analysis: percentages and mean using Ms Excel 2007
To examine levels of industrial pollutants and their effects on water resources and livelihoods along Msimbazi sub catchment.	Data on water resources Data on livelihoods (health, livelihood activities; urban agriculture, livestock keeping),	Structured questionnaire Digital camera (field photo)	Qualitative analysis: such as descriptive method and Qualitative analysis Microsoft Excel: Tables, charts and graphs. Quantitative analysis: Tables, frequencies, Percentages, Mean and Charts and Graphs using Ms Excel 2003 and Ms Excel 2007. SPSS (data coding and analysis)

To reviewed the implementation of the relevant aspects of Tanzania National Industrial Policy on cleaner production in relation to industrial waste discharge.	Industrial Policy Data on cleaner production	Interview guides and Literature review	Qualitative analysis: content analysis (SWOT analysis)

Source: (*Field Survey*, 2012).

CHAPTER FOUR: RESULTS AND DISCUSSION

4.1 Introduction

This chapter presents the results and discusses the research findings from Msimbazi sub catchment. The chapter begins with the laboratory results of water samples collected from the sub catchment for the types and abundance of pollutants discharged by industries, levels of industrial pollutants and their effects on water resources and livelihoods. The chapter ends with review of the implementation of the relevant aspects of Tanzania National Industrial Policy.

4.2 Types and Abundance of Industrial Pollutants into the Sub Catchment

The study sought to determine the types and abundance of industrial pollutants discharged into Msimbazi sub catchment.

It utilized both *in situ* and laboratory measurement. Temperature, pH, Dissolved Oxygen (DO) and Electrical Conductivity (EC) were measured *in situ* while parameters such as Total Suspended Solids (TSS), turbidity, Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) and inorganic components or heavy metals such as, chromium (Cr), lead (Pb) and cadmium (Cd) were measured in the laboratory. The research findings are presented in the table 4.1:

Table 4.1: Physical Chemical Parameters of Msimbazi Sub Catchment Water

AVERAGES FOR WATER QUALITY ANALYZED PARAMETERS										
S/ N	**PARAMETERS**	**UNIT**	**TBS STD**	**WHO STD**	**SAMPLE IDs**					
					A	**B**	**C**	**D**	**E**	**F**
1	pH		6.5-8.5	6.5-8.5	8.50	8.15	10.42	11.33	8.05	8.19
2	EC	μS/cm	3	3	2353	11493	6700	3067	3240	2830
3	DO	mg/l	*	8-10	7.39	0.00	0.46	0.57	0.00	1.29
4	COD	mg/l	60	*	35.07	2451.57	879.39	115.71	122.70	64.31
5	BOD	mg/l	30	10	2.57	9.00	462.67	226.67	151.33	129.00
6	TSS	mg/l	100	>10	11	993	29	112	86	86
7	TURBIDITY	NTU	300 NTU	5-50 mg/l	18	674	35	121	107	357
8	BODY TEMP	°C	20-35	<35	28.33	27.67	27.00	27.67	27.67	28.00
9	LEAD	mg/l	0.1	0.01	< - 0.01	0.106	0.126	0.276	0.192	0.066
10	CADMIUM	mg/l	0.1	0.003	0.010	0.004	0.009	0.006	0.014	0.010
11	CHROMIUM	mg/l	1	0.05	< - 0.010	0.165	0.193	0.345	0.101	0.156

Source: (*Field Survey*, 2012).

A= Upstream from the industries

B= Vingunguti

C= Tabata 1

D= Tabata 2

E= Kigogo 1

F= Kigogo 2

4.2.1 Electrical Conductivity (EC)

Electrical conductivity (EC) of water along Msimbazi sub catchment was measured *in situ*. The findings are presented in figure 4.1:

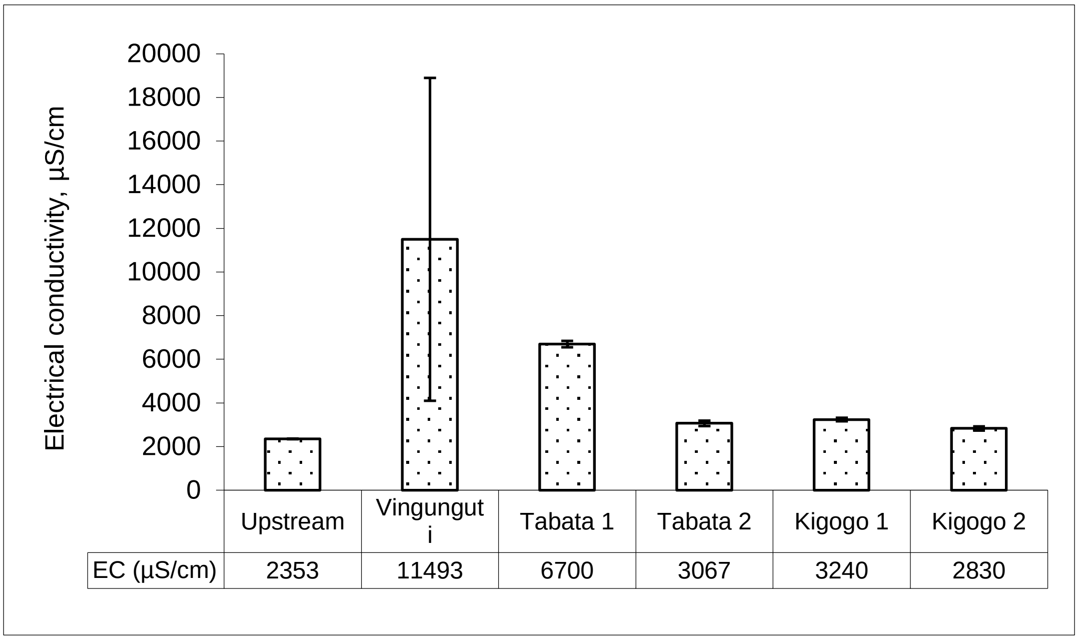


Figure 4.1: The Electrical Conductivity

Source: (*Field Survey*, 2012).

Figure 4.1 shows the results of EC along Msimbazi sub catchment which ranges from 2353µS/cm to EC of 11493µS/cm. The lowest value of EC2353µS/cm was measured at the sampling point upstream from the industries (sampling point A), whereas the highest EC of 11493µS/cm was measured at Vingunguti. The highest EC at Vingunguti can be attributed to the Vingunguti Abattoir and other industries such as OK (footwear and rubber products industry), FIDA (agriculture processors, wholesalers and exporters) that discharges its effluent direct to the sub catchment without treatment. The values of EC are above the permissible limits of TBS and the WHO which are 3µS/cm on both standards. The EC of the study was higher comparing to the previous works of Mwegoha and Kihampa (2010), Walakira (2011) and Durmishi *et al. (*2008).

4.2.2 Potentiality of Hydrogen (pH)

pH was measured along the Msimbazi sub catchment and the findings are shown in the figure 4.2:

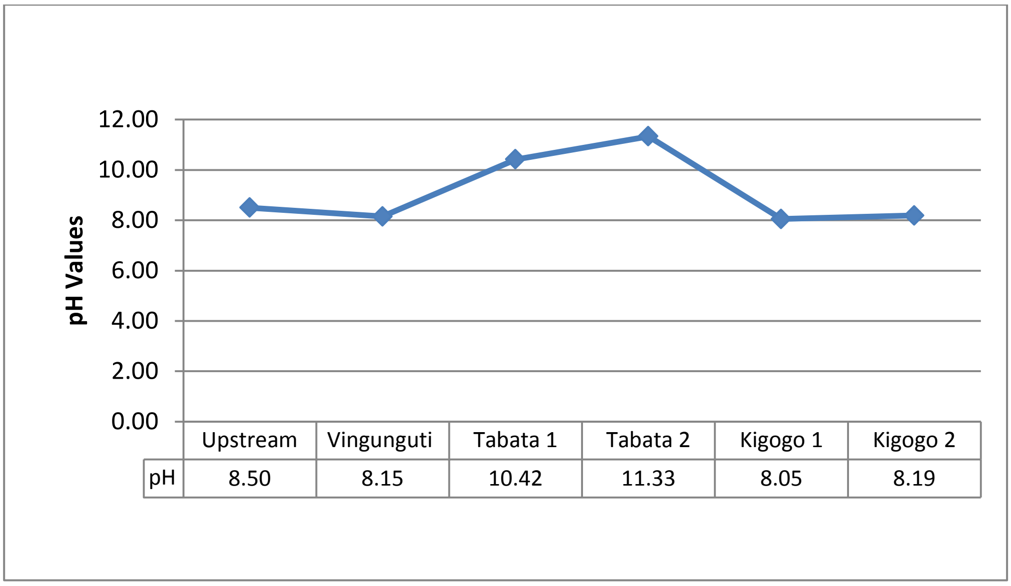


Figure 4.2: pH Levels

Source: (*Field Survey*, 2012).

Figure 4.2, shows different values of pH that ranges from 8.05 and to 11.33. Low pH value was measured at Kigogo 1 and the highest value was measured at Tabata 2. The highest pH of the effluent indicates the basic nature of the effluents. The pH values from Vingunguti, Tabata 1, Tabata 2 and Kigogo 2 exceed the national and international allowable limits of TBS and WHO which are 6.5-8.5. This means that all pH values along the sub catchment area are basic in nature. The values exceeding the national and international allowable limits can be attributed to the industries such as

OK (footwear and rubber products industry), FIDA, Vingunguti Abattoir and steel industries that are discharging wastes into the sub catchment. The pH of the study area varies from one point to another due to different activities that are taking place in each point, such as the industrial activities at Vingunguti point where the Abattoir, OK (footwear and rubber products industry), FIDA (agriculture processors, wholesalers and exporters) discharges wastes into the sub catchment. Murzah soap and detergents limited located at Tabata 1 and steel industry at Tabata 2 can be attributed to the varying pH in different sampling points in the study area. The pH values of the study are higher comparing to that of Durmishi *et al*., (2008) done in Shkumbini river. The pH of aquatic ecosystems depends on chemical and biological activity of water.

4.2.3 Temperature

Water temperature is an important physical parameter for aquatic ecosystems. In the study area temperature was analyzed along the sub catchment and the findings are presented in the table 4.2:

Table 4.2: Body Temperature for Msimbazi Sub Catchment

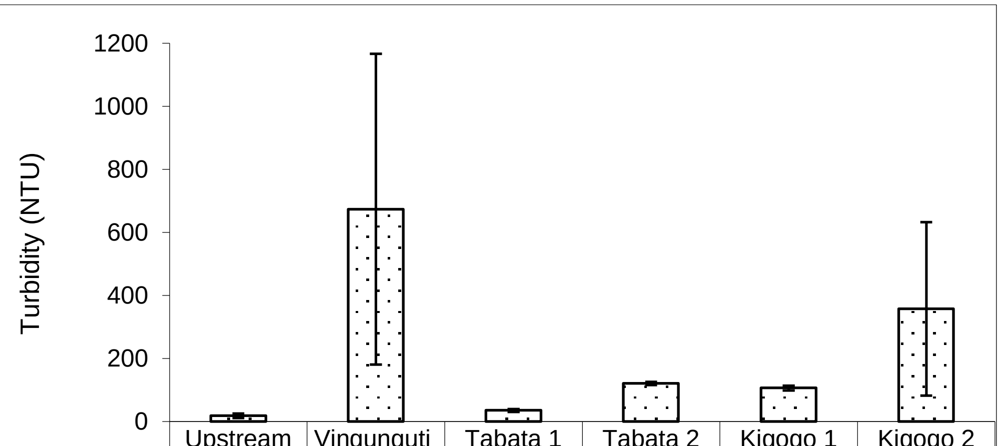
Sampling Location	Body Temperature °C	± Allowance error margin
Upstream	26.33	0.5
Vingunguti	27.67	0.5
Tabata 1	27.00	0.5
Tabata 2	27.67	0.5
Kigogo 1	27.67	0.5
Kigogo 2	28.00	0.5

Source: (*Field Survey*, 2012).

Table 4.2 shows the study findings from the study area. An allowance of 0.5 was provided as the margin of error. The level of temperature at the study area was low upstream from the industries with 26.33°C comparing to the temperature recorded in other sampling points such as Vingunguti with 27.67°C and decreased at Tabata 1 which had 27.00°C and remained constant at Kigogo 1. The highest temperature was recorded at Kigogo 2 which had 28.00°C; the increase in temperature can be attributed to the activities that are carried out around the point such as car washing**.** These concentrations are normal for aquatic lives, and have minimal effects on acidity. According to Durmishi *et al*. (2008), water temperature varies with season, elevation, geographic location, and climatic conditions. It's influenced by stream flow, river line vegetation, groundwater inputs, and water effluent from industrial activities.

4.2.4 Turbidity

The study examined the turbidity of the water in the area of study. The research findings are presented in figure 4.3:



	Upstream	Vingunguti	Tabata 1	Tabata 2	Kigogo 1	Kigogo 2
Turbidity(NTU)	18	674	35	121	107	357

Figure 4.3: Turbidity

Source: (*Field Survey*, 2012).

Figure 4.3 shows the findings from the study area. The turbidity of water along the sub catchment fluctuates from 18NTU to 674NTU sampling points such as Kigogo 2 had 357NTU, Tabata 2 121NTU and Tabata 1 recording the least turbidity at 35NTU comparing to that of upstream from the industries which had 18NTU. The highest values of 674NTU was recorded at Vingunguti and it can be attributed to industries (OK & FIDA) surrounding this area and the presence of larger slaughter house discharges wastes into Msimbazi sub catchment. The turbidity level upstream from industries, Tabata 1 & 2 and Kigogo 1 were within standards while the turbidity levels at Vingunguti (674NTU) and Kigogo 2 (357NTU) exceeded the TBS and WHO acceptable levels whereas WHO recommends 5-50mg/l and TBS recommends 300NTU. Plate 4.1 below shows the pollution source from the Vingunguti Abattoir directed to the Msimbazi sub catchment.

Plate 4.1: Source of industrial waste discharge (Vingunguti Abattoir)

Source: (*Field Survey*, 2012).

4.2.5 Total Suspended Solids (TSS)

The study analyzed the Total Suspended Solids (TSS). The levels of Total Suspended Solids found in the water samples from Msimbazi sub catchment vary from 11mg/l to 993mg/l. The findings are presented in figure 4.4:

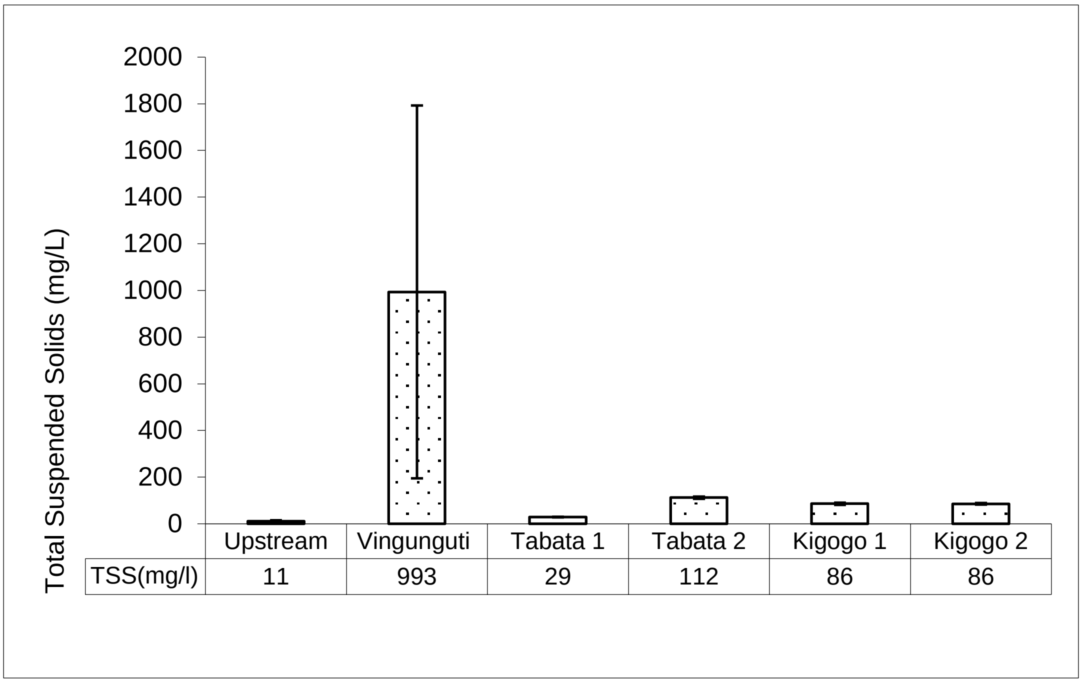


Figure 4.4: Total Suspended Solids (TSS)

Source: (*Field Survey*, 2012).

Figure 4.4 shows the TSS values along the sub catchment. The values range from 11mg/l to 993mg/l. The lowest value of TSS with 11mg/l was recorded upstream from the industries and the highest value of 993mg/l was recorded at the Vingunguti sampling station. The highest TSS can be linked to the discharge of wastes from the Vingunguti Abattoir. The TSS values in the three sampling stations (upstream from industries, Kigogo 1 and Kigogo 2) are within the TBS allowable limits whereas the other remaining sampling stations are above the allowable limits of TBS and WHO.

The results from the study area are in consistency with (Shakila, 2010) who found the level of TSS in effluents being greater than that of the permissible limit. On the other hand the TSS values from the study area were lower comparing to those presented by Azumi and Bichi (2010). Moreover, Somnath (2003) reported that larger solid particles of matter remains suspended as a result of charges on the surface of small particles in the effluent.

4.2.6 Biochemical Oxygen Demand (BOD)

The study analyzed Biochemical Oxygen Demand (BOD) from the water samples taken along the Msimbazi sub catchment and findings are presented in figure 4.5:

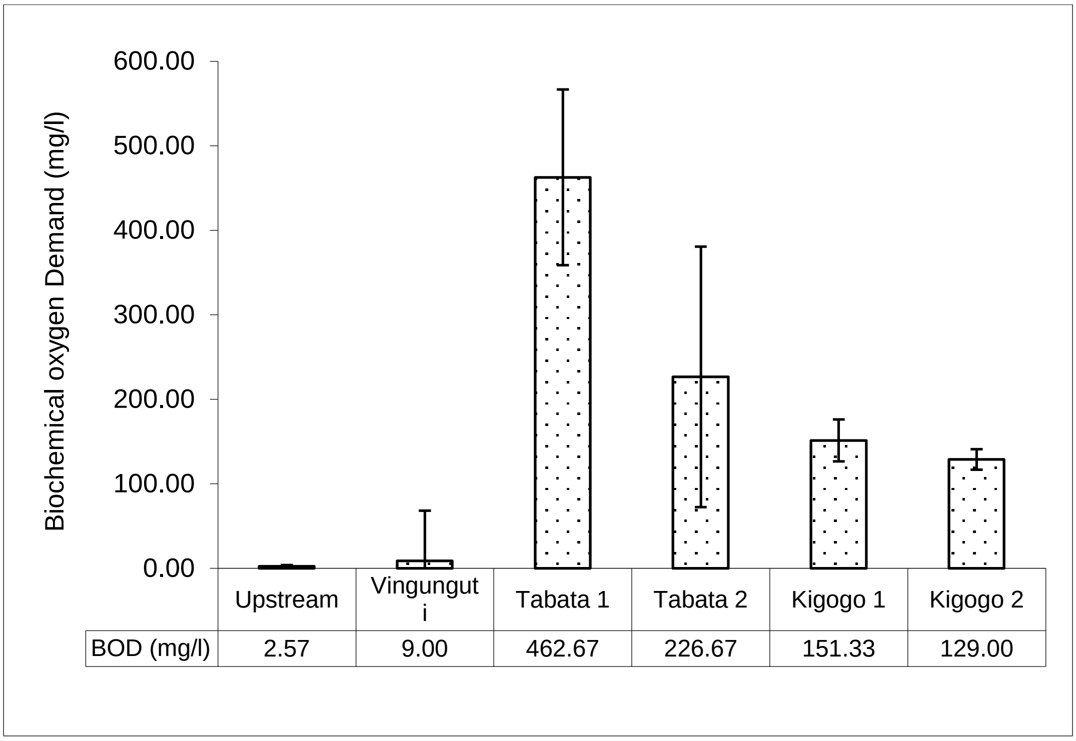


Figure 4.5: Biochemical Oxygen Demand (BOD)

Source: (*Field Survey*, 2012).

The study findings presented in Figure 4.5 shows the BOD. The BOD values of the study area ranges from 2.57mg/l to 462.67mg/l. The BOD values of the study area ranges from 2.57mg/l to 462.67mg/l. The lowest BOD of 2.57mg/l was recorded at the points upstream from the industries, followed by Vingunguti which recorded the lower BOD of 9mg/l. Kigogo 2 recorded the BOD of 226.67mg/l and Kigogo 1 had 151.33mg/l. Tabata 1 BOD was 226.67mg/l and it was highest at Tabata 1 which had the BOD of 462.67mg/l. The highest BOD at Tabata 1 can be linked to the industries like Murzah soap and detergent limited that discharge its wastes into the sub catchment while the higher BOD at Tabata 2 can be attributed to the steel industry that also discharges its wastes into the sub catchment. Only two sampling stations of upstream from the industries and Vingunguti were within the permissible limit of TBS and WHO which recommend the BOD of 30mg/l (TBS) and 10mg/l (WHO). The remaining sampling stations were exceeding TBS and WHO standards. The BOD findings from the study were higher compared to those presented by Durmishi *et al*., (2008). However the findings from the study were found to be low comparing to that of Mwegoha and Kihampa (2010.

4.2.7 Chemical Oxygen Demand (COD)

The study analyzed the COD of water sampled along Msimbazi sub catchment. The results are presented in figure 4.6:

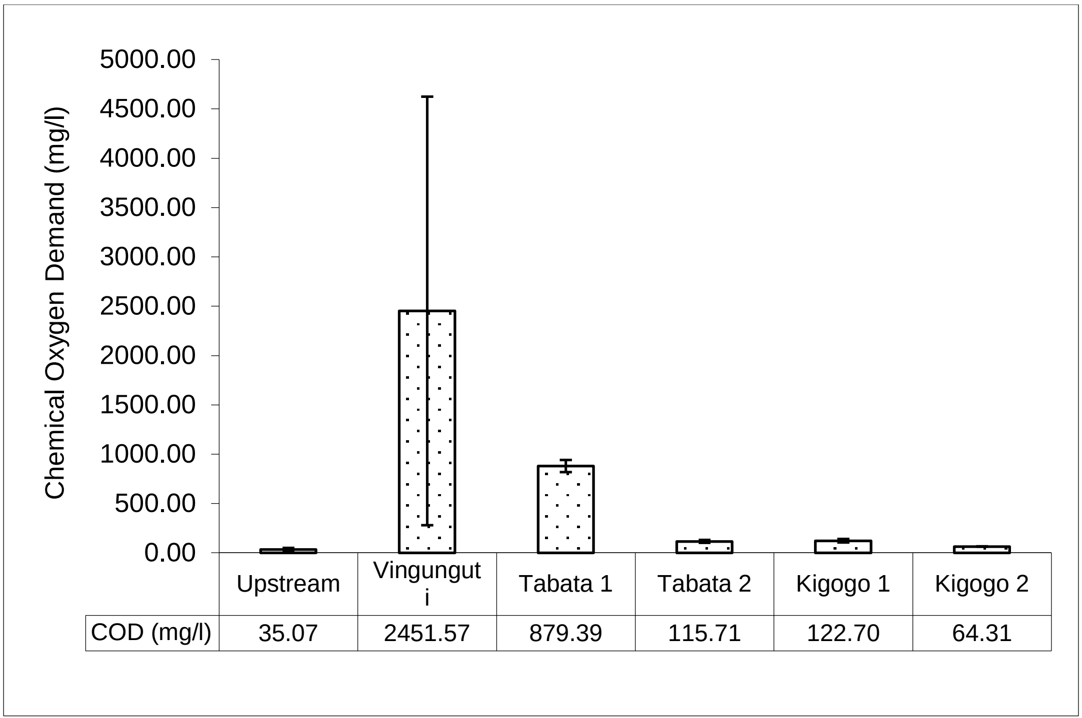


Figure 4.6: Chemical Oxygen Demand (COD)

Source: (*Field Survey*, 2012).

Figure 4.6 presents the COD from the various sampling points in comparison to the samples upstream from industries. The COD values ranges from 35mg/l to 2451.57mg/l. The lowest COD was recorded upstream from the industries with COD of 35.07mg/l whereas the highest COD was recorded at Vingunguti with the COD of 2451.57mg/l. Tabata 1 recorded 879.39mg/l and the COD continued decreasing from Tabata 2 which had a COD of 115.71mg/l; Kigogo 1 recorded a COD of 122.70mg/l and Kigogo 2 which recorded the COD of 64.31mg/l. The highest value of COD (2451.57mg/l) at Vingunguti can be linked to the discharge of raw wastes from the Vingunguti Abattoir as well as other industries located near Vingunguti such as OK (footwear and rubber products industry) and FIDA (Agriculture processors, wholesalers and exporters). Tabata 1 recorded higher COD of (879.39mg/l) comparing to Tabata 2, Kigogo 1 and 2. The higher value at Tabata 1 might have been contributed by the discharge of raw waste from industries like Murzah soap and detergent limited. On the other hand; the decrease on the values of COD in the sampling points of Tabata 2, Kigogo 1 and 2 may be attributed to the decreased industrial pollutants and self purification of the river during the course of its flow (i.e. Chemical, the oxidation of nitrogenous organic matter, resulting in its reduction or mineralization; biologic, the death of microorganisms through antibiosis. time, and various means; and physical, such as dilution, sedimentation, sunlight, etc.). All the sampling points with the exception of sampling station upstream from the industries which recorded the COD of 35.07mg/l they exceeded the TBS recommended permissible limits which is 60mg/l.

Based on the findings from the study area, it is COD from only one sampling station upstream from the industries that fall within the TBS allowable standards while the remaining five sampling station exceeds the allowable TBS standard being led by Vingunguti sampling station which has the highest COD of all, which can be attributed to the industrial activities that are taking place along the sub catchment. WHO does not have guidelines for COD.

4.2.8 Dissolved Oxygen (DO)

Dissolved Oxygen (DO) is an important pollution assessment parameter of the receiving water bodies (Vinod and Chopra, 2012). It’s an important ecological parameter because its level allows breathing of living organisms in water. It is a requirement for almost all forms of life. Aquatic animals, plants and most bacteria require it for respiration (getting energy from food), as well as for some chemical reactions. In the study area DO was measured and the finding are as presented in figure 4.7.

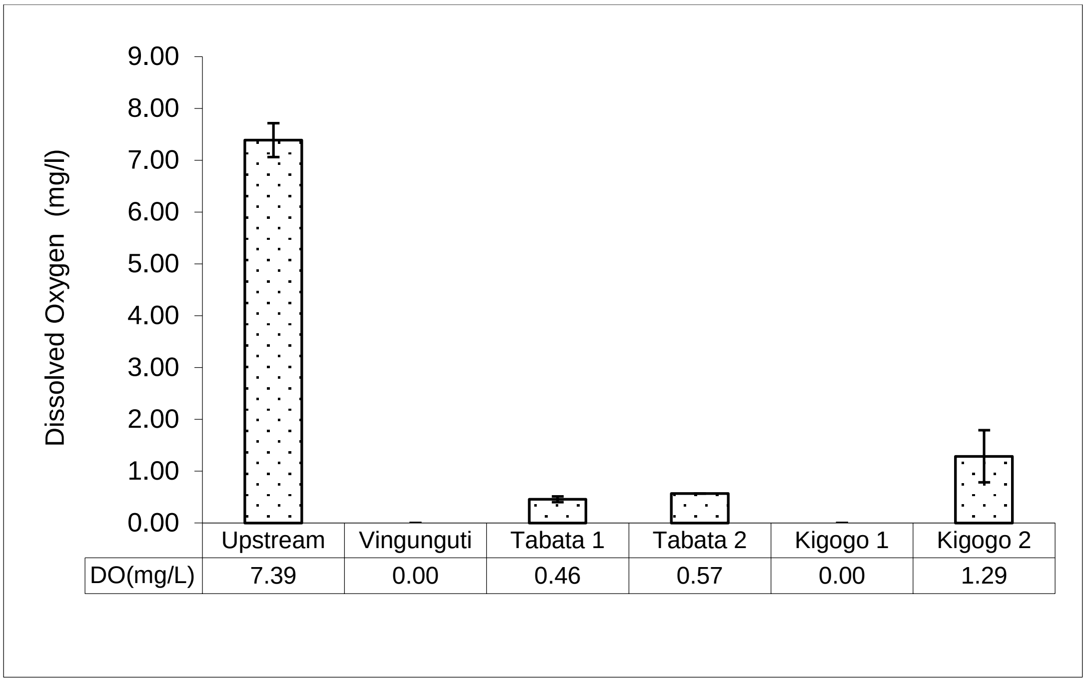


Figure 4.7: Dissolved Oxygen

Source: (*Field Survey*, 2012).

Figure 4.7 shows the DO findings for various sampling stations along Msimbazi sub catchment. The DO for the study area ranges from 0.00 mg/l to 7.39mg/l. The sample upstream from the industries shows the highest DO of 7.39mg/l which is a healthy level of DO and could be an indicator of good water quality due to the presence of living organisms such as fish and frogs. The DO values upstream from the industries sampling station has the highest DO comparing to other sampling stations. This can be attributed to low influence of human activities such as industrial activities. Sampling points such as Vingunguti and Kigogo 1 had a lowest DO of 0.00mg/l comparing to sampling points of Tabata 1 recorded the DO of 0.46mg/l while Tabata 2 recorded the DO of 0.57mg/l and Kigogo 2 recorded the DO of 1.29mg/l. There is variation of DO in the sampling stations. The variations could be attributed to industrial waste discharge especially to sampling points like Vingunguti and Kigogo 1. The DO levels of 0.00mg/l indicate a decreased quality of water in the sub catchment. According to Fine (1998) water is qualified polluted if it has a DO content of less than 3mg/l. TBS does not recommend DO permissible limit while WHO standards recommends 8-10mg/l as a permissible limit. Basing on the WHO standards, the concentration of DO is an important indicator of health aquatic ecosystem (Water Watch Australia Steering Committee, 2002). Persistently low dissolved oxygen harms most aquatic life because insufficient DO for organisms to use.

4.2.9 Heavy Metals

The study also analyzed the heavy metals as part of the pollutants being discharged by industries along Msimbazi sub catchment. The heavy metals, Pb, Cd and Cr were selected for the study due to their long term health effects on human and other living organisms. The concentration of metallic effluents that were analyzed is shown in the table 4.3:

Table 4.3: Heavy Metal Concentration along Msimbazi Sub Catchment

Sampling Location	**Pb (mg/l)**	**Cd (mg/l)**	**Cr (mg/l)**
Upstream	< -0.010	0.01 ± 0.013	< -0.010
Vingunguti	0.106 ± 0.184	0.004 ± 0.006	0.165 ± 0.224
Tabata 1	0.126 ± 0.061	0.009 ± 0.003	0.193 ± 0.224
Tabata 2	0.276 ± 0.453	0.006 ± 0.003	0.345 ± 0.224
Kigogo 1	0.192 ± 0.255	0.014 ± 0.003	0.101 ± 0.224
Kigogo 2	0.066 ± 0.012	0.010 ± 0.003	0.156 ± 0.224

Source: (*Field Survey*, 2012).

4.2.9.1 Lead (Pb)

Lead (Pb) is one among the heavy metals analyzed from the water samples collected from Msimbazi sub catchment. Table 4.3 shows findings of lead ranged from minimum of < -0.010mg/l to maximum of 0.276 (± 0.453)mg/l in all the sampling points along Msimbazi sub catchment. The sampling points of Tabata 2 and Kigogo 1 are having higher ranges of lead. The ranges of lead in four sampling points (Upstream from the industries, Vingunguti, Tabata 1 and Kigogo 2) are within the TBS standards while the sampling points Tabata 2 and Kigogo 1 exceed TBS allowable standards which are 0.1mg/l. However all the sampling points with the exception of upstream from the industries which are below detection level exceed the WHO allowable standard which is 0.01mg/l. The higher lead can be associated with the discharged of untreated waste by the industries such as Murzah soap and detergent limited located along the sub catchment.

4.2.9.2 Cadmium (Cd)

Table 4.3 shows the findings of cadmium from different sampling points along Msimbazi sub catchment. The concentration of cadmium (Cd) ranged from minimum of 0.009 (± 0.016)mg/l to maximum of 0.010 (± 0.010)mg/l in all the sampling points. The ranges of cadmium were within the TBS allowable standard which is 0.01mg/l while on the other hand they exceed the WHO allowable limit which is 0.003mg/l. The cadmium findings are lower comparing to that of Mwegoha and Kihampa (2010).

4.2.9.3 Chromium (Cr)

Table 4.3 shows the findings of chromium (Cr) ranging between < -0.010mg/l minimum and 0.345 (± 0.034)mg/l maximum. The highest concentration of chromium at Tabata 2 can be attributed to the steel industries discharging waste along the Msimbazi sub catchment and the higher concentration at Kigogo 2 can be attributed to the Urafiki textile discharging wastes in the sub catchment from the upper stream that join into Msimbazi.

Although the findings from all the sampling points were within the allowable TBS standard, they were found to be exceeding the allowable limit of WHO which is 0.05mg/l. The finding form the study are supported by Othman (2002), the waters of river Msimbazi and its tributaries are known to contain heavy metals originating from the industries and the water is used for domestic and vegetables irrigation purposes.

The abundance of pollutants discharged by industries were high including EC in the study have increased by 917µS/cm comparing to the result reported by (Mwegoha and Kihampa, 2010), this is an increase by 28.3 percent. DO in the study decreased up to 0.00mg/l comparing to the DO which was found in the previous studies to be 0.76mg/l. The study found that temperature has increased by >1°C comparing to the temperature recorded by (Mwegoha and Kihampa, 2010).

4.3 Effects of Industrial pollutants on Water Resources and Livelihoods

The study examined the effects of industrial pollutants on water resources and livelihoods along Msimbazi sub catchment, different aspects of observed river water quality changes and its causes/sources were assessed qualitatively.

4.3.1 Perceived Causes of Water Quality Changes in the Sub catchment

Respondents were asked if they had observed any change in water quality and what they thought was the possible change of the same. The findings are presented in table 4.4:

Table 4.4: The perceived cause of Water Quality Changes

Changes Source	**Observed Change in River Water Quality**		
	Yes	**No**	**Total**
Industrial Waste Discharge	66	0	66
Domestic Wastes	13	0	13
Municipal Wastes	2	0	2
Population Change	3	0	3
Climatic Change	5	0	5
Sewerage	10	0	10
Not Applicable (N/A)	0	1	1
Total	**99**	**1**	**100**

Source: (*Field Survey*, 2012).

Table 4.4 is a cross tabulation of the perceived causes of changes along the sub catchment as per respondents. 66% of respondents identified industrial waste discharge to be contributing changes into the sub catchment; whereas 2% of respondents identified municipal wastes; 13% of respondents indicated domestic wastes; 3% population increase and 10% of respondents identified sewerage to be the cause of changes. These findings mean that industrial wastes discharge contribute highly towards the change in river water quality as perceived by the respondents. The findings are supported by CEP, (2006) which report that industrial effluents are discharged untreated or partially treated into nearby water bodies.

4.3.1.1 Perceived Effects of Industrial Pollutants on Water Resources

The study findings shows that 99% of the respondents reported that industrial wastes discharge have effects on the sub catchment water quality whereas 1% of the respondents identified industrial pollutants to have no effects on water quality (figure 4.8).

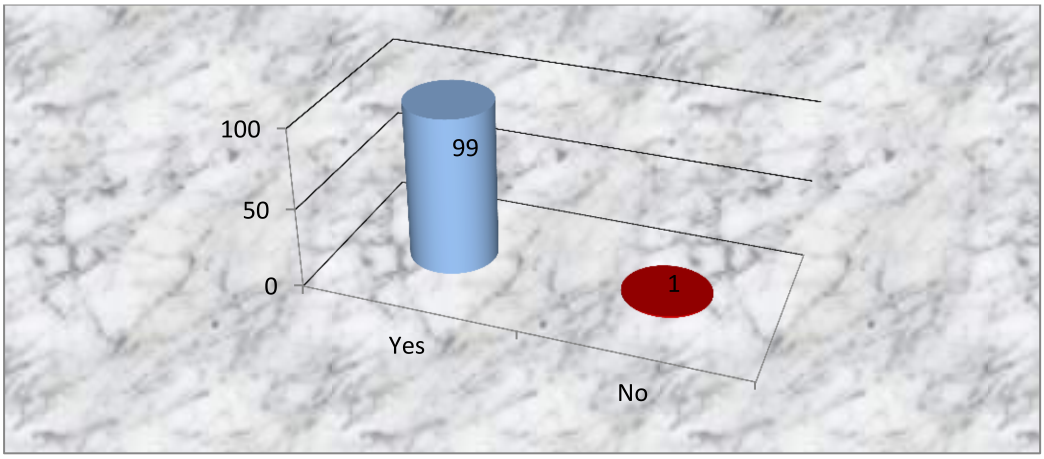


Figure 4.8: Perceived Effects of Industrial Pollutants

Source: (*Field Survey*, 2012).

Further, on the effects of the industrial pollutants on water resources as perceived respondents are reported on figure 4.9.

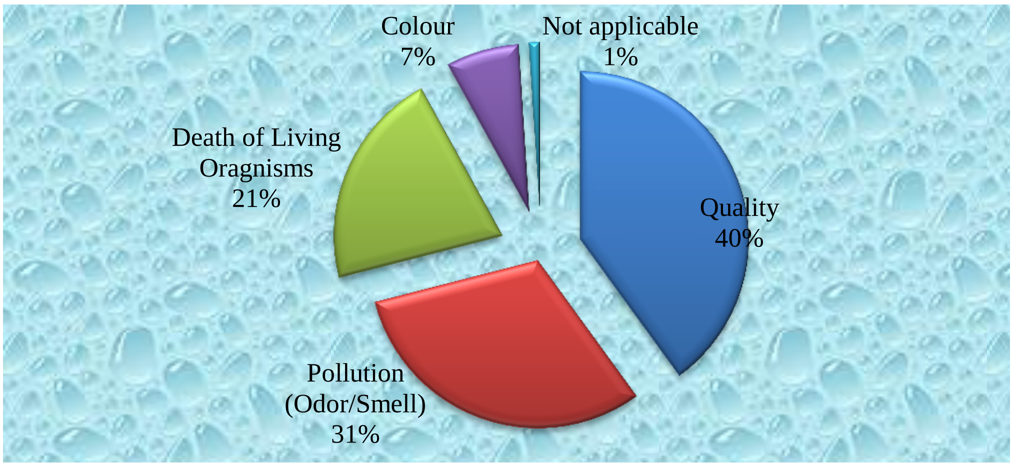


Figure 4.9: Perceived Effects of Industrial Pollutants on Water Resources

Source: (*Field Survey*, 2012).

The results of figure 4.9 indicate that 40% of the respondents considered changes in quality of water as the most common effect of industrial wastes discharge. Further, 31% of the respondents reported pollution (odor/smell) as an effect of industrial pollutants, 21% of respondents reported the death of living organisms while 7% of respondents reported colour change to be the effects of industrial pollutants and on the other hand 1% of the respondent reported industrial pollutants as not having any effects on water resources. From the findings industrial pollutants affect the quality of water, colour change from colourless to black and in some stations, pollution (odor/smell) and the death of living organisms. For water to be in a good quality it should be supportive to life in contrast to these findings which indicate that 21% of the respondents identified the death of living organisms. Laboratory analysis indicated the gradually increasing turbidity after the industrial area.

4.3.1.1.1 Quality

Figure 4.9 show that 40% of the respondents reported industrial pollutants to be affecting the quality of water as water becomes undesirable for different uses. This can be supported by the laboratory results which indicate decreased values of DO at some points such as Vingunguti and Kigogo 1 had a lowest DO of 0.00mg/l. The drop in DO levels indicates decreased water quality which affects aquatic living organisms. From the study the DO is only high at the point upstream from the industries that indicated 7mg/l which indicates that water is clean and it’s able to support economic activities. This is supported by Mokaya *et al*. (2004) who emphasize that industrial discharged wastes result to pollutants which bring about a reduction in dissolved oxygen levels, increased turbidity as well as cause damage to nursery and spawning grounds. Other studies show that effluents from industries have a great deal of influence on the pollution of the water body, as they can alter the physical, chemical and biological nature of the receiving water body (Sangodoyin, 1991).

Parameter such as turbidity was high at some points based on the laboratory results. The high turbidity affects the light penetration beneath the water; especially when water is covered with sediments (Smith and Davies-Calley, 2001). However, the most visually and ecologically significant impact of turbidity is changes in light system which may be considered to be aspects of changed habitat hence affect fish, invertebrates, algae, amphibians that rely upon aquatic habitat for reproduction, feeding, and cover.

4.3.1.1.2 Death of Living Organisms

From Figure 4.9, 21% of respondents reported death of living organisms like fish, invertebrates as one of the effect of industrial pollutants. According to the respondents, previously the sub catchment was used for carrying out fishing activities which are no longer done due to the water pollution. Based on the research findings, the respondents reported industries to be the cause of these changes along the Msimbazi sub catchment. This is supported by the laboratory analyzed data whereby in some sampling stations like Vingunguti and Kigogo 1 had zero DO. The depletion of DO affects living organisms. Frequent death of living organisms such as fishes in waste water in fact do not come from toxicity of matters, but from deficit of consumed oxygen from biological decomposition of pollutants (Durmishi *et al*., 2008). In the study are turbidity was highest at Vingunguti and followed by Kigogo 2. Turbidity affect organisms as eventually settle into the spaces between the gravel and rocks on the bed of a water body and decrease the amount and type of habitat available for creatures that live in those crevices and sometimes those particles can clog fish gills, inducing disease, slower growth and, in extreme cases, death (Waterwatch Australia Steering Committee, 2002).

4.3.1.1.3 Pollution

Figure 4.9, shows that 31% of respondents identified pollution as an effect of industrial pollutants along Msimbazi sub catchment.

Plate 4.3: Industrial Pollutants along the Msimbazi Sub Catchment

Source: (*Field Survey*, 2012).

Plate 4.3 shows polluted water resulted from discharge of untreated wastes from the Vinginguti Abattoir as observed by the researcher. Pollution as identified by respondent is supported by the laboratory results which shows increase in heavy metals such as Pb and Cd, also COD, BOD and turbidity as well as decreased DO especially at the Vingunguti sampling station.

4.3.1.1.4 Colour Change

Figure 4.9, shows 7% of the respondents identified changes in the colour of water from clear to black and milk like as the effect of industrial waste discharge. The respondents associate changes in the color of water with the wastes that are discharged from industries such as OK (footwear and rubber products industry), FIDA, and Vingunguti Abattoir. According to Sharief *et al*. (2005), the negative impact of the effluent on the water quality includes increase in turbidity, color, nutrient load and presence of toxic and compounds. A plate 4.4 shows the changed water colour along the Msimbazi sub catchment.

Plate 4.4: Water colour change and dumping along the Sub Catchment

Source: (*Field Survey*, 2012).

Plate 4.4 shows changed water colour from clear to black and milk like along the Msimbazi sub catchment. The adverse pollution can be evidenced by the peculiar black colour of water, dumped solid wastes, into the sub catchment. This could be a result of the inability to organize waste at source, industrial waste including other toxic wastes are often handled together leading to water pollution (UNESCO, 2000).

4.3.1.2 Effects of Industrial Pollutants on Livelihoods

The study examined the effects of industrial pollutants on livelihoods and the results are as shown in figure 4.10.

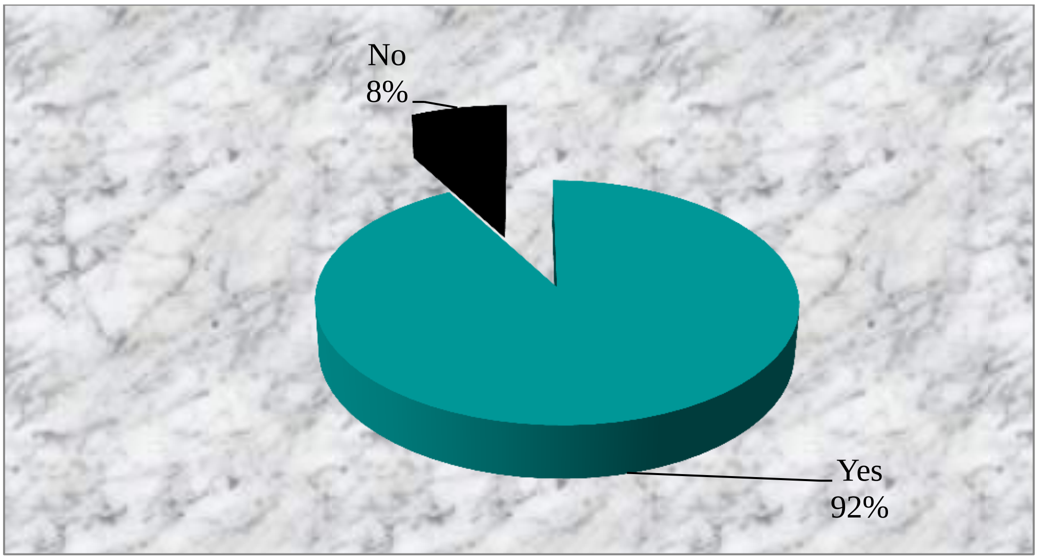


Figure 4.10: General Effects of Industrial Pollutants on Livelihoods

Source: (*Field Survey*, 2012).

Figure 4.10 shows that 92% of the respondents reported industrial pollutants to be effecting livelihood and whereas 8% did not report any effects of industrial pollutants on the livelihoods. Further the research went on examining what were the effects of the industrial pollutants on the livelihoods along the Msimbazi sub catchment as shown below:

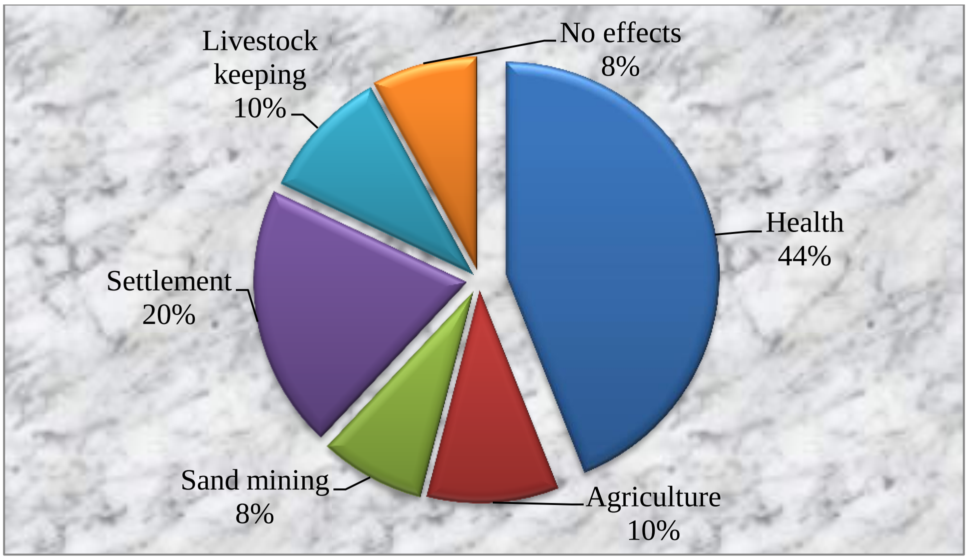


Figure 4.11: Effects of Industrial Pollutants on Livelihoods

Source: (*Field Survey*, 2012).

Figure 4.11 shows the perceived effects of industrial pollutants on livelihoods along the Msimbazi sub catchment. 44% of the respondents reported that their health was affected by the industrial pollutants; 10 percent of the respondents reported agriculture to be affected by industrial pollutants; 8% reported sand mining activities to be affected by industrial pollutants. 20% of respondents reported settlement to be affected by industrial pollutants and 10% of the respondent reported livestock keeping to be affected by industrial pollutants. On the other hand 8 percent of the respondent reported industrial pollutants to having no effects on the livelihoods.

4.3.1.2.1 Perceived Health Effects

The study examined the effects of industrial pollutants on health effects and the results are as shown in figure 4.12.

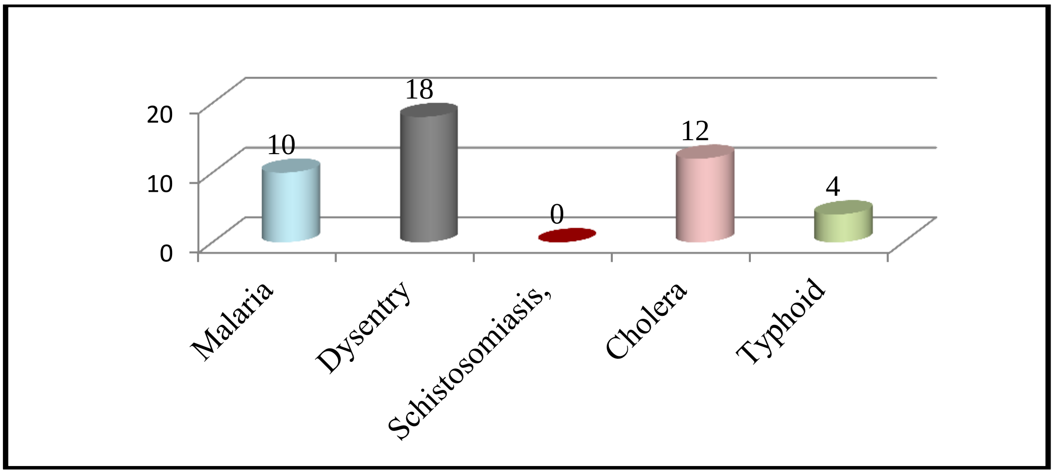


Figure 4.12: Perceived Effects of Industrial Pollutants on Health

Source: (*Field Survey*, 2012).

Figure 4.12 shows the values of the respondents who identified health as a major effect of industrial waste discharge on the livelihoods. 10 respondents identified Malaria as the effect of industrial pollutants on health as wastes from industries create the breeding grounds for , 18 respondents identified dysentery, while 12 respondents indicated cholera as the effects if industrial pollutants on health. 4 respondents identified typhoid as the effects of industrial pollutants. This is supported by findings from different studies like UNEP GEMS/ Water Programme (2006) that identify the industrial revolution of the nineteen century, which contaminated surface waters that resulted in serious human health problems, including typhoid and cholera outbreaks. Moreover WHO (2008) point out that unmanaged wastewater is a habitat to vector of disease, causing child mortality and reduced labor productivity, but receives a disproportionately low and often poorly targeted share of development aid and investment in developing countries.

At least 1.8 million children under five years die every year due to water related disease, or one every 20 seconds. Pimental and Ajayi (2007) confirm that industrial waste discharge results to environmental changes including increased water pollution which have fostered much of the increase and high incidences of malaria as they enable breading grounds for mosquitoes. Approximately 1.2 billion people in developing nations lack clean water because most household and industrial wastes are dumped into rivers and lakes without treatment contributing too many waterborne diseases in humans (Branco *et al*., 2005). The industrial wastes may affect livelihoods such as health through inhalation, ingestion and skin contact with the polluted water or industrial wastes. Health effects as a result of industrial waste discharge include respiratory diseases, skin reactions, allergies, diminution of vision, corneal opacity, abortion, deformity of pregnancy, stunted growth, neurological disorders, mental depression, psychiatric changes, altered immune response, chromosomal aberrations and cancer (Kilivelu and Yatimah, 2008). Lead among industrial pollutants poses a serious threat to human beings and animals as well as plants. In human, it is absorbed directly into the blood stream and is stored in soft tissues, bones and teeth (95% in bones and teeth) (David *et al.,* 2003). Contaminated air, soil, and water by effluents from the industries are associated with heavy disease burden (WHO, 2002) and this could be part of the reasons for the current shorter life expectancy in some countries (WHO, 2003). Table 4.5 below shows the metals that are discharged by industries and their health effects to human.

Table 4.5: Metals Released from Industries and their Effects on Health

Metals	**Health hazards**
Lead	Anemia, abdominal pain, damage to nerves convulsion, hypertension
Cadmium	Inhibits functioning of enzymes, affects gastro intestinal tract, lungs and bones, causes renal problems
Chromium	Carcinogenic, leads to kidney disorders, ulcer, nervous disorder

Source: (Mashi and Alhassan, 2007).

4.3.1.2.2 Effects of Industrial Pollutants on Agriculture

Figure 4.11 shows that 10% of respondents reported agriculture as being affected by industrial pollutants. Pollution of water due to industrial pollutants makes water not to be useful for watering their crops. This is supported by the UN water (2011) which reported that polluted water becomes unfit for drinking, bathing, industry or agriculture effectively reducing the amount of water usable within affected areas.

4. 3 1.2.3 Industrial Pollutants Effects to Settlements

Settlements were reported to be affected by industrial pollutants where 20% of respondents reported that industrial waste discharge affects them through odor which they thought would be posing health risks. This is widely believed to be a direct consequence of industrial pollution reaching the community who live along the Msimbazi sub catchment.

4.4 Review of the Implementation of the Relevant Aspect of National Industrial Policy on Cleaner Production

In order to facilitate implementation of the new Sustainable Industrial Development Policy (SIDP), the major institutions which are actors in the process of industrialization include; the government, the private sector and allied agencies that are appropriately structured to effectively play the relevant roles such as develop views in a bottom-up approach from their respective production units to the apex body. On the other hand the government consolidates democratization process including commitment to rule of law, peace, human rights, transparency, streamlined bureaucracy, and protection of the rights to individual property ownership. The ministry responsible for the industries is the overall co-coordinator for operationalization, monitoring and review of the SIDP at the national level in collaboration with ministries responsible for finance and planning. However, NEMC works as an overseer of all environmental related matters.

4.4.1 Organizations and Policies on Industrial Pollutants

In-depth interviews were conducted among key informants with regard the implementation of relevant policies on industrial waste management and the environment. The findings pointed to involvement of different organizations such as National Environmental Monitoring Council and the Ministry of Trade and Industry as discussed below:

4.4.1.1 National Environmental Management Council

The study ascertained the existence of environmental body called National Environmental Management Council (NEMC). NEMC is charged with tasks to undertake enforcement of environmental laws, compliance, review and monitoring of Environmental Impact Assessment and Environmental Research, raising awareness and collect and disseminate environmental information. According to CEP (2006), the council performs any duty under the Environmental Management Act (2004) or any other law. It can carry out environmental audits, surveys, research and can review and recommend for approval of Environmental Impact Assessment, and enforce compliance of the National Environmental Quality Standards.

4.4.1.2 Policies Governing Industrial Pollutants

As to whether there existed any policy governing industrial waste discharge, NEMC confirmed that there were sectoral policies with respect to the environmental protection. Moreover, it is the responsibility of the Ministry for Industry and Trade and NEMC and other related sector that are responsible for implementing the policy. To some extent, the implementation of the relevant aspects of Tanzania National industrial policy helps in controlling industrial waste discharge into water systems though there are obstacles in the implementation.

4.4. 1.3 Industrial Planning

NEMC was asked whether the industries were planned in the manner that would minimize the adverse effects on the environment at all stages (i.e. location, effluent discharge, waste disposal, use and disposal of products) but was not so categorical about this since NEMC faced the challenge of implementation. Notwithstanding, NEMC maintained that there were measures such as compound offenses, restriction order and fines put in place as legal remedies. For instance, an oil company that discharged oil to the ocean had to pay fine and clean the canal that was directing wastes to the ocean. Whereas this stance sounds good and ambitious, the implementation of this could be a hard task. This ambitious response of cleaning the ocean could have arisen from the fact there are strict environmental laws in place.

4.4.1.4 Legal Actions

Further, the NEMC usually takes legal actions against industries that discharges waste into water bodies. The actions taken include restriction orders, fine payments, notice and orders (stop order), verbal and written (letter) warning. With regard to Environmental Impact Assessment (EIA) in industrial planning and development for taking account of potentially harmful activities on the environment, NEMC maintained that taking account of potentially harmful activities on the Environment (EIA) has undertaken before the industries are established. For the industries which were established before EIA introduced they have to undertake Environmental Audit.

On matters of monitoring and evaluation; the Environmental audits/inventory are carried out for both new and existing industries for pollution control and waste minimisation. For the existing industries NEMC does monitoring within industries and for the new industries before anything begins, EIA has to be undertaken to minimize the negative effects.

NEMC ensures the installation of waste-recycling facilities, the use of clean technology and production of safe and less toxic products is followed by the respective industries. NEMC does monitoring to see if owners have installed waste recycling facilities. It also gives written warning to owners of to install the recycling facilities, after that they do follow up to ensure things are done as required.

According to NEMC; laws, rules, and regulations governing manufacture, handling, use, storage and disposal of toxic chemicals, and dangerous products, hazardous wastes and substances are being reviewed. When asked the content of what was reviewed and after which duration NEMC maintained that as necessity dictated laws are reviewed after five years. For the time being laws have not been reviewed since they are still working and some of the laws are yet to be enforced. NEMC outline the shortcomings of the Industrial policy in relation to environment thereby confirming their indifferent position.

4.4.1.5 Ministry of Trade and Industry

The main responsibilities of the Ministry for Industry and Trade is to develop industrial sector (Small and Medium Enterprises), business sector and markets through working together with the private sector, by preparing and implementing policy, strategy, planning and programming. The main types of industries in Tanzania are agro based and manufacturing industries.

There are several industrial policies implemented by the Ministry of Trade and Industry, including Sustainable Industrial Development policy (1996-2020), Small and Medium Enterprise 2003 and the National Trade policy 2003.

The conditions that are required in prescribing the industrial construction sites includes, location of industries closer to the areas of raw materials, infrastructure and logistical support (roads and other utilities like electricity) and emerging of markets (areas with high population). There is a huge challenge in ensuring that industries in Msimbazi sub catchment are constructed on the prescribed sites due to land ownership status. Further, for already planned and allocated industries have lately been invaded by residents who construct residential houses near to industries. This is an indicator that the laws on environment are not strictly enforced and or recognized. The main challenge that faces the Ministry of Trade and Industry is lack of allocation areas for specified uses. The Ministry for Industry and Trade is striving to ensure that regions separate/ identify areas for various uses.

The Ministry affirmed that planned industries would minimize adverse effects on the Environment at all stages (i.e. location, effluent discharge, waste disposal, use and disposal of products). The Environmental Policy (1997) requires an EIA to be done before the commencement of any activity or industrial investments.

The Ministry of Trade and Industry is influential in the implementation of the relevant aspect of Tanzania National Industrial Policy. The ministry is responsible in controlling industrial waste discharge into water systems through sensitization carried out by the government while working in collaboration with the NEMC which is the main moderator of the Environmental policy.

The goals for National Industrial Policy include; human development and creation of employment opportunities; economic transformation for achieving sustainable economic growth; external balance payments; environmental sustainability and equitable development. Different challenges face these goals, including implementation on the existing laws on the environment, partly affordable to financial limitations. The challenges have affected the basic framework for industrial development and bring forth the huge weakness of the ministry in the implementation of the relevant aspects of industrial policy. Such weakness is further evidenced by the findings that NEMC has legal power; it can take legal actions against Industries that discharge wastes. The Ministry for Industry and Trade is passively involved since legal measures can only be taken by NEMC which is the authority responsible for law enforcement. This research established that the laws, rules, and regulations governing manufacture, handling, use, storage and disposal of toxic chemicals, and dangerous products, hazardous wastes and substances have not been reviewed on the basis that they are still functioning.

About the application of Environmental Impact Assessment (EIA) (in industrial planning and development for taking account of potentially harmful activities on the environment) the Ministry of Trade and Industry insists that EIA is done before any industrial activity commences and; for the industries that were established before the Environmental Policy and Act, the owners are required to do environmental audits. Planning for the industrial location is a challenge due to issues on led ownership and the right to put it to any uses.

The installation of waste-recycling facilities, use of clean technology and production of safe and less toxic products is still a huge challenge. Paradoxically, industrial owners know about the installation of waste recycling facilities but they are reluctant to make installation. To some industries waste recycling was not their ideas hence they start late the recycling process.

The research investigated the extent of practicality of the implementation of relevant aspects of the Tanzania National Industrial Policy and established that it was practical only up 50%. This response is to the effect that the policy needs improvement because if it is practical by only 50% then achieving the objectives for which it is intended will also be only by 50%. A good policy should be workable and practical to a huge extent if it is to make an impact. It was an interesting observation that despite the policy being practical by 50%, the Ministry for Industry and Trade held that the current National Industrial policy met the current state of industrial growth. This response can be taken to imply that there was either poor industrial growth in the country or that the National Industrial Policy is questionable.

4.5 Remedies of Controlling Industrial Pollutants

This study also sought to know remedies of controlling the industrial pollutants in Msimbazi sub catchment (figure 4.13).

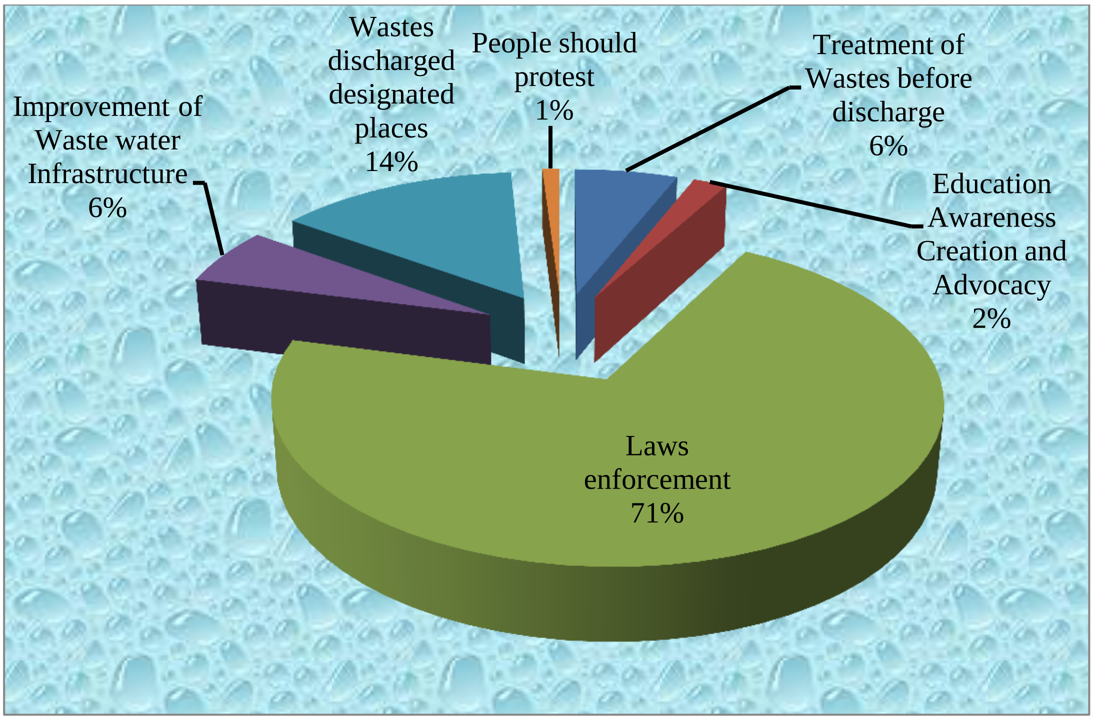


Figure 4.13: Industrial Pollutants controlling remedies

Source: (*Field Survey*, 2012)

The findings in figure 4.13 indicate that the majority 71% of the respondents proposed laws enforcement as a remedy of controlling the industrial wastes. These findings are significant and suggest that there is weak enforcement of the laws on environment and on industrial wastes discharge. Correspondingly, if the laws were enforced then the proposed remedy by 14% of the respondents of discharging industrial wastes in designated places would make sense. Moreover, when the laws have been enforced well, then duo remedies proposed by an equal 6% of the respondents; treatment of industrial wastes and improving water infrastructure will follow forthwith. In the same note there will be no need of protesting as indicated by the 1% of the respondents and awareness through advocacy would have grown drastically. All these remedies taken jointly will see into it that the industrial wastes discharge is considerably minimized thereby creating a cleaner environment.

4.6 SWOT Analysis

The study utilized Strengths, Weaknesses, Opportunities and Threats (SWOT) to analyze data on the implementation of the relevant aspects of Tanzania national Industrial Policy on cleaner production in relation to industrial waste discharge.

Table 4.6: SWOT Analysis

SWOT ANALYSIS ITEMS	**POLICY**
Strength	➢ Recognized by the government and Environmental Authority (NEMC). ➢ Create employment ➢ Well established National Industrial Policy. ➢ It saves people and their environment.

Weaknesses	➢ Lack of support from the industrial owners. ➢ Laxity in law enforcement. ➢ Ineffective implementation of the policy. ➢ Insufficient funds for policy implementation ➢ In adequate /lack of coordination and shared management responsibilities among the sectors that implement the Tanzania National Industrial policy.
Opportunities	➢ Capacity building/ awareness to industrial owners and communities on the effects and remedies for industrial pollutants. ➢ Community involvement in controlling industrial pollutants as they are directly affected by it. ➢ Improvement of waste water infrastructures by industrial owners. ➢ Waste treatment before discharging into the water sources.
Threats	➢ Persistence of effluent discharge by industries despite the existence of policy. ➢ Increase in industrial pollutants. ➢ Deterioration of water quality due to increased industrial pollutants. ➢ Deterioration of livelihoods as a result of industrial pollutants.

Source: (*Field Survey*, 2012)

SWOT analysis indicate that the Tanzania National Industrial Policy on cleaner production has strength such as being recognized by the government and Environmental Authority (NEMC), create employment, it's a well established national industrial policy and its effective implementation of the policy may lead to reduced industrial pollutants.

SWOT identified the weakness of implementation of the relevant aspects of the Tanzania National Industrial Policy. The weaknesses include; lack of support from the industrial owners, laxity in law enforcement by the responsible authorities, ineffective implementation of the policy, insufficient funds for policy implementation and lack of coordination and shared management responsibilities among the sectors that implement the Tanzania National Industrial policy.

The Tanzania National Industrial Policy provide v have the different opportunities. Such opportunities are like; it saves people and their environment, capacity building or awareness to industrial owners and communities on the effects and remedies for industrial pollutants, Community involvement in controlling industrial pollutants as they are directly affected by it, improvement of waste water infrastructures by industrial owners and waste treatment before discharging into the water sources.

In addition, SWOT identified the following threats on the policy implementation; persistence of effluent discharge by industries despite the existence of policy, increase in industrial pollutants, and deterioration of water quality due to increased industrial pollutants and deterioration of livelihoods as a result of industrial pollutants.

The weaknesses and threats of the policy implementation can be minimized if the strength and the opportunities of the policy are well utilized. The strength and opportunities shows that the policy can still be effective to reduce the industrial waste discharge into water systems.

CHAPTER FIVE: SUMMARY OF FINDINGS, CONCLUSION AND RECOMMENDATIONS

5.1 Summary of the Findings

This study assessed levels of industrial pollutants and their effect son water resources and livelihoods along Msimbazi sub catchment. Specifically the study, determined the types and abundance of pollutants of industrial pollutants discharged into Msimbazi sub catchment, examined levels of industrial pollutants and their effects on water resources and livelihoods along Msimbazi sub catchment and reviewed the implementation of the relevant aspects of Tanzania national industrial policy on cleaner production and how it relates with industrial waste discharge. The summary of findings from the study is as follows:

i. Types and abundance of pollutants discharged by industries along the sub catchment were found to be higher and to some points exceeding the World Health Organization (WHO) and Tanzania Bureau of Standards (TBS) standards.

ii. Industrial pollutants was found to be affecting the water resources in terms of quality where the water quality parameters in some stations were exceeding the WHO and TBS permissible limits also livelihoods were found to be affected by the industrial pollutants in terms of health, agriculture and settlement.

iii. Despite of the implementation of the Tanzania National Industrial Policy (SIDP) which is a framework for industrial activities and having NEMC as the enforcer of environmental laws; industries were still discharging their wastes into the sub catchment.

5.2 Conclusions

The study concluded that the types and abundance of industrial pollutants discharged by industries into Msimbazi sub catchment are higher for some sampling points causing heavy metal like lead as well as other parameters like EC pH, DO, COD and BOD exceeded the acceptable limits set by TBS and WHO. EC was exceeding the acceptable limits of 3µS/cm at Vingunguti which recorded 114933µS/cm, Tabata 1 had 67003µS/cm and Kigogo 1 had 32403µS/cm. pH was exceeded the limits at Tabata 1 which recorded the pH 10.42 and Tabata 2 had the pH of11.33. Stations of Vingunguti and Kigogo1had a DO of 0.00mg/l followed Tabata 1 which had 0.46mg/l and Tabata 2 which had 0.57mg/l. COD was exceeding the acceptable limits of 60mg/l in stations like Vingunguti which had 2451.57mg/l, Tabata1 which had 879.39mg/l and Kigogo 2 which had 122.70mg/l. BOD exceeded the acceptable limits at Vingunguti with 462.67mg/l, Tabata 1 which had 226.67mg/l and Kigogo 1 which had 151.33mg/l. Heavy metals like Pb exceeded the acceptable limits for both standards at Tabata 2 which recorded 0.276mg/l and Kigogo 1 which had 0.192mg/l.

Furthermore, the study concluded that pollutants from industries affect water resources in terms of quality whereby important parameters of water quality such as DO was 0.00mg/l in some sampling stations such as Vingunguti and Kigogo1, also pollution into the sub catchment which is indicated by the higher values of EC in stations like Vingunguti, Tabata 1and Kigogo 1. The study also concluded that pollutants from industries were affecting livelihoods in the sub catchment in terms of health as polluted water act as a breeding ground for vectors of diseases, agriculture as water from the sub catchment is not fit for irrigation.

The study also concluded that the industries still discharge their wastes into the sub catchment despite the implementation of Tanzania National Industrial Policy which is a framework for industrial activities. This is due to laxity in the law enforcement by NEMC and lack of co ordinations and shared management responsibilities among the sectors that implement the Tanzania National Industrial Policy.

5.3 Recommendations

Based on the study findings, the Tanzanian government through its authorities such as TBS, NEMC and the Ministry for Industry and Trade should apply the findings and recommendations of this research work so as to enhance sustainable water management through efficient industrial production. The government through its agencies therefore needs to work on the following recommendations:

i. At the national level the Tanzania Bureau of Standards (TBS) should develop standards especially for those parameters that have no standards and recommend schedule for monitoring of water quality.

ii. NEMC and the Ministry for Industry and Trade should ensure industries adopt efficient technology such as Effluent treatment Plants (ETP's) in order to minimize the discharge industrial pollutants into water bodies thus minimize their effects to water resources and livelihoods.

iii. NEMC should improvement the law enforcement in order to control industrial pollutants. The legal, administrative and technical measures should be enforced as required. Legal remedies such as restriction order, compound offenses, and fines put in place as they are necessary to reduce or eliminate the unnecessary discharge of pollutants into the receiving water systems hence lessen their effects.

iv. NEMC should create the awareness among the community at large about the industrial pollutants to local drains as well as the water systems since they are the most affected by the discharged effluents as they use polluted water knowingly or unknowingly in their daily activities like watering gardens, washing thus becoming the victims of industrial pollutants discharge.

v. Industries should regularly and efficiently operate their effluent treatment plants (ETPs) and monitor their effluents to keep them within the standards set by law.

vi. Ministry for Industries and Trade and NEMC should take legal action against dumping of the wastes in water bodies and order each industry to install a waste treatment plant with a vision to treat wastes before being discharged into the sub catchment hence minimizing industrial waste discharge into water sources.

vii. There should be coordination among the sectors that implement the Tanzania National Industrial Policy in order to avoid duplicity in activities and wastage of financial resources.

viii. Awareness to local communities by NEMC on the effects of industrial pollutants to the livelihoods, the remedies to the industrial pollutants and how the local communities can be involved in the whole process.

5.4 Prospective Strategic Researches

The current study tried to put a baseline on levels of industrial pollutants and their effects on water resources and livelihoods along Msimbazi sub catchment. Further studies should particularly put attention on the following research topic:

i. To investigate the health related effects of industrial waste discharge in the sub catchment

ii. To analyze the socio-economic impacts of the co-existence of industries and settlements along the sub catchment

iii. To investigate the implementation of the relevant aspects of national environmental policy in relation to industrial waste discharge along the sub catchment

iv. To examine the alternative methods for industrial waste minimizations

v. To investigate the health effects of local communities residing along industrial sites.

vi. To assess the perception of local communities toward Industrial Waste Discharge.

vii. To examine the effects of industrial waste discharge on the socio-economic activities

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APPENDICES

Appendix 1.0: Questionnaires for households

Preamble

Dear Sir / Madam,

Hello. My name is Mwenda Aselina B, Master’s student at Kenyatta University (Registration Number: I56EA/20381/2010). I would appreciate your contribution to this study dealing with levels of industrial pollutants and their effects on water resources and livelihoods along Msimbazi sub catchment. Any answer provided will be kept strictly confidential, according to research regulations of Kenyatta University.

I would like to thank you in advance for your willingness.

Yours sincerely,

Aselina Mwenda B.

SECTION I:
DATE………………………..

GENERAL INFORMATION OF RESPONDENTS:		
RESPONDENT INFORMATION	**RESPONSE**	**CODES**
Name of District		
Name of Ward		
Name of the street		
Age	18-25 25-33 33-40 40-47 47-54 Above 50	1 2 3 4 5 6
Gender	Female Male	1 2
Education	Non Primary Secondary College / University	1 2 3 4
Household members of the house		

SECTION II

S/N	QUESTION	ANSWER	CODES
1	For how long you have been living in this area?	Less than a year Three years Five years More than five years	1 2 3 4
2	How did you obtain the area you are living now?	Bought Inherited Squatter Rented	1 2 3 4
3	What is the main source of water for your household?	River Rain water Tap water Shallow wells Deep wells Vended water	1 2 3 4 5 6

4	How long does it take you to collect water from your household?	Less than 15 minutes 30 minutes More than 30 minutes	1 2 3

5	What do you do to earn your living?	Unemployed Employed Self-employed Small businesses Small medium enterprises (mama nitilie) Urban agriculture House wife/husband	1 2 3 4 5 6 7
6	If you are self employed what livelihood activities do you practice?	Urban Agriculture Livestock keeping House wife	1 2 3
7	Do you use water from the river?	Never Sometimes Always Hardly	1 2 3 4
8	If you us; What do you use for?	Drinking Cooking Cleanness (washing & mopping) Irrigation (gardens) Construction Recreational (swimming) Others……………………… ……………………………	1 2 3 4 5 6 7
9	For the time you have lived here have you observed any changes in the cleanness/ quality of water in the river?	Yes No	1 2
10	If yes; what do you think is the cause of those changes?	Industrial waste discharge Domestic wastes Municipal wastes Population increase/ change Climate change Sewerages	1 2 3 4 5 6
11	If the answer is industrial pollutants; does it affect your livelihood and livelihood activities?	Yes No	1 2

12	If the answer is Yes: How does it affect livelihood and livelihood activities?	Health Economic activities (can't continue) Changes/ rise in living standards Changes in life style Others………………………. ………………………………	1 2 3 4 5
13	Has any member of your house hold suffered any health problems related to water?	Yes No	1 2
14	If YES: which diseases	Typhoid, Dysentery, Cholera Malaria Schistosomiasis, Bilharzias	1 2 3 4 5 6
14	Does industrial pollutants affect water resources?	Yes No	1 2
15	If YES: can you mention the effects?	Changes in color Odor/ smell Death of living organisms (plants and animals) Others………………………. …………………………….	1 2 3 4
16	Do you know any effects of industrial waste discharge?	Yes No	1 2
17	If YES; can you mention some of the effects?		
18	What can be done to control industrial waste discharge into water systems?		
19	What can be done to reduce the effects of industrial waste discharge?		

Appendix 2.0: Interview Guides for Key Informants

Appendix 2.1: Interview Guide for Ministry of Trade and Industry

Preamble

Dear Sir / Madam,

Hello. My name is Mwenda Aselina B, a Master's Degree student at Kenyatta University (Registration Number: I56EA/20381/2010). I would appreciate your contribution to this study dealing with levels of industrial pollutants and their effects on water resources and livelihoods along Msimbazi sub catchment. Any answer provided will be kept strictly confidential, according to research regulations of Kenyatta University. Thank you for your willingness.

Yours faithfully

Mwenda Aselina B.

SECTION I:
DATE………………………..

GENERAL INFORMATION OF RESPONDENTS:		
RESPONDENT INFORMATION	**RESPONSE**	**CODES**
Name of Respondent		
Occupation/ position		
Employer		

SECTION II

1. What are the main activities of the Ministry for Industry and Trade?

2. What are the main types of industries that are available in Tanzania?

3. When was the industrial policy established and who implements it?

4. What conditions are considered in prescribing the industrial construction sites?

5. What means are used to ensure that industries are constructed on the prescribed sites?

6. Are the industries planned in the manner that minimizes adverse effects on the Environment at all stages (i.e. location, effluent discharge, waste disposal, use and disposal of products)?

7. Does the implementation of the relevant aspect of Tanzania National Industrial Policy help in controlling industrial waste discharge into water systems?

8. As a Ministry do you have any legal actions that are taken against industries that discharges waste into water bodies?

9. What can you say about the application of Environmental Impact Assessment (EIA) (in industrial planning and development for taking account of potentially harmful activities on the environment)?

10. What can you say about the installation of waste-recycling facilities, use of clean technology and production of safe and less toxic products?

11. Are the laws, rules, and regulations governing manufacture, handling, use, storage and disposal of toxic chemicals, and dangerous products, hazardous wastes and substances are being reviewed? If YES; when was; what was reviewed and why?

12. To what extent is the implementation of the relevant aspect of Tanzania National Industrial Policy practical?

13. Does the current National Industrial Policy meet the current state of industrial growth?

14. What are the shortcomings of the industrial policy?

Appendix 2.2: Interview Guide for NEMC

Preamble

Dear Sir / Madam,

Hello. My name is Mwenda Aselina B, Master's student at Kenyatta University (Registration Number: I56EA/20381/2010). I would appreciate your contribution to this study dealing with levels of industrial pollutants and their effects on water resources and livelihoods along Msimbazi sub catchment. Any answer provided will be kept strictly confidential, according to research regulations of Kenyatta University. Thank you for your willingness.

Yours faithfully

Mwenda Aselina B.

SECTION I:
DATE………………………..

GENERAL INFORMATION OF RESPONDENTS:		
RESPONDENT INFORMATION	**RESPONSE**	**CODES**
Name of Respondent		
Occupation/ position		
Employer		

SECTION II

1. What is NEMC, and what is its works?

2. Is there any policy governing industrial waste discharge?

3. Who has responsibility to ensure the implementation of the relevant aspect of Tanzania National Industrial Policy on cleaner production?

4. Does the implementation of the relevant aspect of Tanzania National Industrial Policy help in controlling industrial waste discharge into water systems?

5. Are the industries planned in the manner that minimizes adverse effects on the Environment at all stages (i.e. location, effluent discharge, waste disposal, use and disposal of products)?

6. If no; why?

7. Are there any legal actions that are taken against the industries that discharges waste into water bodies?

8. As a National Environmental Management Council; do you have any legal actions that are taken against industries that discharges waste into water bodies?

9. If yes; what are they?

10. What can you say about the application of Environmental Impact Assessment (EIA) (in industrial planning and development for taking account of potentially harmful activities on the environment)?

11. How is the Environmental audits/inventory carried out for both new and existing industries for pollution control and waste minimisation?

12. As NEMC; what means do use to ensure the installation of waste-recycling facilities, use of clean technology and production of safe and less toxic products is followed by the respective industries?

13. Are the laws, rules, and regulations governing manufacture, handling, use, storage and disposal of toxic chemicals, and dangerous products, hazardous wastes and substances are being reviewed? If YES; when; what was reviewed and why?

14. What are the shortcomings of the industrial policy in relation to environment?

THANK YOU FOR YOUR GENEROUS CONTRIBUTION TO THIS STUDY

Appendix: 3 Water quality analysis

AVERAGES FOR WATER QUALITY ANALYZED PARAMETERS										
S/N	**PARAMETERS**	**UNIT**	**TBS STD**	**WHO STD**	**SAMPLE IDs**					
					A	**B**	**C**	**D**	**E**	**F**
1	pH		6.5-8.5	6.5-8.5	8.50	8.15	10.42	11.33	8.05	8.19
2	EC	µS/cm	3	3	2353	11493	6700	3067	3240	2830
3	DO	mg/l	*	8-10	7.39	0.00	0.46	0.57	0.00	1.29
4	COD	mg/l	60	*	35.07	2451.57	879.39	115.71	122.70	64.31
5	BOD	mg/l	30	10	2.57	9.00	462.67	226.67	151.33	129.00
6	TSS	mg/l	100	>10	11	993	29	112	86	86
7	TURBIDITY	NTU	300 NTU	5-50 mg/l	18	674	35	121	107	357
8	BODY TEMP	°C	20-35	<35	28.33	27.67	27.00	27.67	27.67	28.00
9	LEAD	mg/l	0.1	0.01	< -0.01	0.106	0.126	0.276	0.192	0.066
10	CADMIUM	mg/l	0.1	0.003	0.010	0.004	0.009	0.006	0.014	0.010
11	CHROMIUM	mg/l	1	0.05	< -0.010	0.165	0.193	0.345	0.101	0.156