EFFECTS OF WASTEWATER DISCHARGE ON FRESH WATER QUALITY IN DAR ES SALAAM: A CASE OF MSIMBAZI RIVER

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CERTIFICATION

The undersigned certifies that has read and hereby recommends for acceptance by The Open University of Tanzania, a Dissertation titled: ***"Effects of Wastewater Discharge on Fresh Water Quality in Dar es Salaam: A Case of Msimbazi River"***in partial fulfillment of the requirements for the degree of Master of Science in Environmental Studies of The Open University of Tanzania.

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Dr. Lawi Yohana

Supervisor

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DECLARATION

I, **Amisa Ahmad,** do hereby declare that this dissertation is my own original work, and that it has not been submitted in any other university for a similar or any other degree award.

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Date

DEDICATION

This work is dedicated to my beloved husband, son and daughter who laid the foundation of my crave for knowledge in this world. The work is also dedicated to all my family and friends for their tolerance and prayers contributed to the successfully completion of the study.

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I would like to thank and in fact it is a particular debt of gratitude to my Supervisor Dr. Lawi Yohana whose supervision, guidance, and facilitation that has made this dissertation to come the way it looks.

It is not easy to include all the names of the people who participated in one way or the other towards the materialization of this project. But I wish to acknowledge them all.

Many people contain involved in one or an additional way in this assignment, on the other hand any short comings in this statement exclusively rests on the hands of the researcher.

ABSTRACTS

The aim of the study was to determine the effect of waste water discharge on the fresh water quality for Msimbazi river in Dar es Salaam Tanzania. This river has heavily polluted due to effluents from domestic usage, industries and other human activities. The problems associated with discharging waste water into the river include eutrophication, disease eruption due to increase of various pathogens, environmental pollution and death of animals due to chemicals found in the river. Samples were collected between the periods of October to November 2014 to determine the different parameters. Laboratory analyses were performed in Ubungo Maji. Statistical analysis show that several parameters are significantly higher ($p<0.01$) that is permissible levels: colour (478.25, p=0.0004), DO (p=0.004), turbidity (79.25NTU, p=0.007), EC (13975ms/cm, p= 0.0009), nitrate (23mg/l, p=0.017), BOD (103.17mg/l. p=0.015), TDS (7895.13,mg/l, p=0.0012) COD (203.34mg/l, p=0.0114) and Sulphate (583.68mg/l p=0.042). However pH (98.8, p=0.898), temperature (24.43^{0}C, p=0.84), phosphate (0.627mg/l, p=0.505) were within the required discharge limit. Salender Bridge showed higher value of waste water pollution than Vingunguti. Higher value of pollution could be attributed with effluents discharge from domestic and industrial activities. From this study it can be concluded that waste water treatment mismanagement of industrial wastes and lack of environmental education are the main factors contribute to the effluent pollution in the study area. Further research is recommended on the determination of other parameters which were not covered in the study in different parts of Msimbazi river particularly heavy metals and environmental interaction.

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LIST OF ABBREVIATIONS

APHA	America Public Health Association
BOD	biological Oxygen Demand
COD	Chemical Oxygen Demand
DO	Dissolved Oxygen
SMWW	Standards Methods of Waste Water
WHO	World Health Organization

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background Information

Sewage may be regarded as wastewater and is composed of human body waste which is faecal matters and urine, and the sullage from personal washing, laundry, food preparation and the cleaning of kitchen utensils (Rukunga, 2001). It may also contain industrial and agricultural waste. Sewage is objectionable in appearance and hazardous content. Wastewater may contain different types of disease causing microorganisms. Various report from studies conducted in USA and Europe (Waldichuck, 1986; Ward and Singh, 1987) report epidemiological effects of sewage pollution in the marine environment a potential risk of contracting a mild disease or an infection such as stomachache, vomiting, diarrhea, typhoid fever, bacterial of amoebic dysentery, guardiasis, infective hepatitis, poliomyelitis by pathogenic organisms from bathing in sewage polluted waters (Daby, Turner and Jago, 2001).

Reports on outbreaks of food poisoning from consumption of fecal contaminated sea food are also common. Salmonella, vibrioscholerae and enteroviruse have been isolated from coastal waters worldwide, this implies the potential health problem of considerable significance (Ward and Singh, 1987) resulting from strengthening of pathogens occurrence due to increased of sewage contamination. Nutrients are also pollution problem (Enger and Smith, 2002). Additional nutrients in the form of nitrogen and phosphorus compounds increase the rate of growth of aquatic plants and algae. However, phosphate and nitrogen are generally present in a very limited amount in a polluted freshwater and therefore are a limiting factor on the growth of aquatic plants and algae (Enger and Smith, 2002). A limiting factor is necessary material that is in short because of the lack of it, an organism can reach its full potential growth. Thus when phosphate or nitrates are added to the surface of water, they can act as the fertilizer and promote the growth of undesirable algae population. The excessive growth of algae and aquatic plants due to added nutrients is called eutrophication. Algae and larger aquatic plants may interfere with the use of water and cause the building up of organic matter by fouling boat propellers, clogging water intake pipes, changing the taste and the odor of the water, matter decays, oxygen level decrease, and the fishes and other aquatic species may die due to lack of oxygen (Enger and Smith, 2002).

Pollutants also enter the coastal waters from diffuse sources, often concentrated in storm water drains, to enter the marine system via streams and rivers. When it rains, runoff from farms, farmland, city streets, construction sites, and suburbs lawns, roofs and drive ways enters waterways (Reopanichkul et al., 2009). There are four major source of diffuse source of pollution, sediments from erosion, nutrients, toxic substances and pathogens. (Virginia Department of Conservation and Recreation, 2006; PCD, 2007). As with point source, pollutant levels differ in receiving coastal waters depending on the land development of infrastructure and receiving rate. The highest levels of pollutants tend to be focused at river mouth where carrying water flow slows and suspended particle precipitate out. Dissolved materials and microorganisms remain to be transported by oceanic process (Reopanihkul et al., 2009). Water quality is a term used to describe the chemical, physical and biological characteristics of water, usually in respect to its suitability for a particular purpose. (El-Sadek, Radwan and Abdel-Gawad, 2005). A number of variable are used to measure health of the water: nutrients, bacteria, salts, metal and pesticides. With increase in water consumption to satisfy different demands, quantities of disposed water are rapidly increased (El –Sadek, 2005). Deteriorating water quality can have many ecological, social, and economic effects. These include the loss of marine plant, animal, and fish species, deteriorating shellfish quality, and restriction of recreational use. Areas of our coast are prone to coastal water quality problems, particularly in estuaries, bays, and waters next to densely populated areas. The coastline is long and many activities both land and marine based, take place close to the shore.

1.2 Statement of the Problem

Wastewater discharge into the Msimbazi River almost without any adequate treatment result in nutrient enrichment accumulation the condition known as eutrophication, accumulation of toxic compound in biomass and sediments, loss of dissolved oxygen in water and other nuisance. The wastewater is highly colored, turbid and the vegetation along the stream appears scorched despite the fact that water from this stream is the major resources in the area. It is used for building, irrigation of vegetables, and drink by animals and birds and children use it for recreation.

Eutrophication can have some severe impact on marine ecosystem, for example dissolved oxygen levels may be reduced below those necessary for the successfully growth and reproduction of aerobically respiring organisms. The main effects of eutrophication are the general decrease of species diversity, high turbidity, increase in sedimentation and creation of anoxic condition. Most industries, hotels, homes are found along Msimbazi River. The people living around the River discharge the wastewater without any treatment into the River. These hotels contain wastewater from the kitchen, bathing, washing machine, toilets and other organic matter from garbage, food preparation, cleaning of clothes and dishes. Wastewater from cleaning dishes and clothing contained some organic materials along with soap or detergent which are used to separate the contaminant from dishes or clothes. Soap and detergents are useful because one end of the molecule dissolves in dirty or grease and the other end dissolve in water (Enger and Smith, 2002). When the soap or detergent molecules are rinsed away the water or grease goes with them. Many detergents contain phosphate used as a part of their chemical makeup which contributed to eutrophication.

According to literature, another effect of wastewater on water quality is related to health problems to the people living along the coastal areas due to the potential increase in wastewater discharge along the coastal areas which can lead to many infectious diseases especially gastrointestinal problems such as vomiting, diarhoea, typhoid fever, bacteria or amoebic dysentery, infective hepatitis and poliomyelitis. Also problems of outbreak of food poisoning from consumption of faecally contaminated sea food due to salmonella species, Vibrio cholerae and their enteroviruses. This research was conducted to determine the levels of pollution such as nitrate, phosphate dissolved oxygen, biological oxygen demands and turbidity on coastal water and the special variation of physico-chemical characteristics in coastal water in Indian Ocean. The previous studies conducted on water quality research in Tanzania by Mohammed (1990), showed high level of the assessment of water quality and pollution in Tanzania and the other studies carried out by Van Bruggen (1990), who measured water, temperature dissolved oxygen, conductivity, pH, Biologicl oxygen demand, Chemical oxygen demand, heavy metals, faecal and total coliforms. However, due to increase in population density and various human activities in Dar es Salaam information on the current level of pollution caused by the discharge of wastewater is highly needed for the management purpose. It is also important to assess whether the discharge of wastewater in aquatic environment comply with the national and international standards.

1.3 Significance of the Study

The significance of this study is to assess the current status of water quality in Msimbazi River in Dar es Salaam and it is hoped that the result of this study will assist the relevant polluters such as normal individuals and authorities in designing appropriate preventive measure to ensure that the water quality in the stream is improved.

The other one is to investigate the effects of wastewater discharge on fresh water quality in Dar es salaam and to investigate the gastrointestinal problem due to increase of the usage of polluted water discharged along the ocean without any kind of treatment. To provide public awareness on the effects associated with toxic material found in the waste water; that toxc materials found in wastewater accelerated the health problems such as the effects of nitrate, the condition known as baby syndrome or methemoglobinemia, gastrointestinal disturbances associated with the microbial infection along the coastal areas. Also, eutrophication problems to coastal plants and animals as well as the algae are the effects of toxic material found in wastewater. Not only that but also the significance of this study is to understand the health hazarded to the people who eat fish from Msimbazi river.

1.4 General Objective

The objective of this study was to assess the effects of waste water discharge on the fresh water quality in Dar es Salaam especially in the Msimbazi River and water quality at the coast.

1.4.1 Specific Objectives

(i) To determine the levels of pollution such as pH, nitrate, phosphate, dissolved oxygen and biological oxygen demands, and turbidity in the study sites.

(ii) To determine the spatial variation of physico-chemical characteristics of waste water in Msimbazi River.

1.5 Hypothesis

The levels of nitrate, phosphates, dissolved oxygen; Biological oxygen demand, pH and turbidity in the study site exceed the concentration levels acceptable for fresh water quality. The concentration of the selected physico-chemical parameters decreases with the increasing distance from the discharge point in the study area.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Meaning of Wastewater

Wastewater is composed of human body which is faeces and urine, sullage from laundry, washing kitchen waste and industrial waste (Rukunga, 2001). Sewage can be domestic such as homes, municipal and industrials. Water pollution occurs when something enter water that changes the natural ecosystem and interfere with water use by segments of society. In an industrialized society maintaining completely unpolluted water in all drains, streams, rivers, and lakes is probably impossible (Enger and Smith, 2002). Water is polluted by acids, chloride and disease causing organisms, elevated temperature, heavy metals, nutrient enrichment organic molecules and sediment and toxic chemicals.In general water pollutants can be divided into several broad categories:

Toxic chemicals or acids may kill all organisms present and make the water unfit for human use. If these chemical are persistent, they may bioaccumulate in individual organisms and biomagnifies in food chains (Enger and Smith, 2002). Dissolved organic matter is significant water pollution problem because it decays in the water. As the decomposer microorganisms are naturally present in water breakdown the organic matter, they use up available dissolved oxygen from the water. If too much dissolved oxygen is removed, aquatic organisms die (Enger and Smith, 2002). Disease causing organisms are very important pollution problem in most of the world. Untreated or inadequately treated human or domesticated animals waste is most often the source of these organisms. In developing world sewage treatment and drinking water treatment plants greatly reduce this public health problem.

2.2 Water Quality

Water quality describes the condition of the water including chemical, physical and biological characteristics usually with respect to its suitability for a particular purpose such as drinking and swimming (NOAA, 2011). Water quality is measured by several factors such as concentration of dissolved oxygen. Bacteria levels, the amount of salts, the amount of the material suspended in the water called turbidity.

The Following are the Parameters used to Measure the Quality of water:

Biological parameter includes the bacteria and algae. Physical parameters are such as temperatures; turbidity salinity suspended solids and dissolved solids. Chemical parameters include the pH, dissolved oxygen, biological oxygen demand, nutrients such as nitrogen and phosphorus and organic and inorganic compounds such as toxicants.

2.2.1 Total Dissolved Oxygen

Total dissolved oxygen is an important factors used for water quality control. The effect of waste discharge on the surface of water source is largely determined by oxygen balance of the system and its balance is essential in maintaining biological life system (DFID, 1999). Total dissolved gas concentrations in water should not exceed 110 percent. Concentrations above this level can be harmful to aquatic life and the fish in waters containing excessive dissolved gases may suffer from "gas bubble disease"; however, this is a very rare occurrence (Kentucky, 2011). The bubbles or emboli block the flow of blood through blood vessels causing death. External bubbles can also occur and be seen on fins, on skin and on other tissue. Aquatic invertebrates are also affected by gas bubble disease but at levels higher than those lethal to fish.

Adequate dissolved oxygen is necessary for good water quality. Oxygen is a necessary element to all forms of life. Natural stream purification processes require adequate oxygen levels in order to provide for aerobic life forms. As dissolved oxygen levels in water drop below 5.0 mg/l, aquatic life is put under stress, the lower the concentration, the greater the stress. Oxygen levels that remain below 1-2 mg/l for a few hours can result in large fish kills.

2.2.2 Turbidity

Turbidity is the measure of the degree to which the water loses its transparency due to the presence of particles (Denby at al., 1987). Turbidity results from the scattering of light in water by organic and inorganic particles, particularly sediment. The more total suspended solids in the water the murker it seems and the higher the turbidity. Turbidity is measured in NTU (nephelometric turbidity units) the instrument used to measuring it is called nephelometer or turbidimeter which measure the intensity of light at 90 centigrade as a beam of light passes through water sample. Causes of water turbidity are various parameters influencing cloudless of the water. Some of these are phytoplankton; sediments from the bottom (frequently stir up by bottom feeders like carp) suspended sediments from waste discharge, algae growth and urban runoff. Maximum turbidity in drinking water by WHO should not be more than 5 NTU.The consequence of high turbidity is as the follows:

The suspended particle absorbs heat from the sunlight, making turbid waters become warmer, and so reducing the concentration of oxygen in water. The suspended particle helps the attachment of heavy metal such as mercury cadmium, arsenics chromium and lead, also many toxic materials such as pesticides. The suspended particle scatter the light, thus decreasing the photosynthetic activity of plants and algae, this contributes to the lowering the oxygen concentration (Lenntech, 1998). As the consequences of the particle settling to the bottom, shallow lakes fill in faster, fish eggs and insect larvae are covered and suffocated, and gill structures get clogged or damaged (Lenntech, 1998).

2.2.3 Dissolved Oxygen

Dissolved oxygen is that is dissolved in water by diffusion from the surrounding air, aeration of water that has tumbled over falls and rapids, and as a waste product of photosynthesis (Lenntech, 1998). Fish and aquatic animals cannot split oxygen from containing compounds. Only green plants and some bacteria can do that through photosynthesis and similar which virtually all oxygen we breathe is manufactured by green plants.Environmental impact of total dissolved gas concentration in H_2O should not exceed 110 percent (Lenntech, 1998). The concentration above this level can be harmful to aquatic life. Fish in waters containing excessive dissolved gases may suffer from gas bubble disease; however this is very rare occurrence (Lenntech, 1998). The bubbles block the flow of blood through vessels causing death (Lenntech, 1998). External bubble can also occur and be seen on fins or skin and on the other tissues. Aquatic invertebrates are also affected by gas bubble disease but at levels than that level to fish (Lenntech, 1998).

2.2.4 Salinity

Salinity refers to the movement and concentration of salt in landscapes, and the sources of salt are retreating seas, rain rocks, and salt which are released by weathering process (Lenntech, 1998). The problems associated with salinity are broad such as reduction in the productive capacity of affected land, degradation of the environment and wild habitats, loss of water quality for stock and domestic supplies damage roads and to water using household equipment. Drought can cause coastal water resources to become more saline. Water infrastructure in coastal cities, including sewer system and wastewater treatment facilities face risks from rising sea levels and the damaging impacts of storm surges (EPA, 2009).

2.2.5 Temperature

Temperature is the measure of the warmth or coldness of an object of a substance with reference to some standards value. Coastal water has warmed due to environment changes. Bleaching brought on rising water temperatures cause substantial die off of coral reefs (USC, 2011). Climate change threatens the future of corals which provide habitat for fish and fascination for snorkelers and scuba divers in Florida (UCS, 2011). Warmer ocean put coastal communities at risk, increase infrastructure costs, endanger polar creatures and threatens coral reefs and fisheries (UNS, 2011).

Rising in temperature affect reproduction of some animals such as turtles in various ways such as sea level rise in temperature will affect significant nesting beach areas, increase the chance that sand temperatures will exceed the upper limit for egg incubation which is 34 centigrade and raise in temperature bias the sex ratio toward females because temperature during the incubation determines the sex of the egg (UNS, 2011). Commercial fish and shellfish including cod and lobster have thresholds of water temperatures that limit the condition under which they reproduce and grow whereby temperature influences the location and timing of the spawning, which affects the growth and survival of the young generation.

2.2.6 pH

pH is a measure of acidity and basic of water, which range from 0-14, with 7 being neutral. pH is really a measure of the relative amount of free hydrogen and hydroxyl ions in water (USGS, 2013). Water that has more free hydrogen ions is acidic, whereas water that logs more hydroxyl ions is basic. Since pH can be affected by chemical in water, pH is an important indicator of water that is changing chemically. The pH of water determine the solubility which is the amount that can dissolve in water and biologically availability (amount that can be utilized by aquatic life) or chemical constituents such as nitrogen, phosphorus and carbon. Heavy metal when added to two affecting phosphorus determine whether aquatic life can use it. In the heavy metal the degree to which their soluble determine their toxicity. Encrusted with deposits and it depresses the effectiveness of the disinfection of chlorine thereby causing the need for additional chlorine when pH is high and low, pH water will corrode or dissolve metal and other substances (USGS Water Science School, 2013).

2.2.7 Biological Oxygen Demand

Biological oxygen demand is a measure of the quantity of oxygen used by microorganism (e.g. aerobic bacteria) in the addition of organic matter (APCC). Natural sources of organic matter include plant decay and leaf fall. However plant growth and decay may be unnaturally accelerated when nutrients and sunlight are overly abundant due to human influence. Consumer like fish and other aquatic animals eat some of the producers and the nutrients move up the food chain. When these organisms die, bacteria decompose the organic compounds and release into the water inorganic nutrients such as nitrate, phosphate and calcium. Some of these nutrients end up downstream in the aquatic water column; are aerobic. That means that they cause oxygen to perform their metabolic activity and decomposition. Natural levels of oxygen in the aquatic system are always somewhat depleted by normal levels of aerobic bacteria. In most cases dissolved oxygen concentration exists in every low concentration, if it drops below 5 parts Millions (PPM) fish will live in very long. All clean water species such as trout or salmon will die well above this level and even low oxygen fish such as catfish and carp will be at risk below 5PPM.

There are two commonly recognized methods for the measurements of BOD.Dilution standard method is recognized by EPA labeled method 521013 in standard method for the examination of water and wastewater. Manometric method is limited to the measurement consumption due only to carbonaceous. The sample is kept in a sealed container filled with a pressure sensor which is substance that absorbs C_2O is added in a container above sample level. The sample is stored in conditions identical to dilution method.Unit of measurements is mg/c of oxygen consumed in 5 days a constant temperature of 20^oC.

2.3 Nitrate

Nitrate is a chemical that dissolve water in a similar manner as a table salt. It is colorless, odorless and tasteless when dissolved in water. (Esser et al, 2002). Nitrate is an inorganic compound that occurs under a variety of condition in the environment both naturally and synthetically. Nitrate is a compound that contains nitrogen and water. Nitrogen comes from decomposing organic materials like manure, plants, and human wastes often the nitrogen which comes from ammonia or ammonium. Basically, plants need nitrogen to make amino acids and proteins, which are essential for plant growth. Plants cannot use organic nitrogen directly. "Microorganisms in the soil convert the nitrogen locked up in crop residues, human and animal wastes or compost to ammonium. A specific group of microorganisms convert ammonium to nitrate. Since nitrate is water-soluble, excess nitrate not used by plants can leach through the soil and into the groundwater.

Nitrate is also found wherever biotic things are breaking down or decomposing like animal waste, and septic system absorption fields or mounds. The main sources of nitrogen in groundwater are highly fertilized crops and lawns, and large amounts of human and animal waste (septic systems, sewage, and manure).Studies have shown that nitrate in Wisconsin's and Portage County's groundwater comes from:

Agriculture	90%,
Septic systems	9%, and
Lawns and other	1%

The following (Figure 2.1) is the figure which indicates the sources of nitrate into the atmosphere.

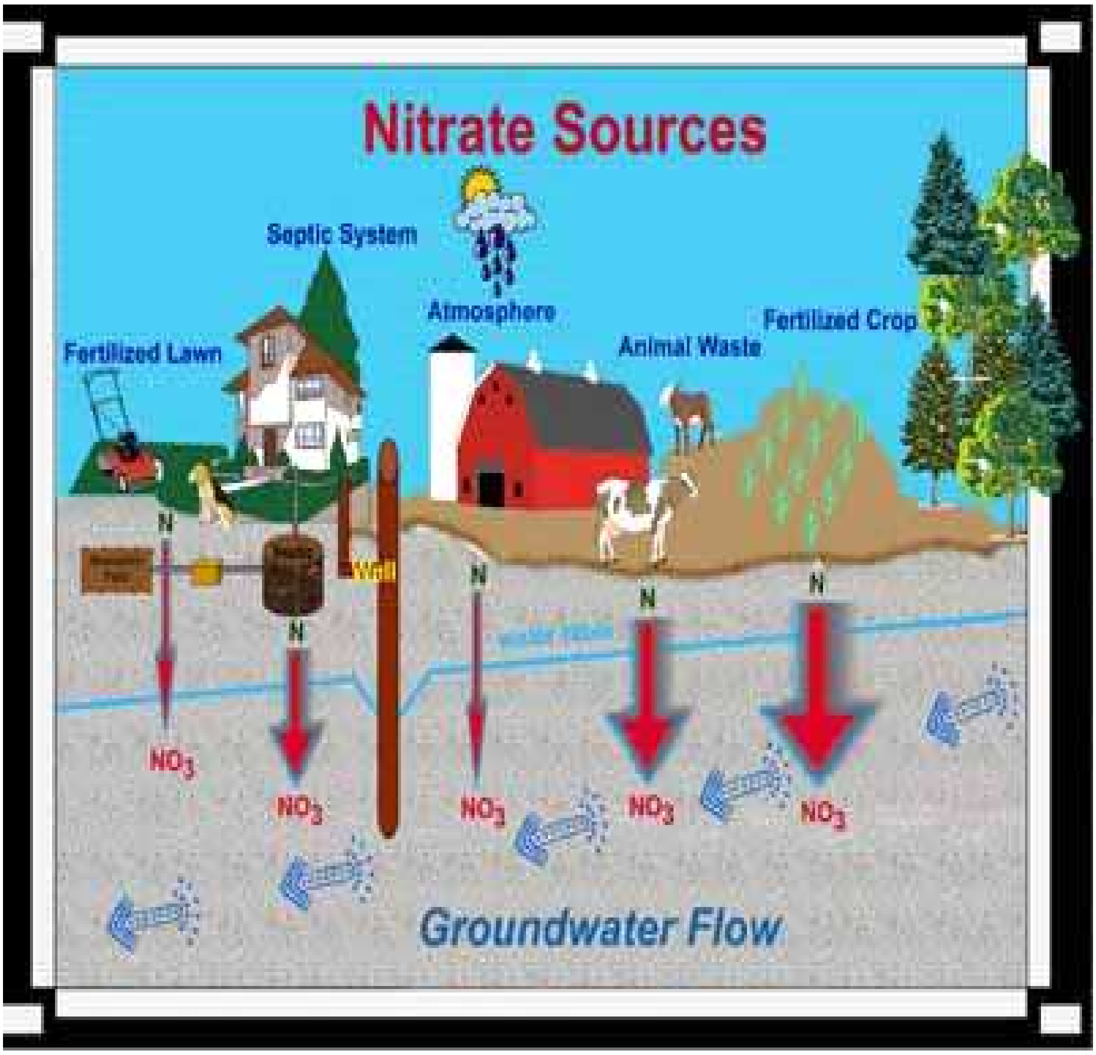


Figure 2.1: The Sources of Nitrate into the Atmosphere

The widths of the red arrows show relative amounts of nitrate leaching into groundwater. The wider the arrow the more nitrate. Nitrate is present in high levels in wastewater due in part to the high nitrates present in human sewage but also from some types of industrial effluent entering the municipal sewer system. Nitrate is also a very common contaminant in both surface water and ground water. Nitrate occurs naturally in source water as a result of decaying plants. However, there are other manmade sources of nitrate that can increase the presence of nitrate in source waters to dangerous levels. Agricultural sources of nitrates include livestock excrement and chemical fertilizers. Nitrate in Ground Water and Surface Water: Because nitrate is highly soluble in water it tends not to get filtered out like some other contaminants as the water seeps through the soil layers to the ground water level. How much nitrate will reach the groundwater zone from agriculture is determined by varying levels of crop watering and irrigation as well as changing levels of rainfall. Another source of nitrates in ground water is from human sewage disposal systems such as unmaintained septic tanks. It is therefore important to monitor nitrates as often as possible in groundwater since nitrate levels can be difficult to predict.

The same sources of nitrates can lead to elevated levels of nitrates in surface water due to runoff from agricultural land into lakes and rivers whether the source is livestock or fertilizer for crops. Surface water is also particularly susceptible to natural nitrate sources such as decaying leaves which varies both seasonally and with weather events. Again the levels of nitrate tend to vary and are fairly unpredictable and so frequent monitoring is essential. Wastewater can be a source of methane when treated or disposed anaerobically. It can be a source of nitrous oxide emission. Wastewater originated from a variety of domestic commercial areas such as in the hotel and accommodation premises and industrial sources may be treated on the site (uncollected), sewered to a centralized plant (collected) or disposed untreated nearby or via an outfall. Treatment and discharge systems can sharply differ between one country and another. Also treatment and discharge system can differ from rural and urban users and for urban high income and urban low income users.

2.4 Phosphates

Is another kind of atom common in the structure of living things. It is present in many important biological molecules such as DNA and in the membrane structure of the cell.In addition the bones and teeth of animals contain significant quantities of phosphorus. The source of phosphorus is atoms, are rocks in nature, new phosphorus compounds are released by erosion of rocks. Plants use dissolved phosphorus compounds to construct the molecule they need. Animals consume plants or other animals and obtain needed phosphorus. When an organism dies or excretes waste products, decomposer organisms recycle the phosphorus compounds back into the soil.

The major impact of widespread use of phosphorus in agriculture is the impact of ecosystem, especially on aquatic ecosystem which is starved of these nutrients. The presence of large amounts of these nutrients in either fresh water or salt water results in increased rates of bacteria, algae and aquatic plants. Increases in these organisms can have many different effects. Many algae blooms are toxic, resulting in killings and human poisoning. Large amounts of plants and algae in aquatic ecosystem will deplete the water of oxygen when they die. Each summer a major dead zone develops in México off the mouth of Mississippi river. This dead zone contains few fish and bottom dwelling organisms. It is caused by low oxygen levels brought about by the rapid growth of algae and bacteria in the nutrients rich waters (Enger and Smith, 2000).

2.5 Pathogens

Pathogen is any disease causing microorganisms or viruses (Nester at al., 1998). Pathogens are group of harmful microorganisms that cause disease and infections on their hosts such as plants and animals (Prescott at al, 1990). They comprise of microscopic organisms such as viruses bacteria and fungus. Pathogens are organisms frequently microorganisms or components of these organisms that cause disease. Microbial pathogens include various species of bacteria, viruses, and protozoa. Many diseases are caused by microbial pathogens, which increase the frequency of these diseases. Contamination of water by pathogen causes route of diseases spread. The water cause the pathogen to reproduce illness such as food borne pathogens cause hundreds of death. The microbes such as bacteria, viruses, or protozoa usually reside in the intestinal tract of humans or other creatures; examples of such microorganisms include Escherichia coli. Bacteria cause many diseases such as cholera, pneumonia, whooping cough tetanus and diphtheria. Many bacteria diseases are dispersed primary on food or in water, including typhoid fever, bacillary dysentery, and paratyphoid fever (Raven and Johnson, 1996).

Typhoid fever is caused by bacterium known as Salmonella typhi to human. The disease spreads through contaminated water or food. The pathogens harm the body by causing direct physical, damage of tissues, by releasing toxic chemicals or by taking over cells genetic machinery to use for their own ends (Levine and Miller, 1991). Viruses are tiny infectious particle composed of a core of nucleic acid either DNA or RNA surrounded by protein coat. Viruses enter living cells and grow within them, usually control of the cells biochemical machinery to such extent they cause infected cells to die. Viruses almost always damage the host cells because viruses cannot reproduce on their own; they rely on replication mechanism of the host cell to make copies of themselves. Pathogens are capable of causing disease after infecting host damage cells cause toxic compound antiviral genome.

2.6 Heavy Metal

Heavy metal is a member of loosely defined as subset of element that exhibit mental metallic properties, example of heavy metal mercury are lead molybdenum and zinc. Most of the heavy metal either alone or in compounds exerts detrimental effect upon organisms. Examples of heavy metals and their impacts are the following:

Mercury exposure can harm the brain, heart, kidneys, lungs and immune system of people of all ages. New babies' and younger children's the nervous system can be affected making a child less able to think and learn. Mercury accumulation in fish may harm the fish and animals that consume them such as birds and mammals. Effects on aquatic animals include reduced fertility, damaged of internal organ of the body, slower growth and development, abnormal behavior and even death. Lead causes neurons developmental effects in children and even at low level of exposure. Other effects include cardiovascular, renal, gastrointestinal and reproductive effects (UNEP, 2002).

Cadmium is a toxic to humans and exposure can cause pulmonary irritation, kidney disease, bone weakness and possibly lung, prostate and kidney cancer (UNEP, 2002). Food and cigarette are largest potential source of cadmium. People with high intake of shellfish and organs meat from marine animals may have a higher intake of cadmium accumulate mainly in the kidney and liver of vertebrates and in aquatic invertebrates and algae (UNEP, 2002). Heavy metal toxicity can damaged or reduce mental and central nervous system function, can lower energy levels and damage to blood composition of lungs kidney, liver, and other vital organs. Long-term exposure may results in slowly progressing physical, muscular and neurological.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Study Area Descriptions

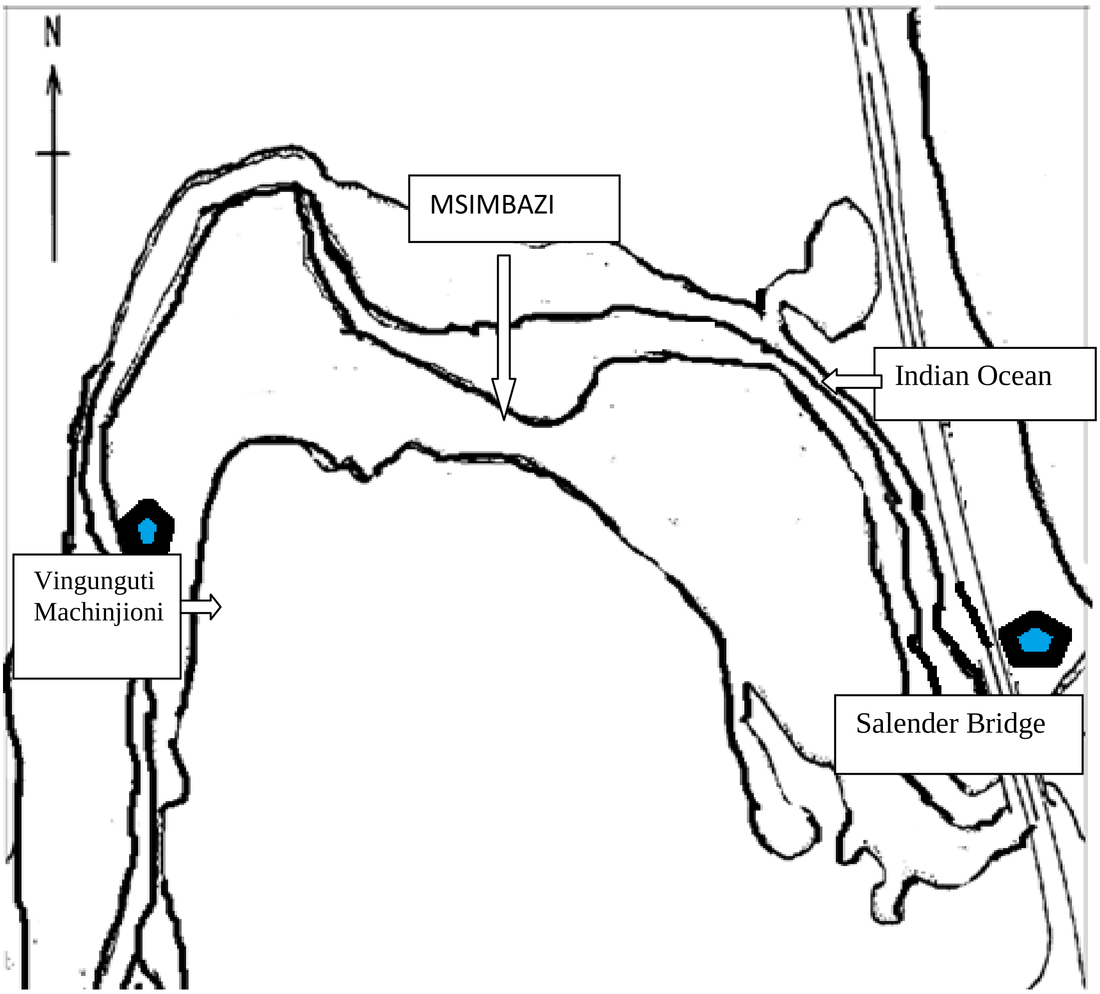


Figure 3.1: A Sketch Map of Msimbazi River
Source: Ngana and Mahanya

The Msimbazi River has the total length of about 35km within a catchment area of about 289 square kilometers (Ngana and Mahaya, 2010). The river flows from Pugu forest reserves with tributaries of Sinza, Ubungo and Luhanga and flows to the eastern side toward Indian Ocean (Ngana and Mahaya, 2010). It is an important water source for the residents of Dar es Salaam and its neighborhood for drinking, bathing, support for agriculture, industries, an environmental buffer, building, discharge of industrial effluents and illegal sewage system. The Msimbazi River drains the urbanized areas of Ilala and Kinondoni Municipalities. Most people in Msimbazi River area are not connected to a sewage system. Septic tanks and pit latrines are used instead. Most people lack any sanitations facilities which cause sedations of wastewater into black and gray water. The latter will flow through ditches, open channels and little strain to a receiving water body which is Msimbazi River and end up into the Indian Ocean.

This study concentrates on Msimbazi River in DSM, the city is traversed by the river, while originates 35km off coast in Pugu forest (Hobbelen, 2001) its catchment area is approximately 260 km^2. It covers one third of the total population and about 50% of the industrial production of the town (ibid.). Msimbazi River is the essential need to the DSM people because it has the fertile grounds and supplies irrigation works. Most of the vegetable and fruits are cultivated around the Msimbazi River. Msimbazi River also acts as an open sewer and in additional as gray water runoff, it collects (untreated) wastewater from industries, drains and waste stabilization ponds (Hebron, 2001).

3.2 Sampling and Sample Size

Sampling was conducted at different points of Msimbazi River in Dar es salaam, the sampling area were Vingunguti Machinjioni in Kinondoni district at the bridge premises which make the boundary between Vingunguti Machinjioni and Barakuda Tabata, and the ending premises of Msimbazi river which is Selander Bridge in Ilala district (Figure 3.1). Sampling was done on a weekly basis from September to November, making a total of 192 samples during morning sessions. During each sampling occasion six samples were collected, three from Vingunguti Machinjioni and three from Selander Bridge the entire samples were collected using stelire bottles. The bottles were kept in a cooled box and transported to the laboratory of Ubungo Maji for analysis of fecal indicator bacteria, biochemical oxygen demand and nutrients.

3.3 Laboratory Analysis of Samples

Wastewater samples from two stations which were Vingunguti Machinjioni and Selander Bridge were collected once a week for two months from September to November, 2014. The analytical work was carried out in Ubungo Maji laboratory. The collected waste water samples were analysed using the Standard Methods of Examination of Water and Wastewater, 20th Edition (1998) and APHA (1995) were used throughout water quality analysis of samples. The following parameters were assessed as part of standard water quality assessment practice.

3.3.1 pH

The samples for pH measurements were taken in sampling bottles and analyses were done onsite. The basic principle of electrometric pH measurement was determination of the activity of the hydrogen ions by potentiometric measurement using a standard hydrogen electrode and a reference electrode. The hydrogen electrode consists of platinum electrode across which hydrogen gas was bubbled at a pressure of 101kPA. Because of difficulty in its use and the potential for poisoning the hydrogen electrode the glass electrode commonly was used. The electromotive force produced in the glass electrode system varies linearly with pH. The linear relationship is described by plotting the measure against the pH of different buffer. Samples pH ware determined by extrapolation (Standard methods for the Examination of Water and Wastewater, APHA).

3.3.2 Chemical Oxygen Demand

The samples were taken into the glass amber bottles and then fixed by using Manganese Sulphate and concentrated sulphuric acid. Then the samples were stored in a cool box before reached the laboratory for analysis. In the laboratory, the portion of the sample were treated and heated in the COD reactor followed by titration to obtain the chemical oxygen demand in the wastewater samples. The quantity of oxidant consumed was express in terms of its oxygen equivalence. Because of its unique chemical properties, the dichromate iron is the specified oxidant in various methods used for chemical oxygen demand analysis; it is reduced to the chromic ion in these tests. Both organic and inorganic components of the sample are subject to oxidation but in most cases the organic component predominates and was the greater interest.

Methods of closed open reflux were reduced to the chromic ion in these tests. Both organic and inorganic components of a sample are subject to oxidation, but in most the components predominates and are of the greater test interest. COD is defined the extent of sample oxidation can be affected by digestion time, reagent strength, and sample COD concentration. COD often was used as a measurement of pollutants in wastewater and natural waters. The open reflux method was suitable for a wide range of wastes where a large sample size was preferred. Most types of organic matter were oxidized by boiling mixture of chromic and sulfuric acids. A sample was a refluxed in strongly acid solution with a known excess of potassium dichromate was titrated with ferrous ammonium sulfate to determine the amount of $K_2Cr_2O_7$ consumed and the oxidized matter was calculated in terms of oxygen equivalent. Ratios of reagent weights were kept, volumes and strength constant when sample volumes other than 50 were used. The standard 2-h reflux time may be reduced, it has been shown that a shorter period yield the same results. Some samples with very low COD or with highly heterogeneous solids content may need to be analyzed in replicate to yield the most reliable data. Results are further enhanced by react a maximum quantity of dichromate provided that some residual dochromate remains.

Apparatus: Reflex apparatus consisting of 500 or 250 ml Erlenmeyer flasks with ground glass 24/40 neck and 300 mm jacket lie beg west or equivalent condenser with 24/40 ground. Apparatus used were reflux apparatus, blender, pipettes, class A and wide bore reagents standard potassium dichromate solution, sulfuric acid reagents and ferrous indicator solution. Treatment of samples with COD of >50. Blend if necessary and pipette 50.00ml into 500ml refluxing flasks for sample with a COD of >900mg O2 /l, use a smaller portion diluted to 50ml, add 1g $HgSO_4$ several glass beads and very slowly add 50.00ml sulfuric acid reagent mix to dissolve $HgSO_4$ cool while mixing to avoid possible loss of volatile materials. Add 25.00ml, 0.04167, $K_2Cr_2O_7$ solution and mix. Attach flask to condenser and turn cooling water. The remained sulfuric acid reagent (70ml) was added through open end of condenser. Open end of condenser was covered with smaller beaker to prevent foreign material from entering refloating mixture and reflux for 2 hours. The condenser was cooled and washed with distilled water. Reflux condenser was disconnected and the mixture diluted to about twice of its distilled water cooled to room temp and titrate excess $K_2Cr_2O_7$ with FAS using 0.10 to 0.15mL (2 to 3drops) ferron indicator. Although the quantity of ferron indicator is not critical, use the same volume for all titrations. Take as the end point of the titration the first sharp color change from blue-green to reddish brown that persists for 1 min or longer. Duplicated determinations should agree within 5% of their average. Samples with suspended solids or components that are slow to oxidize may require additional determinations. The blue-green may reappear. In the same manner, reflux and titrate a blank containing the reagents and a volume of distilled water equal to that of sample.

3.3.3 Nitrogen

The Kjeldahl method was used to determine nitrogen in Vingunguti Machinjioni and Selander Bridge. Kjeldahl method was consisted of three steps which were digested in strong sulfuric acid in the presence of the catalyst, which helped in the conversion of the amine nitrogen to ammonium ions. The ammonium ions were converted into ammonia gas into a trapping solution where it was dissolved and became ammonium ions once again. Finally the amount of ammonia that had been trapped was determined by titration with a standard solution and a calculation made.

Nitrogen is the sum of the organic nitrogen and ammonia nitrogen, the major factors that influences the selection of micro or semi Kjeldahl method to determine the organic nitrogen in its concentration. The micro Kjeldahl method was applicable for the samples containing either low or high concentration of organic nitrogen but require a relative large sample of volume for low concentrations. In semi micro Kjeldahl method which is applicable to sample containing high concentrations of organic nitrogen, the sample volume should be chosen to contain organic plus ammonia nitrogen in the range of 0.2 to 2mg. The block digestion method is the micro method with an automated analysis step capable of measuring organic nitrogen as low as 0.1mg per L when blanks are carefully controlled.Macro kjeldahl method in the presence of H_2SO_4, potassium sulfate (K_2SO_4) and cupric sulfate ($CUSO_4$) catalyst, amino nitrogen of many organic materials is converted to ammonium; free ammonia is also converted to ammonium. After addition of base the ammonia is distilled from an alkaline medium and absorbed in boric or sulfuric acid, also the ammonia may be determined calorimetrically by ammonia selective electrode or titration with standard mineral acid.

3.3.4 Ammonia

The trimetric method was used only on samples that have been carried through preliminary distillation. The sample was buffered at pH of 9.5 with borate buffer to decrease hydrolysis of cyanate and organic nitrogen compounds. It was distilled into the solution of boric acid when titration was used. The ammonia in the distillated was determined by colorimetric method. Dissolved ammonia (NH_3aq) and NH_3 plus aq). By raising pH to above 11 with the stronger base NH_3aq diffuse through membrane and change the internal solution of pH that is used by a pH electrode. If a sample is visibly turbid, it must be centrifuged or filtered through a well-rinsed
0.4 pm Nuclepore membrane filter. Samples containing more than 150 pmo of sulphideare treated as follows:

To 50ml of sample are added to 0.1mL of sulphuric acid (reagent 1) and bromine water (reagent 8) drop by drop until the solution remains pale yellow for about 5 min. The excess bromine is removed by a fast stream of air from a capillary positioned above the surface of the solution. For precision measurements, correct the dilution caused by the added sulphuric acid and bromine water (about 0.4 %), (1 mL of sulphuric acid, reagent 1, per 100mL) or surface water from the same station. The silicate in the diluted water does not react because oxalic acid is present in the sample. Measure the absorbance in a cell of suitable length at 810nm (or 660nm for high concentrations) after a reduction time of 30-60min against a cell of equal length filled with. To calculate the concentration of the diluted sample, multiply the absorbance (sample absorbance- blank absorbance) by the dilution factor of 1.91 (105/55) and the calibration factor. To 50 mL of sample in a plastic reaction flask add 2 mL of the molybdate reagent (reagent 2), swirl and allow to stand for 10-20 min for freshwater and 5-10 min for seawater samples.

Next, add 2 mL of oxalic acid (reagent 4) followed immediately by 1 mL of ascorbic acid(Reagent 6). Mix gently between additions. With amounts of up to about 30 pmoVL, the colour reaches its maximum after ca. 20 min and is then stable for several hours. If the colour is dark blue, indicating a silicate content of more than about SOpmoVL, the reduced sample is diluted with 50mL of acidified.

3.3.5 Dissolved Oxygen

Dissolved oxygen (DO) levels in natural and waste waters depend on the physical and bluchemmeal activities in the water body. The analysis for DO is a key test in water pollution and waste treatment control. The iodometric methods was a micrometric procedure based on oxidizing property of DO white the membrane electrode procedure was based on the rate of diffusion of molecular oxygen across a membrane. The iodometric test was the most precise and reliable titrimetric procedure for DO analysis. It was based on the additional of divalent manganese solution, followed by strong alkali, to the sample in a glass stoppered bottle. DO rapidly oxidize an equivalent amount of the dispersed divalent manganous hydrozide precipitate to hydroxides of higher valance states. In the presence of iodide ions in an acid solution, the oxidized manganese reverted to the divalent state, with the liberation of iodine equivalent to the original DO content. The iodine was titrated with a standard solution of hyposulfite. The titration end point can be detected visually with a starch indication or electrometrically, with potentiometer or dead-stop technique! Experienced analysts can maintain a precision of =50 kg/l with visual end point detection and a precision of =5 g/l with electrometric end point detection 1, 2. The liberated iodine also was determined directly by simple absorption spectrophotometers. This method can be used on a routine basis to provide very accurate estimated for DO in the microgram per liter range provided that interfere particular matter color and chemical interferences are absent.

3.3.6 Phosphate

Phosphorus compounds are plant nutrients and cause algal growth in surface water which depending on the phosphate concentration in the water eutrophication may occur (Putz, 2008). The phosphate compounds that are discharged directly into surface waters comes from fertilizer washed out of the soil, human and animal excretions and detergents and cleaning agents (Putz , 2008). Phosphate analysis in water: Detergents are among the greatest contribution to phosphate content in rivers and lakes because phosphate-containing compounds are used in detergent formulation as water softeners. Phosphate is nontoxic to animal or plant (Jeschofnig, 1998). The principle of this method involves the formation of molybdophosphoric acid, which was reduced to the intensely colored complex, molybdenum blue. This analytical method was extremely sensitive and was reliable down to the concentration below 0.1ppm (mg) phosphorus per liter.Apparatus used: spectronic 20 spectrophotometer was employed in the measurement of color intensity of the blue solution. A wavelength of 650nm was used in these analyses.Reagents are ammonium molybdate reagent, stannous reagent and stock 20.0 pm phosphate solution.

After measuring the absorbance of this solution, a plot of absorbance versus concentration was made. Color development in sample was used for the measuring three standard solutions and for any river, lake, or sewage water samples, which were analyzed for phosphate. Placed in an Erlenmeyer flask, 25 ml of the water sample was analyzed. 1.00ml (using a pipette) of ammonium molybdates solution was put into the flask and swirl mixed. To the flask were added 2 of stannous chloride solution and mixed by swirling. If the phosphate was present a blue color will develop to a maximum intensity in 5 minutes. While waiting a blue color to develop, the wavelength to 650nm was set on the spectrophotometer. The blank solution was used to set it to read zero absorbance. We used 650nm wavelength to measure the absorbance of the solution (y-axis) versus the concentration of the standard (x-axis).

3.3.7 Total Suspended Solids

A sample was well-mixed sample, filtered through a standard glass fiber filter, and the filtrate was evaporated to the dryness in weighed dish and dried to constant weight at 197-181centgrade. The increase in dish weight represents the total dissolved solids. A well-mixed sample was filtered through a weighed standard glass fiber filter and the residue retained in the filter was dried to a constant weight at 103-105C. Increased in weight of the filter represents the total suspended solids. If the suspended material clogs the filter and prolongs filtration, the difference between the total solids and total dissolved solids may provided an estimate of the total suspended solids. Apparatus required were evaporating dish, water bath, and oven. Others were desiccators, analytical balance, graduated cylinder, dish tongs, gooch crucibles, filter, vacuum pumps, crucible tongs, forceps and smooth tipped. Procedure used in testing total dissolved solids was: a porcelain dish has been in the oven at 180C. Then we mixed sample well and poured it into a funnel with filter paper. A pipette was used to transfer 75ml of unfiltered sample in the porcelain dish. The oven was switched on and allowed to reach 105°C, and cooled the container in desiccators.

3.3.8 Biological Oxygen Demand

The BOD samples were taken into the BOD amber bottles and kept into the cool box for storage before laboratory analyses. After reached at the laboratory the samples were incubated in the BOD incubator using the bottle incubation for 5 days at 20°C method. The value of BOD can be obtained after subtracting the titration results of the sample of BOD_1 and BOD_5. The biochemical demands (BOD) determination is an empirical test in which test in standardized laboratory procedure are used to determine the relative oxygen requirement of wastewater, effluents, and polluted waters (Standards methods of wastewater).

The test has its widest application in measuring waste to loadings to treatment systems plants and in evaluating the BOD removal efficiency of such treatment systems. The test measure the molecular oxygen utilized during a specified incubation period for the biochemical degradation of the organic material (carbonaceous demand). And the oxygen used to oxidize inorganic material such as sulphides and ferrous iron. It also measure the amount of oxygen used to oxidize reduced forms of nitrogen (nitrogen demand) unless their oxidation is prevented by an inhibitor. The seeding and dilution procedures provide an estimation of the BOD at pH of 6.5 to 7.5. Measurement of oxygen consumed in 5 day test period (5d BOD or BOD_5): Oxygen consumed after 60 to 90d of incubation (ultimate BOD or UBOD) and continuous oxygen uptake is measured using respirometric method.Respirometric methods provide direct measurement of oxygen consumed by microorganisms from the air or oxygen-enriched environment in a closed vessel under conditions of constant temperature and agitation. Respirometry methods were useful for assessing biogedration of specific chemicals, and treatability of organic industries wastes. The effects of known amounts of toxic compounds on the oxygen-uptake reaction of test wastewater or organic chemical the concentration at which a pollutant or a wastewater measurably inhibits biolologically oxidizable matter; the need for using adapted seed in other biochemical oxygen uptake measurements such as dilution BOD test and stability of the sludge.

3.3.9 Turbidity

Sample for turbidity: No pre treatment of the sample was done after sampling. The bottle was kept in a cool box for temporary storage waiting laboratory analysis. The optical method was used to measure turbidity by using turbidimeter. The amount of turbidity measured in a sample depends on such variables as size, shape and refractive index of the particles. Turbidity in water is caused by suspended and colloidal matter such as clay, silt, finely divided organic and inorganic matter and plankton and other microscopic organisms. Turbidity is an expression of the optical property that cause light to be scattered and absorbed rather than transmitted with no change in direction or flux level through the sample. Most turbidimeters designed for measuring low turbidities give comparatively good indications of the intensity light scattered in one particular direction predominantly at right angles to the incident light. Turbidimeters with scattered light detectors located at 90˚ to incident beam are called nephelometers. Nephelometers were relatively unaffected by small difference in design parameters and therefore were specified as standard instrument for measuring of low turbidities.Turbidity must be determined as soon as possible after the sample is taken. Gently agitate all samples before examination to ensure a representative measurement. Refrigerate or cool to 4 centragrade minimize microbial decomposition of solids, if storage is required for the best results, measure turbidity immediately without altering the original sample conditions such as temperature or pH

3.3.10 Conductivity

Conductivity is the measure of the ability of an aqueous solution to carry an electric current. This ability depends on the presence of ions, on their total concentration, mobility and valence; and on the temperature measurement. Solutions of most inorganic compounds were relative good conductors. Conversely, molecules of organic compounds that do not dissociate in aqueous solution conduct a current very poorly. Conductance of a solution was measured between spatially fixed and chemically inert electrodes.

To avoid polarization at the electrode surfaces the conductance measurement was made with an alternating current. Conductivity was measured with a probe and a meter. Voltage was applied between two electrodes in a probe immersed in the sample water. The drop in voltage caused by the resistance of the water is used to calculate the conductivity per centimeter. The meter converts the probe measurement to micromhos per centimeter and displays the result for the user. Some conductivity meters can also be used to test for total dissolved solids and salinity. The total dissolved solids concentration in milligrams per liter (mg/L) can also be calculated by multiplying the conductivity result by a factor between 0.55 and 0.9, which was empirically determined (see Standard Methods #2510, APHA 1992). All laboratory analysis was carried out in accordance with the Standard Methods for the Examination of Water and Wastewater (APHA, 1998). The calibration of possible meters was according to the manufacturer instruction. Precision and accuracy of the spectrophotometer and the procedures of sample analysis were counter-checked by determining the concentration of known standards.

3.3.11 Colour

Colour is determined by visual comparison of the sample with known concentration of the coloured solutions. Comparison also may be made with special, properly calibrated glass colour disks, called the platinum-cobalt method (SMWW, 2000). The platinum-cobalt method of measuring colour is the standard method and the unit of colour being that produced by 1mg/l in the form of chloroplatinade ion (SMWW, 2000). This method is applicable for industrial wastewater.The best method applicable to portable and surface water both domestic and industrial is spectromephotometric method whereby the colour of filtered sample is expressed in terms that describe the sensation realized when viewing the sample which is red, and green which is designated by the term “dominant wavelength”, the degree of brightness by “luminance” and the saturation (pale, pastel and others) by purity (SMWW, 2000).

3.3.12 Sulphate

Turbid metric method of measuring sulphate is based upon the fact that barium sulphate tends to precipitate form of uniform size and this tendency is enhanced in presence is based upon the fact that Barium Sulphate tends to precipitate the form of uniform size and this tendency is enhanced in presence of sodium chloride, hydrochloric acid and glycerol (SMWW, 2000). SO_4-+Bacl →$BaSO_4$ different from each other.

3.3.13 Infectious Diseases

The infectious disease agents associated with municipal wastewater and sludge are those found in the domestic sanitary waste of the population and from industries that process meats, fish, and other food products (National Academy Press, 1996). These microbial pathogens include a large number of bacteria, viruses, and parasites. Important examples are members of the bacterial genera *Salmonella* and *Shigella*; the infectious hepatitis, Rota and Norwalk viruses; and the parasites associated with giardiasis, cryptosporidiosis, taeniasis, and ascariasis. (National Academy Press, 1996) Bacteria , viruses and parasites including worms and protozoan are types of pathogens that are hazardous to humans. Sewage and waste water is the source of the infectious disease for example bacteria are responsible for several wastewater related disease such as typhoid, paratyphoid, bacillary dysentery and cholera. (Taylor and Yahner, 1996). Diseases caused by viruses which infect people through wastewater include Hepatitis A, polio and viral gastroenteritis. Parasites in wastewater caused the outbreak of disease through drinking water. The types of parasites found in waste water include protozoans and helminthes (parasitic which cause severe diarrhea) and Entameoba hystolytica cause amebiosis which can be controlled by boiling water

(Taylor and Yahner, 1996). Humans "catch" diseases from wastewater in a variety of ways. Pathogens in wastewater may be transmitted by direct contact with sewage, by eating food or drinking water contaminated with sewage, or through contact with human, animal, or insect carriers. (Taylor and Yahner, 1996). For example, direct contact might accidentally occur as a result of walking in fields fertilized with untreated wastes, playing or walking in a yard with a failed septic system, touching raw sewage disposed of in open areas, swimming or bathing in contaminated water, or working with or coming into contact with animals or wastewater and not following proper hygiene. (Taylor and Yahner, 1996). Houseflies can be used to illustrate the dangers posed by disease carriers.

Flies, which have tastebuds on their feet, always land directly on the food they eat-and on any given day, that could mean raw sewage (a fly favorite) followed by picnic food. The hairs on a housefly's body can carry millions of pathogens, which then brush off on anything the fly touches. By making sure that wastewater is treated and disposed of properly, communities can control the spread of disease by flies and other disease carriers, such as rats, lice, cockroaches, and mosquitoes. By controlling the population of these animals and insects, communities also help to control the other, non-wastewater related diseases they may carry. But by far the most common way that people contract diseases from wastewater is through the fecal-oral route, or in other words, by eating food or drinking water contaminated by sewage or by not washing hands after contact with sewage. (Taylor and Yahner, 1996).

3.4 Data Analysis

A t-test was used to analyze the data obtained between the two sampling sites. Such as to determine the means of two groups of sample if they are statistically different from each other.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Physicochemical Parameters

Most of waste water parameters indicated the pollution were higher in Salender Bridge as compared to Vingunguti Machinjioni due to the fact that the activities that add the pollutants are taking place along the river and there is no way that these pollutants are taken away from the river. Therefore there is magnification as on goes down the river from Vingunguti to Salender Bridge.

4.1.1 Temperature

The temperature values of wastewater determined in the two sampling points were significantly differing by 0.42, using t-test one tailed assumed unequal variances of two samples. The standard temperature of water in fresh water is 20^0C-35^0C according to standard of discharge of effluents or wastewater in the world (Kajura, 1995). Therefore the temperature of Selander and Vingunguti Machinjioni was within the acceptable standard of temperature.

The lowest temperature and the highest temperature were observed in the sixth weeks of observation at Salender Bridge. There were no trends of sampling values, the values increased or decreased for each sampling time. Temperature influences the solubility of oxygen in water, vapour and pressure in the measured sample of oxygen permeability (Matsche and Kreuzinger 2001). Temperatures were represented in degree centigrade. The following (Figure 4.1) is the graph of temperature variation in two sampling points.

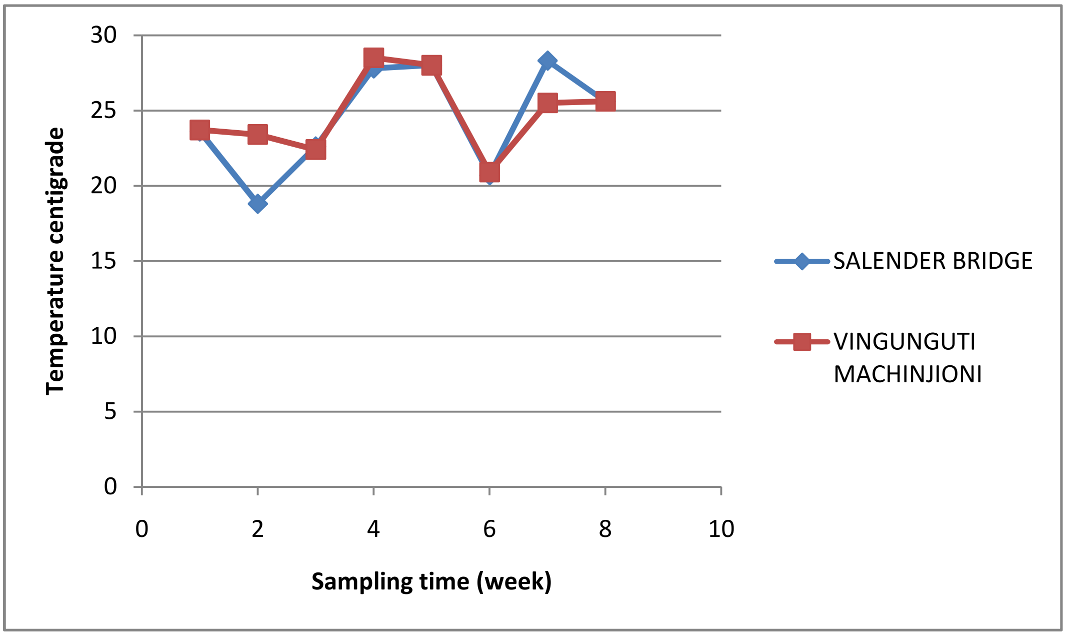


Figure 4.1: Temperature Variation

4.1.2 The pH

The pH is the negative decade logarithms of the H_3O concentration in water sample and is the value of water and the index of acidity or alkalinity. A number of mineral and organic matters interact with one another to give the resultant pH value of the sample (Shah et al., 2006). The pH of Selander Bridge and Vingunguti Machinjioni was not significantly different. The $p(T \leq t)$ two tailed was 0.898. It showed that the water was slightly an alkaline in nature.

The pH of the two sampling points, which were analysed, indicated in Figure 4.2. According to literature, the standard pH of the river is 6.8 - 8.0 according to standard of discharge of effluents or wastewater in the world (Kajura, 1995). The pH of the two sites was within the permitted limit according to Tanzania bureau of standards. The most important effect of pH in water bodies influence on the carbonate balance, the dissociation of ammonium and solubility of the metal ions (Wenner and Sanger, 1996). At low temperature pH raises the solubility of ion of copper, Zink, nickel, lead and cadmium, whereas the solubility of vanadium and mercury decline. At pH 10 occurs a shift from the non toxic ammonia, which leads to critical condition to fish. The pH of most healthy estuarine is 6.0 - 8.5 ranging from slightly acidic to slightly basic. Most organisms are adapted to level within a narrow range of pH, can affect the population and distribution of estuarine inhabitants. The pH influences the availability of toxicity of contaminants marked, dissolve time can indicate the pressure of effluents and atmospheric deposition of substances and however, die variation in pH also occurs and can be caused by photosynthesis and respiration cycles of algae in eutrophic water (Wenner and Sanger, 1996).

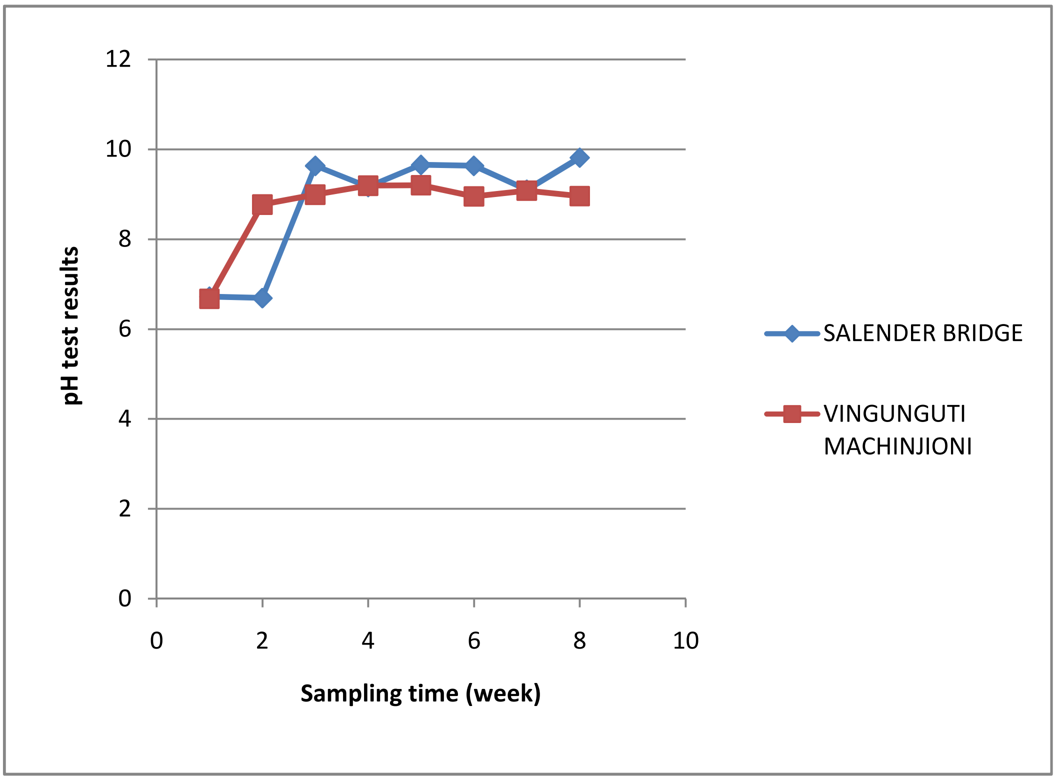


Figure 4.2: pH Value in Sampling Points

4.1.3 Electronic Conductivity

Conductivity is used to determine salinity and is actually a measure of the water to conduct an electrical current (Wenner and Sanger, 1996). Conductivity is proportional to the concentrations of total dissolved solids and major ions, and its measurement is influenced by amount of electric charge each ion mobility and temperature of the water (Chapman, 1992). Conductivity is proven to be useful in determining the extent of influence of runoff and effluents discharge in the aquatic (Wenner and Sanger, 1996).

Electronic conductivity showed highest significantly difference between Selander bridge as compared to Vingunguti Machinjioni. The highest electronic conductivity might be explained by the following possibility:

Discharge to streams can change the conductivity depending on their make-up and a failing sewage system would raise the conductivity because of the presence of chloride, phosphate, and nitrate, an oil spill would lower the conductivity (APHA, 1992). Most of sewage system in Dar es Salaam are directs to Msimbazi river and the treatment are not well done, or partially done. Pollutants from urban, agricultural, industrial and industrial sources usually increase the electrical conductivity of water and make it unsuitable for usage (Coast learn, 2012). Most of the wastewater produced in the city is deposited to the nearest the river especially the people around the river Msimbazi. All the deposition increased electrical conductivity. Wastewater from septic systems and drain field on-site wastewater treatment and disposal system, increase the amounts of electronic conductivity in wastewater (Coast learn, 2012). Waste from urban roads agriculture areas such as gardens situated around stream increased the amount of electronic conductivity especially in Salender Bridge because the entire river wastes deposition at this sampling area. The conductivity of Selander Bridge was higher than of Vingunguti Machinjioni as indicated in Figure 4.3 and appendix. The mean concentration of conductivity of Selander Bridge was above the permissible limits of the world and Tanzania standards of discharge. Higher conductivity is the indicator that polluting discharges have entered the water. High conductivity will result from the presence of various ions including nitrate, phosphate and sodium (Behari, 1997). Aquatic animals and plants are adapted for a certain range of salinity. Outside of this will be negative affected and may die (Fondriest Environmental, 2015).

Effects of the conductivity: Conductivity in streams and rivers is affected primarily by the geology of the area through which the water flows. Streams that run through areas with granite bedrock tend to have lower conductivity because granite is composed of more inert materials that do not ionize (dissolve into ionic components) when washed into the water (EPA, 2012). On the other hand, streams that run through areas with clay soils tend to have higher conductivity because of the presence of materials that ionize when washed into the water and the ground water inflows can have the same effects depending on the bedrock they flow through (EPA, 2012). Discharges to streams can change the conductivity depending on their make-up. A failing sewage system would raise the conductivity because of the presence of chloride, phosphate, and nitrate; an oil spill would lower the conductivity (EPA, 2012). Salts and other substances affect the quality of water used for irrigation or drinking. They also have a critical influence on aquatic biota, and every kind of organism has a typical salinity range that it can tolerate. Moreover, the ionic composition of the water can be critical.

For example, cladocerans (water fleas) are far more sensitive to potassium chloride than sodium chloride at the same concentration pH and water quality. Excessively high and low pHs can be detrimental for the use of water such high pH causes a bitter taste, water pipes and water-using appliances become encrusted with deposits, and it depresses the effectiveness of the disinfection of chlorine, thereby causing the need for additional chlorine when pH is high, and low-pH water will corrode or dissolve metals and other substances.

Pollution can change water's pH, which in turn can harm animals and plants living in the water. For instance, water coming out of an abandoned coal mine can have a pH of 2, which is very acidic and would definitely affect any fish crazy enough to try to live in it. By using the logarithm scale, this mine-drainage water would be 100,000 times more acidic than neutral water so stay out of abandoned mines.

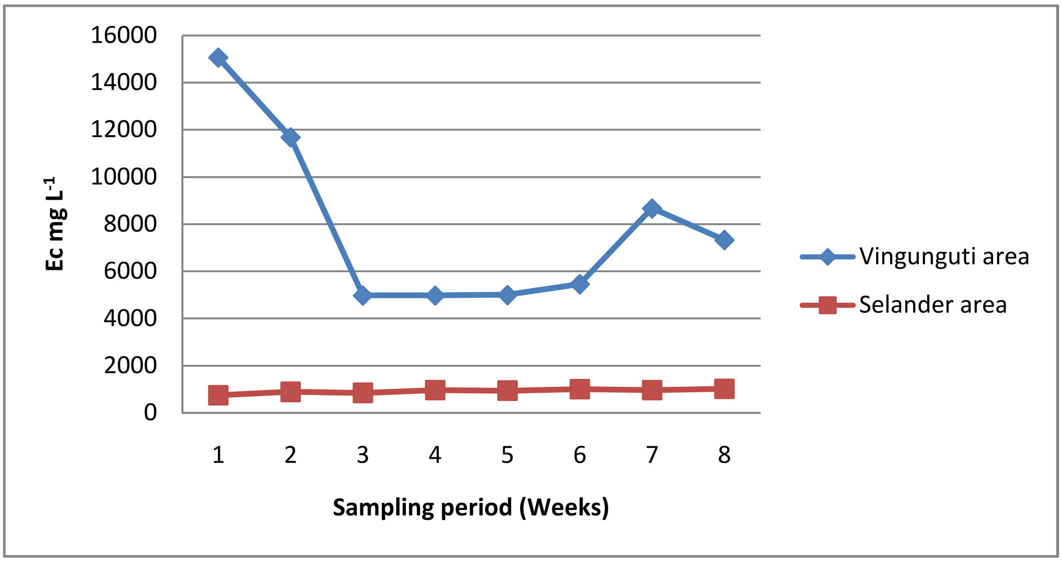


Figure 4.3: Electronic Conductivity

4.1.4 Total Dissolved Oxygen

Total dissolved solids is the total amount of mobile charged ions, including mineral, salts or metals dissolved in a given volume of water which are expressed in units of milligram per volume of water (mg/L), (H.M. digital, 2012). Total dissolved solids were significantly higher for Selander Bridge as compared to Vingunguti Machinjioni. High data for Salender Bridge could be explained by possibility of the following:

Total dissolved solids in water supply originated from natural sources such as sewage urban, agricultural runoff, industrial wastes, chemicals used in the water treatment process and the nature piping or hardware used to convey the water such as plumbing (Oram, 2014). In the United States elevated total dissolved solids has been due to natural environmental features such as mineral springs, carbonate deposits, and sea water intrusion, but other source may include salts used for road deicing, anti-skid materials, drinking water treatment chemicals, stormwater, and agriculture runoff of point and non point wastewater discharge (Oram, 2014).

Therefore, the accumulation of total dissolved in Selander Bridge associated with various activities take place in Dar es Salaam where the stream passed and ended here. Total dissolved solid of Vingunguti was lower than that of Salender Bridge as indicated in Figure 4.4. According to the standards of permissible limits of wastewater discharge effluents the total dissolved solids of Vingunguti Machinjioni is within the limits, this indicated that there is no pollution of water quality.

The highest mean analysed in Salender Bridge, which is the indicators of wastewater. The highest turbidity indicates the following consequences undesirable taste which could be salty, bitter or metallic and indicate the presence of toxic minerals (Water quality, 1998). High total dissolved solids because filter performance have a high rejection rate and know when to change your filter cartilages. Also total dissolved solids lead to hardness of water, which causes the scale buildup in pipes and valves inhibiting the performance (Water quality, 1998).

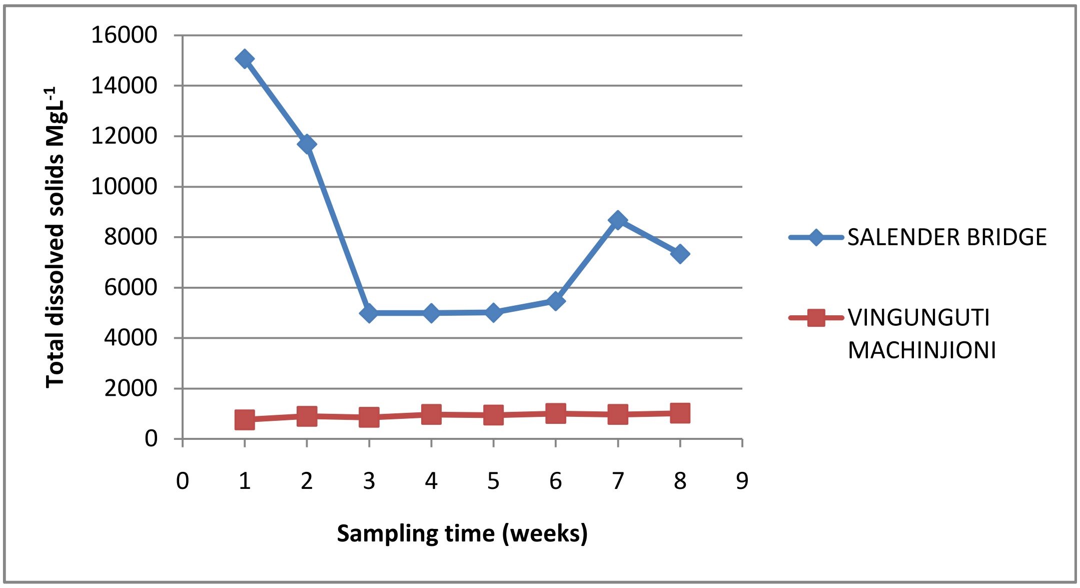


Figure 4.4: Total Dissolved Solids

4.1.5 Colour

Colour is an optical parameter consisting in absorbing of a part of spectrum of visible radiation by substances and suspended particles present in water of sewage. Colour in water may appear as the result of different source activity which is natural sources and anthropogenic source. Natural source include type of vegetation, decay of plant matter, humid substances, algae growth, plankton, minerals, such as iron, manganese, and copper and the anthropogenic sources involving sewage from paper mills, textile mills and food processing.

There are two types of water colour considered apparent colour and true colour, which is distinguished from apparent colour by filtering the sample. True color is mostly found in surface water and apparent color by is caused by coloured suspensions and dissolved matter. Colour measurement is carried by the use of optical principle, light absorbency and place detector in direction of incoming light source. Water colour may be indicator of toxicity and may stain textile and fixtures. It may be a result of the presence of coloured organic substances, metals such as iron, magnesium and copper or industrial wastes. Colour is the vital as most water users, be it domestic, industrial, usually preferred is colourless water.

The colour was significantly higher ($p \leq 0.01$) for Salender bridge as compared to Vingunguti Machinjioni. The difference could be explained by the following reasons: Water whose colour is due to suspended matter is said to have apparent colour which faded out when suspended solids settle. After contact with debris such as leaves, weeds and woods, water picks up tannins, humic acid and humates to take a yellowish brown hue. Iron oxide causes reddish water and manganous oxide gives brown or black is water (APHA, 1992).Industrial wastes from textiles and dyeing operation, pulp and paper wastewaters food processing waste liquids, mining, and refining and slaughter house operations add colour and receiving streams.

Colour in water may result from the presence of natural metallic ions, humas and peat materials planktons, weeds and industrial waste (APHA, 1992).The highest colour was observed in Salender Bridge and the lowest colour was in Vingunguti Machinjioni as indicated in Figure 4.5. The mean average of the Vingunguti

Machinjioni was within permissible limit but the mean concentration Salender Bridge was higher which indicates the availability of toxicity in water.

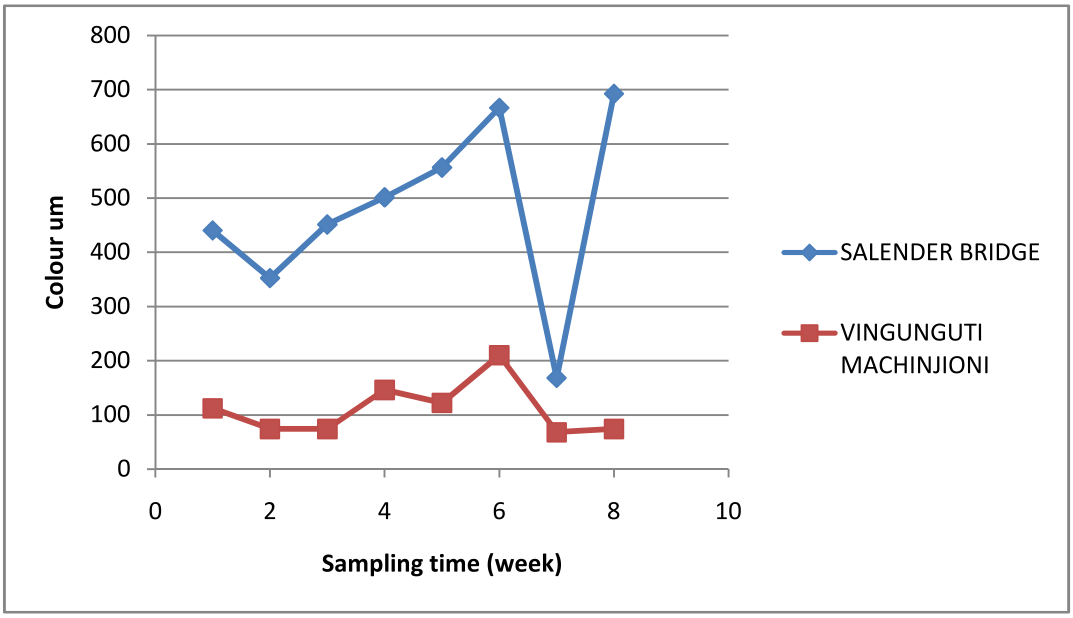


Figure 4.5: Colour Values in Sampling Sites

4.1.6 Turbidity

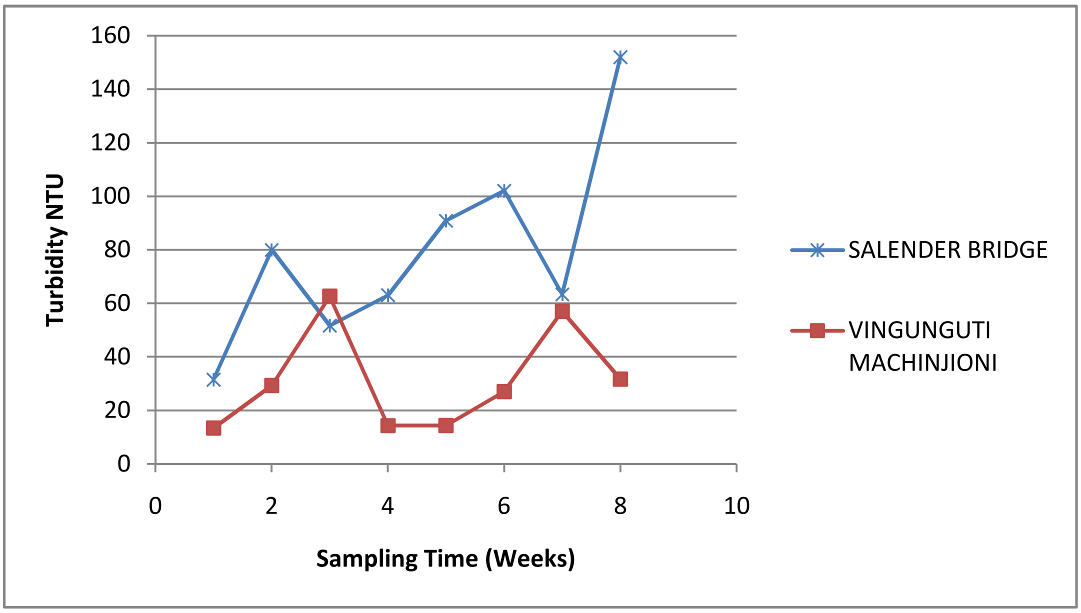
The turbidity was significantly higher for Salender Bridge as compared to Vingunguti Machinjioni. However the data for Salender Bridge indicated high value of turbidity at the sampling periods. High turbidity could be due to the following:

Factors contributing to water turbidity include soil erosion, elevated nutrients inputs that stimulate algal blooms, waste discharge, and an abundance of bottom feeders that stir up sediments (Kreger 2004). Msimbazi River passes through different places where agriculture took place and increase soil erosion which increades amount of turbidity in the Salender areas. In Vingunguti Machinjioni turbidity is lower than that of Salender Bridge as indicated in Figure 4.6. Changes in turbidity can have direct and indirect effects on fish. At extremely high levels, turbidity can directly affect fish growth and survival, for example, by interfering with gill function or the quality of substrata for egg laying (Bash et al., 2001). By limiting the photic zone turbidity can also reduce habitat quality, for example, by reducing macrophyte cover from predators (Goldsborough and Kemp 1998; Berger et al., 1999).

Turbidity also limits fish vision, which can interfere with social behavior, foraging and predator avoidance (Miner and Stein 1996; Meager et al., 2006). This can have varying effects on fish growth and survival, depending on range factors such as ambient light levels and depth; relative visual sensitivities of predators and prey, and non-visual sensory abilities.

Although the effects of turbidity on freshwater fishes are well known, little is known of the effects on marine fishes. Turbidity levels in marine systems are generally not as extreme as fresh water hence; behavioral effects are considered to be more important than physiological effects (Utne-Palm, 1999).

The impact of changes in turbidity on fishes in marine systems is likely to depend on background turbidity levels. In the systems with high levels of algal productivity, high flow and terrestrial inputs such as estuaries, turbidity levels are naturally high. In such areas, turbidity can have a positive effect in reducing predation from visual predators (Johnson and Hines, 1999; Meager, 2003). Turbidity can also have a positive effect in areas with low background turbidity where small increases can enhance feeding of planktivores and larval fish by increasing prey contrast (Boehlert and Morgan 1985; Utne 1997). A similar visual effect is evident when we view a nearby object in thick fog. However, with larger and more conspicuous visual targets, for example, fish prey, for specifics predators, even small increase in turbidity rapidly limit visual range.



4.1.7 BOD and BOD_5

Biological oxygen demand is the measure of the quantity of oxygen consumed by microorganisms during decomposition of organic matter (water quality). Biological oxygen demand is the most used parameter for determining the oxygen demand on the receiving water of the municipal or industrial discharge and it is used for evaluation of efficiency of treatment processed and is an indirect measure of biodegradable organic compound in water. BOD_5 is the biochemical oxygen demand for a period of five days which is equal to the amount of dissolved oxygen required by the organism for the aerobic decomposition of the organic matter present in water. This is measured at 20^0C for a period of five days the parameter yield information on the degree of water pollution with organic matter (Delzer and McKenzie, 2003).

BOD_5 was significantly higher for Salender Bridge as compared to Vinguguti Machinjioni. The increase of biochemical oxygen demand in Salender Bridge could be explained by the possibility of the following:

Urban runoff carries pet wastes from street and sidewalks, nutrients from lawn fertilizers, leaves, grass clippings and paper from residential areas which increase oxygen demand (APEC, 2000). Some of the areas around the Msimbazi River cultivate green vegetable such as spinach, amaranths, Chinese cabbage, and others using fertilizers from industries. Running water carried different wastes down to the river. Therefore the amount of runoff increased and led to the accumulation of biological oxygen demand in Salender Bridge.

Nitrate and phosphates in a body of water can contribute to high level of biological chemical demand. By referring to the data observed in this research the data in Salender Bridge the amount of nitrate and phosphate was high.Decreased of dissolved oxygen in Salender Bridge lead to the increase of biological oxygen demand in this sampling place because of oxygen available in the water is being consumed by bacteria. The amount of dissolved oxygen in Salender Bridge was zero in all the sampling periods. Biological oxygen demand leads to eutrophication in the water in the water body. The BOD_5 of Salender Bridge is the higher than that of Vingunguti Machinjioni as indicated in Figure 4.7. The standard BOD is 5-50mg/L according to standard of discharge of effluents or wastewater in the world (Kajura, 1995). The highest BOD is a best indicator of poor water quality accompanied by low dissolved oxygen obtained at Salender area where there was zero dissolved oxygen.

The problems associated with the higher BOD are as follows: the BOD affects the amount of dissolved oxygen in rivers and streams. The greater water the BOD, the more rapidly the oxygen is depleted in the stream. This means less oxygen is available to higher forms of aquatic life. The consequences of higher BOD are the same as the low dissolved oxygen aquatic organism become stressed, suffocate, and die (APHA, 1992).

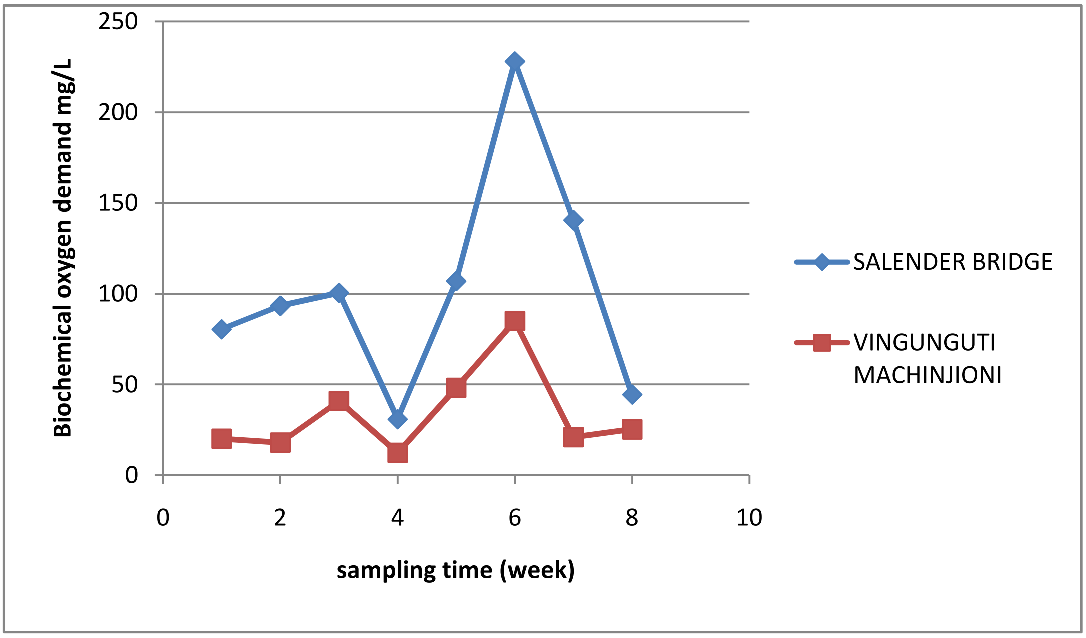


Figure 4.7: Biochemical Oxygen Demand Values

4.1.8 Chemical Oxygen Demand

Chemical oxygen demand is a measure of the capacity to consume oxygen during the decomposition of organic matter and the oxidation of inorganic chemicals such as ammonia and nitrite. COD measurement is commonly made in samples of wastewater or natural waters contaminated by domestic or industrial wastes.The sampling value of chemical oxygen demand for Salender Bridge was higher than the Vingunguti Machinjioni.

The trends of chemical oxygen demand in Salender Bridge increased for the first three weeks and dropped down then increased for two weeks and then decrease slowly.The trends of Vingunguti Machinjioni started high in the first week then decreased, then dropped down. Therefore the trend was not consistency.Chemical oxygen demand was significantly higher for Salender Bridge as compared to Vingunguti Machinjioni.

The high chemical oxygen demand of Salender Bridge could be explained by the following possibility:

High chemical oxygen demand decreased the amount of dissolved oxygen available for aquatic organism. Using the results which were analyzed in this research, it is observed that the dissolved oxygen of Salender Bridge was approximately zero in all the sampling periods. Highest chemical oxygen demand in waste or natural waters caused of contaminated by domestic or industrial wastes. According to the nature of Msimbazi River the indigenous of Dar es Salaam use the river for dumping wastes from homes, markets, and other business activities. The most effluents are from toilets, industries, and other sewage, directs waste waters into the river without any kind of the treatment. All the above activities contributed to the increase of chemical oxygen demands in Salander Bridge.Chemical oxygen demand of Salender Bridge was higher than the COD of Vingunguti Machinjioni as indicated in Figure 4.8. According to the standard to discharge water in Tanzania, the permissible limit is 60ml per litre (Kajura, 1995). The mean of the two sites indicates that the obtained data was above the permissible limit, the difference was slightly in Vingunguti Machinjioni. In Salender Bridge the amount of COD analyzed was too higher which indicate the following:

Adverse human impacts: higher levels of COD in water often correlate with treats to human including toxic algae blooms bacteria from organic wastes and seafood contamination (NOAA, 2003).Adverse impacts to the environment: higher COD level decrease the amount of dissolved oxygen available for aquatic organisms, dissolved oxygen or hypoxia caused reduced cell functioning disrupts, circulatory fluid balance in aquatic species and can result in death of individual organisms (ESA, 2000). As wall the larger dead zone. Hypoxic water can also release pollutants stored in sediment.

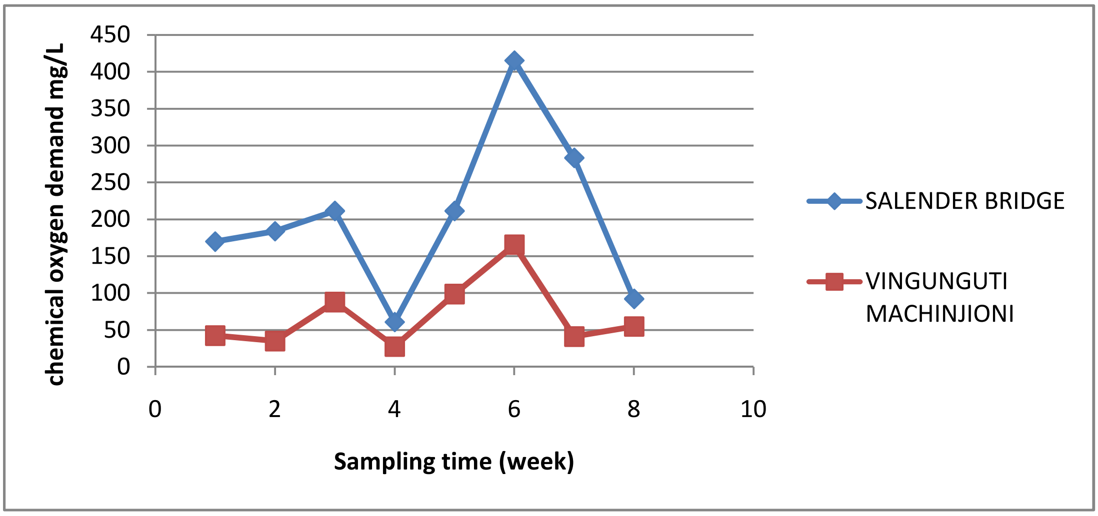


Figure 4.8: Chemical Oxygen Demand

4.1.9 Nitrate

Nitrate was significantly higher for the Salender Bridge as compared to Vingunguti Machinjioni. The higher nitrate in Salender Bridge could be explained by the possibility of the following:

Nitrates caused by the discharges of agricultural and industrial sources and caused eutrophication of water bodies with high concentration of these pollutants make the water unsuitable for drinking and industrial usage (Kregar, 1997). Common source of excessive nitrogen include sewage and agriculture runoff (Kregar, 1997). Most of the sewage system are directed into the river especially Msimbazi River this increased highest amount of sampling points. The excessive nutrients can lead to decreased levels of dissolved oxygen as the results of eutrophication (Kregar, 1997). Sewage carried excessive nutrients such as nitrogen and phosphorus to stream water.

Therefore the amounts of dissolved in Salender Bridge increased amount of nitrate and made the highest accumulation of nitrate. There are variations of nitrate concentration at different sampling locations as shown in Figure 4.9 and appendix 1. The presence of nitrate in water indicates the fully oxidized organic matter. The highest concentration of NO_3 was recorded in Salender Bridge. The increase of nitrate indicates that the wastewater from the abattoir is rich in nitrate. The standard of NO_3 is 10mg/L according to Standard of discharge of Effluents or wastewater in the world (Kajura, 1995). The high amounts of nitrate lead to the following problems:

Excessive concentrations of nitrate in lakes and streams can cause excessive growth of algae and other plants, leading to accelerated eutrophication or 'aging' of lakes, and occasional loss of dissolved oxygen whereby animals and humans cannot use inorganic forms of nitrogen, so nitrate is not a nutrient for us. If nitrate-nitrogen exceeds 10 milligrams per liter in drinking water, it can cause a condition called methemoglobinemia or "blue baby syndrome" in infants and some recent studies has indicated a possible connection between elevated nitrate concentrations and cancer (EPA, 2014).

Methemoglobinemia is the most significant health problem associated with nitrate in drinking water. Blood contains an iron-based compound called hemoglobin, which carries oxygen. When nitrite is present, hemoglobin can be converted to methemoglobin, which cannot carry oxygen. In the blood of adults, enzymes continually convert methemoglobin back to hemoglobin, and methemoglobin levels normally do not exceed 1 percent. Newborn infants have lower levels of these enzymes, and their methemoglobin level is usually 1 to 2 percent. Anything above that level is considered methemoglobinemia (McCasland et al., 2012). The other problems associated with the increase of nitrate are indicated below:

Ammonia and ammonia solution are irritant and corrosive and may be harmful by all exposure routes which results in pain, excessive salvation, and burns to the mouth, throat and oesophagus (Prichard, 2007). Acute inhalation may cause upper respiratory tract irritation and substation exposure can cause burns in the oral cavity, nasopharynx, laynx, and trachea together with airway obstruction, respiratory distress, and bronchiolar and alveolar oedema and ammonia or ammonia solution are corrosive in contact with tissue, and splashes to the eye may results in serious injury (Prichard, 2007). Effects of chronic oral exposure have not been defined in humans experiments, in animals suggests osteoporosis occurring secondary to chronic metabolic aciclosis. Chronic inhalation has been associated with increase in caugh, phlegin, wheeze, and asthma. Ammonia is considered not a human reproductive or development toxicant.

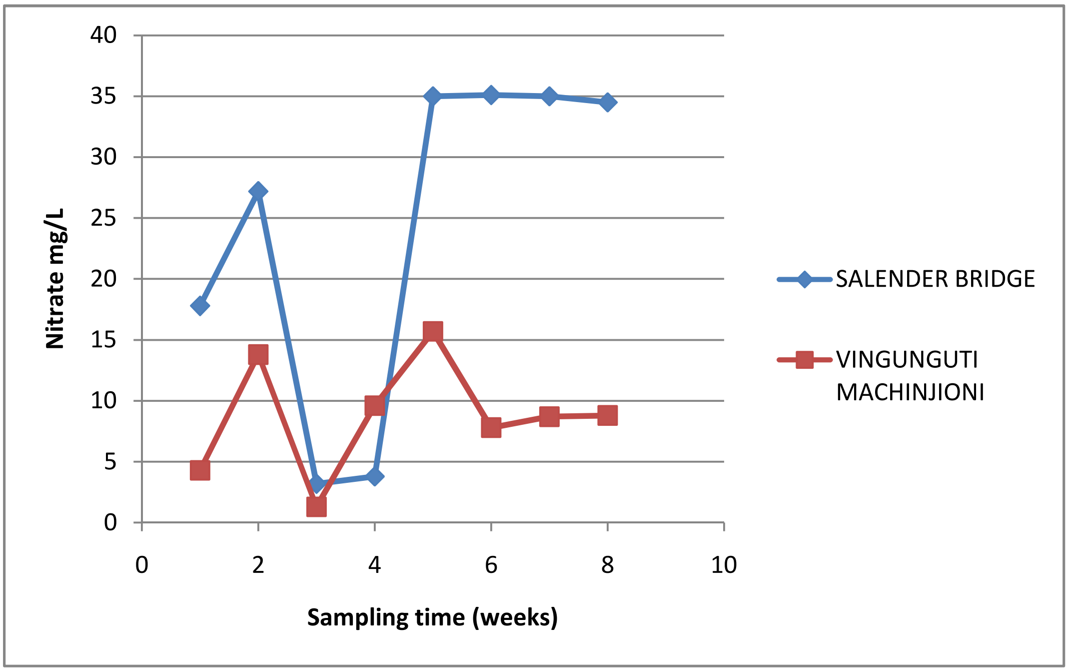


Figure 4.9: Nitrate Values

4.1.10 Sulphate

Sulphate is naturally occurring substance that contains sulphur and oxygen present in various mineral salts that are found in soil (Saskatchewan, 2003). Source of sulphate in water are soil. Decaying plant and animal matter, numerous chemical products such as ammonium sulphate fertilizer contain sulphate in various sulphates and the treatment of water with sulphate or copper sulphate also introduces sulphate into water supply. The other source of sulphate are human activities such as combustion of fossil fuels and sour gases processing release sulphur oxides to the atmosphere some of which are converted to sulphate (Saskatchewan, 2003).Sulphate was significantly higher at Salender Bridge as compared to Vingunguti Machinjioni. The data for Salender Bridge indicated highest value of sulphate at all sampling periods which could be explained by the following reasons:

Many industrial processes, including the food and fermentation industries, generate wastewater containing high levels of organic matter and sulphate (Zub at al., 2008). Therefore the high production in food and fermented industries such as Tanzania brewers, bakery and beverage production in Dar es Salaam whereby all the wastewater are directed into Msimbazi river caused the increased of sulphate at Salender Bridge. Sulphate came from dissolved minerals, acid rain and other sources such as discharged wastewater from industries that use sulphate and sulphuric acid as the mining and smelting operations, kraft pulp and paper, textile mills and tanneries. All these activities lead to the increase of sulphate at the end point of the river. Most of industries are available along Msimbazi River whereby the wastewater from the industries are discharged without treatment. The sulphate of Msimbazi River was observed in two sampling points. It was observed that sulphate at Vingunguti

Machinjioni was lower than that of Salender Bridge and it was within the permissible limits of 500mg/l according to TZS 860:2005 limits for municipal and wastewaters as indicated above in Figure 4.10. The mean concentration of Salender Bridge is higher than the permissible limits.

High amount of sulphate in drinking water lead to the following problems: high concentration amount of magnesium or sodium sulphate may result in intestinal discomfort, diarrhea and consequently dehydration. High concentration of sulphate may also interfere in efficiency of chlorination in some water supplies and may increase the corrosive properties of water (Saskatchewan, 2003). Natural sources of sulphur include volcanoes, decomposition and combustion of organic matter and from sea salt over the oceans. Particles of sea salt formed by the breaking of myriads of bubbles are an important source of atmospheric sulphate. The atmosphere is the main vehicle for transport of sulphur from various sources.

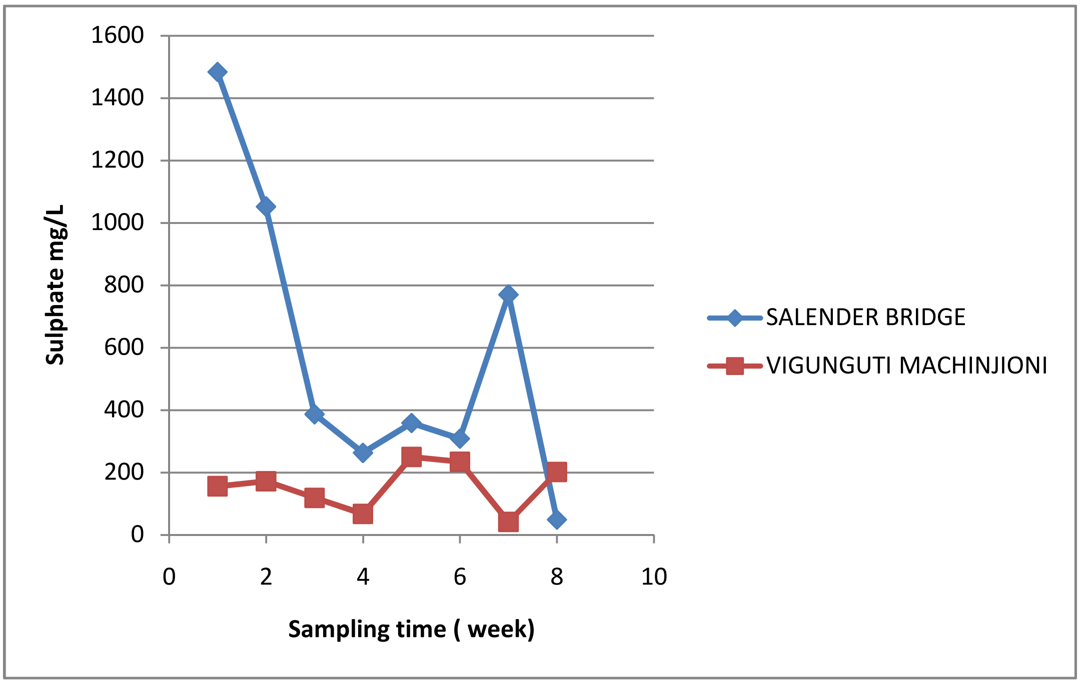


Figure 4.10: Sulphate Values

4.1.11 Phosphate

The lowest concentration of phosphate in Vingunguti Machinjioni and the highest is in Salender Bridge as indicated in Figure 4.11. The standard PO_4 is 10mg/L according to standard of discharge of effluents or wastewater in the world (Kajura, 1995). Health effects of phosphates to human beings: Phosphorus can be found in environment commonly as phosphates. Phosphates are important salt in human body because are part of DNA materials and they take part in energy distribution also they found in plants. Too much phosphate can cause health problems such as kidney damage and esteoporosis (Lenntech, 2014). Phosphate shortage can also occur and lead to the extensive use of medicine. White phosphorus occurs in nature and causes serious danger to our health, it is extremely poisonous and in many cases exposure to it can be fatal (Lenntech, 1998). White phosphorus causes death, before the people exposed do often experience nausea, stomach cramps and drowsiness. Not only that but also the white phosphorus can cause skin burn and damage to the liver, heart the kidney (Lenntech, 1998).

Effects of phosphate to the environment: Phosphates have many effects upon organisms. The effects are mainly consequences of emission of the large quantities of phosphates into the environment due to moving and cultivating. During water purification phosphates are often not removed properly so that they can spread over a large distance when found in surface waters (Lennetech, 1998). The increasing phosphates concentrations in surface water raise the growth of phosphates dependent organism such as algae and duck weed (Lenntech, 1998). These organisms use great a deal of oxygen and prevent sunlight from entering water which makes fairly unlivable for other organisms. The major effects of phosphate and nitrate in the environmental are the eutrophication. Algae differ from microscopic life in our water bodies in their mode of respiration; they release oxygen during the day than they use and absorb more carbon dioxide than they release while animals and non-photosynthesis organism release carbon dioxide and absorb oxygen in their environment (Lenntech, 1998).

Algae remove oxygen supplied from the body of water during photosynthesis beneficial to most forms of life in streams, thus the removal would often be detriment rather than benefit. Species diversity decrease and dominant biota changes, plant and animals biomass increase, turbidity increase, rate of sedimentation increase shortening the life span of the lake, anoxic condition may develop (Lenntech, 1998).The changes in nutrient level and biology can directly affect human activities. The main occurring problems can be as follows: the water can be injurious to health, the amenity value of water may decline, increased vegetation may impede water flow and navigation, commercially important species of fish may disappear, and treatment of drinking water may be difficult and can have an unacceptable taste of odors.

Algae and cyanobacterial blooms, cultural eutrophication causes excessive algae blooms in water bodies with consequent algae over loaded under certain conditional of darkness and warm temperature these blooms may die, decompose and produce offensive sewage like odor. They have a negative impact on water quality creating taste and odors problems and interfering with certain water treatment process. When certain bacteria populations reach very high proportion they can also produce toxics that can render water unsafe for consumption. Excessive aquatic macrophyte growth: Increased nutrient levels can stimulate other forms of primary production in addiction to algae and cynobacteria. The liftoral zones of many nutrient eroded water bodies are often chocked with excessive growth of aquatic macrophyte which influence recreational and industrial activity and alter the structure of food web. Excessive growth of phytoplankton and macroscopic plants in water create aesthetic problem and reduce the value of the body water as a recreation resources and cause the water to appear turbid and aesthetically unappealing. Microscopic plants can completely cover the entire surface of eutrophication lakes making the water almost totally unfit for swimming and boating.

Deep water oxygen depletion: Oxygen is required for all forms on the planet, with exemption of some bacteria. For this reason oxygen depletion is considered to be serious lake management problem often associated with eutrophication, which causes an increase organic matter production, so more material sedimenting down into the profoundly waters, consuming oxygen. Other effects of eutrophication are anoxia which kills fish and invertebrates and also leads to release unpleasant and injurious gases, alga blooms and uncontrolled growth of other aquatic plants.

Production of toxic substances by some species of blue green algae: High concentrations of organic matter which if treated with chlorine can create carcinogenic compounds. Detection of recreational value of a lake or reservoir due to decreased water transparency. Restricted access for fishing angling and recreational activities due to plant accumulation. Decreased number of species and diversity of plants and animals (UNEP). By using the data obtained in two study sites the results indicated the low amount of phosphate than the permissible limits. If the phosphate is low it means that, the pollution is in small amount and the water is safe for living organism found in Msimbazi River. It is our responsibility to maintain the quality of water so that we can avoid the problems identified in the above paragraphs, shown the problems of excess phosphate to the ecosystem in water and wastewater.

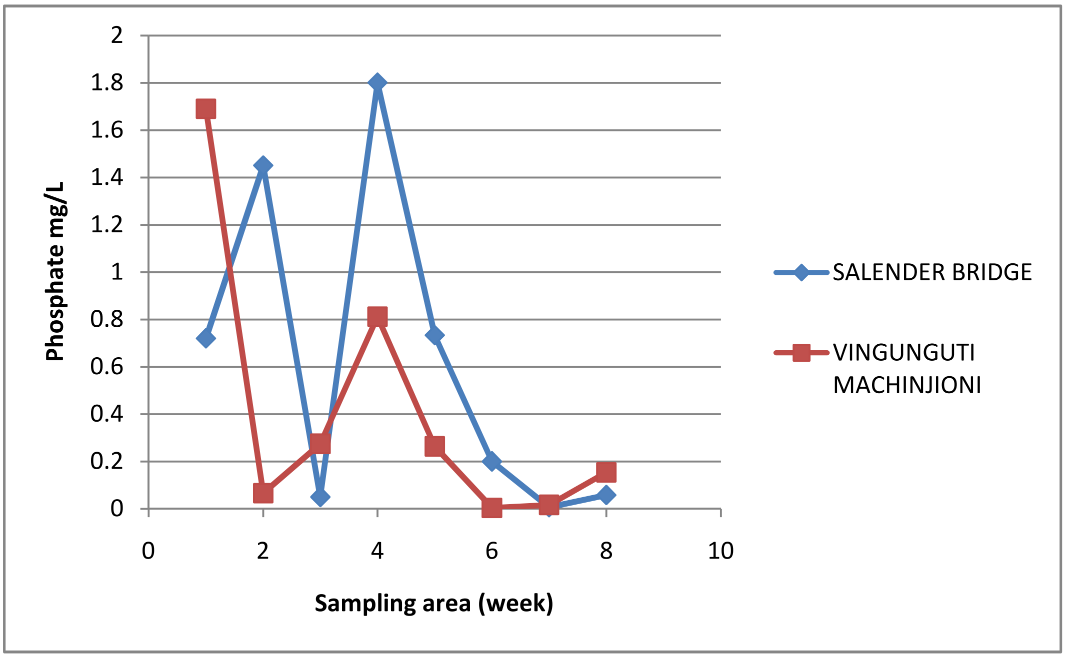


Figure 4.11: Phosphate Values

4.1.12 Dissolved Oxygen (mg/L)

Results of dissolved oxygen are presented in Figure 4.12 and Appendix 1. Dissolved oxygen was significantly higher ($p<0.01$) for Vingunguti Machinjioni as compared to Salender Bridge, however data of Salender Bridge indicated no dissolved oxygen at all sampling periods. Lack of dissolved oxygen at Salender Bridge could be explained by the possibility of oxygen depletion due to industrial effluents discharge into the study areas. Such results agreed with the following reports:

Direct discharge of pollutants from point source and non point source into a river segment add to its carbonaceous biochemical oxygen demand that may depress dissolved oxygen below acceptable concentration (Risberg, 2009).

Low dissolved oxygen primary results from excessive algae growth caused by high levels of phosphorus (Risberg, 2009). Nitrogen is another nutrient that can contribute to algae growth. Die off and decomposition of submerged plants also contribute to low dissolved oxygen (ibid.). Field observation at Selander area showed intense accumulation of algae. In addition results for nitrogen and phosphorus were also high in this sampling area. Therefore low level of dissolved oxygen could be explained by high levels of phosphorus and nitrogen accumulation at Salender Bridge. Dissolved oxygen is highest at Vingunguti Machinjioni. There is no dissolved oxygen obtained at Salender Bridge, it appears 0.0 (or the total absence of dissolved oxygen was observed at Salender Bridge as indicated in Figure 4.12. The results indicated the lowest dissolved oxygen at Salender Bridge which is undesirable condition for aquatic animals. The necessary implementation should be done in order to rectify the conditions which are undesirable.

Dissolved oxygen 4 milligrams per litre are considered to be unhealthy for many aquatic community inhabitants (Wenner and Sanger, 1996). Fish and other estuarine organisms also react as tidal creeks, undergo regular periods of low oxygen (2mg/l) but these instances are usually short lived about 2-3 hours and are part of the natural fluctuation in dissolved oxygen (Wenner and Sanger, 1996). The oxygen content of estuarine water varies with temperature, salinity, turbulence, atmospheric pressure and the photosynthentic activity of algae and submerged plants (Chapman, 1992). Temperature also controls the rate at which planktonic organisms use oxygen. The decline and loss of fish population habitants because of low dissolved oxygen concentration is one of the most problems associated with eutrophication in coastal waters (Deegan and Buchsbaum, 2005).

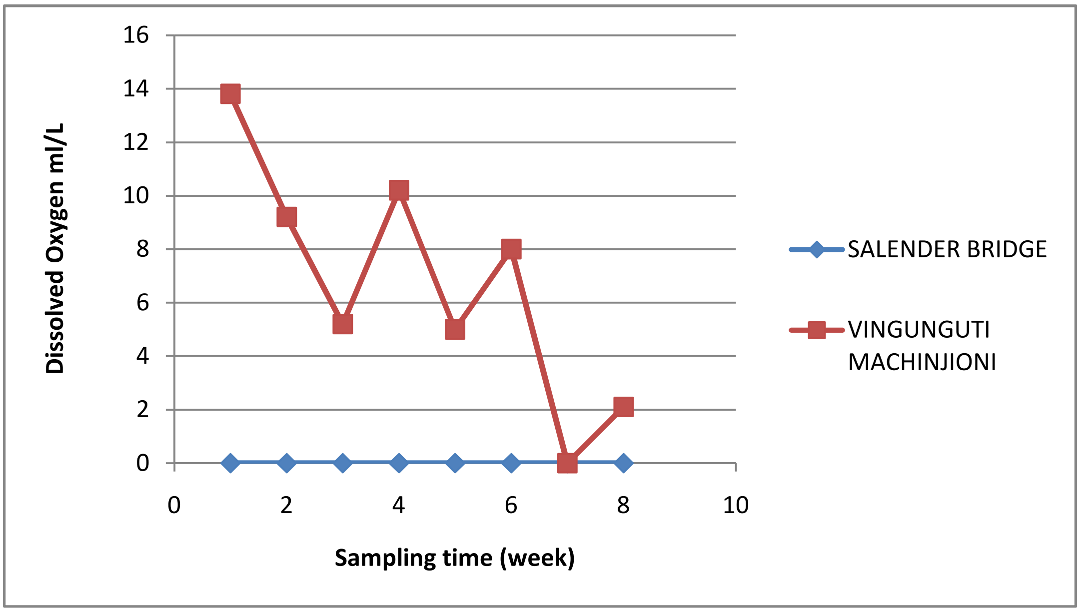


Figure 4.12: Dissolved Oxygen

4.2 The Effects of Wastewater

Untreated sewage is dangerous to public health because it contribute to environmental water, land, and air pollution which facilitate the transmission of disease, depression of land and degradation of the environmental (Rukunga, 2001). Discharging highly polluting waste into a body of water has negative effects on human, animal, and plant life such as reduction of dissolved oxygen which may affect aquatic life, at the same time, the absence of dissolved oxygen in the water which leads to septic condition (Rukunga, 2001). Health hazards to communities' area increased and social amenities such as swimming are decreased and too many pollutants reduce the self purification capacity of water, especially at the point of mixing, and promote the excessive growth of aquatic plants (Rukunga, 2001). Polluted waters are aesthetically objectionable because they emit unpleasant odors. Furthermore, nitrate leads to disease called methaemoglobinemia (or blue baby disease) which is the reduction of oxygen in the bloods stream of babies (Rukunga, 2001).

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATION

5.1 Introduction

`The domestic waste water discharge and industrial discharge of water system without treatment considered as the main source of many toxic and injurious chemical constituents which has the serious effects on public health problems. The rapid increasing population densities, domestic and industrial waste waters in Dar es Salaam, are the large sources of effluents that are discharged in Msimbazi River.

5.2 Conclusion

The amount of pollution in Msimbazi river was high due to the fact that most of parameter analyzed determined in the study such as turbidity, colour, dissolved oxygen, total dissolved oxygen, electronic conductivity, nitrate, biological oxygen demand and chemical oxygen demand exceeded the permissible limit of wastewater discharge in the river. All of these parameters indicated the highest amounts of pollution in waste water. Although other parameters which were within the permissible limit such as pH, temperature, phosphate and sulphate.

The sampling points indicated the highest variation in two sampling areas, such as the all parameters taken in the study except dissolved oxygen were highest in Salender Bridge. Only dissolved oxygen determined higher in Vingunguti. The Salender Bridge contained more pollutants because it is ending points of the river.In the study the possibility for waste water discharge on fresh water quality in Dar es Salaam could be end up if the attention has been given to the development of knowledge to the people on the effects of wastewater discharge in water quality in Tanzania. Treatment of waste water before entering in the river which making the water used for other activities such as irrigation of the gardens and washing machines. For the reduction of the environmental problems which occurs because of waste water discharge in fresh water, improving industrial management of waste water discharges, improving housekeeping practices and management on the water effluents. In order to solve the situation, the reduction of water consumption without decreasing the hygienic standards, prevention of the production of waste water and development of new clean processing methods and treatment of waste water.

5.3 Recommendation

For the assurance of the effective waste water quality in Tanzania the appropriate wastewater treatment strategies are vital such as aerobic and anaerobic treatment of waste water using the modern treatment methods. In communities where wastewater treatment is inadequate or nonexistent, the opportunities for people to become infected seem endless. For example, people have become ill by doing the following:

- Drinking contaminated water, juices made with water, or other beverages made with contaminated water or ice
- Eating food improperly handled by infected people or carriers (often workers in restaurants or food processing facilities)
- Eating vegetables and fruits contaminated by irrigation with polluted water or fertilized with untreated sewage or sewage sludge
- Eating meat or drinking milk from animals that grazed on contaminated pasture or drank contaminated water

- Eating fish or shellfish grown, caught, or harvested in contaminated water
- Eating food exposed to flies or vermin that feed on or come into contact with sewage.

To stop the unnecessary usage of rivers as the dumping areas for rubbish produced in the domestic usage and local industries. Standard sewage network must be constructed to collect the domestic and industrial waste water.

Moreover the construction and maintenance of sewage network must be with high quality and controlling to prevent the leakage of wastewater. The county must have the best rules and regulations so as to protect the environmental from any kind of destruction on water source such as the rivers oceans seas and other water body area.

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APPENDICES

Appendix I: Laboratory Results

Appendix II: Data Analysis by using t-test

DO

time (week)	Salender Bridge	Vingunguti Machinjioni
1	0	13.8
2	0	9.2
3	0	5.2
4	0	10.2
5	0	5
6	0	8
7	0	0
8	0	2.1

t-Test: Two-Sample Assuming Unequal Variances

	Variable 1	*Variable 2*
Mean	0	6.6875
Variance	0	20.25553571
Observations	8	8
Hypothesized Mean Difference	0	
df	7	
t Stat	-4.202782562	
P(T<=t) one-tail	0.002010815	
t Critical one-tail	1.894578604	
P(T<=t) two-tail	0.004021631	
t Critical two-tail	2.364624251	

COLOUR t- test 3 type

TIME	Salender Bridge	Vingunguti Machinjioni
1	440	112
2	352	74
3	451	74
4	501	146
5	556	122
6	666	210
7	168	68
8	692	74

t-Test: Two-Sample Assuming Unequal Variances

	Variable 1	*Variable 2*
Mean	478.25	110
Variance	28843.07143	2442.285714
Observations	8	8
Hypothesized Mean Difference	0	
df	8	
t Stat	5.888669637	
P(T<=t) one-tail	0.000183199	
t Critical one-tail	1.859548033	
P(T<=t) two-tail	0.000366398	
t Critical two-tail	2.306004133	

Phosphate mg/L t- test 3 type

TIME	Salender Bridge	Vingunguti Machinjioni
1	0.72	1.69
2	1.45	0.066
3	0.05	0.275
4	1.8	0.812
5	0.733	0.264
6	0.2	0.0042
7	0.0066	0.017
8	0.058	0.154

t-Test: Two-Sample Assuming Unequal Variances

	Variable 1	*Variable 2*
Mean	0.6272	0.410275
Variance	0.471008263	0.334648434
Observations	8	8
Hypothesized Mean Difference	0	
df	14	
t Stat	0.68356464	
P(T<=t) one-tail	0.252703458	
t Critical one-tail	1.761310115	
P(T<=t) two-tail	0.505406916	
t Critical two-tail	2.144786681	

COD t-test type 3

TIME	Salender Bridge	Vingunguti Machinjioni
1	169.67	42.25
2	183.66	35
3	211.2	87.8
4	60.6	27.5
5	211.2	98.56
6	415.26	165.3
7	283.2	40.97
8	91.93	54.62

t-Test: Two-Sample Assuming Unequal Variances

	Variable 1	*Variable 2*
Mean	203.34	69
Variance	12245.59031	2155.314486
Observations	8	8
Hypothesized Mean Difference	0	
df	9	
t Stat	3.166324692	
P(T<=t) one-tail	0.005716668	
t Critical one-tail	1.833112923	
P(T<=t) two-tail	0.011433337	
t Critical two-tail	2.262157158	

Temperature In C In Centigrade

Time	Salender Bridge	Vingunguti Machinjioni
1	23.6	23.7
2	18.8	23.4

t-Test: Two-Sample Assuming Unequal Variances

3	22.6	22.4
4	27.8	28.5
5	28	28
6	20.7	20.9
7	28.3	25.5
8	25.6	25.6

	Variable 1	*Variable 2*
Mean	24.425	24.75
Variance	12.87071429	7.025714286
Observations	8	8
Hypothesized Mean Difference	0	
df	13	
t Stat	-0.206082347	
P(T<=t) one-tail	0.419959468	
t Critical one-tail	1.770933383	
P(T<=t) two-tail	0.839918936	
t Critical two-tail	2.160368652	

Total Dissolved Solids		t test type 3
Time	Salender Bridge	Vingunguti Machinjioni
1	15060	752
2	11680	893
3	4980	848
4	4980	965
5	5001	944
6	5460	1006
7	8670	963
8	7330	1017
	31.4	

t-Test: Two-Sample Assuming Unequal Variances

	Variable 1	*Variable 2*
Mean	7895.125	923.5
Variance	13983172.98	7899.142857
Observations	8	8
Hypothesized Mean Difference	0	
df	7	
t Stat	5.271734313	
P(T<=t) one-tail	0.000579215	
t Critical one-tail	1.894578604	
P(T<=t) two-tail	0.001158431	
t Critical two-tail	2.364624251	

pH t-test type 3

Time	Salender Bridge	Vingunguti Machinjioni
1	6.72	6.67
2	6.69	8.77
3	9.63	8.99
4	9.16	9.19

t-Test: Two-Sample Assuming Unequal Variances

	Variable 1	*Variable 2*
Mean	8.79875	8.72625

5	9.65	9.2	Variance	1.7312125	0.709855357
6	9.63	8.95	Observations	8	8
7	9.1	9.08	Hypothesized Mean Difference	0	
8	9.81	8.96	df	12	
			t Stat	0.131248115	
			P(T<=t) one-tail	0.448876896	
			t Critical one-tail	1.782287548	
			P(T<=t) two-tail	0.897753792	
			t Critical two-tail	2.178812827	

Sulphate t- test Type 3					
Time	Salender Bridge	Vigunguti Machinjioni			
1	1483.5	156.03	t-Test: Two-Sample Assuming Unequal Variances		
2	1052.09	172.2			
3	386.56	118.89		*Variable 1*	*Variable 2*
4	262.52	67.29	Mean	583.67875	155.315
5	358.14	250.05	Variance	231282.4077	5671.795514
6	308.04	234.64	Observations	8	8
7	770	41.66	Hypothesized Mean Difference	0	
8	48.58	201.76	df	7	
			t Stat	2.48900344	
			P(T<=t) one-tail	0.020828651	
			t Critical one-tail	1.894578604	
			P(T<=t) two-tail	0.041657301	
			t Critical two-tail	2.364624251	

BOD mg/L t- test type 3

Time	Salender Bridge	Vingunguti Machinjioni			
1	80.5	20.1	t-Test: Two-Sample Assuming Unequal Variances		
2	93.42	18			
3	100.5	40.9		*Variable 1*	*Variable 2*
4	31	12.33	Mean	103.1675	33.85375
5	107	48.2	Variance	3748.222621	573.3668268
6	227.92	85	Observations	8	8
7	140.5	21	Hypothesized Mean	0	

			Difference		
8	44.5	25.3	df	9	
			t Stat	2.982240308	
			P(T<=t) one-tail	0.007696756	
			t Critical one-tail	1.833112923	
			P(T<=t) two-tail	0.015393513	
			t Critical two-tail	2.262157158	

Nitrate t-test type 3

Time	Salender Bridge	Vingunguti Machinjioni
1	17.8	4.3
2	27.2	13.8
3	3.2	1.3
4	3.8	9.6
5	35	15.7
6	35.1	7.8
7	35	8.7
8	34.5	8.8

t-Test: Two-Sample Assuming Unequal Variances

	Variable 1	*Variable 2*
Mean	23.95	8.75
Variance	194.9714286	21.53428571
Observations	8	8
Hypothesized Mean Difference	0	
df	9	
t Stat	2.921822976	
P(T<=t) one-tail	0.00849069	
t Critical one-tail	1.833112923	
P(T<=t) two-tail	0.016981381	
t Critical two-tail	2.262157158	

Electronic Conductivity

mg/l t-test type 3

Time	Salender Bridge	Vingunguti Machinjioni
1	25700	1512
2	20300	1789
3	9120	1698
4	8430	1918
5	9210	1884
6	10220	2010
7	15380	1916
8	13440	2020

t-Test: Two-Sample Assuming Unequal Variances

	Variable 1	*Variable 2*
Mean	13975	1843.375
Variance	38694971.43	29336.26786
Observations	8	8
Hypothesized Mean Difference	0	
df	7	
t Stat	5.514068282	

P(T<=t) one-tail	0.00044657
t Critical one-tail	1.894578604
P(T<=t) two-tail	0.000893141
t Critical two-tail	2.364624251

Turbidity t-test type 3

Parameter Ntu	Salender Bridge	Vingunguti Machinjioni
1	31.4	13.4
2	79.9	29.3
3	51.6	62.6
4	63	14.3
5	90.8	14.4
6	102	27
7	63.3	57
8	152	31.7

t-Test: Two-Sample Assuming Unequal Variances

	Variable 1	*Variable 2*
Mean	79.25	31.2125
Variance	1359.508571	365.3983929
Observations	8	8
Hypothesized Mean Difference	0	
df	11	
t Stat	3.27146707	
P(T<=t) one-tail	0.003722876	
t Critical one-tail	1.795884814	
P(T<=t) two-tail	0.007445753	
t Critical two-tail	2.200985159	