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Heavy Metal Pollution Assessment along Msimbazi River, Tanzania

Ghanima Chanzi[1*]

[1]*Department of Water Quality Laboratory, Water Institute, P.O.Box 35059, Dar Es Salaam, Tanzania.*

Author's contribution

The sole author designed, analyzed, interpreted and prepared the manuscript.

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ABSTRACT

Aims: The study aimed to determine the status of accumulations of heavy metals (Cr, Cu, Pb and Cd) in water and soil. The study also established the main entry of heavy metals in the river since heavy metals are referred to a diverse range of highly toxic or poisonous micro-pollutants present at very low concentrations in the environment arising from industrial and mining activities are discharged into sources of water at many sites.

Study Design: The study designed to analyze heavy metal magnitude in water and soil samples on the Msimbazi River from Vingunguti to Jagwani flood area.

Place and Duration of the Study: Msimbazi River is located in the Dar Es Salaam city, Tanzania. It originates from the highland of Kisarawe in cost region. Msimbazi River receives effluent discharges from several industries of different manufacturing processes like dyes and paints, steel, batteries, food processing, vingunguti abattoir, and electrical product. The study was done between March and June 2012.

Methodology: All analysis works were done at the Environmental Laboratory of Ardhi University using the Atomic Absorption Spectrophotometer technique (AAS).

Results: The results showed that water and soil around Msimbazi River have lead, chromium and copper concentrations were higher than the permissible limit as EPA and TBS. There are variations of heavy metals along Msimbazi River due to the discharge of the toxic waste such as oil, industrial wastewater which cause high pollution along and within the river.

**Corresponding author: E-mail: ghanimac777@gmail.com;*

Conclusion: In order to prevent this water source and health of the people, Msimbazi River should not be used for vegetable irrigation as water observed to have heavy metal exceeded permissible limits as per WHO and TBS. Those industries, garages and other economic activities around Msimbazi River have to be rebuilding far away from the river and wastewater should be treated before discharging to the river.

Keywords: Heavy metal; pollution; industrial activities; soil; water; vegetable.

1. INTRODUCTION

Heavy metals refer to a diverse range of micro-pollutants (inorganic and organic contaminants) present at very low concentrations in the environment [1].

Trace metals, including those defined as "heavy", arising from industrial and mining activities are discharged into coastal waters and estuaries at many sites. The term heavy metal refers to any metallic chemical elements that have a relatively high density and are toxic, highly toxic or poisonous at low concentrations [2], and invertebrates living on or in food, and the rate of accumulation caries widely between species and heavy metal concentration found in "clean" conditions. Less is known about the uptake of these metals by ingestion with food or from close contact with contaminated sediments [3].

They are persistent in the environment, resisting degradation through natural processes. They are highly toxic; causing an array of adverse effects includes cancer, allergies and hypersensitivity, damage to the central and peripheral nervous systems, reproductive disorders and disruption of the immune system [4]. Inorganic micropollutants consist of heavy metals, nitrogen, phosphorus, sulphur and chloride. Heavy metals do not decay and thus pose a different land of challenge for remediation. Such metal includes Hg, Pb and Cd, they cause kidney and brain damages, cancer and high blood pressure.

Organic micropollutants are almost exclusively man-made are also present in natural water. Their sources are diverse, from discharge of wastewaters and mining effluents [5]. Aquatic organisms are thus exposed to a mixture of numerous contaminants originating from agricultural and mining activities. Likewise, inorganic micropollutants are caused by mining activities such as extraction of gold by using mercury, industrial wastes and sewage effluent, corrosion of pipes and combustion of coal [6].

Contamination of heavy metal is of great concern. Water pollution by heavy metals can affect many biological systems, it may take very long time to clear and pose danger of bioaccumulation [7].

Msimbazi river receives effluent discharges from several sources such as industries of the different manufacturing processes such as batteries, steel, paints and dyes, food processing, Vingunguti abattoir, electrical products industries, Ubungo subtrary, Zimbire tributary tributary, Kimanga, Kinyenyele and Kwanguku.

So the study covers the assessment of the heavy metal pollution along the river by analyzing concentration of the metals in the water and sediment Environmental [8].

2. MATERIALS AND METHODS

2.1 Study Area Description

Msimbazi River is located in Dar es Salaam city, Tanzania. It originates from the highland of Kisarawe in cost region. It flows toward the northeast and enters the Indian Ocean on the northern part of the city. It is joined by other tributaries and open channel include Sinza, Mambizi and Luhanga streams. Ubungo, Kinyelele, Zimbile, Kwangula are tributaries of Luhanga stream. Msimbazi River receives effluent discharges from several industries of different manufacturing processes like dyes and paints, steel, batteries, food processing, vingunguti abattoir, and electrical product [9].

Msimbazi river receives effluent discharges from several sources such as industries of the different manufacturing processes such as batteries, steel, paints and dyes, food processing, Vingunguti abattoir, electrical products industries, Ubungo subtrary, Zimbire tributary, Kimanga, Kinyenyele and Kwanguku.

2.2 Economic Activities along the River

2.2.1 Vegetable gardening

Msimbazi River surrounded with the vegetable gardening, according to the questionnaire done it shows that the big number of the farmers nearly the river use water from Msimbazi river for watering the vegetables which feed the big population of member of Dar-es-Salaam. Also, Kigogo (Msimbazi valley) have dug a well for vegetable irrigation.

2.2.2 Abattoir activities

Few meters from the river there is big abattoir which all meat supplied to the Dar-es-salaam are depending on this abattoir. They discharge their wastes to the river which causes odour and the color of the river changes to red-brown.

2.2.3 Garage activities and car cleanliness

Along Msimbazi River upstream Jangwani garage and car cleanliness activities are conducted which contribute to the discharge of waste to the river and soil is polluted as they pour oil like petrol, diesel, grease as well as kerosene which may result into presence of hydrocarbons in the soil.

2.2.4 Solid waste disposal along Msimbazi River

There are other activities which contribute to pollution of Msimbazi River as well soil pollution. A large number of population live along the river they dispose of the liquid and solid waste into the river.

Fig. 1. Leachate discharge at Vingunguti abattoir into Msimbazi River

Fig. 2. Vegetables ready for marketing (Vingunguti)

Fig. 3. Channel of Vingunguti abattoir discharging effluent into Msimbazi river

2.3 Sampling

Data were collected through various approaches including personal observation, questionnaire, and literature review and laboratory analysis.

Sampling was done in three days, in which four points were taken into consideration, these points are Jangwani behind Kajima industrial area where Msimbazi joins with Luhanga stream, Kigogo was commonly known as valley or SUKITA and Vingunguti. Samples of cultivated soil and water used for irrigation were collected. Accordingly, 24 soil and 56 water samples were collected at eight weeks of the investigation.

2.3.1 Water and soil samples collection

These were collected in 500ml plastic bottles. The bottles for heavy metal determination were soaked overnight with 10%HCL before collection of samples to satirize the inner. Bottles for other physicochemical parameters were cleaned and rinsed using distilled water only. At every sampling point, two bottles (one for heavy metal analysis and the other for physicochemical parameter determination) were collected.

Samples were collected between 10.00am and 12.30 pm and the source is said to be fairly constant composition over considerable period of the time or substantial distance in all direction and were taken in opposite direction to the flow of river.

Two drops of concentrated nitric acid were used to preserve water samples so as to avoid samples transformation and the temporarily stored in a refrigerator under 4°C in the school of environmental science and technology laboratory at Ardhi University while waiting for analysis.

Soil samples were collected at 0-15 cm and 15-30 cm depth from four sites using auger and stored in plastic then brought to the environmental laboratory for analysis.

2.4 Laboratory Analysis

2.4.1 Physicochemical parameters

Electrical Conductivity, Total Dissolved Solids (TDS) and Temperature were measured by a calibrated Hach Sension 156 conduct meter in Micro Siemens per centimetre, µS/cm or ms/cm, mg/L and % respectively. Temperature and pH were measured using HANNA meter HI 8424 with pH and temperature probes.

2.4.2 Heavy metals

The heavy metal determination from water and soil samples was done at the laboratory of School of Environmental Science and Technology, Ardhi University using Perking Elmer HGA 850 Graphite Furnace and Perking Elmer AS 800 Auto-sampler with a computer interface for operation and readings display. The detection limit of the instrument is 0.01 mg/l.

Perking elmer 100 Atomic Absorption Spectrophotometer was used to determine heavy metal concentrations, pH and temperature were using to measure temperature and pH, Hach Sensation 156 conduct meter capable of measuring specific conductivity, TDS and salinity, soil and vegetable samples dring was done by using Toshniwal hot oven, Non CFC sanyo refrigerator for samples preservation, at 4°C. A 1µm Munktell Swedish filter papers of 125mmØ for water and soil samples filtration, test tubes, pipette, measuring cylinders, auger for soil samples,500mls plastic bottles for water collection, plastics bags for soil collection, aluminium foil for soil and vegetable fine particles.

Reagents and chemicals for heavy metal determination, physicochemical and others parameters used include a known concentration of the samples used for AAS calibration, distilled water was used to minimize sample concentration during analysis. For other parameters, only distilled water was used to rinse the probes of the equipment and for solution preparation.10% HCL acid was used for overnight soaking of the sampling bottles and concentrated nitric acid was used for sample preservation.

2.4.3 Soil samples extraction

A soil sample was dried at 105°C for 24 hours, mortar and pestle followed by sieving analysis to get are very fine particles by using 0.18mm sieve.0.5g of dry material was kept into graduate test tubes. 2ml of aqua regia. The sample was diluted to 10mls with distilled water and left to settle overnight. The supernatant was filtered for analysis by using AAS [10].

2.4.4 Data analysis

Data from the questionnaire were analyzed using SPSS software, version 10 and the analytical data were analyzed using Microsoft Office Excel 2003. Descriptive statistics tool in Microsoft Office Excel 2003 was mainly use to determine various statistics of interest.

3. RESULTS AND DISCUSSION

3.1 Physicochemical Parameters

The highest average pH value of 9.3 was observed at Kigogo stream whereby Msimbazi River joins stream at Jangwani where around this is the river seems to receive effluents from different industries. However, in most cases water in Msimbazi River is alkaline. Higher pH reaching alkaline may cause heavy metals to precipitate in the River, thus settle and become available in the bottom of the sediments of the river [11]. This may hinder heavy metal availability during sampling [12]. That is why we used also took samples of the soil beneath the river. TBS (Tanzania Bureau of Standard) the municipal wastewater to have pH ranging from 6.5 to 8.5; the pH values exceeded the TBS limits.

It was observed that the temperature variation along Msimbazi River is almost minimal ranging from 25.2 at all three sampling points, whereby some industries from Buguruni and Tabata discharge their effluent to Msimbazi River of which may increase the temperature of Msimbazi River water due to running of machines, by-products and wastewater from industrial compounds [13]. Higher temperature increases the kinetic energy of the molecules of the heavy metal present in the river, hence facilitating heavy metals dispersion along the River [14].

The maximum value of TDS at sample from Vingunguti is 1643 mg/l and minimum is 1054 mg/l from Jangwani while the permissible limit is 100 mg/l [15]. The maximum value is caused by the effluents from Vingunguti abattoir being discharge directly Msimbazi River without pretreatment. The higher level of TDS reduces visibility of floating aquatic organisms when they are moving from one place to another [16].

There are great variations of conductivity along Msimbazi River. The maximum conductivity is 32623 µS/cm from Vingunguti and minimum is 1919 µS/cm from Jangwani. The maximum value is caused by the effluents from Vingunguti abattoir being discharge directly Msimbazi River without pretreatment. The higher conductivity represents the higher concentrations of free metal ions in the river water [17].

3.2 Heavy Metal Concentration from Water Samples

The Table 3 shows the concentrations of heavy metal in water from different locations at Msimbazi River. Chromium has shown higher concentration than the rest of heavy metals being analyzed. A maximum concentration of Chromium of 1.14 mg/l was observed at Kigogo which exceed the maxim limit set out by the WHO of 0.08 mg/l. A minimum concentration of 0.06 mg/l of the same metal was observed at Vingunguti. There is no industrial effluent was observed in this area other than wastes from Vingunguti abattoir and old Vingunguti dump site which discharge leachate into Msimbazi River [18].

The higher concentration of chromium may cause adverse effect to the living organism including human as well as the environment because the same water is used for irrigation of vegetables in different areas along the River, this may cause bioavailability of heavy metals in food chain [19].

Industrial effluents and Vingunguti WSP's may be a major source of copper that gives rise to higher concentrations of copper than the rest part of the River.

The lead concentrations throughout Msimbazi River have exceeded the WHO limits of 0.05 mg/l as shown in the Table 3. A maximum concentration of 0.163 mg/l was observed at Vingunguti where Vingunguti WSP's joins Msimbazi River and minimum concentration of 0.133 mg/l at Jangwani. The maximum concentration of lead may be due to Vingunguti WSP's of which consist of different wastes from industrial and domestic effluents, also some garages discharge their wastes which is a mixture of oil and car washing into Msimbazi River.

The concentration of cadmium along Msimbazi River was observed to be below detection limit of the AAS. Therefore the concentrations of cadmium in the Table 3 are shown as < 0.01 mg/l. The absence of cadmium is due to the absence of activities that are likely to contribute cadmium to Msimbazi River.

3.3 Heavy Metal Concentrations from Soil Sample

From the laboratory analysis, the maximum concentration of lead has been observed at Jangwani followed by Vingunguti as indicated in the Table 4. The concentration of lead at Jangwani may be due to the contribution of Luhanga stream which is also used for vegetable irrigation and upstream there is Kigogo garage which uses Msimbazi River water as the source for car cleanliness and discharges the effluent including oil to Msimbazi River and there so many solid wastes dumped into the River which are likely to contain toxic materials including heavy metals.

The Maximum concentration of chromium has been observed at Jangwani and Kigogo (Msimbazi valley) as shown in the Table 4. Along with all four sampling points, the concentration of chromium has exceeded the maximum limit of WHO of 200 mg/Kg and. The level of chromium is too high which may cause environmental impacts as they are heavily available for vegetable uptake which is daily taken by human beings.

The maximum concentration of copper was observed at Jangwani, this may be from the application of pesticides in vegetable fields. However, a minimum copper concentration was observed at Vingunguti. All concentrations are below WHO limit for soil of 200 mg/kg.

Cadmium concentration is minimum compared to the rest of heavy metals analyzed in soil samples. The values have not exceeded the WHO limit of 100 mg/kg.

The concentration of lead in the soil does not exceed the maximum limit set by WHO except for Cr concentration as shown in the table above. These concentrations can be available for uptake by plants on bioaccumulation process.

Table 1. Sources of influents into Msimbazi River

Name of industry/ source of pollution	Activities carried out
Kigogo darajani garage	Oil and wastes from car washing
Kajima industries	Construction activities
Plastic bags cleanliness	Washing of plastic bags
Sukita domestic wastes	Domestic Wastes
Old kigogo solid waste dump	Leach ate from dump
Vingunguti damp	Leachate from damp
Vingunguti abattoir	Abattoir wastes
Murza oil ltd	Soap and cooking oil
Bakhresa kipawa	Food products
Mukwamo industries	Soap and cooking oil
Mohamed enterprises	Juice, water
Polyfoam	Mattress

(Source: Respective Ward Executive Offices)

Table 2. Physical chemical parameters results

Sampling site	pH	Temperature (^oC)	TDS mg/l	Conductivity (µS/cm)
Vingunguti	8.7	25.7	1643	3263
Kigogo	9.3	25.2	1271	2024
Jangwani	9.1	25.2	1054	1919
TBS Standard	6.5-8.5	25	100	2000

Table 3. Heavy metals concentration in water from Msimbazi river (mg/kg)

	Cr	Cd	Cu	Pb
Vingunguti	0.06	<0.01	0.063	0.163
Kigogo	1.14	<0.01	0.065	0.149
Jangwani	0.71	<0.01	0.063	0.133
TBS Standard	0.05	0.05	0.05	0.1

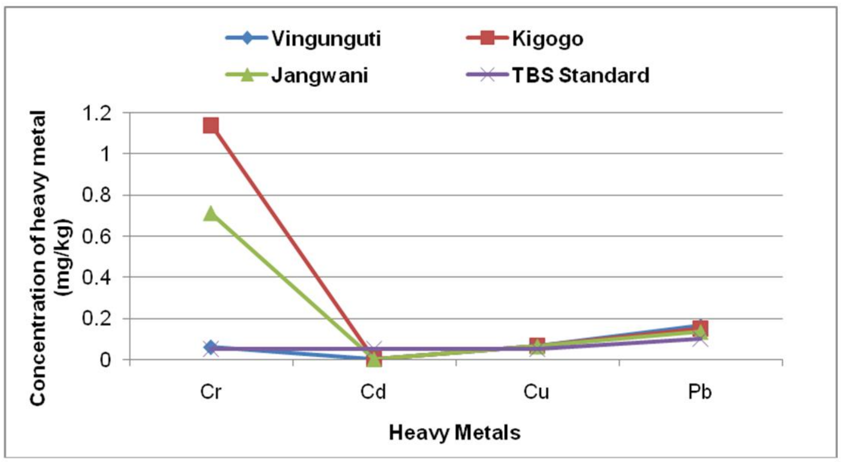

Fig. 4. Concentration of heavy metals in water

Table 4. Heavy metals concentration in soil along Msimbazi river (mg/kg)

Sampling Location	Cr	Cd	Cu	Pb
Vingunguti	190	0.283	12.3	20.6
Kigogo	469	0.534	17.7	19.6
Jangwani	562	0.821	23.2	25.6

4. CONCLUSIONS

According to developing countries in Africa suffers from heavy metal pollution in the environment it is true. The results showed that soil around Msimbazi River has high lead, chromium and copper concentrations were maximum than permissible limit as WHO/ FAO and TBS, and there are variations of heavy metals along Msimbazi River due to discharge of the toxic waste such as oil, petroleum which cause high pollution to the soil along and within the river. found that the presence of heavy metals in water can accumulate in the flora and fauna of the aquatic life since the Metals tend to bioaccumulate in the living organisms body tissues.

Maximum concentration of Lead, Cadmium, Copper and Chromium has been high observed in Jangwani which might be to contribution of Lead is high might be due to contribution of Luhanga stream which is used for irrigation and upstream is Kigogo garage which is used Msimbazi River as major sources for car cleanness and discharge their waste includes oil back to river and there are so many wastes are disposed to the steam from domestic which a likely to contain toxic materials into Msimbazi River.

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COMPETING INTERESTS

Author has declared that no competing interests exist.

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