Occurrence and Seasonal Variations of Lead Concentrations in River Water and Edible Vegetables Grown along Morogoro River Bank

G. Joseph[1] and B. Temba[1]

[1]College of Veterinary Medicine and Biomedical Sciences, Sokoine University of Agriculture, Morogoro, Tanzania.

E-mail: bentemba@sua.ac.tz

Proceedings of the First One Health Conference (embedding the 37th TVA Scientific Conference)

Venue: Arusha International Conference Centre (AICC), Tanzania

Dates: 27th to 29th November 2019

TANZANIA VETERINARY JOURNAL
Volume 37 (2019): Special Issue of TVA Proceedings
ISSN: *0856 - 1451 (Print), ISSN: 2714-206X (Online)*
https://tvj.sua.ac.tz

https://dx.doi.org/10.4314/tvj.v37i1.7s

Occurrence and Seasonal Variations of Lead Concentrations in River Water and Edible Vegetables Grown along Morogoro River Bank

G. Joseph[1] *and B. Temba*[1]

[1]*College of Veterinary Medicine and Biomedical Sciences, Sokoine University of Agriculture, Morogoro, Tanzania.*

E-mail bentemba@sua.ac.tz

SUMMARY

Urban vegetable farming is popular in Tanzania and other countries partly due to readily available market and reliable transport to reach consumers. River banks are usually used to grow such vegetables due to closer proximity to water and whenever necessary use such water for irrigation. However in urban settings river water pollution by toxic heavy metals and subsequent accumulation of the metals in nearby grown vegetables has been reported as among major sources of exposure to humans and animals. Heavy metals, including lead (Pb) have many health effects to human and animals ranging from acute to chronic illnesses. This study was conducted to assess the occurrence of lead in Morogoro river and in edible vegetables (*Amaranthus retroflexus)* grown along the river bank. Water and vegetable samples collected during dry and rainy seasons were prepared and analysed for occurrence and levels of lead using Atomic Absorption Spectrometry (AAS). It was found that concentration of Lead in the water and vegetable samples were up to 0.95 mg/L, and 0.026 mg/Kg respectively. It was also found that 77% of the water samples and 28% of the vegetable samples had lead levels above the WHO recommendations. The frequency and levels of lead occurrence varied with topographical, diurnal and seasonal characteristics of sample collection. The results of this study raise concerns on the use of water for human and animal consumption from rivers which run across urban areas and call for further studies to investigate for any health consequences to consumers.

Key words: *Amaranthus, Lead, Morogoro, River, Water*

INTRODUCTION

The escalating heavy metal pollution in urban water and agricultural systems has raised a global concern (UNESCO-WWAP 2017). Water pollutions are commonly results of geological or anthropogenic processes.

Toxic heavy metals may be released to water bodies due to different natural processes such as volcanic eruptions and rock weathering, and the metals get washed into the water bodies through run off, erosion, and floods (Tchounwou *et al.*, 2012). Human activities including agriculture, industrial applications, oil and minerals mining, and domestic activities, are thought to have substantial contribution to the pollution of water bodies (Ferati *et al.*, 2015). Contamination of fresh water and other aquatic systems pose s high risk of exposure for humans and animals by heavy metals including the toxic ones such as lead.

Lead is an element in the carbon group with symbol Pb (from Latin: Plumbed, meaning "the liquid silver") with an atomic number 82 in the periodic table. Lead exposure to humans and animals may result into serious health problems, ranging from acute to chronic illnesses.

The metal is considered to be among the most hazardous and cumulative environmental pollutants affecting

https://dx.doi.org/10.4314/tvj.v37i1.7s

different biological systems exposed (Patra *et al.,* 2011).

Prolonged exposure of the metal either through air, ingestion direct membrane/skin absorption may lead into different health effects, with the reproductive, renal, hematopoietic and central nervous system among the most vulnerable body systems (Wani *et al.*, 2015).

In most developing countries, lead exposures to humans are commonly from domestic sources from materials like batteries and other home appliances (Kordas *et al.,* 2018). However, in urban areas, water pollutions from human activities have increasingly contributed to the risk, especially through rivers that passes across human settlements (Sakson *et al.,* 2018).

In Tanzania, different urban areas including Morogoro town face similar risk of river pollution by heavy metals including lead due to increasing industrial and agricultural activities (Hellar-Kihampa *et al.,* 2014).

Morogoro town is town and capital centre of Morogoro region, located about 200 km western of Dar as Salaam, Tanzania with a population of 315,866 according to the country 2012 census (NBS 2014). The town centre is drained by Morogoro River and its tributaries including Sole, Mere, Kirundi, Mdirila, Mlali, Kikundi and Kilakala.

The river is a one of the sources of water for irrigation and other domestic use for the populations living along (Due and Anandajayasekeram 1984).

Although some studies report low contribution of anthropogenic activities to contamination of general environment by heavy metals (Mdegela *et al.,* 2009), studies that have investigated specifically in river water mention the activities as among the major sources of significant contamination (Mkoma 2001, Shayo *et al.,* 2007).

This study therefore aimed at establishing current status on the occurrence of Lead (Pb) in Morogoro River, taking into account the increased human activities with risk of polluting the river water. The study focused on relating the frequency and level of pollution with geographical locations of the river point, diurnal and seasonal changes.

MATERIALS AND METHODS

Study area and sample collection

Water samples were collected from eight selected different sites between the two points. The sites (from the highest point down the river) included near Nguzo primary school area, Madaraka Street near Morogoro Central Market, and Nunge Street at Mwere bridge.

Others were Mango Street near Mjini Primary court, Mji mpya at Railway bridge, Msamvu at Msamvu bridge, Mafisa area, and at Mafisa Waste-water Sanitation Point. (Figure 1). *Amaranthus retroflexus* samples were collected from four of the eight points (where the vegetables were found near the river) which are Nguzo area, Mwere Bridge, Mji mpya and Mafisa.

Sampling for both water and amaranthus was done in two rounds, one being a dry season (October) of 2018 and other being rain season (March) of 2019. For each round, eight water samples were collected for eight different days, one sample for each day at each point. The interval between each collection at each point was at least two days and the interval between the first and the last collection was between 28-30 days. Water samples were collected in the morning and evening, whereas the amaranthus was collected once, either in the morning, or evening.

Water samples were collected in 200 ml sterilized plastic bottles and collection was done from around the centre point of the river. The edible vegetative parts of the amarathus were collected by cutting the plant about 2 cm above the soil surface. The samples were transported under cold chain (in cool boxes) to the Sokoine University of Agriculture (SUA) where analysis for lead was carried. A total of 160 samples were collected including 128 waters samples and 32 vegetable samples.

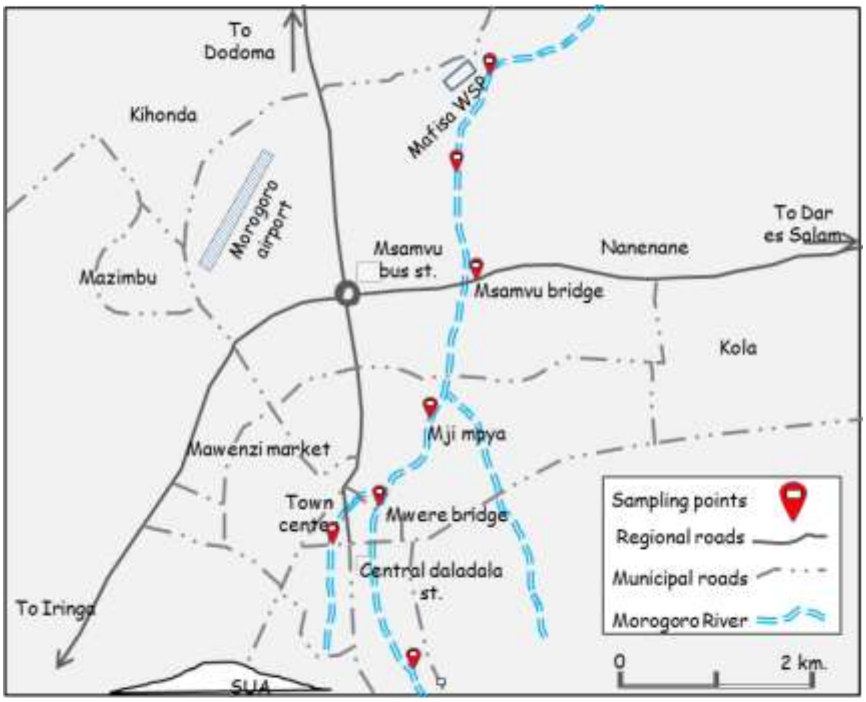

Figure 1. Sketch-map of Morogoro town indicating points of sample collection along Morogoro River

Sample Preparation

In the laboratory the water samples were filtered in sterile cotton cloth to clean off particles. One hundred millilitres from each of the 32 water samples were transferred in clean beakers, and then 2 ml of concentrated HNO_3 and 5 ml of concentrated HCl were added. The solutions were heated at 95 °C and let to evaporate to remain with about15 ml and let to cool. The final volume of each sample was re-adjusted to 100 ml with distilled water, ready for analysis of heavy metal Lead by Atomic Absorption Spectrophotometer.

The amaranthus samples were washed thoroughly with distilled water to get rid of soil and other litters. The amaranthus samples were then sliced using stainless steel knife and followed by drying at room temperature to re powdered and sieved through a mesh of 2 mm size to get fine powder. The powdery product was subjected to acid digestion process. With acid digestion, one gram of each prepared powdered vegetable sample was weighed into different crucibles. All crucibles were put in the furnace for five hours at 600 °C and then left over night. The crucibles were then removed from the furnace, each added with 10 ml of 6 N HCl, then followed by addition of 15 ml of distilled water. The mixtures were filtered into 100 ml plastic bottles using a Whatman® filter paper 1. The filtrates were ready for lead analysis in Atomic Absorption Spectrophotometer.

Detection and quantification of lead

Presence and levels of lead in water and vegetable samples were analysed by using Atomic Absorption Spectrophotometer method modified from the previously established protocol by Parsons and Slavin (1993). In summary, the concentrations of the samples were calculated using calibration curves which were plotted using standard concentration against absorbance according to the principle of Beer's Lambert law (Swinehart 1962).

RESULTS

Calibration

The calibration curve provided linear equations which were used to find graph readings. The limit of detection (LOD) for the method has been validated to be 1 µg/L. whereas the limit of quantification (LOQ) in 2 µg/L. The standards were diluted at 9, 18, 27 and 36 µg/L.

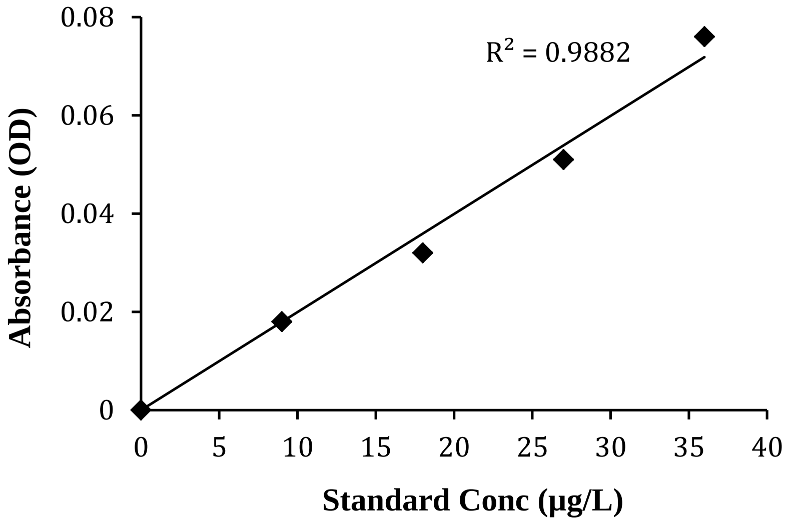

Figure 2: Standard calibration curve for lead determination

Occurrence and level of lead in water

All the analysed water samples (100%) had detectable levels of water, ranging between 0.005-0.141 mg/l (mean 0.056 mg/l). The levels were higher in dry season (mean 0.083 µg/l) than during rainy season (mean 0.029 mg/l). The difference between the two seasons was statistically significant at 95% confidence interval when tested by t-test (p=0.001). The average levels of lead in water collected in the morning and the ones collected in the evening were 0.055 mg/l and 0.056 mg/l respectively, and were not significantly different (p=0.49). Figures 2 illustrate levels of lead at different water sample collection points along the Morogoro River.

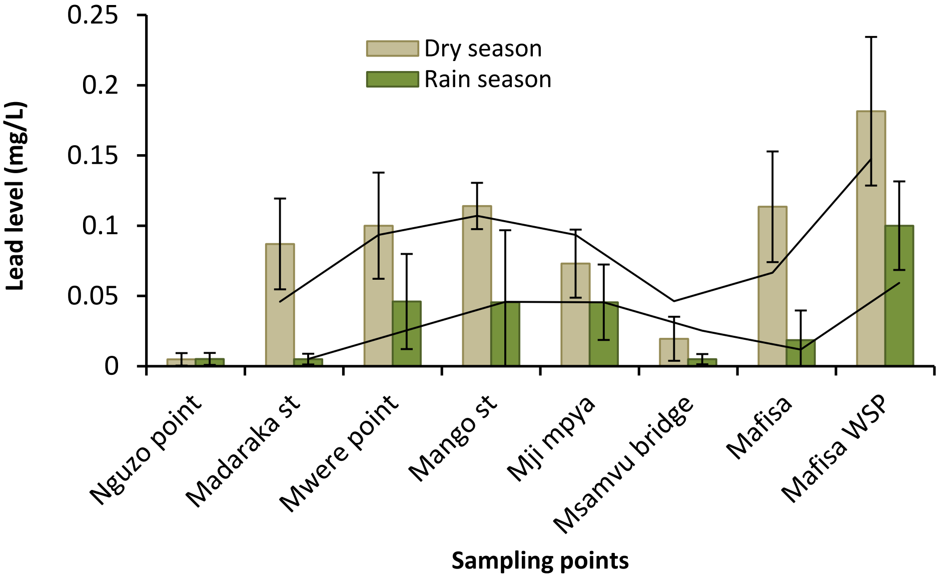

Figure 3. Levels of lead in water samples collected from different points and seasons

Concentration of Lead in *Amaranthus retroflexus* vegetables

The levels of lead in the collected amaranthus samples ranged between 0 mg/kg (<LOD) to 0.026 mg/kg with an average of 0.008 mg/kg. The levels were higher in samples collected during dry season (average 0.014 mg/kg) than in the ones collected during the rainy season (average 0.005 mg/kg). The difference between the two seasons was statistically significant (p = 0.02).

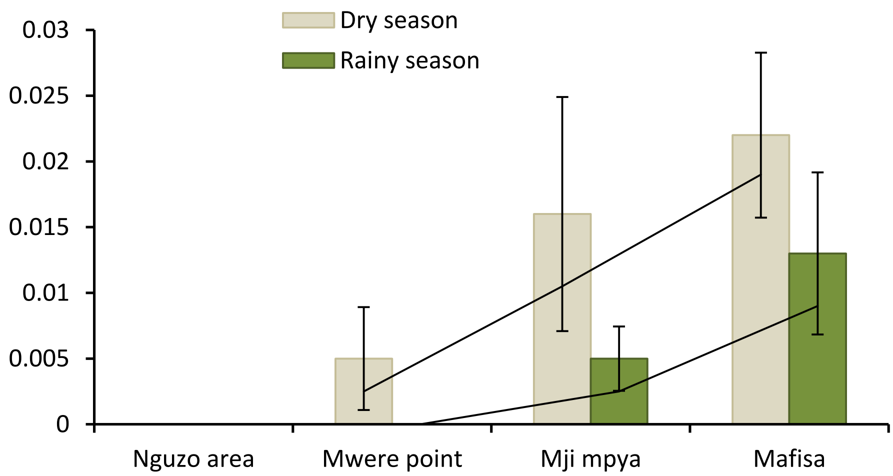

Figure 4. Levels of lead in *Amaranthus retroflexus* samples collected at different points of Morogoro River and seasons.

DISCUSSION

The results of the current study have established that the water in Morogoro River and vegetables grown along the river banks contain lead pollutants, with variable levels depending on the season and location of sample collection. Studies around Morogoro and other urban areas in Tanzania have also reported concerning levels of lead in water and vegetables used for human consumption.

Previously, it has been reported lead levels between 0.034 to 0.090 mg/L in water samples collected in Kingolwira, few kilometres from Morogoro town (Shayo *et al*., 2007) and up to 0.001 mg/L in Dar es salaam (Mahugija 2018). Another study on vegetables collected around Morogoro town had reported lead levels up to 3.15 mg/kg.

This study detected levels up to 0.950 mg/L, in the River Morogoro water and up to 0.026 mg/kg in vegetables. The fact that the water is used for different human activities rise an alarm on the levels, being more serious if the water is used for drinking. The WHO recommends lead limit in drinking water (recognised by codex Alimentarius) at 0.01 mg/L (WHO 1993).

In this study, 77% of the water samples and 28% of the vegetable samples had lead levels above the 0.1 mg/L and 0.1 mg/kg respectively. The frequency is alarming especially considering that the water passes across human settlements.

Morogoro town like many other urban areas has shortage of treated tap water supply (UNICEF 2018) prompting the community to be using the water for drinking, washing fruits or other consumptions. The accumulation of the metal in the amaranthus is an indication of another alternative route the pollutant can reach humans and animals.

A study in Dar es Salaam had reported signals of bio-exposure of lead and other toxic heavy metals to humans, and associated the exposure with drinking contaminated water (Mahugija *et al*., 2018).

The levels of lead in water and in the vegetables have varied according to the topographical location of the collection site and year season (Figure 2 & 3).

The levels in water are low to none at the upper location of the river and during rainy season. The levels are high as the river percolates across the town centre and during dry season. The results coincides with other studies that indicate distributed of heavy metals in river water can be significantly affected by anthropogenic activities (Hussain *et al.,* 2017).

With this study, the upper catchment of the river has little human activates that may effuse water to the river. The Morogoro town centre has several points of car wash, some of them located near to the river and the effluents from the sites can be washed into the river.

Wastewater originating from automobile carwashes have been characterised in different studies to contain high levels of contaminating heavy metals including lead (Adams *et al.,* 2016) and are considered as among the major sources of river water pollutions in urban areas (Mwegoha and Kihampa 2010).

According to (Islam *et al.,* 2015) some river water pollutants are higher during dry seasons although the changes in water characteristics are not always positive during the rainy seasons (Ojok *et al.,* 2017).

The findings of this study shows that lead levels in Morogoro River water exceeds the WHO limits in more than half of the samples collected.

Importantly, lead levels found in edible vegetables grown and irrigated with the river water was above the acceptable limit.

Furthermore, levels of the metal were found to be higher during dry season than rainy season and that the level of lead contamination increased towards the lower catchments of the river and the town centre.

The cause of this difference in lead levels between different points and season is not currently known.

Further research is recommended to investigate and document the observed variations in order to have a clear understanding that will guide intervention measures.

ACKNOWLEDGEMENT

This study is a part of university studies of the first author and was funded by the Tanzania Higher Education Students Loan Board. We thank the Sokoine University of Agriculture for hosting the laboratory works and the help of the technologists at the Department of Soil Science.

CONFLICT OF INTEREST

Authors declare no conflict of interest.

REFERENCES

Adams G, Ogedegbe P, Tawari-Fufeyin. Assessment of presence of heavy metals and other pollution burden parameters and their effect on water quality in Benin City, Edo State. *Env Qual Manag* 26: 65-87, 2016.

Due JM, Anandajayasekeram P. Contrasting farming systems in Morogoro region, Tanzania. *Can J Afr Stud* 18: 583-591, 1984.

Ferati F, Kerolli-Mustafa M, Kraja-Ylli A. Assessment of heavy metal contamination in water and sediments of Trepça and Sitnica rivers, Kosovo, using pollution indicators and multivariate cluster analysis. *Environ Monit Assess* 187: 338-342, 2015.

Hellar-Kihampa H, Potgieter-Vermaak S, De Wael K, Lugwisha E, Van Espen P, Van Grieken R. Concentration profiles of metal contaminants in fluvial sediments of a rural–urban drainage basin in Tanzania. *Int J Environ Anal Chem* 94: 77-98, 2014.

Hussain J, Husain I, Arif M, Gupta N. Studies on heavy metal contamination in Godavari river basin. *Appl Water Sci* 7: 4539-4548, 2017.

Islam MS, Uddin KM. Alteration of water pollution level with the seasonal changes in mean daily discharge in three main rivers around Dhaka city, Bangladesh. *Environments* 2: 280-294, 2015.

Kordas K, Ravenscroft J, Cao Y, McLean EV. Lead exposure in low and middle-income countries: perspectives and lessons on patterns, injustices, economics, and politics. *Int. J. Environ Res Public Health* 15: 2351-2361, 2018.

Mahugija J. Levels of heavy metals in drinking water, cosmetics and fruit juices from selected areas in Dar es salaam. *Tanzan J Sci* 44(1), 2018

Mahugija JA, Kasenya ZS, Kilulya KF. Levels of heavy metals in urine samples of school children from selected industrial and non-industrial areas in Dar es Salaam, Tanzania. *Afr Health Sci* 18: 1226-1235, 2018.

Mdegela RH, Braathen M, Pereka AE, Mosha RD, Sandvik M, Skaare JU. Heavy metals and organochlorine residues in water, sediments, and fish in aquatic ecosystems in urban and peri-urban areas in Tanzania. *Water Air Soil Pollut* 203: 369-379, 2009.

Mkoma SL. Heavy metal pollution in the water resources of Morogoro Municipality. UDSM Library Repository, 2001. Accessed on 21 October 2019 at http://41.86.178.4/xmlui/handle/1/5163

Mwegoha W, Kihampa C. Heavy metal contamination in agricultural soils and water in Dar es Salaam city, Tanzania. *Afr J Environ Sci Technol* 4:763-769, 2010.

NBS. Basic demographic and socio-economic profile, 2014. Accessed on 24th September 2019 from https://nbs.go.tz/nbs/takwimu/census2012/Basic_Demographic_and_Socio-Economic_Profile_PopularVersion-KeyFindings_2012_PHC_EnglishVersion.pdf

Ojok W, Wasswa J, Ntambi E. Assessment of seasonal variation in water quality in river Rwizi using multivariate statistical techniques, Mbarara Municipality, Uganda. *J Water Resour Prot* 09 (01), 2017.

Parsons PJ, Slavin W. A rapid Zeeman graphite furnace atomic absorption spectrometric method for the determination of lead in blood. *Spectrochim Acta Part B At Spectrosc* 48: 925-939, 1993.

Patra RC, Rautray AK, Swarup D. Oxidative stress in lead and cadmium toxicity and its amelioration. *Vet Med Int* 201: 457327, 2011.

Sakson G, Brzezinska A, Zawilski M. Emission of heavy metals from an urban catchment into receiving water and possibility of its limitation on the example of Lodz city. *Environ Monit Assess* 190: 281-281, 2018.

Shayo N, Chove B, A. G. The quality of water in small community supplies of Kingolwira village, Morogoro, Tanzania. *Tanzan Health Res Bull* 9: 56-60, 2007

Swinehart DF. The Beer-Lambert Law. *J Chem Ed* 39 :333, 1962.

Tchounwou PB, Yedjou CG, Patlolla AK, Sutton DJ. Heavy metal toxicity and the environment. *Ex Suppl* 101: 133-164, 2012.

UNESCO-WWAP. Water pollution is on the rise globally. 2017. Accessed on 15th December from http://www.unesco.org/new/en/natural-sciences/environment/water/wwap/facts-and-figures/all-facts-wwdr3/fact-15-water-pollution/

UNICEF. Water, sanitation and hygiene budget brief , 2018 – Tanzania. 2018. Accessed on 15th December 2018 from https://www.unicef.org/tanzania/media/1291/file/UNICEF-Tanzania-2018-WASH-Budget-Brief.pdf. 2018 Tanzania WASH Budget Brief

Wani AL, Ara A, Usmani JA. Lead toxicity: a review. *Interdiscip Toxicol* 8: 55-64, 2015.

WHO. Guidelines for drinking water quality. 2nd edition. 1(49-50), 1993. Accessed on 15 December 2018 from https://www.who.int/water_sanitation_health/publications/gdwq2v1/en/index1.html