Journal of Water Resources and Ocean Science
2015; 4(1): 1-5
Published online January 29, 2015 (http://www.sciencepublishinggroup.com/j/wros)
doi: 10.11648/j.wros.20150401.11
ISSN: 2328-7969 (Print); ISSN: 2328-7993 (Online)

Comparative analysis of heavy metals from groundwater sources situated in Keko and Kigogo residential areas, Dar es Salaam

Isabela Thomas Mkude

Dept. of Environmental Studies, Open University of Tanzania, Dar es Salaam, Tanzania

Email address:
isabela.thomas@yahoo.com

To cite this article:
Isabela Thomas Mkude. Comparative Analysis of Heavy Metals from Groundwater Sources Situated in Keko and Kigogo Residential Areas, Dar es Salaam. *Journal of Water Resources and Ocean Science.* Vol. 4, No. 1, 2015, pp. 1-5. doi: 10.11648/j.wros.20150401.11

Abstract: The study assessed in comparison the concentrations of heavy metals in water samples (n=12) collected from groundwater sources at Keko and Kigogo areas. Three trace elements; Copper, Zinc and Lead (Cu, Zn and Pb). Analysis was done once in dry season and once in rainy season at Ardhi University laboratory. The water samples were taken in 4oc equipment for transportation. Results show low concentrations of Cu and Zn for both seasons and study areas. Pb concentrations were detected beyond the WHO permissible level (min. 0.01mg/l and max. 0.35mg/l). This presence of high concentrations may be due to urban agriculture activities conducted around the areas surrounding Msimbazi river, and also presence and use of onsite facilities (septic tanks and pit latrines). Discharge and runoff collection from garages and industrial wastes is another reasons thought for this high amount of heavy metals. There is need of adopting cheap water treatment technology for domestic purposes so as to protect people from being affected by the use of untreated water directly.

Keywords: Heavy Metals, Trace Elements, Zinc, Lead, Copper, Groundwater

1. Introduction

Water is essential to human life. In all its use, quality and quantity are the most important terms to consider. Quantity of water differs from place to place due to geographical and climate differences, land uses. On the other hand, the quality of water may differ due to pollution from nutrient pollutant flows, disposal of storm water, sewage and other urban wastes. Besides the quality of water due to climate changes as well as changes in land use (particularly in estuaries, bays and shallow enclosed seas) (11). In Tanzania surface water and ground water are used to supply water in urban and rural areas. The use of surface and ground water in different parts of the country differs caused by differences in topography, rainfall pattern and climate, also in each region. However, ground water is a major source of water for many rural areas and those lacking piped water in Tanzania. It is the most viable alternative supplements especially the central and northern parts of the country in the drier regions. Ground water, these consists of both boreholes and shallow wells a source believed to be safe due to natural protection by the aquifers may be highly polluted by different sources. Pollution from industrial discharges and domestic seepage like the use of latrines and septic tanks or that from improper management of solid waste, lack of sanitation or even open defecation practices may pose a serious pollution to the groundwater (10).

Heavy metals are sometimes called “trace elements”, they become of particular interest in recent decades within the framework of environmental investigation. This has without doubt been due to the fact that highly sensitive analytical procedures are available for determining and detecting metal content with high precision (13).

1.1. Problem Statement

Lack of adequate water supply may cause serious health problem and/or even loss of human life. Quality of water used for drinking and other domestic purposes is a fundamental element to be considered during the selection of water sources. The rapid increase of population in the City also increases number of people living in unplanned areas, and this increases also the use of pit latrines and septic tanks as the main sanitation facilities. Improper construction, without consideration of proposed distances to water sources and poor or lack of maintenance of these sanitation facilities causes contamination to the ground water used for domestic purposes and hence poses risk to human health.

1.2. Objective

The main objective of this study was to quantify the selected heavy metals (Cu, Pb and Zn) from groundwater sources at Keko and Kigogo that used for domestic purposes and compare results from two areas.

2. Material and Methods

2.1. Research Design

This research was designed and conducted as a cross sectional multiple case studies, by using qualitative and quantitative data collection approaches. The cases of these studies were Keko and Kigogo areas in different two municipalities of Dar es Salaam City. It was cross sectional design since it referred to a single reference period of study. The phenomenon within the case was the heavy metals in groundwater that used for domestic purposes. The relevant stakeholders involved throughout of the study were the local communities in these two study areas, Keko and Kigogo.

2.2. Study Areas

Keko and Kigogo residential areas were selected due to the fact that, they are located in different municipalities, (Temeke and Kinondoni respectively) but yet they have some common characteristics. They are both unplanned residential areas that people who are living there are in low to middle economic status. Piped water system does not reach to every house; hence most of families find alternative sources of water. Groundwater seems to be the next alternative available since it is cheap and easily available. There are hand dug wells located to their living premises that contain good quantity of water for domestic use, these are normally private owned, while the boreholes (>25m deep) are public owned and located in area that easily accessed by many people through water kiosks. The boreholes are good source of water to these communities since they cost cheaper compared to piped water and its water thought to be cleaner than that from hand dug wells.

2.3. Data Collection Methods

Since it was case study research, multiple data sources were involved to obtain a desirable relevant data. Primary data and secondary data were collected from different data sources and used during the study. Primary quantitative data were obtained by laboratory analysis, while qualitative data were obtained by short interviews with water source owners before water sampling. Secondary data obtained from different previous data sources like research reports, journals, text book, census book, planning reports, and all relevant information to gather all required data mainly through internet. The literature review was conducted to obtain the most relevant information on ground water quality and use in Dar es Salaam.

2.4. Experimental Methods

2.4.1. Sampling and Analysis

Water samples were collected in polyethylene bottles from total of 12 groundwater sources (4 shallow wells and 8 boreholes) from both study areas and analyzed for heavy metals (Cu, Zn and Pb). Duplicate water samples were collected from each source by using grab sampling method and analysis was done in two phases (rainy and dry) seasons. Samples for analysis were stored in sterilized polyethylene bottles at 4 ◦C and transported for analysis at Ardhi University Laboratory. It is recommended that for better results, analysis need to be performed within 20 to 30 minutes after sampling, and not more than 24 hours after sampling (19). Analysis was done using atomic adsorption instrument. All parameters were analyzed according to the Standard Methods for the Examination of Water and Wastewater (3). Microsoft Excel 2007 program was used for analysis of statistical values; average and their standard deviations.

2.4.2. Sampling Points

Total number of 12 sampling points and their general characteristics are shown in table 1. Boreholes are denoted as BH and Shallow wells as SW.

Table 1. *General characteristics of sampling points.*

Study Area	Label		Depth(m)	Number of water users/day	Remarks
Kigogo	SW1	Mbuyuni A	5	15	Not lined, used by 2 families
	SW2	Mbuyuni A	8	30	Stones, used for vegetable irrigation
	BH1	Rutihinda	60	1500	Pumped with 10,000lt storage tank. Extended to 8 kiosks
	BH2	Kigogo CCM	60	3000	Pumped with 10,000lt storage tank. Extended to 4 kiosks
	BH3	Police	65	3500	Pumped with 10,000lt storage tank.
	BH4	Mburahati	60	3700	Pumped with 10,000lt storage tank.
Keko	SW3	Keko Mwanga	3	10	Not lined
	SW4	Keko Machungwa	4	80	Cement, used for different domestic purposes
	BH5	Magereza	50	10-15 water tankers	Pumped with 15,000lt storage tank
	BH6	Unubini	35	1000	Pumped with 10,000lt storage tank.
	BH7	Magurumbasi	40	1500	Pumped with 15,000lt storage tank.
	BH8	Toroli	25	1200	Pumped with 10,000lt and 5000lt storage tanks.

3. Results and Discussion

Tables 2 and 3 give summary of mean values of selected trace elements (Cu, Zn and Pb) from all sampling points during dry and rainy seasons respectively.

Table 2. *Average values for analysed heavy metals from groundwater on dry season.*

	DRY SEASON			
	Sampling Points	**Cu (mg/l)**	**Pb(mg/l)**	**Zn(mg/l)**
Kigogo	SW1	0.010	0.010	0.092
	SW2	0.010	0.010	0.010
	BH1	ND	0.090	0.059
	BH2	ND	0.311	0.054
	BH3	ND	0.081	0.058
	BH4	ND	0.124	0.054
Keko	SW3	0.010	0.270	0.012
	SW4	0.010	0.194	0.010
	BH5	ND	0.309	0.235
	BH6	ND	0.350	0.048
	BH7	ND	0.078	0.046
	BH8	ND	0.232	0.035

ND=Not detected

Table 3. *Average values for analysed heavy metals from groundwater on rainy season.*

RAINY SEASON				
	Sampling Points	**Cu(mg/l)**	**Pb(mg/l)**	**Zn(mg/l)**
Kigogo	SW1	0.01	0.02	0.076
	SW2	0.01	0.03	0.01
	BH1	0.013	0.01	0.059
	BH2	0.01	0.034	0.054
	BH3	0.01	0.01	0.058
	BH4	0.01	0.035	0.054
Keko	SW3	0.01	0.32	0.015
	SW4	0.01	0.169	0.01
	BH5	0.06	0.078	0.28
	BH6	0.01	0.28	0.041
	BH7	0.01	0.075	0.048
	BH8	0.01	0.22	0.033

3.1. Copper (Cu)

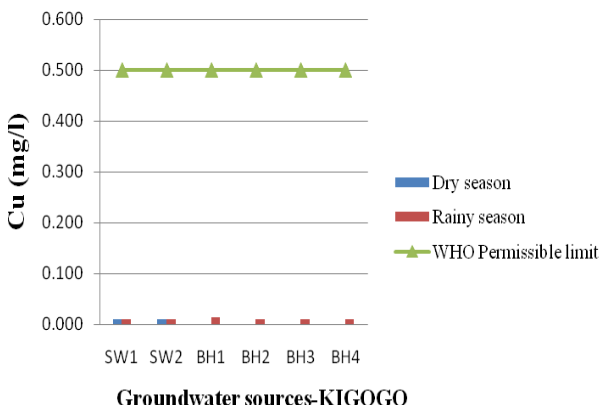

Figure 1. *Mean concentration values for Cu (mg/l) during dry and rainy seasons from Kigogo area.*

Results of mean concentrations of Cu from analysed samples in seasonal comparison are represented in Figures 1 and 2. All 12 water sources detected with some amount of Cu during rainy season (range from 0.0 to 0.013mg/l) although in very minimal amount. In dry season Cu concentration were not detected in most of samples from boreholes while handdug wells were detected with Cu concentrations in both dry and rainy seasons.

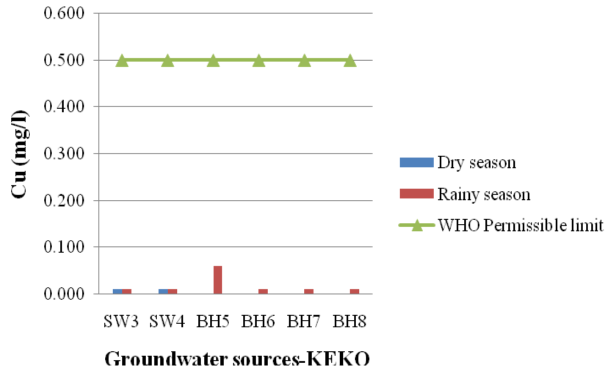

Figure 2. *Mean concentration values for Cu (mg/l) during dry and rainy seasons from Keko area.*

Source of copper may be due to the intrusion of industrial and domestic wastes (2). This is true since, there are some industries at Temeke Municipality that discharge waste water through Msimbazi River that pass through Keko residential areas. In turn during rainy season water runoff collects some amount of discharged wastewater to the groundwater sources. WHO suggests standards for Cu concentrations in drinking water to be 0.5mg/l (20). All water samples are found to be within the WHO permissible limit.

3.2. Lead (Pb)

Lead concentration was found to range from 0.01 mg/l to 0.35mg/l as shown in Figures 3 and 4. Values were elevated from dry season to that of rainy season. Boreholes detected with high amount of Pb compared to hand dug wells at Kigogo. WHO standards (2008), suggest the permissible range of Pb for drinking water to be 0.01mg/l. At Keko area, the situation is worse, since all groundwater sources found to have large amount of Pb in both seasons. It is reported by different scientist that, high concentration of Pb (> 0.01mg/l) has been implicated in causing anaemia, kidney damage and cerebral oedema to human (18), (4). In this case, high concentrations of lead in the body can cause death or permanent damage to the central nervous system and brain which the effects can be in memory. Other effects are high blood pressure, hearing problems, headaches, slowed growth, reproductive problems in men and women, digestive problems, muscle and joint pain (7), (13). Not only that Lead accumulative effects overtime, but also is considered to be the number one health threat to children. Moreover, high concentration of lead is linked to crime and anti-social behavior in children (19). Source of Lead contamination to ground water may be the result of entry from industrial effluents, old plumbing, household sewages, agricultural run-off containing phosphate fertilizers and human and animal excreta (15).

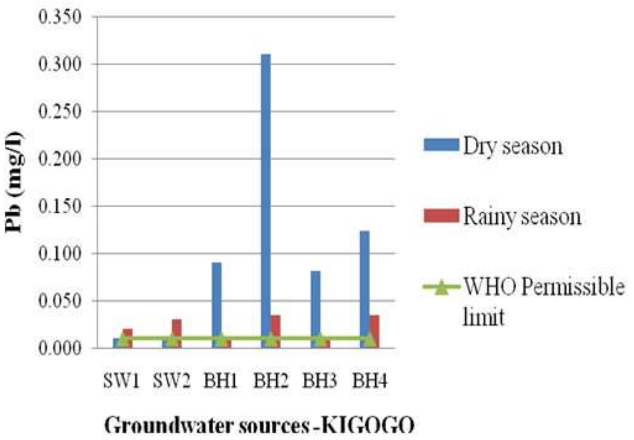

Figure 3. *Mean concentration values for Pb (mg/l) during dry and rainy seasons from Kigogo area.*

These results in Figures 3 and 4 are high compared to that obtained at Ojota area in Lagos state, where the mean value at dry season was 3.2mg/l and the value obtained in rainy season was 1.5mg/l (12). Similarly, study in Chennai City, Tamil Nadu water was detected with slightly amount of Pb ranging 0.01- 0.07ppm for ground water samples (16).

High elevated amount of Pb at Keko may be due to the reported various anthropogenic activities especially runoff and infiltration water from urban agriculture plots which dominate the area. In this area, there is an informal urban vegetable agriculture activity that uses fertilizers. Unfortunately many of these agricultural plots are near surface and groundwater sources. In addition, the onsite sanitation systems (septic tanks and pit latrines) are the ones used with most of dwellers which may also influence the seepage of human waste to groundwater sources leading the high amount of lead

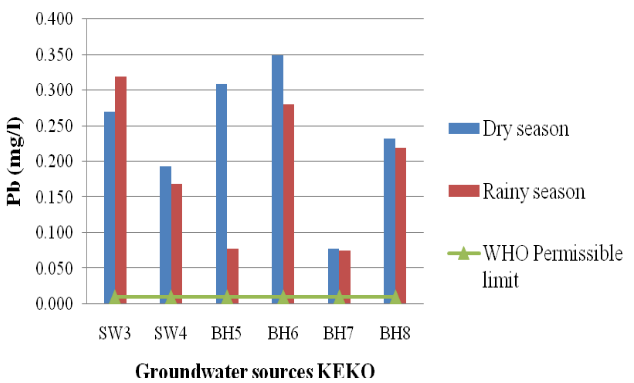

Figure 4. *Mean concentration values for Pb (mg/l) during dry and rainy seasons from Keko area.*

3.3. Zinc (Zn)

The amount of Zinc (Zn) in the study area is given by Figures 5 and 6. The minimum concentrations of Zn were found to be 0.01mg/l while maximum is 0.28mg/l. The results show that borehole in this case was detected with show high amount of Zn compared to hand dug wells for both seasons. The high concentrations of zinc may be attributed to the pollution due to persistent leaching along the top layers of the soil and its widespread dispersion could be attributable to the use of liquid manure, compost material and agrochemicals (16).

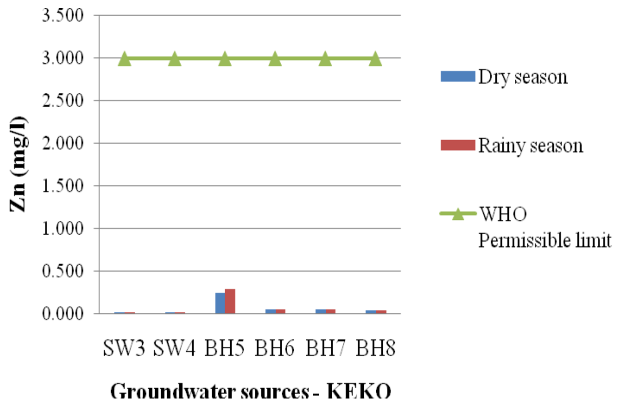

Figure 5. *Mean concentration values for Zn (mg/l) during dry and rainy seasons from Kigogo area.*

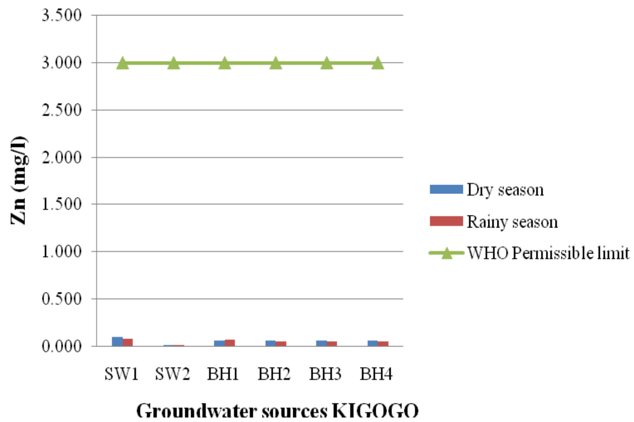

Figure 6. *Mean concentration values for Zn (mg/l) during dry and rainy seasons from Keko area.*

Results were compared to that obtained by (17) in Tamilnadu area, India which also found to be below WHO permissible level. Results from this study also seems to be lower compared to that obtained from lake Manzala water in Egypt (min 0.32mg/l and max 0.66mg/l) which reported to be due to considerable amounts of zinc leached from protection plates of boats containing the active zinc (14).

The water may however be suitable for other uses such as sanitation and irrigation. All samples met the WHO permissible limit of Zn in drinking water which is 3.0mg/l. However the occurrence of small amount of zinc in the sampled may tend water to be not safe for human consumption particularly drinking and cooking. This shows that Zinc toxicity is absent in the study area. However, source of slight high value (BH5) may due to agricultural inputs, domestic waste discharges and the industrial effluents.

4. Conclusion

Total of 12 water samples were collected from groundwater sources from two residential areas that have common characteristics, Keko and Kigogo in two seasonal conditions; dry and rainy seasons. Analysis of dissolved heavy metals in these water samples was done for Pb, Zn and Cu. Concentrations of Zn and Cu were found to be in permissible range of WHO standards of drinking water. Minimum and maximum concentrations of Pb for both study areas in dry and rainy seasons were detected higher than WHO permissible limit of 0.01mg/l. Human health of Keko residents especially children are at high risk throughout the year to be effected by consumption of high amount of Pb because, water from these sources are used for drinking, cooking and other domestic purposes that lead them to ingest this amount of Pb direct to their bodies. It is recommended to adopt some kind of inexpensive treatment to reduce the levels of trace metals in areas supplying water directly to consumers without any type of treatment.

Acknowledgements

The author extends her acknowledgements to all water sources owners who participated and technical staff at Ardhi University Laboratory, Dar es Salaam and all those who participated in one way or another.

References

[1] Abdul Jameel, A., Sirajudeen, J. And Abdul vahith, R., (2012). Studies on heavy metal pollution of ground water sources between Tamilnadu and Pondicherry, India. Advances in Applied Science Research, 3 (1):424-429

[2] Aggarwal, T. R., Singh, K. N. And Gupta, A. K., (2000). Impact of sewage containing domestic waste and heavy metals on the chemistry of Varuna river water.Poll. Res., 19(3): 491-494

[3] APHA, (1998). Standard Methods for the Examinations of water and wastewater. 18th Edition, American Public Health Association, Washington D.C

[4] Egborge A.B.M, (1991). Industrialization and heavy metal pollution in Warri River, University of Benin Press, Inaugural lecture series 32.

[5] FAO, (2008). Coping with water scarcity; An action framework for agriculture and food security.FAO Water Reports, 38. Food and Agriculture Organization of the UN, Rome.

[6] Hussain, A. Z and K. M. Mohamed Sheriff (2013). Status of heavy metal concentrations in groundwater samples situated in and around on the bank of Cooum river at Chennai City, Tamil Nadu Journal of Chemical and Pharmaceutical Research, 5(3):73-77

[7] Jennings, G., Sneed D., Clair, E. (1996): Metals in drinking water. North Carolina Cooperative Extension service Publication no.: AG-473-1. Electronic version 3

[8] Maganga, P. F., Butterworth, J. A. And Marioty, P., (2002). "Domestic Water Supply, Competition for Water Resources and Iwrm in Tanzania: A Review and Discussion Paper." Phys & Chem. Of the earth 27: 919-926.

[9] Mato, R. R. A. M., (2002). Groundwater Pollution in Urban Dar Es Salaam. Tanzania: Assessing Vulnerability and Protection Priorities. University Press, Eindhoven University of Technology. Eindhoven

[10] Ministry of Water and Iirrigation (mowi), (2009). Water sector status report. Ministry of water and irrigation, Dar es Salaam

[11] Mwakalila, S. (2007). "Residents' Perceptions of Institutional Performance in Water Supply in Dar Es Salaam." Physics and Chemistry of the Earth, Parts A/B/C 32(15-18): 1285-1290.

[12] Oyeku O.T and Eludoyin, A. O. (2010). Heavy metal contamination of groundwater resources in a Nigerian urban settlement. African Journal of Environmental Science and Technology Vol. 4(4), pp. 201-214,

[13] Salem H. M. Et al. (2000). Heavy Metals in Drinking Water and Their Environmental mpact on Human Health. Cairo University, Egypt, September, 2000, page 542- 556

[14] Samir M. S and Ibrahim M. Shaker, (2008). Assessment of heavy metals pollution in water and sediments on orechromis niloticus in the northern delta lakes, and their effect, Egypt. 8th International Symposium on Tilapia in Aquaculture

[15] Sirajudeen J, Abdul Jameel A, (2006). Studies on heavy metal pollution of Groundwater sources between Tamilnadu and Pondicherry India. J. Ecotoxicol. Environ. Monit, ,16(5) 443-446.

[16] Srinivas Gowd S. And Govil, P.K. (2007). Distribution of heavy metals in surface water of Ranipet industrial area in Tamil Nadu, India Environ. Monit Assess, 136, 197-207.

[17] Thambavani, S. D. And Mageswari T.S.R,. (2013). A Comprehensive Geochemical Evaluation of Heavy Metals in Drinking Water. Journal of Chemical, Biological and Physical Sciences. Vol. 3, No. 4; 2942-2956

[18] Townsend, A., (1991). Encyclopedia of Analytical science, Academic Press, London

[19] USEPA (2002). On-Site Wastewater Treatment System Manual. Office of water and office of research development. Washington DC.

[20] WHO 2008, Guidelines for drinking water quality, World Health Organization, Geneva.