Journal of Science and Technology
ISSN: 2456-5660 Volume 06, Issue 01, Jan-February 2021

www.jst.org.in *DOI: https://doi.org/10.46243/jst.2020.v6.i1.pp09-15*

Assessment of Selected Heavy Metals Levels In Borehole Water In Ongata Rongai, Kajiado County, Kenya.

Ochiba N.K[1], Abong'o D.A[1], Onyatta J.O[1]
[1] (Department of Chemistry, College of Biological and Physical Sciences, School of Physical Science, University of Nairobi, Nairobi, Kenya)
Corresponding Author: nancy.khayongo@gmail.com

To Cite this Article
Ochiba N.K, Abong'o D.A, Onyatta J.O "Assessment of selected heavy metals levels in borehole water in Ongata Rongai, Kajiado County, Kenya", Journal of Science and Technology, Vol. 06, Issue 01, January-February 2021, pp09-17

Article Info
Received: 06-08-2020 Revised: 18-10-2020 Accepted: 01-11-2020 Published: 08-11-2020

Abstract: *The study was carried out to assess the levels of heavy metals in ground water sampled from ten selected borehole sites in Ongata Rongai town, Kajiado County. The levels of selected heavy metals analyzed were: Zinc, Lead, Mercury, Manganese, Cadmium and Chromium in dry and wet seasons the analysis was done by Flame Atomic Absorption Spectroscopy. Seasonal variation was considered as an aspect of pollution to the subsurface environment where there was no obvious observable environmental degradation or where unknown contaminants could have been disposed of, privately, without any matrix being charged. The analysis of water samples was done using Flame Atomic Absorption Spectroscopy and the results for the metal levels were in the range of: Zinc Below Detectable Limits- 0.73±0.01 (mgl^{-1}); lead 0.21±0.01- 0.33±0.01 (mgl^{-1}), mercury 0.0010 ± 0.0001 - 0.0019±0.0001(mgl^{-1}); 0.256±0.01 (mgl^{-1}); manganese 0.03±0.01- 0.26±0.01 (mgl^{-1}). Cadmium and chromium had levels below detectable limits in dry and wet seasons. The levels of zinc and manganese were higher in the dry season than those recommended by World Health Organization of 3.0mgl^{-1} and 0.01mgl^{-1}respectively. The presence of the heavy metals in the borehole water is of concern since they could impact negatively on human health even at low levels due their accumulation. Stringent management and public awareness are required in order to safeguard the environment and human health in Ongata Rongai town.*

***Keywords**: Heavy metals; Borehole; Underground water; Water quality; Seasonal variation*

I. Introduction

Heavy metals have been known to be one of persistent pollutants in water[1]. There is need to assess the levels of these metals to show the effect of septic tanks constructed at < 16m distance from borehole water[2]. Heavy metals can be toxic in very little concentrations and usually accumulate in the environment and later become a health hazard to humans[3]. A recent publication also demonstrated that septic tanks in Ongata Rongai are a source of inorganic constituent contaminants that enter the borehole water[2].The increase in urbanization is placing a lot of strain on available amenities in Ongata Rongai. The area being very close to the capital City of Kenya, Nairobi, has had its population increasing since its standards of living are a little bit cheaper than living in the capital city and its environs. There is lack of elaborate water services and hence the load of providing water closer to consumers is currently met by boreholes[4]. Report shows that anthropogenic activities are the major contributors to increased quantities of heavy metals in water sources[5]. Ongata Rongai has several quarries in site and the increase in population has contributed to the increase in amounts of domestic effluent which is mostly disposed of by the use of septic tanks[2]. Septic tanks as well as other anthropogenic activities have been known to contribute to increasing quantities of heavy metals in water[6]. Therefore, quality of drinking water and its heavy metal concentration detection is essential in maintaining human health[7].The obtained data was compared to World Health Organization (WHO), Kenya Bureau of Standards (KEBS) and National Environment Management Authority (NEMA) recommended values. The data obtained from this study will be used to advise the borehole owners and authorities in Kajiado County on levels of heavy metals in water from the selected ten boreholes. The results will be used as a baseline data on the levels of heavy metals in the selected borehole water for future reference by other researchers.

II. Material and Methods

The study area, Ongata Rongai, sits on an area of 16.5km^2 and has 66,042 people[8]. It is found at 50 KM from Kajiado County headquarters and 20 KM from Nairobi City's Central Business District (CBD) along the Langata-Magadi road (Figure 1**).** Ongata Rongai is a rapid growing residential urban area in Kajiado County; at latitude of (0° 53' 60" S) and longitude (36° 25' 60" E) (Table no 1).

The rapid growth of real estate in the area which started in the 1990s, has led to the increase in population in Ongata Rongai, a Nairobi city suburb located 16 square kilometers. Greater Ongata Rongai[9], sits within the Nairobi metropolitan, however, it does not lie in the governance borders of the capital and is demarcated from Nairobi, the capital city of Kenya by the Mbagathi River. It is split into two governance locations, Nkaimurunya and Rongai, which are segregated by the Magadi Road. Ongata Rongai is also served by the Kandisi River, a tributary of the Mbagathi River. The study area also possesses two significant industrial activities: Kitengela glass, an artefacts manufacturer hidden in Tuala neighborhood and Tam feeds, an agro-manufacturing industry at Gataka. The sources of water for domestic use are; Kandisi River supplying 10%, Mbagathi River, 20% and private boreholes in the area, 70% of water[10].

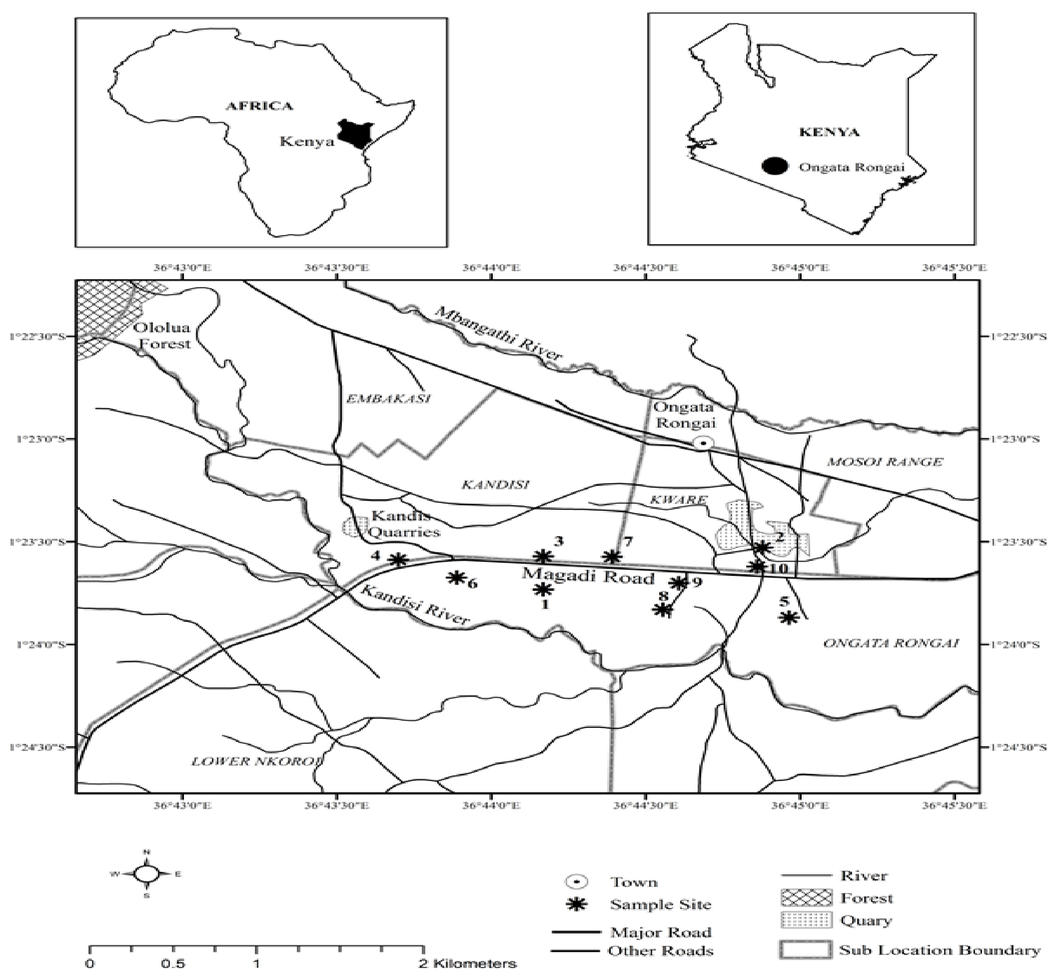

Figure 1: Map showing selected borehole sampling sites in Ongata Rongai

Table no 1 shows the sampling sites, Geographic Information System (GIS) location and a description of the surrounding.

Table no 1: Sampling sites GIS location and a description of the surrounding area

Site No.	**Altitude (m)**	Coordinates	**Description of sampling sites surroundings**
1	1788	01^0 23’ 42” S 36^0 45’ 49” E	Muslim mosque with borehole. The very densely populated area near a slaughterhouse. Surrounded by flats. One Septic tank at 30 m and an abandoned horticulture farm nearby.
2	1794	01^0 23’ 45” S 36^0 43’ 40” E	New life mission. Borehole at the slope. Densely populated shopping centre. Septic tanks at about 33 m
3	1793	01^0 28’ 45” S 36^0 45’ 49” E	Near a shopping Centre. Heavy water abstraction for sale. It has Medium population
4	1780	01^0 25’ 40” S 36^0 23’ 36” E	Mbathi’s house. The borehole has been in use for 15 years. Homestead at a higher side of property’s slope, Septic tank at about 31m
5	1788	02^0 00’ 06” S 37^0 26’ 18” E	Borehole at the chief’s camp. Densely populated, septic tanks at about 15 m
6	1781	02^0 03’ 00” S 37^0 23’ 00” E	Three flats with fifty houses each. The borehole is within the compound of the flat. Septic tanks at about 120 m
7	1791	01^0 38’ 56” S 36^0 44’ 34” E	Muslim mosque and a slaughterhouse nearby in a densely populated area. River 70 m at the bottom of the slope. Mean septic tanks at about 16m
8	1790	01^0 28’ 24” S 36^0 31’ 23” E	Gather's house, with borehole. In a low-density area with bigger plot size homesteads. On flat ground, Septic tank at about 33m
9	1781	02^0 08’ 21” S 37^0 00’ 06” E	Albanus apartments, Borehole next to a flat of 60 houses. One big capacity Septic tank at about 32 m
10	1776	01^0 18’ 30” E 36^0 41’ 22” S	Ndungu Ole Kapara borehole in a remote area. Septic tanks at about 146 m

Chemicals and reagents

Stock solutions of each of 1000ppm of zinc,lead, manganese, cadmium and chromium, and standards were prepared from heating metal reagents (99.9%) while mercury was obtained from mercury chloride. Analytical quality chemicals and reagents were used; they were obtained from BDH laboratory reagents, (Ltd Poole England). Cleaning of glassware and plastic ware was done thrice with deionized water and then immersed in 20% nitric acid overnight. The apparatus were then rinsed thrice with deionized water and a Mermmert oven was used to dry them.

Equipment

A hand-held Global Positioning System (GPS) receiver (Map 410 Magellan) was used to obtain the coordinates of the sampling sites. Analytical balance (Sartorius 1213 MP model), water deionizer (Ionizer Mk 8), Mermmert Oven, Flame Atomic Absorption Spectrophotometer (Perkin Elmer 2380) and sampling plastic containers were used.

Sample collection

Surveys and familiarization with sampling sites (Figure 1) were done in January 2019, by visiting various borehole owners to seek their consent. Sampling was done in March and May, 2019 representing the dry and wet seasons respectively. Samples were collected in May and March to take into account the seasonal variations; May is the wet season while March being the dry season. Water samples were obtained from the selected ten borehole sites (Figure 1) a representative of the Ongata Rongai area for the dry and wet seasons. Water sampling collection was done using the[11] which covers the standard methods for the examination of waters and wastewaters as well as water quality sampling. These was done by opening the tap at each sampling site, draining out the water for 1minute.

Samples from ten boreholes sites in Ongata Rongai area were collected in pre-cleaned 2.0 L plastic containers for heavy metal analysis, each sample was labeled and kept in polyurethane cool boxes then transported to the Cropnut Laboratory, Nairobi, for analysis. On-site data and observation and the description of surroundings of the sampling sites were taken (Table no 1) to include: the exact water resource location, weather conditions at the time of sampling. It was observed that galvanized zinc pipes were used for water piping. Laboratory tests were done according to the[11].Care was taken to ascertain that the samples were truly representing the existing conditions in the study area.

Acid digestion for the analysis of heavy metals

The water samples from the selected ten boreholes were acid digested as recommended by the standard procedure[12].To each 100 ml triplicate water sample in a pre-cleaned 250 ml beaker, 25 ml was prepared of 10% hydrochloric (2.5 ml concentrated hydrochloric acid + 22.5 ml distilled deionized water) was added to the beaker and heated on a hot plate. The solution was boiled until 10-15 ml was left. 10 ml of perchloric acid was added and the solution was heated until perchloric fumes were observed. The remaining sample was put in a 100ml volumetric flask and topped to the mark. The solution was then shaken well and transferred into a clean sampling bottle awaiting analysis by Flame Atomic Absorption Spectroscopy (FAAS). The samples were prepared in triplicates from each site.

Preparation of heavy metal standard stock solutions

The standard stock solutions were prepared in readiness for the heavy metal analysis, 1000 mgl^{-1} of heavy metal ion standard stock solution was prepared by heating 1.0g of each metal salt (99.9%) except for mercury and dissolving it in 30 ml (1:1 v/v) of water: nitric acid solution then transferring the solution to 1000 ml volumetric flask and diluting to the mark. While 1000 mgl^{-1} of mercury (Hg) standard stock solution was prepared by dissolving 1.354g of analytical grade salt of $HgCl_2$ (99.9%) in distilled deionized water and diluting to the mark. The standard stock solutions were diluted to prepare standard solutions for each calibration curves during analysis.

Quality assurance

Quality assurance was ascertained by analysis of blank solutions. Quality control was carried out as recommended by[13]analysis of laboratory reagent and fortified blanks, as well as samples during the analysis. Rinsed blanks and calibration of six standard solutions of all monitored analytes were prepared at parts per million (ppm).

Samples analysis

Samples were analyzed by direct aspiration in FAAS using different wavelengths nanometer (nm) for each element and the flame/gas being air/acetylene, while mercury was done by cold vapor generation in a special accessory. The samples were analyzed in triplicates. They were warmed up and the recommended wavelengths and flame/gas types set for the various heavy metals changed.

III. Result

The levels of selected heavy metals obtained are shown in Table no 2

Table no 2: Heavy metals levels in water from ten borehole sites in dry and wet seasons

Heavy metal level						
Dry Season						
Site	**Zinc** (mgl^{-1})	**Lead** (mgl^{-1})	**Mercury** (mgl^{-1})	**Manganese** (mgl^{-1})	**Cadmium** (mgl^{-1})	**Chromium** (mgl^{-1})
1	0.16±0.01	0.22±0.02	0.0017±0.0002	0.12±0.00	BDL	BDL
2	0.73±0.01	0.33±0.01	0.0017±0.0001	0.09±0.01	BDL	BDL
3	0.16±0.02	0.22±0.01	0.0018±0.0003	0.22±0.00	BDL	BDL
4	0.32±0.00	0.30±0.02	0.0019±0.0001	0.19±0.01	BDL	BDL
5	0.51±0.01	0.42±0.011	0.0017±0.0001	0.26±0.001	BDL	BDL
6	0.21±0.01	0.24±0.01	0.0016±0.0001	0.18±0.01	BDL	BDL
7	0.11±0.02	0.22±0.00	0.0013±0.0002	0.05±0.01	BDL	BDL
8	0.68±0.01	0.24±0.01	0.0010±0.0001	0.13±0.00	BDL	BDL
9	0.14±0.01	0.25±0.02	0.0017±0.0001	0.07±0.01	BDL	BDL
10	0.12±0.00	0.23±0.02	0.0002±0.0001	0.03±0.01	BDL	BDL
Wet season						
1	0.03±0.01	0.21±0.01	0.0017±0.0002	0.17±0.01	BDL	BDL
2	BDL	0.25±0.01	0.0016±0.0002	0.11±0.01	BDL	BDL
3	0.18±0.01	0.27±0.00	0.0018±0.0001	0.20±0.00	BDL	BDL
4	BDL	0.26±0.01	0.0016±0.0001	0.19±0.02	BDL	BDL
5	BDL	0.29±0.01	0.0010±0.0002	0.26±0.001	BDL	BDL
6	BDL	0.25±0.01	0.0006±0.0002	0.18±0.01	BDL	BDL
7	BDL	0.28±0.02	0.0006±0.0001	0.04±0.01	BDL	BDL
8	BDL	0.29±0.01	0.0005±0.0002	0.12±0.01	BDL	BDL
9	0.05±0.01	0.26±0.01	0.0019±0.0001	0.07±0.02	BDL	BDL
10	0.03±0.01	0.25±0.01	0.0004±0.0001	0.04±0.01	BDL	BDL
LOD	0.01	0.001	0.001	0.0001	0.001	0.005
Recommended values in drinking water						
WHO	3.0	0.01	0.006	0.01	0.003	0.05
KEBS	5.0	0.05	0.001	0.01	0.005	0.05
NEMA	5.0	0.01	0.001	0.01	0.003	0.05

Zinc levels in dry and wet seasons

The zinc (Zn) levels were higher in the dry than the wet season. Zinc in water samples was in the minimum range of 0.110± 0. 020 mgl^{-1} to a maximum of 0.23 ±0.07 mgl^{-1} during the dry with a minimum range of below detection limits (BDL) to a maximum of 0.18 ± 0.01 mgl^{-1} in the wet seasons (Table no 2). The highest and lowest zinc levels in the dry season were from Sites 2 and 7 respectively. The two sites have high population density that has contributed to the increase in amounts of domestic effluent discharge[2]. However, site 7 may be having seepage of water from the borehole into the river at 70m below the slope, this may reduce zinc levels during the dry season. In the wet season the highest andlowest levels were from Sites 3 and 7 respectively. Site 3 is near a shopping centre, had a medium population density, there was heavy water abstraction for sale, and thatled to high levels of zinc as a result of human activity in the wet season. There was no zinc levels detected during the wet season in the Sites 2, 4, 5, 6, 7, and 8 this could be due to effect of dilution during wet season .The zinc levels were below the values set by WHO, KEBS and NEMA of 0.3 mgl^{-1}, 0.5 mgl^{-1} and 0.5 mgl^{-1} respectively (Table no 2).

Lead levels in dry and wet seasons

The lead (Pb) levels in most samples were greater in the dry than the wet season. The lead in water samples were in the minimum range of 0.220± 0. 010 mgl^{-1} to a maximum of 0.42 ± 0.01 mgl^{-1} during the dry season and with a minimum range of 0.28 ± 0.02 to a maximum of 0.29 ± 0.01 mgl^{-1} in the wet seasons (Table no 2). The highest and lowest lead levels in the dry season was recorded in Sites 5 and 7 respectively. Lead is mostly used in making car batteries while some proportion is used to manufacture soldier bullets and as radiation shields[16]. Site 5 being located at the chief's camp, an area that is densely population, having many cars parked and soldiers manning the camp, may be receiving contamination from old cars batteries. In the wet season, the highest and lowest levels were from Sites 5 and 1 respectively. Site 1 located in a mosque compound, the area is very densely populated, it is near a slaughterhouse and surrounded by flats (Table no 1). The site that is very densely populated and near a slaughterhouse may have high levels of lead as a result of human activity, however the lowest levels during wet season can be due to seepage of borehole into municipal sewage line that servers the surrounding flats. Lead levels from all the sampling sites were above the WHO, KEBS and NEMA maximum permissible limits of 0. 01 mgl^{-1}, 0.05 mgl^{-1} and 0.01mgl^{-1} respectively in both the seasons (Table no 2).

Mercury levels in dry and wet seasons

The mercury (Hg) levels in most samples were greater in the dry than the wet season. The Hg in water samples was in the minimum range of 0.00020± 0. 00001mgl^{-1} to a maximum of 0.00019 ±0. 0001mgl^{-1} during the dry season, with a minimum range of 0.0004± 0.00001 to a maximum of 0.0019±0.0001mgl^{-1} in the wet season (Table no 2).The highest and lowest mercury levels in the dry season were from Sites 4 and 10 respectively. Site 4 is at a house stead; the borehole has been in use for 15 years. Domestic water uses can be a source of pollution in groundwater. Soaps, cosmetics, skin ointments used as household products[17] in domestic effluents from indoor and or outdoor activities can avail mercury contaminants when wrongly disposed into the environment[18], however Site10 that had the lowest level is a house stead in a remote area was due to low disposal of indoor and outdoor domestic effluents. In wet season the highest and lowest levels were obtained from Sites 9and 10 respectively. Site 9 is at Albanus apartments, it is also next to a flat of 60 houses (Table no 1). The high human population in this area could using household products that contain mercury that when disposed of through domestic effluent can contaminate water. The levels of mercury in both dry and wet seasons were within WHO, KEBS and NEMA allowable limits of 0.006 mgl^{-1}(Table no 1).

Manganese levels in dry and wet seasons

The manganese (Mn) level in most samples were higher in the dry than the wet season. The manganese in water samples were in the minimum range of 0.04±0.01mgl^{-1} to a maximum of 0.26±0.001mgl^{-1} in the dry season with a minimum range of 0.04±0.01 to a maximum of 0.26±0.001mgl^{-1} in the wet season (Table no 2). The highest and lowest manganese levels in the dry season were from Sites 5 and10 respectively. In the wet season the highest level was from Site 5, while the lowest was from Sites 7 and 10(Table no 2). Site 5 being located at the chief's camp, an area that is densely population, had manganese level of 0.26±0.001mgl^{-1} in both the dry and wet seasons. In the wet seasons levels of analytes could be lower as a result of dilution, however the levels of manganese were same in the two seasons. Site 7 at a mosque compound, which is close to a slaughterhouse in a densely populated area was expected to have high manganese level but had the lowest of 0.04±0.01 mgl^{-1} as Site 10, a house stead in a remote area (Table no 2). The manganese levels from Sites 5, 7 and 10 could be attributed to the presence of manganese in rocks or soil in the study area (Table no 2). Manganese levels were generally higher in all the samples than the recommended levels of 0.01 $mgl^{-1}$by WHO, KEBS and NEMA in drinking water (Table no 2).

Cadmium and Chromium levels in dry and wet seasons

The cadmium (Cd) and chromium (Cr) levels were below detectable limits (BDL) of 0.001 $mgl^{-1}$and 0.005 mgl^{-1}respectively for all the water samples in both the seasons (Table no 2). This implies that cadmium and chromium are not in the products used by residents, soil or rocks of Ongata Rongai.

IV. Conclusion

The levels of all the heavy metals analyzed were higher in dry than wet seasons. The lead levels in all the sites were above the WHO, KEBS and NEMA maximum recommended limits of 0. 01 mgl^{-1}, 0.05 mgl^{-1} and 0.05mgl^{-1} respectively in both the seasons. Manganese levels were generally higher in all the samples than the recommended levels of 0.01 mgl^{-1} and 0.03 mgl^{-1} by the WHO and KEBS in drinking water respectively except Site 10, a house stead in a remote area, had levels in the recommended level of 0.03 $mgl^{-1}$by KEBS in the dry season. The cadmium and chromium levels were below detectable limits (BDL) in both the seasons for all the borehole water samples analyzed. This study concludes that: regular analysis of the heavy metals in borehole water to be conducted due to their accumulation nature with time, Water Resources Manage Authority (WARMA) to document the number of boreholes in the area and to provide guidelines on setting up new ones, the source of highly toxic metals like Hg, Cd, and Cr in water be investigated further and that heavy metals levels for soil and rocks in the area should be determined.

References

[1] Jeje J.O., Oladepo K.T. (2014): Assessment of Heavy Metals of Boreholes and Hand Dug Wells in Ife North Local Government Area of Osun State, Nigeria, *International Journal of Science and Technology***3:4**

[2] Abong'o D.A, Onyatta J.O, Hinga M (2017): The Effect of Septic Tanks Sewage Disposal System Distances On Borehole Water Quality in Ongata Rongai, Kajiado County, Kenya: *European International Journal of Science and Technology***6:1-10**

[3] Elinge C. M., Itodo A. U., Peni I. J., Birnini-Yauri U. A., Mbongo A. N. (2011): Assessment of heavy metalsconcentrations in bore-hole waters in Aliero Community of Kebbi Estate, *Advances in Applied Science Research* **2:4 279-282**

[4] Oyem H. H., Oyem M.I., Usese A. I., (2015): Iron, manganese, cadmium, chromium, zinc and arsenic groundwater contents of Agbor and Owa communities of Nigeria, Springerplus**4:104**

[5] World Health Organization (2014): Chemicals of Public Health concern and their management in the African Region.

[6] Sawere B. T., Ojeba C.K., (2016): Assessment of Heavy Metal Concentrations in Borehole-Hole Water in Ozoro Town, Delta State, *International Research Journal of Advanced Engineering and Science*, **1:3 61-65.**

[7] Dusa A. A., Timothy N., Magili S. T., Tukur S. (2017): Determination of Heavy Metals in Boreholes, hand Dug Wells and Surface Water in some Selected Areas of Mubi North local Government Area Adamawa State, Nigeria, *International Research Journal of Chemistry and Chemical Sciences* **4:1 075-081**

[8] Government of Kenya (GoK) (2019): Population and Housing Census. Central Bureau of Statistics.

[9] Kazungu K. R., Gichuru w. P., Gitau W. J. (2011): Planning challenge of Karen and Ongata-Ronga peripheral locations. 47th ISOCARP Congress 2011.

[10] Directory of Cities, Towns, and Regions in Kenya: Langata Rongai. Global Gazetteer Version 2.2. Falling Rain Genomics. Retrieved 5 January 2019.

[11] APHA (1998): Standard methods for the examination of water and wastewater, 20th ed. Washington, DC, American Public Health Association.

[12] Siaka M., Owens M.C., Birch F. G. (1998): Evaluation of Some Digestion Methods for the Determination of Heavy Metals in Sediment Samples by Flame-AAS, Analytical Letters, **31:4, 703-718**, DOI: 10.1080/00032719808001873

[13] USEPA, (2004): Guidelines for Water Reuse, US Government Printing Office, Washington DC.

[14] NEMA (2006): Environmental Management and co-ordination (water quality) regulations.

[15] WHO (2008). World Health Organization. Guidelines for drinking-water quality. Geneva, **1(3): 306-492**.

[16] Gautam K. R., Sharma K. Sanjay, Mahiya S, Chattopadhyaya (2014): Contamination of Heavy metals in aquatic media-Metals in Aquatic Media:Transport, Toxicity and Technologies for Remediation.

[17] Ram Proshad, TaposKormoker&Saiful Islam (2019): Distribution, source identification, ecological and health risks of heavy metals in surface sediments of the Rupsa River, Bangladesh, Toxin Reviews, DOI: 10.1080/15569543.2018.1564143

[18] Shanbehzadeh S., Dastjerdi V. M., Hassanzdeh A., Kiyanizadeh T. (2014): Heavy Metals in Water and Sediment: A Case Study of Tembi River, **2014:5**, DOI: 10.1155/2014/858720