MAYFEB Journal of Materials Science - ISSN 2371-8722
Vol 1 (2019) - Pages 1-14

Heavy Metal Contamination Assessment of Selected Water Sources in Ibadan Metropolis

AGBEDE O.A, Department of Civil Engineering, University of Ibadan, Nigeria, oaagbede@yahoo.com

OJELABI S.A, Department of Civil Engineering, University of Ibadan, Nigeria, ojelabiakin@gmail.com

Abstract- It has been established by previous researchers that there is significant heavy metal contamination of soil and water sources in Ibadan metropolis. The heavy metal concentration of selected water sources in Ibadan, Nigeria was examined in this study. Water samples were collected and their locations taken with the aid of a GPS. The concentration of heavy metals (Lead, Zinc, Iron and Manganese) in the water samples was determined by Atomic Absorption Spectrophotometry (AAS). The results obtained was compared with the WHO and SON specified limit for drinking water. The results showed that rain is free from heavy metal contamination and most of the surface and groundwater samples exceeded the WHO (2006) and SON (2007) recommended concentration for drinking water and more pronounced in urban areas than rural areas. The study recommends enlightenment on heavy metal contamination, improved land use planning and adequate protection of water sources.

Keywords: Heavy metals, Contamination, Assessment

1. INTRODUCTION

Water is essential for human survival and well-being and also important to most sectors of the economy. It is a strategic resource that is used for industrial, domestic, commercial and agricultural purposes.

Heavy metals occurs naturally and their high concentrations in water sources can lead to poisoning and cause a public health issue. Heavy metals can enter a water supply through waste disposal into water bodies, infiltration of heavy metals into soil and industrial activities.

Heavy metals are dangerous because they tend to bio-accumulate in the bodies of man and animals. Water Contaminants include heavy metals and other toxic organic chemicals such as pesticides, PCBs, dioxins, poly-aromatic hydrocarbons (PAHs), petrochemical and phenolic compound (Rao et al., 1998; Njoku et. al., 2009; and Gbadebo et al., 2010).

Contamination of water sources occurs when man-made products such as gasoline, oil, road salts and chemicals get into the water sources and cause it to become unsafe and unfit for human use. Water contaminants include pesticides, herbicides, fertilizers, heavy metals from the combustion of gasoline, road construction, toxic substances from mining sites, and used motor oil also may seep into water sources. The discharge of untreated waste, improper waste disposal and toxic industrial discharge also contaminate water sources.

Contaminated water can have serious health effects. Diseases such as hepatitis and dysentery may be caused by contamination from septic tank waste, poisoning may be caused by toxins that have leached into well water supplies and wildlife can also be harmed by contaminated groundwater. Other long term effects such as certain types of cancer may also result from exposure to polluted water, water animals may be killed and the entire ecosystem destroyed.

Water contamination has become a matter of concern over the last few decades (Canli and Kalay, 1998; Dirilgen, 2001; Vutukuru, 2005; Vinodhini and Narayanan, 2008). Heavy metals are regarded as one of the most serious pollutants discharged into the aquatic environment, due to their environmental persistence and tendency to accumulate in aquatic environment (Schüürmann and Markert, 1998; Edem *et al*., 2008; Amisah *et al*., 2009; Benzer *et al*., 2013).

Surface and groundwater contamination makes valuable water supplies unfit for other uses. A growing number of contaminants will demand higher wastewater treatment standards and more exhaustive monitoring of water contaminants. Water contamination is a major cause of respiratory and stomach ailments and premature death in Cities. It also affects the socio- economic conditions of the urban poor and has a profound impact on urban economy.(Kazi, 2014).
Agbede and Oladejo (2003) in their study of groundwater quality at oil depots in Southwestern Nigeria discovered that the water is acidic to neutral in character, very hard and fresh. Water from the wells was unfit for human consumption due to total hydrocarbon and bacteriological pollution.

Ibadan has eleven local councils. The city is witnessing rapid urbanization; its associated problems which include inadequate infrastructural facilities, traffic holdups, increased water demands, rural-urban migration and increased pollution are experienced on a daily basis.

The city lacks defined land use plan and poorly monitored. Industrial and residential activities are mixed up and this generate a lot of wastes that contaminate water sources.

Ibadan city's development lacks comprehensive water and sewage systems, inadequate garbage collection and disposition and unstable urban environments that increases vulnerability to natural disasters and jeopardize public health. (Tomori, 2006).

Agbede (1991) found that a large percentage of well water samples in Ibadan contain heavy metals like iron, manganese, and copper exceeding the highest desireable level recommended by WHO and USPHS. He further attributed this to the intensive use of natural resources and the large production of wastes in the city.

Ujile (2012) in its study of groundwater contamination by dumpsites in Ibadan observed soil and ground water contamination and a high concentrations of lead, copper and zinc in soils close to the dumpsites.

Adeyemo and Temowo (2010) in the hydrogeological investigation of waste dumps in Ibadan noted the concentration levels of electrical conductivity, total dissolved solids, sodium, potassium, magnesium, nitrate and chloride were higher in water samples collected near the dumpsite than those far away. This is traced to leachate from dumpsite.

Mixed land use, poor waste management, activities of small and medium scale enterprises, urbanization, burning of automobile tires, extraction of lead from used automobile batteries, indiscriminate disposal of used lubricants and unregulated citing of industries are noticeable in Ibadan metropolis. All these activities produce heavy metals and this call for a need to check water sources in the metropolis for heavy metal contaminations.
This work involves analysis and determination of concentration levels of heavy metals in water sources in Ibadan, Nigeria.

2. MATERIALS AND METHOD

Water samples were collected at selected locations across the city of Ibadan. The samples were collected in plastic containers and labeled accordingly with name and date of sampling. The temperature and pH of the water samples were taken on site by using Thermometer and Pocket Digital pH Meter and recorded accordingly.

The Water samples were immediately brought in to the Laboratory for the estimation of the heavy metals (Lead, iron, manganese, Zinc) using standard procedures (Atomic Absorption Spectrophotometer (AAS) Thermo M5 Model) (Trivedy and Goel,1986, APHA 1998).

TABLE 1: Location of Water Samples Collected

Water Sources	Location	GPS Coordinate
Surface Water		
Ogunpa River	Bodija,Ibadan North Local Govt	31N 0600177
		UTM 0819553
Ogbere River	Pegba Bridge,Ona- Ara Local Govt	31N 0603609
		UTM 0811235
Eleyele Dam	Eleyele, Iddo Local Govt	31N 0594507
		UTM 0819999
Eniosa Dam	Eniosa ,Lagelu Local Govt.	31N 0607250
		UTM 0831024
Dandaru Lake	Agodi,Ibadan North Local Govt.	31N 0599014
		UTM 0818050
Ground water		
UCH Borehole	UCH,Ibadan North Local Govt	31N 0599451
		UTM 0817995
Olodo Borehole	Olodo,Egbeda Local Govt.	31N 609665
		UTM 823544
Agbadagbudu Spring	Yemetu-Adeoyo, Ibadan North L/Govt.	31N 0599321
		UTM 0816612
Rainwater		
Oluyole Rain water	Oluyole Estate, Ib. S/West L/Govt.	31N 0592865
		UTM 0814758
Olorunda Rain water	Olorunda,Lagelu Local Govt.	31N 0607753
		UTM 0827649

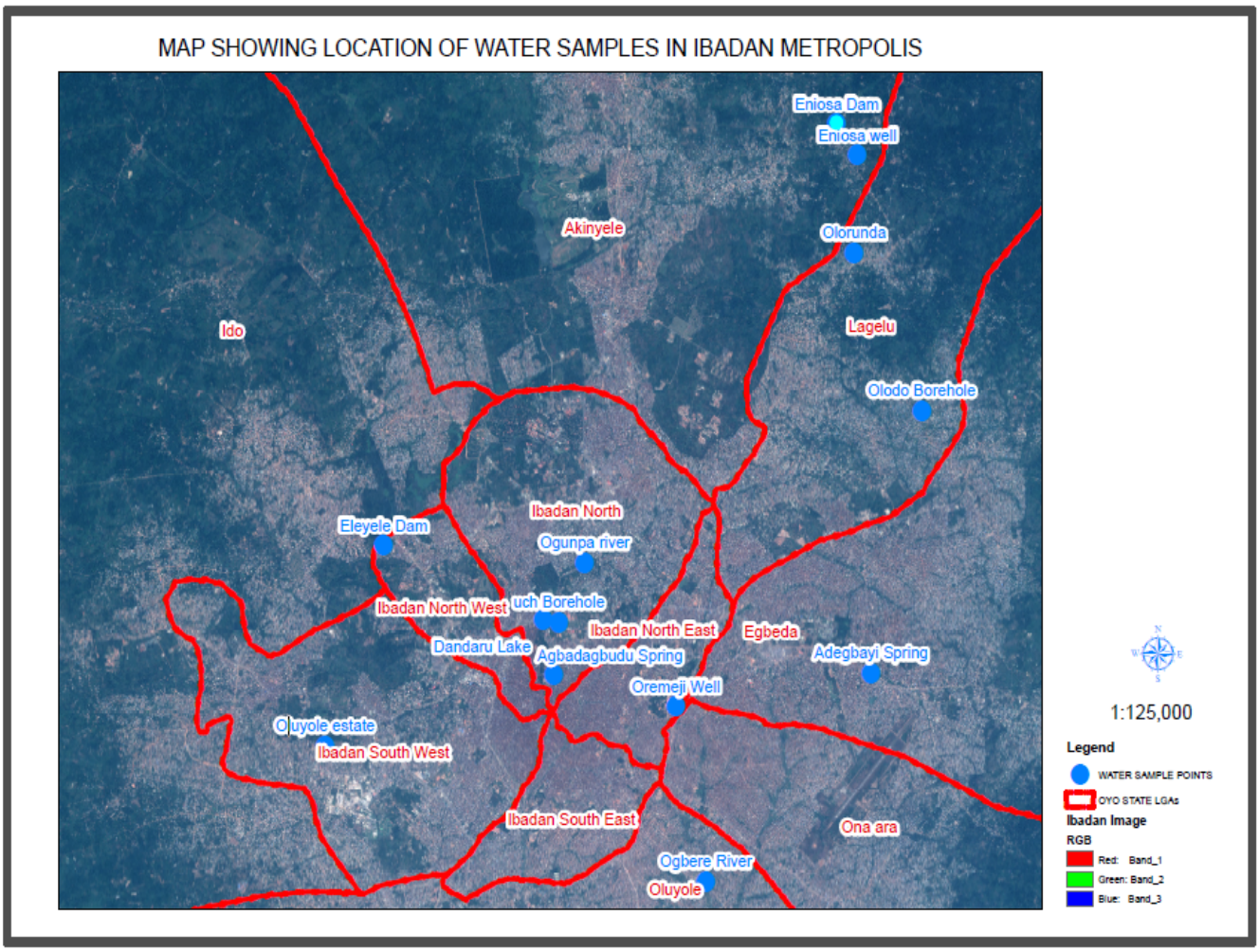

FIGURE 1: Map showing the location of Water sources sampled in Ibadan Metropolis

3. Results and Discussions

TABLE 2: Result of Heavy Metal Concentration

	Groundwater						Surface Water				Rainwater			
	S1	S2	W1	W2	B1	B2	D1	D2	R1	R2	RW1	RW2	WHO Standard	SON Standard
Temp	29.0	28.0	29.0	28.0	28.0	27.0	27.0	26.0	26.5	27.0	22.0	25.0	27	Ambient
pH	**5.30**	**4.10**	**5.54**	**5.81**	7.10	6.50	7.22	7.28	7.52	7.74	8.38	7.48	6.5-8.5	6.5-8.5
Lead (mg/L)	0.004	**0.09**	0.002	**0.25**	0.0068	**0.20**	**0.61**	**0.29**	**0.53**	**0.18**	0.00	0.003	0.01	0.01
Iron (mg/L)	0.03	0.06	0.00	**1.5**	0.036	**1.5**	**4.9**	**1.7**	**3.5**	**1.2**	0.00	0.004	0.3	0.3
Manganese (mg/L)	**0.7**	**1.3**	0.2	**2.5**	0.004	**3.0**	**5.4**	**2.8**	**4.6**	**2.1**	0.0004	0.003	0.1	0.2
Zinc (mg/L)	1.3	1.8	2.8	4.8	0.023	**5.5**	**5.5**	**5.2**	**7.6**	4.3	0.0001	0.017	5.0	3.0

S1 = Adegbayi Natural Spring (Less City); S2= Agbadagbudu Natural Spring (urban);

W1= Well water at Oremeji-Agugu (Urban); W2= Eniosa Well Water(Less City) ;

B1= UCH Borehole (Urban); B2= Olodo Borehole(less city)

D1 = Eleyele Dam Water (Urban) ; D2= Eniosa Dam Water(Less City) ;

R1= Ogbere River Water (Less city); R2= Ogunpa River Water(Urban)

RW1= Rain water at Olorunda-Aba (Rural); RW2= Rain water at Oluyole (Urban).

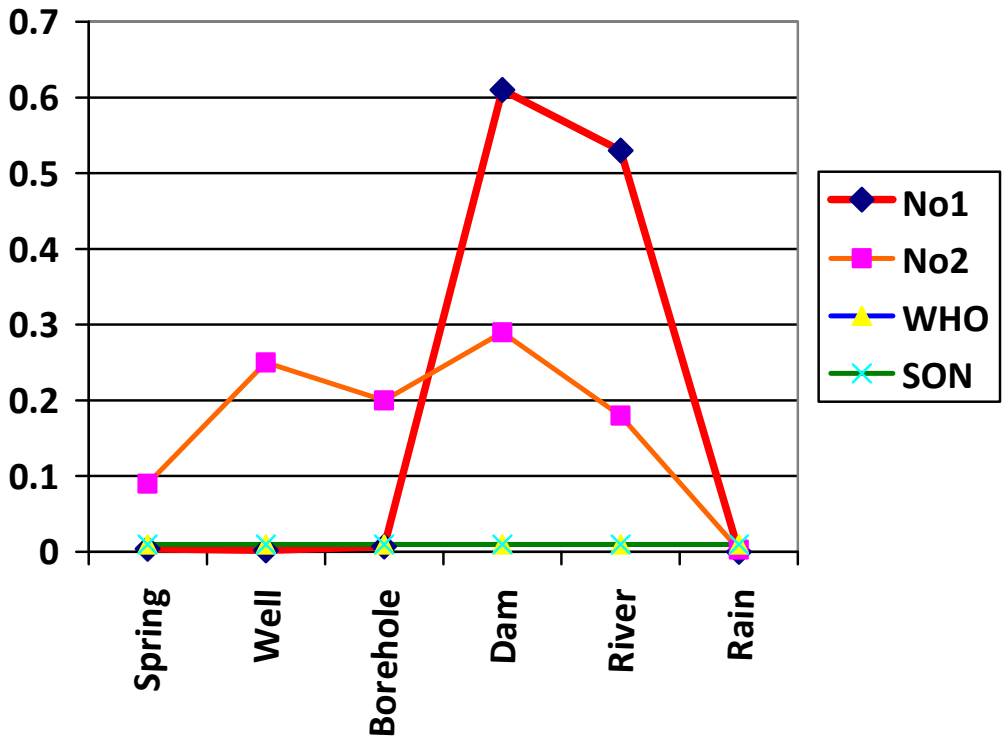

FIGURE 2: Lead Concentration of the Water Sources

Figure 2 above, showed that about 75% of the water sources examined had lead contamination and the lead content exceeds the maximum permissible limit of 0.01mg/l. (SON, 2007 and WHO,2006). All the surface water sources examined and 50% of the groundwater sources had lead contamination. The rainwater sources were free from lead contamination.

The high lead concentration can be linked to the various human activities around the water sources and improper/inadequate land use plan, indiscriminate waste disposal system, infiltration, runoff and use of leaded fuel also contribute.

The use of leaded fuel by automobiles, disposal of used lubricants, breaking of used automobile batteries for lead cell and subsequent discharge of wastes into water bodies is noticeable around the rivers in the metropolis. Indiscriminate disposal of wastes, household batteries, electronic waste scavenging and uncontrolled land use contribute to the contamination of water sources.

Oyeleke et al (2015) in the study of soils in a battery factory in ibadan found that the mean concentrations of Pb was 59.13±48.9 (range 5.00 - 182.00 mg/kg), which was far above the normal crustal average for soils while the other heavy metals were below the normal background level.

Adelekan and Alawode (2011) in their study of the concentrations of heavy metals in soil and groundwater at municipal refuse dumps in Ibadan, found a large deposit of lead and that there is an ongoing build up of heavy metals in soil at the waste dumps studied and concentrations were already higher than established limits.

Lead contamination is hazardous, its long-term accumulation of lead in body tissues has neurotoxic, nephrotoxic, fetotoxic, and teratogenic effects on man just like most heavy metal contaminants (Asogwa, 1979.)

In the study of groundwater in Ibadan metropolis (Olusegun, 2010) discovered that all the untreated water samples contained high lead concentrations and he associated this to severe environmental degradation, which is readily observable in most parts of Ibadan city.
The lead content could be as a result of the activities of road side mechanics who dispose used lubricants without precautions, wear and tear of vehicle parts and combustion of fossil fuel.

Iron

From figure 3 below, the concentration of iron in the water sources assessed ranged from 0.00 to 4.9mg/l. It can be deduced that the concentration of iron in 30% of the groundwater samples and 100% of the surface water accessed were higher than the permissible limit of 0.3mg/l (WHO, 2006 & SON, 2007). Industrial activities, indiscriminate waste disposal and the high concentration of iron in the soil of the study areas could be a major contributor factors.

Moyosore et al.(2014) in their assessment of iron and manganese levels of groundwater in selected areas of Ibadan, found that all the water sampled had levels exceeding the WHO and SON maximum permissible limit.

The public health effect of excess iron includes conjunctivitis, choroiditis, and retinitis if it contacts and remains in the tissues. Chronic inhalation of excessive concentrations of iron oxide fumes or dusts may result in development of a benign pneumoconiosis, called siderosis.

Inhalation of excessive concentrations of iron oxide may enhance the risk of lung cancer development in workers exposed to pulmonary carcinogens.

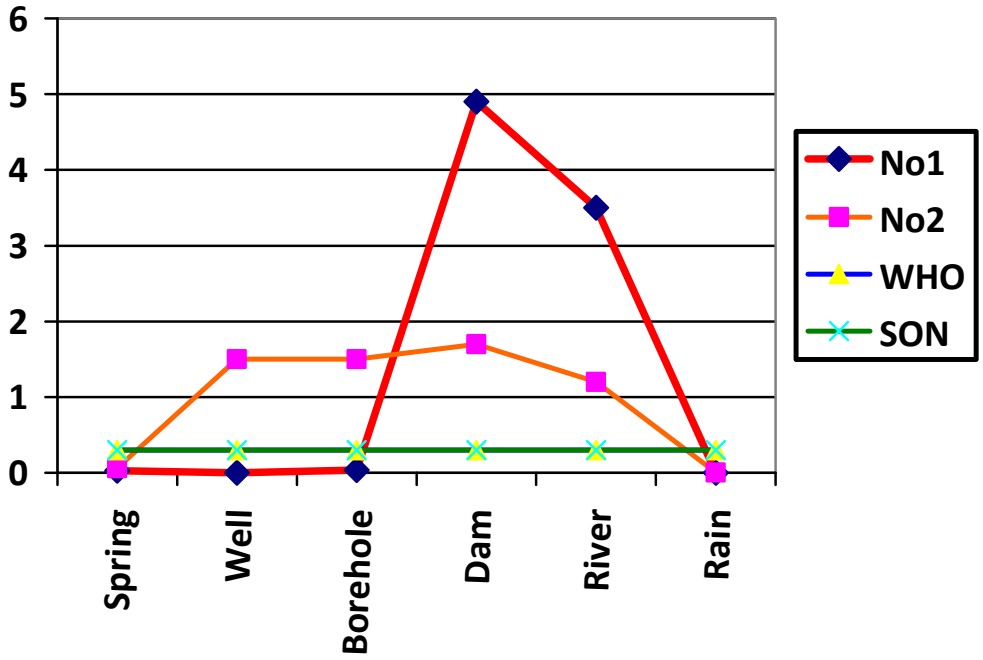

FIGURE 3: Iron Concentration in the Water Sources

Manganese

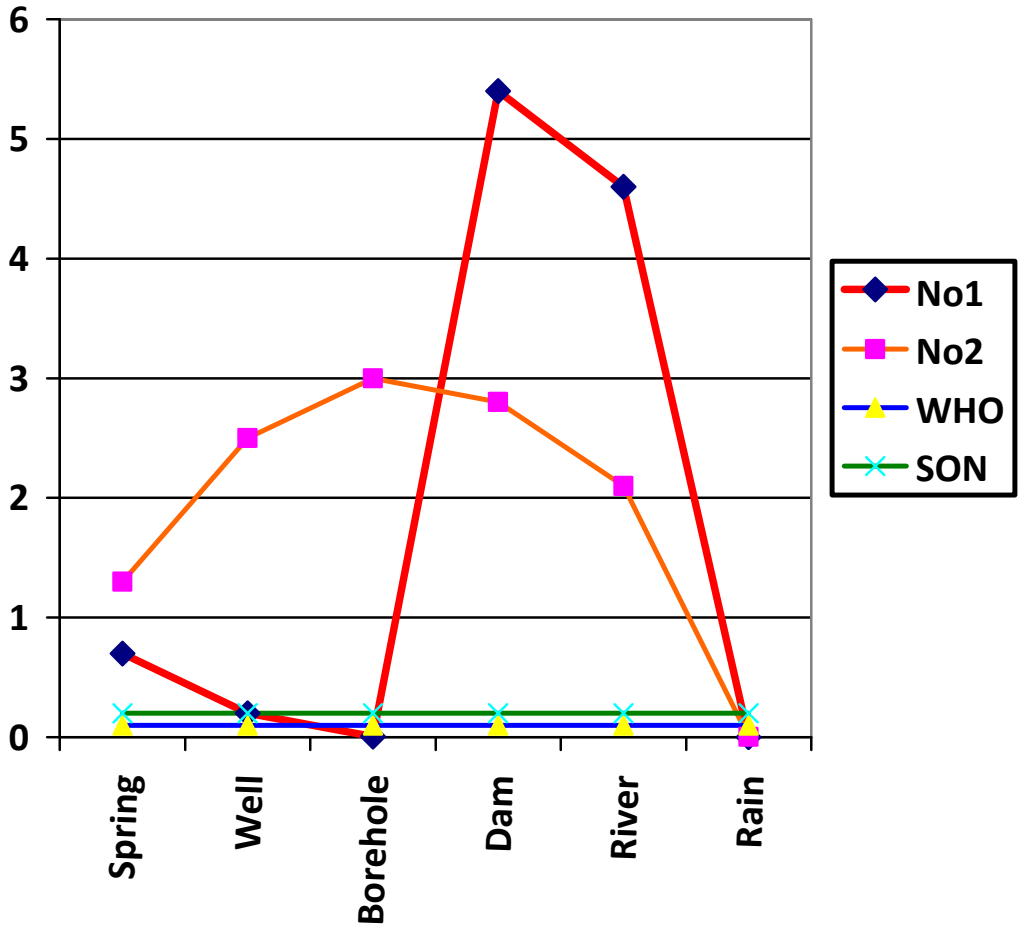

FIGURE 4: Manganese Content of the Water Sources

The manganese concentration ranged from 0.004-3.0mg/l,(fig.3 above) with about 85% of groundwater and surface water sources exceeding the maximum permissible limit of 0.1mg/l. (WHO, 2006) and 0.2mg/l (SON, 2007).The rain water falls within the maximum permissible limit.

Adebisi et al (2007) in its study of Heavy metal contents of Effluents and Receiving Waters from various Industrial groups and their Environs in Ibadan discovered a large discharge of magnesium into water bodies.

Exposure to high concentrations of manganese over a long period has been associated with toxicity to the nervous system, producing a syndrome that resembles Parkinsonism. This type of effect may be more likely to occur in the elderly. Manganese is unlikely to produce other types of toxicity such as cancer or reproductive damage.

Zinc

The concentration of zinc in most of the groundwater samples falls within the maximum permissible limit of 5mg/l, except the borehole with value of 5.5mg/l and this may be associated with the geology and nature of soil in the area.

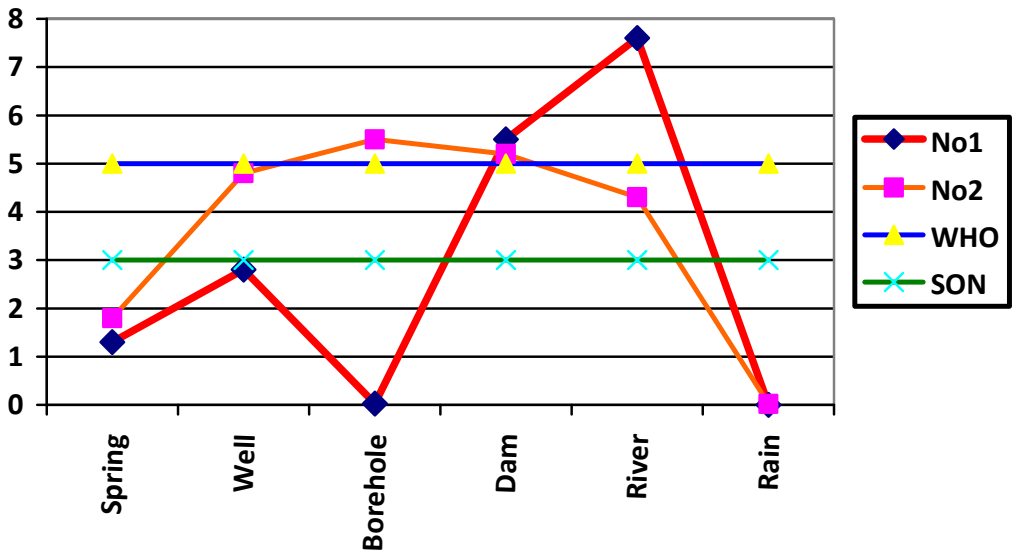

FIGURE 5: Zinc Content of the Water Sources

The Zinc concentration of majority of the sampled water sources fall within the permissible limit.
The assessment of soils in Ibadan metropolis using geochemical approach showed that soils were derived from the weathering of the bedrocks and the concentrations of Cu, Pb, and Zn were found to be greater in soils more than the background. (Odewande and Abimbola,2008).

Adebisi and Fayemiwo (2010) in their study of the pollution of Ibadan soil by industrial effluents showed significant pollutants enrichment of soil by the effluents from the studied industries and this is a likely source of Zinc contaminants into water sources. This calls for effective management of effluent discharge into water bodies in the metropolis.

The health effect of excess zinc in drinking water include acute toxicity arises from the ingestion of excessive amounts of zinc salts, fever, nausea, vomiting, stomach cramps, and diarrhoea.

Conclusion

Water resource plays a vital role in the growth and development of man and the sustainability of the environment. Water resources should not present a risk of public health or contain hazardous chemicals, aesthetically acceptable and must meet up with the intended use.

The study shows that majority of the water sources in the urban settlements are contaminated with heavy metals contaminants. This can be attributed to urbanization, soil contamination and groundwater infiltration, subsurface geology, topography, infrastructural developments, land use pattern and other human induced factors/ activities.

The impact of small and medium scale industries, urban poor, artisans and traders in the contamination of water sources is significant in the study areas.

The heavy metal contamination noticed in the rural settlements can be linked to the indiscriminate use of chemicals in agriculture, encroachment of urbanization into rural settlements and industrial activities.

The study proved that rain water resource is the purest source of water, its quality in urban and rural settlement falls within the maximum chemical permissible limit by WHO and SON.

The protection of water sources, proper waste disposal and proper/ planned land use pattern will reduce contamination. Indiscriminate use of pesticides, herbicides and other chemicals in agriculture should be controlled and Land use for commercial, Industrial and other waste generating activities should be planned, regulated and well monitored for the discharge of their wastes.

REFERENCES

[1] Adebisi, S.A. and Fayemiwo, K.A. (2010) *Pollution of Ibadan soil by industrial effluents.* New York Science Journal 2010;3(10):37-41]. (ISSN: 1554-0200).

[2] Adebisi. S.A, Ipinmoroti, K.O and Amoo, I.A (2007). Heavy Metal Contents of Effluents and Receiving waters from various Industrial Groups and their Environs in Ibadan,Nigeria. Research Journal of Applied Sciences, 2:345-348 URL:http://medwell journals.com/doi=rjasci.2007.345.348

[3] Adelekan B.A and Alawode, A.O *Contributions of municipal refuse dumps to heavy metals concentrations in soil profile and groundwater in Ibadan Nigeria* Journal of Applied Biosciences 40: 2727 – 2737 ISSN 1997–5902 www.biosciences.elewa.org

[4] Adewara A.O, Akinlolu F.A (2008) *Contamination indices and heavy metal concentrations in urban soil of Ibadan metropolis*, Southwestern Nigeria. Environ. Geochem. Health., 30(3): 243-254. Published by SpringerLink Journal (accessed on line from http://www.springeronline.com on 30th October 2016).

[5] Adeyemi, G.O and Temowo,O.O.(2010). Hydrogeological investigation of waste dump environment near Ibadan, Southwestern Nigeria. Proceedings, Annual conference of Nigerian Association of Hydrogeologists on Water Resources Development and Climate Change.12.

[6] Agbede, O.A (1991). "*Water pollution in Ibadan".* Proc. 17th WEDC conference on infrastructure, Environment, water and people. Nairobi, Kenya,p.9-12.

[7] Agbede, O.A and Oladejo, O.S (2003). Study of water quality at oil depots in South Western Nigeria. International Journal of Environmental issues. 1(1), 160-165.

[8] Amisah, S., Adjei-Boateng, D., Obirikorang, KA. And Quagrainie. 2009. *Effects of clam size on heavy metal accumulation in whole soft tissues of Galatea paradoxa* (Born, 1778) from the Volta estuary. Ghana. Inter. J.Fisher. Aquacul. 1(2):14-21.

[9] APHA (1998). Standard Methods for Examination of Water and Wastewater. (16th edition). American Waterworks Association. And Water Pollution Control Federation. American Public Health Association. pp. 80-115

[10] Asogwa .S.E (1979). The Risk of Lead Poisoning in Battery Chargers and possible hazard of their Occupation on the Environment. Nig. Med. J., 9(2): 189-193.

[11] Benzer, S., Arslan, H., Uzel, N., Gül, A. and Yılmaz, M. (2013). *Concentrations of metals in water, sediment and tissues of Cyprinus carpio L.,* from Mogan Lake (Turkey). Iranian Journal of Fisheries Sciences. 12(1):45-55.

[12] Canli, M. and Kalay, M. (1998). *Levels of heavy metals (Cd, Pb, Cu, Cr and Ni) in tissue of Cyprinus carpio, Barbus capito and Chondrostoma regium from the Seyhan River, Turkey*. Turkish Journal Zoology. 22:149-157.

[13] Dirilgen, N. (2001). *Accumulation of heavy metals in fresh water organisms: Assessment of toxic interactions.* FAO. Fischer. Technology. 212:1-13.

[14] Edem, C.A., Akpan, B. and Dosunmu, M.I. (2008). *A comparative assessment of heavy metals and hydrocarbon accumulation in Sphyrena afra, Orechromis niloticus and Lops lacerta from Anantigha Beach market in Calabar- Nigeria*. Afr. J. Environ. Pollut. and Health. 6:61-64.

[15] Gbadebo, A.M., Taiwo, A.M. and Eghele, U. (2010). Environmental impacts of drilling mud and cutting wastes from the Igbokoda onshore oil wells, Southwestern Nigeria. *Indian J. of Sci. and Tech*. 2010; 3(5): 504-510.

[16] Kazi Sabrina Haq, (2014). *Water Crisis and Urban Poor: The Case of Poor Communities in Dhaka City, Bangladesh.* Developing Country Studies ISSN 2224-607X (Paper) ISSN 2225-0565 (Online) Vol.4, No.16, 2014 www.iiste.org

[17] Moyosore, J.O, Coker A.O, Sridhar M.K.C and Adejumo, M (2014) *Iron and manganese levels of Groundwater in selected areas in Ibadan and feasible engineering Solutions* European Scientific Journal April 2014 edition vol.10, No.11 ISSN: 1857 – 7881 (Print) e – ISSN 1857- 7431

[18] Njoku, K.L., Akinola, M.O. and Oboh, B.O. (2009) Phytoremediation of crude oil contaminated soil:the effect of growth of *Glycine max* on the physico-chemistry and crude oil contents of soil *Nature and Science* 2009; 7(10): 79-87.

[19] Odewande ,A.A and ,Abimbola A.F ,(2008). *Contamination indices and heavy metal concentrations in urban soil of Ibadan metropolis, southwestern Nigeria.* Environ Geochem Health. 2008 Jun;30(3):243-54

[20] Olusegun, P.A (2010). *Lead and coliform contaminants in potable groundwater sources in Ibadan, South-West Nigeria.* Journal of Environmental Chemistry and Ecotoxicology Vol. 2(5), pp. 79-83, June 2010 Available online http://www.academicjournals.org/jece

ISSN-2141-226X

[21] Oyeleke, P.O. ,Abiodun,O.A., Salako R.A., Odeyemi,O.E., and Abejide, T.B (2016). *Assessment of some heavy metals in the surrounding soils of an automobile battery factory in Ibadan, Nigeria.* African Journal of Environmental Science and Technology. Vol.10(1), pp.1-8,

[22] Rao, N.S., Rao, V.G., and Gupta, C.P.(1998), Groundwater pollution due to discharge of industrial effluents in Venkatapuram Area, Visakhapatnam, Andhra Pradesh, India. *Environmental Geology* 1998: 33(4): 289-294.

[23] Schüürmann, G. and Markert, B. (1998). Ecotoxicology: Ecological Fundamentals, Chemical Exposure, and Biological Effects. John Wiley & Sons, Inc., New York, and Spektrum Akademischer Verlag, Heidelberg. pp936.

[24] SON, Standards Organization of Nigeria. (2007). Nigerian Standard for drinking water quality. Nigeria Industrial standard NIS 554:2007

[25] Tomori M. A. (2006) *Ibadan Metropolitan area and the challenges to sustainable development.*

[26] Trivedy P.K. and Goel P.K. (1986). *Chemical and biological methods for water pollution studies, Series in Methodology*, Environmental Publications, Karad, 220pp.

[27] UNICEF. (2010) Water Quality Assesment and Monitoring,Technical Bulletin No.6 http://www.who.int/water_sanitationhealth/dwq/guidelines/en/. [Assessed 30th july, 2016]

[28] UNICEF (2007) The New Certified Nigerian Standard for Drinking Water Quality http://www.unicef.org/nigeria/media_2226.html

[29] The United Nations World Water Development Report 2, 2006 *" Water, a shared responsibility".*

[30] Ujile, A.A , Omo-Irabor, O.O. Ogbonna, J *(2012). Groundwater Contamination at Waste disposal sites at Ibadan, Nigeria* Article in Journal of Solid Waste Technology and Management · August 2012 DOI: 10.5276/JSWTM.2012.149 https://www.researchgate.net/publication/257207413

[31] Vinodhini, R. and Narayanan, M. (2008). *Bioaccumulation of heavy metals in organs of fresh water fish Cyprinus carpio (common carp).* International Journal of Environment Science and Technology. 2(5):179-182.

[32] Vutukuru, SS. (2005). *Acute effects of Hexavalent chromium on survival, oxygen consumption hematological parameters and some biochemical profiles of the India major carp, Labeo rohita.* International Journal of Environmental Research and Public Health. 2(3):456-462.

[33] World Health Organization, (1997). *Guidelines for drinking water quality,* 2nd Edition,Volume3 Surveilance and control of community supplies.

[34] World Health Organization, (2006). *Guidelines for drinking water quality* [electronic resource] : incorporating first addendum. Vol. 1, Recommendations. – 3rd ed.

[35] WHO (1996) *Zinc in Drinking-water Background document for development* of WHO *Guidelines for Drinking-water Quality* WHO/SDE/WSH/03.04/17 http://www.who.int/water_sanitation_health/dwq/chemicals/zinc.pdf