ChemSearch Journal 6(1): 74 – 80, June, 2015
Publication of Chemical Society of Nigeria, Kano Chapter

Received: 11/05/2015 Accepted: 19/06/2015
http://dx.doi.org/10.4314/csj.v6i1.12

Evaluation of Heavy Metal Concentrations in Surface and Ground Water Collected from River Challawa, Kumbotso Tannery Dumpsite and their Vicinity, Kano State, Nigeria.

[1] Abdullahi, Z., [1] Inuwa, F. A., [1] Abdullahi, S. H. and [2] Bulus, H.
[1]Department of Pure and Industrial Chemistry, Bayero University, P.M.B. 3011, Kano, Nigeria
[2]Nigerian Institute of Leather and Science Technology, Samaru, Zaria, Nigeria.
Email: azakari.chm@buk.edu.ng

ABSTRACT

A study was conducted to determine the concentration of heavy metals in surface and ground water collected from river Challawa and Kumbotso tannery dumpsite. The samples were analyzed for the levels of Co, Ni, Pb, Cr, Cu, Cd, Zn, and Fe using Atomic Absorption Spectroscopy (AAS). The result showed that all the metals exceeded the standard limit in the water. The estimated metal levels in the water were compared with the safe limits laid down by the World Health Organization (WHO).

Keywords: AAS, Challawa Industrial Area Effluents, Heavy Metals, Tannery

INTRODUCTION

Heavy metal pollution has become a major concern, especially in industrialized countries due to their toxicity, persistence, and bioaccumulative nature. Heavy metals are not only regarded as natural trace components of the aquatic environment but are also commonly known as environmental pollutants particularly receiving input from anthropogenic activities (Alkarkhi *et al*., 2009).Their occurrences not only originated from natural factors such as the weathering of soils and rocks but also from anthropogenic input such as industrial waste, agricultural and mining activities (Abdullah *et al*., 2009).Metals undergo numerous changes in their speciation due to dissolution, precipitation, Sorption, and complexation phenomena when discharged into water body (Solomon *et al*., 2003).When metals enter the environment, they will distribute between the aqueous phase and the suspended sediments during their transport (Karbassi *et al*., 2007). Metals' concentration in river water can be regarded as a good indicator of the river contamination. Metal ions can be either an essential nutrient or toxic to living organisms (Shazili, 2006).When the metals 'concentration exceeds standard permissible limits, it would have toxic effects on living organisms and cause negative impact on lower life forms. For example, transition metals such as copper (Cu), zinc (Zn), cobalt (Co), manganese (Mn), nickel (Ni), and iron (Fe) are essential nutrients; however, they may be toxic if in high concentration. Lead(Pb), cadmium (Cd), mercury (Hg), chromium (Cr), and arsenic (As) are toxic to living organisms even at low concentrations (Dragun *et al*., 2009).Some of the metals such as Pb, Cd, Hg, and As are well known as global contaminants and are listed as the most hazardous inorganic contaminants on the EPA Hazardous Substance Priority List which have detrimental effect on the health of people and ecology (Sin *et al*., 2007).They are freely dissolved in water, extremely toxic, and have the significant impact on environmental and public health concern (USEPA, 2000).When these metals enter the food chain through phytoplankton and are biomagnified in aquatic organisms, they would pose a potential risk to human health (Awofolu *et al*., 2005).Numerous studies were conducted to assess and establish the extent of metal contamination in the rivers. Most riverine studies dealing with metals associated with water, sediment, or biota are concerned with total metal concentration (Doig and Liber, 2006).Elevated total dissolved concentrations of Pb, Cu, Cd, Ni and Zn have been reported in different parts of the world (Alkarkhi *et al*., 2009).These metals present in excessive quantities will interfere with many beneficial uses of the river water due to their toxicity (Suratman *et al*., 2009).

Study Area

The study was carried out in Challawa industrial area of Kumbotso Local Government, Kano State (Fig. 1). Two surface water bodies serve as the main drainage sites for industrial waste disposal, i.e. River Challawa and Kumbotso old tannery dump site which are stagnant surface waters. The human community around this area

also use open well water (ground water) for their daily needs, thus well water *is* the main ground water in this community. Control samples were collected far away from the study area upstream. Surface water was also collected from the ditch of Kumbotso old tannery dump site. Ground waters were collected from 3 open wells in 'Yan danko, Gasau and 'Yan Saama, all within 3km radius from river Challawa.

MATERIALS AND METHOD

Sampling

The sampling was carried out during the dry season. Water samples were collected at 6 sampling stations along the stream of river Challawa, Kumbotso old tannery dumpsite and 3 open wells in the vicinity of Challawa. For the Challawa river, samples were collected 1km before confluence, at confluence and 1km after confluence when mixing is presumed to be complete..

Triplicate of water samples were collected in a clean 120ml plastic containers which were initially washed with detergent and rinsed with de-ionized water. The containers were finally rinsed with 10% nitric acid before sampling. The samples were preserved by adding 1.5ml of concentrated nitric acid to each of the sample. Water samples were then filtered through 0.45 μm cellulose acetate membrane Whatmann No 1.filter paper.

Subsequently, the samples were acidified to pH 2.0 with concentrated nitric acid (HNO_3) This was done to obtain dissolved metal while avoiding the clogging of spectrometry instrument during analysis. As samples may contain particulate or organic materials pre-treatment in the form of digestion is required before analysis.

Digestion of Samples

100ml of filtered sample was taken and added 5ml of concentrated HNO_3 which was then digested in a close chamber for 45 minutes; digestion was completed and made up to 100ml by addition of de-ionised water. Digestion was done to all the samples.

Digested samples were analyzed using Atomic Absorption Spectroscopy (AAS) for selected metals (Cd, Co, Cr, Cu, Fe, Zn, Ni, and Pb).

RESULT AND DISCUSSION

The results of this study was presented either in graphical or tabular format as the case may be and discussed herewith. The results of heavy metal concentration of surface and ground waters are summarized in Table I and II respectively. Table III summarized the statistical test of significance between control and confluence water samples. Fig. 5 and 6 showed the comparison between the concentration of heavy metals in surface and ground water and that of WHO maximum acceptable limits.

From Table I and Fig. 3, the control samples of most heavy metals studied showed lower concentrations when compared to the samples from confluence and kumbotso old tannery dump site, with Cu, Cd, Pb and Cr being highest with mean values of 0.243, 0.233, 0.212 and 0.195mg/L respectively. Zn and Co have lowest values of 0.083 and 0.128mg/L respectively. The values of Cu, Zn, Fe and Ni were found to be below the WHO maximum acceptable limit while those of Co, Cd, Cr and Pb are higher than WHO maximum acceptable limit (Fig. 5). Similar trend has been found in Benue River by Maitera *et al*, (2011), and other Nigerian surface water bodies. In Tin can lagoon by Ehi Eromesele *et al*, (2012), Aiba reservoir by Godwin *et al* (2012) and surface water bodies of Ife north local govt. by Oluyemi *et al*, (2010). However lower heavy metal concentration have been reported in Nigerian water bodies as reported by earlier workers, notable among which are Obire, *et al.*,(2003) on Elechi Creek, Chindah and Braide, (2004) on lower Bonny River and Omoigberale and Ogbeibu, (2005) on Osse River. The change in trend may be due to increased industrialization and thus increase in effluent discharge into surface water bodies.

Samples collected from confluence region showed about 1.5 to 2 times values of most of the heavy metals of which Cu, Ni, Fe, Pb and Cd being highest with values of 0.455, 0.436, 0.379, 0.370 and 0.300 mg/L respectively. The value of Fe was observed to be higher than WHO limit. These have also been found to be statistically significant except for Cd whose increase has not been found to be significant in table III, the increase may be due to its high proportion in industrial effluent discharging into the river. Similar result was observed in Challawa river by Dan'azumi, *et al.*, (2010) and in Cikijing river by Pertiwi, *et al.*, (2010). Cr and Co values remain unchanged with values of 0.195 and 0.128 mg/L respectively and slight increase in values of Co and Zn were found.

Results from kumbotso old tannery dump site showed the highest values with all the metal studied indicating about 1.3 to 5 times the values of control for Co, Cd, Cu, Ni and Zn However, the values of Cu, Zn and Fe are below WHO set limit. This may be due to continuous accumulation of heavy metals from industrial waste in this stationary water body and increasing amount of sediment which act as reservoir for heavy metals (Mai tera *et al.*, 2011). Results for Fe, Pb, and Cr were the lowest with values of 0.246, 0.318 and 0.444 mg/L respectively.

From Table II and Figs. 4 & 6, samples from Yan Saama for ground water study showed higher values of heavy metals followed by Yan danko and then Gasau. Cu, Cd, and Ni are highest in Yan Saama with values of 0.636, 0.433 and 0.257 mg/L respectively while Zn and Co are lowest with values of 0.111 and 0.102 mg/L

respectively. The values of heavy metals are within acceptable limit except for Co, Cd, Fe and Cr. Results from Yan danko showed Ni, Cd and Cu being highest with values of 0.411, 0.367 and 0.334 mg/L respectively while Zn and Co are lowest with values of 0.102 and 0.167 mg/L respectively. Most of the heavy metals are above the WHO acceptable limits.

Values from Gasau showed Cu, Cd and Fe to be highest with mean concentration of 0.455, 0.300 and 0.222 mg/L while Zn, Cr and Pb are lowest with values of 0.120, 0.167 and 0.167 mg/L respectively. The values of heavy metals are within acceptable limit except for Co, Cd, Pb and Cr. The values from the above study agreed with other studies elsewhere. Ehi Eromesele (2012), observed similar trend in Lawanson, Surulere wells, Oluyemi (2010) in well water of Ife north local government, Rami *et al.,* (2012) of pedamambattu village well waters, Deepali and Gwangwar (2010) in haridwar district wells, Tariq *et al*., (2006), in Peshawar ground water, Sharma *et al.,* (1999) in Sanganer, Jaipur and Dubey *et al.,* (2003) at Panipat.

Table I: Mean Concentration of Heavy Metal of Surface Water

Sample	Co *(mg/L)*	Cd *(mg/L)*	Cu *(mg/L)*	Zn *(mg/L)*	Fe *(mg/L)*	Cr *(mg/L)*	Pb *(mg/L)*	Ni *(mg/L)*
Kumbotso	0.641	0.600	0.575	0.445	0.246	0.444	0.318	0.564
SD	±0.462	±0.047	±0.042	±0.298	±0.017	±0.039	±0.037	±0.036
Confluence	0.128	0.300	0.455	0.102	0.370	0.195	0.379	0.436
SD	±0.018	±0.026	±0.074	±0.013	±0.017	±0.039	±0.021	±0.036
Control	0.128	0.233	0.243	0.083	0.185	0.195	0.212	0.180
SD	±0.018	±0.047	±0.043	±0.022	±0.030	±0.039	±0.021	±0.036
WHO	0.05	0.05	1.000	5.000	0.300	0.050	0.050	0.5

SD= Standard deviation

Table II: Mean Concentration of Heavy Metal of Ground Water

Sample	Co *(mg/L)*	Cd *(mg/L)*	Cu *(mg/L)*	Zn *(mg/L)*	Fe *(mg/L)*	Cr *(mg/L)*	Pb *(mg/L)*	Ni *(mg/L)*
YanSaama	0.102	0.433	0.636	0.111	0.308	0.250	0.167	0.257
SD	±0.017	±0.047	±0.074	±0.023	±0.017	±0.067	±0.002	±0.036
Gasau	0.179	0.300	0.455	0.120	0.222	0.167	0.167	0.180
SD	±0.017	±0.047	±0.074	±0.026	±0.030	±0.068	±0.022	±0.036
Yandanko	0.167	0.367	0.334	0.102	0.308	0.278	0.318	0.411
SD	±0.048	±0.047	±0.043	±0.013	±0.017	±0.039	±0.037	±0.036
WHO	0.05	0.05	1.000	5.000	0.300	0.050	0.050	0.5

SD= Standard deviation

Table III: Test of statistical significance between concentration of heavy metals in confluence and control samples

Sample	Co *(mg/L)*	Cd *(mg/L)*	Cu *(mg/L)*	Zn *(mg/L)*	Fe *(mg/L)*	Cr *(mg/L)*	Pb *(mg/L)*	Ni *(mg/L)*
Confluence	0.128	0.300	0.455	0.102	0.370	0.195	0.379	0.436
SD	±0.018	±0.026	±0.074	±0.013	±0.017	±0.039	±0.021	±0.036
Control	0.128	0.233	0.243	0.083	0.185	0.195	0.212	0.180
SD	±0.018	±0.047	±0.043	±0.022	±0.030	±0.039	±0.021	±0.036
T Value	0.00	1.00	3.51	0.99	6.12	0.00	7.87	7.01
P Value	0.99	0.39	0.039	0.39	0.008	0.99	0.004	0.005
Interpretation	>0.05	>0.05	<0.05	>0.05	<0.05	>0.05	<0.05	<0.05

Fig. 1: Study Area

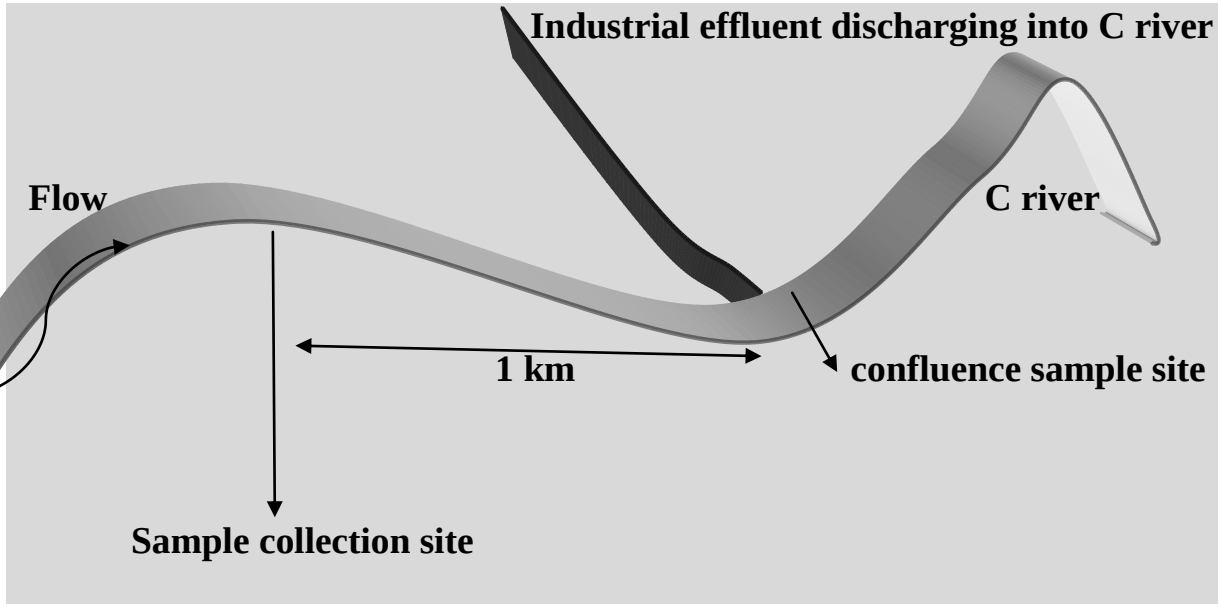


Fig. 2: Schematic Illustration Showing Different Sampling Points Along River Challawa

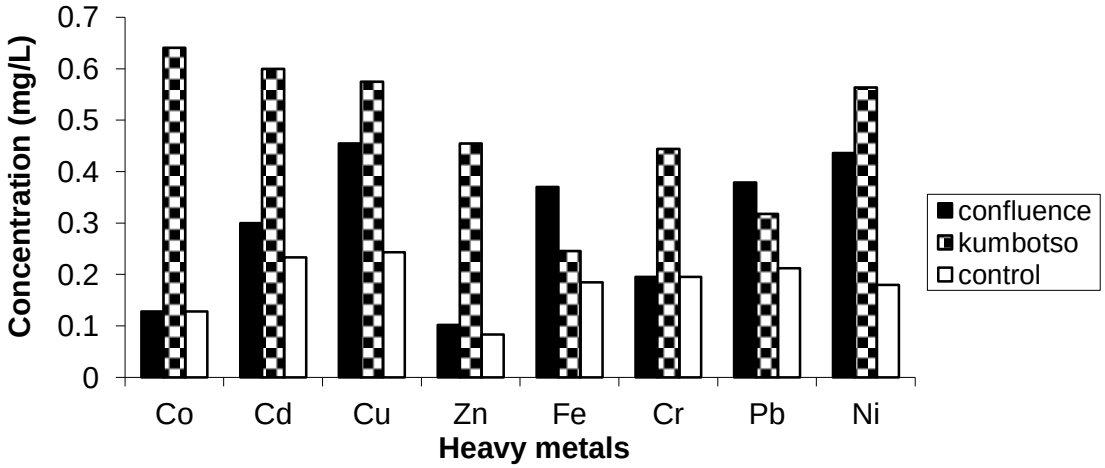


Fig 3: Variation of heavy metals concentrations in surface water collected from kumbotso and challawa

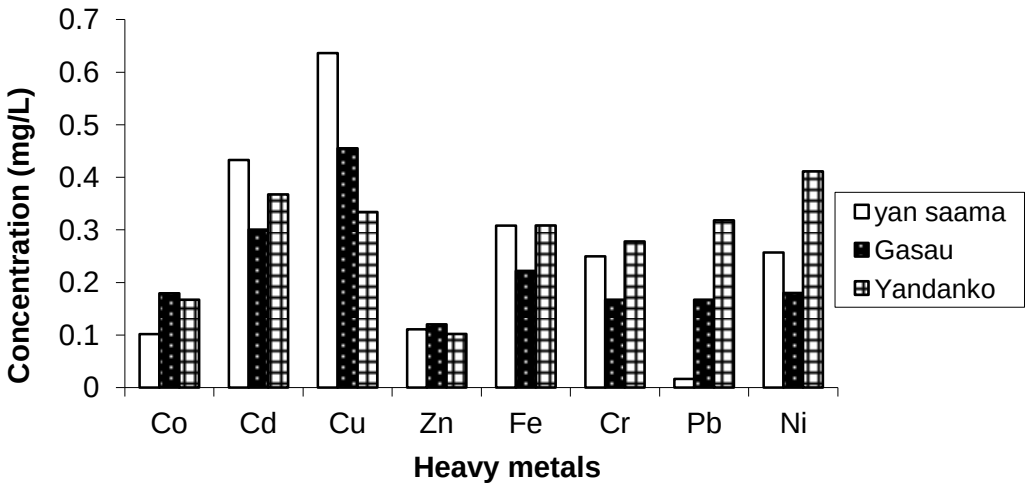
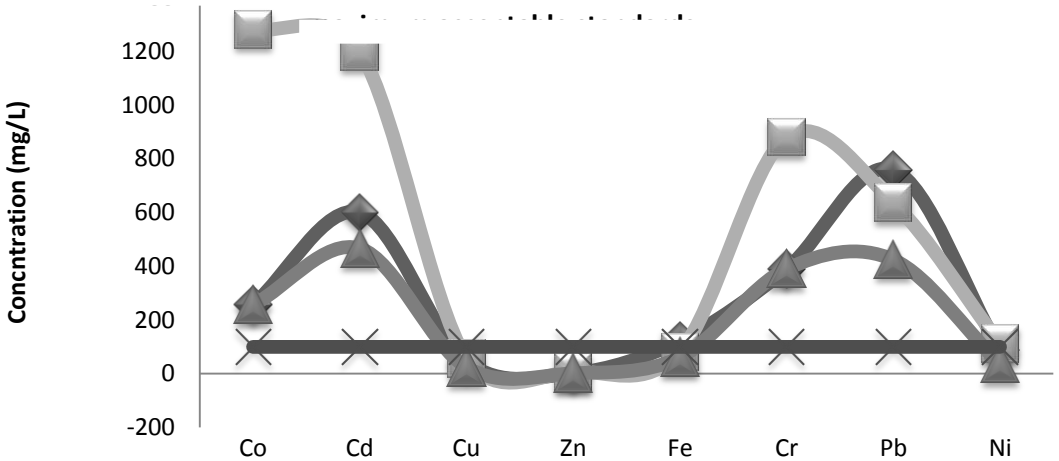
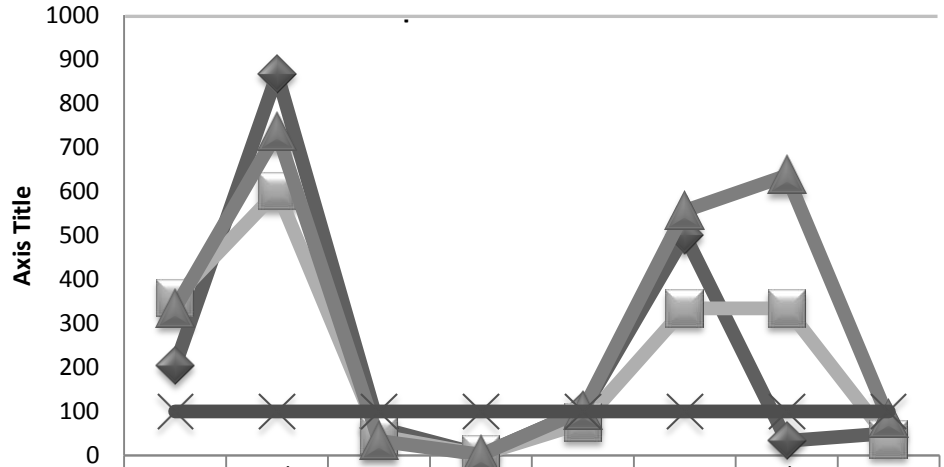


Fig 4: Variation of Heavy metals concentration in Ground water samples in communities hosting tannery industries



	Co	Cd	Cu	Zn	Fe	Cr	Pb	Ni
confluence	256	600	45	2	123	390	758	87
kumbotso	1282	1200	57	9	82	880	636	112
control	256	466	24	2	61	390	424	36
WHO	100	100	100	100	100	100	100	100

Fig. 5: Concentration of Metals in Surface Water as Compared to their WHO Acceptable Limit



	Co	Cd	Cu	Zn	Fe	Cr	Pb	Ni
yan saama	204	866	63	2	102	500	33.4	51
Gasau	358	600	45	2	74	334	334	36
Yandanko	334	734	33	2	102	556	636	82
WHO	100	100	100	100	100	100	100	100

Fig 6: Concentration of Metals in Ground Water as Compared to their WHO Maximum Acceptable Limit

CONCLUSION

The result of this study showed the concentration heavy metals studied (Cd, Co, Cu, Cr, Zn, Ni and Pb) of surface water of challawa industrial area are within WHO acceptable limits except for Co, Cd, Cr and Pb. Significant variation exist between the various sampling sites, contamination comes from industrial effluent discharging into the water bodies. The concentration of heavy metals studied (Cd, Co, Cu, Cr, Zn, Ni and Pb) of ground water of Challawa industrial area are within WHO acceptable limits except for Co, Cd and Cr. Little variation exist among the samples, Similarly industrial waste may also be responsible for high values of heavy metals in ground water. The surface waters and ground waters of Challawa industrial area are not recommended for human consumption except

further treated based on heavy metal concentration. Water from kumbotso old tannery dump site should never be use even for animal consumption or irrigation purposes. There is a need to put legislation in place and enforce same regarding industrial effluent discharge in to the water bodies. Government should provide pipe borne water to challawa industrial area to avoid consumption of unsafe water.

REFERENCES

Abdullah A.R, , Tahir N.M, Loong T.S, T. M. Hoque, and A. H. Sulaiman, (1999) "The GEF/UNDP/IMO Malacca Straits demonstration project: sources of pollution," *Marine Pollution Bulletin*, 39(1–12):229–233,

Alkarkhi F.M., Ahmad A., and Easa A.M (2009)**.** "Assessment of surface water quality of selected estuaries of Malaysia: multivariate statistical techniques," *Environmentalist*, 29(3):255–262.

Awofolu O. R., Mbolekwa Z., Mtshemla V., and Fatoki O. S. **(**2005), "Levels of trace metals in water and sediment from Tyume River and its effects on an irrigated farmland," *Water SA*, 31(1):87–94.

Deepali, K. K.Gangwar (2010) "Determination of heavy metal concentration in effluents,soil,ground, and surface waters in haridwar district tannery well." *New York Science Journal;* 3(4): 82-89.

Doig E. and Liber K. (2006)."Nickel partitioning in formulated and natural freshwater sediments," *Chemosphere*, 62(6):968–979.

Dragun, V. Roje, N. Mikac, and B. Raspor (2009).. "Preliminary assessment of total dissolved trace metal concentrations in Sava River water," *Environmental Monitoring and Assessment*, 159(1–4): 99–110.

Dubey, S.K., Yadav, R., Chaturvedi, R.k., Yadav, R.K. and Minhas, P.S.(2003) Spatial changes in groundwater quality as a result of land disposal of sewage effluent. *A case study, International conference on "Water Quality Management",*

Ehi-Eromosele C. O, Okiei W.O *(2012).* Heavy metal assessment of ground, surface and tap water samples in Lagos Metropolis using anodic stripping voltammetry" *Resources and Environment 2(3): 82-86.*

Godwin Oladele Olutona; John Chijoke Ajaelu; Modupe O. Dawodu **(**2012) ."Evaluation of trace metal levels and speciation pattern in the surface water of Aiba Reservoir,After sorption on Amberlite Xad-16 Resin". *Report and Opinion;* 4: (10)

Karbassi R., Nouri J. and Ayaz G. O (2007), "Flocculation of trace metals during mixing of Talar River Water with Caspian Seawater," *International Journal of Environmental Research*, 1(1):66–73.

Shazili M., Yunus K., Ahmad A.S., Abdullah N., and Rashid M.K.A (2006) "Heavy metal pollution status in the Malaysian aquatic environment," *Aquatic Ecosystem Health and Management*, 9(2):137–145.

Maitera O. N., Ogugbuaja V.O. and Barminas J.T (2011) ."Determination of trace metal levels in water and sediments of River Benue in Adamawa state . "*Nigerian Journal of Ecology and the Natural Environment"* 3(4):149-156.

Oluyemi E.A, Adekunle A.S., Adenuga A. A and Makinde W.O (2010). *Physico-chemical properties and heavy metal content of water sources in Ife North Local government area of OsunState.African Journal of Environmental Science and Technology* 4(10):691-697.

Pertiwi Andarani and Dwina Roosmini. (2010) "Heavy metal(Cu, Cr, and Zn)Pollution profiles in surface water and sediments around textile industry(Cikijing River) *"Study program of Environmental Engineering. Ganesha 10 Bandung.*

Solomon , R and Förstner, U **(**1984**).** Metals in the Hydrocycle, Springer, Berlin, Germany.

Sharma, K.P., Sharma, K., Bhardwaj, S.M., Chaturvedi, R.K. and Subhasini (1999) Environmental Impact assessement of textile printing industries in Sanganer, Jaipur: A case study.; 78: 71-85.

Sin N., Chua H., Lo W., and Ng L.M. **(**2001) **,** "Assessment of heavy metal cations in sediments of Shing Mun River, Hong Kong," *Environment International*,. 26(5-6):297–301.

Suratman, H. C. Hang, N. A. M. Shazili, and N. Mohd Tahir **,** *(2009* **)"**A preliminary study of the distribution of selected trace metals in the Besut River basin, Terengganu, Malaysia," *Bulletin of Environmental Contamination and Toxicology*,. 82.(1):16–19.

Tariq, S.R., Shah, M.H., Shaheen, N., Khalique, A., Manzoor, S. And Jaffar, M.(2006**)** Multivariate analysis of trace metals levels in tannery effluents in relation to soil and water. *Journal of environmental management;* 79: 20-9.

United States Environmental Protection Agency (2007)"The National Water Quality Inventory".*Fact Sheet* No. EPA 841-F-07-003.