Physicochemical Characteristics of Groundwater Samples and Leachate from Gbagede Dumpsite, Amoyo, Kwara State, Nigeria

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Received: February 10, 2019; Revised: March 4, 2019; Accepted: March 10, 2019

Abstract

This study determined the physicochemical properties of groundwater and leachate samples obtained from dumpsite at Gbagede, Amoyo in Kwara State, Nigeria. Water samples collected from two wells located at a distance of 15 m and 150 m from the dumpsite and leachate at Gbagede were analyzed for physical and chemical properties using standard methods. The turbidity of the groundwater samples (GW1 and GW2) and leachate was higher than the World Health Organization (WHO) Standard and Nigeria Standard Drink and Quality Water (NSDWQ) (Reference Standards). The conductivity, nitrate, nitrite, chloride, sulphate, dissolved oxygen, biochemical oxygen demand, zinc, copper, aluminum and nickel of the three samples were generally lower than the Reference Standards while the total suspended solids was barely detected. The pH of the GW1 sample was within the Reference Standards whereas that of GW2 and leachate samples were higher than the WHO and NSDQW standards. The alkalinity of GW1 and GW2 was lower than the Reference Standards whereas that of leachate was higher than Reference Standards. Phosphate levels in the groundwater samples were lower whereas in the leachate, it was higher than the Reference Standards. The chemical oxygen demand was lower in GW1 and GW2 whereas it was higher than the WHO recommended limit in the leachates. Lead content in GW1 and GW2 was lower whereas in the leachate, it was higher than WHO standard. The cadmium content in GW1 was within the Reference Standards; cadmium content in GW2 was lower than that of the Reference Standards whereas it was higher than the Reference Standards in the leachates. In conclusion, the open dumpsite at Gbagede have minimally impacted (5% of the physicochemical characteristics exceeded the reference limit) on the physicochemical characteristics of the ground water whereas the dumpsite had more impact (53% of the physiochemical characteristics) on the physiochemical characteristics of the leachate.

Keywords: **Dumpsite, Groundwater, Physicochemical, Leachate**

1.0 Introduction

The quality and availability of freshwater is one of the most critical environmental and sustainability issues of the present century. Groundwater which is an important source of drinking water constitutes over 90% of the world's readily available freshwater resources [1]. Currently, the quality of groundwater is threatened by factors such as over-abstraction, microbiological, physical and chemical contaminations which are consequences of anthropogenic and human activities that are constantly adding industrial, domestic and agricultural wastes to ground water reservoirs at alarming rate [2,3].

Chemical contaminants find their way into drinking water throughout the world which could possibly threaten human health. The indiscriminate discharge of solid, liquid and gaseous wastes into land and municipal drains remains the only way of disposing off these wastes. Sometimes, the flow of this waste water is interrupted for the construction of dams by farmers for irrigation purposes due to the advantageous presence of potassium, nitrogen, phosphorus and other essential elements [4]. The presence of these metals in groundwater and soils constitute significant threat to human health and ecological systems.

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Ground water might be sullied with metals from wastewater releases or by coordinate contact with metals-debased soils, mucks, mining squanders, landfill, jetsam and flotsam. In Nigeria, open dump is simply the accessible decision for strong waste transfer in urban areas. At these open dumpsites, waste is presented to precipitation, which significantly builds the measure of leachate created. Development of leachates from squander locales or landfills and the arrival of contaminants from residue represent a high danger to groundwater source [5]. Thus, water for human utilization in different territories should along these lines be free from coliforms and high grouping of synthetics substances such that it won't incline to ecological unevenness and sickness [3].

In Amoyo town, there is Gbagede dumpsite which is surrounded by sparsely populated residential areas with prominent farming activities. The uncontrolled dumping activities have resulted to environmental hazards, enormous amount of wastes, unpleasant odour and undue fly infestation in the communities. This dumpsite also serves as breeding grounds for rodents and mosquitoes which are carriers of diseases. Previous researchers have reported on the impact of landfill leachate on groundwater [6-10], but none to the best of our ability has been reported on the physiochemical properties of the groundwater and leachate in the open dumpsite of Gbagede, Amoyo, Kwara State, Nigeria. Thus this study was carried out to determine the physiochemical properties of groundwater samples and leachate from Gbagede dumpsite in Amoyo town, Kwara State, Nigeria and compare data with the standard limits set by the World Health Organisation and the Nigeria Standard Drink and Quality Water.

2.0 Materials and Methods

2.1 Description of the Study Area and Sampling Location

The study area was Gbagede dumpsite at Amoyo, along Ilorin-Ajase-Ipo Road, Ilorin, Kwara State, Nigeria. It is situated within the South-Western Nigeria basement complex (Figure 1) and lies on longitude 4^o 38′ 45.82″ E and 4^o 40′ 13.46″ E and latitudes 8^o 26′ 52.94″ N and 8^o 24′ 13.53″ N. The landfill is surrounded by some residential houses and farmlands.

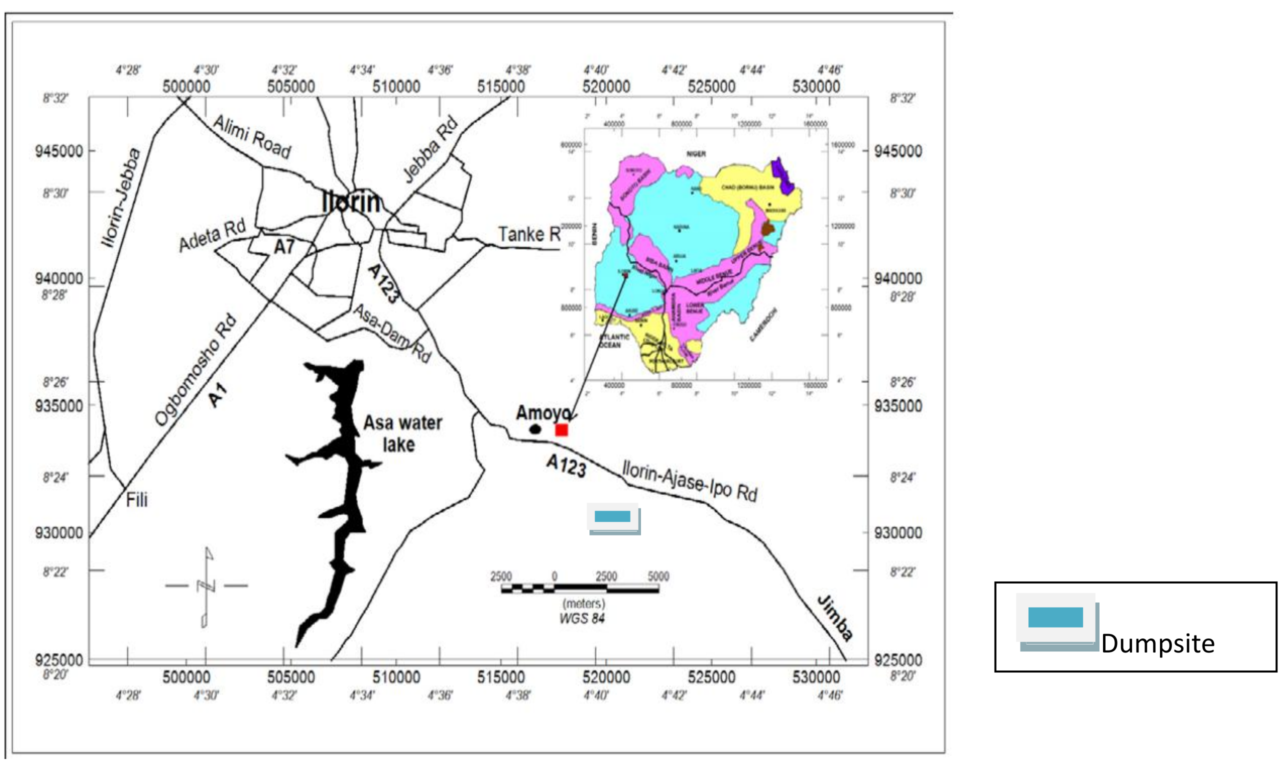

Figure 1: The Studied Area (Amoyo Town)
Source: Baiyegunhi *et al.* [11]

2.2 Collection of Leachate and Groundwater Samples

Raw leachates were collected from three sampling points of the dumpsite (Figure 2) and thoroughly mixed to provide a homogenous representative sample. Groundwater samples were also obtained from the site under study. The groundwater within the dumpsite (50 m) was labeled groundwater 1 (GW1) while the groundwater that was 150 m away from the dumpsite was labeled groundwater 2 (GW2). Each of the water samples was separately collected in sterilized 5-litre jerry can.

Figure 2: Gbagede dumpsite in Amoyo, Kwara State

2.3 Determination of Physicochemical Parameters

The physical and chemical properties of the samples of leachate and groundwater were determined according to the methods described by American Public Health Association [12]. The colour and odour of the samples were observed and recorded while the pH was determined immediately after collection using the portable digital pH meter (HI98108 pHep®, Hanna Instruments, Rhode Island). The physiochemical parameters determined included turbidity, conductivity, chemical oxygen demand (COD), biochemical oxygen demand (BOD), dissolved oxygen (DO), total surface solids (TSS), alkalinity, chloride, sulphate, phosphate, nitrite and nitrate.

2.4 Analysis of Metal Constituents in the Groundwater Samples and Leachate

The concentrations of lead, cadmium, zinc, copper, aluminum and nickel were determined in the leachate and groundwater samples according to the procedures described by APHA [12]. Briefly each sample was thoroughly mixed after which 20 ml each was transferred into a conical flask; 10 ml of concentrated trioxonitrate (V) acid was added and brought to slow boiling before evaporating on a hot plate to 10 ml. A known volume (50 ml) of concentrated trioxonitrate (V) acid was again added to the samples until a clear solution signifying a complete digestion process was obtained. The digest was filtered into 50 ml volumetric flask and made up to the marked level with distilled water. Analysis of the metals was carried out using Flame Atomic Absorption Spectrophotometer (AA-6800; Shimadzu, Japan). The calibration curves were prepared separately for each of the metals by running different concentrations of standard solutions instead of the samples. The analysis was done in triplicates for each metal after which the average concentration was computed. The data obtained on the various physicochemical properties were compared with those of the WHO [13] and the NSDWQ [14].

3.0 Results

GW1 was colourless and odourless whereas GW2 was unclear and particulate. In contrast, the leachate had an earthy greenish brown colour with an offensive odour (Table 1). The pH of GW1 was within the Reference Standards whereas that of the GW2 and leachate exceeded the limit of the Reference Standards. The turbidity of GW1 (9.27 NTU), GW2 (9.89 NTU) and the leachate (9.83 NTU) was generally higher than the standard permissible limit of WHO [13] and NSDWQ standard [14].

The conductivities of the GW1 (159 µs/cm,), GW2 (310 µs/cm) and leachate (947 µs/cm) were generally below the NSDWQ standard. The nitrates, Cd, Pb, Zn, Cu, $SO^{2}_{4,}$ chloride contents of GW1, GW2 and leachate samples were also below the standard permissible limit of WHO [13] and NSDWQ standard [14]. Although the alkalinity and phosphate were generally below the Reference Standards, those of the leachates were higher than the Reference Standards (Table 1). The DO, BOD and TSS of GW1, GW2 and leachates were lower than the WHO [13] standards. The COD of GW1 and GW2 were lower than WHO [13] standards whereas the leachate was higher than the permissible limits.

Table 1: Physiochemical Characteristics of Groundwater and Leachates from Gbagede Dumpsite, Amoyo, Kwara State, Nigeria

Parameters	Groundwater 1 (GW1)	Groundwater 2 (GW2)	Leachates	WHO [13]	NSDQW [14]
Appearance/Colour	Clear	Clear with particles	Greenish brown	Clear	Clear
Odour	No	No	Offensive smell	No	No
pH	7.34	8.56	9.83	6.5-8.5	6.5-8.5
Turbidity (NTU)	9.27	9.89	9.86	5.0	5
Conductivity (µs/cm)	159	310	947	NS	1000
Nitrate (mg/l)	2.3	0.1	43	50	50
Nitrite (mg/L)	0.017	0.005	0.024	3.0	2.0
Alkalinity (mg/L)	15	76	224	80-120	100
Chloride (mg/L)	110.4	56.7	112.48	250	250
Phosphate (mg/L)	4.2	1.7	5.8	5	NS
Sulphate (mg/L)	3	4	9	250	100
DO (mg/L)	1.33	1.20	1.69	<4	NS
COD (mg/L)	40	340	740	410	NS
BOD (mg/L)	0.96	0.86	2.67	5.0	NS
TSS	0.0001	0.0004	0.0007	250	NA
Lead	0.008	0.007	0.031	0.01	0.01
Cadmium	0.003	0.002	0.007	0.003	0.003
Zinc	0.025	0.019	0.010	3.0	3.0
Copper	0.018	0.015	0.028	2.0	1.0
Aluminum	0.009	0.005	0.024	0.2	NA
Nickel	0.009	0.048	0.011	0.2	0.2

NS: Not Stated; NA: Not Applicable

4.0 Discussion

Water quality is neither a static condition of a system, nor can it be characterized by the measurement of only one parameter. Therefore the determinatin of such variables like chemical, physical and biological parameters that affect the quality of water can be used to assess the extent of contamination and pollution of water.

Aesthetic characteristics of water include odour, taste and appearance. The more the amount of solids in water, the less clearer it becomes. Therefore, the clear nature of GW2 when compared with that of GW1 suggest that the amount of solids in GW2 is virtually negliglible whereas the greenish brown colour of the leachate indicates that it contains phytoplanktons and other algae which impacted on the colour of the leachate. Furthermore, the absence of odour in GW1 and GW2 indicates that the source of the water might be from a sink drain whereas the offensive smell of the leachates suggests the presence of organic matter.

The pH of water is very important in determining the quality of water since it affects solubility and the rate of reaction of the metal species that are involved in corrosion. Thus, excessively high or low pH can be detrimental to users of the water. Therefore, the high pH values obtained for GW2 and leachate in the present study could confer bitter taste on the two samples and may reduce the effectiveness of disinfection by chlorination [15,16]. Since the pH of the GW1 is within the permissible limit, it is possible that the GW1 would be better tolerated than the GW2 and the leachate.

Turbidity is an essential physical parameter of water that portrays the nature of water. Turbidity of water might be a consequence of wide array of suspended materials, which extend in measure from colloidal to coarse scatterings and contingent on the level of disturbance [17]. The high turbidity of GW1, GW2 and the leachate may be attributed to human activties including dumping of kitchen wastes, hair, human excreta, appliances and clothes within the studied area and possibly the run-off from the dumpsite [18]. The turbidity of the GW1, GW2 and leachate which were above the maximum permissible limit of the Reference Statndards may prone the groundwater and leachates to harbour pathogenic bacteria that may pose health risk to the inhabitants of that area [19]. Conductivity value is an index used to estimate the amount of dissolved minerals in water samples [20]. The highest conductivity value recorded for the leachate suggests that it contained the highest amount of dissolved material. The high alkalinity value is attributed to the age of the dumpsite and is correlated with its high pH value [21].

Chloride ions enter the groundwater aquifers from solid waste when it comes in contact with rain water and then gain entrance into aquifer [22]. Chloride does not react chemically with species in water and harmless at relatively low concentration. Therefore, the low levels of chloride ions in GW1, GW2 and leachate when compared with the reference standards might be an indication of low mineral pollution arising from the dumping of refuse in the site. The low concentrations of sulphate, nitrite and nitrate in GW1, GW2 and the leachate when compared with the reference standards suggest that most of the wastes in the site do not contain nitrogen and sulphur. It may also be attributed to low agricultural wastes and sewage discharge since nitrogen mostly enters ground water from agricultural activities and nitrogenous fertilizers [23]. The findings in the present study with respect to relatively low concentrations of sulphate and nitrate in the ground water samples and leachate is similar to a previous report by Inuwa *et al*[22]. Phosphate concentration has been reported to encourage eutrophication which could further deplete the levels of dissolved oxygen of ground water [24,25]. The high phosphate concentration of leachate could aid the process of eutrophication, in which the growth of photosynthetic aquatic micro- and macro organisms are stimulated to nuisance levels. This may account for the greenish brown colour ealier reported in this study.

Oxygen molecules are dissolved in water and measured as dissolved oxygen (DO). The presence of DO in water is good for the survival of most aquatic plants and animals. Sufficient level of DO is therefore a good indicator of water quality [26]. The findings in this study with respect to DO in GW1, GW2 and leachate suggest that groundwater and leachate maybe suitable for agricultural and fisheries project. Biochemical oxygen demand (BOD) is the amount of dissolved oxygen needed by aerobic biological organisms in water to break down organic material present in water sample at certain temperature over a specific time period [27] whereas a measure of the amount of oxygen required for complete oxidation to carbon (IV) oxide and water of organic matter present in a sample of water, waste water or leachate is referred to as Chemical Oxygen Demand (COD). Both the COD and BOD are important water quality parameters that indicate the level of organic pollution in water quality assessment [26-28]. The low levels of BOD and COD in GW1 and GW2 suggest that the dumpsite did not alter the permissible levels of BOD and COD of the groundwater samples whereas the high levels of COD in the leachate may be an indication of pollution with its attendant consequences on the amount of oxygen needed by the marine organisms around the dumpsite.

Total Suspended Solid (TSS) is a measure of the total solid in a water or wastewater sample. Suspended solids in ground water are often as a result of sediments carried by the water whose source includes natural and human activities in the water shed. A high TSS can reduce light penetration thus, decreasing algal growth; and low algal productivity can reduce the productivity of aquatic invertebrates, a food source of many fishes [29]. Since the levels of TSS were within the permissble limit, it is possible the groundwater samples and even the leachate can tolerate productivity of aquatic animals.

Metals could exert effects that are beneficial or harmful to human body [30]. Heavy metals are especially renowned for their toxic effects on human beings, aquatic life and the environment. Interestingly, the concentrations of Pb, Zn, Cu, Al and Ni were within the permissible limit in the GW1, GW2 and the leachate. These are indication that might not have accumulated substantially to levels that could be detrimental to the environment including human beings and aquatic animals. In contrast, the level of Cd which has exceeded the permissible limit in the leachates may be of toxicological concerns to the environment.

Overall, the open dumpsite at Gbagede has minimally impacted (5% of the physicochemical characteristics exceeded the reference limit) on the physicochemical characteristics of the ground water whereas the dumpsite had more impact (53% of the physiochemical characteristics) on the physiochemical characteristics of the leachate.

5.0 References

[1] Adedeji, A., Babatunde, A. and Aderemi, A. (2010). Hydrochemical investigation of groundwater quality in selected locations in Uyo, Akwa-Ibom State of Nigeria. New York Science Journal, Vol. 3, No. 4, pp.117-122.

[2] Aydin, A. (2007). The microbiological and physicochemical quality of groundwater in West Thrace, Turkey. Polish Journal of Environmental Studies, Vol. 16, No. 3, pp. 377-383.

[3] Aremu, M.O., Ozonyia, G.N. and Ikokoh, P.P. (2011). Physicochemical properties of well, borehole and stream waters in Kubwa, Bwari Area Council, FCT. Nigeria. Journal of Environmental Agricultural and Food Chemistry, Vol. 10, No. 6, pp. 2296-2304.

[4] Niroula, B. (2003). Comparative effects of industrial effluents and submetropolitan sewage of Biratnagar on germination and seedling growth of rice and blackgram. Our Nature, Vol. 1, pp. 10-14.

[5] Ikem, A., Osibanjo, O., Shridar, M.K.C. and Sobande, A. (2002). Evaluation of ground water quality haracteristics near two waste sites in Ibadan and Lagos, Nigeria. Water, Air and Soil Pollution, Vol. 140, pp. 307-333.

[6] Bello, O.O., Osho, A., Bankole, S.A. and Bello, T.K. (2013). Bacteriological and physicochemical analyses of borehole and well water sources in Ijebu-Ode, Southwestern Nigeria. International Journal of Pharmacy and Biological Sciences, Vol. 8, pp. 18-25.

[7] Salami, L. and Susu, A.A. (2013). Leachate characterization and assessment of groundwater quality: A case of Soluos dumpsite, Lagos, Nigeria. Greener Journal of Science, Engineering and Technology Research, Vol. 3, No. 2, pp. 42-61.

[8] Salami, L., Fadayini, M.O. and Madu, C. (2014). Assessment of a closed dumpsite and its impact on surface and groundwater integrity: a case of Oke Afa dumpsite, Lagos, Nigeria. International Journal of Research and Reviews in Applied Sciences, Vol. 18, No. 3, pp. 222-230.

[9] Aboyeji, O.S. and Eigbokhan, S.F. (2016). Evaluations of groundwater contamination by leachates around Olusosun open dumpsite in Lagos metropolis, Southwest Nigeria. Journal of Environmental Management, Vol. 1, No. 1, pp. 333-341.

[10] Enitan, I.T., Enitan, A.M., Odiyo, J.O. and Alhassan, M.M. (2017). Human health risk assessment of trace metals in surface water due to leachate from the municipal dumpsite by pollution index: A case study from Ndawuse River, Abuja. Nigeria Open Chemistry, Vol. 16, pp. 214-227.

[11] Baiyegunhi, C., Oloniniyi, T.L. and Ige, O.O. (2014). Investigation of geotechnical properties of Biotite Gneiss derived lateritic soil around Amoyo, Ilorin, Southwestern, Nigeria. Global Journal of Geological Sciences, Vol. 19, pp. 3861-3869.

[12] American Public Health Association (APHA) (2005). Standard methods for the examination of water and wastewater. Washington, D.C.

[13] WHO (2001). World Health Organization Guidelines for drinking water quality, incorporating the first and second Addenda. Vol. 1, 3rd edition. World Health Organization, Geneva, Switzerland.

[14] NSDWQ (2007). Nigerian Standard for Drinking Water Quality. Nigerian Industrial Standard NIS 554, Lagos, Nigeria: Standard Organization of Nigeria, pp. 30.

[15] Etim, E.E., Akpan, I.U., Andrew, C. and Edet, E.J. (2012). Determination of water quality index of pipe borne water in Akwa Ibom State, Nigeria. International Journal of Chemical Sciences, Vol. 5, No. 2, pp. 179-182.

[16] Marcus, N.D. and Binbol, N.L. (2007). Introduction and Historical Background. In: Geographical perspective on Nasarawa State. Onaive Printing and Publishing Company Ltd. Nigeria, pp. 1-2.

[17] Prakash, K.L. and Somashekar, R.K. (2006). Groundwater quality - Assessment on Anekal Taluk, Bangalore Urban District, India. Journal of Environmental Biology, Vol. 27, No. 4, pp. 633-637.

[18] Udiba, U.U., Hassan, D.B, Mahmud, A., Odey, M.O., Gauje, B., Umar, S.M., Bashir, I. and Babakura, A.M. (2013). Determination of contaminants levels in forage grasses, Dareta Village, Nigeria. Archives of Applied Science Research, Vol. 5, No. 3, pp. 229-236.

[19] Manivasakam, N. (2000). Physicochemical examination of water, sewage and industrial effluents. IVth edition. Pragati Prakashan, Meerut.

[20] Wongsasuluk, P., Chotpantarat, S., Siriwong, W. and Robson, M. (2014). Heavy metal contamination and human health risk assessment in drinking water from shallow groundwater wells in an agricultural area in Ubon Ratchathani Province, Thailand. Environmental Geochemistry Health, Vol. 36, pp. 169-182.

[21] Adewuyi, G.O., Oputu, O.U. and Opasina, M.A. (2010). Assessment of groundwater quality and saline intrusions in coastal aquifers of Lagos metropolis, Nigeria. Journal of Water Resource and Protection, Vol. 2, pp.849-853.

[22] Inuwa, B., Udib, U., Abdulhamid, H., Bello, I. G., Kabir, A. F. and Saminu, F. (2014). Impact of Gyadi–Gyadi solid waste dumping site on the quality of ground water of the neighbouring environment. International Journal of Scientific and Technology Research, Vol. 3, No. 9, pp. 106-108.

[23] Groen, J., Schumann, J.B. and Geirnaert, W. (1988). The occurrence of high nitrate concentration in groundwater in villages in Northwestern Burkina Faso. Journal of African Earth Sciences, Vol. 7, No. 7/8, pp. 999-1009.

[24] Fakayode, S.O. (2005). Impact of industrial effluents on water quality of the receiving Alaro River in Ibadan, Nigeria. African Journal of Environmental Assessment and Management, Vol. 10, pp. 1-13.

[25] Osibanjo, O. and Majolagbe, A.O. (2012). Physicochemical quality assessment of groundwater based on land use in Lagos City, Southwest, Nigeria. Chemistry Journal, Vol. 2, No. 2, pp. 79-86.

[26] Udiba, U.U., Gauje, B., Ashade, N.O., Ade-Ajayi, F.A., Okezie, V.C., Aji, B.M. and Agboun, T.D.T. (2014). An assessment of the heavy metal status of River Galma around Dakace industrial layout, Zaria, Nigeria. Merit Research Journal of Environmental Science and Toxicology, Vol. 2, No. 8, pp. 176-184.

[27] Sawyer, C.N. and McCarty, P.L. (1978). Chemistry for Environmental Engineering. McGraw-Hill Book Company, New York, USA.

[28] Clair, N.S., Perry, L. and Gene, F.P. (2003). Textbook on Chemistry for Environmental Engineering and Science. McGraw-Hill, New York.

[29] Agwa, O.K., Sito, E. and Ogugbue, C.J. (2013). A spatial assessment of the microbiological and physicochemical quality of a stream receiving raw abattoir waste. Middle-East Journal of Scientific Research, Vol. 14, No. 7, pp. 879-886.

[30] Caussy, D., Gochfeld, M., Gurzau, E., Neagu, C. and Ruedel, H. (2003). Lessons from case studies of metals: Investigating exposure, bioavailability and risk. Ecotoxicology and Environmental Safety, Vol. 56, No. 1, pp. 45-51.