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Assessment of Physico-chemical Parameter of Saclux Paint Industrial Effluent on Nkoho River Sediments of Abia State, Nigeria

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Abstract
Heavy metals are easily adsorbed to sediments, which can act as a sink and secondary source of these contaminants in water and aquatic biota. The study aimed to assess the potential impact of industrial effluents from Saclux Paint Industry on the recipient sediment quality of Nkoho River in Abia state. Samples were taken at the effluent discharged point, upstream and downstream of the discharge point and geo-referenced using Garmin 76CSx Global Positioning system (GPS). Results of the heavy metal concentration of the receiving water body were compared with that of the effluent. Iron (Fe), Zinc (Zn), Manganese (Mn), Cadmium (Cd), Nickel (Ni), Lead (Pb), Chromium (Cr) and Copper (Cu)) in the sediment and effluent were estimated using Atomic Absorption Spectrophotometer (AAS). The results show that Lead was higher (0.15 – 0.23 mg/kg) in the polluted water sediments than in the control water sediment (0.12 – 0.17 mg/l). In all, Manganese (Mn), Cadmium (Cd), Chromium (Cr), Copper (Cu), and Nickel (Ni) had values which were higher in the corresponding sediments.. The resulting data were subjected to Analysis of Variance (ANOVA) and it shows that there were variations in the quality characteristics of the effluent in the different sampling time (September, October and November) as well as in the quality characteristics of the river water samples at the different sampling points, the paint effluent showed significant variations in its quality over time. In conclusion, it was observed that the poor quality of the water occasioned by the further deterioration by the entrance of the paint industry effluents, confer potentials of health hazards to users of the water.

Keywords: Effluent, Sediment, Heavy Metals, Wastewater, Paint Industry, Nigeria

Introduction
Waste water from industries and sewage spillages from burst pipes in urban centres are released into streams and wetlands which finally discharge in waterways and this can be the major cause of industrial pollution to water resources in the country and expose humans to toxic substances through drinking water.In most developed and developing countries, rapid industrialization and human's constant quest for comfort as well as change in taste and fashion has resulted to various forms of advancement in science and technology [1]. This, in turn affects the environment significantly in various ways. In processing basic industrial raw materials to finished goods various harmful wastes, effluents and other toxic by-products are generated alongside the desired products. These toxic materials when discharged into the environment are capable of interfering with environmental components as well as affecting man and other living components of the ecosystem. For instance, in areas where industrial waste effluents are discharged into surface waters, there is general reduction in the quality of such water and its ability to support aquatic life is equally reduced.

Effluent is generally considered to be water pollution, such as the outflow from a sewage treatment plant facility or the waste water discharge from industrial facilities [2]. It is generally recognized that in many developing countries, industrial environmental standards are lacking, and where they do exist, the instruments of control are not efficient. This is largely explained by the absence of reliable and comprehensive system of monitoring of industrial emissions and enforcement of compliance with the industrial standards [3]. Pollution from industrial disposal and effluent discharges has become a serious environmental issue in many countries of Africa, Nigeria inclusive [4]. The ultimate recipient or end point of all forms of pollution is the natural water body [5].

Waste water is water affected in quality from various standard parameters set by anthropogenic influences. The liquid wastes discharged from domestic, industrial, agricultural and related sectors containing various kinds of contaminants can be found in waste water. Various constituents may be present in waste water. They can be rinsed waters, including residual acids, plating metals and toxic chemicals [6]. Iqbal and Gupta have identified dumping of municipal wastes into water bodies as a very important source of water pollution by metals [7]. They noted that water already present in the waste or the water generated by biodegradation together with rainwater can cause leachate to leave the dumping sites into water bodies, including groundwater. The leachate formed by biochemical reactions is rich in organic content and solubilizes many metals, like Pb, Cu, Zn, Cd and Mn, and some of these metals can be toxic, even at trace levels [8]. Heavy metals are easily adsorbed to sediments, which can act as a sink and secondary source of these contaminants in water and aquatic biota [9]. Such accumulation of metals is dependent on a number of factors, which include the pH of the river water, the concentration of metals, anthropogenic inputs and other chemistry parameters of the river itself. Under favorable conditions, metals can solubilize back to the aqueous phase. Contaminated sediments do have several adverse effects on the aquatic ecosystem.

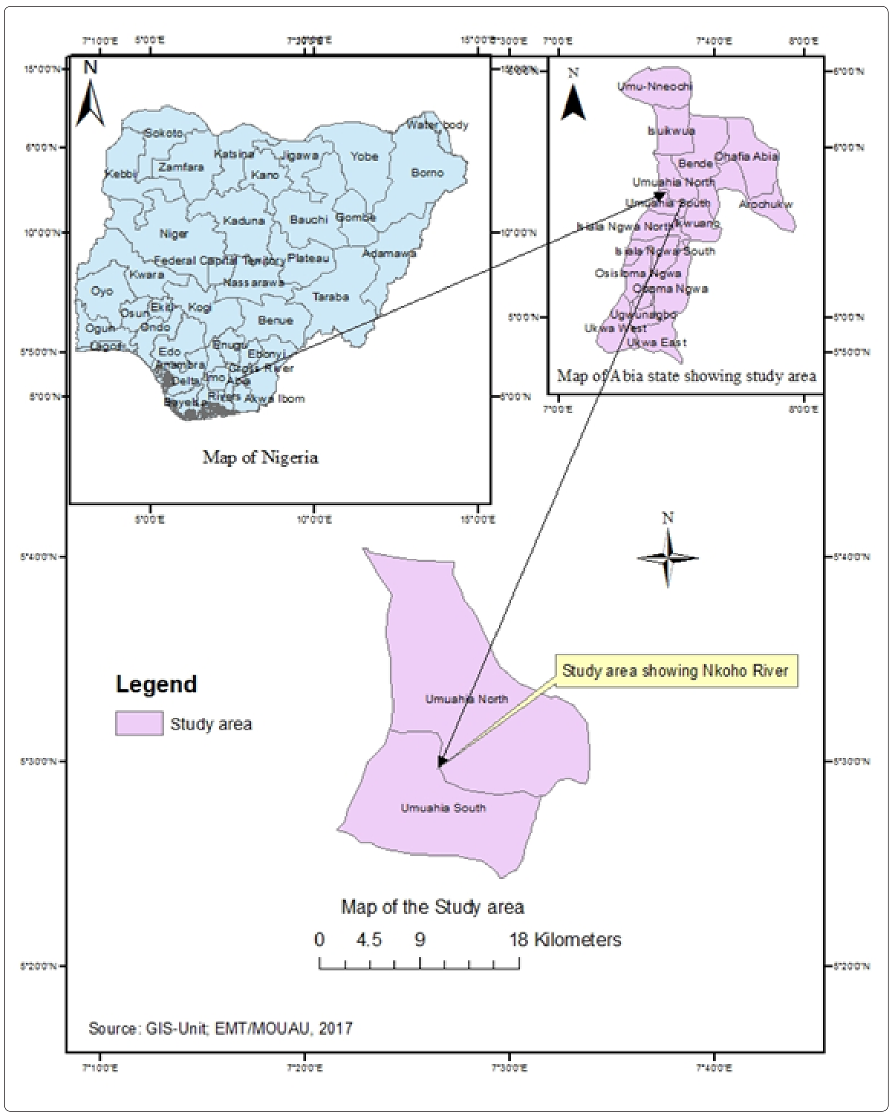
Materials and Methods

Study Area

This study was carried out in Nkoho at Ohokobe Afara-ukwu main stream which is situated in Umuahia North of Abia State in the South-Eastern part of Nigeria. The area is located in the lowland rainforest zone of Nigeria, which lies on Latitude 05°29′ to 05°42′ North and Longitude 07°29′ to 07°33′ East [10]. The area has an average rainfall of 2,238 mm per year that is distributed over seven months rainy season period [11]. It has bimodal peaks, the first occurring in the month of June or July and the second occurring in the month of September. Its minimum and maximum temperatures are 23°C and 32°C respectively and a relative humidity of 60-80% [12].

Umuahia is the capital city of Abia State in southeastern Nigeria. Umuahia is located along the rail road that lies between Port-Harcourt to Umuahia's south and Enugu city to its north. Umuahia has a population of 359,230 according to the 2006 Nigerian census.

The Nkoho River flows across major villages such as Afara, Ihie and Umudere villages of Afara ukwu Ibeku. The River have been subjected to human activities such as irrigation, recreation, swimming purposes, fishing activities, washing and other domestic uses. Over the years tremendous population increase due to urbanization, industrialization, infrastructural and economic development have resulted to serious water pollution and degradation of the water body and this unabated problems of the fresh water ecosystem exist due to ignorance and inadequate information on the extent of depletion on the available consumable fresh water and diminishing global water resources, just as Asuquo, also noted that water, one of nature's greatest gift to man, which is renewable natural resource, that assimilates and recycles some materials therein, is fast fading out.



Sampling Techniques

Sampling point was established and geo-referenced using Garmin Global Positioning system (GPS) at the effluent discharged point (N 05° 29.702′ and E 007°29.084′), 100m upstream (N 05° 29.759′ and E 007°29.062′) and 100m downstream (N 05° 29.639′ and E 007°29.094′) of the discharge channel. Triplicate samples were collected for three months, starting from October-November, 2016.

For the samples that were collected, parameters such as temperature and pH were analysed for physical parameters. Sulphate, nitrate, phosphate and heavy metals were analysed for chemical parameter. Bacteria load, coliforms and *E. Coli* were also analysed for biological characteristics.

Sediment Analysis

Sediment sample was air dried by thinly spreading on a clean laboratory bench surface at room temperature and brought to a relatively homogenous state by thoroughly mixing, and sieving with 2mm mesh before being treated.

The samples collected were analysed for parameters such as pH and temperature with Hannah Multimeter instrument H19829. Sulphate, nitrate and phosphate were determined spectrophotometrically. Total plate count was determined according to the heterotrophic plate count method suggested by the American Public Health Association. Total coliform analysis was done using Most Probable Number (MPN) A Perkin Elmer 3100 atomic absorption spectrophotometer was used for the determination of heavy metals [13].

Statistical Analysis

The data collected from this study was subjected to Analysis of Variance (ANOVA) using Statistical Package for Social Sciences (SPSS). Means were calculated and compared. One-way analysis of variance was used to find the levels of significance of the considered parameters. A further mean separation using mean plots to analyze the inequality in means across the sample locations was done. Results obtained was compared with values recommended as international minimum standards by FMEnv and WHO for domestic and aquatic uses respectively [14,15]. Mean values of the water parameters over the stipulated time in the different locations was differentiated using Fisher's Least Significant Difference (F-LSD) at P-value less than 0.05 (P<0.05) as statistically significant.

Results and Discussion

Results of laboratory analysis of the paint industrial effluent from the the Paint Industry into Nkoho river water are shown in Table 1.

Table 1: Values of Mean + SD for physico-chemical parameters measured for the sediments Quality

	September				October				November			
	Up-stream	Mid-stream	Down-stream	Effluent	Up-stream	Mid-stream	Down-stream	Effluent	Up-stream	Mid-stream	Down-stream	Effluent
Temp. (°C)	28.33 ± 0.57^a	28.57 ± 0.57^a	29.00 ± 0.00^b	29.16	28.67 ± 0.58^a	28.00 ± 0.00^a	28.67 ± 0.58^a	31.00	28.50 ± 0.29^a	28.50 ± 0.00^a	28.67 ± 0.29^a	30.83
E. coli (cfu/ml)	1.33 ± 0.57^a	1.00 ± 0.00^a	1.67 ± 0.57^a	1.67	1.67 ± 1.15^a	1.33 ± 0.58^a	2.33 ± 0.58^a	1.33	1.33 ± 0.58^a	1.67 ± 1.15^a	1.67 ± 0.58^a	1.67
pH	6.23 ± 0.05^a	6.47 ± 0.05^b	6.17 ± 0.05^a	8.87	6.33 ± 0.06^b	6.27 ± 0.06^a	6.13 ± 0.06^a	9.03	6.03 ± 0.06^a	6.20 ± 0.00^b	6.07 ± 0.06^a	8.83
TVC (cfu/ml)	4.33 ± 0.57^a	3.33 ± 0.57^a	3.67 ± 0.57^a	2.17	3.67 ± 0.58^a	3.33 ± 0.58^a	3.33 ± 0.58^b	2.00	2.33 ± 0.58^a	3.33 ± 0.58^b	3.00 ± 0.00^{ab}	2.33
NO_3 (mg/l)	2.61 ± 0.13^a	3.11 ± 0.13^b	2.97 ± 0.03^b	8.54	3.17 ± 0.24^a	3.13 ± 0.05^a	2.88 ± 0.07^b	8.58	3.33 ± 0.49^b	3.13 ± 12^a	2.80 ± 0.17^a	9.13
SO_4 (mg/l)	119.99 ± 1.47^a	147.93 ± 0.90^c	136.73 ± 2.72^b	492.93	126.03 ± 0.12^a	160 ± 0.37^a	144.30 ± 1.19^b	501.03	124.93 ± 2.54^a	143 ± 0.81^c	134.97 ± 2.02^b	524.87
PO_4 (mg/l)	17.10 ± 0.89^a	31.37 ± 0.44^c	20.17 ± 0.19^{ab}	99.23	18.81 ± 0.49^a	26.39 ± 0.02^c	22.82 ± 0.09^b	111.20	17.27 ± 0.81^a	22.57 ± 1.37^c	20.13 ± 1.16^b	120.13
Total coliform MPN	3.67 ± 0.58^b	2.67 ± 0.58^{ab}	2.33 ± 0.78^a	1.67	3.00 ± 10.00^a	2.33 ± 0.58^a	3.33 ± 1.15^a	2.33	2.33 ± 0.58^a	1.67 ± 0.58^a	2.00 ± 1.00^a	2.67

Source: FMEnv. Guidelines and Standards for Water Quality [15,16].
Means with the same alphabet are not significantly different: SD means Standard Deviation
< 0.01 Implies that the values were below the minimum detectable limit of 0.01

Table 1 shows results of the analysis of the sediments of the river bed at the different sampling points, which showed variations in the same way as the water samples. The sediments temperature in the upstream (control) sampling point was in the range of 28.33°C to 28.67°C in the months of September to November as against 28.67°C to 29.83°C recorded for the water samples from the same sampling point. The sediment temperature at the effluent discharge point (midstream) was slightly lower (28.00 to 28.57°C) than that of the sediment upstream. The lower sediment temperature at the midstream could be attributed to possible blockade of sunlight (energy) reaching the bottom due to high turbidity as reported earlier.

The result further showed variations in the microbiological characteristics of the midstream sampling point. From the result, the *E. coli* population of the effluent varied from 1.33 to 1.67×10^2 cfu/g and was found to be lower in the month of October (1.33) than in the month of September and November which recorded 1.67×10^2 cfu/g each. It was observed that these values were low and fell within the acceptable levels of 3.0 cols/100ml [15].

The pH of the sediments was between 6.17 (downstream) to 6.47 (midstream). This trend recorded in the month of September was repeated in October and November where the pH ranges were 6.13 to 6.20 respectively and the pH was always slightly highest in the midstream sediments where the affluent enters the water. The bacteria load was generally higher in the sediments than in the effluent. The range of bacteria load was between 3.33 x 10^4 cfu/g and 4.33 x 10^4 cfu/g in the sediments in the month of September whereas the effluent had 2.17 x 10^4 cfu/g in the same month. The relatively lower bacteria load of the effluent may not be unconnected with the toxicity of the effluent which perhaps hindered free bacteria proliferation in the effluent. Similarly, the bacteria load of the sediment 3.33 - 3.36 x 10^4 cfu/g was recorded for sediment in October and 2.33 - 3.33 x 10^4 cfu/g in November. Generally, the bacteria load of the sediments fluctuated within the sampling time but were generally higher than the load recorded for the effluent itself. This suggests that the paint effluent had adverse effect on the bacteria population at the riverbed.

The sediment samples in the three test months, September, October and November showed variations in the chemical compositions. There were variations also between the water samples from the different locations (upstream, midstream and downstream). Similar variations were recorded in the effluent samples. The nitrate content of both the effluent (8.54 mg/l to 9.13 mg/l) in the three months and the sediments (2.61 to 3.11 mg/l) in September, 2.88 to 3.17 mg/l in October and 2.80 to 3.33 mg/l in November respectively. Sulphate was high in all the samples and the effluents. In the effluent sample, it was highest in the month of November (524.87 mg/l) and lowest in the month of September (492.93). The sulphate content of the effluent was either in the threshold or above the minimum acceptable level. The range in the sediments varied with sampling time and with locations. Sulphate was generally higher in the midstream with a range of 143-160 mg/l as against 119.90 - 126.03 mg/l in the upstream and 136.73 – 144.30 mg/l in the downstream water sample. A similar trend was recorded for phosphate in the water samples. The general variations in the chemical composition of the effluent samples, was attributed to possible changes in the variety or type of paints manufactured at different times. Also, the fluctuations in the chemical content of the sediments could be due to differences in the type of wastes which enters the water at different times of the months. On the whole, the discharge of the paint effluent into the river affected the chemical composition of sediments causing increases in the content of the test radicals (SO_4, NO_3 and PO_4).

The impact on biological contents was less obvious than that of chemical contents as *E. coli* count was lower in the upstream or downstream. The same trend was also observed in the total coliform contents where the test sampling point (midstream) had a range 2.33 col/100g – 2.67 col/100g as against 3.00 to 3.67 col/g in upstream and 2.33 to 3.33 col/g in the downstream sediments.

Table3: Values of Mean + SD for Heavy Metals parameter measured for the river sediment samples at the sampling points; upstream, midstream and downstream

	September				October				November			
	Up-stream	Mid-stream	Down-stream	Effluent	Up-stream	Mid-stream	Down-stream	Effluent	Up-stream	Mid-stream	Down-stream	Effluent
Fe^{2+}	1.81 ± 0.58^{a}	0.83 ± 0.01^{a}	0.64 ± 0.02^{a}	3.72	1.99 ± 0.07^{c}	0.61 ± 0.02^{b}	0.48 ± 0.04^{a}	4.83	1.20 ± 0.04^{a}	0.71 ± 0.02^{b}	0.56 ± 0.04^{a}	4.06
Zn^{2+}	1.18 ± 0.03^{b}	0.41 ± 0.02^{a}	0.36 ± 0.02^{a}	0.65	0.15 ± 0.01^{a}	0.46 ± 0.02^{c}	0.20 ± 0.02^{b}	0.75	0.17 ± 0.01^{b}	0.55 ± 0.02^{c}	0.21 ± 0.02^{a}	0.83
Mn^{2+}	0.09 ± 0.01^{a}	0.35 ± 0.04^{b}	0.19 ± 0.03^{a}	0.13	0.03 ± 0.00^{a}	0.05 ± 0.00^{b}	0.02 ± 0.01^{a}	0.13	0.03 ± 0.01^{a}	0.04 ± 0.01^{a}	0.03 ± 0.01^{a}	0.11
Cd^{2+}	0.02 ± 0.00^{a}	0.03 ± 0.01^{b}	0.02 ± 0.000^{ab}	0.03	0.02 ± 0.00^{a}	0.05 ± 0.01^{b}	0.03 ± 0.00^{a}	0.11	0.05 ± 0.01^{a}	0.07 ± 0.01^{b}	0.03 ± 0.01^{a}	0.17
Ni^{2+}	0.01 ± 0.00^{a}	0.04 ± 0.00^{a}	0.02 ± 0.00^{a}	0.10	0.03 ± 0.00^{a}	0.05 ± 0.01^{b}	0.03 ± 0.00^{a}	0.11	0.03 ± 0.01^{a}	0.05 ± 0.01^{ab}	0.07 ± 0.01^{b}	0.19
Pb^{2+}	0.17 ± 0.02^{a}	0.23 ± 0.03^{b}	0.17 ± 0.01^{a}	0.40	0.13 ± 0.03^{a}	0.25 ± 0.02^{b}	0.13 ± 0.01^{a}	0.44	0.12 ± 0.02^{a}	0.15 ± 0.01^{b}	0.13 ± 0.01^{ab}	0.33
Cr^{3+}	0.02 ± 0.00^{a}	0.05 ± 0.01^{b}	0.03 ± 0.01^{ab}	0.23	0.02 ± 0.00^{a}	0.07 ± 0.01^{c}	0.05 ± 0.00^{b}	0.25	0.05 ± 0.02^{a}	0.12 ± 0.00^{b}	0.10 ± 0.00^{a}	0.23
Cu^{2+}	0.21 ± 0.01^{b}	0.05 ± 0.01^{a}	0.05 ± 0.01^{a}	0.43	0.25 ± 0.01^{c}	0.09 ± 0.01^{b}	0.05 ± 0.01^{a}	0.42	0.27 ± 0.01^{b}	0.10 ± 0.02^{a}	0.11 ± 0.01^{a}	0.45

Source: FMEnv. Guidelines and Standards for Water Quality [15,16].
Means with the same alphabet are not significantly different: SD means Standard Deviation
< 0.01 Implies that the values were below the minimum detectable limit of 0.01

There were also variations and fluctuations in the heavy metal values observed in table 3. However, most metals recorded higher values in the sediment than in the corresponding water samples. The iron content of the sediment was in the range of 1.20 mg/kg to 1.99 mg/kg as against 0.94 mg/l to 1.35 mg/l at the upstream sampling point. The corresponding iron value for the midstream was 1.19 to 2.18 mg/kg for sediment and 0.61 to 0.83 mg/l for water sample. That of the downstream sediment was 0.48 to 0.64 mg/kg Iron and 0.99 to 1.13 mg/l for the water. This result shows higher level of iron in the control sediment samples than in the effluent polluted water sediment samples. This could be attributed to washout from soil and wastes of different metal based occupational fields (Uzokwe and Oghoanine, 2011). In contrast with the trend of Iron in the sediments, Lead was higher (0.15 – 0.23 mg/kg) in the polluted water sediments than in the control water sediment (0.12 – 0.17 mg/l). In all, Manganese (Mn), Cadmium (Cd), Chromium (Cr), Copper (Cu), and Nickel (Ni) had values which were higher in the water samples than there corresponding sediments. The results therefore show variations in the concentrations of the test heavy metals in the water samples and their sediments.

Discussion

The higher levels of the metals in the water sample compared with their sediment samples seem to suggest the existence of the metals in forms (compounds) which solubulize in the water leaving little deposits at the sediment. Notwithstanding the variations, it was observed that only Cadmium, Nickel and Manganese were found in concentrations below the minimum acceptable limits in the water. The other metals had concentrations higher than the acceptable limits. The above observations imply that there are potentials of high risk of health hazards to users of Nkoho river water for domestics as well as for recreational purposes. Also, long time uses of the water may be exposed to possible bioaccumulations of the metals most of which have carcinogenic and other health risk history [17].

Conclusion

From the results of the study, sediment samples were above the permissible criteria by different regulatory bodies as it affects its physicochemical and biological quality. The poor quality of the paint industry effluent was seen as an indication of non-treatment or improper treatment of the effluents prior to its discharge into the Nkoho River. Secondly, there were variations in the constituents of the effluents at the different test times (September, October and November) and these variations were attributed to possible differences in the batches of paint produced at the different test time.

The discharge of effluents into the river caused changes in the quality of the river water which negates the sediments quality also. However, the entrance of the paint effluents aggravated the poor sediment quality of the river. It was also observed that the quality characteristics, varied with sampling points and time (September, October and November). Similarly, slight but significant variations were recorded in the sediment samples at the river bed.

It was finally observed that the poor quality of the sediments occasioned by the further deterioration following the entrance of the paint industry effluents, confer potentials of health hazards to users of the water. This raises strong public health concerns and challenge to appropriate environmental authorities to address without delay.

Recomendations

The results suggest that the effluents being discharged into the Nkoho River have considerable negative effects on the sediment quality in the recipient water body. The consistent discharge of the untreated effluents increases the load of nutrients and pollutants entering the river and this will continue to increase and further diminish the quality of sediments.

It is therefore recommended that careless disposal of wastes should be discouraged and there is need for the industry to install a waste treatment plant with a view to treat wastes before being discharged into the river.

There is also need for regulatory agencies like Federal Ministry of environment (FMEnv), Department of Petroleum Resources (DPR), National Environmental Standards and Regulatory Agency (NESRA) and the likes to closely monitor effluents from industries before its discharge.

References

1. Tuner II BL, Clerk WC, Kates RW, Richards JF, Mathews JT and Meyer WB (1990) "The Earth as Transformed by Human Action" Cambridge University Press P 14-15.
2. Womach J (2005) "Water Supply and Sanitation in the United States" Congressional Research Service Document. CWA Sections 301, 306 and 307.
3. Aluyor EO, Badmus OAM (2003) Time Series Analysis of Pollutant Levels in Industrial Wastewater effluents - A Case Study of a Beverage Industry", Nigerian Journal of Biomedical Engineering 2: 19-32.
4. Uzoukwu BA, Ngoka C,Nnaji N(2004) Monthly Variation of the Physicochemical Properties of Effluents from Rimco Industries Nnewi Nigeria".Global Journal of Pure and Applied Sciences 10: 203-210.
5. Otaraku IJ, Nkwocha, A.C (2010) Assessment of the Physicochemical Quality of Petroleum Refinery Wastewater Effluent ICASTOR Journal of Engineering 3: 65-174.
6. Husain A, Ashhar M, M Javed I (2014) Analysis of industrial waste water in Aligarh city. J Chem Pharm 6: 614-621.
7. Iqbal MA, Gupta, SG (2009) Studies on Heavy Metal Ion Pollution of Ground Water Sources as an Effect of Municipal Solid Waste Dumping Afr J Basic Appl Sci 1:117-122.
8. Mohiuddin KM, OgawaY, Zakir HM, Otomo K, and Shikazono N (2011) Heavy metals contamination in water and sediments of an urban river in a developing country. Int J Environ Sci Technol 4 : 723-736.
9. Varol M, Sen B (2012) Assessment of nutrient and heavy metal contamination in surface water and sediments of the upper Tigris River Turkey Catena 92 :1-12.
10. Keay RWJ (1999) An outline of Nigeria vegetation (4th Edition) Government Printer Lago 43 pp.
11. Nzegbule EC, Ogbonna PC (2008) Quantity and quality of litter fall in pure pine and pine/Gmelina mixed plantations in Umuahia Nigeria Global Journal of Agricultural Sciences 1: 93-96.
12. Ogbonna PC, Nzegbule EC (2010) Quantity and quality of litter fall in pure Gmelina arborea and pure Pinus caribea plantations in Umuahia Nigeria. 33rd Annual Conference of Forestry Association of Nigeria Benin City Edo state in press.
13. American Public Health Association (APHA) (1995) Standard Methods for examination of water and wastewater Analysis (19th Edition), America Public Health Association p 28.
14. FME (Federal Ministry of Environment) (2001) Guidelines and Standards for Water Quality in Nigerian Publication Federal Ministry of Environment 114p.
15. World health organization (WHO) (2004) guidelines for drinking water, quality Third edition Volume 2. Health Criteria and other Supporting Information.
16. Federal Environment Protection Agency (FEPA) (1991) Guidelines and standards for environmental pollution control in Nigeria. Federal Government Press, Lagos Nigeria. 238p.
17. Emory E, Pattole R, Archiobold E, Bayorn M, Sung F (2001). Neurobehavioral effects of low level exposure in human Neonate, Am J Obstet. Gynecol 181: 5-11.