Heavy Metals Pollutions within Lagos South Western Nigeria

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ABSTRACT

Environmental pollution is a global phenomenon which could results from both natural and anthropogenic activities which has resulted to several health and physiological problems in both plants and animals. Dump sites' soils of and Borehole waters from Ojota, Ebutte-Meta, Igando and Bariga in Lagos state were analyzed for heavy metals using atomic absorption spectrophotometer. The data obtained were further subjected to contamination factor and pollution indices analyses. The results obtained showed lead (Pb) to be most concentrated in the soils and ranged from 0.22 ppm to 2.50 ppm, this was followed by the value recorded for zinc (Zn) which was between 0.0015 ppm to 0.020 ppm. The least observed metal in all the soil sample stations was nickel (Ni) which ranged from 0.001 ppm to 0.010 ppm. On the other hand, only water samples from Ojota and Ebutte-Meta were detectable with Pb concentration values of 0.38 ppm and 0.0028 ppm, Ni concentration values of 0.0052 ppm and 0.009 ppm, Zn concentration values of 0.0039 ppm and 0.0020 ppm respectively. On subjecting the concentration of the heavy metals to contamination factor (CF) revealed very slight contamination of the different soils from different areas. There was also very slight contamination of the waters from Ojota and Ebutte-Meta by metals, except for Igando and Bariga that were moderately and severely contaminated by the metals respectively. The Pollution Index (PI) showed that the soils and waters samples are unpolluted with the heavy metals.

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1. Introduction

Environmental pollution implies any alteration in the surroundings but it is restricted in use especially to mean any deterioration in the physical, chemical, and biological quality of the environment [1]. All types of pollution directly or indirectly affect human health. The xenobiotic pollutants are released into the environment by the action of man and occur in concentrations higher than “natural levels” [2]. Pollutants are generally classified as biodegradable and non-biodegradable: Biodegradable pollutants consist of sewage effluents and organic matter that are readily decomposed under normal circumstances. Non-biodegradable substances are those which are not degraded by microorganisms, e.g., heavy metals, plastics, and detergents. Fast urbanization and industrialization have resulted in the tremendous release of xenobiotic compounds into the environment [3]. Large quantities of highly toxic chemicals emitted by industries are generally used in developing countries for enhanced agricultural productivity [4, 5]. Most of the organic pollutants originate from five major industrial categories: petroleum refining, organic chemical and synthetic industries, steel mining and coal conversion, textile processing, and pulp and paper milling [6-9]. However, industries alone are not totally responsible for exposure of environment to the chemicals, also consumers share a part. Utilization of gasoline, aerosol sprays, pesticides, and fertilizers lead to the release of pollutants by the consumers directly into the environment [2]. Effluent from wastewater treatment plants is another cause of xenobiotic pollution [10]. Accidental spillage, illegal dumping, poorly chosen landfalls, and uncontrolled hazardous waste sites are other routes through which the environment is getting contaminated. In fact, inadequate disposal techniques have been cited as the main cause of contamination of biota as well as soil surface and ground matters which could lead to the emergence of disease producing microorganisms and ultimately result in serious health problems [11, 12]. Among the various types of environmental deteriorations, water pollution assumes the most significant proposition. Several studies suggested that the major toxicants present in surface water are heavy metals, pesticides, and phenolics [13, 7, 14]. It is a matter of great concern since these pollutants pose a constant threat to the well-being of humans, animals, and plants rather the whole biosphere. Continuous production of scientific data concerning toxicological effects of major environmental pollutants demands for frequent reviewing of the current body of information.

Lagos state has witnessed remarkable expansion, growth and developmental activities, such as buildings, road constructions, deforestation and many other anthropogenic activities. Though, Lagos seems to have sufficient water resources in terms of quantity, considering the amount of rainfall it receives, the several rivers that pass through it and the multi-layer aquifers underlying it, many Lagos residents are still without potable water. The main reason for water scarcity is the high population growth rate due to migration to the city from other parts of the country. Being a port city and the main commercial hub of Nigeria, Lagos attracts hundreds of thousands of people each year to work in industries. This influx of people into the city has caused over-abstraction of water resources and indiscriminate sinking of boreholes or water wells in many parts of the state not covered by the public water supply network. The generation of all sorts of solid wastes and the improper disposal and management of these wastes has caused water pollution which has further compounded the scarcity of potable water. However, little or no information is available on levels and effects of these wastes on human beings living in the study areas resulting from environmental pollution, hence motivation for this study.

2. The Study Area

The city of Lagos in Nigeria is currently the most populous city in Africa, and one of the fastest growing mega cities in the world. The population of Lagos has grown from 1.9 million in 1975 [15] to 22.5 million in 2016 with a growth rate of 3.2 % per year according to the Lagos Ministry of Physical Planning and Urban Development. Lagos State is bounded on the north and east by Ogun State. In the west, it shares boundaries with the Republic of Benin. Its southern borders are with the Atlantic Ocean. 22 % of its 3,577 km^2 are lagoons and creeks. Its geographical coordinates at 6° 35' North, 3° 45' East.

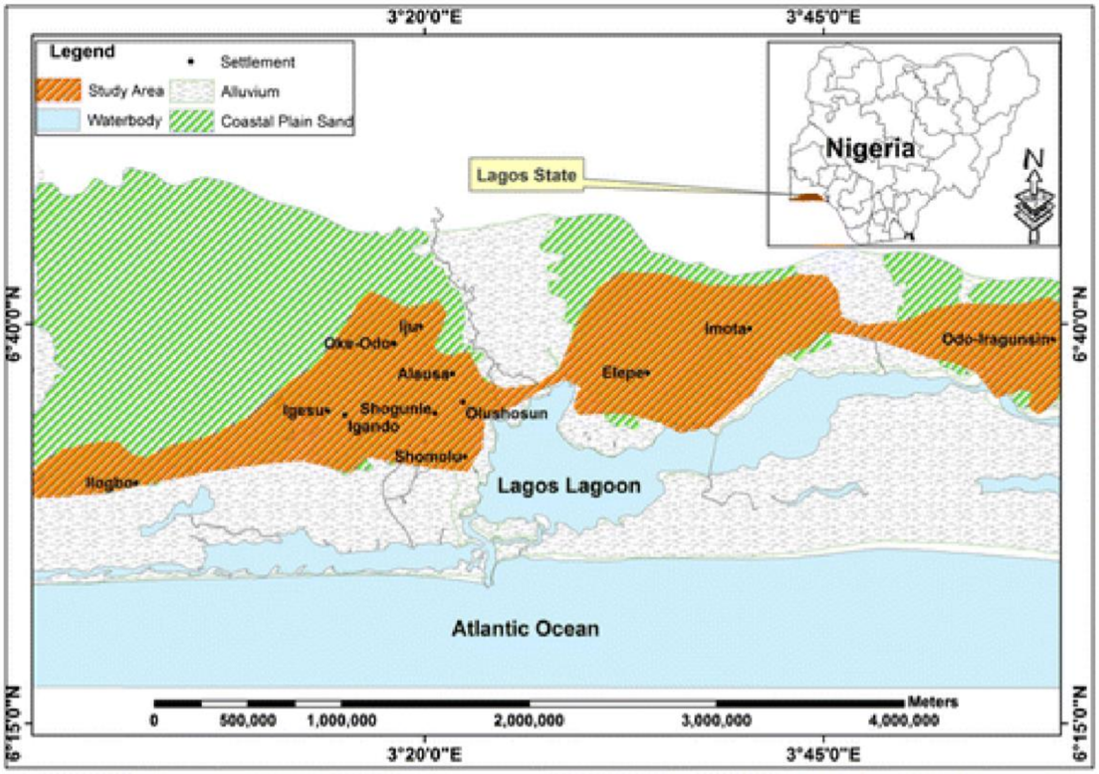

Figure 1: Map of Lagos state showing the study area

3. Materials and Methods

3.1 Sample Collection

Water samples were collected from bore hole of each location for a week and then packed inside reagent bottles while the soil samples were collected from each grid and thoroughly mixed as a representative sample of major dumpsites in Ojota, Ebutte-Meta, Igando and Bariga, Lagos state. At each sampling point, soil samples were collected at a depth between 15 cm and 20 cm below the ground surface and 300 m distance apart from one another. The soil samples were packed in three polyethylene black bags and taken to College Central Research Laboratory, Yaba College of Technology, Yaba, Lagos state for preparation and analysis.

3.2 Sample Preparation

Soil samples were thoroughly mixed together to form a sample representative for that site. At the laboratory, all samples were dried at room temperature for many days until a constant weight was reached, and they were crushed to pass a 2-mm mesh sieve. The soil samples were digested with a mixture of 10 ml concentrated hydrochloric acid (HCl) and 3.5 ml concentrated Nitric acid (HNO_3). Distilled water was added to the digested sample and then filtered through whatman filter paper and were topped up to 100 ml volumetric flask with distilled water. The solution was transferred into sampling bottles for analysis via Sodium Iodide (NaI) detector [2].

3.3 Contamination Factor (CF) of Water and Soil Samples

The contamination factor of the individual metals in the water and soil samples were calculated from the formula adopted from [16] as:

$$CF = C_m/C_b \qquad 1$$

Where: CF = contamination factor, C_m is concentration of metal measured in the water or soil sample, and C_b is background concentration of the metals in the water or soil. The WHO standard or limit was considered as the background values for the individual metals in the water or soil samples.

3.4 Pollution Indices (PI) of Water and Soil Samples

Pollution index is a measure of the degree of overall contamination in a sample station. The procedure of [17] was used to calculate the Pollution Index (PI) for each location is given as:

$$PI = (CF1 \times CF2 \times CF3 \times \ldots \ldots CFn)^{1/n} \qquad 2$$

Where; n = No. of heavy metals and

CF= Contamination factor.

The CF is the metal concentration in water or soil/background values of the metals.

Table 1: Description of the sampling points

S/N	Sample	Specimen	Location
1	A1	Soil	Ojota, Lagos
2	A2	Water	
3	B1	Soil	Ebutte-Meta, Lagos
4	B2	Water	
5	C1	Soil	Igando, Lagos
6	C2	Water	
7	D1	Soil	Bariga, Lagos
8	D2	Water	

Table 2: Maximum permissible limit of heavy metals' level in water samples

S/N	Heavy Metals	Levels (ppm)
1	Zinc (Zn)	0.50
2	Nickel (Ni)	0.05
3	Lead (Pb)	0.10

Source: Permissible limit by [18]

Table 3: Maximum permissible limit of heavy metals' level in soil samples

S/N	Heavy Metals	Levels (ppm)
1	Zinc (Zn)	15
2	Nickel (Ni)	0.02
3	Lead (Pb)	0.05

Source: Permissible limit by [18]

4. Results and Discussion

The mean concentration values of Zn, Ni and Pb for water and soil samples were illustrated in Table 4. The content of Zn ranged between 0.0052 ppm and 0.0039 ppm in soil and water samples of Ojota while it ranges from 0.0015 ppm to 0.0020 ppm for soil and water samples of Ebutte-Meta. It has 0.011 ppm for soil sample in Ojota whereas its content in water sample was not detected. However, its content in soil sample of Bariga is 0.020 ppm whereas its water counterpart was below detected level (BDL) (Table 4). The permissible limit set by [18] for zinc level is 0.5 ppm for human being. Therefore, the soil and water samples in Ojota, Ebutte-Meta, Igando and Bariga-Lagos are useful for both industrial and domestic use. The content of Ni ranged between 0.0010 ppm and 0.0052 ppm in soil and water samples of Ojota while it ranges from 0.0017 ppm to 0.0090 ppm for soil and water samples of Ebutte-Meta. It has 0.0016 ppm for soil sample in Ojota whereas its content in water sample was below detected level (BDL). However, its content in soil sample of Bariga is 0.0100 ppm whereas its water counterpart was below detected level (BDL) (Table 4). The permissible limit set by FAO/WHO (2001) for nickel level is 0.05 ppm for human being. Therefore, the soil and water samples in Ojota, Ebutte-Meta, Igando and Bariga-Lagos are useful for both industrial and domestic use. The content of Pb ranged between 0.22 ppm and 0.38 ppm in soil and water samples of Ojota while it ranges from 0.41 ppm to 0.0028 ppm for soil and water samples of Ebutte-Meta. It has 2.500 ppm for soil sample in Igando whereas its content in water sample was below detected level (BDL). However, its content in soil sample of Igando is 1.600 ppm whereas its water counterpart was below detected level (BDL) (Table 4). These values are higher than the permissible limit set by FAO/WHO (2001) for Pb level is 0.1 ppm for human being. Therefore, the soil and water samples in Ojota, Ebutte-Meta and Igando are not palatable for domestic use except the water for Ebutte-Meta which is useful for both industrial and domestic use. Heavy metals occur naturally in soils following the weathering processes of the underlying rocks. Availability of heavy metals in soils is influenced by environmental conditions that determine the pH and organic matter content in soils [2]. Heavy metal contamination of the soils may pose risks and hazards to humans and ecosystems through direct contact or ingestion, food chain, contaminated drinking water, reduced food quality among others. Soil sediments in the waste water channels may enrich with pollutants present in waste water with time. Increased Pb content in soils recovered from the open waste water channels is a health hazard to workers who regularly clean up the channels especially when they are ignorant about the need to maximize on safety measures. Lead has been associated with multiple organ problems and cancers [6].

Table 4: Mean Heavy metal Concentration for water and soil samples

S/N	SAMPLES	Zn	Ni	Pb
		PPM		
1	A1	0.0052	0.0010	0.22
2	A2	0.0039	0.0052	0.38
3	B1	0.0015	0.0017	0.41
4	B2	0.0020	0.009	0.0028
5	C1	0.011	0.0016	2.500
6	C2	ND	BDL	BDL
7	D1	0.020	0.0100	1.600
8	D2	ND	BDL	BDL

*** ND-Not Detectable**

**** BDL-Below Detected Level**

The contamination factor and the pollution index of the metals from the various towns in Lagos was calculated and listed in Table5. In order to interpret the data showed in Table 4, the soil from the various towns is not contaminated with Zn, Ni and Pb in most of the samples. However, waters from Igando and Bariga were found to be slightly contaminated with Pb. All the soils from the three (3) towns were found to be contaminated with Pb. When a comparative view of the three stations was taken to examine whether the waters and soils were polluted by the heavy metals using the Pollution Index (PI) as categorized, it was observed that the soils samples of Ojota and Ebutte-Meta were very slightly polluted while Igando and Bariga were within moderate and severe contaminated. Also, all the water samples were unpolluted by the metals. Whereas, Bariga was severe moderated.

Table 5: Contamination factor (CF) and Pollution Index (PI) for water and soil samples

S/N	Heavy metals	A1	A2	B1	B2	C1	C2	D1	D2
		CF		CF		CF		CF	
1	Zn	0.010	0.008	0.003	0.004	0.022	ND	0.04	ND
2	Ni	0.02	0.104	0.034	0.18	0.032	BDL	0.2	BDL
3	Pb	2.2	3.8	4.1	0.03	25	BDL	16	BDL
	PI value	0.0763	0.0677	0.0750	0.0273	0.2601	_____	0.5043	_____

*** ND-Not Detectable**

**** BDL-Below Detected Level**

5. Conclusions

This study has investigated the heavy metals concentration on the soils and waters within Ojota, Ebutte-Meta, Igando and Bariga areas of Lagos, South-western Nigeria. It was found out that lead (Pb) was the most concentrated in the soils followed by the value recorded for zinc (Zn). The least observed metal in all the soil sample stations was nickel (Ni). On the other hand, only water samples from Ojota and Ebutte-Meta were detectable with Pb concentration values of 0.38 ppm and 0.0028 ppm, Ni concentration values of 0.0052 ppm and 0.009 ppm, Zn concentration values of 0.0039 ppm and 0.0020 ppm respectively. On subjecting the concentration of the heavy metals to contamination factor (C.F) revealed very slight contamination of the different soils from different areas. There was also very slight contamination of the waters from Ojota and

Ebutte-Meta by metals, except for Igando and Bariga that were moderately and severely contaminated by the metals respectively. The mean concentration of Pb in the dump sites soil samples were above the limits set by WHO (2018) for agricultural and gardening soils. The mean concentration of heavy metals was relatively higher in soil than in borehole water samples at each sampling site. This was an evidence of a build-up of toxic metals in the soils found in dump sites. Presence of monogastric animals such as pigs scavenging on the dump sites suggested a likely pathway through which the metallic contaminants could eventually find their way into soils. This study recommended frequent inspections and treatment of dump sites should be carried out to enhance faster flow and to minimize possible spread of heavy metal contaminated borehole to the densely populated informal settlements that neighbor Lagos industrial area. Residents living nearby should be made aware of the health hazards that could emanate from exposure to untreated dump sites through public education and awareness campaigns.

Rreferences

[1] P. Moschella, R. Laane, S. Bäck, H. Behrendt, G. Bendoricchio, S. Georgiou, P. Herman, H. Lindeboom, M. Skourtous, P. Tett, M. Voss, W. Windhorst, Group report, methodologies to support implementation of the water framework directive, Manag. Euro. Coast Environ. Sci., (2005)137-152, DOI: 10.1007/3-540-27150-3_7

[2] A.A. Hamid, O.O. Aiyelaagbe and G.A Balogun, Herbicides and its applications. Adv. Natur. Appl.Sci.,5(2011)201-213, doi:10.15580/GJSSPN.2016.1.102716175

[3] S. Tabrez, M. Ahmad, Oxidative stress mediated genotoxicity of wastewaters collected from two different stations in northern India, Mutat. Res., 726(2011)15-20, doi:10.1016/j.mrgentox.2011.07.012.

[4] M.I. Ansari, A. Malik, Genotoxicity of wastewaters used for irrigation of food crops. Environ. Toxicol., 24(2009)103-115, DOI:10.1002/tox.20389

[5] M.Z. Alam, S. Ahmad, A. Malik, Prevalence of heavy metal resistance in bacteria isolated from tannery effluents and affected soil, Environ, Monit. Assess, 178(2011)281-291. doi:10.1007/s10661-010-1689-8.

[6] D.E Nye, Smoke gets in your eyes, pollution, aesthetics, and social class. Review of Stradling, Smokestacks and progressives, environmentalists, engineers and air quality in America, 28(2000)422-427, PMID: 11624658.

[7] S. Tabrez, M. Ahmad, Effect of waste water intake on antioxidant and marker enzymes of tissue damage in rat tissues, implications for the use of biochemical markers, Food Chem. Toxicol., 47(2009)2465-2478, doi: 10.1016/j.fct.2009.07.004.

[8] S. Tabrez, M. Ahmad, Cytochrome P450 system as a toxicity biomarker of industrial wastewater in rat tissues. Food Chem. Toxicol., 48(2010)998-1001. doi:10.1016/j.fct.2009.12.024.

[9] A.K. Gupta, M. Ahmad, Assessment of cytotoxic and genotoxic potential of refinery waste effluent using plant, animal and bacterial systems, J. Hazard. Mater., 201(2012)92-99, doi: 10.1016/j.jhazmat.2011.11.044.

[10] M.A. Aboulhassan, S. Souabi, A. Yaacoubi, M. Baudu, Removal of surfactant from industrial wastewaters by coagulation flocculation process, Int. J. Envir. Sc. Tec., 3 (2006)327-332, doi.org/10.1007/BF03325941

[11] A. Malik, M. Ahmad, Genotoxicity of some waste waters of India, Environ. Toxicol. Water Qual., 10 (1995)287-293, doi.org/10.1002/tox.2530100409.

[12] J. Tibbetts, Water world 2000, Environ. Health Perspect., 108(2000)69-73, doi: 10.1289/ehp.108-1637896.

[13] A.H. Siddiqui, M. Ahmad, The Salmonella mutagenicity of industrial, surface and ground water sample of Aligarh region of India. Mutat. Res., 541(2003)21-29, doi.org/10.1016/S1383-5718(03)00176-1.

[14] S. Wasi, G. Jeelani, M. Ahmad, Biochemical characterization of a multiple heavy metal, pesticides and phenol resistant Pseudomonas fluorescence strain, *Chemosphere*, 71 (2008)1348-1355, doi.org/10.1016/j.chemosphere.2007.11.023.

[15] UNDESA, The World's Cities in 2016 – Data Booklet (ST/ESA/ SER.A/392). (2016),

[16] O.S. Edori, F. Kpee, Assessment Models for Heavy Metal Pollution in Soils within selected Abattoirs in Port Harcourt, Rivers State, Nigeria, Singapore J. Sci. Res.,7(2017)9-15, doi: 10.3923/sjsres.2017.9.15

[17] D.L. Tomlinson, J.G. Wilson, C.R. Haris, D.W. Jeffrey, Problems in the assessment of heavy metal levels in estruaries and formation of Pollution Index. Helgol Mar. Res., 33(1980)566-575, doi.org/10.1007/BF02414780.

[18] FAO/WHO, Evaluation of Health and Nutritional Properties of Probiotics in Food Including Powder Milk with Live Acid Bacteria. Report of a Joint FAO/WHO Expert Consultation, Córdoba, Argentina,(2000), http://www.who.int/foodsafety/publications/fs_management/en/probiotics.pdf?ua=1

[19] World Health Organisation, WHO, Constitution of WHO: principles, (2018) http://www.who.int/about/mission/en/,