



Assessment of Heavy Metals Pollution and Microbial Contamination in Water from Alakija e-waste scrap site, Lagos, Nigeria

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Abstract

Keywords:

Coliform, confirmatory faecal coliform, water pollution, heavy metals, Alakija.

The massive expansion of major cities coupled with improved standard of living, industrialisation, advancement in agricultural and construction activities have contributed to the high level of pollution in the environment. The aim of this study was to investigate the heavy metal, physical, chemical and microbial parameters in water samples collected from the e-waste scrap site located at Festac Third gate, Alakija Lagos State. The study site is an illegal scrap site created by scrap and plastic waste collectors. It is a wetland zone located in Festac Town. Water samples were collected from this site between September to December, 2016 representing the dry season while the wet season samples were collected between the months of May and August, 2017. The samples were collected in triplicates monthly and a total of twenty-four samples were collected for the two seasons. The water samples at each site were collected into 2.5ml tight plastic bottles, after being taken from the surface. The samples were transported to the Lagos State Environmental Protection Agency water laboratory for further analyses. The physical, chemical, heavy metals and microbial parameters were determined. The results showed that all examined parameters were within the regulatory limits except for the microbial quality of the water samples that revealed the presence of faecal coliform. Colour ranged from 40.50-46.75 pt.Co.AHPA in the dry season and 84.5-105.00 pt.Co.AHPA in the wet season, when compared to the regulatory limit. Total acidity in the dry season ranged from 12.00-15.25mg/l and that of the wet season ranged from 43.50-45.75mg/l, alkalinity from 103.00-123.75mg/l and 516.00-546mg/l in the dry and wet seasons respectively. The heavy metals were also within the regulatory limits. The study concluded that although the water quality was not compromised but it needs to be monitored because of its closeness to the residential area as many of the residents depend on dug borehole for a clean water source.

Accepted: 27 June 2019

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INTRODUCTION

The vast expansion of major cities coupled with improved standard of living, industrialisation, advancement in agricultural and construction activities have contributed to the high level of pollution in the environment. All have hazardous effect on human health and the ecosystem at large (Uluturhan and Kucuksezgin, 2007). The high level of environmental toxicity in many countries around the world, now calls for serious attention towards pollution control (Islam *et al.* 2015; Ahmed *et al.*,

2015a and b). Water and soil pollution have shown serious hazardous consequences in some less developing countries around the globe. When heavy metals are released into the environment especially into the soil and aquatic ecosystem, it may bioaccumulate and biomagnify in the water, soil and may disrupt the organisms' food chain. Consequently, this disruption possibly will have lethal effect or death on the aquatic organisms in the environment while the release of contaminants in high concentration into water bodies is reduce along the water column.

Pollution in water (fresh, brackish or oceanic) according to Kosygin *et al.*, (2007) may be direct or indirect. Water pollution may be associated with sewage deposition, industrial, agricultural and construction activities. While heavy metals in water have been linked to agricultural runoffs from pesticides, herbicides, fertilizers and industrial effluents (ECDG, 2002; Subramanyam and Sambamurty, 2006; Sathwareet *et al.*, 2007), the most severe human pollution sources of water are oil spills, waste disposal and some hazardous manufacturing activities (Santos *et al.*, 2005; Prasannaet *al.*, 2012). Olivares-Rieumont *et al.* (2005) for example, argues that heavy metals may be ubiquitous in soils and water but may be discharged into the water column causing environmental challenges in the community. This discharge therefore may affect the aquatic ecosystem especially in the benthic part, since it is a source of food to both flora and fauna directly or indirectly. More so, pollutants or contaminants may lead to change in water quality (Prasannaet *al.*, 2012). Some of the pollutants that affect water quality include microbes, nutrient, organic and inorganic chemicals, oil, sediments and heavy metals (Ayangbenro and Babalola, 2017). These metals may in turn penetrate the aquatic food cycle resulting into health issues. Although some trace metals like Zn, Cu and Mn perform a biochemical role in the living activities of all fauna and flora, only a little quantity is needed in aquatic environment (Onjefu *et al.*, 2017).

It should be noted that heavy metals from hazardous waste and materials do not degrade but rather they easily bioaccumulate in and pose ecological risk or threats to human health and other ecological lives in the environment (Onjefu *et al.*, 2017). In addition, many previous studies have shown health issues associated with heavy metals (Onjefu *et al.*, 2017; Ayangbenro and Babalola, 2017; Kacholi and Sahu, 2018). Many health assessments study on metals toxicologies have shown that heavy metals can interrupt the structures and functions of enzymes by attaching itself with thiol and protein groups, or by substituting co-factors in prosthetic groups of enzymes (Onjefu *et al.*, 2017). This study location is a swampy and marshy reserved area that has been hijacked by waste (e-waste and plastic) collectors in Amuwo-Odofin Local Government Area (LGA) and converted to their sorting sites. There are no specific

regulations associated with swamplands, erosion, protected areas and the conduct of environmental impact assessment in Amuwo-Odofin Local Government (Adeleke, 2012). This accounts for the reason why waste dumps and scrap sites are set up anywhere within the local government. Therefore the objectives of this study were to investigate the heavy metals, physical, chemical and microbial pollution in water from the e-waste scrap site at Festac Third gate, Alakija, Lagos State.

MATERIALS AND METHODS

2.1 Study location

The study site is an illegal scrap site created by scrap and plastic waste collectors. It is a wetland zone located in Festac Town Third Gate, Amuwo Odofin LGA, (Fig. 1) Badagy Expressway, Lagos, Nigeria. It lies between Latitude 6.4577°N and Longitude 3.2713°E. The location is a major bus stop (see Fig. 2), where commuters use for public and private transport purposes. Although there are other illegal dumpsites within the local government, this site was chosen because people have shops and businesses around the area also there is a water body situated around the site. The water is used by some of the shop occupants while passers-by, public and private drivers and passengers and other residents dispose of wastes, defecate and urinate into the water.

2.2 Sample collection

Water samples were collected from this site between September to December, 2016 representing the dry season, while the wet season samples were collected between May and August, 2017. The water samples were collected in triplicates monthly and a total of twenty-four samples were collected for the two seasons. The water samples at each site were collected into a 2.5ml tight plastic bottles and it was collected from the surface. The surface water samples were collected by immersing the plastic bottles below the water. Sample code was used on each plastic for identification. The samples were cooled with icepacks and transferred cold to the laboratory for analyses.

2.3 Physical analysis of water samples

The samples were transported to the Lagos State Environmental Protection Agency water laboratory for further analysis. The physical parameters were investigated immediately the samples were collected. This is important as transport and storage can affect the parameters. Some of the parameters examined include colour, appearance, temperature, pH, turbidity, and conductivity, total suspended solid,

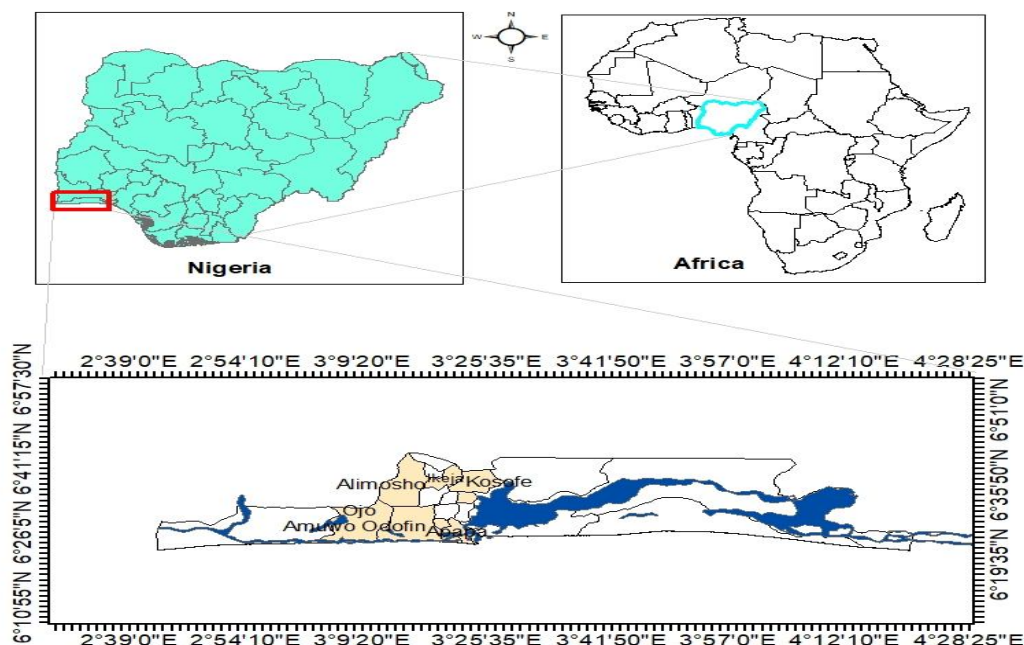


Fig 1: Study Location

dissolved solid and total solid. These parameters were examined using titrimetric method. In addition, pH value and electric conductivity (EC) were measured by using pH meter (model HI 8314) and digital conductivity meter (HI2300 Hanna Ins).

2.4 Chemical analysis of water samples

Some of the chemical parameters investigated include total alkalinity and acidity, nitrate, sulphate, phosphate, biological oxygen demand (BOD) and chemical oxygen demand (COD). These chemical parameters were analysed using UV-Visible Spectrophotometer (Oyiboka, 2014).

2.5 Heavy metal analysis of water samples

Using USEPA method (APHA, 2005), samples were digested for the determination of the heavy metals concentrations. Trace/heavy metals like zinc (Zn), lead (Pb), manganese (Mn), iron (Fe), copper (Cu), chromium (Cr), Nickel (Ni), silver (Ag), and cadmium Cd) were determined. For the detection of heavy metal concentrations, 100ml of water samples were measured and digested into 5ml of nitric acid (HNO₃) using the microwave digestion method at a temperature between 45⁰ and 65⁰C (Oyiboka, 2014). Thereafter, the solution was poured into bottles for heavy metals analyses using Atomic Absorption Spectrophotometer.

2.6 Isolation and Enumeration of total viable bacteria from water samples

Pour plate method was used to get the total bacteria from the water samples. The preparation of buffered

water peptone was done and diluted with the water samples. Afterward, the second 1ml aliquots was diluted with 10ml of the sample, it was inoculated into the plate count agar (PCA) and kept at a temperature of 37 °C for 24 hours (Anon, 1994 and APHA, 1992). Multiple tube fermentation test designed by APHA (1998) was used in the laboratory to isolate the faecal coliform bacteria. Using MacConkey broth, a reasonable coliform test was performed. Three sets of sterilised 10ml of double broth were prepared in five tubes each. Also the tubes were sterilised before the broths were dispensed. By means of sterilised pipette, 10ml, 1m and 1ml water samples were distributed into the 3 sets of tube.

2.7 Bacteria culturing techniques

The bottles were well shaken in readiness for the examination of the general count of bacteria (aerobic plate count) in the water samples, using Water Plate Count Agar (WPCA) at 45°C for culturing (International Standard Organization {ISO} 6222:2010). As the water samples were poured in the agar, the plates were moved in circled in a bid to mix the samples and the agar. The plates were incubated at 2°C for 4 h afterwards, the colonies were counted and the results were written as log colony forming units (CFU/ml).

Furthermore, the water samples were examined for faecal coliform contamination in accordance with relevant ISO standard methods and coliform bacteria (ISO 4788:1990; ISO 4792:1990b). The filtered membranes were cultured into the appropriate agar

plates facing upwards. For faecal coliforms, m-Endo-LES agar (Difco) was used and incubated at $37 \pm 2^\circ\text{C}$ for 22 ± 2 h. For the presence of coliforms, m-FC agar (Difco) was used and plates were incubated in a temperate water bath at $44.5 \pm 0.2^\circ\text{C}$ for 22 ± 2 h. Blue colonies were counted for coliform presence while red metallic colonies were counted for faecal coliforms. The results were reported as CFU/ml.

2.8 Data Analysis

The mean and standard error were analyzed using statistical SPSS version 21 and Microsoft Excel. More so, the significant differences in the concentrations of the parameters in both seasons were determined using One-way ANOVA.

RESULTS AND DISCUSSIONS

3.1 Physical Parameters during the wet and dry seasons

Table 1 showed the physical parameters results obtained from the study location for the dry and wet seasons. The result revealed that almost all the physical parameters differed with seasons. The colour ranged from 40.50 to 46.75pt.Co.AHPA (Platinum Colbat America Public Health Association Method) in the dry season and 84.5-105.00 pt.Co.AHPA in the wet season, when compared to the regulatory limit 250pt.Co.AHPA, it was observed that that the values did not exceed the regulatory limit. The pH in the dry season (7.07-7.11) and in the wet season (7.18-7.28) showed that the water is slightly alkaline and this may probably be due to the construction of road network in the area. In this study, values of the pH water samples were higher during the wet season (7.07-7.11). This may be due to the high level of alkalinity in the water which is as a result of conductivity, a major contributor to alkalinity. More so, increase in concentrations of chloride (87.61-112.40mg/l), sulphate (8.75-11.0mg/l), phosphate (0.93-1.05mg/l) and nitrate (15.97-16.20mg/l) contributed to the high conductivity of the water. Turbidity was also very high; it may be due to waste particles and other construction waste that flooded the area during the rains. Total dissolved solid, total suspended solid and total solid were also higher in the wet season (211.25-277.25mg/l), (33.00-36.50mg/l) and (309.00-319.50mg/l) respectively than in the dry season (7.25-12.5mg/l), (194.0-209.5mg/l) and (209.00-224.00mg/l). One noticeable

29.17- 29.60°C. The overall result showed that all parameters examined in the wet season had higher values than what was obtained in the dry season, this can be seen in Table 1. Results obtained from this study were similar to Hamed *et al.*, (2013) and Silvester and Teresa (2017). When the dry season parameters were compared to the wet season all parameters differ significantly ($p>0.05$) except for temperature ($p<0.05$).

3.2 Chemical parameters

Chemical parameters obtained for the two seasons were shown on Table 2. It can be seen from the results that none of the parameters exceeded the regulatory limits. However, the results showed that the parameters in the wet seasons were higher than the dry season. For example, total acidity in the dry season ranged from 12.00 to 15.25mg/l while that of the wet season ranged from 43.50 to 45.75mg/l, alkalinity from 103.00-123.75mg/l and 516.00 - 546mg/l in the dry and wet seasons respectively. Although no earlier study has been carried out on this site, but the reason for this high parameters in the wet season may be due to increase in the flow of waste, flood and the ongoing construction work. During the wet season, the road, Alakija-Badagry road is usually flooded which sometimes makes it difficult for people to drive or walk through. With the increase in these parameters not all organisms may be able to survive, although they were within the limit, if care is not taken these parameters may still exceed the limits. These results were similar to other works Hamed *et al* (2013), Oyiboka (2014) and Silvester and Teresa (2017) respectively.

thing in both seasons is that all the parameters were within the regulatory limits set by the Lagos State Environmental Protection Agency (LASEPA, 2016) as at the time of this analysis. Temperature was

Table 1: Physical parameters obtained in the wet and dry seasons

Dry season

Month	September	October	November	December	Limits
Parameter					
Colour	43.25±1.181	43.25±1.376	40.50±1.555	46.75±1.181	250pt.Co.AHPA
Appearance	Cloudy particles	with Cloudy particles	with Clear with particle	Clear with particle	Clear
Temperature	29.17±0.132	29.45±0.171	29.35±0.253	29.60±0.173	40°C
pH	7.07±0.023	7.10±0.009	7.11±0.013	7.09±0.155	5.5-9.0
Turbidity	5.20±0.029	5.93±0.887	5.80±0.009	5.09±0.0129	NTU
Conductivity	347±2.4.787	345±2.056	346±6.782	345±17.078	mS/cm
Total suspended solid	7.25±0.629	12.5±1.041	10.7±0.645	8.75±0.854	100mg/l
Total dissolve solid	194±2.489	209.5±1.708	203.25±1.181	196.50±1.	2100mg/l
Total solid	206±1.825	221.00±1.732	224.00±1.707	209.00±4.113	2200mg/l

Wet season

Months	May	June	July	August	Limits
Colour	84.5±1.708	93.25±1.652	94.75±2.0156	105.00±2.160	250pt.Co.AHPA
Appearance	Clear	Clear with particle	Clear	Cloudy with particles	Clear
Temperature	30.00±1.300	30.50±0.645	30.00±1.300	30.25±0.479	40°C
pH	7.18±0.006	7.23±0.019	7.21±0.0138	7.28±0.009	5.5-9.0
Turbidity	11.32±0.132	11.58±0.239	11.52±0.085	11.66±0.114	NTU
Conductivity	630.00±10.614	635.75±8.929	610.00±21.602	629.50±6.958	mS/cm
Total suspended solid	34.75±1.931	36.50±1.190	35.50±1.190	33.00±1.291	100mg/l
Total dissolve solid	275.00±2.082	267.50±8.352	277.25±3.520	211.25±62.082	2100mg/l
Total solid	309.00±3.697	319.00±3.416	319.50±1.708	317.00±4.743	2200mg/l

Co.AHPA: Platinum Colbat America Public Health Association Method

3.3: Trace/Heavy metal concentrations

Table 3 showed the heavy metal results obtained in the two seasons. The level of heavy metal of water depends on conductivity, pH and total dissolve solid (Silvester and Teresa, 2017). More so, it should be noted from the results that the metals decreased in the wet seasons than what was seen in the dry season. This may be due to the fact that the pH of the water increase in the wet season, most of metals may have been diluted during the flood. For, instance, in soil or sediments leaching usually allows the decrease in the values of heavy metals in the wet season. This result corroborates Yi e al., (2011) and Silvester and Teresa (2017). More so, Pb, Cu, Ag, Cd and Ni and Cr were not detected in the water. However, the water may still be monitored because it is closeness to the residential area and many residents depend on dug borehole as a means of clean water.

3.4 Microbial Parameters

The total plate count of bacteria (colonies of bacteria counted in contaminated water) calculated in water samples were found to be too numerous. This implies that the result was higher than the regulatory limit set or waste water. This may be due to high pH. It may also be due to the effect of other waste water at the potholes near the study

site. Furthermore, coliform bacteria were present in all the water samples except for the one collected in the month of November, 2016 but all the samples in the wet season were positive and exceeded the regulatory limits. The total count faecal coliform bacteria (group of total coliform) in water samples were present in the two seasons. It is probably due to the effect waste from around the study location. This may also be due to increase in the temperature and suspended solid. This corroborates the works of Al-Harbi (2003) and Silvester and Teresa (2017).

CONCLUSION AND RECOMMENDATIONS

Due to the various economic activities and the residents living in this area, the site has to be constantly monitored such that the metals do not exceed the stipulated regulatory limits. The results of this present study clearly demonstrated that the area is not contaminated with any hazardous trace/heavy metals. Future studies on trace/heavy metal should be carried out in this area as more sorting sites for plastics and other scraps are growing. More so, due to the too numerous bacteria found around the environment, the health of the people living around this area may be at risk. Constant microbial analysis of the waste water should be carried out.

Table 2: Chemical parameters obtained in the wet and dry seasons

Parameters	September	October	November	December	Limits
Dry Season					
Total acidity (mg/l)	12.00±1.291	13.50±1.258	15.25±1.377	14.25±1.652	NS
Total Alkalinity (mg/l)	123.75±1.493	110.25±3.198	103.00±0.913	109.50±2.217	NS
Chloride mg/l	43.25±1.702	41.25±5.073	46.25±1.4930	46.50±0.957	250mg/l
Nitrate mg/l	1.95±0.171	2.15±0.096	2.10±0.183	2.17±0.085	45mg/l
Phosphate mg/l	0.242±0.022	0.29±0.0621	0.35±0.017	0.29±0.080	2.2mg/l
Sulphate mg/l	35.00±1.080	35.5±1.708	33.5±1.708	32.75±1.250	500mg/l
Dissolve Oxygen mg/l	3.30±0.129	4.17±0.012	3.95±0.184	4.02±0.155	Not less than 2mg/l
Chemical Oxygen Demand mg/l	44.25±2.016	42.50±4.03	44.50±1.708	47.00±1.826	200mg/l
Biological Oxygen Demand mg/l	11.32±1.22	10.80±0.165	11.15±0.214	11.00±0.25	50mg/l
Wet season					
Months	May	June	July	August	Limits
Parameter					
Total acidity (mg/l)	44.75±1.109	44.50±1.708	45.75±1.702	43.50±1.443	NS
Total Alkalinity (mg/l)	531.00±4.20	546.00±6.250	539.00±6.351	516.00±25.681	NS
Chloride mg/l	112.40±1.116	114.67±1.397	112.15±0.456	87.81±25.492	250mg/l
Nitrate mg/l	16.02±0.421	16.07±0.430	15.97±0.421	16.20±0.497	45mg/l
Phosphate mg/l	0.91±0.137	0.93±0.040	1.05±0.0642	0.96±0.012	2.2mg/l
Sulphate mg/l	9.50±0.646	11.00±1.41	8.75±0.854	9.25±1.109	500mg/l
Dissolve Oxygen mg/l	4.747±0.062	4.71±0.024	4.83±0.053	4.67±0.055	Not less than 2mg/l
Chemical Oxygen Demand mg/l	86.75±1.315	87.00±1.871	86.50±1.500	86.75±0.854	200mg/l
Biological Oxygen Demand mg/l	22.24±0.348	21.68±0.528	22.51±0.528	21.60±0.428	50mg/l

Note: NS: Not Specified NTU: Nephelometric Turbidity unit

Table 3: Trace/Heavy metal concentrations in both dry and wet

Dry Season					
Parameters	September	October	November	December	Limits
Zinc	0.00±0.000	0.27±0.027	0.00±0.003	0.15±0.015	5.0 mg/l
Copper	0.00±0.000	0.00±0.000	0.00±0.000	0.00±0.000	3.0 mg/l
Iron	0.12±0.077	0.24±0.114	0.14±0.097	0.12±0.073	10 mg/l
Chromium	0.01±0.009	0.01±0.007	0.06±0.047	0.03±0.023	0.1 mg/l
Manganese	0.01±0.007	0.01±0.003	0.01±0.006	0.06±0.004	5.0 mg/l
Lead	0.00±0.000	0.00±0.000	0.00±0.000	0.00±0.000	0.1mg/l
Cadmium	0.00±0.000	0.00±0.000	0.00±0.000	0.00±0.000	2.0mg/l
Nickle	0.00±0.000	0.00±0.000	0.00±0.000	0.00±0.000	3.0mg/l
Silver	0.00±0.000	0.00±0.000	0.00±0.000	0.00±0.000	<0.10mg/l
Wet season					
Month	May	June	July	August	limits
Zinc	0.00±0.003	0.00±0.000	0.05±0.029	0.00±0.000	5.0 mg/l
Copper	0.00±0.000	0.00±0.000	0.00±0.000	0.00±0.000	3.0 mg/l
Iron	0.06±0.004	0.05±0.002	0.07±0.018	0.09±0.100	10 mg/l
Chromium	0.00±0.000	0.00±0.000	0.00±0.000	0.00±0.000	0.1 mg/l
Manganese	0.03±0.005	0.04±0.022	0.05±0.022	0.02±0.005	5.0 mg/l
Lead	0.00±0.000	0.00±0.000	0.00±0.000	0.00±0.000	0.1mg/l
Cadmium	0.00±0.000	0.00±0.000	0.00±0.000	0.00±0.000	2.0mg/l
Nickle	0.00±0.000	0.00±0.000	0.00±0.000	0.00±0.000	3.0mg/l
Silver	0.00±0.000	0.00±0.000	0.00±0.000	0.00±0.000	<0.10mg/l

Table 4: Microbial Parameters

Dry Season					
Month	September	October	November	December	Limits
Parameter					
Total plate count	TNTC	TNTC	TNTC	TNTC	350cfu/ml
Presence of Coliform	>2420	>2420	>2420	>2420	Negative
Confirmatory faecal Coliform Test	Positive	Positive	Negative	Positive	Negative
Wet Season					
Month	May	June	July	August	
Total plate count	TNTC	TNTC	TNTC	TNTC	350cfu/ml
Presence of Coliform	Positive	Positive	Positive	Positive	Negative
Confirmatory faecal Coliform Test	Positive	Positive	Positive	Positive	Negative

TNTC: Too numerous to count

ACKNOWLEDGMENTS

My sincere appreciation goes to Mr K. Orilogbon and Mr A. Subaru who helped in collecting the water samples and LASEPA water laboratory staff for carrying out the analyses.

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