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ORIGINAL RESEARCH

Heavy Metals Concentration In Underground Water And Its Environmental Health Effects: A Case Study Of Solous Dumpsite, Igando, Lagos

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Abstract:
Introduction: Waste dumping site is a method of disposing commercial, domestic and industrial waste such as heavy metals.
Aim: To investigate the heavy metals concentration in underground water around Solous dumpsite in Igando, Lagos and its effect on human.
Materials and Methods: Water samples from 12 different locations within a distance range of 0.07 - 0.72 km were collected while structured questionnaire was administered to 120 respondents to find out their perceptions about the environment and possible ill-health effect of water. The physicochemical parameters were measured and heavy metals concentration of the water samples were determined using Flame Atomic Absorption Spectrometer.
Results: The water samples contain heavy metals concentrations: Lead (Pb) (0.08-1.20 mg/L), Cadmium (Cd) (0.03-0.08 mg/L), Iron (Fe) (1.4-12.3 mg/L), Nickel (Ni) (0.08-0.19 mg/L), Zinc (Zn) (0.05-0.13 mg/L) and Manganese (Mn) (0.01-0.04 mg/L) respectively. It was revealed that age, educational qualification and year of living in the community explain a significant variance in the perception of the respondents on effect of heavy metal contamination. Furthermore, over 75% of the respondents were not sure of any prior ailment linked to heavy metal contamination.
Conclusion: All water samples analysed were contaminated with heavy metals and respondents were ignorant of the danger. Thus, there is a need for proper provision of safe alternative water supply to the communities in the neighborhood of dumpsite for domestic use and raising awareness on environmental impact of heavy metal toxicity in drinking water to avert serious health challenges.

To Keywords: Heavy metal, Dumpsite, water, Solous

All co-authors agreed to have their names listed as authors.

1. INTRODUCTION

The continuing increase in population and rise of basic industrial developments in major cities of the World has led to greater influence on the environment [1,2]. The activities of human generate huge waste and if poorly managed will give rise to serious environmental pollution [3,4] which affects the socioeconomic of an area as well as the public health [1].

Waste dumping site is an old traditional method of disposing waste situated far away from residential areas [1, 5]. Landfilling is the simplest, cheapest and most cost-effective method of disposing of solid wastes [6]. The wastes are then sorted-out into degradable, non-degradable and recyclable materials by modern landfill facilities. There is no method of waste management of commercial, domestic and industrial waste that is completely safe [1,7]. The poor waste management of dumpsites could result into several adverse environmental and health impacts through attraction of mice, wind-blow litters, methane and carbon dioxide gas produced through biodegradation and underground soil bed or aquifer pollution from leachate [1]. Leachate formed by the filtration of precipitation water through an open landfill may contain large amounts of contaminants such as ammonia, halogenated hydrocarbons suspended solid, inorganic salts, and heavy metals [8-10]. These contaminants bio-accumulate in the soil and through interaction with the soil components, enters food chain through plants or animals [1,11,12]. These contaminants also cause pollution to the underground water thus pose substantial risk to local users and become a major environmental problem [13,14]. Underground water is a valuable source of water supply to industry, domestic, recreation, commerce and agriculture purposes. The major source of water supply for potable drinking water can be from either shallow hand-dug wells or boreholes [15,16]. Contamination of the underground water with heavy metals from leachate can thus be injurious to human life. The toxic level of heavy metals depends on the type of metal wastes at the dumpsite, its degradation and the type of organisms that are exposed to it. The heavy metals such as lead, iron, cadmium, arsenic, copper, zinc, chromium etc in drinking water causes human disease condition. Heavy metals have been shown to also accumulate in plant tissues due to their persistence in the environment [17-23]. The accumulation of heavy metals in human results in oxidative stress in the cell leading to diverse pathologies such as carcinogenesis, brain damage, mental retardation, gastrointestinal abnormalities, etc [17-19, 23-25]. The objective of this study is to assess heavy metals concentrations in groundwater around Solous dumpsite in Igando Lagos State, Nigeria using physicochemical investigating method and administration questionnaire and comparing the data generated with the standards from global regulatory bodies thereby ensuring safety of lives and sustainability of the environment.

2. MATERIAL AND METHODS

2.1 STUDY AREA

This study area covers the Solous dumpsite situated within the longitude 3^{o}26 E to 3^{o}25 E and latitude 6^{o}56N to 6^{o}57N in Alimosho Local Government area of Lagos State, Nigeria as described by Majolagbe et al. [26]. It is surrounded by residential areas, an abattoir and Oba stream that is located about 2.5 km east ward of the dumpsite. The wastes brought to this dumpsite are of different types, ranging from organic to inorganic, hazardous to non-hazardous. Water samples from twelve (12) sampling locations (Fig. 1) of varying depth, and distance from the dumpsite as presented in Table I. The water samples were collected in 60 cl capacity polythene bottles, kept under 4^{0}C till further laboratory analyses.

2.2 CHEMICAL ANALYSES

Chemical reagents used are of analytical grade from Sigma-Aldrich Inc, St. Louis, USA. Physico-chemical parameters: Total hardness (TH), nitrates and phosphates were performed according to the standard methods of American Public Health Association [27], while the pH (pH meter), colour, and electrical conductivity (EC) (Mettler Toledo) of the water samples were determined in-situ. The heavy metals (copper, cadmium, nickel, iron, lead, manganese and zinc) concentrations were analyzed with Perkin Elmer A Analyst 200 Flame Atomic Absorption Spectrophotometer.

2.3 QUESTIONNAIRE

Simple random sampling of the households was done across the households around the dumpsite. A pre-tested questionnaire and a face-to-face interview were used to capture data on the respondents' knowledge and perceptions on whether the dumpsite posed any health risk to them and a source of heavy metal contamination to the underground water they used.

2.4 STATISTICAL ANALYSIS

Results of heavy metals analyses are expressed as mean ± SD was also generated. One way analysis of variance (ANOVA) followed by Tukey's and T-test was used to analyze the results with $p< 0.05$ considered significant. Associations among the parameters and their magnitudes were determined using Pearson correlation. Multiple regression was used to analyze the questionnaire with significance established at $p< 0.05$.

3. RESULTS AND DISCUSSION

The description of the dumpsite location (Fig. 1) and the sampling locations, types of underground water source, and depth of water sample is presented in Table I.

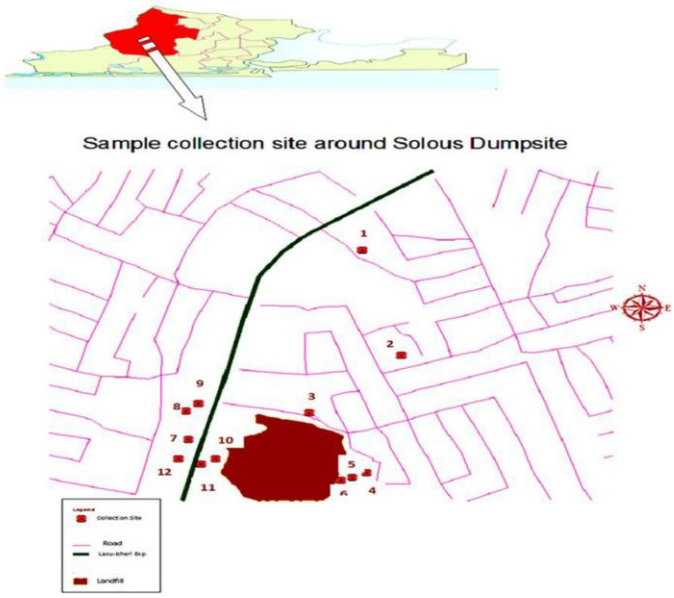

Fig 1: Map showing the study area and sample collection sites of Solous dumpsite from Alimosho Local.

Table I: Description of underground water samples

Water sample locations	Location	Distance from the Dumpsite (m)	Type	Depth(m)
Location 1	Latitude: 6.57229 Longitude: 3.25441	720	Borehole	44.23
Location 2	Latitude: 6.56797 Longitude: 3.25616	400	Well	36.60
Location 3	Latitude: 6.565579 Longitude: 3.2537	70	Borehole	61.00
Location 4	Latitude: 6.56376 Longitude: 3.25521	330	Well	64.05
Location 5	Latitude: 6.56353 Longitude: 3.25485	330	Well	45.75
Location 6	Latitude: 6.56355 Longitude: 3.25462	310	Borehole	54.90
Location 7	Latitude: 6.56483 Longitude: 3.25068	300	Well	33.55
Location 8	Latitude: 6.56595 Longitude: 3.25061	280	Borehole	54.90
Location 9	Latitude: 6.56621 Longitude: 3.25089	250	Borehole	51.85
Location 10	Latitude: 6.56425 Longitude: 3.25144	270	Borehole	76.25
Location 11	Latitude: 6.5642 Longitude: 3.25099	310	Borehole	42.70
Location 12	Latitude: 6.56427 Longitude: 3.25045	350	Borehole	33.55

The physico-chemical parameters of the collected underground water samples are shown in Table II. Water samples from some of the locations were colourless, but location 3, 5, 8, 11 and 12 were cloudy, brownish, brownish yellowish and light yellow in colour respectively. The observed colour could be attributed to contamination from the dumpsite. The measurement of pH relates to the acidity or alkalinity of the water. The investigated underground water has pH value range within the World Health Organization (WHO), Standard Organisation of Nigeria (SON) and Nigerian Standard for Drinking Water Quality (NSDWQ) acceptable range of 6.5 - 8.5 for drinking water [28 - 30]. It was observed that locations 1 and 2 were acidic water with pH less than 7.0 and locations 3 to 12 has alkaline or basic water with pHs greater than 7. This is similar to the result reported by Oluseyi et al. [16] and Majolagbe et al. [26]. The consumption of acidic water has been linked to several disease conditions such as cancers, ulcer and intestinal proliferation [31]. The electrical conductivity (EC) values were found to be within the range of WHO and NSDWQ standard with the exception of four water samples location 5, 6, 11 and 12 which were above the allowable level for potable water. Electrical conductivity is an indication of the amount of total dissolved substitution like heavy metals, in water [32], hence high EC values observed reflect that there is high ion-exchange between the soil and water. The measure of the presence of calcium and magnesium level in water is the total hardness of the water. This result revealed least total hardness value of 17.8 ppm and highest value of 720 ppm which is similar to report of Yusuf [33]. The high value of total hardness renders the water inadequate in laundry work and causes extreme scale formation. The present study revealed phosphate contents ranging between 1.00 and 2.00 mg/L. Although phosphate is absent in drinking water [33], hence, the observed values indicated that all the water samples are contaminated. All samples water has value range below the recommended NSDWQ nitrate value of 50 mg/L for drinking purposes [33, 34].

Table II: Physico-chemical parameters of the collected underground water samples

Sample locations	Color	pH (Mean±S.D)	EC (μS/cm)	TH (ppm)	N (mg/L)	P (mg/L)
Location 1	Colorless	6.15±0.08	83.1	17.8	2.5	1.00
Location 2	Colorless	6.50±0.01	187.0	53.4	2.5	1.00
Location 3	Cloudy	7.46±0.06	122.5	17.8	1.5	1.00
Location 4	Colorless	7.18±0.03	153.5	17.8	2.5	1.00
Location 5	Cloudy	7.83±0.04	1406.0	124.6	10.0	2.00
Location 6	Colorless	8.02±0.01	1676.0	89.0	40.0	1.50
Location 7	Colorless	7.89±0.02	288.0	35.6	5.0	1.50
Location 8	Brownish yellow	7.51±0.01	359.0	720.0	2.5	1.00
Location 9	Colorless	7.49±0.01	353.0	530.0	1.5	1.50
Location 10	Colorless	7.55±0.03	78.2	17.8	1.0	1.50
Location 11	Yellow	8.55±0.00	6570.0	356.0	2.5	1.75
Location 12	Light yellow	8.23±0.00	2940.0	267.0	10.0	1.00

TH-Total Hardness; EC- Electrical conductivity; P-Phosphate; N- Nitrate.

Table III revealed the heavy metals concentration (mg/L) in all the water sample analysed. High level concentrations of heavy metals in drinking water may be due landfill operations [34] which can cause either acute or chronic health conditions such as skin rash, lung irritation, cardiovascular illness, cancer, organ damage, nervous system disorder and immune system damage [17, 19, 35]. It was observed that manganese (Mn) and zinc (Zn) are lower than the regulatory limit in all the water samples and the concentrations of iron (Fe), lead (Pb), nickel (Ni) and cadmium (Cd) were found to exceed the regulatory limit for drinking water, but copper (Cu) was not detected in all the samples water. This result is in agreement with the report of Ogundiran and Afolabi [36]. The high iron level observed in the water samples results in precipitation problems [34] that may be due to high content of iron-based waste materials been generated through domestic and industrial wastes. Although, Pb poisoning is occasionally, but acute or chronic humans and animals' exposure to it as expected in the area investigated in this study can produce adverse health effects that may include liver and kidney damage, internal hemorrhage, and respiratory disorders, haematological damage, increases in blood pressure of some adults, lead-palsy, headache, malaise, diarrhoea, delays in normal physical and mental development in babies and young children [35, 37-39]. Likewise, prolong exposure of humans and animals to high concentration of cadmium as shown in this study might results in several health conditions, such as oxidative stress [17] gastrointestinal disorder, reduction in male fertility, hypertension, anemia, liver damage and kidney dysfunction. In humans the kidney is considered to be the critical target organ susceptible to damage by chronic exposed to cadmium [35, 36 – 38, 40]. Also, exposure to high levels of nickel as observed in this study, has been shown to result in chronic toxic effects as carcinogens in animals and humans [41].

Table III: Heavy Metals concentration (mg/L) in all sample collected

Samples	Cu	Zn	Fe	Pb	Mn	Ni	Cd
Location 1	ND	0.07	1.50	0.60	0.01	0.14	0.08
Location 2	ND	0.06	1.80	0.50	0.01	0.12	0.08
Location 3	ND	0.06	3.40	0.70	0.01	0.16	0.05
Location 4	ND	0.07	3.90	0.80	0.00	0.12	0.04
Location 5	ND	0.13	1.50	1.20	0.02	0.19	0.05
Location 6	ND	0.06	1.40	0.50	0.03	0.15	0.07
Location 7	ND	0.06	1.60	0.80	0.04	0.16	0.07
Location 8	ND	0.06	12.30	0.80	0.04	0.14	0.06
Location 9	ND	0.06	4.70	0.70	0.03	0.14	0.05
Location 10	ND	0.08	2.20	1.10	0.01	0.12	0.03
Location 11	ND	0.06	9.10	0.90	0.01	0.17	0.06
Location 12	ND	0.05	5.30	0.90	0.01	0.18	0.06
WHO Standard[1]	2.00	3.00	0.30	0.01	0.40	0.07	0.003
SON[2]	1.00	3.00	0.30	0.01	0.20	0.02	0.003

Cu: Copper; Zn: Zinc; Fe: Iron; Pb: Lead; Mn: Manganese; Ni: Nickel; Cd: Cadmium; ND- Not detected; 1: WHO, 2006. 2: Standard Organisation of Nigeria (SON), 2015.

In this study, the questionnaire for the evaluation of the perception of the respondents on heavy metals and their effect on humans had 12 items with Cronbach's alphas 0.806 (Table IV). It was revealed that 74.2 %, 81.7 % and 70.8 % of the respondent strongly agree that dumpsite increase heavy metals in the environment, can pass from the dumpsites to the human body through drinking or utilization of contaminated underground water and cause diseases. It takes long time for heavy metals contamination through drinking water to show its harmful effects as strongly agree by 71.7 % respondents. Only 3.3 % strongly agree that there has been any report of symptoms associated with lead and cadmium poisoning. 15.0 % of the respondent confirm that there are some ill health symptoms suffered by the community using the underground water. There is no one that strongly agree with symptoms associated with nickel toxicity. For zinc, copper and manganese toxicity, only 1.7 %, 0.8 %, 1.7 % respondents strongly agree their associated symptoms. These few responses from the respondents confirm that there are ill health symptoms associated with heavy metal contamination.

Table IV: Perception of respondents on heavy metals and their effect on human

Have you heard of heavy metals?	Yes		No		
	113(94.2)		7(5.8)		
ITEMS	**SD n(%)**	**D n(%)**	**NS n(%)**	**A n(%)**	**SA n(%)**
Dumpsite Increase Heavy Metal in Environment	0	1(0.8)	2(1.7)	28(23.3)	89(74.2)
Heavy metals can pass from the dumpsites to the human body through drinking or utilization of contaminated underground water	0	1(0.8)	00	21(17.5)	98(81.7)
If these heavy metals accumulate in the human body, they can cause diseases	1(0.8)	00	1(0.8)	33(27.5)	85(70.8)
The harmful effects of the dumpsite on the human body take long to show themselves.	1(0.8)	00	7(5.8)	26(21.7)	86(71.7)
There have been report of any of the following: loss of appetite, headache, hypertension, abdominal pain, renal dysfunction, fatigue, sleeplessness, arthritis, hallucinations and vertigo cases associated with Lead poisoning by some people using this water	6(5.0)	10(8.3)	76(63.3)	24(20.0)	4(3.3)
Mental retardation, birth defects, psychosis, autism, allergies, dyslexia, weight loss, hyperactivity, paralysis, muscular weakness, brain damage, kidney damage are some of the ill health symptoms suffered by some dwellers in this community	8(6.7)	14(11.7)	65(54.2)	15(12.5)	18(15.0)
Stomach irritation that results in vomiting and diarrhea. Kidney disease, fragile bones and lung damage that could be attribute to exposure to Cadmium has been reported or occur among residents	9(7.5)	16(13.3)	86(71.7)	5(4.2)	4(3.3)
There have been cases of gastrointestinal ulcerations and cancers among the residents in this community which could be attribute to Iron contamination of the underground water used	10(8.3)	16(13.3)	88(73.3)	49(.3)	2(1.7)
Some health problems that had led to decrease of body weight, heart and liver damage and skin irritations which are associated with high level of Nickel has been reported among people in the community	7(5.8)	16(13.3)	89(74.2)	8(6.7)	00
There have been cases of people in the community which have ailment that involve vomiting, diarrhoea, pancreatitis and damage of liver, which are associated with zinc toxicity	10(8.3)	23(19.2)	83(69.2)	2(1.7)	2(1.7)
Adverse health effects including liver and kidney damage, anaemia, immunotoxicity which are associated excess Copper had been reported among some people in this community	12(10.0)	14(11.7)	88(73.3)	5(4.2)	1(0.8)
Adverse health effect that lead to progressive, permanent neurodegenerative disorder, with few options for treatment and no cure which is associated with excess Manganese has been reported in the community	12(10.0)	15(12.5)	87(72.5)	4(3.3)	2(1.7)

The Socio Demographic Data of the Respondents is shown in Table V. It revealed that 58.9% of the respondents were male while 47.1% were female. 43.3% of respondents have been living in the community within 5-10 years, 30.8% of the respondents having been living in the community for more than 10 years, while 25.8% have been living in the same community for less than 5 years.73.3% of the respondents are tenants whiles 26.7% are tenants in the houses where they reside. A total of 96.7% of respondents indicated that their houses were <1km from the dumpsites, while 3.3% respondents indicate that their house is within 1-3 km from the dumpsite.

Table V: Socio demographic data of the respondents

	Frequency	Percentage
Gender		
Male	70	58.3
Female	50	47.1
Total	120	100
Age		
18-25	27	22.5
26-35	47	39.2
36-50	30	25.0
51 and above	16	13.3
Total	120	100
Marital status		
Single	43	35.8
Married	75	62.5
Divorced	2	1.7
Widow	0	0
Total	120	100
Living duration		
<5years	31	25.8
5-10 years	52	43.3
>10 years	37	30.8
Total	120	100
Housing status		
Tenant	88	73.3
Owner	32	26.7
Total	120	100
Educational qualification		
Primary	13	10.8
Secondary	85	70.8
Tertiary	21	17.5
No formal education	1	0.8
Total	120	100
Employment status		
Employed	52	43.3
Self-employed	52	43.3
Unemployed	16	13.3
Total	120	100
Distance of House from dumpsite		
<1km	116	96.7
1-3km	4	3.3
4-7km	0	0
>7km	0	0
Total	120	100

4. CONCLUSION

This study shows that all the water samples collected and analysed from the 12 locations around the Solous dumpsite were contaminated by heavy metals. This could be linked to seepage of the leachate from the landfill to surrounding environment, which poses great danger to human. The respondents were found to be ignorant of the danger attached to high level of heavy metal contamination due to long time accumulation. Hence, measures should be put in place to provide alternative safe water supply to the dumpsite community for domestic use by the regulatory agencies and awareness on environmental heavy metal toxicity in drinking water should be stepped-up to prevent serious health challenges.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

AUTHORS' CONTRIBUTIONS

'Author OO' designed the study. 'Authors OO' and OJ' managed the analyses of the study and wrote the protocol and the manuscript. 'Author OJ' managed the literature searches and the analyses of the study, performed the statistical analysis. 'Author BE' give guidance on the protocol. All authors read and approved the final manuscript."

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