Archives of Current Research International

9(3): 1-12, 2017; Article no.ACRI.35999
ISSN: 2454-7077

Evaluation of Emerging Threats of Contaminants in Boreholes along Ikot Effanga Dumpsite, Calabar Municipality, Nigeria

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Authors' contributions

This work was carried out in collaboration between all authors. Author IEA designed the study, author JAP performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. Author AAB managed the analyses of the study. Authors OBE and ESE managed the literature searches. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/ACRI/2017/35999
Editor(s):
(1) Haifei Shi, Department of Biology, Physiology and Neuroscience, Miami University, USA.
(2) Ayona Jayadev, Department of Environmental Sciences, All Saints' College (Government Aided College Affiliated to University of Kerala), India.
Reviewers:
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(2) Dorota Porowska, University of Warsaw, Poland.
(3) Aniekan Edet, University of Calabar, Nigeria.
Complete Peer review History: http://www.sciencedomain.org/review-history/20971

Original Research Article

Received 7th August 2017
Accepted 8th September 2017
Published 14th September 2017

ABSTRACT

Aim: The study was aimed at evaluating the emerging threats of contaminants in boreholes along Ikot Effanga dumpsite.

Methodology: Groundwater samples were aseptically collected from Five (5) boreholes around the dumpsite into a 1 liter bottle and leachates were also collected in two points of the dump site. Samples were collected monthly from April to June, 2016. The water and leachates were analyzed for heavy metals spectrophotometrically in mg/l. Physico-chemical parameters were also analyzed using appropriate methods.

Results: The levels of turbidity, conductivity, dissolved oxygen, nitrate, manganese, iron, sulphate, chlorine, lead, phosphate and sodium of the leachates from the dump site were all above the WHO acceptable limit, but temperature, pH and total hardness were within the limit. The DO, pH, iron,

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lead, nitrate and phosphate content of ground water 2, 3, 4, 5 were all not within the WHO acceptable range. The levels of manganese were above the WHO limit for ground water 2, 4 and 5. Also, temperature, conductivity, total hardness, alkalinity, turbidity, sodium, chloride and sulphate content of the five (5) ground water samples were all within the WHO limit, but in most cases the control ground water (GW 1) recorded the lowest values. This denotes that the contaminated leachates from the dump site led to the corresponding contamination of the nearby ground waters, making them unsafe for consumption. Statistically, the temperature, conductivity, total hardness, alkalinity, $NO3^-$, $PO4^-$, turbidity, $SO4^{2-}$, Cl^-, Mn, Fe, Pb and Na varied significantly between the ground waters at *P<.05*.

Conclusion: The dumpsite led to the contamination of ground water, as a result, further research on the quality of the ground water need to be carried-out, in order to reveal the health consequences of drinking from ground water close to Ikot Effanga dump sites by evaluating the bacterial and coliform levels of these ground waters.

Keywords: Contaminants; heavy metals; physico-chemical parameters; dumpsite.

1. INTRODUCTION

Groundwater is one of the essential natural resources in any country. In Nigeria, the use of groundwater for public water supply is relatively high with about 40% of the population using it for domestic purposes. Groundwater occupies nearly 97% of the world as source of fresh water and becomes dominant reserve [1]. As fresh water retain nearly 68.7% in polar ice caps and glaciers, about 30.1% of it, is stored as groundwater and not available for use [2]. Groundwater is an important source of portable water in every community and also for irrigation [3].

The rate of people taking drinking water from hand dug wells and boreholes are on the increase each day [3]. Groundwater contamination includes open dumpsite, poorly constructed or maintained landfills, latrines and other waste sites. Each of these generates pathogens and toxins along with heavy metals which can percolate downward and contaminate the aquifers [4]. Others causes of groundwater contamination are indiscriminate disposal of waste such as motor oil, detergents and cleaners into the nearby channel as these can leak into the water sources [5]. It is also evident that groundwater pollution can arise on a different time scale than surface water contamination as slow as 3.2 kilometers a year. The percolation rate depends on the topography; hydrology and the sources of groundwater recharge [6].

The health risks from polluted groundwater depend on the specific pollutants in the water, as these causes diarrhea and stomach disorder with possible severe associated health problems; like cancer, reproductive challenges and others [6]. Solid waste management has remained an undisputable environmental problem in the developing countries of the world and stands out amongst the arrays of global environmental hazards besieging metropolitan cities. The problem has become increasingly complex due to the increase in human population, industrial and technological revolutions, in addition to the fact that the processes that control the fate of wastes in the receiving media are complex. The indiscriminate handling and disposal of waste, leads to environmental degradation, destruction of the ecosystem and poses great risks to public health [7]. The study is aimed at assessing the contamination impact of Ikot Effanga dump site on nearby ground water, with the objectives of evaluating the physico-chemical parameters and levels of heavy metals contamination of ground water and the safety for consumption of the ground water around the dump site.

2. MATERIALS AND METHODS

2.1 Study Area

The Ikot Effanga dumpsite is an open dumpsite situated adjacent to North West filling station, along Lemna Road in Calabar Municipality of Cross River State, Nigeria. The dumpsite covers approximately fifteen (15) hectares of land. It falls within the South-East zone of Nigeria. The study area lies between latitude 04°15' N and longitude 8° 25' E (Fig 1) and covers the Calabar Municipality area of Cross River State. The climate features a tropical heavy rainfall with a lengthy wet season covering 10 months (January - October) and a shorter dry season covering the remaining two months (November and December). The harmattan which significantly influence weather in west Africa is noticeably less pronounced in the city. Temperature are relatively constant throughout the year, with average high temperature ranging from 25-28°C. The Calabar area belongs to the lowland and swampland of South-eastern Nigeria [8].

The vegetation of the study area is characterized by mangrove swamp and rainforest, but due to human activities like cutting down of trees, for roads, building of houses, schools and market it has resulted in the depletion of the rainforest. The soil is composed of coastal plain sand which belongs to tertiary deposits. The alluvial deposits are used for construction with light brown and grey colour. Hydrological Province of the study area is grouped into basement and intrusive rocks, sandstone, shale and alluvial deposits. The lithology is characterized by an underlying aquifer. The surface and ground water bodies are recharged by high precipitation. The aquifer is confined with few aquicludes made up of silt, clay and sandstone. The Ikot Effanga dump site is over a decade old and is close to Ikot Effanga Mkpa stream.

The main activities of the study area are farming, auto-mechanic repairs, picking of recyclable waste by scavengers, construction activities by LEMNA Company and petrol selling by North-west filling station.

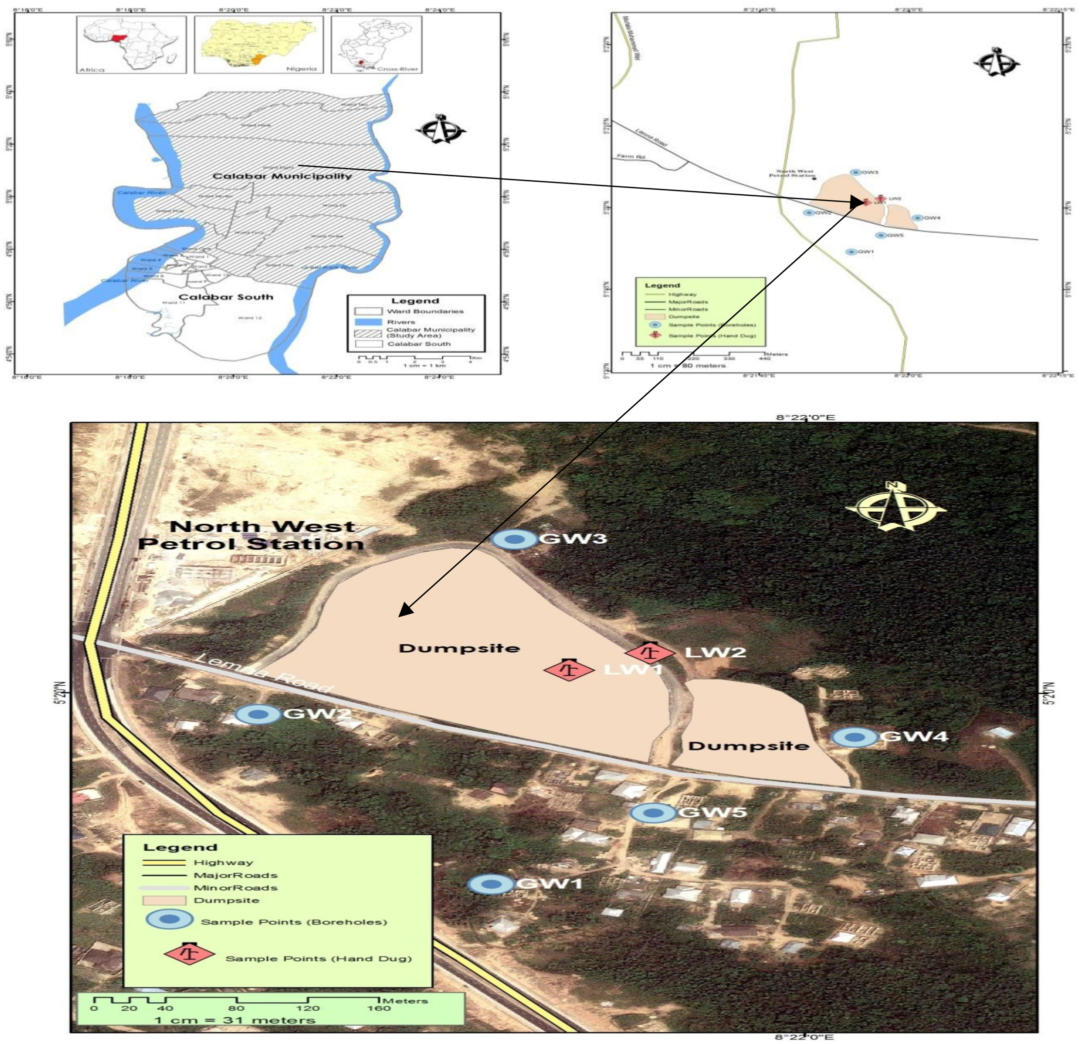

Fig. 1. Map showing the Ikot Effanga dump site and the ground water stations

2.2 Collection of Borehole and Leachates Samples

In a bid to determine the impact of the open dumpsite on groundwater quality in Ikot Effanga dumpsite, ground water samples were collected from Five (5) existing boreholes, which are about four (4) inches in depth within a 100-386 meters range from the dumpsite. The control ground water point (GW1) was the farthest form the dump site. Leachates were also collected from two points of the dump site, at about one (1) meters depth. The borehole water samples were collected once in a month for a period of three (3) months; from April to June, 2016, and a total of fifteen (15) water samples were collected in all. Groundwater samples were collected aseptically; by using methylated spirit to clean the mouth of the tap using and then water samples collected using 1 liter plastic bottle which has been cleaned by soaking in 10% nitric acid and rinsed with distilled water. At the sampling site, groundwater samples were labelled GW1 (Control), GW2, GW3, GW4 and GW5 respectively. Immediately after collection of the ground water and leachates samples, they were preserved in an ice chest before transporting to Cross River State Water Board Treatment Laboratory for analysis of heavy metals using UV/VIS Spectrophotometer (HACH 5000) in accordance with [9,10,11].

2.3 Laboratory Analysis for Heavy Metals

In the laboratory, the samples were digested according to standard methods for the examination of water and waste water [9]. Each sample was thoroughly mixed, 20ml of each sample was transferred into a conical flask, then 10ml concentrated nitric acid was added to it and brought to slow boiling before evaporating on a hot plate to lowest volume. (5-10ml) concentrated HNO_3 acid was added until digestion was completed, as shown by a light colour clear solution. Metal concentration in the digest was determined using UV/VIS Spectrophotometer (HACH 5000) in Cross River State Water Board Treatment Laboratory. The metals analyzed were Iron, Manganese and Lead to the nearest milligram per litre (mg/l).

2.4 Physico-chemical Parameters Measurement

Water Temperature, pH, Electrical conductivity and Dissolved oxygen were all measured in-situ using their respective equipment as described by [12,13,14]. Dissolved Oxygen was measured using dissolved Oxygen (D.O) meter (DO-5509 model) in mg/l, Hydrogen ion (pH) concentration was determined using a pocket sized pH meter (pH-1 model). A thermometer was used to measure temperature in degree celsius. Also, Electrical Conductivity was measured with the aid of Hannah conductivity meter (BM-211 model) to the nearest µs/cm. All the other parameters were analyzed in the laboratory. Nitrate content, Phosphate content, Chloride content, Total hardness, Sulphate content, sodium content were all determined using UV/VIS Spectrophotometer (HACH 5000) in Cross River State Water Board Treatment Laboratory, Calabar. The criterions behind the selection of these parameters are based on the parameters being the common pollutants in groundwater resources around the dumpsites.

2.5 Statistical Analysis

The obtained data were subjected to descriptive statistical analysis such as mean, standard deviation and ranges. Analysis of variance (ANOVA) statistics were used to test for the significance of difference in the physico-chemical parameters and heavy metals between the five (5) ground water samples (for the 15 ground water samples) at 0.05 level of significance and at their relevant degree of freedom. All statistical analysis was done using Predictive analytical software (PASW).

3. RESULTS

3.1 Physico-chemical Parameters of Leachate

The summary of the mean leachate physico-chemical parameters from Ikot Effanga dump site is shown in Table 1. Water temperature of the leachate varied from 27.6 to 27.7°C, with a mean and standard deviation of 27.650 ± 0.070°C. The leachate had a pH range of 6.88 to 7.61, having a mean and standard deviation of 7.245 ± 0.456. The leachate turbidity varied from 123.4 to 128.5 N.T.U (Nephelometric turbidity unit), with a mean and standard deviation of 125.95 ± 3.606 N.T.U, while the conductivity ranged from 1194 to 1350 µs/cm and having a mean of 1272.00 ± 110.308 µs/cm. The leachate had a dissolved oxygen range of 0.60 to 0.80 mg/l, having a mean and standard deviation of 0.700 ± 0.141 mg/l. The total hardness varied from 368.7 to 495.1 mg/l, with a mean and standard deviation of 431.90 ± 89.378 mg/l, while the nitrate ranged from 80.3 to 86.4 mg/l and having a mean of 83.350 ± 4.313 mg/l. The sulphate content of the leachate varied from 132.4 to 146.0 mg/l, with a mean and standard deviation of 139.20 ± 9.616 mg/l, while chlorine content ranged from 245.0 to 763.0 mg/l and having a mean of 504.00 ± 366.281 mg/l. The phosphate content of the leachate varied from 166.0 to 364.9 mg/l, with a mean and standard deviation of 265.45 ± 140.643 mg/l, while sodium content ranged from 213.0 to 358.1 mg/l and having a mean of 285.55 ± 102.601 mg/l (Table 1).

The levels of turbidity, conductivity, dissolved oxygen, nitrate content, sulphate content, chlorine, phosphate content and sodium content of the leachates from the dump site were all above the WHO acceptable limit, but temperature, pH and total hardness values fell within the limit (Table 1).

3.2 Heavy Metals Concentration in Leachate

The summary of the mean of some heavy metals concentration in the leachates from Ikot Effanga dump site is shown in Table 2. The concentration of manganese varied from 3.42 to 6.70 mg/l, with a mean and standard deviation of 5.060 ± 2.319 mg/l. The leachate had an iron concentration range of 27.9 to 34.8 mg/l, having a mean and standard deviation of 31.350 ± 4.879 mg/l. The concentration of lead varied from 16.82 to 17.3 mg/l, with a mean and standard deviation of 17.06 ± 0.339 mg/l. The levels of manganese, iron, lead concentrations in the leachates from the dump site were all above the WHO acceptable limit (Table 2).

3.3 Physico-chemical Parameters of Ground Water

The summary of the physico-chemical parameters of ground water around the dump site is shown in Table 3. The physico-chemical parameters varied across the five (5) ground water samples analyzed. The water temperature of the ground water varied from 27.6 to 27.8°C, having a mean and standard deviation of 27.780 ± 0.089°C. The pH ranged of 4.05 to 6.09, having a mean and standard deviation of 4.280 ± 0.208. The water conductivity ranged from 22.70 to 69.3 µs/cm and having a mean of 42.490 ± 18.320 µs/cm. The total hardness varied from 17.1 to 34.2 mg/l, with a mean and standard deviation of 20.520 ± 7.647 mg/l, while the alkalinity ranged from 6.54 to 6.85 mg/l and having a mean of 6.626 ± 0.159 mg/l. The dissolved oxygen varied from 1.08 to 4.85 mg/l, with a mean and standard deviation of 2.564 ± 0.821 mg/l. The nitrate content ranged of 8.00 to 16.50, having a mean and standard deviation of 13.200 ± 3.280. The phosphate content of the varied from 4.50 to 44.20 mg/l, with a mean and standard deviation of 27.800 ± 4.420 mg/l, while turbidity ranged from 0.96 to 1.28 N.T.U, having a mean of 1.126 ± 0.128 N.T.U. The sulphate content varied from 24.1 to 51.2 mg/l, with a mean and standard deviation of 36.580 ± 10.550 mg/l, while chloride ranged from 22.6 to 60.1 mg/l and having a mean of 45.960 ± 8.785 mg/l. The sodium content ranged from 13.0 to 24.1 mg/l, having a mean and standard deviation of 20.520 ± 7.647 mg/l (Table 3).

The dissolved oxygen, pH, nitrate and phosphate content of the four (4) ground water samples (GW 2, 3, 4, 5) were not within the WHO limit except the control (GW 1) which was within the range. Also, the temperature, conductivity, total hardness, alkalinity, turbidity, sodium, chloride and sulphate content of the five (5) ground water samples were all within the WHO limit, but in most cases the control ground water (GW 1) recorded the lowest values for each parameter. Overall, the mean dissolved oxygen, pH, nitrate and phosphate content were above the WHO limit, while the other parameters were all within the WHO acceptable limit. Statistically, the temperature, conductivity, total hardness, alkalinity, turbidity, sulphate content, sodium content, chloride content, nitrate content, phosphate content varied significantly between five (5) ground water samples at $P<0.05$, while dissolved oxygen and pH did not vary significantly between the five (5) ground water at $P>0.05$ (Table 3).

The distribution of the physico-chemical parameters showed variations between the five (5) ground water samples with control ground water (GW1) recording lower values for most analyzed parameters except for temperature, DO, pH, sulphate content , chlorine content and turbidity as shown in Figs. 2, 3, 4, 5 and 6.

Table 1. Mean, ranges of physico-chemical parameters of leachates from Ikot Effanga dump site, Calabar

S/N	Physico-chemical parameters	Mean values and ranges of parameters	WHO limit
1	Temperature (°C)	27.650 ± 0.070 (27.6 – 27.7)	<40
2	PH	7.245 ± 0.516 (6.88 – 7.61)	6.5 – 8.5
3	Turbidity (N.T.U)	125.95 ± 3.606 (123.4 – 128.5)	5
4	Conductivity (µs/cm)	1272.00 ± 110.308 (1194 – 1350)	250
5	Dissolved oxygen (mg/l)	0.700 ± 0.141 (0.60 – 0.80)	>4
6	Total hardness (mg/l)	431.90 ± 89.378 (368.7 – 495.1)	150
7	Nitrate (mg/l)	83.350 ± 4.313 (80.3 – 86.4)	10
8	Sulphate (mg/l)	139.20 ± 9.616 (132.4 – 146.0)	100
9	Chloride (mg/l)	504.00 ± 366.281 (245.0 – 763.0)	100
10	Phosphate (mg/l)	265.45 ± 140.643 (166.0 – 364.9)	0 – 5
11	Sodium (mg/l)	285.55 ± 102.601 (213.0 – 358.1)	100

Values are in Mean ± standard deviation (Ranges in parenthesis)

Table 2. Mean, ranges of some heavy metals in leachates from Ikot Effanga dump site, Calabar

S/N	Heavy metals (mg/l)	Mean values and ranges of parameters	WHO limit
1	Manganese	5.060 ± 2.319 (3.42 – 6.70)	0.05
2	Iron	31.350 ± 4.879 (27.9 – 34.8)	0.3
3	Phosphate	265.45 ± 140.643 (66.0 – 364.9)	0.01

Values are in Mean ± standard deviation (Ranges in parenthesis)

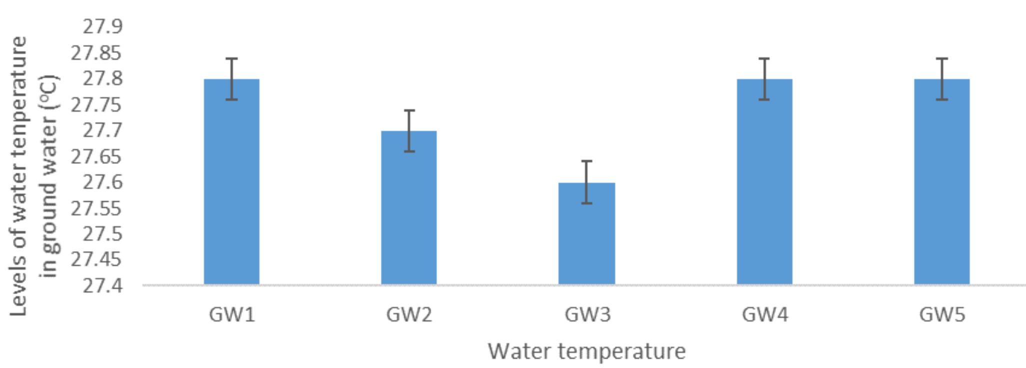

Fig. 2. The distribution of temperature of ground water around Ikot Effanga dump site

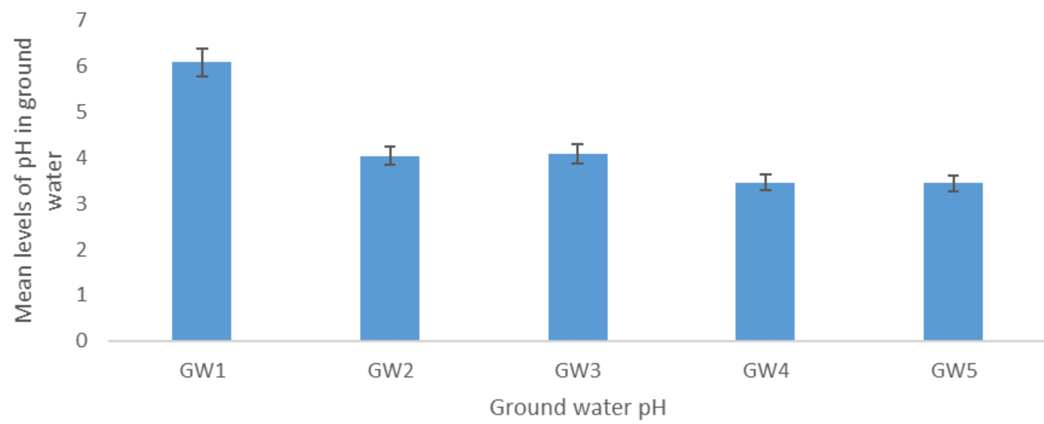

Fig. 3. The distribution of pH of ground water around Ikot Effanga dump site

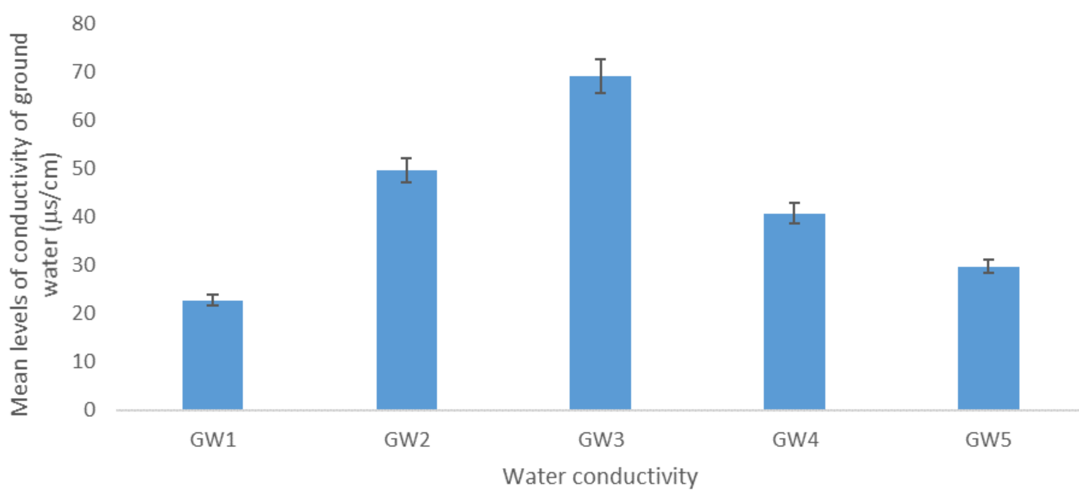

Fig. 4. The distribution of conductivity of ground water around Ikot Effanga dump site

3.4 Heavy Metal Concentration in Ground Water

The summary of the mean heavy metals concentration of ground water around the dump site is shown in Table 4. The heavy metals concentration varied across the five (5) ground water samples analyzed. The manganese concentration of the ground water varied from 0.05 to 0.08 mg/l, having a mean and standard deviation of 0.068 ± 0.013 mg/l. The iron concentration ranged of 0.23 to 0.66 mg/l, having a mean and standard deviation of 0.486 ± 0.108 mg/l. The concentration of lead ranged from 0.010 to 0.081 mg/l and having a mean of 0.047 ± 0.025 mg/l (Table 4).

The lead and iron concentration were all above the WHO limit in the four (4) ground water (GW 2, 3, 4 and 5) except the ground water 1 (GW) (control), while manganese was above the WHO standard for ground water 2, 4 and 5. Overall, the mean manganese, iron and lead were above the WHO permissible limit. The concentration of manganese, iron and lead varied significantly between the five borehole water at $P<0.05$.

The distribution of the heavy metals concentration showed variations between the five (5) ground waters with the control (GW1) recording lower values as shown in Fig. 7.

4. DISCUSSION

The collection and disposal of wastes pose potential threat to contaminate the environment especially groundwater due to uncontrolled percolation of fluids (leachate) derived from the wastes [15]. Landfill poses a threat on groundwater contamination in the nearest future [16] and landfills or open dumpsite, waste deposited eventually forms part of the prevailing hydrological system. The decomposition of most waste produces methane and can cause fire outbreak, green house emission as well as produces strong leachate, which pollute surface and groundwater resources [17]. The health risks from polluted groundwater depend on the specific pollutants in the water as these causes diarrhea and stomach disorder with possible severe associated health problems, like cancer, reproductive challenges and others [6]. Waste may remain active for a numbers of years, especially under moisture-deficient conditions [18,19]. According to this study, the leachate from the Ikot Effanga dump site was polluted due to the fact that the overall mean turbidity, conductivity, dissolved oxygen, nitrate, manganese, iron, sulphate content, chloride content, phosphate content and sodium content were all above the WHO recommended standard. This denotes that the contamination of the ground water around the dump site as reflected by the unhealthy levels of dissolved oxygen, pH, nitrate, phosphate, manganese, iron, lead of the underground water is caused by the leachates from the dump site. Also, the levels of most parameters were lowest in the control ground water (GW 1) except for temperature, DO, pH, sulphate content , chlorine content and turbidity, which were necessary for parameters like DO and pH, further indicating that the presence of the dump site close to the ground waters (GW 2, 3, 4 and 5) led to their contamination, making them unsafe for human consumption. Overall, the levels of the analyzed physico-chemical parameters were all within the within the WHO limit, further proving the fact that closer ground waters to dump sites will likely be contaminated. High level of phosphate and sodium content were also observed in the leachates, and this could be as a result of the dumping of waste compounds containing organophosphates, sodium phosphate and so on which contains high levels of phosphorus and sodium in the dump site.

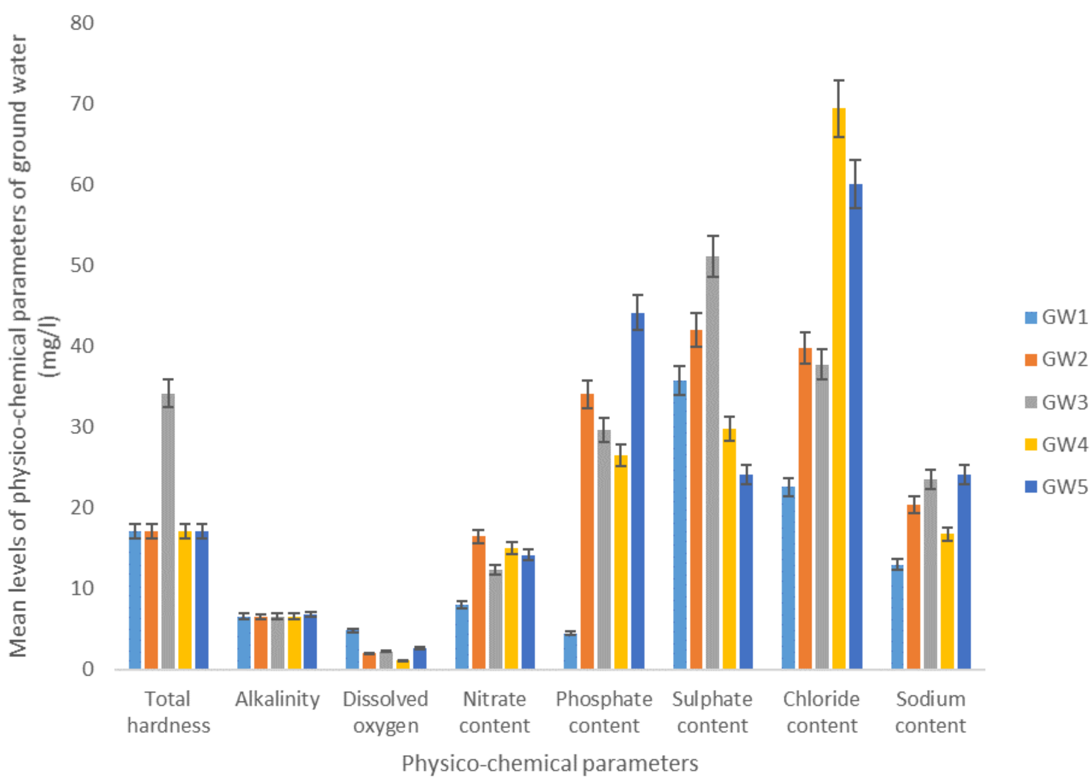

Fig. 5. The distribution of some physico-chemical parameters of ground water around Ikot Effanga dump site

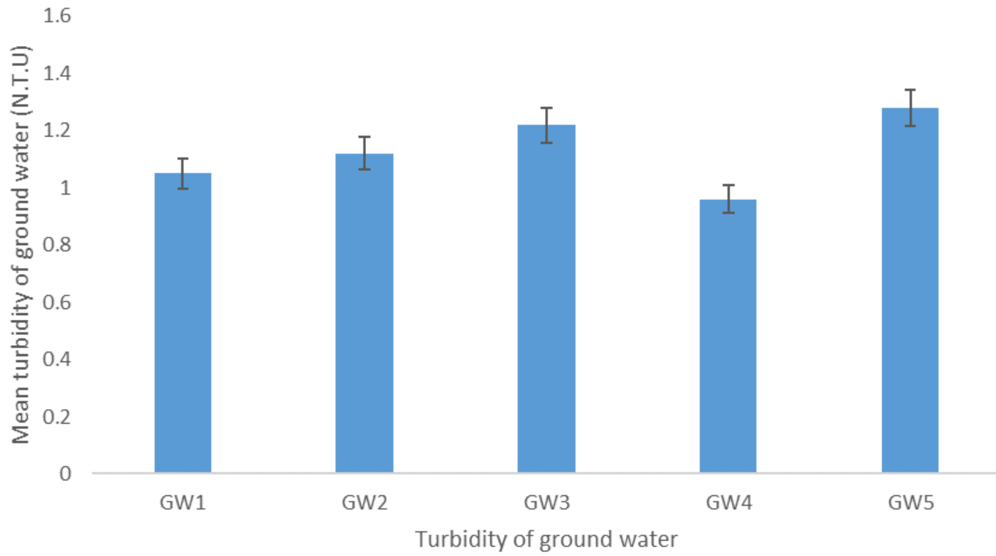

Fig. 6. The distribution of turbidity of ground water around Ikot Effanga dump site

Table 3. Mean and ranges of physico-chemical parameters of ground water around Ikot Effanga dumpsite

Physico-chemical parameters	GW1 (control)	GW2	GW3	GW4	GW5	MEAN	WHO limit
Temperature (°C)	27.80[a]	27.70[b]	27.60[c]	27.80[d]	27.80[e]	27.780 ± 0.089 (27.60 – 27.80)	<40
PH	6.09[a]	4.05[a]	4.09[a]	3.46[a]	3.45[a]	4.280 ± 0.208 (4.05 – 6.09)	6.0 – 8.5
Conductivity (µs/cm)	22.70[a]	49.80[b]	69.30[c]	40.80[d]	29.8[e]	42.490 ± 18.320 (22.70 – 69.30)	250
Total hardness (mg/l)	17.10[a]	17.10[b]	34.20[c]	17.10[d]	17.1[e]	20.520 ± 7.647 (17.10 – 34.20)	150
Alkalinity (mg/l)	6.58[a]	6.54[b]	6.58[c]	6.58[d]	6.85[e]	6.626 ± 0.159 (6.54 – 6.85)	100
Dissolved oxygen (mg/l)	4.85[a]	2.01[a]	2.23[a]	1.08[a]	2.65[a]	2.564 ± 0.821 (1.08 – 4.85)	>4
Nitrate (mg/l)	8.00[a]	16.50[b]	12.30[c]	15.00[d]	14.20[e]	13.200 ± 3.280 (8.00 – 16.50)	10
Phosphate (mg/l)	4.50[a]	34.10[b]	29.70[c]	26.50[d]	44.20[e]	27.800 ± 4.420 (4.50 – 44.20)	0 – 5
Turbidity (N.T.U)	1.05[a]	1.12[b]	1.22[c]	0.96[d]	1.28[e]	1.126 ± 0.128 (0.96 – 1.28)	5.0
Sulphate (mg/l)	35.80[a]	42.00[b]	51.20[c]	29.8[d]	24.1[e]	36.580 ± 10.550 (24.10 – 51.20)	100
Chroride (mg/l)	22.60[a]	39.80[b]	37.80[c]	69.5[d]	60.1[e]	45.960 ± 8.785 (22.60 – 60.1)	100
Sodium (mg/l)	13.00[a]	20.40[b]	23.50[c]	16.80[d]	24.10[e]	19.560 ± 4.677 (13.0 – 24.1)	100

Values are in Mean ± standard deviation (Ranges in parenthesis), GW = Ground water.
Values with different superscript are significantly different at P< 0.05

Table 4. Mean and ranges of heavy metals in ground water around Ikot Effanga dumpsite

Heavy metals (mg/l)	GW1 (control)	GW2	GW3	GW4	GW5	MEAN	WHO limit
Manganese (Mn)	0.05[a]	0.08[b]	0.05[c]	0.08[d]	0.07[e]	0.068 ± 0.013 (0.05 – 0.08)	0.05
Iron (Fe)	0.23[a]	0.51[b]	0.66[c]	0.65[d]	0.38[e]	0.486 ± 0.108 (0.23 – 0.66)	0.30
Lead (Pb)	0.010[a]	0.081[b]	0.031[c]	0.046[d]	0.066[e]	0.047 ± 0.025 (0.010 – 0.081)	0.01

Values are in Mean ± standard deviation (Ranges in parenthesis), GW = Ground water.
Values with different superscript are significantly different at P< 0.05.

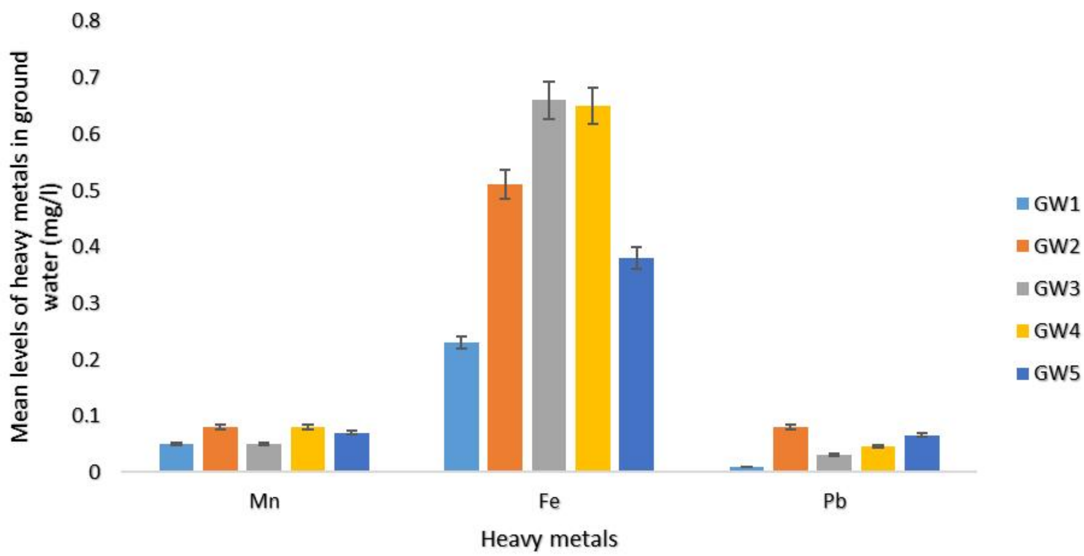

Fig. 7. The distribution of heavy metals in ground water around Ikot Effanga dump site

According to the study, there were variations in the levels of the various parameters studied between the five ground water samples. The temperature, conductivity, total hardness, alkalinity, nitrate, phosphate, turbidity, sulphate, chloride, manganese, iron, lead and sodium levels varied significantly between the five ground water, but all the other parameters did not vary significantly. The variations in the studied parameters could be due to the differences in the depth of the boreholes, its distance from the dumpsite, excavations technique used in drilling the boreholes and the hydrological soil strata that vary from one place to another of not less than 50 meters [20]. These differences could also be due to the fact that variation in physiochemical and Heavy metal parameters in underground water is the function of waste management strategies in waste disposal and season [21].

The lead and manganese concentration of all the ground water analyzed were lower than the range reported by [22], but higher than that reported by [23]. Iron concentration range was higher than that reported by [22], but was within the same range with that of the findings of [23]. In terms of the physico-chemical parameters, the pH, conductivity and dissolved oxygen of the borehole waters studied were lower, while the temperature was higher than that reported by [24]. Also, the turbidity, nitrate and chloride levels were lower than that reported by [23]. The variations in the studied parameters between the different studies compared could be due to the difference in age of land fill [15,25], depth of the ground water, its distance from the dumpsite, excavations technique used in drilling the boreholes and the hydrological soil strata [20], composition of waste, geographical location, as well as the fact that underground water contamination is the function of waste management strategies in waste disposal and season [21]. The differences in contamination level of underground water could also be due to the differences in leachate percolation, chemical composition of leachate, rainfall, depth and distance of the boreholes from the dumpsite [26].

The leachates from the dumpsite contaminated the ground waters around the dumpsite, by raising or lowering some of the studied parameters to unhealthy limits. The study revealed that the leachate from the dumpsite altered the dissolved oxygen, pH, iron, lead, nitrate and phosphate content of the four (4) ground water (GW 2, 3, 4, 5) making the parameters above or below the WHO limit except the control (GW 1) which was within the range. The levels of manganese were above the WHO limit for ground water (GW) 2, 4 and 5. Also, the temperature, conductivity, total hardness, alkalinity, turbidity, sodium, chloride and sulphate content of the five (5) ground water were all within the WHO limit, but in most cases the control ground water (GW 1) recorded the lowest values for each parameter except for pH and DO which were necessarily higher in the control. This denotes that the borehole waters were polluted and unsafe for consumption.

5. CONCLUSION

In conclusion, the study revealed that dumpsite are capable of contaminating ground water, as it brought about the contamination of the underground water around the Ikot Effanga dumpsite due to their abnormal pH, DO, phosphate, nitrate, lead, iron and manganese levels. It was also revealed that the levels of different parameters studied varied between ground water. As a result, further research on the consumption quality of ground water need to be carried-out, so as for further reveal the health consequences of drinking from ground water close to dump sites by evaluating the bacterial and coliform levels of these ground waters.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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