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Hydrological and Public Health Implications of Dumpsite-Induced Ground and Surface Water Contamination in South-western, Nigeria

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Abstract

Environmental pollution has been increasing globally over decades which have contributed to negative impact on the environment and human health. Waste are generated on a daily basis due to intensity of human activities due to increase in population, urbanization and industrialization which had led to increase in the demand for water consumption. Adequate waste management facility is a pivot to urban infrastructure that ensures protection of the environment and human. Groundwater has become a dependable source of water supply to supplement the needs of city dwellers in many of the developing countries like Nigeria. Open dumping and indiscriminate disposal of waste in our environment threatens the public health resulting to water pollution. Therefore, sustainable waste management practices with regular compliance with environmental regulations are necessary to preserve the environment. This study examines the physicochemical and bacteriological characteristics of ground and surface water impacted by waste dumps and its possible health implications on the dwellers of Ilokun village in Ado-Ekiti metropolis. Samples were collected from three (3) hang dug wells, a bore hole (1) and surface water around the vicinity of the dumpsite and analyzed for parameters such as Odour, pH, Turbidity, Total dissolved solids (TDS), Total Alkalinity, Electrical conductivity, Total hardness, Calcium hardness, magnesium hardness, Nitrate, Nitrite, Iron, Magnesium, manganese, Chloride, Aerobic mesophilic count and Total coliform using standardized laboratory methods. The physicochemical analysis revealed varying levels of adherence to World Health Organization (WHO) guidelines. The bacteriological characteristics of the water samples showed that Aerobic Mesophilic Count, cfu/ml values of the water samples ranged from13.20 x 10^2 to 19.80 x 10^2 which implies that all the water samples are not within the recommended standard of 1.0 x 10^2cfu/ml. Total coliform in terms of Most Probable Number (MPN/100ml) ranged from 4 to 26 which shows that all the water samples are above the limit of Nil (0). The Biological Oxygen Demand (BOD) ranged between 113.23mg/l to 923.00mg/l with an average of 589.08mg/l while Chemical Oxygen Demand (COD) also ranged between 189.35 to 680mg/l with an average of 512.45mg/l indicating presences of high organic matter of leachate. The study revealed that the water is contaminated and not fit for consumptions to prevent human health risks. It is therefore, important that the dumpsite should be properly designed to prevent leachate infiltration and regular monitoring of groundwater quality is done in the vicinity to ensure that the water is portable to prevent spreading of water related diseases.

Keywords: Hydrological analysis; Solid Waste; Dumpsite; Leachate infiltration; Health risks

1. Introduction

Solid waste disposal is one of the most prevailing environmental challenges in Nigeria, especially in rapid urbanizing regions of South-western Nigeria due to increase in population and industrialization. Nigeria is said to be the most populous country in Africa with high industrial activities, which has resulted in contamination and pollution of most water resources (Pona et al., 2021). The uncontrolled disposal of municipal Solid Waste and indiscriminate disposal into open dumpsites poses significant threat to groundwater and surface water quality. Indiscriminate disposal of municipal solid waste (MSW) in water bodies remains a prevalent practice (Duru et al., 2019). Dumpsite leachate are

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rich in heavy metals, inorganic matters and microbial pathogens can infiltrate into surrounding aquifer, thereby contaminating groundwater and surface water sources such as well and borehole. In a research carried out by Odu et al, 2025 in River state revealed that leachate significantly elevated Iron, lead and mercury level beyond permissible limits in groundwater. Also, the work of Ariyo et al (2021) reported moderate level of heavy metal concentration in ground water near Ibadan dumpsite with metal contamination decreasing with distance from the waste site. Since most communities in South-western, especially Nigeria rely on shallow wells and borehole for drinking water, these problems pose serious concerns about public health and environmental sustainability. Uncontrolled solid waste disposal at dumpsite usually results in the release of leachate containing toxic heavy metals and pollutants. In Nigeria where many communities rely solely on groundwater, there is limited scientific data on how dumpsites contributes to heavy metals accumulation and changes in physicochemical parameters of both groundwater and surface water. Majority of landfills and dumpsites in Nigeria are constructed without proper engineered liners, pipes, tanks, collection equipment, or monitoring facilities which lead to leaching of leachates into groundwater (Ifeoluwa, 2019). Many dumpsites in Nigeria allows leachate infiltration into nearby water sources while residents using these sources for drinking and domestic purposes are at risk of toxicological and pathogenic contaminations. The lack of data challenges effective water management and increases the risk of water borne diseases such as cholera, typhoid e.t.c.

Due to changes in domestic and commercial consumption patterns, the amount of solid waste (SW) increases every year globally (Rahman *et al*., 2021) and this situation has made waste management a challenge for all countries. (Vinti and Vaccari,2022). Global municipal solid waste production reached 1.3 billion tons per year in 2010 and this is expected to increase to 2.2 billion tons per year by 2025 (Hoornweg and Bhada-Tat, 2012). Irrational dumping and management of solid waste causes severe, sometimes irreparable, environmental and public health damage. (Akinbile and Yusuf*.,* 2011; Osanaiye *et al*,2013). The open dumps further pollute the environment by adding greenhouse gases and eventually harmful leachates into the immediate surroundings. (Odunlami *et al.,*2012; Pandey *et al.,*2016). According to Efe, 2013, most of the cities in Nigeria generates solid waste at an alarming rate such that in most cases, the volume of waste produced is often more than what the city system could handle. Waste management facility is a pivot to urban infrastructure that ensures protection of the environment and human health. A lots of tons of solid waste are generated daily in Nigeria and Ado is not an exception which eventually ends in open dumps and wetlands. This acts have led to contamination of soils, surface and ground water bodies that resulted in to health problems and destruction of the environment at large. However, Individuals residing in close proximity to the dumping sites may experience negative effects from the indiscriminate disposal of municipal solid waste through open dumping method. These health hazards include conditions like gastrointestinal disorders, skin and irritation, fever, respiration distress and a host of other illness. (Dixit et al., 2023). There are many studies on the public and environmental health hazards of open dumping (Chavan et al., 2022, Ajibade., et al., 2021, Olasunkanmi et al 2024). According to the World Bank, (2023) Nigeria generates approximately 32 million tons of solid waste annually. The Ministry of Environment estimates that the country's urban areas generate about 0.65kg/capita/day of municipal solid waste. However, a study published in the Journal of Environmental Science and Health Part B by Ojo (2018) found that Ado-Ekti generates around 150-200 tons of solid waste per day, 0.5kg/cap/day.

Designing Landfills must be in such a way that would prevent wastes/leachates from migrating or penetrating into adjoining locations. They are mostly placed in area where land features act as natural buffers between the landfill and the environment. The bottom and sides of landfills are usually lined with layer of clay or plastic to keep the liquid waste called leachate, from contaminating the underground, surface water and the soil. Leachate production must be reduced and control through prevention of external water from percolating into layers of municipal solid waste. An assessment of pollution levels of Ilokun dumpsite is of necessity to obtain a detailed information of related parameters on groundwater and surface water within the vicinity of dumpsite that could give sufficient perspectives of environmental impacts of the dumpsite pollution. This will help develop a more useful quality leachate database for other landfills for predicting the future pattern of leachate composition in advance. WHO estimates that as at 2020 up to 2 billion people worldwide do not have access to safe drinking water. Also, according to WHO in 2020, three hundred and twenty-three thousand, three hundred and twenty (323,320) cases of cholera and eight hundred and fifty-seven (857) deaths were notified from twenty-seven (27) countries. The menace caused by uncontrolled/open dumpsite has been a concern to all and the need to assess and recommend efficient management strategies for dumpsite has brought about this study.

2. Materials and method

2.1. Study Area

Ado-Ekiti is the capital city of Ekiti State in southwestern Nigeria is the study area for this research. The town is located between latitudes 7°37′N and 7°41′N and longitudes 5°13′E and 5°18′E respectively. Ado-Ekiti is regarded as urban center for its vibrant commercial activities in the state. The city has a tropical climate of wet and dry seasons, the wet season is usually between April and October, while the dry season spans from November to March, with an annual rainfall range of 1,200 mm to 1,600mm. According to NPC (2007) Ado-Ekiti has a population of 308,62 and with the growth rate of 3.14% according to EKSMA Ado-Ekiti is projected to have a population of 520,891 in 2024 using a geometric increase method and as a result of this the town is growing into a thickly populated town caused by the influx of civil servants, and business people, and the presence of different higher institutions. The map of Ado and Arial Google map of Ilokun is shown in Figure 1 and Figure 2.

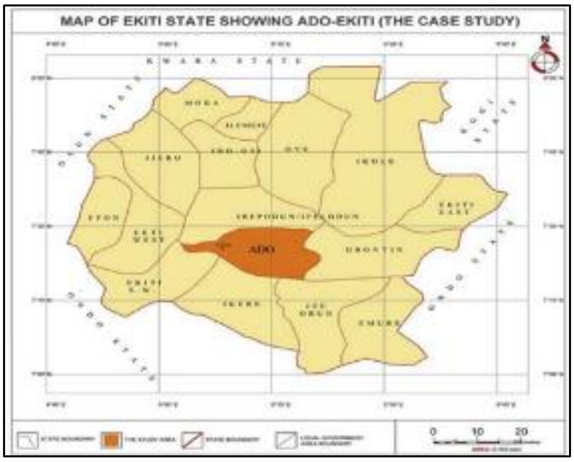


Figure 1 Map of Ekiti state showing Ado-Ekiti

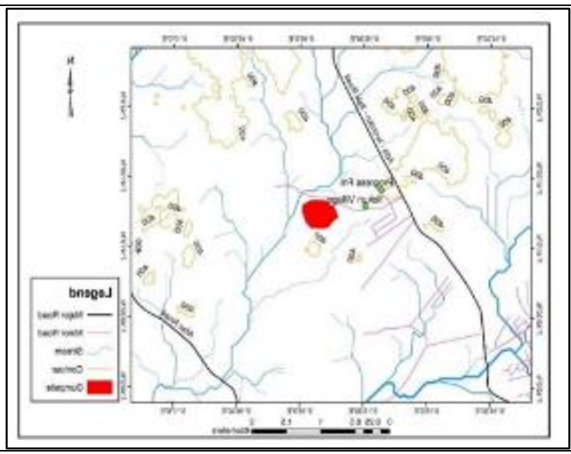
Figure 2 Google Arial Map of Ilokun Dumpsite, Ado Ekiti

2.1.1. Site Location

The Ilokun dumpsite (7.6667°N, 5.2333°E) is situated along Ekiti-State University Road, off Ado Ekiti, Ifaki- Ekiti Road at approximately Km 10. It serves as the main dumpsite for Ado Ekiti under the supervision of the Ekiti State Waste Management Board (EKSWMB), where municipal solid waste (MSW) collected from the residents is disposed. The dump site's span is 24.7 hectares, with a topography that varies significantly, with elevation ranging from 337 to 405 meters above mean sea level. The dumpsite has been in existence for over 20 years and is still in existence till today. Figure 3 shows the over view of the dumpsite while Figure 4 shows the map of Ilokun dumpsite in Ado, respectively.

(a)

Figure 3 Over view of Ilokun dumpsite



(b)

Figure 4 Location of Ilokun Dumpsite

2.2. Laboratory and Field Methods

Three (3) existing hand dug wells of an average depth of 40m with distance of 45, 60 and 85m close to the vicinity of the dumpsite, a bore hole located within the vicinity were carefully selected as sampling points for groundwater quality with a river water adjacent to the dumpsite. Physicochemical and bacteriological parameters of the water samples were taken and analysis were carried out. Appearance and colour of the water samples were determined by Hazen disk comparator while odour and taste were determined by observation.

pH of each sample were determined with a pH meter (Hanna HI-2020) in accordance with ASTM D4972. Prior to sample analysis, the meter was calibrated according to manufacturer instruction with buffer solution 4, 7 and 9. The pH measurement involved inserting the probe of the pH meter into the water sample.

Nitrate content in the samples was determined calorimetrically by UV/Visible spectrophotometer in accordance with EPA 3521 and APHA 4500-NO_3-B. The method is based on a yellow complex formation between brucinesulphate and nitrate in the presence of sulphuric acid. Prior to analysis of the samples, the equipment was calibrated with working standards from potassium nitrate salts.

Nitrite **:**To an aliquot of sample solution containing nitrite (0 .02-0 .80 ppm when diluted to 25 ml in a 25-ml calibrated flask, add 1 ml of 0 1% p-aminophenylmer captoacetic acid solution and 2 ml of the 1% N-(1 naphthyl) ethylenediamine dihydrochloride solution Set aside for a minimum of 15 min for full colour development and dilute to the mark with distilled water, a bluish violet colour develops and remain stable for 48h. 2ml of concentrated HNO_3 and 5ml of concentrated HCL were added to 100ml of sample. The sample was covered and heated on a hot plate at 90^0 C to 95^0 C until the volume has been reduced to 15-20ml. It was cooled and the walls of the beaker was washed down with distilled water and filtered to remove silicates and other soluble materials. The volume was adjusted to 100ml and presented for metal/mineral analysis

Chloride was determined by Argentometric method/Mohr's method. This method employs silver nitrate as titrant and potassium chromate as the end point indicator. The chloride ion present in the water/wastewater sample is precipitated as white silver chloride. As the chloride ions in the sample are being wholly precipitated, any addition of silver nitrate solution will lead to a level at which the solubility product of silver chromate is exceeded and it begins to form a reddish-brown precipitate. This is taken as the end point. A known volume of filtered sample (50ml) is taken in a conical flask, to which about 1ml of potassium chromate indicator is added and titrated against standard silver nitrate till silver dichromate ($AgCr0_4$) starts precipitating. The reddish- brown colour indicated the end point Silver nitrate solution, $AgNO_3$(0.0257M): Dissolve 4.791g silver nitrate crystals, dried at 105^{o}C in 1000ml of distilled water. K_2CrO_4 indicator: Dissolve 50g of K_2CrO_4 in 1000ml distilled water and store for 24hours before use or 5g of K_2CrO_4 in distilled water and make up to 100ml. add silver nitrate solution in drops to produce a slight red precipitate and then filter. Keep the filtrate for use as indicator OR Dissolved K_2CrO_4 solution with little of distilled water, this will make an orange colour. Allow for a little time and add little quantity of 0.03M of AgNO3 gradually until it formed almost brown-pink precipitate, then store for 24hours. Note: allow the salt to completely dissolve before make up to the mark. Heat if not dissolve immediately. Colour reddish brown. Filter the solution after 24 hours to get orange product (filtrate).

Cl^- (mg/l) = (A-B) x 0.0141 x 35.45/50ml OR (A-B) x M x 70,900 or 35450 /ml sample

A = Volume of $AgNO_3$ used for sample titration (ml)

B = Volume of $AgNO_3$ used for blank titration (ml)

Electrical Conductivity (Hanna HI98192). Was conducted by shaking the sample mechanically at 15rpm for 1 hour to dissolve soluble salts. Calibration of the conductivity meter was done according to the manufacturers instruction's using KCL reference solution to obtain the cell constant.

Total Dissolved Solid

Apparatus used are Evaporating dish, Oven, Desiccators, Analytical balance and funnel. 100ml of water sample was measure, filter and dry in an evaporating dish and weighed (W_1). The filtrates were transferred into the pre-weighed evaporating dish and heat to dryness at 105^{o}C. The process of drying continues, cooling and weighing until a constant weight (W_2) is obtained.

Total dissolved solids (mg/l) = (W_2-W_1) x 1000/100

Total Alkalinity: Pipette 50ml of water sample in a 250ml conical flask and add 2 to 3 drops of methyl orange indicator and mix properly. Titrate with 0.02M HCl to the end point

Titre value x M x 100,000/50. Where M is the Molarity of Acid.

Turbidity (NTU): 10NTU was prepared by taken 2.5ml of Formazin Standard into 100ml conical flask and make it up with distilled water. The Turbid meter must be **POWER ON** for at least 30minutes before use. And Load 0 NTU into the machine and Zero adjustment knob should be rotated until the instrument display 0.00. Load 10 NTU into the machine and correction button was adjusted to 10.00. The sample was loaded in the assay bottle into the machine and record the reading when it is stable. Calcium Pipette 50ml of water sample into clean 250ml conical flask and add 2ml of 1M of NaOH and mix properly. A little quantity of murexide/NaCl mixed indicator and Titrate the pink colour solution with 0.01M EDTA to purple colour end point. The titre value was obtained using the formula:

Calcium hardness as mg$CaCO_3$/l = Titre Value x 1000 x 0.400/50ml

Magnesium hardness is calculated from the difference in titre value of total hardness and calcium hardness using the formula:

Magnesium hardness as mg$CaCO_3$/l = V_t - V_c of 0.01M EDTA x 1000 x 0.243/50ml

2.3. Determination of Metal/Mineral

An Atomic Absorption Spectrometer (AAS) Buck Scientific model 211 VGP was used to determine the metal content of the samples in accordance with APHA 20th Edition 3111B and 3111D, ASTM D3561 and ASTM D5198. The method requires direct aspiration of the digested sample in an acidic medium into an air/acetylene flame at specified wavelengths for each of the metals under investigation. The equipment was calibrated prior to use with working standards of known concentration to obtain a calibration curve. The concentrations of the metals in the samples were obtained by aspirating the digested samples directly into the flame

2.4. Microbial Analysis

Aerobic Mesophilic Count: One ml of each dilution was inoculated on Plate Count Agar(PCA) in a sterile petri dish and incubated at mesophilic temperature (typically between 30 and 37^{o} C) in an aerobic environment for 18 to 24hrs and colonies on the plates were counted with a colony counter and the Aerobic mesophilic count was calculated using the formula;

AMC (CFU/g) = Number of colonies multiplied by dilution factor and divided by weight of the sample in gram.

Coliform & *E.Coli*: One ml of each dilution as explained above was inoculated on Mac-Conkey agar and incubated at 37^{o}C for 24-48hrs for estimation of Coliforms while Eosin Methylene Blue agar was used for determination of E.coli. The number of Pink colonies on Mac-Conkey agar showed the presence of coliforms while metallic green sheen colonies on Eosin Methylene Blue agar indicated the presence of E-.coli. Biochemical test was further carried out to confirm the presence of the organisms.

All the parameters were measured according to the standard method for examining water and wastewater by APHA (2005). Table 1. shows the coordinates of Ground water samples collection.

Table 1 Sampling points of Groundwater samples and surface water

WELL WATER SAMPLES	LATITUDE	LONGITUDE	
A	7^{o}68’81’’	5^{o}25’91’’	411.85
B	7^{o}68’79’’	5^{o}25’86’’	412.85
C	7^{o}68’84’’	5^{o}25’84’’	411.811
BOREHOLE SAMPLE	7^{o}41’47’’	5^{o}15’26’’	409.83

3. Results and analysis

3.1. Groundwater Samples Analysis

The results of the groundwater samples are shown in Table 2, with their comparison with recommended standards. The physical parameters such as appearance except water sample C, colour, odour, turbidity, conductivity and temperature all are in conformity with recommended guide line standards for drinking water quality of WHO and NSDWQ.

The chemical characteristics of the water samples include, pH ranged from 6.39 to 7.40 with sample water A to C below the recommended standard. This implies that the water sample is acidic in nature and this could be as a result of disposed heavy metals and disinfectant that are not properly disposed on the dumpsite which have infiltrated downward through seepage according to Akinbile & Yusuf (2011) and Adejumo & Oloyede (2024). Total Dissolved Solid ranged from 387.8 to 572.4 for well water samples and 296.21mg/l for borehole water sample respectively. All the values are within the recommended standard except well water sample A with a higher value of 572.4mg/l. T. Alkalinity. Chloride, Magnesium hardness, Nitrate, Total hardness and Calcium iron of both well and borehole water samples are all within the stipulated recommended standard.

Calcium hardness for the ground water are in conformity with the recommended standard except well water sample B, with a value of 51.8mg/l. Manganese values ranged from 0.13 to 0.31mg/l which is not within the recommended standard of 0.1mg/l for WHO and 0.2mg/l for NSDWQ respectively. Accumulation of manganese can cause neurological disorder for the people.

The bacteriological characteristics of the samples from the three wells and borehole were also reported in Table 2. Aerobic Mesophilic Count, cfu/ml values of the water samples ranged from 13.20 x 10^2 to 19.80 x 10^2 with sample well water having the highest value. This implies that all the water samples are not within the recommended standard of 1.0 x 10^2. Also, the Total coliform in terms of Most Probable Number (MPN/100ml) ranged from 4 to 26. This implies that all the water samples are above the limit of Nil (0) with well water A having the highest Coliform of (26)

Table 2 Physicochemical and Bacteriological Parameters of the Groundwater Samples

S/N	**Parameters**	**Unit**	**Sample A Well 1**	**Sample B Well 2**	**Sample C Well 3**	**BH Borehole**	**NSDWQ (2007) Max. desirable**	**WHO (2011) Max. desirable**
1	Appearance	U	Clear	Clear	N.Clear	Clear	Clear	Clear
2	Colour	H.U	10.00	10.00	10.00	5.00	5 -15	5-15
3	Odour		Odourless	Odourless	**Odourless**	Odourless	Odourless	Odourless
4	Temperature	°C	26.01	29.00	28.12		NA	NA
5	Turbidity	NTU	8.52	7.21	9.17	5.60	5-15	5-15
6	Ph		6.77	6.39	6.39	7.40	6.5 –8.5	6.5-8.5
7	TDS	mg/L	572.4	387.8	413.60	296.21	500	500
8	E. Conductivity	υS/cm	914.3	692.6	705.10	406.20	1000	1000
9	T. Alkalinity	mg/L	64.61	92.4	85.70	90.30	250	250
10	Chloride Cl^{-2}	mg/L	3.81	4.3	3.43	0.50	150	100
11	Magnesium Hardness. Mg^{+2}	mg/L	7.42	9.05	7.58	3.20	50	50
12	Calcium Hardness. Ca^{2+}	mg/L	44.6	51.8	37.72	12.82	50	50
13	T. Hardness	mg/L	113.5	145.37	173.56	65.31	400	400
14	Calcium	mg/L	25.60	34.90	29.70	11.50	75	75
15	Manganese	mg/L	0.13	0.26	0.31	0.19	0.2	0.1
16	Nitrate	mg/L	0.19	0.26	0,36	0.04	50	11
17	Nitrite	mg/L	0.11	0.07	0.09	0.001	0.2	1.0
18	Iron	mg/L	0.29	0.19	0.03	0.18	0.3	0.3
19	Magnesium	mg/L	4.62	6.06	5.78	2.13	20	20

	MICROBIOLOGICAL		**ANALYSIS**					
20	Aerobic Mesophilic count	Cfu/ml	13.20x10^2	16.40x10^2	19.80x10^2	13.45x10^2	1.0 x 10^2	1.0 x 10^2
21	T. Coliform	MPN/ 100ml	26.00	12.00	16.0	4.00	Nill	Nil (0)

3.2. Surface water Analysis

The values of the physicochemical parameters of the surface water sample is shown in Table 3 The physicochemical values obtained shows that the water quality parameters of the surface water (river) have values greater than the recommended standards by WHO (2011) and NSDWQ (2007). The reduction in some of the values of the surface water near the refuse dumpsite can be attributed the dilution of the leached contaminants in the waste fill dumpsite during precipitation during runoff and dilution as the water flows. The rate or extent of dilution in the river will depend large on the volume of water in the river at time the contaminant enters the water body. The river is at a close range to the dumpsite therefore, the water can easily get polluted from the leachate runoff from the dumpsite which can poses great danger to human life and aquatic organisms in the river.

Table 3 Physicochemical and Bacteriological Parameters of Surface water samples

S/No	Parameters	Unit	Water Sample	NSDWQ (2007) Max. desirable	WHO (2011) Max.desirable
1	Appearance	U	Faint Yellowish	Clear	Clear
2	Colour	H.U	25.00	5 -15	5-15
3	Odour	Odourless	Odourless	Odourless	Odourless
4	Temperature	°C	23.00	NA	NA
5	Ph		6.54	6.5-8.5	6.5-8.5
6	Turbidity	NTU	18.45	5-15	5-15
7	TDS	mg/L	645.30	500	500
8	E. Conductivity	υS/cm	1017.26	1000	1000
9	T. Alkalinity	mg/L	39.51	250	250
10	Chloride Cl^{-2}	mg/L	7.54	150	100
11	Mag. Hardness (Mg^{+2})	mg/L	5.65	50	50
12	Calcium Hardness (Ca^{+2})	mg/L	21.89	50	50
13	T. Hardness	mg/L	97.63	400	400
14	Calcium	mg/L	17.20	75	75
15	Manganese	mg/L	0.29	0.2	0.1
16	Nitrate	mg/L	0.67	50	11
17	Nitrite	mg/L	0.29	0.2	0.1
18	Iron	mg/L	0.41	0.3	0.3
19	Magnesium	mg/L	8.54	20	20
	MICROBIOLOGICAL	**ANALYSIS**			
21	Aerobic Mesophilic count	Cfu/ml	26.60 x 10^2	1.0x 10^2	1.0 x 10^2
22	T. Coliform	MPN/100ml	24.00 x 10^2	Nill	Nil (0)

3.3. Leachate Analysis

The Biological Oxygen Demand (BOD) indicating presence of organic matter of leachate ranged between 113.23mg/l to 923.00mg/l with an average of 589.08mg/l. Chemical Oxygen Demand (COD) also ranged between 189.35 to 680mg/l with an average of 512.45mg/l indicating presences of organic matter of leachate. It shows that the leachate might have contaminated the groundwater resources in the vicinity of the dumpsite. Table 3 shows the leachate values of the dumpsite.

Table 3 Leachate Parameters

S/NO	Parameters (mg/L)	Sample 1	Sample 2	Sample 3
1.	Biochemical Oxygen Demand (BOD)	212.45	113.23	189.35
2.	Chemical Oxygen Demand (COD)	689.10	725.00	680.00
3.	Total Dissolved Solid	712.00	923.00	668.00

4. Conclusion

The results of the bacteriological analysis of the water samples of the hand-dug wells and borehole sampled around the dumpsite showed that the groundwater is contaminated as revealed in the coliforms count and aerobic mesophilic count that shows values above the specified highest desirable limits of WHO. However, all the physicochemical parameters of groundwater in the vicinity of the dumpsite were within the recommended limits of WHO except pH of well 2 and 3 which is acidic in nature (WHO, 2011) and NSDWQ, (2007). The high level of Biological Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) is an indicating presences of organic matter of leachate.

Recommendations

The following are recommended suggested towards effective waste disposal management system in Ilokun dumpsite based on the findings from the current study:

- The government should ensure that the existing Ilokun dumpsite is investigated and rehabilitated for long term use,
- The unabated dumping of refuse at Ilokun dumpsite by EKSWMB should stop immediately due to the formation of highly concentrated leachate, which has been contaminated the surface water and underlying soil in the vicinity.
- An Engineering frame work should be designed and monitored for effective waste collection, disposal and management of leachate at the dumpsite.
- Strict laws should be enacted and proper enforcement to back it up.

Compliance with ethical standards

Disclosure of conflict of interest

The authors state that there is no known competing financial interest or personal relationship may have influenced any work disclosed in the study.

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