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Effects of Solid Waste Dumpsite on Groundwater Quality in Idu District, Federal Capital Territory (FCT) Abuja

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ABSTRACT
This study assessed the effects of the waste dumpsite on groundwater quality in Idu District, Federal Capital Territory, Abuja, Nigeria. The was aimed at assessing the increased deposition of waste in the dumpsite, urbanization, industrial activities, and indiscriminate waste disposal practices that pose contamination risks to groundwater resources serving as the primary water supply for residents. The study involved waste characterization at the dumpsite and analysis of groundwater samples from seven boreholes located at varying distances from the dumpsite. Water samples were collected and analyzed for physico-chemical parameters (pH, Total Dissolved Solids, Dissolved Oxygen, Chemical Oxygen Demand, Biological Oxygen Demand, chloride, total hardness, and colour), heavy metal concentrations (magnesium, zinc, iron, chromium, and lead), and bacteriological parameters (Total Coliform Count, E. coli, and Faecal streptococci). Waste characterization revealed that organic waste constituted the highest proportion. Groundwater analysis showed that pH values (6.38–7.95) fell within WHO standards, while iron concentrations (2.43–21.08 mg/l) significantly exceeded the 0.30 mg/l limit. Water hardness (81–418 mg/l) and chloride levels (5.08–49.98 mg/l) exceeded permissible limits in several samples. Bacteriological analysis revealed contamination with Total Coliform Counts reaching up to 144 CFU/ml and presence of E. coli (11–12 CFU/ml) in samples closest to the dumpsite. One-way ANOVA revealed significant differences ($p < 0.05$) in contaminant concentrations between wells located within 50 meters and those beyond 100 meters from the dumpsite. The study concludes that groundwater quality in the vicinity of the waste dumpsite is compromised, with contamination levels influenced by distance from the dumpsite, shallow water table depth, and the geological characteristics of the area.

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INTRODUCTION

The management of solid waste remains one of the most pressing environmental challenges facing developing nations, particularly in rapidly growing urban centers like Abuja, Nigeria. In recent decade, the Federal Capital Territory (FCT) and particularly the Idu area has witnessed exponential growth in human population and industrial activities since its designation as the industrial layout. This development birthed a corresponding surge in municipal solid waste (MSW) generation. Generally, Nigeria produces millions of tonnes in waste each year, yet only about a little of the wastes are collected or managed properly. This waste management crisis is characterized by

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indiscriminate refuse dumping, blocked drainage systems, and overflowing dumpsites (Sulaiman & Maigari 2016). In the absence of sophisticated sanitary landfills, open dumpsites remain the predominant method of waste disposal. Idu District, an industrial and residential area within the FCT, hosts one of the region's largest dumpsites, receiving thousands of tons of heterogeneous waste daily locally called Gosa dumpsite.

The primary environmental threat from such dumpsites is not the solid waste itself, but the liquid byproduct known as leachate. Leachate is formed when water (from rainfall, surface runoff, or the waste's inherent moisture) percolates through the waste mass, dissolving and suspending a complex mixture of organic and inorganic contaminants, heavy metals, and pathogenic microorganisms (Ferronato & Torretta 2019). Open dumping is a common solid waste disposal method in major cities in Nigeria; this habit has a detrimental effect on the surrounding environment, as it discharges leachate from the dumpsites into the aquifers, leading to several waterborne diseases. If the dumpsite lacks an engineered liner and leachate collection system—as is the case with the Idu dumpsite—this toxic liquid infiltrates the underlying soil layers and eventually reaches the shallow aquifer (Ebisintei, et.al, 2015).

Groundwater in the Idu District is a vital resource, supplying domestic, agricultural, and industrial needs via boreholes and hand-dug wells. Contamination of this resource poses direct risks to public health, including waterborne diseases (typhoid, cholera, dysentery), heavy metal poisoning (lead, cadmium, arsenic), and long-term chronic conditions such as cancer and neurological disorders. This study therefore analysis the effects of the waste on the groundwater of the area and will provide clue on the influence on the groundwater quality of the area.

METHODOLOGY

The study was conducted at the Gosa dumpsite in Idu District, FCT Abuja, located between latitudes 9°01' N and 9°03' N and longitudes 7°19' E and 7°21' E. The area experiences temperatures ranging from 21°C to 26.7°C, with rainy season lasting from April to October and average annual rainfall of approximately 1,650mm. The site is underlain by crystalline basement rocks including migmatite gneiss, granodiorite, porphyroblastic gneiss, Pan African granite, granite gneiss, and amphibolites, which are highly fractured and jointed. Purposive sampling was employed, with sampling sites chosen based on proximity to the dumpsite. Seven groundwater samples were collected from boreholes at distances ranging from less than 10 meters to greater than 100 meters from the dumpsite. Four samples were collected at close proximity (<50m) and three at greater distances (>100m). Samples were collected during the rainy season to observe temporal variations. All containers were deionized with distilled water and rinsed with sample before collection. Water samples were analyzed within three hours of collection to avoid unpredictable changes (WHO, 1971).

RESULTS AND DISCUSSION

Nature of Waste Present at Gosa Dumpsite

The waste composition was determined from the characterization of the waste on Gosa dumpsite. The organic waste determined contained food wastes, residues of plants and other biodegradable materials. This kind of wastes decomposes and generates methane, a potent greenhouse gas. Plastic waste determined includes packaging materials (pure water sachet, polythene bags etc.), bottles, bags, and other single-use plastic items. These kinds of wastes degrade very slowly and can pose environmental hazards.Textile waste identified contained discarded clothing, fabrics, and other textiles which could potentially be donated (re-use) or recycled to reduce waste.

Glass waste identified comprised glass bottles, jars, and broken glass. Metal and aluminum waste like cans, steel cans, off cuts of iron, roasted iron and other metal items are less prominent in the dumpsite. This is generally attributed to the increased activities of iron scrape scavengers around the dumpsite and Abuja in

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general. Paper and paper-like packaging materials constituted a portion of the collection, however, it less significant perhaps because paper and carton are recyclable, and can easily be degraded by continuous rainfall.

This evaluation agrees with Frederick *et al.,* (2019), and Nwosu & Chukwueloka, (2020) where both verified organic waste as the most abundant waste. This is because the place where the dumpsites are located is surrounded more with residential buildings, offices and restaurants.

Groundwater Quality Analysis

Seven groundwater samples were collected for groundwater quality evaluation. Four of the samples were taken from boreholes few meters away the dumpsite while three of the samples were collected farther away from the site. The parameters analyzed for all samples comprised of TDS (mg/l), pH, Salinity (PSU), D.O (mg/l), Mg (mg/l)Hardness(mg/l), Fe (mg/l), , Chloride (mg/l), Cu (mg/l), Al (mg/l), Ca (mg/l), Mn (mg/l), Pb ((mg/l), Total Coliform Count (CFU/ml), E. Coli (CFU/ml) and Feacal streptococci (CFU/ml) and compared with WHO Standard. Their concentrations are shown in Table 1**.**

Table 1: Results of Groundwater Analysis

PARAMETER								**WHO STANDARD**
	GROUNDWATER SAMPLES							
	GW1F	**GW2N**	**GW3N**	**GW4F**	**GW5N**	**GW6N**	**GW7F**	**WHO limit**
	Lat 9.0279	**Lat 9.0258 00°**	**Lat 9.0204 26°**	**Lat 9.0141 59°**	**Lat 9.0175 20°**	**Lat 9.0191 35°**		**Lat 9.0166 08°**
	Long 7.3320	**Long 7.3324 66°**	**Long 7.3338 84°**	**Long 7.3323 57°**	**Long 7.3344 58°**	**Long 7.3348 25°**		**Long 7.3363 88°**
TDS (mg/l)	209.8	587.6	589.4	111.6	301.4	487.3	578.3	1000mg/l
Ph	7.93	7.55	7.95	7.1	6.38	7.43	7.12	6.5-8.5
Salinity (Ppt)	0.96	2.01	2.06	0.8	1.09	1.06	0.6	
D.O(mg/l)	10.1	10.56	10.24	10.49	10.02	10.1	10.09	<8.00
Chloride(mg/l)	49.78	11.99	49.98	5.08	14.04	49.74	42.62	0.4mg/l (max)
Hardness(mg/l)	146	410	407	81	201	218	418	100mg/l
Fe(mg/l)	20.58	2.43	20.9	2.45	2.43	21.08	21.08	0.3
Mg(mg/l)	28.54	62.36	81.55	24.3	89.49	122.72	91.2	50
Cu(mg/l)	0.49	0.26	0.54	0.24	0.61	0.41	0.31	<2.00
Al(mg/l)	0.45	0.02	0.42	0.01	0.01	0.45	0.01	0.2
Ca(mg/l)	105.4	189.33	205.03	56.93	94.18	308.4	351.36	75
Mn(mg/l)	1.62	0.25	1.68	0.23	0.27	0.62	1.58	0.5
Pb((mg/l)	0.02	BDL(<0.00001)	0.03	BDL(<0.00001)	BDL(<0.00001)	BDL	BDL	<0.0100
Total Coliform Count(CFU/ml)	TNTC	144	TNTC	142	165	TNTC	TNTC	100ml
E. Coli(CFU/ml)	12	ND	11	ND	ND	11	11	100ml
Feacal streptococci (CFU/ml)	TNTC	4	TNTC	2		TNTC	TNTC	100ml

BDL = Below Detection Limit; TNTC = Too Numerous to Count; GW1F &N = Groundwater sample collected Far & Near to the dumpsite

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The consideration of the pollution indicator parameters in table indicate that the pH of water for ground water is 6.38 - 7.95, which falls within the world health organization (WHO) standard. The total dissolve solids (TDS) of surface water of range between averaged 111.6 – 589.5 mg/l which is within the WHO standard for all groundwater samples. The presence of chloride in the water range between 0.6 – 2.06ppt. The water hardness was between 81 - 418 mg/l and are above the WHO standard. This is due to the concentration of ions presence in the samples. Scale deposition in treatment works in pipes and tanks may result from hardness above 200 mg/L. This may also cause high soap consumption which may lead to formation of scum, and heating may cause deposits of calcium carbonate scale (WHO, 2011). There were high heavy metals (Fe, Mg, Cu, Al, Ca, Mn, and Pb) presence in the ground water, Table 4.1.

The concentrations of heavy metals in water are highly significant since they also verify the toxic nature of waters. Cu in all the samples was within the WHO limits. High ingestion of Cu can cause damage to liver and kidney which can result to death. It also can causes stomach upset, wooziness, diarrhea and vomiting. Fe inside all the samples were above the WHO boundary with the ground water. The Fe concentration of ground water conversely, does not cause potential health threat as they are lower than the suggested daily dietary limit (7mg – 18mg). Water containing elevated iron concentrations may be dirty, stains in laundry and plumbing fixtures (Adams, 2001; WHO, 2011). The amount of Pb in the ground water fell within the WHO limit. Lead has noxious impacts on humans having more impact on children who more susceptible (Payne, 2008). Too much exposure to lead can cause various neuro-developmental challenges and a 4.1-fold heighten the threat of attention-deficit, hyperactivity disorder in children (Brodkin *et al*., 2007). But the amount of it in the ground water (borehole water) is not enough to cause severe health hazard. The amount of manganese in ground water samples did not exceed the WHO boundary. The excessive concentration of manganese in water would result in the issue of taste and precipitation (Longe and Balogun, 2010). Calcium concentration falls within the WHO limit. However, their low level still poses the effect of hardness of water (Chauhan and Rai, 2010). E. Coli presence was t detected in ground water with 12 CFU/ml in some sample. The total coliform count and Faecal streptococci in the water detected were 144 CFU/ml and 4 CFU/ml. The presence of the Faecal streptococci is an indication that animal or human wastes are deposited in the Gosa landfill as the area where this dumpsite is situated out sketch of the city. The total coliform count validates the concentration of the dissolve oxygen detected in the water. The higher the bacterial load the higher the oxygen required for degrading the organic material (Rabia *et al.,* 2022). The result of the ground water indicated that water quality is chemically and bacteriologically polluted based on the facts that some parameters are above WHO limits. Although, some of these spikes reduces with distance away from the dumpsite, but shallowness of some of the boreholes may be responsible for the spikes. This is because the natural treatment process by the soil profile seems to inefficient to neutralize the seepage of pollutants from the site

CONCLUSIONS

Having evaluated different parameters obtained from this study, the following are concluded:

1. The dumpsite consists of waste that are indiscriminately dumped without proper waste management procedures been considered.
2. The groundwater system in the area shown high risk for potential groundwater pollution
3. The concentration of some water parameters varies with distances away from the dumpsite. This shows that the geology and geomorphological characteristic of the area have influence on the leaching of the pollutants from the dumpsite into the water system
4. Depth to water table in the area is shallow, which makes seeping liquid from the dumpsite to percolate easily into the water system.

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