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Assessment of Water Collected from Boreholes Within Unsanitary Landfill in Anambra State

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ABSTRACT

Leachate infiltration from indiscriminate dumping of refuse has been a course of concern to the public. These leachates are a source of organic or inorganic pollutants to the underground water which poses health-associated risks to the public. The present study aims to determine the physicochemical properties and quality levels of boreholes located within the unlined dumpsite environment. Thirty-two borehole samples (sixteen upstream and sixteen downstream samples) were collected within the dumpsite environment. The upstream samples are closer to the dumpsite, while the downstream(control) is far away from the dumpsite. The physicochemical parameters were assessed using American Public Health Association standard methods. The quality of the boreholes was compared using the WHO allowable threshold. The result revealed that nitrites, chemical oxygen demand, and biochemical oxygen demand values exceeded the WHO drinking water limits for both locations which can constitute environmental and public health problems. The upstream sample's physicochemical characteristics values were greater than the downstream samples based on its closeness to the landfill. The seasonal variation revealed that the wet season values were significantly greater than the dry season values due to the percolation of leachates from the dumpsite during the rainy season. It is concluded that indiscriminate dumping of refuse using unlined dumpsite practices within the residential neighbourhood can damage the environment and induce public health risks of the residents.

Keywords*:* Physicochemical parameters, borehole water, leachate, Awka, dumpsite

INTRODUCTION

Water is fundamental for plants, animals, and human life continued existence. The quality of water is a common health impediment. Groundwater is an abundant natural resource that can be rendered unusable when its qualities are significantly hampered by chemical pollution through anthropogenic activities [1]. The population and urbanization growth contribute to boosting the demand for water distribution in the society [1]. The degradation of groundwater quality due to agricultural, industrial and urban activities plays a critical role [2, 3]. Moreover, anthropogenic events like the discharge of solid waste enhance the possibility of borehole pollution [4,5]. Improper management of solid waste poses a severe danger to the ecosystem [6,7]. Landfills or open dumping are the most widespread waste disposal practice for municipal solid waste around the world [8]. Lack of financial provision in developing countries encourages open dumping and unlined landfill which causes a severe environmental and health-related threat to the public. Many researchers had found a positive correlation between improper waste disposal and groundwater degradation [7, 9].

Unlined solid waste dumpsites have many harmful impacts on the surrounding environment. The leachate from these dumpsites serves as an important source of environmental pollution around the world. Leachates that originated from landfill is considered as the main sources of groundwater and surface water contamination and may infiltrate through the soil and reach water aquifers [10, 11]. The effects of leachate on the groundwater have been studied [12-15]. It is also reported that municipal, industrial and bio-medical wastes contain toxic compounds which can induce health-related risks through leachate [16].

The physicochemical characteristics of water can affect water quality and its usage [17]. The determinations of the water quality status are necessary to identify water quality associated problems [18]. The water quality assessment is necessary to ensure that the qualities of water are good for potable water usage. Therefore, in the present study, the environmental impact of leachate infiltration on groundwater quality within the unlined dumpsite and possible public health risks to the residents living within the area were evaluated. The results presented can serve as important data for policymakers on regulating indiscriminate dumping of refuse.

MATERIALS AND METHODS

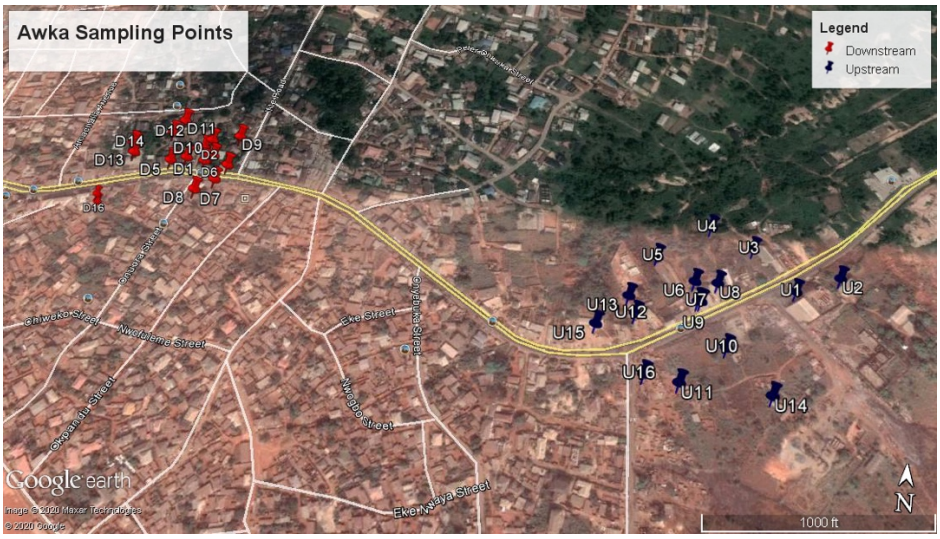


Figure 1: Map of sampling points located within the dumpsite

Sampling Description

The present study was undertaken in Agu-Awka area, which is located in Awka South Local Government Area in Anambra State. The area is situated within an unlined dumpsite. The city has two main seasons (rainy and dry season). The average annual rainfall ranges from 1500 to 1650 mm [19]. The sampling points are shown in Figure 1. The upstream samples are located within a distance of 500-700 feet from the dumpsite, while the downstream sampling points are situated 619-788 m far from the upstream points.

Collection and Treatment of Borehole Samples

Sixteen samples of borehole water with an average depth of about 200-220 feet were collected monthly for upstream and downstream samples respectively. The downstream samples serve as the control. The wet season was sampled for 4 months, while the dry season was sampled for 3 months. The sampling collection of the upstream samples were done close to the dumpsite, while the downstream samples (control) collection were done between 619-788 m far from the upstream site. The freshly blown and washed polyethylene sample bottles were used for sampling collection. Before sample collection, the sampling bottles were thoroughly rinsed with the sampling water. The water samples were collected from the selected locations. The samples from 16 points per sampling site were combined to form a composite sample. Acidification of the samples was done with 10 % HNO_3 and then stored in the refrigerator at a temperature of 4 °C before analysis.

Physicochemical Evaluation

Parameters like suspended solids (TSS), total solids and total dissolved solids were measured using gravimetric analysis. Turbidity was measured using a turbidity metre (Model: AQ4500). pH and conductivity were measured using pH metre (Model: HI991300) and conductivity (Model: DDS-307) respectively. Chlorides, total alkalinity, total acidity, total hardness magnesium hardness and calcium hardness were determined by volumetric analysis. Sulphate, nitrate, nitrite, phosphate and were measured spectrophotometrically (Model: PD303). Chemical oxygen demand was measured using the dichromate digestion method. The temperature was measured using a thermometer. The Winkler method was adopted for the determination of Dissolved Oxygen and bacterial oxygen demand. All the analyses were performed in triplicates using analytical reagent grade chemicals. The physicochemical parameters were done on the borehole water samples using the standard methods [20].

Statistical Assessment

Pearson correlation analyses were done to determine the relationship between the physicochemical parameters of the upstream and downstream borehole water samples. The statistical significance was considered for $p<0.05$.

RESULT AND DISCUSSIONS

Physiochemical parameters of borehole samples for both seasons and locations were shown in Table 1. The borehole samples showed different concentrations of physicochemical parameters in both study locations. Conductivity is an important parameter that determines water quality. Upstream mean values for the wet and dry seasons ranged from 143 – 154.8 mg/L, while downstream mean values ranged from 132 – 140 mg/L. The upstream mean values were higher than the downstream value. The values were within acceptable limits [21, 22].

Turbidity is an excellent proof of water quality because it measures the degree of cloudiness of fluid [23]. The average turbidity values for the upstream location were higher than the downstream location. The upstream mean values ranged from 0.59-073 NTU, while the downstream mean values ranged from 0.40 – 0.41 NTU. The values were below the WHO threshold limit. The turbidity values were lower than the previous report [24]. The pH level of portable water indicates how acidic or alkaline it is. The upstream samples mean values for wet and dry seasons ranged from 6.78 – 7.44, while downstream mean values ranged from 6.76 – 7.44, the values were below the WHO allowable limits. The pH results agreed with the values obtained by [13, 25].

Total dissolved solids (TDS) measures the number of inorganic salts and organic compounds matter in water which might affect its taste [26]. The upstream samples mean values for wet and dry seasons ranged from 67.73 – 71.03 mg/L, while downstream mean values ranged from 62.43 – 68.15 mg/L. Higher values of total solid were reported in similar results [27]. The upstream samples were greater than the downstream samples. The TDS values were below the WHO allowable limits.

The total alkalinity of upstream average values for the wet and dry seasons varied from 44.73-47.03 mg/L, while the downstream values ranged from 38.47-39.63-mg/L. The values were lower than 204-224 mg/L obtained in the previous report [28]. The values in the wet season were higher than in the dry season. The values were below the WHO permissible limit.

Total hardness is a property of water that makes it difficult to form lather with soap as a result of calcium and magnesium salts present in the water. The total hardness upstream mean values ranged from 99.37-100.1 mg/L for the upstream samples at the wet season and dry season and ranged from 80.43-88.33 mg/L at the wet and dry season for the downstream samples. The values were lower than the reported values obtained [28,29]. The upstream samples were greater than the downstream samples due to their closeness to the dumpsite. The maximum concentration of total hardness was observed during the wet season for both locations. Both samples were within the WHO allowable limit.

The magnesium hardness mean values for the upstream site for the wet season and dry season ranged from 59.83-60 mg/L and 48.2-53.28 mg/L for downstream values. The values reported were higher than the obtained values 36 to 41 mg/L, which were earlier reported [28]. The upstream samples were predominantly higher than the downstream samples.

The calcium hardness mean values for the upstream and downstream locations for the wet season and dry season ranged from 39.53-40.05 mg/L, while downstream mean values ranged from 32.23-35.05 mg/L. The wet season values were higher than the dry season values for both locations with maximum values observed for the upstream locations. The calcium hardness results were lower than the reported values [13].

The mean chloride values for the upstream location for wet and dry seasons ranged from 87.83-88.93 mg/L respectively, while the downstream values ranged from 71.47-77.18 mg/L for wet and dry seasons respectively. The maximum values of chloride detected were lower than the maximum obtained values reported [30]. The upstream values were generally higher than the

downstream values. The chloride values for both locations were below the WHO limit of 250 mg/L.

The nitrate values for the upstream location for wet and dry seasons ranged from 20.1-23.68 mg/L, while for downstream locations ranged from 17.37-20.28 mg/L. High nitrate concentration above WHO permissible limit which was higher than the results obtained were reported previously [31]. The maximum values were observed at the upstream location. The nitrate values were within the WHO allowable limit. The temperature values of upstream and downstream locations for both seasons did not exceed the WHO permissible limits.

Phosphate values for the upstream location for wet and dry seasons ranged from 26.57 – 30.35 mg/L, while downstream site values ranged from 22.4 – 24.88 mg/L for both seasons. The values were within WHO permissible limits of 250 mg/L for both seasons and locations.

Upstream site values for sulphate for wet and dry seasons ranged from 21.73 – 22.77 mg/L. The downstream values for the wet and dry seasons ranged from 14.3 – 15.43 mg/L. Higher values of sulphate greater than the study samples were reported [27]. The values were below WHO allowable limits.

Total solids (TS) concentrations were greater in the wet season than the dry season for both locations. The values for the upstream location for the wet and dry season ranged from 82.6 – 88.4 mg/L, while downstream site values ranged from 74.93 – 81.4 mg/L for both seasons. The values of total solids were lower than the previous value of 103 to 799 mg/L reported [30]. The total solids were within WHO limits.

Total suspended solids (TSS) are characterized as solid contaminants that are suspended in a liquid. Upstream site values for wet and dry seasons ranged from 14.87 – 17.83 mg/L. The downstream values for wet and dry ranged from 11.6 – 13.2 mg/L. TSS values were within WHO limits for both locations.

Nitrite mean values of 3.61 mg/L for upstream values of wet season and value of 3.18 mg/L for the downstream site for the dry season were above WHO permissible limits. The mean values of 2.67 mg/L for downstream values for the wet season and 2.95 mg/L for upstream values for the dry season were below the threshold limit. The nitrite values were higher than the previously reported values of 0.7 to 0.9 mg/L [13].

Biochemical oxygen demand (BOD) values were above WHO allowable limits for both locations and seasons. Dissolved oxygen (DO) decrease signifies water pollution. Dissolved oxygen values were within WHO allowable limits for both sampling sites and seasons. The DO values obtained from this study were higher than the previous report [13]. Chemical oxygen demand (COD) values were above the WHO threshold limit for both locations and seasons. The values were above WHO permissible limits which were reported in a similar study [32].

The physicochemical parameters for the boreholes revealed a strong positive correlation between the upstream and downstream sites values for the wet season ($r= 0.998$, $P=0.000$) and dry season ($r=0.995$, $P=0.000$). The P-value was less than 0.05 for both seasons, which indicated it was significant. The significance of this demonstrated that the downstream samples had a

significantly lower value than the upstream samples. The correlation analysis values between the wet and dry season upstream values (r= 0.998, P=0.000) and downstream values (r=-0.998, P=0.000) revealed a strong significant linear relationship. Hence, the upstream sample's values physicochemical properties were mostly greater than the downstream sample values for both wet and dry seasons due to its proximity to the pollution source.

Table 1: Levels of physicochemical properties in the borehole water

	Wet Season				Dry Season				WHO, 2017
Parameters	**Upstream**		**Downstream**		**Upstream**		**Downstream**		
	Range	**Mean**	**Range**	**Mean**	**Range**	**Mean**	**Range**	**Mean**	
Total alkalinity (mg/L)	40.3–53.6	44.73±6.23	31.7–46.2	39.63±6.55	38.4–58.2	47.03±10.14	32.4–46.6	38.47±7.32	100
Total hardness (mg/L)	94.6–107	100.1±6.41	79.8–95.8	88.33±7.21	92.7–109	99.37±8.55	73.5–90.3	80.43±8.78	500
Mg hardness(mg/L)	52.4–68.4	60±8.8	45.4–60.4	53.28±7.05	54.6–66.3	59.83±5.95	43.2–55.1	48.2±6.17	–
Ca hardness (mg/L)	37.2–42.2	40.05±2.55	34.4–35.8	35.05±0.66	37.8–42.7	39.53±2.75	30.3–35.2	32.23±2.61	–
Chloride (mg/L)	77.1–101	88.93±12.52	65.9–89.4	77.18±11.39	80.2–94.1	87.83±7.05	64.1–82.2	71.47±9.51	250
pH	7.03–7.84	7.44±0.37	7.16–7.4	7.28±0.12	6.74–6.85	6.78±0.06	6.66–6.94	6.76±0.16	6.5-8.5
Nitrate (mg/L)	16.5–30.9	23.68±7.52	15.7–25.4	20.28±4.76	15.4–27.8	20.1±6.72	14.2–22.5	17.37±4.49	50
Phosphate (mg/L)	23.2–36.5	30.35±6.14	19.9–29.4	24.88±4.87	20.6–30.4	26.57±5.24	18.5–26.3	22.4±3.9	250
Sulphate (mg/L)	19.2–23.2	21.73±1.78	13.2–15.5	14.3±1.01	21.7–24.5	22.77±1.51	13.3–16.9	15.43±1.89	250
Turbidity (NTU)	0.56–1.0	0.73±0.20	0.32–0.43	0.4±0.05	0.57–0.64	0.59±0.04	0.35–0.46	0.41±0.06	5
Temperature(^{0}C)	28.2–29.4	28.9±0.51	28.5–29.9	29.13±0.65	28.1–29.1	28.57±0.50	28.3–29.5	28.83±0.61	30
Conductivity (µs/cm)	135–168	154.8±16.19	126–155	140±14.63	128–153	143±13.23	120–142	132±11.14	500
Nitrites (mg/L)	3.14–4.24	3.61±0.53	2.4–2.87	2.62±0.25	2.79–3.16	2.95±0.19	3.1–3.24	3.18±0.07	3
Total Solids (mg/L)	76.6–96.9	88.4±9.02	71.8–89.6	81.4±7.60	74.0–95.3	82.6±11.23	70.3–80.3	74.93±5.03	500
Total suspended solid (mg/L)	13.9–22.4	17.83±4.17	10.5–17	13.2±3.04	13.2–18.2	14.87±2.89	11.6–13.4	12.53±0.90	30
Total dissolved solids (mg/L)	64.5–71.6	71.03±5.01	61.3–75.3	68.15±5.73	60.8–77.1	67.73±8..42	58.7–66.9	62.43±4.15	500
BOD (mg/L)	8.2–13.1	10.68±2.30	6.1–10.2	8.13±2.18	7.8–8.2	7.90±2.17	6.1–6.4	6.3±0.17	6
DO (mg/L)	2.3–3.2	2.65±0.39	3.6–4.5	4.08±0.38	1.9–3.5	2.53±0.85	2.5–4.8	3.27±1.33	7.5
COD (mg/L)	24.2–37.3	28.95±5.80	21–24.1	22.93±1.34	27.2–31.5	29.97±2.40	23.8–24.9	24.4±0.56	10

CONCLUSION

The present study showed that the leachates from the waste materials in the dumpsite site had steadily contaminated the borehole water. The upstream samples levels were greater than the downstream samples due to their proximity to the pollution source. Based on the result, the nitrite, COD, and BOD values exceeded the WHO threshold limits recommended for drinking water which poses serious health risks. The wet season concentration levels were

predominantly greater than the dry season as a result of leachate migration from the dumpsite due to rainfall. Therefore, the use of unlined or indiscriminate dumping of refuse within residential areas can release organic and inorganic contaminants into the underground water and the environment which can trigger public health associated risks. Sanitary dumpsites should be designed and constructed to regulate and reduce pollution, while unlined dumpsites should be discouraged.

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