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IMPACT OF SOLID WASTES ON WELL WATER QUALITY IN PARTS OF KADUNA METROPOLIS, NIGERIA

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ABSTRACT

The monitoring of well water quality is very significant as it helps to ascertain the health hazards associated with the use of contaminated water. In this study, seven (7) wells (W_1 - W_7), were considered at distances of: 30 m, 32.5 m, 34 m, 35 m, 37 m, 39 m and 40 m, from a dumpsite. The depths of the wells (W_1 - W_7)were: 10.5, 9.8, 10.6, 10.7, 8.9, 7.5 and 9.5, respectively. The result clearly shows that the presence of the waste dumpsite close to the wells had impacted the quality of their waters. For instance, well W_1, by virtue of being the closest to the dumpsite was found to have higher readings of measured quality parameters than the remaining six wells despite the fact it had metallic apron. W_1 recorded TDS, BOD, COD, chloride and nitrates of: 356 mg/l, 4.50 mg/l, 430 mg/l, 2.5 mg/l and 4.8 mg/l, respectively during the month of June. On the other hand, it recorded TDS, BOD, COD, chloride and nitrates of: 370 mg/l, 4.90 mg/l, 440 mg/l, 2.82 mg/l, 5.0 mg/l, during the month of July; while it recorded TDS, BOD, COD, chloride and nitrates of: 350 mg/l, 4.52 mg/l, 436 mg/l, 5.6 mg/l and 21.1 mg/l, respectively during the month of August. Result for regression analysis indicates that the depths and distances of the wells to the dump site contributed: 72.2%, 80.8%, 60.4%, 73.0%, 91.3% and 71.4%, respectively for the variations in the turbidity, alkalinity, BOD, COD, chloride and nitrate, which were all statistically significant at 95% confidence level. On the other hand, the depths and distances of the wells to the dump site contributed only: 16.0%, 3.5%, 46.3%, and 7.3%, respectively to the changes in the electrical conductivity, hardness, TDS and fluoride of the wells but were not statistically significant at 95% confidence. It was discovered that the wells are more polluted during the rainy season due to higher infiltration of rainwater. It was recommended that the wells should be provided with proper lining and a cover. Additionally, dumpsites should be adequately designed and strategically located such that they are less likely to be a source of groundwater contamination.

Keywords: Wells, water quality, Physico-chemical and waste dumpsite

INTRODUCTION

Groundwater is a very important resource and is known to occur in much more quantity than surface water. It has been estimated that about 97% of all fresh water found on the earth are being stored underground, implying that the amount of groundwater on the earth is more than the surface water (Nkrumah, 2011). Nigeria is blessed with large quantity of groundwater resource as it is estimated to be 6.0 ? 10^{18} and its quantity is affected by human activities(Edet*et al.*, 2011; Ezeribe*et al.,* 2012). Despite the high quantity of groundwater, its availability is limited by numerous factors. It is available only when the rocks in the zone of saturation are permeable enough to transmit sufficient water to wells, streams and springs or when the zone of saturation is perennial or at least long enough in each season to allow for practical exploitations (Linsley and Franzing, 1986). Recently, there has been concern over the impact of solid and hazardous waste within the human environment in Nigeria. Poor waste management practices have led to severe soil and groundwater contamination, which also led to adverse health effects.

Additionally, solid wastes management and disposal has been a major problem that results in environmental degradation and groundwater contamination. Depending on their source of origin, solid wastes could be industrial, commercial, or domestic in nature (Oladipo, 1999). However, if any waste manifest hazardous characteristics, it is considered as hazardous waste (Weddle and Klein, 1989). In some cases, less than half of the wastes generated in urban areas are collected by municipal authorities entrusted with their disposal (Okpala, 1997). In the management of solid wastes, it is quite important that the final disposal is done with much caution i.e. it should be ensured that the dumpsites do not serve as a source of groundwater contamination due to leaching of pollutants from the site. Serious groundwater quality concerns will be raised wherever dumpsites are constructed and managed arbitrarily. Water quality describes the physical, chemical and biological characteristics of water usually, with respect to its suitability for serving a particular purpose (Adamu, 2008) and contamination of ground water can occur from both above and below the surface (Adamu, 2008; Swistock, *et al.,* 2009; Ojo*et al.,* 2012). It is therefore important that the quality of drinking water be assessed so that pollution and contamination are identified and eliminated (Mara, 1976).

The main objective of this paper is to assess the impact of solid waste dumpsite on the quality of some well waters that are used for domestic purposes in some parts of Kaduna metropolis, Kaduna State.

MATERIALS AND METHODS

Study Area

Asikolaye area is part of Kaduna City and it is located in the Kaduna North Local Government Area of Kaduna State (Fig. 1). Its approximate coordinates are 10°31'12.2"N, 7°24'17.3"E. According to the residents of the Area, the solid waste dumpsite has been in existence for more than 15 years. It is majorly used for the disposal of solid wastes of all kinds generated from domestic households.. During reconnaissance survey, it was realized that irrigation farming is also being practiced at an area very close to the dumpsites.

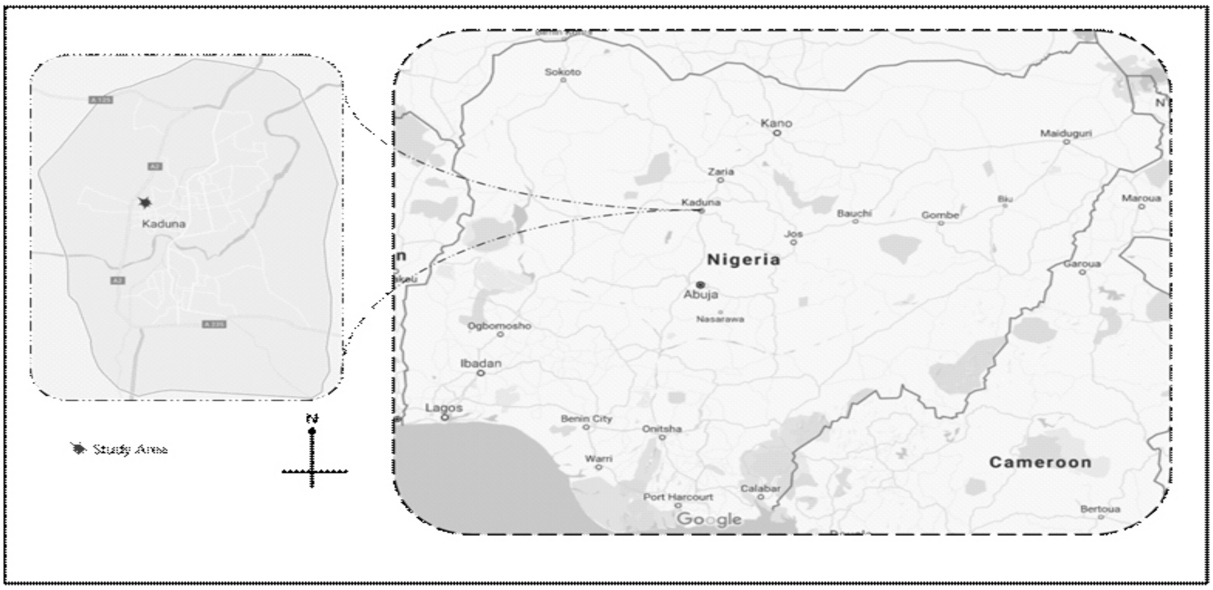

Fig. 1: A Map Showing the Study Area Sample Collection Sites

Samples of the well water were collected from seven (7) hand-dug wells at various distances to the dumpsite. The seven wells were designated as: W_1, W_2, W_3, W_4, W_5, W_6, and W_7. The distances of the wells from the dump site range from 30-40m; while their depths range from 7.5-10.7m as shown in Table 1. However, all the wells had metallic apron except W_4. The samples were collected in cleaned bottles as described in (Debnath, 1998). Sampling was conducted once in each of the three months considered (June, July and August) and the physico-chemical analysis were carried out on the samples using standard methods (APHA, 1999) in the Environmental Health Laboratory of the Department of Water Resources and Environmental Engineering, Ahmadu Bello University, Zaria. The statistical analysis was carried out using Statistical Package for Social Sciences (SPSS) version 17.0.

Table 1: Distances of the wells from the dump site and their depths

Wells	W_1	W_2	W_3	W_4	W_5	W_6	W_7
Distances (m)	30.0	32.5	34.0	35.0	37.0	39.0	40.0
Depths (m)	10.5	9.8	10.6	10.7	8.9	7.5	9.5

The Table 2 shows the parameters measured, the apparatus and the reagent used in the analysis of the well water samples (Adamu*et al.,* 2014; Nuhu, 2014).

Table 2: Parameters, Reagent and Glassware/ Apparatus used

Parameter	Reagents	Glass Ware/Apparatus
Electrical Conductivity (EC)		Conductivity meter (MC-1, Mark V)
Turbidity		Turbidimeter (2100N, HACH)
Colour		Lovilibond comparator (DB 410)
Temperature		Thermometer
pH	Buffer solutions	pH Meter (pHS -25) with electrode component, conical flask, beaker, measuring cylinder
Hardness	Eriochrome black indicator, ethylene tetra-acetic acid, buffer solution	Burette, pipette, conical flask, measuring cylinder, retort stand, wash bottle
Alkalinity	Phenolphthalein indicator, Tetraoxosulphate (vi) acid (H_2SO_4), methyl orange indicator	Burette, pipette, conical flask, measuring cylinder, retort stand
Total Dissolved Solids (TDS)		Petri dish, water bath, oven, chemical weighing balance, measuring cylinder, conical flask, filter paper
Biochemical Oxygen Demand (BOD)	Manganese sulphate solution, starch solution indicator, sodium thiosulphate, concentrated tetraoxosulphate (vi) acid	Flask, BOD bottle, retort stand, incubator
Chemical Oxygen Demand (COD)	Standard potassium dichromate value, concentrated Tetraoxosulphate (vi) acid, ferrous ammonium sulphate, ferroin indicator	Refluxing bottles with glass bed, refluxing machine
Nitrate		Multi-Parameter digital meter (HI 83200, HANNA)
Chloride	Silver nitrate solution, potassium dichromate indicator,	Conical flask (250ml), burette, pipette, retort stand,

RESULTS AND DISCUSSION

The result of the physico-chemical analysis for samples obtained in the month of June is shown in Table 3. The results showed that W_1 has the highest turbidity, TDS, BOD, COD, chloride and nitrates of values of: 7.66 NTU, 356 mg/l, 4.50 mg/l, 430 mg/l, 2.5 mg/l and 4.8 mg/l, respectively. This could be due to the fact that the W_1 is closer to the dumping site than the remaining wells. The presence of the dump site close to the well can lead to the infiltration of both organic and inorganic pollutants into the well thereby interfering negatively with the quality of well water. This result implied as expected that the closer the well to the dumpsite, the higher the pollution of the well. It is important to note that W_4 has higher TDS value (360mg/l) than $W_{1.}$ It could be due to the fact that W_4 has no apron which could reduce the passage of pollutants into the well. It can also be observed that the W_1 has the highest pH value of 7.66 and there was successive decrease in pH from W_1 to $W_{7.}$ The pH determines the corrosiveness of water when it is transmitted through a pipe as well the chemical reactions in water (Ciroma, 2002; Peavy, *et al,* 1985).

Table 3: Results of the Physico- hemical Analysis of the wells water for the month of June

No	Parameter	WHO	W_1	W_2	W_3	W_4	W_5	W_6	W_7
1.	pH	6.5-8.5	7.66	7.52	7.44	7.41	7.33	7.28	7.28
2.	Temperature (°C)	5-50	26	26	26	26	26	26	26
3.	Electrical conductivity (μs/cm)	1.2-14	630	580	580	680	590	640	640
4.	Turbidity (NTU)	5-25	7.96	7.83	5.15	5.10	2.16	2.05	2.00
5.	Alkalinity (mg/l)	100-500	12.00	13.00	6.00	9.00	7.00	12.00	8.00
6.	Hardness (mg/l)	100-500	797.96	808.06	777.76	747.46	656.55	787.86	808.06
7.	7.TDS (mg/l)	500	356	337	340	360	333	347	334
8.	8.BOD_5 (mg/l)	< 3	4.50	3.30	0.20	2.40	0.30	1.5	2.00
9.	COD(mg/l)	-	430	350	190	160	330	230	250
10.	Colour (units)	5.0	5.00	5.00	5.00	5.00	5.00	5.00	5.00
11.	Chloride (mg/l)	200	2.45	2.35	2.20	2.30	2.25	2.15	2.25
12.	Nitrate (mg/l)	10	4.8	2.3	2.1	1.3	1.2	2.0	1.6
13.	Fluoride (mg/l)	0.75-1	0.27	0.24	0.20	0.10	0.14	0.23	0.26

The result of the physico-chemical analysis for samples obtained in the month of July is shown in Table 4. The results revealed that W_1 has the highest values of TDS, BOD, COD, chloride, nitrates and alkalinity of: 370 mg/l, 4.90 mg/l, 440 mg/l, 2.82 mg/l, 5.0 mg/l and 19.0 mg/l, respectively. The values obtained in July were higher than those obtained in the month June because of the likely influence of(Gabriel, 2014). This influences the infiltration as well as leaching of pollutants from the dumpsite. Additionally, the presence of the dump site close to W_1 has affected its water quality as judged according to the results for BOD and nitrate. Both readings are higher than the permissible limit given by WHO (2005). Higher readings for BOD and nitrate suggest the presence of organic matter contaminants in the water. For these parameters, the results suggest that the level of pollution of a well is a function of its distance from the dumpsite. Hence, the closer a well is to the dumpsite the higher the pollution of its water. Water samples from W_1 showed highest readings for most parameters measured, including chloride. Although results for chloride are generally below the permissible given by WHO (2005), this indicates possible contamination with sewage. Chlorides are responsible for brackish taste in water and are an indication of sewage pollution due to chloride content of urine (Tebbutt, 1998; Adamu*et al.*2015).

Table 4: Results of the Physico-chemical Analysis of the wells water for the month of July

No	Parameter	WHO	W_1	W_2	W_3	W_4	W_5	W_6	W_7
1.	pH6.	5-8.5	7.70	7.60	7.40	7.31	7.42	7.38	7.30
2.	Temperature (°C)	5-50	25.5	25.5	25.5	25.5	25.5	25.5	25.5
3.	Electrical conductivity (µs/cm)	1.214	690	610	610	670	620	700	590
4.	Turbidity (NTU)	5-25	7.80	7.90	5.94	5.43	3.30	3.10	2.12
5.	Alkalinity (mg/l)	100 -500	19.0	17.00	13.00	11.00	14.00	16.00	10.00
6.	Hardness (mg/l)	100-500	881.27	899.80	790.81	670.12	810.80	798.10	910.20
7.	TDS (mg/l)	500	370	361	360	361	345	350	344
8.	BOD_5 (mg/l)	< 3	4.90	3.35	2.90	1.90	0.60	3.00	0.30
9.	COD(mg/l)	-	440	340	190	170	350	220	260
10.	Colour (units)	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
11.	Chloride (mg/l)	200	2.82	2.45	2.72	2.30	2.39	2.52	2.31
12.	Nitrate (mg/l)	10	5.00	2.40	2.00	1.21	1.28	2.30	1.72
13.	Fluoride (mg/l)	0.75-1	0.11	0.26	0.22	0.31	0.19	0.21	0.29

The results of the physico-chemical analysis for samples obtained in the month of August are shown in Table 5. The results as expected showed that W_1 has the highest values of Turbidity, TDS, BOD, COD, chloride and nitrates of: 11.97NTU, 350 mg/l, 4.52 mg/l, 436mg/l, 5.6 mg/l and 21.1 mg/l, respectively. However, the W_4 recordedthe highest electrical conductivity value (690 µs/cm) than $\mathbf{W_1}$ despite the fact that W_1 is closer to the dumpsite which could be due to fact the W_4 has no apron. The nitrate and chloride values obtained in August are higher than the ones obtained in July. This could be due the fact that rainfall is more pronounced in the month of August than July (Gabriel, 2014) in the area, which plays role in influencing the infiltration of contaminants into the ground water.

Table 5: Results of the Physico-chemical Analysis of the wells water for the month of August

No	Parameter	WHO	W_1	W_2	W_3	W_4	W_5	W_6	W_7
1.	pH6.	6.8-8.5	7.68	7.62	7.49	7.50	7.32	7.30	7.29
2.	Temperature (°C)	5-50°C	26	26	26	26	26	26	26
3.	Electrical conductivity (µs/cm)	1.214	660	600	590	690	600	640	650
4.	Turbidity (NTU)	5-25	11.97	10.85	9.10	8.96	6.26	5.20	4.30
5.	Alkalinity (mg/l)	100-500	12.01	3.00	9.00	11.00	7.00	8.00	11.00
6.	Hardness (mg/l)	100-500	798.99	809.07	778.80	750.96	799.96	788.87	808.72
7.	TDS (mg/l)	500	350	346	340	360	333	324	342
8.	BOD_5 (mg/l)	< 3	4.52	3.34	3.20	3.10	2.40	2.42	2.10
9.	COD(mg/l)	-	436	353	335	302	236	190	160
10.	Colour (units)	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
11.	Chloride (mg/l)	200	5.60	4.50	4.40	4.35	3.26	3.20	2.10
12.	Nitrate (mg/l)	10	21.1	14.32	12.62	11.30	9.3	8.8	7.1
13.	Fluoride (mg/l)	0.75-1	0.32	0.29	0.26	0.25	0.23	0.21	0.20

The mean values of the physico-chemical parameters for the three months (June, July and August) are shown in Table 6. The average value of each parameter was subjected regression analysis to determine whether the variations in qualities of the well waters are influenced by both the depth of the wells and their distances to the dumpsite. The Table showed that pH range from (7.29-7.68); while EC range from (593-693 µs/cm), Turbidity (2.04-9.24 NTU), Alkalinity (6.97-14.3 mg/l), Hardness (722.7-842.3 mg/l), Total dissolved solids (337.0-360.3 mg/l), BOD (1.10-4.64 mg/l), COD (210.6-435.3 mg/l), Chloride (2.22-3.62 mg/l), Nitrate (3.5-10.3 mg/l) and Fluoride (0.19-0.26 mg/l).

Table 6: Results of the average Physico-chemical analysis of the wells water for the month of June, July and August

No	Parameter	W_1	W_2	W_3	W_4	W_5	W_6	W_7
1.	pH	7.68	7.58	7.44	7.41	7.36	7.32	7.29
2.	Temperature (^{0}C)	26	26	26	26	26	26	26
3.	Electrical conductivity (s/cm)	660	697	593	680	603	660	627
4.	Turbidity (NTU)	9.24	8.86	6.73	6.50	7.72	3.45	2.04
5.	Alkalinity (mg/l)	14.3	14.3	9.3	10.3	9.33	12.0	6.97
6.	Hardness (mg/l)	826.1	839.0	825.6	722.7	755.8	791.6	842.3
7.	TDS (mg/l)	358.7	348.0	346.7	360.3	337.0	340.3	340.0
8.	BOD_5 (mg/l)	4.64	3.33	2.10	2.47	1.10	2.31	1.47
9.	COD (mg/l)	435.3	347.7	238.3	210.6	305.3	313.3	223.3
10.	Colour (units)	5.0	5.0	5.0	5.0	5.0	5.0	5.0
11.	Chloride (mg/l)	3.62	3.1	3.1	2.98	2.60	2.62	2.22
12.	Nitrate (mg/l)	10.3	6.3	5.6	4.6	3.9	4.4	3.5
13.	Fluoride (mg/l)	0.23	0.26	0.23	0.22	0.19	0.22	0.25

Table 7: Regression Analysis on Physico-chemical parameters with distances and depths of the wells

Model number	Dependant variables	Independent variables	Coefficient of Determination (R^2)	Standard error of the estimate
1	Turbidity	Distance, depth	0.722	1.422
2	Alkalinity	Distance, depth	0.816	1.177
3	pH	Distance, depth	0.925	0.039
4	BOD	Distance, depth	0.602	0.749
5	COD	Distance, depth	0.730	41.527
6	Chloride	Distance, depth	0.913	1.336
7	Nitrate	Distance, depth	0.714	1.239
8	EC	Distance, depth	0.160	43.887
9	Hardness	Distance, depth	0.035	55.323
10	TDS	Distance, depth	0.463	6.746
11	Fluoride	Distance, depth	0.073	0.027

The regression analysis results showed that 92.5% of the variations in the pH of the wells were contributed by the depths and distances of the wells from the dump site which was statistically significant at 95% confidence level. However, depths and distances of the wells from the dump site contributed: 72.2%, 80.8%, 60.4%, 73.0%, 91.3% and 71.4%, respectively for the variations in the turbidity, alkalinity, BOD, COD, chloride and nitrate, which were all statistically significant at 95% confidence level. On the other hand, the depths and distances of the wells from the dump site contributed only: 16.0%, 3.5%, 46.3%, and 7.3%, respectively to the changes in the EC, hardness, TDS and fluoride of the wells but were not statistically significant at 95% confidence level because the computed F- value was less than the critical value.

CONCLUSION

The mean values of the physico-chemical parameters analysed for the June, July and August for the six (6) wells (W_1 - W_7) showed that the pH range from (7.29 - 7.68); while Electrical Conductivity range from (593 - 693 µs/cm), Turbidity (2.04 - 9.24 NTU), Alkalinity (6.9 - 14.3mg/l), Hardness (722.7 - 842.3mg/l), Total dissolved solids (337.0 - 360.3mg/l), Biochemical oxygen demand (1.10 - 4.64mg/l), Chemical oxygen demand (210.6 - 435.3mg/l), Chloride (2.22 - 3.62mg/l), Nitrate (3.5 - 10.3mg/l) and Fluoride (0.19 - 0.26mg/l). This paper also indicates that well W_1 is more polluted than the remaining six wells as it was the closest to the dumpsite. The W_1 recorded TDS, BOD, COD, chloride and nitrates of: 356mg/l, 4.50mg/l, 430mg/l, 2.5mg/l and 4.8mg/l, respectively during the month of June. On the other hand, it recorded TDS, BOD, COD, chloride and nitrates of: 370mg/l, 4.90mg/l, 440mg/l, 2.82mg/l, 5.0mg/l, during the month of July; while it recorded TDS, BOD, COD, chloride and nitrates of: 350 mg/l, 4.52mg/l, 436mg/l, 5.6 mg/l and 21.1mg/l, respectively during the month of August. It was discovered that the wells are more polluted during the rainy season due to the influence of rainfall in the pollution of well water. Also, the result suggests that the level of pollution of a well is a function of its distance from the dumpsite, the closer the well from dumpsite, the more polluted it is. However, depths and distances of the wells from the dump site contributed 72.2%, 80.8%, 60.4%, 73.0%, 91.3% and 71.4%, respectively for the variations in the turbidity, alkalinity, BOD, COD, chloride and nitrate, which were all statistically significant at 95% confidence level. On the other hand, the depths and distances of the wells from the dump site contributed only 16.0%, 3.5%, 46.3%, and 7.3%, respectively to the changes in the electrical conductivity, hardness, TDS and fluoride of the wells but were not statistically significant at 95% confidence. It was recommended that the wells should be properly line and should be provided with apron. The solid waste dumpsites should also be properly constructed and managed so as to minimise the risk of groundwater pollution

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