

PHYSICO-CHEMICAL PARAMETERS OF SOME POLLUTANTS AFFECTING SOILS AND GROUNDWATER QUALITY LOCATED AROUND SELECTED DUMPSITES IN AKKO LOCAL GOVERNMENT AREA OF GOMBE STATE, NIGERIA

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ABSTRACT

The habit of locating domestic wastes disposal sites around water sources in Nigeria without recourse to the potential danger of pollution is worrisome. This study assessed the impact of solid wastes on soils and groundwater quality at selected dumpsites in Akko Local Government Area of Gombe State, Nigeria. The characterization of four (4) most active dumpsites was conducted using Tchobanoglous procedure, while conventional pollutants and heavy metals concentrations were assessed using titrations and digestive procedure. Average food waste of 22.45% constituted the highest percentage of waste generated while plastic made up of 15.93%. Paper waste constituted 5.46%, ash/charcoal 9.86, batteries 3.8%, diapers 6.10, wood 5.5%, glass waste 3.9%. The compositions indicated that the communities are low income citizen who survive on daily basis food supply. Twenty (20) groundwater samples were collected from five different locations, ten (10) of the samples from well water while ten from boreholes. From the results, samples contained nitrates 12.9 mg/L, pH 5.9, Biological oxygen demand 132.8 mg/L were observed to fall within recommended limit of WHO except for phosphates 12.56 mg/L, dissolve oxygen 6.9 mg/L and chemical oxygen demand 403.5 mg/L which were higher than the recommended limit of WHO. Analysis of heavy metals for both water and soil samples reveals that no traces of Cadmium was found in all samples except for Hammadu Kafi 0.0085 mg/L, while Copper was not found in any of the samples collected, Manganese has the highest concentrations of 2.69 mg/kg for soils and 0.86 mg/L for water sample which were both higher than WHO 0.02 mg/L limits. Results from analysis of cadmium 0.009 mg/L and iron 0.9 mg/L indicated slight variation from the standard. It is therefore recommended that dumpsites should not be located close to water sources and water used for drinking should be treated before consumption.

Keywords: Wastes characterization, Leachates, Physicochemical characteristics, Biochemical Oxygen Demand, Coliform count

1 INTRODUCTION

Human activities on earth give rise to generation of wastes which are not of immediate need where they arise, these activities include farming, industrialization, mining, commercial activities which result to waste generation. The waste generated when dumped on an opened dumpsite (not designed dumpsite) pollutes the soils and surrounding ground water therefore making it unpleasant for consumption. [1] refers to solid wastes as the range of garbage arising from animal and

human activities that are discarded as unwanted and allow to decay. Solid waste is generated from industrial, residential and commercial activities in a given area, and may be handled in a variety of ways. From the above definition, solid waste can be considered as something, which the holder discards or intends to discard because they have become useless and unwanted such as: papers, plastic container, bottles, cans, food and even junked cars, tires, refrigerators, stoves and scraps of broken electronic goods, broken furniture, hospitals waste, and other packaging materials are all examples. The open and unsafe dumpsites contain multiple disposals of domestic, municipal, industrial and medical wastes, which are common practice in most cities in developing countries [2]. These dumpsites have become breeding ground for diseases and animals especially rats, birds, and stray animals, thereby contributing greatly to their nourishment and growth. Assessing the impact of solid waste on soil and water quality around dumpsites offers unique opportunities for the protection of human health, plants and the environment at large [3]. The problem is that, dumping the waste on soil is one means by which the soil and ground water quality become contaminated. The polluted soil affects human health through direct human contact, inhalation of the polluted airborne dust and the consumption of untreated water around active dumpsites. Studies on the effects of unlined waste dumps on the host soil and underlying shallow aquifers have shown that soil and groundwater system can be polluted due to poorly designed waste disposal facilities [4]. Uncontrolled waste dumpsites threaten the groundwater supply as movement of leachates from dumpsites through the soil and the aquifers pose a risk to the environment and human health.

2 THE STUDY AREA

The study area is Akko, one of the local Government areas of Gombe State Nigeria. Its head quarter is in the city of Kumo on the A345 highway south of the state capital Gombe (about 40 km approx). Kumo is a cosmopolitan community of more than 30 different tribes, ranging from renowned Fulani and Hausa, to Jukun and Tulaa. Kumo also serves as the second largest commercial centre of Gombe State. The town of Akko is located between Latitudes $10^{\circ}17'00''$ and $10.28333^{\circ}N$ and Longitudes $10^{\circ}58'00''E$ and $10.96667^{\circ}E$ in the west of Gombe town. Historically, Kumo town was a small settlement of few tents inhabitants. It received its first impetus with the transfer of Gombe divisional headquarter to Akko in 1993. Kumo served as the seat of administration of Gombe State as well as the local Government headquarters. This historical development and associated landmark event enhanced its further growth in population, size and cosmopolitan composition [5].

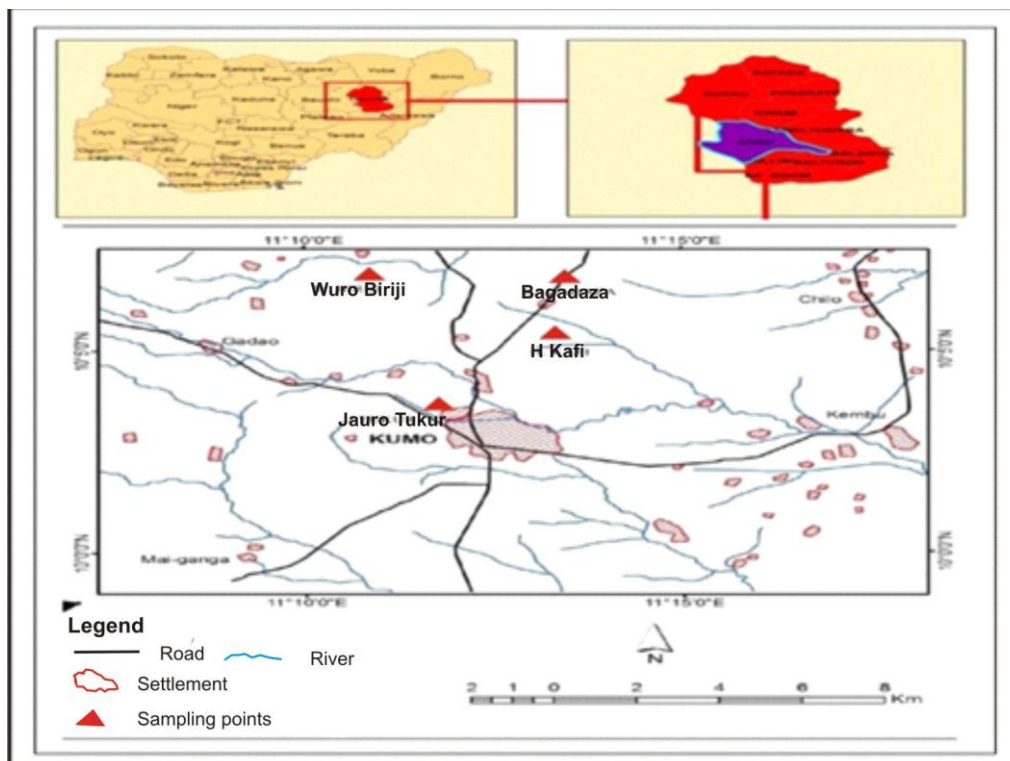


Figure 1. Map of Akko Local Government showing sampling points, modified after [5]

3 MATERIALS AND METHODS

Standard procedures were followed for the collection, preparation and analysis of the samples for characterization. The procedure used by [6] for waste characterization was adopted for this research work. Large volume of solid wastes from the dumpsites was mixed using rakes, shovels, leather bags, to the extent that each component of the waste was thoroughly mixed. The samples were then weighed by crane scale balance mounted on a plumb wood to avoid error due to parallax. At first, weigh of empty bag was measured, before loading the solid waste in to the bag, the reading from the crane scale was recorded, the bag was emptied on a tarpaulin bag spread on the ground to avoid contamination, the process is repeated until a total weight of 200kg was recorded and needed for the characterization. Following identification and segregation, different components were sorted and placed into the labeled containers. Plastic bags were used during the characterization process, weight of each bag was measured before commencement of the sorting exercise, they were labeled with a masking tape, weight on a scale balanced placed on a leveled ground and the calibration of the scale was frequently measured with a known weight.



Plate 1. Solid waste Characterization Exercise in Akko Local Government Area, Gombe State

3.1 Sample sites, collection, preparation and analysis

In order to achieve a desired output and conduct a thorough study, four most functional dumpsites were selected viz; Jauro Tukur, Bagadaza, Wuro Biriji, and Hammadu Kafi in Akko local Government. Water samples and control samples were also collected within Akko Local Government Area in other to achieve the required result. The samples were collected in form of hand dug well water and borehole water, the earlier were collected at a distance of 10 to 30 meters away from the dumpsite while the later were collected at a distance lesser than 5meters away from dumpsites. A total of 16 water samples were collected, eight from hand dug well water, eight from borehole water to assess the impact of the dumpsite on the water quality and four samples from control site at Wuro Bajoga which is excluded of dumps effect. Four soil samples were collected from each dumpsite at the depth of 20cm beneath the top soil for heavy metals analysis and one from control site in line with [7]. The equipment used for the sampling are; sealed bottle (air tight), hand gloves, facemasks, shovel, rake, polyethene bag, soil auger, electronic weighing scale, conical glass, hydrochloric acid, and nitric acid. Other equipment used includes atomic absorption spectrometer, electric oven, plate count ager, autoclave, and incubator similar to [8].

3.1.1 Soil sampling techniques, collection and preparation

The random sampling technique was adopted for the purpose of this research. At the sampling site, one sample was collected from solid waste for characterization, and soil sample for testing heavy metals. Polyethene bags were used for sample collection, labeled and properly tied; this is similar to a procedure specified by [9]. The soil samples were collected using auguring method under the supervision of a qualified laboratory technician with the aim of determining the concentrations of some selected heavy metals from the soil samples.

3.1.2 Procedure for heavy metals determination

In the determination of the availability and composition of heavy metals in the soil samples collected at each sampling station, the digestive method was used, as recommended by [10] procedure.

3.1.3 Determination of physicochemical and Microbiological properties of water samples

The water samples were collected around 12:30pm to 3pm, during the month of April directly from both the boreholes and wells, the containers were well sterilized with ethanol to ensure sanity of the water sample. The containers were air tight to avoid contamination and maintain the sample's properties as they were collected.

(a) Temperature determination

Temperature was determined by using mercury in glass thermometer. The thermometer was rinsed with distilled water before and after each use, and the unit of measurement is centigrade degrees °C.

(b) pH and conductivity determination

The pH of the sample was determined at the water source immediately after collection using digital pH meter with a glass electrode [11].

(c) Determination of Dissolved Oxygen and Biological oxygen demand

The dissolved oxygen (DO) of the sample was tested the day the samples were collected. The samples were initially used to rinse the bottles and were filled up by ensuring no air bubble remained in the bottle. 2 ml of alkali-iodide-acid reagent was also added. Biological oxygen demand (BOD) is the difference between DO₁ on the first day, and DO₅ after 5 days. Therefore;

$$BOD = \frac{(DO_1 - DO_5) \times \text{volume of BOD bottle}}{\text{ml of sample used}} \quad (1)$$

(d) Determination of Chemical Oxygen Demand

400 mg of sulphuric acid (H₂SO₄) was measured and placed in a reflux flask. 20ml of the sample and 20ml of distilled water was added and mixed, the 10ml of standard potassium dichromate (K₂Cr₂O₇) solution and glass beads are already treated to 600°C for an hour. The flask was then attached to the reflux condenser and 300 ml of concentrated H₂SO₄ was added, mixing thoroughly while adding the acid. The mixture was refluxed for an hour, cooled and the condenser was washed with distilled water. The mixture was distilled for about 15 minutes with distilled water and cooled to a room temperature. Three (3) drops of ferroin indicator was added and the mixture was titrated with Fe (NH) to a colour change from blue-green to a reddish brown. A blank consisting of 20ml of distilled water was refluxed in the same manner together with the reagent. Therefore the Determination of Chemical Oxygen Demand (COD) was calculated as:

$$COD = \frac{(a-b)N \times 8000}{\text{ml of samples}} \quad (2)$$

Where N = Normality of titrate; a = ml titrant for blank; b = ml titrant for sample



Plate 2. Atomic Absorption Spectrophotometer Buck Scientific 2002

The data obtained was analyzed using simple descriptive statistics and Analysis of Variance (ANOVA). This is because it allows one to determine the means of more than two variables and to determine whether the differences between the samples are simply due to random error (sampling errors), or whether there are systematic treatment effects that causes the mean in one sample to differ from the mean in another.

4 RESULTS AND DISCUSSION

Result from wastes compositions shows that the average food waste (22.45%) had constituted the highest percentage of waste generated followed by plastic with (15.93%). Miscellaneous waste was also found to be outrageous (13.36%). Paper waste constitute (5.46%), ash/charcoal (9.86), batteries (3.8%), diapers (6.10), wood (5.5%), glass waste (3.9%). Textile makes up (13.4%), while rubber constitute (4.23%) of the total waste. This is similar to a research conducted by [12].

4.1 Physicochemical and Microbiological Parameters of Water Samples

(i) Temperature

The groundwater temperature for well water and borehole water is presented in Figure 2. From the results, the temperatures were slightly lower. It was also observed that all samples analyzed fall within the [13] Standard for drinking water quality except for well water at Hammadu Kafi which was 28.3°C hand dug wells 27m far away from dumpsites.

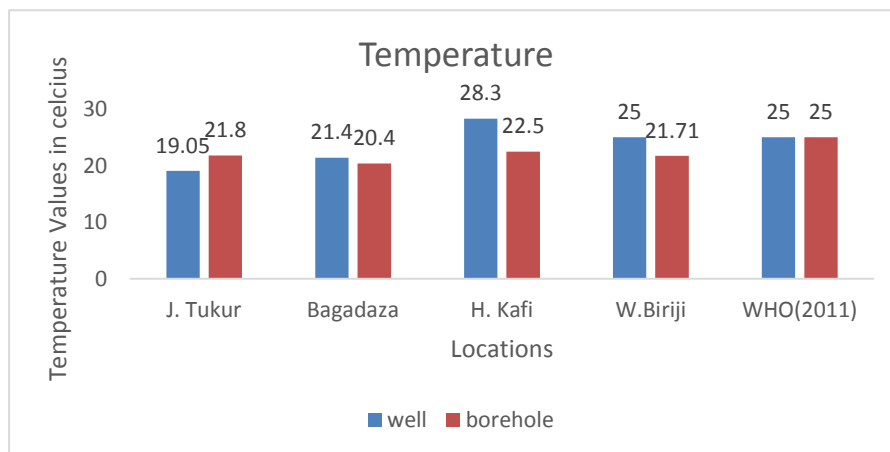


Figure 2. Temperature Concentration

(ii) pH Concentrations

From Figure 3, the groundwater pH for well water and borehole water versus the World Health Organization [13] guidelines. From the table below, Jauro Tukur was recorded highest value of pH 7 for both well and borehole samples, which became highest value for pH for all sample collected. It shows slight variation in groundwater pH in borehole water, however; in both samples, the pH was within the acceptable range of 6.5 to 8.5 except for well water at Bagadaza, Hammadu Kafi and Wuro Biriji which slightly shows pH below limit.

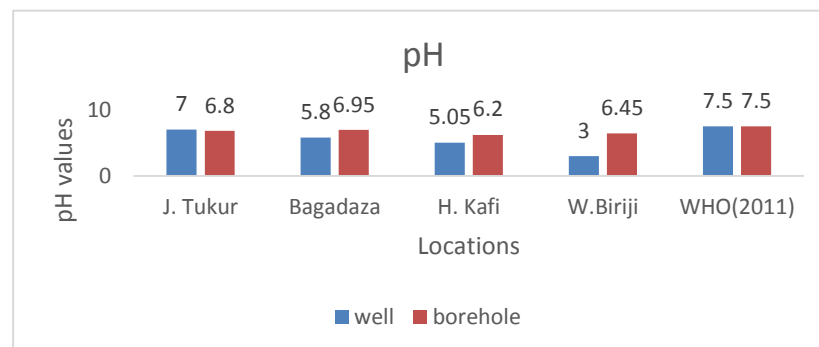


Figure 3. pH Concentrations

(iii) *Biochemical Oxygen Demand*

Figure 4 shows the levels of Biochemical Oxygen Demand (BOD) for well water and borehole water compared to recommended guidelines as provided by the [13]. The results showed that the levels of BOD in groundwater were below the recommended guideline as recommended by [13]. The measurements of BOD were higher in the borehole water than in the Well water in all the sampled wells. This was as a result of increased inflow of organic matter from the pit latrines due to increased moisture.

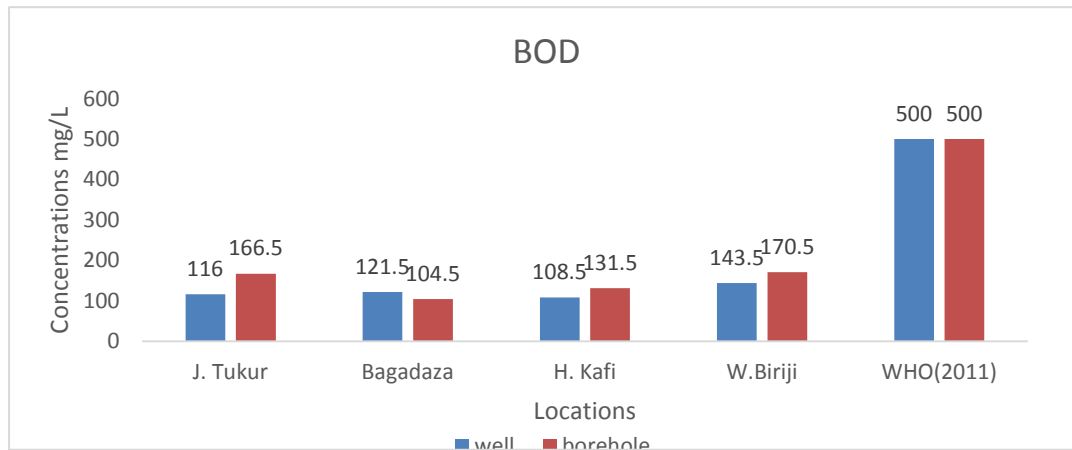


Figure 4. BOD Concentrations mg/L

(iv) *Sulphate Concentration*

Figures 5 shows the levels of sulphate in groundwater for well water and borehole water against the recommended [13] guideline limit of 400 mg/L. The results show that sulphate levels were below the [13] guideline limit of 400 mg/L in both samples. Higher levels of sulphate concentrations were however registered in borehole water compared to well water except for hammadu kafi where Sulphate concentration in the well water is higher.

(v) *Nitrates Concentrations*

Borehole samples had a mean nitrate concentration of 8.93 to 12.9 mg/L, while well water had mean concentrations of 10.35 to 21.21 mg/L respectively. A comparison with the guideline given by WHO (50mg/L) showed that the nitrate concentration in all the water samples were within the recommended limit as it can be seen in Figure 5.

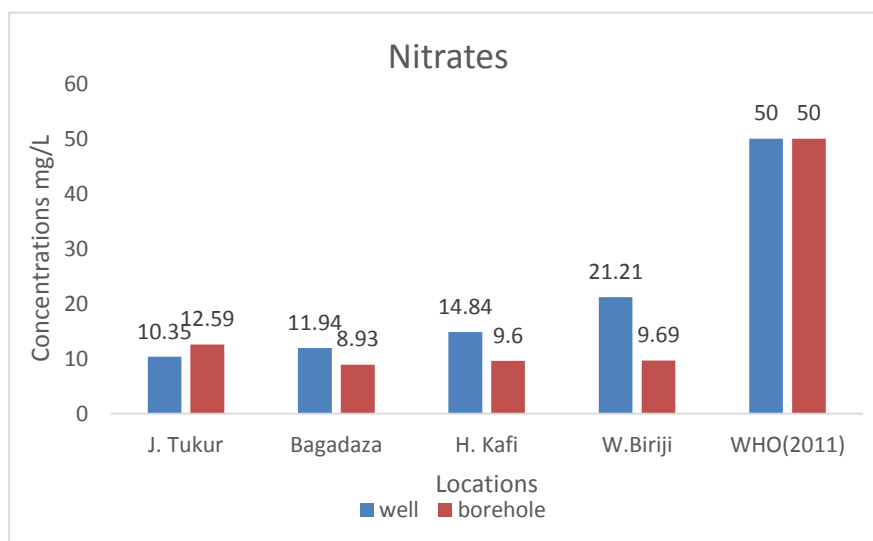


Figure 5. Nitrates Concentrations mg/L

(vi) Phosphate Concentrations

The water collected from all sample points are considered unsafely for drinking purposes as show in Figure 6. However, the use of water collected from the above sources for domestic purpose could have health implications, because it contains phosphate at a level higher than the recommended value of 5.0mg/L set by [13].

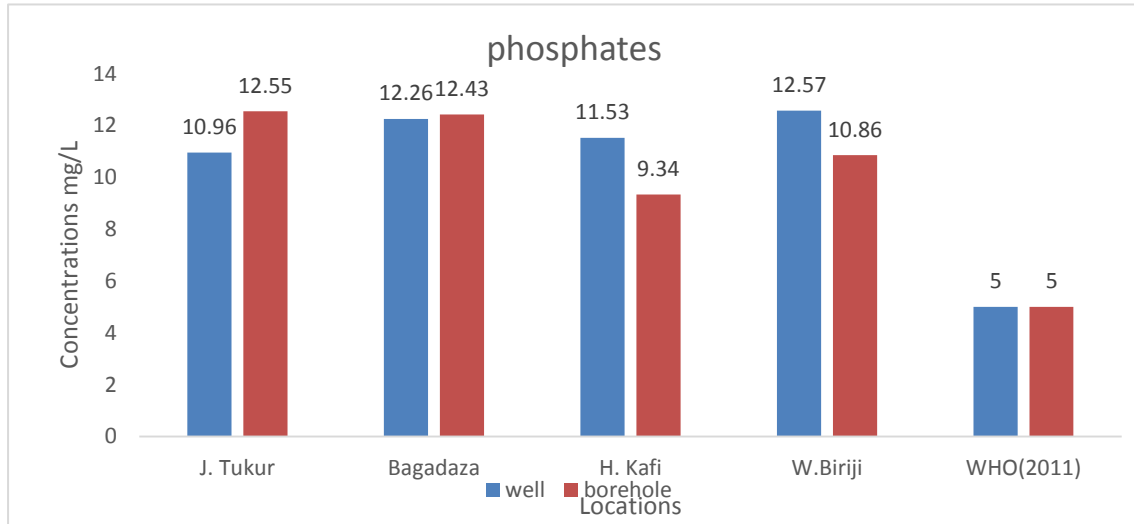


Figure 6. Phosphate Concentrations mg/L

(vii) Escherichia Coliforms

Figure 7 shows the levels of Escherichia coliforms counts/100ml for well water and borehole water compared to the [13] recommended guideline. The figure shows that all the wells were polluted with Escherichia coliforms in both well and borehole water sample. For borehole water samples, higher levels of the pollutant (145,264,200 and 70.5) counts/100ml were recorded compared to well water samples with records of (33, 24.5, 56 and 80) counts/100ml. This difference could have been caused by increased percolation from the dumpsites as the borehole are located much closer to the dumps than the wells. The presence of Escherichia coliforms in drinking water is reflected through biological indicators like the total coliforms. The Escherichia coliforms originates from intestinal tract of warm blooded animals and is usually an indicator of the presence of pathogens in water. The values recorded might be as a result of other sources of pollutants such as pit latrines and sewages around the water sources.

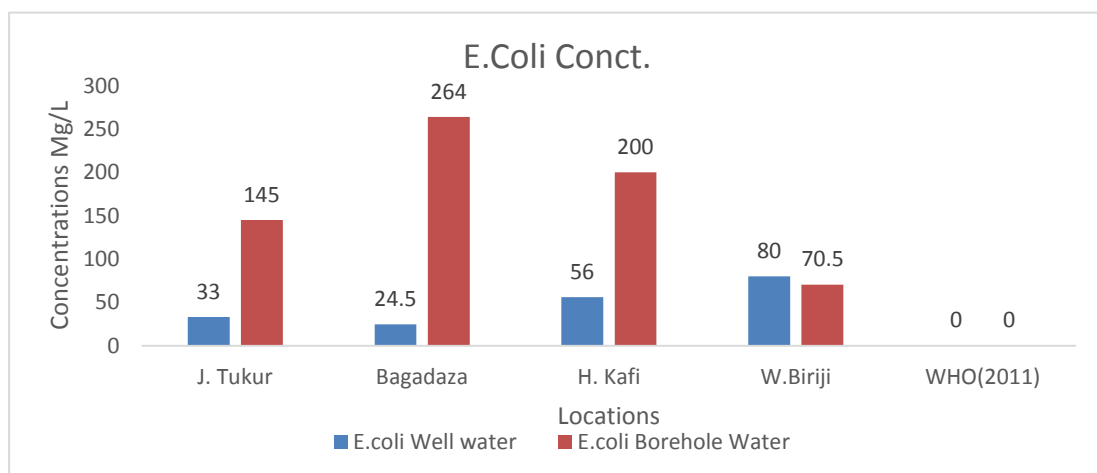


Figure 7. Mean Concentrations of Escherichia coliforms in count/100ml (E.coli)

4.1.1 Comparison of Physicochemical and Microbiological properties of well water samples with WHO standards

Table 1, shows the results of the comparison between the physicochemical properties of well water and WHO limits.

Table 1. Comparison of Physicochemical Properties of Well Water with WHO [13]

Test	Number of Parameters	Mean	Standard Error	Significance diff
J. Tukur	14	111.24	45.21	0.475
WHO	14	174.24	-74.25	
Bagadaza	14	113.9	43.18	0.482
WHO	14	174.24	-74.25	
H. Kafi	14	67.78	21.87	0.18
WHO	14	174.24	-74.25	
W.Biriji	14	111.39	21.87	0.488
WHO	14	174.24	-74.25	
J. Tukur	14	112.67	39.09	0.469
WHO	14	174.24	-74.25	
Bagadaza	14	93.75	36.08	0.338
WHO	14	174.24	-74.25	
H. Kafi	14	49.65	16.58	0.113
WHO	14	174.24	-74.25	
W.Biriji	14	127.12	47.22	0.596
WHO	14	174.24	-74.25	
W.Bajoga	14	34	9.12	0.025

From Table 1, it was revealed that there is no significant difference in the physico-chemical properties of well water with respect to WHO limits. This is because p-value from the analysis is greater than 0.05 level of significance, we therefore accept our null hypothesis and concluded that there is no significance difference in almost all the parameters under analysis. This is similar to [14] on the effects of Solid wastes leachate on ground water quality at a Municipal Landfill in Akure, Nigeria.

4.2 Concentrations of heavy metals in soils

The average concentrations from the soil samples have shown higher values than the limit of WHO of some of the heavy metals. Cobalt concentrations are J. Tukur (66 Mg/kg), Bagadaza (86 Mg/kg) and H. Kafi (57 Mg/kg) while Wuro Biriji is below the recommended value by [13]. It was observed that only H.Kafi has higher record of Iron concentration of 451 Mg/L even though it is not significant and iron has less effect on the body. Nickel in all samples were recorded to have exceeded the limits except for Bagadaza where there is no record found. Manganese in all samples were recorded much higher than the recommended with concentrations of 596 Mg/L, 761mg/L, 644mg/L and 346mg/L for J.Tukur, H. Kafi, Bagadaza and Wuro Biriji respectively. All samples from the control site fall within the recommended values of [13]. In all the sampling locations, no record of lead was found. Table 2 below shows the summary of the findings.

Table 2. Concentration of Heavy Metals in Soil Samples (mg/Kg)

S/N	Parameters (mg/Kg)	J. Tukur	Bagadaza	H. Kafi	W.Biriji	W. Bajoga	WHO [13]
1	Copper (Cu)	6.5	1	23	1	0.01	100
2	Cadmium (Cd)	0	0	0.9	0	0	3
3	Cobalt (Co)	66	86	57	38	0	50
4	Chromium (Cr)	0	0	0	0	3	26
5	Iron (Fe)	389	278	451	352	201	400
6	Manganese (Mn)	596	761	644	346	0.01	20
7	Nickel (Ni)	259	0	92	112	0	50
8	Lead (Pb)	0	0	0	0	0	50

4.2.1 Comparison of Mean Concentrations of Heavy metals in Well Water, Borehole Water and Soil Samples using ANOVA

Table 3. Shows the Post Hoc test showing similarity and dissimilarity between the means of concentrations of heavy metals. This shows that the mean concentrations of metals is the same for well water and borehole but that in the soil is significantly different thus, we can refer that the soil concentrations levels are more critical than that of water. From Table 3, since the p-value (0.000) < α (0.05) we thus reject the null hypothesis and thus conclude that there is significant difference between the mean concentrations of metals in well water, borehole and soils. This is as a result of the nature of solid waste, concentrations of the metals and distance of the water sample from source of contaminations.

Table 3. Post Hoc test between the means of concentrations of heavy metals

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	471232.409 ^a	6	78538.735	5.529	0.000
Intercept	231941.429	1	231941.43	16.327	0.000
Source	459331.586	2	229665.79	16.167	0.000
Location	11900.823	4	2975.206	0.209	0.933
Error	1605237.798	113	14205.644		
Total	2308411.636	120			
Corrected Total	2076470.207	119			

Table 4, depicts the mean concentrations for well and borehole as 0.204 and 0.228 while soil is 131.46. Assessing these values via their 95% confidence bound, the confidence interval in well and borehole contains “zero” hence indicating that the impact of their concentration level are not significant supporting the above result from ANOVA table but that of soil DOES NOT contain “zero” thus implying that its concentration level is significant and should be closely examined.

Table 4. Post Hoc Test for Mean Concentrations in Soil, Well Water and Borehole Water

Metal	N	Subset	
		1	2
Well	40	0.204183	
Bore hole	40	0.228225	
Soil	40		131.46
Sig.		0.999	1

Decision Rule: Reject the null hypothesis (H_0) if p-value (significant) is less than α (0.05) otherwise fails to reject. From the Table 3, above it shows that since the p-value (0.933) > α (0.05), we fail to reject the null hypothesis (H_0) and then conclude that the mean concentration of metals across the four locations including the control are not significantly different. Although J. Tukur and H. Kafi have confidence interval that do not contain zero (suggesting that the concentration may be significant), the overall mean for all locations are not sufficient to be considered different).

5 CONCLUSIONS

From this study, the average compositions of solid wastes explicitly represent the overall wastes components in the dumpsites. Average food wastes had constituted the highest percentage of waste generated followed by plastic wastes. Miscellaneous wastes were also found to be outrageous. Paper wastes, ash/charcoal, batteries, diapers, wood wastes, glass wastes, textile and rubber wastes were found in significant quantities. The compositions indicated that the communities where the dumpsites are located are low income citizens who survive on daily basis food supply. It was noticed that there are no records of metallic contents recorded as scavengers do visit the dumpsites with magnets to pick all sorts of metals for selling to recycling companies. From the results it was also observed that the physicochemical parameters such as (biological oxygen demand, total dissolved solid, alkalinity, nitrates, sulphate, turbidity, conductivity, chloride, total hardness, colour and pH fall within recommended limit by WHO except for phosphates, dissolve oxygen and chemical oxygen

demand which are higher than the recommended limit. Therefore, the water obtained from the sources, is not safe for drinking because of its contaminations. It is recommended that other sources of pollutants such as pit latrines, sewages and some engineering properties of soil such as permeability and compressive strength should be investigated. Improved design of dumpsites should also be encouraged.

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