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Impact of Waste Dumpsites on the Physicochemical and Microbiological Qualities of Well Water Sources Located in Their Vicinities

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Abstract: Indiscriminate dumping of wastes at any available space within the vicinity of residential quarters is a common practice in many developing countries like Nigeria. The negative environmental impacts of waste dumpsites have continued to generate public health concern. In this study, the impact of waste dumpsites on the physicochemical and microbiological qualities of underground water sources located within their vicinities in Delta State, Nigeria, were assessed using standard biochemical techniques. A total of 45 water samples were collected from hand dug wells in Warri, Agbarho and Agbor (all in Delta State) at distances of about 500m, 1km and 1.5 km radius of dumpsites and analysed for physicochemical and microbiological quality using the ASTM and standard microbiological techniques respectively. The results revealed that all the analyzed parameters decreased with distances away from the dumpsites. The physicochemical parameters such as turbidity, dissolved solid were significantly (P<0.05) above the WHO regulatory limits at ≤ 1km radius of most dumpsites. The total heterotrophic bacteria count, which ranged between 2.1×10^3 to 6.52×10^6cfu/ml, was also significantly (P<0.05) higher than regulatory limits. Findings from this study suggest that waste dumpsites could impact negatively on the microbial and some chemical qualities of hand dug well waters sited in their vicinities. Hence, the location of dumpsites at least 1km distance away from residential quarters as well as simple boiling and filtration treatment of drinking water sources in the study areas are recommended.

Keywords: Water, Dump Sites, Heavy Metals, Pathogens, Delta State

1. Introduction

Materials that are discarded because they have served their purpose or are no longer useful could be described as wastes. Wastes are usually in solid, liquid or gaseous forms. Generation of waste mostly occurs from residential, commercial, institutional, and industrial activities. Waste management and disposal process has remained a key challenging issue globally. In Nigeria, indiscriminate and open dumping of waste in any available space is a common practice, and most of the waste dumpsites are located close to residential areas, roads, farms, markets, hospital and churches [1]. According to Ibude [2], improper management of municipal solid wastes create unsanitary conditions, which predisposes the environment to pollution and its attendant health hazards.

One of the major environments greatly impacted by waste dumpsites globally is the water environment. Water is one of the major natural resources needed by man for existence. One of the essential requirements for sustainable socioeconomic development has been attributed to the availability of safe and reliable sources of water [3]. Water is classified into surface and underground water sources. Surface water includes rivers, streams, ponds, lakes, while underground water includes wells and borehole waters among others. Despite the fact that water occupies over 70% of the earth, the availability and accessibility of portable water remains a major challenge in many developing countries. This has been attributed to the increasing pollution of soil and water bodies by diverse humans and industrial wastes. Indiscriminate dumping of solid and liquid wastes, coupled with poor management strategies have been reported to affect the physicochemical and microbial qualities of soil and waters bodies in their vicinities. According to Anilkumar *et al.* [4], the qualities of ground water sources close to the municipal solid waste dumping sites in Kerala, India, were polluted by the waste leachate. Also, it was found that solid waste dumpsites in the vicinity of surface water bodies in Accra Ghana caused a marked elevation in the bacterial and helminth egg counts of the water body [5].

Although, ground water is reportedly less polluted when compared with surface water due to its natural filtration properties, recent studies have shown that most hand dug wells and other underground water sources are becoming increasing contaminated by leachates from sewages, municipal waste dumpsites and hydrocarbons located in their vicinities [6-11]. Depending on the locations and rate of generation, leachates are usually laden with hazardous chemicals, pathogens and toxins, which are potential public health threats if not well monitored and treated. Hence, the need to continuously monitor the chemical and microbiological qualities of most commonly used underground water sources in several developing countries.

This study was therefore carried out to determine the physicochemical qualities and microbial loads of commonly used hand dug well water sources in and around the selected dumpsite located at Warri, Agbarho and Agbor, in Delta State, Nigeria.

2. Materials and Methods

2.1. Study Location

The study area is located within Nigeria Delta in the Southern portion of Nigeria. Warri is between latitude 5°32'N and 5°40'N and longitude 5°42'E and 5°50'N while Agbor is situated between latitude 6°05'N and 6°25'N and longitude 6°05'E and 6°25'E and Agbarho is between latitude 5°34'N and 5°40'N and longitude 5°42'E and 5°50'E All the communities are in Delta State Nigeria.

Figure 1. *Map of Delta State Showing Warri, Agbarho and Agbor.*

2.2. Sample Collection

Experimental water samples were collected from three hand dug wells located at about 500 m, 1 km and 1.5 km radius of the dumpsites. The water samples were collected using sterile containers in accordance with the procedures reported earlier [12]. Fifteen (15) well water samples were collected from Warri, Agbarho and Agbor locations, giving a total of Forty five (45) hand dug well water samples.

2.3. Determination of Physicochemical Parameters of Water Samples

2.3.1. Determination of PH

The hydrogen ion concentration (pH) of each sample was measured using digital Jenway pH meter. The electrode was inserted into the sample and the results were read from the screen. The pH meter was calibrated after each reading using pH buffer (7.00).

2.3.2. Turbidity (Absorptiometry Method)

Turbidity is the amount of suspended particulate matter in a water body which interferes with the passage of light through water. The turbidity of the samples was determined using HACH DR 2010 spectrophotometer. Twenty-five milliliters (25 ml) of the sample was dispensed into a cuvette and placed in the light chamber and absorbance was measured at 580nm using distilled water as blank. The turbidity values were recorded in nephelometer turbidity unit (NTU) [13].

2.3.3. Total Dissolved Solids

The total dissolved solid of the samples were measured with HACH TDS/Conductivity meter. Two hundred milliliters of the test samples were collected with a beaker and the meter electrode probe was inserted into the sample and result in milligram/litre (mg/l) was read from the screen. The meter was calibrated using distilled water after each measurement.

2.3.4. Total Suspended Solids (Gravimetric Methods)

The sample was well shaken and 100ml was filtered through a dried and pre-weighed filter paper. The filter paper with suspended residue was dried at 105°C in an oven to a constant weight or mass. The filter paper and the residue were cooled and weighed [14].

$$\mathrm{TSS\ (mg/L)} = \frac{(\mathrm{A}-\mathrm{B})}{\mathrm{S}} \times 1000$$

Where A= weight of dried residue plus filter paper (mg)
B=weight of filter paper alone mg
TSS=Sample volume.

2.3.5. Determination of Total Solids

This was obtained by the addition of the results from total dissolved solids and total suspended solids.

T.S mg/l=TDS + TSS

2.3.6. Determination of Electrical Conductivity

The conductivity of the samples was measured with HACH TDS or Conductivity meter. Two hundred millilitres of the samples were collected with a beaker and the meter electrode probe was inserted into the sample and result in micro siemens (иs/cm^{-1}) read from the screen. The meter was calibrated using distilled water after each measurement.

2.3.7. Biochemical Oxygen Demand (BOD)

Two sterile 300ml BOD bottles were filled with the samples. One of this was analysed immediately for it oxygen content using Jenway potable DO meter and the result designated DO_0 (initial dissolved oxygen). To the second bottle was added 100ml of diluted water solution and the bottle was then wrapped with aluminum foil and incubated at 20 C for 5days.The wrapping was necessary to prevent light penetration to avoid photosynthetic activities of phytoplankton that may be present in the sample. On the fifth day, the oxygen content of the second bottle was analysed and designated DO (final DO).The difference between Do_o and DO was calculated and multiplied by the diluting factor (d) [13].

$$\text{Mg/l } BOD_5 = DO_0 - DO_5 \text{ (d)}$$

2.3.8. Determination of Chloride Content

To 10ml of the test sample in a corvette, was added 1ml of 95% isopropyl alcohol, 0.5ml of Glycerol and 5ml of conditioning reagent which consist of Sodium chloride, Barium chloride, Conc. Hydrochloric acid, Citric acid and was left for 5minutes to allow colour development after which the absorbance was read at 450 nm with HACH DR2010 spectrophotometer using distilled water as blank [13].

2.3.9. Nitrate (Cadmium Reduction Method)

To 25ml of the test samples in a cuvette, was added nitrate reagent (HACH chemicals) containing cadmium, Gentisic acid. Magnesium sulphate, Potassium sulphate and Sulphanilic acid. It was then shaken vigorously and left for 5minutes until an amber colour developed. The absorbance was read at 500nm with HACH DR2010 spectrophotometer using distilled water as blank (APHA, 1990) [13].

2.3.10. Determination of Sulphide Content

To 20ml of the test sample in a cuvette, was added phosphate reagent (HACH Chemicals) containing Ammonium molybdate, Antimony Potassium tartrate and ascorbic acid. 1ml of 95% ethanol and 1ml of concentrated sulphuric acid was then added. It was shaken and then left for 5minutes to allow for colour development and the absorbance was determined at 880nm with HACH DR2010 spectrophotometer using distilled water as blank [13].

2.4. Culturing and Enumeration of Bacteria in and Water Samples

The collected well water sample was thoroughly shaken to obtain a homogenous sample. An aliquot (1.0 ml) was diluted serially to 10^{-7} dilution [12]. From the dilution of 10^{-1} to 10^{-6} of each sample, 0.1ml aliquot was transferred aseptically onto freshly prepared Nutrient agar plates. The inoculated plates were inverted and incubated at 37°C for 24h after which the plates were examined for growth. The discrete colonies which developed were counted and the average counts for duplicate cultures were recorded as aerobic heterotrophic bacteria in the sample.

2.5. Isolation, Characterization and Identification of Bacteria in the Water Samples

Pure cultures of bacteria were obtained by aseptically streaking representative colonies of different morphological types, which appeared on the cultured plates onto freshly prepared Nutrient agar plates and MacConkey agar plates and incubated at 37°C for 24 h. Discrete bacteria colonies which developed were sub-cultured onto Nutrient agar slopes and incubated at 37°C for 24 h. These served as pure stock cultures for subsequent colonial and biochemical characterization. The bacterial isolates were identified using the Bergey's Manual of Bacteriology.

2.6. Statistical Analysis

Data obtained was analysed using Microsoft 2003 excel programme. Analysis of variance ANOVA (F-test) was done to determine the statistical difference in microbial count between the sampling stations while seasonal variation in bacterial and fungal counts for the air samples at 95% confidence level was determined using t - test.

3. Results

3.1. Physical Parameters of Hand Dug Water Samples

The pH, turbidity, total solids, dissolved solids and suspended solids of the hand dug wells from Warri are presented in Table 1. The pH values ranged from 6.94 ± 0.03 to 7.59 ± 0.11, turbidity values from 8.67 ± 0.42 to 14.4 ± 0.58 and dissolved solids values from 523.5 ± 30.5 to 841 ± 58. The results showed that the pH, turbidity and total dissolved solid values for the hand dug wells water samples collected from Warri were within the WHO regulatory limit for drinking water. The pH, turbidity, total solids, dissolved solids and suspended solids of hand dug wells located in the vicinity of dumpsites from Agbarho are presented in Table 2. The pH values ranged from 6.86 ± 0.09 to 7.3 ± 0.07, turbidity values from 8.3 ± 1.0 to 12.8 ± 0.12, and dissolved solids values from 595 ± 4.5 to 690 ± 10.1. The results showed that the pH of the well water samples close to dumpsites at Agbarho town were within the WHO limit for drinking water. But the turbidity and dissolved solid were above the WHO regulatory limit for drinking water. As shown in Table 3, the pH values ranged from 6.87± 0.03 to 7.37± 0.33, turbidity values ranged from 7.3 ± 1.3 to 12.41± 0.33 and dissolved solids values from 645± 5 to 866.3± 86.9 The results showed that the pH for hand dug wells in the vicinity of dumpsites at Agbor were within the WHO regulatory limit for drinking water. Like those from Agbarho, the turbidity and dissolved solid were above the WHO regulatory limit for drinking water.

Table 1. *Physical parameters of hand dug well water samples from Warri.*

	WW1 Wet	Dry	WW2 Wet	Dry	WW3 Wet	Dry	WHO Standard
pH	6.94± 0.03	6.7± 0.11	7.03± 0.15	6.92± 0.02	7.59± 0.11	7.03± 0.02	6.5-8.5
Turbidity (NTU)	14.4± 0.58	11± 0.5	9.97± 0.32	9.3± 0.01	8.67± 0.42	7.32± 0.15	0-5 NTU
Total solids (mg/l)	1015± 29.2	1080± 60	1080±57.7	930± 40	857± 70.3	646± 39	1000mg/l
Suspended solids (mg/l)	287.7± 7.4	239± 2	248.3± 8.82	207.5± 2.5	190.33± 6.84	122.5± 8.5	500mg/l
Dissolved solids (mg/l)	841± 21	727± 58	831.7±55.5	722.5± 37.5	666.7± 66.8	523.5± 30.5	500mg/l

Key: WW =Well water, WHO = World Health Organization NTU= Nephelometer turbidity unit

Table 2. *Physical parameters of hand dug well water samples from Agbarho.*

	WW1 Wet	Dry	WW2 Wet	Dry	WW3 Wet	Dry	WHO Standard
pH	7.86± 0.09	6.9± 0.1	7.95 ± 0.06	7.2± 0.1	7.81± 0.11	7.3± 0.07	6.5-8.5
Turbidity (NTU)	12.8 ± 0.12	8.3± 1.0	11.83 ± 0.29	7.55± 0.85	11.07 ± 0.27	7.4 ± 1.1	0-5 NTU
Total solids (mg/l)	985.± 31.8	950± 10	983.33 ± 8.82	930 ± 10	910 ± 5.8	815 ± 5	1000mg/l
Suspended solids (mg/l)	328.3 ± 13.02	280± 10	305 ± 10	290 ± 40	255 ± 5.8	220 ± 4.0	500mg/l
Dissolved solids (mg/l)	690 ± 38.8	656± 10.1	678.3 ±12.01	620 ± 50	655 ± 5.77	595 ± 4.5	500mg/l

Key: WW =Well water, WHO = World Health Organization NTU= Nephelometer turbidity unit

Table 3. *Physical parameters of hand dug well water samples from Agbor.*

	WW1 Wet	Dry	WW2 Wet	Dry	WW3 Wet	Dry	WHO Standard
pH	7.87± 0.03	7.2 ± 0.1	7.2 ± 0.33	7.1± 0.05	7.37± 0.33	7..3± 0.2	6.5-8.5
Turbidity (NTU)	12.41± 0.33	10 ± 0.3	11.27± 0.55	8.63± 0.45	9.8± 0.67	7.3±1.3	0-5 NTU
Total solids (mg/l)	1146.7 ±90.62	970± 6.5	936± 23.3	910±10	907.5± 19.72	875± 5.0	1000mg/l
Suspended solids (mg/l)	280.3± 6.36	280±10	269± 13.02	250± 10	231± 17.95	210±10	500mg/l
Dissolved solids (mg/l)	866.3±86.9	690± 10	666.7±51.3	650±0.1	696.3± 18.9	645± 5	500mg/l

Key: WW =Well water, WHO = World Health Organization NTU= Nephelometer turbidity unit

3.2. Chemical Parameters of Water Samples

The BOD, electrical conductivity, chloride, nitrite and sulphide content of the water samples from the vicinity of Warri dumpsite are presented in Table 4. The BOD values ranged from 10.5 ± 1.45 to 28.1 ± 2.9, electrical conductivity from 64 ± 1.26 to 95 ± 12.5, chlorides from 115 ± 5 to 132 ± 0.28, nitrites from 0.05 ± 0.005 to 0.08 ± 0.07 and sulphide from 0.011 ± 0.01 to 0.052 ± 0.09. It was observed that the BOD, electrical conductivity, chlorides, nitrites and Sulphide were within the WHO regulatory limits. The BOD, electrical conductivity, chloride, nitrite and sulphide content of the water samples from the vicinity of Agbarho dumpsite are presented in Table 5. The BOD values ranged from 16.25 ± 1.5 to 18.0 ± 1.50, electrical conductivity from 64 ± 1.26 to 95 ± 12.5, chlorides from 146 ± 0. 53 to 181 ± 13.0, nitrite from 0.0104 ± 0.01 to 0.129 ± 0.00 and sulphide from 0.007 ± 0.00 to 0.013 ± 0.03. It was observed that the BOD, electrical conductivity, chlorides, nitrites and Sulphide were within the WHO regulatory limits. The BOD, electrical conductivity, chloride, Nitrite and sulphide content of the water samples collected sites close to Agbor dumpsite are presented in Table 6. The BOD values ranged from 16.25 ± 1.5 to 16.79 ± 0.17, electrical conductivity from 66.5 ± 1.5 to 95.3 ± 2.6, chlorides from 126 ± 0. 17 to 157 ± 13, nitrites from 0.011 ± 0 to 0.324 ± 0.223, and sulphide from 0.01 ± 0.02 to 0.053 ± 0.039. It was observed that the BOD, electrical conductivity, chlorides, nitrites and sulphide were within WHO regulatory limits.

Table 4. *Chemical parameters of hand dug well water samples from Warri.*

	WW1 Wet	dry	WW2 Wet	Dry	WW3 Wet	Dry	WHO Standard
BOD (mg/l)	28.1± 2.9	20.8± 1.5	19.4±1.7	16.0±2.5	14.8± 1.6	10.5±1.45	6mg/l -240mg/L
Electrical conductivity(us/cm)	95 ± 12.5	91.5± 1.5	83.3±11.2	84.5± 1.5	64± 1.26	66.5±1.5	1000us/cm
Chlorides (mg/l)	132±0.28	132±0.28	127±3.2	121±0.7	122±0.19	115±5	250Mg/l
Nitrites (NO_2-N) (mg/l)	0.019±0.005	0.015±0.005	0.016±0.003	0.005±0.05	0.011±0.23	0.08±0.07	3.0mg/l
Sulphide (S^{2-}) (mg/l)	0.052±0.009	0.025± 0.05	0.048±0.036	0.012±0.01	0.044±0.033	0.011± 0.01	0.05mg/l

Key: BOD= Biochemical oxygen demand, WW = Well water

Table 5. *Chemical parameters of hand dug well water samples from Agbarho.*

	WW1 Wet	Dry	WW2 Wet	Dry	WW3 Wet	Dry	WHO Standard
BOD (mg/l)	18.0± 1.5	17.32±1.75	17.5±1.2	17.0± 1.0	17.0± 1.5	16.25±1.5	6mg/l -240mg/L
Electrical conductivity (us/cm)	95 ± 12.5	91.5± 1.5	83.3±11.2	84.5± 1.5	64± 1.6	66.5±1.5	1000ms/cm
Chlorides (mg/l)	181±13	179± 3	176±13	168±0.33	153±0.12	146± 0.53	250Mg/l
Nitrites (NO_2-N)(mg/l)	0.129± 0.013	0.12± 0.01	0.114±0.0081	0.11± 0.0	0.0104± 0.0032	0.09±0.01	3.0mg/l
Sulphide (S^{2-}) (mg/l)	0.0133±0.0029	0.009± 0	0.012±0.003	0.008± 0	0.0107± 0.002	0.007± 0	0.05mg/l

Key: BOD= Biochemical oxygen demand. WW = Water well, WHO = World Health Organization

Table 6. *Chemical parameters of hand dug well water samples from Agbor.*

	WW1 Wet	Dry	WW2 Wet	Dry	WW3 Wet	Dry	WHO Standard
BOD (mg/l)	16.7±0.13	16.79±0.17	16.7±0.86	16.44±1.0	16.40±0.30	16.25±1.5	6mg/l -240mg/L
Electrical conductivity (us/cm)	95.3± 2.60	91.1±1.5	92.3±1.86	84.5±1.5	78.3±4.41	66.5±1.5	1000us/cm
Chlorides (mg/l)	149±3.73	147±3.73	157±13	128±0.42	130±1.6	126±0.17	250Mg/l
Nitrites (NO_2-N) (mg/l)	0.0341±0.025	0.12± 0	0.0302±0.199	0.011±0	0.324±0.223	0.09±0	3.0mg/l
Sulphide (S^{2-}) (mg/l)	0.053±0.039	0.015±0.0015	0.047±0.037	0.01±0.002	0.043±0.034	0.009±0.002	0.05mg/l

Key: BOD= Biochemical oxygen demand, WW = Well water, WHO = World Health Organization

3.3. Microbial Parameters of Water Samples

The bacterial counts of the water samples from Warri dumpsite are presented in Table 7. The bacteria counts ranged from 3.32 ± 0.195 to 6.92± 0.103 for the hand dug wells. The bacteria counts for the hand dug wells were higher than the WHO regulatory limits. The bacterial counts for the water samples from Agbarho dumpsite area ranged from 4.02 ± 0.097 to 5.95 ± 0.43. The bacterial counts were higher than the WHO regulatory limits. The bacterial counts of the water samples from Agbor dumpsite ranged from 5.3 ± 0.016 to 6.35 ± 0.073. The bacterial counts were also higher than the WHO recommended limit

3.4. Distribution of Bacteria in Water Samples

The distribution of organisms in the hand dug water samples are presented in Table 8. The isolated bacteria were majorly *Streptococcus* sp, *Shigella, E. coli*, *Pseudomonas* sp, and *Salmonella* sp. The bacterial counts were observed to be more in water samples collected during the wet season

Table 7. *Bacterial load (Log10 cfu/ml) of hand dug well water samples.*

Location	WW1 Wet	Dry	WW2 Wet	Dry	WL3 Wet	Dry	WHO Standard
Warri	6.92±0.103	5.47± 0.3	5.93± 0.29	5.16± 0.035	4.78± 0.32	3.32 ± 0.195	2.0
Agbarho	5.95 ± 0.43	5.44±0.325	5.54±0.39	4.725±0.425	5.17± 0.42	4.02±0.097	2.0
Agbor	6.35±0.073	5.92±0.04	6.05±0.193	5.69±0.185	5.57±0.28	5.3±0.16	2.0

Key: WW = Well water. WHO = World Health Organization

Table 8. *Distribution of bacteria isolates in hand dug water samples.*

Bacteria	Wet Season			Dry Season		
	WW 1	WW2	WW 3	WW 1	WW 2	WW 3
Streptococcus sp	++	++	+	++	++	+
*Shigella*sp	+	+	+	+	-	-
Escherichia coli	+++	++	++	+	+	+
Pseudomonas sp	++	+	+	+	+	+
Salmonella sp	++	++	++	+	+	+

Keys: - = absent, + = Rare, ++ = intermediate, +++ = large in number, WW = well water.

4. Discussion

Globally, the quest for safe drinking water continues unabated to date. In this study, the chemical and bacteriological qualities of a commonly used underground water source (hand dug wells) were studied in three major towns located Delta State, Nigeria. The physical parameters (pH, turbidity, total dissolved solids, total suspended solids and total solids) of the ground water samples from Warri, Agbarho and Agbor showed that the pH of water samples in all three towns fell within the WHO recommended limit of 6.5 - 8.5. The reported pH of the water samples were higher than values reported by Uyinmadu *et al.* [15], while monitoring wells at Ojota, Lagos. However values were lower than those reported by Adekunle *et al*. [16] for groundwater sources in Abeokuta, Nigeria.

The reported turbidity values for the water samples were lower than values of 1.05 ± 0.05 to 1.35 ± 0.27 reported by previous worker for ground water in Benin City, Nigeria

[18]. Higher values of 145± 12.3 were reported for leachates from dumpsites in Warri [19]. The recorded values for the water samples were higher than WHO recommended limit of 0-5 NTU. High level of turbidity could harbor pathogenic microorganisms. The colloidal materials provide adsorption sites for chemicals that may be harmful to health or may cause undesirable taste or odour in drinking water [17]. Turbidity therefore is of great importance as pathogenic organisms could be carried in the tiny colloidal particles thus, necessitating water treatment before drinking.

Total dissolved solid (TDS) is an indicator of non-point source pollution problems associated with various land use practices. In this study, the reported values were higher than values of 74± 1.00 to 260 ± 12.49 mg/l reported for water in Benin City, Nigeria [18]. They were however lower than values of 7.070 ± 140 reported for leachates from landfill in Ojota Lagos [16]. The recorded TDS values were however lower than WHO standard for drinking water of 500 mg/l. This could be due to purification of the water by non-porous aquifers such as clay by simple filtration (adsorption and absorption), dilution and in some cases chemical reactions and biological activity as water percolates down the earth structure from the dumpsites [20]. The total dissolved solid was higher in the wet seasons than the dry season. This could possibly be due to the increased leaching of contaminants from the dumpsites towards the ground water source during wet season.

The reported results for BOD showed that its values were within the WHO standard of 240mg/l respectively. Lower values of 0.60 to 0.90 mg/l were reported by Unyimadu *et al.* [15] for water in Ojota Lagos while higher values of 10.6 mg/l were reported by Adeyemi *et al.* [16] in Abeokuta. Chloride contents were within the WHO allowable limit of 250mg/l. Higher values of 90.46 to 250mg/l were reported for water in Ojota Lagos [15]. Usually at values higher than WHO standard, chloride could cause corrosion of metals and impact detestable taste. Nitrite contents were also within the WHO allowable limit of 3.0mg/l. Similar values have been reported [18]. The presence of nitrite in drinking water can be as a result of sanitary sources or runoffs with nutrient flowing into soil from nearby farm lands and/or industrial effluents [8]. It was reported that Nitrite accumulation in drinking water could cause methemoglobinemia in infants [17]. Sulphide content values were equally within the WHO allowable limit of 0.05mg/l. This value is in agreement with the values reported earlier [18]. Values which are higher than the WHO permissible limit impact unpleasant odour and corrosion in water distributing system. The concentration of sulphide may also be dependent on leaching in the soil [18].

The microbial parameters (bacterial counts) of the ground water samples from Warri, Agbarho and Agbor showed they were above WHO regulatory limit of 2.0 log_{10}cfu/ml. Generally, the total bacteria population of ground water samples was higher in the wet season than the dry season. This observation compares favourably with the study conducted by previous workers [16]. The bacteria isolated included *Escherichia coli*, *Streptococcus, Shigella, Salmonella and Pseudomonas* species. Their presence in the studied underground water sample poses a serious public health concern. A similar finding was reported in previous study on the quality assessment of hand dug wells in Awka, Anambra State, Nigeria [8]. These bacteria have been associated with a number of health problems such as cholera, vomiting, diarrhoea and urinary tract infections [21]. Therefore, the continual use of such contaminated water for drinking and other domestic purposes could pose potential health hazards.

5. Conclusion

The present study revealed that the dumpsite had impact on both the microbial and some physicochemical parameters of underground water. Most of the tested microbial parameters were above the set standards by regulatory bodies. The results obtained were comparable to results obtained from other studies conducted in various parts of Nigeria. The present investigation showed that microbial load in the well water samples decreased with increasing distances from the dumpsites. The study also revealed that the chemical and biological contents of the underground water sources were potentially elevated by seepages from the solid waste dump sites in their vicinities, though a few of them were still within the WHO permissible limit as at the period of study. The need for the location of solid waste dumpsites at least 1km away from residential quarters was identified in this study.

Recommendations

a. Dumpsites should be located at about 1 km away from residential areas to avoid contamination of the air and ground water sources
b. Groundwater (well and borehole water) should be treated before use for domestic purposes.
c. Educational programmes be organized for public awareness of impact of indiscriminate dumping of refuse.
d. Ground water sources in Warri, Agbarho and Agbor should be routinely checked for the level of pollutants and polluted water should be treated and channeled for industrial rather than domestic purposes.
e. Programmes should be organized to educate the general populace on proper disposal of refuse, treatment of sewage and the need to purify our water to make it fit for drinking because the associable organisms are of public health significance being implicated in one form of infection or the other.
f. Educative programmes should be organized by researchers and government agencies to enlighten the people on proper use of groundwater.

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