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Full Length Research Paper

Pollution effect of pit latrines on shallow wells at Isale-Igbehin community, Abeokuta, Nigeria

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The study examined the pollution effect of pit latrine on shallow wells at Isale-Igbehin community, Abeokuta, Nigeria. The study was carried out in September, 2007. Both the bacteriological and physiochemical components of the water were analyzed. These include the total coliform count, fecal coliform, taste, odour, colour, temperature, pH, total dissolved solids, conductivity, total hardness, total alkalinity, total titratable acidity, chloride and nitrate. The samples were analyzed using titrimetric and spectrophotometric methods. Correlation analysis was applied as part of analytical tool in this study. Findings showed that all the 12 samples tested positive to coliform count while 5 of the samples tested positive to fecal coliform. Half of the samples produced foul odour as 4 samples tasted sour. Most of the physico-chemical parameters fell within World Health Organization and European Union permissible standard for potable water. Significant relationship exists between the bacteriological and some of the physico-chemical parameters. The polluted water in most of the locations is capable of resulting in health problems, therefore not good for human consumption.

Key words: Pollution, pit latrine, shallow well, bacterial, potable water.

INTRODUCTION

Groundwater pollution has been the focus of attention by many researchers in the recent times (Weissman et al., 1976: Graun, 1984; Whelan et al., 1984; Hyelni, 1994; Dillion, 1997; Pedley and Howard, 1997; Howard et al., 2002; Khazael et al., 2004; Priiss-Ustun et al., 2004; Ayanlaja et al., 2005; Pritchard et al., 2007). Leachate from pit latrine is one of the major sources of this pollution. It is partly responsible for low access to potable water and sanitation problem especially in many developing countries (WHO, 2002). Therefore, there is an urgent need to provide an improved water supply and a safe means of excreta disposal.

Pit latrine is a common method of excreta disposal in the developing world. It is popular and widely used in urban slums as well as rural areas probably because it is the simplest, cheapest and the most efficient excreta disposal that is within the reach of the poor people. Rybezynski et al. (1977) affirmed that pit latrine remains to date, the most widely used technique for excreta disposal in the developing countries, both in the urban as well as the rural areas. Ground water is often polluted because pit latrines are mostly located near water source such as shallow wells. In fact, pit latrine has been identified as a major source of contamination of wells with fecal matter (Molard et al., 1994; Howard et al., 2002; Ayanlaja et al., 2005; Pritchard et al., 2007). Bacteria, viruses and other contaminants such as nitrate infiltrate the surrounding soil through leachate from pit latrine to ground water and are transported by it. Dillon (1997) asserted that in the latrine pits, the liquid soaks away through the base and side of the pit.

The mass and chemical composition of feces, urine and the microbial composition of feces from adult is compose of calcium, carbon, nitrogen, organic matter, phosphorus, potassium, sodium, magnesium, chloride and sulphate (Feachem et al., 1983; Cancer, 1988). Human waste also contain large numbers of enteric micro-organisms that have high concentration of nutrients and a high oxygen demand, all of which may have adverse impact on groundwater quality (Dillon, 1997). At least, an average adult excrete about 2,000,000,000 coliform bacteria in each day (Geidrich, 1966).

The presence of bacteria in water indicates the preference of pathogenic organism causing water related

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diseases. The pathogenic organisms are the most important sources of serious illness and death especially among young children in poor countries. Water- related diseases such as cholera, bacillary dysentery, typhoid, hepatitis, diarrhea and others are all feco-oral in their transmission (Trivedi et al.,1971; Feachen, 1983; Kukkula, 1997; Nassinyama et al., 2002; Priis-Uston., 2004). Unsafe water and poor sanitation account for 3. 7% of the global diseases, and 80% of all the diseases in the developing world. Diarrhea alone accounted for the yearly death of 1.6 million people around the world (WHO, 2007). Children under 5 years are the most vulnerable.

Shallow wells are important source of water supply in the study area. The closeness of most of these pit latrines to shallow wells is capable of causing ground water pollution, consequently leading to water-borne diseases and possible outbreak of epidemics. Therefore, it becomes imperative to embark on the study of the pollution effect of pit latrine on shallow wells with the aim of analyzing the physico-chemical and bacteriological components of the water.

Study area

Abeokuta lies in the latitude 7.10° north of the Equator and longitude 3.20° east of the Greenwich meridian). Isale-Igbehin is located in the southern part of Abeokuta.

Abeokuta enjoys a tropical climate with distinct wet and dry season. The wet season spans from March / April to October and dry season from November to February/March. The little dry season in the mid-wet season of July/August months is dominant at Abeokuta (Adedokun, 1978; Omotosho, 1988; Adejuwon and Odekunle, 2006). The mean annual rainfall is 1156 mm. The mean annual temperature is 27°C while the mean relative humidity ranges from 42% in February to 77% in July (Oguntoyinbo, 1978; Barbour et al., 1982).

The relief is characterized by escarpments which rise from the river plain to a height of approximately 150 m above the sea level in the west and in the southern and northern plains. The east and southern areas are characterized by deeply dissected hills rising to approximately 180 m above sea level.

MATERIALS AND METHODS

Field investigation

An analytical investigation was carried out to determine the pollution effect of pit latrine on shallow wells at Isale Igbehin, Abeokuta. In the course of this investigation, a number of physic-chemical as well as bacteriological parameters were examined from the various shallow wells sampled.

Sampling method

In order to assess the quality of the well water in the study area, 12 samples were taken at different location. The sampled wells were selected by purposive sampling technique. This sampling method was used because of the difficulty of identifying every home using pit latrine and shallow well in the community. Distance, location, soil type, depth and well age were taken into account in the assessment of the water quality. The 12 water samples were named as samples 1 (Ws1), sample 2 (Ws2)…… samples 12 (Ws12).

Sample collection and storage

The water samples analyzed for this study were collected during wet season period in September, 2007. Sampling materials used include 1 L plastic bottles (2), plastic funnel, distilled water, rope and pitcher.

For the bacteriological analysis, the bottles were oven-dried at 40°C for 30 min and later rinsed with ethanol (for sterilization) after which the sample was added. For physiochemical analysis, the sample bottles were rinsed with distilled water and later with a little quantity of the sample. Parameters such as temperature, odour, colour and taste were taken in the field. Total dissolved solids (TDS), conductivity and pH were analyzed instantly in the laboratory, after the samples were collected. However, the total acidity, total alkalinity, total hardness were examined within 24 to 48 h after collection. Analysis for nitrate and chloride could not be carried out immediately after collection due to unavailability of chemical. Therefore, the samples for these analyses were tightly sealed to prevent contamination and gas dissolution and kept in the fridge. However, the bacteriological analysis was carried out the day the samples were collected. The water samples collected for this study were analyzed at the laboratories of Water Resources Management and Agrometeorology (WMA), Environmental Management and Toxicology (EMT), and Biology Department University of Agriculture, Abeokuta.

Analytical method

The determination of appearance, odour, and taste was carried out by human sense of vision, smell and taste. The temperature was taken *in-situ* with the use of capillary filled thermometer. The thermometer was first suspended in the air to know the temperature of the environment. After this, it was inserted in all the samples to know their various temperatures. Temperature was measured immediately the water was collected. The pH, conductivity and TDS were measured through the use of electrode. Total hardness, total alkalinity, total acidity, chloride and nitrate were analyzed in the laboratory. Total hardness, total acidity and chloride were analyzed by

Table 1. The physical-chemical properties of water sample of selected wells.

Table sample	pH	Conductivity (n/s cm)	TDS (mg/L)	Temperature (°C)	Total hardness(mg/L)	Total alkalinity (mg/L)	Total acidity (mg/L)	Nitrate (mg/L)	Chloride (mg/L)
1.	7.90	1040	510	28.5	438	112	550	22.5	38.0
2.	7.30	1000	500	28	330	120	200	34.5	49.5
3.	7.50	1160	570	28.9	278	58	150	50.6	59.0
4.	7.30	910	450	31	270	104	200	49.5	34.0
5.	7.30	700	340	29	225	62	300	40.8	33.5
6.	8.00	490	240	30	154	64	100	28.1	29.5
7.	7.70	640	310	29.5	240	74	150	43.1	29.8
8.	8.30	620	310	29	196	98	200	45.0	30.3
9.	7.80	630	310	30	200	104	600	43.1	25.0
10.	7.70	630	310	29.5	190	90	200	27.8	24.5
11.	8.10	720	350	30	214	98	250	37.5	25.5
12.	7.10	560	280	28.5	206	78	200	35.3	26

titrimetric method while nitrate analysis was carried out by spectrophotometer method. Total coliform count and fecal coliform counts were taken for bacteriological analysis. However, correlation analysis was employed to show the relationship between the physiochemical and bacteriological components of the water.

ANALYSIS OF RESULT

The results of the physiochemical analysis of the water samples of the selected wells are shown in Table 1. Table 2 indicates the selected international water quality standard guidelines. Temperature ranged from 26.5 to 31°C. All the water samples were colourless. The odour of samples 1, 2, 3, 4, 6 and 10 were offensive while samples 3, 6, 8 and 11 had sour taste. The pH values of the samples ranged from 7.1 to 8.3. Chloride, nitrate, total acidity and alkalinity ranged from 24.5 to 59.0 mg/L, 22.5 to 50.6 mg/L, 100 to 600 mg/L and 62 to 120 mg/L, respectively. The TDS ranged from 240 to 570 mg/L while the electrical conductivity ranged from 490 to 1160 ns/cm.

The quantitative aspect of bacteriological analysis indicated that all the 12 samples were positive to coliform count in the laboratory. The total coliform count varied from 1.30 × 10 cful/ml to 3.30 × 10 cfu/ml (Table 3). The colonial growth pattern of 8 of the samples was brownish coalescing colonies (Table 4). Samples 1, 3, 6, 7 and 10 tested positive to fecal coliform (Table 5). This implies that the water is contaminated and detrimental to human health. It can be concluded that Samples 1.3.6.7 and 10 have fecal coli form.

The distance of pit latrine from shallow wells varied from 1.7 to 23.9 m in the study area (Table 6). The depth of the well ranged from 4.4 m in Sample 1 to 10.4 m in Sample 12. Samples 9 and 12 were characterized by clay soil while the remaining 10 samples were characterized by sandy soil.

Correlation analysis between the bacteriological and physic-chemical properties of well water showed that nitrate, chloride and temperature are significant to the total coliform and fecal coliform at 0.05 levels while conductivity is significant at 0.01 levels (Table 7). However, total acidity, total alkalinity total hardness, pH and TDS values are not significantly related to total coliform and fecal coliform. Also shallow well characteristics including depth and well age are not significantly related to the total coliform and fecal coliform counts while the distance to pit latrine is significant at 0.01 levels.

DISCUSSION

The result of the analysis of the water samples showed that the water was affected by bacterial from pit latrine. All the samples were colourless while some of the samples have offensive odour and sour tastes. Odour is derived from bacteria, dissolved gases, mineral matter or phenols (Powell, 1964). The odour in Samples 1, 2, 3, 4, 6 and 10 is an indication of bacterial contamination,

Table 2. Selected international water quality standard guidelines.

S/N	Parameter	Maximum allowances Limits in water mg/1			
		USEPA 1974	WHO 1993	EU 1998	ICMR 1975
1	Appearance	-	-	-	-
2	Temperature (°C)	-	-	-	-
3	Total dissolved solids (mg/L)	500	1000	-	1500
4	PH	6.5-8.5	6.8	6.5-9.5	-
5	Total hardness (mg/L)	-	-	-	500
6	Total titratable acidity (g/100 g)	-	-	-	-
7	Total alkalinity (mg/L)	-	-	-	-
8	Chloride (mg/L)	250	250	250	-
9	Nitrate (mg/L)	10	50	50	-
10	Sulphate (mg/L)	250	250	250	175
11	Sodium (mg/L)	-	200	200	-
12	Magnesium (mg/L)	-	-	-	-
13	Calcium	-	-	-	200
14	Biochemical oxygen demand	-	-	-	-
15	Cyanide (mg/L)	0.2	0.07	0.005	-

WHO, World Health Organization (1993), E.U, European Union (1998), ICMR, Indian Council of Medical Research (1975), USEPA, United State Environmental Protection Agency (1974).

Table 3. Total bacteria count (cfu/ml).

Samples	Bacteria count (× 10 cfu/ml)
a	1.40
b	1.50
c	3.30
d	2.05
f	2.30
g	1.70
h	1.65
i	2.10
j	1.30
k	3.70
l	1.40
m	2.30

Cfu-Colonies forming unit.

of the well water. Colour in water is attributed to materials in solution. These materials are primarily organic compounds leached from decaying vegetation and inorganic coloured compound found in industrial waste effluents. Ground water may become very coloured if they are associated with pest or lignite deposit (Powell, 1964).

Water temperature samples fluctuate from 26.5 to 31°C. The temperature is significant to the total coliform and fecal coliform at 0.05 levels. The physical, chemical and bacteriological processes were significantly influenced by the temperature of the water used (Powel, 1964). Olajire and Imeokporia (2001) maintain that temperature affects not only the biochemical and chemical reaction in the water body but also the reduction in the solubility of gases and amplification of tastes and colour of water. The pH value range of 7.1 to 8.3 for the samples is within the potable water standards (WHO, 1993; EU, 1998).

The pH value confirms excess hydroxyl ions which indicate a basic solution with a pH value greater than 7.0 (Powel, 1964). The variation in the samples pH value shows that the acidic soil leaches are more in some locations than the others (Feller, 1997). The pH is

Table 4. Coliform tests for water samples collected at Isale-Igbehin.

Samples	Colonial growth pattern
1.	Greenish metallic colony (tiny)
2.	Brownish coalescing colonies
3.	Purple centered and tiny greenish metallic sheen colonies
4.	Brownish coalescing colonies
5.	Brownish coalescing and tiny greenish metallic colonies
6.	Brownish coalescing colonies and tiny greenish metallic colonies
7.	Tiny greenish metallic colonies
8.	Brownish coalescing colonies
9.	Brownish coalescing colonies
10.	Tiny greenish metallic sheen colonies and brownish coalescing colonies
11.	Brownish coalescing colonies
12.	Brownish coalescing colonies

Table 5. Completed micro biological test for water samples.

Samples	Growth on nutrient agar	Gram reaction
1.	Growth (+ve)	Gram positive rods seen
2.	No growth	-
3.	Growth	Gram positive rods
4.	No growth	-
5.	No growth	-
6.	Greenish colonies growth on agar	Gram positive rods
7.	Growth	Gram positive rods
8.	No growth	-
9.	No growth	-
10.	Greenish colonies growth on agar	Gram positive rods
11.	No growth	-
12.	No growth	-

Table 6. The characteristics of sampled well in the study area.

S/N	Distance to pit latrine (m)	Depth	Soil	Well age
1.	4.2	4.50	Sand	15
2.	1.8	5.0	Sand	10
3.	1.7	4.20	Sand	18
4.	3.0	4.90	Sand	11
5.	15	5.30	Sand	10
6.	3.75	9.10	Sand	13
7.	17.5	8.60	Sand	15
8.	19.8	5.20	Sand	12
9.	18.5	6.00	Clay	17
10.	9.0	4.40	Sand	14
11.	23.9	5.0	Sand	20
12.	16	10.40	Clay	18

significant to the coliform count. TDS is an indication of the general nature of water quality (Olajire and Imeokporia 2001). The TDS are solids in water that can pass through a filter. These materials include carbonate, bicarbonate, chloride, sulphate, phosphate, nitrate, calcium, magnesium sodium, organic ions and other ions.

Table 7. The relationship between the bacteriological and physiochemical with some other characteristics of shallow well at Isale-Igbehin, Abeokuta.

Chemical properties	Fecal coliform	Bacteria count
Nitrate	-0. 110	0.419*
Chloride	0. 368	0.036*
Total acidity	0. 127	-0.176 ns
Total alkalinity	0. 073	0.163 ns
Total hardness	0.339	0.68 ns
pH	-0.138	0.339 ns
Conductivity	0.494	0.236 ns
TDS	0.376	0.239 ns
Temperature	0.010	0.424 x
Depth	-0.179	-0.199 ns
Age	0.218	-0.310 ns
Distance to pit latrine	0.688	0.000 xx

X-Correlation is significant at the 0.05 level (2 tailed). Xx-Correlation is significant at the 0.01 level (2 tailed).Ns-Not significance.

TDS is used to estimate the quality of potable water because it represents the amount of ions in the total coliform and fecal coliform. Sample 6 with 240 mg/L contain the lowest value of TDS while Sample 7 has the highest value of 570 mg/L in the study area. The TDS is considered appropriate since it falls within the allowable limit of 1000 mg/L (WHO, 1993) and maximum allowable limit of 1500 mg/L (ICMR, 1975) for potable water. Conductivity is the ability of water to conduct electric current. It signifies chemical purity of a low electrical conductance (Benam et al., 1993). Conductivity is highly significant to the total coliform. The value of the conductivity which ranges from 490 to 1160 Os/cm is within the EU permissible limit of 2500 Os/cm for portable water.

The nitrate concentration in the samples varied from 22.5 to 50.6 mg/L. All the water samples except Sample 3 with the value of 50.6 mg/L fall within the WHO and EU permissible limit for portable water. Therefore the fear of methemoglobinemia is alleviated. Since the permissible limit is 50 mg/L, the nitrate concentration in Sample 3 would not have significant negative effect. The sources of nitrate to ground water include natural geologic deposit, mineralization of soil organic nitrogen, intense use of fertilizer, human and animal sewage (Vomocil, 1987; Hallerg and Keeney, 1993., Dillion, 1987). Correlation analysis revealed that nitrate is significant to fecal and total coliform counts in the samples. This is an indication that nitrate from pit latrine escape to the shallow wells. The nitrate level could probably be attributed to leachate of nitrate from the nearby pit latrines. Chlorides are present in all waters. The sources include sedimentary rocks (particularly the evaporates), Salt 'seeps', oil field drainage, domestic and industrial contaminants. Well water may contain chloride concentration in several hundred parts per million of chloride (Powell, 1964). Chloride is one of the constituents found in human excreta. Like nitrate, the chloride in the samples could be possibly traced to fecal contamination of shallow wells. Chloride increases with fecal coliform and is significant to coliform count. The low content of chloride in the samples with values ranging from 24.5 to 59.0 mg/L is within the permissible limit for potable water.

The total titratable acidity appeared not to be too high for most locations. Though, the values ranged from 100 to 600 mg/L, only Locations 1 and 9 record 550 and 600 mg/L. None of the other10 samples exceeded 300 mg/L. The total acidity could have been caused by the pressure of free mineral acids and carbon acids. Total alkalinity is the ability of water to neutralized acid due to the presence of hydroxide. Bicarbonate and carbonate with the presence of borate, phosphate, silicate and other ionic constituents impact additional alkalinity to the water. The lowest value of total alkalinity was recorded in Sample 3 with 58 mg/L while the highest value of 120 mg/L was recorded in Sample 2

From the health point of view, the most important characteristic of good quality water is obviously an absence of pathogenic organisms (Richard et al., 1977). By convention, water contamination is considered to be the introduction or release into water organisms or toxic substances that render it unfit for human consumption (Gordon et al., 1966). Meanwhile, water bodies polluted by fecal discharge from man and other animals may transport a variety of human pathogens. These microbial agents include pathogenic bacteria, viruses, protozoa and several more complex multicultural organisms that can cause gastro-intestinal illness (Dillion, 1997). The most common water borne bacterial pathogen detected in contaminated potable water supplies in the USA during 1961 to 1983 were *Shigella*, *Salmonella*, *Camphilobacter*, toxigenic, *Escharichia coli, Vibrio* and *Yersina* species (Craun, 1985). Others include *Mycobacterium, Pasteurella, Leptospira and Legionella, Iklebsiella* species.

Since *E. coli* first became recognized as the most appropriate bacteriological indicator of water pollution by human excrement, the most probable number of coliform group has been universally used as an indicator (Godd, 1998). But for small household supplies such as wells and springs, the WHO suggests a zero *E. coli* count. The standard laid down by WHO is attainable; for example, there were no *E. coli* in 13,000 samples taken in London in 1964 to 1965 (Southgate, 1969). However, due to socio-economic issues, the maintenance of these standards for general applicability in tropical developing countries is being hindered. In general, the present study confirms that the shallow well water in most part of Isale-Igbehin is highly polluted. The presence of fecal coliform in most of the samples is an indication that the inhabitants are prone to health hazard.

Conclusion

This study examined the pollution effect of pit latrine on shallow wells at Isale-Igbehin, Abeokuta, Nigeria. The result shows that shallow wells can be polluted by pit latrine. Though some of the physiochemical properties analyzed fell within the WHO and EU permissible limit for potable water standards, the bacteriological analysis has shown that such water is harmful to human health. All the samples tested positives to coliform count while Samples 1, 3, 6, 7 and 10 tested positive to fecal coliform. This shows that the water from the shallow wells could lead to outbreak of diseases including cholera, dysentery, diarrhea, hepatitis among others. The authors thereby recommend that:

(i) Prompt well water quality assessment should be undertaken;
(ii) The public health workers should ensure that the distance of pit latrine to shallow wells meet the recommended distance of 30 m by WHO;
(iii) Government should ensure adequate and efficient public water supply through the provision of pipe borne water;
(iv) Public enlightenment campaign on the effect of contaminated water and the danger of sitting shallow wells close to pit latrines be embarked upon by the government and the media (print and electronic), schools, religious bodies e.t.c.

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