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Full Length Research Paper

Lead and coliform contaminants in potable groundwater sources in Ibadan, South-West Nigeria

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The present study investigates possible contamination of untreated and treated groundwater by lead, faecal coliform and *Escherichia coli* in a hundred randomly selected boreholes from different parts of Ibadan metropolis, located in South-West Nigeria. Total lead contents in the water samples were measured by atomic absorption spectrophotometer while coliform count was undertaken using the multiple tube fermentation technique. Detection of *E. coli* in the water was by the presumptive and confirmative tests. Data obtained showed that all the untreated water samples contained lead concentrations in the range of 1.0 - 12.0 ppb, with a mean value (X) of 4.9 ± 0.18 ppb. Seventy-three percent of the borehole water samples had coliform, with 18% of these borehole samples having detectable *E. coli*. All the sachet "water" samples that were supposedly treated having lead concentrations that were in the range of 2.0 - 9.0 ppb with one of them having coliform bacteria. The results obtained supported previous findings that severe environmental degradation, which is readily observable in most parts of Ibadan city, could possibly contribute to pollution of ground water source like boreholes. Supply of adequately treated water from public waterworks to the teeming population in Ibadan city is an important problem that must be solved by the government.

Key words: Groundwater, sachet water, Ibadan, lead, coliform, environmental pollution.

INTRODUCTION

Boreholes and wells are groundwater types that form an integral part of water supply systems in urban and rural communities of Nigeria (Pickering and Owen, 1995), and so can be described as indispensable because of inadequate public water supply systems in most communities in Nigeria (Sayjad et al., 1998). According to Egwari and Aboaba (2002), natural processes and anthropogenic activities of man can contaminate groundwater, and such activities could be domestic, agricultural or industrial in nature. Uncontrolled discharge of toxic effluents to the soil, stream and rivers by industries and indiscriminate dumping of garbage and faeces have been reported to heavily contaminate groundwater in Nigeria (Erah et al., 2002).

Anaele (2004) reported extensive contamination of residential wells and boreholes by sewage from the numerous septic tanks, latrines and soak away pits often sited near them. Majority of residents drink water from these groundwater sources without any form of treatment. Reasons adduced for this unhealthy practice ranged from lack of access to basic methods of water treatment to simply ignorance of hazards associated with the ingestion of contaminated water (Anaele, 2004). This is particularly true of borehole water since its sparkling look gives a false impression of absolute purity to unsuspecting consumers (Anaele, 2004).

Several research findings such as those of Egwari and Aboaba (2002) and Erah et al., (2002) showed that water from several boreholes and wells in some urban centers in Nigeria were heavily contaminated with lead, toxic organic wastes, faecal coliform and *Salmonella typhii*. Coliform in water, though harmless to human health had been shown to portend the most probable presence of other pathogenic microorganisms like *S. typhii, E. coli, Pseudomonas, Vibrio* spp., *Shigella* spp., *Aeromonas hydrophilia* among others (USEPA, 2009; Egwari and Aboaba, 2002; Shelton, 2002).

Indiscriminate dumping of materials laden with lead on land and use of leaded gasoline had been shown to contribute to the lead load of underground water sources of many Nigerian cities (Ademoroti, 1986; Ademoroti, 1986;

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Ayoola, 1979; Erah et al., 2002). A very recent assessment of soils for heavy metals' concentrations of Ibadan metropolis by the duo of Adewara and Akinlolu (2008) using petrographic studies and X-ray diffractograms, confirmed a heavy contamination of the industrial and densely populated residential areas of Ibadan metropolis by lead, copper and zinc.

Although, Shelton (2002), suggested that the permissible limit for lead in drinking water is 0.05 µg/dl, but the current limit by WHO standards is 10 ppb (or 0.5 ppb), it has been established that long-term accumulation of lead in body tissues has neurotoxic, nephrotoxic, fetotoxic, and teratogenic effects on man just like most heavy metal contaminants (Asogwa, 1979; Hoekman, 2005; The Washington Times, 2005). The situation in Nigeria is disturbing as recent reports also suggested that 80% of the hospital patients on admission in Nigeria had water related problems while kidney diseases are on the rise in the last two decades (Anaele, 2004).

In view of a recent study by Adewara and Akinlolu (2009), and survey findings from urban centres like Lagos and Benin as reported by Anaele (2004) and Erah (2002), this present study intends to investigate the current trend of contamination of groundwater sources especially boreholes in Ibadan. The present study analyzed water samples from one hundred carefully selected boreholes in Ibadan for assessment of total lead and total microbial contamination.

Ibadan is the largest indigenous city located within the coordinates; 7°23′47″N 3°55′0″E / 7.39639°N 3.916667°E in Nigeria, West Africa has an area of 828 km^2 and a population of approximately 2.6 million by the 2006 census (Wikipedia, 2010). Ibadan cannot be described as an industrial city because, it has a few small and medium manufacturing industries, but its economic landscape is heavily dotted with hundreds of artisans that handle or process numerous articles containing metals, which they often dispose carelessly to their immediate environment. A recent assessment of soils for heavy metals' concentrations of Ibadan metropolis using petrographic studies and X-ray diffractograms confirmed a heavy contamination of the industrial and densely populated residential areas of Ibadan metropolis by lead, copper and zinc (Adewara and Akinlolu, 2008). The city just like most urban centres in Nigeria (Anaele, 2004), has an almost non-existent public water treatment facility for the supply of adequately treated water to the residents of this city. This situation had forced the majority of Ibadan residents to source water for drinking and other domestic needs from several other water source especially wells and boreholes.

MATERIALS AND METHODS

All the samples for this study were drawn from the city's residential sectors, with none of them having any industry using lead or its compounds. The sectors were identified and demarcated from the approved geographical map of the Ibadan city. The main city, exclusive of the expansive suburban areas was divided into twenty sectors for the purpose of sampling, with five boreholes per sector. None of the boreholes were located near any in battery producing industry or battery repair and maintenance artisans. The five functional boreholes which were randomly selected were chosen if a criterion of a separation from each other by a minimum of 500 meters distance was met and were collected per city sector for analysis using standard procedures for the collection of the water samples (APHA, 1998).

Twenty out of the hundred boreholes sampled were located in small-scale factories involved in the production of sachet packaged water (popularly called "pure water"). Water from each of the boreholes had earlier been pumped into 3000 to 5000 L plastic storage tanks. To ensure that the holding tanks of the water to be sampled is contaminant free, each of these tanks were thoroughly washed, with deionized water, sterilized with chlorinated water, and then rinsed again with excess of deionized water until all traces of chlorine had been eliminated prior to sampling. Each water sample was collected from a tap that had its mouth sterilized appropriately with cotton wool soaked in methylated spirit and made to pass through sterilized filters, after which each was collected in new 1L PVC bottles, which had previously been washed, soaked in 10% nitric acid and finally rinsed in deionized water. Each bottle was labeled and stored in the freezer immediately after collection. Faecal coliform counts and lead concentrations were measured and used as indicators of possible contamination of water sampled in the survey. Presence of *E. coli* was also assessed in all the samples analysed. Actual analysis for total coliform was done within twenty-four hours of collection.

METHODS

Lead determination

Complete digestion of the raw borehole and treated sachet water samples was done with nitric, perchloric, and hydrofluoric acids in a fume chamber. Metals in water samples were extracted and analyzed in accordance with the standard method of analysis raw water samples (APHA, 2002). Concentration of total lead was determined in each of the water samples using a Buck Scientific Atomic Absorption Spectrophotometer Model 200A at appropriate wavelengths (Erah et al., 2002). The digestion and analytical procedures were checked by analysis of DOLT-3 Matrix Certified Reference Material with known concentration for heavy metals (Cantillo and Calder, 1990)

Assessment of coliform contamination

Total coliform counts in the samples were determined using the multiple tube fermentation technique (APHA, 2002). This involved inoculating multiple fermentation tubes containing MacConkey broth with 1 ml of water sample at 37°C for 24 h, after which the count was done with a Suwtex 560 colony counter. Detection of *E. coli* in the water was carried using the presumptive and confirmative tests (APHA, 1998).

RESULT AND DISCUSSION

The results of mineral lead analysis are as shown in Table 1 and presented in Figure 1. The mean lead content of 4.91 ppb was about ten times the WHO permissible limit of 0.05 µg/dl (0.5 ppb) of lead in drinking water (WHO, 1998),

Table 1. Frequency distribution of total lead concentrations in borehole water samples.

Lead concentration (x) ppb	Frequency (f)	Cumulative frequency	Fx
1.0	08	08	08
2.0	13	21	26
3.0	09	30	27
4.0	22	52	88
5.0	13	65	65
6.0	07	72	42
7.0	13	85	91
8.0	06	91	48
9.0	04	95	36
12.0	05	100	60
-	$\Sigma f = 100$	$\Sigma f = 100$	$\Sigma fx = 100$

(ppb = parts per billion = µg/L) (WHO permissible limit for lead in drinking water 0.05 µg/dl or 0.5 ppb).

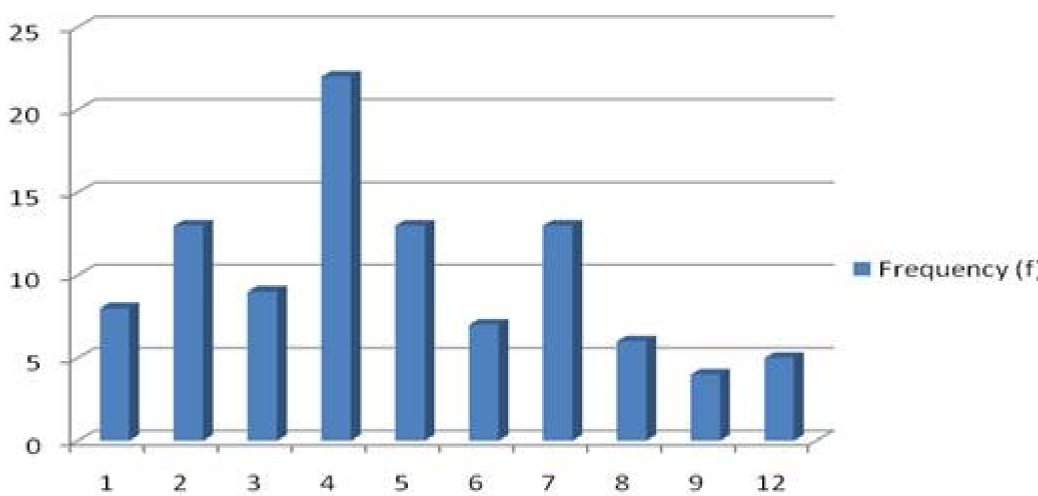

Figure 1. Histogram presentation of the distribution of total lead in borehole water samples.

confirming possible contamination of underground water by lead pollutants. The degree of contamination ranged from 1.0 -12.0 ppb (24 times the permissible limit). Since the residents totally depend on such water for all their daily domestic needs, long-term accumulation of lead in the body via oral ingestion and dermal absorption is a possibility (Florence et al., 2003). Lead as a cumulative body poison (Bernard and Becker, 1998) may be contributory to the onset of chronic or sub clinical symptomatic lead poisoning (HMT files, 2005). Clinical symptoms associated with such poisonings in adults that often occur at blood lead levels greater than 80 micrograms per dl (3.9 micromole per litre) had been well documented by several sources (Sofoluwe et al., 1971; Williams et al., 1999). Such symptoms include abdominal pains, headache, irritability, joints' pain, fatigue, anaemia, peripheral motor neuropathy, deficits in short –term memory, and hypertension (Burns and Baghurst, 1999). Since the boreholes sampled were not located near any important source of industrial battery wastes and yet had significant levels of lead contaminants, data obtained confirmed earlier research findings that several other less recognized sources, apart from occupational or industrial release of lead wastes could contribute significantly to the problem of pollution of underground water by lead (Erah et al., 2002; HMT files, 2005). The results buttressed the findings of Adewara and Akinlolu (2008) that confirmed significant concentrations of metals like lead, copper and zinc in the soils of residential and industrial areas of Ibadan metropolis. Microbiological examination of the

Table 2. Frequency distribution of coliform counts in borehole water samples.

Coliform counts (c)	Frequency (ƒ)	Fc
0	27	00
1	23	23
2	11	22
3	19	57
4	07	28
5	08	40
6	05	30
-	Σ ƒ = 100	Σ ƒc = 200

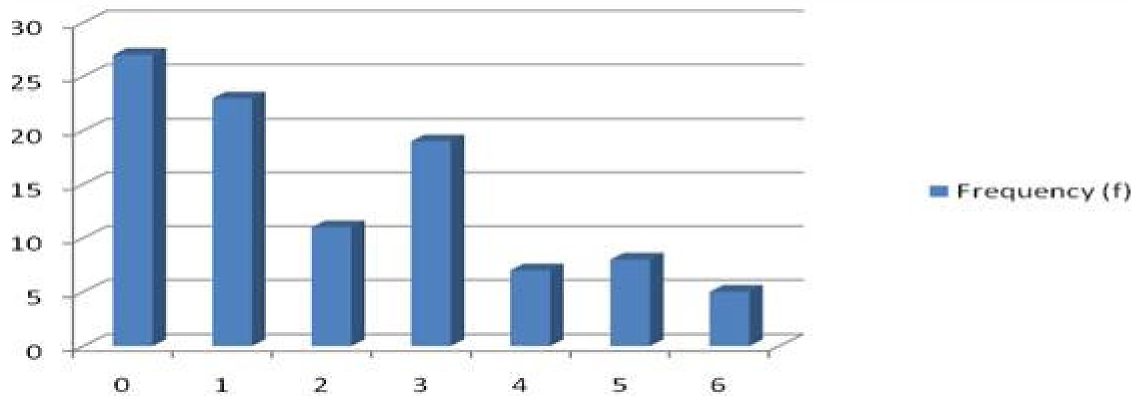

Figure 2. Histogram presentation of the distribution of total coliform counts in borehole water samples.

water samples clearly showed that 73% of the boreholes had coliform bacteria with 18 having *E. coli* (Table 2 and Figure 2).

Data as obtained was disturbing since the presence of any type of coliform bacteria in drinking water is not acceptable by WHO water quality standards. This observation supports earlier reports by Anaele (2004), Erah et al. (2002) and Egwari and Aboaba (2002) that most underground water sources in urban centres of Nigeria may contain substantial microbial contaminants including very harmful ones like *E. coli, S. typhii* among others. According to Anaele (2004), indiscriminate sinking of boreholes near toilet soak-away, pit latrines, dirty gutters and poor drainages had been known to contribute to the presence of contaminants in water from such boreholes. This is of particular significance considering the implicit trust, a substantial proportion of the Nigeria population has in the “absolute purity” of water from boreholes (Anaele, 2004). The population is often ignorant of possible chemical and microbial contaminants in untreated water and is often deceived by the sparkling nature of borehole water.

Mean total lead concentration in the twenty borehole water sample from the “pure water” factories was 5.7 ppb while the mean lead level in the processed sachet packaged water (pure water) was 4.8 ± 0.2 ppb. Nineteen (19) of the twenty samples were coliform free confirming that majority disinfected the raw borehole water properly. Analysis also showed that all the treated “pure water” samples had high lead concentrations that were in the range of 2.0 - 9.0 ppb. This is an indictment against the quality assurance control measures of these so called ‘pure water’ industries since their products had excessive lead levels. Since many unsuspecting consumers in Nigeria depend on such water to quench their thirst especially when away from home, it is obvious that very few can hardly escape from lead contaminated water

CONCLUSION AND RECOMMENDATIONS

Data obtained in this study agreed with several other surveys earlier carried out in other Nigerian urban centers like Benin City and Lagos (Erah et al, 2002; Anaele, 2004; Egwari and Aboaba, 2002). It can therefore be concluded from the study that Ibadan residents consuming untreated borehole water are potentially exposed to possible acute, sub chronic or even chronic plumbism and water borne diseases like typhoid fever, dysentery, diarrhea etc. It is recommended here that chlorinating agents be provided by the government at heavily subsidized prices to all and sundry to assist in the elimination of pathogenic microorganisms in the untreated water supplies (Schute, 1995). Intensive education of the Nigerian population on correct treatment procedures of water for domestic use should be done on the electronic media especially TV and radio on continual basis. This measure, though might reduce the incidence of diseases attributable to microbiologically unsafe water, it will not remove chemical contaminants such as lead (Anon, 1980).

To reduce lead contamination, the local mass media should disseminate information on the need for a more careful handling and disposal of materials that contain lead especially lead paints. Enactment of appropriate legislations to regulate the handling and disposal of lead accumulators by battery chargers in order to control pollution of the environment by lead wastes is likewise recommended. Practical measures to ensure this is the formulation and implementation of policies that will promote comprehensive planning, and redesign of our urban centers to allow for construction of sewage and drainage systems.

Legal framework should be put in place at the national level to put stringent laws to regulate the citing of wells and boreholes, as findings from this study corroborate observations of Erah et al. (2002) that indiscriminate sinking of boreholes and wells without proper geological surveys contributes to the presence of faecal coliform in underground water. And more importantly, the government at all levels in Nigeria should also be admonished and take the issue of supply of adequately treated water to the public as an essential public service.

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