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Original Article

Effects of Pit Latrines on Borehole and Well Water in Maryland, Lagos, Nigeria

Tajudeen O. Yahaya[1*], Danlami M. Bashar[2], Umar Usman Liman[3], Ja'afar Umar[1], Abdulrakib Abdulrahim[2], Clement B. Gomo[3]

[1]Department of Biological Sciences, Federal University Birnin Kebbi, PMB 1157, Kebbi State, Nigeria
[2]Department of Microbiology, Federal University Birnin Kebbi, Kebbi State, Nigeria
[3]Department of Biochemistry and Molecular Biology, Federal University Birnin Kebbi, Kebbi State, Nigeria

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***Corresponding author:**
Tajudeen O. Yahaya,
Email: yahayatajudeen@gmail.com and yahaya.tajudeen@fubk.edu.ng

Abstract

Background: Pit latrines are the most common human excreta and urine disposal facilities in low-income countries because they are economical. However, leachate from the facilities may percolate into the ground and compromise groundwater, necessitating periodic monitoring of nearby groundwater. This study assessed the effects of pit latrines on borehole and well water in Adesoye, Barracks, Onigbongbo, Arowojobe, and Shonibare in Maryland, Lagos, Nigeria.

Methods: Water samples were analysed for physicochemical parameters (electrical conductivity, total dissolved solids, hardness, calcium, pH, and chloride), heavy metals (lead, nickel, cadmium, copper, and zinc) and microbial content (bacteria, coliforms, and fungi). The mean values of each parameter was compared with the World Health Organization standards and used to calculate the average daily intake (ADI) and hazard quotient (HQ) of the heavy metals.

Results: The physicochemical analysis revealed that each of the borehole and well water samples contained permissible levels of electrical conductivity and calcium. They also contained one or more non-permissible levels of pH, hardness, total dissolved solids, and chloride. The heavy metal analysis revealed non-permissible levels of lead and nickel in all of the water samples, while other heavy metals were within the permissible limits. Total bacteria and coliforms were above the permissible limits in all of the water samples, while fungi were undetected in some samples. The ADI and HQ of the heavy metals were within the threshold limit.

Conclusion: The results suggest that groundwater in the areas is unsuitable for consumption. Consumers should treat groundwater and seek experts' advice before sinking groundwater.

Keywords: Chloride, Coliform, Heavy metals, Pit latrines, Lead

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Introduction

Water is a universal solvent and a fundamental component of life.[1] It is utilized for a variety of things, including laundry, cooking, agriculture, and industrial activities.[2] All biochemical processes in the body require water. Water aids to maintain the body temperature, moistening of joints, protection of delicate tissues, and the elimination of waste products.[3] Water exists in three forms namely rain water, ground water, and surface water. The ground water sources include boreholes and hand-dug wells.[4] However, water can be contaminated by several processes, compromising its quality and making it unsuitable for use. Contaminants affect the purity, chemical composition, and microbiological integrity of water.[5] Contamination of water sources can occur from natural processes such as leaching of rocks or from the uses mentioned earlier.[6]

Pit latrines which are the most common facility for human excreta and urine disposal in several regions of the world, may be a source of water pollutants.[7,8] Pit latrines are often utilized by low-income earners because they are the simplest, cheapest, and most efficient excreta disposal method within their reach.[9] However, leachate from pit latrines may infiltrate the soil and compromise ground water.[10] Pathological microorganisms such as bacteria, fungi, and viruses, as well as chemicals such as calcium (Ca), carbon (C), sodium (Na), magnesium (Mg), chloride (Cl), sulphate, and organic matters are found in latrine leachate.[11,12] Human excreta and urine may also contain heavy metals such as cadmium (Cd), lead (Pb), zinc (Zn), cupper (Cu), chromium (Cr), nickel (Ni), and arsenic (As).[13,14] Heavy metals are toxic, non-biodegradable, and have been implicated in several health hazards, including respiratory, genetic, and hematological diseases, as well as skin, eye, and brain damages.[15] Overall, the adverse effects of the pollutants suggest that groundwater sources such as boreholes and wells in places with a high density of pit latrines need to be monitored regularly.

In Maryland, Lagos, Nigeria, pit latrines are commonly used to dispose of excreta, just like in many other places in Nigeria. Either within or around Maryland, at least 34.5% of the residents use pit latrines.[16] Generally, in Lagos, even in secondary schools where a high standard of hygiene is expected, 13% of people use pit latrines.[17] Even more importantly, the majority of the people in Lagos obtain their water from boreholes and wells because they are the most reliable sources of water within their reach. Yet, there is a paucity of information on the effects of pit latrines on the quality of groundwater. This study was conceptualized to assess the levels and health risks of physicochemical parameters, heavy metals, and microorganisms in boreholes and well water in Adesoye, Barracks, Onigbongbo, Arowojobe, and Shonibare areas in Maryland, Lagos, Nigeria.

Materials and Methods

Description of the Study Area

This study was conducted in Adesoye, Barracks, Onigbongbo, Arowojobe, and Shonibare areas in Maryland, Lagos, Nigeria (Figure 1). Lagos is located at 11 m above sea level and the country's south-western area

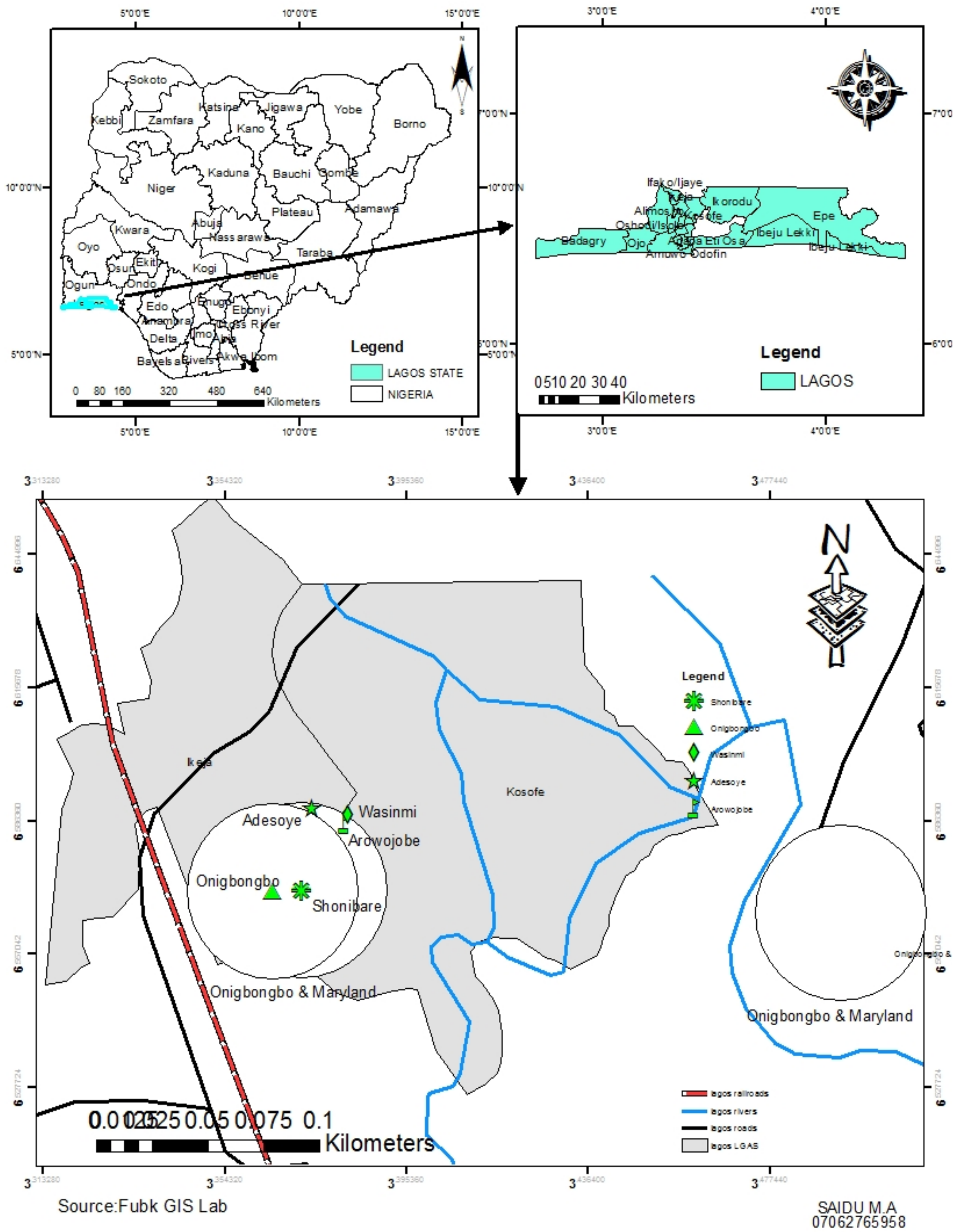

Figure 1. Geographical Location of the Study Areas (Lagos).

with latitude of 6° 27 N and longitude of 3° 23 E.[18] Lagos is Nigeria's smallest state in terms of landmass, with a total landmass of 3577 km^2 including sea bodies.[19] It is, however, one of the world's most populous and fastest growing cities.[15] Lagos is estimated to have a population of 17.5 million people.[19] Lagos is bordered by Ogun State on the north and east, and the Atlantic Ocean's shoreline and the Republic of Benin on the south and west, respectively. Primarily, the Lagos' vegetation consists of tropical swamps and mangrove forests. The wet (March to November) and the dry (December to February) seasons are the two major seasons in the state. The state's average air temperature ranges between 30 and 38˚C. Pit latrines as an excreta disposal method and groundwater as a source of water are common among low-income earners in the state. Thus, there is a need for regular monitoring of the impact of leachate from pit latrines on groundwater in the state.

Sample Collection

Water samples were collected from 10 boreholes and 10 wells in Adesoye, Barracks, Onigbongbo, Arowojobe, and Shonibare areas of Maryland, Lagos, in August 2021. The samples were randomly selected from boreholes and wells situated near pit latrines in the areas. They were put in clean, sterilized plastic containers, sealed carefully, and taken to the lab. Then, they were kept in the fridge at 4°C before being tested for physicochemical, heavy metal, and microbial properties.

Physicochemical Analysis

Time-sensitive parameters such as pH and electrical conductivity were measured at the sampling sites using a Pye-Unicam pH meter and a conductivity meter (model 292), respectively. In the laboratory, a Vial Chloride Meter was used to measure chloride, a complexometric EDTA titration was used to test hardness, and an HM Digital TDS meter was applied to assess total dissolved solids (TDS) and calcium (Ca) (model TDS-4).

Heavy Metal Analysis

The procedures used by Yahaya et al[20] were applied in the heavy metal analysis. All of the water samples were digested by measuring 100 mL into a beaker and adding 5 mL of concentrated HNO_3. The mixture was heated slowly until it evaporated and left 19 mL. The heating was restarted with the addition of more HNO_3 until it was completely digested. The digest was filtered into a 100-mL volumetric flask, and allowed to be cool, after which distilled water was used to top up the solution to the 100 mark on the flask. A UNICAM 969 atomic absorption spectrophotometer was used to determine the levels of Pb, Ni, Cd, Cu, and Zn in the solution.

Microbiological Analysis

Water samples were analysed for total bacteria, coliforms, and fungi using the procedures used by Yahaya et al.[6] The total bacteria count was determined using filtering aliquots of 50 mL from each sample by a 0.45 m paper filter and placing the filter on a nutrient agar plate, and incubating it at 37˚C for 24 hours. The total coliform counts were determined by the same way for the bacteria, but the filter was placed on lauryl tryptose broth and incubated aerobically at 45˚C for 24 hours. The fungi colonies were also determined by the same method for bacteria, but the nutrient was enriched with an antibiotic to kill bacteria.

Health Risk Assessment of the Heavy metals

The health risk of the heavy metals in the water samples was calculated from the average daily intake (ADI) and hazard quotient (HQ) of the heavy metals using equations 1 and 2.[21]

$$ADI = \frac{Cx \times Ir \times Ef \times Ed}{Bwt \times At} \qquad (1)$$

Where *Cx* is the concentration of the heavy metals in water, *Ir* represents the ingestion rate per unit of time, *Ef* indicates the exposure frequency, *Ed* stands for the exposure duration (equivalent to Nigerians' life expectancy), *Bwt* means the body weight, and *At* is the average time (*Ed* x *Ef*). The standard values and units for these variables are presented in Table 1.

In equation 2, *RFD* represents the oral reference dose (mg/L/day) of the selected heavy metals, which are presented in Table 2. Heavy metals with *HQs* of one or less were deemed non-toxic.[18]

$$HQ = \frac{ADI}{RFD} \qquad \text{Eq. (2)}$$

Quality Control and Assurance

To ensure accurate analyses of physiochemical parameters and heavy metals, standard reference materials for all the elements were applied alongside the samples. All the reagents used were analytical grade. Glass and plastic materials were washed by soaking them in 5%

Table 1. Standard Values for Calculating Average Daily Ingestion of Heavy Metals[6]

Exposure Factor	Unit	Value
Exposure frequency (*Ef*)	Days/year	365
Ingestion rate (*Ir*)	L/day	2
Exposure duration (*Ed*)	Years	55
Average body weight (*Bwt*)	kg	65
Average time (*At*)	Days	20075

Table 2. Oral Reference Doses of Heavy Metals in Water[6]

Heavy Metal	Value
Cu	0.04
Zn	0.3
Pb	0.0035
Cd	0.0005
Ni	0.02

HNO_3 overnight and thoroughly rinsed with deionized water before using. Blank samples were examined after five analyses to check for background contamination. Triplicate reading of each physiochemical parameter, heavy metal, and microorganism was performed, and the values were reproducible at 95% accuracy. As a result, the mean values of each physiochemical and heavy metal was used for further analyses.

Data Analysis

Values obtained from various parameters were presented as mean ± standard deviation (SD). The ADI and HQ of the heavy metals were calculated using the Excel software.

Results and Discussion

Physicochemical Properties of the Water Samples

Tables 3 and 4 show the physicochemical parameters of the borehole and well water samples collected in Adesoye, Barracks, Onigbongbo, Arowojobe, and Shonibare areas of Maryland, Lagos. All the water samples contained the world health organization's (WHO's) acceptable levels of electrical conductivity and calcium. Moreover, all the well water samples contained permissible levels of pH as well as non-permissible levels of TDS (Baracks and Onigbongbo), hardness (Onigbongbo), and chloride (Adesoye, Onigbongbo, and Arowojobe). All of the borehole water samples contained acceptable levels of TDS and hardness, but not so for pH in Onigbongbo, Adesoye, and Shonibare. The level of chloride was unacceptable in Onigbongbo and Shonibare, as well. These results indicate that the water may not be suitable for consumption. High chloride levels in the body can lead to heart diseases, stomach cancer, and strokes.[22,23] Metals' solubility is increased by chlorides, resulting in a rise in their concentration in drinking water.[24,25] Excess acidity of body is promoted by acidic water, which promotes premature aging, vision and memory loss, hormonal imbalance, malignancies, renal diseases, obesity, and diabetes.[26] Almost all diseases are linked to a high level of body acidity.[26] TDS levels above a certain threshold may cause constipation and aggravate renal and heart disease.[27] Hard water is linked to an increased risk of cardiovascular disease, stunted growth, and reproductive failure.[28] The result of the current study is consistent with that of Adedeji et al,[29] who detected non-permissible levels of some physicochemical parameters in hand-dug wells and boreholes close to latrines in some areas in Ibadan, Nigeria. It is also in line with the study by Ndoziya et al,[8] who reported distance-dependent non-permissible levels of physicochemical parameters in some groundwater near latrines in Harare, Zimbabwe. The result is also comparable to that of Templeton et al,[30] who observed higher than the permissible levels of nitrate in groundwater sited near pit latrines in three West African cities, namely Dakar, Abidjan, and Abomey-Calavi. However, the results were different with those of Adejuwon and Adeniyi[10] who did not detect any abnormality in the majority of the physicochemical properties assessed in the well water samples collected in Isale Igbehin, Abeokuta, Ogun State, Nigeria, which is an area with a high density of pit latrines. Fadiji et al[9] also found permissible levels of the majority of the physicochemical parameters evaluated in well water located near the vicinity of pit latrines in Ijero, Ekiti, Nigeria. Moreover, Ahaneku and Adeoye[31] did not find abnormalities in the physicochemical parameters of well water which was close to pit latrines in Fokoslum, Ibadan, Nigeria. Although most of the studies, including

Table 3. Mean Levels (mg/L) of Physiochemical Parameters of Borehole Water Samples Collected in Adesoye, Barracks, Onigbongbo, Arowojobe, and Shonibare Areas in Maryland, Lagos

Area	pH	EC	TDS	Acidity	Hardness	Calcium	Chloride
Adesoye	4.5 ± 0.27	350 ± 2.0	240 ± 3.00	57 ± 2.00	87 ± 1.00	34.87 ± 0.20	141.8 ± 0.02
Barracks	6.3 ± 0.02	50 ± 3.0	252 ± 2.00	66 ± 4.00	77 ± 3.00	30.86 ± 0.02	276.5 ± 0.04
Onigbonbo	4.6 ± 0.20	380 ± 3.0	274 ± 2.00	67 ± 3.00	127 ± 2.00	111.02 ± 0.01	404.13 ± 0.03
Arowojobe	7.30 ± 0.02	320 ± 3.0	231 ± 1.00	BDL	108 ± 1.00	3.29 ± 0.02	425.40 ± 0.02
Shonibare	5.30 ± 0.02	230 ± 3.0	165 ± 2.00	21 ± 1.00	59 ± 2.00	23.65 ± 0.02	503.39 ± 0.01
WHO[33]	5.5-9.0	≤1500	≤500	-	≤150	≤200	≤250

Abbreviations: BDL, below detectable levels; WHO, World Health Organization; EC, electrical conductivity; TDS, total dissolved solids.
Values were expressed as mean ± SD.

Table 4. Mean Levels (mg/L) of Physicochemical Parameters of Well Water Samples Collected in Adesoye, Barracks, Onigbongbo, Arowojobe, and Shonibare areas in Maryland, Lagos

Area	pH	EC	TDS	Acidity	Hardness	Calcium	Chloride
Adesoye	5.8 ± 0.01	200 ± 3.0	151 ± 6.00	143 ± 3.0	33 ± 4.51	13.23 ± 0.03	368.68 ± 0.06
Barracks	7.30 ± 0.20	790 ± 10.0	560 ± 5.00	BDL	105 ± 5.0	42.08 ± 0.01	163.07 ± 0.01
Onigbonbo	7.18 ± 0.02	1020 ± 1.0	734 ± 4.00	BDL	209 ± 1.0	83.77 ± 0.03	262.33 ± 0.03
Arowojobe	6.60 ± 0.05	460 ± 2.0	331 ± 2.00	23 ± 4.0	136 ± 1.0	54.51 ± 0.02	233.97 ± 0.00
Shonibare	5.70 ± 0.02	440 ± 3.0	316 ± 4.00	133 ± 3.0	73.0 ± 2.0	29.0 ± 2.00	77.99 ± 0.23
WHO[33]	5.5-9.0	≤1500	≤500	-	≤150	≤200	≤250

Abbreviations: BDL, below detectable levels; WHO, World Health Organization; EC, electrical conductivity; TDS, total dissolved solids.
Values were expressed as mean ± SD.

the current study, did not measure the distances between the groundwater and pit latrines, but studies suggest that contamination of groundwater by pit latrines varies with distance. According to Kusi[32] and Ndoziya et al,[8] pit latrines can spread their leachate into groundwater up to 10 m or more as groundwater movement is either lateral or vertical. Thus, the inconsistency between studies might stem from the varying distances between pit latrines and groundwater in the various studies. The areas under current study are in particular overcrowded just like other parts of Lagos. So, groundwater and pit latrines should be expected to be closed, thereby observing contaminated groundwater. The level of environmental sanitation and maintenance of pit latrines and groundwater, which vary widely, may also contribute to the inconsistencies.

Levels of Heavy Metals in the Water Samples

Tables 5 and 6 show the levels of Pb, Ni, Cd, Cu, and Zn in the samples of borehole and well water collected in Adesoye, Barracks, Onigbongbo, Arowojobe, and Shonibare areas in Maryland, Lagos. Water samples from all the areas mentioned contained WHO non-permissible levels of Pb and Ni, while other heavy metals were within the permissible limits. This result is consistent with most previous studies conducted in residential areas with a high density of pit latrines. Chika and Prince[34] detected high levels of Pb and Ni in borehole and well water in residential areas in Ikorodu, Lagos, Nigeria. Momodu and Anyakora[35] observed higher than the permissible levels of some heavy metals in borehole and well water in residential areas in Surulere, Lagos. Ganiyu et al[36] also reported non-permissible levels of certain heavy metals in groundwater in residential areas in Ibadan, Southwest Nigeria. The result of the current study indicates that consumers of groundwater in the areas are prone to Pb and Ni toxicities. High blood pressure, imbalance of vitamin D and calcium metabolism, neurological diseases and multi-organ damage are only a few of the health risks associated with excessive Pb exposure.[37] High levels of Ni can induce cardiovascular and renal problems, as well as lung and nasal cancer.[38] Although Zn was within the permissible limits, but it can reach toxic levels in the body. High levels of Zn in the body can cause abdominal pain, anemia, liver and kidney injuries and cancers.[39] However, the ADI and HQ of the heavy metals were within the threshold of 1 (Tables 7 and 8). This suggests that heavy metals may not induce severe health hazards. This is particularly true for those who have the average life expectancy in Nigerians (i.e., 55 years) because the risks were calculated using the life expectancy. However, after the average life expectancy, the risk increases with age. Nonetheless, in strict environmental conditions, there are no safe levels for heavy metals in substances. Furthermore, heavy metals can interact with other toxic substances and synergistically raise the toxicity of a them. For instance, Cu can combine with the substances to increase the toxicity of nearly all heavy metals.[40] Ni and Pb combination can increase a substance's toxicity.[41] Cadmium had variable interactions with different heavy metals.[40] Lead and Cd have synergistic effects in toxicity.[42] Daily dietary intake of foods such as rice and vegetables can be responsible for the heavy metal concentrations in the latrines' leachates.[14] Some heavy metals might also reach human excreta and urine through inhalation.[14] According to Lingo and Perri,[43] over 90% of the rise in urine and blood heavy metal levels might be attributed to some factors such as pollutant exposures,

Table 5. Mean Levels (mg/L) of Heavy Metals in the Borehole Water Samples Collected in Adesoye, Barracks, Onigbongbo, Arowojobe, and Shonibare Areas in Maryland, Lagos

Area	Pb	Ni	Cd	Cu	Zn
Adesoye	0.17 ± 0.03	0.41 ± 0.02	0.01 ± 0.00	0.24 ± 0.003	1.98 ± 0.003
Barrack	0.2 ± 0.03	0.22 ± 0.02	0.01 ± 0.00	0.24 ± 0.003	1.22 ± 0.002
Onigbonbo	0.20 ± 0.03	0.02 ± 0.01	BDL	0.19 ± 0.001	1.43 ± 0.002
Arowojobe	0.11 ± 0.02	0.03 ± 0.01	BDL	0.22 ± 0.001	1.09 ± 0.001
Shonibare	0.17 ± 0.03	0.04 ± 0.02	0.001 ± 0.00	0.09 ± 0.002	1.31 ± 0.003
WHO [44]	0.01	0.02	0.003	0.005	3.0

Abbreviations: BDL, below detectable levels; WHO, World Health Organization.
Values were expressed as mean ± SD.

Table 6. Mean Levels (mg/L) of Heavy Metals in the Well Water Samples Collected in Adesoye, Barracks, Onigbongbo, Arowojobe, and Shonibare areas in Maryland, Lagos

Location	Pb	Ni	Cd	Cu	Zn
Adesoye	0.17 ± 0.03	0.21 ± 0.01	BDL	0.23 ± 0.010	2.04 ± 0.03
Barrack	0.20 ± 0.02	0.12 ± 0.01	BDL	0.24 ± 0.04	1.22 ± 0.01
Onogbonbo	0.15 ± 0.05	0.03 ± 0.00	BDL	0.20 ± 0.01	1.45 ± 0.03
Arowojobe	0.13 ± 0.03	0.02 ± 0.01	BDL	0.23 ± 0.003	1.12 ± 0.002
Shonibare	0.20 ± 0.02	0.02 ± 0.01	BDL	0.11 ± 0.004	1.31 ± 0.003
WHO [44]	0.01	0.02	0.003	1.3	3.0

Abbreviations: BDL, below detectable levels; WHO, World Health Organization.
Values were expressed as mean ± SD.

Table 7. Average Daily Intake of Heavy Metals (mg/L) in Borehole and Well Water Samples Collected in Adesoye, Barracks, Onigbongbo, Arowojobe, and Shonibare Areas in Maryland, Lagos

Area	Pb		Ni		Cd		Cu		Zn	
	Borehole	Well	Borehole	Well	Borehole	Well	Borehole	Well	Borehole	Well
Adesoye	0.005	0.005	0.013	0.006	0.003	0.00	0.007	0.007	0.061	0.063
Barrack	0.006	0.006	0.007	0.004	0.00	0.00	0.007	0.008	0.037	0.038
Onigbongbo	0.01	0.01	0.001	0.009	0.00	0.00	0.006	0.006	0.044	0.034
Arowjobe	0.003	0.004	0.001	0.001	0.00	0.00	0.007	0.007	0.033	0.035
Shonibare	0.005	0.00	0.00	0.001	0.00	0.00	0.00	0.00	0.003	0.041
RDI [45]	0.21		0.05		0.06		0.90		8	

Values were expressed in mL/day. RDI recommended daily intake

Table 8. Hazard Quotient of Heavy Metals in Boreholes and Well Water Samples collected in Adesoye, Barracks, Onigbongbo, Arowojobe, and Shonibare Areas in Maryland, Lagos

Area	Pb		Ni		Cd		Cu		Zn	
	Borehole	Well	Borehole	Well	Borehole	Well	Borehole	Well	Borehole	Well
Adesoye	0.004	0.003	0.001	0.000	0.001	0.00	0.00	0.00	0.002	0.002
Barrack	0.004	0.004	0.001	0.00	0.001	0.00	0.00	0.00	0.001	0.001
Onigbongbo	0.04	0.03	0.00	0.00	0.00	0.00	0.002	0.002	0.001	0.001
Arowjobe	0.002	0.003	0.00	0.00	0.00	0.00	0.002	0.002	0.00	0.00
Shonibare	0.004	0.00	0.00	0.001	0.00	0.004	0.00	0.00	0.00	0.001

tobacco smoking, pharmaceuticals, lead-based paint and inadequate coated foods.

Levels of Microorganisms in the Water Samples

Tables 9 and 10 reveal the levels of bacteria, coliform, and fungi in the borehole and well water samples collected in Adesoye, Barracks, Onigbongbo, Arowojobe, and Shonibare areas in Maryland, Lagos, Nigeria. The total bacteria and coliforms were above the WHO's permissible limits in all the water samples. Fungi was above the permissible limits in the borehole water samples collected only in Adesoye and Onigbongbo. Non-permissible levels of fungi were also found in the well water samples collected in Adesoye, Onigbongbo, and Shonibare. This result is consistent with that of Okeke et al,[46] who found non-permissible levels of microorganisms in areas with a high density of pit latrines in Enugu, Nigeria. The finding is also in line with Fadiji and colleagues' findings[9] who detected abnormal levels of bacteria and coliform in well water close to latrines in Ijero, Ekiti, Nigeria. Ndoziya et al[8] reported abnormal coliform counts in groundwater close to pit latrines in Harare, Zimbabwe. A systematic review conducted by Graham and Polizzotto[47] compromising 24 articles on the effects of pit latrines on ground water quality in low-income countries, including Africa, detected abnormal microorganisms in all the water. The results of the current study suggest that the groundwater may predispose consumers to health hazards. Waterborne bacteria may also cause diseases such as cholera, diarrhea, typhoid fever, and dysentery.[48] The detection of faecal coliforms in the water samples is direct evidence of faecal contamination and the occurrence of waterborne diseases.[49] Although most coliforms are harmless to humans, but some such as *Escherichia coli*, can cause severe diarrhoea.[50] The detection of fungi species in some areas under the current study shows that water from the boreholes and wells is unsuitable for consumption. Some species of fungi can cause allergic reactions and some can produce mycotoxins.[18]

Table 9. Levels of Microorganisms in the Borehole Water Samples Collected in Adesoye, Barracks, Onigbongbo, Arowojobe, and Shonibare areas in Maryland, Lagos

Area	Total Bacteria (CFU/mL)	Total Coliform (CFU/mL)	Total Fungi/Yeast (CFU/mL)
Adesoye	150000 ± 200	400	200 ± 40
Barrack	200000 ± 500	600	0.00
Onigbongbo	20000 ± 300	400	200 ± 50
Arowojobe	300000 ± 200	300	0.00
Shonibare	350000 ± 500	200	0.00
WHO[51]	≤ 100	0	0

Abbreviations: World Health Organization.
Values were expressed as mean ± SD.

Table 10. Levels of Microorganisms in the Well Water Samples Collected in Adesoye, Barracks, Onigbongbo, Arowojobe, and Shonibare Areas in Lagos

Area	Total Bacteria (CFU/mL)	Total Coliform (CFU/mL)	Total Fungi/Yeast (CFU/mL)
Adesoye	2.00000 ± 350	500	100 ± 20
Barrack	350000 ± 200	950	0.00
Onigbongbo	270000 ± 400	520	200 ± 30
Arowojobe	200000 ± 600	300	0.00
Shonibare	200000 ± 100	350	200 ± 40
WHO [51]	≤ 100	0	0

Abbreviations: World Health Organization.
Values were expressed as mean ± SD.

Conclusions

The results of the study demonstrated that well and borehole water in Adesoye, Barracks, Onigbongbo, Arowojobe, and Shonibare areas of Maryland, Lagos contain one or more non-permissible levels of pH, hardness, TDS and chloride. The borehole and well water in all the areas also contained non-permissible levels of Pb and Ni as well as total bacteria, coliforms, and fungi (in some areas). Consequently, the water may not be suitable for consumption.

Recommendation

- People are advised to treat borehole and well water from the areas before consuming it.
- To prevent pit latrine contamination, an expert's advice should be sought before sinking a borehole or well.
- Agencies in charge of water, the environment, and health in the areas should put in place measures to prevent contamination of boreholes and wells by latrines.
- Similar studies like the current study should be carried out periodically in the areas.

Authors' Contribution

Conceptualization: Tajudeen O. Yahaya.
Data curation: Clement B. Gomo.
Formal analysis: Umar Usman Liman.
Investigation: Abdulrakib Abdulrahim.
Methodology: Tajudeen O. Yahaya.
Project administration: Tajudeen O. Yahaya.
Resources: Tajudeen O. Yahaya.
Supervision: Tajudeen O. Yahaya.
Validation: Danlami M. Bashar and Ja'afar Umar.
Visualization: Umar Usman Liman.
Writing – original draft: Tajudeen O. Yahaya.
Writing – review & editing: Danlami M. Bashar, Ja'afar Umar.

Competing Interests

The authors declared no conflict of interest.

Ethical Approval

Not applicable.

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