EFFECT OF THE PROXIMITY OF HAND-DUG WELLS TO SEPTIC TANKS ON WATER QUALITY IN AREGBE COMMUNITY, ABEOKUTA, OGUN STATE, NIGERIA

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Abstract: This study examined the possible effects of the proximity of hand-dug wells to septic tanks on the quality of water in Aregbe community, Ogun state. It was noted that the community is not a prominent beneficiary of government-provided water facilities hence the relatively high dependence of its residents on groundwater sources particularly hand-dug wells for their daily water needs. However, a sizable percentage of these hand-dug wells were sited close to their respective septic tanks. This study determined the number of hand-dug wells in the community, the distances between these hand-dug wells and their respective septic tanks, the presence and concentration of the pollutants (i.e. the physical, chemical and microbial parameters of water) in the groundwater with respect to the distances, comparison between the quality of the groundwater samples and international potable water standards and ultimately the possible effects of the groundwater consumption on human health in the study area. The result obtained from the laboratory analysis of the well water samples were statistically analysed using f-test and t- test Analysis of Variance and the mean values obtained for the parameters analysed were also compared with WHO standard for drinking water. The results obtained from the study showed that wells located farther from septic tanks in Aregbe community had better quality of water than the wells closer to the septic tanks indicating that wells in close proximity are liable to contamination which renders the water unfit for consumption
Keywords: Groundwater, septic tanks, distances, wells, pollutants, contamination

Introduction

Worldwide, 1.1 billion people do not have access to clean water, and so about 2 million children die yearly due to avoidable water borne diseases. The Water and Sanitation Program Africa (WSP-AF) reported that 440 children die every week of waterborne diseases (Banya and Zajda, 2015). Study by Lawrence *et al* (2001) pointed to site sanitation facilities as one cause of groundwater pollution in urban settings. Most water distribution facilities do not deliver or have failed to meet the water requirement of the served community due to corruption, lack of maintenance or increased population. The paucity of piped water has made communities to find alternative source of water, and groundwater source has been a ready source, (Adelekan, 2010).

Groundwater makes up about twenty percent of the world's fresh water supply which is about 0.61% of the entire world's water, including oceans and permanent ice. Groundwater is naturally replenished by surface water from precipitation, streams and rivers when this recharge reaches water table. It is estimated that the volume of groundwater comprises 30.1% of all freshwater resource on earth compared to 0.3% in surface fresh water; the icecaps and glaciers are the only larger sources of fresh water on earth at 68.7%. Ground water can be a long-term 'reservoir' of the natural water cycle (with residence times from minutes to years) as it can take a very long-time to complete its natural cycle (Sophocleous, 2002) and this is one of the reasons why its portability must be ensured.

Septic systems or tanks are water-tight chambers sited below ground water level which receive excreta and flush toilets and other domestic sullage (collectively known as waste water). Septic tanks allow for safe disposal of wastewater particularly in rural areas (where it might otherwise flow into rivers, streams, etc). Home owners are usually advised to site their wells or water source to a minimum of 30 meters away from their septic tank locations or any septic tank closest to the proposed well site. Septic waste discharged to coarse-textured soils proceeds vertically through the unsaturated zone and into ground water. Once in ground water, a septic plume develops and moves with ground water flow and it moves at a rate like the ground water velocity. Chloride is potentially a good indicator of a septic plume, while sodium, pH, and specific conductance may occasionally be useful for delineating a plume. High alkalinity, acidity, calcium and magnesium hardness, total dissolved solids and the presence of bacteria in each water sample are also indicators of faecal contamination in water (McQuillan, 2004).

Septic systems can contaminate ground water with dissolved solids, nitrate, anoxic constituents (manganese, iron and hydrogen sulfide), organic compounds, and microorganisms. There is a widespread misperception that nitrate is a universal indicator of ground-water contamination by sewage. Chloride and stable isotopes are used to geochemically fingerprint the impacts of septic systems versus other sources of ground-water contamination. Ground-water nitrate originating from septic systems and primary sewage treatment plants is enriched with ^{15}N due to biological fractionation. If ground-water de-nitrification occurs during migration away from any nitrate source area, ^{15}N enrichment will occur. Septic effluent discharged below the ground surface is not subject to the evaporative enrichment of ^{18}O that can occur in wastewater ponds, and this is reflected in the isotopic composition of ground water impacted by these sources (McQuillan, 2004).

Water from wells can be polluted through other means, (Onunkwo and Uzoiji, 2011). However, the most common cause of pollution is attributable to proximity of septic tanks to wells especially where the adjoining geological formation is fissured. A septic tank stores waste for a period during which it undergoes pre-treatment. About 70% of the waste contains germs and pathogens which pose real threat of contamination and diseases and is therefore very dangerous to human life (Fosse Septique, 2008). Septic tanks have been found to fail and leak profusely, causing environmental damage (Sincero *et al*, 2004). Waste in septic tanks contains germs and pathogens which pose real threat of contamination to underground water and can serve as a vehicle for the spread of water borne diseases such as cholera, dysentery, schistosomiasis, lym, phaticfilariosis, parasitic and viral infections (Ameloko *et al.*, 2018).

Groundwater from shallow and deep (borehole) wells has become the major source of potable water in most semi-urban and rural areas of Nigeria. Groundwater is usually preferred to surface water because it is available in most areas, potable without treatment and of low cost technologies [Oparaocha *et al*, 2008]. Because of the foregoing, governments and individuals in Nigeria have explored groundwater in forms of shallow and deep wells for the supply of potable water. Consequently, there is the need for the assessment of the quality of groundwater at local scales in the country in order to ascertain quality and to prevent diseases and hazards as a result of consumption of contaminated water.

Aregbe community is a community largely dependent on the consumption of the water generated from its hand-dug wells. It was discovered that majority of the hand dug wells are located very close to septic tanks in the community and this can serve as a threat to the health of the consumers as seepage from these septic tanks into the wells is injurious to the human health thus indicating the need for proper analysis of the groundwater supply in the area.

Materials and Methods

Study area

Aregbe is a community in Odeda Local Government area of Abeokuta, Ogun State located in the western part of Nigeria. It is found along latitudes 7.166608^0N and 7.179757^0N and longitudes 3.408357^0E and 3.417423^0E. The community is located towards the outskirts of Abeokuta, Ogun State. The study area falls under the crystalline Basement Complex area of Ogun State, South-western Nigeria. The basement rocks comprise of folded gneiss, schist, quartzite, older granite, and amphibolite's/mica schist (Jones and Hockey, 1964). The occurrence of groundwater in crystalline rocks depends on the extent and depth of weathering and fracturing. Hence, the groundwater is mostly contained in the weathered/ fractured formations and is primarily recharged through surface precipitation and secondarily through lateral flow from rivers and tributaries.

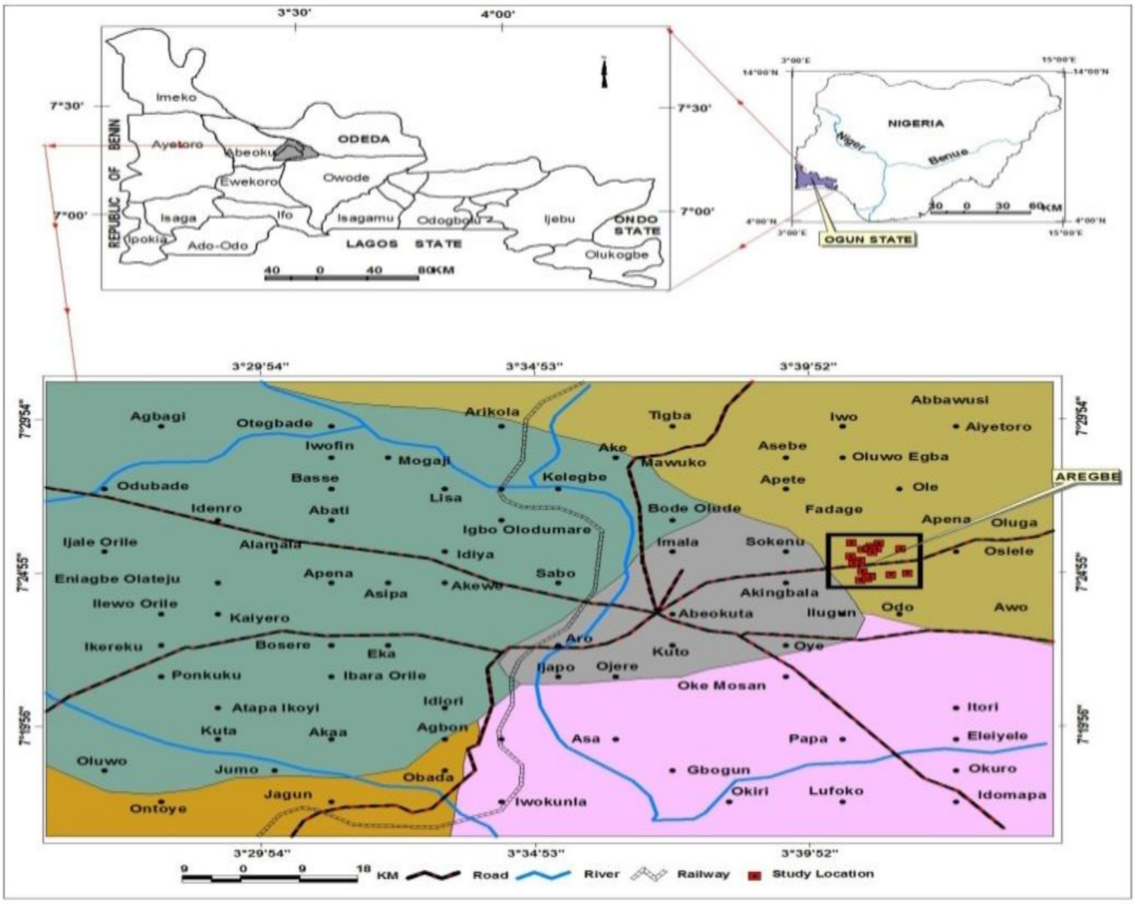

Fig 1: Map of Abeokuta showing the location of Aregbe community

The parameters examined were; pH, temperature (temp.), electrical conductivity (EC), alkalinity, total hardness, magnesium hardness, calcium hardness, chloride, total dissolved solids (TDS), carbonates, bicarbonates, Total Coliform Count (TCC), Escherichia coli Count (*E. Coli* count) and *Salmonella typhi* (Typhi)

Production of map showing the spatial distribution of the hand-dug wells in the community

This was achieved by geo-locating the hand-dug wells in Aregbe community, Abeokuta, Ogun State using the GPS. The coordinates of these wells were obtained and processed using the GIS Arc View software to produce the map of the area showing the distribution of these wells in it.

Determination of the distances between the hand-dug wells and the septic tanks closest to them

The approximate distances between the hand-dug wells in Aregbe community and the septic tanks closest to them were determined using a meter rule. The values obtained were recorded and the wells were named in the order of the houses from which they were obtained to ensure easy access and recognition when the representative water samples were to be collected.

The distances measured were grouped into five; ranging from (0.0-10.9) meters, (11.0-20.9) meters, (21.0-30.9) meters, (31.0-40.9) meters and >41meters. A total of twenty-one sample points which is twenty percent of the wells geo-located were selected based on the density of each group in the total number of wells.

$$\frac{Number\ of\ wells\ in\ a\ category * 21}{Total\ number\ of\ wells}$$

Analysis of the effect of the distances between the hand-dug wells and the septic tanks on the quality of the water samples collected.

This was achieved by collecting the representative water samples from the well locations (which gave a total of 21 sample points) as described above and analysing the water samples in the laboratory to determine their individual composition of the physical, chemical and microbial parameters that measure how potable a given water sample is and to establish the relationship and variations between these parameters along their respective distances.

Collection procedure

The sample bottles were rinsed with distilled water at each collection point and two samples were collected per well location to store the water for physio-chemical analysis and microbial analysis, respectively.

Physical parameters

The physical parameters such as pH, temperature, electrical conductivity and total dissolved solids were analysed in-situ during the sampling process and the values were recorded accordingly.

Chemical parameters

The samples for the chemical parameters which included alkalinity, total hardness, magnesium hardness, calcium hardness, chloride, carbonates and bicarbonates were collected with a 2½ litres polythene bottles.

Microbial parameters

The samples for the determination of microbial analysis such as total coliform count, *E. coli* and *S typhi* were collected with 120 ml polythene bottles and refrigerated at 4^0C.

Quality assurance protocol

These were the processes undertaken to ensure accurate reproducible and reliable result during the analysis;

i) The sample bottles were rinsed with tap water and later with distilled water.
ii) The sample bottles were arranged in order of the well locations.
iii) The labelled sample bottles were rinsed with the individual sample point water before they were collected.
iv) The bottles were properly covered after sampling to prevent contamination during transportation and storage.
v) Samples were preserved accordingly on site and immediately transferred to a refrigerator in the laboratory. Samples were allowed to cool down and attain room temperature before analysis. All reagents were of analytical grade and running blank for all determination checked contaminations. All equipment and procedures used were calibrated with appropriate standards and blank determinations were checked before analysis. Appropriate significant figures and statistical data were used throughout the result analyses.

Analytical procedure

A.) ***Physical parameters***

The pH, temperature, electrical conductivity (EC), and total dissolved solids (TDS) were determined electrochemically using Jenway 3150 pH meter model already calibrated using buffer 4 and 7. Temperature is expressed in Degree Celcius (^{0}C), the electrical conductivity is expressed in Micro Semens per Centimetre (us/cm) and the total dissolved solids are expressed in Milligrams per Litre (mg/l).

B.) ***Chemical parameters***

The procedures used for measuring the chemical parameters of the samples collected are discussed below with all results expressed in mg/l:

i.) *Alkalinity:* 100 ml of the water sample was put into a 250 ml conical flask. 3 drops of phenolphthalein and 3 drops of methyl orange indicator was used and titrated with 0.2M of H2SO4 (sulphuric acid). A peach colour was observed from orange and the titre value was recorded at the point of the change.

$$Calculation = \frac{Titre * Molarity * 100}{ml\ of\ sample}$$

ii.) *Total Hardness*: 50 ml of the water sample was measured into the conical flask. 2 ml of Ammonia Buffer solution was added followed by 3 drops of Eriochrome Black T. It was titrated with EDTA until the colour changed from purple to blue. The titre value was recorded at the point of the change.

$$Calculation = \frac{Titre\ value*100}{Vol\ of\ sample}$$

iii.) *Calcium Hardness*: 50 ml of the water sample was measured into a conical flask. 2 ml of 2M NaOH (Sodium Hydroxide) followed by 1 g of meroxide indicator. Titration was done with EDTA until the colour changed from purple to peach. Titre value was recorded at the point of change.

$$Calculation = \frac{Titre\ value * 100}{Vol}$$

iv.) *Magnesium Hardness:* The Magnesium Hardness of the water samples were determined using the expression below:

Magnesium Hardness= Total Hardness - Calcium Hardness

v.) *Chlorides:* 100ml of the water sample was measured into a conical flask. 1 ml of potassium chromate was added to serve as an indicator. The solution was titrated with silver nitrate until the colour changed from yellow to brown.

$$Calculation = \frac{Titre\ value * 100}{vol\ of\ sample}$$

vi.) *Carbonates and Bicarbonates:* 3 drops of phenolphthalein indicator was added to the measured sample. The water sample changed to pink which indicated the presence of carbonate. Sample was titrated to colourless by using 0.1M Sulphuric acid (H2SO4). 2 drops of methyl orange indicator to the same water sample and it was titrated with the same acid until a colour change from orange to pink was observed.

$$Carbonate(CO_3 = \frac{Vol\ of\ acid\ used * M * 30 * 1000}{Vol\ of\ sample\ used}$$

$$Bicarbonate\ (HCO_3) = \frac{Vol\ of\ acid\ used * M * 61 * 1000}{Vol\ of\ sample\ used}$$

C.) ***Microbial parameters***

The microbial parameters for the water samples were determined as described below:

i.) *Total coliform count method:* The coliform group of bacteria is the principal indicator of pollution in water. If present in water in any water body, it implies the water is unsuitable for domestic, dietetic or other uses.

Procedure

The water samples were incubated for 24 h and the formation of colonies were observed. When no colonies are observed, the sample can be incubated further for 12 h (to give 36 h of incubation altogether) and the colonies formed can be counted thus:

$$Total\frac{coliforms}{100ml} = \frac{Coiform\ count * 100 * D}{Vol\ (ml) of\ diluted\ sample\ filtered}$$

Where: D= Dilution factor for the sample

ii.) *The breed method (the total viable cells count (TVCC):* The number of colonies of microorganisms obtained under certain growth conditions and media from a definite size of inoculums of water sample is used to deduce the possible number of such colonies in one millilitre or 100 millilitres of that particular water source. It measures the organisms that are able to grow under the given set of growth conditions and it assumes that one cell gives rise to one colony.

Procedure

The test tubes and pipettes were washed and sterilized The various media were prepared according to the specifications by the producer's literature and sterilized at 121^0C for 15 min in an autoclave. The dilutions of the water samples were prepared (10-1, 10-3, 10-6). The glucose broth (5% Glucose in Nutrient Broth) and the Yeast extract broth (for the pre-enrichment of bacteria and fungi in treated or chlorinated water sample) are prepared. This is necessary because the organisms may be denatured during water treatment. Known volumes of water samples (either the dilutions of it or the inoculated pre-enrichment medium) were transferred onto the surface of well-dried soil media prepared by dividing one plate into four quadrants by ruling the back of the plate with a grease-pencil. Using the standard Pasteur pipette, 1.0ml of each sample was delivered unto one quadrant from about 3 feet above the surface. The plates were rotated on the bench several times (clockwise and anti-clockwise) to achieve evenly spreading of the water inoculums on the surface of the solid sugar. The plates were allowed to dry and then incubated, turned upside down at 29^0C and at 37^0C for 72 h.

The plates were examined after every 24 h and the colonies growing on each medium were counted. The plates showing between 30 and 300 colonies were counted using a magnifying lens. The total viable microbial cells (Bacteria and Fungi) in the water samples were counted as Colony Forming Unit (CFU#) per millilitre.

Value of count × Dilution factor = Xcfu/ml.

Where X is the value estimated.

The VCCC is both qualitative and quantitative and it can be expanded to include viruses or bacteriophages by including selective media for it.

Results and Discussion

The data obtained from the laboratory were statistically analysed using the Statistical Package for Social Sciences (SPSS) and the statistical tools used were:

1.) F-test and T-test (ANOVA)

Ho: there is no significant relationship between the laboratory values obtained and the distances between the hand-dug wells and the septic tanks.

Hi: **there is a significant relationship between the laboratory values and the distances between the hand-dug wells'.**

To analyse the variances in the standard deviation for each category, the distribution was tested to a 5% level of significance and the degrees of freedom varied from 8 to 11 to 13.

2.) Descriptive Statistics (Mean, Standard Deviation and Variance): Result is presented using the listed descriptive statistics

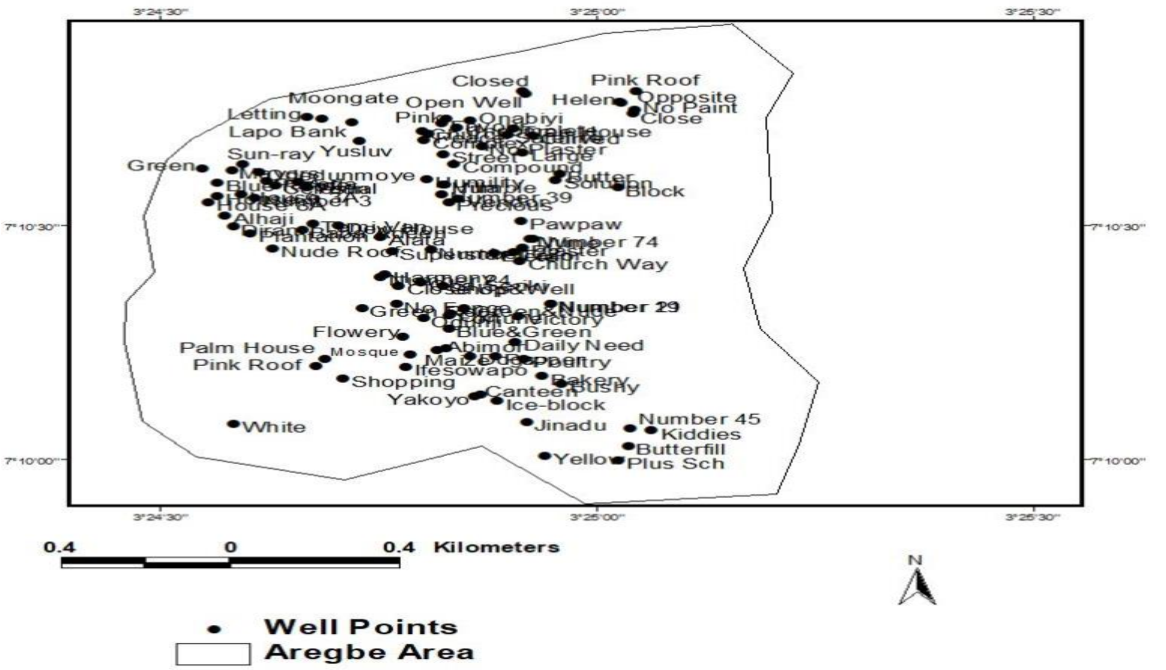

Fig 2: Map of Aregbe Community showing the spatial distribution of wells

Figure 2 above shows the distribution of hand-dug wells across Aregbe community. 104 wells were accessed and geo-located in the community and they are evenly spread across the community. The map also shows the respective name given to these well locations.

Table 1: Distances between the hand-dug wells and septic tanks

Category	Distance (m)	Total No. of wells	No. of sample wells
A	(0.0-10.9)	8	2
B	(11.0-20.9)	32	6

C	(21.0-30.9)	45	9
D	(31.0-40.9)	15	3
E	>41	4	1

Table 1 above shows the distances (in meters) between the hand-dug wells in Aregbe and their respective septic tanks, the distances were grouped into five categories in as seen above and the number of representative well locations are also shown.

Table 2 showed the movement of parameters of water quality parameters across the given distances. It can be observed that while the other categories varied in the values obtained for the parameters examined, water samples from Category A generally have the highest values for majority of the parameters tested for.

Table 3 above showed that the null hypothesis raised was rejected for the first three categories of water samples tested which implied that there was a significant relationship between the values obtained for those categories along their respective distances. However, the hypothesis was accepted for the last two categories which were the farthest distances from the septic tanks which implied that there was a significant reduction in the values obtained from these water samples in comparison with the first three categories.

Table 2: Analysis of the physico-chemical and microbial parameters of the well samples

Distance (m)		PH	Temp	E.C	TDS	ALK	CL	HARD	CAL	MG	CAR	BICAR	TCC	E.CO	TYP
0.0 – 10.9	7.5	6.5	28.3	450	260	145	133	296	118.4	177.6	126	256.2	2.7	0.4	0.0
	8.7	7.27	26.8	750	420	160	150	395	158	237	132	268.4	1.6	0.1	0.0
11.0 -20.9	11.6	6.4	27.7	90	50	132	55	132	52.8	79.2	126	256.2	2.0	0.0	0.0
	17.4	5.9	27.4	190	100	121	89	202	80.8	121.2	120	244	5.1	0.2	0.0
	17.8	6.44	28.4	280	130	142	74	206	82.4	123.6	132	268.4	1.7	0.0	0.0
	18.2	7.46	27.8	320	160	159	76	200	80	120	141	286.7	1.6	0.0	0.0
	18.5	6.55	28.6	210	110	145	76	200	80	120	123	250.1	1.1	0.0	0.0
	18.9	5.89	28.3	320	170	110	82	274	109.6	164.4	87	176.9	3.2	0.4	0.0
21.0 – 30.9	21.8	6.69	28.1	280	140	138	105	192	76.8	115.2	120	244	3.4	0.0	0.0
	23.6	7.06	28	330	160	153	108	226	90.4	135.6	138	280.6	1.4	0.0	0.0
	24.0	6.14	29	140	80	136	71	108	43.2	64.8	120	244	3.2	0.0	0.0
	24.4	7.51	28.5	320	170	162	63	202	80.8	121.2	142	288.7	1.3	0.0	0.0
	25.6	7.52	28.7	210	120	162	108	142	56.8	85.2	144	292.8	3.3	0.0	0.0
	25.8	6.0	28.3	320	150	128	79.	192	76.8	115.2	123	250.1	1.6	0.0	0.0
	26.1	5.74	28.2	210	110	113	80	174	69.6	104.4	96	195.2	0.7	0.0	0.0
	27.3	5.7	29	390	190	110	100	188	75.2	112.8	93	189.1	1.3	0.0	0.0
	28.8	5.92	27.8	290	140	112	86	210	84	126	96	195.2	2.7	0.3	0.0
31.0-40.9	31.8	6.06	28.5	170	110	131	82	134	53.6	80.4	120	244	2.1	0.0	0.0
	32.3	6.55	28.1	210	100	145	92	190	76	114	129	262.3	1.0	0.0	0.0
	36.9	6.76	28.7	380	200	149	81	250	100	150	135	274.5	2.9	0.1	0.0
>41	>41.1	7.01	28.7	70	40	152	77	208	83.2	124.8	126	256.2	4.5	0.3	0.0

Table 3: Test of null hypothesis

Category (m)	Distance (m)	Mean	Variance	Std	F_{CAL}	F_{TAB}
0.0 – 10.9	7.5	142.8643	17043.75	130.5517	3.55	2.16
	8.7	193.2979	42235.53	205.5128		
	11.6	72.09286	4792.632	69.22884	16.677	4.82
	17.4	93.3285	5963.471	77.22351		
11 - 20.9	17.8	105.3529	8597.647	92.7235		
	18.2	112.8257	10325.07	101.6123		
	18.5	96.45357	6578.286	81.10663		
	18.9	109.4064	9740.813	98.695		
	21.8	103.5136	7776.67	88.18543	16.28778	3.69
	23.6	118.4329	10675.42	103.3219		
	24	74.66714	4574.191	67.63276		
21 -30.9	24.4	113.3579	10572.65	102.8234		
	25.6	97.16571	7302.842	85.45667		
	25.8	105	9123.339	95.51617		
	26.05	84.77429	4923.052	70.16446		
	27.3	106.0071	10855.76	104.191		
	28.8	98.28	7398.635	86.01532		
	31.8	82.97571	5041.281	71.00198	16.82336	19.40
31.0-40.9	32.3	96.71071	6699.666	81.85149		
	36.9	125.5686	12990.75	113.977		
>41	>41.1	84.12214	6045.029	77.74978	*35.69	234.9

Table 4: Relationship between the mean values of the parameters and WHO standard for drinking water

Parameters	Category					WHO Standard
	A	B	C	D	E	
Ph	6.89	6.44	6.43	6.46	7.01	6.5-8.5
Temp. (^{0}c)	27.55	28.03	28.40	28.43	28.70	37.5
EC (us/cm)	600	235.0	276.7	253.3	70.0	1000
TDS (mg/l)	340.0	120.0	140.0	136.7	40.0	500
Alkalinity(mg/l)	152.5	134.8	134.8	141.7	152.0	30-500
Chloride (mg/l)	141.5	75.3	88.9	85.0	77.0	250
Total hardness (mg/l)	345.5	202.3	181.6	191.3	208.0	500
Calcium (mg/l)	138.2	80.9	72.6	76.5	83.2	200
Magnesium (mg/l)	207.3	121.4	108.9	114.8	124.8	150
Carbonate (mg/l)	129.0	121.5	119.1	128.0	126.0	200-1000
Bicarbonate (mg/l)	262.3	247.1	242.2	260.3	256.2	200-1000
Total Coliform Count (cfu/100ml)	2.15	2.45	2.10	2.0	4.5	0.0
E.Coli (cfu/100ml)	0.25	0.1	0.03	0.03	0.3	0.0
Salmonella typhi (cfu/100ml)	0.0	0.0	0.0	0.0	0.0	0.0

Table 4 above showed that the mean values of the physical and chemical parameters were in line with WHO standard for drinking water except for pH and Magnesium and water samples from Category A (wells closest to the septic tanks) which had the highest mean values for most of the parameters. However, the Table further showed that the water samples exceeded the standard for the microbial parameters tested and particularly water samples from Category E which were the farthest from the septic tanks had more microbial contaminants than the other categories.

The temperature of water samples were generally ambient ranging between 27.55 and 27.40°C with a mean of 28.70°C. A high water temperature negatively impacts water quality by enhancing the growth of micro-organism which may increase taste, odour, colour and corrosion problems (Olatunde *et al.*, 2020). Hydrogen ion concentration (pH) values of from all wells sampled fell within WHO acceptable pH range of 6.5 – 8.5. pH, a measure of acidity or alkalinity of water is one of the most important water quality parameters when determining the portability of water. Alkaline waters cause corrosion of metal pipes and plumping systems while waters with pH less than 6.5 are more likely to contain microbial contaminants that can pose negative effects on the gastrointestinal tracts when consumed, thereby, resulting in diarrhea (Rahmanian *et al.*, 2015). The EC ranges from 70-600 μS cm-1 with none of the samples falling outside the acceptable WHO limit of 1000 μS cm-1. y. EC is the measure of the capacity water to conduct electricity, while TDS is defined by the presence of inorganic salts and organic matter in water (Rusydi, 2018). Consumption of water with high hardness value can lead to gastrointestinal irritation (Alam *et al.*, 2017). Alkalinity and hardness are collective used in predicting the corrosivity and scale formation of water in distribution networks (Boyd *et al.*, 2016). The presence of *E. coli* in the water samples indicates that there is seepage from septic tanks and possibly animal waste contamination which renders the water source unsafe for drinking and use can lead to illness.

The results showed that there is a well-defined relationship between the proximity of a septic tank to a hand-dug well and the quality of the water pumped or extracted from such well. The result showed that the water samples collected from the wells in Category A which were the closest to the septic tanks had relatively higher contents of the physical and chemical parameters tested such as EC, TDS, Alkalinity, Chloride, Total hardness, Calcium hardness, Magnesium hardness, Carbonates and Bicarbonates and exceeded the W.H.O. Chloride concentrations are usually lower than 10 mg L-1 in freshwaters, however, a maximum limit of 250 mg/l is recommended in drinking water (Olatunde *et al.*, 2021) Cl− concentrations in all water samples ranges from 75 to 141.5 mg/l and are within the permissible limit of 250 mg/l set for drinking water. However, for some of the parameters analysed which indicates that this is very likely to have occurred due to the seepage or influx of septic fluid into these wells and this is in agreement with Noss and Billa (1998); Kaplan (1987) that 'septic systems that are placed close to the zone of saturation are effective in attenuating nitrogen, but are ineffective at attenuating pathogens, organic matter and phosphorous', this however does not imply that the septic tanks analysed are the only sources of this contamination.

However, a major interest in the results obtained is shown in Table 4 whereby the representative water sample obtained from the wells farthest from septic tanks in the course of this research (which is denoted as Category E) has a higher mean count of bacteria for both Total Coliform Count and E. Coli when compared with W.H.O. Standard for drinking water than the wells in Category A to D which implies that the source of contamination of this water sample can be from sources different from the influx of septic fluid into it as it was observed in the course of the research that some of the wells were either uncovered or pumped with indiscriminate and unhygienic bailers (or fetchers) and some of the wells in the community were also sited very close to solid waste dump sites and these are also sources of groundwater contamination and this is also in agreement with Fubara-Manuel and Jumbo (2014) who said that 'the qualities of dug well water depend largely on the presence of biological, chemical and physical contaminants as well as environmental and human activities in such environment'.

However, it should be noted also that only one sample point was selected from this category (i.e. Category E) due to its density in the total number of wells geo-located in Aregbe community as opposed to other categories and this made the mean values for the individual parameters from this category used wholly with no multiple to be divided by and this could be an indication that the faecal contamination of the water samples from this category is not from the septic tanks closest to them.

Conclusion

The distances between the hand-dug wells in the study area and the surrounding septic tanks were determined using a metre rule. The results obtained from the analysis proved that the wells located close to septic tanks (even though they were within range of the WHO Standard) had significantly higher mean values for the physico-chemical parameters examined than the wells located farther from the septic tanks. However, it was observed that the water samples for wells farthest from the septic tanks had the highest mean values for the microbial parameters which were the major concern of this study. This brings about the conclusion that the faecal contamination of these wells may have been from anthropogenic activities as well as seepages from the septic tanks into groundwater storage. This might create a problem for potable water use in the community so there it is imperative that well should be sited at reasonable distances from septic tanks.

Recommendations

This study recommends that the quality of the water extracted from the hand-dug wells in Aregbe community should be maintained. This study also recommends that new wells in the community should be sited at a minimum of 21-30 metres away from the surrounding septic tanks as distances lesser than this from the research. Also, adequate care should be made to ensure that wells are well covered and dump sites or landfills are not located in close proximity and that the bailers used to extract or pump water from these wells are clean, hygienic as they are all means of possible faecal contamination.

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