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Physico-Chemical and Microbiological Quality of Groundwater used in Asaba, Southern Nigeria

Dr. O.O . Lokoyi, saintlovet@gmail.com.

Sylvester Agbonifo Imiere. slyimiere@gmail.com

Irene Onotseike Okolie. igenegbaiirene@gmail.com

Nnedinma Jean-Phylis Azifuaku. jeanphylisnnedinma@gmail.com

ABSTRACT

Groundwater which is stored water below the ground is a highly significant resource for the provision of good quality drinking water. However, the utility of water is more or less limited by its quality which makes it unsuitable for particular purposes. Assessment of water quality is therefore an important aspect of water resources survey. Hence, the research was undertaken to determine the microbial and physicochemical qualities of ground water used for the commercial production of sachet/bottle water in Asaba, Nigeria. Groundwater samples (borehole water) were collected from three different areas within Asaba. The physicochemical parameters were determined such as pH, temperature, turbidity, conductivity, total dissolved solids, total suspended solids, total alkalinity, biological oxygen demand, chemical oxygen demand, dissolved oxygen, total organic carbon, sulphate, nitrate, and phosphate. The heavy metal concentration was also determined, and the results were compared with the standards prescribed by the WHO and Nigerian authorities. Total heterotrophic bacteria and the fungi counts of the water samples were ascertained by pour plate method as described by Chessbrough. The assessed groundwater samples from the 3 sites had physicochemical properties whose levels were generally within tolerant and safety levels with the exception of the heavy metal Cadmium which was at elevated and above safety standard tolerant levels. The bacterial and fungal microbial isolates were at intolerable elevated level which is above recommended standards in all samples. It is recommended that all levels of government should provide potable water to her citizen and also embark on consistent routine monitoring of groundwater in urban and rural areas in order to ascertain the state and quality of the water.

Keywords: Assessment, Groundwater, Contaminants, Comparative, Commercial production.

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INTRODUCTION

Water is an essential part of human nutrition, both directly as drinking water or indirectly as a constituent of food, in addition to various other applications in life. Groundwater which is stored water below the ground is a highly significant resource for the provision of good quality drinking water. However, the utility of water is more or less limited by its quality which makes it unsuitable for particular purposes. In Nigeria, about 52% of its citizenry lack access to safe drinking water (Taiwo et al 2015). Assessment of water quality is therefore an important aspect of water resources survey. Available data of the quality of water is generally stable overtime as it is predominately determined by chemical compositions of rocks, serving as aquifers. Water quality depends on the physical, chemical, microbial or bacteriological composition of water (Ayaode and Ayebande, 1978), Abimbola et al, (2002), Ajibade, (2008) and Edet and Offiong, (1998b).

The importance of water to man and the environment cannot be overemphasized; hence it becomes the duty of the government to protect the health of its citizenry. The National Agency for Food Drug Administration and Control (NAFDAC) is saddled with that responsibility in Nigeria. Government public water utilities such as water cooperation's' are statutorily charged with the responsibility of supplying water from conventional water treatment plants that use water from surface water sources as impounded reservoir (dams), flowing streams, lakes and deep groundwater obtained through boreholes. As the country population grew with increased industries, water supply by these governmental utilities became inadequate in quality and quantity. In recent times, drilled borehole groundwater in all its applications has become the main stay for meeting the water needs of the populace as a result of governmental utilities inadequacies. This has however led to the emergence and proliferation of private water enterprise that operates side by side with the government owned public water utilities. Indices showed that the rate of water supply for industrial, agricultural and domestic uses was however lower compared to population growth rate (Gbadegesin and Olorurunfemi, 2007).

Ground water quality differs from place to place and from one environment to another based on various factors such as land use, local climate, slope of the land, type of rocks at the surface, which may more or less affect the quality of suitability for human consumption (Taiwo et al, 2015). Polluted/contaminated groundwater resource brings about possible invitation of water-borne diseases such as cholera, typhoid and even gastrointestinal infections.

In Asaba and many other places in Nigeria, public water supply is generally unreliable thereby encouraging the digging of boreholes, sale of drinking water in polythene sachet due to its availability and affordability. There is however concern about the assessment of the groundwater which serves as sources and purity of water.

Good quality water from source to packaging must or are supposed to be colorless and tasteless as well as being free from microbial and chemical contaminants and where present must be at safe and acceptable levels based on the country and WHO standards. Consumers tend to be more concerned with appearance and taste of water than the invisible load of potentially harmful microorganisms as well as other contaminants that may be present and toxic chemicals above

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acceptable levels in the water. Hence, the research was undertaken to determine the microbial and physicochemical qualities of ground water used the commercial production of sachet/bottle water in Asaba, Nigeria

MATERIALS AND METHODS

Study Area and Sample Collection

The groundwater samples for the research were obtained from drilled boreholes in three locations in Asaba, Delta State, Nigeria. Asaba is a city located at the western bank of the Niger River. It is the capital of Delta State, Nigeria and one of three towns in Oshimili South Local Government Area, a fast developing urban area. Groundwater samples (borehole water) were collected from three different areas within Asaba (labelled Asaba, 1, 2 and 3) and subjected to physicochemical and microbiological test in the laboratory to comparatively assess their quality and suitability levels against the Nigeria and WHO standard for groundwater.

Microbiological Analysis

The microbiological analysis was carried out as well in test for isolates and the respective counts also using standard and appropriate microbiological laboratory procedure and analytical techniques for the determination of the aforementioned microbiological parameters.

Microbiological Parameters

Heterotrophic bacterial plate count (HPC)

Total heterotrophic bacteria counts of the water samples were ascertained using Nutrient agar (NA) by pour plate method as described by Chessbrough (2009). Aliquot of 1 ml of the 10-4 dilutions of the samples was used to incubate the plate in triplicates; the plates were incubated at 37°C for 48 hrs. Thereafter the mean counts of the bacteria colonies were taken. The bacteria isolates were further isolated in order to attain pure cultures. The pure cultures were then characterized and identified to determine the bacteria species using the standard microbial/fungi identification methods (Chessbrough (2009).

Fungi: Aliquot of 1 ml of 10-4 dilution of the samples were inoculated into potato dextrose agar (PDA) in triplicate and incubated at 28°C for 72 hrs. Thereafter the developing colonies were counted and the mean values were thus determined. Culture characteristics of each colony morphology e.g. size, shape, margin, elevation, consistency, colour, transparency was also determined.

Laboratory Analysis on Physiochemical Properties on Water Sample

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The water samples were analysed and the physicochemical properties described in the methods from a guide manual (CPCB, 2000). Total Dissolve Solid (TDS), Total Suspended Solids (TSS) and conductivity in the water samples were determined by filtration and conductivity/TDS meter.

RESULTS

Table 1: Mean value of Physicochemical Analysis of groundwater in Asaba

Physicochemical properties	Asaba 1	Asaba 2	Asaba 3
pH	5.5	4.8	5.2
EC (µS/cm)	39.3	92.4	30.6
Sal. (g/l)	0.018	0.042	14.2
Col. (Pt.Co)	ND	ND	ND
Turb. (NTU)	ND	ND	ND
TSS (mg/l)	ND	ND	ND
TDS (mg/l)	19.2	45.5	15.2
COD (mg/l)	13.7	14.5	6.5
HCO3 (mg/l)	36.8	42.8	30.9
Na	0.45	0.63	0.16
K	0.28	0.54	0.09
Ca	0.93	2.95	0.62
Mg	0.66	1.73	0.28
Cl	53.1	70.8	17.8
P	0.016	0.035	0.013
NO2	0.478	0.582	0.460
NO3	0.982	1.682	0.823
NH4N	0.505	0.512	0.36

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SO4	0.051	0.054	0.02
Fe	0.435	0.437	0.904
Mn	0.165	0.163	0.334
Zn	0.374	0.375	0.623
Cu	0.072	0.074	0.181
Cr	0.025	0.026	0.107
Cd	0.015	0.008	0.043
Ni	0.009	0.006	0.034
Pb	0.018	0.013	0.052
V	0.008	0.005	0.022
THC	ND	ND	ND

Key: Asaba 1 = Okpanam- Asaba Area,
Asaba 2 = Asaba City center
Asaba 3 =Asaba –Benin express Area
ND = Not Detected

Microbial Analysis

Table 2: Occurrences of bacteria/fungi in different water sources.

Bacterial isolates	**Asaba 1**	**Asaba 2**	**Asaba 3**
Esherichia coli	_	+	_
Staphylococus epid.	+	+	+
Streptococcus spp	+	_	_
Enterobacter spp	+	_	+
Fungi isolates			
Aspergillus flavus	+	+	_
Aspergillus niger	+	_	_
Penicillium spp	+	+	_

Table 3: Mean values of the bacteria and fungi counts of the various water sources.

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Microbe	Asaba 1	Asaba 2	Asaba 3
Bacterial Count (cfu/ml)	15.00 X104	27.3 X104	18.5 X104
Fungi Count (cfu/ml)	2.00X104	3.00X104	2.00X104

Figures Showing Comparative Mean Values of Physico-Chemical Analysis of Samples (Sample1 Asaba Okpanam, Sample 2 Asaba Central and Sample 3 Asaba Express Way)

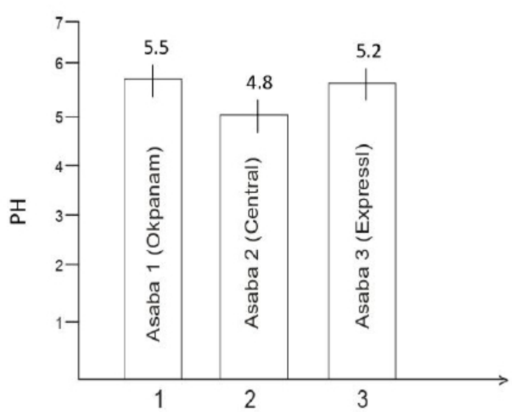

Fig 1 Sample

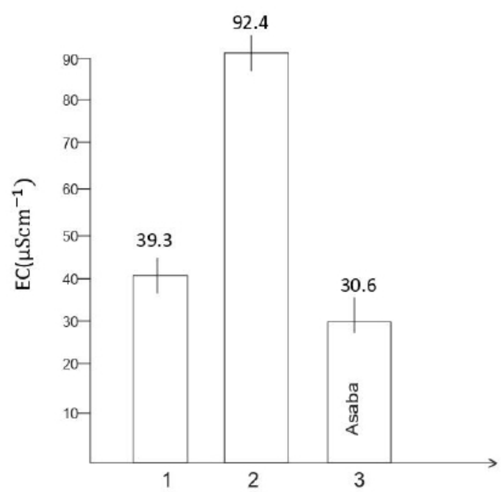

Fig 2 Sample

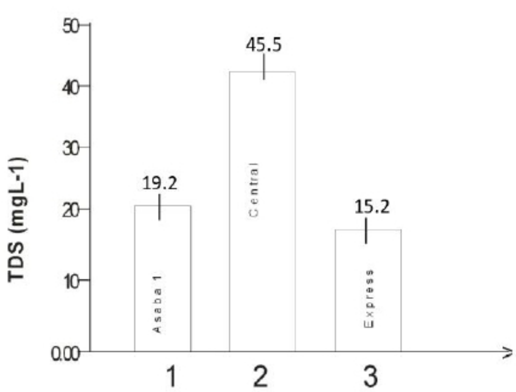

Fig 3 Sample

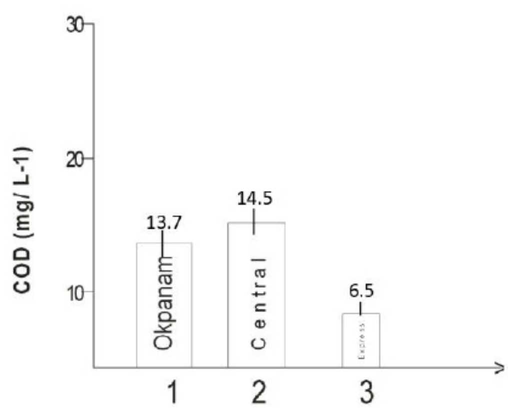

Fig 4 Sample

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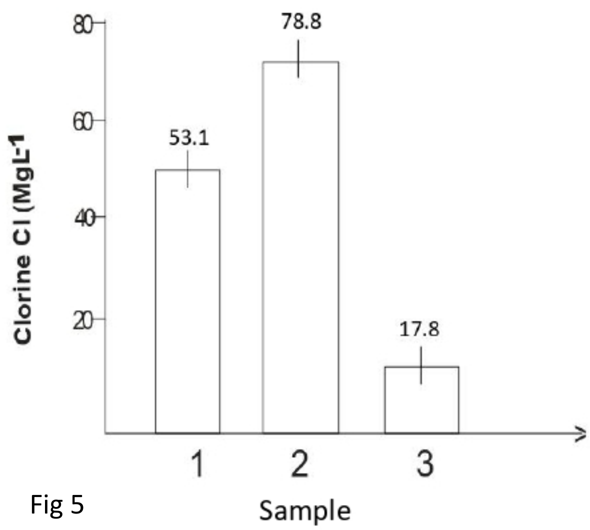
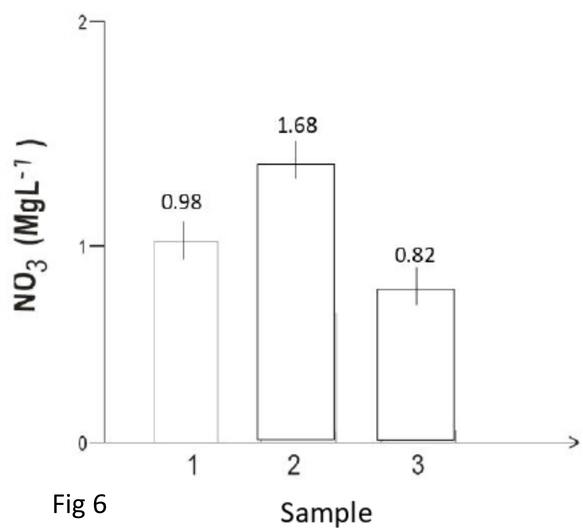


Fig 5



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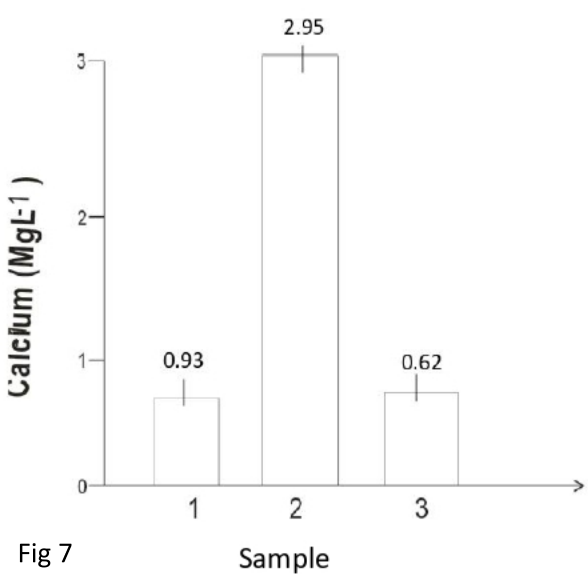

Fig 7

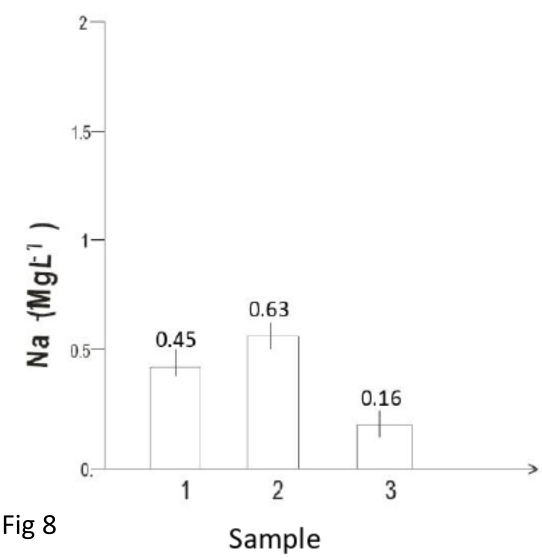

Fig 8

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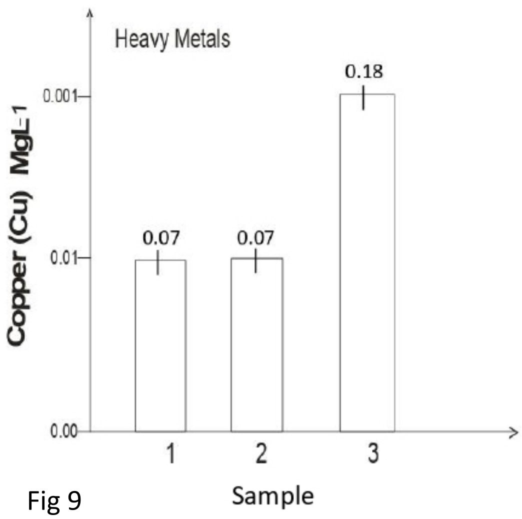

Fig 9

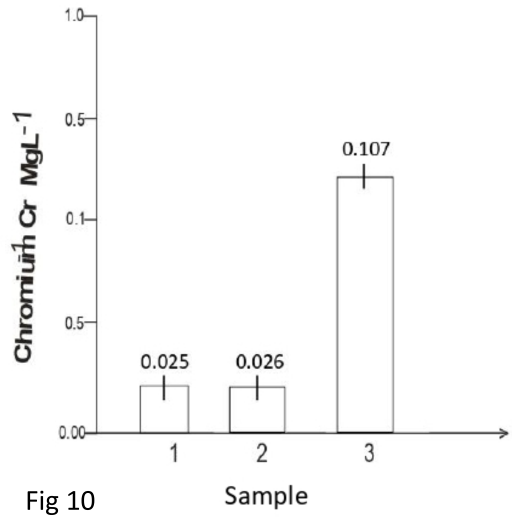

Fig 10

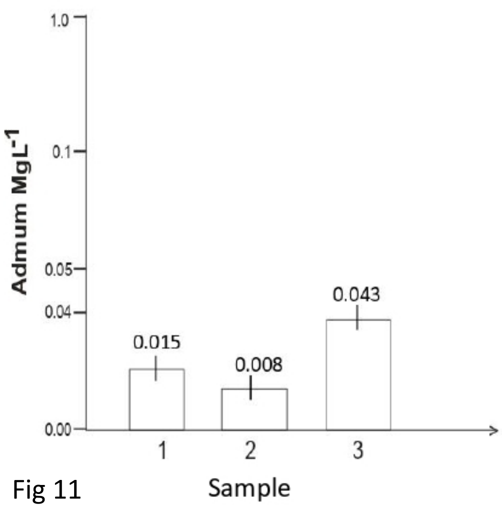

Fig 11

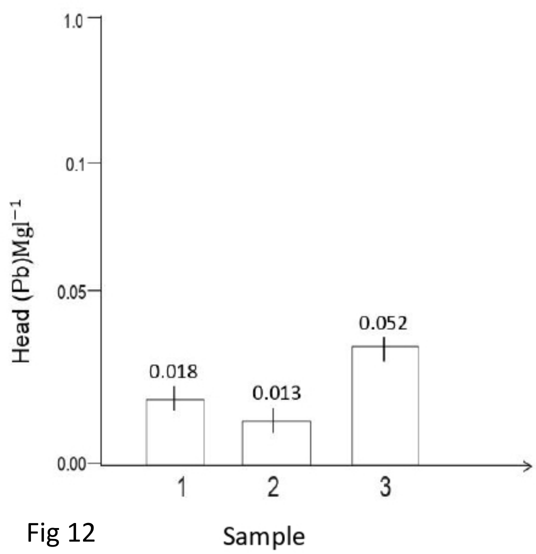

Fig 12

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Vol. 9 Issue 12
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Comparative Mean Total Counts of Microbial Isolates in Samples (Sample1 Asaba Okpanam, Sample 2 Asaba Central and Sample 3 Asaba Express Way)

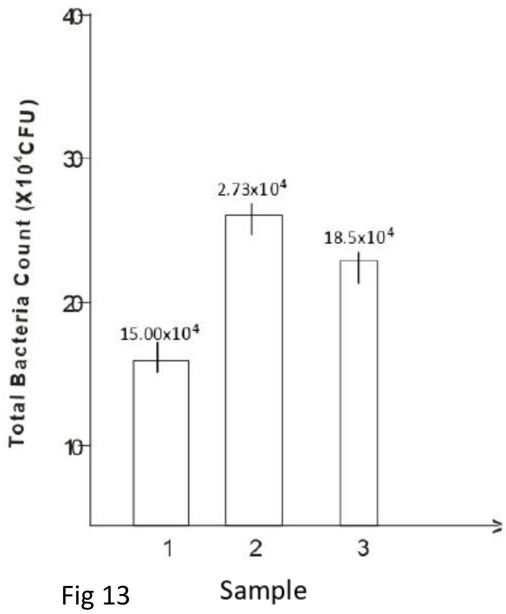

Fig 13

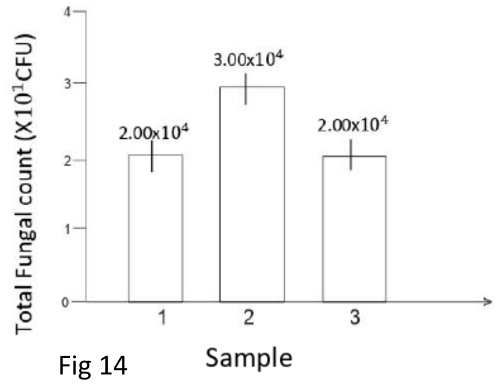

Fig 14

Discussion

The table one (1) and figures 1-12-, showed generally and mostly, the physical properties of the samples. Parameters such as Turbidity (Turb) and Total Suspended Solids (TSS) showed non-detection while others such as Chemical Oxygen Demand (COD), Electrical Conductivity (Ec), Total Dissolved Solids (TDS)were within acceptable limits in line with WHO prescribed standards, although on a comparative note, the individual mean values of the aforementioned parameters of the samples varied. On the contrary, the mean pH values of all the sites/areas were in elevated acidic levels (4.8-5.5) beyond the Nigeria and WHO desirable and permissible standard ranges of 7.0-8.5 and 6.5-9.2 respectively (FRNOG, 2011). The level of acidic elevation in the three sites comparison-wise decreased from Asaba 2 to Asaba 1 and to Asaba 3. The marked general difference in high acidic levels may be attributable to possible differences in levels of land use and nature of discharges that trickles into the ground (Rizka, 2018). High acidity promotes corossivity, a costly problem in water distributing systems and possible toxicity as high acidity increases solubility of heavy metals which creates health risk with increasing concentrations. The detected light metals such as Sodium , Calcium, among others and the compound anions, (Sulphate, Nitrate, Nitrites Chloride) in all the sites/areas had mean values

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that falls within the acceptable standards despite slight variations from each other, indicating safety levels for human consumption and general utility. Hardness and softness of water is determined by the amount of light metal ions such as calcium. The water in all three(3) sites can be regarded as soft as their individual calcium content levels is within the acceptable limits(0-75 mg/l) (FRNOG, 2011). Although hardness is not necessarily a health concern, it can be a nuisance as it can cause mineral build up in plumbing, fixtures and water heaters, and poor performance of soap and detergents. The heavy metals found in the water samples specifically Nickel, Zinc, Copper and Lead were observed to have unelavated concentration values within standard target and intervention limits in each of the sites/areas. Another heavy metal, Chromium on the other hand however had concentration mean values in all sites above standard target but approximately at intervention levels in sites 1 and 2 and above it in site 3 (standard target and intervention concentration value for Chromium are 1 microngram per litre/ 0,001miligram per litre and 30microngram per litre/0.03 miligram per litre (FRNOG, 2011). Also heavy metal Cadmium have concentration values in all three sites above both standard target and intervention levels which creates cause for concern and attention because of the health risks associated with steady and excessive accumulation of Cadmium. Cadmium high level contents in ground water in the sites/areas could have been raised possibly as a result of entry into the ground environment of industrial discharges, metal plating, batteries, paints and pigments water pipes, plastic stabilizers and landfill leachate. Cadmium have been a known cause of high blood pressure, liver and kidney damage, anemia, destruction of testicular and red blood cells respectively (Walter,1982). Site/Area 3 was observed to have the highest concentration content level of all the individual heavy metals detected and analyzed, followed by site/area 1 and lastly site/area 2. Tables two(2)and three(3) and figure 13,, showed the microbial isolates and mean load count for bacteria isolates from the three sites which showed to be at elevated level in comparison with the approved standards (FEPA, 1989; WHO, 2013), with the highest being in site two (2) central Asaba, followed by site three (3) and finally by site one(1). The consequences are not farfetched as this elevated mean load count could trigger outbreaks of water borne infections within the populace (Taiwo et al., 2015; WHO, 2015). Also, bacterial mean load count is higher than the safe standard levels by WHO and Federal Government of Nigerian. Although there is no provided basic for fungal standard by WHO, and in Nigeria, fungal isolate mean load count levels,(table 3, figure 4,, cannot be ignored as a health risk, as have already been pointed out by Nwankwo et al., (2020) and Helena et al., (2016).

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Conclusion

The assessed groundwater samples from the 3 sites had physicochemical properties whose levels were generally within tolerant and safety levels with the exception of the heavy metal Cadmium which was at elevated and above safety standard tolerant levels. The bacterial and fungal microbial isolates were at intolerable elevated level which is above recommended standards in all samples. Comparison-wise however the quality of the samples as analyzed under stated parameters generally depreciated quality-wise from sample two(2) Asaba Central, to sample one(1), Asaba-Okpanam site and lastly sample three(3), Asaba-Benin express site.

Following from the findings of this study, it was recommended that all levels government should provide potable water to her citizen and also embark on consistent routine monitoring of groundwater in urban and rural areas in order to ascertain the state and quality of the water. Domestic/household use of groundwater from boreholes should always be subjected to standard purification process/methods before utilization for consumption purposes.

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