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Microbial Examination of Groundwater Supply Sources in Abia State, Nigeria

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Abstract: This study examined the microbial quality of groundwater supply sources in Abia State. The aim was to have the overall picture of water situation in the state. Groundwater samples were collected from fifteen (15) sampling points. Five (5) water samples were collected from each zone; Ohafia, Umuahia and Aba zones respectively. Points for borehole water sampling were based on purposive sampling. The microbial water analysis was carried out using the standard method the multiple tube fermentation test. The media preparation and culturing were used in determining the variation in biological properties of the water samples. The standard test for the coliform group was to estimate the number of bacteria of the coliform group present in a given volume of water as index of the degree of pollution. The findings showed that only SPL 6 (Umuahia zone) had no coliform count and no growth of any organism was isolated. On the basis of the result, the water sample is potable for domestic uses. All other sampled sites had coliform count above the WHO recommended standards and therefore not potable. In all, four organisms (*Eshericia coli*, *Klebsiella* spp., *Streptococci* spp. and *Staphylococci* spp.) were isolated. The study recommends amongst others that; the Water Board should ensure periodic re-examination of the quality of private borehole water supplies.

Key words: Microbial · Examination · Groundwater · Sources · Abia State

INTRODUCTION

Groundwater, which is the major source of water supply in urban environment faces a lot of challenges in terms of pollution. Groundwater resources naturally are continually collected, purified and distributed in the hydrologic cycle, a process that works when water is not polluted faster than it is replenished or chemicals added that cannot be broken down by microbial action. Adelana [1] and Ahianba *et al*. [2] stated that a number of potential sources of groundwater pollution are characteristically associated with urban environment. This confirms that groundwater pollution in urban environments is not restricted to shallow alluvial aquifers but can also affect bedrock aquifers [3].

It was estimated that 40.1% of Nigerians derive their sources of water from groundwater sources [4]. Other studies also show that 33.82% of Nigerians resort to surface water sources to meet their domestic water supply needs [5]. This category of people is exposed more to the risks from the effects of flooding and solid waste dumps. Transported sediments and leachates from wastes (Especially biological wastes) could easily contaminate both surface water and groundwater [6]. Therefore, it is worrisome that the health of people who depend on these sources of water could be jeopardized as a result of the complacent attitude of environmental regulatory agencies to ill-advised waste disposal methods [7].

Foster [8] and Gbodi [9] revealed that in developing nations, many groundwater exploitation schemes are developed without due regard for quality issues especially as "quality" is not a stable unchanging parameter. Ijioma [10] identified deterioration of groundwater quality in the basement aquifers of two catchments in Uganda through the corrosion of borehole rising mains and the seepage of sewage waste. Shallow wells have become very important sources of water supply for domestic use due to general inadequacy and unreliability of pipe borne water. The implication is family health is endangered if water from these wells are used for drinking as we shall see in nitrate contamination of groundwater [11-14].

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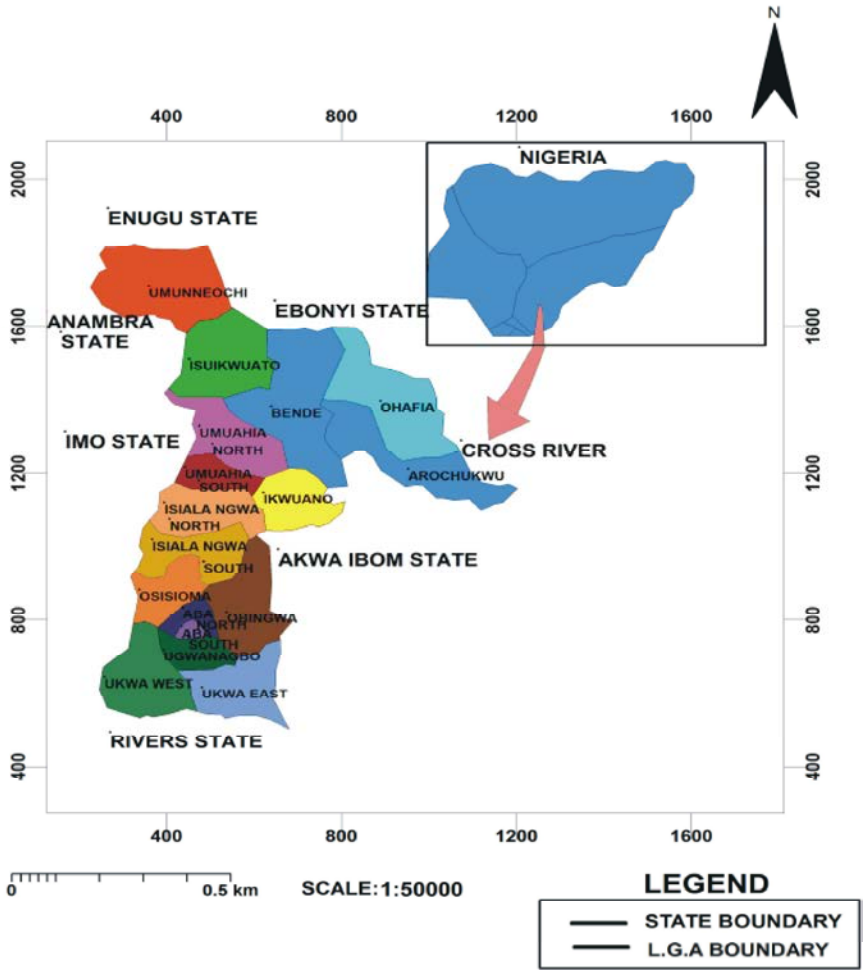

Fig. 1: An insert map of Nigeria showing Abia State

Groundwater is liable to pollution through geo-chemical processes such as release of gaseous materials by volcanic eruption, rock weathering, formation and permeation, through rocks and soils. According to Nkemdirim *et al.* [15] the effect of a polluted groundwater through any of these processes remains for a long time and this calls for quality assessment from time to time.

Adequate attention appears to have been given to studies of physicochemical quality of water samples and quantity of water used and supplied both in the study area and elsewhere [16-25]. However, these studies did not treat the microbiological aspects of water quality to find out the coliform organisms present in the water samples. This work hoped to address these issues.

Geography of the Area: Abia State lies within approximately latitudes 4°40` and 6°14` north and longitudes 7°10` and 8° east and shares common boundaries with Enugu State in the North and Ebonyi State in the northeast; to the west is Imo State and to the northwest is Anambra State. To the south and southwest, it shares borders with Rivers State and to the east and southeast with Cross River and Akwa Ibom States respectively (Figs. 1 and 2). The State covers an area of about 5, 243.7sq.km which is approximately 5.8 percent of the total land area of Nigeria. With its capital at Umuahia, it has seventeen local government areas (LGAs).

In terms of relief, Abia State lies generally on a flat and low-lying land, generally less than 120m above sea level. Geologically, there are nine main geological formations from south to north. These include: the Benin formation (Coastal Plain Sand); the Bende-Ameki Group - Eocene (Clay, clayey and shale); the Nkporo Shale Group - Upper Senionian (Shale and mudstone); the Nsukka formation (Upper Coal Measures), the Igali sandstone (False-bedded Sandstone), the Eze-Aku Shale Group and the Asu River Group [26].

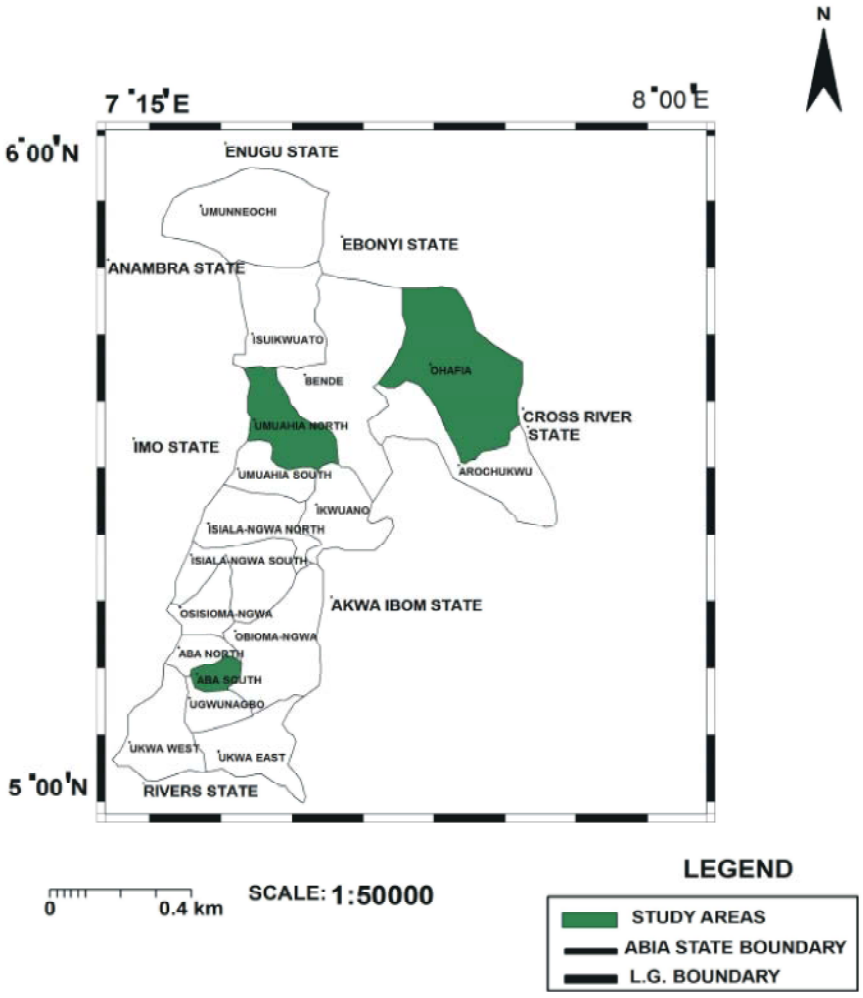

Fig. 2: Abia State showing the study locations

Table 1: The study areas with their geographical co-ordinates

Zone	Urban Centres	Latitude/Longitude
Abia North	Ohafia	05°37'0''N , 07°50'0''E
Abia Central	Umuahia North	05°32'06''N, 07°29'52''E
Abia South	Aba South	05°06˙12¨N, 07°21˙24¨E

Source: Researcher's fieldwork

Abia State falls within the sub equatorial climatic zone with clearly marked dry season and double maxima rainfall in August and September. Relative humidity is usually high throughout the year. It varies considerably between the rainy and the dry seasons. The rainy months often have an average relative humidity of 80-90 percent while the dry months have an average relative humidity of 50-70 percent. The average monthly sunshine hours of the area are 4.8. The mean monthly evapotranspiration is 136 mm (Abia State official website). The soils of Abia State fall within the broad group of ferrallitic soils of the coastal plain sand and escarpment [8]. The vegetation is ordinarily considered part of tropical rain forest which is the dominant natural vegetation in most parts of southern Nigeria. Table 1 shows the selected urban centres for the study.

Method of Study: This study adopted the scientific method. The water samples from boreholes for microbial analyses were collected from fifteen (15) sampling points. Five (5) water samples were collected from each zone; Ohafia, Umuahia and Aba zones respectively. Points for borehole water sampling were based on purposive sampling. This was to ascertain the quality aspect of the water supplied to the urban population. The pilot and reconnaissance survey helped the researcher on this judgment as we were familiar with the relevant characteristics of the population. Points were chosen where greater number of the people obtains their water

Table 2: GPS Lat-Long Location of Sampling Points

Samples	Northing	Easting	Elevation	Remarks
	Ohafia Zone			
SPL 1	05°37^{l}02.5^{II}	07°49^{l}34.5^{II}	22.5m	Commercial/Functional
SPL 2	05°37^{l}00.7^{II}	07°49^{l}28.5^{II}	22.6m	Commercial/Functional
SPL 3	05°36^{l}56.8^{II}	07°47^{l}43.7^{II}	22.6m	Commercial/Functional
SPL 4	05°37^{l}12.0^{II}	07°49^{l}30.7^{II}	22.6m	Commercial/Functional
SPL 5	05°32^{l}06.2^{II}	07°29^{l}39.0^{II}	22.7m	Commercial/Functional
	Umuahia Zone			
SPL 6	05°32^{l}16.2^{II}	07°29^{l}45.6^{II}	23.2m	Private/Functional
SPL 7	05°31^{l}55.7^{II}	07°29^{l}52.0^{II}	23.2m	Commercial/Functional
SPL 8	05°31^{l}27.0^{II}	07°29^{l}52.6^{II}	24.4m	Commercial/Functional
SPL 9	05°32^{l}05.1^{II}	07°30^{l}12.1^{II}	26.6	Commercial/Functional
SPL 10	05°06^{l}54.1^{II}	07°22^{l}49.6^{II}	26.9m	Commercial/Functional
	Aba Zone			
SPL 11	05°07^{l}12.3^{II}	07°22^{l}24.1^{II}	27.7m	Commercial/Functional
SPL 12	05°06^{l}19.2^{II}	07°22^{l}44.2^{II}	29.2m	Commercial/Functional
SPL 13	05°06^{l}22.9^{II}	07°22^{l}32.8^{II}	29.5m	Commercial/Functional
SPL 14	05°06^{l}31.8^{II}	07°21^{l}55.5^{II}	30.3m	Commercial/Functional
SPL 15	05°06^{l}37.2^{II}	07°21^{l}57.1^{II}	30.5m	Commercial/Functional

for domestic use while some were based on preference for a particular source irrespective of the distance to be covered. The deterministic data were collected with the help of GPS (Global Positioning System) to get the coordinates of the locations where water samples were randomly collected (Table 2).

Before the tap water samples were collected, cotton wool soaked in 70 per cent ethanol was used to sterilize the nozzle of the tap and the tap was allowed to run for two-three minutes. The water samples were collected in sterilized (Sterilizing agent 5% HNO_3) 1 litre plastic container, rinsed with the water to be collected and then filled with the water samples. As soon as each of the 1-litre plastic cans was filled to the brim to avoid air bubbles, the cap was used to seal it firmly. The samples (SPL) were properly labeled as SPL 1, SPL 2, SPL 3, etc to show the different points for the analysis of microbial parameters. The samples were kept in a cooler box containing ice, before being sent to the Central Services Laboratory of the National Root Crop Research Institute, Umudike (NRCRIU) within two (2) hours for the analysis. Results were presented in tables to show the relationship of variables for easy analysis.

Microbial Analysis Procedure: The microbial water analysis was carried out using the method outlined by Longe *et al*. [13] the multiple tube fermentation test. The lactose broth was prepared according to the manufacturer's instruction and 9 ml of the broth dispensed into each tube with a Durham tube introduced into each of the tube in an inverted position ensuring that the tube does not entrap any gas bubble. Thereafter, 1 ml of each of the water sample was aseptically introduced into the tubes containing either double or single strength concentration of the lactose broth (10 and 1 ml, respectively). The tubes were incubated for 24 hours at 35°C, after the incubation period the tubes were examined for gas production and lactose fermentation.

The tubes which were positive are seen to ferment the lactose broth from orange colour to yellow colour with the production of gas in the durham's tube. The negative sample did not ferment the lactose broth nor produced gas. The tubes which were positive were inoculated on to a macconkey agar and incubated for 24 hours at 35°C. At the end of 24 hours, the isolated organisms were observed for their colony/morphological characteristics as well as their gram staining and biochemical reaction for proper identification and confirmation (Table 5).

RESULTS AND DISCUSSIONS

Five (5) water samples were analyzed for each study area making a total of fifteen (15) analyzed water samples. The objective of microbial analyses was to ascertain the total coliform count (TCC) and the total microbial load (TML) contents per 100ml of sample. The media preparation and culturing were used in determining the variation in biological properties of the water samples. Tables 3 and 4 show the result of the analyses.

Table 3: Result of microbial analysis for total coliform count (TCC)

Samples	Microbial Count	Isolated Organisms
Ohafia		
SPL 1	5.0×10^1 cfu ml^{-1}	*Klebsiella* spp. isolated
SPL 2	4.1×10^1 cfu ml^{-1}	*Klebsiella* spp. isolated and *Eshericia coli* isolated
SPL 3	4.3×10^1 cfu ml^{-1}	*Eshericia coli* and *Klebsiella* spp. isolated
SPL 4	4.9×10^1 cfu ml^{-1}	*Eshericia coli*
SPL 5	4.4×10^1 cfu ml^{-1}	*Klebsiella* spp. isolated
Umuahia		
SPL 6	Nil	No growth isolated
SPL 7	2.6×10^1 cfu ml^{-1}	*Eshericia coli* isolated
SPL 8	2.1×10^1 cfu ml^{-1}	*Eshericia coli* isolated
SPL 9	4.1×10^1 cfu ml^{-1}	*Klebsiella* spp. and *Eshericia coli* isolated
SPL 10	3.4×10^1 cfu ml^{-1}	*Eshericia coli* isolated
ABA		
SPL 11	3.0×10^1 cfu ml^{-1}	*Eshericia coli* and *Klebsiella* spp. isolated
SPL 12	3.0×10^1 cfu ml^{-1}	*Eshericia coli* isolated
SPL 13	1.0×10^1 cfu ml^{-1}	*Eshericia coli* isolated
SPL 14	4.0×10^1 cfu ml^{-1}	*Eshericia coli* and *Klebsiella* spp. isolated
SPL 15	3.9×10^1 cfu ml^{-1}	*Eshericia coli* and *Klebsiella* spp. isolated

Table 4: Result of microbial analysis for total microbial load (TML)

Samples	Microbial Count	Isolated Organisms
Ohafia		
SPL 1	2.5×10^1 cfu ml^{-1}	*Eshericia coli* and *Klebsiella* spp. isolated
SPL 2	3.2×10^1 cfu ml^{-1}	*Klebsiella* spp. and *Streptococci* spp. isolated
SPL 3	4.3×10^1 cfu ml^{-1}	*Eshericia coli* and *Klebsiella* spp. isolated
SPL 4	3.5×10^1 cfu ml^{-1}	*Eshericia coli* and *Klebsiella* spp. isolated
SPL 5	3.2×10^1 cfu ml^{-1}	*Klebsiella* spp. and *Streptococci* spp. isolated
Umuahia		
SPL 6	Nil	No growth isolated
SPL 7	3.6×10^1 cfu ml^{-1}	*Klebsiella* spp. and *Streptococci* spp. isolated
SPL 8	3.2×10^1 cfu ml^{-1}	*Klebsiella* spp. and *Streptococci* spp. isolated
SPL 9	4.1×10^1 cfu ml^{-1}	*Eshericia coli* and *Klebsiella* spp. isolated
SPL 10	2.2×10^1 cfu ml^{-1}	*Klebsiella* spp. and staphylococci isolated
ABA		
SPL 11	3.5×10^1 cfu ml^{-1}	*Streptococci* spp.; *Eshericia coli* and *Klebsiella* spp. isolated
SPL 12	2.8×10^1 cfu ml^{-1}	*Eshericia coli* and staphylococci isolated
SPL 13	1.0×10^1 cfu ml^{-1}	*Eshericia coli* isolated
SPL 14	3.9×10^1 cfu ml^{-1}	*Klebsiella* spp. and *Streptococci* spp. isolated
SPL 15	3.5×10^1 cfu ml^{-1}	*Klebsiella* spp. and *Streptococci* spp. isolated

Table 3 shows the result of microbial properties of the water samples through media preparation and culturing. In Ohafia, total coliforms ranges from 4.1/100ml in SPL 2 to 5.0/100ml in SPL 1. SPL 1 had coliform count of 5.0/100ml and only one organism (*Klebsiella* spp.) was isolated. SPL 2 and SPL 3 had coliform count of 4.1/100 and 4.3/100ml, respectively and two organisms (*Klebsiella* spp. and *Eshericia coli*) each were isolated from these samples. SPL 4 and SPL 5 had coliform count of 4.9/100 and 4.4/100ml and one organism each (*Eshericia coli* and *Klebsiella* spp.) were isolated, respectively.

Quantitatively, the presence of total coliform count and *Eshericia coli* shows that the water samples have been contaminated. Following the Akaninyene and Atser [4] guideline for microbial quality of drinking water which stated that, E. coli or thermo-tolerant coliform bacteria must not be detectable in any 100ml sample of water for the water to be considered potable. Based on this, the water samples are unfit for human consumption [7, 8].

In Umuahia, total coliform ranges from 0 to 4.1/100ml. SPL 6 had no microbial count and no growth was isolated. On the basis of this result, the water sample is potable for domestic use. SPLs 7, 8 & 10 had coliform counts of 2.6/100ml, 2.1/100ml and 3.4/100ml respectively and the same organism, *Eshericia coli* was isolated. While SPL 9 had coliform count of 4.1/100ml and two organisms (*Klebsiella* spp. and *Eshericia coli*) were isolated. Comparing the result with the international standards, apart from SPL 6, other water samples (SPLs 7-10) have proven to be inadequate in terms of quality [9, 10].

Table 5: Gram Staining, Biochemical reaction and Colony Characteristics of isolated organisms

Samples	Isolated organisms	Gram staining	Biochemical reaction	Colony Morphology & characteristics
SPL 1	*Klebsiella*	Gram –ve	Citrate +v	A large pink mucoid colony on Macconkey Agar.
SPL 11	*Streptococci*	Gram +ve	Catalase –ve	Appearance of a zone of inhibition on blood agar
	Klebsiella	Gram –ve	Citrate +ve	A large pink mucoid colony.
	E. coli	Gram –ve	Citrate –ve	A large red colony surrounded by a turbid zone.
SPLs 2-9; 13-15	These samples have some of the organisms as described above.			
SPLs 10 & 12	Staphylococci	gram +ve	Catalase +ve	A very small opaque colony on macconkey agar.

In Aba, SPL 11 had 3.0/100 ml coliform count and two organisms (*Eshericia coli* and *Klebsiella* spp.) were isolated. SPLs 12 and 13 had coliform count of 3.0/100ml and 1.0/100 ml respectively and one organism (*Eshericia coli*) was isolated in each. SPLs 14 and 15 had coliform count of 4.0/100ml and 3.9/100ml respectively and two organisms (*Eshericia coli* and *Klebsiella* spp.) were isolated. Comparing the result with the international standards, the water samples have proven to be inadequate in terms of quality [11, 12].

In all, for total coliform count, only two organisms (*Klebsiella* spp. and *Eshericia coli*) were isolated and the water samples were thus polluted by these organisms. SPL 6 (Umuahia) had no microbial count and no organism was isolated. In terms of pollution by the number of isolated organisms, SPL 1 (Ohafia zone) is the highest polluted in terms of the number of organisms isolated while SPLs 13 (Aba zone), 8 and 7 (Umuahia zone) were the least polluted sources. Table 4 shows the result of total microbial load (TML).

Table 4 shows result of total microbial load of the water samples. From the table, in Ohafia, SPL 1 had 2.5/100 ml microbial load while two organisms (*Eshericia coli* and *Klebsiella* spp.) were isolated. SPL 2 and 5 had microbial load of 3.2/100ml each while two organisms (*Klebsiella* spp. and *Streptococci* spp.) were also isolated respectively. SPLs 3 and 4 had 4.3/100 ml and 3.5/100ml microbial load respectively and two organisms in each (*Eshericia coli* and *Klebsiella* spp.) were isolated. Following the Nkemdirim *et al.* [15] international standards for drinking water, the result confirms the presence and threat of feacal pollution /contamination of the water samples.

In Umuahia, the results of the analysis showed that only water sample (SPL 6) had neither coliform nor *E. coli*. The implication of this is that the water sample is safe for domestic purposes. SPLs 7 and 8 had microbial load of 3.6/100ml and 3.2/100ml respectively and two organisms were (*Klebsiella* spp., *Streptococci* spp.) were isolated. SPL 9 had microbial load of 4.1/100ml and two organisms (*Eshericia coli*, *Klebsiella* spp.) were isolated, while SPL 10 had microbial load of 2.2/100ml and two organisms (*Klebsiella* spp. and staphylococci) were isolated. The result of the analysis in Umuahia zone shows that apart from SPL 6 which had neither coliform nor *E. coli*, all other samples were polluted and thus not good for domestic purposes.

In Aba, SPL 11 had microbial load of 3.5/100ml while three organisms (*Streptococci* spp.; *Klebsiella* spp. and *Eshericia coli* spp.) were isolated. SPL 12 and 13 had microbial load of 2.8/100ml and 1.0/100ml respectively. SPL 12 had two organisms (*Eshericia coli* and staphylococci) while SPL 13 had only one organism (*Eshericia coli*). SPLs 14 and 15 had microbial load of 3.9/100ml and 3.5/100ml respectively while two organisms (*Klebsiella* spp. and *Streptococci* spp.) were isolated in each. The result of these analysis (Aba zone) revealed that the water samples were polluted by organisms and therefore not potable [12].

A cursory look at Table 4 shows that four organisms (*Eshericia coli*, *Klebsiella* spp., *Streptococci* spp. and staphylococci) were isolated and the water samples were polluted by these organisms. In all, SPL 11 is the highest polluted in terms of the number of organisms isolated while the least is SPL 13 which was polluted by only one organism. Samples (SPLs) from which *Streptococci* spp. and staphylococci were isolated may have been from other sources of contamination such as the soil or from the container with which the samples were collected [13].

The colony morphology and characteristics of these organisms are shown in Table 5 below.

CONCLUSION AND RECOMMENDATIONS

The laboratory analyses of the water samples have shed some light on potable water supply to the urban areas of Abia State. This study has utilized and explored the different techniques and avenues of geographical research on potable water analyses to arrive at its findings. Hence, quantitatively, the presence of total coliform count and *Eshericia coli* shows that the water samples have been contaminated. The WHO guideline for microbial quality of drinking water stated that, *E. coli* or thermo-tolerant coliform bacteria must not be detectable

in any 100ml sample of water for the water to be considered potable. Based on this, comparing the result with the international standards, apart from SPL 6 (Umuahia zone), the water samples have proven to be inadequate in terms of quality and unfit for human consumption. The study recommends amongst others that: the Water Board should ensure periodic re-examination of the quality of private borehole water supplies; the borehole owners should use professional drillers who should penetrate as much of the aquifer as possible to achieve good inflow and to allow for drawdown of water level during pumping; and on striking the aquifer, representative samples should be collected for bacteriological and physicochemical analyses to verify the state before final development and thereafter routine analyses for stability.

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