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Microbes, Mineral Elements and Geophysical Nature of Public Water Sources in Akungba-Akoko, Nigeria

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Author's contribution

The only author performed the whole research work. Author AOA wrote the first draft of the paper, read and approved the final manuscript.

Research Article

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ABSTRACT

Aims: To determine the bacteriological quality and geophysical abiotic components including mineral elements of public drinking water sources in Akungba-Akoko community located in South West Nigeria.
Study Design: Water and soil samples were collected from selected ground water (e.g., well, borehole) and surface water (e.g., streams) in 20 various locations of Akungba-Akoko community. Similarly, Geographical positioning system (GPS) of the sampling site was determined.
Methodology: Total bacteria and coliform content of water samples were enumerated using the pour plate technique. The physico-chemical parameters such as pH, turbidity and temperature and mineral elements constituents were determined. Total bacterial count, phosphorus (P) and copper (Cu) were also determined in the soil samples.
Results: The total bacterial count ranged from as low as 1.0 x 10^2 cfu/mL in GLAS site to 1.22 x 10^6 cfu/mL in sample site GLA9, while the coliforms count ranged from 5.0 x 10^1 cfu/mL in well water of sample site GLG1 to 36 x 10^4 cfu/mL and 3.8 x 10^5 cfu/mL in sample site GL9 and GL7 respectively. As for soil sources, the total heterotrophic bacterial count range was from 1.8 x10^5 cfu/g to 8.7 x10^5 cfu/g. Total hardness of the water sources ranged from 4.46 ppm in sample site GLA2 to 216.86 ppm in well water (GLWS 6) in Akungba. High levels of lead in some areas as in Araromi pond zone (GLCW16) and Well water 2nd Market (GLBWS 6) among others, exceeded the maximum permissible level of 0.10 mg/L. The pH

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of water sources range from pH 5.52 to pH 7.91 while temperature ranges from 23ºC to 28ºC.
Conclusion: This study shows that many sources of public drinking water supply in Akungba-Akoko are microbiologically substandard with possible infiltration of some chemical contaminants. Hence, routine monitoring and protection of the water resources is necessary in this community to improve the quality of drinking water and avoid possible associated health risks.

Keywords: Akungba-Akoko; geophysical; microbes; mineral elements; Nigeria; water .

1. INTRODUCTION

Water is valuable for domestic purposes and related biotic components in our environment. Unsafe water continues to be a global public health threat, placing people at risk for diarrheal and other diseases as well as chemical intoxication [1]. Therefore, maintaining a safe drinking water remains essential to human health as transient bacteria contamination may have serious health implications. Water meant for public use originates from different sources, thus there is need to determine various factors that influence water quality [2].

Increase in human population exerts enormous pressure on the provision of safe drinking water especially in developing countries [3]. Bacteria has a unique characteristic, being ubiquitous in every habitation on earth growing in soil, acidic hot spring, radioactive waste, water and the live bodies to plants and animals [4]. Thus there is a need to assess quality of water in all ramifications. The physico-chemical and microbiological analysis of surface and ground water are important for their desirability for domestic and industrial purposes [5].

Akungba-Akoko is a rapidly growing University community and this puts pressure on the available infrastructure over time. This is a community without municipality pipe water. Due to the increasing dependence on surface water and the envisaged population growth, the quality of water from the available sources may become questionable. Therefore it is important at this early stage to begin to determine prevailing factors that may likely impact on water quality and consequently predict the health implication if major structural and infrastructural interventions are not carried out. This study therefore sought to determine the microbiological quality and some geochemical formations of water resources in Akungba-Akoko community as part of a larger study for adequate provision of water supply that will conform to a reasonable extent with international standards and ensure that the water resources are protected from pollution that posses health risk to the Nigerian population and environment.

2. MATERIALS AND METHODS

2.1 Study Site

Water samples were collected from various sources such as well, bore hole and stream in Akungba-Akoko, a community in which the Ondo State University now renamed Adekunle Ajasin University is located in Akoko South West Local government area of Ondo State that is located between longitude 5.440E and 5.450E and latitude 7.24 N and 7.28N. It is a conglomerate of other small towns and villages like Akowonjo, Apole, Okele, Ugbama, Araromi and Ago-Egbira. The town is surrounded by little hills and bounded by some towns such as Ikare in the North, Oka in the East, Etioro in the South, and by Supare in the West. The notable hills are Otapete in the south, Okerigbo in the North, Akunmeren in the west and in the East by Oke oko hills [6]. Samples were collected from selected areas of the town.

2.1.1 Geographical positioning system (GPS)

Water and soil samples were collected from 20 selected wells, borehole and streams in various locations of Akungba-Akoko community. A GPS locator was used to determine the Geographical positioning system (GPS) of this area, which is often affected by the solar energy. However, care was taken to get accurate measurement. The readings were taken at the point of sampling. This helps to get the idea of topographic locations with regards to water tables of sampling site and related geological formation.

2.2 Sampling Techniques

Water samples were collected in sterile 200 ml sampling bottles that were transported in cold boxes to the laboratory. Soil samples were collected in clean polythene bags. This facilitates the determination of the soil structure and enumeration of microbial species from these sites.

2.3. Bacteriological study

The pour plate technique was used for the total plate count, for heterotrophic bacteria in water and soil samples. Diluted samples were seeded onto sterile plate count agar and incubated at 37ºC for 24 hours [7]. The presence of coliform was determined by using most probable number (MPN) method, and *E. coli* was identified by culture on Eosine methyline blue (EMB) agar plates according to Chao et al. [8]. The presence of coliform bacteria, such as *E. coli*, in surface water is a common indicator of fecal contamination and in agreement with World Health standard set in USEPA [9].

2.4 Isolation and Identification of Microorganisms from Sample Sources

Media generally used to isolate bacteria in the samples were plate count Agar (PCA), Nutrient Agar (NA) and Eosin Methylene Blue (EMB). The isolated organisms were identified by standard microbiological techniques including the Gram stain reactions, cultural characteristics and reaction to various fermentative sugars [10].

2.4.1 Coliform count

Coliforms were enumerated in the studied samples following some sequence in conformity with standard method recommended in water sources using lactose fermenting medium described in USEPA [9] as stated below. The test was carried out in some sequential stages, namely presumptive, confirmed and completed test. It was started using a most probable number (MPN) whereby appropriate combination of water sample sizes used were chosen by examining the MPN Tables available in Standard methods for the examination of drinking water as stated by APHA [11] and APHA, [7], by inoculating water samples serially diluted to varying strength into lactose broth medium in which inverted durham tubes were placed to determine gas evolution by coliforms organisms due to lactose fermentation. This signifies positive result under this context and read appropriately to determine both positive and negative test. The presence of coliforms was however confirmed by streaking the positive sample source on EMB agar for complete observation of the coliforms.

2.5 Laboratory Analysis of Physico-Chemical Parameters

The pH and temperature of the water samples were determined using appropriate instruments like the pH meter (Model 600 Fisher Scientific Co., U.S.A) and suitable thermometer while the colour was assessed physically. Similarly, the conductivity of the water was determined using a salinometer calibrated to read the samples @25ºC in millisciemens per cm. These tests were done using the method of FAO [12] with some scientific modifications.

2.5.1 Total hardness of water samples

Two millimeters of hydra pH buffer powder solution meant for hardness determination is added to 100 ml of the sample and swirled. 0.1-g scoop of ManVer 2 powder used as hardness indicator powder was also added to the solution and swirled. The mixture was titrated against 0.800M EDTA until a change from red to pure blue was observed as an end point. It is then read and value expressed as mg/L ($CaCO_3$) standard 500mg/L.

2.5.2 Total dissolved solids (TDS)

The TDS was determined by filtering the well-mixed water samples through a standard glass fiber filter and the filtrate is evaporated to dryness in a weighed dish and dried to constant weight at 180ºC. The increase dish weight represents the total dissolved solids in a sample.

2.5.3 Determination of mineral elements

Water samples collected from various sites in Akungba-Akoko, Ondo State were analyzed for some physical and chemical properties. The components analyzed under these context included; Na, calcium (Ca), magnesium (Mg), manganese (Mn), total hardness, chromium (Cr), nickel (Ni), cobalt (Co), Iron (Fe), copper (Cu), lead (Pb), phosphorus (P), Chloride (Cl), Zinc (Zn), cadmium (Cd) and Ca-hardness, and Mg-hardness) in the water sources. Phosphorus (P) and copper (Cu) were also determined for the soil samples. The Ca and Mg content of the samples was determined using extraction method. The resultant reading was taken on the Atomic Absorption Spectrophotometer (AAS).

3. RESULTS AND DISCUSSION

Different sites in Akungba-Akoko within the geographical location of longitude E005^{0}44' and E005^{0}44' and latitude N07º27' and N07º29' (Fig. 1) were sampled for their water quality parameters. This has correlation with previous study and documentation as in Akungba Map, [13] and Ologungbede, [6] that gave a range of longitude 5.44ºE and 5.45ºE to latitude 7º28'N.

This study helps to assess the geophysical and microbiological quality of water meant for human consumption in different areas of the University community. Results in Table 1 show that the total bacterial count range from as low as 1.0×10^4 cfu/mL in sample site GLA5 to 1.22×10^6 cfu/mL in well water at (GLA9) while the coliforms count ranged from 1.0×10^2 cfu/mL in GLA5 to 3.6×10^5 cfu/mL and 3.8×10^5 cfu/mL in sample site GLA9 and GLA7 respectively. The most probable number of zero recorded in some bore-hole sources like that of A.A.U (GLA4) Akungba-Akoko campus and Ilale (GLG4) Akungba make it significantly good source of water compared with areas like sampling sites GLH2, GLG2, GLB4, GLC2, and GLA9, having high counts up to 1800 MPN of coliforms and relative high coliforms count on EMB agar to complete the test. Tables 4 to 7 show the metals and mineral element constituents of the water and soil samples from the tested sites.

The physico-chemical properties of the water sample sources shows variation in some parameters such as pH ranging from pH 5.52 and 5.87 in sample site GLG4 and GLG2 respectively to pH 7.67 in GLI. The temperature recorded also varies from 23℃ to 28℃ for all the sample sources (Table 2). The colour of the water sources physically assessed also has slight variation in their clarity as shown in Table 1. Result in Tables 2 to 4 shows the metals and mineral element constituents of water samples from different sites while Figs. 2-4 show that of the soil. These components determine some enrichment pattern of some of the water sources, part of which could however constitute health threats at relatively high levels. The total hardness of the water sources ranged from 4.46 ppm in a rocky zone (GLA2) to 216.86 ppm in Well water (GLBWS 6) Akungba. This is still within the maximum allowable level of 500mg/L for drinking water (Corrosion Doctors, 1981). Similarly, Nickel varies from 0.16 mg/L in University Borehole (GLA4) water to 0.58 mg/L in the elevated zone Araromi quarters (GLE) while the concentration recorded for lead is 0.02 mg/L in sample site GLC1 to 58.16 mg/L and 63.91 mg/L in GLBWS 6 and GLCWS 14 respectively (Table 2 and 3). The nickel exceeded the specified amount of 0.1mg/L [14] for the entire sampling site while lead maximum allowable level of 0.05mg/L is exceeded in many sites except GLC1 (0.02) and GLA2 (0.05) [15; 16]. The presence of this kind of heavy metals in public drinking water is a concern because it serves as a kind of health threat.

In this study, the samples sources were populated by many viable heterotrophic bacteria whereby the total bacterial counts for the water samples sources generally exceed the limit of $1.0X10^2$ cfu/ml, which is the standard limit of heterotrophic count for drinking water [17]. Previous investigations [18] reported that the high total heterotrophic count is indicative of the presence of high organic and dissolved salts in the water. Under this context it was observed that coliform counts were high in the water sources from all study area of Ondo State except GLA5 site (Table 1). These results however may pose a potential threat for infectious disease outbreak because of the nature of organisms involved (8). This high level of coliforms count from most sources analyzed is not acceptable with reference to permissible water standards as it should not contain detectable *E. coli* or total coliform bacteria in a 100 ml sample [3]. Most of the samples did not comply with bacteriological standards of The USA Environmental Protection Agency (EPA) as Total coliform counts generally exceeded 1,600 MPN/ml as reflected in environmental protection regulation [17, 19]. The presence of total coliforms does not necessarily have a direct public health implication. Instead, total coliform is used as an indicator of a potential pathway of contamination within a treatment technique requirement (EPA, Federal Register / Vol. 75, No. 134 / 2010 / Proposed Rules).

The reasons for non-conformance to standards of some water sources in specific locations studied is due to poor orientation of the inhabitants on this water quality standard and some lapses on part of government unit concerned, which they partly worked upon before the end of this study. This have relevance with the study of Dreyer [20] who gave insight to the setting up of water supply programme in South Africa in 1994 led by the Reconstruction and Development Programme which is the overarching development approach of the government, whereby water is one of the basic needs and a priority.

Some physico-chemical studies like pH of water sources that ranged from pH 5.52 to pH 7.91 and temperature between 23ºC to 28ºC (Table 2) still falls within some permissible range in correlation with the World Health Organization Standard in WHO/UNICEF [3] and APHA (7). There was high level of lead in GLA3 (Table 2b), which exceeded the maximum permissible level of 0.10 mg/L [3]. Similarly, some of the physico-chemical parameters here such as the pH in sites GlA 1, GLA 8, GL1, and turbidity in GLA3, GLB3, GLF2, GLH2 (Table 2a) did not conform with international standards and specified drinking water regulation as stated in EPA [17]. Hence, this study shows how some geological components influence microbiological quality of water sources in Akungba-Akoko, Ondo state. The town is fast growing with the advent of the University by extending to more geographical areas.

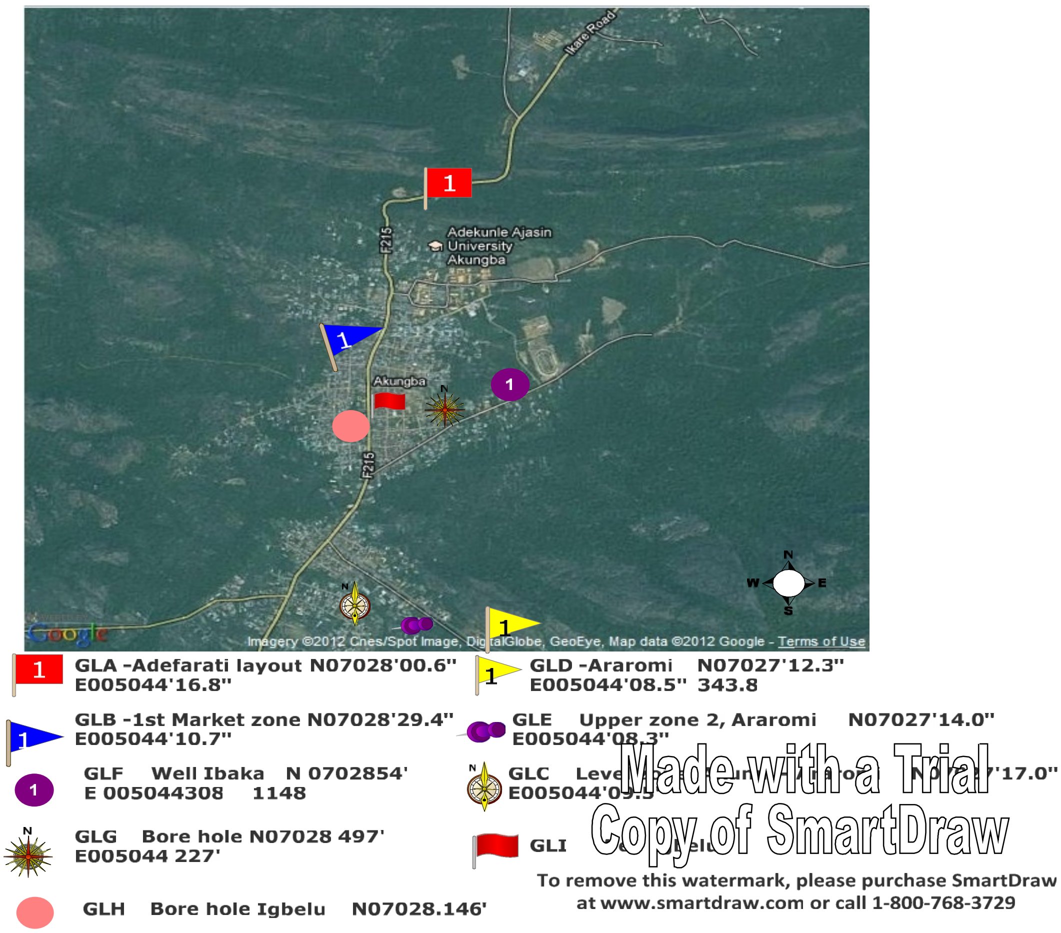

Fig. 1. Geographical positioning system of some sampling sites in Akungba-Akoko, Ondo State, Nigeria

Legend: GL codes A to I: Geographical Locations used for sampling site

Table 1. Microbial population of water sources Akungba-Akoko

Site code	Description	Point of collection	Total bacterial counts (cfu/mL x10^4)	Coliforms count (cfu/mL x10^2)	MPN
GLA1	Well water	Surulere St, Adefarati quarters	42	70	25
GLA4	Borehole water	AAUA borehole	18	300	0
GLA5	Storage tank	AAUA storage tank	1.0	1.0	100
GLA6	Borehole water	Pioneer Hostel A.A.U.A	9.4	26.4	15
GLA7	Stream water	Oroke stream	102	3800	115
GLA8	Stream water	Oroke stream 2	5.2	3.5	1225
GLA9	Well water	Oroke well	122	3600	1800
GLB1	Stream water	Omi Olokewo, Okusa quarters	980	72	125
GLB3	Well water	Apex Rd, Ibaka quarters	36	6.5	15
GLB4	Stream water	Okele stream	98	190	1800
GLC2	Well water	Akunmi well	75	400	1800
GLC3	Borehole water	Akunmi borehole	9	300	8
GLF	Borehole water	Univ Rd, Ibaka quarters	5.3	5.5	0
GLF2	Stream water	Isakare stream	4.2	6.5	15
GLG1	Well water	AAUA Perm Site Rd, Ilale quarter	31	5.0	15
GLG2	Well water	Ilale well	85	1600	1800
GLG3	Borehole	Ilale borehole	37	100	0
GLG4	Borehole water	Ilale borehole 2	3.5	2.0	1800
GLH1	Well water	Akwa well	3.9	1.5	25
GLH2	stream	Akwa stream	87	2400	1800
GLI	Well water	Igbelu's well	4.0	4.5	70

Legend: AAUA - Adekunle Ajasin University, Akungba –Akoko
GL codes A to I: Geographical Locations used for sampling sites
MPN: Most Probable Number

Table 2a. Physico-chemical properties of water sample sources

Site code	Sample sources	pH	Temp. ºC	Turbidity
GLA1	Surulere St, Adefarati quarters -Well	**7.91**	24.4	Clear
GLA2	Surulere St, Adefarati quarters -Rock AAUA	7.16	26.5	Clear
GLA3	Adefarati residence, Stream via AAUA	6.6	30	**Turbid**
GLA4	AAUA borehole	7.03	28	Clear
GLA5	AAUA storage tank	6.52	23	Clear
GLA6	Pioneer Hostel AAUA -Borehole water	7.09	24.1	Clear
GLA7	Oroke stream	6.10	27	Clear
GLA8	Oroke stream 2	7.65	25	Slightly turbid
GLA9	Oroke well	5.97	26	Slightly turbid
GLB2	Omi Olokewo, Okusa quarters -Stream water	6.43	26.0	Slightly turbid
GLB3	Apex Rd, Ibaka quarters -Well	7.02	23.7	**Turbid**
GLB4	Okele stream	6.02	26	Slightly turbid
GLB5	Glomax Rd, Akungba -Well	7.02	25	Clear
GLB7	11 ABE STR -Well	6.8	30	Slightly turbid
GLC1	Level zone, Araromi -Well	6.9	30.1	Clear
GLC2	Akunmi well	5.96	28	Clear
GLC3	Akunmi borehole	5.92	28	Clear
GLD	Upper zone 1, Araromi -Well	6.5	30	Clear
GLE	Upper zone 2, Araromi -Well	5’54	30.1	Clear
GLF	Univ Rd, Ibaka quarters -Borehole water	7.54	25.8	Clear
GLF2	Isakare stream	6.50	25	Turbid
GLG1	AAUA Perm. Site Rd, Ilale quarter-Well	7.14	24.6	Clear
GLG2	Ilale well	5.87	28	Clear
GLG3	Ilale borehole	5.93	27	Clear
GLG4	Ilale borehole 2	5.52	24	Clear
GLH1	Akwa well	7.15	26	Clear
GLH2	Akwa stream	6.14	26	Turbid
GLI	Igbelu’s well	7.67	24	Clear

Table 2b. Some Physico-chemical properties and mineral elements constituents of water sample sources in selected areas (mg/L)

Site code	Ca	Mg	K	Na	Ca-hardness	Mg-hardness	Total hardness	Pb	Cr	Ni	Co	PO4-P
GLA2	1.52	0.16	0.42	1.04	3.80	0.66	4.46	0.05	0.12	0.21	0.02	0.07
GLA3	6.06	0.92	1.10	1.82	15.14	3.78	18.92	**0.13***	0.12	0.30	0.01	0.05
GLA4	18.28	1.30	6.22	4.68	45.65	5.36	51.02	0.09	0.14	0.16	0.02	0.07
GLB3	19.91	1.11	2.93	5.03	49.71	4.56	54.27	0.10	0.17	0.21	0.00	0.08
GLB5	12.62	1.08	2.82	4.19	31.52	4.43	35.95	0.08	0.12	0.16	0.04	0.08
GLB7	23.06	1.30	38.98	8.94	57.58	5.34	62.92	0.11	0.22	0.16	0.05	0.07
GLC1	23.84	0.42	3.80	2.68	59.52	1.75	61.27	0.02	0.11	0.26	0.03	0.07
GLD	7.93	0.29	0.44	2.04	19.81	1.17	20.98	0.07	0.16	0.21	0.00	0.11
GLE	26.17	0.88	1.47	3.41	65.34	3.61	68.95	0.07	0.16	0.58	0.02	0.09

Exceeded the maximum permissible level of 0.10 mg/L

Table 3. Mineral elements constituents of water sample sources in other areas of Akungba-Akoko (mg/L)

s/n	Site code	Sources	Ca	Mg	K	Na	Ca-hardness	Mg-hardness	Total hardness	Pb	Cd
1	GLBWS 1	Bore hole sample 2, Glo max	4.89	4.73	12.22	19.49	31.70	0.02	31.72	4.89	4.73
2	GLAWS 2	Well water pioneer hall, AAUA	1.83	0.89	4.58	3.65	8.23	0.04	8.27	1.83	0.89
3	GLBWS 3	Well water, Ibaka	3.34	6.43	8.34	26.46	34.81	0.02	34.83	3.34	6.43
4	GLAWS 4	Borehole –Therapy pharmacy	2.39	6.45	5.97	26.57	32.53	0.02	32.55	2.39	6.45
5	GLBWS 5	Stream water, Apex	7.36	4.67	18.38	19.24	37.62	0.01	37.63	7.36	4.67
6	GLBWS 6	Well water 2nd Market	58.16	17.40	145.21	71.64	216.86	0.00	216.86	58.16	17.40
7	GLBWS 7	Well water, post office	38.48	10.95	96.09	45.10	141.19	0.04	141.23	38.48	10.95
8	GLAWS 8	Well water, AAUA permanent site rd.	19.89	4.73	49.68	19.49	69.17	0.01	69.18	19.89	4.73
9	GLAWS 9	Well water, Adefarati's house	12.66	5.25	31.60	21.63	53.23	0.07	53.30	12.66	5.25
10	GLAWS 10	Stream water, Adefarati	2.65	3.10	6.62	12.77	19.39	0.04	19.43	2.65	3.10
11	GLCWS 11	Well water-level zone, Akunmi, Araromi	2.25	0.88	5.61	3,64	9.24	0.07	9.31	2.25	0.88
12	GLGWS 12	Bore hole, palace quarters	4.33	4.76	10.80	19.60	30.40	0.02	30.42	4.33	4.76
13	GLCWS 13	Small Pond, Rawa's zone, Araromi	47.54	2.46	118.70	10.12	128.82	0.10	128.92	47.54	2.46
14	GLCWS 14	Pond, Akinduro's zone	34.41	7.40	58.92	30.41	116.40	0.03	116.43	34.41	7.40
15	GLCWS 15	Large Pond, Rawa's zone, Araromi	17.89	3.67	44.67	15.12	59.79	0.01	59.80	17.89	3.67
16	GLCWS 16	Pond- Oguns zone, Araromi	63.91	7.90	159.57	32.53	192.11	0.04	192.15	63.91	7.90

Table 4. Metal in water sample sources in mg/L

S/N	Sample code	Sources	Electrical conductivity (uS/cm)	TDS	Mn	Fe	Cu	Zn
1	GLC1	Well-Level zone, Akunmi-Araromi	129	65	0.02	0.39	0.01	0.11
2	GLD	Well-Upper zone 1, Akunmi-Araromi	66	33	0.01	0.12	0.00	0.13
3	GLE	Well-Upper zone 2, Araromi	154	77	0.02	0.78	0.01	0.19
4	GLA2	ROCK zone stream -AAUA	18	9	0.01	0.37	0.01	0.19
5	GLA4	AAUA borehole	230	113	0.01	0.03	0.01	0.12
6	GLA3	STREAM AAUA	64	31	0.01	0.41	0.01	0.13
7	GLB5	Well-GLOMAX RD	152	77	0.01	0.06	0.01	0.08
8	GLB3	Apex Rd, Ibaka quarters-well	190	98	0.01	0.04	0.00	0.03
9	GLB7	Well- 11 ABE STR	458	230	0.01	0.04	0.02	0.10

Legend: GL codes A to I: Geographical Locations used for sampling sites
TDS: Total dissolved solids

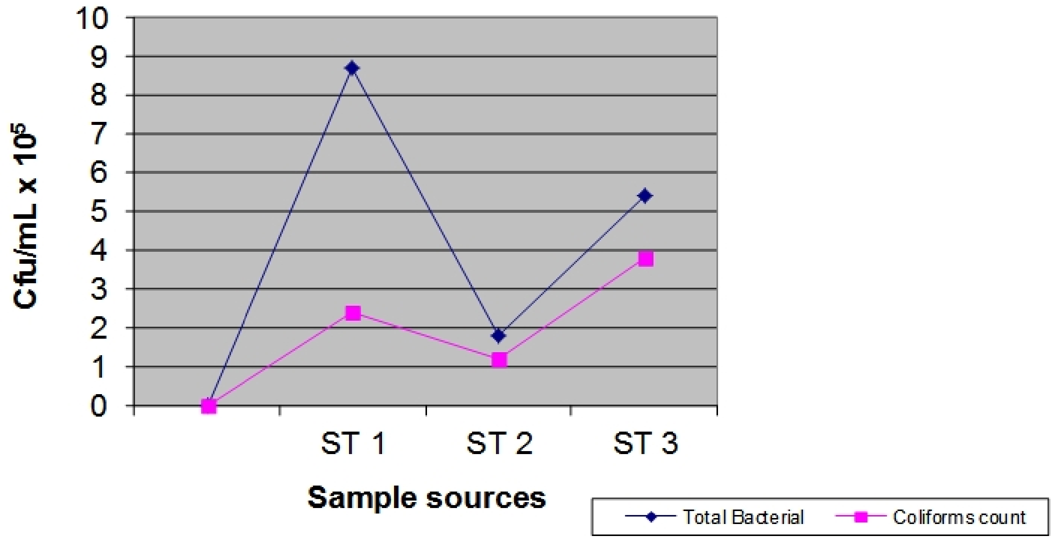

Fig 2: Total Bacterial and coliforms count on soil samples using different media (Cfu/mL)

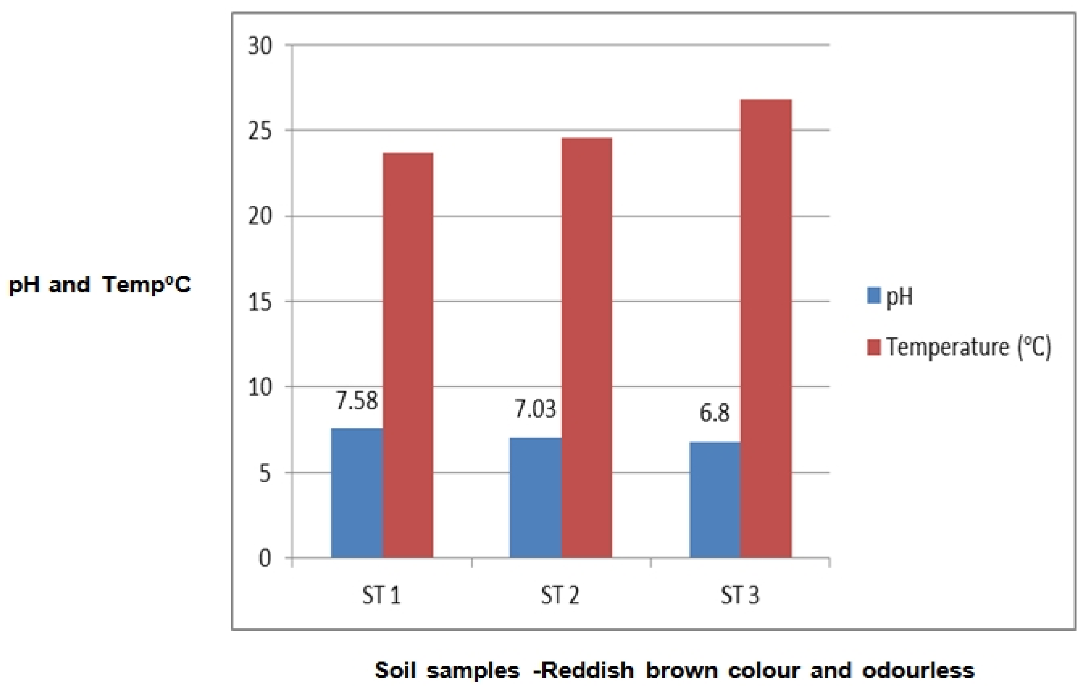

Fig. 3. Physico-chemical parameters of the soil samples from stream sources in Akungba-Akoko

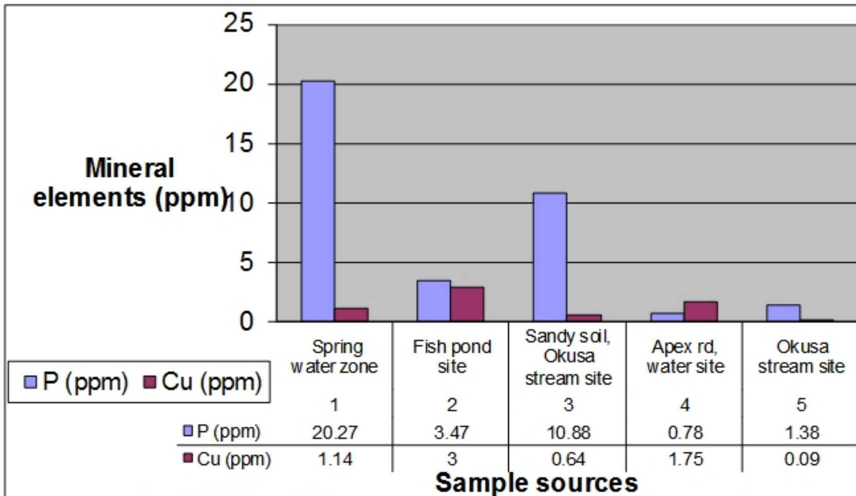

Fig 4: Mineral elements constituents of some soil sources

4. CONCLUSION

Water-quality information is used to protect human health, to preserve and restore healthy environmental conditions, and to sustain a water monitoring strategy. The results of this study help determining the microbiological contaminants coupled with some geophysical, ecological and physicochemical parameters of public water sources in Akungba-Akoko community of Ondo State with the view of using available data for possible environmental monitoring in case of contamination of public water sources in this area. The study recommends a strategy for nationwide water-quality monitoring and technical monitoring improvements to support sound water-quality decision-making at all levels of government and in local areas.

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COMPETING INTERESTS

Author has declared that no competing interests exist.

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