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Hydrogeophysical and hydrochemical analysis of shallow water wells around Ire-Akari area, Akure southwestern Nigeria

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The hydrogeophysical and hydrochemical analysis of the shallow wells around Ire-Akari area Orita-Obele Akure, Ondo state was carried out to understand the geologic layer constituting the aquifer, its suitability or otherwise as source of potable / drinking water and the tendency of the overburden to naturally protect the aquifer. The result of the hydrochemical analysis showed that most of the physio-chemical and microbial parameters are found within the WHO permissible limit. Also, the overburden serves as the protective capacity to prevent surface infiltration/leachate effect particularly at depth greater than 10 m. Therefore, wells of appreciable depth (> 10 m), well ringed, and covered could serve as source of drinking water with minor treatment.

Key words: Hydro-geological, Hydro-chemical, physiochemical microbial parameters and infiltration/leachate.

INTRODUCTION

The quality of groundwater is a function of natural processes as well as anthropogenic activities (Badmus et al., 2001). Quality of water is principally affected by pollution from diverse sources, (Sajil-Kumar et al., 2013). Inorganic chemicals and micro- organisms are common in human environments. The majority of pathogenic micro- organisms (potentially disease causing virus/bacteria or pathogens) that are found in water come from human and animal excrements (Olasheinde et al., 1998). Thus, the presence of contaminants above World Health Organization (WHO) standard can cause different kinds of diseases: Typhoid fever, Paratyphoid fever, Dysenteries, Gastroenterities, Infectious Hepatitis, Schistosomiasis, Asiatic cholera, Back pains, Pneumonia, Nasal congestion (Ojelabi et al., 2001).

As the population of Ire-Akari community continues to increase; human activities including soil fertility remediation, indiscriminate refuse/waste disposal, and the use of septic tanks, soak-away pits and pit latrines are also on the increase. These activities are capable of producing leachates into the groundwater formation that serve as source of water to the inhabitants of the estate.

Thus the main purpose of the study therefore, is to study the hydrogeologic setting of the area, to investigate the degree of capability of the overburden in protecting the aquifer (particularly the shallow hand-dug wells) which is prevalent in the area / the deep boreholes and to investigate whether the levels of inorganic chemicals and microbial contaminants in shallow wells and boreholes in the vicinity are sufficient to affect the health of the inhabitants.

Local geology

Ire–Akari area is on latitudes 7° 16’ N to 7° 18’N and longitudes 5°10’ E to 5° 18’E is underlain by Precambrian rocks typical of the basement complex of Nigeria

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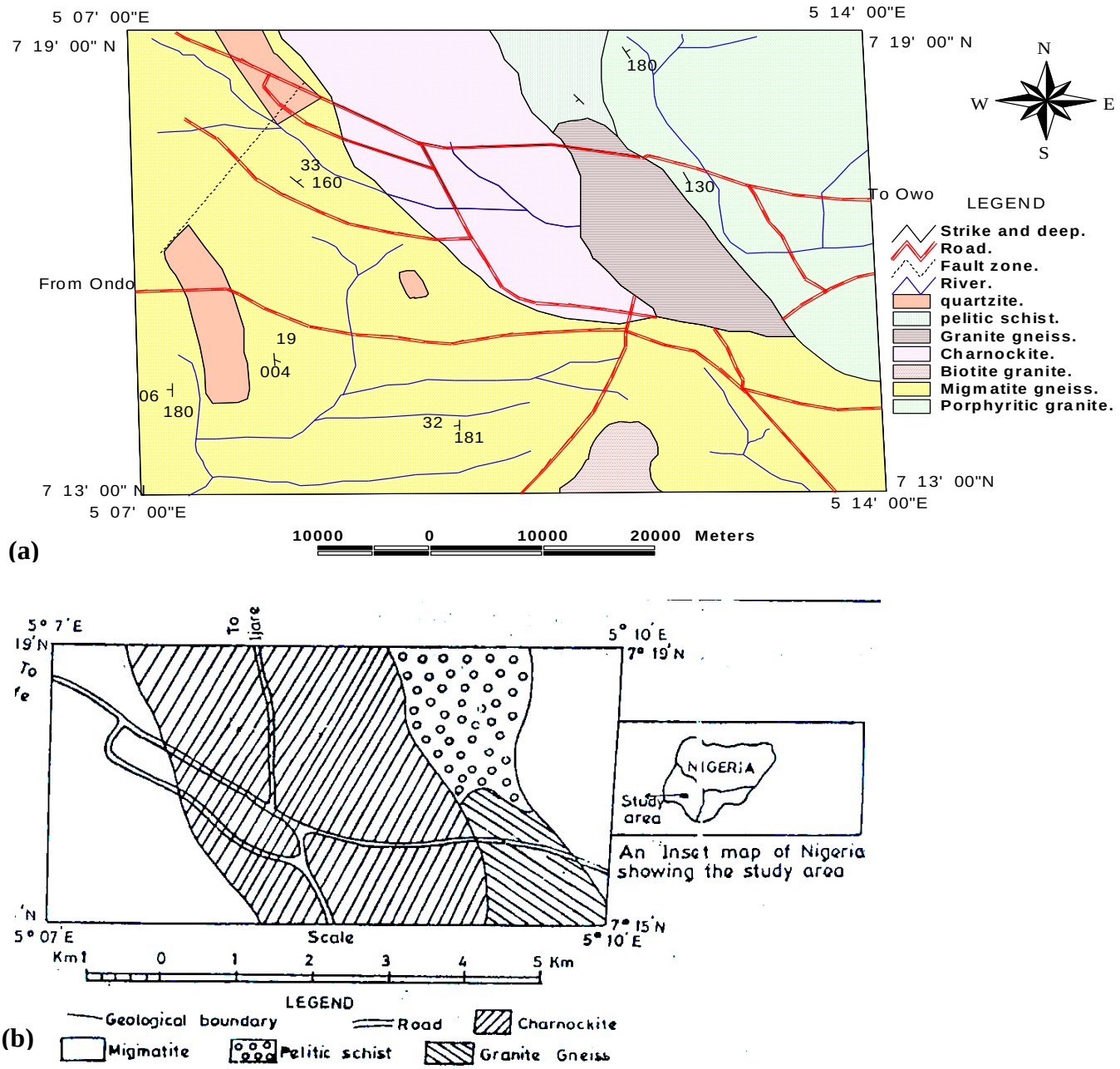

Figure 1. Geological Map of (a) Akure area (Owoyemi, 1996) and (b) Study area.

(Figure 1). The main rock types in the area are granites and charnockites, which are extensively developed, occurring largely as smooth, widely distributed outcrops, residual hills and boulders in some places. The charnockites range in textures from coarse to fine-grained based on the petrography and structural characteristics (Olanrewaju, 1987; Adelusi and Balogun, 2001). There is association between the charnockites and non–charnockitic granite rocks due to their field relationship (Rahaman, 1976, 1988; Coorav, 1972, 1974).

There are also three textural types of granite that can be recognized in this area; they are fine to medium grained granite biotite \ biotite muscovite granite, medium to coarse-grained non – porphyritic biotite – hornblende and the porphyritic biotite hornblende granite.

Scope of the study

The scope of the study involves well data collection, geologic mapping, geophysical data collection, chemical

Table 1. Frequency distribution of hand-dug wells in Ire-Akari area, Akure Ondo State.

Total depth (m)	Frequency	Static water level (m)	Frequency
4.0 - 4.5	-	4.0 -4.5	1
4.6 - 5.1	1	4.6 - 5.1	2
5.2 - 5.7	2	5.2 - 5.7	2
5.8 - 6.3	2	5.8 - 6.3	2
6.4 - 6.9	2	6.4 - 6.9	3
7.0 - 7.5	4	7.0 - 7.5	4
7.6 - 8.1	3	7.6 - 8.1	3
8.2 - 8.7	6	8.2 - 8.7	6
8.8 - 9.3	9	8.8 - 9.3	7
9.4 - 9.9	7	9.4 - 9.9	5
10.0 - 10.5	5	10.0 - 10.5	8
10.6 - 11.1	4	10.6 - 11.1	4
11.2 - 11.7	6	11.2 - 11.7	6
11.8 - 12.3	4	11.8 - 12.3	4
12.4 - 12.9	3	12.4 - 12.9	3
13.0 - 13.5	2	-	

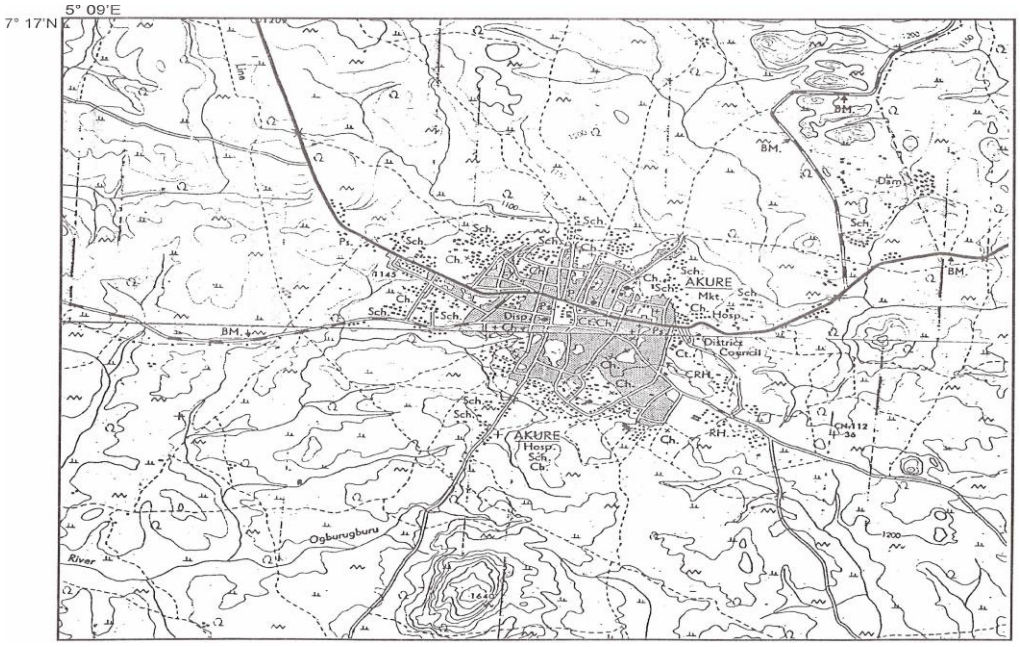

Figure 2. Topographical Map of Akure area (after Federal Surveys, 1966).

and microbial analysis of water samples. Also, the overburden protective capacity rating of the hand-dug wells will be evaluated.

MATERIALS AND METHODS

(a) Hand dug wells

The determination of the static water level and total depth of hand-dug wells (Table 1) were carried out with the aid of deep meter. The positions of the water sources were taken using GPS Garmin 60. This was done at the peak of dry season during the month of February 2006. A total of sixty (60) wells were assessed covering the entire area (Figure 2).

(b) Collection of water samples

A total of four wells water samples were collected from different residential houses at Ire-Akari area along Orita-Obele in Akure. In the samples collected, the well conditions is such that the following environmental conditions were observed about the well conditions,

Table 2. Conditions of hand-dug wells in Ire-Akari area.

Sample	Well No	Total depth (m)	Purpose	Environmental conditions
A	1	10.5	Domestic and Drinking	Clean, Covered, Raised and Ringed
B	8	7.4	Domestic and Drinking	Clean, Covered, Raised and Ringed
C	34	9.8	Domestic and Drinking	Clean, Covered, Raised but not Ringed
D	49	5.3	Domestic	Clean, Covered, not Raised and not Ringed

which include whether it was opened, covered, raised, unraised, ringed, unringed, dirty, or clean environment (Table 2).

(c) Chemical and microbial analysis

The analysis was carried out using the photometric titration, turbidimetric and atomic absorption. Physical parameters such as odour, taste and colour were identified while temperature, conductivity, pH; Total dissolved solids (TDS) were measured on the field using TDS/Conductivity meter and colour comparator for pH. All the water samples were bacteriologically analysed according to the standard specification of the 1984 World Health Organization (WHO), which include the presence of aerobic and anaerobic bacteria, presumptive faecial coliform at the Microbiology Department of Federal University of Technology, Akure.

(d) Geophysical investigation

Previous studies have shown that geophysical methods are capable of delineating quality of groundwater. Sultan et al. (2009) combined gravity, magnetic and resistivity methods to study groundwater of Sinai in Egypt. But in this study, resistivity method was employed. Electrical resistivity method is the most commonly applied geophysical method for measuring apparent resistivity of subsurface materials (Mondal et al., 2013).

The geophysical investigation involved the use of vertical electrical sounding (VES) using R50 DC Resistivity meter; Schlumberger configurations were employed (Ako, 1982; Afolayan et al., 2004). The electrode spread begin from AB/2 = 1 m increasing in most cases to a maximum length of 100 m (AB/2 = 100 m). The orientation of the spread is approximately N-S to minimize interference from other rock types. A total of twenty-two (22) sounding stations were occupied (Figure 2) to cover the entire study area.

RESULTS AND DISCUSSION

Static water level and depth distribution of hand-dug wells

The results of the depth distribution of hand-dug wells in the area (Table 1) and the histograms (Figure 3a and 3b) revealed that the area is characterised mostly by deep hand-dug wells and the deeper the wells the lesser it is susceptible to surface infiltration / leachates effects. Also the static water level distribution map (Figure 4) show shallowness in depth towards the central portion of the study area suggesting susceptibility of the aquifer to pollution while increase in depth coincide with increase of the total depth distribution map (Figure 5) suggest that the southwestern, southern and upper central portions are least susceptible to pollution.

Hydrochemical analysis of hand-dug wells in Ire-Akari area

Contaminants in drinking water that have an adverse health impact are grouped into five categories: inorganic chemical contaminants, organic chemical contaminants, microbiological contaminants, radiological contaminants and turbidity (Rhode and Hartmann, 1980). In this study, the focus on the assessment of the level of contamination of the groundwater and open wells has been on the chemical and microbial contaminants because of the major concern of the impact on the health of the inhabitants.

Microbial and chemical analysis

Table 3 revealed the results of the chemical analysis carried out in the study area conform to the WHO permissible limit (WHO, 2004). However, the results of microbial analysis (Table 4a) show that the coliform number count per 100 ml varied. The results of the first three samples conform to the guidelines for drinking water quality, which are 100 in 100ml (WHO, 2004) except in Well 49.

The water samples were analysed for both the dissolved chemical constituents and coliform counts. The result of hydrochemical analysis shows that the dissolved chemical constituents concentration falls within the WHO standard for drinking water suggesting the water is safe for drinking. However, the total coliform count which is used as indicators to measure the degree of pollution and sanitary quality of well water was tested for. The results shows that the coliform count ranges between 13-<180 colony forming units per 100 ml (13-<180 CFU/100 mL) (Table 4b) and it suggest that Total coliform bacteria are not likely to cause illness, but their presence indicates that the water in the area may be vulnerable to contamination by more harmful microorganisms. This is evident in the results observed in well 49 with high coliform count <180 CFU/100 mL and the well condition reveals that it is not raised and ringed which makes it more vulnerable. This is also possibly due to the shallowness of the hand-dug well. Maximum Acceptable Concentration for Drinking Water = none detectable per 100 mL (WHO, 2004).

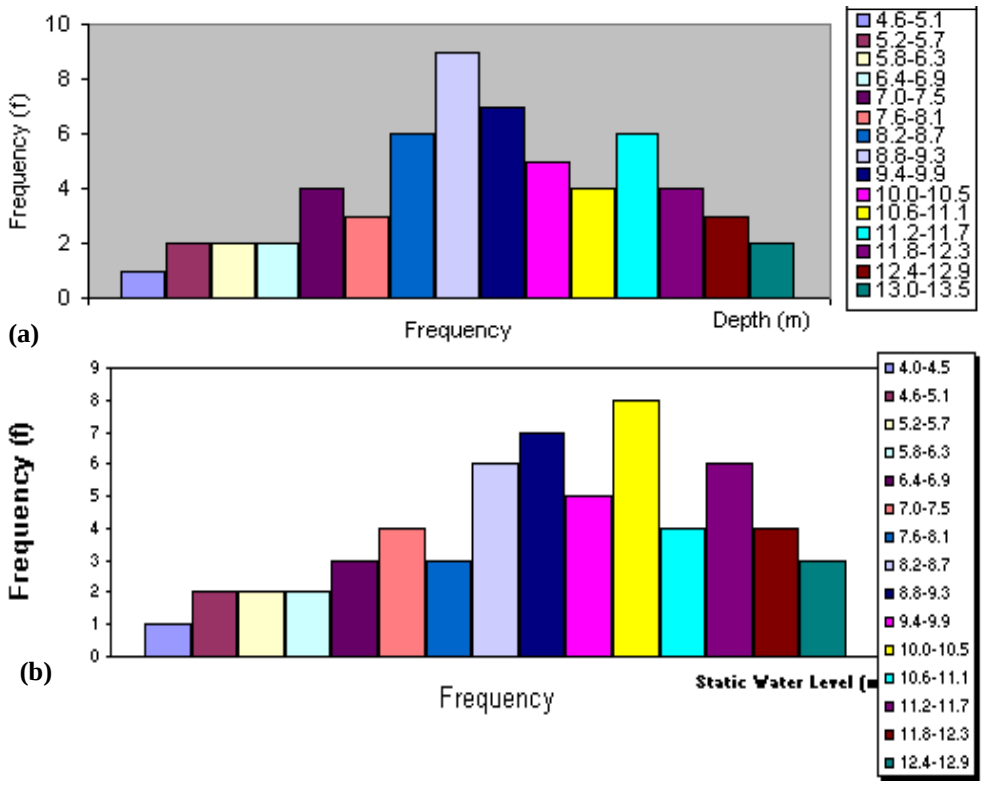

Figure 3. (a) Histogram of hand-dug well depths in Ire-Akure area, Akure SW Nigeria (b) Histogram of static water level of head dug wells in Ire-Akari area, Akure SW Nigeria.

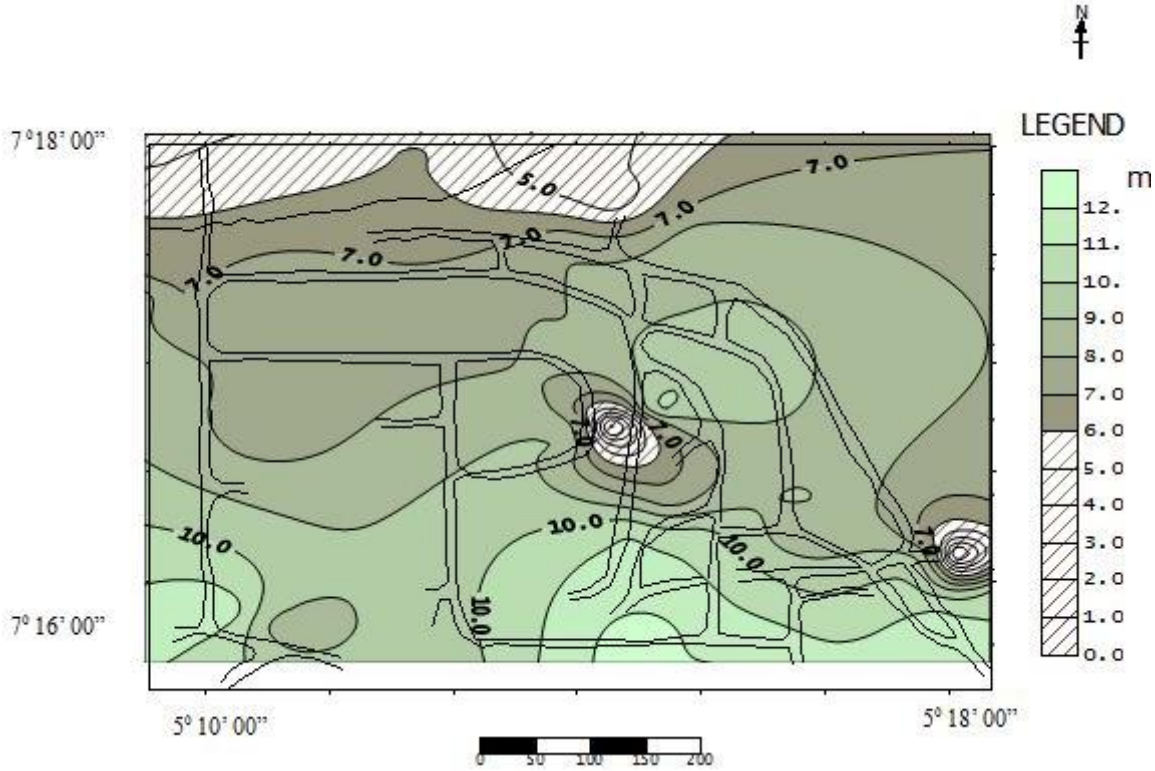

Figure 4. Static water level map of Ire Akari.

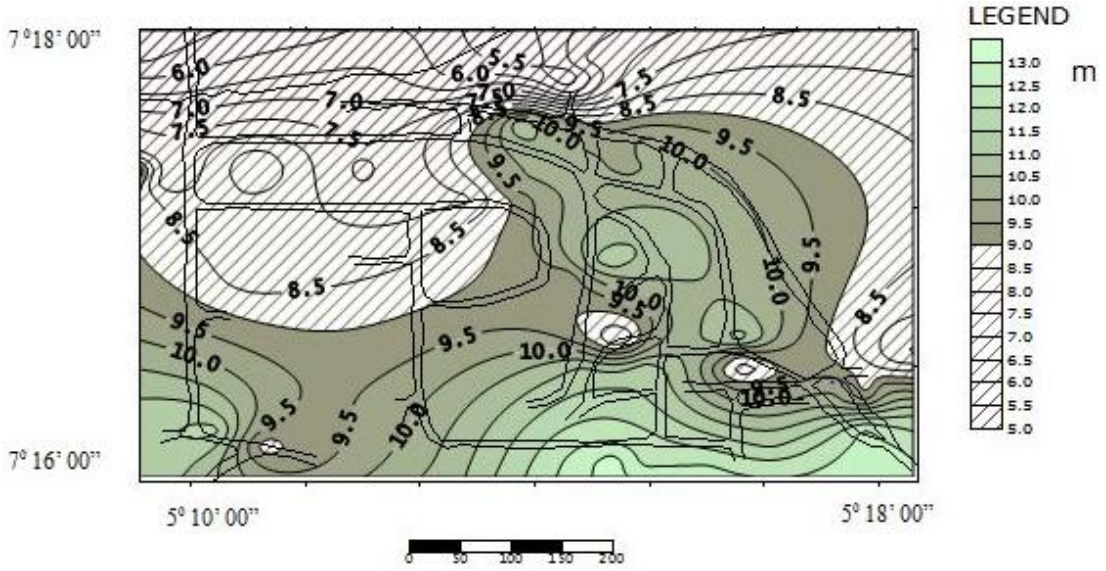

Figure. 5 Total depth of hand-dug wells in Ire-Akari.

Table 3. Result of chemical analysis of some hand-dug wells in Ire-Akari area, Akure

Chemical parameter	Well 1	Well 8	Well 34	Well 49	WHO (2004)	
					Permissible(mg/l)	Excessive (mg/l)
pH	6.51				7.5±1	<6.5 or >8.5
Conductivity	68.50 µs/m	77.60	86.60	96.80	1000	
Salinity	BDU	BDU	BDU	BDU		
Total alkalinity	122.00	135.00	147.00	162.00		
OH^-	BDU	BDU	BDU	BDU		
CO^-_3	BDU	BDU	BDU	BDU		120.0
HCO^-_3	122.00	135.00	147.00	162.00	500.0	1000.0
Chloride	46.09	51.06	62.08	68.05	200.0	600.0
Total hardness	60.00	65.00	59.95	66.65		
Mg^{2+}	1.45	2.55	2.89	3.60	50.0	150.0
Ca^{2+}	26.45	27.98	29.03	40.05	75.0	200.0
Calcium hardness	66.00	69.95	70.01	72.22		
Nitrate	0.21	0.22	0.21	0.25	45.0	100.0
Nitrite	0.012	0.015	0.020	0.018		
SO_4^{2-}	0.13	0.15	0.18	0.15	200.0	400.0

*BDU= Below Detection Limit .

The bacteria plate count analysis are within the permissible WHO limit except in Well 49 which should be limited to domestic purposes unless if treated.

Hydrogeophysical analysis

Figure 6a and 6b is the isoresistivity maps at depths 10, 15 and 20 m respectively. The isoresistivity maps gave information on the effects/degree of weathering, mapping of lithological changes with depth, monitoring the structural trends of hydrogeologic importance with depth.

Most of the hand-dug wells in the area are found within depth 10 to 15 m, thus appreciable overburden of significant weathering (low resistivity) and/ or the presence of thick hardpan overlying the aquifer could assist in preventing surface infiltration or underground pollution.

Figure 7, is the overburden protective capacity map showing the ability of the overburden in protecting the aquifer from the surface pollution. From this map (Figure 7), wells within the upper and lower western, and

Table 4a. Result of chemical analysis of some hand-dug wells in Ire-Akari area, Akure

Chemical parameter	Well 1	Well 8	Well 34	Well 49
pH	6.51			
conductivity	68.50 µs/m	77.60	86.60	96.80
Salinity	BDU	BDU	BDU	BDU
Total alkalinity	122.00	135.00	147.00	162.00
OH^-	BDU	BDU	BDU	BDU
CO^-_3	BDU	BDU	BDU	BDU
HCO^-_3	122.00	135.00	147.00	162.00
Chloride	46.09	51.06	62.08	68.05
Total hardness	60.00	65.00	59.95	66.65
Mg^{2+}	1.45	2.55	2.89	3.60
Ca^{2+}	26.45	27.98	29.03	40.05
Calcium hardness	66.00	69.95	70.01	72.22
Nitrate	0.21	0.22	0.21	0.25
Nitrite	0.012	0.015	0.020	0.018
SO_4^{2-}	0.13	0.15	0.18	0.15

*BDU= Below Detection Unit.

Table 4b. Result of microbiological analysis of some hand-dug wells in Ire-Akari area, Akure

Sample code	Most probable no.	Coliform per count	Bacteria plate count (cfu/ml)
1	1-4-0	13/100	3.1×10
8	1-3-2	14/100	3.8× 10
34	1-4-1	17/100	4.6×10^1
49	1-5-5	<180/100	3.5×10^2

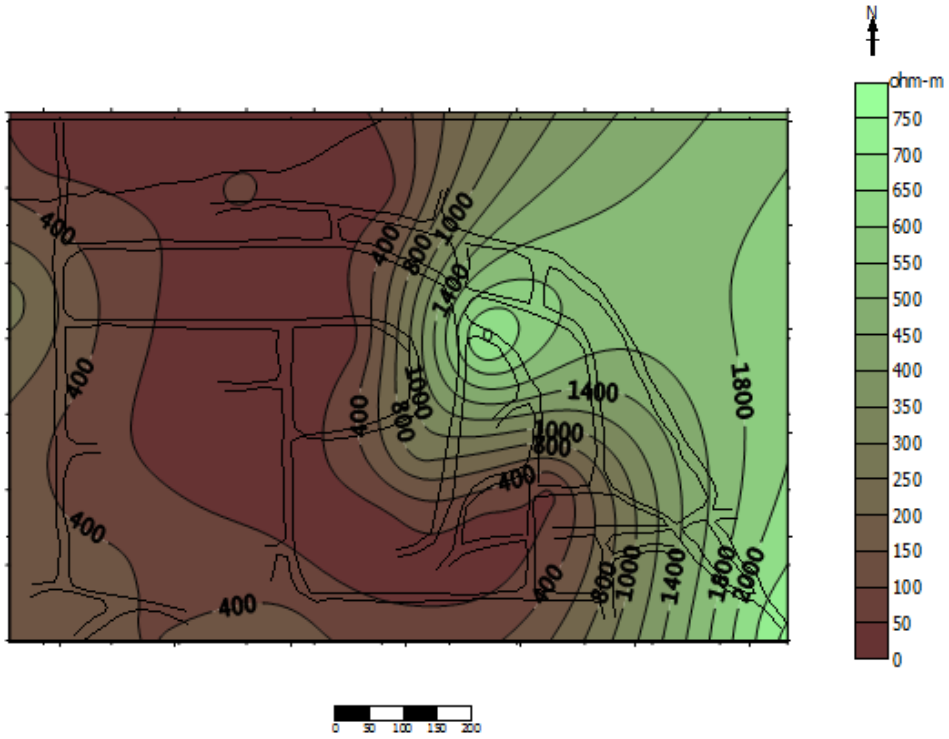

Figure 6a. Isoresistivity distribution map at depth = 10 m.

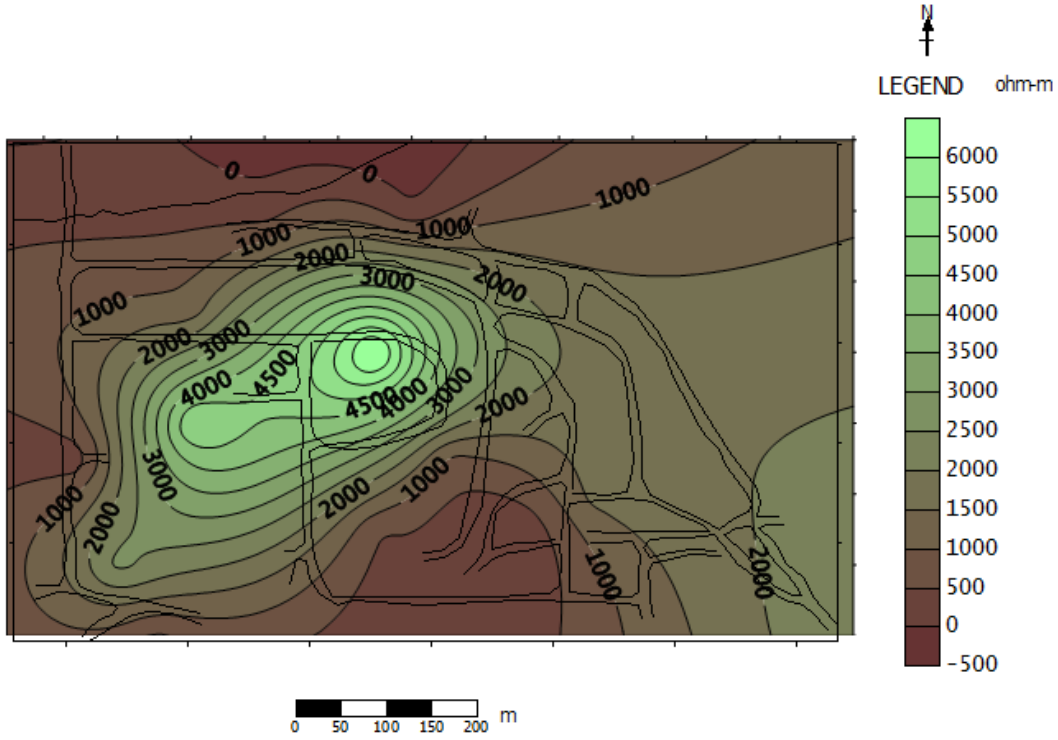

Figure 6b. Isoresistivity distribution map at depth =20 m around Ire-Akari area.

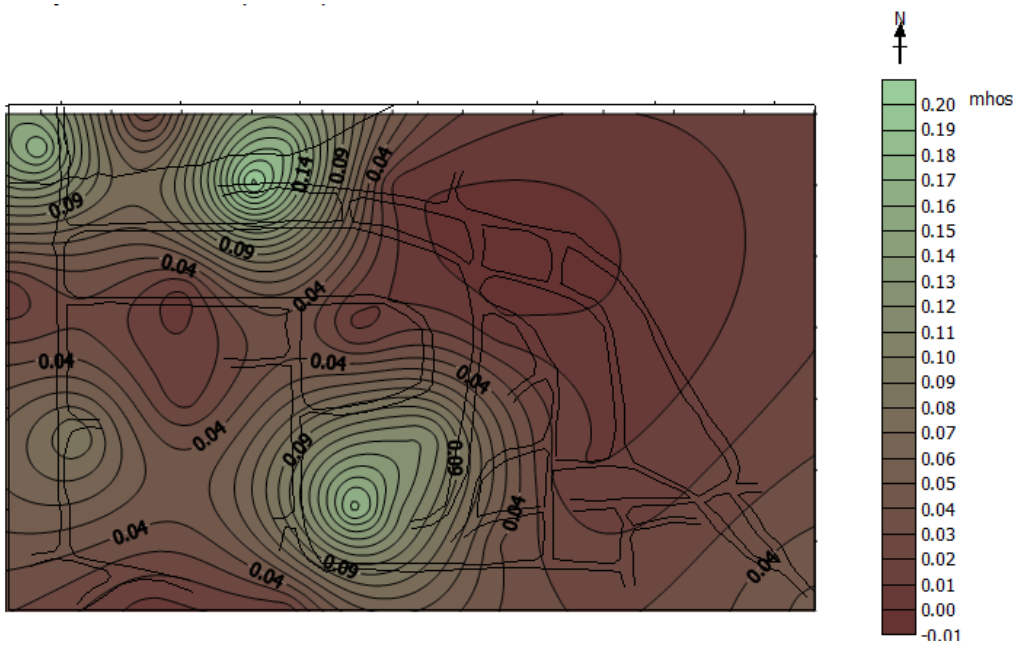

Figure 7. Overburden Protective Capacity map of Ire-Akari area, Akure Nigeria.

southwestern portions are well protected naturally.

The protective index which explains the degree of vulnerability to pollution is measured by the increase in its conductance, which is influenced, mainly by the increase in overburden.

Conclusion

The hand-dug wells in Ire-Akari area should be located within the weathered basement (depth of between 10 to 15 m) and should be covered, raised, ringed to prevent

surface/leachates infiltration and caving of the wells since the formations are generally weak. The use of geophysical method in selecting appropriate locations for groundwater development should be encouraged within the community. The safe level distance of hand-dug wells from refuse dump site, pit latrines, soak-away pit among others should be strictly adhered to.

REFERENCES

Adelusi AO, Balogun O (2001). A geoeletric investigation for groundwater development of Orita-Obele area, near Akure SW Nigeria. Global J. Pure Appl. Sci. 7(4):707-717.

Afolayan JE, Olorunfemi MO, Afolabi O (2004). Geoelectric/ Electromagnetic VLF survey for Groundwater development in a Basement Terrain – A case study. Ife J. Sci. 6(1):74-78.

Ako BD (1982). Geophysical prospecting for groundwater in an area without geological database. J. Min. Geol. 18(2):88-103.

Badmus BS, Odewande AA, Ojelabi EA, Oyedele T (2001). Leachate Contamination Effect on Groundwater Exploration. Afr. J. Environ. Stud. 2(1):38-41.

Coorav PG (1972). Notes on charnokites of Ado-Ekiti – Akure area western Nigeria. Dessauvagie TFJ Whiteman A.J. (eds) African Geology, Ibadan p. 45-53.

Coorav PG (1974). Some aspects of the Precambrian of Nigeria: Rev. J. Min. Geo. B (1,2):17-43.

Mondal NC, Singh VP, Ahmed S (2013). Delineating shallow saline groundwater zones from Southern India using geophysical indicators. Environ. Monit. Assess. 185:4869-4886. DOI 10.1007/s10661-012-2909-1.

Olarewaju VO (1987). Charnokitic-Granite association in SW Nigeria. Rapakiwi granite type and charnokitic plutonism in Nigeria. J. Afr. Sci. 6(1):67-77.

Ojelabi E, Fasunwon OO, Badmus BS, Onabajo DR, Okubanjo OO (2001). Geophysical and Chemical Analysis of Groundwater Samples in Ago-Iwoye Area,Southwest Nigeria. Afr. J. Environ. Stud. 2(1):77-80.

Rahaman MA (1976). A review of the basement geology of southwestern Nigeria. In Kogbe. C.A. Ed. Geo. Nig. Elizabethan publishing Co. Lagos pp. 41-58.

Rahaman MA (1988). Recent advances in the study of the basement complex of Nigeria. In Precambrian geology of Nigeria, Geo. Surv. Nig. pp. 11-43.

Rhode B, Hartmann G (1980). Introducing mycology by examples. Schering Aktiengesellschaft.

Sajil-Kumar PJ, Elango L, James EJ (2013). Assessment of hydrochemistry and groundwater quality in the coastal area of South Chennai, India. Arab J. Geo. DOI 0.1007/s12517-013-0940-3.

Sultan AS, Mahmoud IM, Fernando MS (2009). Hydrogeophysical study of the El Qaa Plain, Sinai, Egypt. Bull Eng. Geol. Environ. 68:525-537 DOI 10.1007/s10064-009-0216-z.

Verma SK, Pantulu KP (1990). Software for the interpretation of resistivity sounding data for groundwater exploration: Nat. Geo. Res. Ins. Hydarabad India.