ISSN: 2639-7455

Research Article

Earth & Environmental Science Research & Reviews

Geophysical Well Logging Approach Towards Resolving Groundwater Problems of Kolo Community Niger Delta, Nigeria

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Submitted: 20 Jun 2022; **Accepted**: 18 Jul 2022; **Published**: 19 Jul 2022

Citation: *Okoro Felibens Edeheri, Ibeneme Sabinus Ikechukwu. Nwugha Victor Ndubuisi, Okereke Chikwendu Njoku, Akaolisa Casmir Zanders, (2022). Geophysical Well Logging Approach Towards Resolving Groundwater Problems of Kolo Community Niger Delta, Nigeria. Eart & Envi Scie Res & Rev. 5(3): 61-69.*

Abstract
The need to find suitable aquifers for underground water production for the use of Kolo Community in Niger Delta Southern Nigeria was identified. Four pilot boreholes were drilled to the depth of 100m each with Gamma Ray and Electric logs comprising of SP, SPR, Resistivity (N8, N16, N32, and N64) ran in the four wells to their total drilled depths. From the gamma ray log, five to six aquifers with average thickness varying from 2m to 19m were identified. Resistivity data obtained were generally low and resistivity values above 600 Ohm-m were recorded to be aquifers with higher groundwater quality and aquifers with resistivity values below 600 Ohm-M were considered to be highly contaminated. For Kolo community, fresh water exploitation should be done with boreholes drilled to a depth of approximately 60metres and the borehole screen properly placed between 48 to 57 meters. It is hereby concluded that the gamma ray and electric logs can effectively be utilized to characterize aquifers to solve underground water problems in riverine areas of the Niger Delta, Nigeria.

Keywords: Aquifer, Electric logs, Gamma Ray log, Groundwater, Kolo Community, Niger Delta, Riverine.

Introduction
The potable water supply is very essential for the successful activities in any given community with Kolo community Niger Delta, Nigeria not being an exception. Several boreholes drilled in this community are producing iron contaminated water. The ferrous/iron in the underground is oxidized to ferric iron on exposure to the atmosphere thereby giving rise to colouration of wares after prolonged exposure. The iron content in the wells around the area is over 30mg/l and WHO recommended limit is 0.3mg/l [1]. The aquifers of this area have not been properly delineated to know which aquifers produce highly contaminated ferrous water and which ones have less contamination or no contamination at all. The cost of treating the high iron content is not sustainable for long term operations. The sole objective of this study is to isolate the contaminated aquifers in the area and identify the aquifers that are likely to contain less or no iron. Groundwater exploration within Niger Delta has variously been studied by [12] for Rumuohia community in Emohua Local Government Area of Rivers State, [2] for Obio/Akpor Local Government Area of Rivers State, [3] for Nigeria LNG base Port Harcourt, [4] for Ubima community in Rivers State and [5] for Opuama community Warri North, Niger Delta Nigeria. A preliminary study of groundwater quality using hierarchical classification approaches for contaminated sites in indigenous communities associated with crude oil exploration facilities in Rivers State, was carried out by [6]. They were able to group the heavy metal occurrence in the groundwater of the area into clusters for both wet and dry seasons as 5 distinct clusters were identified for wet season and 4 clusters were identified for dry season.

Location of the study area
The area under investigation falls within the Eastern part of the Niger Delta. The area is specifically between Latitudes N4.7981 to N4.8327 and longitudes E 6.37572 to E 6.46384. Below is the location map of the study area. The area is accessible from Yenagoa through the Yenagoa-Ogbia Road.

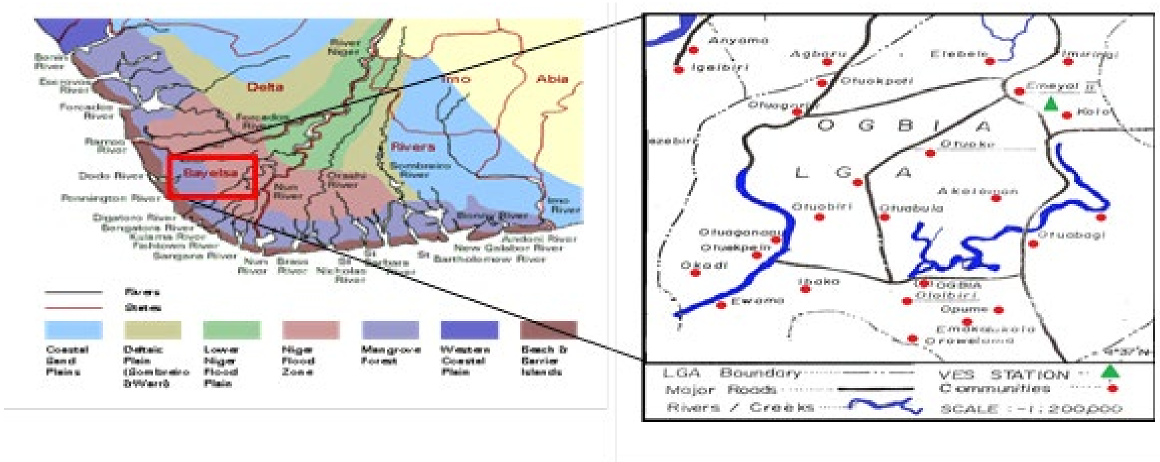

Figure 1: Location Map: Kolo, Ogbia, Eastern Niger Delta Nigeria (Source: rivcho.org)

Geology of the Area

The area lies within the Niger Delta, Southern Nigeria, a deltaic area with thick sediments of up to 8 km towards the centre, [7,8], [9]. The formation of the Niger Delta can be associated with pile up of sediments carried by the River Niger and associated tributaries. [9] opined that the sediments of the Niger Delta are made up of three distinct formations, the Akata, Agbada and Benin Formations. The Benin Formation overlies the Agbada Formation and consists of loose sands of fine to medium and very coarse grains which are occasionally pebbly with some clayey separations. This formation is very prolific in-terms of groundwater production. Recent deposits of mainly intercalating sand, silt and clay/shale cover the Benin Formation. Thickness of the recent deposits is estimated to be between 40m and 150m [10].

Materials and Method

In carrying out this research, the following equipment were used: mechanical drilling equipment, drilling rods, drilling mud and other drilling accessories as well as Mount Sopris MGX 11 Geophysical logging equipment with accompanying Wellcad software package. The field work was carried out within two weeks of continuous work on site. The field activities involved drilling of four test wells, sample collections and open hole geophysical logging.

Drilling of four Tests Wells

The drilling involved the use of manually operated tripod drilling rig. The mud rotary drilling method was used in the operations. The drillings were carried out at four selected points within the locality. The wells studied were drilled from surface to 100m crossing the shallow aquifer systems of the study area. Disturbed samples were collected from the wells at 3metres intervals or whenever changes of soil type were noticed. The wells were logged to their total drilled depths.

Open Hole Geophysical Logging

The drilled wells were subjected to open-hole geophysical logging using the Mount Sopris MGX11 Ultra-modern logging equipment. Different types of logs were used; Spontaneous Potential, SP, Resistivity (N8, N16, N32 and N64), Single Point Resistance, Gamma Ray logs. During logging, the probe was lowered into the open hole and one or more electrodes were suspended on a conductor cable as it goes into a borehole filled with drilling fluid. The logging data were imported into the Wellcad software for processing and interpretation.

Figure 2: Drilling Operation

Figure 3: The Logging Process

Results and Discussion

Strata samples (Strata logs)

The drill cuttings revealed that the subsurface is capped by clayey cover. The layer of clay is underlain by sands and clay sequence. The sand bodies are coarse grained, occasionally very coarse, gravelly and occasionally pebbly. In most cases, the layers of sand are confined by thin layers of clay or sometimes very thick layers of clay. The clay beds are grayish brown, sandy to silty and sometimes organic in nature.

Description of the Lithologic Units

Lateritic Soil Cover: The Lateritic soil cover was encountered in all the wells occurring in upper 0m - 5m. This is the upper capping soil in all the wells.

Clay Beds: The clay beds are grey to brown in colour with thicknesses varying from 1 to 5 meters. The clay beds separated the aquifers of the area.

Sand: Thickness of the sand is relatively high in the area studied. The sand bodies are generally loose and unconsolidated. They are fine–medium grained to gravely and pebbles. Sand colour varies from reddish brown to brownish and occasionally light grey to whitish.

Aquifer Systems

The aquifer systems were meticulously established by the interpretation and critical analyses of the lithologic logs and open-hole geophysical logs.

Borehole 001: The 100m deep borehole 001 encountered six aquifers between 0 - 100m. The first aquifer is between 8 -25m. This aquifer is characterized by medium to coarse grained brownish white sand. The second aquifer is sealed off from the upper aquifer with a layer of clay. This aquifer is 28m-35m. A third aquifer is 39m to 45m and a fourth aquifer from 49m to 57m and the fifth aquifer is from 58m to 85m while the sixth aquifer starts from 88m to the drilled depth. The aquifers with low resistivity values indicated ferrous iron contamination as a result of increased conductivity. The fourth aquifer with a peak resistivity value of over 1000 Ohm-m was recommended for screening. This is the aquifer with the highest resistivity value and therefore the lowest level of conductivity with a peak resistivity at 48metres. This aquifer is sandwiched between two clay layers. The high resistivity value indicates lower conductivity, therefore less ions in solution. The down-hole log of the borehole is shown in figure 4 below.

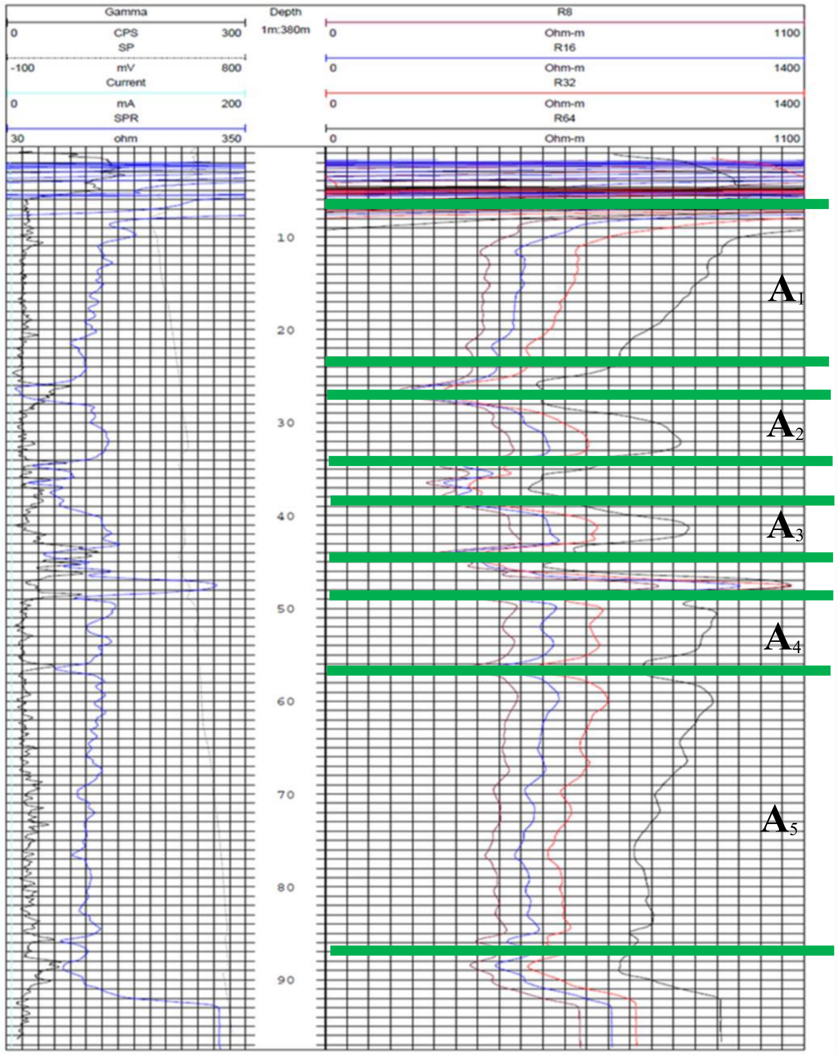

Figure 4: Open-hole geophysical log of well 1.

Borehole 002: A borehole of 100m was drilled at point 2. Both the lithologic log and down-hole geophysical logs of the borehole revealed the presence of five aquifers. The first aquifer is from 5m-20metres. This aquifer was separated from the second aquifer with a layer of clay. The second aquifer was from 27m to 34m. The third aquifer is from 37m to 49m was also separated by a layer of clay. The forth aquifer is from 50m to 89m while the fifth aquifer is from 91m to the drilled depth. The resistivity values obtained in well 2 were far lower than those obtained in well 1. This indicates that there is a higher ferrous contamination around the well 2 point. The aquifers in this well are five as against the six obtained in well point 1. Below is the down-hole log of the borehole at point 2 (Figure 5).

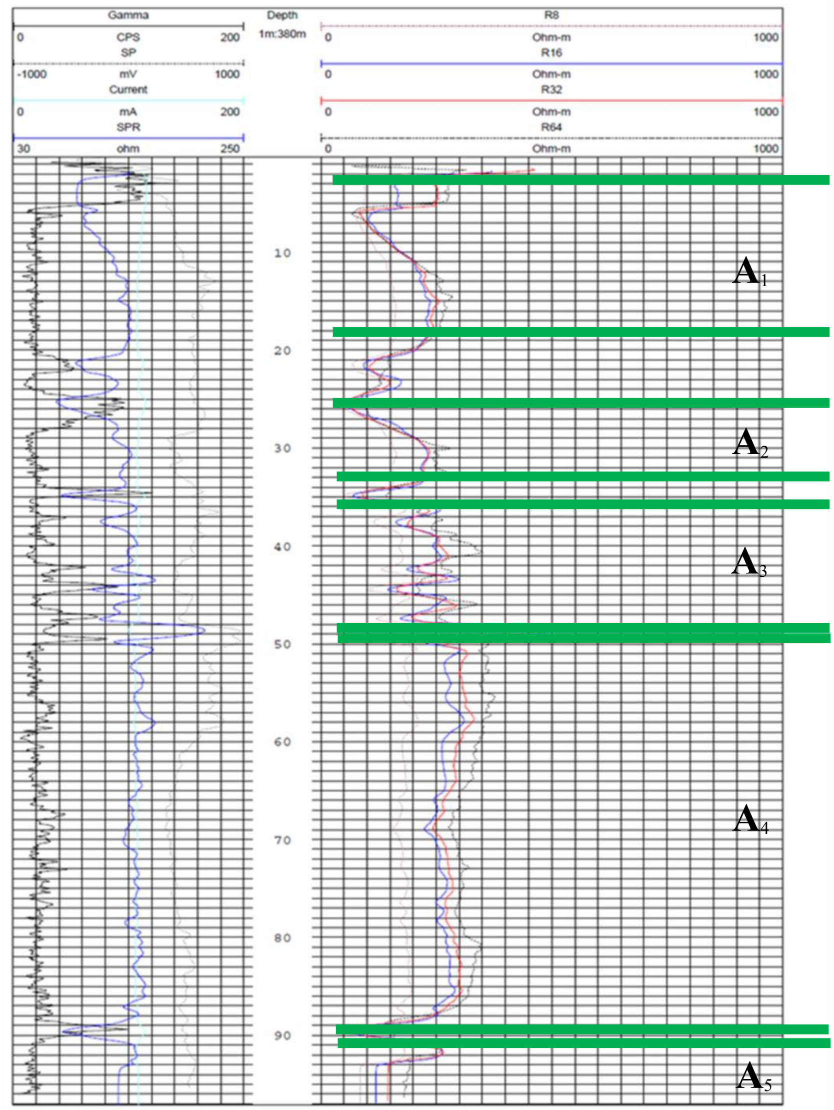

Figure 5: Open-hole geophysical log of well 2

Borehole 003: The borehole 003 drilled to 100m total drilled depth revealed different aquifer units. Six aquifers were encountered. From 5m-20metres was marked with sandy formation with low resistivity values. The second aquifer runs from 29m to 36m with low resistivity value. The third aquifer is from 49m to 67m with relatively low resistivity values. The forth aquifer is from 69m to 75m with relatively low resistivity values. The fifth aquifer is from 77m to 87m with relatively low resistivity values. The last aquifer is from 89m to 92m with average resistivity values. Although this well had six aquifers, the resistivity values obtained for the aquifers were also far lower than that of well point 1. The resistivity values were far below acceptable standards for potable water. Figure 6 below is the down-hole log of the borehole 003.

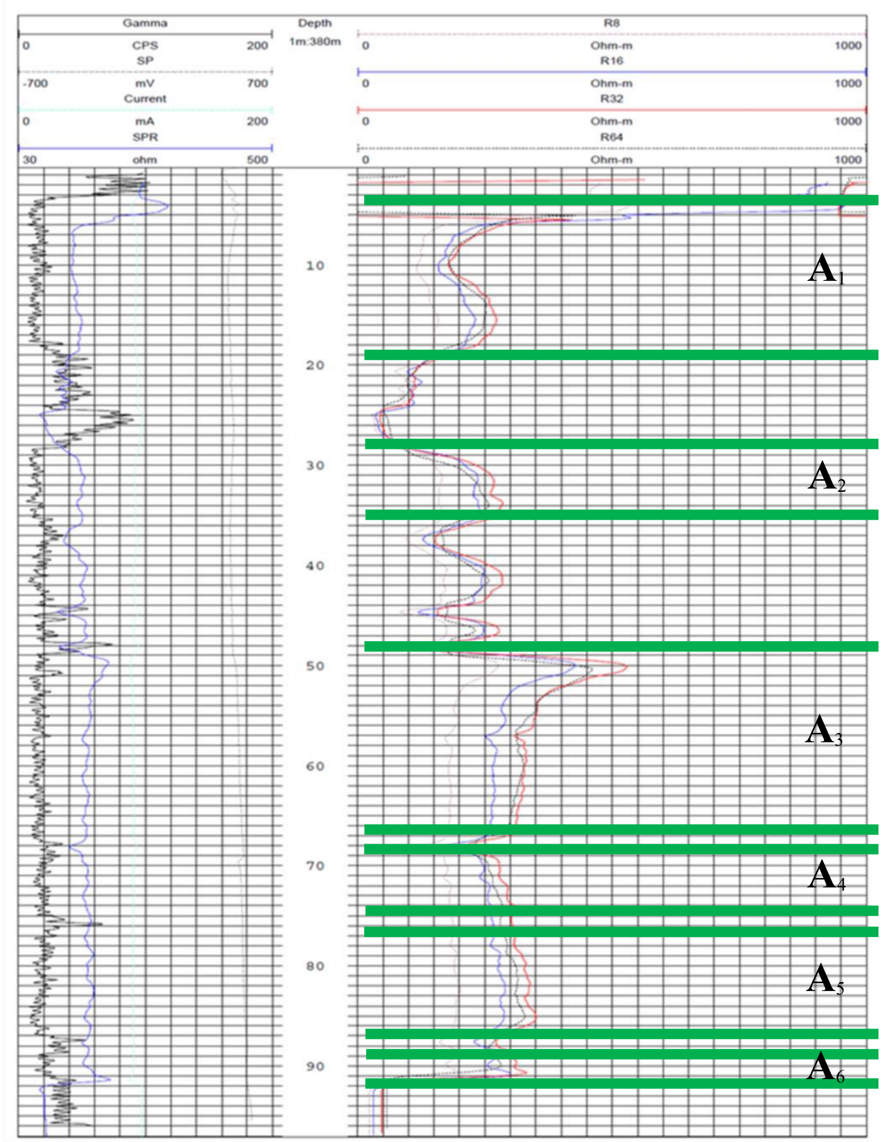

Figure 6: Open-hole geophysical log of well 3

Borehole 004: The down-hole geophysical logs of the borehole 004 revealed six major aquifers. From 5m-18metres was marked with sandy formation with low resistivity. This upper aquifer was sealed off from the aquifer below with a layer of clay. The second major aquifer runs from 28m to 34m with a low resistivity. The third aquifer is from 38m to 44m. The fourth aquifer is from 49m to 51m. The fifth aquifer was encountered between 52m to 82m while the last aquifer was from 84m to 97m. All the aquifers were separated by layers of clays. Generally the resistivity values were much lower than those obtained in well one which is indicative of more contamination around this well point. Below is the down-hole log of the borehole at point 4 (Figure 7). The correlation panel of the logs is shown in figure 8

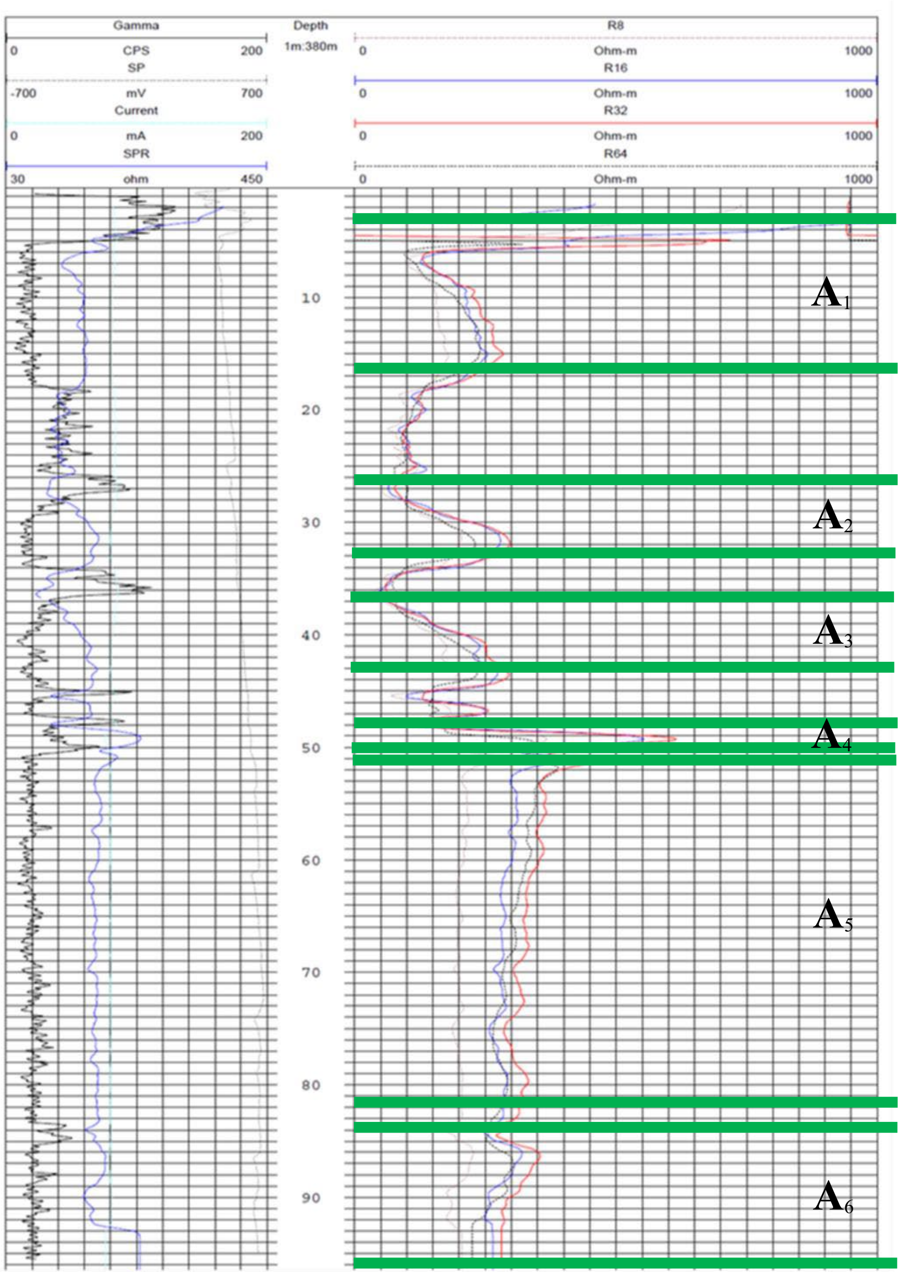

Figure 7: Open-hole geophysical log of well 4

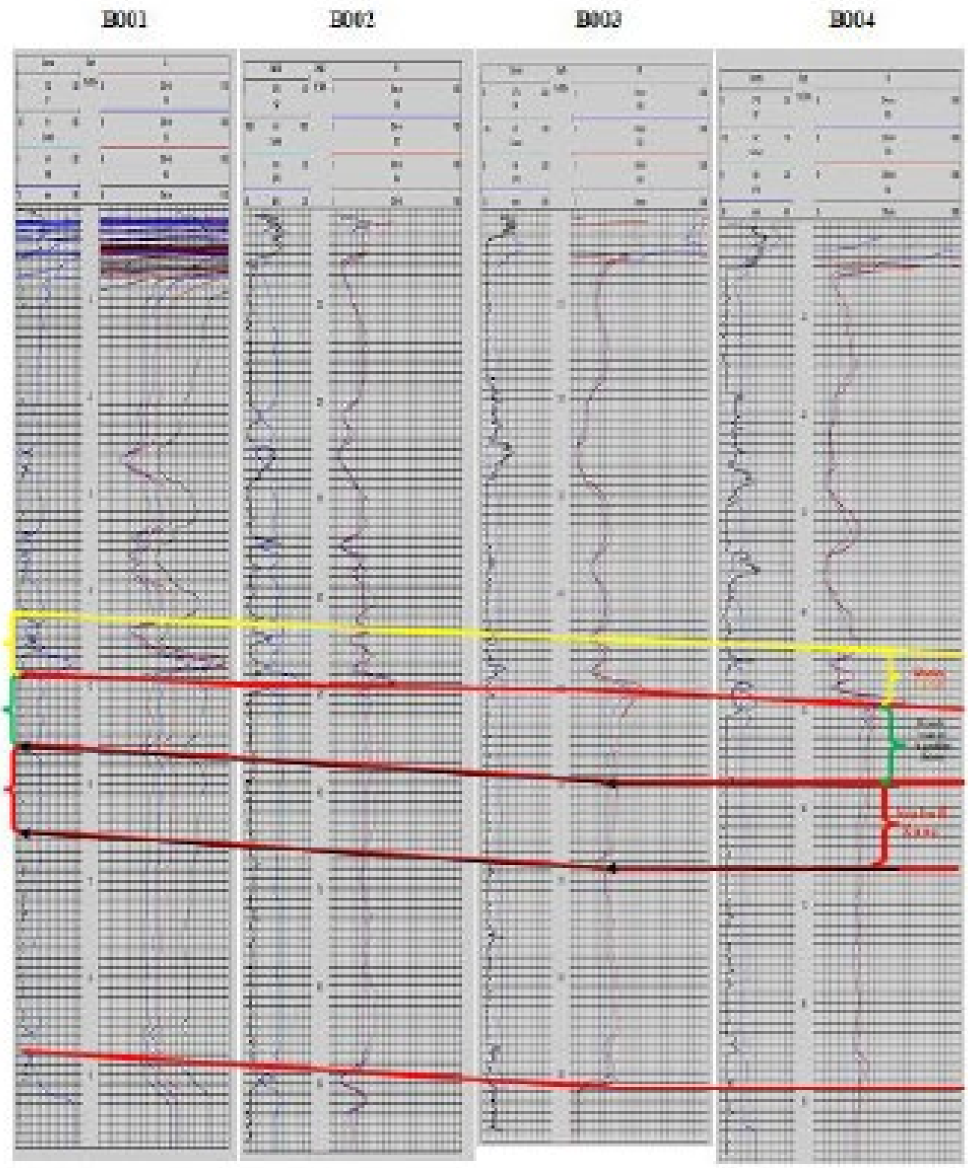

Figure 8: Correlation Panel of the log suite in the area.

Conclusion and Recommendations

The groundwater study was carried out with the brief to determine the geophysical characteristics of the underlying soil layers at the site in order to properly characterize the aquifers of the area and to isolate aquifers with less ferrous/iron contamination for the use of the inhabitants of the area. It is also required that recommendation be made for suitable water well depth for production optimization and water quality control for the proposed water supply facility for the Kolo community. The open-hole geophysical logs encountered a high resistivity layer between 48 and 59metres sandwiched between clay layers which was very pronounced in all the wells. The investigation confirmed within the depths explored the presence of brownish sandy formation with fairly high resistivity values in three of the four wells but more pronounced in well point 1. At well point 1 the resistivity values were generally high with the peak resistivity exceeding 1000 Ohm-m at about 48metres depth. This formation was well defined in well point 1. For Kolo community, fresh water exploitation should be done with boreholes drilled to a depth of approximately 60metres and the borehole screen properly placed between 48 to 57 meters.

Recommendation

Although there is good prospect in the well locations within Kolo community, we recommend that wells be completed targeting the isolated aquifers at 48 to 57metres within the area. This will allow the well tap the best water available in the area. The highly contaminated aquifers should be properly sealed-off using class "A" cement plug, to avoid contaminated water seeping into the producing aquifer due to hydrostatic perturbations [6,11].

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