Bacteriological Evaluation Of Groundwater In Ekiti-State, Southwestern Nigeria.

A. O. Talabi, A.K. Ogundana.

Abstract: Drinking contaminated groundwater can have serious health effects. Bacterial assessment of groundwater in Ekiti State was carried out to determine its potability and source(s) of pollutants. Consequently, 73 groundwater samples were collected for bacterial analysis and NO_3^- determination. At each location, depth of each well and depth to water table were measured using dipmeter. Temperature (°C), EC (µS/cm) and pH were measured in-situ using a multiparameter potable meter (model Testr-35). Subsequently, the bacteriological analysis was carried out using nutrient agar medium to obtain plate count of living bacteria (viable cell count) while Coliform count was achieved using a lactose medium inoculated with serial dilution of the sample. Nitrate (NO_3^-) concentrations in the groundwater were determined colorimetrically by Spectronic -20 (Gallenkamp, UK). In situ measurements revealed that pH ranged from 6.0 – 8.9 (av. 6.87), NO_3^- (mg/L) 1.2 to 19 (av. 6.86) mg/L while EC<1000µS/cm for all sampled groundwater. Virtually all samples tested positive to bacterial contamination with coliform count ranging from 0 - 8 (av. 2.15) cfu/100mL and total bacteria count (TBC) from 2 – 25 (av. 9.42) cfu/100ml. The groundwater in the study area is low mineralized fresh water. However, it has been polluted bacteriologically arising principally from surface phenomena of improper disposal of wastes and human faeces.

Keywords: Bacterial, coliform count, contaminated groundwater, pollutants, potability.

1 Introduction

Good quality water is an essential resource for the continuity of ecosystem. It is a prerequisite to healthy living hence the development of water resources is a significant part of integrated community development policy. Report by [1] indicated that water borne diseases killed more than six million children every year arising from lack of access to save drinking water. Various researchers have reported on the serious and severe illness like typhoid fever, cholera and dysentery as being caused by the use of contaminated water. Also water of poor physico-chemical quality may have adverse health effect causing unavoidable economic and human losses [2]. [3] indicated that around 2.6 billion people do not have access to a toilet and that around 1.8 million a year (6,000 people a day), 90% of whom are children, die of faecally-transmitted diseases while statistics revealed inadequate sanitation as the underlying cause of 2, 213, 000 deaths per year due to unsafe water and hygiene especially in developing countries [4]. Ekiti State (study area) is blessed with surface water in form of streams and rivers (Ero, Osun, Ose and Ogbese). Most of the surface water is perennial, prune to contamination, expensive to develop and has distribution problem as it may be located far from where demand is required.

Groundwater in form of springs, wells and boreholes serve as alternative source of water in the study area especially during the dry season when most of the surface water would have dried up. By 1991 Census, the population of Ekiti State (part of Ondo state) was 1,441,850 while the estimated population upon its creation in 1996 was put at 1,750,000. The 2006 census revealed a population of 2,384,212 for Ekiti State. This population surge coupled with mechanized farming and rising standards of living have put water demand on the rise; though without corresponding increase in the quantity/quality of the resource. Consequently, there is increase in anthropogenic activities resulting into generation of all sorts of illegal rubbish dumps including roadsides, open drainages and vacant plots of land which is environmentally unsustainable and unhealthy (Fig1). The indiscriminate dumping of wastes is responsible for a variety of problems such as contamination of water bodies, proliferation of insects, rodents, diseases outbreaks and blocked drainages leading to perennial flooding. Study by [5] in the study area, revealed that open dumping has the highest percentage of 37.7% among various techniques in management of waste products while dumping in drainages, use of waste container have 29.2% and 16.7% respectively. WHO reported that the pollution of surface and groundwater spreading across the world could be attributed to population expansion, rapid urbanization, industrial and technological expansion that often leads to generation of enormous wastes from domestic and industrial sources [6]. In the study area apart from indiscriminate dumping of wastes, improper sanitary conditions are rampant. Animals' dungs and human faeces often litter the bare surfaces of ground and rock exposures (Fig 2).

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Fig. 1. Illegal dumpsites (A; Oke-Ila and B; Ile-Abiye) and C; channel littered with waste at Ile-Abiye area. [7]

specific locality investigated a pointer to the need to extend such investigation to cover the whole of Ekiti State. The unsanitary situation in the study area has revealed that many of its residents have no latrines and open defecation is still being practiced. Hence, this study is on bacteriological assessment of groundwater in Ekiti State with a view to determine the groundwater potability status, determine the possible effects of different rock units on the groundwater quality and attempt to proffer solutions to the unsanitary practices in the area.

Fig. 2. Open Refuse Dump at Okeyinmi Ado-Ekiti

Dug wells/springs are not properly protected and could easily be polluted by wash off of animal and human wastes by rainfall (Fig 3). Previous work in the study area basically on geophysical exploration usually aimed at developing groundwater resources for drinking purpose include the work of [8], [9], [10], [11], [12]. Other workers including [13], [14] and [15] did not incorporate bacteriological analysis while the works of [16], [17], [18] and [19] dealt on bacteriological evaluation of groundwater but were localized to specific parts of Ekiti State. Results of their work revealed bacterial contamination of groundwater in the

Fig. 3. Spring water under the influence of anthropogenic activities (Odeyemi et al., 2011)

2. Study Area

2.1. Location and Environmental Settings

Ekiti State where the present study is confined is located within latitudes 7^0 15′ - 8^0 5′N and longitudes 4 ^{0} 44′ – 5^0 45′ E and covers a land area of 6,353 km^2. It is located in SW part of Nigeria. Ekiti State lies south of Kwara and Kogi States, East of Osun State and bounded by Ondo State in the East and in the south. Ekitiland which constitutes 52% (1,441,850) of the 1963 population of the old Ondo State (2,747,121) consists of 16 Local Government Areas. The creation of Ekiti State in 1996 led to upsurge in population with improved socio-economic activities with attendant consequences of increased anthropogenic activities. The development in the area did not match provision of safe water by government and people resulted to utilization of any available water without paying attention to its quality. People need to be re-orientated for safety of the environment and by extension provision of good quality water.

2.2 Geological and Climatic Setting

Geologically, Ekiti State is an Archaean-Early Proterozoic terrain underlain by the basement complex of southwestern Nigeria which belongs to the Pan African mobile belt east of West African Craton [20], [9]. There are three major rock groups in the study area; the migmatites, the matasediments and the intrusive. These groups of rocks comprise of five distinguishable lithologies namely:

Migmatite-gneiss, Quartzite/Quartz-Schist, Granite, Charnockite, Aplite and Pegmatite (Fig.4). The gneisses and migmatites represent highly denuded hills while quartzite, Older Granites (porphyritic and fine-medium grained) and charnockite commonly form ridges, hills and whalebacks in the study area. The rocks are not evenly distributed but migmatites predominate, covering a greater proportion of the area. The migmatites constitute the oldest rock in the area into which others intruded. The migmatite-gneiss rocks composed of a mafic portion made up of biotite, hornblende and opaque minerals while the felsic portion is quartzo-feldspartic. Compositional variation in the rock outcrops are indicated by closely spaced alternating bands of leucocratic minerals (quartz and feldspars) and melanocratic minerals indicated by the preponderance of biotite minerals. The quartzite in the study area occurs as hills and mountains, exhibiting white to gray colour due to varied iron oxide in the rock. Quartzite is very resistant to chemical weathering and often forms ridges and resistant hilltops. The Older granite and charnockitic rocks occur as intrusions within the migmatite-gneiss-quartzite complex. The granitic rocks outcropped as domes and hills in the area while the charnockites outcropped as oval or semi-circular hills of between five and ten meters (10m) high with a lot of boulders at some outcrops. Surficial materials characterized by relatively deeply weathered soil profile or regolith (laterite) in the low lying areas, due to the relatively humid climatic conditions capped the saprolith layers. Ekiti State enjoys tropical climate with two distinct seasons (rainy season (April – October) and dry season (November – March). The wet season is controlled mainly by the prevailing south-westerly winds from the Gulf of Guinea while the dry season provides the dry continental northeast wind (Harmattan) that originated from the Sahara desert. Annual temperature ranges between 21°C and 28°C with high humidity while the mean annual rainfall is1500mm.

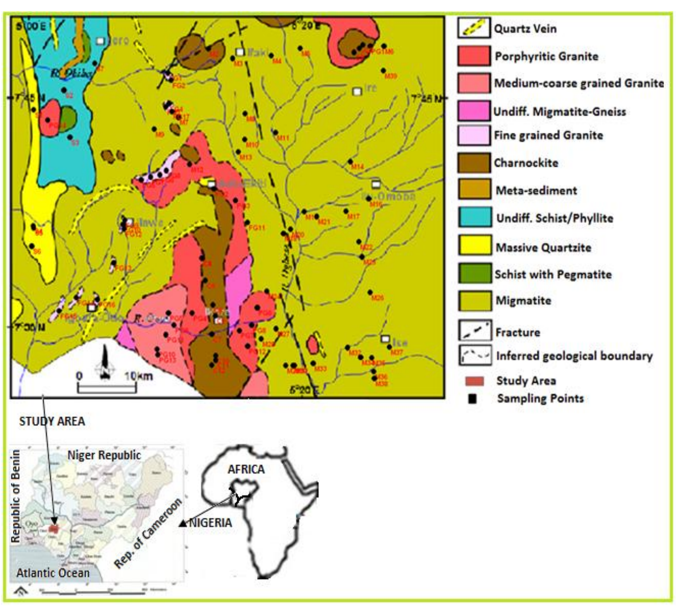

Fig. 4 Location and Geology of The study area (Modified after Talabi and Tijani, 2011)

3. Methodology

3.1 Sampling and Laboratory analysis

This research work began with a preliminary study of the topography and geology of the study location. Seventy-three sampling points were earmarked for sampling of groundwater (Fig.4) based on rock units; migmatite (30), schist (4), porphyritic granite (11), fine-medium grained granite (17) and charnockite (11). At each location, the environmental conditions were noted while depth of each well and depth to water table were measured using dipmeter. Temperature (˚C), EC (µS/cm) and pH were measured in-situ using a multiparameter portable meter (model Testr-35). Subsequently, seventy-three (73) shallow groundwater samples were collected in polyethylene bottles and kept at 4˚C in refrigerator till analyses for bacteriological and NO_3^- determinations were executed at the Water Resources Laboratory of Federal Ministry of Water resources, Akure, Ondo State Nigeria. The bacteriological analysis was carried out using nutrient agar medium to obtain plate count of living bacteria (viable cell count). One (1) ml of water sample was placed with liquefied agar at 40 ºC in a Petri dish. The agar sets to a jelly, thus fixing the bacteria cell in position.The plate was then incubated under appropriate condition (24 hours at 37 ºC for bacteria organism from animal or man. At the end of the incubation, the individual bacteria would have produced colonies visible to the naked eyes and the number of colonies was assumed to be a function of the viable cells in the original sample. Coliform count was achieved using a lactose medium inoculated with serial dilution of the sample. The appearance of acid and gas after 24 hours at 37 ºC was taken as positive indication of the presence of coliform bacteria; results were expressed as number of colonies per 100 ml. As a confirmation for bacteria, tubes were subculture appropriately in fresh medium for 24 hours at 44 ºC under which conditions such bacteria as appropriate will grow. Nitrate (NO_3^-) concentrations in the groundwater were determined colorimetrically by Spectronic -20 (Gallenkamp, UK) as described by [21]. Results obtained were subjected to statistical evaluation using SPSS 17.0.

4. Results and Discussion

The summary of the results of both physical and chemical parameters measured in the study area is presented in Table 1. As shown in Table 1, pH ranged between 6.0 – 8.9 (av. 6.87) indicating slightly acidic to neutral water. For all samples analyzed, EC<1000µS/cm. This shows that the shallow groundwater (max. depth 15m) is low-mineralized freshwater [22]. The concentrations of NO_3^- (mg/L) vary from 1.2 to 19 (av. 6.86 mg/L) fell within [23] approved standard for drinking water. Despite the fact that the groundwater was low mineralized, virtually all samples tested positive to bacterial contamination with coliform count ranging from 0 -8 (av. 2.15)cfu/100mL and total bacteria count (TBC) from 2 – 25 (av. 9.42)cfu/100ml. The pollution of groundwater is a reflection of the poor sanitary conditions of people in the study area where open dump of refuse predominate waste management system [5]. Chemical potability of groundwater in the study area had been confirmed by earlier workers [14], [15], [18] and [19]. The pollution as a result of faecal pollutants can be redressed if necessary sanitary conditions are maintained in the area. There are a few ways that treatment can help, such as the pump and treat method whereby groundwater is removed and treat it on the/ surface. In-situ treatment is also possible by leaving the groundwater in place and using oxidation, which is just putting in oxygen or using bioremediation, which helps break down the substances in the aquifer.

Table.1. Summary of parameters measured in the study area

Parameters	Min	Max	Mean	Stdev
Temp.(˚C)	23.90	29.90	26.68	0.95
pH	6.00	8.90	6.87	0.63
ECμS/cm	104.00	990.00	542.06	231.20
NO_3^- (mg/L)	1.20	19.00	6.86	4.41
Water Level (m)	0.00	11.50	4.96	3.38
Depth (m)	1.50	15.10	7.23	3.19
TBC (cfu/100mL)	2.00	25.00	9.42	5.47
Col. Count (cfu/100mL)	0.00	8.00	2.15	1.80

4.1 Source (s) of Pollutant in the groundwater of the study Area

Over 70% of Ekiti State population relies to some extent on groundwater as a source of drinking water and still more use it to supply their factories with process water or their farms with irrigation water. It is thus critical that the groundwater in the study area be unpolluted and relatively free of undesirable contaminants. A groundwater pollutant is any substance that when it reaches an aquifer, makes the groundwater unclean or otherwise unsuitable for a particular purpose. Groundwater can become polluted by many sources. Household waste, chemical spill, agricultural waste such as manure and fertilizers, landfills and improper disposal of chemicals are the major sources of pollution. If any of these sources end up in drinking water, major illnesses such as giardiasis, cholera, and hepatitis could be developed [24], [25]. Although human-caused sources are mostly what pollute groundwater, naturally occurring contaminants are also pollutants. These can come about if metals such as iron and manganese dissolve into water while it is flowing through rocks and sediments. Groundwater can also be naturally contaminated by hydrogen, sulfide, and decaying bodies. These may not sound as harmful, but they can be just as bad as anything caused by humans. To assess the pollutant source of groundwater in the study area TBC (cfu/100mL) was plotted against NO_3^- concentrations (Fig. 5). The diagram revealed that the TBC and NO_3^- are mildly negatively correlated. Nitrate (NO_3^-), unlike many ions is not derived from rocks; rather it is often associated with faecal pollution [26]. Based on this statement a positive correlation was expected between TBC and NO_3^-. Both nature and people can be responsible for nitrate found in groundwater. Of the human activities that contribute nitrate to groundwater, agriculture and human waste disposal are by far the largest sources [27]. Nitrogen is a major constituent of the earth's atmosphere and occurs in many different gaseous forms such as elemental nitrogen, nitrate and ammonia. Natural reactions of atmospheric forms of nitrogen with rainwater result in the formation of nitrate and ammonium ions. While nitrate is a common nitrogenous compound due to natural processes of the nitrogen cycle, anthropogenic sources have greatly increased the nitrate concentration, particularly in groundwater [28]. The concentration of NO_3^- in groundwater of the study area is within approved [23] standard for drinking purpose. However, the source of NO_3^- is from natural process rather than anthropogenic source. To further determine other possible source (s) of pollution of groundwater in the study area, concentrations of NO_3^- ions were plotted against water level and well depths as indicated in Fig.6 (A and B) while the TBC was plotted against well depth as shown in Fig.6C. The NO_3^- concentrations revealed very weak negative correlations of -0.03 and -0.10 with both water level and well depth respectively. As for the TBC vs. depth a weak negative correlation with coefficient r = -0.09 was obtained. Despite these weak correlations, a critical examination of the plots revealed that wells with water leve less or equal to10m; were prone to NO_3^- contamination as demarcated by line L in Fig. 6A. In a similar manner, wells with depth less or equal to12m were affected by NO_3^- pollution as indicated by circle M in Fig.6B. The few wells with depth greater or equal to12m have very low NO_3^- concentrations (circle N). Similar observation was noted for TBC vs. depth as indicated in Fig.6C. Wells with depth greater or equal to10m were less proned to faecal contamination. These observations revealed that the pollution of groundwater decreased with increasing depth for both NO_3^- and bacterial contaminants. It could be concluded that the pollution of groundwater in the study area was from or near the ground surface and by implication from the human faeces that were not properly disposed as well leachetes from open waste dumps in the area.

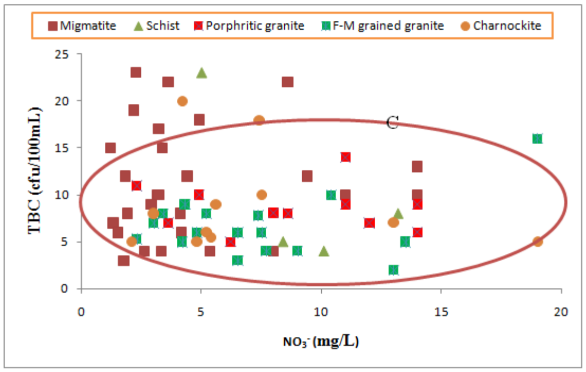

Fig.5. Scatter plot of NO_3^- vs. TBC

5. Conclusions

Bacteriological analyses of some well waters in Ekiti State have been carried out. Measured in-situ parameters revealed that the groundwater of the study area was fresh, low mineralized and chemically potable. However, virtually all sampled groundwater tested positive to bacterial contamination warranting treatment of the groundwater before it could be suitable for consumption. Surface phenomena, majourly indiscriminate waste dumps and improper disposal of faeces were responsible for the pollution of groundwater in the study area

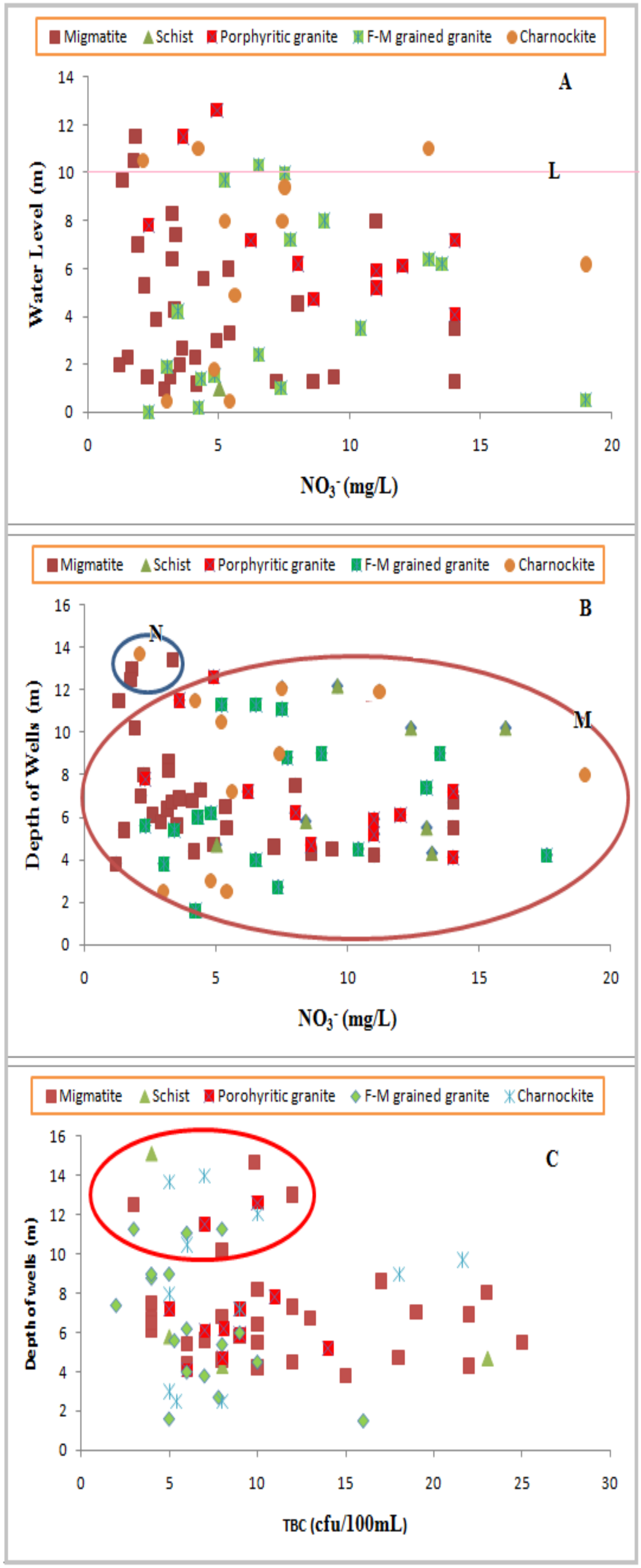

Fig. 6. Cross plots of: (A) NO_3^- vs. Water level (m), (B) NO_3^- vs. Well depth (m) and (C) TBC vs. Well depth (m)

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