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Shallow Wells' Water Sustainability Appraisal at Ikere-Ekiti, Southwestern Nigeria

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Abstract. This study examines sanitary situations and the volumes of water in shallow wells at Ikere-Ekiti, Southwestern Nigeria during the dry season of 2023 with a view to observe the hygienic levels of the wells, categorize the area into different groundwater potential zones and discuss alternative means for groundwater sustainability of areas with poor groundwater potential. In-situ hygiene characteristics of 30 randomly selected wells in the area were examined to provide preliminary qualitative quality status of the wells' water for potability and human health sustainability. Subsequently, in-situ parameters (Temp. (˚C), pH, EC (μS/cm) and TDS (mg/L)) of water from the wells were measured based on rock units with 5,15 and 10 wells from migmatite, granites and charnockites respectively using a portable multi-parameter pH meter. The wells' coordinates were measured using Garmin GPS MAP 64sx. The water level and depth of each well were measured using a dip meter while their diameters were taken employing a tape meter. The volume of water in each well was estimated employing the formula, $V= \pi r^2 h$, where π is 3.14, r is the radius (m) and h is the depth (m) of the wells. The estimated volumes of water were categorized and employed in producing the groundwater potential map of the study area using Surfer 8. In-situ hygiene characteristics revealed that most of the wells fell short of the basic hygiene requirements for wells' water rendering their water non potable and inalienable to human health sustainability. Measured in-situ parameters revealed that elevation (m) ranged from 365 - 391, 358 - 387 and 305 - 385 on migmatite gneiss, granite and charnockite respectively. Following the same order, temperature (˚C) ranged from 26.8 - 29.1, 27.0 - 30.2 and 27.0 - 29.9, pH from 4.37 - 6.55, 4.66 - 6.92 and 4.22 - 6.9, EC (μS/cm) from 306 -389, 306 - 426 and 283 - 459 and TDS (mg/l) from 50 - 270, 71 - 294 and 38 - 286 respectively. The water level (m) ranged from 2.37 - 6.90, 0.84 - 11.3 and 0.77 - 5.59 while the depth of the wells (m) ranged from 5.30 - 12.2, 3.40 - 15.00 and 1.70 - 6.83 on migmatite gneiss, granite and charnockite respectively. The estimated volume of water (m^3) obtained following the same order of rock units ranged from 4.27 – 19.84 (av. 9.41), 2.82 – 45.49 (av. 4.53) and 1.52 - 9.09 (av. 9.62) respectively. Groundwater potential evaluation revealed that the wells located on migmatite gneiss fell in the fair - very good potential zones, while all of the wells located on charnockitic terrain were in the very poor - poor groundwater potential zones. Water from granites cut across all the zones. This study clearly revealed that groundwater sustainability in the study area is far from being achieved. Wells' water hygiene was very poor while volume of water in the wells was low and cannot meet the water demands for human consumption and other domestic activities. Recipe can be sourced from the artesian wells in the area or through rain harvesting during the rainy season.

Keywords: Groundwater sustainability, water level, estimated volume, in-situ parameters, rock units

Introduction

Water is the most basic and critical requirement for human survival. Water is very important for maintaining adequate food supply and productive environment for all living

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organisms (Kılıç, 2020). Water is found in air, sea, land, rivers, lakes and oceans. While the water in the air moves between the earth and the atmosphere as a result of the hydrological cycle, the water in the land is in the form of underground waters (Çepel & Ergün, 2003). One of the main features that distinguish our world from other planets is that it contains water. Water has been the most important factor in the formation of civilizations in history and the most important point determining the residential areas. Three-quarters of our world is covered with water and the human body is mostly made up of water.

Water is vital for the sustainability of all living things and the continuity of ecosystem. It is a biological solvent that provides both the transport and dissolution of vitamins and minerals in the body. It is important in regulating body temperature, facilitates the work of the kidneys and other organs, protects and acts as a cushion, plays a fundamental role in moisturizing the skin and removing toxins and cleansing the body. In addition, water supports the conversion of nutrients taken into the body into energy and also helps the absorption of nutrients. Water also is the main ingredient of carbohydrates, fats and proteins in the human body as well as performing many vital activities such as circulation, excretion and reproduction (Akın, et al., 2007). Water is an indispensable resource of life and we feel uncomfortable when we are dehydrated even for a short time.

Groundwater is the world's largest distributed store of fresh water that is central to sustaining ecosystems and enabling human adaptation to climate variability and change (Taylor, et al., 2013). Groundwater is one of the most important freshwater resources, supporting agricultural, industrial and domestic water uses (Siebert et al., 2010; Gleeson et al., 2020). Globally, groundwater is the source of one third of all fresh-water withdrawals, supplying an estimated 36%, 42% and 27% of the water used for domestic, agricultural and industrial purposes, respectively (Döll, et al., 2012). In many environments, natural groundwater discharges sustain baseflow to rivers, lakes and wetlands during periods of low or no rainfall. The main advantages of groundwater are that it occurs in situ, often of potable quality and does not require expensive treatment and permits scaled development using infrastructure that is usually of lower cost in relation to surface water feed supplies. Thus groundwater is more ideal for poverty alleviation and sustainability than surface water (Nyagwambo, 2006, Taylor et al., 2009). Groundwater is the most abstracted raw material on earth (Jarvis, 2012). It is the primary source of drinking water for half of the world's population, including over 1.5 billion city dwellers. In some areas, groundwater dependence approaches 100% (Howard, 2015). Therefore, due to the increasing role of groundwater, there is the need to assess the groundwater potential of Ikere-Ekiti for sustainable development and management.

Sanitation plays an important role in well water sustainability. There is increasing appreciation of the linkages between sanitation and environment; being pillars of groundwater sustainability (Talabi, 2018). The use of unimproved sanitation facilities (such as unsanitary maintenance of wells and their features, proximity to potential pollution sources such as pit latrines, indiscriminate dumping of refuse and poor sanitation) by over two thirds of Nigerians is really a crisis that has serious environmental/groundwater sustainability implications (Abubakar, 2017). Sangodoyin (1993) observed that the unsanitary mode of disposal of wastes, such as open defecation in streams and the dumping of refuse in pits, rivers and drainage channels as seen in most Nigerian urban settlements could be expected to affect surface and groundwater quality. Open defecation including the use of flying toilets are the worst forms of sanitation lapses as they pollute public open spaces, water bodies, railway lines, building construction sites (Ordinioha & Owhondah, 2008; Schram & Wampler, 2018).

Sanitation has become a global problem arising from a growing human population, agricultural expansion, and climate change (Vörösmarty et al., 2000; Wheater & Gober, 2015). Sustainable management of groundwater resources is particularly critical, with 50% of the world's drinking water and 43% of irrigation sourced from aquifers (Siebert et al., 2010). Thus, it becomes critical to investigate groundwater potential of Ikere-Ekiti employing estimated volume of water in its wells and their preliminary hygiene situations. The study provides rudiment for long-term groundwater sustainability, governance and management.

Location of Study

The study area, Ikere-Ekiti is located within Ekiti State in the Southwestern part of Nigeria (Figure 1). It lies approximately on latitude $7^0$30' North of the Equator and longitude $5^0$14' East of Greenwich Meridian and situated at an average elevation of 381 meters above sea level. Ikere-Ekiti is bounded in the north by Ado-Ekiti, in the south by Akure North local government, in the east and west by Ise-Orun and Ekiti South-west local governments respectively (Andrew, 2016). The town, Ikere-Ekiti is strategically located serving as a gate way to Akure, the capital of Ondo State.

The last National Population Census puts the total population of Ikere local government at 147,355 (NPC, 2007), making it the 4th biggest city in Ekiti. The study area is generally accessible with good network of roads, motorable tracks and footpaths linking parts of the towns and various parts of the country, providing easy access to both farmsteads and outcrop areas. The settlement pattern in the area is nucleated and the major occupation of the inhabitants is farming and they are locally acknowledged for their contribution to Cocoa and rice production in the western part of Nigeria.

Ikere-Ekiti experiences a tropical climate with distinct wet and dry seasons (Adebayo, 1993). The wet and dry seasons are associated with the prevalence of the most maritime south westerly monsoon winds from the Atlantic Ocean and the dry continental north easterly harmattan winds from the Sahara deserts respectively. The rainy season spans from April – October while the dry season is from November – March every year. Temperature is almost uniform throughout the year with very little deviation from the mean annual of 27^0C. February and March are the hottest months with mean temperature of 28^0C and 27^0C respectively while June with temperature of 25^0C is the coolest (Adebayo, 1993). The mean annual total rainfall is 1367mm with a low coefficient of variation of about 10%. Rainfall is highly seasonal with well-marked wet and dry seasons and double maxima as a result of the brief stoppage of rain experienced in August (Ogundare, 2016). The vegetation in this region is classified as rainforest, boasting a rich diversity of hardwood varieties. The considerably high rainfall in this area supports the growth of dense and thriving vegetation, featuring three distinct types of trees, including Mahogany, Iroko, and Obeche. The vegetation signature of the study area has been altered due to prolong human activities like bush burning, agricultural practices and climate change (Talabi, et al., 2012). Ikere-Ekiti is also known for its large number of hills, notably the Olósùnta and Òrólè (a gigantic inselberg). The hills are steep-sided and the soil derived through their weathering is fertile supporting agricultural activity. Òrólè and Olósùnta Hills of Ikere-Ekiti are located at Northern and southern parts of the town respectively. They are both steep-sided hills and these two hills are the largest/tallest hill so far in Ekiti-State. Ikere-Ekiti is a rugged terrain that lies within the Precambrian crystalline basement complex of southwestern Nigeria where the occurrence of water is highly erratic. According to Ademilua et al. (2014), crystalline basement rocks do not make good aquifer because of their zero level of porosity and permeability. However, a secondary porosity can develop through a simple process of weathering, fractured/fissured systems, networks of joints and cracks in the crystalline basement rocks (Nyagwambo, 2006). In view of the erratic occurrence of groundwater in the study area and the seasonal variation of rainfall, estimated volume of water in the wells of Ikere-Ekiti was carried out so that area affected by shortage of water can be ameliorated employing alternative water sources.

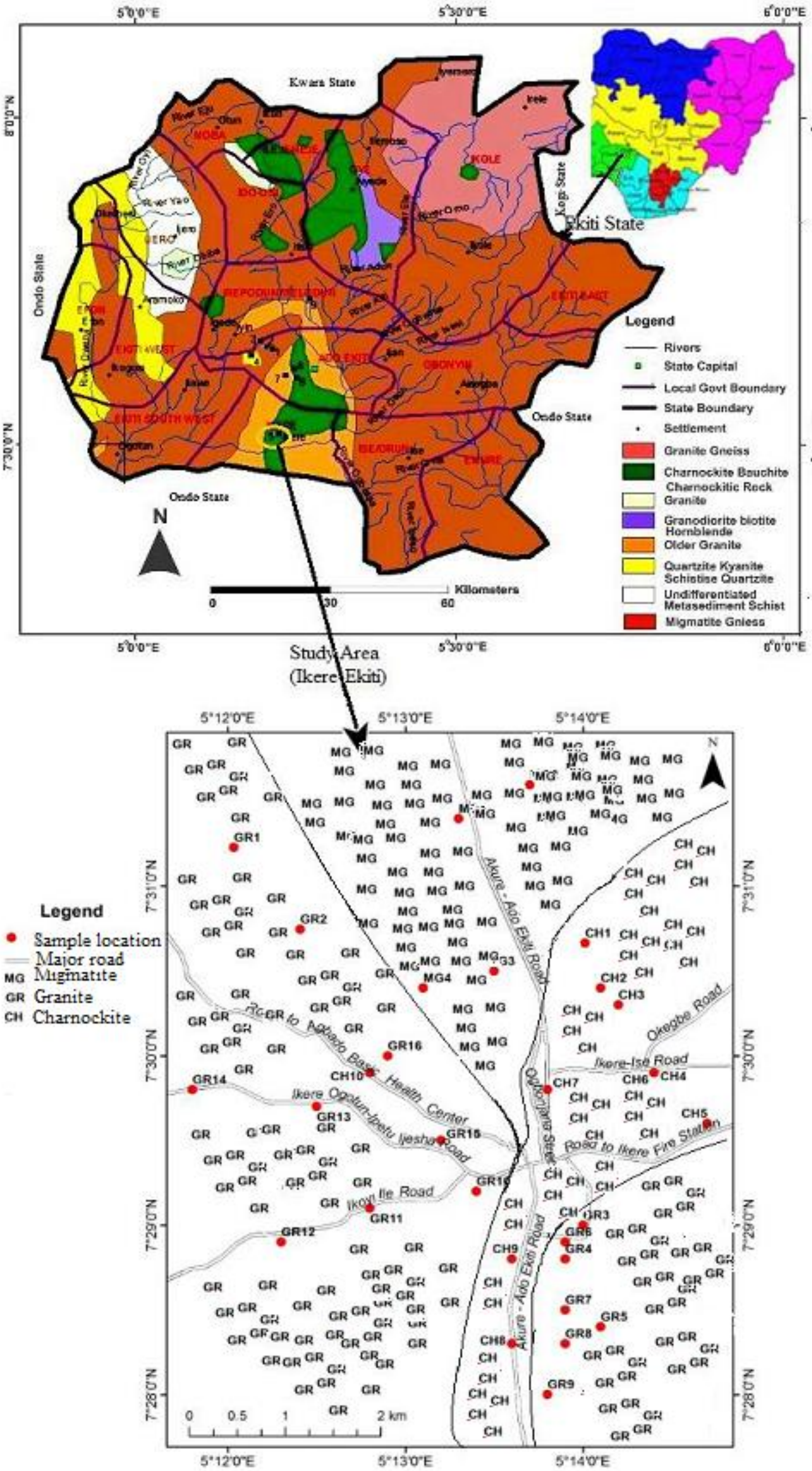

Figure 1. Location of study indicating sampling points

Methodology

Prior to obtaining groundwater samples, a base map was prepared and a reconnaissance assessment of the research area was conducted to determine how many samples to be taken from each rock unit. Based on how widely spaced out a particular rock outcrop was in the area, 5, 15 and 10 wells located on migmatite, granite and charnockite respectively were slated for examination. Prior to basic physical examinations, basic hygiene characteristics (distance of well <10 to pit latrine, well lined, on a cement base, on rope and bucket or motorized, marshy surrounding etc.) needed to be maintained at each well were observed and recorded. The geographic location and diameter of each well was measured at each location employing a Garmin GPS MAP 64sx and a tape meter respectively. The geographic coordinates were used to produce the map of the area by employing 12 Arch GIS and Surfer 15 software.

Subsequently, the in-situ parameters (temperature (°C), pH, EC (μS/cm), TDS (mg/L)) of water in each well were measured using a Multi-parameter Testr™ 35 Series S/N: 1382654. Water level and depth of each well were measured employing a Dip meter. The water column and volume of water in each well were estimated by subtracting water level from the well's depth. Assuming the well to be approximately cylindrical, volume of water in the well was estimated using the formula $V = \pi r^2 h$ where $\pi = 3.14$, r (m) = radius of the well, h (m) = water column and V (m^3) = volume of water in a well. Data obtained were subjected to descriptive statistics and the groundwater potential of the area employing volume of water in wells of the area was obtained using Surfer 12 software.

Results and Discussion

The results of the physical parameters of shallow wells' water from the study area are presented in Table 1. General hygiene conditions of the wells (Table 1) revealed that majority of the wells' water is clean, colourless and odourless. About 70% of the wells sampled are not on cement base, not lined and not properly covered. Also, over 80% of the wells are on bucket tied to ropes for fetching of water. This withdrawal method could be source of introducing contaminants into the groundwater of the area. Furthermore, the result revealed that the temperature (°C) on migmatite gneiss, granite and charnockite ranged from 26.8 - 29.1, 27.0 - 29.9 and 27.0 - 30.2 respectively, a reflection of the ambient temperature of the environment.

The water level (m) on migmatite gneiss, granite and charnockite ranged from 2.37 - 6.90, 0.84 - 11.3 and 0.77 - 5.59 respectively. The well depth (m) following the same order of rock units had average values of 8.56, 7.94, and 4.49 respectively. This observation showed that the wells have shallow depths and it is also a reflection of ease of hand drilling of the overburden thickness developed over the rock units. Charnockite being the hardest had the shallowest overburden.

The calculated water column (m) in each of the 30 wells ranged from 0.50 - 6.90 (av. 8.50), 1.20 - 7.50 (av. 2.83) and 0.89 - 4.77 (av. 1.97) on migmatite, granite and charnockite respectively while the estimated volume of water (m^3) following the same order of rock units were from 4.27 – 19.84 (av. 9.41), 2.82 - 102.21 (av. 13.42) and 1.52 - 9.09 (av. 4.53) respectively. The areas covered by granite recorded the highest volume of water therefore the occurrence of groundwater appeared to be more favorable in areas covered by granite than the other rock units as revealed by the average volume of water on each rock types (Figure 2). The occurrence of groundwater on the charnockite indicated a consistent low volume of water with the lowest average value of 4.53m^3. Charnockite is a very hard rock that is not easily susceptible to weathering justifying the low volume of water in wells located on such terrain.

Table 1. Physical parameters of water from the wells in the study area

Rock Unit	Norting	Easting	Well radius (m)	Water Level (m)	Well Depth (m)	Water Column (m)	Water volume (m3)	Elev (m)	SG	Temp (ºC)	pH	EC (µS/cm)	TDS (mg/L)	Remarks
MG1	7º31.4′	005º13.3′	1.90	4.50	6.20	1.75	19.84	391	1.002	26.8	5.14	306	270	Well is on a cement base, not lined, partially covered with rusting iron sheet. Water is odourless and colorless
MG2	7º31.5′	005º13.5′	0.48	6.90	12.2	5.30	9.01	381	1.002	29.1	4.37	384	33	Well is not on cement base, is not lined but properly covered. Water is odorless and colorless.
MG3	7º31.6′	005º13.7′	0.50	2.90	5.30	2.43	4.27	365	1.002	28.4	6.55	322	221	Well is not on cement base, lined, covered with odorless/ colorless water
MG4	7º30.5′	005º13.5′	0.50	2.37	9.27	6.90	7.28	378	1.002	28.2	5.92	378	113	Well is not on a cement base, not lined, covered. Odorless, milky color water.
MG5	7º30.4′	005º13.1′	0.47	5.33	9.83	0.50	6.67	391	1.002	27.4	5.58	389	50	Well is on a cement base, lined, covered. Odorless, milky color water.
CH1	7º30.6′	005º13.8′	0.40	1.02	3.02	2.00	1.52	371	1.002	27	6.22	307	126	Well is on a cement base, lined, covered, odorless with milky color.
CH2	7º30.4′	005º14.1′	0.61	0.77	1.70	0.93	2.09	376	1.002	29.5	5.9	306	275	Well is not on a cement base, partially covered, not lined. Water is odorless and colorless.
CH3	7º30.3′	005º14.2′	0.54	1.24	2.13	0.89	1.92	377	1.002	29.7	4.66	403	162	Well is on a cement base, lined, covered, odorless with colorless.
CH4	7º29.9′	005º14.4′	0.50	3.00	7.77	4.77	6.10	377	1.002	29.9	4.74	409	135	Well is not on a cement base, not lined, covered. Water is odorless and colorless.
CH5	7º29.6′	005º14.7′	0.65	5.59	6.85	1.26	9.09	358	1.002	29.3	5.64	362	71	Well is on a cement base, not lined, covered. Water is odorless and milky color.
CH6	7º29.9′	005º14.4′	0.61	2.2	5.12	2.92	5.88	377	1.002	28.3	5.36	392	133	Well is not on a cement base, not lined, covered. Water is colorless with foul odor.
CH7	7º29.8′	005º13.8′	0.45	1.72	4.20	2.48	2.67	387	1.002	29.5	6.92	334	294	Well is on a cement base, lined, covered, odorless and colorless water.
CH8	7º28.3′	005º13.6′	0.70	2.7	4.38	1.68	6.74	383	1.002	30.2	5.88	381	83	Well is on a cement base, not lined, covered. Odorless, milky color water.
CH9	7º28.8′	005º13.6′	0.70	2.13	3.50	1.37	5.39	370	1.002	39.3	6.35	359	289	Well is not on a cement base, not lined, partially covered. Odorless, brown color water with visible particles.

CH10	7ᴼ29.9′	005ᴼ12.8′	0.45	4.83	6.20	1.37	3.94	381	1.002	28.3	5.2	426	72	Well is not on a cement base, lined, covered. Odorless, colorless water.
GR1	7ᴼ30.9′	005ᴼ13.8′	0.46	10.9	12.50	1.60	8.33	382	1.002	28.6	5.88	319	72	Well is lined and water is colorless and odorless
GR2	7ᴼ29.0′	005ᴼ14.0′	0.46	4.20	6.60	2.40	4.29	362	1.002	29.7	5.2	342	71	Well is on a cement base, lined, covered, clean, colorless, odorless water.
GR3	7ᴼ28.8′	005ᴼ13.9′	1.92	4.90	8.83	3.93	45.49	362	1.002	29.1	5.26	342	41	Well is not on a cement base, lined, not properly covered, clean, odorless, colorless water.
GR4	7ᴼ28.4′	005ᴼ14.1′	0.50	11.3	18.8	7.50	14.76	381	1.003	31	6.9	382	70	Well is not on a cement base, lined, not properly covered, clean, odorless, colorless water.
GR5	7ᴼ28.9′	005ᴼ13.9′	0.50	3.30	4.50	1.20	3.53	369	1.002	29.3	5.99	370	227	Well is not on a cement base, lined, not properly covered, odorless, brown color water.
GR6	7ᴼ28.5′	005ᴼ13.9′	0.46	4.60	6.20	1.60	4.03	380	1.002	29.5	5.23	402	43	Well is not on a cement base, lined, covered, odorless, brown color water.
GR7	7ᴼ28.3′	005ᴼ13.9′	0.46	9.80	11.15	1.35	7.41	385	1.002	29	5.53	357	48	Well is on a cement base, not lined, properly covered, colorless water with foul smell.
GR8	7ᴼ28′	005ᴼ13.8′	0.39	3.40	5.90	2.50	2.82	376	1.002	29.9	5.16	428	105	Well is not on a cement base, lined, covered, odorless, colorless water.
GR9	7ᴼ29.2′	005ᴼ13.4′	0.65	0.84	2.62	1.78	3.48	356	1.003	29.4	6.42	346	286	Well is not on a cement base, not lined, partially covered. Odorless, colorless water.
GR10	7ᴼ29.1′	005ᴼ12.8′	0.85	3.22	7.30	4.08	16.56	361	1.003	29.4	4.64	405	182	Well is not on a cement base, not lined, not covered. Odorless, colorless water.
GR11	7ᴼ28.9′	005ᴼ12.3′	0.80	3.43	5.70	2.27	11.45	366	1.003	28.9	5.66	393	60	Well is not on a cement base, not lined, not covered. Odorless, milky color water.
GR12	7ᴼ29.7′	005ᴼ12.5′	0.60	1.80	3.40	1.60	3.84	366	1.002	29.2	4.37	459	87	Well is not on a cement base, not lined, not covered. Odorless, colorless water.
GR13	7ᴼ29.8′	005ᴼ11.8′	0.44	3.56	5.56	2.00	3.31	364	1.002	28.7	4.22	422	38	Well is not on a cement base, lined, covered. Odorless, milky color water.
GR14	7ᴼ29.5′	005ᴼ13.2′	0.45	1.51	5.08	3.57	3.23	366	1.002	29	6.3	405	189	Well is not on a cement base, not lined, covered. Odorless, colorless water.
GR15	7ᴼ30.0'	005ᴼ12.9’	0.50	10.00	15.00	5.00	11.78	305	1.002	27	6.83	283	86	Well is not on a cement base, lined, covered. Odorless, brown color water.

The granite in the study area has medium to coarse grained texture and in some area the texture is porphyritic. The granite is more susceptible to weathering and this can result into thick overburden to hoist groundwater. Migmatite is a mixed rock that has been subjected to metamorphism. The rock is equally more susceptible to weathering than the charnockite. Thus, this research showed that wells on migmatite and charnockite terrains have low volume of water compare to wells on granitic terrain, though the wells on charnockite appeared to be the worst in terms of availability of groundwater (Figure 2). Areas covered by charnockitic rocks are a problematic zone that deserves special attention as regards groundwater sustainability.

The result (Table 1) also revealed that pH ranged from 4.37 – 6.55 on migmatite gneiss, 4.22 - 6.9 on granite and 4.66 -6.92 on charnockite. From the results, pH is <7 for all the groundwater in the study area and only 4samples out of the 30 sampled water fell within the approved standard for drinking water (WHO/UNICEF, 2017). Acidic water is very important in groundwater chemical evolution. It controls the behavior of most water quality parameters and enhances dissolution of trace metals which when the occurrence is above approved standard for drinking water could be deleterious to human health. Acidic water has been claimed to have antimicrobial effects, making it potentially beneficial for skin, hair, and washing produce (Hansen et al., 2018). However, it can also have many undesirable and potentially dangerous side effects. Among the side effects are tooth damage, leaching of heavy metals into the water and damage of plumbing materials (WHO, 1986).

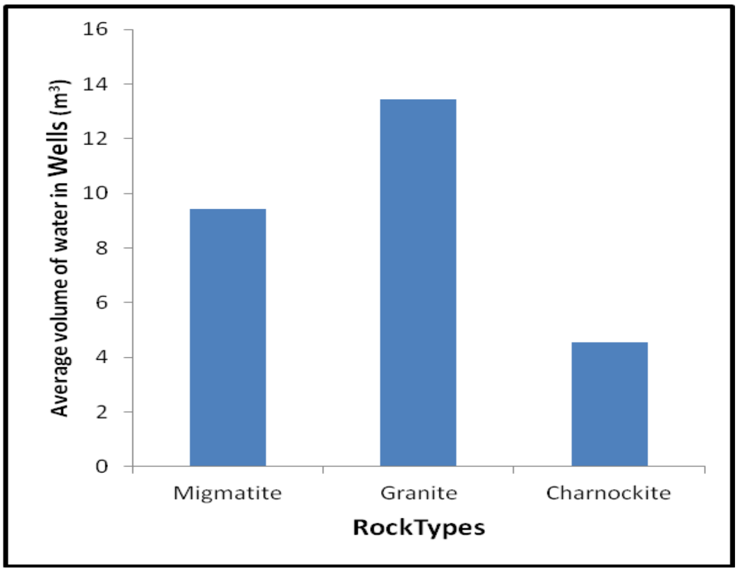

Figure 2. Average volume of water in shallow wells at the study area

The results shown in Table 1 indicated that the groundwater from the study area have varied TDS (mg/ L) and EC(μS/cm) values due to presence of different lithologies and differential response of their mineral constituents to weathering. All EC (μS/cm) and TDS (mg/L) values irrespective of rock units were less than 1000 (μS/cm) and 500 (mg/L) respectively and are within WHO (2017) approved standard for drinking water. Water based on TDS (mg/L) values can be classified as fresh water (TDS ≤1,000), saline (TDS>10,000) and brine (TDS>100,000) (Talabi, 2016). Based on this classification, the groundwater of the study area is fresh water.

Groundwater Potential of the Area

Groundwater potential map of the study area based on availability of water in each well was developed using Sulfer 8 as presented in (Figure 3). The map corroborated the earlier submission that the area covered by granite has more groundwater. Furthermore, Ikere-Ekiti was classified into five groundwater potential zones based on physical examination of the estimated volume of water in the various wells of the study area (Table 2). This classification is in tandem with Talabi, (2018), in which groundwater of Ekiti-State was classified into six groundwater potential categories; very poor (volume of water in wells ≤4.4m^3), poor (4.4 m^3 < volume of water ≤8.8m^3), fair (8.8 m^3 < volume of water ≤13.2m^3), good (13.2 m^3 < volume of water ≤17.6m^3) and very good (volume of water >17.6m^3). This classification model was adopted for the present study. Thus, Ikere-Ekiti groundwater was classified into five groundwater potential zones; very poor, poor, fair, good and very good (Table 2).

Table 2. Groundwater potential zones of Ikere-Ekiti based on rock units

Rock Type/ Water Zones	≤4.4 (m^3) (Very poor)	4.4 - 8.8 (m^3) (poor)	8.8 - 13.12 (^{m3}) (Fair)	13.12 - 17.5 (m^3) (Good)	>17.6 (m^3) Very (Good)
Migmatite	1	2	1	0	1
Granite	8	2	2	2	1
Charnockite	5	4	1	0	0

The classification revealed that groundwater occurrence at Ikere-Ekiti is eractic and extremely worrisome on areas located on charnockite with 90% of the area falling into very poor to poor geoundwater potential zones. On ganitic terrains that covered greater part of the study area, groundwater occurrence cut across the five classification categories. Though, granitic terrains appear more promising in terms of groundwater occurrence but this study needs additional research employing geophysical survey to substantiate groundwater potential occurrence in the area. The groundwater potential map (Figure 3) indicated that areas covered by granites are more favorable for groundwater occurrence. The eractic occurrence of groundwater in the study area is confirmed by Figure 3 as majority of areas on very poor to poor groundwater potential are on charnockite and granitic rocks. In view of the skewness of the sampling based on rock units, judging the precise occurrence of groundwater is difficult as large samples were taken from granitic rock terrain being the most available rock in the study area.

The essence of this work is to proffer solution to groundwater sustainability especially during the dry season. This result vividly revealed the poor nature of groundwater on virtually all rocks in the area. Rain harvesting could be employed for groundwater sustainability in this area. In addition, deep boreholes could be drilled after detailed geophysical survey has been carried out.

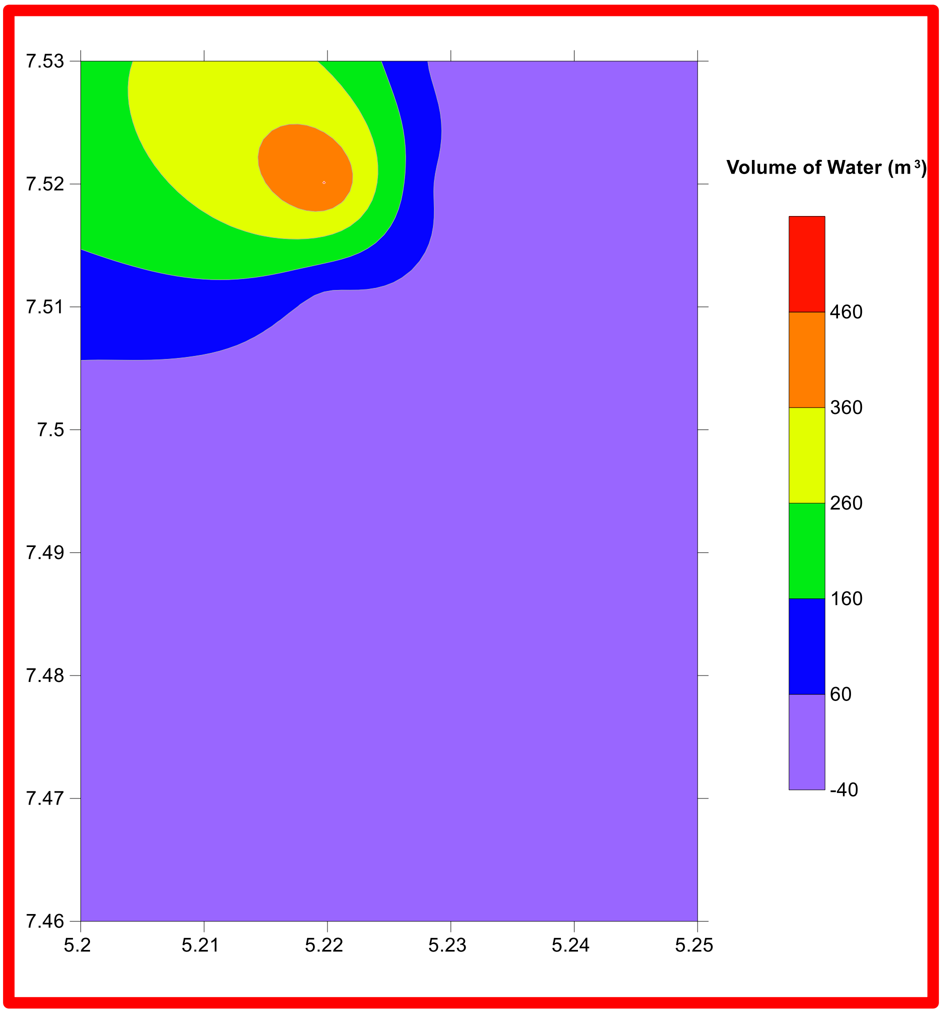

Figure 3. Groundwater potential map of the study area

Conclusion

This study examined the sanitary situation and volume of water in each well at Ikere-Ekiti based on rock units. Poor sanitary conditions were observed in most of the wells and intensive hygiene education becomes necessary as groundwater in the area was pruned to contamination. The study revealed three main rock units (migmatites, granite and charnockites). Generally, volume of water was low in all the wells irrespective of the type of rock units. However, wells located on charnockites had the lowest volume of water while those on granite were better than those located on both charnockites and migmatites. This study clearly revealed that groundwater sustainability in the study area is far from being achieved. Wells' water hygiene was very poor while volume of water in the wells was low to the extent that they cannot meet the water demands for human consumption and other domestic activities. Recipe can be sourced from the artesian wells in the area or through rain harvesting during the rainy season.

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