Evaluation of Yield of Wells in Ado-Ekiti, Nigeria

P. O. Ale J. O. Aribisala M. S. Awopetu
Department of Civil Engineering, Faculty of Engineering, Ekiti State University, Ado-Ekiti, Ekiti State, Nigeria

Abstract
Pumping tests were conducted on twenty selected boreholes and five hand-dug wells cut across Ado Ekiti Metropolitan (AEM) area, with the view to ascertain yield of the wells. Constant rate pumping test and recovery method test were carried out. It was revealled that discharge is directly proportional to the yield of the boreholes and hand-dug wells at a constant drawdown, hence the discharge rate gives the yield of each of the selected boreholes. The borehole depth ranges between 40 – 120 m while hand-dug well ranges between 3 – 15m. Borehole yield in the AEM area ranged between 0.267 l/s and 2.0 l/s. The yield was not totally dependent on the depths, but also on such parameters as porosity and permeability. The potential of groundwater in AEM as it relates to quantity is high as all wells yielded water. The average water consumption in litres per person per day for high class income earners was estimated at 196 l/d, while that of low class income earners was 119 l/d. Most residence in AEM depend on ground water for domestic water demand. Possible improvement strategies to groundwater exploitation were highlighted. These improvement strategies and remedies are predrilling geophysical survey before siting of boreholes, monitoring groundwater exploration to avert depletion of groundwater potential zones encouraging sufficient recharge period and conducting regular laboratory tests.
Keywords: yield, boreholes, hand-dug wells, recharge, Ado Ekiti.

1. Introduction

Water constitutes about 70% of the earth's surface and has the ability to exist in three states of matter; as solid, liquid and gas (Anomohanran, 2011). The volume of earth's water is estimated at about 1304million cubic kilometers. Out of which 1268 million cubic kilometers or 97% is contained in the oceans with 50 cubic kilometers of salt water, while 2.5% or 32million cubic kilometers form the world's total supply of fresh water, while the remaining 4 cubic kilometers is underground. (Aribisala, 2010b)

Groundwater is a reliable source of water. It is found beneath the earth's surface as a body of water which is trapped in the pore spaces of permeable rock. The localization of groundwater in fractured zone and weathered zone will make the yield of wells in crystalline bedrock terrain to be highly variable (Anomohanran, 2011). According to Egbai (2011), groundwater is the water that fully saturates pores or cracks in soils and rocks. The volume of groundwater extracted by gravity drainage from saturated water bearing material is referred to as the yield. Water is usually found to exist in different forms at different depths below the surface of the earth toward its centre, (Omosuyi, 2010).

Anomohanran (2011) reported that the volume of water available at different depths would depend on the zone of rock fracture. He further mentioned that in this zone, the stresses are within the elastic limits and there exist interstices. Water is stored in the voids; hence the amount of water would depend upon the porosity. It was further mentioned that the maximum depth of this zone below the ground surface ranges between 100meters or less and 1,000 meters or more. Nwankwo (2011) asserted that in crystalline rocks, most of the water is met within 100m of the surface, while in sedimentary rocks, water is found up to a depth of 1,800m. Although lesser quantity of water is found below 1000m. Therefore, before embarking on groundwater exploration, information on the zone of rock fracture is normally gotten through geophysical survey. The information on the rock fracture would determine the depth at which a productive aquifer could be located.

According to Oladapo and Akintorinwa (2007), an aquifer is a formation or part of a formation that contains sufficient saturated permeable material to yield significant quantities of water to wells. Aquifer may be a layer of gravel or sand, sandstone, limestone, lavaflow or fractured granite. The major productive aquifers in the world are unconsolidated sand and gravel, limestone, dolomite, basalt and sandstone. Egbai (2011) submitted that the location and yield of aquifer are dependent on geologic conditions; such as the size and sorting of grains in unconsolidated deposits and faulting, solution openings and fracturing in consolidated rocks (limestone, granite, lava, volcanic ash).

It is a reasonably defensible statement that the yield of an individual well in consolidated rocks cannot be predicted accurately. However, the average yield to be obtained from a group of wells can be estimated reasonably well where sufficient data on existing wells are at hand. The adequacy of the estimate will depend largely on the completeness of data available and on the experience and judgment of the evaluator, (Cederstrom, 1972)

In the last few years the hydrologist's task has been to state categorically that the average yield of wells in various hard-rock formations is a certain number of gallons a minute. In dealing with this difficult problem it must be understood clearly that the estimate arrived at in such a study cannot refer to the yield of a single well but rather to the average yield per well where a number of wells is considered. This study examines the yield of wells. Pumping tests were conducted on twenty selected boreholes and five hand-dug wells cut across AEM area, with the view to ascertain yield of the wells. The results of this study will help in water management planning

2. Material and Method

2.1 The study area

The study area is capital city or administrative head quarter of Ekiti State, Nigeria (Figure 1 and 2). Ado Ekiti metropolitan (AEM) area (Figure 3) is located approximately between latitudes $7^0 15'$N, $7^0 17'$N and longitude $5^0 19'$E, $5^0 23'$E. The area enjoys tropical wet and dry type of climate, dominated by seasonal migration and pulsation of two air masses. The warm and tropical continental (CT) air mass from Sahara which is associated with dry season, and warm humid tropical marine (MT) air mass from Gulf of Guinea, influences the area during wet season. The wet season usually last from April to October, with a short break in July/August, while dry season is from November to March. The temperature, however, is high. It is usually higher just before the rain with an average of about 26^0C for each month. The annual rainfall is at about 1,300mm. The topography is generally undulating land surface with a characteristic landscape that consists of old plains broken by steep-sided outcrops dome rocks that may occur singularly or in groups.

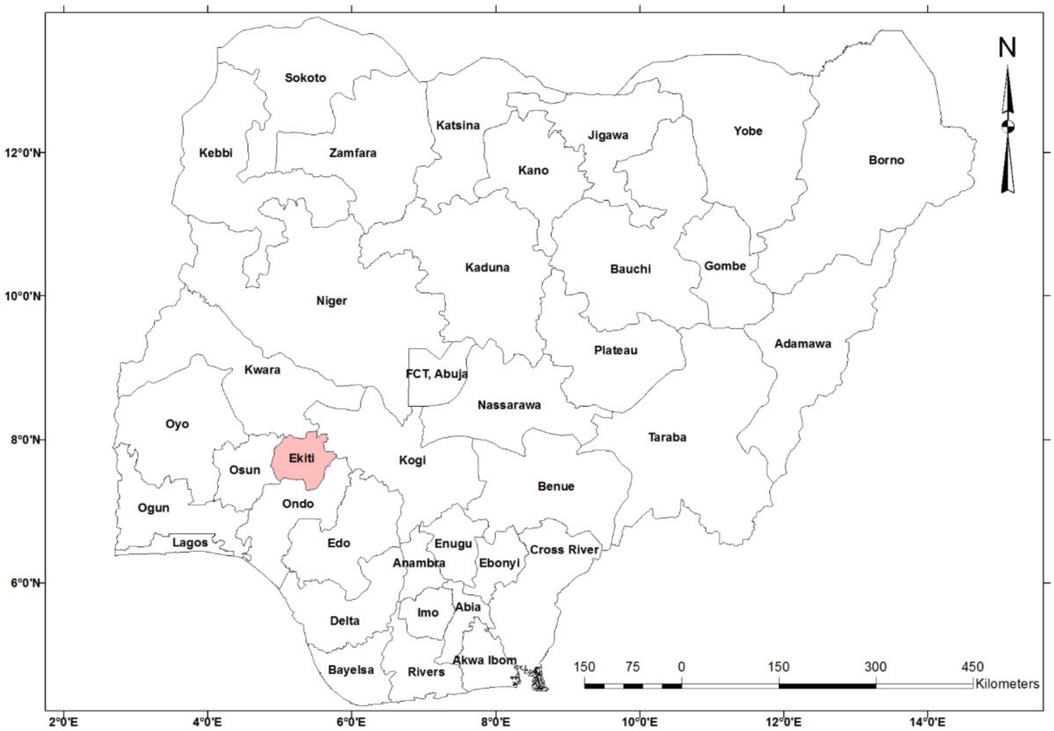

Figure 1: Map of Nigeria showing Ekiti State

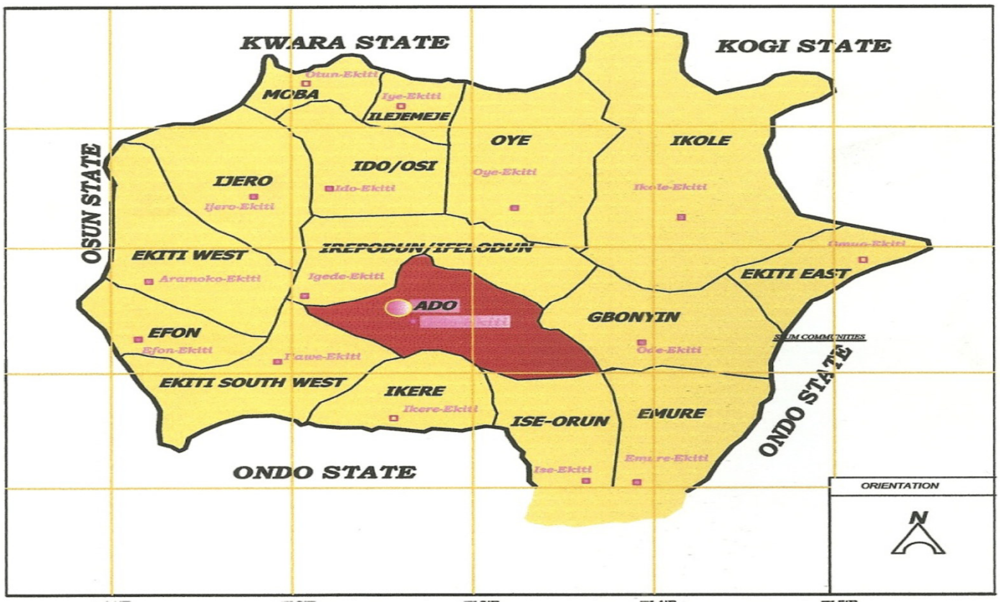

Figure 2: Map of Ekiti State showing Ado-Ekiti (Source: Oriye, 2013)

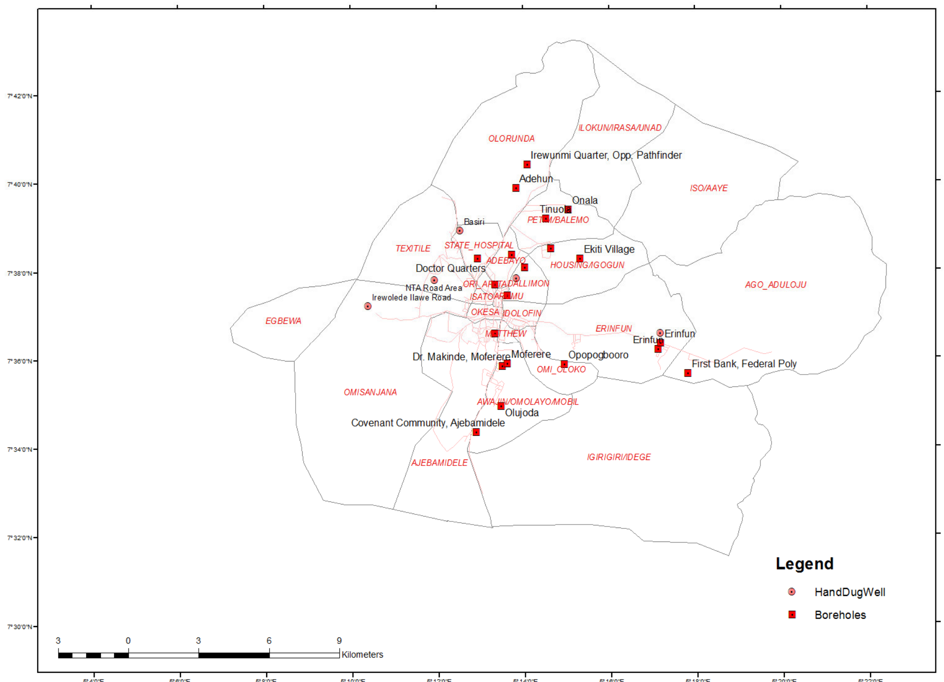

Figure 3: Map of the study area (AEM)

2.2 Data collection

Two major sources of data were used in this study. These are primary and secondary data. The primary data consisted of personal visits to locations of existing boreholes and hand-dug wells in the study area, identifying sampling points and collecting well inventory. Practicing consultants on borehole drilling in the AEM area were also contacted for information on the boreholes drilled in the study area. Questionnaires were administered to 5% of the population to collect information on the per capita consumption per person per day in the study area (litres/day). In this study, 15,431 persons were selected from low, medium and high density areas of Ado-Ekiti using stratified random sampling. This sample size represents the 5% of the total population.

The secondary data consisted of published and unpublished documents for relevant information, such information were extracted from journals, conference papers and available textbooks. Existing drilled boreholes were identified across the study areas and where there were no boreholes the existing hand-dug wells were used, and well inventory were collected. The depth of the boreholes and the overburden thickness were measured using dip metre. Two different methods were used in conducting pumping tests on the selected boreholes and hand dug wells. These methods are constant rate pumping test and recovery method test.

2.3 Constant Rate Pumping Test

Constant rate pumping tests were conducted on the selected boreholes. The materials used for these tests included; 20-litre bucket as a standard measure, generating set to power the pump, stop watch to record time intervals and rubber hose connected to the pipe from the borehole to discharge the water into the buckets. In conducting this test, the initial or static level of the water in the boreholes was measured using a dip metre. The generating set was thereafter switched on to start the pumping. The pumping was allowed to run continuously for a long period of two hours before the rate of pumping was adjusted for the boreholes to maintain constant discharge. At this point, the water level was measured to know the drawdown and a calibrated 20-litre bucket was then filled from the constant discharge from the boreholes while a stopwatch was simultaneously set to record the time taken, in seconds, to fill the bucket. This process was repeated for four hours for each of the selected boreholes. It was therefore observed that the water level and the drawdown in the boreholes were constant throughout the four hours pumping.

With the constant discharge from the boreholes, a state of equilibrium was maintained between the rate of discharge and the rate of recharge from the aquifer. In this condition of equilibrium, the rate of pumping or discharge is directly proportional to the yield of the borehole or well at the constant drawdown. In other words, the discharge per unit time in litres per second gives the yield of each of the selected boreholes at the constant drawdown.

2.4 Recovery Method Test

Recovery method test was conducted on the selected hand-dug wells. The materials used for this test included; dip metre, generating set and stop watch. In conducting the test, dip metre was dipped into the well to determine the overall depth of the well and the water level before pumping started.

The generating set was then put on to power the pump and the water in the well was gradually pumped out until the bottom level of the well was reached. The stop watch was also set to record the time taken for the pumping as the water level in the well reduced at different depth interval. As soon as the bottom of the well was reached, the well was left to recharge while the stop watch also recorded the time taken for the water to come back to original level before pumping started. The volume of the water pumped was calculated by measuring the diameter and the overall depth of the well. The ratio of the volume of water to the time taken gave the rate of the pumping in litres per second while the volume per day (m^3/day) gave the yield of the well.

3. Results and Discussion

3.1 Yield and Specific Capacities of Selected Hand-dug Wells (HDW)

The daily yield and specific capacities of the selected hand dug wells are shown in Table 1

Table 1: Yield and Specific capacities of the selected hand dug wells

Hand dug Well number	Hand dug well Location	Yields (l/s)	Drawdown	Specific Capacity m^3/day/m
HDW 1	Behind NNPC Filling Station, Off Okeila Housing Road, Okeila	0.339	2.44	12.004
HDW 2	Behind Jesus Chapel, Basiri, Ado-Ekiti	0.267	2.44	9.455
HDW 3	Fabian Avenue, NTA Road, Ado-Ekiti	0.333	1.83	15.722
HDW 4	Iremo Street, Odo-Ado	0.372	2.44	13.173
HDW 5	Irewolede Estate, Ilawe Road, Ado-Ekiti	0.367	1.83	17.325

Source: Field works 2012

From the table 1, the yield ranged between 0.267 litres/second at Basiri and 0.367litres/second at Irewolede Estate. The table also shows specific capacity of 9.455m^3/day/m at Basiri and 17.327m^3/day/m at Irewolede Estate. The pumping rate and the yield are further illustrated in figures 6

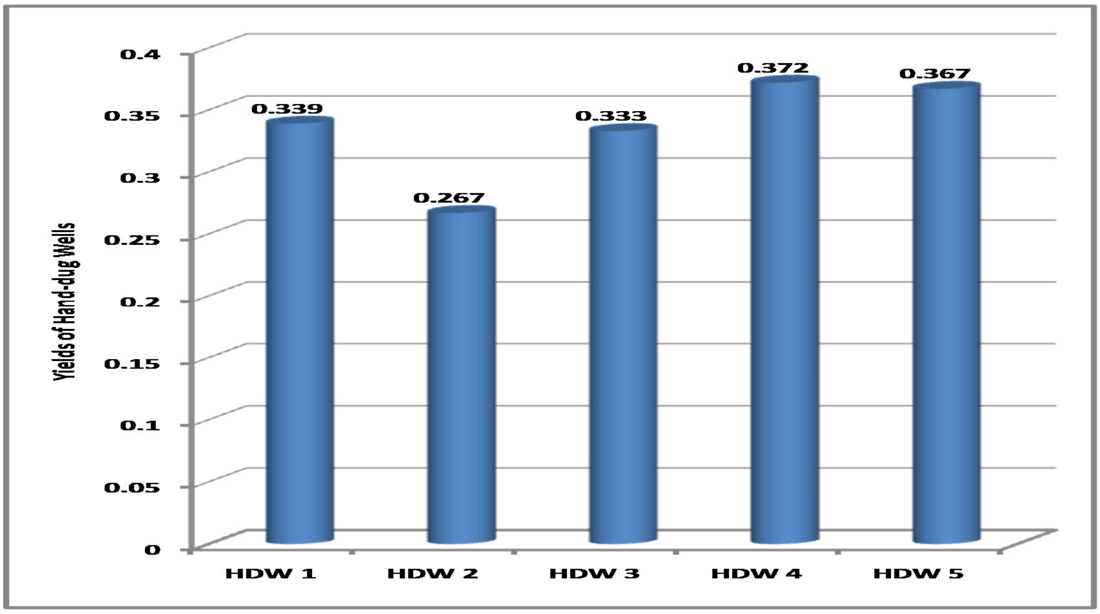

Figure 4: Yield of Selected Hand dug Wells in Ado-Ekiti

3.2 Yield of Selected Boreholes

The pumping rate, the daily yield, the drawdown and the specific capacities of the selected boreholes are shown in table 1. It is observed from the table1 above that the lowest yield of 0.268 litres/second was recorded at Opopogbooro and the highest yield of 2 litres/second was recorded at Covenant Community, Ajebamidele. The yields are further illustrated in Figures 5 and 6. It can be deduced from values of the yield that groundwater can be assessed all over Ado-Ekiti. This implies high potential in quantity. However, ther is a need to verifttythis by extensive geophysical survey.

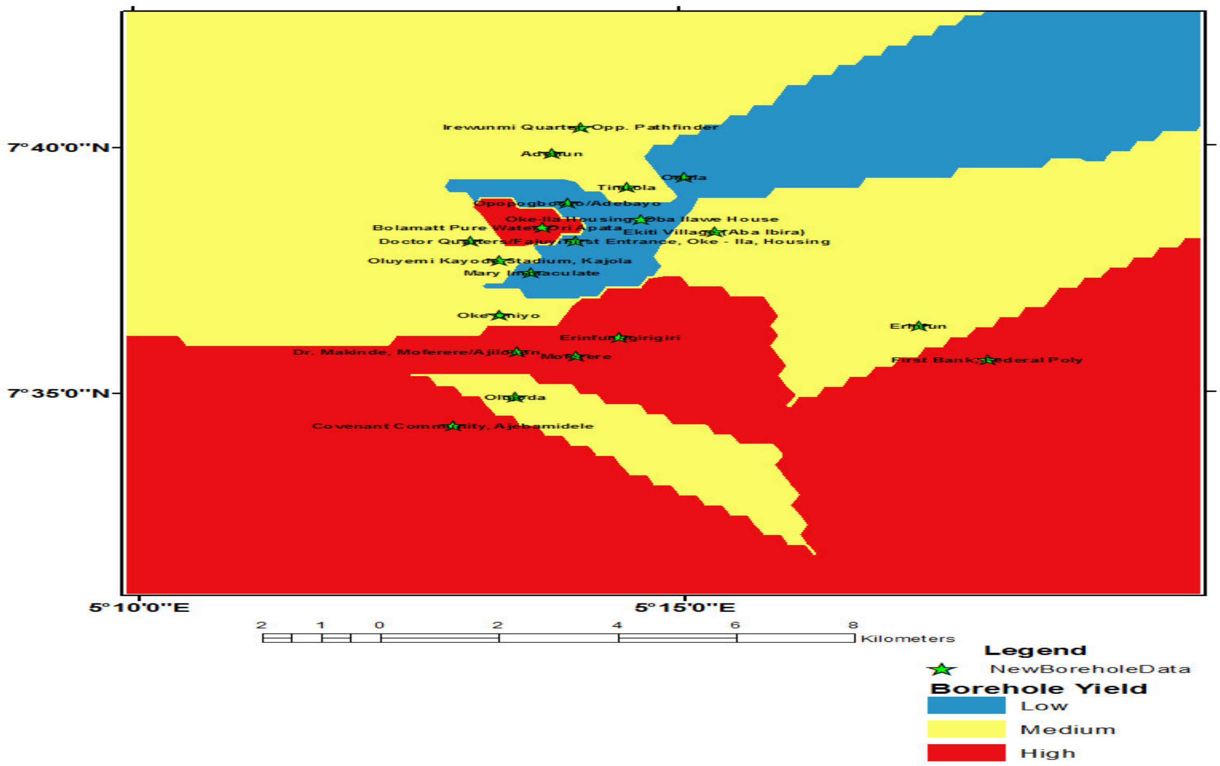

Figure 5: Map Showing the Borehole Yields

Table 2: Yield of Selected Boreholes

Borehole Number	**Borehole Location**	**Volume of Water Pump in Litres**	**Time Taken in (Sec)**	**Yield l/s**	**Draw-down (m)**	**Specific Capacity (m^3/day/m^3)**	**Remarks**
BH1	Bolamatt Pure Water, Ori Apata	20	11	1.863	5.49	29.319	High
BH2	First Entrance, Oke-Ila, Housing	20	71	0.282	7.92	3.076	Low yield
BH3	Oke-Ila Housing Estate, Alawe House	20	65	0.310	3.35	7.995	Low yield
BH4	Onala Quarter	20	56	0.358	2.44	12.677	Low yield
BH5	Tinuola	20	37	0.541	2.44	19.157	Medium yield
BH6	Aba-Ibira Settlem-ent, Ekiti	20	33	0.615	4.27	12.444	Medium yield
BH7	Pathfin-der	20	33	0.604	10.97	5.757	Medium yield
BH8	First Bank, Federal Poly, Ado	20	11	1.849	10.67	14.972	High yield
BH9	Opopogbooro	20	75	0.268	10.06	2.302	Low yield
BH10	Adehun	20	44	0.455	10.67	3.684	Medium yield
BH11	Doctors' Quarters	20	41	0.484	9.14	4.575	Medium yield
BH12	Oluyemi Kayode Stadium	20	29	0.681	10.36	5.679	Medium yield
BH13	Mary Immaculate	20	67	0.299	701	3.685	Low yield
BH14	Oke Oniyo	20	31	0.653	15.58	3.621	Medium yield
BH15	Covenant Community, Ajebamidele	20	10	1.958	11.58	14.609	High yield
BH16	Dr. Makinde, Moferere	20	11	1.886	7.01	23.245	High yield
BH17	Moferere	20	10	1.947	6.10	27.577	High yield
BH18	Olujoda	20	35	0.576	10.67	4.664	Medium yield
BH19	Erinfun	20	11	1.875	10.67	15.183	High yield
BH20	Erinfun	20	44	0.451	10.06	3.873	Medium yield

Source: Field Work, 2012

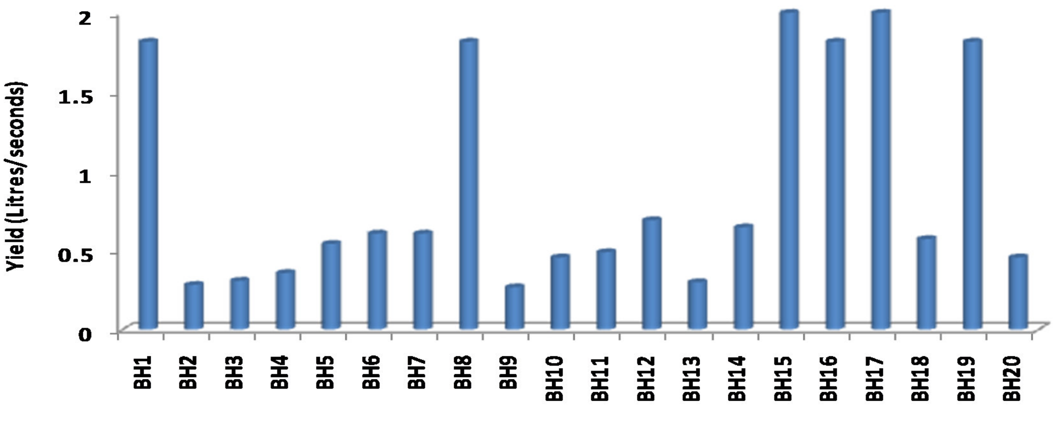

Figure 6: Chart Showing the Yield of selected boreholes (Litres/seconds)

The drawdown of the selected boreholes ranged between 2.44m at Onala/Tinuola and 15.58m at Oke Oniyo, while the specific capacities range between 2.302m^3/day/m at Opopogbooro and 29.319m^3/day/m at Ori Apata.

The specific capacity is significant because it measures the productive capacity of a borehole or well and it helps in the selection of the appropriate pump for the borehole (Karanth, 1987).

$$\text{Specific Capacity} = \frac{Yield}{Drawdown} \ (m^3/day/m)$$

4. Conclusion

Boreholes yield in the study area ranged between 0.267 litres/second and 2.0 litres/second with the lowest yield recorded around Opopogbooro, while the highest yield was recorded around Covenant Community, Ajebamidele and Moferere area along Ajilosun. There is availability of groundwater all over AEM are that can support domestic use.

For effective groundwater planning and development in the study area, it is recommended that;

i. Predrilling geophysical survey should be carefully conducted and test pumping must be carried out for economic and environmental purposes.
ii. Groundwater exploration should be well monitored to avert depletion of groundwater potential zones.
iii. Government should build storage reservoirs where groundwater resource extracted could be stored for later distribution to encourage sufficient time for groundwater recharge.

References

Anomohanran, O. (2011): Determination of Groundwater Potential in Asaba Nigeria using Surface Geoelectric Sounding: International Journal of the Physical Sciences 6 (33); 7651-7656.

Anomohanran, O. (2013): Investigation of Groundwater Potential in some Selected Town in Delta North District of Nigeria, International Journal of Applied Science and Technology 3(6); 61-66.

Aribisala, J.O. (2010b). The Essential Key to Human Survival and Development: 28th Inaugural Lecture, University of Ado-Ekiti; Nigeria, 47.

Cederstrom. D. J. (2008) Evaluation of Yields of Wells in Consolidated Rocks, Virginia to Maine http://pubs.usgs.gov/wsp/2021/report.pdf 02/07/2015

Egbai, J.C. (2011): Vertical Electrical Sounding for the Determination of Aquifer Transmissivity, Australian Journal of Basic and Applied Sciences, 5(6); 1209-1214.

Karanth, K.R. (1987): "Groundwater Assessment, Development and Management". Tata McGraw-Hill Publishing Company Limited, New Delhi Pp. 576-657.

Nwankwo, L.I. (2011): 2D Resistivity Survey for Groundwater Exploration in a Hard Rock Terrain: A Case Study of MAGDAS Observatory, UNILORIN, Nigeria, Asian Journal Earth Science 4, 1:46-53.

Oladapo, M.I., Akintorinwa, O.J. (2007). Hydrologeophysical Study of Ogbese Southwestern Nigeria Global J. Pure and Applied Sci. 13 (1) 55-61.

Oriye Olusegun (2013). Urban expansion and urban land use in Ado Ekiti, Nigeria. American Journal of Research Communication, 1(2): 128-139} www.usa-journals.com ISSN: 2325-4076.