Journal of Occupational Safety and Environmental Health
A Publication of the Society for Occupational Safety and Environmental Health

VALIDATION OF GROUNDWATER POTENTIAL ZONES MAP WITH YIELDS OF EXISTING BOREHOLES AND WELL WATER LEVELS IN OKE-ERO LGA, KWARA STATE, NIGERIA

Adeogun B. K., Agboola A. A. and Ajibike M.A.

Department of Water Resources and Environmental Engineering, Faculty of Engineering
Ahmadu Bello University, Zaria
Correspondence to: adeogunbk@gmail.com

ABSTRACT

The motivation for this research project arose from the realization that many boreholes fail in Oke-Ero LGA due to improper investigation, and over abstraction of groundwater from areas of low to moderate yields. This research investigated existing borehole yields and well water levels. The values of borehole yield ranged from 0.65 to 3.57 l/s, reflecting a wide margin between the highest and the lowest yield value, with an average yield of 1.35 l/s. This indicates that borehole yield is generally moderate across the study area. The values of borehole depth ranged from 45 to 60 m with an average of 52 m, with a static water level that ranged from 4.2 to 19.7m. . The existing groundwater potential zones map of the area was subsequently cross-checked with the pumping test data and well water levels using excel and pearson correlation in SPSS. The excel results of correlation between the borehole yields and groundwater potential map mean yields showed a strongly positive correlation of 0.81 while that of well water level and the groundwater potential zones map mean water level reflected a strongly positive correlation of 0.70. Also, the SPSS pearson correlation between borehole yields and groundwater potential map mean yield indicated a strongly positive correlation of 0.9, while the relationship between well water levels and the groundwater potential zone map mean water level reflected a strongly positive correlation of 0.84. The strongly positive correlation between the map and the borehole yields, and water levels, is an indication that the map can be used in the management plans of groundwater resources and preventing excessive exploitation in the area.

INTRODUCTION

On earth the most remarkable substance is water. The usefulness of water to the survival of both plants and animals cannot be overlooked; all living things depend on water. We use it to wash, drink, cook, swim and lots more and as it is, human beings cannot live more than a few days without water (Agboola, 2019). The quality and quantity of water determine the rate of public health, energy, cell function, food production, and other components of life. The social and economic development of any nation is determined by availability and accessibility to water. Adequate and equitable access to water for most domestic and other uses reduce high level of hunger and poverty in the rural areas.

Water deficiency in Nigeria is rising because the demand for water resources is increasing for irrigation, generation of energy and water supply; it also increases with increase in population and economic development, according to the Federal Ministry of Water Resources and Japanese International Cooperation Agency (FMWR-JICA, 2014). Recently, unlike before during dry season the source of groundwater and some rivers dry up utterly (FMWR-JICA, 2014). Hence, proper planning, development and management of water resources is very important more than earlier in order to surpass environmental hazards. For proper groundwater resources utilization, adequate planning and management of the groundwater potential and assessment qualitatively and quantitatively are required. Groundwater may be a suitable resource in many places today, but to keep the groundwater supply

sustainable, necessary assessments need to be conducted (European Commission, 2006).

The extraction of groundwater can be done by boreholes and hand-dug wells (protected and unprotected) which in permeable geological formations are referred to as aquifers; which allow storage and passage of water through them. In Nigeria, the number of boreholes for public water supply is approximately 57,600 boreholes for public water supply with total pumping of 458 m^3/day (Hisashi, 2011). However, these boreholes do not have aquifer characteristic and yield data, nor are they georeferenced.

Between all known sources of potable water, groundwater has been found to be the best option especially in Africa. Currently in Nigeria, more than 70% of the available source of potable water is from groundwater. Except in Abuja, where over 80% of the municipal area is connected to pipe borne water network (Ali, 2012). Inhabitants of Nigerian cities, towns and villages mostly rely on groundwater resources. Based on the above comments, it can be concluded that groundwater is a major source of clean water particularly in low income countries of the world, such as Nigeria. The volume of water that can be obtained from a deep aquifer is difficult to determine; yet, this volume is an important factor to be considered in planning and in development of an aquifer. In view of the ever increasing demand for groundwater, greater emphasis is ow being placed on a planned and optimal utilization of this resources.

Therefore, the present study focused in assessing the yield of existing boreholes and well water levels. The data was correlated with existing groundwater potential zones map in Oke-Ero, Kwara State, Nigeria

Study Area

Oke Ero is a Local Government Area in Kwara, Nigeria. Its headquarters is in the town of Iloffa, Latitude 8°05'36.3"N and Longitude 5°08'32.4"E. Other Major towns in Oke Ero are Idofin, Kajola, Ekan Nla, Ayedun, Ilale and Erin Mope. Others are Odo-owa, Egosi, Imode, Idofin Odo-Ase. The Oke-Ero Local Government Area was carved out of the Ekiti Local Government Area of Kwara State. Oke-Ero has an area of 438 km² and a population of 57,619 at the 2006 census, the population has since grown steadily with a projection of 76,900 in 2016 by the National Population Commission of Nigeria. This Local Government Area (LGA) comprises of 10 political wards; Iloffa, Ayedun, Ekan, Idofin/Odo-ashe, Idofin Igbana I, Idofin Igbana II, Imode/Egosi, Odo-owa I, Odo-owa II and Imoji/Ilale ward. Oke Ero is surrounded Okunran, Araromi Opin, Osi, Osan Ekiti, and Omu-Aran in Irepodun Local Government as shown in Figure 1

In Oke-Ero, the average annual temperature is 24.7°C. The average annual rainfall is 1281mm. The driest month is January, with 9mm of precipitation. Most of the precipitation falls in September, averaging 237mm. With an average of 27.0°C, March is the warmest month. August is the coldest month, with an average temperature of 22.6°C. Throughout the year, temperature varies by 4.4°C (Agboola, 2019)

Figure 1: Map showing Oke Ero LGA (Source: Map Data, 2020)

MATERIALS AND METHODS

Equipment and Software

The materials used for this study are listed as follows:

- GPS
- Arc GIS 10.4
- Microsoft Excel 2016

Validation of the potential zones

In this work, a field survey was carried out by randomly selecting wells in different zones using GPS to locate boreholes and wells and also, determined the borehole yields by pumping test and, groundwater levels were determined manually; these results were used to validate an existing Groundwater Potential Zone Map (GPZ Map) developed through integrated weighted overlay by Agboola (2019). Table 1 shows the borehole yield intervals that ranges from 0 to >1.5 l/s which was reclassified into low zone (0.0-0.9 l/s), moderate zone (1.0-1.5 l/s) and high zone (> 1.5 l/s) and also, well water levels which ranged from 0.8 to 15.2 m were also reclassified into high zone (0.8-6.6 m), moderate zone (6.61-9.5 m), low zone (9.5-15.2 m) as used by Agboola (2019) to develop the groundwater potential map.

Table 1: Classified weighted overlay Values, Borehole Yield and well level ranges.

Yield interval (l/s)	Groundwater Potential	Well level interval (m)
0.0-0.9	(Low)	above 9.5
1.0-1.5	(Moderate)	6.61-9.5
>1.5	(High)	0.8-6.6

Sources: Modified from Akinwumiju *et al*., 2017 and Ajaykumar *et al.*, 2016.

Borehole yields and well levels, obtained from the fieldwork, were used to test the accuracy and reliability of the map by correlating the map and/or Table 1 with the yields and water levels obtained from this study. Also, the correlation between the water level and GPZ Map mean water levels was evaluated using excel and the pearson correlation in SPSS.

RESULTS AND DISCUSSIONS

Validation of Result

To realize the objective of this study, borehole yield data from nine locations and twenty well water level data were collected. The boreholes and wells were selected randomly within the LGA and the locations of wells and boreholes were superimposed on the Groundwater Potential Zone Map as indicated in Figure 2. The blue colour indicates high groundwater zone, the green colour reflect moderate groundwater zone while the red colour implies low groundwater zone, according to Agboola (2020)

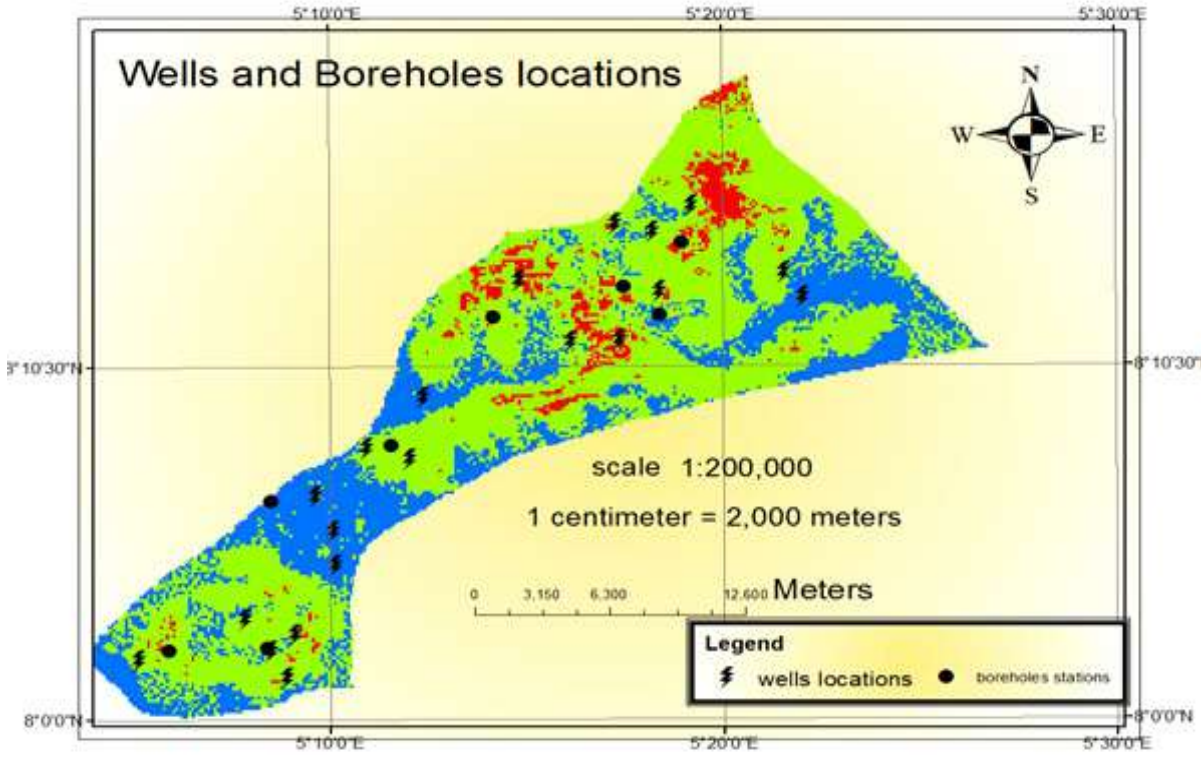

Figure 2: Boreholes and wells Locations Superimposed on Groundwater Potential Zone Map (Souce: Agboola, 2019; with modification)

The results are presented in Table 2. Table 2 showed that the yields (0.45, 0.81 and 0.52 l/s) of the three boreholes located in the low groundwater potential zones of the GPZ Map were in agreement with the map low potential zones, developed from Table 1 data (using the range 0-0.9 l/s) in the study area.

Similarly, the yields of the three boreholes selected in the moderate zone area were 1.46, 1.28 and 1.34 l/s, which were within the moderate range of 1 to 1.5 l/s of Table 1 from which the GPZ Map was based. These results showed perfect agreement between the borehole yield and the map. However, only one borehole yield out of the three samples collected at the high yield zones of the map showed moderate yield of 1.43 l/s which was not in agreement with

the high yield potential area.

The borehole yield values range between 0.45 to 2.51 l/s, with an average yield of 1.35 l/s, which shows that borehole yield is generally moderate across the study area, with borehole depths that range from 45 to 60 m; this suggests an average groundwater depth of 53 m, which shows that groundwater can easily be assessed at moderate cost within the LGA.

Table 2: Pumping test and groundwater potential results

GPZ Map		**Borehole (Field) Data**			**Coordinates**
potential zone	**Zone Mean Groundwater yield (l/s)**	**depths(m)**	**yields (l/s)**	**Potentials**	
Low	0.45	58	0.45	Low	$8^0$14’7”N $5^0$18’57”E
Low	0.45	55	0.81	Low	$8^0$3’2”N $5^0$5’46”E
Low	0.45	60	0.52	Low	$8^0$15’53”N $5^0$19’15”E
Moderate	1.25	45	1.46	Moderate	$8^0$4’44”N $5^0$8’27”E
Moderate	1.25	47	1.28	Moderate	$8^0$12’48”N $5^0$17’29”E
Moderate	1.25	60	1.34	Moderate	$8^0$2’2”N $5^0$5’53”E
High	2.25	48	2.51	High	$8^0$2’6”N $5^0$8’24”E
High	**2.25**	**45**	**1.43**	**Moderate**	**$8^0$11’58”N $5^0$18’25”E**
High	2.25	55	2.32	High	$8^0$6’28”N $5^0$8’30”E

The borehole yield and GPZ Map mean yields were correlated statistically using excel and the result is as shown in Figure 3. Figure 3 showed a strongly positive correlation between the borehole yields and GPZ Map with correlation value of 0.81.

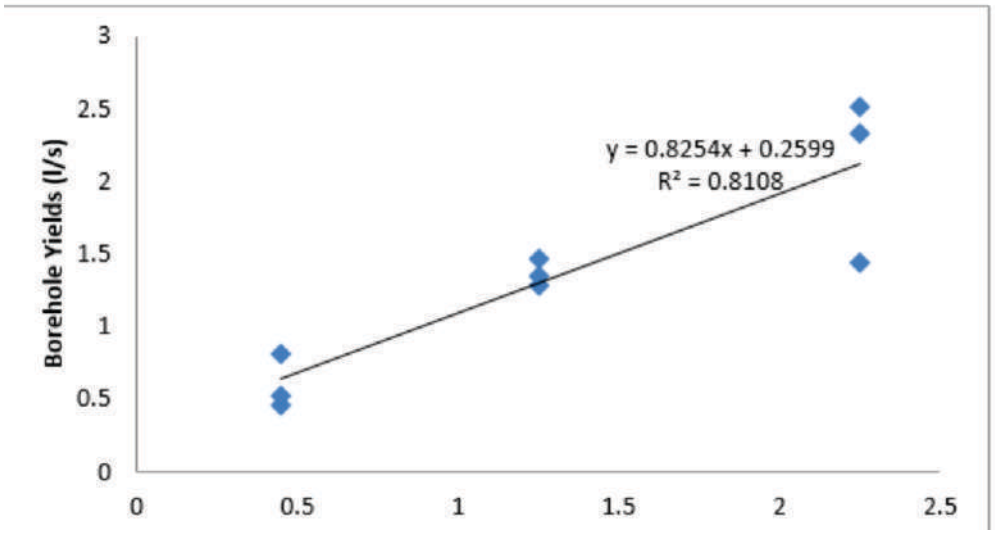

Figure 3: Correlation between Borehole Yields and Groundwater Potential Zones Map Mean Yields

The results of well water levels with respect to the map zones (low, moderate and high yield zones) are presented in Table 3. Out of the twenty samples, six samples were not in agreement with the groundwater potentials of the GPZ Map as highlighted in Table 3. The water levels at the locations were 9.26m in the low potential zone, 10.1 and 6.54 m in the moderate potential zone and 7.96, 6.97 and 7.72 m in high potential zone. Furthermore, the result of correlation between the water level and GPZ Map mean water levels showed strongly positive correlation of 0.701 as shown in Figure 4. Also, Pearson correlation in SPSS was used to further analyze the relationship between borehole yields and GPZ Map mean yields, as shown in the Appendix, with a strongly positive correlation of 0.9. The correlation between well water levels and GPZ Map mean water levels reflected a strongly positive correlation of 0.84 as shown in the Appendix

Table 3: Well depth and Groundwater potential results

GPZ Map		Well Water (Field Data)		Coordinates
Potentials	**Depth Ranges (m)**	**Potential**	**Water level (m)**	
Low	7-9	**Moderate**	**9.26**	**$8^0$2'30"N $5^0$9'7"E**
Low	7-9	Low	11.25	$8^0$12'60"N $5^0$14'50"E
Low	7-9	Low	13.45	$8^0$14'41"N $5^0$17'18"E
Low	7-9	Low	12.9	$8^0$12'40"N $5^0$18'23"E
Moderate	4-6	Moderate	8.41	$8^0$2'58"N $5^0$7'50"E
Moderate	4-6	Moderate	8.99	$8^0$1'44"N $5^0$5'9"E
Moderate	4-6	Moderate	9.15	$8^0$1'12"N $5^0$8'55"E
Moderate	4-6	Moderate	7.89	$8^0$7'61"N $5^0$10'57"E
Moderate	4-6	**Low**	**10.1**	**$8^0$11'10"N $5^0$16'10"E**
Moderate	4-6	**High**	**6.54**	**$8^0$11'14"N $5^0$17'23"E**
Moderate	4-6	Moderate	7.27	$8^0$15'13"N $5^0$19'14"E
Moderate	4-6	Moderate	8.2	$8^0$13'12"N $5^0$21'35"E
High	1-3	High	5.83	$8^0$12'30"N $5^0$22'4"E
High	1-3	**Moderate**	**7.92**	**$8^0$14'26"N $5^0$18'14"E**
High	1-3	High	3.41	$8^0$15'21"N $5^0$11'56"E
High	1-3	High	4.75	8°9'35"N 5°12'23"E
High	1-3	High	5.65	$8^0$2'1"N $5^0$8'31"E
High	1-3	**Moderate**	**6.97**	**$8^0$5'34"N $5^0$10'6"E**
High	1-3	**Moderate**	**7.72**	**$8^0$6'35"N $5^0$9'39"E**
High	1-3	High	5.8	$8^0$4'33"N $5^0$10'10"E

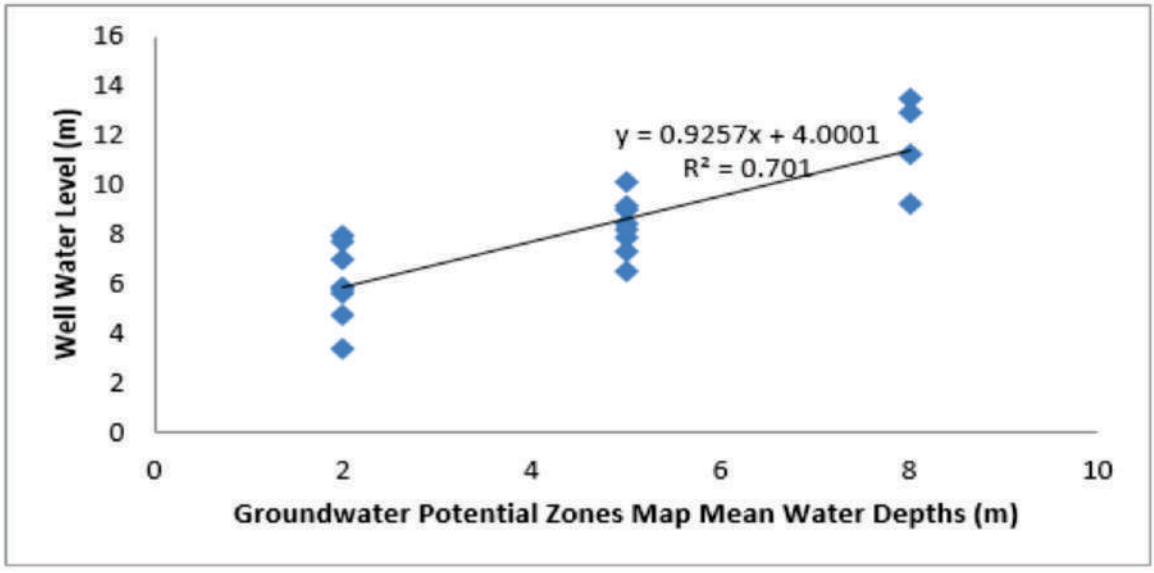

Figure 4:Correlation between well water level and Groundwater Potential Zones Map mean water depth

CONCLUSIONS

The judicious utilization of groundwater resources coupled with proper water management is essential for ensuring groundwater sustainability. The correlation between borehole yields and GPZ Map mean yields showed strongly positive correlation of 0.81 while that of well water levels and GPZ Map

indicated strongly positive correlation of 0.70. Pearson correlation in SPSS was also used for the analyses and the results reflected very strongly positive correlation of 0.90 and 0.84 between the former and latter parameters, respectively. The strongly positive correlations between the map and the borehole yields, and then, the water levels are indications that the map can be used in the management plans of groundwater resources and preventing excessive exploitation in the area. Also, the high potential zones will have a key role in the future expansion of drinking water and irrigation development in the study area. Furthermore, it is felt that the present methodology can be used as a guideline for further research.

REFERENCES

Agboola A. A. (2019). Assessment of Groundwater Potential Zones in Oke-Ero Lga Of Kwara State Nigeria Using Gis Based Integrated Approach. Seminal presentation at Department Of Water Resources, Ahmadu Bello University, Zaria, Nigeria

Agboola A. A, Adeogun B. K. and Ajibike M. A. 2020. Determination Of Annual Groundwater Recharge And Demand In Oke-Ero Lga, Kwara State, Nigeria. Fuoye journal of engineering and technology.

Ajaykumar K, Sankhua R. N and Bhavana N. U. (2016) Assessment of Groundwater Potential Zones using GIS Technique: a case study of Shivganga River basin, Pune, Maharashtra, India. *Research Student, Department of Environmental Science*, SavitribaiPhule Pune University.

Akinwumiju *A.* S., Olorunfemi, M. O. and Afolabi, O. (2016) GIS-Based Integrated Groundwater Potential Assessment of Osun Drainage Basin, Southwestern Nigeria. *Ife Journal of Science* vol. 18, no. 1 (2016)

Ali K. A. 2012. Development of Water Supply Infrastructure in Nigeria: Challenges and Prospects. Nigeria Society of Engineers. 38 p.

European Commission (2006). *Water Resources Strategy* (European Commission report) In Support to the Federal Ministry of Water Resources. Federal Ministry of Water Resources, Abuja, Nigeria.

FMWR-JICA (2014). The Project for Review and Update of Nigeria National Water Resources Master Plan. Federal Ministry of Water Resources – Japan International Cooperation Agency (FMWR-JICA) January 2014, Abuja Nigeria. Available online @:

Hisashi O. (2011). *Improvement of Rural Water Supply Sector in Nigeria* JICA-FMWR: Field Survey Result Report. FMWR,Abuja.

Map Data (2020). Eke Ero. Map Data, 2020. Available online @ https://www.google.com/maps/place/Oke+Ero

APPENDIX

Correlation between GPZ Map mean yields and Borehole yields

Correlations

		Mean Groundwater yield (l/s)	Borehole yield (l/s)
Mean Groundwater yield (l/s)	Pearson Correlation	1	.900**
	Sig. (2-tailed)		.001
	N	9	9
Borehole yield (l/s)	Pearson Correlation	.900**	1
	Sig. (2-tailed)	.001	
	N	9	9

**. Correlation is significant at the 0.01 level (2-tailed).

Correlation between GPZ Map mean water levels and well water levelsCorrelations

		zone	Well water level (m)
zone	Pearson Correlation	1	.837**
	Sig. (2-tailed)		.000
	N	20	20
Well water level (m)	Pearson Correlation	.837**	1
	Sig. (2-tailed)	.000	
	N	20	20

**. Correlation is significant at the 0.01 level (2-tailed).