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Articles

Relationship Between Well Yield and Well Characteristics in Some Parts of Afon River Catchment Area of Kwara State, Nigeria.

IROYE, K.A.
Geography Department, University of Ilorin, Ilorin, Nigeria.

Abstract

This study examines the relationship between well water yield and well characteristics in some parts of Afon River catchment area of Kwara State, Nigeria. The required data were collected directly from 27 wells over a period of nine months (January September, 1994) using an improvised well-depth estimator. The data sets were processed using regression analysis. ResultS indicate that the well characteristics examined account for 78.1% variability in well yield. Also, well water yield is found to be a function of well depth and well diameter. The study thus recommend the sinking of more wells and deepening of existing ones to increase both the quantity and quality of water supply in the study area.

Introduction

In Nigeria today, as in many other developing countries, increase in rate of urbanization has led to the relative neglect of rural areas, even where the population of rural dwellers still remain a large proportion of the total population. One very important aspect of this neglect has been the absence of government policies directed towards effective provision of drinking water for the rural dwellers. This disparity between the urban and rural water supply which is in favour of urban centres started since the period of colonial administration and is still continuing today, both at regional, state and federal levels (Adeyemi 1988).

Water is very essential in every human endeavour. It is also needed for drinking, personal hygiene and for other domestic purposes. It is needed for industrial, agricultural and public uses; infact, accessibility to its sources has been a basic indicator for classifying the world into

developed, developing or underdeveloped nations (White et. al. 1972; Faniran et. al., 1981). To this extent, there is no doubt that water, like air, food and sunlight, is a valuable natural resource that can meet the requirements of man (Faniran and Ojo, 1980).

In view of the importance which water holds, various personal efforts have been put up by the rural dwellers at providing potable water supply for domestic requirements. This is through the use of traditional water sources such as streams, springs, ponds, shallow wells and dry streambed diggings. However, potable water supply through these sources have always been problematic as most of the sources usually dry up in dry periods forcing women and children who are the traditional drawers of water to trek long distances daily in search of water (Faniran, 1977; Daly et. al., 1975). In few cases where such water sources are found, they are usually highly polluted resulting in incidences of water-borne, water-washed, water-based or water-related diseases. (Sule, 2003).

In view of these problems, the use of groundwater thus becomes the safety option for the people as it remains the only permanent water source for most of the areas throughout the year. Omorinbola (1979) listed some advantages of utilizing groundwater as a supply option in rural villages to include:

i Availability on the spot which therefore saves time and expenses on dam construction, laying of pipes, etc.
ii Lack of risk of water-borne diseases as groundwater is naturally free of bacterial pollution.
Iii Minimal loss to evaporation
Iv Low capital investment as compared with high initial lump sum capital investment of pipe-borne water schemes.

Thus, because of the importance which groundwater holds over other traditional water sources such as rivers, streams, springs, ponds, lakes, etc, there is need for its evaluation, hence the attempt in this study to relate well yields to well characteristics with a view to suggest ways of increasing both quantity and quality of water supply in the study area .

The study area

The study area consists of three rural villages: Laduba, Budo Ago and Budo Agun which are located on the Afon river basin; midway between Afon town and Ganmo in

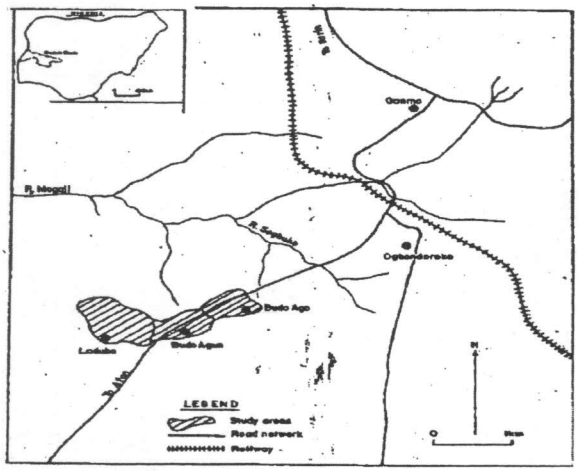

Fig. 1 Map of the study area

Asa Local Government Area of Kwara State of Nigeria (Figure 1).

The entire area lies on latitude 8°26' North and longitude 4°55'E. The villages have grown both in physical size and population to form multi-locality covering an area extent of about 1.6 sq km .The study area has a humid tropical climate characterized by dry and wet season with a mean temperature of 26.2 °c and potential evapotranspiration of 4.4 mm. The mean annual rainfall for the area is 1150 mm while the mean monthly rainfall ranges between 0.32 mm in December and 191.1 mm in September.

The area is underlain by igneous and metamorphic rocks of basement complex. These rocks have been greatly weathered in many places in situ, hence there are several pockets of weathered sand and sandy clay lenses within the area. A study earlier carried out by Ayoade and Oyebande (1978) on the underground aquifers in basement complex rock in Ilorin city of about 20 km from the study area shows that water yield is about 16,275 litres per hour. This fact was supported by Omorinbola (1983) who reveals that, the regolith aquifers in the basement complex are uniquitous and substantial water can be collected from underground by tapping it through wells and boreholes. The study area is drained only by few streams which are seasonal, hence, the high reliance on hand dug wells for both domestic and commercial needs.

Methodology

This work is based on data collected from direct fieldwork. The data sets were on well characteristics and these include data on depth to water, total well depth. depth of water, diameter of well and the volume of well water. These data sets were collected from the 27 accessible wells (Figure 2), using tape-rule and an improvised well-depth estimator made with 30 meter long string graduated in meters with beads and a big pad lock attached to one of its ends. This instrument was used in taking measurements on well characteristics by suspending the padlock into the well and taking measurements by counting the number of beads down the suspended string. In cases where the measuring point on the string does not coincide with the position of the bead, the number of beads down in the well is counted and the measuring tape is used in reading off the remaining length of the string from the position of the first bead in the well. This data collection method is justified in terms of cost, convenience and replicability

Measurements on depth to water were taken twice daily (6.30 am and 7.30 pm)

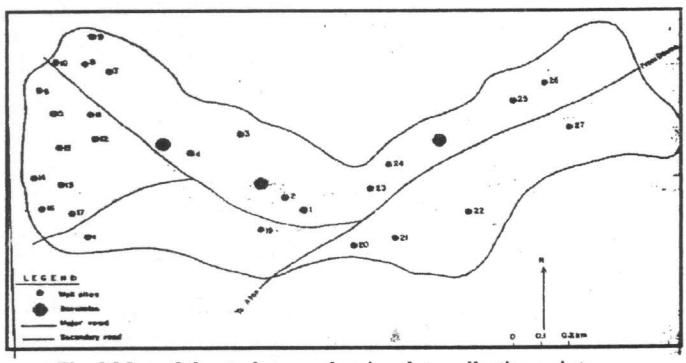

Fig. 2 Map of the study area showing data collection points

for a period of 9 months (January September, 1994) while measurements on well diameter and total well depth were taken just once during the study. Readings on depth of water (morning and evening) were obtained by getting the difference between the total well depth and depth to water. Volumes of well water in cubic meter were subsequently calculated for each well from the formula: $\pi r^2 h$,

where, = constant value of 3.142
r = radius of the circular opening of the well
h = depth of water

Analysis and Discussion of Results

Well characteristics

The study area is underlain by basement complex rock that has been studied by various workers as regards its water yielding capacity (Ayoade and Oyebande, 1978; Omorinbola, 1983; Oyegun et. al., 2007). Table 1 shows the descriptive statistics of the well characteristics examined

Depth of Well

Wells in the study area are shallow types as they are usually hand dug with crude implements such as diggers, shovels and hoes. The digging process is usually very tedious and takes a minimum of 3 days to complete. The process is regarded as having been completed whenever the diggers intersect the water table. Well depth in the study area range between 1.67 m and 6.86 m with a mean depth of 4.65 m and standard deviation of 1.25 m. The coefficient of variation obtained for well depth was 26.88%

Depth to water

Measurements on depth to water will aid in monitoring the rate of water drawn-down and replenishments. While the evening data provides information on rate of drawn-down; the morning records which were taken very early in the morning before the wells were visited by anyone provides data on rates of replenishments. The mean depth to water for the wells range between 1.61 m and 5.0 m with a standard deviation of 0.78 m and coefficient of variation of 27.3%

Records on depth to water apart from aiding in calculating the volume of well water, also helps in mapping the water table, Figures 2 and 3 show the temporal variations on depth to water for both the morning and evening readings on two of the studied wells (well numbers 7 and 24) and the mean values for all the twenty seven wells.

Table 1: Well Characteristics and Water Yield

Serial no of wells	Well location	Total well depth (m)	Well diameter (m)	Mean depth to water (m)	Mean depth of water (m)	Volume of wel l water in cubic meters (US Gallons)
1	**Lamoko**	4.49	0.94	2.16	2.33	1.61 (433)
2	Ile Nla	4.36	0.98	2.59	1.77	1.33 (351.1)
3	Idiose	3.30	0.89	2.49	0.81	0.58 (153.1)
4	Apana	4.60	1.37	2.57	2.03	2.98 (786.2)
5	Are	4.10	1.17	2.55	1.55	1.69 (446.2)
6	Kangi	4.31	0.97	2.64	1.67	1.32 (348.5)
7	Ikuda	5.21	1.00	2.57	2.64	2.09 (551.8)
8	Ikuda II	4.89	0.67	2.85	2.04	0.73 (192.7)
9	Malubi	5.96	1.30	3.52	2.44	3.37 (889.7)
10	Malubi II	3.05	0.97	2.59	0.46	0.34 (89.8)
11	Okankan	4.87	0.17	2.86	2.01	2.19 (578.2)
12	Odepo	4.21	1.05	2.42	1.79	1.56 (411.9)
13	Baale	4.27	1.20	2.51	1.76	2.02 (533.3)
14	Okejagun	5.54	0.92	2.45	3.09	2.07 (546.5)
15	Ibitapa	6.24	0.84	3.39	2.85	1.57 (414.5)
16	Ibitapa II	5.16	1.27	2.47	2.69	3.42 (902.9)
17	Okejagun II	1.67	1.10	1.61	0.06	0.06 (15.8)
18	Okejagun III	5.07	1.24	2.00	3.07	3.72 (982.1)
19	Surulere	3.86	1.20	2.52	2.66	3.01 (794.6)
20	Daodu	3.74	0.92	2.60	1.14	0.76 (200.6)
21	Daodu II	6.72	1.36	4.36	2.36	3.42 (902.9)
22	Koredc	2.67	1.41	2.46	0.21	0.33 (87.1)
23	Idigba	6.21	1.17	3.47	2.74	2.96 (781.4)
24	Idigba II	3.38	0.76	2.60	0.78	0.35 (92.4)
25	Teru	6.86	0.94	5.00	1.86	1.28 (337.9)
26	Oke Aro	6.49	1.20	4.69	1.80	2.03 (535.9)
27	Mogaji	4.21	1.18	2.81	1.40	1.53 (403.9)
Mean (m)		**4.65**	**1.04**	**2.84**	**1.85**	**1.79**
Standard Deviation (m)		**1.25**	**0.26**	**0.78**	**0.85**	**1.08**
Coefficient of Variation		**26.88 %**	**17.59%**	**27.33%**	**45.11%**	**60.13%**

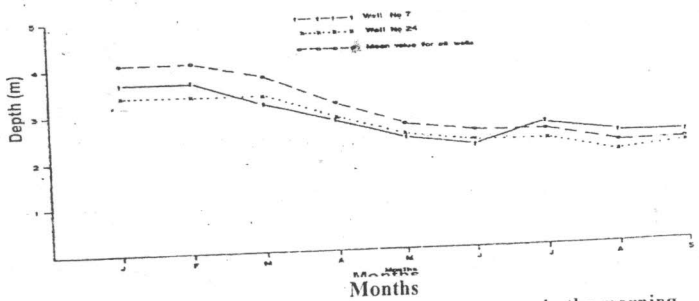

Fig. 2 Temporal variation of mean depth to water in the morning

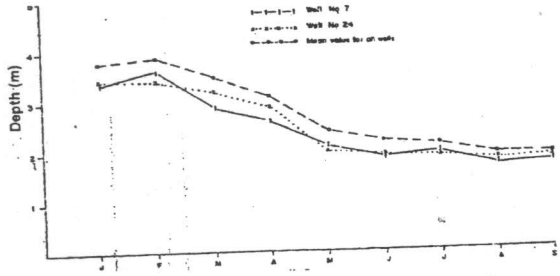

Fig. 3 Temporal variation of mean depth to water in the evening

The figures show both the morning and evening readings exhibiting close pattern with very high values between the months of January and March, after which the values drastically dropped between the months of April and May. The reason for this is not unconnected with the water budget position of the study area which prevented the early rainfall received in March/April to cause any significant rise in water table. This period is regarded as time of "occult recharge". This was followed by a period of rapid rise of water table in May/June when soil moisture deficit position has been overcome.

Depth of Water

Data on depth of water show the variation in thickness of the zone of saturation at each observation site. This parameter is one of the strongest factors determining the volume of well water. The maximum water level (morning and evening) for all the wells was recorded in August while the minimum was recorded in February. Wells numbered 7,14 and 18 recorded the greatest depth of water while wells numbered 10, 17 and 22 recorded the lowest. The reason for this may be due to the fact that, the first sets of wells were located on a very good water yielding aquifer. A value of 1.85 m was obtained as the mean value of

depth of water in the study area while 0.85 m and 45.11% were obtained as the standard deviation and coefficient of variation respectively. Figures 4 and 5 depict the temporal variation in depth of water for two of the sampled wells (well numbers 7 and 24) and the mean value for all the sampled wells. The graph exhibits similar pattern like depth to water. The mean depth of water was lowest in January/February and rises to its peak values between the months of July and September.

Diameter of Wells

Well diameters in the study area ranges between 0.17 m and 1.41 m with a mean value of 1.04 m Values of 0.26 and 17.59% were obtained as the standard variation and coefficient of variation respectively. Thus, well diameters exhibit high variability in the study area.

Volume of Well Water

Data on volume of well water shows a very high variability. Highest volume of water in all the wells was recorded in August while the least was observed in February. Well number 18 recorded the highest volume with a mean yield of 3.72 cubic meters (982.1 US gallons) for the study period while well number 17, which had no water for the first five months during the data collection period, recorded the lowest mean volume of 0.06 cubic meters (15.8 US gallons). The reason for the very low yield of well number 17 may not be unconnected with the shallowness of the well which is just 1.67 meter deep. This value is less than the mean value of 4.64 meters obtained for all the wells.

However, various factors account for the high variation in the volume of well water. These factors apart from the effect of climate include well diameter, depth of well, relief of the area where such well is sited and the nature of underlying rock.

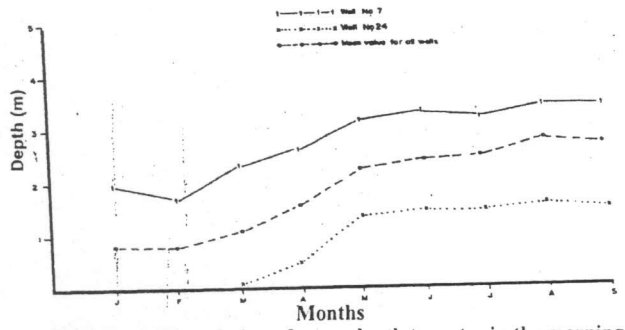

Fig. 4 Temporal variation of mean depth to water in the morning

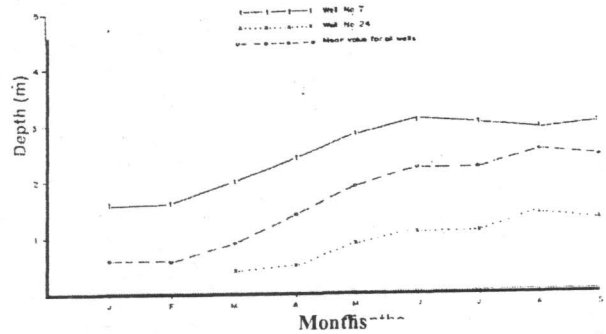

Fig. 5 Temporal variation of mean depth to water in the evening

Relationship between well characteristics and water yield

Table 2 shows the correlation matrix generated between the five variables examined vis: depth, well diameter, depth to water, depth of water and volume of well water. Though all the five examined parameters are positively related to well yield; volume of well water is significantly related (r = 0.60) to only three of the five characteristics. This is with well depth (r = 0.63), depth of water (r = 0.81) and well diameter (r = 0.886).

Table 2: Correlation Matrix of the Well Characteristics

	X1	X2	X3	X4	X5
Well depth	1.00				
Well diameter	0.09	1.00			
Depth to water	0.79	0.16	1.00		
Depth of water	0.81	0.34	0.36	1.00	
Volume of well water	0.63	0.87	0.54	0.81	1.00

Source: Author's fieldwork

The significant relationship between well depth and volume of water is expected. This is because, substantially deep wells are able to penetrate deeper into the water table, hence making the yields of such well to be less subjected to the influence of climate. In the same vein, wells with wide diameter permits considerable storage of water than those with smaller diameter, hence the significant relationship between well yield and well diameter.

The relationship between well yield and well characteristics is further subjected to multiple regression analysis; the result is as presented in Table 3.

The result shows that the four examined variables combined to explain 78.1% of the total variance in well yield in the study area. The relationship is expressed by the equation:

Well water yield = 1.698 0.166 well depth + 1.443 well diameter + 0.215 depth to water + 1.156 depth of water

.....(eq. 1)

Table 3: Multiple Regression between Well Water Yield and Well Characteristics

Variables Intercept	Regression Coefficient	Standard error	T-test	Significant Level	R^2 explains %
Intercept	-1.698	0.596	-2.849	0.009	
Well depth	-0.166	0.418	-0.380	0.008	
Well diameter	1.443	0.419	3.443	0.002	78%
Mean depth to water	0.215	0.479	0.449	0.658	
Mean depth of water	1.156	0.430	2692	0.013	

Source: Author's fieldwork

The result thus indicates that well depth is the most important well characteristic affecting well yield in the study area

Conclusion and Recommendations

This study, which focused on the effects of well characteristics on water yield, was based on data collected from direct field work covering twenty seven wells in three rural communities of Kwara State, Nigeria. The result showed that well water yield is a function of well depth and diameter. In order to increase the quantity of water supply in the study area, the study thus recommends:

i. Deepening of the unproductive wells in the study area so as to remove the loose particles of soil and other debris already accumulated in them. This is to allow for deeper penetration of the wells into the water table so as to yield substantial volume of water throughout the year. If this is done, the problem of well water replenishment not matching rate of withdrawal especially during the dry season will substantially be reduced.

ii. Government should team up with the villagers to sink more wells in the area. Digging should however be carried out during the dry season when the water table must have gone down to stable level. Such wells should be modern type with covers; they should have concrete lining and be fitted with pumps for lifting water to a raised tank from where it can be drawn using taps. This suggestion will not only ensure adequate water supply throughout the seasons, but also solve the problem of water contamination and prevent the usual breakdown problem associated with the use of hand pump wells.

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