



Static Water Level and Elevation Analyses of Shallow Hand-Dug Wells in Ilorin Metropolis, Nigeria

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Authors' contributions

This work was carried out in collaboration among all authors. Author OEO designed the study, wrote the protocol and wrote the first draft of the manuscript. Authors HOS and SOA managed the analyses of the study and the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Aim: This study was conducted to reveal the depth to water level and surface elevation in selected hand-dug wells within Ilorin metropolis to assist in planning and management of water resources within the study area.

Place and Duration of Study: The study was conducted in Ilorin metropolis, North Central, Nigeria.

Methodology: A total of twenty-six (26) hand-dug wells were sampled and relevant spatial information was acquired using a handheld GPS; data collected include: longitude, latitude, elevation and depth to water, then the static water level above sea level was estimated by the difference between depth to water and elevation. Statistical analyses such as mean and standard deviation were determined, also a base map, contour maps and 3-D elevation model of the study area were produced using ArcGIS 10.4 and Surfer 10 software.

Results: The depth to water within the study area ranges between 1.6 m and 13.3m, while elevation were between 284.1 m and 377.9 m, then the static water level ranges between 270.8 m and 371.4 m. The static water level contour map showed a radial and multidimensional groundwater flow

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pattern trending in the NE–SW and NW–SE directions while the 3-D elevation model revealed an undulating terrain.

Conclusion: The study concluded that the depth to groundwater is relatively shallow and this can guide proper development and management of groundwater resources within the metropolis.

Keywords: Groundwater, static water level; elevation; Ilorin metropolis; hand-dug well.

1. INTRODUCTION

A well is a source of water been dug or drilled into the ground to access groundwater in an aquifer below the water table [1]. No doubt, the high demand on limited freshwater resources and the susceptibility of surface water sources to pollution has increase the dependency on groundwater globally. In Nigeria, the legal publication of the 2006 census reported that an estimate of 48% (about 67 million) Nigerians makes use of surface water for domestic activities, 57% (79 million) depends on hand dug wells, 20% (27.8 million) harvest rain water, 14% (19.5 million) have access to pipeborne water and 14% (19.5 million) have access to borehole water sources [2,3]. This noticeable low access to pipeborne water and boreholes can be traced to the high financial cost of installing these facilities by an individual, hence majority of such facilities are provided or supported by Government and Non-governmental agencies or wealthy individuals.

Edungbola [4] and Ajibade [5] revealed how limited water resources were in Ilorin metropolis before the development of dams such as Agba dam in 1952, Asa Dam in 1978, to meet the challenging demand of providing assessable potable water for the populace. Studies on hydrogeological characterization of groundwater sources in Ilorin metropolis provide efficient description of water level, flow rates, pumping/recovery tests, aquifer transmissivity, drawdown, overburden thickness etc., but with main emphases on boreholes [6,7,8,9,10]. Meanwhile, there is dearth of studies on hydrogeological analyses of shallow hand-dug wells which are the most utilized and closest to the poor masses Therefore, this study is aimed to reveal the depth to water level and elevation information in selected hand-dug wells within the metropolis which can assist in planning and management of water resources in the environment.

1.1 Study Area

Ilorin is the capital of Kwara State, Nigeria (Figure 1). The study area is within Ilorin

metropolis located between longitude 4° 28' to 4° 40' and latitude 8° 21' to 8° 33', which is geologically underlain by the Pre-Cambrian Basement Complex comprising of migmatites, gneisses, metasediments, and overburden made up of clay, sand and silt therefore making weathered/fractured rocks the common source of groundwater at greater depth as the regoliths/overburden forms the seasonal aquifer near surface [10]. Ilorin metropolis drainage system forms a dendritic drainage pattern with River Asa flowing across the town forming tributaries such as Rivers Agba, Aluko, Atikeke, Mitile, Alalubosa, Odota, Okun, and Osere. The elevation above the sea level across the metropolis ranges between 200 m to 394 m [11].

2. METHODOLOGY

A total of twenty-six (26) hand-dug wells were sampled within Ilorin metropolis based on their close proximity to old filling stations with buried underground storage tanks containing petroleum products at shallow depths, where spatial information such as longitude, latitude and elevation were obtained using a handheld Global Positioning System (GPS). The difference between the depth to groundwater level and the earth surface was used to determine the static water level above sea level. These information was statistically analyzed for mean, standard deviation, range of depth and elevation across the study area to know the level of dispersion. ArcMap 10.4 and Surfer 10 geographic information system software were used to produce the study area map and contour maps for analyses using the coordinates (latitude, longitude and elevation), and depth to water level respectively.

3. RESULTS AND DISCUSSION

3.1 Descriptive Analysis of Static Water Level and Elevation

The coordinates, elevation, depth to water and static water level were presented in Table 1, while the statistical summary of lowest and highest levels, mean and standard deviation in Table 2.

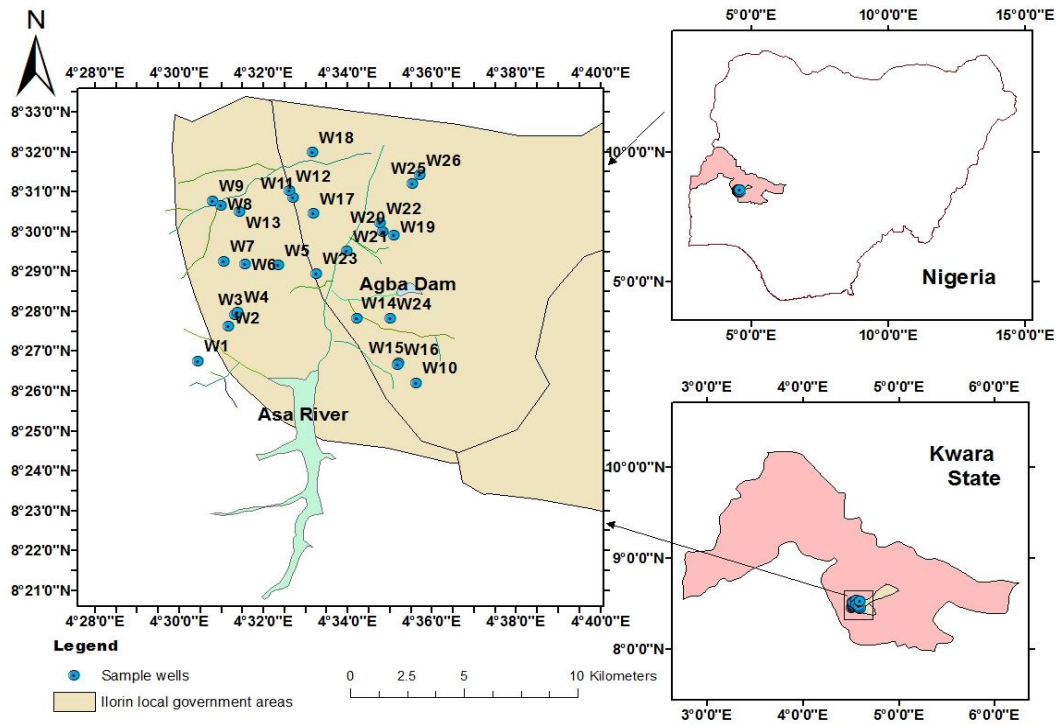


Fig. 1. Map of the study area (Showing Nigeria and Kwara state inset) (Developed by author using ArcGIS)

The depth to water were found to range from 1.6 m to 13.3 m with the mean value of 5.7 m as compared to a previous study in the metropolis that revealed a range of 2.06m to 10.3m with a mean value of 7.08 m [9], and a similar research in Ilara-Mokin town, Ondo State, a Precambrian Basement Complex rock underlain environment with depth to water ranges between 1.85 m and 8.07 m and mean value of 4.76 m [12]. This variation supports the statement that there is a high level of uncertainty in groundwater management in basement aquifers [13].

Elevation within the study area varies between 284.1m and 371.4m with a mean value of 320.6m, this is within the reported range of altitude in Ilorin as revealed in Olabode, Ajibade, & Yunisa, [11] of 200 m to 394 m. Static water level above sea level from depth to water level and elevation above sea level ranges between 270.8 m and 371.4 m with a mean value of 314.9 m as compared to a previous work [14] where static water level of wells and boreholes in Ilorin ranges between 288.5 m and 357.0 m with a mean value of 313.8 m.

3.2 Contours and 3-D Elevation Mapping of the Study Area

The Static water level above sea level and surface elevation data were converted to Digital Elevation Model (DEM) using 3D analyst softwares. The contour maps were generated using Surfer 10 by applying the kriging statistical method to make grids, the produced grids were subsequently used to model a Static Water Level contour map showing groundwater flow direction (Fig. 2), 3-D elevation model of the metropolis (Fig. 3) and an overlay map of the elevation and static water level (Fig. 4).

Fig. 2 revealed a pictorial representation of the static water levels and the groundwater flow pattern based on the principle that water in its normal state flows in a perpendicular direction from zone of higher elevation to lower elevation suggesting that wells dug in zones of lower elevation will possible have high volume of water based on the hydrogeological condition of the aquifer [12].

The 3-D elevation map (Fig. 3) also revealed a topographical view of the undulating structure of the terrain within the study area, as well as an overlap of the contour maps of both the static water level and elevation is shown in Fig. 4.

Table 1. Descriptive information within the study area

Code Name	Latitude	Longitude	Elevation	Depth to water	Static water level
W1	8.44594	4.50763	363.1	3.5	359.6
W2	8.46053	4.51973	377.9	6.5	371.4
W3	8.46525	4.52238	344.2	3.2	341.0
W4	8.46647	4.52328	356.3	2.2	354.1
W5	8.48589	4.53958	284.5	3.1	281.4
W6	8.48639	4.52606	308.3	5.4	302.9
W7	8.48765	4.51771	342.1	8.1	334.0
W8	8.51077	4.51688	305.1	4.8	300.3
W9	8.51281	4.51335	301.7	1.8	299.9
W10	8.43674	4.59390	376.9	10.9	366.0
W11	8.51418	4.54533	311.8	4.0	307.8
W12	8.51713	4.54382	304.0	6.2	297.8
W13	8.50819	4.52404	313.4	2.0	311.4
W14	8.46375	4.57044	317.6	4.6	313.0
W15	8.44509	4.58683	362.1	10.9	351.2
W16	8.44442	4.58652	360.4	8.7	351.7
W17	8.50753	4.55324	290.5	5.0	285.5
W18	8.53314	4.55285	291.0	7.0	284.0
W19	8.49849	4.58500	318.8	3.2	315.6
W20	8.49987	4.58069	308.6	1.6	307.0
W21	8.49179	4.56640	284.1	13.3	270.8
W22	8.50355	4.57947	300.6	4.4	296.2
W23	8.48253	4.55449	302.5	8.3	294.2
W24	8.46355	4.58360	319.4	4.7	314.7
W25	8.52010	4.59246	294.9	9.6	285.3
W26	8.52371	4.59544	295.2	5.7	289.5

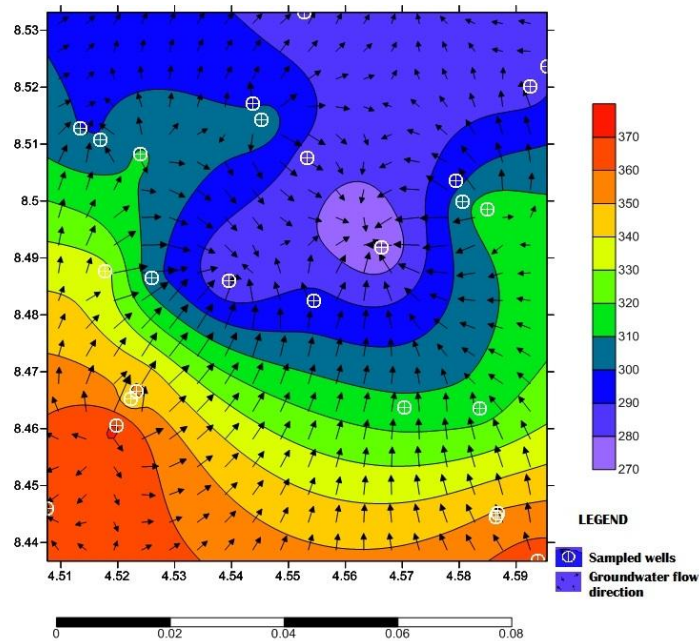


Fig. 2. Static water level contour map showing groundwater flow direction

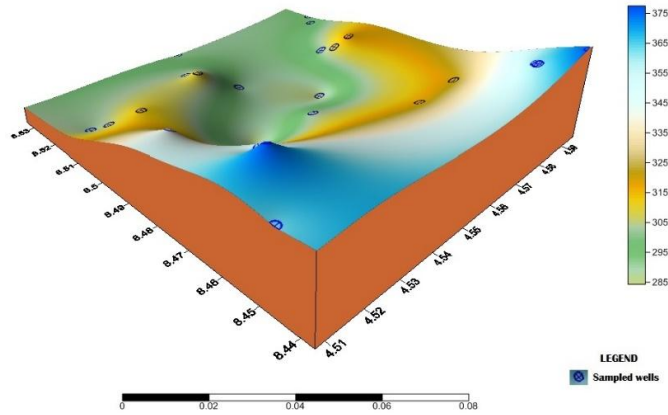


Fig. 3. 3-D Elevation model of the metropolis

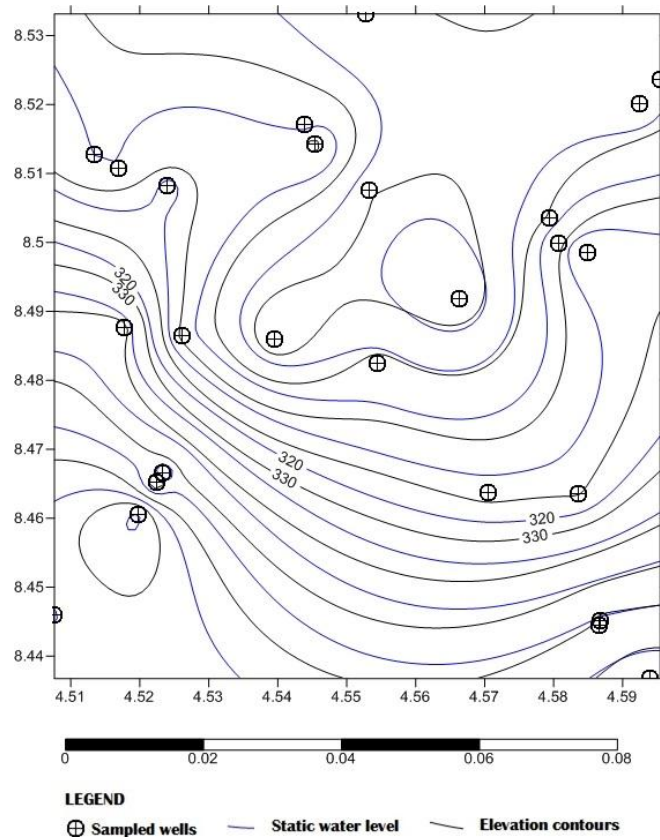


Fig. 4. Overlay map of the elevation and static water level contours

Table 2. Summary of descriptive information on sampled hand-dug wells

Well Information	Lowest value	Highest value	Mean	Standard deviation
Elevation (m)	284.1	377.9	320.6	29.4
Depth to Water (m)	1.6	13.3	5.7	3.1
Static Water Level (m)	270.8	371.4	314.9	29.2

4. CONCLUSION

The depth to water within the study area is less than 14 m indicating the groundwater could be vulnerable to contamination and the groundwater flow direction is generally radial and multi-dimensional, trending mainly in the NE–SW and NW–SE directions. In line with the findings of this study showing near surface and shallow depth to water level in the metropolis, it is suggested that affordable hand-dug wells can be installed in areas where the cost implication for installing a borehole cannot be met in the metropolis. Also, the maps and information obtained in this study will guide and help groundwater prospecting for individuals and households.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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