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Preliminary Investigation of the Groundwater Occurrence in Parts of Ede Metropolis

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Abstract-The groundwater system in the fractured basement rocks identified in parts of Ede metropolis is poorly understood. However, preliminary studies and data obtained in this area show that many parts have poor groundwater occurrences and constant borehole failures and unproductivity. In basement areas, the permeability of rocks are principally secondary arising from fracture development hence, the occurrence of groundwater and the recharge of this fractured zones are based on the vertical and sub-vertical infiltrations of surface and rainwater. Little information exists regarding this process and mechanisms that control the hydraulics such as the groundwater recharge and flow directions in Ede. The purpose of this study is to evaluate the groundwater levels through hand-dug well and the use of VES to determine the geophysical parameter of the subsurface for understanding of the groundwater flow directions, the impact of land use activities on the aquifer recharge and contamination. Preliminary data acquired from 30 water wells taken on monthly bases from January to June, 2016 show spatial variations in the groundwater levels and possible flow direction in Ede. The results show that there are significant variations in the static water levels with values ranging from 14.4% - 55.5%, 4% - 16%, 3% - 14.2%, 0.005% - 12%, and 0.3% - 10%. The variations are due to reduction in the amount of water recharged into fractured zones and change in the well depth with time. Some of the wells especially on the first group have highly weathered pegmatitic material having clay that flows with water. This flow reduces the depth water hole with time if the borehole is down to the appropriate depth and if the borehole is not well completed.

***Keywords: Aquifer, Geophysical, Groundwater, Infiltration, Recharge zones, VES*.**

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1. Introduction

Groundwater is one of the most precious natural resources (Konig and Weiss 2009; Wood, 2002) within the subsurface geology of the earth. In basement area, surface water resources are not everywhere and where available are highly unreliable and prone to contamination; therefore, groundwater is often the primary water resource in these area (Scanlon et al., 2006). Groundwater level (GWL) is an essential factor related to the direction of flow which helps in hand dug well/borehole sitting. It is also important for sustainable groundwater resource management, for grounding and lightning prevention/protection systems, and in understanding the direction of contaminant plume within the subsurface structures (Adebayo et al., 2015; Sakamoto and Sekiguchi, 2001; Gautam and Biswas, 2016). It is therefore necessary to know the direction of groundwater flow and take steps to ensure that land use activities in the recharge area will not pose a threat to the quality of the groundwater Freeze and Cherry, (2002). The electrical resistivity method is suitable in this respect, as it is an efficient and economical method for investigating the presence of groundwater.
Vertical Electrical Sounding (VES), a geoelectrical method, which measures vertical alterations in soil resistivity, was well suited for the subsurface investigation of geologic environments (Nejad, 2009). Vertical Electrical Sounding (VES) has been attested as a popular groundwater prospecting technique

because of its simplicity and it gives detailed information of subsurface geology (Lowrie, 1997; Ezomo and Ifedili, 2006; Ugwu et al., 2016a)

In 1-D resistivity sounding survey there are two electrode configurations that are applied in VES profiling: The Wenner and Schlumberger arrays (Rucker et al., 2009). The Schlumberger configuration of electrodes provides for high signal-to-noise ratio, good resolution of horizontal layers, and good depth sensitivity (Ward, 1990). It is easier to use than the Wenner technique because only two of the four electrodes are moved between successive readings, relatively low cost and its capacity to distinguish between saturated and unsaturated layers (Hadi, 2009).

Little information exists regarding the estimation of GWL and determination of groundwater flow direction in Ede. The purpose of this study is to evaluate the groundwater level by taking the inventory of some hand-dug wells and geophysical parameters of the subsurface establish groundwater flow direction. Measurements of water levels in wells provide the most fundamental indicator of the status of this resource and are critical to meaningful evaluations of the quantity and quality of ground water and its interaction with surface water (Charles and William, 2011).

1.1 Hydrogeology of Ede

Ede is underlain by complex array of rock types of different hydrogeological characteristics most of which are crystalline in nature as in most of south-western Nigeria. The hydrogeological system of basement rocks is complex. These basement rocks are made of impervious igneous rock and metamorphic rock of varying grade. The groundwater here occurs in isolated aquifer controlled by secondary porosity and permeability created by fracturing (Ayayi and Abegunrin, 1990; Lukuman et al., 2015). In fresh, non-fractured crystalline rocks, the porosity is often less than 3% (Offodile, 2011). However, the porosity of fractured depends on the degree of interconnectivity of these fractures and voids. Though there is no known research work that specifically characterize in details the geology of Ede town, a regional description of the geology has been stated. Geological Survey of Nigeria (GSN, 1965) generalized the rock types in the regional area into pegmatite and pegmatite schist. Borehole lithology data shows highly weathered pegmatitic rock which produces clay in highly weathered areas and impermeable non-water bearing formations and in places are fractures of granitic materials of water bearing gravelly and sandy medium.

The generic recharge potentials of crystalline bedrocks based on mineralogy and texture classification (Griffiths et al., 2011), show that the primary recharge potentials of coarse crystalline rocks are high while the secondary potential is medium, that of the fine crystalline rocks are opposite. The recharge potential for metamorphic rocks are medium rock in primary conditions and low for the weathered. This indicated the complexity of the occurrence of water in the basement rock like Ede where groundwater occurs in basin and pockets. Ede has superficial deposit of varying degree of weathering ranging from clayey, silt, lateric stones to gravelly quartzite and sands. This deposits allows the varying infiltrations making a better understanding of the hydrogeologic conditions here important.

2. Methodology

2.1 Hydrogeology investigation

This entailed measurement of the depth to water table (static water level) and actual depth of the wells. It was carried out with the aid of a rope and measuring tape. Thirty water wells were measured on monthly bases from January to June, 2016 in Ede metropolis. Hand held high precision GPS receiver was used in determining the geographical co-ordinate of the water wells. The selection of the number of wells to be monitored to adequately present static water level and the corresponding elevations was based on the existence of high production wells, the frequency of their use and accessibility. Well near rivers are avoided due to the potential for rapid fluctuating water levels. Random sampling within blocks (e.g., randomly selected wells within each section of an aquifer), as adopted as recommended by the department of Water Resources on groundwater Elevation Monitoring Guidelines (DWR, 2010).

To determine and define seasonal and long-term trends in groundwater levels a consistent measurement frequency must be established. At minimum, semi-annual monitoring of the designated wells in each basin or sub-basin should be conducted to coincide with the high and low water-level times of year for each basin. A monthly monitoring frequency was adopted for this research. This quarterly or monthly-monitoring of wells provides a better understanding of groundwater fluctuations (DWR, 2010).
For the water level measurement, a graduated steel tape was used. The steel tape was sanitized using a weak bleach solution and rinsed with the water from the particular well to be measured to avoid contaminations. The interpretation of the ground water levels in the wells were done by plotting the data versus time. This type of figure is known as a hydrograph.

2.2 Geophysical investigation

The preliminary investigation of the groundwater occurrence would be followed up by geophysical investigation. Vertical Electrical Sounding (VES) employing, the Schlumberger array would be used during the geophysical investigation. The sitting of VES points would be guided by water well locations. The resistivity sounding data would then be interpreted using appropriate software to obtain better estimation of resistivity and thickness values of the subsurface layers. Depth to the groundwater table below the surface in the study area is therefore determined. The interpreted result of the vertical electrical sounding would complement the result of the hydrogeology investigation.

3. Results and Discussion

Due to the heterogeneous variation in the hydrogeological characteristics of basement rocks the thirty wells under investigation were classified under 5 groups depending on their closeness to one another A close look at the static water levels in the various wells across the groups indicates varying degrees of reductions (Figures 1-5).
The possible reasons for these variations in the Static water levels in the aquifer are climatic condition, the rate of recharge of the fractured zones, the rate of abstraction and land-use activities. However, because the wells under study are under the same climatic conditions the important parameters considered to having serious influence on the water resources in Ede are the land use conditions, the rate of recharge and use of the resource, the depth and completion of the wells.
The most affected wells in terms of decrease in the static water levels are in the group one with value ranging from 14.4% - 55.5%, the second group have values in the range of 4% - 16%, the third group is from 3% - 14.2%, group four from 0.005% - 12%, while fifth group ranges from 0.3% - 10%. Another striking observation made in some of the wells is the loss of depths within 6 months of the study in well under group one and two.
The groups 1 and 2 (Figures 1 & 2) shows water wells with the highest ranges in the decrease of the static water levels due partly to loose in the depths in the wells, reduction in the rate of recharge and rate of use of water. Their locations could have been closer to the areas of recharge and hence the wide ranges of changes in the static water levels. The groups three and four (Figures 3 & 4) had less reduction in the static water levels and also reduction the well depth with time. Group five show another area close to the recharge zones but with more stable rock material since the depth remained fairly constant throughout the time of study.

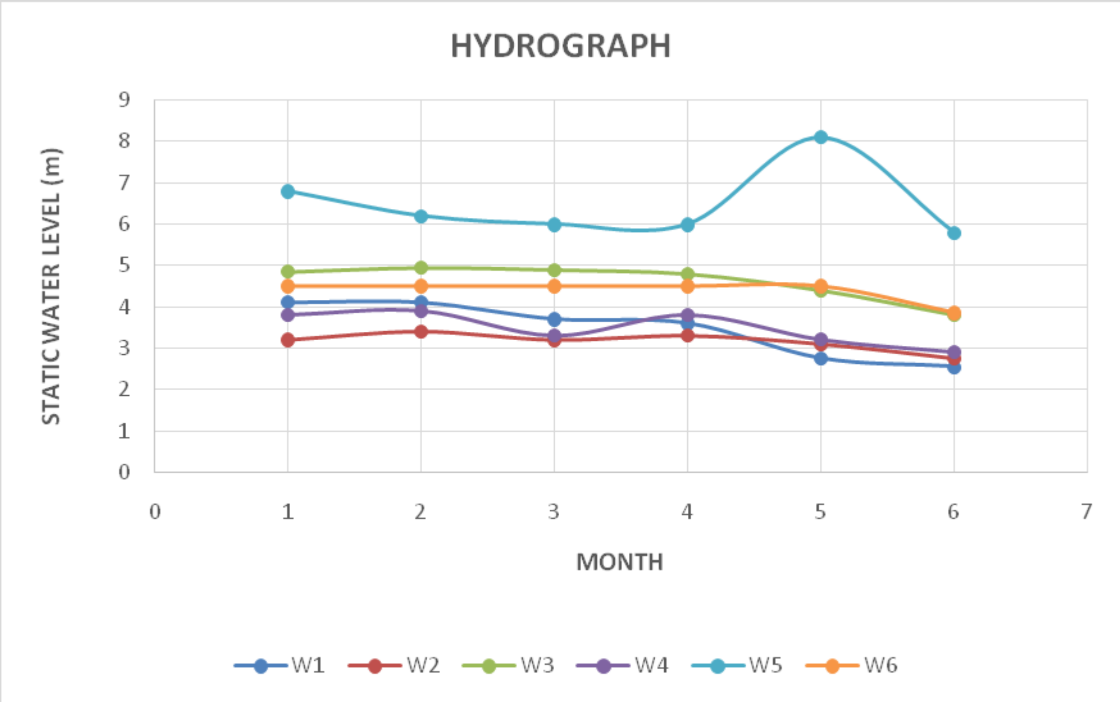

Figure 1: Static water levels for group one for group one with depth variation of 14.4% - 55.5%

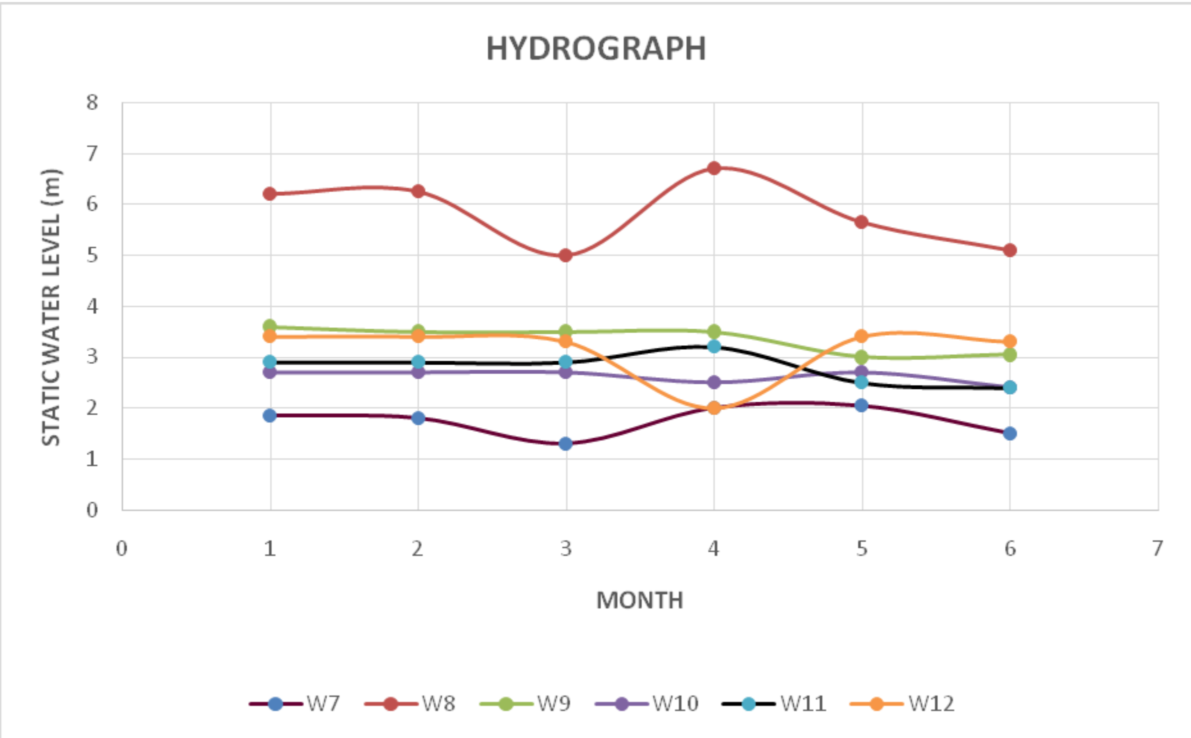

Figure 2: Static water levels for group Two with depth variation of 4% - 16%.

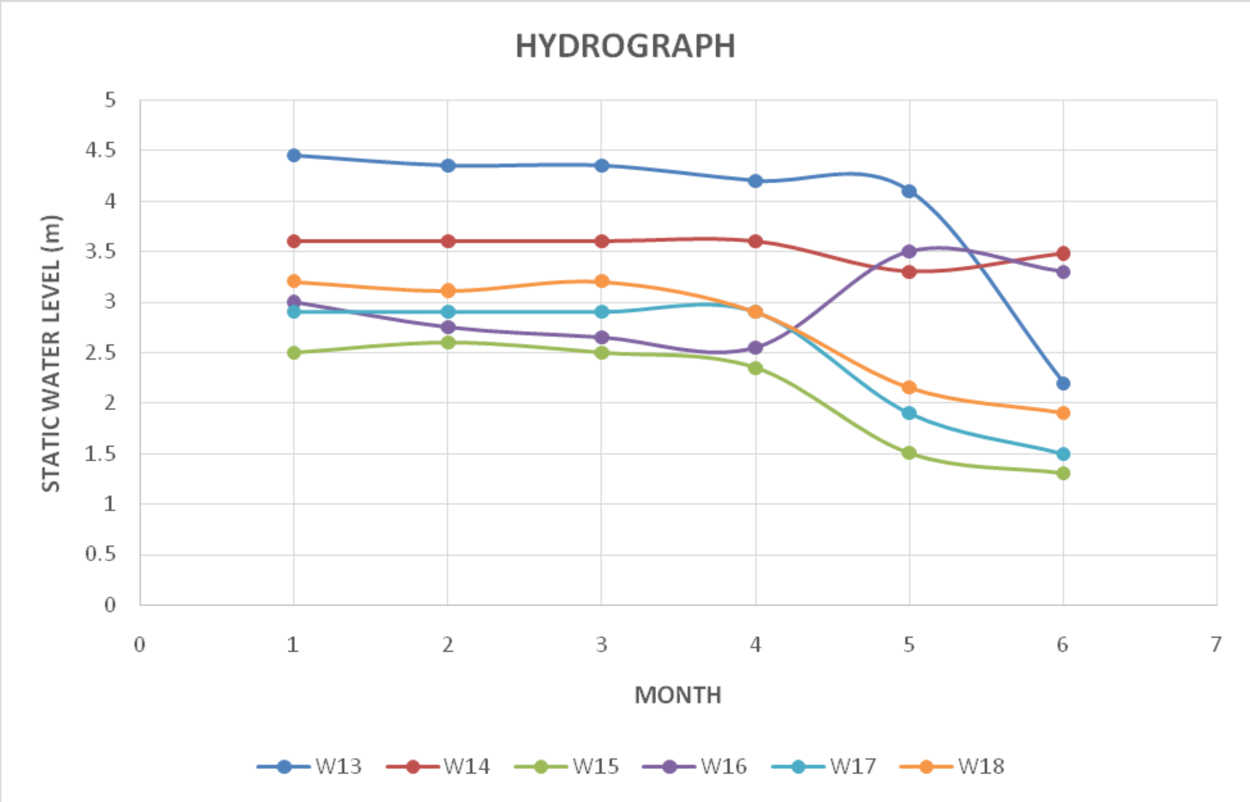

Figure 3: Static water levels for group Three with depth variation of 3% - 14.2%.

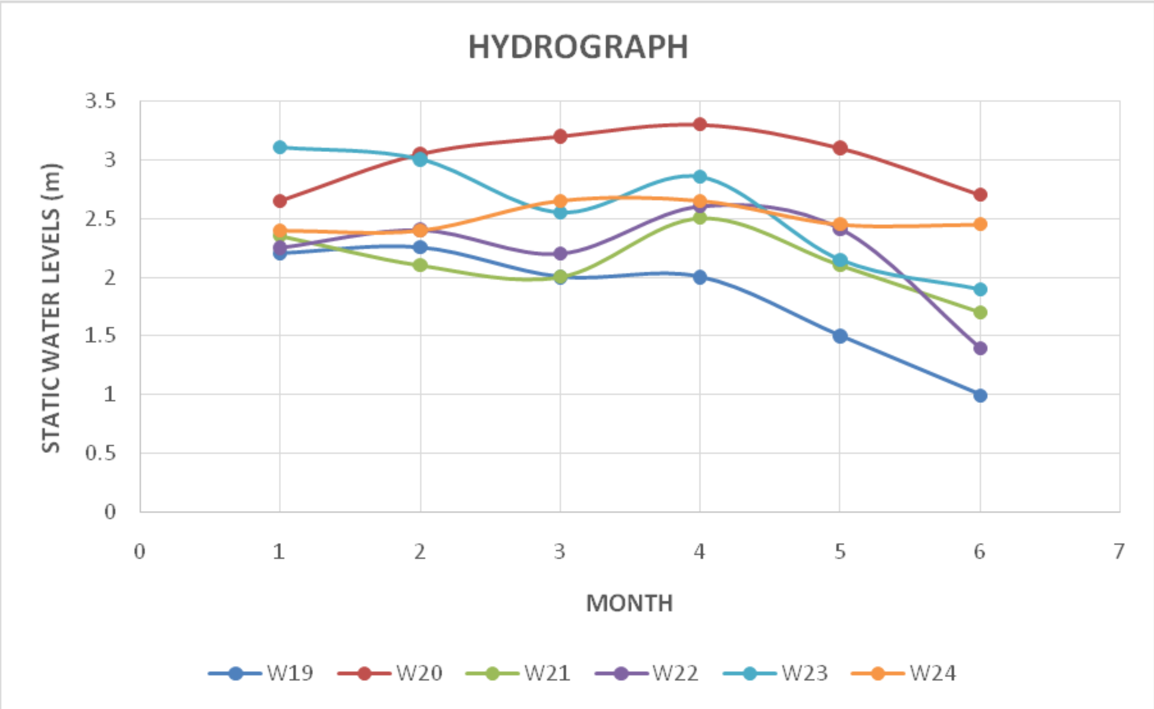

Figure 4: Static water levels for group Four with depth variation of 0.005% - 12%.

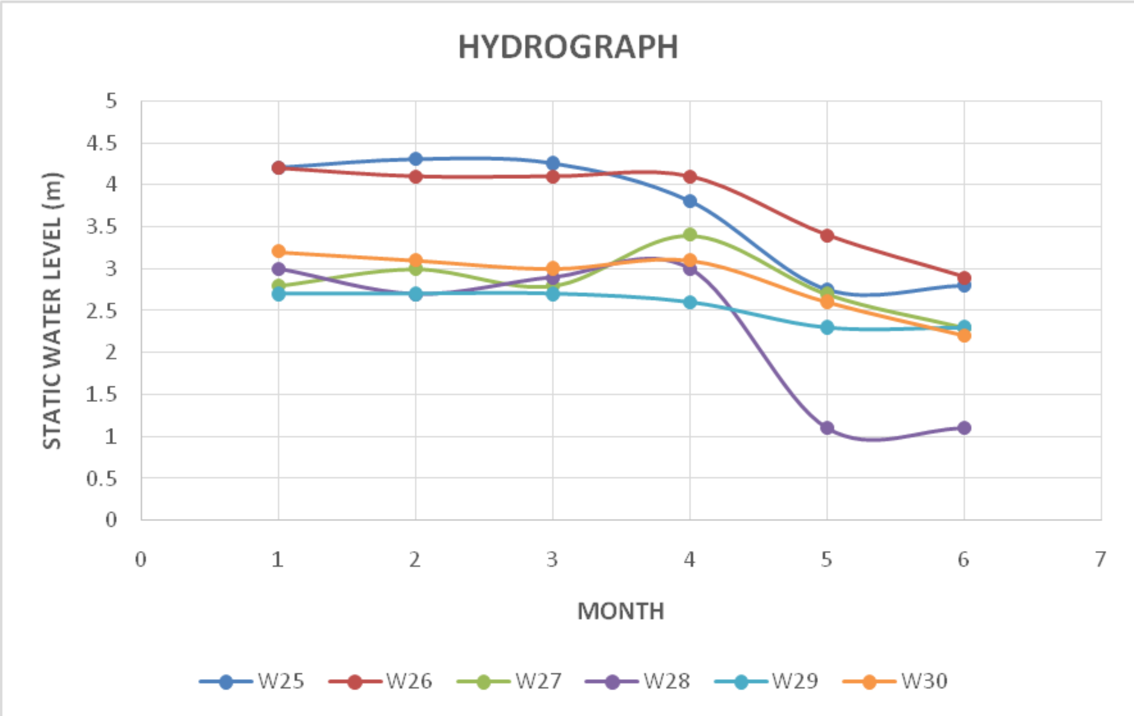

Figure 5: Static water levels for group Five with depth variation of 0.3% - 10%.

4. Conclusion and Recommendations

The study shows that there are significant variations in the static water level in Ede with values ranging from 14.4% - 55.5%, the second group have values in the range of 4% - 16%, the third group is from 3% - 14.2%, group four from 0.005% - 12%, while fifth group ranges from 0.3% - 10%. The variations are due to reduction in the amount of water recharged into fractured zones. Some of the wells especially on the first group have highly weathered pegmatitic material having clayey materials that flow with water. These clays reduce the depth of the water hole with time. However, the study should be carried on periodically for some years to establish better models and hydrogeological characteristics of the groundwater system in Ede for sustainable water development and management.

Geophysical and Geological survey of any point for groundwater development should be carried out, and interpreted to determine the thicknesses and depth to the water bearing aquifer of such a point. The flood plains should not be built on to encourage adequate infiltration to the aquifers; and lastly borehole should be drilled to an appropriate depth into the water bearing bed and pump installed at lower depths to avoid the effect of seasonal variation in the static water level.

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