Journal of Environmental Science and Resources Volume 4, June 2012

www.cenresinpub.org
ISSN 2277-0097

DETERMINATION OF SEASONAL VARIATIONS OF AQUIFER DEPTH IN A PART OF BASEMENT COMPLEX OF ILORIN METROPOLIS

S. Olatunji[1*] and L. M. Johnson[2]
[1] Department of Physics, University of Ilorin, Ilorin, Nigeria
[2] Department of Geology and Mineral Science, University of Ilorin, Ilorin, Nigeria.
E-mail: sam61ng@gmail.com.,mobolajijay@gmail.com

ABSTRACT

Depth to water table was monitored for six consecutive months by direct measurement in nine hand-dug wells within Ilorin metropolis, lying within the basement complex of north central Nigeria. Weekly time series of rainfall and well water level were cross-correlated to investigate seasonal variations in groundwater-level response times, based on periods of 6-month duration. The aims are to monitor the fluctuation of the aquifer recharge, determine the drying rate, detect possible seepage in the studied wells and to analyse geohydrological information. The result shows that in two of the wells some volumes of water are leaking fast at the rate of 0.333m/week and 0.295 m/week to the host rock probably through underground connected pores. This could imply that the wells are seated on fractured and or porous basement. Further with exception of well 2, all other wells show appreciable response to the rainfall. This implies that rainfall is a major recharge source to the aquifer in the study area.
Key words: *Well, Aquifer, Aquiclude, Drying-rate, Recharge, Borehole.*

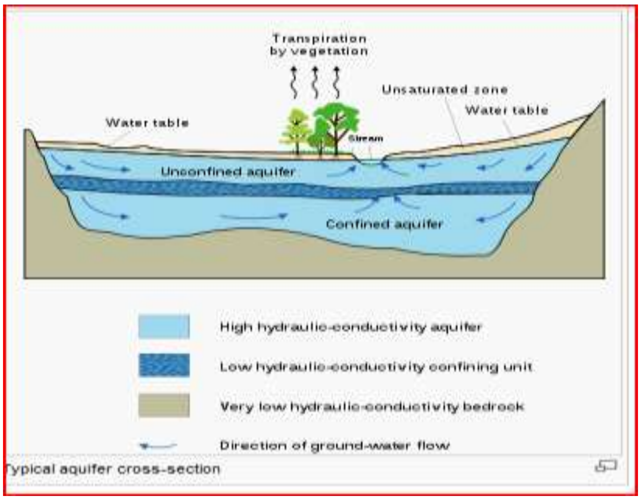
INTRODUCTION

Water is needed to survive. Water is not only necessary for drinking but also for irrigation and hygiene. Common sources of useable water around the area in question are borehole, spring, river, rain and hand dug wells. High cost makes borehole out of reach for common man. Spring and river water are easily contaminated by activities such as fishing, sewage flow, drainages etc. Olugboye (1978) Rain sourced water is seasonal. Not less than four months are off the raining period per year in the area. Hand dug well is sometimes cost intensive for local people and poses danger to the passer-by. However, it appears the most reliable source especially to the local community as it is to be sited anywhere and sometimes it can be resourceful round the year. Hand dug wells are dug until at least first aquifer is encountered. Hence, hand dug wells vary in diameter and depth. When using a ventilator for fresh air during digging, it becomes even possible to dig up to 30 meter or more. A hand dug level determines how to support the walls.

Aquifer

An aquifer is a geologic formation, group of formations, or part of a formation that contains sufficient saturated permeable material to yield significant quantities of water to springs and wells (McGinley 2007) That is, aquifers are underground layers of porous rock or sand that allow the movement of water between layers of non-porous rock (sandstone, gravel, or fractured limestone or granite). Water infiltrates into the soil through pores, cracks, and other spaces until it reaches the zone of saturation where all of the spaces are filled with water. The zone of saturation occurs because water infiltrating the soil reaches an impermeable layer of rocks so that it is not able to penetrate any further into the earth. This impermeable layer is known as an aquitard/aquiclude. The top of the zone of saturation is known as the water table. The water table typically follows the form of the above ground topography. The depth of the water table is typically greater in regions with low rainfall than in regions with high rainfall. The water table can rise in wet years and fall in dry years. (McGinley 2007)

Aquifer can be classified into confined/artesian, unconfined/pyretic/free, semi-confined and complex (Fig. 1) Confined aquifer is bounded up and below by aquiclude and filled with water which is under pressure. Unconfined aquifer is usually underlain by aquiclude but the top of the aquifer consists of soil layers that are permeable enough to provide easy passage of water, at least in vertical sense. A semi-confined aquifer is an aquifer underlain by an impermeable stratum and bounded at the top by soil layers of relatively low permeability (hydraulic conductivity), especially in horizontal sense. Some characteristics that determine the quality of an aquifer include depth, thickness, porosity, pore connectivity, recharge sources etc. Aquifer recharge sources in the area studied are mainly rain and underground flow.



Typical aquifer cross-section

Fig. 1: Cross-section of Typical

Movement of Water through Aquifers

Two main forces drive the movement of groundwater as hydraulic head. First, water moves from higher elevations to lower elevation due to the effect of gravity. Second, water moves from areas of higher pressure to areas of lower pressure due to pressure gradient created around the area. Subsurface water has the potential to move through four different types of rocks: unconsolidated rock like sand and gravel, porous sedimentary rocks, porous volcanic rocks like basalt, and fractured rocks. Movement in the consolidated rocks is through fractures. The amount of movement through fractured rock depends on the frequency and interconnectedness of the fractures (Driscoll1986, McGinley 2007)

Brief Geomorphology and Geology of the Area

The area lies in the Precambrian Basement complex of northern Nigeria around coordinate 8.5131^0 N and 4.609^0 E (Fig.2) and is underlain by rock of metamorphic and igneous type. The hydrological setting of the area studied is typical of what is obtained in other Basement complex area where the availability of water is a function of the presence of thick-little clay overburden material and presence of water filled joints, fracture or faults within the fresh Basement rocks. The humid tropical climate of Ilorin has particularly encouraged relatively deep weathering of the near surface rocks to produce porous and permeable material that allows groundwater accumulation as shallow aquifer which is recharged principally through infiltration of rainwater.

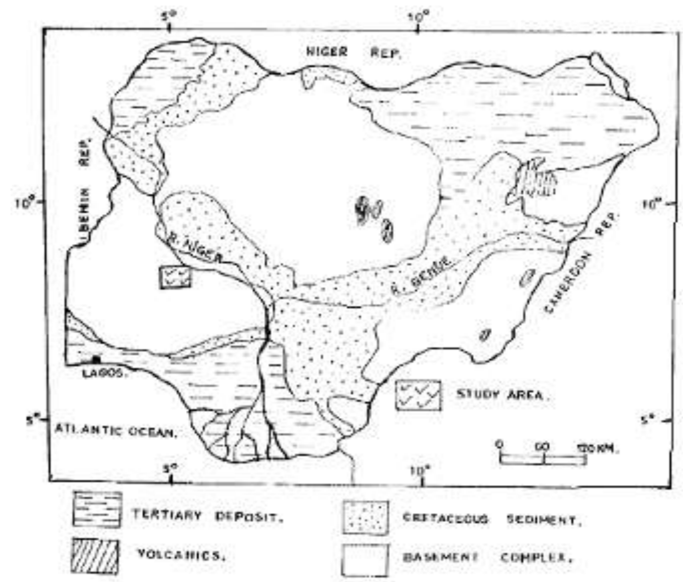


Fig. 2: Simplified Geology of Nigeria Showing the Location of the Study Area
(After: GSN, 1984)

Basement rocks of north Nigeria has been classified into four by Jacobson, Snelling and Truswell (1963). Rahman (1976), in his review of the Basement complex geology of southern Nigeria, recognized five major groups of rock. Also, Odeyemi, (1976) classified specified four classes. These are summarised *viz:*

- The migmatite-gneiss complex
- The metasediment, complex of schist, calc gneiss, quartzite and meta-conglomerate.
- The phophoritic older granite.
- Miscellaneous rock type, mostly post orogenic like Aplites, pegmatite, and dolerite dykes.

The geology of the study area (Ilorin) may be grouped in to:

a Surface/Superficial Geology

Apart from the obvious outcrops of solid rocks in some places, most part of the area is covered by dark sandy or clayey loam top soils. This is usually followed by laterite and red soil which form the bulk of the superficial deposited with thickness varying between 4-8m. These obscure much of the underlying geology. In some cases, the laterites may form capping and are exposed on a few ridges (Olugboye 1978)

b Subsurface/Solid Geology.

This is composed of the weathered, slightly weathered and fresh (fractured or unfractured) crystalline Basements rocks. The oldest rocks in the area comprise Gneiss complex whose principal member is biotite-hornblende gneiss with intercalated amphibolites. This underlies over half of the study area other rocks types are the older granites mainly porphiritic granite, Gneiss and granite-gneiss and quartz-schist (Fig.2)

MATERIALS AND METHODS

Instrumentation and Data Collection

Materials used for the field work are shown in table 1. Having located the coordinates and elevations of the nine target wells (Table 2) a loaded rope would be immersed into the well to measure the depth of the water table by an indirect method. This would be measured by direct method on the tape. This was accomplished weekly for six months.

Table 1: Instrument list

S.N.	**Instrument**	**Purpose**
1.	Navigator (i.e. G.PS)	Location determination
2.	Tape rule	Indirect depth measurement

t depth measurement

4.	Thick rope	Direct depth measurement

Table 2: Coordinates and Elevations of the Target Wells

Properties	W1	W2	W3	W4	W5	W6	W7	W8	W9
Latitude(^{0})N	8.5131	8.5131	8.5133	8.5135	8.5132	8.5148	8.5153	8.5153	8.5135
Longitude(^{0})E	4.609	4.609	4.609	4.6093	4.6092	4.6083	4.6080	4.6098	4.6086
Elevation(m)	313	303	306	306	305	310	308	303	306
Azimuth(^{0})	064	310	118	350	336	317	355	039	068

Physical View of the Wells Studied

Well One: (Coordinate: 4.609^{0}E, 8.5131^{0}N)

(a) Top View

(b) Inner View

Well Two: (Coordinate: 4.609^{0}E, 8.5131^{0}N)

(a) Top View

b) Inner View

Well three: (Coordinate: 4.609^{0}E, 8.5133^{0}N)

(a) Top View

(b) Inner View

Well Four: (Coordinate: 8.5135^{0}E, 4.6093^{0}N)

(a) Top View

(b) Inner View

Well Five: (Coordinate: 8.5132^{0}E, 4.6092^{0}N)

(a) Top View

(b) Inner View

Well Six: (Coordinate: 8.5148^{0}E, 4.6083^{0}N)

(a) Top View

(b) Inner View

Well Seven: (Coordinate: 8.5153^{0}E, 4.6080^{0}N)

(a) Top View

(b) Inner View

Well Eight (8) (Coordinate = 8.5153^{0}E, 4.6098^{0}N)

(a) Top View

(b) Inner View

Well Nine: (Coordinate: 8.5135^0E, 4.6086^0N)

(a) Top View

(b) Inner View

RESULTS AND DISCUSSIONS

A weekly variation of depth to water table with time was obtained for each well as shown in figures 3 through 11.

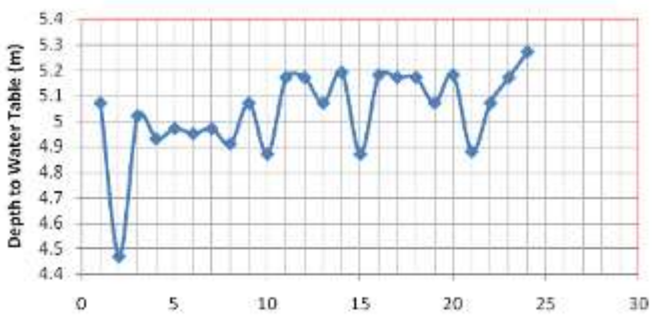


Fig. 3: Depth/Time (m/week)

Well one has the maximum depth to water table of 5.27m and minimum of 4.46m within the month considered (Fig. 3). This gives a drying rate per week of the well as

$$x = \frac{(5.27 - 4.47)}{24} \quad , = 0.033333 \text{ m/week}$$

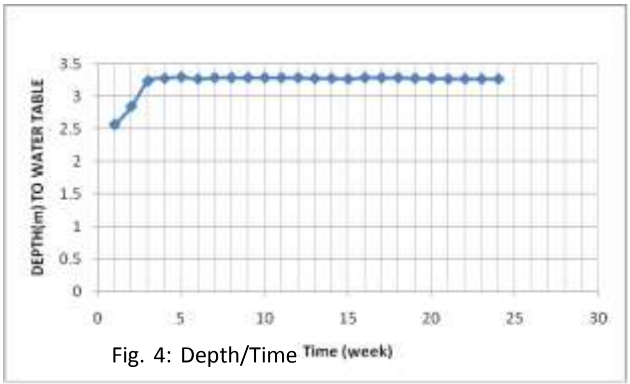


Fig. 4: Depth/Time

Well two (Fig. 4) has a maximum depth to water table of 3.26m and minimum of 2.56m.At week 3-24 a constant depth to water table was maintained due to dryness of the water well.

$$x = \frac{3.27 - 2.56}{24}, = 0.02958 \text{ m/week}$$

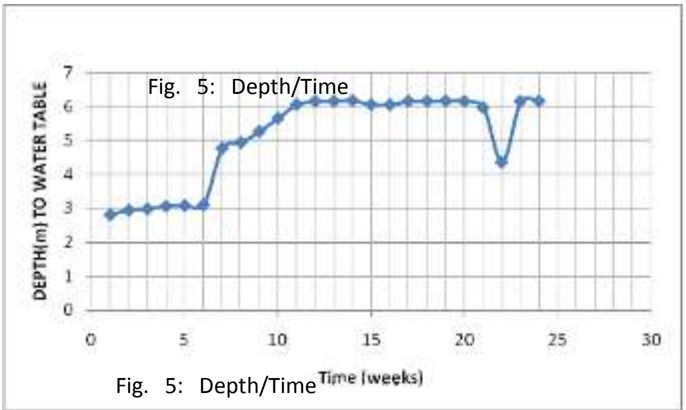


Fig. 5: Depth/Time

In well three (Fig. 5) it is shown that at a particular period of time the depth to water table varies and the drying rate is given below.

$$x = \frac{6.17 - 2.81}{24}, = 0.14 \text{ m/week}$$

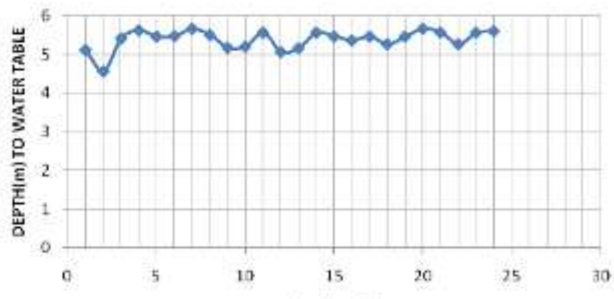


Fig. 6: Depth/Time (m/week)

The depth to water table of well four varies appreciably per week and the variation is between 4.56 m and 5.66m depth (Fig. 6).

$x = \frac{5.66 - 4.56}{24}$, = 0.0458 m/week

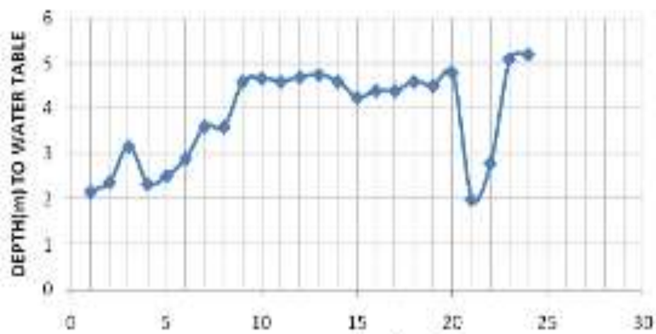


Fig. 7: Depth/Time (m/week)

Figure 7 shows remarkable variations between week 9 and week 20 of the field work in well five. The drying rate is given by

$x = \frac{5.2 - 2}{24}$ **,** **=** 0.1083 m/week

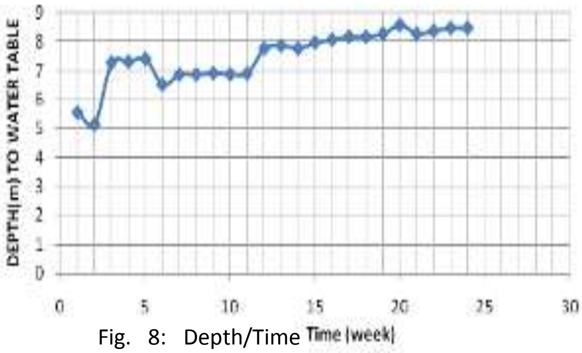


Fig. 8: Depth/Time (m/week)

From the result obtained from well six, at week 6- 11 the depth to water table has a small variation and at week 12, the depth to water table increased (Fig. 8) and the drying rate is given by

$$x = \frac{8.46-5.15}{24}, = 0.1379 \text{ m/week}$$

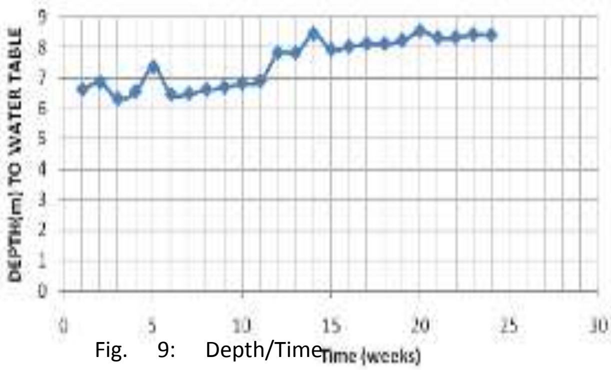


Fig. 9: Depth/Time (m/week)

Well seven which has the maximum depth to table of the entire well used in the field work has a peak value of 8.44 m which occur at week 20 of the research (Fig. 9) The drying rate for well seven = $\frac{8.44-6.62}{24}$, = 0.0758 m/week

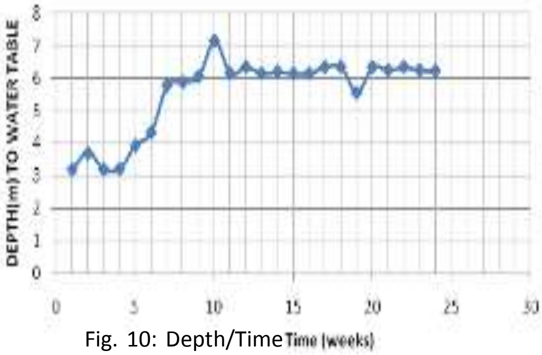


Fig. 10: Depth/Time (m/week)

Well eight has a peak value of 7.14 m (Fig. 10) which marked the maximum depth to water table of the well within the study time

The drying rate for well eight $x = \frac{7.14-3.2}{24}$, **=** 0.1641 m/week

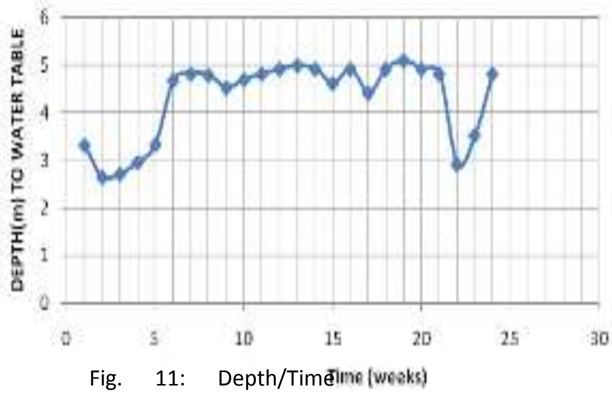


Fig. 11: Depth/Time (m/week)

Well nine experiences small variation within 6th and 21st week. Later at the 22nd week the depth to water table increases due to effect of the new year rainfall (Fig. 11).

The drying rate for well nine $x = \frac{5.1-2.65}{24}$**, =** 0.1020 m/week

Nine wells were used during the field work in the study area. The results for 2nd, 10th, 15th and 21st weeks show that the depth to water table varies due to effect of rainfall whose recharge effects were exemplified on the aquifer. The drying rates obtained for all the wells are summarized table 3.

Table 3: Drying Rates

Well	1	2	3	4	5	6	7	9	10
X (m/week)	0.333	0.295	0.140	0.0458	0.1083	0.1379	0.0758	0.1641	0.1020

It could therefore be suggested that some volumes of water are leaking fast to the Earth probably through underground connected pores. A very high drying rate obtained for wells 2 and 3 could imply that they are seated on fractured, porous basement, as proposed by Oyawoye (1964). Further, with exception of well 2, all other wells shows appreciable response to the rainfall. This could imply that rainfall is a major recharge sources to the aquifer in the study area.

CONCLUSION

This research has provided information on the depth to the shallowest water table and that rainfall appears as the major source of aquifer recharge in the area. Low drying rate in most of the wells could signify that the most of the wells there are underlain by semi or impermeable formation such as fresh basement or slightly fractured basement rock body. This information is vital to the development of an effective water scheme for the area and possibly beyond other areas underlain by the formation. Although the present investigation has not investigated this issue in any great detail, it is concluded that, the major sources of Aquifer recharge is RAINFALL. The drying rate is also moderate in most of the well. This implies that most of the wells could be resourceful within the month studied. In addition it shows that the wells are underlain by impermeable rocks that limit the aquifer leakages.

REFERENCES

Driscoll, F. (1986): *Groundwater and Wells*. St. Paul, MN: Johnson Filtration Systems, 2nd edition. *ISBN 978-0961645601*

Geological Survey of Nigeria, GSN. (1984): *Geological Map of Nigeria*. Publication of the Geological Survey of Nigeria.

Jacobson, R.R.E., Snelling, N.J. and Truswell, J.F., (1963). *Age Determination in the Geology of Nigeria, with Special Reference to the Older and Younger Granites*. In: *Overs. Geol. Min. Resources*. Vol. 9. Pp 168-182.

McGinley M. (2007); USGS; Harold Ornes "Aquifer". In: *Encyclopedia of Earth*. Eds. Cutler J. Cleveland (Washington, D.C.: Environmental Information Coalition, National Council for Science and the Environment)

Odeyemi, I. B., (1976): *A Review of the Orogenic Event in the Precambrian Shallow Ground water Occurrence in the Basement*. Msc. thesis, University of Ibadan Pp.183.

Olugboye, M. O., (1978): Proposals on Rural water supply A hydro geological Case study of the Mopa water supply scheme, Mopa, Kwara state. M.Sc. Thesis, Univ. of Ife, Ile- Ife. Nigeria Pp. 93.

Oyawoye, M. O., (1964): *Geology of Nigerian Basement Complex*. Journal of Mining and Geology. Vol. 1.

Rahman, M. A., (1976): Review of the Basement Geology of south western Nigeria . In kogbe, C. A, (1976. Ed) *Geology of Nigeria*. Elizebethan publishers, Lagos. Nigeria. Pp. 41-58.