DETERMINATION OF GROUNDWATER FLOW DIRECTION IN KUJE, FCT, ABUJA, NIGERIA

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Abstract
Groundwater elevation contour map of Kuje in FCT, Abuja was plotted to determine the groundwater flow direction. Surface elevations, longitudes and latitudes of twenty locations evenly distributed within the study area were measured and recorded with the use of Global positioning system (GPS). Static water level in the hand dug wells of the area was also measured with the aid of a meter tape. Contour map of the area revealed that water flow direction is toward the North-eastern and South-eastern parts of the area. It is therefore recommended that boreholes for potable groundwater exploitation could be sited in the North, South and Eastern parts of the area. The present study act as a guide for future groundwater exploration, hence the information will be useful to both the Government and Individuals especially those in water industries in sinking and maintaining boreholes for optimum groundwater exploitation.

Keywords: Groundwater, Flow direction, Kuje

Introduction
Groundwater is commonly understood to mean water occupying all the voids within a geologic stratum (Deborah *et al*. 1996). It is not usually static but flow through the rock. The ease with which water can flow through a rock mass depends on a combination of the size of the pores and the degree to which they are interconnected (Neilson, 1991). The global importance of groundwater as a major source of fresh water for agricultural and domestic uses cannot be over-emphasized. Approximately 97% of the earth's useable fresh water is stored as groundwater (Delleur, 1999). Also, groundwater constitutes an important component of the water cycle, and it is partly used to maintain soil moisture, stream flow and wetlands, as well as being the sources of drinking water, agricultural and industrial supplies in many parts of the world. However, the flow of groundwater in aquifer does not always reflect the flow of water on the surface. 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 & Cherry, 1979). This is because the water table elevation is approximately the same as the gaining borehole surface elevation, both elevations may be used to construct water table map (contour) and to predict groundwater flow direction (Oseji, 2010). According to (Buddermeier & Schloss, 2000), groundwater would flow from the highest values of contour

lines to the lowest values in direction perpendicular to the contour lines. Given that water always flow from a region of higher head to a region of lower head (Wehrmann, 2007), it is found that groundwater use within an area at a higher water level directly affects the quality of water available to people living in regions of lower water levels (Oseji, 2011). The purpose of this study was to determine the groundwater flow direction within the evenly distributed regions of Kuje in Federal Capital Territory, Abuja. Also, to determine the locations or regions that are likely to suffer more due to groundwater pollution within the study area.

Physical Setting

The study area is in the South-eastern part of Abuja, the Federal Capital Territory of Nigeria. It lies between latitudes 08^0 53' 24'' N and 08^0 53' 47'' N and longitudes 07^0 14' 24'' E and 07^0 14' 35'' E. It is located at about 13.2 kilometer from Abuja municipality (Fig. 1.). The topography of the area is drained by seasonal river channel and undulating. The agent of weathering and erosion being water as indicated by rivers in the mapped area, and biological weathering resulting from plants penetration in between fracture zones of rocks. On exposure to the surface, the rocks are subjected to various temperatures and different form of mechanical, chemical and biological surface processes resulting in the present condition of rocks and its environs.

Geologically, the study area is predominantly underlain by the Precambrian basement complex rocks. The lithological units in the study area are migmatite gneiss, granite, and schistose gneiss. The migmatite gneiss is the most wide spread rock unit. The granite occurs in several locations. They are porphyritic and of medium-coarse-grained texture. Granites mostly occur as intrusive, low-lying outcrops around the gneiss. They are severely jointed and fairly intruded by quartz veins (Oyawoye, 1967).

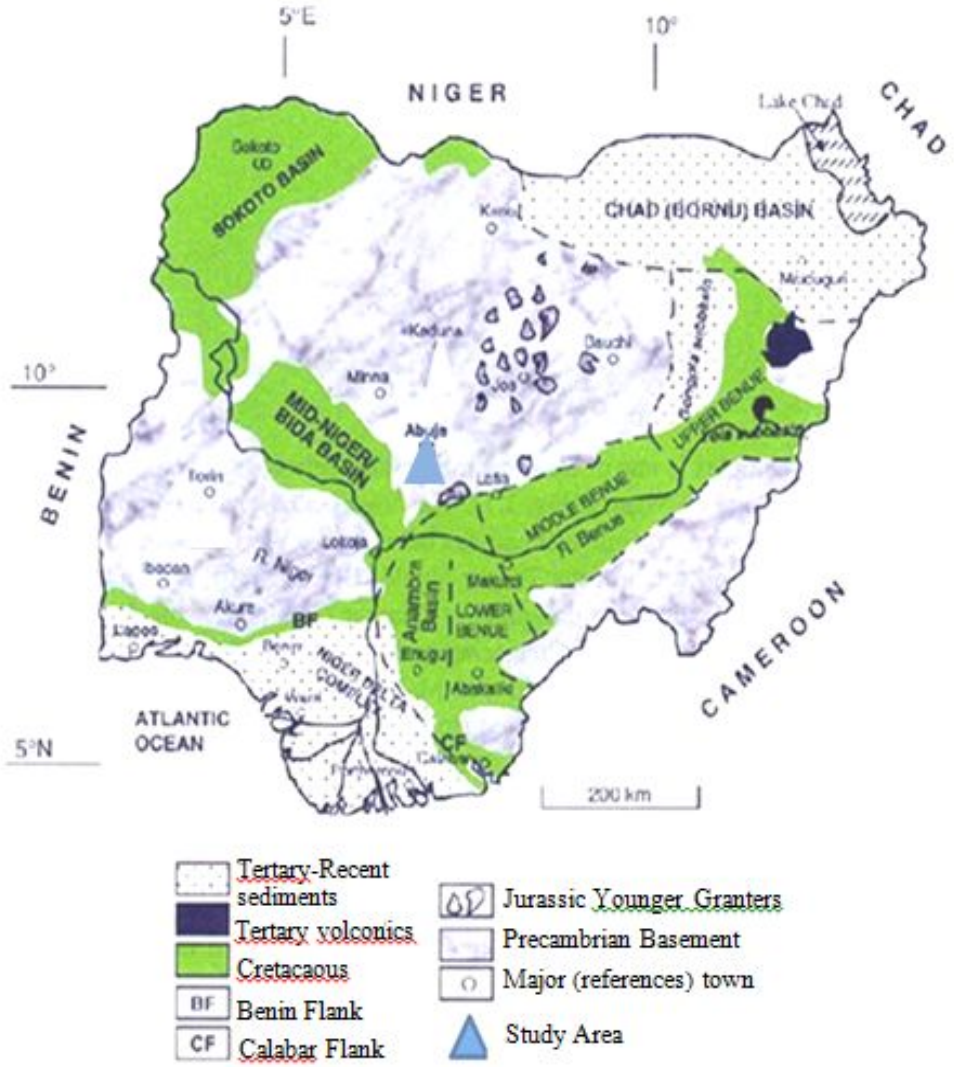

Figure 2: Geological Map of Nigeria (After Obaje & Abaa, 1996)

Methodology

The global positioning system (GPS) was used to measure the longitude, latitude and surface elevations with respect to the mean sea level at twenty locations evenly distributed within Kuje community of FCT, Abuja. With the aid of a meter rule, the depths to the water level in the hand dug wells were measured directly and recorded. The static water level of the different locations were obtained by subtracting the elevation with respect to the mean sea

level from the depth to the water level in the hand-dug well (Buddermeier and Schloss, 2000)

Let *Dwl* = depth from the surface of the earth to the water level in the hand dug wells.
E = surface elevation with respect to the mean sea level

Therefore, $Swl = E - Dwl$

Swl is the static water level otherwise known as the true or uniform water level.

The values of the static water levels were contoured using the longitudes and latitude in mapping out the locations within Kuje Community. According to Buddermeier and Schloss (2000), groundwater flows from the highest values of the contour lines to the lowest values in the direction perpendicular to the contour lines.

Determination of Groundwater Flow Direction

The plotting of static water levels of water sources was done on a map, in the case of this study, hand dug wells. The direction of groundwater flow was determined by constructing perpendicular lines to the contour lines, and the lines pointing away from a high level contour to a low level contour. This method is used in engineering or soil mechanics as a first check from problems of flow under hydraulic structures like dams, and it is also used in solving groundwater flow problems where the geometry makes analytical solutions impractical.

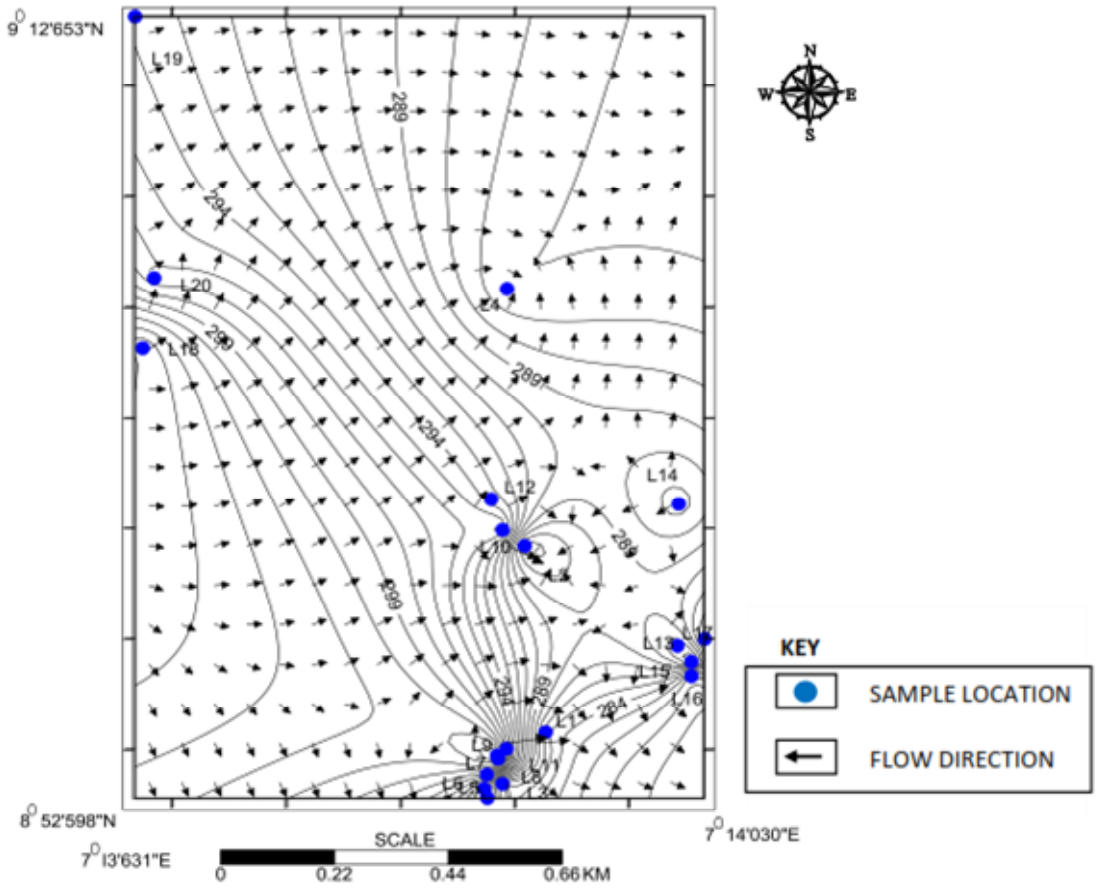

Figure 2: Flow Direction of Kuje Area

Results and Discussion

The water elevation contour map of the study area revealed that groundwater flows towards the North-eastern and South-eastern parts of the area. Based on the flow pattern in the study area, it is therefore recommended that boreholes for potable groundwater exploitation

could be sited in the North, South and Eastern parts of the area. The research did not only pave way for a clear picture of the flow system but went further to recommend that dumpsite should not be sited in this regions to avoid groundwater contamination.

Table 1: Data collected on the field

Location	Longitude	Latitude	Elevation (m)	S.W.L (m)	Dept (m)	HASL (m)	SWLASL (m)
1.	N08^0 52' 688"	E007^0 13' 708"	22	6	8	291.2	285.2
2.	N08^0 52' 691"	E007^0 13' 675"	15	6.1	6.5	291.2	285.1
3.	N08^0 52' 604"	E007^0 13' 640''	12	7	7.2	292.7	285.7
4.	N08^0 52' 687"	E007^0 13' 647"	12	9.7	10.3	295.7	286
5.	N08^0 52' 581"	E007^0 13' 616''	11	6.3	6.9	297.3	291
6.	N08^0 52' 596"	E007^0 13' 611"	15	6.7	6.9	298.3	291.6
7.	N08^0 52' 619''	E007^0 13' 615"	14	5.3	6	302.4	297.1
8.	N08^0 52' 645''	E007^0 13' 633''	15	3.6	4.2	306.9	303.3
9.	N08^0 52' 650''	E007^0 13' 631''	15	2	2.8	305.4	303.4
10.	N08^0 52' 657''	E007^0 13' 640"	14	2.5	3.5	298.8	296.3
11.	N08^0 52' 661''	E007^0 13'646"	13	2.5	3.9	299.3	296.8
12.	N08^0 52' 707''	E007^0 13' 622''	12	5.8	7.1	299.2	293.4
13.	N08^0 52' 769"	E007^0 13'916''	11	9.5	9.9	300.3	290.8
14.	N08^0 52' 759"	E007^0 13' 918''	10	9	10.1	300.6	291.6
15.	N08^0 52' 743"	E007^0 13'938''	14	7.8	8	300.4	292.6
16.	N08^0 52' 720"	E007^0 13'938"	16	8.4	8.6	289.6	281.2
17.	N08^0 52' 780''	E007^0 13'959''	17	8m	8.1	292.2	284.2
18.	N08^0 52' 692''	E007^0 14'012''	15	2.4m	4.5	306.4	304
19.	N08^0 52' 653''	E007^0 14'000''	20	3.7	4.6	297.5	293.8
20.	N08^0 52^l 648	E007^0 14'030''	11	3.5	8m	299.8	296.3

Note: SWL = Static Water Level
HASL = Height Above Sea Level
SWLASL = Static Water Level Above Sea Level

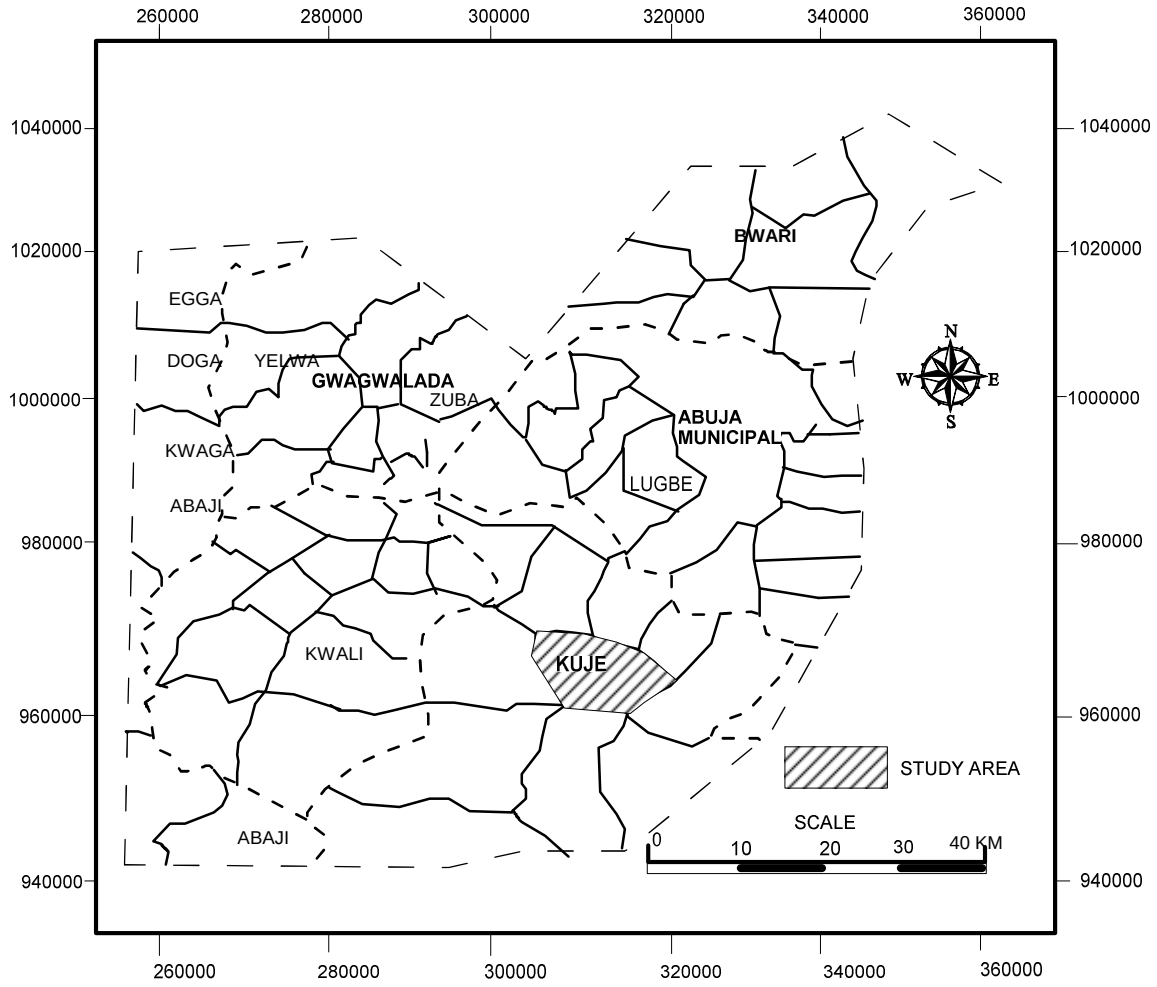

Figure 1: Map of Abuja with Study Area

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