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GROUNDWATER FLOW PATTERN IN CHOBA AND ITS ENVIRONS, NIGER DELTA, NIGERIA

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ABSTRACT
Groundwater flow pattern in Choba and its environs were undertaken to determine the flow pattern, direction, elevation, and possibly area for site of borehole and dumpsite, using 32 borehole site, randomly distributed between the three major communities of Aluu, Uniport and Choba community in the study area. The study revealed that the groundwater flow direction in the study area is towards the south and south-western part of the study area. Based on the flow pattern from the study, borehole for potable groundwater may be sited in the north, north-western and north-eastern part of the study area, while dumpsites may be sited in the south and south-western part of the study area, so as to avoid groundwater contamination in the study area.

Keywords: *Groundwater, Choba, Environs, Niger Delta etc.*

I. INTRODUCTION
Water is of fundamental importance to plants and animals, and most importantly, to human. It is therefore very vital in maintaining life processes and growth. Potable (drinking) water is not commonly found and its provision limits the establishment and maintenance of villages and towns to places where a reliable potable water supply exists (Shankar, 1994 and Huisman, 1966). Groundwater is considered to be the largest reservoir of drinkable water and plays a major role in augmenting the water supply to meet the ever increasing demands for domestic, agricultural and industrial usage. Due to the long retention and residence time of groundwater and natural filtration capacity of aquifers; groundwater is less contaminated as compared to surface water.

In the practice of hydrogeology in Nigeria, the most ignored aspect is the measurement of water levels and their flowing pattern (system) in space and time. Numerous borehole drillers are on parade and almost every day new boreholes emerge, but quite unfortunate, that very few own or even think of owning water meters. The result is the parading of thousands of boreholes without continuous or even occasional water level record. What is common are scanty data on static water levels taken immediately after construction of haphazard boreholes. Thereafter, no continuous recording of groundwater levels is ever made.

Oteze (1983) notes that in Nigeria, the available records on groundwater levels are those taken immediately after drilling and those undertaken during specific studies and that systematic water level measurements over a long period are rare. The importance of data on water levels can however not be over emphasized. Freeze and Cherry (1979) note that the measurement of water level movements in piezometers and observation wells is an important facet of many groundwater studies; and give an example where a water table hydrograph measured during an infiltration event was used to analyze the occurrence of groundwater recharge.

The speed of groundwater movement is measured in feet per year; this is why pollutants that enter groundwater require many years before it purifies itself or is carried to a monitored well. The size of the spaces in the soil or rock and how well the spaces (Turtuosity) are connected determine the speed at which groundwater flows.

The depth to the water table can be determined by digging or drilling a hole progressively deeper into the ground. The depth at which groundwater begins to seep into the hole indicates that the surrounding material is saturated with water and this marks the height of the local water table where there is no surface water (Buddemeier and Schloss, 2000).

The water table varies in depth according to local topography and prevailing climate. Groundwater usually flows toward, and eventually drains into, stream, rivers, lakes, creeks, and boreholes. The flow of groundwater in aquifer does not always mirror the flow of water on the surface. It is therefore necessary to know the direction of groundwater flow since the awareness helps us to map out the land area that recharges the public water supply, wells, streams, rivers, lakes, or creeks and thereby supports steps to ensure that land use activities in the recharge area will not pose a threat to the quality of the groundwater. With this information, one could also predict how contaminants move through the local groundwater system, since contaminants generally move in the direction of groundwater flow. It is also important to know if the groundwater system is a recharge or discharge system (gaining type or a losing type). The quality of water is affected by

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the quality of groundwater entering the system of water supply in the borehole. This is so because the water tables elevation is approximately the same as the gaining borehole surface elevation; both elevations may be used to construct water table maps (contour) and to predict groundwater flow direction.

II. LOCATION OF STUDY AREA

The study area includes, Choba, Aluu and Uniport campuses, all in Obio / Akpor and Ikwerre Local Government Areas respectively. The study area is located in the Niger Delta region, bordering the Atlantic Ocean. The area lies approximately in latitudes 6^o54^1N and longitudes 4^053^1E (Figure 1).

University of Port Harcourt; and Indomie Group of Companies are located within 10km east of the of the study area 'Choba and It's Environs' in present day Obio Akpor Local Government Area of Rivers State. The presences of these institutions have undoubtedly added to a great increase in the population of the area. Rapidly increasing population, rising standards of living and exponential growth in industrialization and urbanization tends to add pressure on natural resources (Amos-Uhegbu, et al, 2014). Most local groundwater supplies in Aluu, Uniport and Choba area comes from an unconfined aquifer made up of loose soil materials such as sands, gravels, and floodplain deposits left by stream and rivers (Oseji, et al. 2006; and Okolie, et al. 2005).

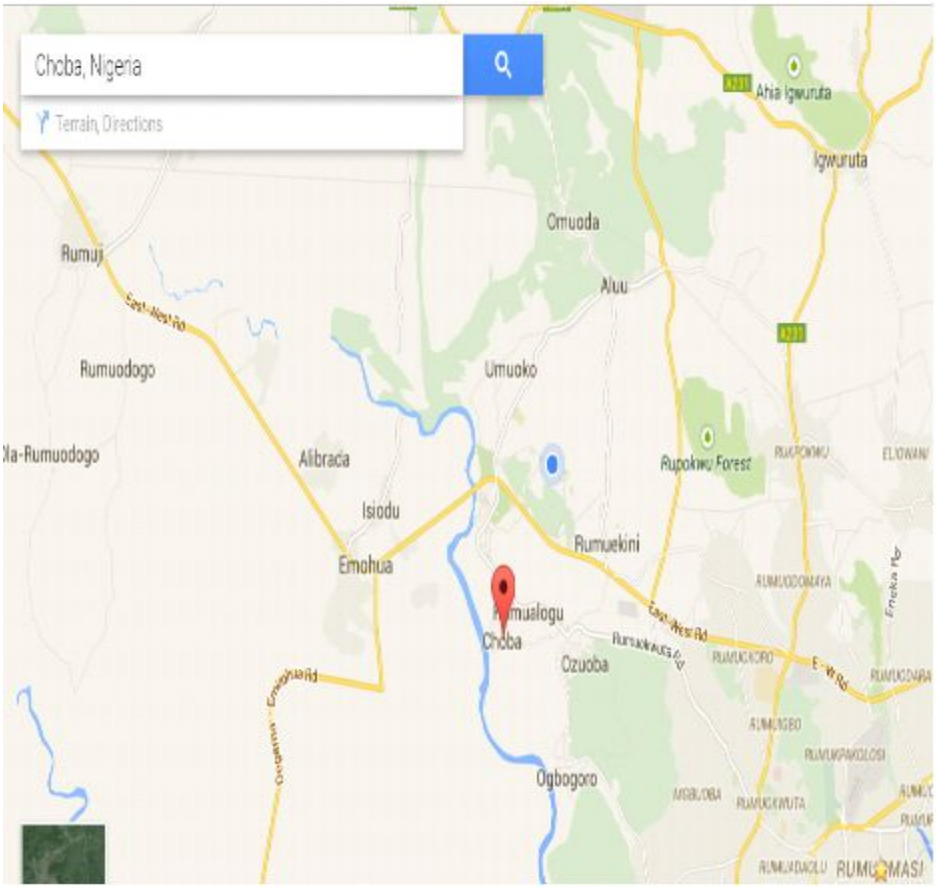

FIGURE 1: Map of the Study Area (Google)

III. OBJECTIVE

The objectives of this study include:-

1. To determine the groundwater flow pattern and direction in the study area.
2. To establish the Depth to Water Levels, using Water Meter within the Study Area
3. To determination the Static Water Levels within the Study Area

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IV. CLIMATE AND VEGETATION OF THE NIGER DELTA

The climatic conditions in the Niger Delta is modelled by such elements of climate as rainfall (precipitation); relative humidity, temperature, wind and sunshine. These elements have direct impact on ground flow water pattern of any area. The Niger Delta falls under the climatic characteristic considered as humid, semi-hot equatorial type or simply the wet equatorial type (NDES, 1997). It lies mainly in the wet equatorial climate region, but in its northern extremities, the climate is tropical wet-and-dry climate, known as Koppen's AW climate (NDES, 1997).

The study area is of typical rain forest vegetation. This is as a result of high rainfall which produces thick vegetation and falls within four ecological zones namely coastal ridge barrier, lowland forest and fresh water swamp forest. The fresh water swamp forest is noted to have tidal influences that are left up to 45km inland from the coastline and it is immediately behind the mangrove swamp from the point where the land rises slightly. According to the World Bank report, majority of the mangrove forest is found in the Niger Delta and also the mangrove forest is the least disturbed of the forest zones.

V. STRATIGRAPHY OF NIGER DELTA

In an advancing delta, such as that of the Niger Delta, sediments of the three environments described below become superimposed. The submarine delta fringe will encroach on holomarine sediments and will, in turn be covered by a younger lower deltaic plain which subsequently will be overlain by the next younger upper deltaic plain. Three highly diachronous lithostratigraphic units are therefore recognized in the Niger Delta subsurface, comprising an upper continental Benin Formation, an intervening paralic unit called the Agbada Formation and a basal unit the Akata Formation (Short and Stauble, 1967; Frankl and Cordry, 1967). Table 1 is the table showing the stratigraphic units of the Niger Delta.

TABLE 1: STRATIGRAPHIC UNITS OF THE NIGER DELTA

GEOLOGIC UNIT	LITHOLOGY	AGE
Benin Formation	Coarse to medium sand with subordinates silt with clay lenses	Miocene
Agbada Formation	Mixture of sand, clay and silt	Eocene
Akata Formation	Clay	Paleocene

(Etu-Efeotor and Akpokodje, 1990)

Benin Formation

The Benin Formation is the youngest sediment, it overlies the Agbada Formation and was deposited in the continental-fluviatile environment and consists mainly of sands, gravels and back swamp deposits. The Niger Delta is overlain by laterally extensive Benin Formation to a depth as wide as 200meters thick in some places. The clay strata that are present in this location arc of varying thicknesses and they make the groundwater formation a multi-aquifer system (Etu-Efeotor and Akpokodje).

Agbada Formation

This formation underlies the Benin Formation and is the second Formation among the three strongly diachronous Niger Delta Complex formations. The formation was laid down in paralic, brackish to marine fluviatile, coastal and fluvio-marine environments (NDES, 1997). The formation is made up of intercalations of sands, silt and shales in various thicknesses and proportions, indicative of cyclic sequences of offlap units. The units consist of a series of offlap cycles better called offlap rhythms (Weber and Daukoru, 1975). Rhythms begin with marine sands, laid down during a marine transgression.

The formation occurs between depths of approximately 300m and 5.5km and ranges in age from Eocene to Recent. It represents the Delta front mega depositional sequence of the Niger Delta stratigraphy.

Akata Formation

This formation is the basal major time-transgressive lithological unit of the Niger Delta complex. It is composed mainly of marine shales, but contains sandy silty beds which are thought to have been laid down as turbidites and continental slope channel fills. The shales are typically uncompacted and o'er pressured, forming diapiric structures (NDES, 1997). Whiteman (1982) in his work concluded that the Akata Formation is rich in planktonic foraminifer which indicates deposition on a shallow marine shelf environment. The formations occur- between depths of approximately 600m to 12km below that Agbada and ranges in age from Eocene to Recent. It represents the pro-Delta mega facies.

VI. MATERIALS AND METHODS OF STUDY

The most direct accurate method of determining the direction of groundwater flow is by measuring the elevations of multiple locations over the aerial extent of an aquifer. Measurements are plotted on the map of the area and lines are drawn to connect points of equal elevation. These lines represent equal pressure between connected points and are called equipotential lines. The equipotential lines and map together are called an equipotential map. Groundwater moves along flowpath perpendicular to equipotential lines and the direction of movement is from higher value to lines of lower value (higher to lower elevation or pressure)

Groundwater flow paths are usually shown by arrows on equipotential surface maps pointing in the direction of groundwater flow.

VII. FIELD MATERIALS

The following instruments were employed during the study:-

- The Global Positioning System (GPS) for taking the coordinates in the Study Area
- Water Meter for the measurement of the Depth to Water Levels within the Study Area.

VIII. METHODS

Three major stages of field procedures were employed in this study; and 32 boreholes were investigated within the study area. The depth at which water begins to seep into the hole indicates that the surrounding material is saturated with water and this mark the depth to water level in the well.

- With the aid of a water meter, the depths to the water levels in the wells within the study area were measured and recorded.
- The Global Positioning System (GPS) of type 310 were used to measure the longitude, latitude, and the surface elevations with respect to the mean sea level at points within the study area. The mean sea level is the lowest surface within the earth. All elevations are taken with respect to the mean sea level.
- The surface elevations at different points vary due to topographic variations, the true water levels were obtained by subtracting the measured depths to the water levels in the drilled wells from the surface elevation to get uniform water level otherwise known as the elevation of the water Level (Buddermeier and Schloss 2000) and hence reduce topographic variations

This uniform water level coincides with the static water level in the case of an unconfined aquifer, while it is the piezometric surface, if it is the case of a confined aquifer (Buddermeier and Schloss, 2000).

$$Swl = E - Dwl$$

E= the surface elevation with respect to the mean sea level

Swl= the true or uniform water level otherwise known as the static water level in the case of an unconfined aquifer.

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The values of the static water levels were contoured on the map of the study area. These lines represent the water table contours.

According to Buddermeier and Schloss (2000), groundwater flows from the highest values of contour lines to the lowest values in a direction perpendicular to the contour lines.

IX. DATA PROCESSING

The results of the base and contour maps from the study area were improved upon by using suffer 8 program.

X. RESULT AND INTERPRETATION

The GPS readings for locations, Latitudes and Longitudes, Elevations and Water Meter reading, measured from 32 boreholes in the Study Area presented in table 2, 3 and 4 below:

TABLE 2: Filed Data Acquired for the Static Water Levels and Elevations within the Study Area (Choba Community)

S/ N	GPS LOCATIONS	LATITUDE S(M)	LONGITUDS (M)	ELEVATION S (E)M"	DEPTH TO WATER LEVELS (D_{HDW})M"	STATIC WATER LEVEL (S_{WL})=E-D_{HDW} M
1	HOLY GHOST WORSHIP CENTRE INC, CHOBA COMMUNITY	6^{O} $54^{1}15^{11}$N	4^{O} $53^{1}22^{11}$E	24	9.65	14.35
2	WALI COMPOUND,CHOBA	6^{O} $54^{1}13^{11}$N	4^{O} $53^{1}19^{11}$E	16	9.75	6.25
3	MR MARCUS COMPOUND, CHOBA COMMUNITY	6^{O} $54^{1}13^{11}$N	4^{O} $53^{1}20^{11}$E	24	10.41	13.59
4	KUBA LAUNDRY SERVISES ,UNIPORT ROAD	6^{O} $54^{1}12^{11}$N	4^{O} $53^{1}26^{11}$E	29	10.60	18.4
5	129 UNIPORT ROAD, CHOBA TOWN	6^{O} $54^{1}12^{11}$N	4^{O} $53^{1}26^{11}$E	29	11.20	15.8
6	CHINDAH ORIJI COMPOUND, CHOBA	6^{O} $54^{1}13^{11}$N	4^{O} $53^{1}26^{11}$E	32	11.26	20.74
7	WORLU COMPOUND, CHOBA, UNIPORT ROAD	6^{O} $54^{1}17^{11}$N	4^{O} $53^{1}33^{11}$E	23	11.26	10.85

TABLE 3: Field Data Acquired for the Static Water Levels and Elevations within the Study Area (Uniport Campuses)

S/N	GPS LOCATIONS	LATITUDES	LONGITUDES	ELEVATIO NS	DEPTH TO WATER LEVELS	STATIC WATER LEVEL
1	BESIDE U&C BANK,CHOBA CAMPUS	6^{0} 54^{1} 27^{11}N	4^{O} $53^{1}50^{11}$E	20	12.41	7.59
2	BACK OF UBA, CHOBA CAMPUS	6^{O} $55^{1}22^{11}$N	4^{O} $52^{1}47^{11}$E	33	11.3O	21.7
3	BLOCK B, AMINO KANO HOSTEL	6^{O} $54^{1}32^{11}$N	4^{O} $53^{1}45^{11}$E	36	10	26
4	SCIENCE EDU LAB, CHOBA CAMPUS	6^{O} $54^{1}37^{11}$N	4^{O} $53^{1}42^{11}$E	25	8.84	16.16

5	FACULTY OF AGRIC,DEMONSTRATION FARM	6^{O} $54^{I}38^{II}$N	4^{O} $53^{I}39^{II}$E	21	8.32	12.68
6	KWAME NKRUMAH HALL EXTENTION	6^{O} $54^{I}32^{II}$N	4^{O} $53^{I}36^{II}$E	16	9.48	6.52
7	13 DEGEMA STR, DELTA CAMPUS	6^{O} $54^{I}09^{II}$N	4^{O} $53^{I}57^{II}$E	31	12.86	18.14
8	1 NEMBE STR, DELTA CAMPUS	6^{O} $54^{I}10^{II}$N	4^{O} $53^{I}05^{II}$E	16	11.62	4.38
9	1 SANGBAMA STR, DELTA AMPUS	6^{O} $54^{I}11^{II}$N	4^{O} $53^{I}09^{II}$E	21	11.45	9.55
10	BORI STR, DELTA CAMPUS	6^{O} $54^{I}15^{II}$N	4^{O} $53^{I}04^{II}$E	13	10.30	2.7
11	BEHIND DEPT OF MUSIC HALL	6^{O} $54^{I}15^{II}$N	4^{O} $53^{I}06^{II}$E	14	9.30	4.7
12	BEHIND SCH. LIBRAY, ABUJA CAMPUS	6^{O} $54^{I}13^{II}$N	4^{O} $53^{I}15^{II}$E	12	4.36	7.64
13	CATHOLIC CHURCH, ABUJA CAMPUS	6^{O} $54^{I}59^{II}$N	4^{O} $53^{I}12^{II}$E	8	4.40	3.6

TABLE 4: Field Data Acquired for the Static Water Levels and Elevations within the Study Area (Aluu Community)

S/N	GPS LOCATIONS	LATITUDES	LONGITUDES	ELEVATIONS	DEPTH TO WATER LEVELS	STATIC WATER LEVELS
1	DOCTOR'S QUARTER, MAN O WAR ROAD, ALUU	6^{O} $54^{I}03^{II}$N	4^{O} $53^{I}18^{II}$E	15	9.13	5.87
2	NURSE'S QUARTER, MAN O WAR ROAD, ALUU	6^{O} $54^{I}03^{II}$N	4^{O} $53^{I}21^{II}$E	11	8.93	2.07
3	GLO/WANA VILLA UP ROAD, OMUOKO, ALUU	6^{O} $54^{I}32^{II}$N	4^{O} $53^{I}28^{II}$E	24	6.60	17.4
4	RCCG, OMUOKU, ALUU	6^{O} $54^{I}22^{II}$N	4^{O} $53^{I}21^{II}$E	8	6.65	1.35
5	CHIEF WOKOMA COMP	$6^{0}54^{I}25^{II}$N	$4^{0}54^{I}21^{II}$E	32	6.69	25.3
6	WENENDAH COMPOUND, ALUU	$6^{0}54^{I}31^{II}$N	$4^{0}54^{I}31^{II}$E	19	6.52	12.48
7	IBENEME COMP, ALUU	$6^{0}54^{I}31^{II}$N	$4^{0}54^{I}29^{II}$E	20	6.58	13.42

The map (figure 2) below is a base map, generated from the GPS Longitudes and Latitude readings, showing the different locations where the field data were acquired within the Study Area.

Figure 3, is the map, showing the generated contour and the flow directions / pattern of the groundwater within the Study Area. From the map, the arrow at the eastern part of the Study Area (Choba) is pointing towards the southern part of the Study Area. From the north (Uniport), the arrow is also pointing to the south, and finally, From the Western part (Aluu), the arrow is pointing towards the southern part of the Study Area. It is therefore concluded that the groundwater flow pattern in the study area flows towards the Southern part of the Study area, it drains into the New Calabar River (Choba River).

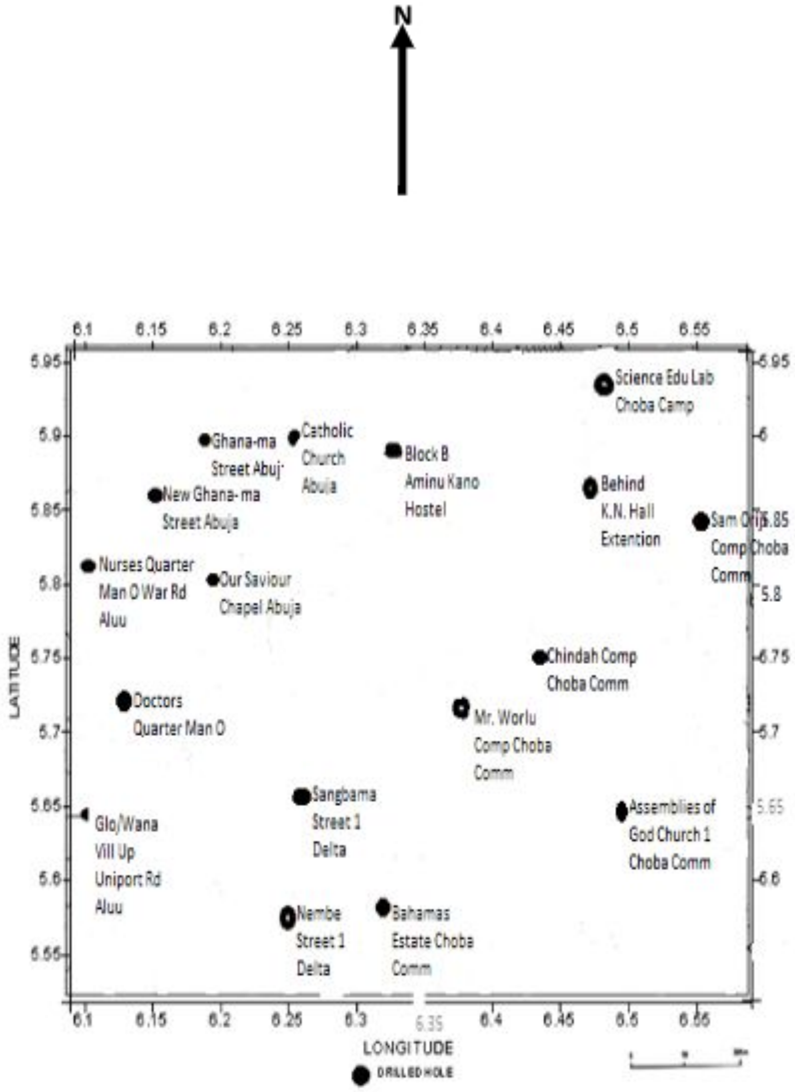

Figure 2: Generated base Map of the Study Area Showing GPS Locations and Drilled Holes.

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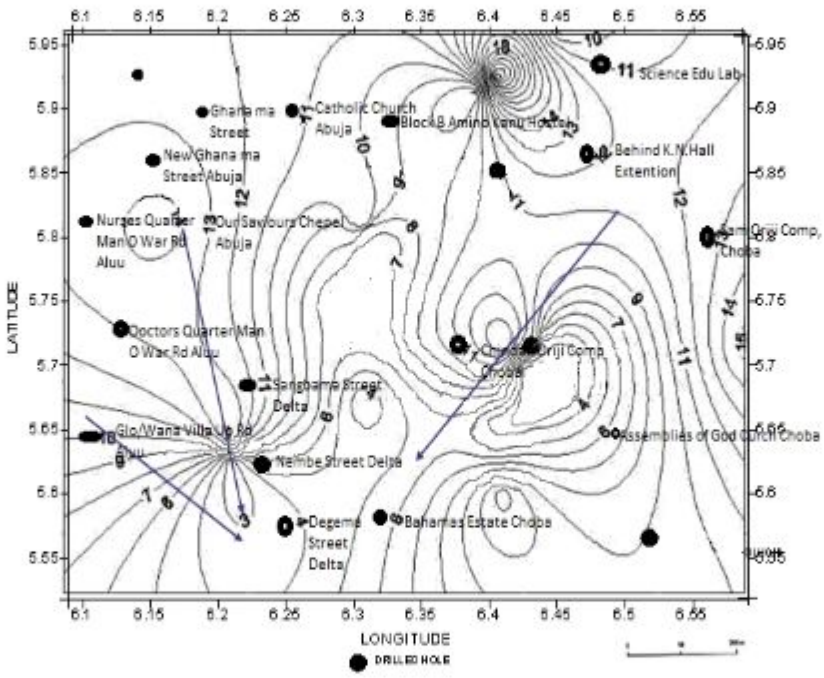

Figure 3: Generated Contour Map, showing the direction of Groundwater Flow in the Study Area

XI. DISCUSSION

ELEVATIONS OF THE STUDY AREA

Elevation is the height of the ground surface above Mean Sea level (MSL). Water tend to flow on the surface from regions of higher elevation to regions of lower elevation. As a consequence of this, the elevation of Aluu reveals that surface water tend to flow from the western part to the southern part of the study area; The ground elevations of Uniport Campuses (Abuja, Delta and Choba) reveals that the surface water tend to flow from the northern part to the southern region of the study area; And from the ground elevations of Choba community also reveals that the surface water tend to flow from the north-eastern parts to the southern parts of the Study Area.

DEPTH TO WATER LEVELS (D_{HDW}) OF THE STUDY AREA

Depth to water levels groundwater flow is very slow compared to surface water movement. However, Groundwater, like surface water flows downhill in the direction determined by the slope of the water table. Groundwater is therefore, from high water level to low water level (Buddemeier and Schloss, 2000). From the depth to water levels in Aluu, it is observed that the groundwater flow from West down to the southern part of the study area; The results of the depth to water levels in Uniport is shows that the groundwater flow from the north to the southern part of the study area; And groundwater flow pattern in Choba community could be inferred to flow from the north-eastern parts to the southern parts of the study area.

STATIC WATER LEVEL (S_{WL}) OF THE STUDY AREA

The Static Water Level is the distance from ground level down to the water in a well. It is the resting level ground of water when the well is not being pumped.

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The static water levels of Aluu revealed that the groundwater flow pattern is from the West to the south of the study area; The static water level (SWL) values from Uniport reveals that the groundwater flow pattern is from the northern part to the south of the study area; and the static water levels of Choba Community indicates that the groundwater flow pattern is from the north-eastern part to the southern part of the study area.

XII. SUMMARY AND CONCLUSION

SUMMARY

The maximum ground elevation values of the study area are Block B Amino Kano Hostel with 36m followed by 33m at Back of UBA, Choba Campus and the minimum ground elevation is at the Catholic Church, Abuja Campus with ground elevation of 8m. The study also revealed that the Static Water Levels of the study area has the highest values at Block B Amino Kano Hostel with 26m and at the Back of UBA with 21m respectively. At RCCG Omuoko, Aluu, the Static Water Level is closest to the surface with 1.35m.

The water elevation contour map of the study area, revealed that the groundwater flow direction is toward the southern parts of the region.

CONCLUSION

This study had paved way for a clear picture of the flow system in study area. Based on the flow pattern and the aquifer system in the study area, dumpsite location in the study area should be sited in the south parts of the area and not in the north, west, or eastern regions in order to minimize groundwater contamination. For potable water supply in the study area, it is recommended that boreholes should be sited in the north, west, and eastern regions and not within the south parts of the study area.

Continuous watertable piezometric surface records should be maintained to furnish information for researches in the future.

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