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Evaluation of the Groundwater Potentials of the Lower Benue Valley, South Eastern Nigeria

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Abstract:- As population increases more water would be needed for Agriculture, Industry and domestic uses. Normally the easiest and most convenient way to meet the public demand for water is to utilize surface water resources, unfortunately fresh water rivers and lakes are less plentiful than may at first be imagined and in fact account for less than 0.01 per cent of the world total water, coupled with the present trend in global warming and consequent decrease in surface water, hence, groundwater exploration will assume greater importance. Although occurrence of groundwater is universal, it is nevertheless not evenly distributed nor easy to exploit everywhere. The study area was discussed under three hydro geologic Divisions: Abakaliki, Ajalli and Alluvial Divisions. Abakaliki Division is made up of thin, shallow and continuous aquifers which are mainly localized and usually unconfined. Ajalli comprises both confined and unconfined aquifers, a very promising province with associated perched aquifers that serves as sources of springs and streams to communities in the area. The third Division - the Alluvial found mainly at the banks of major rivers have shallow, highly prolific aquifers, though very sensitive to the rhythm of rainfall. Wells and boreholes in the Abakaliki and Ajalli Divisions could be contaminated and polluted by saline and surface waters. This can be handled by making proper and adequate studies and planning with the aim of sinking deep boreholes.

I. INTRODUCTION

Water is one of the most valuable natural resources on earth without which mankind cannot survive. At minimum subsistence level human beings generally require about 2.5 litres of water every day for direct consumption. In the industrialized climes, the average demand of water is between 116 litres to 545 litres per capita per day.

The total estimated volume of water in the earth is nearly 1360 x 10^6 km^3 out of which 1320 x 10^6 km^3 (97.0 %) is confined to the Ocean and is too saline to be used for human consumption (Nace,1971). Fresh water found in lakes, rivers, groundwater, atmospheric water, ice caps, snow fields etc. accounts for about 38 x 10^6 $km^{3.}$. Nearly 20 x 10^6 km^3 (52.6 %) of fresh water remain frozen as ice and snow and is not readily available for use.

The single largest source of available fresh water in the hydrological cycle is groundwater (Maitra and Ghose, 2017). Latest figure shows that rivers and lakes contain less than 0.126 x 10^6 km^3 or 0.009% of total water, the groundwater is estimated having about 8.467 x 10^6 km^3 or 0.622% of total water. A large part of groundwater is however not available to us as it occurs at a depth, extraction from which is difficult and uneconomical. The world's available groundwater has been estimated as 4.2 x 10^6 km^3 which is 10.5% of the total fresh water reserve and 0.3% of total water. Roughly one-fifth of all water used in the world at present is obtained from groundwater.

UNESCO (1978) estimates that 24 percent of the world's ground water resources is located in Africa yet world Resources Institute(1987) reports that most sub-Saharan African countries do not have enough information about their groundwater locations, recharge areas and available volumes to develop plans.

A number of studies have earlier been attempted on groundwater resources of Nigeria, this is an addition to the growing literature on groundwater evolution, exploration and exploitation in the country. The paper is divided into three main sections, the first discusses the geomorphological and geological setting of the region, while the second concentrates on the hydrogeology and the last on the discussion and conclusion.

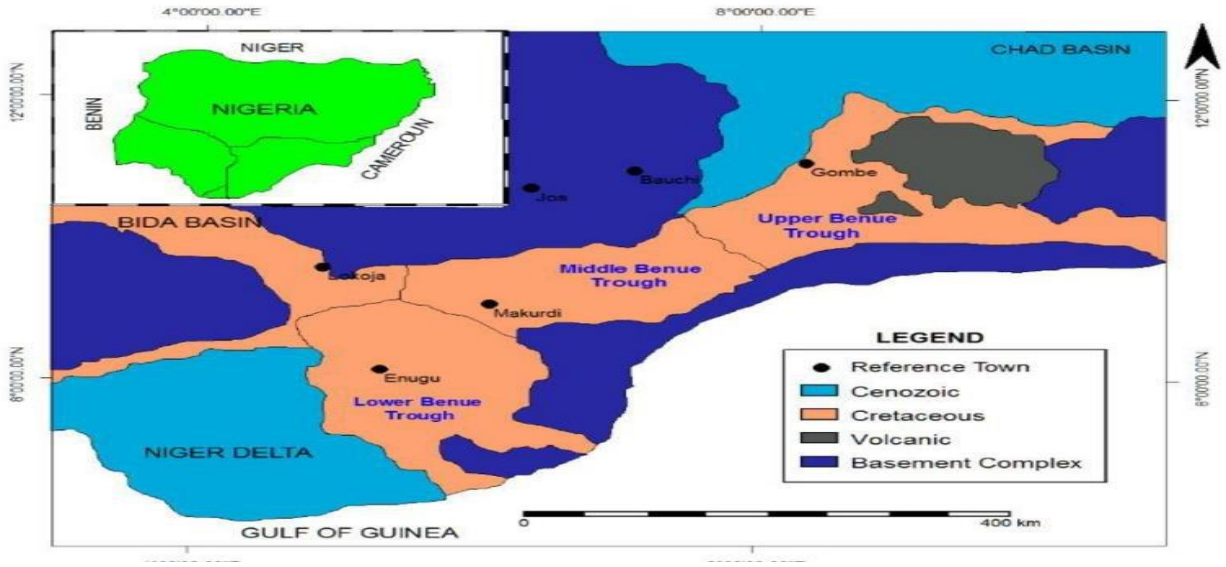

Fig.1. Map of the Lower Benue Trough
Study Area (Source: Researchgate)

II. GEOMORPHOLOGY AND GEOLOGY

The Nsukka-Awgu-Okigwe cuesta is the prominent relief feature in the study area. It has an average elevation of 400metres. The scarp face is towards east and dips at an angle of nearly 80^0 and less.

The Escarpments is characterized by massive false bedded sandstones and numerous river valleys and deep gullies which forms the head waters of many streams(Ofomata,1975), amongst which are Nyaba, Atavo rivers etc.

The escarpments divided the area into two distinct geo-hydrological Basins. The Abakaliki Basin to the East and the Anambra Basin to the West. The area is covered by rocks of cretaceous age, Sedimentation began in mid-cretaceous time.

Generalized Stratigraphic Chart of the Southern Benue Trough

BASIN		FORMATION	AGE		ENVIRONMENT	DEPTH	SANDSTONE PETROLOGY	TECTONO-SEDIMENTOLOGIC STAGE
CRETACEOUS	ANAMBRA	Nsukka Formation Ajali Formation Mamu Formation Nkporo/Enugu formations	MAASTRICHTIAN		MARGINAL MARINE	0m	QUARTZ ARENITE	PLATFORM STAGE
			CAMPANIAN		SHELF	100m		
			SANTONIAN		FOLDING / MARGINAL MARINE			DEFORMATION STAGE
	ABAKALIKI	AWGU GROUP (Awgu Formation/ Agbani sandstone/ Nkalagu Formation)	CONIACIAN		MARINE		FELDSPATHIC SANDSTONE	
			TURONIAN	UPPER	MARINE	1000m		
				MIDDLE	SHELF	1150m		
				LOWER	MARINE	1350m		
		EZE-AKU GROUP (Eze-Aku shale/ Agaila/Makurdi/ Amaseri sandstone/Ibir sandstone)	CENOMANIAN	UPPER	MARINE	1500m		TROUGH STAGE
				MIDDLE	MIXED			
				LOWER	SUBCONTINENTAL			
		ASU-RIVER GROUP (Abakaliki shale/ Minor intrusions)	UPPER ALBIAN	LATE	NEARSHORE	1880m		
				MIDDLE	INTERNAL AND EXTERNAL SHELF	1980m		
				EARLY				
			MIDDLE ALBIAN		MARINE BASIN	2130m		
		Un-named Basal Units	PE-MIDDLE ALBIAN (Aptian, Neocomian)		DELTAIC	3630m		RIFTING STAGE
					NON MARINE			
		MAJOR DISCORDANCE			METAMORPHIC	5000m		
		PRECAMBRIAN BASEMENT						

After Ojoh, 1992; Petters, 1991 and Murat, 1970. After Hoque and Nwajide, 1985

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The rocks belong to eight geologic formations:-

1. Asu-River Group
2. Eze-Aku shale
3. Awgu shale
4. Nkporo shale
5. Mamu formation
6. Ajalli sandstone
7. Nsukka formation
8. Alluvium

The Asu River Group consist of poorly bedded sandy shales with sandstone and sandy limestone lenses. The sediments are folded mainly in the south of Abakaliki with fold axes stretching NE-SW. the beds are associated mineralization. The sandstone beds are well exposed at the hills.

The Eze-Aku shale comprise hard grey to black shales and siltstones with frequent facie changes to sandstone or sandy shale. It has a thickness of about 1000metres and below. It passes laterally into the shaly limestone at Nkalagu area.

The Awgu Shale is of coniacian age. It consist of bluish grey, well bedded shales with occasional intercalations of fine grained sandstone and thin often marly shelly limestones. It has a thickness of about 800metres.

Overlying the Awgu shale is the Nkporo Shale, which has a maximum thickness of about 1000metres. It consist of dark shales and mudstones with occasional thin beds of sandy shales and sandstone with intercalations of thin beds of shelly limestone.

The Mamu Formation (Lower Coal Measure) succeeded the Nkporo Shale. It comprise of sandstone, carbonaceous shales, sandy shales and some coal seams. It is known to be up to 400metres thick and marks the phase of deltaic – lagoonal environment.

The Ajalli Sandstone (False bedded Sandstone) caps the Mamu Formation. The Ajalli Sandstone consist of thick friable, poorly sorted sandstone, typically pure white in colour, but occasionally ironstained. It has a thickness of about 330metres and the sands are characteristically current bedded.

The Nsukka Formation (Upper Coal Measure) follows the Mamu Formation and they are similar both in lithology and stratigraphy except that it contains thinner coal seams.

The sedimentary materials in the study are believed to have suffered two large –scale folding /faulting episodes which affected much of the Benue Trough (Nwachukwu, 1972). Magmatism which accompanied tectonism resulted in the injection of numerous intrusive bodies into the Eze-Aku and Asu-River Groups.

Thick Tertiary and Alluvial sediments cover much of the southern portion of Anambra Basin. The cretaceous materials are also overlain by a significant thickness of regolith formed by weathering and ferrugenisation of the top horizons.

III. HYDROGEOLOGY

The area under study can be categorized into three hydro-geologic groups or divisions:

- The Abakaliki Division
- The Ajalli Division
- The Alluvial Area

- The Abakaliki Division comprises of shales and sandstones but predominantly of shaly formation of the Asu River Group, the Eze-Aku Shale, Awgu Shale and Nkporo Shale. The aquifers in this Formation are generally thin, extensive and unconfined, having been formed by the top weathered horizons, in conjunction with fractured shales and sandy horizons. Communities living in this area take advantage of the shallow unconfined nature of the aquifers to sink hand dug wells.

A detailed study of the geohydrology of the area is still is ongoing. However, dug wells at Obollo Etiti and Abakaliki show aquifers of saturated thickness of about 3.9m; while deeper boreholes expose aquifers of saturated thickness of 22m. The yield of the aquifers in this division has not been fully established. Generally, wells dug within the Asu-River Group yield more water than those in other Formations. This is explained by the intense fracturing of the shales of the Asu-River Group relative to those of other Formations

The major factor militating against groundwater development in the Abakaliki hydrogeological division is the occurrence of saline groundwater around Abakaliki, Enyingba and Awgu. Analysis of field data has shown that occurrences of these saline water are strongly influenced by the orientation of dominant tectonic features.

Another problem is the scarcity of confined aquifers. The complex tectonic history, complex folding/faulting which makes it difficult to reconstruct the hydro stratigraphy of the area further compounds the problem. The result is that in boreholes located on the basis of extrapolation of information from other locations have proved abortive.

- Ajalli Division

The second hydro geologic division lies beneath the escarpment. In the eastern portion unconfined aquifers are located in the argillaceous beds of the Ajalli sandstone and coal seams of the Nsukka formation. In the western part, they are capped by considerable thickness of shales of the Imo Formation

The test yield of boreholes are high, with an average of over $62m^3$/hr., these are usually associated with low to moderate drawdown. The specific capacity varies from 0.8 to $37m^3$/hr./m. Saturated thickness of the aquifers varies from 40m to 153m with an average of about 77m. Pumping test data from boreholes at Udi, Ibeagwa-ani, Aku and Ukehe gave Transmissivity (T) values ranging from 37 to

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$61m^2$/hr. and storativity(S) of the order of 2 x 10^{-2}. These values indicate the presence of prolific aquifers.

The potential of the aquifers decrease towards the west, where they are confined beneath the shales of the Nsukka Formation. This is attributed to the decreasing thickness of the aquifers in this region. This thinning nature of the aquifers was confirmed by the result of Hydro geophysical investigations carried out along 9^{th} mile corner-Nsude - Ebo traverse.

The occurrence of perched aquifers is very prominent within the hydro geologic province. Although perched aquifers are insignificant for large scale groundwater development, they however form sources of many springs and streams for villages and towns situated along their course.

- Alluvial Area

This Group occupies much of the low lands of the Niger-Anambra Rivers. They are also found at the banks of the Cross-river in Abakaliki area. The division is made up of gravel, sand, silt, clay and carbonaceous matter.

The aquifers are situated at shallow depths in the western part of the area, while much deeper ones are met in the East.

Very high yields associated with low drawdowns give a specific capacity of over $20m^3$/hr. /m. for practical purposes, the groundwater potential of the Alluvial Division is unlimited as recharge conditions are excellent. This is because of the high rainfall associated with this area with its attendant low runoff. Because of shallow aquifer depths, there is fluctuations of the groundwater table due to the groundwater/ surface water interaction.

IV. DISCUSSION

The aquifers of the Abakaliki Division are generally thin, extensive and unconfined. These features account for their rapid recharge from antecedent rainfall. Detailed studies have not been carried out here, but preliminary studies show that they have high yield, but on some occasions pump failures have been met. This is attributed to the rapid drawdowns associated with these aquifers. It is suggested that for optimal abstractions, the use of motorized pumps have to be discouraged while low discontinuous withdrawals through hand pumps and dug wells be used. Because most of the aquifers in this province are shallow and unconfined, deeper situated aquifers should be the target when large regional or urban water supply is needed.

The second hydro geologic Division, the Ajalli has prolific aquifers with large groundwater storages, but the potential decreases towards the west, where the result of hydro geophysical studies show the thinning of aquifers. There is also an observed declining water table due to localized intensive abstractions in some urban centers. It is suggested that a detailed analysis of the area be undertaken to avoid failure in future.

The Alluvial Division has a great groundwater potential. But depths to water table are shallow and the water is subject to pollution and contamination. Deep boreholes rather than wells should be employed to avoid near surface contamination and pollution.

V. CONCLUSION

The groundwater potential of the study area is high. Prolific aquifers are located in the three hydro geologic divisions.

The problems militating against the development of groundwater in the Abakaliki division could be tackled by conducting adequate hydro geological and geophysical studies. This will help in locating areas with good aquifers and areas affected by tectonism that should be avoided when sinking boreholes.

The Ajalli division is the most promising of the three, with deep confined aquifers. The perched aquifers occurring in this province serve as springs and streams to the communities in the area.

The Alluvial division is characterized by aquifers of high yields low drawdown and excellent recharge conditions. Depths to water table are shallow. This features is exploited by the communities living in the area to sink hand dug wells.

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