

Climate Change and Groundwater Resources of Part of Lower Niger Sub- Basin around Onitsha, Nigeria

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Abstract— The impact of climate change on water resources and the environment is on the increase and has resulted to the increased dependence on unprotected surface and groundwater resources. The study tends to evaluate the aquifer behaviour of the Benin Formation of Southeastern, Nigeria with the view of establishing the impact of the climate change on groundwater resources of part of lower Niger Sub-Basin. Since the hydrology of aquifer and health of the ecosystem are closely connected, understanding the water resources of a system will enable its management in an integrated manner to ensure the sustainability of the ecosystem and the water it provides. The water bearing formation of the study area consist mostly of continental sands and gravels with hydraulic conductivity ranging from 4.9m/day to 33.99m/day. This forms the major aquifer in parts of the Lower Niger Sub Basin. The depth to the watertable lies between 2m and 8m near the coast and deepens inland to over 150m. The Niger River with a discharge of about 4000m³/s at Onitsha recharges the aquifer in the month of September than other times of the year. Increasing rate of erosion in the coastal areas of the Lower Niger Sub-Basin along the Niger River and Anambra River around Onitsha with its socioeconomic consequences is attributed to climate change and requires urgent attention.

Index Terms— groundwater, Lower Niger Sub Basin, climate change, aquifer recharge/discharge, coastal erosion

1 INTRODUCTION

THE study was carried out in the lower Niger Basin around Onitsha. The commercial activities of Onitsha and its adjacent towns have contributed significantly to the environmental problems of parts of lower Niger Sub Basin (Fig. 1). Climate change and its consequences are also visible in the highly populated city of Onitsha and surrounding towns. The increased rainfall intensity with resultant flash floods has implications on public health, water and food security. The flooding of Nigeri River and Anambra River during the rainy season affects the quality of the groundwater recharged by the rivers in the area. The arenaceous Benin Formation (Quaternary) of the area overlain by the alluvial deposits near River Niger plains facilitates the impact of climate change on the groundwater. The formation stretches from Anambra Embayment into Dahomey Basin and form the major aquiferous unit in the southern part of Nigeria [1]. It occurs in the coastal region of southern Nigeria and dips at low angle in the southeastern part [2]. The areas of along the bank of River Niger and Anambra River such as Onitsha, Okija, Ozubulu, Atani and Ogaru are among the communities significantly vulnerable to the impact of climatic variability and extreme event that characterize the area. The socioeconomic implications of this climatic variability abound affecting public health, water and food security. Important component of surface water planning and management such as prediction of river discharge and its avariability [3] requires adequate attention. The impact of climate change on our environment is the consequence of anthropogenic activities. Understanding the potential impacts of climate change on climate sensitive sectors such as water, agriculture, and energy of the national economy is a top priority due to the growing adverse impacts of climate

change associated risks [4].

The groundwater of the study area contains high concentration of Iron attributed to the geology of the area. Although the iron level is relatively high, it is within WHO permissible level [5]. The saline water intrusion from the beach extends to as far as 1km inland in some areas and the aquifer of the area is classified as deep unconfined aquifer in Imo River Basin [6]. The study is aimed at determining the influence of River Niger on the groundwater resources of the Lower Niger Sub Basin with respect to the impact of climate change.

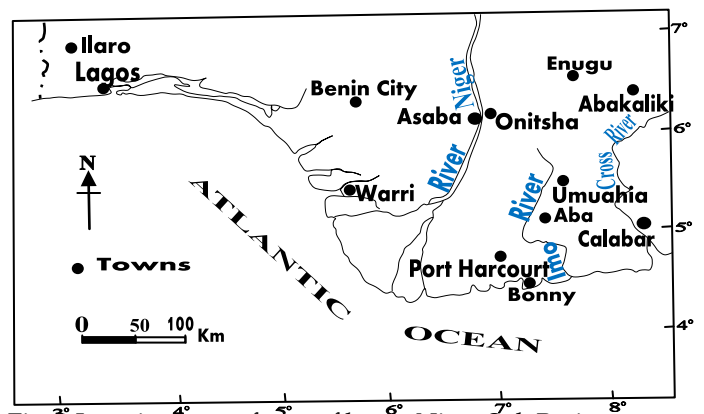


Fig. 1 Location map of part of lower Niger Sub Basin

Climate and Physiography

The study area is characterized by two main climatic periods, the dry season (October to March) and the rainy season (April to September). The dry season is characterized by extreme aridity, dusty atmosphere, lowering of shallow groundwater

levels and surface water due to excessive temperature that encourage evapotranspiration [7]. The implications of climate change have shown a positive trend in Africa as annual incidents of disaster events have increased in the region [8]. The annual rainfall in the area is about 2000mm with a mean monthly rainfall of about 500mm in the coastal area of Onitsha. The rainfall occurs as violent downpours accompanied by thunderstorms, high runoff and heavy flooding, soil leaching and extensive sheet outwash. Devastating impact of coastal erosion along the bank of River Niger and Anambra River are facilitated by climate change. The resultant sediments have caused the siltation of River Niger at the river mouths. The unprecedented flooding of 2012 that affected over 100 communities in Anambra State, Nigeria also left an untold hardship on the socioeconomic potentials of the study area (Pic. 1). Over 60% of the precipitation in the area is loss to evapotranspiration [9] with less than 40% left for infiltration. The prevalent geomorphic features also ensure groundwater recharge.

Onitsha Fig. 2 indicates a bimodal regime with rainfall peaks occurring in the months of July and September. The variation in the on-set and cessation of rainfall in recent times in the study area has raised issues of concern as over 70% of the population depends on rain fed agriculture for their livelihood.

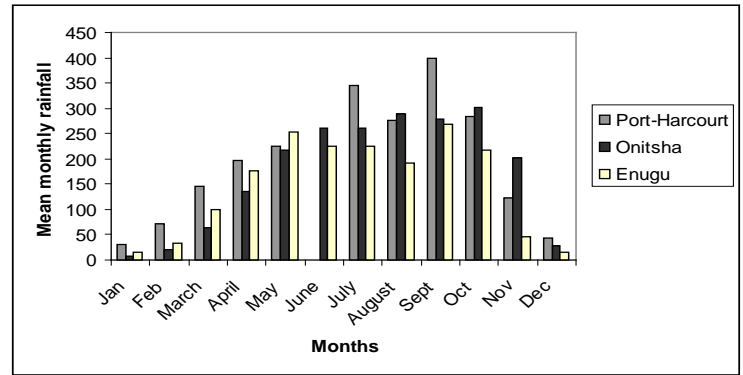


Fig. 2. Bimodal regime and rainfall peaks of the study area.



Pic.1



Pic. 2

Pic 1 and 2. Consequences of climate variability.

Histogram of monthly rainfall for Enugu, Port-Harcourt and

Geological and Hydrological Factors affecting Groundwater Regime

Benin aquifer represents a large continental aquifer made up of sand and gravel deposits which filled the topmost part of Niger Delta Basin, and Diahomay embayments. The embayments are rift structures which evolved from the tectonic activities associated with the drifting of South America plate away from the African plate [10]. Anambra River together with Idemili, Orashi and Nkisi River are the major tributaries of River Niger on the southeastern part of Nigeria. The tributaries constitute an extensive dendritic system and form the major means of livelihood to rural inhabitants along the River Niger and its tributaries. Although the hydraulic pattern of the Niger Delta area is yet to be established [11], the subsurface water flow is expected to reflect a mirror image of the surface drainage.

Apart from the river channels, the entire area covered by Benin Formation generally appears flat lying and featureless. The high altitude does not exceed 180m above mean sea level. The ground level however, slopes very gently from the higher ground in the North towards the coastal region and Niger

floodplain [2]. The aquifer thickness varies in the same manner and reaches up to 107m thick. The high transmissivity and storativity of the aquiferous unit makes it suitable to be exploited through boreholes. Climate change, population growth and urbanization affect the recharge systems and processes of the aquifer units of Benin Formation. High rates of abstraction from closely and randomly spaced boreholes has been associated with the tremendous lowering of the water table and reduced hydrostatic pressure with resultant subsidence [11]. The River Niger with a discharge of over 4000m³/s plays significant roles in the Niger Delta Basin. The discharge from River Niger at various locations in Nigeria and variation of Upper Niger flow over years were adopted from the works of [12].

Coastal Erosion

Elevation of water level results to the ingress of the sea due to the low topography of the coastal plain thereby flooding the plain. Gully erosion is a notable occurring environmental hazard in southeastern part of Nigeria [13]. The occurrence of flooding and coastal erosion along the bank of River Niger and Anambra River at Onitsha and environs are facilitated by the variation in the duration of rainfall and rainfall amount attributed to climate change. The impact of the wave on the shoreline erodes the river bank and the sediments transported into the deeper waters due to the steep slope [11]. The impacts of coastal erosion are exacerbated by climate change and allied anthropogenic activities along the bank of the River Niger and its tributaries. Attempted measures to control the impact of coastal erosion have been unsuccessful due to poor coordination of the measures and lack of political will to implement recommendations.

Method of Study

Data on the geology of the area were collected from borehole drilling site while hydrological data were obtained from field records. Existing topographic and geological maps of the country were used to establish the extent and topographic factors of the study basin. Groundwater levels were measured with water level indicators while rainfall and river discharge

records were obtained from meteorological records and existing publications. Due to the paucity of data, available data were correlated to compute the missing ones.

Result and Discussion

Table 1 below shows the discharge of River Niger at different locations. The behavior of River Niger in relation to the aquifer of Benin Formation is shown in Fig. 3. The data so presented were first plotted to observe the trends, seasonal fluctuations and special events. The important features were also merged to observe the relationships in the trends.

Table 1 Monthly discharge m³/s hydrograph of River Niger system at different locations

Month/Location	Jebba	Markurdi	Lokoja	Onitsha
Jan	1750	350	1850	1850
Feb	1760	340	1800	1840
March	1750	345	1780	1790
April	1300	350	1350	1350
May	650	650	1360	1360
June	500	2000	2400	2400
July	1000	4300	6000	6000
August	1350	7500	9600	9600
Sept	2600	12000	16000	16,600
Oct	2500	12000	17000	16,600
Nov	700	4600	9200	7200
Dec	1700	1400	3600	3000

By correlating the monthly and annual rainfall, River Niger discharge and groundwater level, the influence of the climate change on groundwater can be determined. The discharge of the River Niger at Lokoja is higher than the discharge at Onitsha in the months of October - December whereas in earlier months they were almost equal, showing that the River has lost some water possibly to the groundwater (Fig 3). The effect of water on health and livelihood of the people can be analyzed from health reports. However, it is noteworthy that human behavioral factor also play a major role on health of the people.

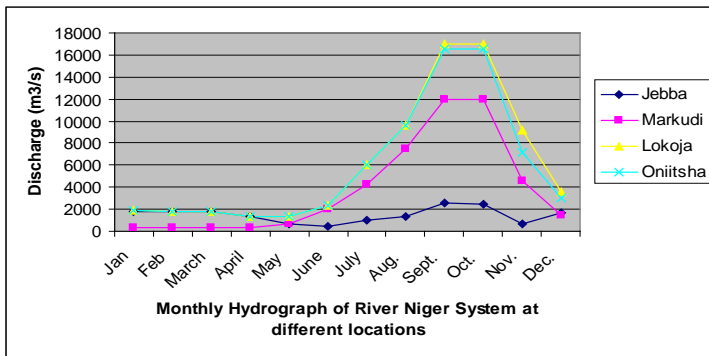


Fig. 3. Monthly Hydrograph of River Niger system at different locations

The depth to aquifer in the coastal area of Onitsha ranges from 2m to 8m and increases to about 150m farther inland. The phreatic nature of the aquifer in most areas and its high dependence on River Niger for recharge makes it vulnerable to the impacts of climate change. The groundwater levels were recorded from boreholes downstream of the Niger Bridge in the lower Niger Sub Basin. The data obtained at Atani, Okija, Umuezealori, Akili Ogidi and Ozubulu were taken as the representative of the study area. Variations in the depth to water level in borehole tapping Benin Formation were also observed from 2006 to 2008 Fig. 4.

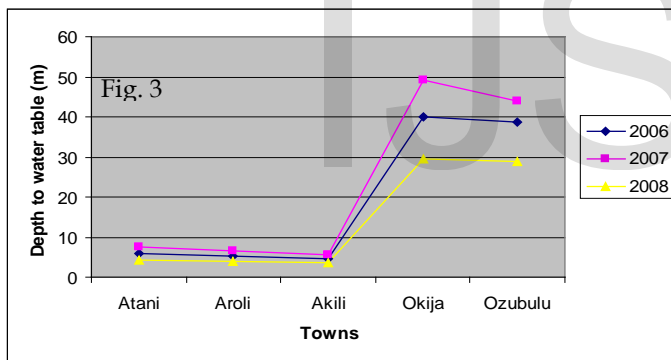


Fig. 4 Variation in water level in boreholes of Benin Formation

Conclusion

Though groundwater regime of the Benin aquifer is related to the rainfall of the area, they are more strongly related to the volume of water in the River Niger which enhances its recharge and discharge. On the other hand, the flow of the River Niger is influenced by the rainfall index and runoff in the upper catchments areas. Some of the water discharge into the surrounding aquifer thereby recharging it. From the correlation index of the River Niger and groundwater and rainfall, it can be concluded that the fluctuation of groundwater storage and hence levels were influenced more by the River Niger

discharge and stands the vulnerability of the climate change that affects the river.

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