Journal of African Earth Sciences 135 (2017) 96-107

Contents lists available at ScienceDirect

Journal of African Earth Sciences

journal homepage: www.elsevier.com/locate/jafrearsci

Aquifer prospect and vulnerability of Upper Maastrichtian sandstones: Case of Ajali and Nsukka formations in the Northern Enugu Province, southeastern Nigeria

Stephen N. Ukpai^{a,*}, Hilary N. Ezeh^a, James O. Igwe^b

^a Department of Geology, Ebonyi State University, PMB 058 Abakaliki, Nigeria
^b Department of Geology, University of Nigeria, Nsukka, Nigeria

ARTICLE INFO

Article history: Received 6 November 2016 Received in revised form 18 August 2017 Accepted 22 August 2017

Keywords: Groundwater Upper Maastritchian Erosion Vegetation Anambra basin

ABSTRACT

Two typical aquifer systems, namely, regional aquifer and local Perched aquifer have been delineated in the study area. The regional aquifer was identified at about 100 m depth around lowland areas, although prone to polluting effects from farming activities, erosion and weathering processes. This study investigated extents of groundwater pollution and permeability of the aquifers from water sample and grain size analyses. Results show porosity ranging from 49 to 50% and hydraulic conductivities as follows: 7.0 m/day for the sandstone of Nsukka Formation, 34.6 m/day for the outcrop of Ajali sandstone and 10.4 m/day for the sandstone at saturated subsurface zone with transmissivity of about 572 m^2/day . The results signify that the regional aquifer is recharged by substantial rate of infiltrations vis-a-vis surface outcrops, and is therefore vulnerable to infiltration of pollution plumes. The groundwater is mainly acidic at pH ranging from 5.05 to 7.41 with a mean value of about 6.48, hence the pollution from dissolved iron in many places. Three main water types were identified, namely, Ca-Mg-HCO₃, Ca-HCO₃-Cl₂ and Mg-Na-HCO₃-SO₄-Cl₂ facies, all signifying dominance of groundwater species arising from precipitation recharge. This has resulted in the influences of surface effluents from run off as indicated by nitrate pollution in some areas. Thus, active hydrologic cycle controls the chemical facies in the water resources of the region, and with its hydraulic influence on the landscape, the quality status of groundwater, as well as the growth of agricultural products have been impaired.

© 2017 Elsevier Ltd. All rights reserved.

1. Introduction

1.1. Background information

Considerable geologic attention has been paid to the Anambra Basin, especially when the exploration and mining of coal started in 1903. This attention led to the stratigraphic synthenses that delineated the Ajali sandstone and the overlying Nsukka Formation of the Upper Maastrichtian and late Upper Maastrichtian period respectively. But then, the Ajali sandstone and Nsukka Formation are mined for whitish sandstones and ironstones for construction purposes. It is therefore necessary to evaluate environmental impacts of the mining activities on groundwater system in the formations, with a case study in the northern part of Enugu district.

* Corresponding author. E-mail address: ukpaisteve@gmail.com (S.N. Ukpai).

The district comprises Aku, Akpugo, Nkporogu, Nrobo, Ikwoka, Eha-Aluma, Ozala, Ikwoka and Opi areas; all drained by River Otta and River Ora in the east and River Adada in the west. The rivers emanate from a central escarpment that forms a watershed, and where groundwater originates and flows in opposing eastwards and westwards directions as shown in cross section, A-A' (Fig. 1a). The flow of water controls the dispersion of polluting plumes to the aquifers, which poses a threat to the health of the populace in the area. The contamination of the groundwater was mainly from point and non-point sources; the point sources emanate from localities of weathered ironstones, whereas the non-point or diffused sources emanate from indiscriminate defaecations from animal farming, domestic wastes and fertilizer application to farmlands. Apart from acute problem of environmental devastation across the region (Egboka, 1983) via mining and erosion, the populace was faced with shortage of groundwater. This problem is possibly enhanced by characteristic high elevations from mean sea level which range from 200 m to greater than 1200 m (Fig. 1). However, areas with









Fig. 1a. Map of the study area showing Locations, surface water shed and groundwater divide.

elevations less than 300 m are prospective localities for development of sustainable groundwater. Therefore, the aim of this study is to determine the major reason for incessant scarcity of groundwater in the region, and has been attributed to great depths to static water level. The specific objectives were to: investigate the aquifer potential of the region, as well as to map vulnerability and contamination levels in groundwater of the area; in order to infer the status of the quality from Ajali sandstone in the Northern Province of Enugu area. It was observed that the Ajali Formation is very transmissive, hence, prolific and produces a regional aquifer beneath the static water level (saturated zone), whereas the overlying Nsukka Formation forms perched aquifers above the watertable at shallower depth. Thus, for steady groundwater supply, boreholes should be drilled into the deep saturation zone. Pollution due to anthropogenic activities is potential threat to the groundwater guality, particularly from places where the Ajali Formation outcrops, and other areas where the overburden Nsukka Formation were removed by erosion.

1.2. Regional stratigraphic and geomorphologic setting

Anambra Basin is located in the southwestern part of the Benue Trough, which geographically falls within the Lower part of the trough (Kogbe, 1999). The Benue Trough is one of the basins that evolved by series of transgressive and regressive movements, triggered by tectonic events that occurred in stages (Benkhelil, 1989). The stages include the Rift phase, followed by sequences of Trough, Deformation and Platform stages. The Rift and Trough stages occurred consecutively, one after the other in Albian times (Hoque and Nwajide, 2002). These were the periods when the first and second tectonic events occurred, causing the breaking and rifting of the Gondwana super-continent. The rifting separated the African plate from the South American plate and created aulacogen with sedimentary incursion that formed the Benue Trough (Ojo, 1992). In the Santonian time, another tectonism affected the entire Trough, resulting in the deformation of the sediments, followed by uplift of some parts of the trough, hence, the emergence of the Abakaliki anticlinorium, as well as consequential depressed platform to the southwest of the trough. The platform stage marked the sedimentary infill of the depression, now known as Anambra Basin, wherein the study area is located.

Incursion of post-Santonian sediments in the Anambra Basin occurred in two depositional cycles (Murat, 1972). The first cycle took place from late Campanian to early Maastrichtian time when the sea became shallower and the Nkporo shale was deposited as pro-deltaic sediments that form the basal stratigraphic unit of Anambra Basin (Reyment, 1965). From early to middle Maastrichtian was a successsion of paralic sediments known as the Mamu Formation, referred to in the older literature as the Lower Coal Measures (Tattam, 1944) which essentially consist of shale/ sandy shale, carbonaceous shale, sandstone and coal seams; and overlain by Upper Maastrichtian fluviodeltaic Ajali sandstone. Lithologically, the Ajali sandstone is mainly friable and whitish, underlying the Nsukka Formation of late Upper Maastrichtian where Upper Cretaceous sediments terminate. The Nsukka Formation, known in the older literature as the Upper Coal Measures (Simpson, 1954), comprises mainly of ironstone and small sandstone members with clay/mudstone intercalations and coal beds in some localities.

1.3. The study area

1.3.1. Location and physiography

Northern Enugu Pronvince is located within the tropical hinterland, from Latitudes 6° 40[°] N to 6° 60[°] N and Longitudes 7° 15[°] E to 7° 30[°] E of southeastern Nigeria. The area is generally covered by incoherent lithosoils, mostly found at steep slopes of conical hills where they often appear as red earth. The vegetation is characterized by shrubs and grasses that are yellowish on the outcrops of Ajali Sandstone due to high leaching of soil nutrients, hence, the food crops in the area are grown by applying fertilizer to the soil. The grasses are more greenish with some tall trees on the Nsukka Formation, which has lured farmers in the area to Livestock breeding, including cattle ranching.

1.3.2. Geology and hydrogeology

Fig. 1b presents detailed lithofacies units of southwestern part of the study area, depicting the typical geology of the area, which consists of two units; A and B, representing major and minor



Fig. 1b. Detailed map of the Southwestern part of the study area showing the typical Geology.

Download English Version:

https://daneshyari.com/en/article/5785507

Download Persian Version:

https://daneshyari.com/article/5785507

Daneshyari.com