An Evaluation of Aquifer Characteristics of the Idemili River Catchment Area of Southeast, Nigeria

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ABSTRACT

Hydrogeologic studies were carried out in the Idemili River Catchment area of southeast Nigeria in order to determine its aquifer characteristics. The geologic formations underlying the study area are the Ogwashi Asaba Formation and the Nanka Sands. Pumping test were carried out for 72hrs on each borehole and the following data were obtained, borehole depth, static water level, dynamic water level, drawdown and borehole yield. The data were then used to compute, Transmissivity, hydraulic conductivity and specific capacity. At Akaboukwu, Uruagu, Nnewi where the Ogwashi Asaba Formation was intercepted. The depth of borehole drilled was 137 meters, static water level and dynamic water level recorded are 103 meters and 104.2 meters respectively and the drawdown was 1.21 meters. Computation made for hydraulic head, transmissivity, hydraulic conductivity, and specific yield were 29 meters, 65.62m²/day 2.262m/s and 4.394m²/hr. respectively. The depth of borehole in the Nanka Sands ranged from 134 meters in Mbanagu, Otolo Nnewi, through 186 meters at Nkolofia, Awka Etiti to as high as 237 meters at Eziumuru, Nnobi. Static water level ranged from 40.84 meters at Ndimgbu, Otolo, Nnewi through 97.07 meters at Ochannachi, Nnobi, to 143 meters at Awkaetiti. Drawdown values ranged from 0.24 meters at Umuezeani, Nnobi through 1.19 meters at Ndimgbu, Nnewi to 3.2 meters at Eziumuru, Nnobi. Borehole yield values of 62.53m³/day at Umumelum, Nnobi through 119.96m³/day at Nkolofia, Awkaetiti, to 233.80m³/day at Ndimgbu, Nnewi were obtained. Computation made for hydraulic head ranged from 50 meters at Eziumuru, Nnobi through 61.22 meters at Awkaetiti to 94 meters at Ndimgbu, Nnewi. Transmissivity values ranged from 24.42m²/day at Umuobi, Nnobi through 61.70m²/day at Awkaetiti to 121.87m²/day at Ndimgbu, Nnewi. Hydraulic conductivity values ranged from 0.411m/s at Umuobi, Nnobi through 3.937m/s at Nkolofia, Awkaetiti to 4.479m/s at Umuhai, Nnobi. Specific capacity values ranged from 1.496m²/hr at Eziumuru, Nnobi through 8.864m²/hr at Umudim Nnewi to 20.14m²/hr at Awkaetiti. The recovery test showed that the time for the borehole to fully recover ranged from 3 minutes at Umudim Nnewi through 9 minutes at Umuhai, Nnobi to 15 minutes at Akaboukwu, Uruagu, Nnewi. These results if properly harnessed indicate that aquifers would be viable for groundwater exploitation in order to meet the daily water needs of an ever growing population.

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INTRODUCTION

The study area (Idemili and environs) lies within latitudes 6°00'N and 6°10'N and longitude 6°50'E and 7°00'E and falls within the Anambra River Basin of Nigeria (Ofodile, 2002), with an area extent of approximately 351.56km². The major towns in the study area include Nnewi, Nnobi, Umuoji, Uke and Ojoto. It is accessible via Awka-Nnewi and Onitsha-Nnewi asphalt roads. The population of

the area is dense about 206,000 (NPC, 2006; Mac-millan, 2006; Oformata, 2002). The moisture laden southwest monsoon winds that comes from the Atlantic Ocean causes much rainfall in the area during the raining season resulting in an average rainfall of 1850mm/year (Ileoje, 1985). Precipitation in the area recharge the aquifers in the catchment area.

Brief Geology and Hydrogeology of the Area

The study area is underlain by two main Formations; the Eocene Nanka Sands and the Quaternary Ogwashi-Asaba Formation. (Nwajide, 2013; Reyment, 1965). The Nanka Sands underlies, Nnobi, Ojoto and some parts of Nnewi. In the study area it is a sequence of poorly consolidated, poorly sorted, friable, medium to coarse sands of Eocene age. The Formation contains thin band of claystone, siltstone and shale. The units have good porosity and permeability. The sandstone unit is aquiferous (Nwajide, 1979). Overlying the Nanka Sands is the Ogwashi-Asaba Formation. This consists of alteration of lignites and clays. The formation is aquiferous

with good porosity and permeability. Fig. 1 shows geologic map of the study area.

The aquifers in the area range in depth from 134m to 237m. Water levels occur at shallow depths in the plains and valley courses while the water levels occur at greater depths in the highland areas (Okpoko, 2017). Groundwater recharge in the study area is by infiltration from rainfall and surface runoff.

The cost of exploitation of deep aquifer is high amongst the inhabitants in the area with the attendant risk of drilling abortive boreholes because most times professionals are not involved during exploitation.

Fig: 1 Geologic map of the study area (Abor Sheet 300)

The study area displays highlands and lowlands with topographic heights ranging from 60m to 180m at Umuoji and 300m to 320m above sea level at Nnobi; the elevation of the land slopes generally to the west of the area. The rivers and streams that made up the drainage system in the study area comprised River Idemili, Mmiri John, Ngbor and Ezigbo. Hydraulic connectivity exists between the surface water systems and the groundwater systems. Through the phases of

hydrogeologic cycle the groundwater system is recharged from infiltration of part of overland flow into the soil (Fetter, 2001; Heath, 1983). The drainage pattern of the Anambra basin is dendritic with individual streams flowing from sandy highlands to shaly lowlands. Meteorological, topographical and geological factors contribute to the amount of their flow and discharge. Fig. 2 and 3 are maps of Nigeria indicating study areas and topographic map of the study areas.

Fig. 2: Map of Anambra State Showing study area and inset is map of Nigeria (Ileoje, 1985)

Fig. 3: Topographic Map of Study Area (Adopted from Abor, Sheet 300).

Climate and Vegetation

The study area lies within the Equatorial Monsoon climatic belts of Nigeria typified by the rainy and dry seasons. Average rainfall for the area is 1650mm to 2000mm a year (NIMET, 2012; Inyang, 1975). The rainy season lasts for about eight months (March to October) and the dry season last for about four months (November to February) in the study area. Rainfall is not so heavy within the months of March and May while rainfall is heaviest between June and September. The driest period is between November and February.

According to National Oceanic and Atmospheric Administration NOAA (2007), the climate is comparatively

congenial. Average maximum and minimum temperatures are 32°C and 23°C respectively. The relative humidity for the wet months is 60% to 71%. Evaporation rates are low 1.4mm in the rainy season to a maximum value of 6.0mm in the dry months.

The study area lies within the Tropical Rainforest Vegetation belt (Fig. 4). The heavy rain forest in some places have given way to light rainforest as a result of man's encroachment on the environment. Tropical Rainforest vegetation is characterized by tall trees with canopy strata, thick undergrowth and shrubs. Oil palm trees dominate the landscape and other species of trees found in the area include iroko, mango, Mahogany and oil bean

Fig. 4: Vegetation map of Nigeria showing the study area. (Macmillan, 2006).

MATERIALS AND METHODS

Materials used for this study include note book, pencil, gum, leather bag, meter tape, water level sounders, Global Positioning System (GPS), board markers and topographic map (Abor Sheet 300). Road network, relief, drainage system were indicated on the base map produced from the topographic maps. Observations made during field work were recorded on the field notebook. Coordinates of the borehole sites were measured using the (GPS). Meteorological data for rainfall, temperature and evaporation were obtained from literature review of the area. Pumping test and recovery test was used to evaluate aquifer parameters of the area.

Data were collected during field studies and borehole drilling/pumping test operations, and from existing records, using standard procedures. Drill cuttings obtained during drilling were kept in wooden boxes. Water levels were obtained with the aid of water level depth sounders and the hydrogeological parameters used for the studies were obtained from borehole water samples, during which measurements were made and values obtained for depth of borehole, static water level, hydraulic head, dynamic water level, drawdown, borehole yield. The transmissivity, hydraulic conductivity and specific capacity were then computed from the raw data using relevant formulae.

RESULTS AND ANALYSIS

The results obtained for this study are presented in tables for the evaluated hydrogeologic (aquifer) parameters Pumping test results (Table 1), recovery test results (Table 2) and the draw down equilibrium graphs obtained from pumping test (Fig. 5 to 16) are also presented herewith.

DISCUSSIONS

At Akaboukwu, Uruagu, Nnewi underlain by the Ogwashi Asaba Formation, borehole drilled depth was 137 meters, static water level and dynamic water level recorded were 103 meters and 104.2 meters respectively and the drawdown was 1.21 meters. Computation made for hydraulic head, transmissivity, hydraulic conductivity, and specific yield are 29 meters, 65.62m²/day, 2.262m/s and 4.394m²/hr. respectively. The pumping test (Constant Discharge Test) and Recovery Test results showed that the groundwater resource potential is excellent, with high yield, high Transmissivity, minimal drawdown and high specific capacity.

The depth of borehole in the Nanka Sands ranged from 134 meters in Mbanagu, Otolu Nnewi, through 186 meters at Nkolofia Awkaetiti to as high as 237 meters at Eziumuru, Nnobi. Static water level ranged from 40.84 meters at Ndingbu, Otolu, Nnewi through 97.07 meters at Ochannachi, Nnobi, to 143 meters at Awkaetiti. Drawdown value ranged from 0.24 meters at umuezeani, Nnobi through 1.19 meters at Ndingbu, Nnewi to 3.2 meters at Eziumuru, Nnobi. Borehole yield gave values of 62.53m³/day at Umunemelum, Nnobi through 119.96m³/day at Nkolofia, Awkaetiti, to 233.8m³/day Ndingbu, Nnewi. Computation made for hydraulic head ranged from 50 meters at Eziumuru, Nnobi through 61.22 meters at Awkaetiti to 94 meters at Ndingbu, Nnewi. Transmissivity values ranged from 24.42m²/day at Umuobi, Nnobi through 61.70m²/day at Awkaetiti to 121.87m²/day at Ndingbu, Nnewi. Hydraulic conductivity values ranged from 0.411m/s at Umuobi, Nnobi through 3.937m/s at Nkolofia, Awkaetiti to 4.479m/s at Umuhai, Nnobi. Specific capacity values ranged from 1.496m²/hr at Eziumuru, Nnobi through 8.864m²/hr at Umudim, Nnewi to 20.14m²/hr at Awkaetiti. The recovery test showed that the time for the borehole to fully recover ranged from 3 minutes at Umudim Nnewi through 9 minutes at Umuhai, Nnobi to 15 minutes at Akaboukwu, Uruagu, Nnewi.

The results of the aquifer characteristics of the study area revealed that, both the Nanka Sand and Ogwashi Asaba Formation aquifers are prolific especially if the geophysical/drilling and completion works are scientifically executed.

CONCLUSION

The results of this study showed that the aquifers characteristics of the studied area are good to excellent which make them highly productive. Groundwater supply here receives ample infiltration from abundant rainfall. The humidity is high both in the rainy season and dry season with a moderate temperature. Drawdown is minimal and transmissivity high as shown in pumping test results, suggesting good porosity and permeability and the characteristic friability normally associated with the underlying geologic units. Boreholes exploit the aquifers from shallow depths at the valley courses and lowlands to very great depths in the upland areas. The recharge of the aquifer is high and are due to the high favorable climatic, topographic and geological conditions. Groundwater exploitation in the area is very promising thus ensuring sustainable water supply to the inhabitants of the area.

Table 1: Hydrogeologic Data of Study Area.

Location	Town	Geologic Formation	Cord N	Cord E	Elevation (m)	Depth Borehole	Depth of Water Level	Hydraulic Head	Dynami Water Level	Drawdown	Yield m ³ /Day	Transmissivity	Hydraulic Conductivity	Specific Capacity
1	Ndimgbu Otolu Nnewi	Nanka Sand	06 ⁰ 089.41	06 ⁰ 947.96 ¹	135	154	40.84	94.16	42.03	1.19	233.8m ³ /day	121.87m ² /day	1.358m/s	8.1866m ² /hr
2	Akaboukwu Uruagu Nnewi	Ogwashi-Asaba	06 ⁰ 038.30 ¹	006 ⁰ 887.74	132	137	103.0	29	104.21	1.21	127.6m ³ /day	65.62m ² /day	2.262m/s	4.394m ² /hr
3	Mbanagu Otolu Nnewi	Nnaka Sand	06 ⁰ 094.10 ¹	006 ⁰ 943.14 ¹	130	134	52.33	77.67	52.83	0.52	214.67m ³ /day	112.49m ² /day	1.448m/s	17.20m ² /hr
4	Inyaba Umudim Nnewi	Nanka Sand	06 ⁰ 030.10 ¹	006 ⁰ 887.24 ¹	141	180m	61.35	79.65	62.12	0.77	163.8m ³ /day	50.05m ² /day	0.628m/s	8.864m ² /hr
5	Umunemelum Nnobi	Nanka Sand	06 ⁰ 03.927 ¹	006 ⁰ 562.88 ¹	181	235.3	121.23	59.77	122.62	1.42	62.53m ³ /day	25.64m ² /day	0.428m/s	1.835m ² /hr
6	Umuobi Nnobi	Nanka Sand	06 ⁰ 03.449 ¹	006 ⁰ 56.432 ¹	202	241	142.7m	59.3	113.55	0.85	79.8m ³ /day	24.42m ² /day	0.411m/s	4.1m ² /hr
7	Umuezeani Nnobi	Nanka Sand	06 ⁰ 05.517 ¹	006 ⁰ 92.284 ¹	148	172	114.48	33.52	114.72	0.24	100.3m ³ /day	61.04m ² /day	1.821m/s	17.418m ² /hr
8	Umuhai Nnobi	Nanka Sand	06 ⁰ 05.080 ¹	006 ⁰ 94.045 ¹	145	164	118.8	26.2	120.24	1.44	140.74m ³ /day	117.36m ² /day	4.479m/s	4.0724m ² /hr
9	Ochannachi Nnobi	Nanka Sand	06 ⁰ 06.256 ¹	006 ⁰ 92.729 ¹	140	152	97.07	42.93	93.31	2.24	185 m ³ /day	72.28m ² /day	1.682m/s	3.4417m ² /hr
10	Awka-Etiti	Nanka Sand	06 ⁰ 03.753 ¹	006 ⁰ 96.071 ¹	203 ¹	233	143.78m	61.22	144.10	0.32	154.7m ³ /day	61.70m ² /day	1.007m/s	20.14m ² /hr
11	Nkolotia Awka-Etiti	Nanka Sand	06 ⁰ 03.263 ¹	006 ⁰ 95.971 ¹	170	186	139.96	30.04	140.89	0.93	119.96m ³ /day	118.27m ² /day	3.937m/s	5.374m ² /hr
12	Eziumuru Nnobi	Nanka Sand	06 ⁰ 04.459 ¹	006 ⁰ 57.433 ¹	175	237	125	50	128.2	3.2	114.9m ³ /day	42.12m ² /day	0.842m/s	1.4963m ² /hr

Table 2: Pumping and Recovery Test Result of Study Area.

LOCATION	PUMPING TEST					RECOVERY TEST			
	TIME PUMPING STARTED (MINS)	TIME TO DRAWDOWN EQUILIBRIUM (MINS)	STATIC WATER LEVEL (M)	WATER LEVEL AT EQUILIBRIUM (M)	DRAWDOWN EQUILIBRIUM (M)	TIME PUMPING STOPPED (MINS)	WATER LEVEL WHEN PUMPING STOPPED (M)	INITIAL WATER LEVEL (M)	TIME TO RECOVERY (MINS)
1	0	25	40.84	42.03	1.19	0	42.03	40.84	12
2	0	7	103.00	104.33	1.30	0	104.21	103.00	15
3	0	60	53.33	52.85	0.52	0	52.33	52.85	6
4	0	4	61.35	62.12	0.77	0	61.35	62.12	3
5	0	5	121.23	122.65	1.42	0	121.23	122.65	6
6	0	6	142.73	143.56	0.86	0	143.56	142.73	5
7	0	8	114.48	114.72	0.24	0	114.48	114.72	4
8	0	5	118.85	120.45	1.65	0	120.45	118.80	9
9	0	30	97.07	99.31	2.24	0	99.31	97.07	7
10	0	25	143.78	144.11	0.32	0	144.10	143.78	6
11	0	60	139.96	140.89	0.93	0	140.89	139.96	6
12	0	10	125.00	128.20	3.20	0	125.00	128.20	10

Fig. 5: Drawdown Graph of Location 1.

Fig. 6: Drawdown Graph of Location 2

Fig. 7: Drawdown Graph of Location 3

Fig. 8: Drawdown Graph of Location 4

Fig. 9: Drawdown Graph of Location 5

Fig. 10: Drawdown Graph of Location 6

Fig. 11: Drawdown Graph of Location 7

Fig. 12: Drawdown Graph of Location 8

Fig. 13: Drawdown Graph of Location 9

Fig. 14: Drawdown Graph of Location 10

Fig. 15: Drawdown Graph of Location 11

Fig. 16: Drawdown Graph of Location 12

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