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Assessment of Static Water Level Dynamics in parts of the Eastern Niger Delta

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ABSTRACT
The maximum static water level in the study area occurs around Ulakwo, at 18.2 meters below ground surface and Erema, 15.24 meters below ground surface in the northern parts of the study area. Values of static water level decrease in the central parts to 3.7m, 3.23m and 2.3m for Omoku, Bodo and Abonema respectively. The value approaches near surface in the southern parts and near the coast, 0.34m at Abissa, 0.69m at Brass and zero at Akassa. Artesian conditions prevail in places where a thick clay sequence completely seals the underlying sandy aquifer over a long lateral distance with sufficient confining pressure as in the very deep wells at Bonny or in the perched aquifers in the clayey southern parts of the study area like Abam Ama, Old GRA and Iva Valley, Port Harcourt. The static water level map clearly shows that the major regional direction of groundwater flow is from north to south. Changes in groundwater flow directions which occur at some places in the southeast, northwest and northeast, generally serve localized discharge areas. The resultant flow path eventually joins and feeds the major regional north-south flow direction. This flow pattern (local and regional) is generally consistent with the geology and stratigraphy of the area.

KEYWORDS: *Static water level, aquifers, groundwater flow, Niger Delta*

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I. INTRODUCTION

The level to which an urban centre meet its water demand depends on a variety of factors: physical/geographic which can be linked to natural recharge due to a combination of good rainfall and receptive subsurface geology or good aquifers that can store and transmit quality groundwater devoid of salinity and other impurities while the second factor is driven by the economic scarcity (Ajibade *et al.*, 2011).In the study area, the main source of recharge is through direct precipitation where annual rainfall is as high as 2000 – 2400mm. The water infiltrates through the highly permeable sands of the Benin Formation to recharge the aquifers. Groundwater in the study area occurs principally under water table conditions. Multi-aquifer systems occur in the study area and the upper aquifers are generally unconfined (Etu-Efeotor, 1981; Offodile, 2002; Edet, 1993; and Udom, 2004).

The rate of aquifer recharge depends to a large extent on the infiltration capacity of the soil, percolation, evapotranspiration rate, subsurface lithology and the overland drainage characteristics of the area. Where sandy clays form a part of the soil layer, recharge usually occurs through a distant outcrop of the porous formation and partially through the lateritic sandy clay which exist to a few meters. Tahal (1998) observed that about 30% - 40% of yearly average rainfall (2,280mm) could in fact infiltrate and recharge the Benin Formation. Recharge by precipitation is 60% - 70% of rainfall in the north where sandy porous outcrops exist. Therefore, sandy porous outcrops of the older rocks in the north serve as recharge area. There, recharge can be as high as 60% - 70% of the rainfall. Recent sediments form the discharge areas in the south. This paper therefore, assesses and evaluates the static water levels dynamics in parts of the Niger Delta.

Description of the Study Area

The study area is the Niger Delta Sedimentary Basin (Fig. 1). Lithostratigraphically, these rocks are divided into the oldest Akata Formation (Paleocene), the Agbada Formation (Eocene) and the Youngest Benin Formation (Miocene to Recent). Generally, the present knowledge of the geology of the Niger Delta was derived from the works of the following researchers (Reyment, 1965; Short & Stauble, 1967; Murat, 1970; Merki, 1970) as well as the exploration activities of the oil and gas companies in Nigeria. The formation of the so called proto-Niger Delta occurred during the second depositional cycle (Campanian-Maastrichtian) of the southern Nigerian basin. However, the modern Niger Delta was formed during the third and last depositional cycle of the southern Nigerian basin which started in the Paleocene.

The geologic sequence of the Niger Delta consists of three main Tertiary subsurface lithostratigraphic units (Short & Stauble, 1967) which are overlain by various types of Quaternary deposits (Table 1)

Table 1: Quaternary deposits of the Niger Delta (after Etu-Efeotor & Akpokodje, 1990)

Geologic Unit	Lithology	Age
Alluvium	Gravel, Sand, clay, silt	
Freshwater Backswamp, meander belt	Sand, clay, some silt, gravel	
Saltwater Mangrove Swamp and backswamp	Medium-fine sands, clay and some silt	Quaternary
Active/abandoned beach ridges	Sand, clay, and some silt	
Sombreiro-warri deltaic plain	Sand, clay, and some silt	

The major aquiferous formation in the study area is the Benin Formation. It is about 2100m thick at the basin centre and consists of coarse-medium grained sandstones, thick shales and gravels. The upper section of the Benin Formation is the quaternary deposits which is about 40 – 150m thick and comprises of sand and silt/clay with the later becoming increasingly more prominent seawards (Etu-Efeotor & Akpokodje, 1990). The formation consists of predominantly freshwater continental friable sands and gravel that have excellent aquifer properties with occasional intercalations of claystone/shales (Olobaniyi & Oweyemi, 2006). According to Etu-Efeotor (1981), Etu-Efeotor & Akpokodje (1990), Offodile (2002), Udom *et al* (2002), the Benin Formation is highly permeable, prolific and productive and is the most extensively tapped aquifer in the Niger Delta. All the boreholes in the study area are drilled into the Benin Formation. The Benin Formation consists of fluvial and lacustrine deposits deposits whose thicknesses are variable but generally exceed 1970 meters (Asseez, 1989). The lithologies of the Benin Formation include sands, silts, gravel and clayey intercalations. The sands are fine to coarse-grained, gravelly, poorly sorted and sub-angular to well rounded. According to Onyeagocha (1980), the rocks of the Benin Formation are made up of about 95 – 99% quartz grains, Na+K – Mica 1 -2.5%, feldspar 0.5 1.0% and dark minerals 2.3%. These minerals are loosely bound by calcite and silica cement. The clayey intercalations have given rise to multi-aquifer systems in the area.

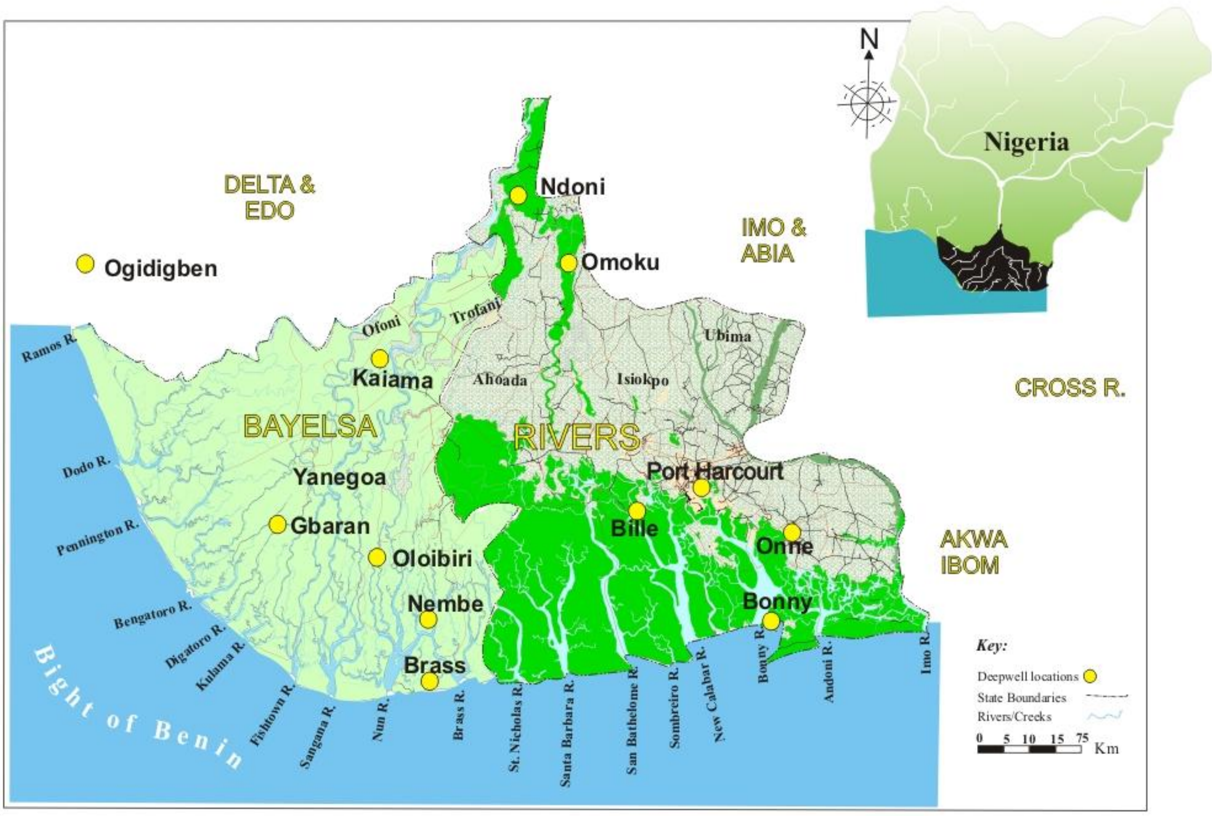

Fig.1: Location Map of the Study Area

Methods of Study

Measurement of Static Water Levels

Static Water Level (SWL) is the level at which water stands in a well or unconfined aquifer when no water is being removed from it either by pumping or by flow. It is usually expressed as the distance from the ground surface (or a measuring point near the ground surface) to the water level in the well.

Static Water Levels (in unconfined aquifers) in the study area were measured and recorded with electronic dip meter. The electronic dip meter consists of a graduated tape, usually in meters and feet with a sensor or electrode attached to the lower portion. The sensor (electrode) is lowered into the boreholes and as it touches the water, the electric circuit is completed and a bulb on the cable reel lights up or a whistling noise or beep is activated. The depth to water level is now read out and recorded. The water level data determined in boreholes in different geomorphologic units in the area are given in Table 2 below:

II. RESULTS

Table 2: Static water levels and borehole locations in the study area.

S/No.	Location	S.W.L (m)		S/No.	Location	S.W.L (m)
1	Ahoada	7.2		34	Baa Lenku	10
2	Ogbo	7.0		35	Bien Gwara	9.14
3	Edocha	4.26		36	Baan	6.1
4	Abua	3.3		37	Sii Babble	9.45
5	Ndoni	7.55		38	Uegwere	5.4
6	Idu	6.2		39	Tombia	4.52
7	Ebubu			40	Abonnema	2.3
8	Omoku	3.7		41	Bakana	1.25
9	Obie	7.6		42	Ke	2.16
10	Erema	15.24		43	Abissa	0.34
11	Ubeta	5.79		44	Bille	0.61
12	Obagi	5.49		45	Buguma	3.6
13	Bassambiri	0.8		46	Krakrama	7.1
14	Atubo	1.37		47	Abalama	
15	Nembe			48	Isiokpo	15.24
16	Ogbia	2.5		49	Ogbakiri	11.9
17	Brass	0.69		50	Omarelu	15.24
18	Otegila	4.0		51	Egbede	
19	Okoroba	0.0		52	Elele	
20	Amakalakala	9.14		53	Igbodo	25
21	Otugidi	0.91		54	Ulakwo	18.2
22	Otuesaga	12.19		55	Opiro	13
23	Akassa	0		56	Rumuonye	22
24	Kolo	NA		57	Chokocho	10.3
25	Onne	7.49		58	Egwi	8.25
26	(NAFCON)	3.23		59	Odagwa	4.57
27	Bodo	6.1		60	Okehi	24.23
28	Buan	7.57		61	Obite	17.68
29	Alesa Eleme	6.1		62	Egbeke Nwuba	9.14
30	Ebubu	15.24		63	Umuechem	10.26
31	Bane	14.02		64	Rumuewhor	5.5
32	Bori	9.14		65	Okrika	11.14
33	Kpor	10.41		66	Ibuluya-Dikibo	8.2
	Beeri					
		5.49		97	Amarata	6.55
67	Bolo 1	6.5		98	Ukubie	1.01
68	Kalio-Ama	Artesian		99	Tebidaba	2.04
69	Abam Ama	5.48		100	Aguobiri	3.6
70	Okujagu	0.61		101	Koluama	0.91
71	George Ama	0.9		102	Olegbobiri	6.7
72	Ogoloma	5.0		103	Gbaran	4.37

S/No.	Location	S.W.L (m)		S/No.	Location	S.W.L (m)
73	Ogu	3.05		104	Igbogene	5.64
74	Daka-ama	1.2		105	Okolobiri	7.62
75	Kalaibiama	2.44		106	Isampou	4.57
76	Bonny	3.0		107	Odi	1.91
77	Iloma Opobo	1.6		108	Kaiama	3.0
78	Gborokiro	2.5		109	Agudama-Epie	5.79
79	Ikuru	2.5		110	Oporoma	4.6
80	Nkoro	1.5		111	Korokorosei	3.7
81	Abalamabie	1.0		112	Yenagoa	5.5
82	Queens Town	3.0		113	Forupa	1.0
83	Minima Opobo	5.49				
84	Oloma II	2.7				
85	Oloma I	9				
86	NDBDA	4				
87	Borokiri					
88	Govt. House	5.6				
89	Agbere Odoni	1.2				
90	Ekeremor	1.0				
91	Toru Ndoro	5.5				
92	Torofani	4.0				
93	Ofoni	2.1				
94	Amabulou	1.5				
95	Letugbene	1.0				
96	Forupa					

III. DISCUSSION OF RESULTS

Groundwater level varies in the area. It is closer to the surface in the coastal areas and deeper as one goes into the hinterland. It also varies with nearness to rivers and creeks. The Sombreiro Deltaic Plain and the Coastal Plain Sands area recorded water level at greatest depth in the region. The maximum static water level in the study area occurs around Ulakwo, at 18.2 meters below ground surface and Erema, 15.24 meters below ground surface in the northern parts of the study area (Table 2). Values of static water level decrease in the central parts to 3.7m, 3.23m and 2.3m for Omoku, Bodo and Abonema respectively. The value approaches near surface in the southern parts and near the coast, 0.34m at Abissa, 0.69m at Brass and zero at Akassa. Artesian conditions prevail in places where a thick clay sequence completely seals the underlying sandy aquifer over a long lateral distance with sufficient confining pressure as in the very deep wells at Bonny or in the perched aquifers in the clayey southern parts of the study area like Abam Ama, Old GRA and Iva Valley, Port Harcourt.

On a regional scale therefore, the static water levels appear to decrease fairly systematically from the north to the south. North of the study area can therefore be regarded as the recharge area while the south is the discharge area. Oteze (1983) observed that in Nigeria, available records on groundwater levels are those made immediately after drilling and those undertaken during specific studies. Systematic water level measurements over a long period of time are rare. Table 2 shows the static water levels in some locations in the study area while Figure 2 is a static water level map of the area from where the regional groundwater flow pattern can be inferred. Most of these boreholes were drilled during the National Borehole Programme (1980 – 1984). It clearly shows that the major regional direction of groundwater flow is from north to south. Changes in groundwater flow directions which occur at some places in the southeast, northwest and northeast, generally serve localized discharge areas. The resultant flow path eventually joins and feeds the major regional north-south flow direction. This flow pattern (local and regional) is generally consistent with the geology and stratigraphy of the area. Outcrops of older rocks in the north serve as recharge areas, while recent sediments form the discharge areas in the south.

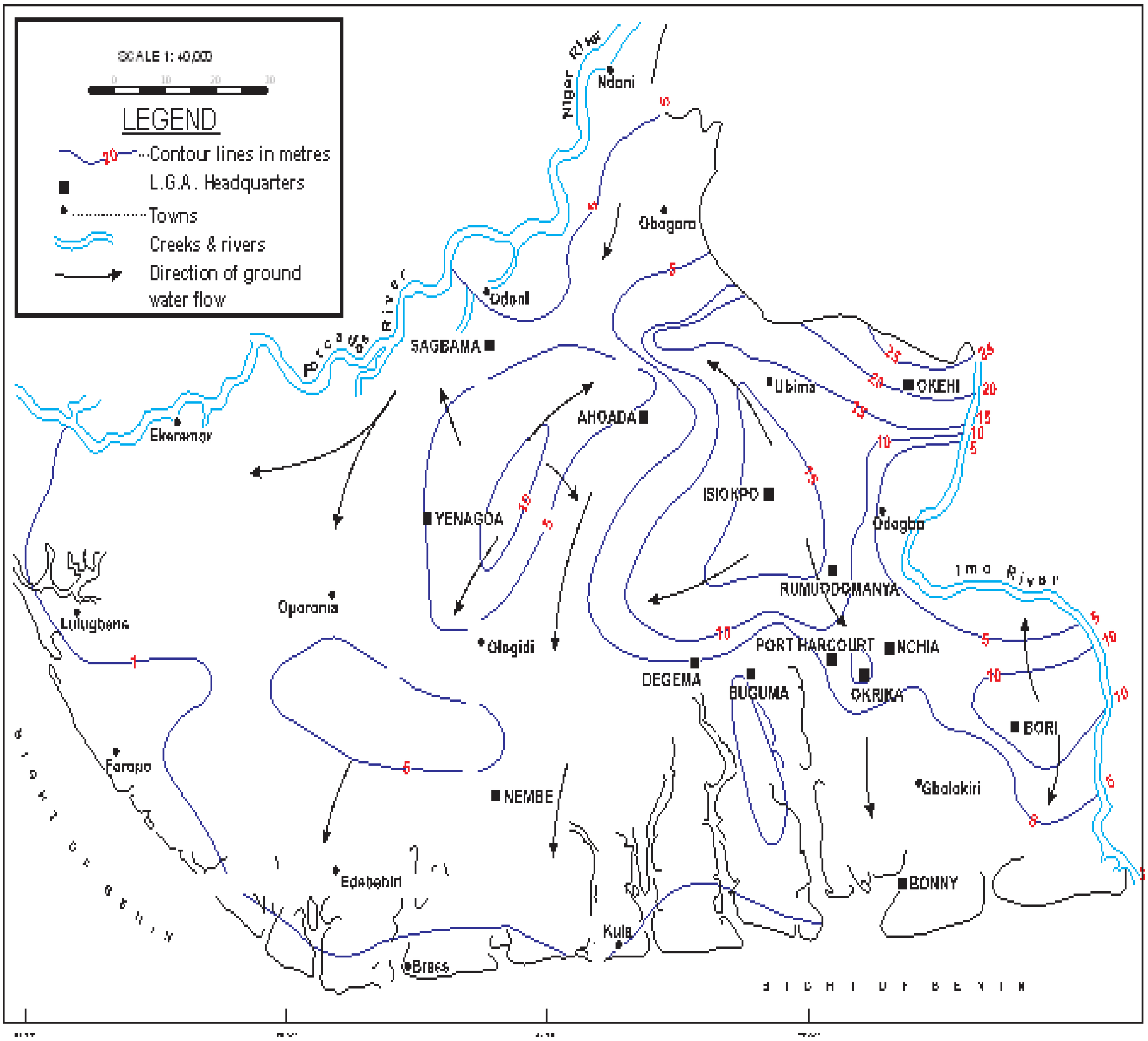

Fig.2: Static Water Level Map of Study Area

IV. CONCLUSION

This study revealed that the maximum static water level in the study area occurs around Ulakwo, at 18.2 meters below ground surface and at Erema, 15.24 meters below ground surface in the northern parts of the study area. It was also observed that values of static water level decrease in the central parts to 3.7m in Omoku, 3.23m at Bodo and 2.3m for Abonema, respectively. The value approaches near surface in the southern parts and near the coast, 0.34m at Abissa, 0.69m at Brass and zero at Akassa. Artesian conditions also prevail in places where a thick clay sequence completely seals the underlying sandy aquifer over a long lateral distance with sufficient confining pressure as in the very deep wells at Bonny or in the perched aquifers in the clayey southern parts of the study area. It was also noticed that the major regional direction of groundwater flow is from north to south. Changes in groundwater flow directions which occur at some places in the southeast, northwest and northeast, generally serve localized discharge areas. The resultant flow path eventually joins and feeds the major regional north-south flow direction. This flow pattern (local and regional) is generally consistent with the geology and stratigraphy of the Niger Delta.

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