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Application of GeoInformatics in Development of Groundwater Prospect Model for borehole management and development projects in Nigeria.

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Abstract

The research on application of geo-Informatics in developing groundwater prospect model, aims at producing a geo-environmental template for groundwater development and management that can help geo scientist and other stakeholders during bore hole drilling to identify non polluted sites for location of water wells, as well as Aquifer of high prolific nature for best groundwater yield during abreaction and also to avoid pollution of such groundwater wells and subsequent groundwater contamination. This research will also enhance effective harnessing of groundwater potentials in the seventeen (17) local government areas of Abia State. Arc GIS 10.2 was used in this model development, using the data extracted from Depth of water table, recommended water table depth for each local government area (LGA), thickness of prospective horizon, mean resistivity, lithology, x and y coordinate likewise the aquifer yield capacity. Excel spread sheet was also used to prepare a graphical representation of depth to water table, recommended well depth, thickness of the prospective horizon and Mean resistivity as well as Groundwater yield capacity for Abia State, Nigeria measured in (m3 h).These data were processed and fused into the groundwater prospect map showing the local government areas that have prolific yield (P) of groundwater (of 25m3/ h) , medium to high yield (M-H) (16m3/h) , medium yield (M) (14m3/h), low to medium yield (L-M) (12m3/h), low yield (10m3/h), and sample points. The results have identified the individual local government areas in Abia state that have the aquifer carrying capacity to produce sustainable groundwater in Abia state for development and management of water wells for public water supply system in the area.
Key words: Geo-Informatics, Groundwater, Prospect, Model, Prolific Aquifer.

Introduction

The development of groundwater prospect model in Abia state, has become a necessity in the research area of groundwater management and development, due to the high level proliferation of borehole development projects in the state. Enyinna et al (2018) noted that 'Proliferation of borehole development projects has caused serious negative effects on groundwater quality in Abia state because of the pressure it has mounted on the aquifer, that results from continuous abstraction of groundwater from several boreholes in the area with resultant effects of salt water intrusion into groundwater sources and wrong site locations of water wells within areas of high pollution risk zones that end up in causing contaminant infiltration into groundwater wells, through solute transport'. These problems have prompted this research that aims at Application of Geo-Informatics in Development of Groundwater Prospect Model so as to identify best location for well development with Aquifer of high prolific nature in other to produce a geo-environmental template for groundwater development and management that can help stakeholders during bore hole drilling, to identify the water well location that are within non polluted sites, to avoid pollution of groundwater wells and subsequent groundwater contamination.

The general conception of domestic water use in Abia State indicates that groundwater resource is the major source of consumable water within this study area. This groundwater resource is regularly extracted through hand-dug wells and drilled boreholes. Furthermore, due to the importance of this valuable groundwater resource, there is need for a dynamic approach in applying Geoinformatics in developing groundwater prospect model for groundwater exploration and exploitation instead of the use of previous traditional field method that was completely relied upon in selection of well sites for groundwater development projects, Semere (2003). This traditional method involved a none geo-environmental approach where by drilled bore holes and hand dug wells are incessantly established without consideration of guidelines that could control health hazards arising from establishment of water wells at close proximity to land use activities that could allow infiltration of contaminants, emerging from pollutants from such land use activities.

Groundwater prospect model will be a dynamic instrument in groundwater exploration and exploitation plans by the government in managing water resources as well as assisting government, none governmental agencies, communities and all stakeholders in water sector to clearly visualize mapped out groundwater prospect zones, Nwachukwu et al (2013), that are between a highly prolific and none prolific nature during groundwater development and at such concentrate on establishment of water wells within the highly prolific areas that are viable in yielding more groundwater that could efficiently serve the entire population of the state towards a better economic development of the area.

The development of this groundwater prospect model will assist in the mitigation of problems of failed hand pumps, hand-dug wells and drilled boreholes at large. As a result it is indispensable not to give consideration to occurrences of these failed water wells without the development of a standard groundwater prospect model. This good groundwater prospect model will propel government to award contracts of water borehole projects to only viable areas, excluding zones with difficult subsurface geology and non-permeable aquifer that may not allow successful groundwater production from such development projects. Groundwater prospect model will allow fair distribution of public water boreholes to communities in reduction of economic wastes, and environmental degradation, as well as frustration caused by hardship to the affected communities; based on a model of distribution with no consideration for areas with groundwater development difficulty, Nwachukwu et al (2013).

Since the development of groundwater prospect model requires the use of Geoinformatics, it becomes very necessary to briefly explain the meaning of Geoinformatics in relation to data analysis that will help in such geological model formation. According to Burrough (1986), The

Geographic information system is used in management of geographic data that will serve as the basis for formation, evaluation, formatting, storage and exhibition of locational characteristic of geographic information records.

Venkatachalam et al. (1991) noted that geographic information system facilitates the use of comprehensive management approach that incorporates numerous spatial data. Geographic information system has also been used by different stakeholders in the field of science and technology in developing cartographic maps for groundwater prospects models, Ghosh (1993).

Saraf et al. (1998) stated that Geoinformatics helps in developing an acceptable basis for assessment, evaluation and interpretation of a vast set of numerical information that supports experts in determining the type of planning and management that could be applied in groundwater development for sustainable best management practice.

This study aims at developing groundwater prospect model that will help in harnessing the groundwater potentials in the seventeen (17) local government areas of Abia State. This will enable all stakeholders in the study area to identify different geological zones that have the aquifer viability and potential for high prolific yield of groundwater resources this pre-supposes that the groundwater prospects model will display the spatial dimension of geological zones that will yield more groundwater or little or no groundwater during exploitation/ water well development. This will be done with the help of groundwater parameters of different geological constituents. Sander (1996) in Sanjiv et al. (2010) noted that the application of best practice of groundwater development is very necessary in analyzing the different parameters used in developing groundwater prospect model, this will ensure the elimination of establishing water wells within areas that have little or insufficient groundwater storage or non-permeable aquifer but ensure that the water well development will be established in areas with prolific permeable aquifers with sustainable groundwater storage for efficient water supply system in the area.

Study Area

Abia State is my study area and it is located at latitude 4^0 40' and 6 ^{0} 14' North and longitude 7^0 10' and 8^0 East of the equator. This State was created in August. 1991 with 17 local government areas with a population of 2,845, 380, projected to get to 3,555, 326 by 2014 at a growth rate of 2.7%. United Nations population fund UNFPA (2008). Its land form is predominantly made of table terrane of about 120 meters above sea level. It has nine main ***geological formations*** with one that occupies a very small area making it ten. They include: Benin formation (coastal plain sand) occupies mainly the southern part of the state, others include Bende-Ameke group, Alluvium, Mamu formation, Nkpkoro shale group, Nsuka formation (upper coal measures), Ajali sand stone (false bedded sandstone) Eze-aku shale group, Asu river group and Imo shale. Figure 1 below show the geological map of abia state wth diferent sample locations. Hydrology of Abia state could be traced to Imo River. its tributary and Aba River. Imo River has its origin from northwestern part of the state, and flows southwest through Abia and Imo state towards the Atlantic Ocean. It flows through the southeastern part of Ukwa East and Ukwa West local government areas. Some other important rivers in the state include: Igwu River, Azumini blue River and Kwa-Ibo River.

Abaji et al 2018 stated in a research on Characterization of Aquifers Using Geo-electrical Methods in parts of Abia State, Southeastern Nigeria they observed, most of the boreholes drilled in Umuahia South, Ikwuano, Isiala Ngwa North, Isiala Ngwa South, Osisioma, Obingwa, Aba North, Aba South, Ugwunagbo, Ukwa West, and Ukwa East which is the southern part of the state, passed through the Coastal Plain Sands and the recent Alluvium , with borehole depth between 21.02-250m, and water levels observed to be within 4.57m in Ukwa West and 35.97m in Aba South with depth of about 9.15 m to 53.05 m extended to aquifer zone for Umuahia Local Government Area though with depth of about 35.0m.

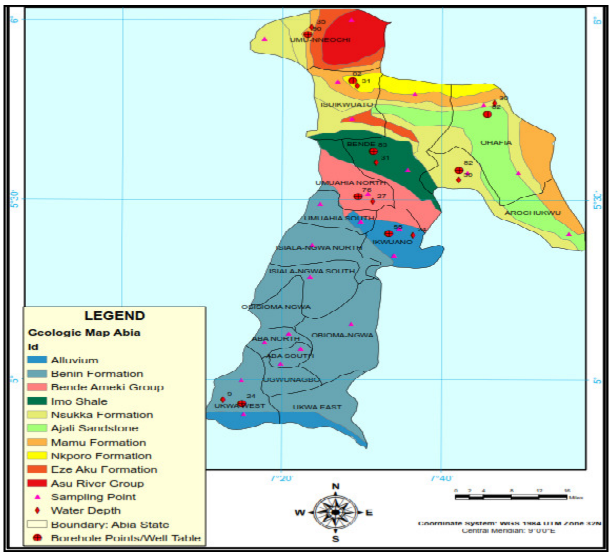

Figure 1: Map showing the geological formations in Abia State

The ***climate*** shows seasonal variations of rainy season and dry season with heavy thunder storms as signs of the starting of the rainy season that begins in March, until it breaks in August "August break" but continues in September to October. The month of November welcomes the dry season which stays for about 120 days, thus, four months with its end in February. The maximum rainfall is above 2200mm in the southern part of the state and between 1900mm- 2000mm in the northern part. In dry season, the area experiences very serious heat causes January to March to be the hottest months in the year with mean temperature of above 27°C. There is also high relative humidity which covers from the January to December. The rainy season also has the highest relative humidity that exceeds 90%.

Materials and Methods

Arc GIS 10.2 was used to develop groundwater prospect model for Abia state using the data extracted from the following parameters like, Depth of water table, recommended water table depth for each local government area (LGA), thickness of prospective horizon, mean resistivity, lithology, x and y coordinate likewise the aquifer yield capacity. These data were processed and fused into the groundwater prospect map with map, showing the local government areas that have prolific yield (P) of groundwater, medium to high yield (M-H), medium yield (M), low to medium yield (L-M), low yield and sample points.

Results and Discussions

The map below displays the ground water prospect model for all the local government areas of Abia state. The local government areas with prolific yield, recorded yield of 25m3/ h. the LGA's with medium to high yield zone has a yield of 16m3/h. the LGA's with medium yield has yield of 14m3/h. and those LGA's with low to medium yield is 12m3/h, while those with low yield recorded 10m3/h.

Table 1 below shows the groundwater potential yield for Abia State.

Prolific Level of Groundwater	Groundwater yield capacity (m3 h)
Prolific yield (P)	25
Medium to High yield (M-H)	16
Medium yield (M)	14
Low to Medium yield (L-M)	12
Low yield (L)	10

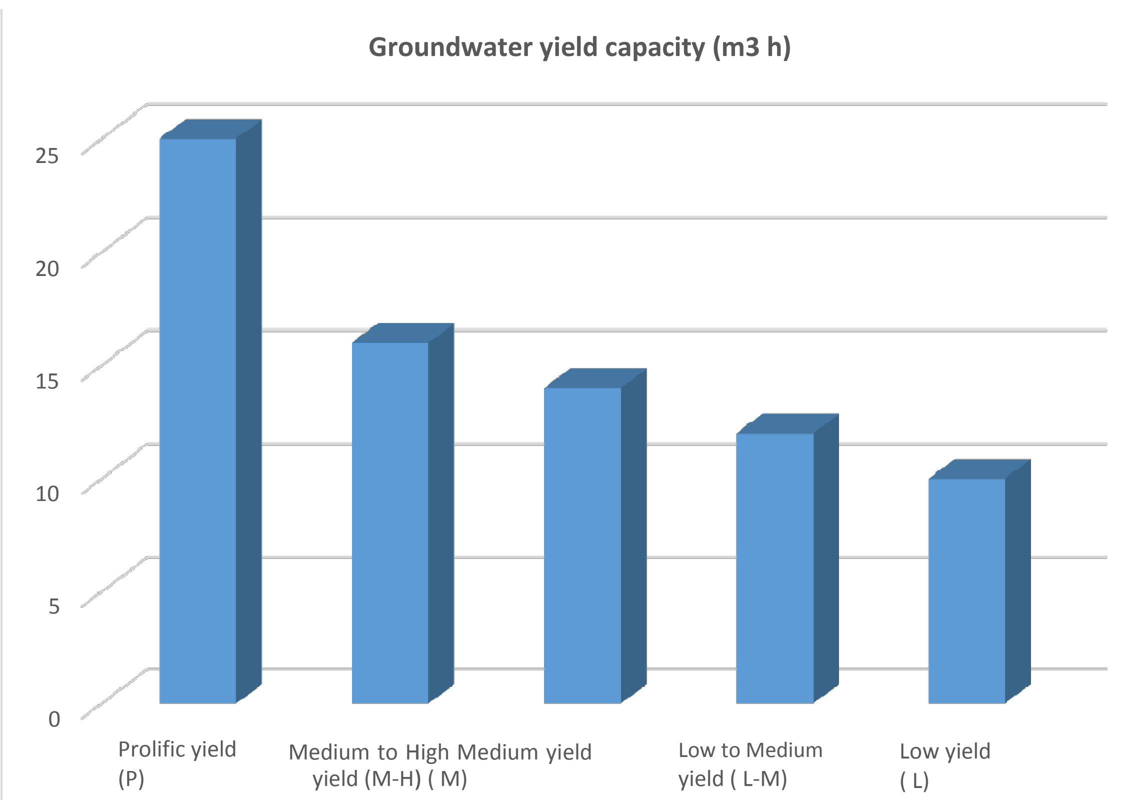

Figure 2: Groundwater yield capacity for Abia State, Nigeria measured in (m3 h)

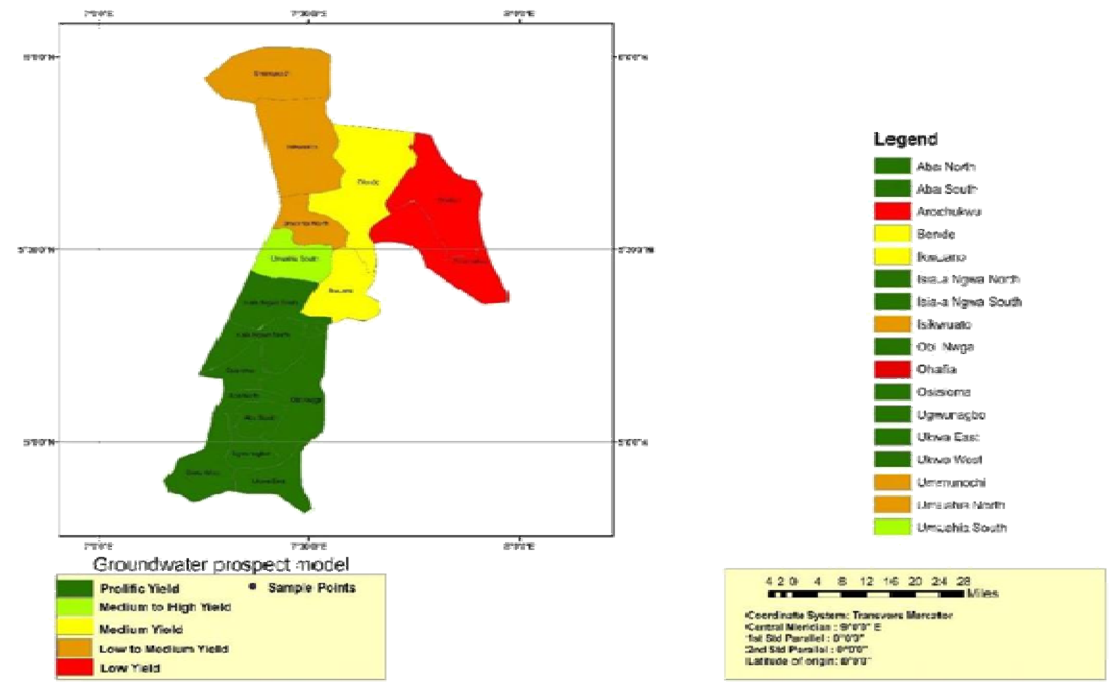

Figure 3: Groundwater prospect model for 17 LGAs in Abia State

The local government areas in Abia state, have the following groundwater yield capacity: Ukwa west, Ukwa East, Ugwunagbo, Obingwa, Osisioma, Aba North, Aba South, Isialangwa South Isialangwa North have prolific yield with $25m^3h$, But Umuahia South has medium to high yield of $16m^3h$. Bende and Ikwuano have medium yield of $14m^3h$. Umuahia North, Isikwuato and Umunnochi have low to medium yield of $12m^3h$ while Arochukwu and Ohafia have low yield of $10m^3h$. Therefore, all the LGA's with prolific yield of groundwater will definitely have sustainable groundwater withdrawal that encourages borehole drilling or groundwater extraction for public water supply system while the LGA with medium to high yield will also encourage groundwater extraction. The areas with Medium yield will also have some positive capacity for groundwater extraction. The LGA's with low to medium yield and the areas with Low yield also have the capacity to produce water but with aquifers that are not as productive as the first three yields on the legend in the groundwater prospect model.

The table below has the following abbreviations and meanings: LGA, local government areas, WTD, depth to water table, WRD, recommended well depth, TCK, thickness of the prospective horizon, RES =Mean resistivity. LIT= Lithology, X= X coordinate, Y= Y coordinate. YLD= Aquifer yield, P= Prolific, M-H= Medium to high yield. L-M= Low to medium yield, L-D= Low yield to dry well.

Table 1; Seventeen LGA's, water table longitude and latitude and groundwater prospect level

L.G.A	WTD	RWD	TCK	RES	LIT	XCD	YCD	YLD
Aba north	120	360	240	1242	sand	5.333333	7.316666	P
Aba south	100	300	200	1109	sand	5.100001	7.350001	P
Arochukwu	240	240	320	3020	Shale-sandstone	5.416667	7.500001	L-D
Bende	230	230	320	3500	Shale-sand	5.566667	7.633333	M
Ikwuano	200	200	320	3280	Sandstone	5.433333	7.566666	M
Isiala Ngwa north	130	130	300	1210	sand	5.116667	7.366666	P
Isiala Ngwa south	100	100	300	1287	sand	5.185278	7.601944	P
Isikuato	250	250	360	2100	Sandstone	5.533333	7.483333	L-M
Obi Ngwa	120	120	320	1250	sand	5.149722	7.330277	P
Ohafia	180	180	280	3050	Sandy shale	5.616667	7.833333	L-D
Osisioma	130	340	210	1150	Sand	5.416667	7.500001	M-H
Ugwunagbo	100	300	200	962	Sand	5.185278	7.601944	P
Ukwa west	120	320	200	850	Sand	5.116667	7.366666	P
Ukwa east	100	320	220	840	Sand	5.104722	7.142501	P
Umuahia north	300	400	100	3280	Sandy shale	5.533333	7.483333	L-M
Umuahia south	180	300	120	1720	Sand	5.508056	7.481666	M-H
Ummunochi	250	400	150	2270	Sandstone	5.104722	7.142501	L-M

Source: Anambara Imo river basin development Authority (2012) in Nwachukwu et al (2013)

The recommended well depth, Aba North recorded 120 feet, Aba south recorded 100 feet Arochukwu recorded 230 feet Bende recorded 240 feet , Ikwuano recorded 250 feet Isialangwa north recorded 130 feet, Isialangwa south recorded 100 meters Obingwa recorded 120, Ohafia recorded 180 feet Osisioma recorded 130 feet, Ugwunagbo recorded 100 feet, Ukwa west recorded 120 feet , Ukwa East recorded Umuahia north 300 feet , Umuahia south 180 feet and Umunnochi 250 feet

Figure 4 below shows, Depth to water table, recommended well depth, thickness of the prospective horizon, Mean resistivity

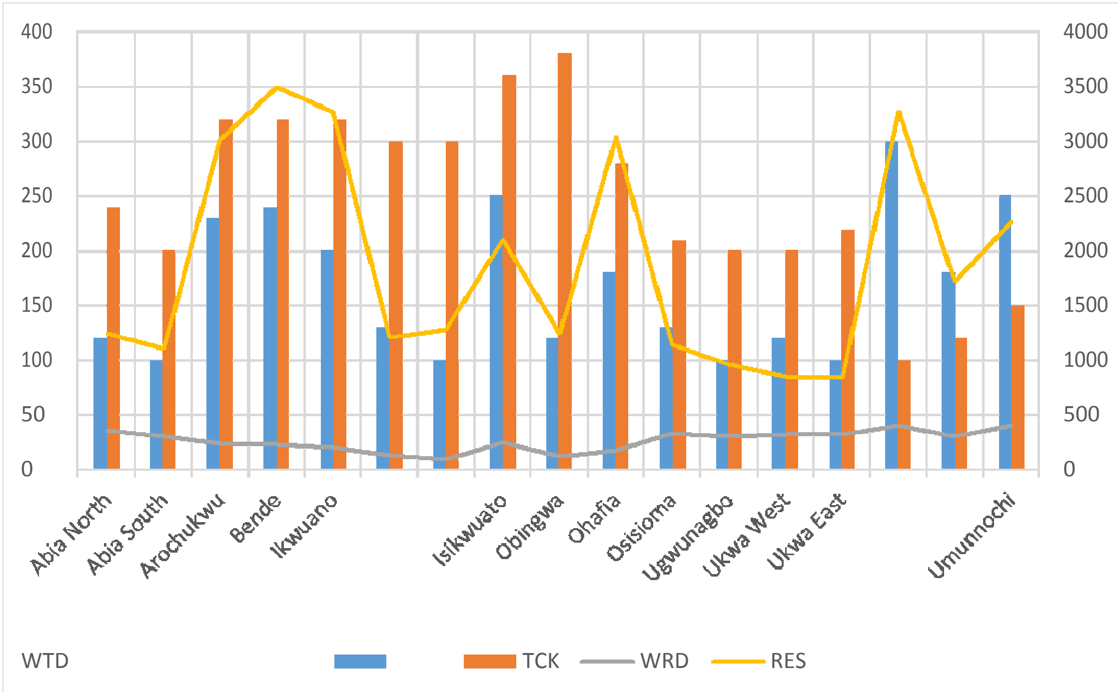

Figure 4: Depth to water table, recommended well depth, thickness of the prospective horizon, Mean resistivity

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