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APPLICATION OF GEOINFORMATICS AND DRASTIC MODEL IN DEVELOPING GROUNDWATER VULNERABILTY INDEX MODEL FOR ABIA STATE NIGERIA.

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Abstract

Application of geo-informatics and drastic model in developing groundwater vulnerability index model for Abia state Nigeria was researched on due to the rising conditions of groundwater contamination that have triggered water related diseases in the area. This was as a result of land use activities taking place in within water wells and around Aquifers of shallow water table. Arc GIS 10.2 was used to develop aquifer vulnerability index via transformation of hydrogeological data into 2D map while the weighting and data processing were done with the aid of DRASTIC model. The results show that Aba south (Ukwa west, Ukwa East, Ugwunagbo, Obinngwa and Osisioma) have extremely high vulnerability which is attributed to the shallow water table and the coastal sand nature of the aquifer. Furthermore, those aquifers resident in Abia central senatorial district (Isiala Ngwa south, Isiala Ngwa north, Ikwuano and Umuahia south LGAs) have high vulnerability, while Umuahia north LGA has moderate and high vulnerabilty. The aquifers resident in Abia north senatorial district (Umunnochi, Isiukwuato, Ohafia and Bende) LGAs have moderate and low vulnerability while Arochukwu LGA shears low, vulnerability. This model has shown that Abia south senatorial district is bound to have more groundwater contamination because of how extremely high venerable the groundwater aquifer is than Abia Abia central and Abia north senatorial district which moderate and low Aquifer vulnerability to pollution It is expected that this model will help the actors in the groundwater management sector to know the areas where groundwater table are under more risk of pollution than the other and for easier planning of sustainable groundwater source protection zone and bore hole development projects. The government and other actors in the water sector are therefore advised to acquire lands within areas of borehole development projects for public water supply systems to prevent land use activities that could cause pollution to groundwater sources so as to conserve groundwater in a sustainable form.

Key words: Vulnerability index, Drastic Model, Development project, Aquifer Groundwater, Pollution Arc GIS.

Introduction

Groundwater resources are highly dependable resources, spatially distributed to dominate about 80% of the geographical space of my study area. This means that most residents of the state are highly dependent on groundwater resources, thereby exposing these valuable resources to over exploitation, leading to proliferation and high level vulnerability to depletion and contamination. Enyinna et al (2018) stated that Proliferation of borehole projects and hand dug wells has contributed to reduction in groundwater quality in Abia state because of the pressure it is continuously giving to the aquifer, through regular abstraction by individuals for both commercial, domestic, Industrial and agricultural uses. They also specified that the drilling of boreholes and hand dug wells are done at different numerous locations which causes salt water intrusion into groundwater while the drilling location of these water wells close to land use activities results to contaminant solute transport into the established wells.

The application of geographic information system in developing groundwater vulnerability index will assist the government and other agencies that are stakeholders in the water sector to clearly understand the aquifers that have become or likely to become vulnerable to depletion and subsequent contamination since these model will show the vulnerability index of the groundwater resources in the area.

The aim of this study is to establish the spatial distribution of groundwater locations that are vulnerable to pollution and subsequent contamination activated by several land use activities and groundwater over exploitation. This would be achieved through application geo-Informatics and Drastic Model, This theory of groundwater vulnerability was established in France in 1960 in other to make stakeholders in the water sector to know and understand the risk associated with groundwater contamination and to introduce a management best practice that will integrate all required hydro-geological parameters for sustainable groundwater protection and management. Vrba et al. (1994).

Furthermore, the development of groundwater management strategy for developing sustainable groundwater source protection zone that will protect groundwater from exposure to vulnerability, requires obtaining hydrogeological data for computation, input and analysis and making use of geographic information system in showcasing cartographical representation of vulnerability index map. Enyinna (2016)

The development of groundwater vulnerability index model for Abia state could be carried, considering the approach of Kumar et al (2015) which specified that there different means of achieving a model development in other to predict contaminant transport for risk evaluation of groundwater and investigation of groundwater flow direction for verifying if groundwater movement is along the contaminant pathway that makes it possible for the contaminant to be transported into the water table or not therefore, making groundwater vulnerability possible. Therefore, in achieving model development, identification of hydrological features should be put into consideration for selection of proper model while the next in consideration should be model abstraction for accumulation of field data for describing the method of modeling and assisting in specifying software to be applied during modelling. The next is handpicking of the best software that will be suitable for modeling and yielding the best result. While the next step involves the data computation, which will lead to adjustment of the calibrated model peradventure any error is observed and in that case, model parameter uncertainty will be clarified for ascertaining the authenticity of the model after which the future groundwater vulnerability can be forecasted to achieve model realization supervisory plan. Asokraj et al (2015) used the Overlay and index methods combine factors controlling the mobility of pollutants from ground surface into vadose zone resulting in vulnerability indices at different locations with the primary objective of producing a map for groundwater vulnerability by applying SINTACS model which the inputs are acquired from remote sensing and geographic Information systems.

Study Area

The Study area for this research is Abia state, and the state in Nigeria. It has with 17 local government areas and it is located within latitude 4_0 40! and 6_0 $14_!$ North and longitude 7_0 $10_!$ and 8_0 East of the equator.

Materials and Methods

The vulnerability index was modelled for the purpose of confirming how vulnerable the water tables and aquifers are to pollution and subsequent contamination, in the 17 local government areas of Abia State. In designing the model, DRASTIC model was used for calculations of data from different hydrogeological parameters while ARC GIS 10.2 was used in processing the data from these parameters that translated into this Vulnerability Index Model. In DRASTIC model, **D**=Water table depth in an unconfined aquifer is the length between the surface of the ground to the water table for unconfined aquifer while the unconfined aquifer will be from ground surface to the bottom of confining aquifer layer.

R=groundwater recharge rate is total volume of water that hits the surface of the ground for infiltration to water table, **A**=aquifer media types of rock formations that make up the aquifer system ranging from sand, sandstone gravel shale and shale-sand, **S**=soil media is the topmost part of the vadose zone where pronounced biological activities take place, **T**=topography or slope is the different gradient variations of the land surface, **I**=impact of vadose zone is the unsaturated or saturated over the water table,**C**=hydraulic conductivity is the capability of the components of the aquifer to discharge water. The following DRASTIC equation was used to calculate the DRASTIC index for Aquifer Vulnerability of Abia state.

Table 1: DRASTIC Model Equation

DRASTIC Index=D_r x D_w + R_r x R_w + A_r x A_w + S_r x S_w + T_r x T_w + I_r x I_w + C_r x C_w .(1)
r = rating for each parameter while w= weight for each parameter.
Aller et al (1987) specified that weight must be assigned to geological settings as follows:
D=5, R=4, A=3, S=2,T=1, I=5, C=3.
DRASTIC Index = 5D_r + 4R_r+3A_r + 2S_r + T_r + 5I_r +3C_r. ....(2)

Results and Discussion

Table 2: Hydrogeological parameters in seventeen local government areas of Abia state

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:Nwachukwu et al. (2013) Abia state water corporation and Anambara-Imo river basin rural development authority

The meanings of abbreviations displayed on table 6-1 below are:

LGA= Local government areas. WAT= Water table (feet). RWD= Recommended well depth.

TCK= Thickness of prospective horizon. RES= Mean resistivity. LIT= Lithology.

XCD= X coordinate while YCD= Y coordinate. YLD= Groundwater yield capacity.

Most Data from table 2 above and Hydraulic conductivity from table 3 below were fused into ARC GIS to develop the Aquifer vulnerability index model for Abia state,

Table 3: Aquifer hydraulic characteristics

Location	Transmittivity	Hydraulic conductivity	Specific Storage
Southern basin (Niger Delta coastal plain sand aquifer	2.05 - 9.10	0.385 - 1.71 0	053 - 0.26
Lower Benue Trough	0.24 - 4.17	0.045 - 0.781	1.03 x 10-5 - 7.75 x 10-3

Figure 1 below shows the vulnerability index model for the 17 local government areas of Abia state. The Local government areas with index ranking of ten are of (extremely high vulnerability) while the areas ranked one are of (extremely low vulnerability)

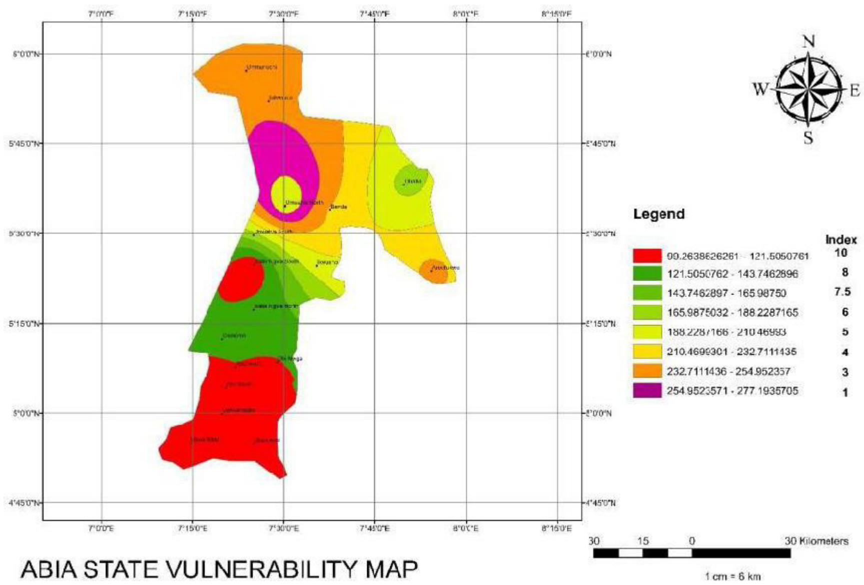

Figure 1: Vulnerability index model for the 17 local government areas of Abia state.

Aba south, Ukwa west, Ukwa East, Ugwunagbo, Obinngwa and Osisioma, extremely high vulnerability which is attributed to the shallow water table and the coastal sand nature of the aquifer. Furthermore, those aquifers resident in Abia central senatorial district under Isiala Ngwa south, Isiala Ngwa north, Ikwuano and Umuahia south LGAs have high vulnerability, while Umuahia north LGA has moderate and high vulnerabilty. The aquifers resident in Abia north senatorial district under Umunnochi, Isiukwuato, Ohafia and Bende LGAs have moderate and low vulnerability while Arochukwu LGA shears low, vulnerability.

Conclusion

This model has shown that Abia south senatorial district is bound to have more groundwater contamination because of how extremely high venerable the groundwater aquifer is than Abia Abia central and Abia north senatorial district which moderate and low Aquifer vulnerablility to pollution This model will help the actors in the groundwater management sector to know the areas with which groundwater table are under more risk of pollution than the other and for easier planning of sustainable groundwater source protection zone and bore hole development projects.

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