Groundwater Quality Assessment of Asaba, Coastal Region of Nigeria Using Water Quality Index, and GIS Method

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Abstract: Groundwater remains as a vital source of potable water for human consumption worldwide particularly in sub-Saharan African, including Nigeria as the primary source of safe water. The evaluation of this resource makes it suitable for different uses such as domestic and irrigation. The research attempt to evaluate groundwater quality of Asaba coastal region, using water quality index and GIS techniques to characterize and map the spatial distribution of groundwater quality parameters with the objective of determining its suitability for drinking and irrigation purposes within the study area. 62 groundwater sampling borehole was access with nine parameters being analysis at each sampling point (pH, Total dissolve solid, Ammonia, Chloride, Sulphate, Nitrate, Sodium, Calcium and Iron.) The Finding from the WQI indicate that mean and standard deviation were 57.21 and 18.16 respectively, with spherical model of weak spatial dependence. The groundwater result shows that 6.45% (excellent water), 29.03% (good water), 48.39% (poor water and 16.13% (very poor water). The Shapiro-wilk test conformed normality (p=0.836) satisfying the distributional requirement for empirical bayesian kriging without data transformation.

Keywords: *Water Quality Index, Groundwater Quality, Spatial Distribution, Kriging.*

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I. INTRODUCTION

Groundwater can be utilized for drinking, domestic, industrial and irrigation all over the world. Nigeria being located in sub-Saharan African, is faced with freshwater accessibility challenges despite having significant resources. Groundwater stands as a dependable and reliable source of potable water especially where surface water is polluted. (Adelana & MacDonald 2008, Oteze, G.E 1991). Groundwater pollution has developed into a major issue and problem around the world in the last decades (Umar et al. 2009). Groundwater across many regions, particularly in arid region like Northern Nigeria faces scarcity while in other regions have significant water availability.

Groundwater quality and sources is assess by the following influencing factor such as precipitation recharge, inland surface water infiltration and sub-surface geochemical reactions, hence variation in the origin of the recharge water with hydrological and human influences can cause periodic fluctuations in the quality of groundwater (Vasanthavigar et al. 2010).

Polluted water not only degrades water quality but also poses serious health threat to human, economic development and social wellbeing of people (Milovanovic 2007). Groundwater quality in particular has attracted serious attention as excellent water quality is essential for domestic needs and irrigation purposes. In Asaba, Nigeria the most reliable water source is groundwater that is accessed through household and community boreholes. Municipal water supply in the area is limited or has gone into extinction, therefore residents depends more on self-help supply systems boreholes which quality varies and need monitoring (Akpovi, 2021). These groundwater sources have quality risks due to pollution from septic tanks and poor siting and surface water are being faced with pollution from seasonal variability (Ramakrishnaiah et al. 2009) and according to Taki (2003), the impact of groundwater pollution are not only restricted to damages to water abstraction wells and aquifers reservoirs but through it transition into rivers and streams can also contaminates surface resources water resulting in severe environmental consequences. Until recently, groundwater assessment can be analysis with GIS incorporating various databases in solving water resources problem. Evaluating water quality, mitigating flood risk, determining water

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availability and managing water resources at both local and regional scales can be effectively be achieved using GIS tool (Ketata Rokbani et al. 2011, Singh and Khan 2011). The Spatial analysis capabilities of GIS can enable the interpolation of groundwater quality parameters at unsample locations using data points creating continuous surfaces that reveal distribution of water quality characteristics in the study area. (Shabbir and Ahmad 2015; Sumathi et al. 2008). The range of interpolation techniques such as inverse distance weighting, spline, trend surface analysis and kriging are present within ArcGIS 10 to support the process (Johnston et al. 2001). Various researchers has applied the techniques in determining water quality. Tahlawi et al. (2014) employed multiple water quality indices to evaluate the suitability of groundwater for various uses and applied the study to Assiut Governorate, located north of the investigated area that shares similar hydrogeological and aquifer characteristics. Melegy et al. (2014) investigated the geochemical mobilization of heavy metals in water as a contributing factor to various diseases in Sohag Governorate, collecting 42 groundwater samples from quaternary aquifer along with eight surface water sample for analysis. Water Quality index (WQI) was originally developed by Brown et al.(1970), which has become one of the most widely applied method for assessing groundwater quality due to its ability to comprehensively convey water quality information. The water quality index provides a single numerical value that integrates multiple water quality parameters resulting to a clear measure of water suitability for drinking and other uses at specific location and time (Boateng et al. 2016; Akter et al. 2016). This numerical values simplifies the overall state of water quality into one term to support decision making and management of groundwater resources. It has been used in several studies to assess groundwater water quality (Rabeiy. 2018, Sadat-Noori et al. 2014; Rajankar et al. 2010), and surface water river's bodies (Trivedi et al. 2009; Singh et al. 2008). The aim of the present study is to (1) evaluate groundwater quality for potable use with WQI, (2) to spatially map groundwater parameters using GIS and deterministic techniques (3) to categories groundwater for its suitability in the study area.

II. MATERIALS AND METHODS

➢ *Study Area*

The study area Asaba (120km^2) is located in the south region of Nigeria with coordinates at latitude 6°8′ N to 6°16′ N and longitudes 6°36′E to 6°45′E (Fig. 1). Its boundary to the East is Onitsha Head Bridge, South to Ibusa, and North to Illah and Ebu.

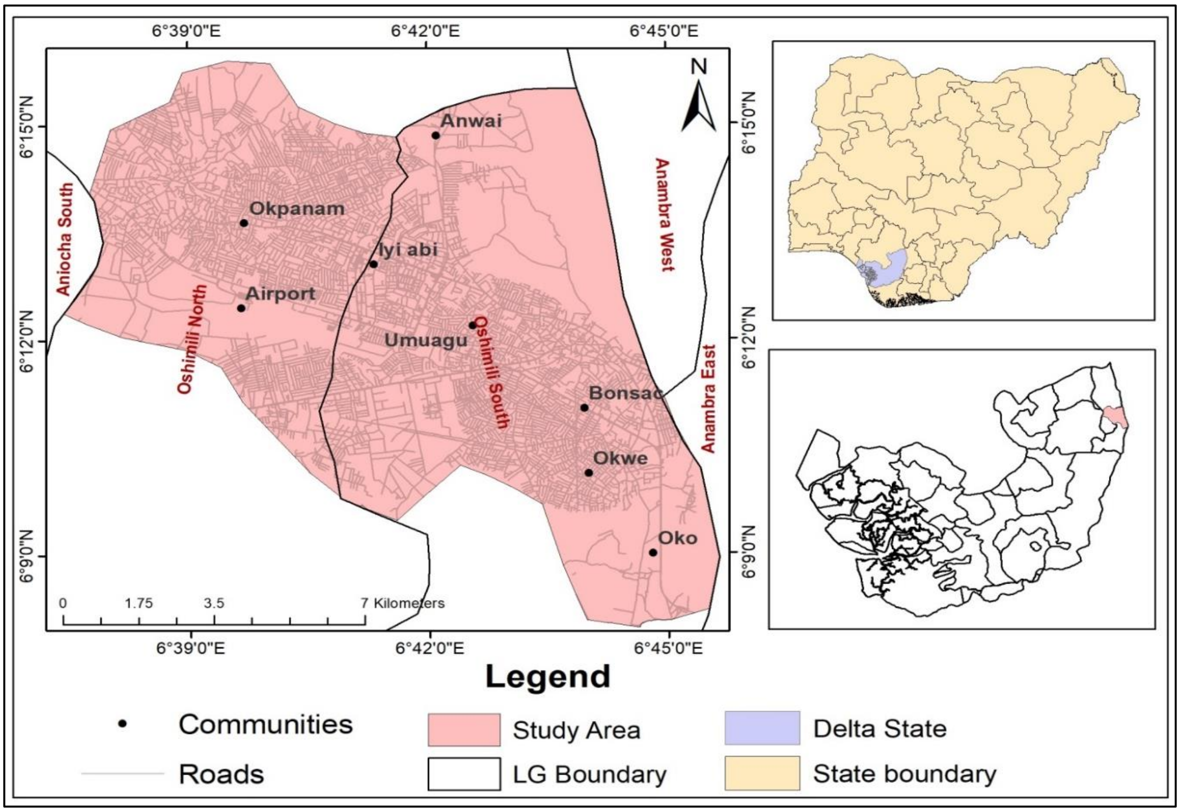

Fig 1 The Locational Map of Asaba

Asaba lies within the tropical rainforest region with receiving annual rainfall between approximately 1500mm and 2700mm. The area maintains a mean temperature of about 28–32°C with relative humidity ranging from 69% to 80%. (Chinwuko et al., 2024). Hydro geologically, the region is situated on a terrace along the lower Niger River, underlain with alluvial terrace deposit of about 25-30m thick which also overlies the Oligocene Ogwashi-asaba formation shaping the region subsurface features. (Chinwuko et al., 2024). Groundwater is the primary water source in Asaba with aquifer thickness between 20.4m to 33.9m (Anomohanran 2011). The region is being faced with an extended rainy

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season lasting from February to December, which sustains streams and canal such as Iyibu River, fed by the Anwai River ensuring it continuous all year round flow. Major industries and land uses in the region include filling stations, hospitality, pharmaceuticals, plastics, steel production and agriculture. To assess groundwater quality in the study area, 62 samples were collected from boreholes, most of which are used for agriculture and drinking purposes. The depths of these wells range from 28m to 185m, with samples subjected to chemical analysis to evaluate water quality and to identify potential pollution sources. Field measurement of physiochemical parameters that include pH were conducted using potable instrument. For each groundwater sample, nine parameters were analyzed and they are: pH, total dissolved solid, ammonia, chloride, sulphate, nitrate, sodium, calcium and iron.

- *Groundwater Quality Index*

The portability of groundwater quality for various purposes such as drinking can be evaluated from its water quality index.

Water quality index (WQI) is used to assess the suitability of groundwater with the aim of drinking (Rajankar et al. 2010; Kumar et al. 2007). WQI was computed using nine (9) measured parameters at each sampling site and in order to account for the varying impacts of contaminants on human health, groundwater quality were assigned weights between 2 to 5. The initial step in WQI estimation involves determining the relative weight of each parameter as shown in Eq (1). (Shabbir and Ahmad 2015)

$$W_k = \frac{w_k}{\sum_{k=1}^{n} w_k} \qquad 1$$

Where w_k represent the weight assigned to each parameter, W_k represent its relative weight, and n is the number of groundwater parameters considered. The second step in the WQI calculation is to determine the quality rating scale (qk) of each parameter using Eq. (2) (Singh and Khan 2011; Srinivas et al. 2011).

$$q_i = \left(\frac{V_k - V_{kd}}{S_k - S_{kd}}\right) X\ 100 \qquad 2$$

Where q_k represent the quality rating for the k water parameter, V_k represent the measured value for the k parameter at a given sampling site, and S_k is the standard permissible value for the k parameter assigned as stated by the WHO (Vasanthavigar et al. 2010). V_{kd} refers to the ideal value of k parameter in pure water (set to 0 for all parameters except pH which is 7). The overall water quality index is then calculated by combining the quality rating with their respective unit weight as shown in Eq (3). The computation of WQI in this study was performed using mathematical function in Microsoft Excel.

$$WQI = \sum_{k=1}^{n} W_k\ X\ q_k \qquad 3$$

- *Spatial Analysis Using Kriging*

The kriging algorithm in ArcGis was applied to analyze the spatial and temporal distribution of pollutants. (ESRI, 2019). Unlike deterministic interpolation method, kriging incorporates probability through statistical modeling. Kriging variants includes Ordinary kriging (linear), Indicator kriging (non-linear) and Empirical Bayesian kriging (Bayesian) This study employed empirical Bayesian kriging, an automatic interpolator that differs from other methods gain by adjusting spatial process parameters that accounts for errors in semivariogram estimation and utilizing intrinsic random functions as the kriging model.

III. RESULTS AND DISCUSSION

- *Spatial Distribution of Groundwater Parameters*

Statistical analysis of groundwater characteristics was conducted to evaluate the ranges of chemical parameters and examine their deviation from WHO standards as presented in Table 1 (Organization WHO 2011).

Table 1 Variation of Physiochemical Groundwater Parameters and WHO Guidelines

S/No	Physiochemical Parameters	Min	Max	Mean	Standard Deviation	WHO Value
1	pH @ 25°C	3.01	6.5	5.346	0.78648	6.5-8.5
2	Total Dissolved Solids, mg/L	28	190	67.7927	48.24083	1000
3	Ammonia (NH3), mg/L	0.02	0.8	0.4211	0.19598	0.2
4	Chloride, (as Cl-), mg/L	8.15	76.2	27.8709	23.6206	250
5	Sulphate, (as SO_4^{2-}), mg/L	1.5	14.8	4.7376	3.4376	250
6	Nitrate, (as NO_3^-), mg/L	0.89	3.62	1.7098	0.5255	50
7	Sodium (Na), mg/L	5.65	47.2	19.1524	14.1353	200
8	Calcium (Ca), mg/L	1.69	25	5.8687	6.6881	-
9	Iron (Fe), mg/L	0.11	1.15	0.2944	0.1510	0.3

Milligrams per liter is the measurement unit of all water parameters except pH that is without unit.

The maximum value for two groundwater quality parameters which are ammonia and iron where observed to exceed the acceptance limit as assigned by WHO.

Ammonia is a chemical contaminant found in drinking water and groundwater. This contaminants indicate pollution from fertilizers, sewage and industrial activity. WHO limit for ammonia is assigned 0.2mg/L and above this value can cause taste and odour problems, making water unacceptable for drinking. The ammonia concentration in the study area starts

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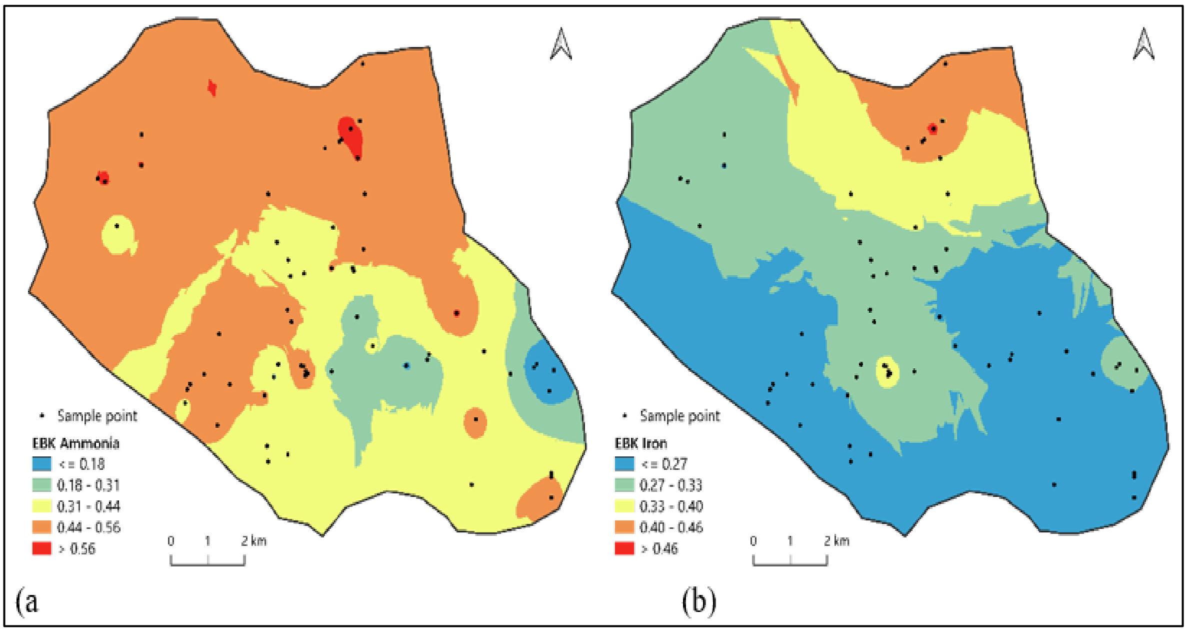
from 0.02md/L as it minimum value to 0.8mg/L as it maximum value. 52 groundwater sampling sites are exceeding the WHO limits which shows 83.9% of the region having high ammonia contaminants. Elevated ammonia is often attributed to fertilizer leaching into aquifers, leakages from septic tanks, discharges from chemical, pharmaceutical or steel industries and breakdown of plants and animal residues. Spatial distribution of ammonia in the study area is developed using Empirical Bayesians kriging techniques in ArcGIS 10 as presented in Fig. 2a with ranges of five categories indicating area cover in % and size in Km^2. From Table 2, ammonia with ≤ 0.18 concentration occupied an area of 1.12% ($1.318km^2$) safe water for consumption located at the extreme of eastern part of the study area.

Iron is one of the most abundant metal in the earth crust present in drinking water and groundwater. It is found in water as ferrous (Fe^{2+}) or ferric (Fe^{3+}) ions. It causes reddish brown stains of plumbing fittings, impart metallic taste making water unpleasent to drink. (Vasudevan et al. 2009) This contaminant indicate pollution from natural leachng, and indsutrial comtimamtion. WHO limit for Iron is 0.3mg/L and above makes water unacceptable for drinking. The iron concentration in the study area starts from 0.11md/L as it minimum value to 1.15mg/L as it maximum value. 24 groundwater sampling sites are exceeding the WHO limits. Spatial distribution of iron in the study area is developed using Empirical Bayesians kriging techniques in ArcGIS 10 as presented in Fig. 2b with ranges of five categories indicating area in % cover and size in Km^2. From Table 2, Iron with ≤ 0.27 concentration occupied an area of 46.28% ($54.529km^2$) safe water for consumption located at the extreme of south and western part of the study area.

pH is among the most significant paramters in groundwater assessment that indicates the degree of acidity or alkalinity. The pH scale is logarithmic ranging from 0 to 14 and values below 6.5 reflect increasing acidity. In the study area nearly all measured values fall below the lower permissibile limit of 6.5 confirming the presence of acidic groundwater. The recorded pH values ranged from minium of 3.01 to maximum of 6.5 with a mean value of 5.346. Values of pH below 6.5 are caused by caron dioxide dissolution forming H_2CO_3, decomposition of organic matters, sulfide minerals like pyrite oxidized to produce sulfric acid, and acid rain,industrial pollution and agricultural runoff all contribute in lowering pH as found in the study area as an urbanizing region.. Spatial distribution of pH is created using ArcGIS as given in Fig. 2c. From this figure, we notice that high level of pH is located at the west of the investigated zone.

TDS concentration varies from 28 to 190 mg/l with a mean value of 67.7927mg/l, while the WHO limit is 1000mg/l. The study zone can be expressed as low TDS concentrations when compare to WHO guidelines. TDS are found from agricultural runoff, industrial discharges and sewage infiltration into aquifers. Spatial distribution of TDS using ArcGIS is presented in Fig. 2d and Table 3 shows the surface areas of TDS, with their corresponding categories estimated Chloride concentration of the groundwater samples is varying from 8.15 to 76.2 mg/l. Chloride is an important parameter in assessing groundwater quality where higher concentration of chloride indicates a higher grade of organic pollutants, industrial discharge and seawater intrusion (Singh and Khan 2011).



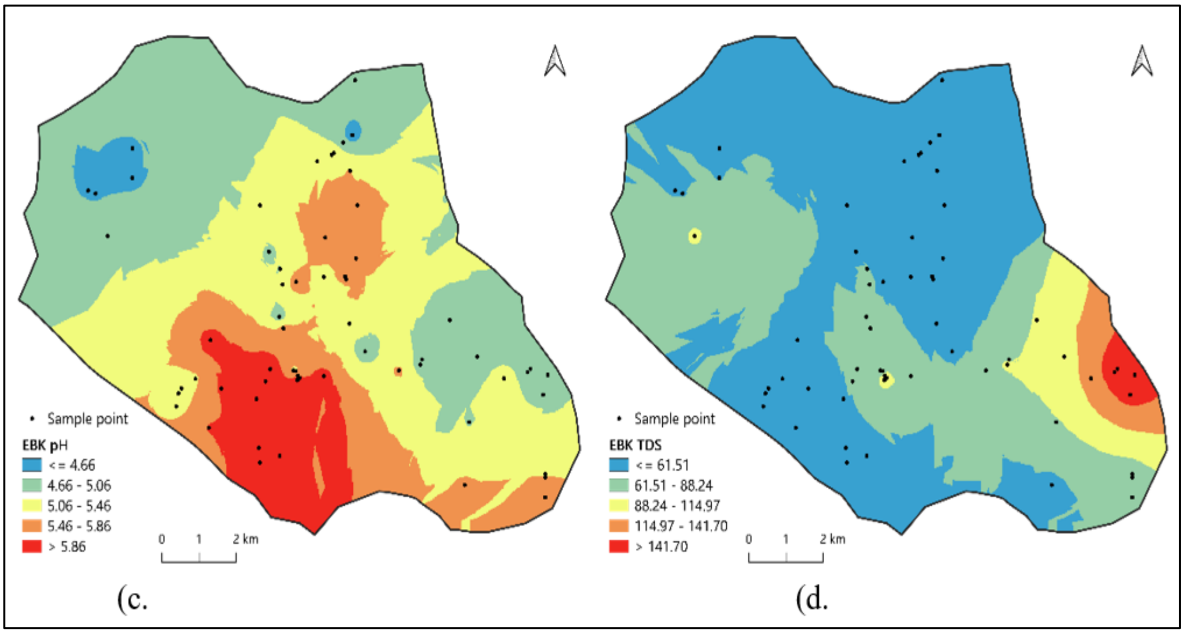


Fig 2 Spatial Distribution of Groundwater Parameters Using EBK for a Ammonia, b Iron c pH, and d. TDS

Table 2 Surface Areas of Ammmonia, Iron and pH Parameters Showing Categories Estimated

Ammonia			Iron			pH		
EBK — Categories	Area (km²)	Area (%)	EBK — Categories	Area (km²)	Area (%)	EBK — Categories	Area (km²)	Area (%)
≤ 0.18	1.318	1.12	≤ 0.27	54.529	46.28	≤ 4.66	2.558	2.17
0.18 – 0.31	8.747	7.42	0.27 – 0.33	38.558	32.73	4.66 – 5.06	41.658	35.36
0.31 – 0.44	41.813	35.49	0.33 – 0.40	17.468	14.83	5.06 – 5.46	42.449	36.03
0.44 – 0.56	64.877	55.06	0.40 – 0.46	7.193	6.10	5.46 – 5.86	19.024	16.15
> 0.56	1.066	0.90	> 0.46	0.073	0.06	> 5.86	12.132	10.30
Total	**117.821**	**100.00**	**Total**	**117.821**	**100.00**	**Total**	**117.821**	**100.00**

The study zone expressed low Cl- concentrations when compare to WHO limit (250mg/L) make it acceptable for drinking purpose. Spatial distribution of Chloride using ArcGIS is presented in Fig. 3b and Table 3 shows the surface areas of Cl- with their corresponding categories estimated with highest surface area of 53.587km^2 (45.48) having concentration of ≤ 21.88mg/L.

Sulphate (SO_4^{2-}) are naturally occuring anion found in ground and surface water and concentration above WHO limit (250mg/L) causes bitter taste, cathartic actio, laxative effect and scaling in pipes signaling contamination fro fertilizer or sewage. The value of sulphate in this research was found in the range of 8.15 to 76.2 mg/l with average value 27.8709mg/l. Spatial distribution of sulphate is generated using ArcGIS 10 with significant value > 9.14mg/L have surface area of 0.957km^2 as showed in Fig. 3b and Table 3, its significant values are located in the east zone of the study area.

The nitrtate concentration in the study area starts from 0.89mg/L as it minimum value to 3.62mg/L as it maximum value. There is sampling sites that exceeded the WHO limits (50mg/L) making the groundwater suitable for drinking purpose. Spatial distribution of nitrate in the study area is developed by ArcGIS 10 as presented in Fig.3c with ranges of five categories indicating significant area > 2.58 has (0.044km^2) as also presented in Table 4 found in the central areas within the study area.

Table 3 Surface Areas of TDS, Chloride and Sulphate Parameters Showing Categories Estimated

TDS			Chloride			Sulphate		
EBK — Categories	Area (km²)	Area (%)	EBK — Categories	Area (km²)	Area (%)	EBK — Categories	Area (km²)	Area (%)
≤ 61.51	64.500	54.74	≤ 21.88	53.587	45.48	≤ 4.13	61.206	51.95
61.51 – 88.24	41.416	35.15	21.88 – 34.99	45.742	38.82	4.13 – 5.80	44.410	37.69
88.24 – 114.97	7.220	6.13	34.99 – 48.11	12.595	10.69	5.80 – 7.47	7.857	6.67
114.97 – 141.70	3.146	2.67	48.11 – 61.23	3.776	3.21	7.47 – 9.14	3.390	2.88
> 141.70	1.538	1.31	> 61.23	2.121	1.80	> 9.14	0.957	0.81
Total	**117.820**	**100.00**	**Total**	**117.821**	**100.00**	**Total**	**117.820**	**100.00**

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Sodium salts are naturally present in both food and drinking water. Although no definitive conclusion has been established regarding the association of it in drinking water to hypertension, concentrations exceeding 200 mg/l as specified by WHO may result in an unacceptable salty taste. Figure 3d show the spatial distribution of sodium in the study area as developed by ArcGIS 10 with ranges of five categories indicating significant area > 36.64 has (01.673km^2) as also presented in Table 4 are mostly found in the extreme east end areas within the study area.

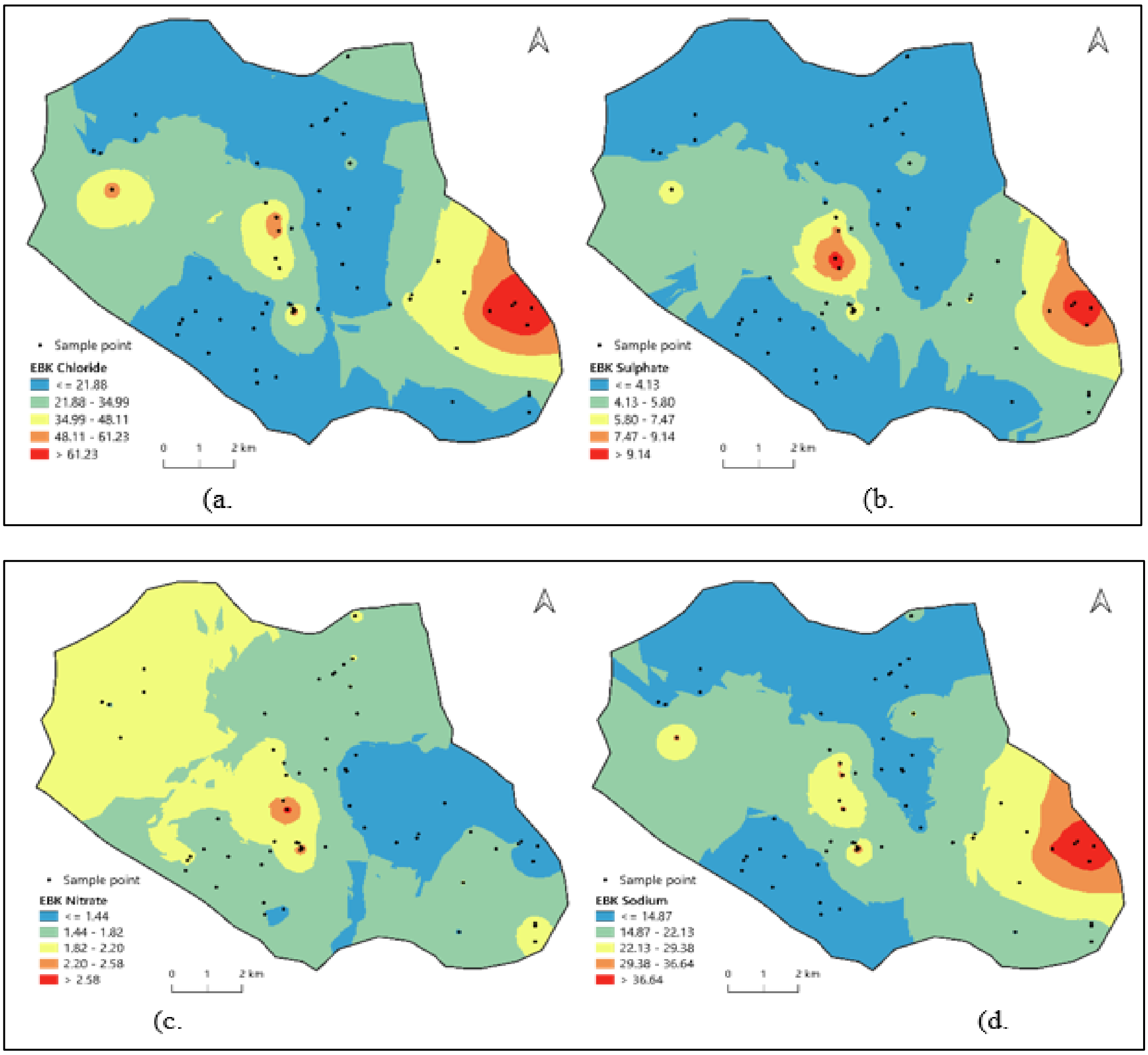

Fig 3 Spatial Distribution of Groundwater Parameters Using EBK for a Chloride b Sulphate c Nitrate and d. Sodium

The concentration of sodium within the study area starts from 5.65 mg/l as the minimum value to 47.2mg/l as the maximum value. Calcium concentration in the study area ranges from 1.69 to 25 mg/L as maximum values which fall below the WHO limit for drinking water purpose hence it acceptable. Table 4 shows the surface area of calcium estimate with dominant concentration ≤ 5.05mg/L cover an area of 79.157km^2. Figure 4 show the spatial distribution of calcium in the study area as developed by ArcGIS 10 with dominant concentration located in the north east and west of the study area.

Table 4 Surface Areas of Nitrate,Sodium and Calcium Parameters Showing Categories Estimated

Nitrate			Sodium			Calcium		
EBK — Categories	Area (km²)	Area (%)	EBK — Categories	Area (km²)	Area (%)	EBK — Categories	Area (km²)	Area (%)
≤ 1.44	18.269	15.51	≤ 14.87	43.285	36.74	≤ 5.05	79.157	67.18
1.44 – 1.82	60.748	51.56	14.87 – 22.13	55.102	46.77	5.05 – 9.89	18.592	15.78
1.82 – 2.20	38.141	32.37	22.13 – 29.38	13.943	11.83	9.89 – 14.74	12.995	11.03
2.20 – 2.58	0.618	0.52	29.38 – 36.64	3.817	3.24	14.74 – 19.58	5.874	4.99
> 2.58	0.044	0.04	> 36.64	1.673	1.42	> 19.58	1.202	1.02
Total	**117.820**	**100.00**	**Total**	**117.820**	**100.00**	**Total**	**117.820**	**100.00**

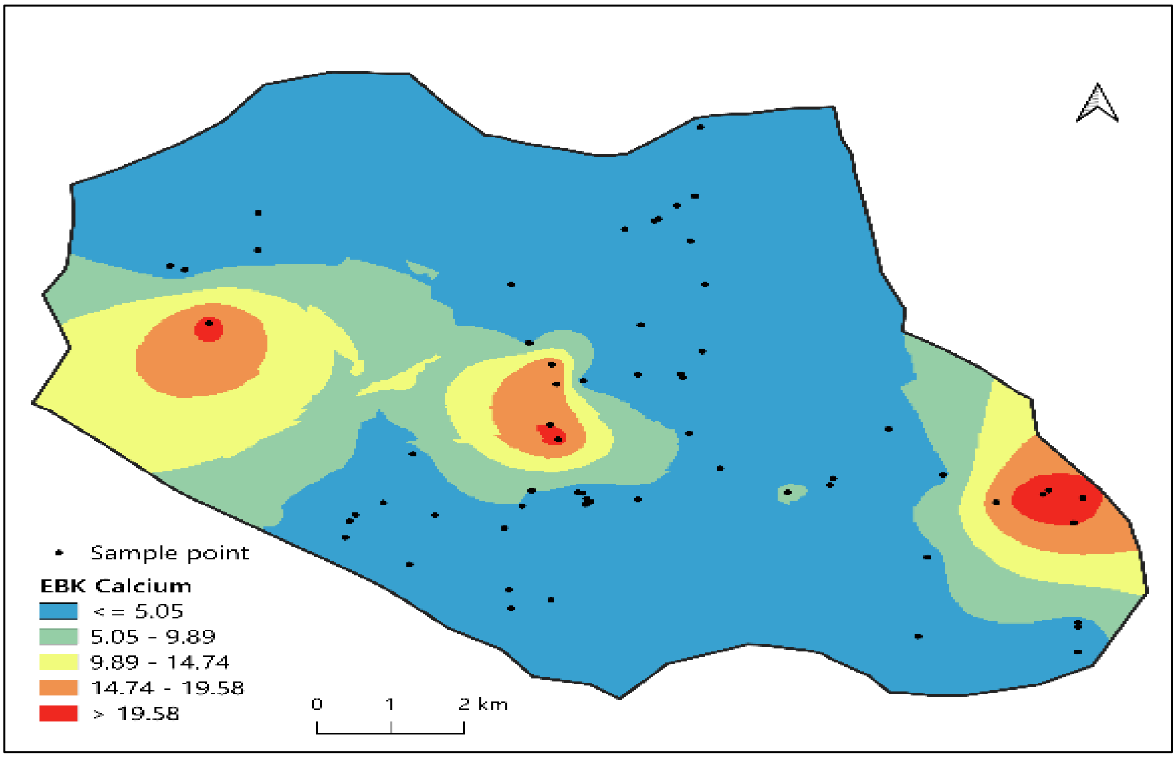

Fig 4 Spatial Distribution of Calcium in Groundwater Parameters Using EBK

The correlation coefficient among the groundwater parameters were examined to assess the degree of relationship between them as given in Table 5. The correlation matrix showed strong correlation($r \geq 0.9$) among parameters SO_4^{2-} and Na, Cl- and TDS, Na and TDS, Cl- and Na. In contrast moderate correlation were observed among several water quality parameters including this relationship between Ca and Cl- and Ca and SO_4^{2-}. Based on this analysis, the results suggests that parameters of SO_4^{2-}, Na, and Cl- originate from the same source. The spatial distribution maps of the three elements as illustrated in Figs. 3a, b and 3d demonstrate that they exhibit similar distribution patterns and are concentrated within the same geographical region. The occurrence of Ca, Na and SO_4^{2-} in groundwater is attributed to the dissolution of carbonate minerals, together with the contribution from sewage discharge and industrial activities. In addition, the dissolution of gypsum associated with fertilizer application serves as additional source for calcium thereby enhancing the calcium content of groundwater.

Table 5 Correlation Coefficient Between Groundwater Parameters

	pH	**TDS**	**NH_3**	**Cl-**	**SO_4^{2-}**	**NO_3-**	**Na**	**Ca**	**Fe**
pH	1								
TDS	-0.134	1							
NH_3	-0.057	-0.380**	1						
Cl-	-0.218	0.909**	-0.288*	1					
SO_4^{2-}	-0.159	0.759**	-0.271*	0.879**	1				
NO_3	0.089	0.114	0.444**	0.218	0.294*	1			
Na	-0.101	0.886**	-0.302*	0.965**	0.904**	0.254*	1		
Ca	-0.197	0.641**	-0.449**	0.743**	0.788**	0.005	0.697**	1	
Fe	-0.008	0.164	0.344**	0.156	0.094	0.170	0.112	-0.057	1
**. Correlation is significant at the 0.01 level (2-tailed).									
*. Correlation is significant at the 0.05 level (2-tailed).									

➢ *WQI Results and Evaluation*

For the estimation of water quality index (WQI) a three step approach was followed. In the first step each of the nine parameters was assigned a weight (wi) based on its known impact on primary health as presented in Table 6. Weighted values were allocated to the water quality parameters ranging from 2 to 5. A weight 5 was assigned to parameters such as chloride and sulphate due to their critical importance in water quality assessment. Conversely, a weight of 2 as allocated to iron and ammonia reflecting their comparatively lower impact. In the second step, the relative weight (Wi) of each parameter was calculated using Eq. (1). An excel program was developed to estimate the water quality index at each sampling location and the statistical result were summarized and classified into five categories as presented in Table 7 (Katata – Rokban et al., 2011).

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The Water Quality Index (WQI) was computed as a composite score for each sample. Descriptive statistics for WQI are given in Table 8. The Shapiro-Wilk test confirmed normality (p = 0.836), satisfying the distributional requirement for Ordinary Kriging without data transformation.

Table 6 The Weight (wi) and Relative Weight (Wi) of Each Chemical Parameter

Parameter	WHO standard	Weight	Relative weight
pH	6.5	3	0.096774194
T.D.S	1000	4	0.129032258
Ammonia	0.2	2	0.064516129
Chloride,	250	5	0.161290323
Sulphate	250	5	0.161290323
Sodium (Na), mg/L	200	4	0.129032258
Nitrate	50	3	0.096774194
calcium	75	3	0.096774194
Iron	0.3	2	0.064516129
		31	1

Table 7 Classification Based on Water Quality Index

WQI	Classification	Total no. of samples	Percentage %
0 - 25	Excellent water	4	6.45
26 - 50	Good water	18	29.03
51 - 75	Poor water	30	48.39
76 - 100	Very poor water	10	16.13
> 100	Water unsuitable for drinking purpose	0	0
Total		**62**	**100**

Table 8 WQI Descriptive Statistics.

Statistic	Value
Number of samples	62
Minimum	17.95
Maximum	98.27
Mean	57.21
Standard deviation	18.16
Coefficient of variation (%)	31.75
Shapiro-Wilk (p-value)	0.836 — normally distributed

The water quality of the study area was found using the WQI which is a combined parameter that gives an equal importance to all the parameters which were considered. Table 8 and Fig 6 displays the result of the water quality index, quality class and spatial distribution map of the WQI using the empirical Bayesian kriging for the 62 sampling locations in the study area. The classification based on WQI as presented reveals that 6.45 % (4 location) of the total samples fall in excellent water, 29.03% (18 locations) falls within good water, whereas 48.39 % (30 locations) of the total groundwater samples falls within poor water. The remaining 16.13% (10 locations) of samples falls within very poor water however none fall within the unsuitable class for drinking. The range from 51-100 depicts the water as acceptable however might need some form of treatment.

Table 9 Result of Water quality index and its quality class for the study area

		locations			
S/N	Description	latitude	longitude	WQI	Water quality rating
1	Coolspring Energies Filling station Abraka	N06.16545	E006.74905	34.803	good water
2	Mr. Celestine Residental House Iyiabu	N06.19259	E006.68852	67.18	poor water
3	Ministry of Works Asaba	N06.21312	E006.70038	47.513	good water
4	Rainoil Filling Station, Along 74 Road	N06.23976	E006.69753	57.006	poor water
5	General Steel Mill Asaba	N06.19148	E006.69528	17.946	excellent
6	Residential House Cable Point Back Of Total	N06.19196	E006.74957	62.985	poor water
7	Gabbs, Bonsac	N06.18173	E006.73063	77.531	very poor water
8	Osadeby University, Girl Hostel	N06.25556	E006.70257	76.552	very poor water
9	Fedral Road Safety Command Asaba	N06.18762	E006.66013	59.431	poor water
10	Catholic Church Okpanam	N06.24056	E006.64870	77.653	very poor water

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11	A.A Rano Filling Station Abraka	N06.17050	E006.74914	70.365	poor water
12	Seth Hotel Oduke	N06.16814	E006.72957	41.527	good water
13	Mrs Ozah Residential House Iyiabu	N06.19061	E006.68886	57.01	poor water
14	Plastic/Polythene Industry Iyiabu	N06.19110	E006.68953	58.557	poor water
15	Along Anwai Road, Fishery Site	N06.24366	E006.70196	96.764	very poor water
16	Factory Animal Care Services Fertilizer/Feeds	N06.19693	E006.70525	83.037	very poor water
17	Auto Mechanic Village	N06.20183,	E006.68546	55.583	poor water
18	Cattle Market/Abattoir	N06.20427	E006.68453	83.485	very poor water
19	Mr Omosiro Godwin Residential Estate	N06.19411	E006.71870	65.873	poor water
20	Doko Hotel Dla Road	N06.20290	E006.70153	43.004	good water
21	Dwellpet Fuel Station	N06.19519	E006.71912	63.432	poor water
22	Mother Of Christ Guest House Okpanam	E06.23079	E006.63982	75.27	poor water
23	Nnpc Filling Station Okpanam	N06.23421	E006.64870	75.905	very poor water
24	Mechanic Workshop Opposite Vidgock International	N06.22840	E006.67974	60.044	poor water
25	Federal Specialist Hospital	N06.23597	E006.70149	52.638	poor water
26	Agroland Awani	N06.24210	E006.69977	98.266	very poor water
27	Achine Sweetlife Hotel	E06.19077,	E006.66416	55.896	poor water
28	Meri Energy Station	N06.18477	E006.65956	53.321	poor water
29	Ogwa Umuekwo Hall	N06.19591	E006.73251	73.422	poor water
30	Chukwrah Residential House/Battery Repairs Umagu	N06.20383	E006.72581	84.907	very poor water
31	St Patrick Church Cable Point	N06.18770	E006.74846	66.646	poor water
32	Customary Court Cable Point	N06.19330	E006.74538	68.71	poor water
33	Stef suites no 2 leo okonwe str.	N06.19120	E006.73899	50.591	good water
34	Delta State Primary Health Care	N06.21701	E006.70296	49.211	good water
35	Mechanic Workshop Beside Guldtip Hotel.	N06.21473	E006.68464	73.664	poor water
36	Auto mechanic worsksop opposite shrine bar.	N06.21127	E006.68520	72.449	poor water
37	Mr. Happy. Residential house ikukoma	N06.17420	E006.68466	36.395	good water
38	Residential Building Back Of Governor Villa	N06.18021	E006.66751	42.334	good water
39	Residential House No 25 Ulo	N06.19027	E006.68118	25.194	excellent water
40	Behinde Irebhule Godfrey Str Ulo	N06.19304	E006.68228	29.527	good water
41	Chipet Filling Station	N06.16983	E006.74907	37.82	good water
42	Mr Frank Residentail Iyiabu	N06.19268	E006.68788	67.857	poor water
43	Fadama Office Asaba	N06.21245	E006.70057	50.466	good water
44	Scrap Market/Lorry/Custom Market	N06.221581	E006.64280	67.384	poor water
45	Nscdc Hq Asaba	N06.18867	E006.66075	62.144	poor water
46	Methodist Church, Infant Jesus	N06.23054	E006.10380	73.759	poor water
47	LFC Winners Church Cable	N06.19264	E006.74473	63.358	poor water
48	Mr. Collins residential house yanga market	N06.19275	E006.71348	19.943	excellent water
49	Chiromas Plaza Okpanam	N06.23143	E006.63802	76.94	very poor water
50	Residential building Along 74	N06.23802	E006.69350	54.201	poor water
51	Deputy Gov's Office Asaba	N06.21185	E006.68846	22.436	excellent water
52	Opp. Govt house	N06.22846	E006.70333	37.038	good water
53	Junior Staff Quarters	N06.21304	E006.69522	63.612	poor water
54	S.S.G Office	N06.22149	E006.69551	46.119	good water
55	Residential Building 74 Road	N06.23944	E006.69695	52.522	poor water
56	No 14 Ebuka Ogbonnaye Avenue	N06.17265	E006.67992	35.804	good water
57	Swa-Life Crescent	N06.17587	E006.67960	37.278	good water
58	17 Dcns &Dcns Ogwu	N06.18651	E006.67904	45.889	good water
59	Four Traits School	N06.18870	E006.67048	42.842	good water
60	Plot 27 Block V Ddpa Housing	N06.19922	E006.66779	34.703	good water
61	Residential Building Iyiabu	N06.19164	E006.68902	57.585	poor water
62	Hotel Building Iyiabu	N06.19112	E006.68912	55.368	poor water

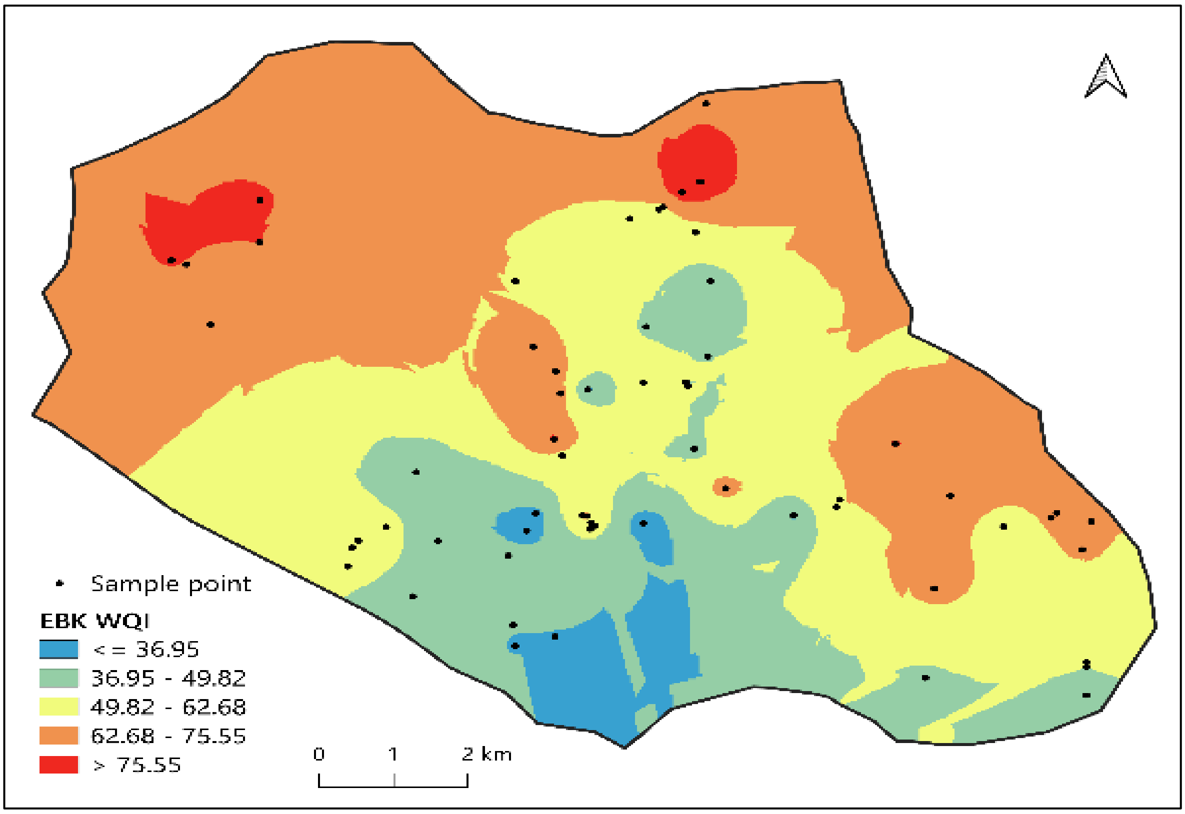

Fig 5 Spatial Distribution of WQI in Groundwater Parameters Using EBK

The categories of 36.95 – 49.82 (yellow color coded) which is good water is found in the central and eastern part of the study area while the categories 62.68 – 75.55 (brown color coded) represent poor water are mostly found in the north and west region of the study area.

IV. CONCLUSION

This study aims to evaluate and investigate the groundwater quality condition of Asaba, Nigeria. The application of GIS techniques and water quality index was utilized on result from water groundwater parameters and both as shown that they are effective tool in analyzing groundwater quality. The result indicate that most groundwater parameter sources are same and each groundwater parameter spatial distribution was developed and areas of high concentrations where located in the north and north east zones of the present study. Map produce through spatial distribution via GIS techniques confirm the water pollutant distributional locations and this will assist water planner and decision makers in planning remedial, mitigation and control measures for groundwater contamination in a comprehensive manner. WQI result reveals minimum value of 17.95, maximum value of 98.27 with mean value of 57.21 and from the total sampling site poor water having 48.39% seems to be more dominants for the region hence there is need for constant monitoring pollution patterns and its trends with respect to urbanization in the study area which will result in achieving sustainable management of groundwater. The water quality classification map produced for this study area should guide the development of effective groundwater management strategies.

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