SPARTIAL ANALYSIS OF GROUNDWATER USING GEOGRAPHIC INFORMATION SYSTEM (GIS) AND WATER QUALITY INDEX (WQI) IN YENAGOA LOCAL GOVERNMENT AREA BAYELSA STATE, NIGERIA.

Abstract

The purpose of the study is to examine the spartial analysis of groundwater using geographic information system and water quality index (WQI) in the study area. Fifty (50) water samples were collected and analysed in accordance to APHA, 2012. The data-set were further analysed using water quality index (WQI) and geographic information system (GIS). The results of the indicate that Igbogene 1, Yenagwe 1 & 2, Akenfa 1, Ekeki 1, Yenizue-Epie 1, Swali 1, Igbogene 2, Akenfa 2, Agudama 1 & 2, Etegwe 2, Opolo 1 & 2,Yenizuepie 2, Swali 2, Akaba 2, Ogu 2, Akaibiri 2, Gbarantoru3 & 5, Ogbuna 1, 3 & 4, Okolobiri 1, 2, & 5 and Tombia 2 & 4, water quality index shows that the quality ranges from poor to very poor. While the samples, Yenigwe 1, Biogbolo 1, Kpansia 1 & 1, Amarata 1, Ogbogoro 1, Ogu 1, Akaba 1,Okutukutu 1, Kpansia3, Amarata 2, Ogbogoro 2,Akaibiri 1, Gbarabtoru 1, 2 & 4, Ogbuna 2, Okolobiri 3 & 4 and lastly, Tombia 1 & 3 all ranges from good, very good to excellent water quality. However, the study shows a very high spartial variation in water quality.Therefore,groundwater should be regularly monitored and treated.

Key Words:*Spartial, Water Quality Index, and Geography Information System.*

Introduction:

Water is an essential natural resource in our environment for societal growth and development. Water is life and support the life of all living things.It is a clear liquid originated from rain which can be found in rivers, lakes, seas and even underground as groundwater (Mustapha and Tasi'u, 2022). Water is an important resource, which human activities such as industries, domestic uses agriculture, irrigation, human husbandry, transport and recreation depends on (Digha, 2021, Digha and Martha, 2022). Water is the richest solvent on earth that sustains all forms of life (Mudassir and Lawal, 2022). About 70% the earth surface is occupied by water, this include the oceans, lakes, rivers, lagoons, ponds and other water bodies (Rilwanu, 2014; Chima, 2018; Digha, 2021 and Mustapha et al, 2022). Water is an indispensable natural resource and it is a major concern of many geographers, earth scientist among other researchers have beenon the acquisition of a reliable source of drinking water (Akinbinu, 2015; Chima, 2018; Digha, 2018; and Egai, 2t al, 2022).

Water quality is an assessment of water condition including, physical, chemical and biological parameters (Oketota et al, 2006; Osinbanjo et al, 2012; Digha and Ekenem, 2015 and Digha, 2021). Lawson (2011) analysed water with regard to physical, chemical and biological parameters of water. The quality of water changes with respect of the flow dynamics of acquifers.

More so, the quality of groundwater is influence by both natural and anthropogenic factors. The natural factors maybe as a result of earthquake, volcanic eruption and fire outbreak. While the anthropogenic factors include, oil spillage, effluents discharge into lakes or directly on the land, solid waste disposal on landfills and industrials activities. Water pollution is one of the most serious environmental problem in the globe today (Digha and Abua, 2018; Adesogan et al, 2019 and Digha, 2022). Water is said to be polluted when it changes in its quality or composition either naturally or as a result of human activities such that it becomes less useful for drinking, domestic activities, industrial, agricultural, recreational wildlife and other uses (God, 2006; Digha, 2022).

Water pollution is an environmental hazard, an environmental is any condition, process or state adversely affecting the environment (Okoro et al, 2012; Eze et al, 2021 and Digha, 2022b). These hazards can be physical, chemical and bacteriological present in water. According to World Health Organization (2022) that over 2 billion people live in water-stressed countries which is expected to be exacerbated in some regions as a result of climate change and increase in population. More so, globally, 2 billion people use a drinking contamination of drinking poses a serious health risk to inhabitant of these regions consuming these polluted water sources. The most important chemical risks in drinking water arise from arsenic, fluoride or nitrate, pharmaceutical, pesticides, per and polyfluroalkylsubstances (PFASs). Microbial contaminations drinking water can transmit disease like diarrhoea, cholera, dysentery, typhoid and polio, and estimated to cause 485,000 diarrhoealdeath annually (Chima and Digha, 2009; WHO, 2022).

Study Area

The study area is located within longitude $6^0 10^1$ and $6^0\ 26^1$ East of the Greenwich Meridian o^0 and Latitude 4^{0-51+1} extending to 5^0DO^1 North of the Equator O^0. The study area morphologically lies within the Niger Delta plains. It is a part of the sedimentary basic of the Niger Delta (Chima et al, 2007; and Egai et al, 2022). It is a low lying broad and gentle sloping in North-South direction to the Atlantic Ocean. According to Oyegun (1999) that a close examination of the micro relief is formed from the gradational materials resulting to a homoclinial (gently inclined) geomorphic structure extending Westwards and are broken by small log back rides and shallow basins, Oyegun (1999) further affirmed that, a topographical map of the study area show that the area equal heights and isohyets of about 12.30m above sea level. Sand beach ridges are common particularly along the Ekole Creek for example the Famgbe sand Beach opposite Yenagoa (Chima et al, 2007). The River Nun, Ekole creek and the Epie creek are the major drainage arteries.

The study area is characterized by high rainfall. There are two major seasons, the wet (rainy) season and the dry season. The rainy or wet season last for eight months from March to October, while the dry season last for four months from November to February. A short break in the rainy season isobserved around late July and August but it occurs mostly in August thus the name August break is given. This implies, two periods of high rainfall in the year which means the study area experiences double maxia-rainfall. The mean monthly temperature varies between 25^0C to 32^0C. the mean annual temperature is constant within Bayelsa State.

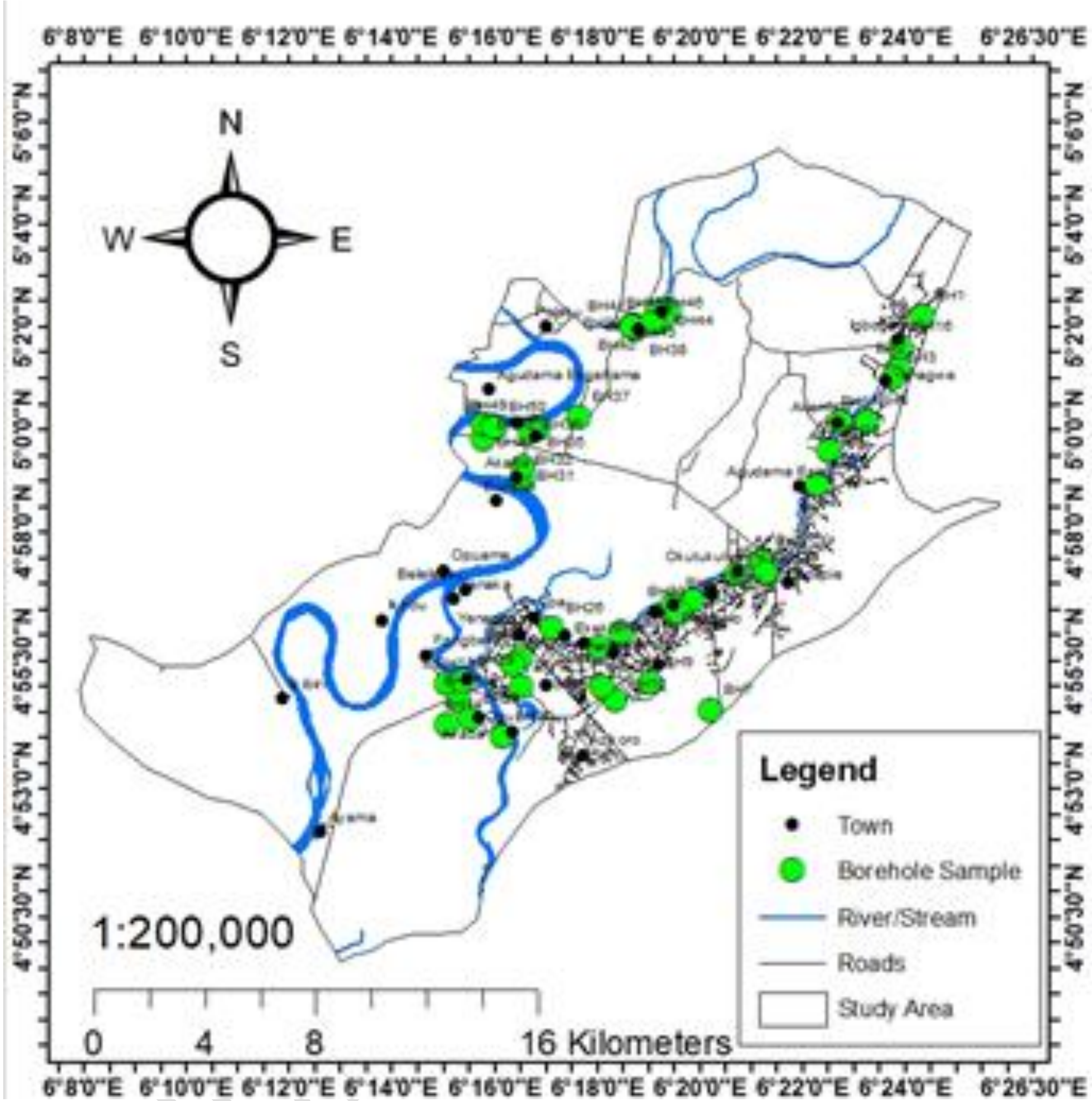

Figure 1: Map of the study area showing borehole samples

Materials and method

The water samples were collected and analyzed between November and December 2021 in a once-off sampling exercise. The water samples were collected between 6am and 7am at all locations on same day. The water quality parameters selected for the study were pH, salinity, Electrical conductivity, Turbidity, TDS, TSS, NO_3^-, SO_4^{-2}, TA (Total alkalinity), TH (total hardness), Ca, Mg. Na, K, Fe, Mn, Total coliform (T.col), Total Heterotrophic Bacteria (THB) and fungi.

The collection, transportation, preservation and analyses of water sample were carried out as prescribed in the standard methods for water examination (APHA, 1985) and interpreted based on the World Health Organisation Standard for Drinking Water Quality and the Nigerian Drinking Water Quality Standard. The concentrations of the physico-chemical and bacteriological constituents as they affect the quality of drinking water were used to determine the level of groundwater pollution in the study area.

For parameters like PH, temperature, turbidity, total dissolved solids, electrical conductivity, turbidity calibrated meters were used in the analyses. For other parameters like alkalinity, chloride as iron, chromium, cadmium, copper, zinc was analysed using atomic absorption spectrophotometric techniques. While total and faecal coliform were determined using multiple fermentation and most probable number (MPN) techniques using media such as nutrient agar and macConky agar.

Water Quality Index Determination

The water quality index (WQI), first introduced by Horton (1965) in United States, later by Brown et al., 1970 for determining water quality according to the suitability of water for various beneficial purposes, and has been used by various workers in their studies (Tyagi et al, 2013; Kapoor et al., 2016; Ramakrishnaiah et al., 2009). A water quality index is a weighted average of selected ambient concentrations of pollutants usual linked to water quality classes (United Nations, 1997). Water quality indices provide a way to distill thousands of records of environmental data into meaningful value that indicate the health of water resources and create a yardstick for measuring and assessing water quality.

To calculate water quality index, 11 parameters of groundwater quality are selected from the dataset of study area. Each parameter is assigned weight according to its relative importance for quality of water for drinking purposes (Table 3) Total Dissolved Solids (TDS), Nitrate (NO_3), Chloride(CL), Total hardness (TH), Iron (Fe) and weight of 4 is assigned to Sulphate (SO_4), Sodium (Na), pH, Electrical Conductivity and weight of 3 is assigned to Magnesium (Mg), Calcium (Ca) and Potassium (K). The relative weight of each parameter is calculated by following formula;

In stage 2 the relative weight (Wi) is computed from the following equation:

$Wi = \frac{wi}{\sum_{i=1}^{n} wi}$ …………………………..(1)

Where:

Wi is the relative weight,

Wi is the weight of each parameter and

n is the number of parameters.

In the third step, a quality rating scale (qi) for each parameter was assigned by dividing its concentration in each groundwater sample by the World Health Organization (WHO) standard for drinking water and the result multiplied by 100. qi = (ci/si) x 100

where:

qi is the quality rating,

ci is the concentration of each chemical parameter in water sample in mg/l,

si is the World Health Organization drinking water standard for each chemical parameter mg/l, according to the guidelines.

For computing the WQI, the Sliis first determined for each chemical parameter which is then used to determine the WQI as indicated by the following equations; Sli = Wi x qi

WQI = ΣSli ………………………(2)

Where:

Si is the sub index of the parameter,

qi is the rating based on concentration of the parameter,

n is the number of parameters.

The computed WQ1 values were classified into five types, excellent water, good water, poor water, very poor water and water unsuitable for drinking, according to Brown et al., (1970), Abbasiet al., (2000), and Jonathan et al., (2012), Austin andAyibawari, 2022.

Results and Discussion

Table 1:Physico-Chemical Parameters of Groundwater in Yenagoa

Borehole	Lat	Long	Town	pH	EC	TDS	NO_3	Cl	SO_4	TH	Ca	Iron	Mg	Na
BH1	5.036889	6.405972	Igbogene 1	6.12	406	203	0.36	39	1.4	25	22.4	0.6	6.35	10.86
BH2	5.01975	6.398167	Yenagwe1	6.3	715	356	0.165	15	0.8	45	8.5	0.14	2.48	4
BH3	5.016722	6.396528	Yenagwe 2	6.38	857	430	0.335	21	1.67	18	13.7	0.4	3	6.5
BH4	5.002366	6.387691	Akenfa 1	6.1	782	391	0.175	14	0.86	37	8.85	0.37	2.5	4.85
BH5	4.957417	6.35375	Etegwe 1	5.99	164	82	0.165	14	0.82	35	8.6	0.38	2.76	4.54
BH6	4.94325	6.324806	Biogbolo 1	5.93	175	84	0.094	16	0.48	32	9	0.3	2.85	5.2
BH7	4.908472	6.337083	Kpansia 1	5.6	763	383	0.085	14	0.45	30	7.4	0.15	2.38	4.74
BH8	4.929167	6.300806	Ekeki 1	6.69	1156	578	0.096	22	0.5	46	12.48	0.35	3.62	5.8
BH9	4.917722	6.317583	Kpansia 1	6.14	269	135	0.348	34	1.75	101	20	0.14	5.65	9.95
BH10	4.91175	6.305972	Yenizue-Epie 1	6.74	1652	826	0.42	47	2.1	45	27.86	0.36	7.5	13.58
BH11	4.925861	6.275583	Amarata 1	6.05	422	211	0.204	37	0.96	91	21.48	0.16	6.2	9.84
BH12	4.916	6.2755	Swail 1	6.87	722	361	0.49	23	2.45	33	16.74	0.36	4.4	7.6
BH13	4.917028	6.251222	Ogbogoro 1	6.43	928	464	0.078	16	0.39	27	9.2	0.26	2.58	5.4
BH14	4.903722	6.251222	Ogu 1	6.2	160	80	0.162	24	0.8	56	14.56	0.12	3.8	6
BH15	4.91125	6.255611	Akaba 1	6.91	530	265	0.17	8	0.86	15	6.75	0.18	1.76	3.85
BH16	5.026869	6.398981	Igbogene 2	6.33	496	248	0.137	13	1.28	65	8.16	0.39	2.42	5.82
BH17	5.002678	6.379307	Akenfa 2	6.13	164	82	0.341	55	5.6	93	33.97	0.4	8.7	15.9
BH18	4.992793	6.375336	Agudama 1	5.88	334	167	0.23	58	5.5	200	34.5	0.7	8.84	17.4
BH19	4.98176	6.37166	Agudama 2	6.01	173	87	0.22	46	4.38	128	27.6	0.68	7.45	13.54
BH20	4.953314	6.355015	Etegwe 2	5.99	164	82	0.165	14	0.82	35	8.6	0.8	2.76	4.54
BH21	4.952838	6.34541	Okutukutu 1	5.85	91	46	0.132	14	1.42	56	8.78	0.32	1.96	4.62
BH22	4.94409	6.331098	Opolo 1	5.93	84	42	0.374	43	3.4	90	26.74	0.65	6.4	12.43
BH23	4.940728	6.326492	Opolo 2	6.38	94	48	0.41	65	5.6	115	35.6	0.4	7.64	14.9
BH24	4.933825	6.307698	Kpansia 2	5.86	348	174	0.127	14	1.38	26	9.5	0.11	2.64	4.86
BH25	4.916093	6.301615	Yenizue-Epie 2	6.4	422	211	0.318	90	10.8	148	56.88	0.44	12.76	28.64

BH26	4.935199	6.285502	Amarata 2	6.74	194	97	0.187	22	0.28	47	12.69	0.112	4.2	6.38
BH27	4.923142	6.272686	Swail 2	6.46	486	243	0.172	19	1.64	116	11.28	0.35	3.54	5.38
BH28	4.905837	6.258554	Akaba 2	5.99	77	38	0.213	40	4	111	23.86	0.4	5.72	12.58
BH29	4.918221	6.25624	Ogbogoro 2	6.2	160	80	0.162	24	0.8	56	14.56	0.12	3.8	6
BH30	4.899849	6.269169	Ogu 2	6.28	172	86	0.348	52	5.25	41	29.78	0.43	6.88	16.7
BH31	4.983667	6.276111	Akaibiri 1	6.14	285	142	0.218	14	2.48	17	10.35	0.31	2.87	5.48
BH32	4.987861	6.275722	Akaibiri 1	6.59	355	178	0.231	20	3.5	34	14.36	0.364	3.54	7.6
BH33	5.000389	6.279556	Gbarantoru 1	6.01	420	210	0.31	20	4	52	13.3	0.136	4.2	6.5
BH34	4.999861	6.280667	Gbarantoru 2	5.97	583	292	0.318	34	4.8	48	22.18	0.32	5.68	9.45
BH35	4.999656	6.279361	Gbarantoru 3	5.96	363	182	0.22	20	3.85	36	14.7	0.36	2.53	6.84
BH36	4.999222	6.2785	Gbarantoru 4	5.92	364	182	0.23	30	3.64	30	13.82	0.132	4.86	8.35
BH37	5.004056	6.294028	Gbarantoru 5	6.15	310	155	0.197	12	3	26	17.48	0.38	2.25	5.42
BH38	5.032306	6.312556	Ogbuna 1	6.49	379	189	0.271	13	4.3	43	9.47	0.348	2.84	5.46
BH39	5.033528	6.311917	Ogbuna 2	6.35	304	152	0.176	14	2.34	27	10.2	0.186	3	4.96
BH40	5.034	6.311778	Ogbuna 3	6.52	279	140	0.185	11	2.97	30	9.78	0.36	2.56	3.75
BH41	5.033361	6.311056	Ogbuna 4	6.08	285	143	0.121	12	2.58	21	8.5	0.372	2.58	4.34
BH42	5.038194	6.323444	Okolobiri 1	6.15	382	191	0.278	62	4.84	43	32.76	0.388	10.72	18.68
BH43	5.038	6.319889	Okolobiri 2	5.99	457	274	0.328	16	4.75	44	13.6	0.374	3.52	7.48
BH44	5.035417	6.321361	Okolobiri 3	6.6	348	174	0.281	12	3.84	41	9.55	0.328	2.84	4.72
BH45	5.034306	6.318833	Okolobiri 4	6.83	298	199	0.217	12	3.76	35	9.28	0.146	1.78	5.46
BH46	5.03425	6.31789	Okolobiri 5	6.62	306	153	0.227	13	4	35	10.32	0.346	2.1	4.8
BH47	4.996806	6.262944	Tombia 1	6.24	436	218	0.29	14	3.46	45	9.88	0.33	3	5.75
BH48	5.001417	6.263	Tombia 2	6.08	307	154	0.214	21	3.2	22	13.25	0.39	4.34	6.58
BH49	5.000861	6.265528	Tombia 3	6.1	376	188	0.245	32	4	19	18.72	0.136	5.63	9.36
BH50	5.000639	6.266833	Tombia 4	5.67	357	178	0.235	33	3.85	10	19.3	0.382	5.82	9.65
WHO 2012				6.5-8.5	1000	500	50	250	100	150	100	0.3	0.2	200
NSDWQ 2007				6.5-8.5	500	500	10	100	-	100	50	0.3	20	-

Interpolation of groundwater quality parameters in Yenagoa

The spatial distribution of groundwater quality parameters surfaces created by using Inverse Distance Weighted (IDW)method show the spatial distribution of groundwater quality parameters (pH, TDS, Conductivity, Total Hardness, SO4, NO3, Fe, Cl, Mg, Na, Ca). (see figures 2,3,4,5,6,7,8,9,10,11,12 and 13).

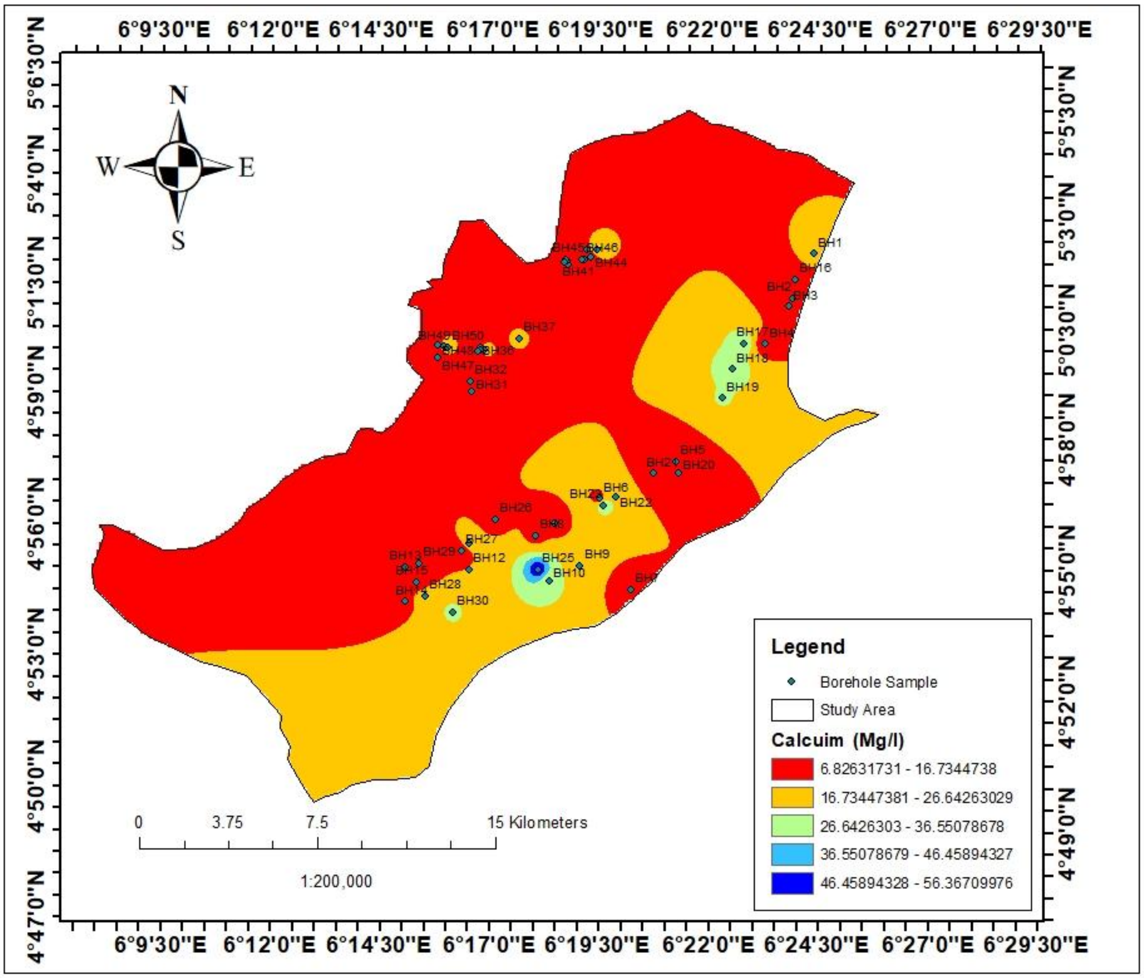

Figure 2: Spartial Concentration of Calcium (Mg/l) in the study Area

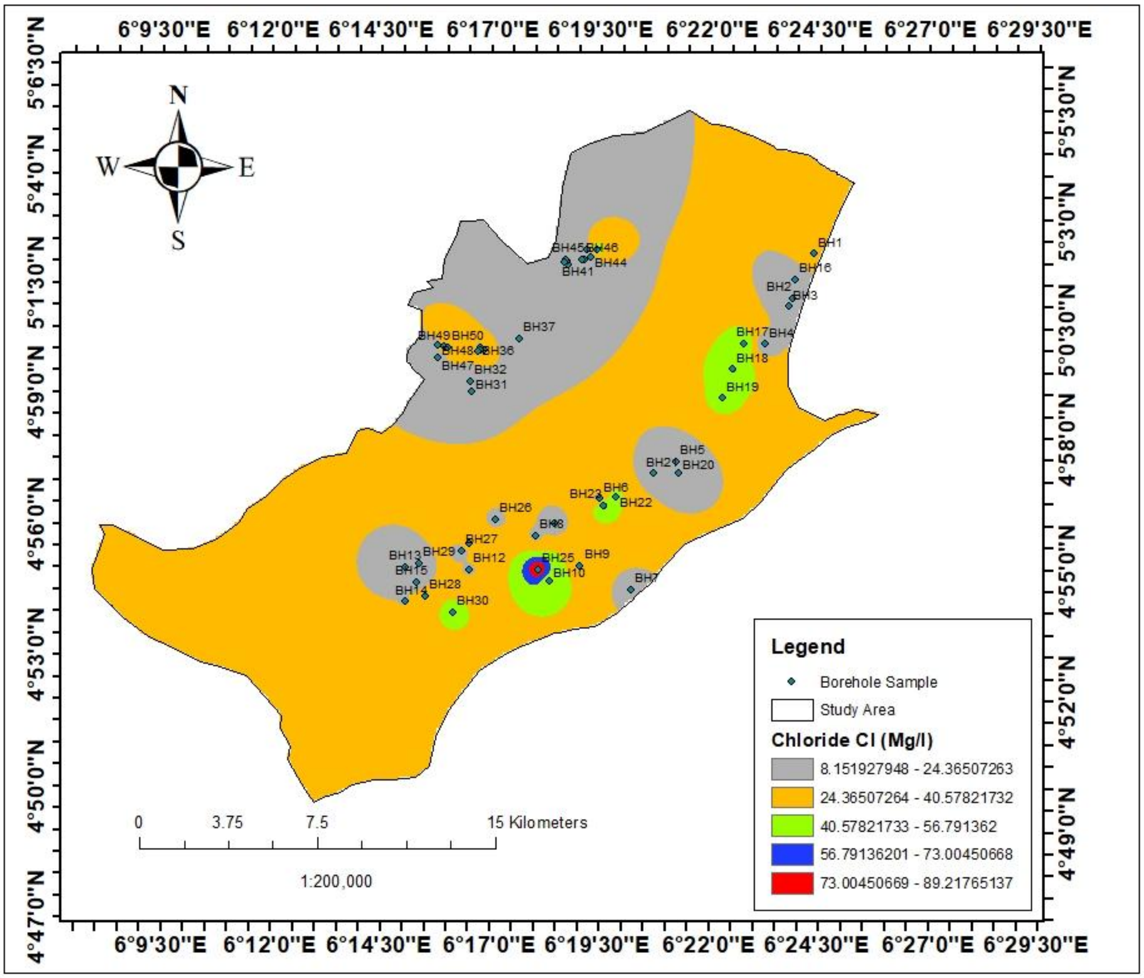

Figure 3: Spartial Concentration of Chloride Cl (Mg/l) in the study Area

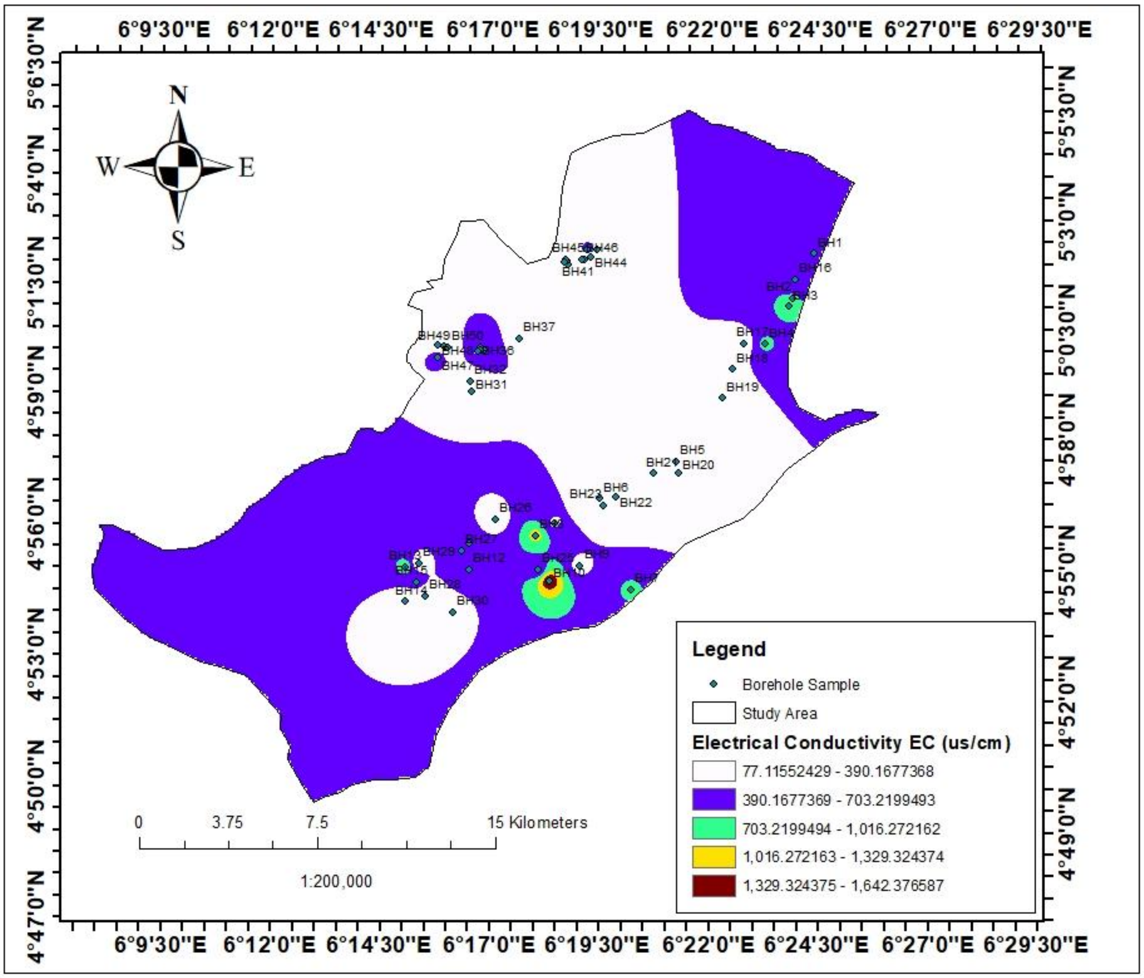

Figure 4: Spartial Concentration of Electrical Conductivity EC (us/cm) in the study Area

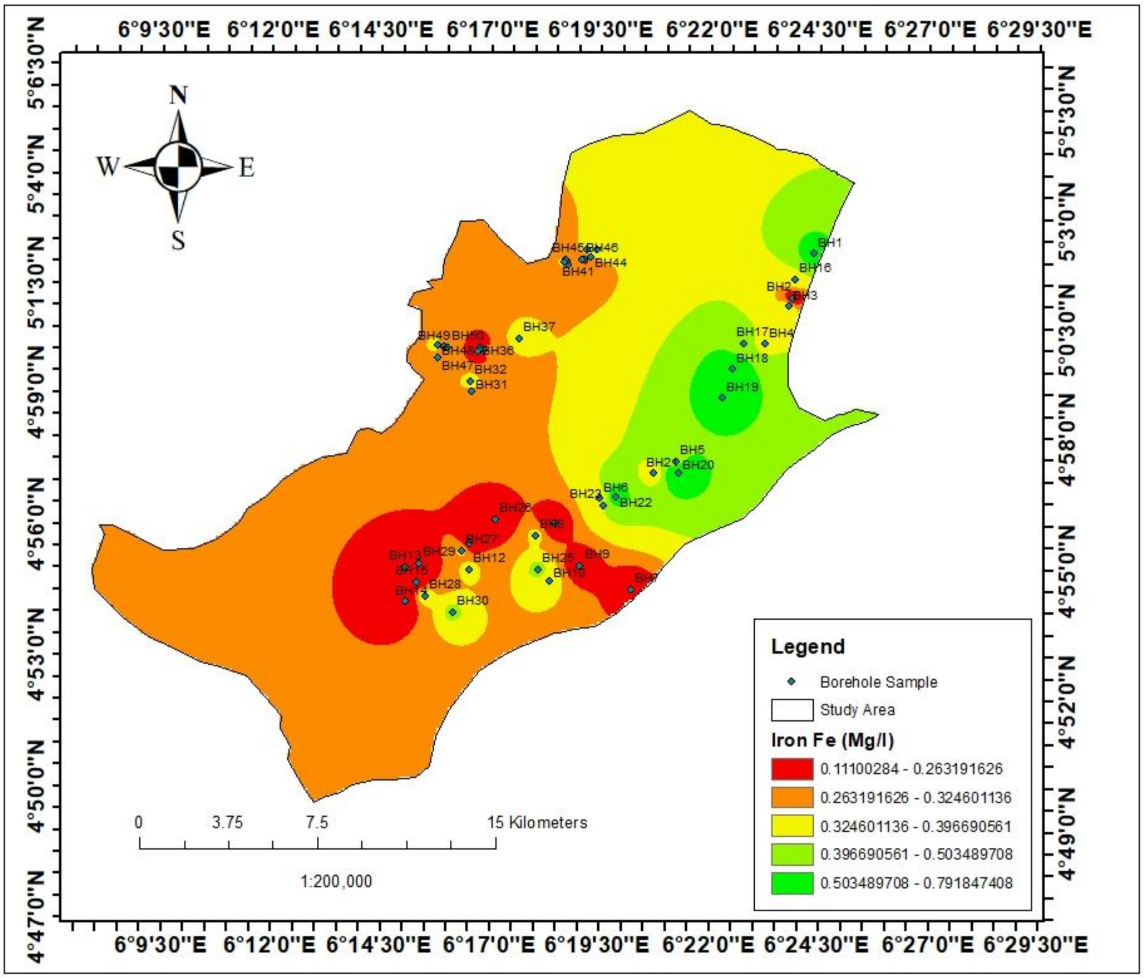

Figure 5: Spartial Concentration of Iron Fe (Mg/l) in the study Area

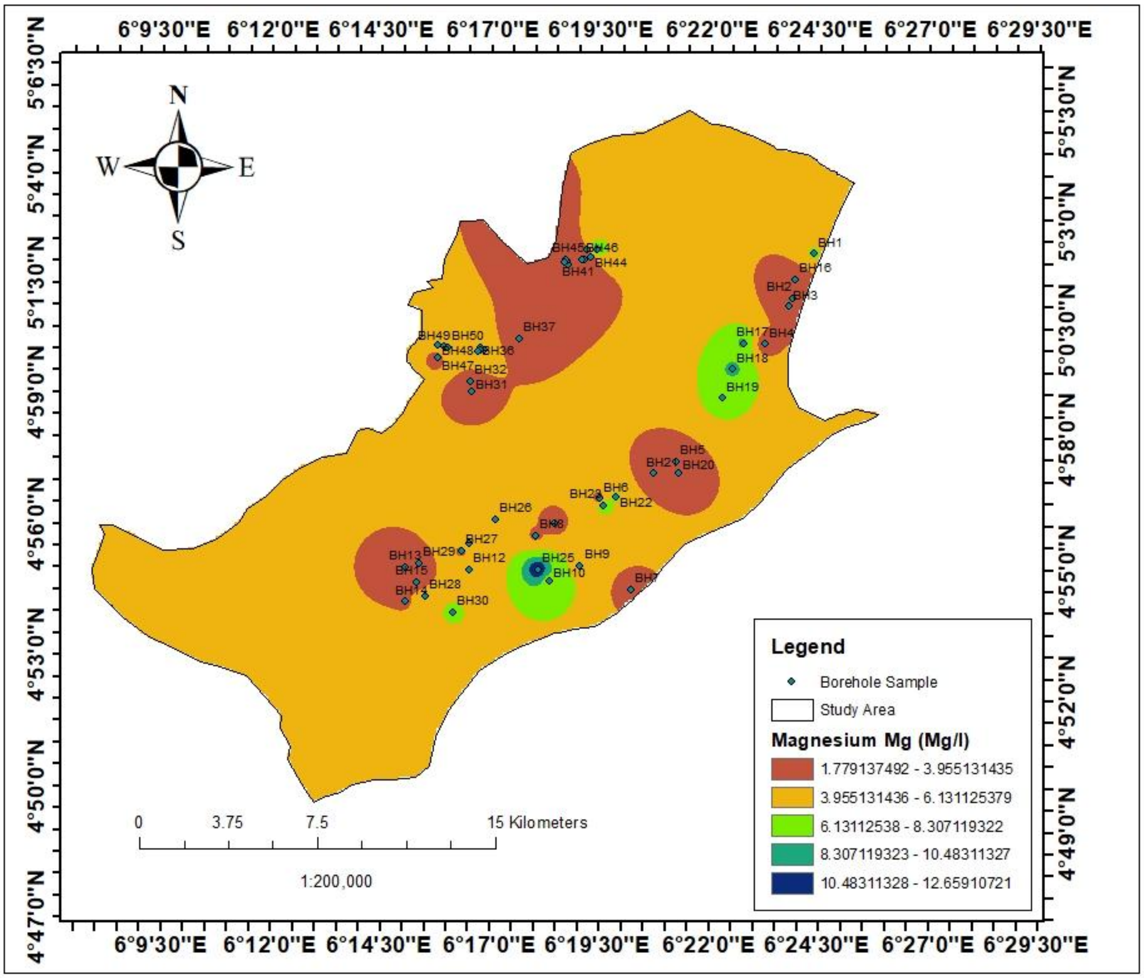

Figure 6: Spartial Concentration of Magnesium Mg (Mg/l) in the study Area

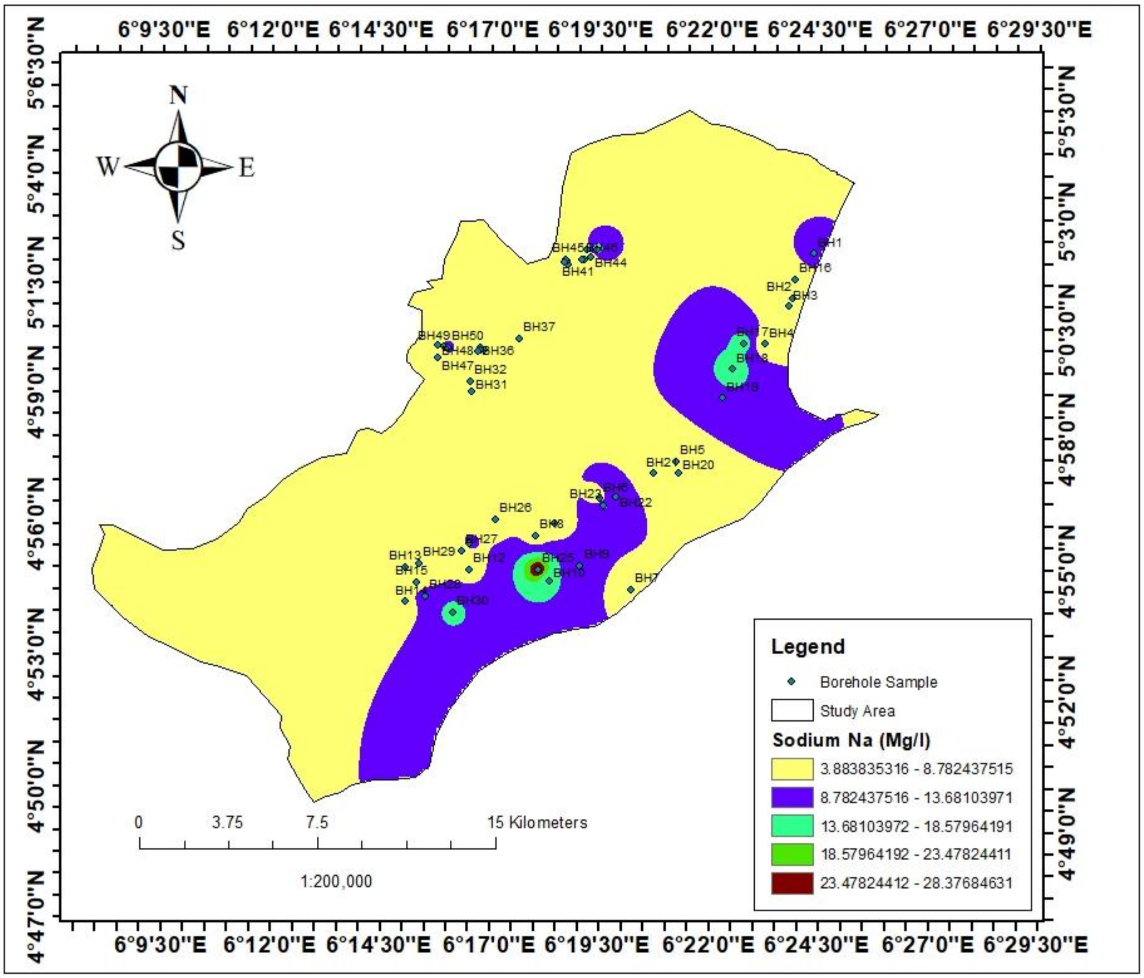

Figure 7: Spartial Concentration of Sodium Na (Mg/l) in the study Area

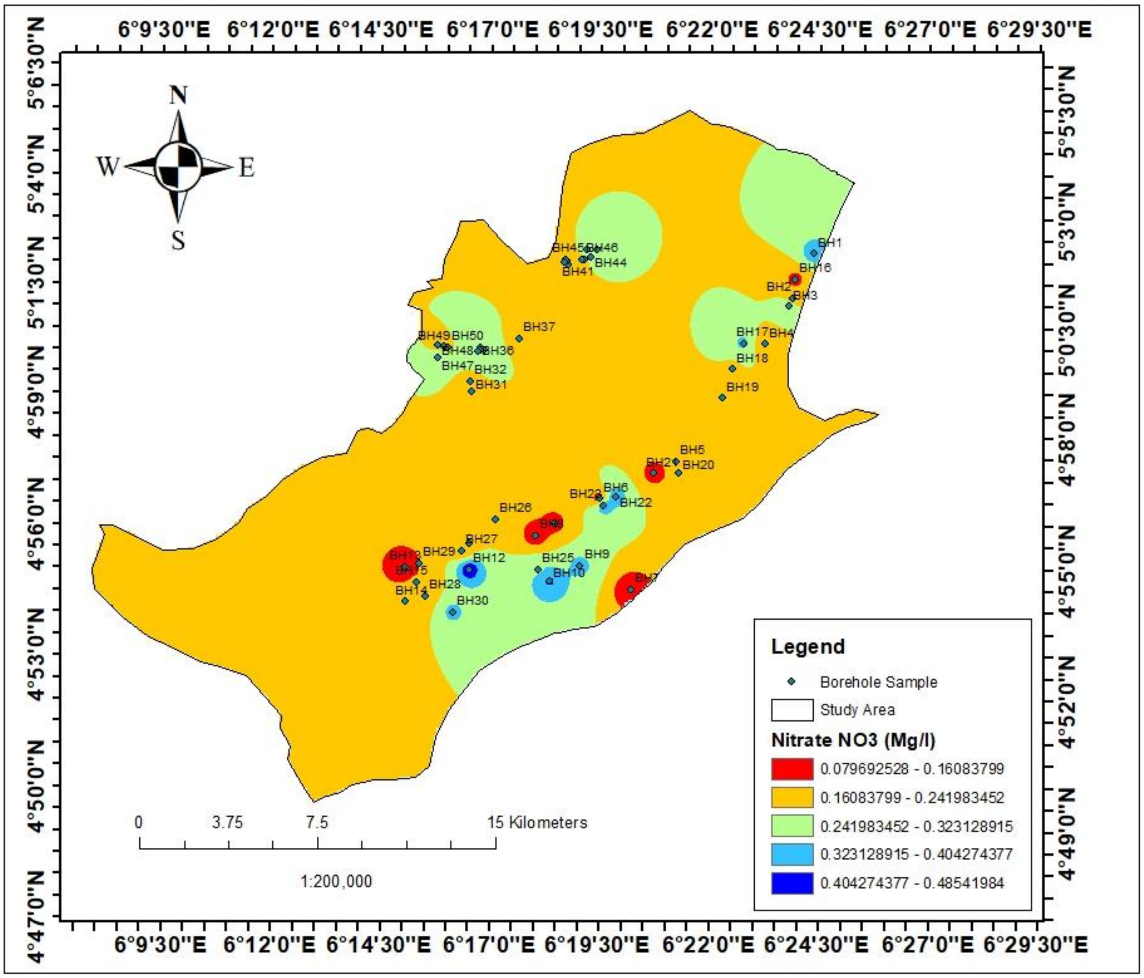

Figure 8: Spartial Concentration of Nitrate NO_3 (Mg/l) in the study Area

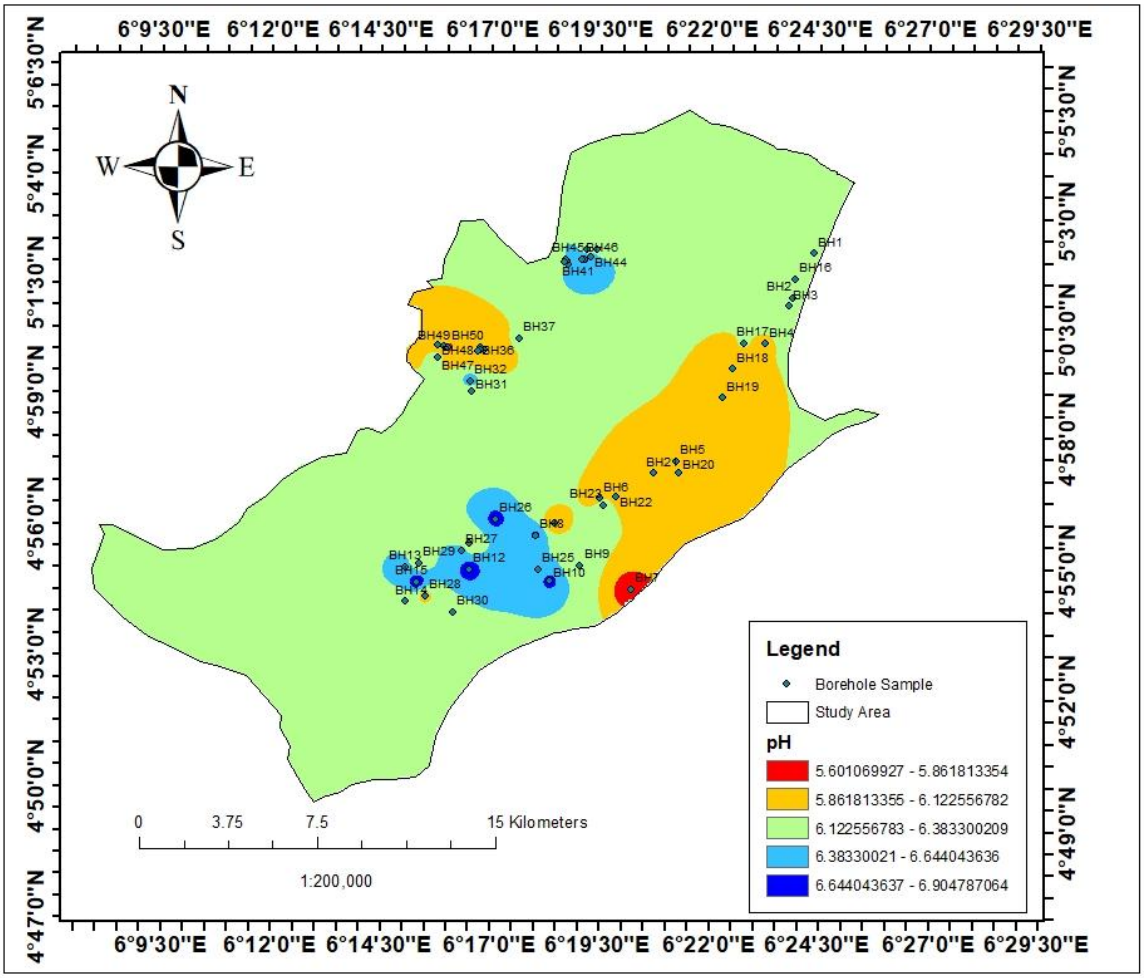

Figure 9: Spartial Concentration of pH in the study Area

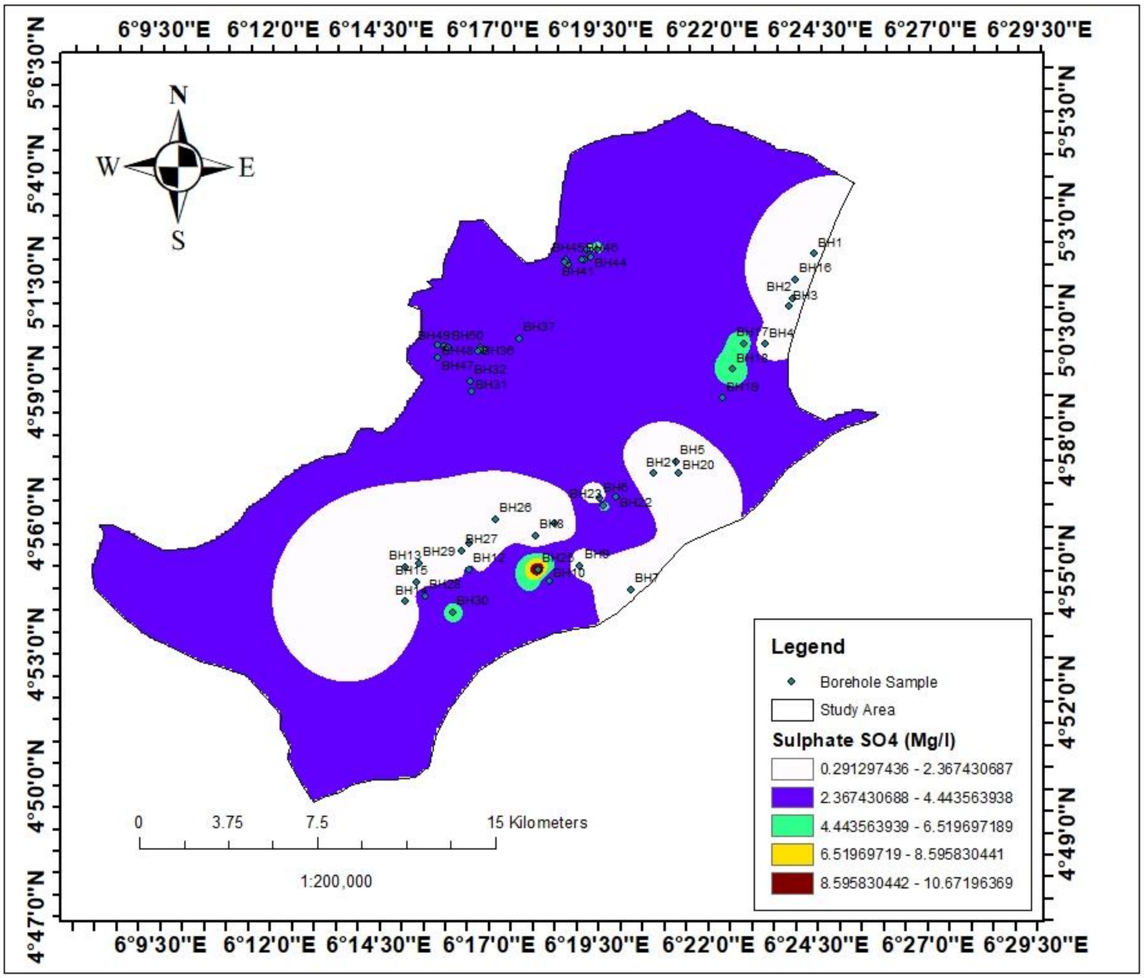

Figure 10: Spartial Concentration of Sulphate SO_4 (Mg/l) in the study Area

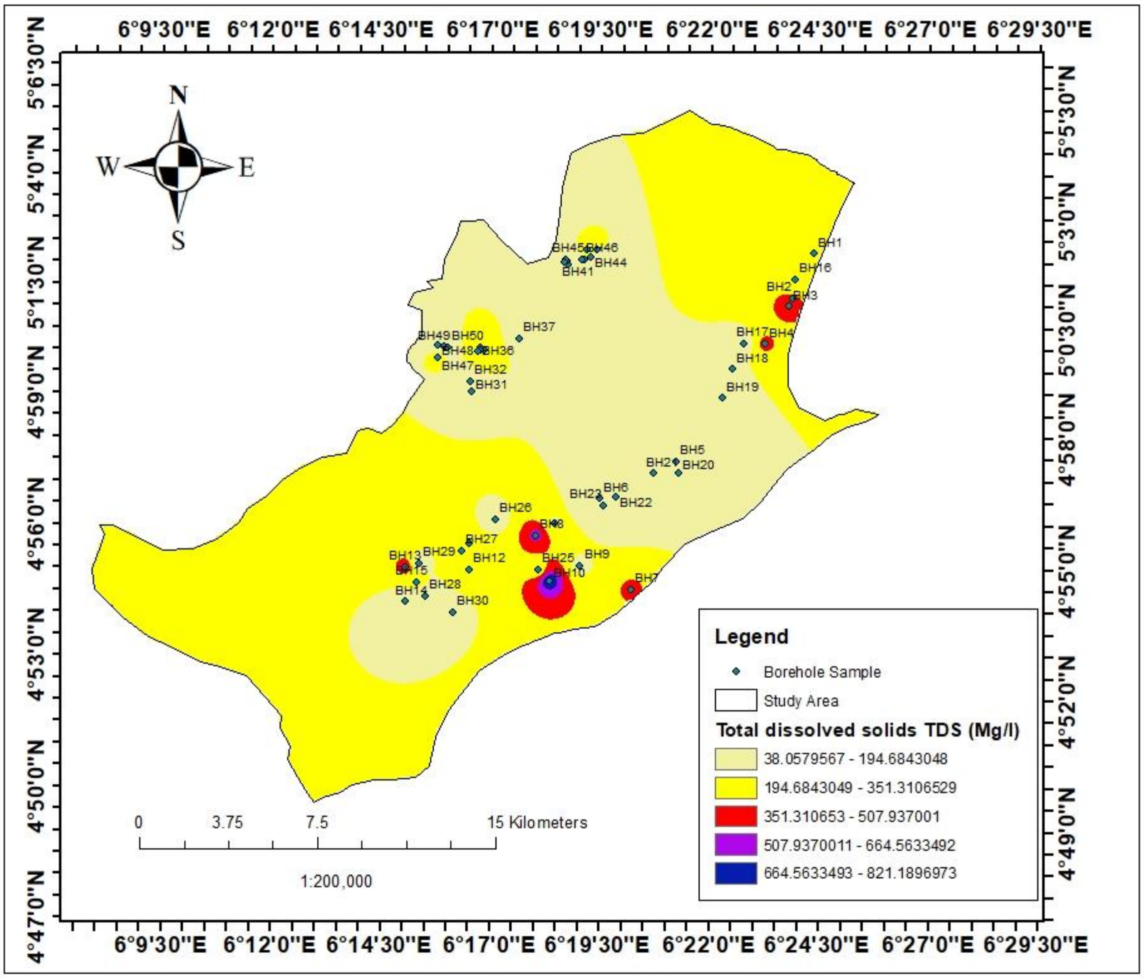

Figure 11: Spartial Concentration of Total Dissolved Solids TDS (Mg/l) in the study Area

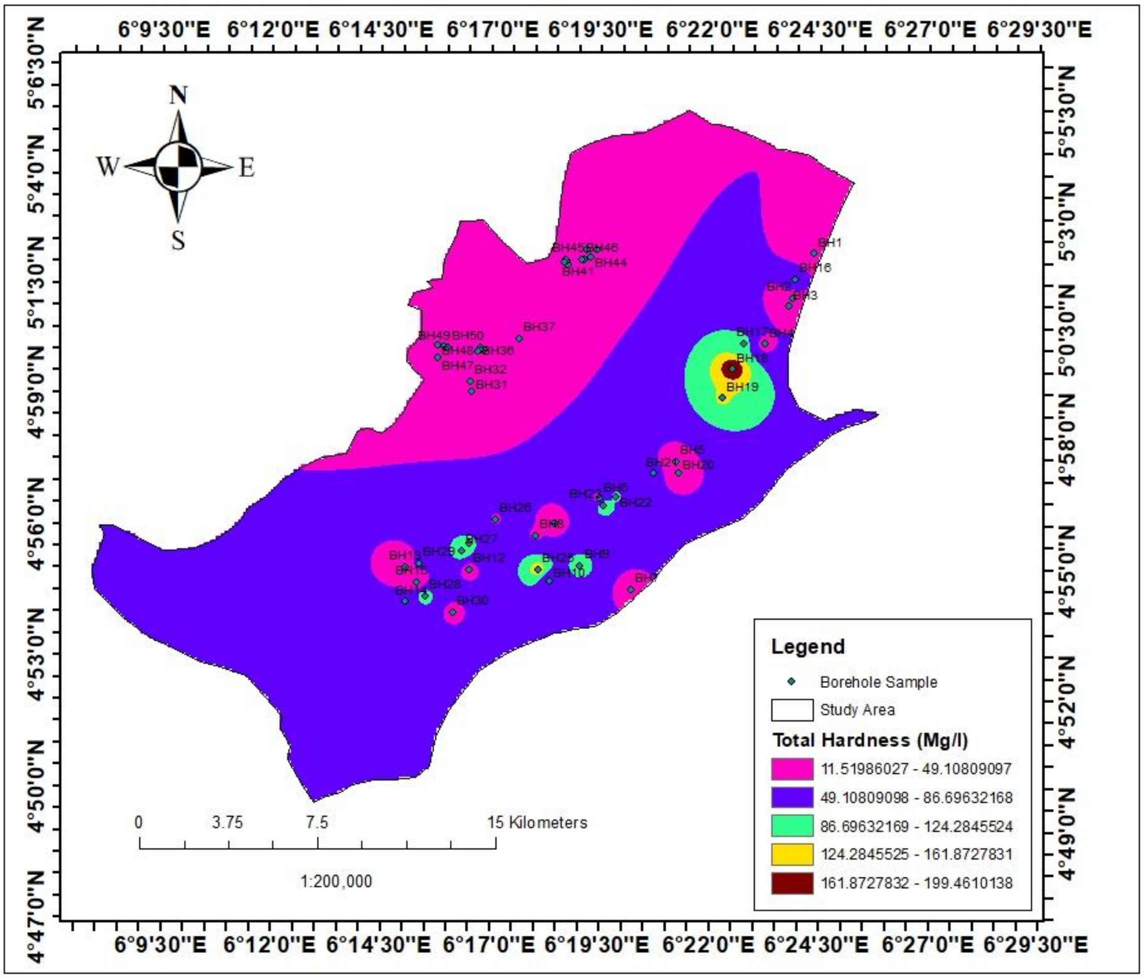

Figure 12: Spartial Concentration of Total Hardness (Mg/l) in the study Area

RESULTS OF THE WATER QUALITY INDEX ANALYSIS

The computed WQI values were classified into five types, excellent water, good water, poor water, very poor water and water unsuitable for drinking, according to Brown et al., (I970), Abbasiet al., (2000), and Jonathan et al., (2012).

TABLE 2: CALCULATION OF RELATIVE WEIGHT OF EACH PARAMETER

s/n	Chemical Parameters	Desirable Limit	*Weight* (wi)	Relative weight (Wi)
I	Ph	7.5	4	0.085106383
2	Electrical Conductivity	1000	4	0.085106383
3	Total dissolved solids	500	5	0.106382979
4	Nitrate	50	5	0.106382979
5	Chloride	250	5	0.106382979
6	Sulphate	150	4	0.085106383
	Total Hardness	100	5	0.106382979
8	Calcium	70	3	0.063829787
9	Magnesium	30	3	0.063829787
I0	Sodium	200	4	0.085106383
11	Iron	0.3	5	0.106382979
			Σwi= 47	ΣWi = 1

TABLE 3: WATER QUALITY CLASSIFICATION BASED ON WATER QUALITY INDEX (WQI) VALUE; (BROWN *et al*, I970 &RAMAKRISHNAIAH*ET AL*, 2009)

Water Quality Index Value (WQI)	Class	Water Quality Status
<50	I	Excellent Water
50-I00	II	Good Water
I00-200	III	Poor Water
200-300	IV	Very Poor Water
>300	V	Unsuitable Water

TABLE 4: SUMMARY OF WATER QUALITY OF THE STUDY AREA IN YENAGOA

Borehole	Town	Lat	Long	Water Quality Index (WQI) Value	Class of Water
BH1	Igbogene 1	5.036889	6.405972	182	Poor water
BH2	Yenagwe1	5.01975	6.398167	44	Excellent water
BH3	Yenagwe 2	5.016722	6.396528	122	Poor water
BH4	Akenfa 1	5.002366	6.387691	113	Poor water
BH5	Etegwe 1	4.957417	6.35375	116	Poor water
BH6	Biogbolo 1	4.94325	6.324806	92	Good Water
BH7	Kpansia 1	4.908472	6.337083	47	Excellent Water
BH8	Ekeki 1	4.929167	6.300806	107	Poor water
BH9	Kpansia2	4.917722	6.317583	44	Excellent Water
BH10	YenizueEpie 1	4.91175	6.305972	110	Poor water
BH11	Amarata 1	4.925861	6.275583	50	Excellent Water
BH12	Swail 1	4.916	6.2755	110	Poor water
BH13	Ogbogoro 1	4.917028	6.251222	80	Good Water
BH14	Ogu 1	4.903722	6.251222	38	Excellent Water
BH15	Akaba 1	4.91125	6.255611	56	Good Water
BH16	Igbogene 2	5.026869	6.398981	119	Poor water
BH17	Akenfa 2	5.002678	6.379307	122	Poor water
BH18	Agudama 1	4.992793	6.375336	212	Very Poor water
BH19	Agudama 2	4.98176	6.37166	206	Very Poor water
BH20	Etegwe 2	4.953314	6.355015	242	Very Poor water
BH21	Okutukutu 1	4.952838	6.34541	98	Good Water
BH22	Opolo 1	4.94409	6.331098	197	Poor water
BH23	Opolo 2	4.940728	6.326492	122	Poor water
BH24	Kpansia3	4.933825	6.307698	35	Excellent Water
BH25	YenizueEpie 2	4.916093	6.301615	134	Poor water
BH26	Amarata 2	4.935199	6.285502	35.6	Excellent Water
BH27	Swail 2	4.923142	6.272686	107	Poor water

BH28	Akaba 2	4.905837	6.258554	122	Poor water
BH29	Ogbogoro 2	4.918221	6.25624	38	Excellent Water
BH30	Ogu 2	4.899849	6.269169	131	Poor water
BH31	Akaibiri 1	4.983667	6.276111	95	Good Water
BH32	Akaibiri2	4.987861	6.275722	111.2	Poor water
BH33	Gbarantoru 1	5.000389	6.279556	42.8	Excellent Water
BH34	Gbarantoru 2	4.999861	6.280667	98	Good Water
BH35	Gbarantoru 3	4.999656	6.279361	110	Poor water
BH36	Gbarantoru 4	4.999222	6.2785	41.6	Excellent Water
BH37	Gbarantoru 5	5.004056	6.294028	116	Poor water
BH38	Ogbuna 1	5.032306	6.312556	106.4	Poor water
BH39	Ogbuna 2	5.033528	6.311917	57.8	Good Water
BH40	Ogbuna 3	5.034	6.311778	110	Poor Water
BH41	Ogbuna 4	5.033361	6.311056	113.6	Poor Water
BH42	Okolobiri 1	5.038194	6.323444	118.4	Poor Water
BH43	Okolobiri 2	5.038	6.319889	114.2	Poor Water
BH44	Okolobiri 3	5.035417	6.321361	100.4	Good Water
BH45	Okolobiri 4	5.034306	6.318833	45.8	Excellent Water
BH46	Okolobiri 5	5.03425	6.31789	105.8	Poor Water
BH47	Tombia 1	4.996806	6.262944	101	Good water
BH48	Tombia 2	5.001417	6.263	119	Poor water
BH49	Tombia 3	5.000861	6.265528	42.8	Excellent Water
BH50	Tombia 4	5.000639	6.266833	116.6	Poor water

The result of the water quality index in table 4 shows that BH1 Igbogene 1 has WQI value of 182 which indicate poor water. BH2 Yenegwe 1 has 22 presenting excellent water. BH3 Yenegwe 2 with a WQI of 122 shows poor water quality. BH4 Akenf 1 with WQI 113 indicates poor water. BH5 Etegwe 1 with a WQI of 116 also shows poor water qulity. BH6 Biogbolo 1 with a WQI value of 92 indicates good water. BH7 Kpansia 1 with water quality (WQI) of 47 is an excellent water quality. BH8 Ekeki 1 with a value 107 represents poor water quality. While BH9 Kpansia

2 has water quality index (WQI) vlue of 44 showing that the water quality index for this location is excellent water. BH10 Yenizue-Epie with a WQI of 110 indictes poor water. While BH11 Amarta 1 with a value 50 shows an excellent wter. On the other hand BH12 Swali 1 with WQI 110 indicates poor water. Table 4 further shows that BH13 Ogbogoro 1 WQI value of 80 indicates good water. BH14 Ogu 1 with a WQI value of 38 represents an excellent water quality, moreso; BH15 Akaba 1 with a WQI value of 56 indicates a good water quality. While, BH16 Igbogene 2 with a WQI value of 122 shows a very poor water quality. In the same vein BH18 Agudama 1 has a WQI value of 212 which shows that the water is very poor. BH19 Agudama 2 with a value of 206 indicates a very poor water. BH20 Etegwe 2 with a value of 242 indicates very poor water quality. This is about the wost water quality in the study area. BH21 Okutukutu 1 with a water quality index (WQI) of 98 indicates good water. BH22 Opolo 1 has a water quality index (WQI) value of 197 which shows that the water is poor quality. In the same vain, BH23 Opolo 2 with a value of 122 also indicates poor water quality. However, BH24 Kpansia 3 with WQI of 35 shows an excellent water quality. While BH25 Yenizue Epie 2 with a value of 134, represent poor water quality. While BH26 Amarata 2 with WQI of 36, indicates an excellent water quality. BH 27 Swali 2 with WQI of 107 shows a poor water quality. BH28 Akaba 2 with a WQI of 122 also shows a poor water quality. While BH29 Ogbogoro 2 with a WQI of 38, represent an excellence water quality. BH30 Ogu 2 with a WQI of 131 shows a poor water quality. While, BH31 Akaibiri 1 with a WQI of 95 indictes good water quality. BH32 Akaibiri 2 with a WQI of 111 shows a poor water quality. BH33 Gbarantoru 1 with a WQI of 43 represents an excellent water quality. While, BH34 Gbarantoru 2 with a WQI of 98 shows good water quality. BH35 Gbarantoru 3 with a WQI of 110 shows a poor water quality. Also, BH36 Gbarantoru 4 with a WQI of 42 represents an excellent water quality. While BH37 Gbarantoru 5 with a WQI of 116, shows a poor water quality. BH38 Obuna 1 with a WQI of 106 shows a poor water quality. BH39 Obuna 2 with a WQI of 58 indicates a good water quality. BH40 Obuna 3 with a WQI of 110 shows a poor water quality. BH41 Obuna 4 with a WQI of 114 shows a poor water qualiy. BH42 Okolobiri 1 with a WQI of 118 shows a poor water quality. BH43 Okolobiri 2 with a WQI of 114 shows a poor water quality. BH44 Okolobiri 3 with a WQI of 100 indicates a good water quality. BH45 Okolobiri 4 with a WQI of 45 represents an excellent water quality. BH46 Okolobiri 5 with a WQI of 106 shows a poor water quality. BH47 Tombia 1 with a WQI of 101 indicates a good water quality. BH48 Tombia 2 with a WQI of 119 shows a poor water

quality. BH49 Tombia with a WQI of 43 represents an excellent water quality. While BH50 Tombia 4 with a WQI of 117, shows a poor water quality. (see figure 13 for the water quality index of Yenagoa LGA).

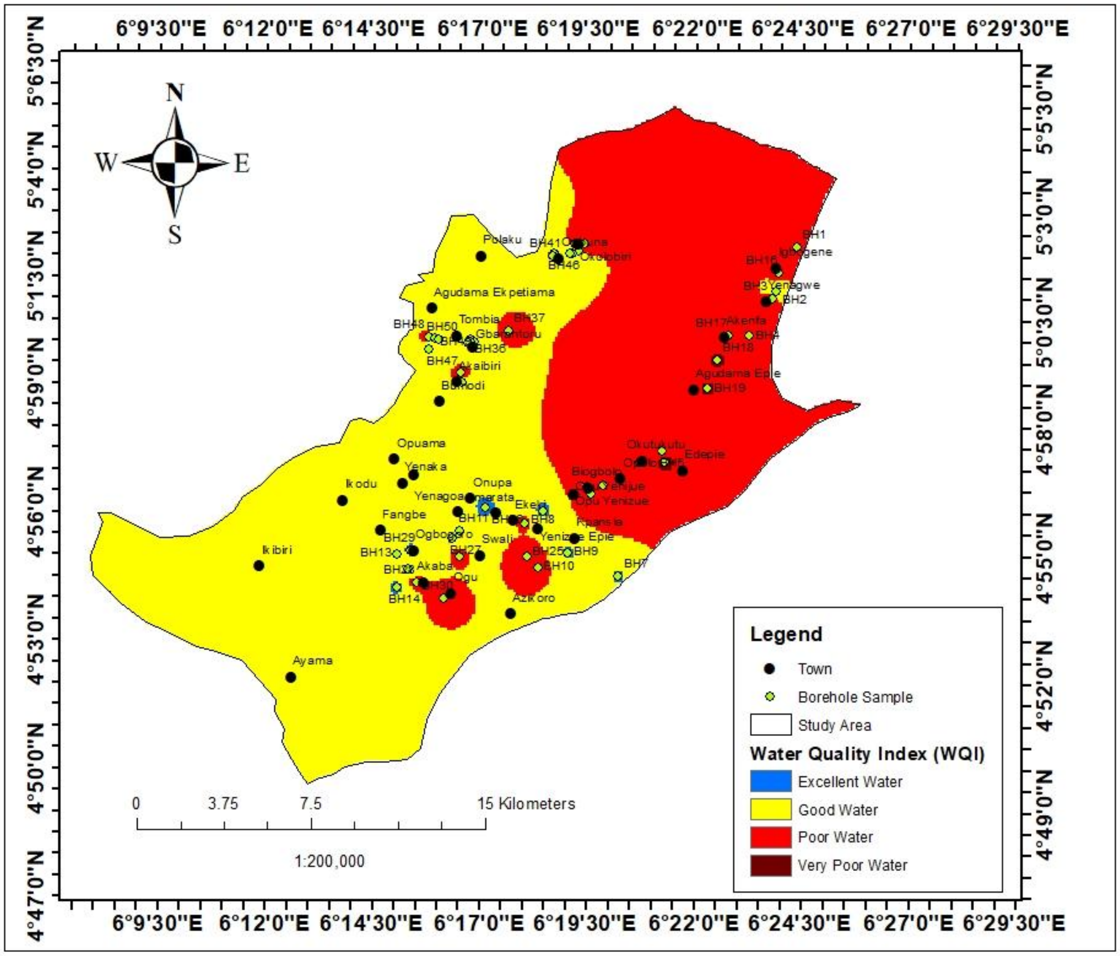

Figure 13: **A GIS Map Showing Spatial Distribution of Water Quality Index (WQI) in Yenagoa L.G.A**

Source: **Service Layer Credits: Abia State University, Department of Geography and Planning GIS Lab. (2021)**

Conclusion

Life cannot be sustained without water, not just water but it must be one of desirable quality. Water that is not of a desirable quality is threat to human society and the environment especially the biosphere. The study reveals that most of the sampled locations had water quality index ranging from poor to very poor. This may have serious negative implication on the inhabitants and ecology of the study area. In the light of the above, groundwater in the study area must be treated to ensure its portability be consumption and other uses.

Recommendations

The researcher wishes to proffer some recommendation based on the observed findings of the study.

1. Dumping of solid wastes should be limited to only collection centres.
2. Motor parks and mechanic workshop should be control to restricted areas.
3. Groundwater should be properly treated before use.
4. There should be regular monitoring of bore-well water from time to time.
5. Regular clearing of drainages will ensure the evacuation of polluted water through surface run-off with infiltrating into the groundwater.

REFERENCES

Adesogan, S.O. Sasanya, B.F. and Makinde, O.J. (2019). Assessing the Quality of Surface Water for Direct Rural Water Supply: A Case Study of Osun River, Nigeria. *African Journal of Environmental Health Sciences.* 6:1-8

Austin, O. O. and Ayibawari, O.E. (2020) Spatial Analysis of Groundwater Quality Indices across Yenagoa Communities in Bayelsa State Southern Nigeria. *Asian Journal of Geological Research* 3(4): 54 – 63.

Buba, S; Sumaila, Koud Marcus, N.D. (2019). Impact of Goal Mining on Water Quality in Maignga, Akko L.G.A. Gombe State, Nigeria. *Gombe Journal of Geography and Environmental Studies.* 1(2): 163-168.

Chima, G.N. (2018). *Water, Water Everywhere but not Enough*" 37th Inaugural Lecture. Abia State University Uturu, Abia State Nigeria. Abia State University Press.

Chima, G.N., Alozie, M.C, Digha, O.N. and Enyinna, G.C. (2007). Swamp Reclamation for Human Habituation: Its Implication on the sustainability of Wetlands (A case of Yenagoa Town, Bayelsa States). *Int. J. Biotechol and Allied Sci* 2(3): 230-237.

Digha, O.N. (2021). Evaluation of Groundwater Quality Using Pollution Index in Some Communities of Bayelsa State, Nigeria. *International Journal of Innovation Environmental Research.* 9(3)1-9.

Digha, O.N. (2022a). Spartial Analysis of Groundwater Quality Using Geographic Information System (GIS) in Ogbia L.G.A., Bayelsa State, Nigeria. *Proceedings of the 15th Annual International Conference of Trans AfricanUniversities and Allied Institutions Research and Development Network* (TAUIRDN). Isaac Jasper Boro College of Education Sagbama, Bayelsa State & University of Buea Cameroon. 117-140.

Digha, O.N. (2022b). Pollution Assessment of private Bore-Holes Water Supply using Contamination Index and Contour in Ogbia Local Government Area of Bayelsa State Nigeria. *Nigeria Association of Hydrological Sciences (NAHS) Proceedings of the 12th National Conference, Port Harcourt. Theme: Climate Change: Issues and Challenges for Sustainable Water Management I Nigeria.* 10th -14th Oct. 2022. Pp: 103-121.

Digha, O.N. and Abua, M.A. (2018). Assessment of Pollution Status of Ikwette Stream at Obudu Cattles Ranch Bottom Hill, Cross River State, Nigeria. *International Journal of Environment and Pollution Research* 6(1): 8-12.

Digha, O.N. and Ekenem, J.O. (2015). Effects of Population Density on Water Quality in Calabar Municipality Cross River State Nigeria. *Journal of Environment and Earth Science.* 5(2): 7-21.

Digha, O.N. and Martha, A.E. (2022). Seasonal Variation of Physico-Chemical and Bacteriological Characteristic of Sagbama River, central Nigeria Delta, Bayelsa State, Nigeria. *Journal of Environment and Earth Science*. 12(5): 46-54

Egail, A.O.; Edirin, A and Digha, O.N. (2022). Comparative Assessment of Heavy Metals Pollution in Surface Water in Ekole River and Epie creek in Yenagoa Metropolis using Geographical Information System. *Journal of Geographical research* 5(3): 49-62.

Eze, B.E. Eni, D.I. and Hzoezie, A.D. (2021). Spatial Assessment of the Effect of Graveyard on Borehole Water Quality in Calabar Metropolis. NAHS 11th*Annual Conference Book of Proceedings*, Calabar 9-12 August, 20221. Pp. 153-158.

Goel, P.K. (2006). *Water Pollution, Causes, Effects and Control.* Second Revised Edition New Age International Publishers.

Horton, R.K. (1965). An index number system for rating water quality. *J. water pollu. Cont.fed.*, 37(3): 300 -305

Hwankwoala, H.O; Udom, G.J. and Ugwu, S.A. (2011). Some Heavy Metal Investigations in Groundwater Sources in Yenagoa, Bayelsa State, Nigeria. *Nigerian Journal of Applied technology in Environmental Sanitation.* 1(2): 163-170.

Jonathan, Y. Tijani, O.J. and Obiemi, M.O. (2012). Underground Water Assessment in Minna Using Water Quality Index. *Journal of Environment.* 2:36-30

Kapoor, B.B., Inam, F. Deo, S.S. (2016). Assessment of Physical-Chemical Quality of Groundwater in some Rural Areas Receiving Industrial Wastewater Discharges in

Nagpur District, Maharashtra State, India. *TIJST*, 4(5). Brown, R.M.; Mccleland, C. R.; Deininger, R. A. and Tozer, R. G. (1970). "A Water Quality Index – do we dare" water and sewage works October. P. 339-343.

Lawson, E.O. (2011). Physico-Chemical parameters and heavy Metal Contents of Water from the Mangrove Swamps of Lagos Lagoon, Nigeria. Advances in Biological Research 5(1):08-21.

Mudassir, H. I. and Lawal, I.S. (2022). *Water Quality Status of Ajiwa Reservoir, Kastina State, North Western Nigeria Using Water Quality Index.* Nigerian Association of Hydrological Sciences. (NAHS) Proceedings of the 12th National Conference Port-Harcourt. Theme: Climate Change: Issues and Challenges for Sustainable Water Management in Nigeria. 10th – 14th October, 2022.

Mustapha, S and Tasi'u, Y.R. (2022). Assessment of Groundwater Potential Using Integrated Method in Dange-Shuni Area, Sokoto State, Nigeria. *Nigeria Journal of Hydrological Sciences.* 9.27-44

Oketola, A.A, Osibanjo, O.; Ejelonu, B.C., Oladimeji Y.C. and Damazio, O.A. (2006). Water quality assessment of River Ogun around the cattle market of Isheri, Nigeria. *Nigeria J. Applied Sci*. 6(3): 511-517.

Okoro, H.K., Adeyinka, A.; Jondiko, O.E. Ximaba, B.J. and Kakalanga, S.J. (2012). Assessment of Heavy Metal Contamination in groundwater: a case study of central industrial district in Ilorin, Kwara State Nigeria. *International Journal of Physical Sciences*. 7(28): 5078-5088.

Olatunji, J.A; Odediran, O.A; Oboro, R.I. and Olaschinde, P.I. (2015). Assessment of Groundwater of Ilorin Metropolis Using Water Quality Index Approach. *Nigerian Journal of Technological Development*. 12(1):18-21.

Osibanjo, O.; Adegbenro, P.D. and Adewale, M.G. (2012). The Impacts of surface water quality of Ona River Alaro in Oluyole industrial Estate, in Ibadan. *Nigeria Afri. J. Biotechnol.* 10(4):696-702.

Oyegun, C.U. (1999). "*Climate, Relief and Drainage"* in Alagoa, T. E. (ed), L. and People of Bayelsa State. Central Niger Delta. Onyoma Research Publications, Pp. 31-43.

Ramakishnaiah, C. R. Sadashivaiah, C., and Rarigonna, G. (2009). Assessment of Water Quality Index for Groundwater in Tamkur Taluk, Karanataka state, India. *E-Journal of Chemistry*. 6(2): 523-530.

Tyagi, S. Sharma, B., Singh, P. and Dobhal, R. (2013). Water Quality Assessment in terms of Water Quality Index "*American Journal of Water Resources* 1(3):34-38.

United Nations (UN) (1997). Glossary of Environment Statistics, Studies in methods, Series F. No. 67