MAPPING OF GROUNDWATER POTABILITY IN BOSSO LGA OF NIGER STATE USING GEOGRAPHICAL INFORMATION SYSTEM.

[1]Adeoye, Peter Aderemi*, [1, 2]Jibril Ibrahim and [1]Owoyemi Michael Toba

***corresponding Author: peter.adeoye@futminna.edu.ng**

[1]Department of Agricultural and Bioresources Engineering, Federal University of Technology, P.M.B. 65, Minna, Niger State, Nigeria.

[2]Niger State College of Agriculture, P.M.B. 109, Mokwa, Niger State, Nigeria.

ABSTRACT

In Nigeria today, the government is providing not many households with drinking water. By sinking boreholes and digging shallow wells, each individual / community has resorted to offering water for itself. Therefore, this research focused on the determination of groundwater quality for chosen villages in the Bosso Local Government Area of Niger state and the production of spatial distribution maps for some parameters of drinking water. Twenty-five communities were chosen in the LGA, and during rainy and dry seasons both shallow wells and borehole water were sampled. The results showed that shallow well water is more influenced by both physicochemical and bacteriological pollution in some villages / communities than boreholes in the region. Spatial maps were also provided showing different parameters, places and their intensities. Although the range of the research does not include causes of spatiality, the existence of some of the surplus water quality parameters may be due to the closeness of shallow well to pit latrines, fast urbanization and indiscriminate household waste deposition. It was also found that seasonal variations are a significant factor in parameter spatiality. The research proposes treatment of shallow wells and borehole water in the region before use by human and for animal, most especially those communities that some water quality parameters have exceeded allowable permissible limit recommended by World Health Organization (WHO) and Nigeria Standard for Drinking Water Quality (NSDWQ).

Keywords: Contaminants, Groundwater, Geographical information system (GIS), Portability and Water Quality Index

1. INTRODUCTION

Water is a natural resource of prime importance. It was ranked second only to oxygen as an important substance for life, and access to fresh water and sanitation facilities is a precondition for all other life objectives agreed globally, including the eight Millennium Development Goals (MDGs) developed by the United Nations in 2000 and expanded upon in 2002 at the World Summit on Sustainable Development (Genevieve and Carrie, 2008).

While water quality management contributes both directly and indirectly to achieving all eight MDGs, it is most closely tied to the targets of Goal 7, to ensure environmental sustainability (UNEP GEMS/Water 2007). While water quality management contributes directly and indirectly to the achievement of all eight MDGs, it is closely linked to the objectives of Goal 7 to ensure sustainability of the environment. It is a well-known fact that for several good reasons, clean water is absolutely vital (Mandalam et al., 2009).

It was commonly stated that the groundwater is the cleanest source of water. There is no doubt that groundwater remains a major source of water globally. It is the cause of about one-third of global water withdrawals and offers a big part of the worldwide population with drinking water (Parker, 2000). However, spatial irregularities in groundwater incidence and extraction patterns with related economic and ecological issues are challenges faced by many groundwater resource managers in many nations, despite the abundance of global groundwater aggregates (Macdonald et.al, 2012).

Tirkey *et al.* (2013) stressed that there is an enormous decrease in freshwater in this contemporary age, perhaps owing to population growth, urbanization, industrialization, agriculture. The lack of surface water makes individuals dependent on groundwater to meet their requirements. Groundwater is considered to be one of the most reliable and accessible source of portable water in both urban and rural regions globally due to its relative abundance and unpolluted nature due to the limited motion of pollutants in the soil profile (Owoyemi, 2018). Many towns and cities meet their water requirement either through shallow wells or boreholes. Rain water is the primary source of ground water recharging, and if waste is not correctly disposed of, it percolates into the soil and causes contamination. Pesticides, fertilizers and countless point sources of contamination are also a danger to groundwater quality.

Minna Metropolis and its adjacent Local Government Areas are more agricultural settlements, and year-round and year-round farming operations. A confirmed study recently indicated that Minna and its metropolis ' so-called water sources are not suitable for human consumption (Owoyemi, 2018). Therefore, this research evaluates groundwater quality through research of the Water Quality Index (WQI) and spatial distribution of WQI through the Geographical Information System (GIS) as a significant instrument that could be helpful to policy makers in taking helpful action. Because assessing groundwater quality status for human consumption is essential for socio-economic growth and development, this study will further create information base for planning future water resource development policies in relation to spatial mapping of water quality parameters in chosen villages.

2. MATERIALS AND METHOD

Minna, Niger State's capital, is situated in North- central Nigeria. In addition to being the state of hydroelectric power generation in the nation, the state is also renowned for its agricultural operations. Bosso Local Government Area is situated between latitude (8^0 10^1N and 11^0 30^1N) and longitude (3^0 30^1E and 7^0 30^1E) within the capital town as shown in Figure 1. The area has an average annual rainfall of 1300 mm. The raining season begins from April to October on average. Rarely does the temperature drop below 22^0C. The peaks are 40^0C (February - March) and 35^0C (November – December).

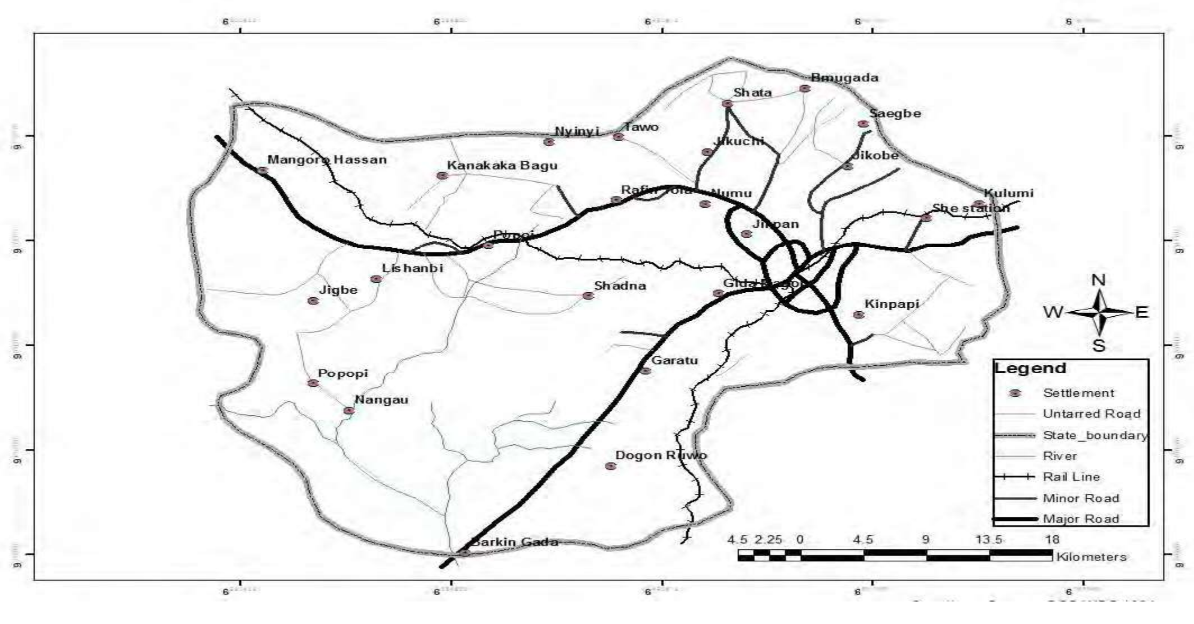


Fig. 1: Geographical Location of Bosso Local Government Area (Google Map, 2018)

Water samples were collected from shallow wells and boreholes and kept at a temperature of 4^0C with ice pack to enable samples to keep their natural state during travel to the laboratory. Samples collected were correctly labeled as they have been obtained from four (4) distinct boreholes and shallow wells in each of the 25 villages shown in Figure 2. All were taken for laboratory analysis to the Upper Niger River Basin Development Authority's Water Quality Assessment and Monitoring Laboratory. The processes were normal techniques prescribed by the World Health Organization (WHO) and the Nigeria Standard for Drinking Water Quality (NSDWQ).

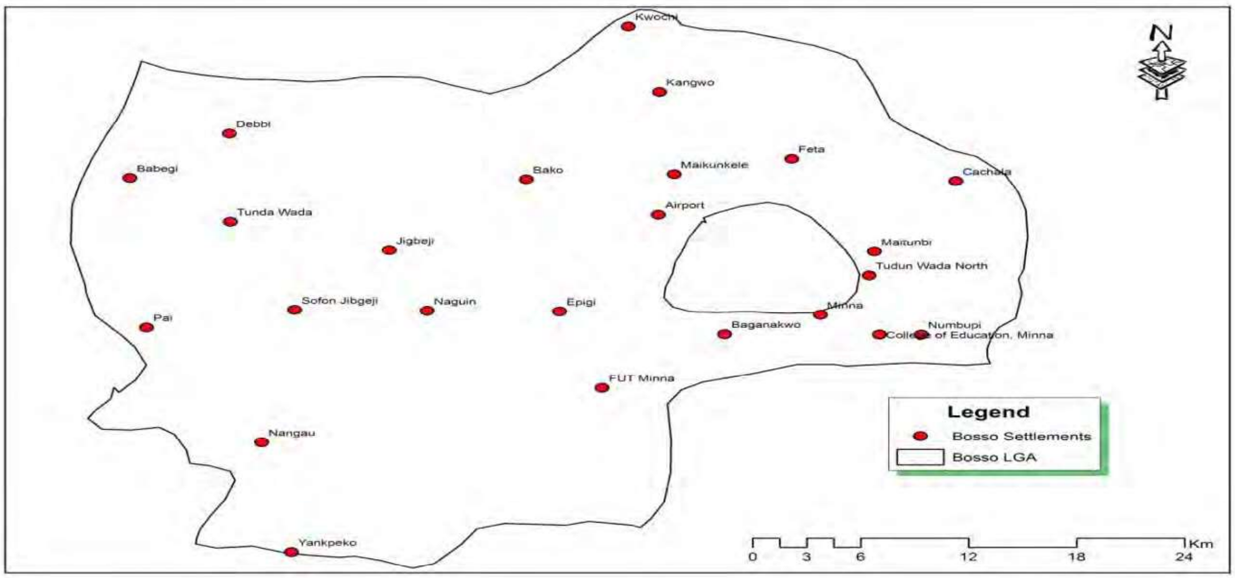


Fig. 2: Bosso Local Government Area showing Sample Collection Points (Google Map, 2018).

Water temperature was measured using a mercury thermometer, pH was measured using a digital pH meter (Model 201, Orion Research INC.), Nephelometer turbidity was evaluated using 0.02 NTU norms, Electrical Conductivity (EC) and Total Dissolved Solids (TDS) were measured using a salinometer (Thermo Electron Corporation, Model Orion k150, USA). Dissolved oxygen was determined instantly after collection and, according to the United States Environmental Protection Agency (USEPA), samples for biochemical oxygen demand (BOD_5) were incubated in the laboratory for five days at 20^0C. After analysis, the water quality parameters were then transformed and interpolated into ArcGis software to produce spatial maps for the parameters. The statistical analysis of the physico-chemical parameters was carried out with the help of the MS Excel Program.

3. Results and Discussion

Tables 1 and 2 present the shallow well and borehole water samples parameters respectively for some of the village visited.

Table 1: Quality of water samples for Shallow well water at different villages

Location	Month	Temp (^0C)	Col (Ptco)	Tur (NTU)	Ph	EC (µs/cm)	NO_3 (mg/L)	SO_4 (mg/L)	TDS mg/L	PO_4 (mg/L)	DO (mg/L)
Jikpan	March	28.1	7.6	0.61	6.5	46.9	0.67	249.6	53.6	0.06	16.4
	June	29	6.6	0.53	6.6	47.1	0.59	300.1	53.7	0.07	18.1
	Sept.	25	9.9	0.59	7	44.4	14.3	413	58.6	0.65	24.5
	Dec.	26.4	8.9	0.43	7.1	43.4	14.21	411.6	58.9	0.61	23
G/mangoro	March	28.9	14.3	7.21	7.8	1214	31.4	402.6	606.4	0.12	25
	June	29.5	12.7	7.56	7.5	1213.1	33.4	214.4	607.4	0.25	23.1
	Sept.	31.6	13.9	7.81	8.4	1209.1	25.4	421.5	614.9	0.31	24.5
	Dec.	30.1	14.5	7.77	8.2	1211.6	23.9	412.3	613.9	0.33	23.6
Dongo ruwa	March	26.8	8.9	3.2	9.4	780.4	73.9	212.6	102.4	0.29	28.2
	June	25.4	10.3	4.2	9	782.3	74.3	221.4	110.3	0.23	27.4
	Sept.	32.5	10.9	3.8	7.2	779.2	88.1	241.3	1116.3	0.43	20.71
	Dec.	31.2	9.4	4.6	6.8	781.6	86.2	222.9	1114.6	0.61	2016
Shatai	March	31	13.3	11.3	6.6	1699.2	70.1	213	291.6	0.44	39.3
	June	32	14.5	11	6.5	1673.2	75.1	24.6	275.7	0.47	41.3
	Sept.	30.7	18.5	11.7	6.8	1666.4	84.1	235.3	230.1	0.05	33.3
	Dec.	31.6	17.2	11.2	6.7	1662.4	83.6	240.4	229.3	0.02	30
Bmugada	March	30.4	14.3	7.1	6.7	1440.2	40.1	60.8	1211.3	0.27	21.6
	June	31.2	10.2	7.3	5.2	1441.3	41.1	65.9	1215.1	0.3	22.5
	Sept.	34	10.5	7.7	7.7	1441.4	13.9	80.5	1213.6	2.25	24.1
	Dec.	32.9	9.6	7.7	7.3	1441.6	14.9	73.4	1200.9	0.22	23.6
Saegbe	March	33.2	4.9	13.6	6.9	1021.4	6.4	96.7	788.6	0.06	28.2
	June	30.1	6.4	18.9	6.7	1114.6	8.2	13.3	733.6	0.14	21.6
	Sept.	31.1	3.4	16	6.8	1022.3	6.3	34.6	789.3	0.08	29.5
	Dec.	30.5	7.9	19.1	6.6	1114.3	8	25.3	732.5	0.1	22.5
M/Hasssan	March	30.2	22.3	7.7	6.5	1721.1	19.7	18.9	406.4	0.11	28.9
	June	31.1	20.9	8.7	6.6	1722.3	20.1	18.2	409.2	0.13	29.1
	Sept.	29	22.1	12.7	9	1600	95.3	17	415.7	0.71	22.5
	Dec.	29.6	21.6	14.8	8.4	1646.1	93.4	16.6	411.9	0.21	23.6
K/ Bagu	March	28.4	11.3	12.1	6.6	946	41.6	30.2	633.6	0.22	24.8
	June	27.8	11.4	10.6	6.8	929.4	42.5	30.5	640.1	0.23	21.4
	Sept.	24.2	8.9	5.3	7.1	957.4	55.4	31.2	621.5	0.99	30.2
	Dec.	23.6	9.6	4.8	6.9	994	59.3	31.6	606.4	0.21	26.1
Jikuchi	March	26.2	4.3	4.3	7	21.4	70.4	29.6	1224.6	0.99	27.6
	June	27.6	4.5	4.5	7	20.9	70.8	30.8	1214.7	0.93	25.6
	Sept.	27.9	3.5	0.9	7.1	21.7	71.5	22,5	1330.3	0.65	22.1
	Dec.	28.1	3.2	0.7	7	22.6	71.9	22.4	1329	0.61	22.4

Table 2: Quality of water samples for Boreholes water at different villages

Location	Month	Temp (0C)	Col (Ptco)	Tur (NTU)	Ph	EC (µs/cm)	NO3 (mg/ L)	SO4 (mg/L)	TDS mg/L	PO4 (mg/L)	DO (mg/L)
Jikpan	March	27	3	0.3	6.8	20.6	22	93.8	20.9	0.02	3.6
	June	28.1	2.5	0.1	8.1	22.3	34	100.1	25.1	0.05	4
	Sept.	23	4	0.3	5.7	17.4	50	122	58.4	0.2	6.2
	Dec.	25.3	3.6	0.2	7.4	19.1	74.7	154.8	22.9	0.18	5.1
G/mangoro	March	27.7	5.7	3.17	8.1	534.2	10.3	151.4	235.9	0.03	5.6
	June	29	6.1	3.3	7.8	416.1	10.3	161.3	100.8	0.01	5.9
	Sept.	30	4.5	3.7	8.3	300.4	7.5	141.3	240.1	0.02	4.2
	Dec.	28.9	5.8	3.4	8.5	333.1	7.8	155	238.8	0.1	5.2
Dongo ruwa	March	25.7	3.6	1.4	9.8	343.4	24.2	79.9	39.8	0.08	6.3
	June	27.1	3.9	2	6.9	341.1	23	81.2	300.8	0.1	4.2
	Sept.	23.5	3.2	1.7	7..0	343.2	29.1	85.3	69.3	0.06	6.1
	Dec.	30	3.8	2	7.1	343.9	28.2	83.8	433.6	0.18	4.6
Shatai	March	29.8	5.3	4.9	6.9	747.6	22.9	80.1	113.4	0.13	8.7
	June	28.4	5	4.9	6.4	721.4	25	74.3	97.3	0.1	6
	Sept.	31	6.2	5	7.5	760.1	30	91	114.3	0.12	5.2
	Dec.	30.3	6.9	4.9	7	731.5	27.3	90.4	89.2	0.01	6.7
Bmugada	March	29.2	5.7	3.12	7	633.7	13.1	22.9	471.2	0.08	4.8
	June	31.1	4.5	3.2	8	410.6	10.3	20.8	420	0.06	3.9
	Sept.	28.7	4	3.4	7.4	294.6	8.9	28.7	206.3	0.05	4.6
	Dec.	31.6	3.8	3.39	7.6	234.3	4.9	27.6	467.2	0.06	5.2
Saegbe	March	31.9	2	5.9	7.2	449.4	2.1	36.4	306.8	0.02	6.3
	June	30.1	2.8	4.1	7.6	470.1	2.1	22.9	364.1	0.06	6.1
	Sept.	27.9	3.1	2.9	7.4	497.3	2.4	19.1	240.3	0.04	4.7
	Dec.	28.9	2.6	2.3	7	490.4	2.7	5	285.4	0.04	4.8
M/ Hasssan	March	29	8.9	3.4	6.8	757.3	6.4	7.1	158.1	0.03	6.4
	June	30	8.4	4	6.9	730.2	15.2	6.4	100.1	0.01	5
	Sept.	28.9	8.1	5.2	8.1	741.3	20.6	6	140.5	0.04	4.7
	Dec.	28.4	8.6	6.5	8.7	724.3	30.5	6.2	160.2	0.06	5.2
K/ Bagu	March	27.3	4.5	5.3	6.9	416.2	13.6	11.4	246.5	0.06	5.5
	June	26	4.9	4.1	6.8	400.9	15	11.5	205.5	0.04	5.9
	Sept.	23.4	3.2	3	7	452.3	20.6	11.4	281	0.05	5.5
	Dec.	22.7	3.8	2.1	7.2	437.4	19.4	11.9	235.9	0.06	5.8
Jikuchi	March	25.2	1.7	1.9	7.3	9.4	83	11.1	476.4	0.29	6.1
	June	26	1.3	5.6	7.3	9.1	53	10.4	472.1	0.15	6.5
	Sept.	28	1.9	12	7.4	9.6	42.5	8	500.2	0.17	4.3
	Dec.	27	1.3	11.3	7.3	9.9	23.5	8.4	517	0.18	5

The Electrical Conductivity (EC)

Electrical conductivity is a measure of the water sample's ability to convey electrical current and is related to the concentration of ionized substance in water (i.e. an approximate measure of total inorganic substance concentration in water). The EC values acquired for the wet and dry seasons in the villages were 411,68 µS / cm and 1721 µS / cm respectively for both boreholes and shallow wells and were discovered to be within the designated limits (1000 µS / cm) of (WHO, 2004) and (NSDWQ, 2007). Therefore, it does not pose any health issue and the water can be used for consumption except in villages such as *Popoi* and *Shadna* and part of *Mangoro Hassan.* Where parameters of samples from shallow wells have shown that electrical conductivity is high above the permissible threshold as shown in Figures 3a and 3b. Therefore, it is highly suggested that individuals in these villages should treat the water before it can be used for domestic purposes.

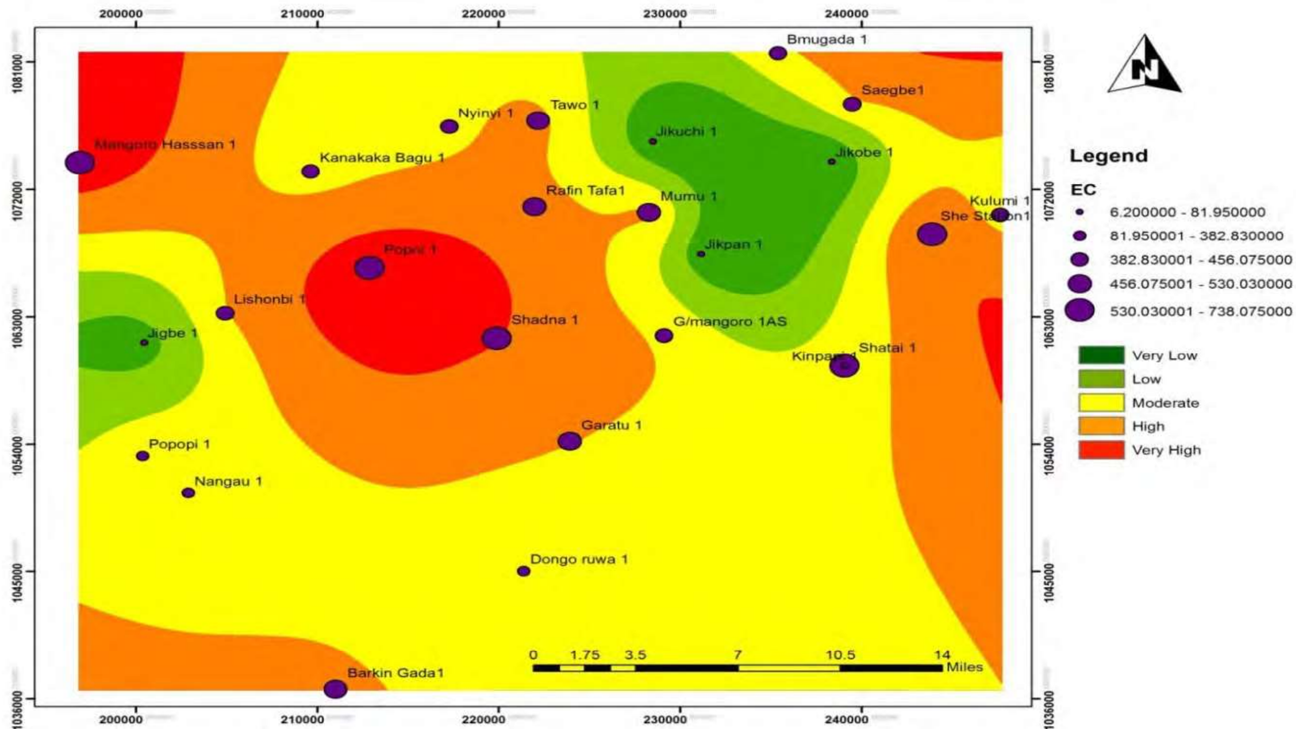


Fig. 3a: Spatial Distribution of Electrical Conductivity (d/S/m) for wet season in Bosso

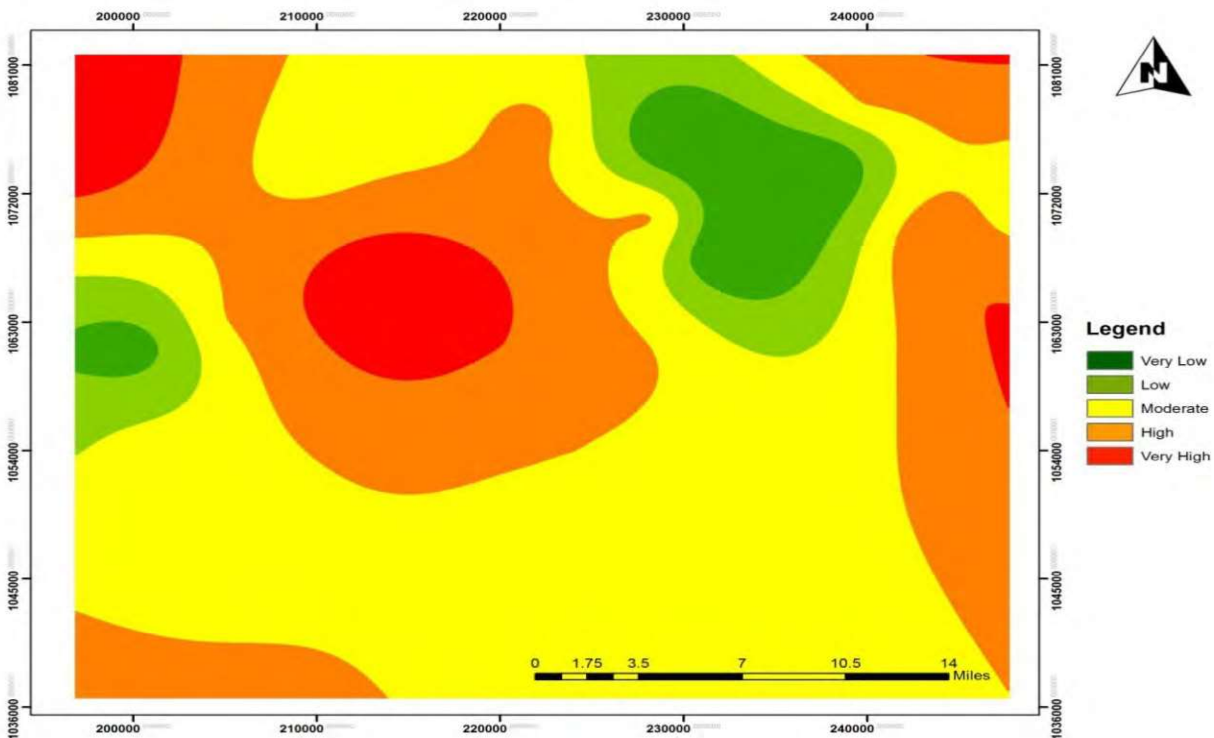


Fig. 3b: Spatial Distribution of Electrical Conductivity (dS/m) for Dry Season

The Turbidity Level

The water quality is determined on the basis of the turbidity value. As acquired, the turbidity values varied from 4.04 to 8.38 NTU for both borehole and shallow well and are within the recommendation limit of WHO (2004) and NSDWQ (2007). The places where water was gathered and turbidity level are as shown in Figure 4.

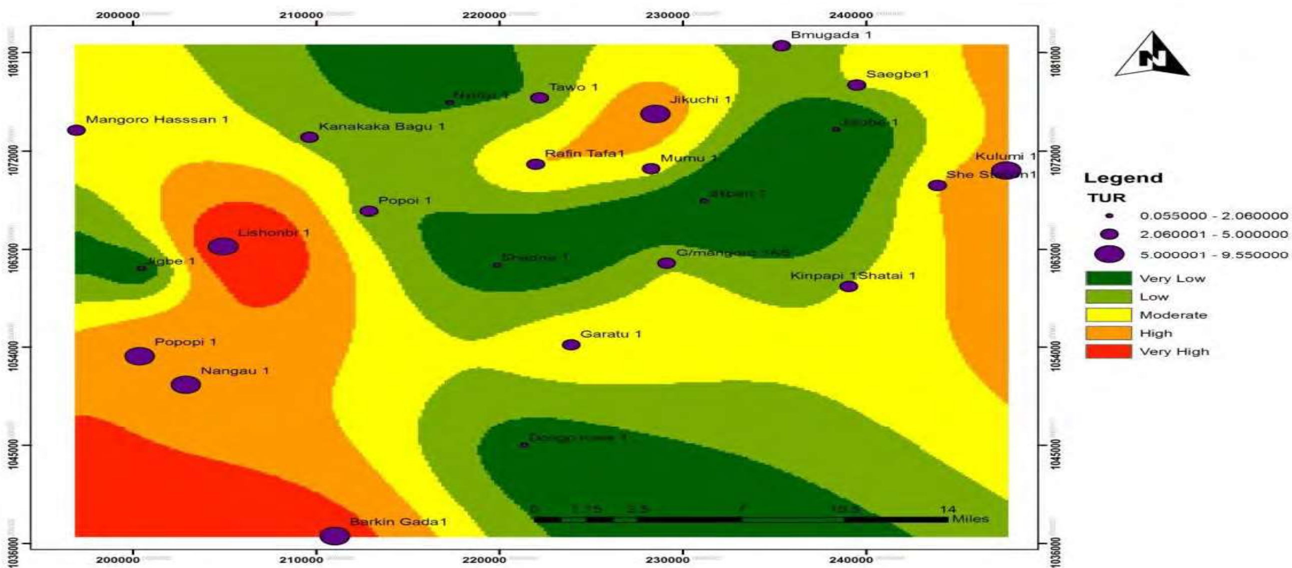


Fig. 4: Spatial distribution of Turbidity(mg/l) in Bosso LGA

Total dissolved solid (TDS)

It is an established fact that it is crucial to classify groundwater based on their TDS in order to determine the suitability of groundwater for drinking purposes. The concentration of total dissolved solid in the villages ranged from 274.75mg / l to 690.00 mg / l with a mean 274.75 mg / l. While the shallow well water's TDS value exceeds the permissible limit of 500 mg / l (a standard set by WHO), that of the boreholes is within the desirable limit. TDS above desired limit may trigger irritation of the gastrointestinal tract. Higher concentration of these can influence individuals suffering from illnesses linked to the kidney and heart. Figure 5 presents the spatial distribution map of TDS.

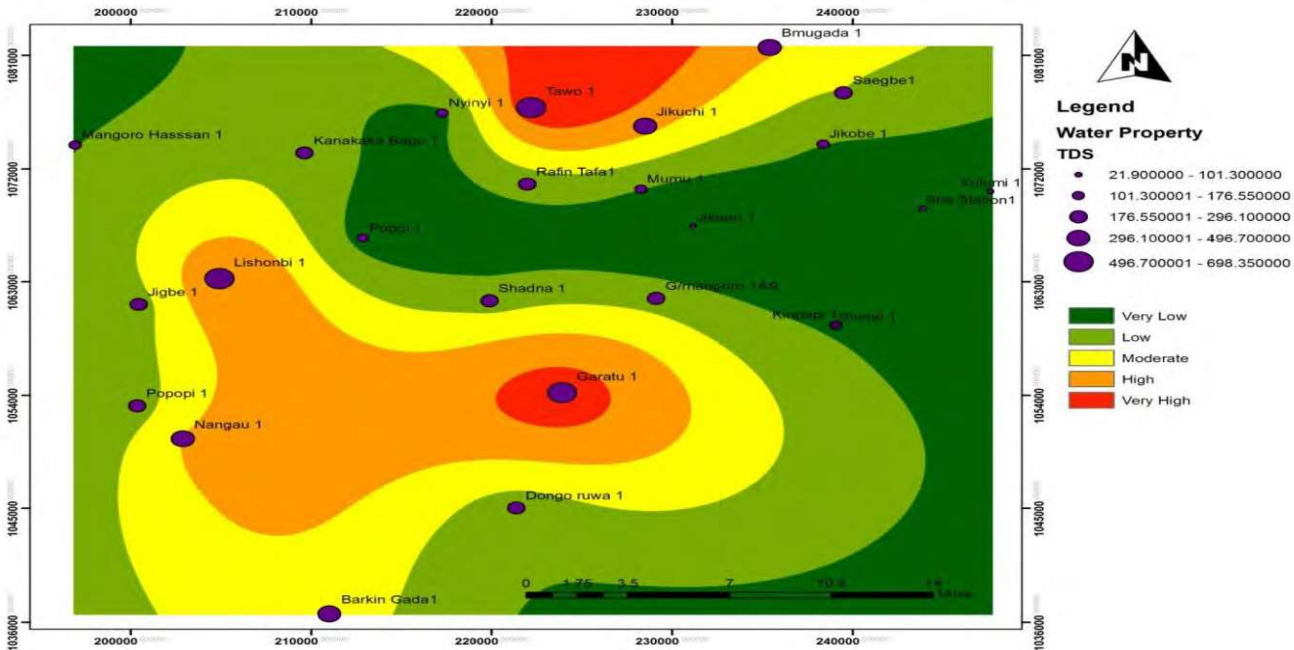


Fig. 5 Spatial distribution of TDS (mg/l) in Bosso LGA

The Presence of Nitrates

Nitrates are the end result of organic nitrogen aerobic stability; and a product of nitrogen transformation. This phenomenon mostly happens in contaminated water. As a consequence of water specimens from shallow wells in the study region, the nitrate values were noted, in particular, in places such as *Dongo Ruwa, Shatai, Mangoro Hassan, Jikuchi, Jikobe, Garatu, Taiwo*, Station, *Lishonble* and *Kulumi,* the threshold of 50 mg / l is slightly higher. While only those samples from *Jikuchi* and *Mumum* communities are slightly greater than the maximum permissible limit for the samples collected from boreholes. Without adequate treatment, such water is not fit for human and animal consumption. Because literature has shown that greater levels of nitrate in drinking water cause methemoglobinaemia (blue-baby syndrome), stomach cancer, metabolic disease, and poisoning of livestock. Figure 6 shows the spatial nitrate distribution map for the selected villages.

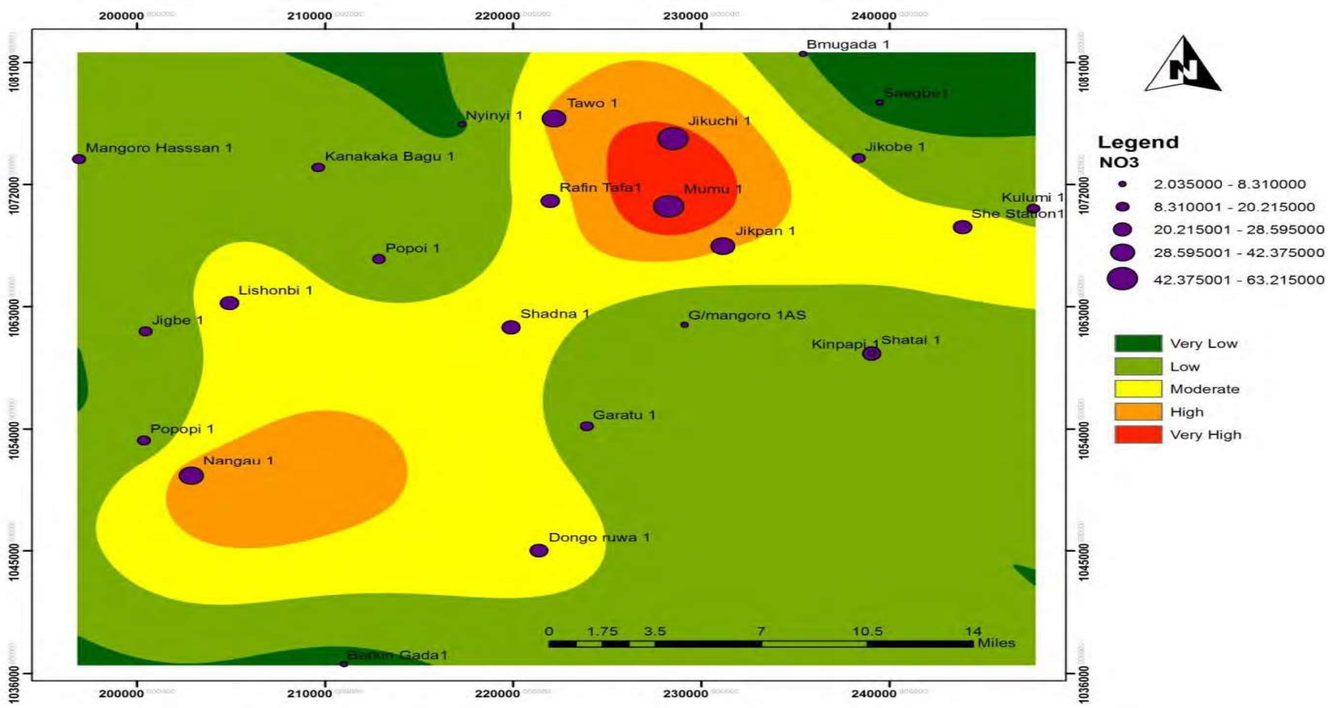


Fig. 6: The spatial distribution of nitrates in Bosso LGA

Coliform Bacteria

Total coliforms are regarded as "indicator" organisms, meaning their existence is an indication that the water body may also have other diseases causing organisms. The coliform assessment of borehole and shallow well water showed that in the dry season, the coliform count are respectively 0.19 and 1.55 cfu/100ml. While the number of coliforms for shallow well water samples and borehole during the rainy season is 1.91 and 0.19 cfu/100ml. The outcome, however, showed that coliform concentration in *Jikpan, Tawo, She* station, *Lishonbi, Nyniyi*, and *Bakin Gada* water samples is greater than the permissible threshold as shown in Figure 7. It will undoubtedly cause health-related issues for those who drink such water.

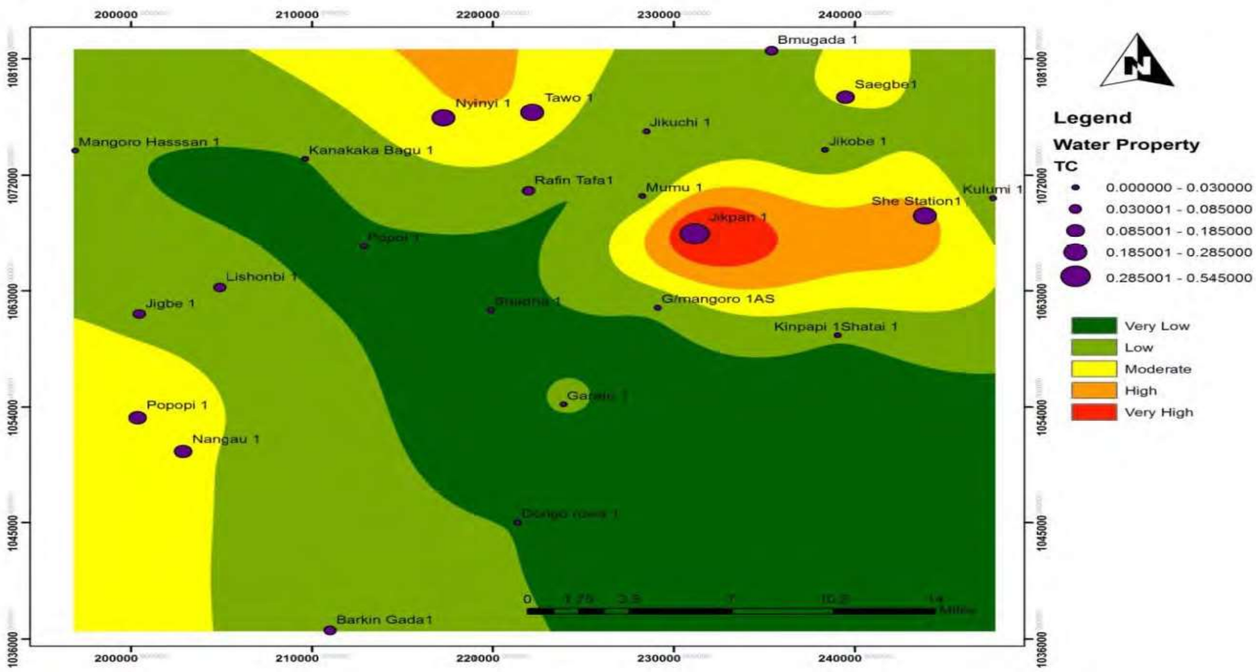
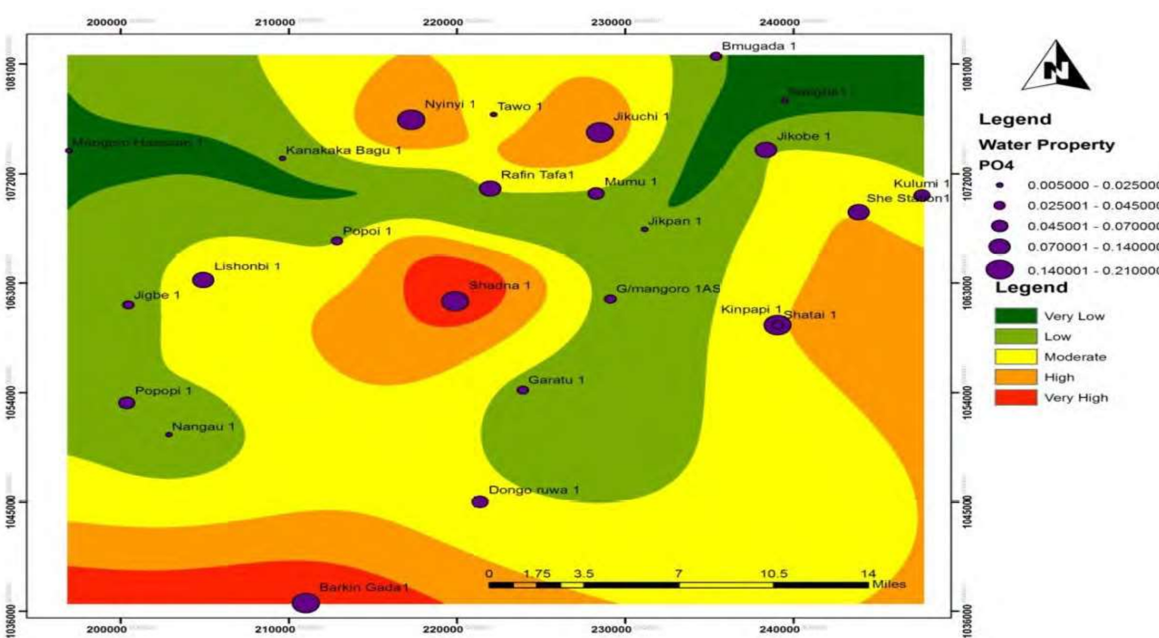


Fig. 7: Spatial distribution of coliform in Bosso LGA

The Presence of phosphates

Phosphate is a significant water parameter that adversely affects digestive issues when it presents at elevated concentrations. The existence of phosphates in water has more impact on surface water than groundwater since most phosphate pollution issues eutrophication and algae bloom. Phosphates as small as 15 mg / l in groundwater have been recorded to considerably increase microbial development in water. The phosphate concentration obtained in the water samples ranged from 0 to 1.9 mg / l, with samples from shallow wells in the *Shadan* getting the largest mean concentration of 1.9 mg / l, whereas the average borehole well value is 0.55 mg / l, which is within the permissible limit. The phosphate spatial map is shown in Figure 8.



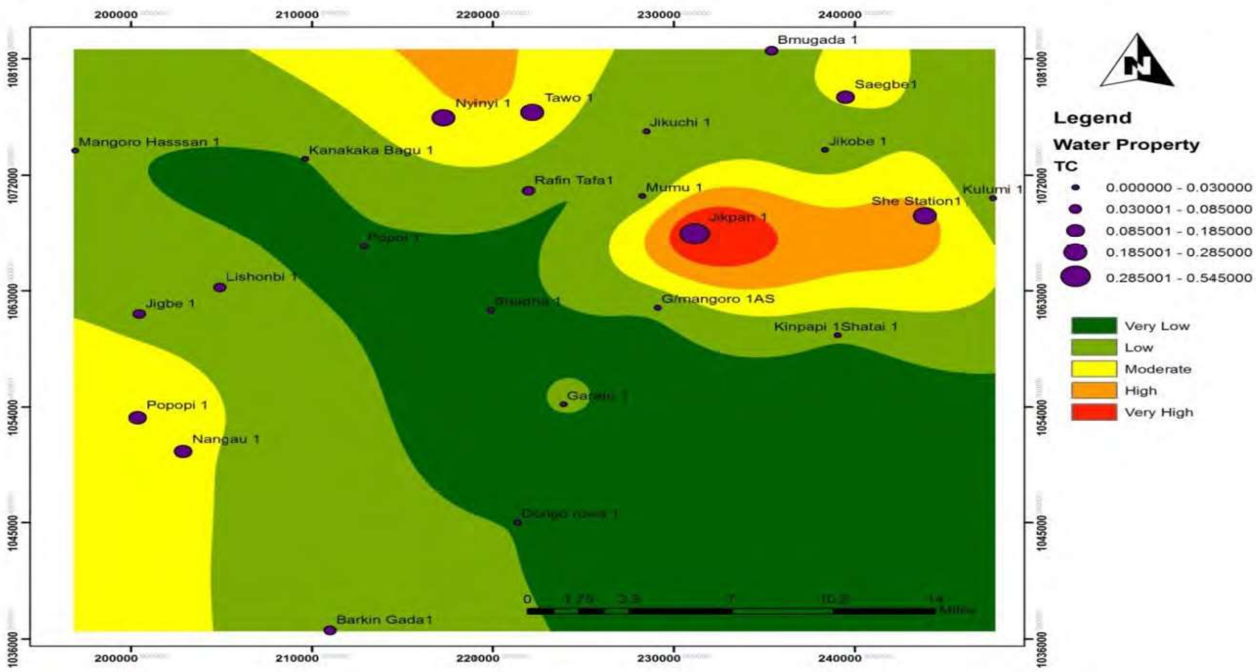


Fig. 7: Spatial distribution of coliform in Bosso LGA

The Presence of phosphates

Phosphate is a significant water parameter that adversely affects digestive issues when it presents at elevated concentrations. The existence of phosphates in water has more impact on surface water than groundwater since most phosphate pollution issues eutrophication and algae bloom. Phosphates as small as 15 mg / l in groundwater have been recorded to considerably increase microbial development in water. The phosphate concentration obtained in the water samples ranged from 0 to 1.9 mg / l, with samples from shallow wells in the *Shadan* getting the largest mean concentration of 1.9 mg / l, whereas the average borehole well value is 0.55 mg / l, which is within the permissible limit. The phosphate spatial map is shown in Figure 8.

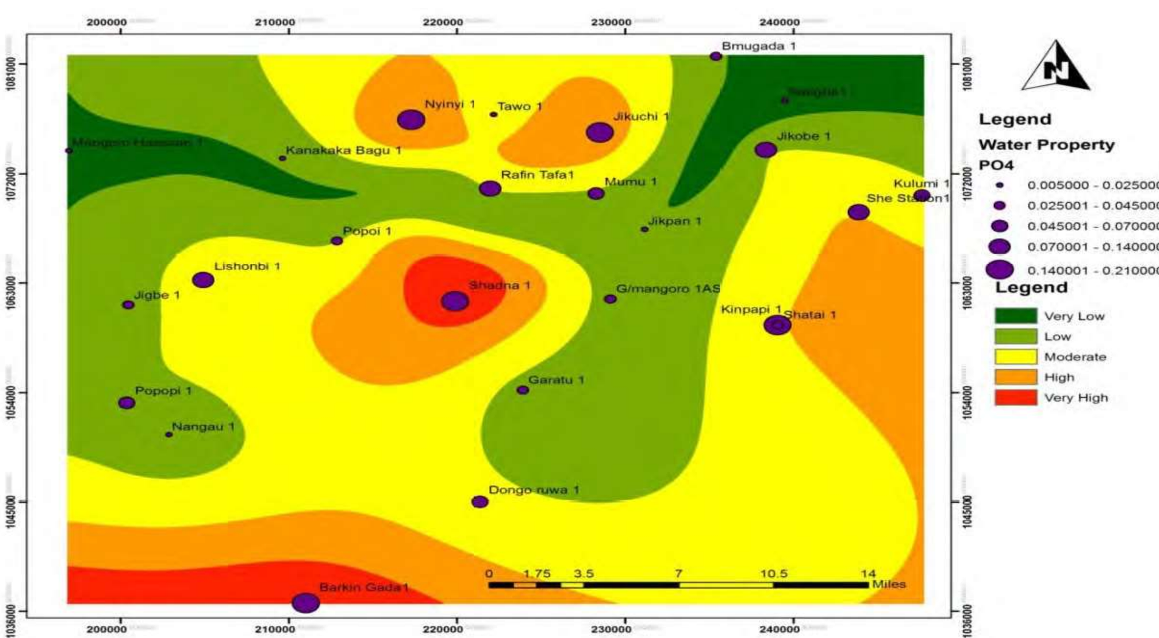


Fig. 8: Spatial distribution map of phosphate in Bosso LGA

4 CONCLUSION AND RECOMMENDATIONS

This research focused on determining groundwater quality of 25 communities in Niger State's Bosso Local Government Area, as well as generating spatial distribution maps of drinking water quality parameters (EC, TDS, NO3, PO4, and TC) for the villages. It was discovered that in some villages / communities shallow well water fell short of WHO and NSDWQ limits in terms of physico-chemical and bacteriological characteristics compared to boreholes water samples in the region. Spatial maps showing provided which showed different parameters, places and intensities will create data accessible to government agencies, non-governmental organizations and other stakeholders who may be prepared to help communities. Pit latrines, fast urbanization and indiscriminate deposition of domestic waste can be ascribed to the bad state of the shallow wells due to their proximity. It was also found that seasonal variations are significant factors in parameter spatiality. It is suggested on the basis of the above that:

• Shallow wells and some water boreholes in the area should be treated before use for human and animal consumption, most notably those communities that have parameters concentration exceeding the permissible limit recommended by the WHO and NSWQS for certain water quality parameters.

• Site(s) should be properly surveyed when fresh wells and boreholes are to be constructed in order to prevent drilling or digging in an abandoned dumping region.

• In relation to their shallow wells, villagers should also be informed about the environmentally friendly culture of siting pit latrines and septic tanks.

• More research should be done on possible presence of heavy metals in drinking water, perhaps owing to unseen underground activities.

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