The Effects of Land Use Pattern on Groundwater Quality in Hadejia-Jama'are-Komadugu-Yobe Basin (HJKYB), Nigeria

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Abstract

The study evaluates the nature of land use pattern in Hadejia-Jama'are-Komadugu-Yobe Basin and its impact on quality of groundwater within the area. Satellite imageries of 1988, 2002 and 2018 of the study area were used to generate the land use / land cover (LULC) maps, and to understand the chemistry of groundwater; groundwater samples were collected and analysed. The study approach employed the use of descriptive and multivariate statistical tools. The results of descriptive statistical analysis indicate high mean concentration is observed for Electrical conductivity (322.1 µs/cm), HCO_3^- (221.09mg/l) and TDS (154.32 mg/l). The low mean concentration is found to be (-3.03mg/l) and (0mg/l), for Mo and Ni respectively. Based on the Eigen value-one criterion, eleven (11) components were chosen after Varimax rotation. The first Varimax factor (VF1) contained strong factor loading on Pb, Mo, Cd and Ni which account for 15.404% variance of the water quality data. The 2nd Varimax factor (VF2) has strong loading on electrical conductivity (EC), total dissolved solid (TDS), Cl and temperature, with a variance of 14.068%. The 11 Varimax factors explained 81.91% of the variability of the water quality data. The strong loading for Pb, Mo and Cd could be due to industrial effluents. While high loading for EC, TDS and Cl could be due to salinity build-up process in the area, as a result of the intensive agricultural activities. These suggest that anthropogenic factors, from industrial effluents and agricultural practices may have affected the concentration of these parameters. In addition to natural process, built up land and cropland are the anthropogenic processes controlling groundwater quality in the study area. Therefore, there is need to appropriately control the indiscriminate discharge of pollutants and regulate the use of agrochemicals in the area.

Keywords: Hadejia-Jama'are-Komadugu-Yobe Basin, land use, groundwater quality, statistics, pollutants, agrochemicals, heavy metals

INTRODUCTION

Land uses affect groundwater resources through different means of recharge and demands for water. Stephen and Jan (2014) have observed that significant changes in land use that affect groundwater are taking place, due to population growth, food demands and increased biofuel cultivation. Over the last few decades, the changes in land use is believed to be occurring locally, regionally, and globally, and is expected to carry on in the future (Mishra *et. al.*, 2014). Lack of proper land use, especially inappropriate land management, leads to many groundwater quality problems. Emergent groundwater quality problems are very common and may emerge from unsuitable land use and control (David and

Robert, 2009). The usage and management of landscapes may have impacts on water quantity and water quality due to the effects of agriculture, forestry, urbanization, and industrialization on the landscape.

Groundwater quality deterioration is an environmental problem in many developing countries, Nigeria inclusive. During the past decades, there has been an increase in the growth of the human population in the urban cities of developing countries, with a concomitant increase in the number of industries and intensive agricultural activities (Mustapha *et al*., 2019). Rapid development and urban growth augment its utilization, diminish availability, and enhance vulnerability to contaminate the quality (Das, 2009).

The Hadejia-Jama'are-Komadugu-Yobe Basin (HJKYB) is one of the most important basins in Nigeria, as a result of its socioeconomic and environmental importance. The major Rivers especially Hadejia and Jamaare are believed to carry along industrial effluents and agrochemicals mostly from the upstream to downstream part of the area. In the upstream parts of the area, for example Kano City; untreated or poorly treated effluents, due to industrial activities, particularly from the tannery, textile, pharmaceuticals, plastic, and paints industries, are being discharged into drainage and river channels such as the River Challawa, that joins River Kano and forms part of the river system flowing into the River Hadejia. The discharge of these effluents into water bodies from upstream without proper treatment can constitute great risk to water resources downstream of the basin. Farmers excessively use agrochemicals in order to increase yields of their crops, which may eventually be transported by runoff and are percolated into groundwater.

According to Dogara *et. al*., (2007) HJKYB provides supports to a population of several million people that rely on the rivers for their many activities, including domestic supplies, irrigation, rearing of animals and industrial activities, among others. It has been observed that, over many years, many factors have led to severe deterioration of the land and water resources in the area. These factors include but are not limited to rapid increases in population and urbanization, among others. The by-products of the industrialization, urbanization, and intensive agriculture, all of which go hand in hand with derive to develop, result in a deterioration of the environment (Doody, 2000). Apart from triggering groundwater quality problems in the area; inappropriate land use may lead to soil erosion, salinization, and desertification, among others.

Degradation of soil and water from agriculture occur due to residues of used chemicals (Agnieszka, 2018). The discharge of agricultural, domestic, and industrial effluents, into water channels, are believed to be aggravating the water quality problems in the study area, as observed in areas around Hadejia and Nguru, because of widespread kidney and other renal problems being experienced by the inhabitants of the areas. The prevalence of kidney disease has been traced to possible contamination of water sources due to the large-scale use of agrochemicals to improve agricultural production and pollutants from other sources upstream and within the wetlands area (Ahmed *et al*., 2018).

Aim and Objectives of the Research

The aim of this work is to provide an evaluation of the land use pattern in the Hadejia-Jamaare-Komadugu-Yobe Basin and its impact on the quality and condition of the groundwater of the area. The specific objectives include the following:

1. Assessment of land-use changes in relation to impacts on groundwater quality.
2. To determine the concentration of the physicochemical parameters of water.
3. To observe relationship between the groundwater and different factors like geology, soil, and drainage.

Study Area

The Hadejia-Jama'are-Komadugu-Yobe Basin is located within the Sudan-Sahel-Guinea vegetation zones of northern Nigeria, covering parts of Kano, Jigawa, Bauchi, Yobe, Plateau and Borno States (Fig. 1). It is bounded by latitudes10°00′N-13°00′N and longitudes 07°25′-11°00′E. According to Water Resources Engineering and Construction Agency (WRECA) (1972) the catchment area is approximately 84,138 km^{2}.

The geology of HJKYB has been widely reported in many publications. The area is underlain by rocks of Basement Complex, Chad Formation and Younger Granites. The Basement Complex rocks are of Precambrian age and can be found in the western, southern, and south eastern parts of the study area (Fig. 2). The rocks of the Basement Complex consist of migmatite-gneiss, schists, and granites of the Pan-African (600±150 Ma) and older. According to Obaje (2009), the Basement Complex rocks are found to be intruded by the Younger Granites of the Jurassic age and calc-alkaline in composition. They are unconformably overlain by Cretaceous and younger sediments.

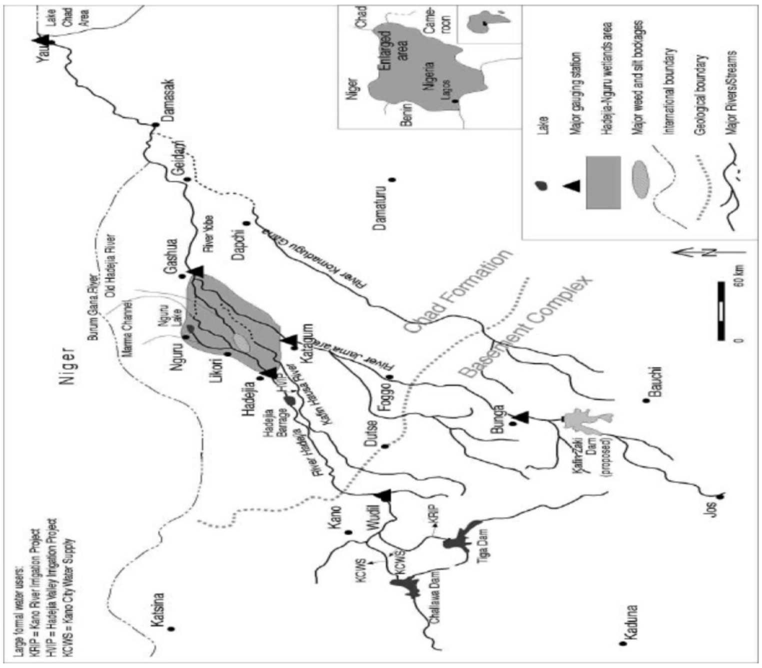

Figure 1: Catchment Map of the Study Area (After Goes, 2002)

The Chad Formation is found at the north and north eastern parts of the area. They consist of fine to coarse grained sand, with intercalation of sandy clay and clay. The dunes in the middle part of the basin and alluvial deposits along the river systems are superficial deposits, occurring as parallel ridges extending northeast-southwest for several kilometres and as high as 15 m – 20 m.

A hydrogeological divide separates the two geologic domains.

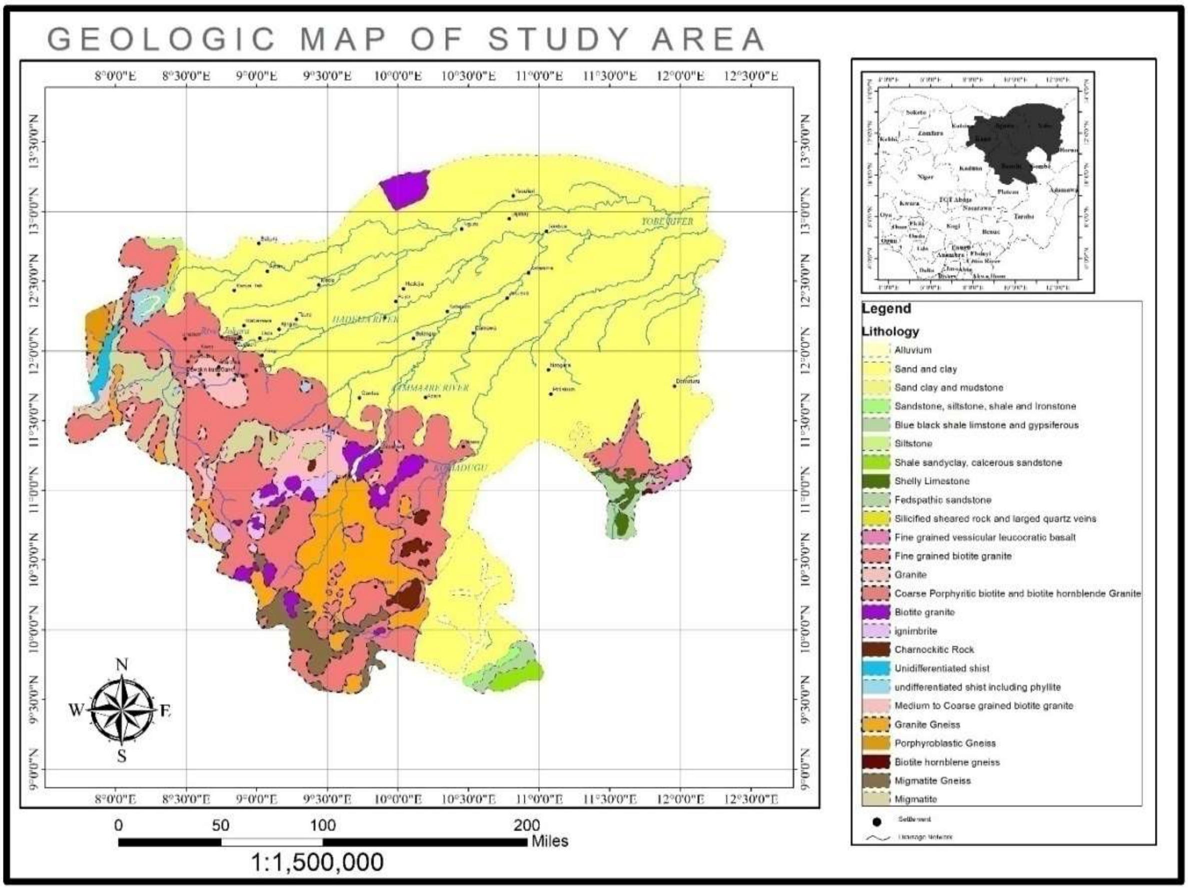

Figure 2: Geological map of parts of the study area (Modified from the Nigerian Geological Survey Agency, 1994).

MATERIALS AND METHODS

Satellite imageries of 1988, 2002 and 2018 of the study area were used to generate the Land use / land cover (LULC).The landsat images were downloaded from United States Geological Survey (USGS) Earth Explorer. Satellite image pretreatment was done by spatial enhancement based on the number of pixels.

To assess the chemistry of groundwater in the study area; 81 groundwater samples were collected in clean 120 ml sampling polyethylene bottles. At each sampling point, the bottle was properly rinsed with distilled water and with the water to be sampled. In situ measurements of pH, temperature, TDS, and conductivity were done using conductivity meter Hanna HI 9811-5. These allowed a quick assessment of water quality at the sampling points. At each sampling point, one sampling bottle was used for sampling anion, while another bottle used for cation, addition of 2 drops concentrated HNO_3 acid to maintain a pH of less than 2.0 as described by Deb *et. al*., (2008). The acidification was to prevent adsorption of ions on the wall of the sampling bottle and to prevent bacterial activities. Upon proper collection and packaging, the samples were taken to Centre for Dry land Agriculture, Bayero University, Kano, and Pollution Control Laboratory for analysis of cations and anions, respectively. All analysis of cations was carried out using Agilent 4210 MP-AES.

Descriptive and multivariate statistical analyses of the water quality parameters were done in order to understand their grouping, similarities, and characteristics. These were done using SPSS Software Package and Minitab software for Principal Component Analysis and Cluster Analysis respectively.

RESULTS AND DISCUSSION

Assessment of Land use Land covering the study area

In the analysis of land use land cover conducted, using data from Landsat 5, ETM+ and Landsat 8; five (5) types of land use classes were identified in the period of 1988, 2002 and 2018 in the study area, as shown in Figs. 3,5 and 7. These land use classes are; Crop land, Grass land, Tree cover, Built up land and Water body. The percentage of land use for the area during the period is shown in Figs. 4, 6 and 8, indicating crop land and grass land having greater percentages.

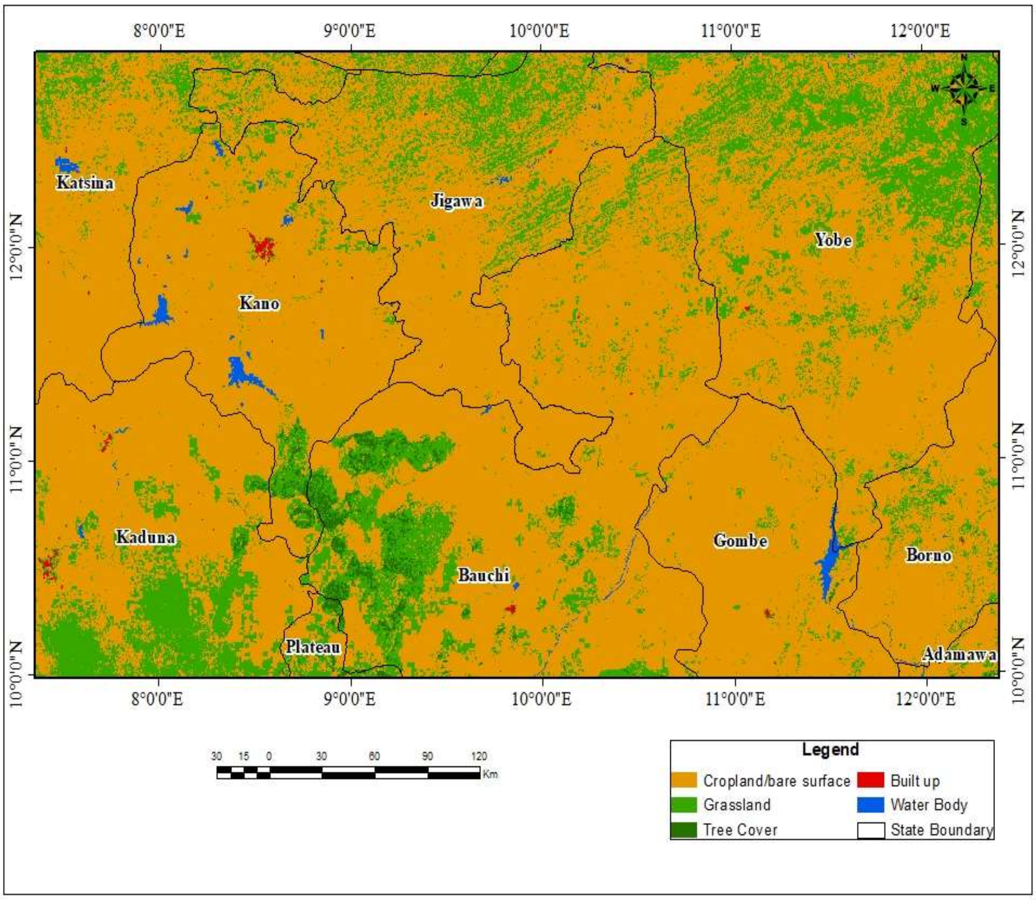

Figure 3: Land Use /Land Cover Map of the Study Area (1988)

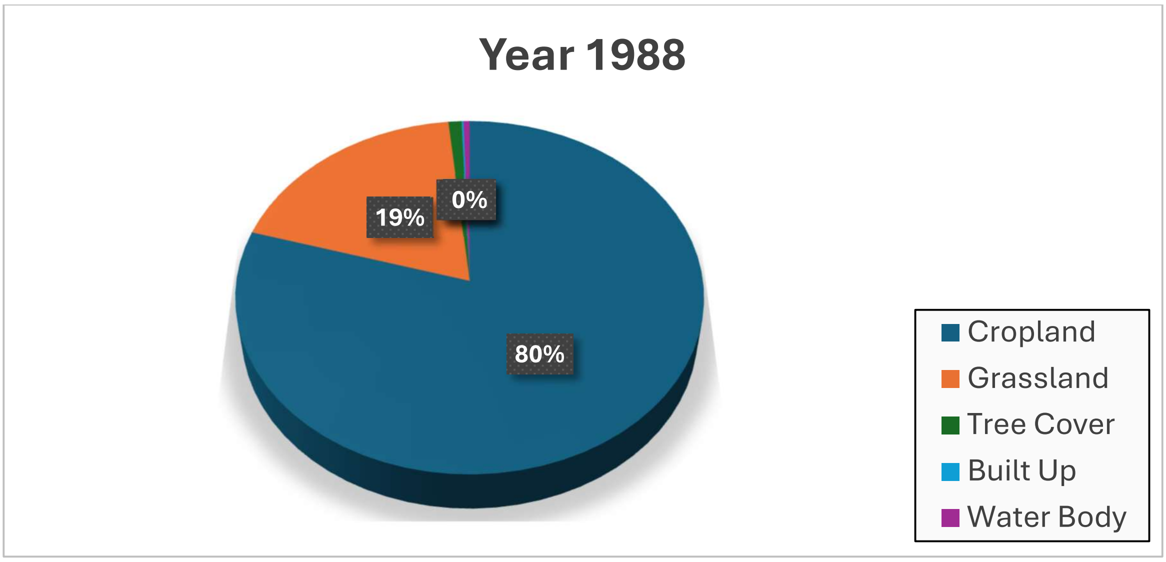

Figure 4: Land use chart for the year 1988

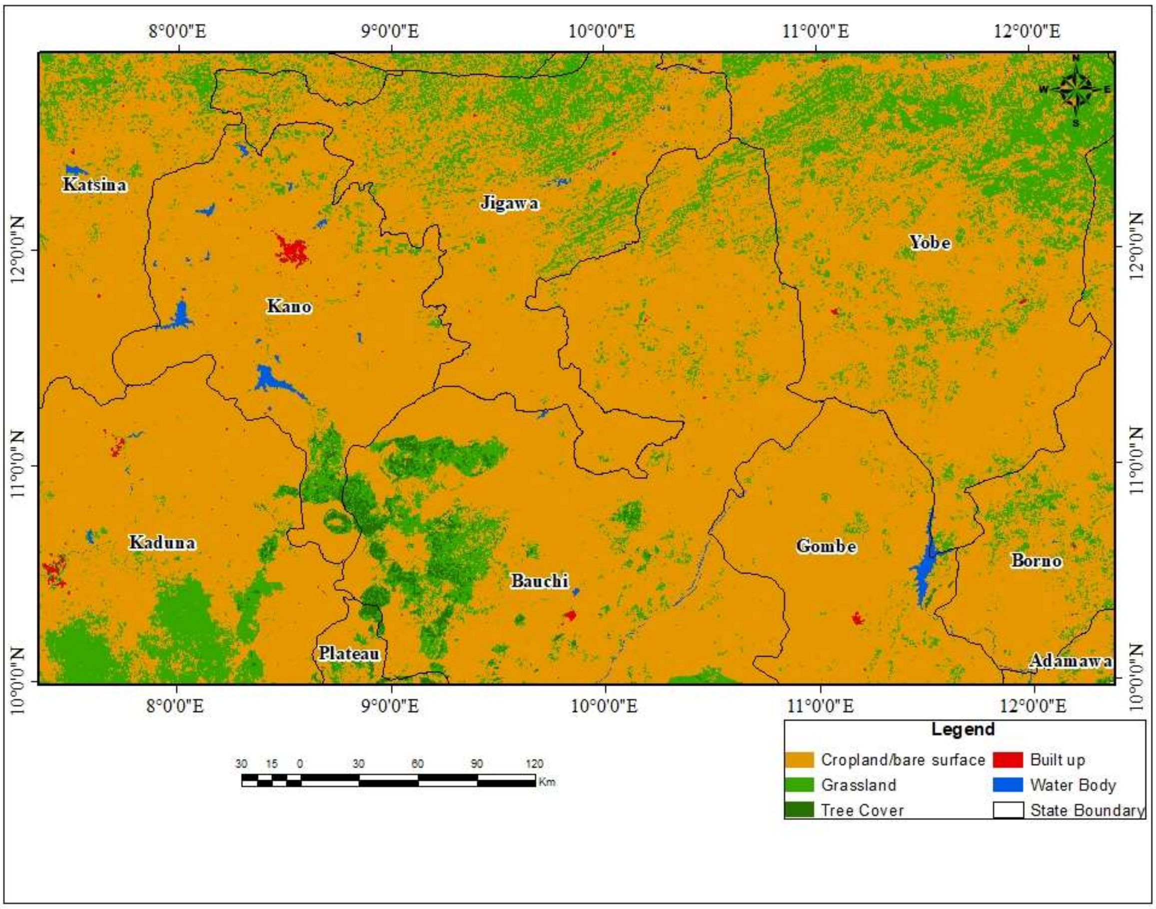

Figure 5: Land Use / Land Cover Map of the Study Area (2002)

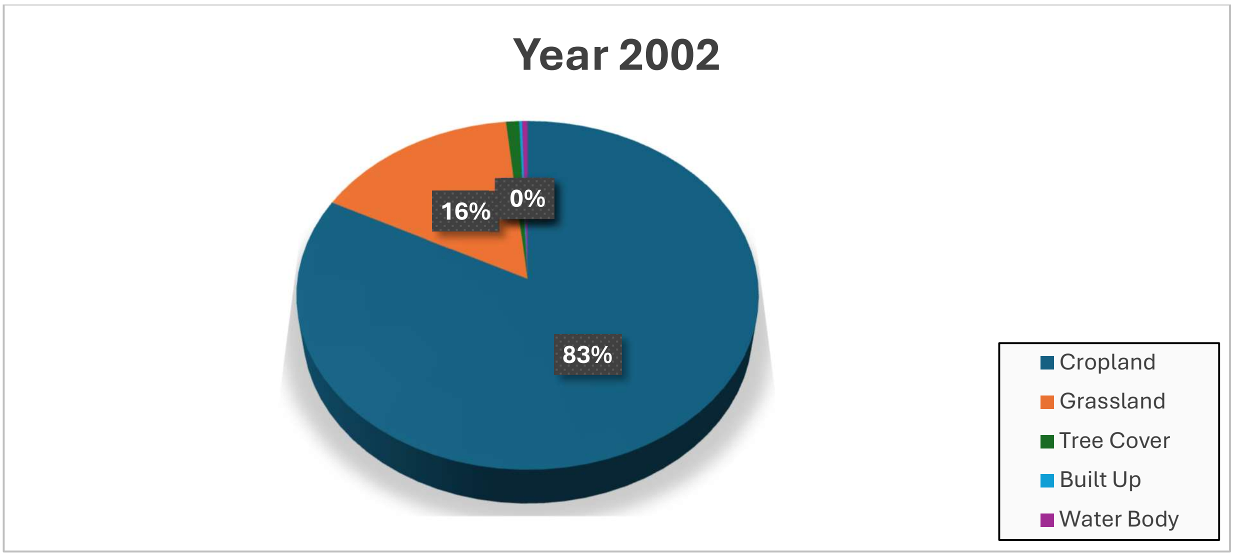

Figure 6: Land use chart for the year 2002

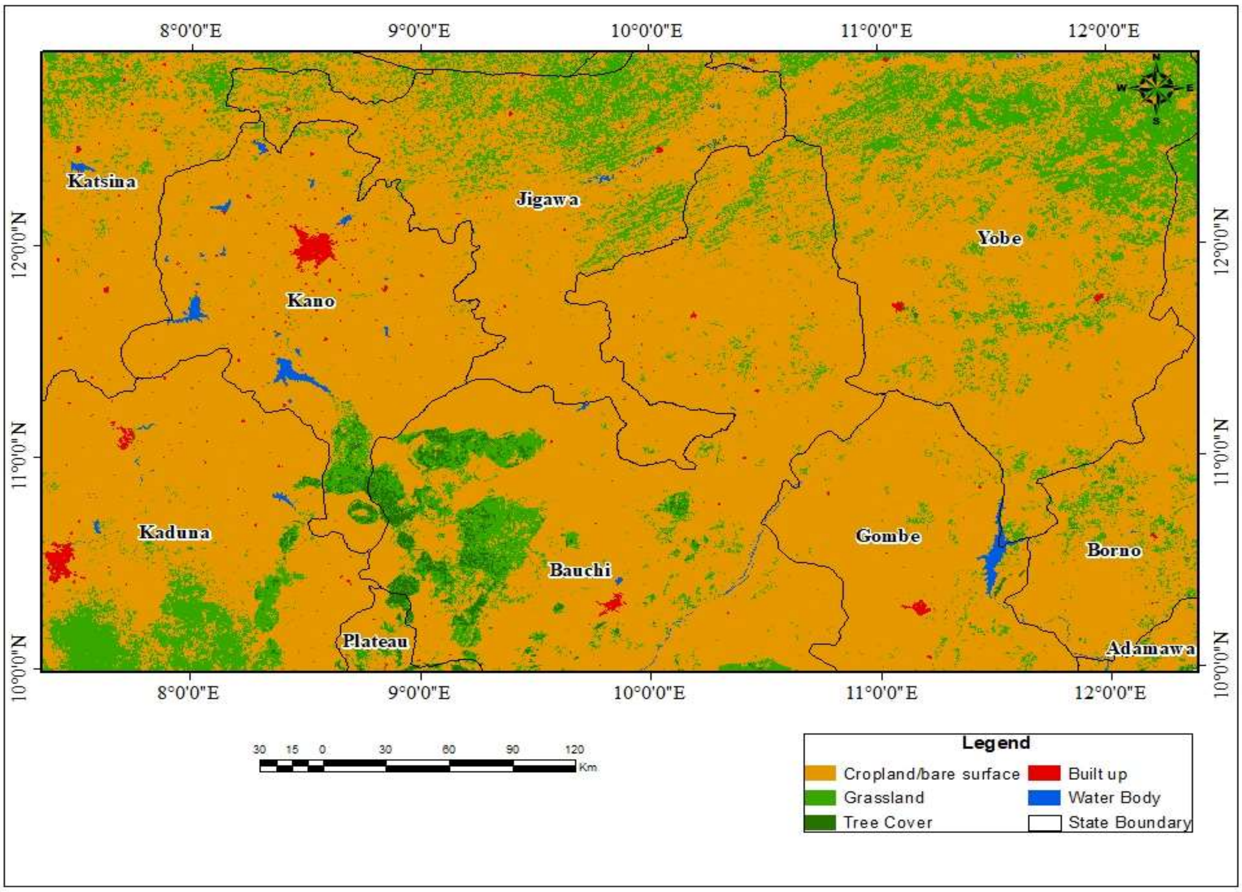

Figure 7: Land Use/Land Cover Map of the Study Area (2018)

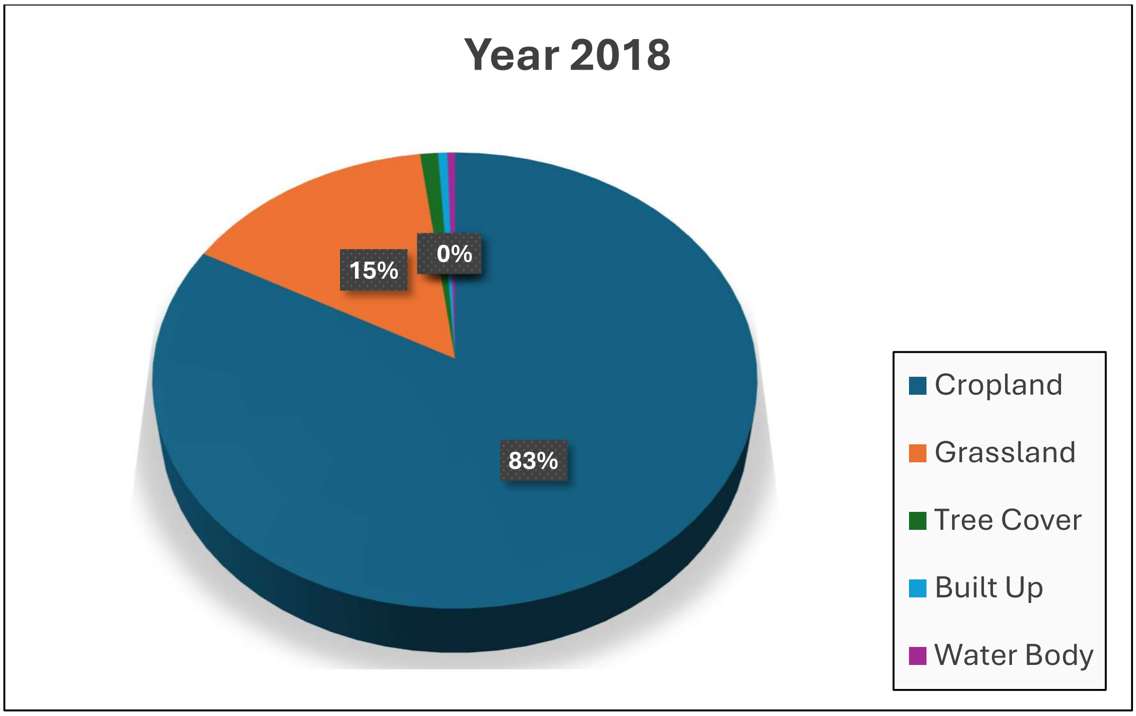

Figure 8: Land use chart for the year 2018

The study shows that cropland increased significantly from 1988 to 2018 as shown in Fig. 9, while grass land decreased in the same period (Fig. 10). These are primarily due to intensive agricultural activities and the need for feeding the increasing population of the study area.

Built up land increased tremendously in the area during the period of 1988 to 2018 (Fig. 12), which can be directly related to increasing population, to satisfy needs for food, shelter, and other infrastructural developments.

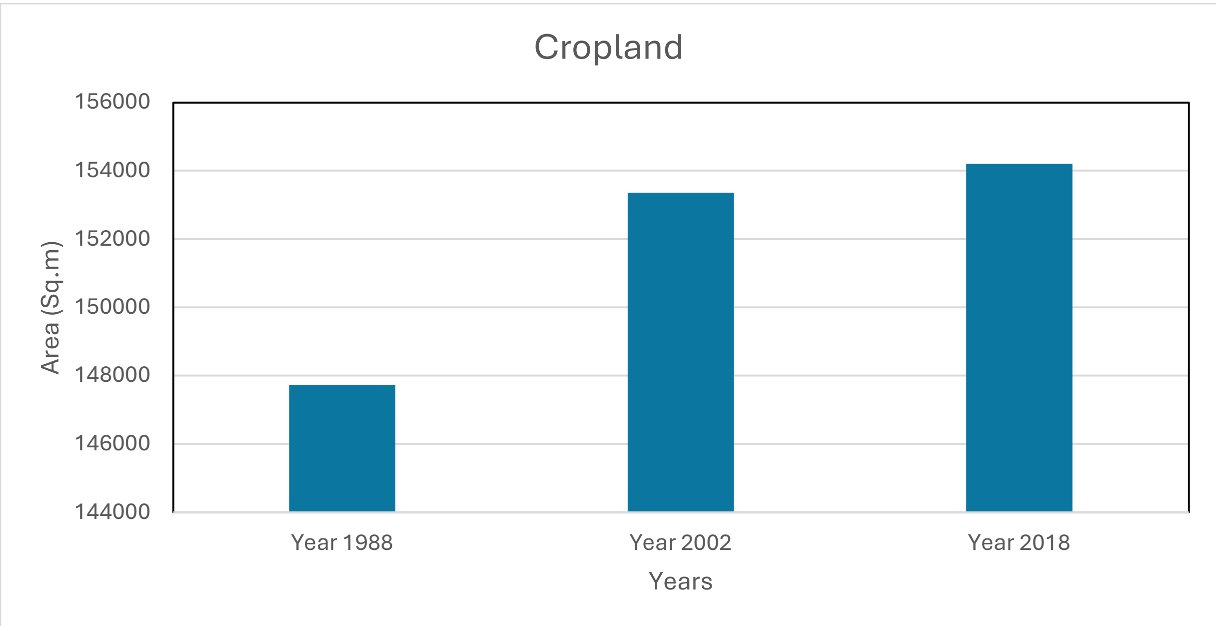

Figure 9: Changes in Cropland from year 1988-2018

Figure 10: Changes in Grass land from year 1988-2018

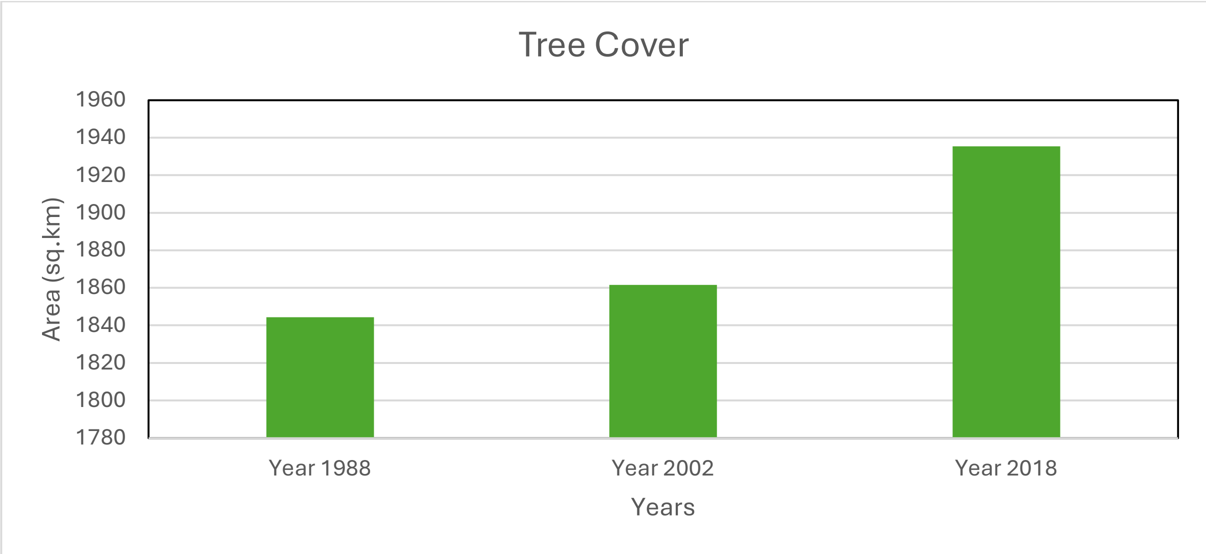

Figure 11: Changes in Tree cover from year 1988-2018

Tree cover increased significantly in the period of 1988 to 2018 (Fig. 11), due to various afforestation programmes been supported by States and Federal Ministries of Environments and Funds from Donor Agencies.

The water body (Fig. 13) decreased significantly from 1988 to 2002, partly due to poor reservoir operations and wasteful discharge of water, owing to activities like Kano City Water Supply, Hadejia Valley Irrigation Project, and Kano Valley Irrigation Project, among others. Another reason is siltation of some reservoirs and their channels. The increase in the amount of water body from 2002 to 2018 can be due to climatic change being experienced and dredging of some of the reservoirs after the flooding of 2003 within the study area, that affected mostly Kano and Jigawa States, causing loss of lives and property.

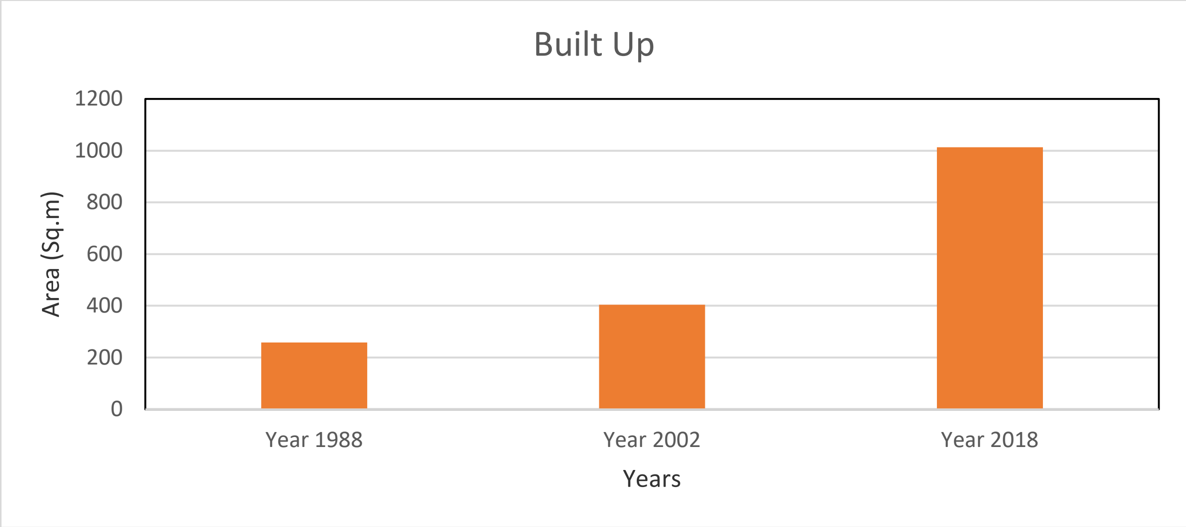

Figure 12: Changes in Built up land from year 1988-2018

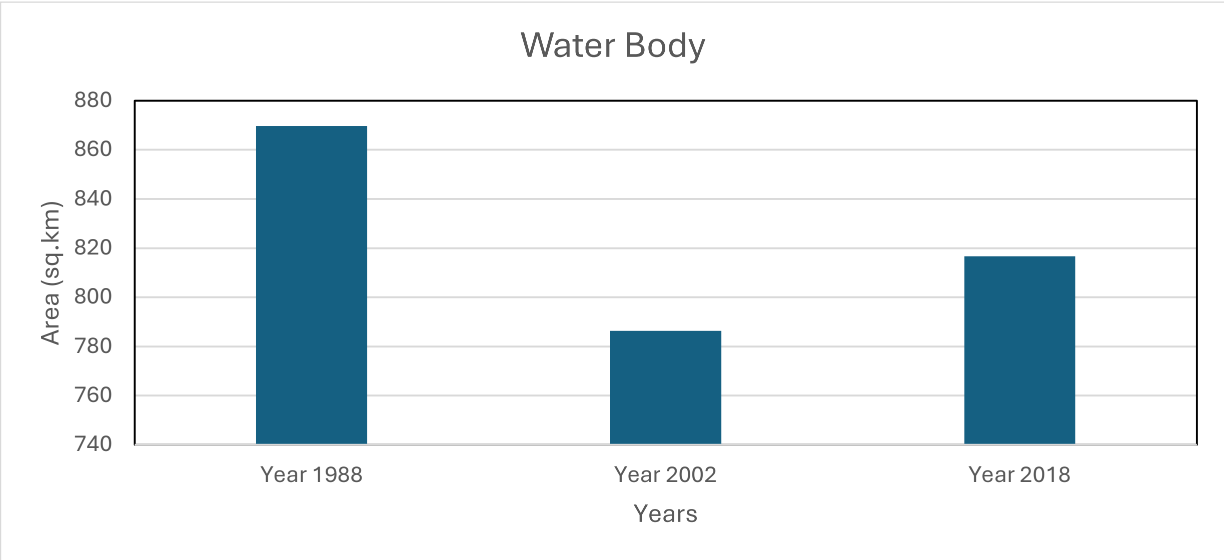

Figure 13: Changes in Water body from year 1988-2018

Groundwater Quality Assessment

The results of data generated for Groundwater Quality Assessment of the study area, conducted with a view of identifying different classes of the water, concentration of different parameters as well as the suitability of water for irrigation.

Descriptive Statistics of Water Parameters

The results of groundwater quality analysis of twenty-nine (29) groundwater quality parameters from the study area alongside their minimum, maximum, mean, and other relevant statistical distribution parameters are presented in Tables 1, 2 and 3. Electrical conductivity has the highest mean concentration, having (322.1 µs/cm), HCO_3^- (221.09mg/l) and TDS (154.32 mg/l). The low mean concentration is observed to be 0mg/l for Ni.

Table 1. Comparison of physical water parameters and relevant standards

Parameters	Min.	Max.	Mean	WHO Standard (2017) Guideline Value	Samples within Permissible limits (%)	Non-Permissible Limits (%)	Remark
pH	5.7	9.1	7.94	6.5-8.5	76.54	24.69	
Temperature	23.7	40.2	33.11	30° C	13.58 (Ambient)	86.42	30° C is the ambient condition
TDS	20	2050	154.32	1000mg/l	97.53	2.47	NG7(Aura1) 2050mg/l and NG8 (Aura 2) 1550mg/l
EC	60	4090	322.1	1480 µS/cm	97.53	2.47	• WHO (2004) MPL • NG7(Aura1) 4090 µs/cm and NG8 (Aura 2) 3100µS/cm

The pH has value ranging from 5.7 to 9.1 with a mean value of 7.94. 76.54% of pH have values within the permissible limit of WHO (2011) of 6.5-8.5. 22.22% have values less than the permissible limit and are slightly acidic; while 2.47% have values above the permissible limit and are alkaline, these locations are NG7 (Aura 1) and NG8 (Aura 2) with pH of 9.1 and 8.9 respectively. The high concentration of some metals in many locations in the study area could as well be related to the low pH. The metals may have leached from the rocks and sediments. However, additional anthropogenic process may have contributed.

Table 2: Comparison of chemical water parameters and relevant standards

Parameters	Min.	Max.	Mean	WHO Standard (2017) Guideline Value	Samples within permissible limits (%)	Non-Permissible limits (%)	Remark
NO_3	0	2.46	0.33	50mg/l	100	0	
NO_2	0	1.85	0.21	3mg/l	100	0	
NH_4	0	1.5	0.08	35mg/l	100	0	
SO_4	2	200	30.34	250mg/l	100	0	
Cl	0	96	11.57	250mg/l	100	0	
HCO_3	0	561.2	221.09	1000mg/l	100	0	WHO (2004) MPL
P	-1.76	9.87	3.47	NR	NA	NA	
S	-8.64	13.54	3.49	NR	NA	NA	
Se	-0.01	4.3	0.16	0.04mg/l	17.28	82.72	
Zn^{2+}	0.02	5.9	0.4	5mg/l	100	0	
Cd	0.18	71.74	1.26	0.003mg/l	0	100	
Ca^{+}	34.05	132.05	72.85	100mg/l	19.75	80.25	WHO (2011)
Fe^{3+}	0.29	381.23	58.32	0.3mg/l	0.01	99.99	Total Iron
Ba	0.08	0.84	0.3	1.3mg/l	100	0	
Cu^{2+}	-0.01	0.46	0.2	2mg/l	100	0	
Ni	-0.02	0.36	0	0.07mg/l	0.01	99.99	
As	-0.07	1.54	0.41	0.01mg/l	4.94	95.06	
Co	-0.08	0.09	0.02	NR	NA	NA	
Pb	0.02	4.54	0.09	0.01mg/l	0	100	
K^{+}	0	79.55	9.4	15mg/l	79	21	WHO (2004)
Mo	0	0.02	-3.03 (ND)	NR	NA	NA	
Mg^{2+}	0	6.74	1.83	50mg/l	100	0	WHO (2011)
Mn^{+}	0.01	1.23	0.19	0.4mg/l	88.88	11.11	WHO (2004)
Na^{+}	-0.8	0.45	0.04	50mg/l	100	0	
Al	0.01	4.52	0.88	0.9mg/l	64.20	35.80	

Table 3: Descriptive Statistics of Water Parameters

Parameters	Mean	±Std. Error	Median	Mode	±Std. Dev.	Variance	Kurtosis	Skewness	Range	Min.	Max.	Sum	Count
pH	7.94	0.78	7.3	7.6	7.03	49.43	78.7	8.81	64.3	5.7	9.1	643.2	81
Temperature	33.11	0.38	33.5	36.3	3.4	11.59	0.74	-0.48	16.5	23.7	40.2	2682	81
TDS	154.32	31.11	70	60	279.96	78379.9	33.56	5.56	2030	20	2050	12500	81
EC	322.1	61.92	170	90	557.31	310599	33.38	5.54	4030	60	4090	26090	81
NO_3	0.33	0.05	0.2	0.19	0.41	0.17	12.99	3.31	2.46	0	2.46	26.67	81
NO_2	0.21	0.03	0.14	0.14	0.27	0.07	17.09	3.62	1.85	0	1.85	17.33	81
NH_4	0.08	0.02	0.02	0	0.19	0.03	43.4	6	1.5	0	1.5	6.29	81
SO_4	30.34	3.34	23.5	8	29.9	894.18	12.62	2.88	198	2	200	2427	81
Cl	11.57	1.71	6.8	0	15.41	237.58	13.09	3.12	96	0	96	936.8	81
HCO_3	221.09	9.43	205	195	84.87	7202.53	4.68	1.3	561.2	0	561.2	17908.3	81
P	3.47	0.2	3.63	4.46	1.83	3.33	2.91	0.42	11.63	-1.76	9.87	280.9	81
S	3.49	0.43	3.78	N/A	3.83	14.64	0.68	-0.39	22.18	-8.64	13.54	282.52	81
Se	0.16	0.06	0	-0.01	0.57	0.33	34.93	5.42	4.31	-0.01	4.3	12.98	81
Zn^{2+}	0.4	0.08	0.2	0.11	0.72	0.52	43.25	6.05	5.88	0.02	5.9	32.01	81
Cd	1.26	0.88	0.38	0.38	7.93	62.89	80.96	9	71.56	0.18	71.74	101.99	81
Ca^{+}	72.85	3.17	69.34	N/A	28.49	811.62	-0.89	0.49	98	34.05	132.05	5900.9	81
Fe^{3+}	58.32	7.37	43.76	N/A	66.29	4394.46	7.67	2.4	380.94	0.29	381.23	4724.16	81
Ba	0.3	0.02	0.27	0.2	0.16	0.03	2.28	1.42	0.76	0.08	0.84	24.31	81
Cu^{2+}	0.2	0.01	0.16	0.15	0.1	0.01	-0.47	0.62	0.47	-0.01	0.46	16.55	81
Ni	0	0	-0.01	-0.01	0.04	0	76.65	8.64	0.38	-0.02	0.36	-0.1	81
As	0.41	0.03	0.46	0.13	0.3	0.09	1.48	0.62	1.61	-0.07	1.54	33.25	81
Co	0.02	0	0.02	0.03	0.02	0	15.39	-1.27	0.17	-0.08	0.09	2.01	81
Pb	0.09	0.06	0.03	0.03	0.5	0.25	80.88	8.99	4.52	0.02	4.54	7.36	81
K^{+}	9.4	1.47	4.63	4.74	13.27	176.04	17.87	3.89	79.55	0	79.55	761.17	81
Mo	-3.03	3.03	0	0	27.26	743.05	81	-9	245.35	-245.3	0.02	-245.35	81
Mg^{2+}	1.83	0.9	1.65	1.21	0.93	0.87	9.13	2.23	6.74	0	6.74	148.21	81
Mn^{+}	0.19	0.03	0.1	0.06	0.23	0.05	6.64	2.5	1.22	0.01	1.23	15.16	81
Na^{+}	0.04	0.02	0.03	0.02	0.15	0.02	19.13	-3.3	1.25	-0.8	0.45	3.48	81
Al	0.88	0.11	0.47	0.03	1.01	1.01	2.25	1.58	4.51	0.01	4.52	71.65	81

Multivariate Analysis of Water Parameters

To identify the combination of parameters and to understand the relationship between them, PCA was used on the physicochemical data of the study area. The PCA result is presented in Table 4.

The Kaiser criterion (Kaiser, 1960) was applied on the water quality of the study area, in order to determine the total number of components to be extracted. The Kaiser Meyer Olkin (KMO) was found to be 0.543. The KMO result obtained was very significant (0.000), indicating that PCA can provide significant reduction in the dimensionality of the data.

Eleven (11) components were chosen after Varimax rotation, based on the Eigen value-one criterion. In the analysis, correlation coefficients of greater than 0.5 are considered significant. The 11 Varimax factors altogether explained 81.91% of the variance of the water quality data. The Eigen value, Variance and Cumulative variance are shown in Table 4.

The different principal components can be used to link the land use changes in the area to the underlying process possibly responsible for the groundwater characteristics in the study area.

The first Varimax factor (VF1) contained strong factor loading on Pb, Mo, Cd and Ni. It accounts for 15.404% of the total variability of the water quality data. Even though industries are not well developed in the area, but many are found localized in the urban centres, which are mostly unregulated in terms of management of discharges. The Pb and Cd may have originated from discharge of contaminants from these industries and agricultural activities, through the use of pesticides and insecticides. Therefore, the first principal component expressed the degree of occupation by industrialization and agriculture which correspond to cropland and built-up land uses respectively.

The 2nd Varimax factor (VF2) has high loading for EC, TDS, Cl and Temperature with variance of 14.068%. The high loading for EC, TDS and Cl can be due to salinity built-up process in the area due to intensive agricultural activities taking place in the study area. High concentration of TDS and Cl may lead to salinity of the water. Barzegar (2017) reported that, the process of salinity built-up is common in areas of irrigation, whereby there is constant accumulation of ions in the upper soil horizon thus leading to the salinity built-up, especially when groundwater exploitation rate used for irrigation is higher than the recharge of aquifer systems. The 2nd principal component expressed the degree of agriculture which is represented as cropland land use.

The 3rd Varimax factor (VF3) has higher loadings for NO_2, NO_3, SO_4 and HCO_3 with variance of 10.075%. The 3rd principal component indicates organic and inorganic pollution occasioned by agriculture, represented as cropland land use and residential pollution represented by built up land use.

Table 4: Rotated Component PCA of the water quality parameters

Parameter	VF1	VF2	VF3	VF4	VF5	VF6	VF7	VF8	VF9	VF10	VF11
Pb	0.995	-0.021	-0.039	-0.038	-0.041	0.004	-0.011	-0.033	-0.007	-0.017	0.001
Mo	-0.994	0.016	0.039	0.05	0.046	0.011	0.011	0.034	0.005	0.017	0.001
Cd	0.994	-0.013	-0.041	-0.055	-0.046	-0.006	-0.01	-0.034	-0.009	-0.016	0.001
Ni	0.989	-0.032	-0.03	0.011	-0.023	-0.043	-0.016	-0.024	0.018	-0.058	0.013
EC	-0.025	0.963	0.042	-0.104	-0.014	-0.028	0.055	0.009	-0.037	-0.014	0.012
TDS	-0.026	0.963	0.045	-0.098	-0.01	-0.03	0.055	0.01	-0.035	-0.014	0.014
Cl	-0.044	0.848	0.242	-0.033	0.037	0.106	-0.044	-0.059	0.095	-0.008	0.031
Temp	-0.073	-0.521	0.047	0.025	-0.048	-0.176	0.039	-0.076	0.476	-0.134	0.15
NO_2	-0.031	0.064	0.920	-0.109	0.071	-0.012	-0.093	0.046	0.018	0.008	0.115
NO_3	-0.038	0.031	0.873	-0.209	0.099	0.054	-0.166	0.072	0.06	0.02	0.113
SO_4	-0.083	0.419	0.633	-0.069	-0.077	-0.074	0.056	-0.066	-0.033	0.136	0.205
HCO_3	-0.063	0.095	0.584	0.292	-0.26	-0.051	0.174	-0.018	0.006	-0.018	0.235
Cu	-0.227	-0.147	0.016	0.772	0.064	-0.265	-0.131	0.123	0.148	-0.109	0.078
Ca	0.018	-0.063	-0.091	0.706	0.325	-0.036	0.268	0.08	0.297	0.001	0.324
P	-0.056	0.127	0.187	-0.679	-0.04	-0.161	0.075	-0.04	0.154	-0.123	0.088
Mg	0.188	-0.033	0.085	-0.549	-0.488	-0.168	-0.068	-0.048	-0.228	-0.146	0.381
K	-0.025	-0.005	-0.029	0.309	0.862	0.216	-0.04	0.035	-0.011	0.073	0.122
Na	0.094	-0.022	-0.045	0.008	-0.838	0.122	-0.133	0.003	-0.123	0.025	0.199
Co	0.053	-0.036	-0.004	0.19	0.116	0.876	0.062	-0.176	0.01	-0.059	0.048
As	-0.166	0.18	-0.049	-0.327	-0.07	0.766	0.161	0.078	0.197	-0.021	0.02
Zn	-0.014	-0.045	-0.041	-0.13	0.109	0.007	0.848	-0.124	-0.126	-0.168	0.074
Ba	-0.037	0.13	-0.081	0.108	-0.006	0.223	0.801	0.148	0.15	0.099	0.264
Fe	-0.077	-0.091	0.062	0.09	0.007	-0.121	-0.082	0.877	-0.069	-0.116	0.124
Mn	-0.053	0.195	-0.128	-0.012	-0.028	-0.106	0.179	0.662	0.218	0.316	0.262
Al	-0.014	-0.082	0.255	0.38	0.151	0.352	-0.053	0.545	-0.201	-0.116	0.147

Parameter	VF1	VF2	VF3	VF4	VF5	VF6	VF7	VF8	VF9	VF10	VF11
Se	-0.033	0.005	-0.048	-0.081	-0.143	-0.17	0.028	-0.002	-0.822	0.017	-0.09
NH_4	-0.012	-0.058	0.28	0.197	-0.059	-0.036	-0.009	0.009	0.006	0.803	0.157
S	-0.167	0.117	-0.321	-0.26	0.264	-0.071	-0.183	-0.054	-0.15	0.634	-0.02
pH	-0.019	0.026	-0.025	-0.089	0.054	-0.004	-0.081	0.049	0.137	0.112	0.751
Eigen Value	4.467	4.08	2.922	2.629	1.942	1.677	1.432	1.309	1.157	1.124	1.014
Variance	15.404	14.068	10.075	9.066	6.697	5.783	4.939	4.515	3.989	3.876	3.497
C. Variance	15.404	29.472	39.547	48.614	55.311	61.094	66.033	70.548	74.536	78.412	**81.91**

The 4th Varimax factor (VF4) has higher loading on Cu, Ca, P and Mg which account for 9.066% variance. Ca^{2+} is the predominant cation in the study area. High concentration of Ca^{2+} in parts of the study area could partially be attributed to weathering of basement rocks upstream of the basin. The 5th Varimax factor (VF5) contained strong factor loading on K and Na. These parameters could be related to weathering of silicates minerals of basement rocks upstream of the basin. Additional concentration of K^{+} could be from Potassium fertilizer due to agricultural activities in the area. The 4th and 5th components indicate the likely hood of natural process responsible for their high loadings in the study area.

Groundwater quality is highly connected to land use in the area. This was observed by linking land uses and water quality of the study area. It is clear that anthropogenic factors, mostly agricultural activities have played a vital role in the nature of groundwater chemistry in the area. The different land uses have significant impact on groundwater quality. The link between land use and groundwater was established through identifying effects of land use changes on groundwater quality of the study area. The relationship between many principal components to agricultural activities in the area has confirmed the results of land use analysis, which provided 80-83% to crop land from 1988 through 2002 and up to 2018.

Results of water quality analysis are presented using Hierarchical Agglomerated Analysis (HACA) and illustrated as the Dendrogram shown in Fig. 14, indicating two (2) major groups of clusters, followed by several subgroups. In Group 1; P, Cl, TDS, EC, NO_3, NO_2, SO_4, HCO_3, Se, Mg, Na, Cd, Pb and Ni are found in the same group. The group contains parameters indicating organic and inorganic pollution. Those with highest similarity in the group are; TDS and EC, Cd, Pb and Ni, followed by NO_2 andNO_3.

In Group 2; S, NH_4, pH, Temperature, Zn, Ba, As, Co, Ca, Cu, K, Fe, Al, Mo, and Mn are found in the group, showing major and trace elements such as Ca, K and Fe, Al, Mn respectively, as well as physical parameters, such as pH and Temperature. In this group,

Ca and Cu have highest similarity followed by Zn and Ba, while As and Co, Fe and Al have the equal similarity.

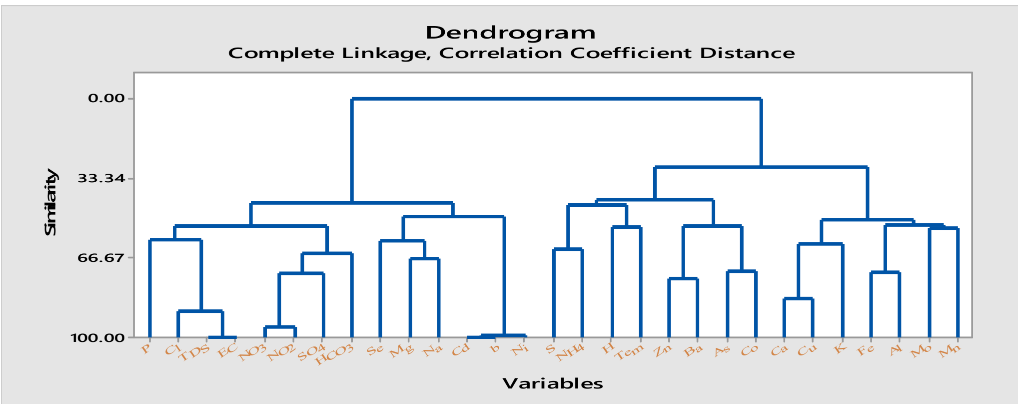

Figure 14: Dendrogram of Water Quality Parameters from the study area showing their similarities

CONCLUSION

Groundwater quality in the study area can be highly linked to land uses. Major changes in land use that have significant impact on groundwater quality are taking place in the study area, due to intensive agricultural activities and effluents from textiles and tannery industries, among others. The link between land use and groundwater was established. The association between many components of Varimax factor to agricultural activities in the area has confirmed the results of land use analysis, which donated 80-83% to crop land from 1988 through 2002 and up to 2018.

The findings of this research suggest the possibility of effects of anthropogenic activities; industrial effluents and intensive application of agro chemicals.

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