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Analysis of Anions Distribution in Gobbiya Dam Water, Bogoro Local Government Area of Bauchi State by GIS

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Abstract: - Water quality is one of the main challenges that societies faces, threatening human health, limiting food production, reducing ecosystem functions, and hindering economic growth. In this research water sample from Gobbiya dam were collected at ten different points on the dam water surface using a water sampler with the coordinate of the sampling point recorded using a Global Positioning System (GPS) camera. Powder pillow reagents with a DR/890 colorimeter was used to determine the level of anions in the water samples after which Geographical information system (GIS) were used to estimate by interpolation the levels of anions at unmeasured distance on the dam water surface. The result obtained showed that the concentration of sulphate and phosphate has no statistical difference across the ten sampling points as revealed by ANOVA ($P \leq 0.05$) ,Whilst Chloride, Nitrate, Ammonium showed a statistical differences across the ten sampling points and where further subjected to Turkey Pair-Wise test to determine the points of variation. The average concentrations of the anions determine are as follows: Phosphate, Chloride, Nitrate, Ammonium, Sulphate (0.06±0.01, 0.48±0.24, 14.4±10.30, 3.95±2.82, 2.40±0.97) mg/dm^3, respectively. The anions determined in the dam water are within the permissible limit set by WHO and FEPA for domestic and irrigation purposes.

Keywords: Anions, GIS, Dam water, ANOVA, Turkey Pair-Wise, Colorimeter, Powder Pillows, coordinates, GPS.

I. Introduction

The functions and importance of water cannot be over-emphasized; water is primary for life and occupies a very important place in science, philosophy and religion. The qualities of water control the productivity of the aquatic habitat. It is a medium by which organic and inorganic wastes and sediments are distributed throughout the ecosystem. Aquatic bodies may be marine, fresh water or estuary, freshwater habitats are broadly classified into two main groups, namely; standing water or lentic, and flowing water or lotic. The lentic environment sometimes known as the standing water series includes all forms of inland water (lakes, reservoirs, ponds, bogs, swamps, etc.) in which water motion is not that of continuous flow in a definite direction. Essentially, the water is standing although a certain amount of water movement occurs such as wave action, internal current of water flow near inlets and outlets (Avoaja, 2005).

Water is a basic natural resource and its availability has played an important role in the evolution of human settlements. Humans depend mainly on freshwater available in inland lakes and rivers, which constitute less than 50% of the total amount of the water in biosphere (Wetzel, 1983). As a result, there has been a growing necessity for conservation of water because of growing populations and increase in pollution of surface waters (Abubakar *et al.*, 2015). Inland water bodies depend on the amount of annual rainfall, size, seepage, climate and geographical location. Most water bodies in the savannah region of Nigeria are seasonal.

Geographical Information System or Science (GIS) is a system designed to capture, store, manipulate, analyse, manage and present spatial or geographical data. GIS applications are tools that allow users to create interactive queries, analyse spatial information, edit data in maps, and present the result of all these operations (Colin, 2004).

Spatial analysis is the study of location and shapes of geographic features and the relationship between them, it allows for evaluating suitability when making predictions and understanding how geographical features are located and distributed (Beale, 2012).

Spatial interpolation is the process of using points with known values to estimate values at other points. In GIS applications, spatial interpolation is typically applied to a raster with estimates made for all cells. Spatial interpolation is therefore a means of creating surface data from sample points. Using Geostatistical tool, the concentrations of physico-chemical parameters of water surface at unmeasured location can be estimated (Wilhelm *et al.,* 2003). Some of the Geostatistical tools that are commonly used for spatial analysis in GIS include:

- Trend surface analysis; an inexact interpolation method, approximates points with known values with a polynomial equation.
- Regression model; relates a dependent variable to a number of independent variables in a linear equation (an interpolator), which can then be used for prediction or estimation.
- Thiessen polygons; assume that any point within a polygon is closer to the polygon's known point than any other known points
- Density estimation; measures cell densities in a raster by using a sample of known points
- Inverse distance weighted (IDW) interpolation; is an exact method that enforces that the estimated value of a point is influenced more by nearby known points than those farther away.
- Thin-plate splines; create a surface that passes through the control points and has the least possible change in slope at all points. In other words, thin-plate splines fit the control points with a minimum curvature surface.
- Kriging; assumes that the spatial variation of an attribute is neither totally random (stochastic) nor deterministic. Instead, the spatial variation may consist of three components: a spatially correlated component, representing the variation of the regionalized variable; a "drift" or structure, representing a trend; and a random error term. The interpretation of these components has led to development of different kriging methods for spatial interpolation (Colin, 2004).

II. Materials and Method

2.1 materials/ equipment

430 pH/conductivity meter JENWAY, serial No. 20051, (part No. 430-201, made in PRC), DR/890 colorimeter of serial no. 130290694066, produced by Hach company world headquarters, Loveland, USA, GPS camera, Glass wares, powdered pillows.

2.2 Chemicals and Reagent

All the reagents / chemicals that were used in this research were of ana;ytical grade.

2.3 Description of the study area

Gobbiya village is in Bogoro local government area of Bauchi state, Nigeria. Bogoro is located at an elevation of 584 meters above sea level; it has an area of 894 km^2 and a population of 84,213 at the 2006 census.

Bogoro Local Government has a coordinate of 9°39'0" N and 9°37'0" E in DMS (Degrees Minute Seconds), Gobbiya dam in Bogoro LGA was constructed between the years 2015 and 2017 and became fully operational in 2018. It is used for irrigation farming, fishing, as a source of drinking water for livestock, for domestic and social activities by the host and surrounding communities.

2.4 Water sampling

Water sample was collected at 10 points and their coordinates recorded using a GPS camera during the dry season (April 2022). The Water was sampled at a depth of 25 cm with the use of a sampling tip. The Temperature and pH of water sample was measured on the dam whilst the anions (, Cl^-, SO^{2-}, NO^-, PO_4^-, NH_4) were measured in the Laboratory.

The water parameters are selected based on human activities that characterize the study area in relation with the possible parameters present in agricultural runoff and sewage effluents.

2.5 Coordinates of Sampling Points

Table1. Geographical sampling in ten points located on the Gobbiya dam water

Points	Sampling point	coordinates
A	N 9°39'06.1"	E 9°42'14.3"
B	N 9°39'07.2"	E 9^{0}42'17.1"
C	N 9°39'12.9 "	E 9°42'19.1"
D	N 9°39'15.5"	E 9°42'14.3'

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E	N 9º39'19.9"	E 9º42'08.7"
F	N 9º39'17.9"	E 9º42'19.9"
G	N 9º39'13.2"	E 9º42'20.0"
H	N 9º39'11.7"	E 9º42'25.2"
I	N 9º39'19.3"	E 9º42'27.9"
J	N 9º39'11.7"	E 9º42'28.3"

Following the instruction of instrument operational manual provided by the manufacturer, the analysis of phosphate, chloride, sulphate, nitrate and ammonium was carried out using DR/890 colorimeter and powder pillows. The blank solutions preceded the same way and used for the preparation of the calibration solutions and for measurement of the blanks. In the present study the anions concentrations are used to prepare a sampling inventory, which will be computed and stored in database of geographical information system (GIS). Tools like GIS have helped to make use of the sampling data to estimate the levels of anions at unmeasured locations (Wilhelm et al. 2003).

The data were spline interpolated using the interpolation technique at a 3km resolution and finally imported into ArcGIS 9.2 where cells values express the anions concentration in sampling point. The spline method is an interpolation method that estimates the values using mathematical function that minimizes overall surface curvature, resulting in a smooth surface that passes exactly through the input points.

III. Result and Discussion

Table 2: concentration of anions in the sampling points

Points	NH_4	SO_4^{2-}	Cl^-	NO_3^-	N	PO_4^-	P_2O_5	P
A	1.22^a±0.00	4.00±0.10	0.50^a±0.10	4.40^a±0.00	1.00^a±0.00	0.05±0.01	0.03±0.01	0.01±0.01
B	0.36^b±0.02	3.00±0.10	0.30^b±0.05	1.50^b±0.02	0.30^b±0.02	0.06±0.01	0.04±0.01	0.02±0.01
C	1.10^a±0.20	3.00±0.17	0.70^a±0.02	3.90^a±0.20	0.90^a±0.20	ND	ND	ND
D	0.97^a±0.30	1.00±0.10	0.40^b±0.04	3.70^a±0.30	0.80^a±0.30	ND	ND	ND
E	2.55^c±0.08	2.00±0.00	1.00^c±0.00	9.20^c±0.08	2.10^c±0.08	ND	ND	ND
F	7.50^d±0.10	2.00±1.00	0.70^a±0.01	26.7^d±0.10	6.00^d±0.10	0.13±0.01	0.10±0.1	0.04±0.01
G	6.69^e±0.10	3.00±0.17	0.40^b±0.00	24.5^e±0.10	5.50^e±0.10	ND	ND	ND
H	6.57^e±0.02	1.00±0.42	0.20^b±0.10	23.90^e±0.02	5.40^e±0.02	ND	ND	ND
I	6.44^e±0.22	2.00±0.76	0.30^b±0.00	23.40^e±0.22	5.30^e±0.22	ND	ND	ND
J	6.32^e±0.10	3.00±0.10	0.30^b±0.15	23.00^e±0.10	5.20^e±0.10	ND	ND	ND

In table 2: A-J= sampling points on Gobbiya Dam water. Values are mean ± standard deviation (n=3). The values with no letters did not show significant differences in all the ten sampling points while those lettered displayed a significant difference as indicated by ANOVA ($p \leq 0.05$), those with same letters on same column are significant different ($P \leq 0.05$) as revealed by Turkey Pair-wise difference ($P \leq 0.05$).

3.1 Nitrates-Nitrogen

NO_3 concentrations ranged from 1.50 mg/l to 26.70mg/l, with an average of 14.4 mg/l. ANOVA showed a significant variation ($p<0.001$) between the NO_3 values, the highest level is found at point J and the least at point B . The concentration of nitrate was converted to obtain the concentrations of Nitrogen and ammonium. Similar trends were observed by Mustapha (2008) who assessed water quality using physic-chemical parameters for Oyun Reservoir in Nigeria. The researcher recorded high nitrates during rainy season. NO_3 is found in little amounts in natural waters and mostly it is of mineral origin, while most coming from organic and inorganic sources, such as effluent discharges animal waste and fertilizer runoff (Irenosen *et al*., 2012).

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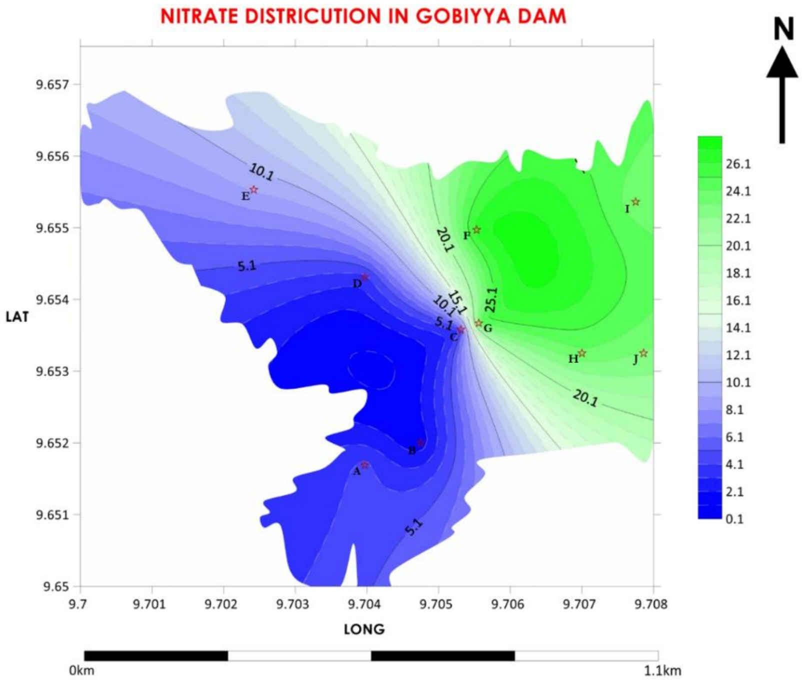

Figure 1: Spatial distribution of Nitrate as calculated by interpolation method using information system

*sampling points

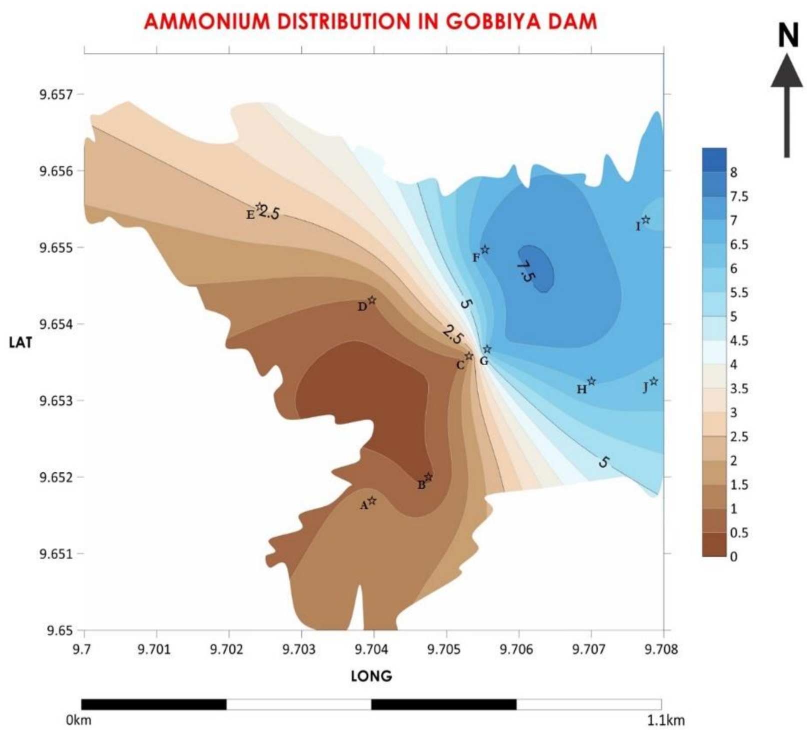

Figure **4.**1: Spatial distribution of Ammonium as calculated by interpolation method using information system

*sampling points

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3.2 Phosphate-Phosphorus

The concentration of phosphate ranged from (0.01-0.04) mg/l with an average of 0.02 mg/l. The concentration of phosphate was converted to obtain the concentration of phosphorus and phosphorus pentaoxide. The range and mean values were below the stipulated limit of 5 mg/l for FEPA (1991) and < 6 mg/l for WHO (2004) for domestic and drinking water. Olanrewaje *et al*. (2017) studied the physic-chemical properties of Eyeleye dam and obtained the value of phosphate to be (1.71 – 2.10) mg/l which is higher than the value in Gobbiya dam water.

3.3 Sulphates

The measured SO_4 values ranges from 1.00 mg/l to 4.00 mg/l with an average of 2.4 mg/l and very low compared to the EPA standard of 400 mg/l, the highest concentration was found at point A as shown by the sulphate distribution map below. ANOVA showed a significant variation ($p<0.001$) between the SO_4. Patil *et al*. (2013) assessed water quality parameters in Kolhapur, India and found similar variations (0.6 mg/l to 8 mg/l) with high recordings during rainy season while lowest during the dry summer season.

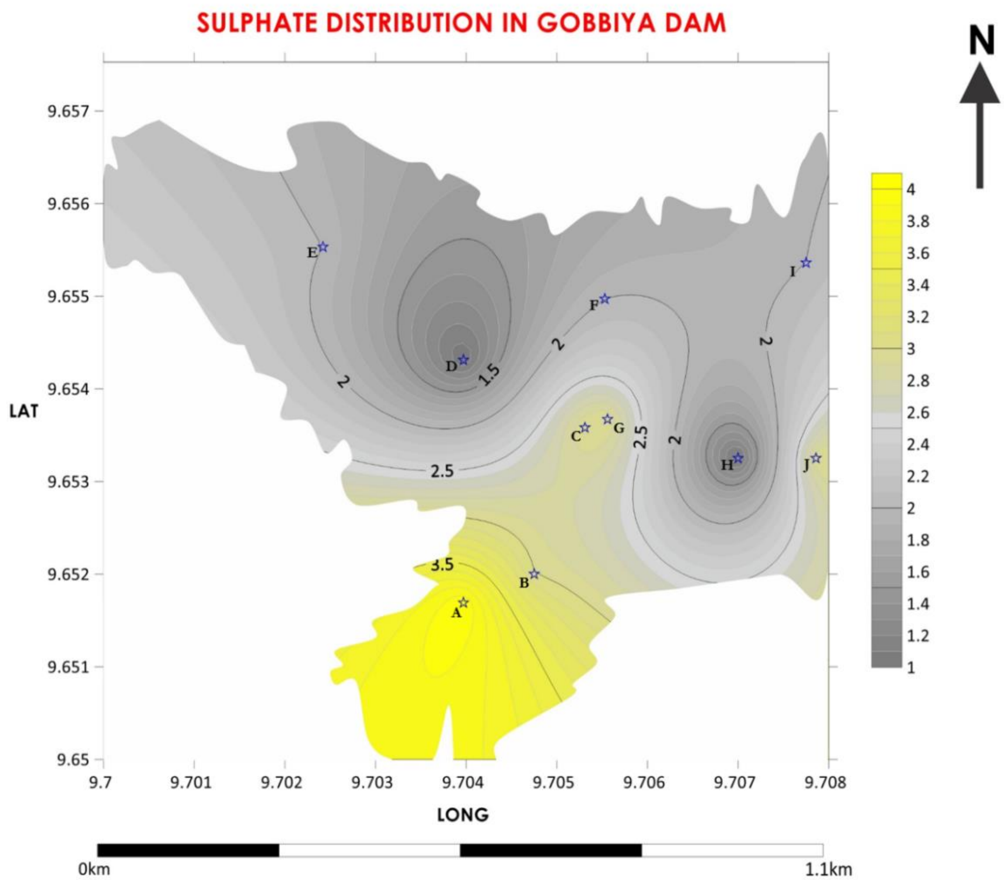

Figure 5: spatial distribution of Sulphate as calculated by interpolation method using information system

*sampling points

3.4 Chloride

The recorded chloride concentrations ranged between (0.3 – 1.0) mg/l, the mean value was 0.48 mg/l. the highest concentration is at point E as shown on the chloride distribution map below. There was significant difference found between the sampling points. All the sampled points have chloride values below the standard limits of 250 mg/l set by both WHO (2004) and FEPA(1991) for drinking and irrigation water. In Challawa dam Kano, the value of chloride ranges between (3.47 – 10.72) mg/l (Waziri *et al*., 2015) which is not consistent with the values obtained in Gobbiya dam water but below the limit set by some standard organization.

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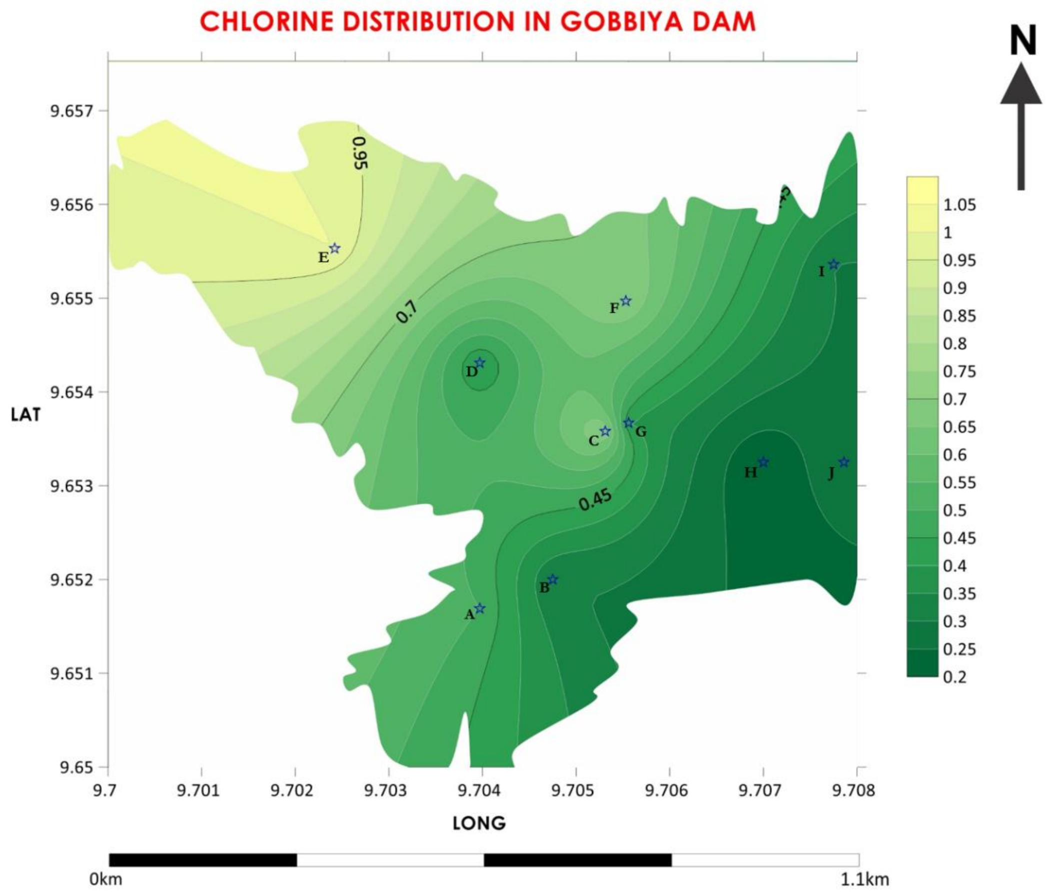

Figure 6: Spatial distribution of Chlorine as calculated by interpolation method using information system

*Sampling points

IV. Conclusion

The dam water has a significant turbidity value which might be as a result of the nature of the soil from which it was excavated from.

Gobbiya dam can be said to be un-polluted because most of the parameters determined are within the standard limits of standard organisations WHO (2006) and FEPA(1991). Anthropogenic activities are the major factor contributing to the dams anions level, the dam surrounding is characterise by intense agricultural activities year round (irrigation and rainy season farming) with the consistent application of nitrate, phosphate and other types of fertilizers as plant nutrient. Agricultural runoff and Animal waste from cattle ranches and grazing cattle which utilize the dam as source of drinking water are the major contributors to the presence of anions in the dam water. The quality of the dam water is liable to change in the shortest period of time due to constant increasing agricultural activities in the dam surrounding.

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