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Physiochemical Parameters and Water Quality Index (WQI) of Ashaka Quarry and Environs, Bajoga LGA, Gombe State, Nigeria.

Dagare, A. M

Government Secondary School (GSS) Nangere, Yobe State.

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ABSTRACT

Physical and chemical characteristics of water are important parameters to be considered in water quality index. The study aimed to evaluate the physiochemical parameters and water quality of Ashaka quarry and Environs, Gombe State for domestic and industrial uses. To achieve these objectives, 15 water samples were randomly collected within and outside the quarry and taken to the laboratory for analysis to determine the concentration of the chemical elements. Atomic Absorption Spectrophotometry (AAS) was used to determine the concentration of the elements. Physical parameters determined were Electrical Conductivity (EC), pH and Temperature which were instantly measured in the field with electronic digital meters. Results of the physicochemical parameters showed that temperature was 26.5 ºC, pH 7.46, EC 387µs/cm, Calcium 8.83mg/l, Magnesium 7.51mg/l, Sodium 5.93mg/l, Potassium 5.66mg/l, Chloride 1.86mg/l, Sulphate 0.87mg/l and bicarbonate 15.09mg/l. Likewise, for the pollution index, Weighted Arithmetic Water Quality Index procedure (WAWQI) was adopted due to its versatility and simplicity in the computation. Water Quality Index (WQI) obtained from the study area was 67.37 meaning the water is poor, unfit for drinking which require proper treatment before consumption but can be used for irrigation and industrial applications. Moreover, two categories of the pollution levels were obtained which were samples (SW1 - SW9, GW10, GW11 and GW12) categorized as "grade C" with status described as poor water quality and water samples GW13, GW14 and GW15 categorized as "grade D" described as very poor water, unsuitable for drinking unless proper treatment is done. Descriptive statistics was used to interpret the results of the analysis. Proper monitoring is paramount to safeguard human health.

Keywords: Drinking water, Physicochemical, Quarry, Water Quality Index.

INTRODUCTION

Provision of safe and clean drinking water is crutial for good living and scarcity of this resource is a serious challenge facing developing countries especially Africa. Study of freshwater involves examination of the physical and chemical composition of the water samples for good wellbeing. Use of polluted water for daily need such as bathing, cooking, drinking, washing and irrigation is a normal routine in developing countries with inadequate infrastructures and regulatory laws (Dasilveira et al., 2021; Ahmed and Alam, 2019. Anthropogenic activities like agricultural practice, industrial and mining pollute both surface and groundwater resources and pose threat to human health. Activities such as agriculture, mining, and blasting of limestone as a major raw material for cement production in Ashaka has resulted to both surface and groundwater deterioration as well as severe environmental degradation in that locality. Major water pollutants are bacteria, viruses, parasites, fertilizers, pesticides, pharmaceuticals products, plastics, nitrates, phosphate, fecal waste and even radioactive substances. These do not always change the colour of the water because they are mostly regarded as invisible pollutants but have great impact on human wellbeing. Several diseases are linked to consumption of polluted water such as cholera, diarrhea, skin infection, typhoid fever, cancer, malnutrition etc. With regard to this, the quality of water of Ashaka quarry and environ, Gombe State will be assessed using ten (10) physiochemical parameters for domestic and industrial applications using water quality index method.

Water Quality Index (WQI) is a method commonly used to calculate the level of pollution of both surface and groundwater from sets of data in to a single entity which was first developed by (Horton, 1965) to classify water quality. Horton, 1965; Tyegi et al, 2013 adopted the method based on rating of different water quality

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parameters, assisting in understanding the overall water quality status of a particular water source. It is an effective method used globally to determine the suitability of the water for drinking, irrigation and industrial applications. Many methods has been developed and yielded effective results by different national and international organizations to summarize water quality globally in an easily understandable format such as weighted Arithmetic water quality index (WAWQI), National Sanitation Foundation WQI (NSIWQI), Canadian Council of Ministers of Environment WQI (CCMEWQI), Oregon WQI (OWQI). But for the sake of this study, WAWQI was adopted due to its versatility and simplicity in the mathematical computation over other methods. WAWQI was employed by Brown et al., 1970 and widely used by many scientists to classify water quality for human usage based on rating (Hajar, 2019; Adeyemi et al., 2017, Abdulhameed, et al., 2010; Maheswaram and Elangovan, 2014; Useh et al., 2022. Mohammad et al., 2010; Ogbodo et al., 2020; Zayed, 2020).

WAWQI index method use the most commonly measured physicochemical characteristic and classify the water quality according to its degree of purity (Tygai et al., 2013). It was used to determine the composite effects of individual parameters on the overall water quality and as strong tool for water quality monitoring in different nations for protection and preservation of water use (Ani and Fasakin, 2016; Wu et al., 2020). To make things easy, WQI reduces a large amount of information on physiochemical aspects to a simple expression that is easily interpreted by technicians, environmentalists and general public universally. Water quality needs to be closely assessed and maintained for achieving socioeconomic development and environmental preservation (Zayed et al., 2021).

Study Area And Geology

The study area (Fig. 1) lies in the Upper Benue Trough (Gongola Arm) situated in the Northeastern Funakaye LGA, Gombe State (Nigeria) which lies on latitudes 10°51'N & Longitudes 11°25'E. The road gives access to Ashaka Cement Plc via Gombe – Potiskum highway about 16 Km away from Bajoga town. Gombe State is bordering Bauchi and Jigawa states to the west Plateau, Taraba and Adamawa to the south, Yobe and Borno to the east.

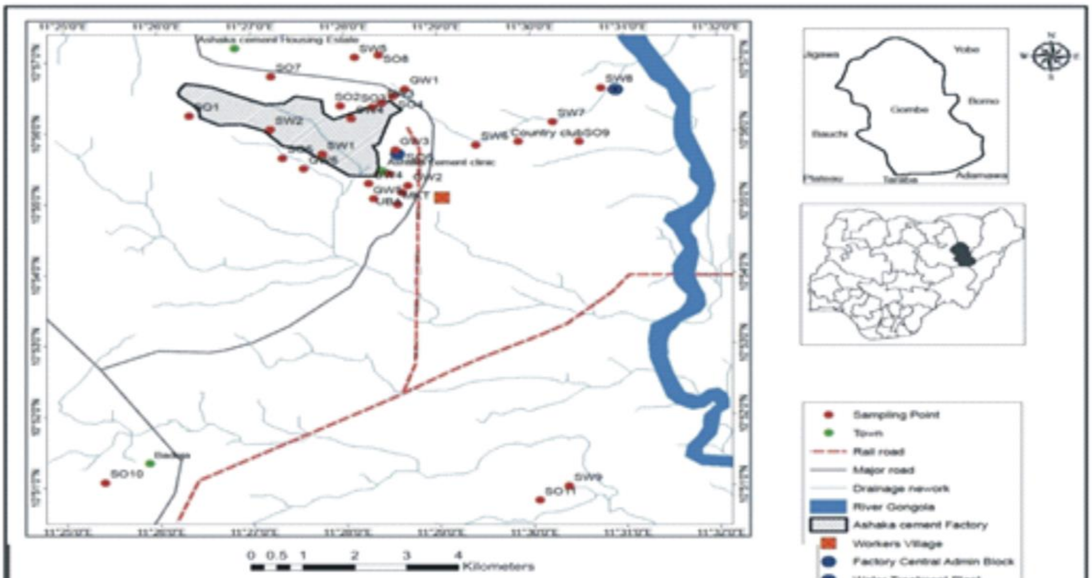

Figure 1. Location map of study area

Source: GIS expert extracted from goggle map (2018)

The study area falls within the Upper Benue Trough which comprised of two different sub-basins; the N-S trending Gongola sub-basin and the E-W trending Yola sub-basin (Yandoka et al., 2014; Guiraud and Maurin 1992; Guiraud, 1990). Ashaka Quarry belongs to Gongola arm with three (3) exposed sections of different Formations and thicknesses. The Formations were the transitional Yolde Formation overlain by Pindiga Formation containing the mineral deposit of interest (limestone) about 8m with large lateral extent in the quarry inter-bedded with thin shale beds and overlain by Gombe Formation. On the other hand, Yola Sub-basin consist essentially of volcanic plugs of various sizes and shapes with their vents irregularly distributed typifying volcanic activities unrelated to any specific control and the rocks are thought to have formed from the late Cretaceous to recent times (Adekeye and Ntekim 2007).

The Basin is considered as an intracontinental Cretaceous Basin about 1000km in length stretching in a NE-SW direction and lying unconformably upon the Precambrian Basement (Benkhalil et al, 1989) and better known due to field work of the geologic survey of Nigeria (GSN). Study of Cretaceous systems and inland basins was dated back to early 1950's when oil exploration began in the nation (Nwojiji et al., 2013). Benue Trough generally is separated from the Chad basin by the Zambuk ridge which runs roughly north eastwards from about Gombe town through Zambuk to Biu plateau (Offodile, 1976).

The origin and tectonic evolution of the Trough was related to a pull apart basin that was initiated during the separation of African and south American continent (Wright, 1968; Burke and Dewey, 1973; Olade, 1975; Fitton, 1980; Benkhelil, 1982a). It's the failed arm of RRR triple junction following the opening of the South Atlantic in the Cretaceous (Burke et al., 1971). King, 1950 considered it as a rift – bounded basin while Carter et al.,1963 interpreted the origin of the Upper Benue Trough in terms of rift faulting and folding associated with basement flexuring while Stonely, 1966 proposed the basin as a graben-like structure. Another vital information obtained on the basin apart from the field work were data from wells drilled by the Nigerian National Petroleum Corporation NNPC (Nwajide, 2013). The sedimentary sequence infilling the study area includes continental and marine deposits ranging from Upper Aptian to Paleocene in age (Mboringong *et al.*, 2013). The stratigraphic units consists of Bima Sandstone, Yolde Formation, Pindiga Formation, Gombe Formation and Kerri – Kerri Formation (Abubakar, 2006).

MATERIALS AND METHODS

Thermometer, pH meter, multi conductivity meter, UV-Vis spectrophotometer, 50 mL burette, 25 mL pipette, 250 mL conical flasks, retort stand were used. The following reagents were also used for the analyses: Na-EDTA, NH4Cl, Erichrome Black-T, Aqueous ammonia, HCl. Doubly distilled, de-ionized water in the preparation of all solutions in the experiments. Water samples collection was done using 750cl Polythene plastic containers, which were pre-rinsed with nitric acids and soaked in distilled water for some hours to kill germs.

To achieve this objectives, nine (9) surface water and six (6) groundwater samples were randomly collected from different locations of the study area and analyzed for major physiocochemical parameters in National Centre for Petroleum Research and Development (NCPRD) Bauchi State using the American Public Health Association (APHA) procedures. The samples were properly labeled, sealed, and taken in an iced packed cooler to the laboratory for Physiochemical analysis using Atomic absorption Spectrophotometry (**AAS Model 210 VGP)**. American Public Health Association (APHA) standard procedure for water and waste water was used using high grade chemicals.

Ten (10) parameters including EC, pH, temperature, Na^+, K^+, Ca^{2+}, Mg^{2+}, Cl^-, $HC0_3{}^-$ and $S0_4{}^{2-}$ were used to characterize the water quality for domestic and industrial uses. Concentrations of the elements analyzed were compared and interpreted with Nigerian standards for drinking water permissible limits of National Standard for Drinking Water Quality (NSDWQ) and World Health organization (WHO) standard. Descriptive statistics was used for the data interpretation.

Weighted arithmetic index technique proposed by Brown et al., 1970 was considered for evaluation of the water quality. The method involves two steps. Firstly, it required computation of the unit weight (Wn) for each parameter and secondly, determination of quality rating score (Qn) for all the parameters except pH= 7 which was calculated by dividing the concentration of each parameter by its specific standard multiply by 100. Assessment of the water quality is paramount to human health and socioeconomic development. WQI is mathematically calculated using the following equations:

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Step 1.

Wn = K/Sn ……………………………….................................. (1)

Where,

Wn is the weighted unit of nth water qualiy parameter
K is the constant of proportionality,
Sn is the standard permissible value for the nth water quality parameter

K = 1/∑1/Sn ………………………………………………………... (2)

Step 2.

Qn = [Vn/Sn] – [Vi/Vi] x 100 ……………………………………… (3)

Where,

Vn is the actual amount of parameter observed

Vi is the ideal value of the parameter, Vi = 0, except for pH = 7

WQI = ∑QnWn/∑Wn ……………………………………………. (4)

Where,
Qn is the quality rating of the nth water quality parameter
Wn is the unit weight of nth water quality parameter

RESULTS AND INTERPRETATION

Table 1. Statistical description of the sampled water

Parameter	**pH**	**Temp**	**EC**	**K**	**Na**	**Mg**	**Ca**	**Cl**	**HC03**	**S04**
N	15	15	15	15	15	15	15	15	15	15
Min	6.52	25.8	20	2.01	3	1.02	1.9	0.68	8.75	0.35
Max	8.46	27	1360	10.3	11.03	20.61	23	3.87	24.53	1.43
Sum	111.88	397.8	5800	84.95	88.89	112.63	132.5	27.84	226.31	13.11
Mean	7.458667	26.52	386.6667	5.6633	5.926	7.508607	8.8333	1.856	15.0873	0.874
Std error	0.60128	0.084628	103.7157	0.62957	0.628929	1.257922	1.43701	0.25006	1.093491	0.081526
Variance	0.384612	0.107429	161352.1	5.9455	5.93328	23.7355	30.975	0.93801	17.9358	0.99697
Standard Deviation	0.620171	0.327763	401.6869	2.43834	2.435833	4.8719	5.5655	0.96851	4.23507	0.31574

Source: Using Excel (2013)

Table 2. Calculated mean for water quality rating of all the samples collected

S/N	Parameter	Wn = K/Sn	Observed Value (Vn)	Ideal Value (Vi)	WHO Limits (Vs)	Vn - Vi	Vs – Vi	Qn	Qn*Wn
1	pH	0.424457	7.46	7	8.5	0.46	1.5	87.764	37.25
2	Temp	0.144315	26.5	0	25	26.5	25	154.8	2.234
3	EC	0.014432	387	0	250	387	250	106	15.297
4	K	0.300657	5.663	0	12	5.663	12	11.773	0.566
5	Na	0.018039	5.926	0	200	5.926	200	15	1.082
6	Ca	0.048105	8.833	0	75	8.833	75	0.744	0.010
7	Mg	0.072158	7.509	0	50	7.509	50	2.965	0.053
8	Cl	0.014432	1.856	0	250	1.856	250	47.166	14.180
9	$HC0_3$	0.012026	15.087	0	300	15.087	300	0.218	0.002
10	$S0_4$	0.00902	0.874	0	400	0.874	400	503	0.06

WQI = $\sum QnWn / \sum Wn$ = 70.74/1.05 = 67.37

Source: Brown et al., 1970

Table 3 Categories of Water Quality Index (WQI)

S/N	WQI	Status	Grading	Description
1	0 – 25	Excellent	A	Drinking, irrigation and industrial use
2	26 – 50	Good	B	Drinking, irrigation and industrial use
3	51 – 75	Poor	C	Irrigation and Industrial use
4	76 – 100	Very poor	D	Irrigation
5	Above 100	Unsuitable for drinking	E	Require proper treatment before use

Source: Modified (Brown et al., 1970, Wekesa and Otieno, 2022)

Table 4 Results of the surface water quality status of each sampling location

S/N	Sites Codes	Site Name	WQI	Grading	Status of WQI	Possible Use
1	SW1	Quarry	70.51	C	Poor water quality	Irrigation and Industrial
2	SW2	Quarry	69.22	C	Poor water quality	Irrigation and Industrial
3	SW3	Quarry	69.85	C	Poor water quality	Irrigation and Industrial

4	SW4	Juggol	64.97	C	Poor water quality	Irrigation and Industrial
5	SW5	Behind Estate	52.66	C	Poor water quality	Irrigation and Industrial
6	SW6	Juggol	65.96	C	Poor water quality	Irrigation and Industrial
7	SW7	Juggol	67.79	C	Poor water quality	Irrigation and Industrial
8	SW8	Airport Road	60.43	C	Poor water quality	Irrigation and Industrial
9	SW9	Bajoga Road	58.90	C	Poor water quality	Irrigation and Industrial

Source: Modified after (Brown, 1970)

Table 5: Results of the groundwater water quality status of the sampling location

10	GW10	Outside Quarry	53.93	C	Poor water quality	Irrigation and Industrial
11	GW11	Jalingo	65.74	C	Poor water quality	Irrigation and Industrial
12	GW12	Trailer park	53.64	C	Poor water quality	Irrigation and Industrial
13	GW13	Jalingo	82.17	D	Very Poor water quality	Irrigation
14	GW14	Jalingo	81.47	D	Very Poor water quality	Irrigation
15	GW15	Jalingo	84.73	D	Very Poor water quality	Irrigation

Source: Modified after (Brown, 1970)

DISCUSSION AND FINDINGS

A statistical summary indicating minimum, maximum, mean and standard deviation of the physiochemical parameters was also made. Table 1 revealed that the minimum and maximum value of pH was 6.52 and 8.46, temperature was 25.8 to 27 °C, electrical conductivity was 1360 to 5800s/cm, potassium was 2.01 to 10.3mg/l, sodium was 3 to 11.03mg/l, magnesium was 1.02 to 20.61mg/l, calcium was 1.9 to 23mg/l, chloride was 0.68 to 3.87mg/l, bicarbonate was 8.75 to 24.53mg/l and Sulphate was 0.35 to 1.43mg/l.

Table 2 shows the overall water quality index (WQI) computed to determine the potability of the samples analyzed in to a single value. The result (67.72) shows that the water were categorized under two grades "C and D" Table 4 and 5 which were described as poor and very poor water being suitable for irrigation and industrial purposes but unsuitable for drinking unless properly treatment is done before consumption. This might have resulted from the anthropogenic activities taking place in the cement factory for years.

Presence of Ashaka water treatment plant within the factory is saddled with purification of the polluted water before distributing it to homes so as to reduce threat to human health. Surface water sample SW1 – SW9 and groundwater sample GW10 – GW 12 were classified as grade " C" and referred to as poor water suitable for irrigation and industrial used while GW13 – GW15 are of grade "D" with very poor water status. It can only be used for irrigation purpose due to higher values of WQI obtained. Quality rating (Qn=0), indicates total

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absence of pollutants, while Qn ranging between 0 – 100 means the pollutants are within the standard limits and in case of Qn > 100 shows that the pollutants are above the permissible limits (Gungoa, 2016).

Table 3 described different categories of the Water quality rating scale in terms of status, grading and possible use. It is a global standard that formed the basis for computation of Water Quality Index (WQI) for both surface and groundwater assessments (Brown et al., 1970, Wekesa and Otieno, 2022). Table 6 shows the concentration of chemical elements analyzed in comparison with Nigerian and International standards for drinking.

Table 6. Comparison of the Physiochemical parameters with World Health Organization (WHO) and National Standard for Drinking Water Quality (NSDWQ) Standards.

Site Codes	Site Name	Coordinate	pH	Temp (°C)	EC (µs/cm)	K Mg/L	Na Mg/L	Mg Mg/L	Ca Mg/L	Cl Mg/L	$HC0_3$ Mg/L	$S0_4$ Mg/L
SW1	Quarry	10°55700' N 11°27.750' E	7.78	26.7	480	6.1	5.0	9.62	11.2	0.93	13.72	0.63
SW2	Quarry	10°56.056' N 11°27.201' E	7.91	26.7	600	5.0	4.11	9.21	12.9	2.63	16.93	1.25
SW3	Quarry	10°56.341' N 11°28.300' E	6.88	26.8	340	8.2	5.01	5.8	8.2	1.87	21.66	0.87
SW4	Juggol	10°56.201' N 11°28.072' E	7.80	26.5	80	5.03	5.06	5.42	7.5	1.54	13.13	0.35
SW5	Behind Estate	10°57.086' N 11°28.071' E	6.89	26.6	20	2.01	5.0	3.23	3.0	2.14	11.63	1.06
SW6	Juggol	10°55.967' N 11°29.427' E	7.99	26.5	80	5.16	3.02	4.4	6.6	0.92	9.25	0.93
SW7	Juggol	10°56.141' N 11°30.232' E	8.37	26.7	100	5.08	3.0	4.39	6.8	0.68	8.75	0.57
SW8	Airport	10°56.601'	6.8	26.2	140	5.11	5.01	5.01	5.3	2.77	17.2	0.66

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	Road	N 11°30.838' E	0								5	
SW9	Bajoga Road	10°50.900' N 11°30.301E	7.50	26.7	240	3.05	3.3	1.02	1.9	1.14	15.93	1.17
GW10	Outside Quarry	10°56.600' N 11°28.651' E	6.84	26.7	80	3.1	7.12	5.61	5.1	3.25	24.53	0.98
GW11	Jalingo	10°55.177' N 11°28.487' E	6.85	26.4	420	6.3	8.0	8.63	6.7	2.56	18.11	1.43
GW12	Trailer park	10°55.683' N 11°28.512' E	6.52	25.8	80	3.01	6.07	5.21	5.6	3.87	14.29	0.81
GW13	Jalingo	10°55.299' N 11°28.252' E	8.46	27.0	700	9.0	11.03	10.63	11.6	1.25	12.59	1.22
GW14	Jalingo	10°55.063' N 11°28.301' N	7.49	26.6	1360	8.5	9.2	20.61	17.1	1.06	13.67	0.43
GW15	Jalingo	10°55.500' N 11°27.552' E	7.80	25.9	1080.0	10.3	8.96	13.84	23.0	1.23	14.87	0.75
Average			7.46	26.5	387	5.66	5.93	7.51	8.33	1.86	15.09	0.87
WHO, 2011			6.5 -8.5	25 – 28	1000	12	200	50	100	250	300	400
NSDWQ, 2015			8.5	28	1000	-	250	-	100	250	-	100

Source: Field work (2015). WHO, 2011, NSDWQ, 2015.

CONCLUSION

WQI of all the samples collected from Ashaka quarry and Environs has been categorized in to two grades, namely "C and D", unsuitable for drinking but applicable for irrigation and industrial uses. This could be probably due to the impact of mining operation and other anthropogenic activities taking place in the locality.

Introduction of pollutants in to water source has great impact on the environment and human health, This calls for systematic monitoring of the groundwater for guarding the health of the people in the area.

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