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Assessment of the Water Quality of Bar-Bula Village Well Waters, Tafawa Balewa Local Government Area, Bauchi State, Nigeria

Chidi J. OGHAM[1*], Jonathan D. DABAK[1], Kiri. H. JARYUM[1]

[1]*Department of Biochemistry, Faculty of Basic Medical Sciences, College of Health Sciences, University of Jos, Nigeria;*

Corresponding author: chidiogham@yahoo.com

ABSTRACT

There was a report of health challenges in our study area due to the consumption of water from wells sited in the community. The research was aimed at assessing the water quality parameters of the wells consumed by the villagers towards providing information on the possible health implication(s) of its consumption. Two sampling sites were selected, well 1 and well 2, which were hitherto the sole sources of water in the village. Physico-chemical and microbiological quality parameters of samples were done in order to assess their conformance with the specification of Nigerian Standard for drinking water quality (NIS 554-2015). The results indicated that all physical water quality parameters have their mean concentration values below the maximum permissible limits, except colour which had total mean concentrations of 16.5 ± 0.65 TCU and 15.3± 0.65 TCU for well 1 and well 2 respectively, are relatively above the allowable unit range of 15 TCU (NIS-554-2015). The water quality assessment of wells also revealed high concentration of cadmium (0.11 mg/L and 0.16 mg/L, for well 1 and 2 respectively as against 0.003 mg/L specified by standard) and magnesium (185 mg/L and 105 mg/L for well 1 and 2 respectively as against the maximum permissible limit of 20 mg/L specified by the standard). The microbial values of samples fall below the maximum permissible limit prescribed by the NIS standard. From the study, it was concluded that the presence of cadmium in the well waters indicated that the water is unfit for consumption.

Keywords: Cadmium, consumption, Bar village, water quality, standard

INTRODUCTION

Water is a vital resource as well as a major factor in pollution studies. The physical, chemical and biological characteristics of the water defines its quality, which consequently is a factor of the area's geology and effects of human activities (Ishaku & Ezeigbo, 2010). Water resources can be termed to be polluted when there is/are presence of toxic contaminant(s) that could be injurious to humans and other organisms in that source of water (Wang et al, 2017). Natural constituent of water due to the geology of the area in which the water occurs (natural pollution) can cause pollution of the water or the pollution may be caused by the impacts of human activities on the water (Pan et al., 2018).

Fresh water can be obtained underground. The water underneath the surface of the earth that flows naturally to the earth surface through seeps or springs and are collected in wells, tunnels, or drainages are referred to as ground water (Ye et al., 2017; Ambrosi, 2017). Overtime, ground water has been the main source of water. In modern times, they are important source of water for many municipalities and industries and for irrigation (Lee et al., 2007). Ground water is essentially the only water resources for all life forms (Zhuang *et al*., 2011).

Environmental pollution is a critical phenomenon in recent times (Ali and Khan, 2017). Environmental pollution and contamination by heavy metals is a menace to the environment with serious consequences (Hashem et al., 2017). The proliferation of heavy metals in the environment has been on the rise due to extensive industrialization and urbanization, causing a significant surge in their accumulation over time. (Khan et al., 2014; Shen et al., 2017). Although heavy metals occur naturally, their entry in the environment are mostly due to both natural causes, such as weathering of rocks and volcanic activities, and also human activities such as industrial emissions, mining, smelting, pesticides and phosphate fertilizers application (Tang et al., 2020).

Bar is a rural community situated between hills on the east and west sides, with Bununu rivers running to the north with a population of approximately 1300 people. Narration has it that some mineral resources were once exploited in the area in quantities not viable for commercial purposes.

Several years ago, a severe health crisis was reported in the above-mentioned village, as a result of a switch in the community's water source from surface to well water for the population's use. The outbreak of the unknown disease was marked by severe clinical symptoms, resulting in the death of some members of the population. The disease was believed to have originated from the consumption of hand-dug well water installed in the area in October 2003. The incident was reported in national newspapers, and the previously active population has been living in fear due to the unfamiliar disease.

This work was therefore designed to investigate the cause of this strange disease by assessing the physico-chemical and microbial properties of the well water and to try and give possible explanation to the causative agent of the disease.

MATERIAL AND METHODS

Study Area and Sampling Sites

The study was conducted in Bar village of Bununu district of Tafawa Balewa Local Government Area of Bauchi State, North-East Nigeria (Figure 1). The village is situated in the wet Tropical Savannah zone, with its location around latitude 9°54′ and 9°18′ north of the equator and longitude 9°41′ and 9°24′ east of the Greenwich meridian. Bununu district is located in the Sayyawa Chiefdom of the Bauchi South senatorial district, and also lies within the Tropical Savannah agro-ecological zone. It is located at Lat/Long(dec) 9.9052,9.69015 (Figure 2 - 4). The geology in the vicinity of Bar is primarily composed of granite and metamorphic rocks (Umar, 2011). The Bar and Bula villages (Bununu belt) are quite similar to the adjoining rocks in the neighboring Jos-Plateau trending belts of Nigeria. The predominant rock types in the area are metavolcanics and metasedimentary rocks that are intruded by numerous granitoids, as well as felsic and mafic intrusives (Umar, 2011). Metamorphism in the study areas varies from moderate greenschist to high-grade amphibolite facies (Umar, 2011). Dass, Nabordo, Tashan Durumi, Zull and Toro are around the catchment areas and have exhibited several occurrences and potentials of meteorites and gold. Gold mineralization is mainly associated with shear zones, which cut across metavolcanics, metasedimentary, and granitic rocks (Umar, 2011).

Figure 1. Map of Nigeria (source; http://www.maphill.com)

Figure 2. Location of Tafawa Balewa LGA, Bauchi State

Figure 3. Location of Bar village, Tafawa Balewa LGA

Figure 4. GPS capture of the study area

Water Sampling

The representative water samples were collected from two (2) hand dug-out wells used by the people of Bar village of Tafawa Balewa L.G.A of Bauchi State for drinking, cooking and other domestic purposes. Samples of water (100mL) from each well were collected in *Sterile WhirlPak* sampling bags for chemical analysis and the same quantity taken using special *Sterile polyethylene* containers (Samra et al, 2008) for microbiology analysis. When collecting the water samples from the hand-dug wells, a clean properly rinsed rubber bucket was used to fetch the well waters. Sample bottles were rinsed with deionized water twice before samples were collected.

One liter each of the samples collected were preserved and a volume of 0.5 mL concentrated nitric acid which was obtained from Water and Sanitation Agency (WATSAN) laboratory, Bauchi and kept in ice-chests with ice packs at a temperature of 4 °C before transportation to same laboratory. The samples were stored in that temperature until the analyses were completed.

Figure 5: Sampling Well 1

Figure 6: Sampling Well 2

Methods

The determination of colour in the laboratory was carried out by the use of a spectrophotometer. The instrument gives a direct reading value of the colour. Physical water quality parameters, such as pH, temperature (TEMP), conductivity (COND), total dissolved solids (TDS) and dissolved oxygen (DO) were measured *in situ* using a special multi-parameter meter *HACH HQ40d* (DO in mg/L) and a *Mettler Tolledo SevenGo* portable meter (COND, TDS, TEMP & pH). Turbidimeter was used for turbidity measurement. Fluoride was measured by the use of potentiometric method while elemental analysis was carried out by the use of spectrophotometric method (AAS). The widely used Pour Plate method (Taylor et al., 1983) was used in culturing, enumeration and isolation of bacteria and fungi.

Data on the water quality parameters of the water samples from the wells were subjected to repeated measure analysis of variance (ANOVA) using SPSS software package (Version 21).

RESULT AND DISCUSSION

Physical Parameter of Water Samples

Table 1 shows the physical parameters of water samples obtained from the two wells in the study area. The results indicated that all water quality parameters have their mean concentration values below the permissible standards, except colour which total mean concentration values of 16.5 ± 0.65 TCU and 15.3± 0.65 TCU for well 1 and well 2 respectively, are relatively above the allowable unit range of 15 TCU (NIS-554-2015).

Table 1: Results of physical parameters of water samples obtained from two wells of the study area

Parameter	Water Sample S_1	Water Sample S_2	NIS STD MPL
Temperature, ^{0}C	26.1±0.21	25.6±0.21	Ambient
TDS, mg/l	210±7.06	110±7.06	500
CND, uS/cm	430±19.55	230±19.55	1000
Turbidity, NTU	3.0±0.05	2.5±0.05	5
Colour, TCU	16.5±0.65^a	15.3±0.65	15
Odour/Taste	Unobjectionable	Unobjectionable	Unobjectionable
pH	7.4±0.28	7.4±0.28	6.6 – 8.5

Key: CND – Conductivity; TDS – Total dissolved solids; NTU – Nephelomeric turbidity; MPL – Maximum permissible limit

Values are expressed as mean ± SEM, n = 4. ^{a}Values are significantly higher than MPL ($p < 0.05$)

Elemental Analysis of Water Samples

Table 2 shows the mean concentrations of the metal ions, DO, and BOD in the water samples obtained from the two water sources in the study area. The result showed that magnesium and cadmium ions were far higher than the maximum permissible limits in drinking water when compared to the NIS while other metals were within the permissible limit. For magnesium, the total mean concentration values of 185 ± 6.55 mg/L and 105± 6.55 mg/L for well 1 and well 2 respectively, are relatively above the allowable maximum permissible limit of 20 mg/L (NIS-554-2015).

The heavy metal, Cadmium, is found to be significantly ($p<0.05$) higher than the permissible limits in water samples S_2 (0.16 mg/L) and S_1 (0.11 mg/L). Zinc concentration was observed to be slightly high in the S_2 (3.13 mg/L ± 0.13) as against the NIS value which is 3 mg/L.

Table 2: Chemical parameters of water samples obtained from two wells of the study area

Parameter	Water Sample S_1	Water Sample S_2	NIS STD MPL
Ca^{2+} mg/L	62.24±2.02	30.88±2.02	150
Mg^{2+} mg/L	185±6.55[a]	105±6.55[a]	20
Al^{2+} mg/L	0.004±0.001	0.003±0.001	0.2
Cu^{2+} mg/L	0.15±0.05	0.07±0.05	1
Fe^{2+} mg/L	0.02±0.01	0.08±0.01	0.3
NO^{-}_3 mg/L	18.92±0.13	28.16±0.03	50
CN^- mg/L	0.003±0.001	0.001±0.001	0.01
Ni^{2+} mg/L	0.001±0.00	0.0012±0.00	0.02
Cd^{2+} mg/L	0.11±0.01[a]	0.16±0.01[a]	0.003
Pb^{2+} mg/L	0.005±0.00	0.0032±0.00	0.01
Al^{2+} mg/L	0.006±0.000	0.017±0.000	0.2
Zn^{2+} mg/L	2.86±0.13	3.13±0.13	3
PO_4^{2-} mg/L	0.05±0.13	0.0032±0.13	0.1
SO_4^{2-} mg/L	1.0±0.13	2.0±0.13	100
Cl^- mg/L	34.0±1.78	40.0+1.78	250
F^- mg/L	0.17±0.02	0.10±0.02	1.5
DO mg/L	8.8±0.08	7.4±0.08	30
BOD	1.98±0.02	1.82±0.02	25

Values are expressed as mean ± SEM, n = 4. [a]Values are significantly different from standard ($p < 0.05$)

Microbial Analysis of Water Samples

Table 3 shows the mean values of the microbial parameters in the water samples obtained from the two wells in the study area. The microbial values for the wells all fall below the maximum allowable limit stated by the NIS standard.

Table 3: Results of Microbial parameters of the water samples obtained from two wells of the study area

Parameter	Water Sample S_1	Water Sample S_2	NIS STD MPL
Total Coliform count cfu/ml	8	6	10
E.coli cfu/100ml	0	0	0
Protozoa – giardia	0	0	3
Faecal Streptococcus/enterococcus cfu/100ml	0	0	0
Clostridium perfringens spore cfu/100ml	0	0	0

Discussion

Concentrations of Water Quality Parameters Relative to their Benchmark Values

Assessing water quality status is crucial in comparing the measured water quality parameters with the Nigerian Standard for Drinking water quality (NIS-554-2015).

Table 1 shows the results of the water quality parameter which indicated that all the water quality parameters have their mean concentration values below the maximum permissible limits, except colour which had a total mean concentration value of 16.5 ± 0.65 TCU and 15.3± 0.65 TCU for well 1 and well 2 respectively. These values are relatively above the maximum permissible limits of 15 TCU (NIS-554-2015). The reason for this may be attributed to the presence of dissolved ions and organic matter. However, according to the Nigerian standard, there is no feasible health impact on the consumption of water with high colour presence. pH of naturally occurring surface water affects its colour. Indicator effect is a phenomenon where there is an increase in colour as a result of increasing pH of the test sample. Dissolved or colloidally dispersed substances in water causes the absorption of certain wavelengths of light giving them a certain colour appearance. Colour alone cannot elicit adverse health effect but the nature and composition of the dissolve particulates could be harmful.

Chemical and Microbiological Analysis of Water

Comparison of the values of the parameters obtained after analysis of water from the two sources with that of NIS showed a higher concentration of magnesium ions and cadmium while other parameters measured fall within the permissible limit (table 2). For magnesium, the total mean concentration values of 185 ± 6.55 mg/L and 105± 6.55 mg/L for well 1 and well 2 respectively, are above the maximum permissible limit of 20 mg/L (NIS-554-2015). Magnesium in conjunction with calcium when dissolved in water makes water hard. The rise in the magnesium content of water concurrently leads to increase in water hardness which is associated with the amount of dissolved multivalent cations in the water. Hard water is not a common health hazard (De Oliveira et al., 2012), but it adds a little quantity magnesium and calcium in diets of human. In some instance, water can be a main contributor of calcium and magnesium to the diet where their dissolution in water is quite high, and the correlation between hard water consumption and reduced cardiovascular disease mortality had been suggested by some research (De Oliveira et al., 2012). Symptoms of magnesium excessive intake, which usually develop after serum concentrations exceed 1.74–2.61 mmol/L, can include nausea, regurgitation, reddening of the face, urine retention, ileus, depression, and drowsiness leading to muscle weakness, difficulty breathing, severe hypotension, spasmodic heartbeat, and cardiac arrest (Musso et al., 2010). The source of high magnesium in the study area could be due to hydrolysis of fosterite (Mg Olivine) shown in the reaction below:

$$Mg_2S_1O_4 + 4CO_2 + 4H_2O \leftrightharpoons 2Mg^{2+} + 4HCO^-_3 + H_4S_1O_4$$

If the specification of Nigerian Standard for drinking water quality (NIS 554-2015) is used as a reference, the maximum concentration levels of Cd exceed the risk screening values, which indicated that there existed a potential water contamination risk in the study area.

Cadmium is a heavy metal that is found to be far higher than the maximum permissible limit in water sample S_2 which is 0.16 mg/L and is also high in water sample S_1 (0.11 mg/dl) as against the NIS maximum permissible limit of 0.003 mg/L. However, the mean content of Cd in the waters was not only higher than risk screening value, but also exceeded the risk intervention value issued by the specification of Nigerian Standard for drinking water quality control criteria, suggesting a comparatively higher degree of contamination for Cd in water consumed in the village.

Cadmium is an inessential and harmful element for humans. Exposure to cadmium is harmful at even very low levels and with injurious health implications and as well as adverse environmental degradation. Cadmium, cadmium chloride and some other cadmium compounds exhibit similar range of toxicological properties. Cadmium alongside arsenic, lead and mercury are among ten chemicals of major public health concern listed by WHO (IPCS, 2005–2007). Cadmium cannot be degraded in nature and thus once it finds its way into the environment, it remains in circulation. Cadmium and cadmium compounds are relatively soluble in water when compared to other metals. Therefore, they are more easily absorbed and mobile, for instance, in soil, generally more bio-available and tend to bio-accumulate in plants and animals, through uptake and drinking of water, or through the food chain.

When metals are ingested either via drinking water or through the food chain, they accumulate in the kidney and liver of the body (Dabak et al., 2011; Dabak et., 2012). From recent studies, renal tubular damage is most likely the health implication generated from the consumption of this metal. Cadmium ingestion causes an increase in urinary protein excretion due to the damage of proximal tubular cell. (Dabak et al., 2015a; Dabak et., 2015b). The degree of the effect depends on the length of action and amount of exposure.

At levels somewhat higher than those for which kidney proteinuria is an early effect indicator, skeletal damage is manifested. It expected that public notification is required when any source of drinking water contains more than 5 parts per billions of cadmiums, as this could be a serious health consequence to the community (Genchi et al., 2020). The results of this study show that Cadmium concentration is far above the 5 parts per billion. This could have been or part of the cause of the strange disease observed in the area.

Low-dose exposure to elevated levels of cadmium over a long period of time has different health consequences than a single high dose exposure. Acute health effects, such as flu-like symptoms, intestinal tract ailments and lung irritation, can be caused by intense short-term exposure (Genchi et al., 2020). Anomalously high isolated Cd values in the two wells in the study area could be as a result of minerals deposits in the earth's crust where the wells were dug. The hazards of Cd are considered to be potential carcinogen and other causes of many diseases – especially cardiovascular, kidney, blood, nerve and bone diseases. Thus, local residents who are exposed to Cd excessively through agricultural product consumption and contaminated water consumption are likely to come down with these ailments (Li et al., 2018; Wei et al., 2009; Fu et al., 2012).

Zinc concentration was observed to be slightly high in the S_2 water sample (3.13 mg/L $\pm$ 0.13) as against the NIS value which is 3 mg/L. No possible health impact is expected from the consumption of water containing such amount of the metal.

Bacteriological analysis shows that both of the samples have Coliform count that did not exceed recommended value (table 3). The bacteria, Coliform, are not harmful microorganisms and they are also to be mildly infectious.

CONCLUSION

The assessment of the water quality revealed that most of the water quality parameters measured were within the maximum permissible limits with the exception of colour. Cadmium and Magnesium concentration values which were found to be above the maximum permissible limits of the NIS. The measured parameters of well 2 were higher than that of well 1. Based on the findings of this study, Cd could have been the primary pollutant which could be the potential prime suspect involved in the adverse strange health challenges experienced by the villagers.

Authors' Contributions

CO contrived, planned, carried out and funded the study; CO also prepared the manuscript; JD supervised, mentored and provided significant input to several sections to improve clarity and accuracy; KJ reviewed, edited validated the draft. The final manuscript was perused and approved by all the authors.

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Conflict of Interests

The authors declare that there are no conflicts of interest related to this study.

REFERENCE

[1] H Ali and E Khan. (**2017**). Environmental chemistry in the twenty-first century. *Environmental Chemistry Letters*, *15*(2), 329-346.

[2] JP Ambrosi (**2017**). Pollution and ecological risk assessment of heavy metals in the soil-plant system and the sediment-water column around a former Pb/Zn-mining area in NE Morocco. Ecotoxicology and Environmental Safety, 144, 464.

[3] JD Dabak; SY Gazuwa and GA Ubom (**2011**). Comparative hepatotoxicity test of cadmium and lead in rats. *Journal of Medicine in the Tropics*. 14: 12-18.

[4] JD Dabak; SY Gazuwa and GA Ubom (**2012**). Nephroprotective potential of Ca and Mg against Cd and Pb nephrotoxicity in rats. *Asian Journal of experimental Biological sciences*. 3(1): 214-221.

[5] JD Dabak; SY Gazuwa and GA Ubom (**2015a**). The Nephroprotective Effects of Graded Concentrations of Calcium and Magnesium on Nephrotoxicities Induced by a Constant Toxic Concentration of Cadmium and Lead in Rats. *International Journal of Biochemistry Research and Review*. 7(1): 36-44.

[6] JD Dabak; SY Gazuwa and GA Ubom. (**2015b**). The hepatoprotective effects of concomitant administration of calcium and magnesium on cadmium and lead co-intoxicated rats. *British Journal of Applied Science & Technology* 11(5): 1-10.

[7] JD Dabak; SY Gazuwa and GA Ubom (**2017**). Nephroprotective effect of graded concentrations of Mg on cd and Pb co-intoxicated rats. *Journal of Basic and Applied Research International* 23(1): 41-50.

[8] JD Dabak; SY Gazuwa and GA Ubom (**2018**). Effect of grade concentrations of Ca on nephrotic cells of Cd and Pb co-intoxicated rats. *Journal of Environmental Toxicology and public Health* 3: 9-17.

[9]GS De Oliveira Jr; JS Knautz; S Sherwani, and RJ McCarthy (**2012**). Systemic magnesium to reduce postoperative arrhythmias after coronary artery bypass graft surgery: a meta-analysis of randomized controlled trials. *Journal of cardiothoracic and vascular anesthesia*, *26*(4), 643-650.

[10] S Fu; CY Wei (**2012**). Multivariate and spatial analysis of heavy metal sources and variations in a large old antimony mine, China. *Journal of Soils and Sediments*, 13 (1), 106.

[11] G Genchi; MS Sinicropi; G Lauria; A Carocci and A Catalano (**2020**). The Effects of Cadmium Toxicity. *International journal of environmental research and public health*, 17(11), 3782. https://doi.org/10.3390/ijerph17113782

[12] MA Hashem; MS Nur-A-Tomal; NR Mondal and MA Rahman. (**2017**). Hair burning and liming in tanneries is a source of pollution by arsenic, lead, zinc, manganese and iron. *Environmental Chemistry Letters*, *15*(3), 501-506.

[13] IPCS (**2005–2007**). Cadmium, cadmium chloride, cadmium oxide, cadmium sulphide, cadmium acetate, cadmium sulphate. Geneva, World Health Organization, International Programme on Chemical Safety (International Chemical Safety Cards 0020, 0116, 0117, 0404, 1075 and 1318; http://www.who.int/ipcs/publications/icsc/en/index.html).

[14] JM Ishaku & HI Ezeigbo (**2010**). Seasonal variation in chromium hexavalent and copper contamination in groundwater of Jimeta-Yola Area, Northeastern Nigeria. *Global Journal of Geological Sciences*, *8*(2).

[15] FU Khan; AU Rahman, A Jan. and M Riaz (2004). Toxic and trace metals (Pb, Cd, Zn, Cu, Mn, Ni, Co and Cr) in dust, dustfall/soil. *Journal of the Chemical Society of Pakistan (Pakistan)*, *26*.

[16] M Lee; IS Paik; I Kim; H Kang and S Lee. (**2007**). Remediation of heavy metal contaminated groundwater originated from abandoned mine using lime and calcium carbonate. *Journal of Hazardous materials*, 144 (1-2), 208.

[17] XY Li; ZG Li; CJ Lin; Bi, XY Liu; X Feng; H Zhang; J Chen and TT Wu (**2018**). Health risks of heavy metal exposure through vegetable consumption near a large-scale Pb/Zn smelter in central China. Ecotoxicology and Environmental Safety, 161, 99.

[18] CG Musso (**2010**). Magnesium metabolism in health and disease. Int Urol Nephrol; 41:357-62.

[19] LB Pan; Y Wang; J Ma; Y Hu; BY Su; GL Fang; L Wang and B Xiang. (**2018**). A review of heavy metal pollution levels and health risk assessment of urban soils in Chinese cities. Environmental Science and Pollution Research, 25 (2), 1055, 56.

[20] W Qu; EJ Tokar; AJ Kim; MW Bell and MP Waalkes (2012). Chronic cadmium exposure in vitro causes acquisition of multiple tumor cell characteristics in human pancreatic epithelial cells. Environmental health perspectives, 120(9), 1265-1271.

[21] Z Samra; J Bahar; L Madar-Shapiro; N Aziz; S Israel and J.Bishara (**2008**). Evaluation of CHROMagar KPC for rapid detection of carbapenem-resistant Enterobacteriaceae. *Journal of clinical microbiology*, *46*(9), 3110- 3111.

[22] F Shen; RM Liao; A Ali; A Mahar; D Guo; RH Li; XN Sun, MK Awasthi, Q Wang and ZQ Zhang. (**2017**). Spatial distribution and risk assessment of heavy metals in soil near a Pb/Zn smelter in Feng County, China. Ecotoxicology and Environmental Safety, 139, 254.

[23] SON (NIS 554-2015). Standards Organization of Nigeria, Nigerian Standard for drinking water quality pp 15-16.

[24] JX Tang; MM He, Luo, M Adeel and F Jiao (**2020**). Heavy metals in agricultural soils from a typical mining city in China: spatial distribution, source apportionment, and health risk assessment. Polish of Journal Envrionmental Studies, 29 (2), 1,

[25] RH Taylor; MJ Allen and EE Geldreich. (**1983**). Standard plate count: a comparison of pour plate and spread plate methods. *Journal-American Water Works Association*, *75*(1), 35-37.

[26] SU Umar (**2011**). Geology and structural analysis of foliation planes of granite gneiss exposed around Kanwara, Dass, Bauchi. Unpublished Bachelor Thesis, Abubakar Tafawa Balewa University Bauchi.

[27] H Wang; IC Prentice; TF Keenan; TW Davis; IJ Wright; WK Cornwell and Peng, C. (**2017**). Towards a universal model for carbon dioxide uptake by plants. *Nature plants*, *3*(9), 734-741.

[28] CY Wei; C Wang and LS Yang. (**2009**). Characterizing spatial distribution and sources of heavy metals in the soils from mining-smelting activities in Shuikoushan, Hunan Province, China. *Journal*

of Environmental Sciences, 21 (9), 1230.

[29] M Ye; P Yan; S Sun; D Han; L Xiao Zheng; S Huang; Y Chen and S Zhuang (**2017**). Bioleaching combined brine leaching of heavy metals from leadzinc mine tailings: Transformations during the leaching process. Chemosphere, 168, 1115.

[30] JK Zhuang Hourigan; PL Koch; BD Ritts and ML Kent-Corson (**2011**). Isotopic constraints on intensified aridity in Central Asia around 12 Ma. *Earth and Planetary Science Letters*, *312*(1-2), 152-163.