ANALYSIS OF GROUND–WATER AND STREAM FOR PHYSICO–CHEMICAL PARAMETERS IN DOMA LOCAL GOVERNMENT OF NASARAWA STARE, NIGERIA

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Abstract

The water quality examination in Doma Local Government Area of Nasarawa State, Nigeria was conducted by determining the physico-chemical parameters of nine water samples collected from the wells, boreholes and streams located in major towns of the local government area. Results showed temperature range of 28.60 to 29.10ºC, pH (7.15 to 7.45), conductivity (0.32 to 0.47 μscm^{-1}), total dissolved solids (284 to 453 mgL^{-1}), total suspended solids (242 to 394 mgL^{-1}), alkalinity (0.92 to 1.54 mgL^{-1}), dissolved oxygen (63 to 85 mgL^{-1}), biochemical oxygen demand (3.61 to 5.74 mgL^{-1}), chemical oxygen demand (4.01 to 7.31 mgL^{-1}), turbidity (0.13 to 0.30 NTU^{-1}), chloride (0.11 to 0.34 mgL^{-1}), and total hardness (1.26 to 4.32 mgL^{-1}). Results of atomic absorption spectrophotometric (AAS) analysis of samples for dissolved minerals showed mean metal concentrations to vary widely depending on the geochemical sources of the water samples as follows: Na (1.89 to 2.84 mgL^{-1}), K (1.65 to 2.52 mgL^{-1}), Pb (0.05 to 0.85 mgL^{-1}), Cr (0.18 to 0.52 mgL^{-1}), Mn (0.36 to 0.81 mgL^{-1}), Fe (1.29 to 1.86 mgL^{-1}), Zn (0.51 to 1.00 mgL^{-1}), Ni (0.44 to 0.79 mgL^{-1}), Mg (8.88 to 13.34 mgL^{-1}), Cu (0.55 to 0.69 mgL^{-1}) and Ca (6.14 to 10.67 mgL^{-1}). The results obtained for the physicochemical parameters agreed with the limits set by both national and international bodies for drinking and domestic water with few exceptions. However, there is a need for further monitoring for these water bodies for the benefit of mankind.

Keywords: *Physico–chemical, parameters, well, stream, borehole, Nasarawa State.*

INTRODUCTION

Water is a universal solvent essential to man for various activities such as drinking, cooking, industrial and agricultural processes, waste disposal and human recreation. The two main problems man contends with are the quantity (source and amount) and quality of water in Nigeria (Adeniyi, 2004). Yet man's assessment of the value of water is very low until he finds himself without it (Aremu, 2008). Man found the need to explore how sources of water supply as society began to develop in order to accommodate the progressively enlarging domestic, agricultural and industrial demands since water appears to have no substitute. It therefore, contributes directly or indirectly to all aspect of development of life (McCann, 1993). Indeed, Adetoye (1982) referred to water as the "matrix of life" because the progress of any development in the community, state and nation at large lies on the availability of potable water. In view of its occurrence and distribution pattern, water is not easily available to man in the desirable amount and quality. This is a problem experienced in most cities and towns in the developing nations not to mention their rural settings.

experienced in this part of the world (Edwards, 1993) sustainable development and essential demand element in health, food production and poverty reduction (Adekunle *et al.,* 2004). Sources of and it is generally obtained from two principal natural sources: surface water such as fresh water, lakes, rivers, streams, etc, and ground water such as water, and borehole water (McMurry & Fay, 2004; Mendie, 2005).

Water quality is a term that is most frequently used, but rarely defined, probably because it has no fixed definition, but apparently fairly well understood by users. Thus, the quality of water is a reflection of the source environment and the activities of man, including the use and management measures. However, the desirable properties of water quality should include: Adequate amount of dissolved oxygen at all time, a relatively low organic content, pH value near neutrality, moderate temperature, and freedom from excessive amount of infectious, toxic substances and mineral matter (Adeniyi, 2004; Aremu & Inajor, 2007). Thus, an assured supply of water both qualitatively and quantitatively for these purpose greatly improves the social and economic activities of the people (Faniran, 1977; Akujuru, 2001; Oyebande, 1986). A clean, safe supply of drinking water, which is free from harmful micro-
issolved minerals is essential for life and
n of public health. Accessibility and availability of fresh clean water is a key to

contaminants in well water could be from the use of dirty, rusted and unhygienic containers used for fetching water from the well, disposal of waste close to the well e.g. cans, containers and leaving the well open, construction of wells close to toilets, gutters and soak away (Karanth, 1993). In fact, due to inadequate supply of pipe-borne water in villages, towns and cities in Nigeria, many people have been sourcing their daily water needs from wells, boreholes, and streams. Although, the standards vary from place to place, the objective anywhere is to reduce the possibility of spreading water borne diseases to the barest minimum in addition to being pleasant to drink, which implies that it must be wholesome and potable in all respect (Edet & Offiog, 2003). Indeed, it has been estimated that as many as 80 % of all diseases in the world are associated with unsafe water (Morgan, 1984). Therefore, a good knowledge of physico-chemical and bacteriological qualities of sources of water in this area is necessary so as to guide its suitability and safety for use.

This research work was aimed at:

(1) Determining the quality of ground and surface water by carrying out a physico-chemical analysis of the water samples from streams, boreholes and wells which are the main sources of potable water for the inhabitants of Doma Local Government Area, Nasarawa State, Nigeria. (2) Assessing the influence of mineral content on ground and surface water and (3) Comparing the results obtained with the standards set out by the European Union (EU) and the World Health Organization (WHO) for water quality evaluation.

MATERIALS AND METHODS

Study Area

Doma Local Government Area is one of the Local Government Areas in Nasarawa State, Nigeria. It is located in north-central geopolitical zone of Nigeria otherwise known as the middle belt region, with the villages: Rutu, Yalwan Ediya, Alagye, etc and lies within latitude 08º66″ – 08º72″ north and longitude 07º64″ – 07º69″ east. Doma is the fifth largest populated Areas in Nasarawa state, after Lafia the state capital, Keffi, Karu and Akwanga Local Government Areas, respectively. The location of the Annur College of Education (ACE), Doma, Federal Government Science and Technical College (FGSTC), Doma plus the already existing Government Girls Science School, Government College, etc. has led to rapid population growth of the area (Fig 1).

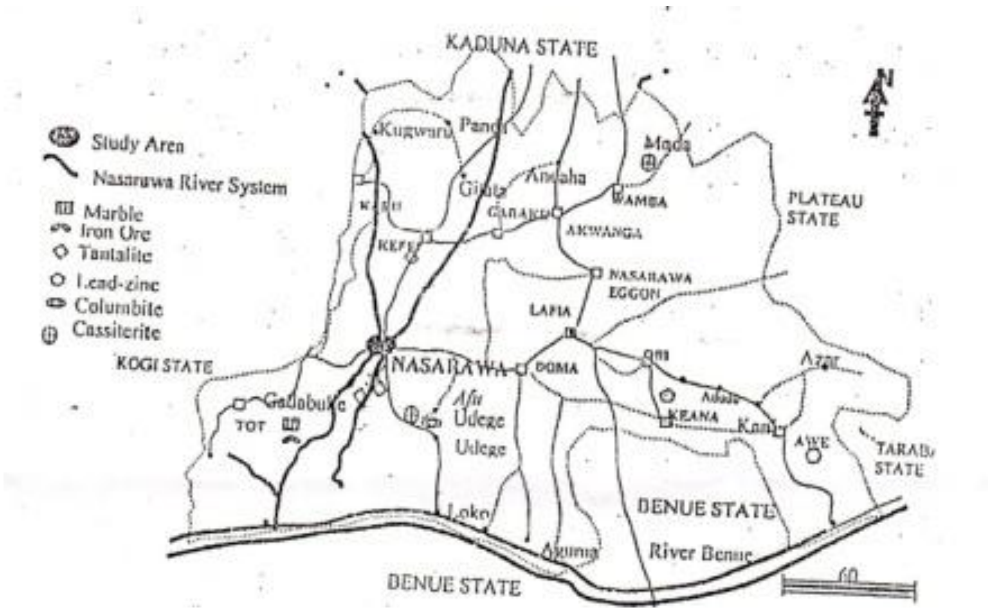

Fig. 1: Map of Nasarawa State showing the study area

According to the 2006 census, Doma has a population of 51,662 people (Moumouni *et al.,* 2006). An investigation through major towns in the local government revealed that the major water sources for most activities is groundwater (wells and boreholes), and sometimes surface water (streams and rivers) during the dry season. These water sources are the alternatives to the inconsistent flow of pipe borne water supply, which would have been more reliable source of safe water for the growing population. Therefore, constant monitoring of surface water and groundwater quality in the area is needed so as to record any alteration in the quality, which may lead to outbreak of health disorder or serious health effect.

Physico–chemical Analyses

The water sample pH was measured using a BNC pH meter and electrical conductivity was measured using conductivity meter model NATOP PB5 (London, UK). Other physico–chemical parameters determined in the water samples were: alkanity and total hardness by titrimetry method (APHA, 1995), chloride ion was measured by chloride ion meter (Model KRK, Cl–5Z Japan), phosphate (molybdophosphoric blue colour method in H_2SO_4 system) and nitrate were estimated using a PYE UNICAM visible spectrophotometer (London, UK), total dissolved solids by gravimetric method and chemical oxygen demand (COD) by APHA (1995) method. All the chemicals used were of analytical reagent grade and obtained from British Drug Houses (BDH), London).

Mineral Analysis

The elemental analysis (except Na and K) was done in the water samples using Perkins Elmer and Oak Brown (UK) atomic absorption spectrophotometer. The instrument settings and operational conditions were done in accordance with the manufacture's specifications. Na and K were determined by using a flame photometer (Model 405, Corning, UK).

Statistical Analysis

All the data generated were analyzed statistically. Parameters evaluated were mean, standard deviation and coefficient of variation.

RESULTS AND DISCUSSION

Tables 1 to 3 show the physico-chemical parameters of the water samples collected from the wells, boreholes and streams representing the various sources of drinking water from three different geographical zones of Doma Local Government Area of Nasarawa State, Nigeria. There is a wide variation in the sources obtained for the parameter which are revealed by coefficient of variation percent (CV %) of each sample location which ranged between 0.89 % in temperature and 54.55 % in chloride for well water samples (Table 1); 2.56 % in pH and 100.00% in chloride for the borehole water samples (Table 2); 2.48 % in TSS and 46.31% in chloride for the stream water samples (Table 3). Similar observations have earlier been made by Aremu *et al.* (2008); Adeniyi (2004); Ahmed (2002).

Table 1: Physico-chemical analysis of three well water samples from Doma LGA, Nasarawa State, Nigeria

Parameter	AWW	LWW	SWW	Mean	SD	CV%
pH	7.45	7.15	7.36	7.32	0.15	2.05
Temperature (^{0}C)	28.60	29.10	29.0	28.90	0.26	0.89
Chloride (mgL^{-1})	0.21	0.34	0.11	0.22	0.12	54.55
Turbidity (NTU^{-1})	0.13	0.30	0.14	0.19	0.09	47.37
Conductivity µSCM^{-1})	0.32	0.38	0.47	0.39	0.08	20.51
NO_3 (mgL^{-1})	ND	ND	ND	NA	NA	NA
Alkalinity (mgL^{-1})	1.54	0.92	1.21	1.22	0.31	25.41
BOD (mgL^{-1})	5.02	3.61	5.74	4.79	1.08	22.55
COD (mgL^{-1})	7.31	4.01	6.22	5.85	1.72	29.40
TDS (mgL^{-1})	453	284	361	366.00	84.61	23.12
TSS (mgL^{-1})	242	315	394	317.00	76.02	23.98
% DO_2	63	85	70	72.67	11.24	15.47
Total hardness (mgL^{-1})	4.32	1.26	4.32	3.30	1.77	53.64

AWW = Angwan Alarama well water; **LWW =** Lower Benue Housing unit well water; **SWW =** Sarkin Mata well water; **ND =** Not detected; **NA =** Not applicable; **SD =** Standard deviation; **CV% =** Coefficient of variation percent; **BOD =** Biochemical oxygen demand; **TDS =** Total Dissolved Solids; **TSS =** Total suspended solids.

Table 2: Physico-chemical analysis of three boreholes water samples from Doma LGA, Nasarawa State, Nigeria

Parameter	ABW	LBW	SBW	Mean	SD	CV%
pH	6.86	7.21	6.98	7.02	0.18	2.56
Temperature (^{0}C)	26.20	25.40	29.10	26.90	1.95	7.25
Chloride (mgL^{-1})	0.16	0.31	0.52	0.33	0.33	100.00
Turbidity (NTU^{-1})	11.32	7.15	4.58	7.68	3.40	44.27
Conductivity μSCM^{-1})	0.45	0.43	0.35	0.41	0.05	12.19
NO_3 (mgL^{-1})	ND	ND	ND	NA	NA	NA
Alkalinity (mgL^{-1})	2.19	1.83	0.59	1.54	0.84	54.55
BOD (mgL^{-1})	6.30	5.97	6.78	6.35	0.41	6.46
COD (mgL^{-1})	5.53	7.66	4.96	6.05	1.42	23.47
TDS (mgL^{-1})	382	412	340	378.00	36.17	9.57
TSS (mgL^{-1})	253	198	305	252.00	53.51	21.23
% DO_2	104	54	80	79.33	25.01	31.53
Total hardness (mgL^{-1})	3.97	2.60	4.13	3.57	0.84	23.53

ABW = Angwan Alarama borehole water; **LBW =** Lower Benue Housing unit borehole water; **SBW =** Sarkin Mata borehole water; **ND =** Not detected; **NA =** Not applicable; **SD =** Standard deviation; **CV% =** Coefficient of variation percent; **BOD =** Biochemical oxygen demand; **TDS =** Total dissolved solids; **TSS =** Total suspended solids.

Table 3: Physico-chemical analysis of three stream samples from Doma LGA, Nasarawa State, Nigeria

Parameter	ASW	LSW	SSW	Mean	SD	CV%
pH	6.73	6.12	5.92	6.26	0.42	6.71
Temperature (^{0}C)	27.3	27.1	28.5	27.63	0.76	2.75
Chloride (mgL^{-1})	2.15	1.55	0.76	1.49	0.69	46.31
Turbidity (NTU^{-1})	3.52	2.23	1.67	2.47	0.95	38.46
Conductivity μSCM^{-1})	0.58	0.46	0.65	0.56	0.09	16.67
NO_3 (mgL^{-1})	ND	ND	ND	NA	NA	NA
Alkalinity (mgL^{-1})	1.75	0.82	1.29	1.29	0.47	36.43
BOD (mgL^{-1})	6.32	6.18	6.71	6.40	0.27	36.43
COD (mgL^{-1})	5.76	6.01	5.20	5.66	0.41	7.24
TDS (mgL^{-1})	469	441	534	481.33	47.71	9.91
TSS (mgL^{-1})	302	295	310	302.33	7.51	2.48
% DO_2	100	61	59	73.33	23.12	31.53
Total hardness (mgL^{-1})	3.89	3.81	4.09	3.93	0.14	3.56

SD = Standard deviation; **CV% =** Coefficient of variation percent; **ND =** Not detected; **NA =** Not applicable; **ASW =** Angwan Alarama stream water; **LSW =** Lower Benue Housing unit stream water; **SSW =** Sarkin Mata stream water.

Table 4 shows the standard comparison of the accepted level of mean values of physico-chemical parameters of wells, boreholes and streams, respectively. The pH values of the water ranged from about neutral to slightly alkaline (6.5 to 8.5) and the mean pH values of all the water sources fall within the range of 6.5 to 8.5, set by World Health Organization (WHO, 1971) and European Union (2007). The pH values, which give the indication of acidity and alkalinity of the waters, showed that the surface and ground waters in the area are safe for agricultural, recreational and domestic uses. Temperature values (27.63 to 28.90^{o}C) are above the level recommended values of 25.00^{o}C, the turbidity value which ranged from 0.19 (NTU^{-1}) in well water sample to 2.47 (NTU^{-1}) in stream are close to the one recorded for some ponds and associated food crops in Nigeria (Aremu *et al.*, 2005) and differ from some wells, boreholes and streams in other parts of the country, Nigeria (Aremu *et al.*, 2008; Akhionbare, 2004; Adeyeye, 1997). Turbidity is mainly the function of suspended materials in the water sample which ranged from colloidal to coarse dispersion. The electrical conductivity (EC) of the water samples ranged between 0.39 μscm^{-1} in well to 0.56 in stream which fall within WHO recommended limits of 250 μscm^{-1}. The total dissolved solids and alkalinity values of the water samples in the area are within the recommended limits, respectively for drinking water by WHO (Table 4). The concentration for chloride ranged between 0.22 mgL^{-1} in well and 1.49 mgL^{-1} in stream and for nitrate, it was not available in both ground water and surface water samples. In this study, the value, 1.49 mgL^{-1} of chloride obtained for the surface water in the area is an indication that the stream will conveniently support aquatic life without ecological effect (Fried, 1991). Chloride is present in nearly all natural waters at varying concentrations depending on the geochemical conditions. Chlorides are the most stable component in water with concentration being unaffected by most natural physico-chemical or biological processes (Oludare *et al.*, 2002). The dissolved oxygen (DO) and biochemical oxygen demand after five days (BOD_5) were found within the range of 72.67 to 79.33 mgL^{-1} and 4.79 to 6.40 mgL^{-1}, respectively. The DO is an important water quality parameter and has special significance for aquatic organisms in natural waters (Willock *et al.*, 1981). The highest DO value (79.33 mgL^{-1}) obtained for the borehole water sample may be due to aeration process during water treatment.

Table 4: Level of physico-chemical properties (mgL^{-1}) in the well, borehole and stream water samples compared in Doma, Doma LGA, Nasarawa State, Nigeria

Parameter	Well	Borehole	Stream	EU(mgL^{-1})	WHO (mgL^{-1})
pH	7.32	7.02	6.26	6.5-8.5	6.5 – 8.5
Temperature (^0C)	28.9	26.90	27.63	25	25
Chloride (mgL^{-1})	0.22	0.33	1.49	250	250
Turbidity (NTU^{-1})	0.19	7.68	2.47	5.0	5.0
Conductivity μscm^{-1})	0.39	0.41	0.56	250	250
NO_3 (mgL^{-1})	ND	ND	ND	50	50
Alkalinity (mgL^{-1})	1.22	1.54	1.29	200	200
BOD (mgL^{-1})	4.79	6.35	6.40	Na	na
COD (mgL^{-1})	5.85	6.05	5.66	Na	na
TDS (mgL^{-1})	366.00	378.00	481.33	500	500
TSS (mgL^{-1})	317.00	252.00	302.33	500	500
% DO_2	72.67	79.33	73.33	75	80
Total hardness (mgL^{-1})	3.30	3.57	3.93	150-500	100-500

ND = Not detected; **na =** Not available; **EU =** European Union; **WHO =** World Health Organization

Table 5 shows the metal concentrations (mgL^{-1}) in the three (3) different well water samples that comprise Lower Benue Housing Unit, Angwan Alarama, and Sarkin Mata, respectively located in Doma Local Government Area of Nasarawa State, Nigeria. Magnesium considered as the highest metal concentration in well water sample ranging from 8.07 mgL^{-1} in Obushugu to 20.72 mgL^{-1} in Local Housing Unit followed by calcium which ranged from 9.50 mgL^{-1} in Angwan Alarama to 12.37 mgL^{-1} in Lower Benue Housing Unit. The lowest value recorded was chromium ranged from 0.08 mgL^{-1} in Lower Benue Housing Unit to 0.25 mgL^{-1} in Sarkin Mata. The metal concentrations of cadium and arsenic were not at detectable range of AAS in all the well water samples. The most highly variable mineral was zinc (103.92%) followed by nickel (68.75%) while the lowest variable value recorded was manganese (2.78%). The mineral that had the highest variation equal to or greater than 50% were copper, chromium, nickel and zinc. Table 6 shows the level of metal concentrations (mgL^{-1}) in the three (3) different borehole water samples that consist of Lower Benue Housing Unit, Angwan Alarama and Sarkin Mata, respectively. Magnesium was still highly concentrated ranging from 7.92 mgL^{-1} in Sarkin Mata to 13.62 mgL^{-1} in Angwan Alarama followed by calcium which ranged from 5.24 mgL^{-1} in Sarkin Mata to 8.42 mgL^{-1} in Lower Benue Housing Unit. The lowest value recorded was chromium which ranged from 0.36 mgL^{-1} in Lower Benue Housing Unit to 0.38 mgL^{-1} in Angwan Alarama. Cadium, arsenic and copper were not detected in all the borehole water samples. Manganese recorded the highest variability of 34.88% while the least was chromium with 2.70%. The levels of concentration of metals in the three different streams water samples that comprise of Lower Benue Housing Unit, Angwan Alarama and Sarkin Mata, respectively are presented in Table 7. Magnesium is generally high in all the samples ranged from 5.57 mgL^{-1} in Angwan Alarama to 13.91 mgL^{-1} in Lower Benue Housing Unit followed by calcium which ranged from 3.35 mgL^{-1} in Angwan Alarama to 7.59 mgL^{-1} in Sarkin Mata. The least concentrated metals were lead, chromium and nickel with different ranging values of 0.04 mgL^{-1} in Lower Benue Housing Unit to 0.06 mgL^{-1} in Sarkin Mata, 0.37 mgL^{-1} in Local Housing Unit to 0.67 mgL^{-1} in Sarkin Mata, and 0.26 mgL^{-1} in Angwan Alarama to 061 mgL^{-1} in Sarkin Mata, respectively. Cadium and arsenic were not at detectable range of AAS in all the stream water samples. Magnesium had the highest variability of 49.89 while the least was copper (5.79%).

Table 5: Metal concentration (mgL^{-1}) of the three well water samples in Doma, Doma LGA, Nasarawa State, Nigeria

Metal	AWW	LWW	SWW	Mean	SD	CV%
Na	1.51	2.05	2.13	1.89	0.34	17.99
K	1.70	1.85	2.03	1.86	0.17	9.14
Pb	ND	0.66	1.04	0.85	0.27	31.76
Cd	ND	ND	ND	NA	NA	NA
Cr	0.08	0.20	0.25	0.18	0.09	50.00
Mn	0.37	0.35	0.37	0.36	0.01	2.78
Fe	1.65	1.83	2.10	1.86	0.23	12.37
Zn	0.30	1.11	0.12	0.51	0.53	103.92
As	ND	ND	ND	NA	NA	NA
Ni	0.21	1.09	0.62	0.64	6.44	68.75
Mg	20.72	8.07	11.22	13.34	6.59	49.40
Cu	0.43	0.91	0.32	0.55	0.31	56.36
Ca	12.37	9.50	10.15	10.67	1.50	14.06

SD = Standard deviation; **CV% =** Coefficient of variation percent; **ND =** Not detected; **NA =** not applicable; **AWW =** Angwan Alarama well water; **LWW =** Lower Benue Housing Unit well water; **SWW =** Sarkin Mata well water.

Table 6: Metal concentration (mgL^{-1}) of the three borehole water samples in Doma, Doma LGA, Nasarawa State, Nigeria

Metal	ABW	LBW	SBW	Mean	SD	CV%
Na	2.05	1.99	1.75	1.93	0.16	8.29
K	1.68	1.69	1.59	1.65	0.06	3.64
Pb	0.67	0.60	0.53	0.60	0.07	11.67
Cd	ND	ND	ND	NA	NA	NA
Cr	0.36	0.38	0.36	0.37	0.01	2.70
Mn	0.54	0.26	0.48	0.43	0.15	34.88
Fe	2.15	1.18	1.28	1.54	0.53	34.42
Zn	0.74	0.62	0.82	0.73	0.10	13.69
As	ND	ND	ND	NA	NA	NA
Ni	0.70	1.00	0.66	0.79	0.19	24.05
Mg	9.36	13.62	7.92	10.30	2.96	28.74
Cu	ND	ND	ND	NA	NA	NA
Ca	8.42	7.88	5.24	7.18	1.70	23.68

SD = Standard deviation; **CV% =** Coefficient of variation percent; **ND =** Not detected; **NA =** Not applicable; **ABW =** Angwan Alarama Borehole Water; **LBW =** Lower Benue Housing unit borehole; **SBW =** Sarkin Mata borehole water.

Table 7: Metal concentrations (mgL^{-1}) of the three stream water samples in Doma, Doma LGA, Nasarawa State, Nigeria

Metal	ASW	LSW	SSW	Mean	SD	CV%
Na	3.15	2.10	2.92	2.84	0.71	25.00
K	2.87	1.39	3.30	2.52	1.00	39.68
Pb	0.04	ND	0.06	0.05	0.01	20.00
Cd	ND	ND	ND	NA	NA	NA
Cr	0.37	ND	0.67	0.52	0.21	40.38
Mn	0.55	0.79	1.08	0.81	0.27	33.33
Fe	1.29	1.59	0.99	1.29	0.30	23.26
Zn	0.81	1.37	0.83	1.00	0.32	32.00
As	ND	ND	ND	NA	NA	NA
Ni	0.45	0.26	0.61	0.44	0.18	40.91
Mg	13.91	5.57	7.16	8.88	4.43	49.89
Cu	0.69	0.66	0.74	0.69	0.04	5.79
Ca	7.47	3.35	7.59	6.14	2.41	39.25

SD = Standard deviation; **CV% =** Coefficient of variation percent; **ND =** Not detected; **NA =** Not applicable; **ASW =** Angwan Alarama Stream Water; **LSW =** Lower Benue Housing unit stream water; SSW = Sarkin Mata stream water.

Table 8 represents a summary of levels of the mean of the concentrations of metals in the different water samples (i.e wells, boreholes and streams). Magnesium showed the highest concentration in all the different type of waters ranging from 8.88 mgL^{-1} in stream to 13.32 mgL^{-1} in well water samples followed by calcium which varied from 6.14 mgL^{-1} in stream to 10.67 mgL^{-1} in well water sample. The concentration of lead obtained for the all water samples are higher than the WHO limit of 0.01 mgL^{-1} and maximum contaminant level (MCL) of 0.015 mgL^{-1} for drinking water (Nkono & Asubiojo, 1997). Therefore, the ground and surface water samples need to be treated so that the lead level meets these standards before it could be safe for drinking and use for domestic activities. The surface water may not also support recreational purposes until the Pb level is reduced since lead level above 0.01 mgL^{-1} may result in neutrological damage in young children (Fatoki *et al.*, 2002).

Table 8: Level of metal concentrations (mgL^{-1}) in the well, borehole and stream water samples compared in Doma, Doma LGA, Nasarawa State, Nigeria

Metal	Well	Borehole	Stream	EU(mgL^{-1})	WHO (mgL^{-1})
Na	1.89	1.93	2.84	200	200
K	1.86	1.65	2.52	Na	Na
Pb	0.85	0.60	0.05	0.01	0.01
Cd	Na	Na	na	0.005	0.003
Cr	0.18	0.317	0.52	0.05	0.05
Mn	0.36	0.43	0.81	0.05	0.2
Fe	1.86	1.54	1.29	0.2	0.3
Zn	0.51	0.73	1.00	Na	na
As	Na	Na	0.02	0.01	0.01
Ni	0.64	0.79	0.44	0.02	0.02
Mg	13.34	10.30	8.88	Na	0.20
Cu	0.55	Na	0.69	2.0	1.0
Ca	10.67	7.18	6.14	Na	na

na = Not available; **EU =** European Union; **WHO =** World Health Organization

It is a well known fact that minerals are very necessary for life (Aremu *et al.*, 2005; Buss & Robertson, 1976; Adeyeye & Faleye, 2004; Mertz, 1981; Parker, 1972). Magnesium is an essential constituent for bone structure, for reproduction and normal functioning of nervous system. It is also a part of the enzyme system (Shills & Young, 1988). Calcium helps in blood clotting, muscle contraction and in certain enzymes in biochemical process in living organism. Calcium is usually present as carbonate or bicarbonates, sulphate, chloride and nitrate in high saline water (Wright *et al.*, 1988). There is no health objection to high calcium content in water; the limitation being made on the grounds of excessive scale formation (WHO, 1993). The concentrations of Mn and Zn in all the samples are above the WHO limits of 0.1 and 0.05 mgL^{-1} highest desirable level for Mn and Zn in drinking water. They are also above the 0.18 and 0.002 mgL^{-1} levels for Mn and Zn, respectively in water meant for aquatic ecosystem use (Fatoki *et al.*, 2002). On this basis, the surface waters (stream and river) cannot support aquatic life if other conditions are not favourable. The concentration of Cu which ranged from 0.55 mgL^{-1} in well to 0.69 mgL^{-1} in stream is below 1.0 mgL^{-1} set as the maximum that is allowable for a safe drinking water, hence may not pose danger to the community. The concentrations of sodium and potassium ranged from 1.89 mgL^{-1} in well to 2.84 mgL^{-1} in stream and 1.65 mgL^{-1} in borehole to 2.52 mgL^{-1} in stream water samples, respectively. The sodium content in water is important for a healthy person, except when combined with excessive concentrations of sulphate. This combination can cause gastrointestinal initiation (laxative effect) for person placed on low sodium diet because of the heart, kidney, or circulatory ailment or complication of pregnancy. The usual low sodium diet allow in drinking water is 20.00 mgL^{-1} (Ademoroti, 1996). Potassium is primary and intracellular cation, mostly this cation is bound to protein in the body with sodium influencing osmotic pressure and contribution to normal pH equilibrium (Fleck, 1976). The concentrations of sodium and potassium in all the samples fall within the WHO limits of 200 mgL^{-1} and 100 mgL^{-1} and hence water from different sources analysed are desirable level for consumption without any toxic effect.

Iron has the concentration ranged from 1.29 mgL^{-1} in stream to 1.86 mgL^{-1} in well. The values obtained may not be unconnected with the geology or the mineral nature of the soil in the studied area. The lowest value (1.29 mgL^{-1}) obtained exceeds the 0.3 to 1.0 mgL^{-1} permissible level recommended by WHO for the Fe in drinking water (Fatoki *et al.*, 2002). Hence, the waters may have taste and aesthetic problem. Iron is one of the essential components of haemoglobin which is necessary for transport of oxygen in the body of living organism. It also occurs in the prosthetic group of the cytochromes which function in electron transport and in some enzymes like dehydrogenenases (Wheby, 1974); it is also facilitates the oxidation of carbohydrates, proteins and fats. It also contributes significantly to the prevention of anaemia, which is wide spread in developing countries like Nigeria (Bender, 1992). Therefore, the highest concentration of Fe obtained in this analysis is not unacceptable to the consumers, but could give rise to iron-dependant bacteria which in turn can cause further deterioration in the quality of water by production of slimes or objectionable (undesirable) colour. Some methods of aeration of aeration can equally remove or reduce irons content through simple chemicals reaction (Okedi & Oni, 1997). The present of one metal can significantly affect the impact that another metal may have on an organism. The effect of metal can be synergistic, additives or antagonist (Elisler, 1993).

CONCLUSION

The study has presented data on the concentrations of metals and physico–chemical parameters of water samples from the well, borehole and stream in Doma local government area of Nasarawa State, Nigeria. Thus being the most detailed study of its kind on the area. The results showed that some heavy metals and physico–chemical parameters are above the World Health Organization (WHO) limit for drinking water. Thus, the water sources may not be acceptable as water supply to the community. There is therefore a need to ensure that these sources are protected not only from flood but also from dumping of wastes and grazing of animals as it is common around many water sources. Furthermore, the data generated in this study will serve as baseline information with which future environmental impact assessment of anthropogenic activities could be progressively monitored in the area.

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