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Physicochemical and Bacteriological Qualities of Groundwater from Some Localities in the Adamawa Region of Cameroon

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Abstract: The present research was carried out to assess the chemical and microbiological safety of groundwater from eight sampling points in the Adamawa region of Cameroon. Some physicochemical parameters (turbidity, conductivity, alkalinity, total dissolved solids and pH) were determined using standard methods. Minerals and heavy metals were analyzed using Atomic Absorption spectrophotometer while pathogens and waterborne bacteria were screened according to reference methods. Results showed that most physicochemical parameters (pH, salinity, calcium, magnesium, chloride, sulfate and phosphate) were acceptable with regard to existing norms. However, some samples exhibited values above these norms. Turbidity and suspended matter were higher than recommended for drinking water in most samples. Fortunately, no heavy metal was detected in water from the eight localities. With regard to bacteriological safety, only one sample (Mbe) was not contaminated with pathogenic microorganisms. Those collected in Belel appeared to be contaminated by such pathogens as clostridia, Fecal coliforms, Fecal streptococci, salmonella and shigella and *Staphylococcus aureus*. Neither pseudomonas, nor vibrio was detected. At the whole, the study revealed that groundwater from covered wells, generally considered as safe and potable, needs to be treated prior consumption and use.

Key words: Groundwater, physicochemical properties, bacterial contamination, safety, consumptions, Cameroon

INTRODUCTION

Cameroon, situated in the center of Africa is blessed with different climatic and agro-ecological zones with very diverging climates and geography. These include the forest, the mountains and the savannah. Hence, water sources for domestic and agricultural activities largely depend on the agro-ecological zone. In the forestry and highlands regions of Cameroon, water is easily accessible from lakes, rivers and springs. However, in the sudano-sahelian zone which includes the Adamawa region, people get drinking water from traditional open wells characterized by a diameter of about 1 m. This poses the question of the quality of drinking water used for decades by local populations. Clearly, drinking water in rural areas of Cameroon hardly meets standards as noted by UNICEF. In effect, this United Nations agency estimates that only 51% of rural localities have access to improved drinking water in Cameroon while 2% of these localities use piped connections.

Moreover, this groundwater is used without any chemical or physical treatment especially in villages. Now a days, changes in population density (characterized by important growth) and habits (increasing use of chemical inputs in agriculture and animal husbandry) are impacting the environment in both rural and urban areas. One consequence could be the effect of human activity on groundwater reserve. This might considerably affect the overall quality of water. In this respect, recent studies carried out in Douala (Cameroon) revealed the high prevalence of water-borne diseases including parasitic and bacterial infections within populations (Ako *et al*., 2009). Investigations realized in the Adamawa region corroborate this trend with a dramatic consequence on school children. Garba and Mbofung (2010) revealed the high prevalence of waterborne parasites in this category of pupils: 43.8% were affected by schistosoma, 61.9% by entamoeba among other diseases. In the same light, recent developments in Cameroon with a dramatic outbreak of cholera clearly demonstrate the importance of drinking water quality for the consumers and for public health in general.

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Given the above, government and local authorities have put in place an overall strategy to increase the production of potable water in urban and rural areas. To this effect, covered wells are drilled in villages and water pumps installed to distribute this groundwater generally considered as potable. Despite the installation of such units, significant prevalence of water-borne diseases are still recorded among populations. The present research was therefore, designed to investigate the physico-chemical and bacteriological qualities of groundwater from newly constructed wells in some villages of the Adamawa region of Cameroon.

MATERIALS AND METHODS

Description of water sampling area: The water sampling area is located in the Adamawa region of Cameroon in the heart of sudanian agro-ecological zone characterized by two different seasons: a rainy season (from May-September) and a longer dry season (from October-April). The region main activities are cattle rearing and agriculture. Water is generally fetched from open wells dug by villagers and used in domestic activities (drinking and cooking). These open wells are very often associated with water quality hazards due to exposure to the surrounding environment (and human activities). Recently, the local governments initiated a program of controlled and covered wells construction to provide people with good quality groundwater. In this program, eight wells were constructed in four localities including 5 in Belel (7°03'North latitude and 14°26'East longitude), 1 in Mbe (7°51'North latitude and 13°35'East longitude), 1 in Meiganga (6°31'North latitude and 14°17'East longitude) and 1 in Tignere (7°22'North latitude and 12°39'East longitude). With regard to human activities, Belel is a pasture zone with high concentration of cattle while Mbe, Meiganga and Tignere are more urbanized localities with little agriculture and livestock activities (Fig. 1).

Sampling: Groundwater samples were collected from eight wells (40-60 m depth) namely Goumdjel Troua, Walde Sodepa, Goumdjel Pastoral, Belel Chefferie, Belel Ecole, Mbe, Meiganga and Tignere. The first five sampling points are situated in the locality of Belel. Samples were collected using clean and sterile plastic bottles, transported in a cool box and kept at about 4°C for microbiological analyses. For mineral analyses about 5 mL of concentrated hydrochloric acid was added to 250 mL of each water sample and evaporated to 25 mL. The concentrate was filtered using a cellulose membrane (0.45 µm) and transferred to a 50 mL flask and diluted to mark with distilled water. The samples were then kept at about 4°C.

Physicochemical analyses: Turbidity, pH, conductivity and phosphates were determined according to the methods described by Nkansah *et al.* (2011). Some minerals and heavy metals (Ca, Mg, Cl, Fe, Co, Cr, Pb, Cd) were analyzed Atomic Absorption (AAS 50B, Australia) as described by Ali *et al.* (2010). Total Dissolved Solids (TDS), alkalinity, HCO_3 and SO_4 were screened according to standard methods for the examination of water and wastewater (APHA, AWWA and WEF, 1999).

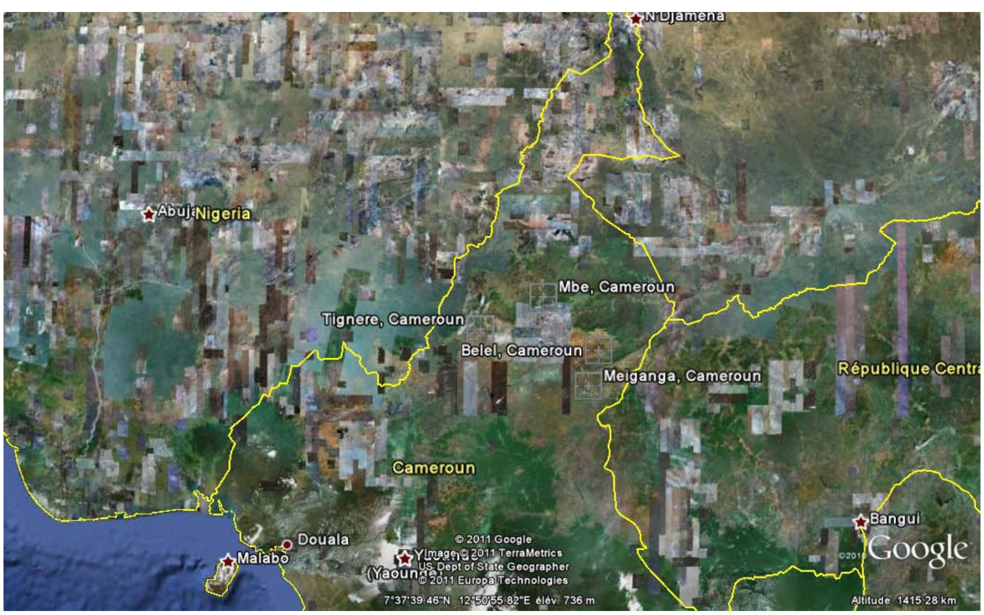

Fig. 1: Water sampling localities

Bacteriological analyses: Quality indicators and pathogenic bacteria were screened respecting sampling methods and plating conditions and using appropriate culture media as recommended by AFNOR.

Statistical analyses: All the analyses were repeated three times. The results are expressed in means±standard deviations. Means were calculated using Microsoft Excel while correlations between water samples and their significance were obtained with Statistica for Windows (Manugistic Inc. Software, Rockville USA). A Principal Component Analysis (PCA) based on physicochemical and bacteriological quality of samples was carried out to classify samples using STATBOX 6.6 (Grimmersoft, France).

RESULTS AND DISCUSSION

The physico-chemical parameters were analyzed to present the overall aspect and chemical composition of groundwater from studied wells in the Adamawa region and are shown in Table 1.

The turbidity measured on the samples was higher than 05 Nephelometric Turbidity Unit (NTU) except for two villages, Meiganga and Tignere where values of about 1NTU were recorded. Turbidity measurements were therefore higher than recommended by WHO (1998) which estimate that water with a turbidity <05 NTU is acceptable to consumers. It is estimated that high turbidity may constitute health risk through protection of microorganisms from treatment and stimulation of microbial growth. Turbidity is the reflection of the total suspended matter to which it is inversely related on one hand and is an indication of clay and inert particles (Nkansah *et al*., 2011). This is corroborated by the amount of suspended matter measured. Thus, the two samples with the lower turbidity (Meiganga and Tignere) also had lower suspended matter with respective values of 0.03 and 0.04.

The pH of the water fell within the acceptable WHO range of 7.5±1 except for the sample from Belel Chefferie (8.86±0.02). The lowest pH (6.76) was recorded in sample from Walde Sodepa. The effect of pH on water quality results in either taste complaints (for high pH) or corrosion (acidic pH). At the whole, water from Adamawa region exhibited high ph compared to groundwater from the Kwahu West District of Ghana (Nkansah *et al*., 2011).

Very low alkalinity was measured in samples. All values were <1 and very far from the WHO limit of 200 ppm. The lowest value was 0.04 while the highest was 0.71. This traduces low concentrations of carbonates, bicarbonates. In this respect, six of the eight samples had low contents in HCO_3^- which ranged between 4.0±0.2 and 31.41±1.01 mg L^{-1}. Two samples (Belel Chefferie and Belel Ecole) had higher concentrations of HCO_3^- (150.06±10.12 and 150.06±4.46 mg L^{-1}, respectively).

The conductivity of all samples was below limit acceptable value of 2500 µs cm^{-1} (European Drinking Water Directive, 1998). The lowest and highest conductivities were 125.5±0.39 and 1446.66±1.15 µsec cm^{-1} recorded, respectively in Goumdjel Pastoral and Tignere. The highest value, recorded for calcium was 45.29±1.98 mg L^{-1} for Goumdjel Pastoral while the

Table 1: Physicochemical characteristics of groundwater from 8 localities

	Village								
Physico-chemical parameters	Goumdjel Troua	Goumdjel Pastoral	Walde Sodepa	Mbe	Meiganga	Tignere	Belel Chefferie	Belel Ecole	Norm
Turbidity (NTU)	11.6±0.1	9.59±0.14	174.57±3.43	35.00±1.02	1.2±0.4	1.4±0.1	11.16±1.02	24.86±0.55	05 NTU
pH	8.22±0.16	7.47±0.10	6.76±0.12	7.25±0.34	6.93±0.05	7.2±0.03	8.86±0.02	7.96±0.02	6.5≤pH≤8.5
Conductivity (µsec cm^{-1})	269±1.73	125.5±0.39	167.30±0.02	203.00±0.02	456.00±1.73	1446.66±1.15	1219.66±7.12	1299.33±12.04	<2500 µsec cm^{-1}
Alkalinity (ppm $CaCO_3$)	0.12±0.00	0.05±0.00	0.04±0.00	0.09±0.00	0.21±0.01	0.71±0.00	0.6±0.0	0.64±0.04	200
TDS (mg L^{-1})	0.2±0.01	0.33±0.02	1.13±0.51	1.8±0.06	0.03±0.00	0.04±0.00	5.33±1.56	21.33±3.02	Not mentioned
Ca^{2+} (mg L^{-1})	41.76±1.98	45.29±1.98	43.33±4.00	37.34±2.14	6.21±0.04	21.04±0.12	7.61±0.05	7.73±0.91	200 mg L^{-1}
Mg^{2+} (mg L^{-1})	33.61±3.12	35.65±2.55	17.91±0.91	13.34±0.13	33.06±0.15	107.72±0.15	12.39±1.03	11.90±0.90	150 mg L^{-1}
HCO_3^- (mg L^{-1})	8.00±0.05	11.20±0.17	15.66±1.89	31.41±1.01	11.00±0.12	4.0±0.2	150.06±10.12	150.06±4.45	/
Cl^- (mg L^{-1})	31.82±0.81	31.82±0.81	29.98±1.43	7.23±0.75	18.02±0.71	26.73±1.04	17.75±0.86	14.2±1.9	200 mg L^{-1}
Fe^{2+} (mg L^{-1})	0.089±0.00	0.11±0.00	0.22±0.00	0.13±0.00	1.10±0.09	0.27±0.08	11.37±0.12	13.14±1.12	0.3 mg L^{-1}
SO_4^- (mg L^{-1})	68.06±2.98	62.36±0.74	32.45±0.06	21.04±0.06	17.01±1.01	35.07±0.09	11.79±0.48	10.51±2.03	400 mg L^{-1}
PO_4^{3-}	0.78±0.01	0.90±0.03	0.29±0.00	0.41±0.06	ND	0.68±0.05	ND	ND	5 mg L^{-1}
Cobalt	ND	ND	ND	ND	ND	ND	ND	ND	/
Cr	ND	ND	ND	ND	ND	ND	ND	ND	5 µg L^{-1}
Pb	ND	ND	ND	ND	ND	ND	ND	ND	10 µg L^{-1}
Cd	ND	ND	ND	ND	ND	ND	ND	ND	5 µg L^{-1}

ND = Not Detected or below detection limit in the conditions of analyses

Table 2: Bacteriological quality of groundwater from eight localities

Microorganisms	Villages								
	Goumdjel Troua	Goumdjel Pastoral	Walde Sodepa	Mbe	Meiganga	Tignere	Belel Chefferie	Belel Ecole	Norm
Total flora (CFU mL^{-1})	1.54×10^4	3.00×10^4	1.3×10^3	1.5×10^2	1.25×10^2	5.9×10^2	2.6×10^5	1.7×10^5	10
Sulfite reducing clostridia (CFU/5 mL)	0	0	0	0	7	0	25	0	Absence
Fecal coliforms (CFU/100 mL)	1.7×10^3	6.9×10^3	0	0	0	30	1.3×10^2	1×10^2	Absence
Fecal streptocci (CFU/100 mL)	0	0	0	0	0	0	14	12	Absence
Salmonella/Shigella (CFU/100 mL)	0	2.3×10^3	0	0	0	0	25	30	Absence
Vibrio (CFU/100 mL)	0	0	0	0	0	0	0	0	Absence
Pseudomonas aeruginosa (CFU/100 mL)	0	0	0	0	0	0	0	0	Absence
Staphylococcus aureus (CFU/100 mL)	0	0	1×0^2	0	0	0	0	0	Absence

lowest value was 6.21±0.04 mg L^{-1} for Meiganga. All samples were within the maximum permissible limit (200 mg L^{-1}) set by WHO. Similarly, magnesium (between 11.90±0.90 mg L^{-1} for Belel Ecole and 107.72±0.15 mg L^{-1} for Tignere) and sulfates (between 10.51±2.03 mg L^{-1} for Belel Ecole and 68.06±2.98 mg L^{-1}) were lower than the respective WHO maximum limits of 150 and 400 mg L^{-1}.

The concentration of chloride ion ranged from 7.23±0.75 mg L^{-1} (for Mbe) to 31.82±0.81 mg L^{-1} (Goumdjel Troua). The level of chloride is lower than the WHO highest desirable limit (200 mg L^{-1}).

For iron, worrisome values were determined for three samples: Belel Ecole (13.14±1.12 mg L^{-1}), Belel Chefferie (11.37±0.12 mg L^{-1}) and Meiganga (1.10±0.09 mg L^{-1}). This present high risk to consumers and could probably be due to the ferralitic nature of the Adamawa soils.

Very low PO_4^{3-} was measured for 5 samples. The concentrations were between 0.29±0.00 mg L^{-1} (Walde Sodepa) and 0.90±0.03 mg L^{-1} (Goumdjel Pastoral) and far below the permissible limit (5 mg L^{-1}). The low phosphate indicates that contamination from agriculture inputs is not virtually important. Interestingly, the heavy metals screened (cobalt, chromium, lead and cadmium) were not detected. The absence of these heavy metals is very positive for the quality of groundwater from the Adamawa region and for their use as drinking water. It is another sign of the very low level, even total absence of chemical pollution in rural areas of the region of study.

Different bacteria were screened and numbered to assess the microbiological quality of the water. The eight samples showed variable amounts of total flora and pathogens (Table 2). The total viable cell count showed that samples from Meiganga, Mbe and Tignere had the lowest count with, respectively 1.25×10^2, 1.5×10^2 and 5.9×10^2 CFU mL^{-1}. The highest count was for Belel Chefferie (2.6×10^5 CFU mL^{-1}). In general the five water samples collected around the Belel village contained more total flora than the other samples. Total viable count gives a picture of the safety of the samples. At the whole, none comply with existing norms (10 CFU mL^{-1}). The high total flora for Belel samples could be explained by the presence of fecal coliforms (Goumdjel Troua), fecal coliforms and Salmonella/Shigella (Goumdjel Pastoral), fecal coliforms, sulfite reducing clostridia, fecal streptococci and salmonella/shigella (Belel Chefferie) and fecal coliforms, fecal streptococci and salmonella/shigella (Belel Ecole). The presence of such bacteria in drinking water must be considered as harm to human health since they are associated with food toxi-infections. Fecal coliforms and Fecal streptococci is an indication of fecal contamination due to human or animal fecal wastes (Rompre *et al*., 2002). The difference in fecal contaminants counts between the samples could be due to the level and intensity of animal husbandry activities in the localities. In this light, Belel is one of the most vital cattle breeding centers in the Adamawa region and host significant ranches with hundreds herds and thousands cows.

All samples showed negative results for the presence of Vibrio and *Pseudomonas aeruginosa*. The first bacterium is associated with cholera, one of the worst virulent diarrheas causing agent. Vibrio is generally found in saline water and their presence in fresh water is mostly due to contamination by animal feces. The second is a gram negative pathogen which is more virulent to immune-compromised persons such as HIV positive persons. The presence of *Pseudomonas aeruginosa* is also believed to be due to contamination by humans (Rosenberg, 2003).

A correlation study between samples showed that significant positive correlations exist between Goumdjel Troua, Goumdjel Pastoral, Walde Sodepa, Belel Chefferie and Belel Ecole (Table 3).

Similarly, significant correlations were also obtained between water samples from Mbe, Tignere and Meiganga. These two groups of samples are confirmed by the Principle Component Analysis (PCA) of the eight groundwater samples based on the physico-chemical and bacteriological composition (Fig. 2). Clearly the PCA

Table 3: Correlations between water samples from the eight localities

Variables	Goumdjel Troua	Goumdjel Pastoral	Walde Sodepa	Mbe	Meiganga	Tignere	Belel Chefferie	Belel Ecole
Goumdjel Troua	1*	0.99*	0.98*	0.55	0.23	0.35	0.99*	0.99*
Goumdjel Pastoral	-	1.00*	0.95*	0.52	0.20	0.32	0.97*	0.97*
Walde Sodepa	-	-	1.00*	0.65	0.32	0.44	0.98*	0.98*
Mbe	-	-	-	1.00*	0.91*	0.94*	0.55	0.56
Meiganga	-	-	-	-	1.00*	0.99*	0.22	0.22
Tignere	-	-	-	-	-	1.00*	0.34	0.34
Belel Chefferie	-	-	-	-	-	-	1.00*	1.00*
Belel Ecole	-	-	-	-	-	-	-	1.00*

Values with *indicate a significant correlation between two samples at 5% level

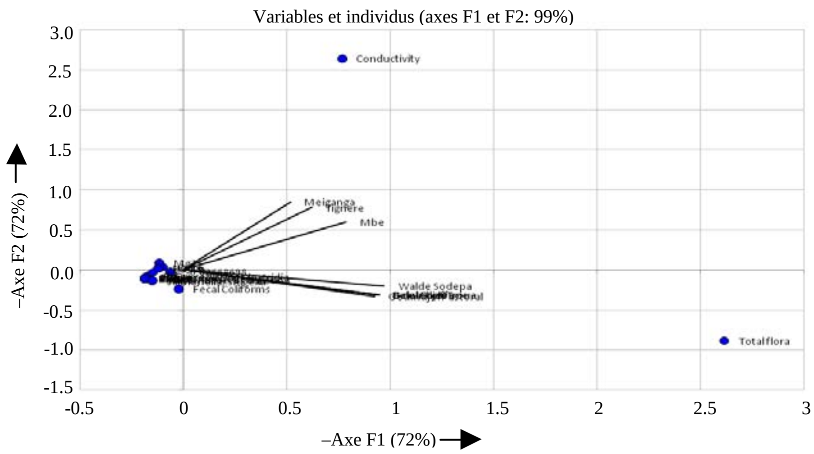

Fig. 2: The principal component analysis profile of the 8 groundwater samples based on their physco-chemical characteristics and microbiological composition

opposes two groups of samples: the first group is made up of highly correlated samples with high total flora and the second group comprises samples with low total flora and which are also correlated between them by the similarity of their physic-chemical properties.

CONCLUSION

The study of groundwater from eight improved wells drilled in the Adamawa region of Cameroon revealed a globally satisfying physico-chemical feature. For most parameters studied except for turbidity, samples fell in the conventional admissible limits indicating the low impact of human activity on the chemical content. Generally, the water was not contaminated by heavy metals. However, the microbiological quality of all samples is questionable. Pathogens and indicators were detected and numbered at significant amounts for some samples. The comparison of wells helped in distinguishing two groups of samples. Those collected in areas with high cows concentrations appeared most contaminated by bacteria. This study challenges the general opinion in rural areas who believes that water from covered and improved wells is safe and could be used without any treatment.

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