



Rainwater Quality in Some Urban and Rural Sites of Cameroon (Central Africa)

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Abstract

Seventy-two rainwater samples were investigated in some rural and urban sites across Cameroon for their chemical content. The objectives were to assess the potability of rainwater and the possible source of atmospheric inputs and to understand the biogeochemical cycles of the major ionic species. Rainwater in most of the sites was acidic (pH ranging from 4.92 to 6.41). A significant contribution of Ca^{2+} was observed in all sites, due mainly to the incorporation of soil dust in the precipitation. The K^+ and NO_3^- contributions to the ionic load of rainwater in rural sites are a reflection of the dominant agricultural activities across Cameroon. High Ca^{2+} , Mg^{2+} , SO_4^{2-} , and K^+ to Na^+ enrichment ratios relative to seawater ratios indicated the significant terrigenous influence on water chemistry, mainly from the Sahara dusts. About 62.5% of the samples were $\text{Ca}^{2+}\text{-Mg}^{2+}\text{-Cl}^-\text{-SO}_4^{2-}$ water type. Based on TDS, major ion, and trace metal contents, rainwater is considered suitable for human consumption.

Keywords

Atmospheric pollution • Rainwater chemistry • Rural • Urban • Cameroon • Water quality

1 Introduction

Rainfall signature integrates both the long-range transport of chemical species by clouds and the local scavenging of atmospheric aerosols during the rain event. These vary strongly both from event to event and within a single event because rainout and washout proportions strongly depend on the environment of the sampling site (urbanized, rural, or remote) (Bertrand et al. 2009). Understanding the main constituent of rainwater chemistry, what affects them, and their ecotoxicology is very important since rainwater plays a great role in earth water storage replenishment and ecosystems' life and equilibrium.

In spite of difficulties in collecting and preserving rain samples in tropic zones, precipitation chemistry in both rural and urban areas has been the subject of interesting research in the last few decades (Freydier et al. 2002; Sigha-Nkamdjou et al. 2003). However, in Cameroon, only few studies have been conducted on rainwater chemistry (Sigha-Nkamdjou et al. 2003; Galy-Lacaux et al. 2009; Wirmvem et al. 2014).

This study presents the chemical composition of rainwater determined at some urban and rural sites in Cameroon. This study is valuable in understanding the possible origin of atmospheric pollutants and the biogeochemical cycles of the major ionic species which are essential to determine deposition trends and improve modeling of atmospheric processes, as well as developing suitable emission control strategies.

2 Materials and Methods

Monthly rainfall samples were collected in Douala (January–November 2018), Yaoundé (January to September 2018), Dang (September to December 2018), and Ndop and Ndawara (June to October 2017). Douala and Yaoundé represent the urban sites, while Dang, Ndop, and Ndawara are located in the rural areas of Cameroon. Samples were collected

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monthly using artisanal bulk collectors. On the last day of the month, water from the container was properly shaken to mix and filter directly (through a 0.2 μm mesh) into a 100-mL bottle (previously rinsed with distilled water and dried in the laboratory to avoid contamination). The collected samples were stored in a refrigerator at 4 °C and analyzed for Na^+ , NH_4^+ , K^+ , Mg^{2+} , Ca^{2+} , Cl^- , NO_3^- , and SO_4^{2-} using standard methods. Alkalinity (HCO_3^-) was determined by titration. The trace metal content of rainwater samples from the urban sites was also analyzed.

3 Results

3.1 Rainwater Chemistry and Sources of Major Ionic Species

Figure 1 presents the Piper diagram for the mean rainwater chemistry in the rural and urban sites (Table 1).

4 Discussion

From the Piper diagram (Fig. 1), it is apparent that samples collected in the rural sites (Ndop, Ndawara, and Dang) are of the $\text{Ca}^{2+}\text{-Mg}^{2+}\text{-Cl}^-\text{-SO}_4^{2-}$ water type, demonstrating the dominance of alkaline earths over alkali and strong acidic anions over weak acidic anions. In the urban sites (Douala and Yaoundé), the rains are of the $\text{Ca}^{2+}\text{-Mg}^{2+}\text{-HCO}_3^-$ water

type. This is corroborated by the slightly acidic character of rainwater sampled (see Table 2) resulting from the dissolution of NO_3 and CO_2 forming nitric and carbonic acids, respectively, whose effects have been neutralized by ionic species coming from soil dust particles.

Summary statistics of trace metal concentrations in rainwater sampled at Douala and Yaoundé (urban sites) are presented in Table 1. The most abundant trace metal in rainwater is Zn (145.11 ppb) followed by Fe (84.95 ppb). The high values of metals in rainwater samples may be due to local point sources of atmospheric pollution, long-range atmospheric transport of anthropogenic activities (like mining) from other parts of the country, and the soil dust which affects the composition of wet atmospheric deposition. The monthly concentration of some of the trace metals in rainfall at urban sites of Douala and Yaoundé was within the WHO guideline values for drinking water.

In order to determine the marine contribution in the composition of rainwater, the ratio of sea salts in rainwater was calculated considering Na^+ as sea salt tracer and assuming that all Na^+ was of marine origin. As shown in Table 3, the SO_4^{2-} , K^+ , Ca^{2+} , and Mg^{2+} to Na^+ ratios of rainfall in both the urban and rural sites are higher than those in seawater basically suggesting a terrigenous origin of the ions. The dominance of Ca^{2+} , SO_4^{2-} , and K^+ relative to Na^+ and Cl^- confirms the inference that precipitation in Sub-Saharan Africa is highly influenced by terrigenous dust mostly from the Sahara Desert soils (Goni et al. 2001; Freyrier et al. 2002; Galy-Lacaux et al. 2009).

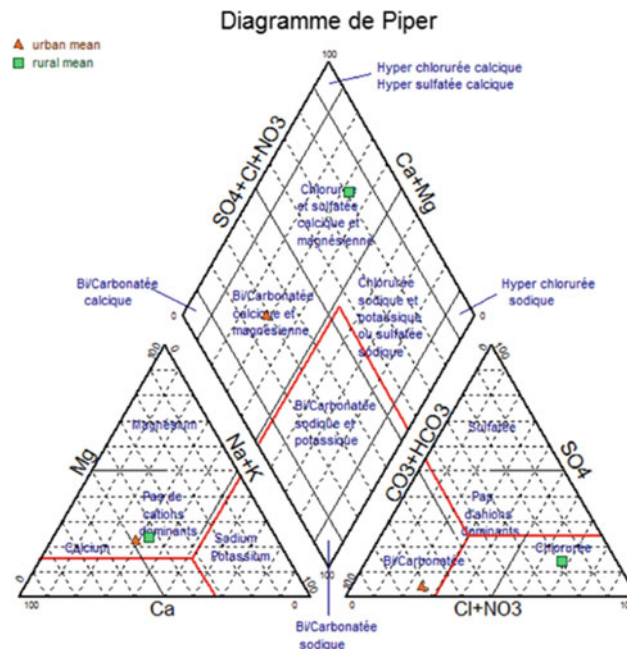


Fig. 1 Piper diagram of rainwater in urban and rural sites

Table 1 Summary statistics of trace metal concentration in rainfall at urban sites (ppb)

Element	Min	Max	Mean	Standard deviation
Mn	1.07	12.00	5.49	3
Fe	45.34	264.88	84.95	48
Be	0.01	0.02	0.01	0
Cr	0.11	13.07	1.81	3
Co	0.01	0.25	0.08	0
Ni	0.22	11.23	3.38	4
Cu	0.71	9.76	2.44	3
Zn	6.46	493.57	145.11	155
Ga	0.06	2.75	0.25	1
As	0.07	2.93	0.37	1
Rb	0.29	9.20	2.25	3
Sr	1.20	59.02	8.95	12
Ag	0.32	12.88	2.45	3
Cd	0.01	0.19	0.07	0
Cs	0.01	0.18	0.02	0
Hg	0.36	36.30	2.66	8
Tl	0.01	0.09	0.02	0
Pb	0.14	2.15	0.99	1
Th	0.10	47.71	2.96	11
U	0.04	0.77	0.09	0

Table 2 Mean pH values of rainwater sample collected

	Douala	Yaoundé	Ndop	Ndawara	Dang
pH	5.61	5.59	5.05	4.82	6.41

Table 3 Seawater, and urban and rural sites' rainwater ratio

	Cl ⁻ /Na ⁺	SO ₄ ²⁻ /Na ⁺	K ⁺ /Na ⁺	Ca ²⁺ /Na ⁺	Mg ²⁺ /Na ⁺
Seawater	1.16	0.12	0.02	0.04	0.23
Urban sites	4.29	1.42	0.46	1.84	0.51
Rural sites	1.13	2.24	3.03	3.25	1.07

5 Conclusions

The results obtained reveal that the major source of chemical enrichment in rains in both rural and urban sites across Cameroon is terrigenous dust mainly from the Sahara Desert soils, and anthropogenic and agricultural activities. Concentrations of trace metals that were determined in the rainwater samples of urban sites are relatively low. Major ions and trace element concentrations in rainwater of all the sites were within the WHO guideline values for drinking water. Based on the chemical characteristics of rainwater in the studied sites, domestic harvesting of rainwater could be taken as an alternative to pipe-borne water supply.

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