Major element and organic carbon fluxes in a small catchment of humid tropics: Site of Nsimi (South Cameroon)

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The humid tropical ecosystems play an important role in controlling the worldwide elemental and carbon global cycles (White and Blum, 1995). While weathering inputs to large tropical rivers (Amazon, Congo) have received considerable attention (Gaillardet *et al.*, 1995), the current weathering/erosion processes at the small catchment scale are still at low level of knowledge in the humid tropics (Viers *et al.*, 1997 ; Braun *et al.*, 1998 ; White *et al.*, 1998). The present study aims (1) to identify the major weathering processes occuring on the scale on a representative humid tropical catchment on granitic basement and (2) to quantify the particulate/solute fluxes of major ions and organic carbon (COD, COP). During the period from August 1994 to December 1997, hydrological and geochemical data have been collected in the different pools (atmospheric depositions, surficial and ground waters) of the small catchment of Nsimi (South Cameroon) (0.6 km^2). This is drained by the Mengong brook which belongs to the Nyong river basin (27800 km^2). This basin is the second largest of Cameroon and is entirely located under the tropical rainforest between the latitudes 2°48′N and 4°32′N.

Site presentation

The geomorphology of the Nsimi catchment is representative of the erosion surface of the South Cameroon Plateau which is mainly constituted by a succession of convex rounded hills separated by flat swamps of variable stretch. Two convex hills of about 700 m high surround a large swampy zone which represents 20% of the whole catchment area. The Mengong brook, fed by several springs located all around the basin head, flows towards the Soo stream, the most important left side tributary of the Nyong river. The elevation ranges from 668 m at the outlet to 710 m. The springs lie between 673 and 677 m. The hills are covered by the semi-deciduous rainforest (60%) damaged by food crops (40%). The swamp is entirely preserved and covered by raphia palm trees and a hydrophilic vegetation. The clearing of the early forest is the strongest perturbation brought about this ecosystem. The catchment has been preserved from burning and clearing during the time of study. The pedological cover is developed on a intensively faulted granitic basement (charnockite), liberian in age (2800 My). The hillside soil cover reaches 40 m of thickness at the hilltop. These are complex polygenetic lateritic soils. In the flat swamp, a hydromorphic soil cover about 1–2 meter thick developes either directly on the parent charnockite or on oxidized saprolitic horizons. The thickness of pedological materials may reach about 20 m straight above the outlet.

Hydrological functionning

The humid tropical climate of the region is marked by two dry and two wet seasons. Their duration in the hydrological year is the following: the long wet season from september to december, the long dry season from december to march, the short wet season from April to June and the short dry season from July to August. The most rainy months are September and October. They account for at least 30% of the annual rain. The tropical depressions produce stormy individual rainfall events that are sometimes very intense. The mean annual rainfall and runoff on the watershed are 1793 $\pm$ 196 mm and 383 $\pm$ 114 mm, respectively (calculated from 1995 to 1997). The mean annual air temperature is 24°C ± 1. According to the seasons, the catchment hydrological response is different. During the rainy seasons, especially during the longest, rainfall is higher than evapotranspiration. The Mengong discharge is directly linked to the rain events. This is enhanced by the swamp flooding and the contribution of the springs. During the dry seasons (from December to February and August), the Mengong runoff is only related to the groundwater discharge. The spring contribution to the discharge is low. The annual hydrological budget is positive when the annual rainfall reaches 1500 mm, 90% of the regional annual rainfall.

Hydrogeochemistry

The atmospheric depositions taken into account in this study are the wet open field (WOFD) and throughfall depositions (TF). The WOFD are acidic (pH = 5) and cationic charge is very low ($TZ^+ = 31 \pm 32$ $\mu eq.L^{-1}$). The TF cationic charge (TZ^+) is 167 ± 73 $\mu eq.L^{-1}$, 6 times those of WODF. Mg^{++} and K^+ are the most abundant cations. Na^+ represent only about 4% of TZ^+. The TF COD contents are highly variable from 0.70 to 11 $mg.L^{-1}$. In the TF, fhe correlations between COD and K/SiO_2 are good indicating the forest biological cycling of both last elements. Na is not correlated with these elements suggesting an other origin for this one.

Based on colour and TZ^+, the catchment waters can be divided in two groups. The first (hillslope ground and spring waters) corresponds to clear waters with low cationic charge ($TZ^+ \sim 100$ $\mu eq.L^{-1}$) and DOC content (< 1 $mg.L^{-1}$). These waters are acidic (3,6 < pH < 6). The pH values and Cl content do not vary through time while the other ions show large concentration range.

The second group (Mengong brook and surficial swamp ground water) displays tea colour due to the high COD content (15 $mg.L^{-1}$). The coloured waters have higher cationic charge (180 < TZ+ < 352 $\mu eq.L^{-1}$) than hillslope groundwaters. They are acidic (5.5 ± 0.4) and display a bad agreement between the sum of cations and anions due to the abundance of organic acids lowering the ANC (acid neutralizing capacity) measurement. The surficial water chemistry is similar to that of the Rio Negro and the organic-rich North tributaries of the Congo (DUPRE *et al.*, 1996), typical black water stream. Individual flood event analysis allows to demonstrate that the concentrations of major inorganic solutes (Na^+, Ca^{2+}, Mg^{2+}, SiO_2), DOC and particulate matter are related to instantaneous discharge.

Chemical fluxes

The major ion export due to weathering is very low compared to other humid tropical catchments. The atmospheric contribution is of 20% for Na^+ and 10% for Mg^{2+} and Ca^{2+}. The K^+ budget is highly influenced by biogenic recycling ($[K]_{output}$ = 31 $mole.ha^{-1}.an^{-1}$; $[K]_{input}$ = 57 $mole.ha^{-1}.an^{-1}$). Chloride is conservative on the catchment scale ($[Cl]_{input} \sim [Cl]_{output}$). Export is similar to TSS and TDS ([TDS] = [TSS] = 3 $t.km^{-2}.an^{-1}$). The SiO_2 export is 360 $mole.ha^{-1}.an^{-1}$ in which a small proportion is of biogenic origin as shown by the throughfall analyses. The DOC export is 3435 $mole.ha^{-1}.an^{-1}$ while POC export is only of 400 $mole.ha^{-1}.an^{-1}$. The outputs of carbon are mainly organic and mostly as colloidal form (DOC/TOC = 80%) (VIERS *et al.*, 1997). These results indicate the strong influence of the hydrological functionning and of the swamp organic-rich accumulation in the element mobilization and transfer in the discharge waters. Compared to other small catchments in the world the Nsimi catchment shows very low weathering rates except for SiO_2. This is due to the thick lateritic soil cover which is base cation poor.

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