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SEASONAL FLUCTUATIONS OF MAJOR, TRACE ELEMENTS COMPOSITION AND ^{87}SR/^{86}SR RATIOS OF THE CONGO RIVER. IMPLICATIONS FOR THE HYDROLOGICAL FUNCTIONING AND INPUT TO THE OCEAN.

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ABSTRACT :

During one year, a monthly sampling of the Congo River at Brazzaville has been realised. This study has revealed that major, trace element concentrations and $^{87}Sr/^{86}Sr$ ratios display large variations as a function of the river discharge. Good correlations are observed between element ratios and isotopic ratios. These variations result from mixing between at least two different water pools. The existence of at least two different water pools is correlated with the hydrologic functioning of the Congo Basin. The first water pool corresponds to the streams flowing in the Southern hemisphere; the second one corresponds to the streams flowing in the Northern hemisphere. Using the characteristics of the main tributaries of the Congo River (chemical composition, Négrel, 1992; Négrel et al., 1993, % of water input to the Congo River, Note d'information P.I.R.A.T. n°2, 1989) and a logarithmic law previously shown on the Oubangui and Sangha Basins, a modelization of the content fluctuation is proposed.

The second result concern the exportation rate at Brazzaville. Because of the geometry of the Congo Basin and the location of the Brazzaville station, limestones terranes near the Atlantic ocean are not drained by the Congo River. Input of weathering of these terranes is calculated and the exportation rate for Ca, Mg and Sr by the Congo River at Brazzaville is under estimated because limestones contribution between Brazzaville and the Congo outfall is neglected.

Thirdly, the comparison between the Congo and the short coastal streams output shows that especially for Ca and Sr the input to the ocean from the centre of the African continent is under estimated respectively of about 45% and 20%. This result shows the importance of this type of rivers for the input of Ca and Sr to the ocean.

According to Négrel et al. (1993) a modelization with four source reservoirs, say the weathered silicate, carbonate and salty rocks sources and rain water inputs, shows that atmospheric inputs carried by rainwater to the Congo river water are important for Ca, Na, Mg and Sr. For rock weathering inputs, dissolved Na and Sr inputs are dominated by silicate weathering while dissolved Ca and Mg inputs are controlled by carbonate dissolution.

1 - INTRODUCTION

Since 1986, a program I.N.S.U., P.I.R.A.T., D.B.T. has been developed on large intertropical forestry systems in order to characterize the functioning of these area and to quantify geochemical processes like erosion, input to the ocean and exchanges between continents and atmosphere.

This study is managed on the Congo Basin located in the centre of the African continent. For this purpose, major, trace element concentrations and strontium isotopic ratios have been determined on the dissolved load of the Congo river during one year.

Major and trace elements characterise both the chemistry of the dissolved fraction and the exportation rate (Durum et al., 1960; Livingstone, 1963; Carbonnel & Meybeck, 1975; Berner & Berner, 1987). The long period isotopes (like Sr) are good tracers of geochemical mechanisms at the earth surface (Eastin & Faure, 1970; Curtiss & Stueber, 1973; Stettler & Allègre, 1977; Graustein, 1981; Gosz & Moore, 1989; Aberg et al., 1989, Négrel et al.,1993). The $^{87}Sr/^{86}Sr$ ratios are not modified by the radioactive decay on the time scale of the studied process and variations of this ratio are only related to mixing of different strontium sources.

Measurements have been made on the Congo at Brazzaville on monthly samples during the 1989 period. The objective of this study was :

(1) to investigate the seasonal variations (concentrations and $^{87}Sr/^{86}Sr$ ratios) of the Congo river dissolved load; to correlate the chemical and isotopic characteristics with the hydrologic

functioning of the Congo basin and to compare them with the Oubangui Basin (Négrel & Dupré, this volume) located northern of the Congo Basin and which exhibits different hydrological regime.

(2) to compare the input to the ocean between a world wide stream (Congo) and a short coastal river (Kouilou). Indeed, carbonated series located near the Atlantic ocean are not integrated by the Brazzaville station located 600 km east from this ocean. These series can play a prominent part in the input to the ocean for species like Ca or Sr.

(3) to investigate the origin of some dissolved species carried out by the Congo River related to the different sources (atmospheric inputs and carbonate and silicate weathering).

2 - BASIN PRESENTATION, SAMPLING AND ANALYSES

The Congo Basin extends in the centre of the African continent (fig. 1). The Congo river is 4700 km long and drains a large basin (3.7 10^6 km^2) and is constituted by 4 main tributaries: Oubangui, Zaïre, Kasaï and Sangha-Likouala. The discharge fluctuations of the Congo regime are mainly due to the distribution of its tributaries on both side of the Equator. Figure 2 shows the hydrologic characteristics of the Congo at Brazzaville (Olivry et al., 1988), this station represents the mixing of the 4 main tributaries. The long term (1903-1986) annual average discharge at Brazzaville is about 40,900 m^3/s (Olivry et al., 1988), the proportions of each tributary are represented in figure 3 (Bricquet J.P, pers. comm.). Actually, an important discrepancy exist on the budget of the Congo discharge (fig. 3); at the Brazzaville station, 10 to 25% of the water mass is not identified.

Samples were taken monthly during one year by an automatic P.V.C collector (Sigha & Bricquet, 1987) at Brazzaville. Associated with the water sampling, the monthly discharge has been determined. The sampling of the main tributaries has been realised during high water period (Négrel, 1992). After collection, samples were filtered through 0.2 µm acetate cellulose filters with a pressurised 47 mm diameter Sartorius® polycarbonate filtration unit, stored and acidified with ultra pure HNO_3 in polypropylene acid washed containers for cations and isotopes determination. An aliquot was collected before acidification for anion determination. Analytical procedure for water studies in laboratory including : acid titration for HCO_3, ionic chromatography for Cl and SO_4. Conventional flame atomic absorption spectrophotometry procedures for Ca, Na and Mg. K and Sr concentrations were determined by mass spectrometry using the isotope dilution technique with a mixed ^{41}K; ^{84}Sr spike solution after chemical separation. The analytical precision for the measurement of major ions (Ca, Na, Mg, Cl and SO_4) by atomic absorption and ionic chromatography is better than 15%. Using the mass spectrometry techniques, the analytical precision is around 3%.

The strontium isotopic compositions were determined on a solid source mass spectrometer. The separation of dissolved Ca, Rb, Sr from the water samples was carried out by cation-exchange chromatography (Birck, 1986; Négrel, 1988). Strontium contamination during sampling and chemical processing was estimated through a blank determination which is around 100 pg of Sr and is negligible in terms of the total quantity of strontium processed in water analysis. Mass fractionation corrections were applied by normalising the average $^{87}Sr/^{86}Sr$ ratios to a $^{86}Sr/^{88}Sr$ ratio of 0.1194. The accuracy of the $^{87}Sr/^{86}Sr$ analysis was evaluated by analysing the N.B.S. 987 standard. Our mean value is 0.710254 ± 60 (2σ mean; 47 measurements).

3 - RESULTS

Data of chemical and isotopic compositions of the Congo River and its tributaries are given in table 1.

3.1. Monthly sampling at Brazzaville

Analysed elements in stream water (Cl, SO_4 Ca, Na, Mg, Sr) display large concentration variations greater than analytical errors. Element concentrations vary by factor up to 2.8 for Cl,

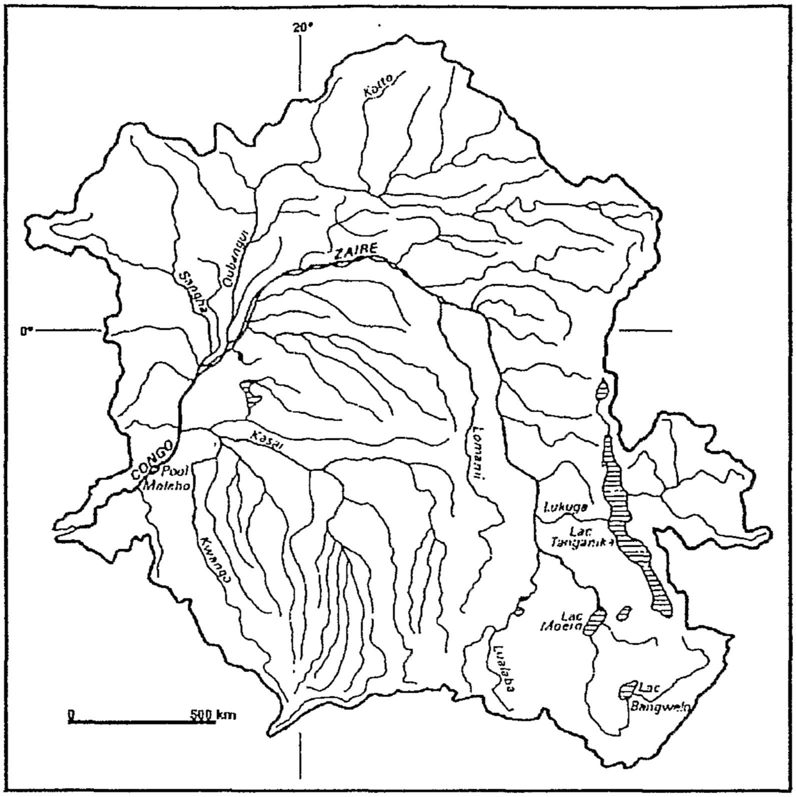


Figure n° 1

General situation of the Congo basin.

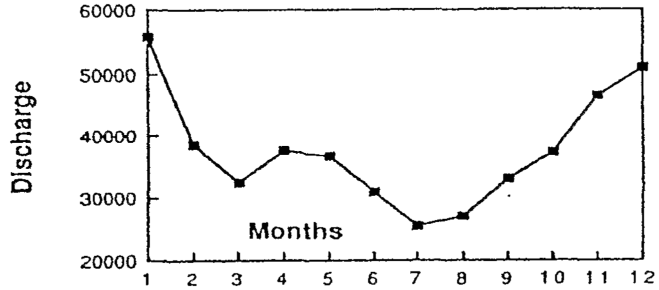


Figure n° 2

Mean monthly discharge of the Congo river for the study period.

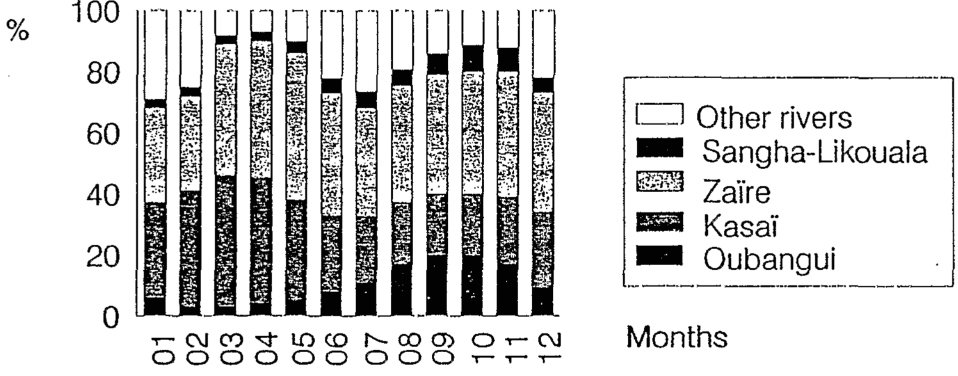


Figure n° 3

Proportions of each tributaries of the Congo river (BricquetJ.P. , personal communication).

2 for SO_4 2.5 for Na, 2.2 for Mg, 1.7 for Ca and 1.4 for Sr. K was only determined on four samples at Brazzaville. An inverse trend between solute concentration and discharge (fig. 4) is observed excepted for SO_4. For Mg, higher and lower concentrations are linked with hydrological extremum. For Ca and Na, extreme concentrations are not linked with hydrological extremum. For Cl and Sr, only lower concentrations are correlated with highest discharge. Content fluctuations as discharge function are different between Oubangui River (Négrel & Dupré, this volume) and Congo River at Brazzaville. As previously studies have shown (Note d'information P.I.R.A.T. n°2, 1989), we observed a shortage between the charge balance $\Sigma +$ and $\Sigma -$ on four of our samples. This shortage ranges between 5 and 19% and can be explained by high organic acids concentration in the Congo tributaries.

The $^{87}Sr/^{86}Sr$ ratios also exhibit greater variations than analytical errors. On the monthly samples, the $^{87}Sr/^{86}Sr$ range is about $1.3\ 10^{-3}$ between the lower value (0.7187 on October) and the upper value (0.7200 on June). Nevertheless, the $^{87}Sr/^{86}Sr$ ratios are identical between peak and moderate flow (fig. 5). We can also notice a correlation between $^{87}Sr/^{86}Sr$ ratios and Ca/Na and Na/Sr ratios (fig. 6).

3. 2. Short coastal river sampling

The Kouilou River which drains the occidental part of the Congo Basin exhibits high element concentrations (Table 1) comparatively to the rivers flowing in the centre of the basin. The $^{87}Sr/^{86}Sr$ ratio is close to 0.71014.

4 - DISCUSSION

4. 1. Correlations $^{87}Sr/^{86}Sr$ ratios - element ratios

The relationship between $^{87}Sr/^{86}Sr$, Ca/Na and Na/Sr ratios (fig. 6) represents mixing of two different components. The first end member is characterized by high $^{87}Sr/^{86}Sr$ (up to 0.720) and Na/Sr (up to 550) ratios and low Ca/Na ratio (close to 0.7). The second end-member exhibits opposite characteristics ($^{87}Sr/^{86}Sr$, Na/Sr and Ca/Na ratios close respectively to 0.709, 150 and 2.5). According to the results obtained by Négrel et al. (1993) on streams flowing on the Congo Basin, the first end-member corresponds to silicate weathering while the second one corresponds to carbonate weathering. The proportions of these two components are different in each stream.

At the Brazzaville station, Olivry et al. (1988) have shown that the first peak flow between October and January corresponds to high flow period in the northern part of the basin (Oubangui and Sangha-Likouala). During this period, we observe low Na/Sr and isotopic ratios and high Ca/Na ratios in our samples of the Congo River at the Brazzaville station. The second high flow period (Olivry et al., 1988) during April and May is mainly due to the input of water from the meridional part of the basin (Zaire and Kasaï). During this period, we observe high Na/Sr and isotopic ratios and low Ca/Na ratios in our samples of the Congo River at the Brazzaville station.

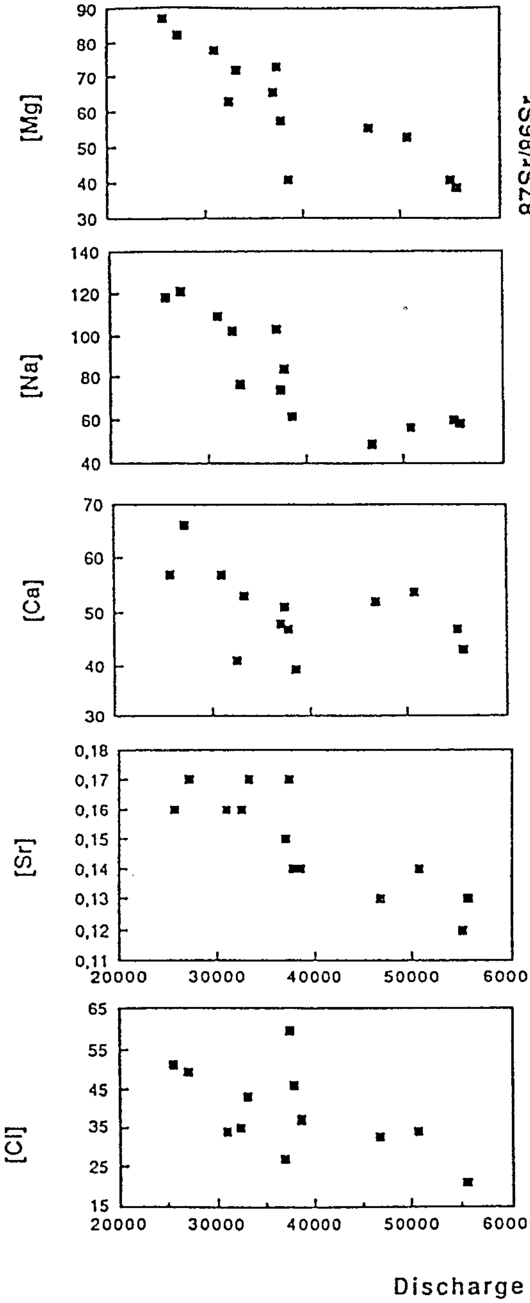
4. 2. Modelization of concentration fluctuations

At the Brazzaville station, the Congo water mass has two distinct origins. The first is located in the Northern hemisphere while the second is located in the Southern hemisphere. On the Oubangui Basin (Négrel, 1992), and on the Sangha Basin (unpublished data), the seasonal concentration fluctuations with discharge follow a logarithmic law : $C = C_0\ W^b$.

where C : content
W : river discharge
C : content for W = 0
b is close to 0.5 for Na and 0.8 for Ca, Mg and Sr.

Identical relationship has been obtained by Probst et al. (1992) on the Oubangui Basin, Edwards (1973) and Walling & Webb (1983) on different basins with different b values. At Brazzaville, this logarithmic law is different and could be related to hydrologic factors (fig. 2) because of the basin location on both side of the Equator.

To modelize the content fluctuations, the idea is to use the same b parameter on the southern tributaries of the Congo River (Kasaï and Zaïre). So, we can calculate at the Brazzaville station the Ca, Na, Mg and Sr contents range and compare these with the observed ones.



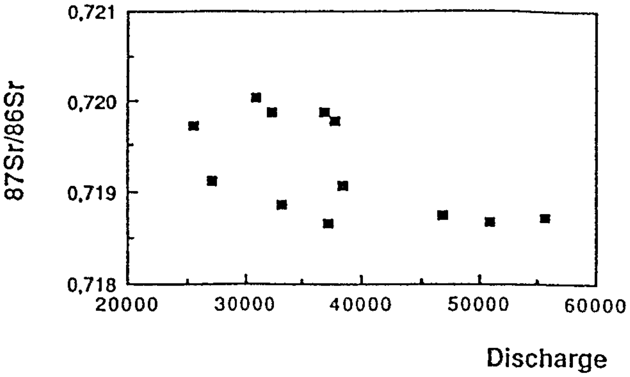


Figure 5

Relationship between 87Sr/86Sr ratios and the discharge (in m^3/s) on the Congo monthly samples.

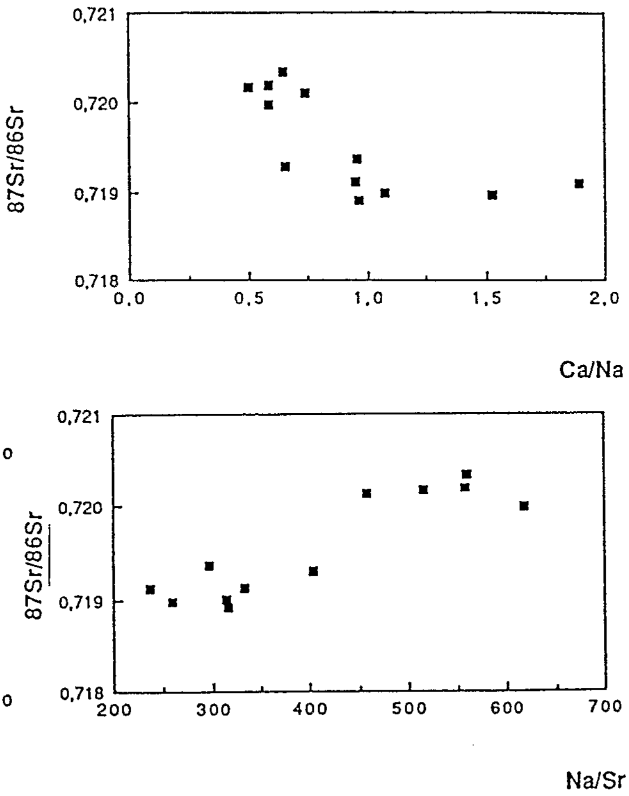


Figure 4

Relationship on the Congo monthly samples between element concentrations (in 10^{-6} mol/l) and discharge (in m^3/s).

Figure 6

Correlation between dissolved solids 87Sr/86Sr ratios and dissolved solids cation ratios Ca/Na and Na/Sr on the Congo monthly samples.

Dissolved Cl content in Congo river waters came from atmospheric input and weathering of saltrock formations. Because these formations are located in the Zaire part of the basin, we cannot modelize the Cl fluctuations. For SO_4 concentrations, no variations with discharge are observed. As other studies have shown (compilation in Berner & Berner, 1987), sulfate content in river water is lesser than sulfate content in rain water (mean value in river water: 13 µmoles/l; mean value in rain water: 35 µmoles/l, Négrel, 1992). These studies have suggested that the sulfate contents are controlled by biological uptake.

The discharge range of the Northern and Southern zone is determined using the discharge at Brazzaville (Table 1) and the proportion of each unit (fig. 3). The discharge range of the Northern zone shows a peak flow between September and January. On the other hand, the discharge range of the Southern zone shows a first peak flow between March and May and a second peak flow between October and January. It is important to notice that the cumulated discharge of the Northern and Southern zone is lesser than the observed discharge at the Brazzaville station (see § 2).

Contents range for Ca, Na, Mg and Sr is determined using the discharge of the Northern and Southern zone (table 2), the sample of each stream during high water stage (Négrel et al., 1993) and the logarithmic law determined on the Oubangui Basin (Négrel, 1992) and Sangha Basin (unpublished data).

Theoretical and observed range for Ca, Na, Mg and Sr are reported in table 2 and figure 7. The range of content fluctuations is identical between calculation and observation. Between extremum, concentrations vary by a factor close to 1.2 for Ca (1.7 observed); 1.5 for Na (2.3 observed); 1.5 for Mg (2.2 observed) and 1.2 for Sr (1.4 observed). This implies that the logarithmic law can be used on rivers flowing on the Congo Basin on both side of the Equator.

Nevertheless, a discrepancy exists between calculated and observed values. This discrepancy is more important for Ca and Sr than for Mg and Na. To explain this divergence, we have calculated the chemical and isotopic budget for November 1989 using the Congo (this study) and its tributaries samples (Négrel et al., 1993) and the discharge of these streams (Note d'information P.I.R.A.T. n°2, 1989). The chemical budget at Brazzaville calculated by the sum of (concentration x discharge) is upper than the observed one. The shift is close to 21% for Na, 15% for Sr, 13% for Mg and 2% for Ca. For Ca, the shift is weak because concentrations of each tributary are close. For isotopic budget, similar results are obtained.

The first hypothesis to explain this difference concern the concentrations used in this calculation which may be not representative. Transectal studies (Négrel, 1992) on the Congo river have shown large contents variations in confluence zones. The second hypothesis concerns the stream discharge. Several hydrological studies have been realised on the Congo basin (Devroey, 1951; Unesco 1972, 1974, 1979; Olivry et al., 1988). But, actual uncertainties exist concerning discharge of rivers flowing on the right bank (Zaire and Kasaï rivers) and, secondly, lateral drift from Batékés plateaus.

The divergence could also be ascribed to the adsorption of elements on the suspended load. However, the bulk load (dissolved + suspended) calculated for Sr concentrations and isotopic ratios on high water stage using samples of the main Congo tributaries (Négrel et al., 1993) is upper than the observed one at Brazzaville and unvalid this hypothesis (Négrel, 1992).

At the first order, and in spite of this discrepancy, the modelization of the content ranges allows us to conclude that concentration fluctuations as a discharge function result from a mixing between different water pools. The existence of different water pools is mainly due to the geographic location of the Congo basin on both side of the Equator.

4. 3. Dissolved load output by the Congo River

Between Brazzaville and Congo river outfall, only minor tributaries connect the Congo River. The drainage basin of these rivers represents 2% of the total basin area (Van Ganse 1959; Devroey, 1941). The increasing of the stream discharge associated with this rivers input is close to 4% (Deronde & Symoens, 1980). These authors have concluded that the Brazzaville station corresponds to the Congo outlet. Dissolved solid transported by the Congo River was estimated by Meybeck (1978); Deronde & Symoens (1980); Sarin et al. (1989) and this study (table 3). Weak differences are observed between all of these studies.

Table 1 :

$^{87}Sr/^{86}Sr$ ratios, HCO_3, Cl, Ca, Na, Mg and Sr concentrations (in 10^{-6} mol/l) for the Congo monthly samples, the Congo tributaries and the Kouilou River. Congo discharge (in km^3/s) are from Bricquet (personnal communication), Tributaries discharge (in km^3/s) are from Note d'information P.I.R.A.T. n°2, 1989.

SAMPLES	DISCHARGE	HCO3	Cl	SO4	Ca	Na	Mg	K	Sr	Σ−	Σ+	87Sr/86Sr	2 σ
. CONGO													
11/88	55000	-	32	-	47	60	41		0.123			0.718876	3E-05
01/89	55600	134	21	12	43	58	39	30	0.125	179	252	0.718726	3E-05
02/89	38500	167	37	13	39	62	41	34	0.144	230	256	0.719065	2E-05
03/89	32400	267	35	18	41	102	63	46	0.164	338	356	0.719881	3E-05
04/89	37800	300	46	12	47	84	58		0.137			0.719794	3E-05
05/89	36900	300	27	16	48	103	66		0.150			0.719886	3E-05
06/89	31000	330	34	17	57	109	78		0.160			0.720046	2E-05
07/89	25600	370	51	15	57	118	87		0.158			0.719708	3E-05
08/89	27100	330	49	22	66.	121	82		0.165			0.719127	4E-05
09/89	33200	270	43	22	53	77	72		0.168			0.71888	3E-05
10/89	37300	260	59	15	51	74	73		0.170			0.718669	5E-05
11/89	46700	184	33	11	52	49	56	36	0.131	239	301	0.718762	3E-05
12/89	50800	150	34	16	54	57	53		0.136			0.718685	3E-05
TRIBUTARIES													
Oubangui	7500	235	22	13	65	63	41	28	0.170	283	303	0.719682	3E-05
Zaïre	34650	375	47	29	68	135	98	56	0.238	480	523	0.717924	2E-05
Kasaï	11500	155	27	13	44	53	38	33	0.118	208	250	0.720442	2E-05
Sangha	4750	130	18	8	63	34	31	30	0.147	164	252	0.716346	3E-05
Likouala	2000	-	16	9	40	13	39	-	0.087	-	-	0.716216	5E-05
SHORT COASTAL RIVER													
Kouilou		-	145	29	192	131	167	-	0.510	-	-	0.710137	2E-05

Table 2 :

Modelization of the concentration fluctuations, results of discharge (in km^3/s) at Brazzaville (Bricquet J.P., personnal communication), range of the Southern (Zaïre and Kasaï Rivers) zone (subscript Discharge S) and Northern (Oubangui and Sangha-Likouala Rivers) zone (subscript Discharge N) discharge; observed (obs.) and calculated (calc.) Sr, Ca, Na, Mg content range with discharge.

Sample	Discharge	Discharge N	Discharge S	Sr obs	Sr calc	Ca obs	Ca calc	Na obs	Na calc	Mg obs	Mg calc
01/89	55600	4620	37590	0.125	0.187	43	59	58	87	39	66
02/89	38500	2350	26370	0.144	0.203	39	64	62	105	41	80
03/89	32400	1750	27670	0.164	0.201	41	63	102	104	63	79
04/89	37800	2530	32510	0.137	0.194	47	61	84	95	58	72
05/89	36900	3470	29810	0.150	0.197	48	62	103	98	66	74
06/89	31000	4000	19960	0.160	0.211	57	68	109	114	78	87
07/89	25600	4500	16130	0.158	0.217	57	70	118	122	87	92
08/89	27100	6830	17370	0.165	0.208	66	68	121	110	82	84
09/89	33200	9160	19560	0.168	0.199	53	65	77	100	72	76
10/89	37300	15300	22500	0.170	0.19	51	65	74	78	73	74
11/89	46700	14850	33400	0.131	0.186	52	60	49	85	56	64
12/89	50800	7010	32610	0.136	0.189	54	60	57	89	53	67

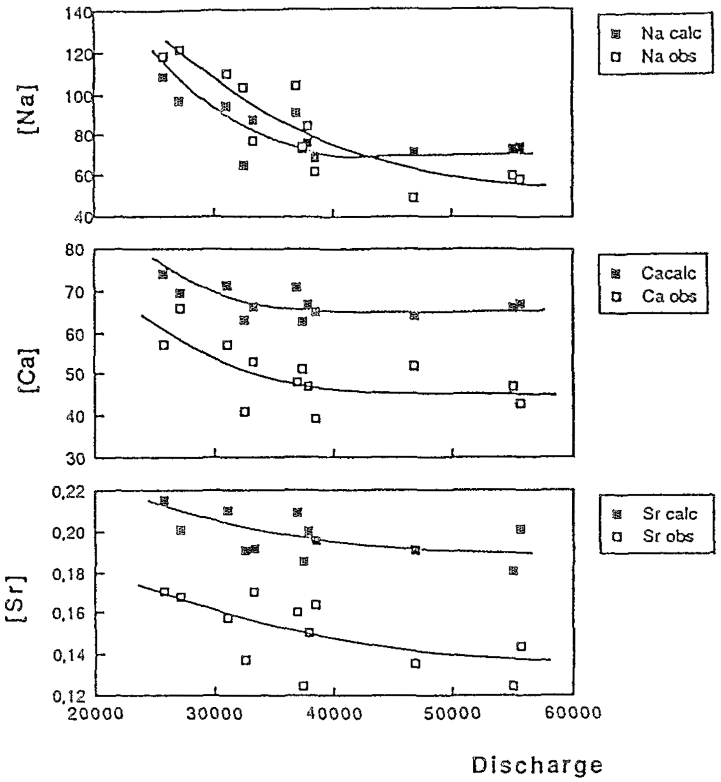


Figure 7
Range of calculated and observed Ca, Na and Sr concentrations with discharge of the Congo River.

	Ca	Na	Mg	Sr
Congo				
Meybeck 1978	74	68	87	
Sarin et al. 1989	64	74	58	
Deronde & Symoens 1980	70	108	44	
This study at Brazzaville	60	93	72	0,2
This study at the Congo outfall	83	96	89	0,22
Kouilou				
This study	8	2	-	0,02

Table 3
Dissolved solids output by the Congo River and the Kouilou River in 109 mol/y.

Nevertheless, for some elements like Ca, Mg and Sr, budget of the Congo River may be under estimated because of the existence of schist-limestone and schist-sandstone terranes between Brazzaville and Congo river outfall. These lithologies are drained by several rivers in Congo, Zaire and Angola (Cahen et al., 1984; Jamet & Rieffel, 1976; Denis, 1974; Denis & Rieffel, 1975). We have no samples from rivers flowing in Zaire and Angola but we have samples from rivers flowing in the occidental part of the Congo Basin (Nyari and Foulakari) which drain schist-limestone and schist-sandstone terranes (Négrel et al., 1993).

The increase between the Congo discharge at Brazzaville and at the outfall is close to 50 km^3/y. Rivers flowing on schist-limestones represent 30 km^3/y, those flowing on schist-sandstone represent 20 km^3/y (Van Ganse, 1959). Using chemical characteristics of the Nyari and Foulakari rivers (Négrel et al., 1993), we obtain an increasing of the Ca budget between Brazzaville and the Congo outfall close to 30%. The increasing is close to 20% for Mg, 10% for Sr and 3% for Na. These results show the importance of the schist-limestone terranes on the Ca, Mg and Sr budget of the Congo River.

Furthermore, until today, the dissolved solid exportation rate from continents to the oceans has been calculated using world wide streams (Durum et al., 1963; Meybeck, 1988; Berner & Berner, 1987). In these studies, short coastal streams have always been neglected. Although the discharge of these streams is lesser than the world wide streams, the exportation of some elements such as Ca, Mg and Sr by short coastal streams must be considered. In order to study the influence of these rivers, we have compared the Congo River output at the outfall and the Kouilou River one.

The main stream of Kouilou is formed after confluence of Loesse and Nyari Rivers. Annual average discharge of Kouilou is close to 1200 m^3/s (Unesco, 1979) and represents 3% of the Congo annual discharge. We have calculated Ca, Na and Sr monthly concentrations using the logarithmic law determined on the Oubangui Basin (Négrel, 1992; Probst et al.,1992). The annual exportation rate for these elements is given in table 2. For Na, Kouilou exportation rate represents 2% of the Congo one. For Ca and Sr, Kouilou exportation rate represents respectively 11% and 5% of the Congo one.

At the first order, 4 short coastal streams flow from the centre of the African continent to Atlantic ocean across limestones terranes. This implies that exportation rate from the centre of this continent is under estimated of about 45% for Ca and of about 20% for Sr.

The Sr budget to the ocean has been investigated by Palmer & Edmond (1989) using only the major world rivers. The value they give for the Zaire river is quite different from our value because they don't take in account the short coastal streams.

Using the calculation of Palmer & Edmond (1989) for the continental input by rivers to the ocean and our results of Sr carried out by the centre of the African continent, we obtain an increase of about 2% for the Sr content from continental input to the ocean. This implies that the Sr budget to the ocean requires the knowledge of the short coastal streams outputs because of the possible existence of carbonate terranes.

4. 3. Origin of some chemical species carried as dissolved form by the Congo River

The dissolved load carried out by rivers results from rock weathering and atmospheric inputs. Several studies have shown that atmospheric inputs can be an important constituent of rivers chemistry (Meybeck, 1983; Stallard & Edmond, 1981; Sarin et al., 1989; Négrel et al., 1993). On the Oubangui Basin (Négrel & Dupré, this volume), 3 components have been evidenced : rainwater inputs, weathered silicate and carbonate; saltrocks are not present on this basin. Considering the main lithological types observed in the Congo Basin, the modelization of dissolved species behaviour in rivers is to use four source reservoirs, say the weathered silicate, carbonate and saltrocks (located in the Zaïre area) sources plus the rain water inputs. We have developed an inversion scheme to compute a multimixing equation for Ca, Na, Mg and Sr (Négrel et al., 1993) between these four end-members using Cl as rain inputs reference. This calculation allows the quantification of the input of each main reservoir for each element on every monthly samples of the Congo river at Brazzaville.

To summarize, *for the rain contribution*, Na vary between 18 (August) and 43% (November), Mg between 24 (July) and 51% (February), Ca between 26 (August) and 44% (February-March). Sr is quite constant and vary between 12 and 16%.

For the rock weathering inputs, the results show that dissolved sodium input is dominated by silicate weathering (29 to 77%) with a weak proportion originating from carbonate weathering (0.1-1.6%). Likewise, dissolved Na originating from saltrocks dissolution range between 2 and 42%.

Dissolved calcium input is dominated by carbonate dissolution (30-56%) in February, April, June and August to December; by silicate dissolution (33-41%) in January, March and May; in July the proportion is close between carbonate and silicate input (28-29%). Salty rock dissolution contribute for 3-15% of dissolved Ca.

Dissolved magnesium input is dominated by carbonate dissolution (30-56%) in July, and September to December; by silicate dissolution (33-41%) in March, May, June; in January, February, April and August the proportion is close between carbonate and silicate input. Salty rock dissolution contribute for less than 1% of dissolved Mg excepted in January.

For Sr, whatever the sample is, the input is dominated by silicate weathering (46 to 81%); 2 to 20% and 0 to 21% of dissolved strontium came respectively from carbonate and salty rock dissolution

At the Brazzaville station, for an average year after normalization to the discharge, sodium and strontium are dominated by silicate weathering while calcium and magnesium are dominated both by silicate and carbonate weathering.

These results agree with those obtained on the main rivers of the Congo Basin (Négrel et al., 1993) and show the importance of rainwater inputs (20-50% for Ca, Na and Mg; 15% for Sr) and carbonate weathering even though these formations are poorly exposed in the main part of the basin.

5 - CONCLUSION

1) The one year study of the Congo River has revealed that the concentration and isotopic variations are dependent of the hydrologic functioning and result from mixing between different water pools.

2) The exportation of elements by the Congo River is under estimated because of the limestones contribution between Brazzaville and the Congo outfall.

3) This study shows the importance of the short coastal streams contribution to the input to the oceans. The conclusion is that if limestones are present, the input of Ca, Mg and Sr to the ocean is under estimated because of the short coastal streams contribution.

4) Using a classical modelization with four source reservoirs, say the weathered silicate, carbonate and salty rock sources and the rain water inputs, an inversion scheme is used to compute the multimixing equation for Ca, Na, Mg and Sr on monthly samples of the Congo river. Atmospheric inputs carried by rainwater to the Congo river water are important for Ca, Na, Mg and Sr. For rock weathering inputs, dissolved sodium and strontium inputs are dominated by silicate weathering while dissolved calcium and magnesium inputs are dominated by carbonate dissolution.

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