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by

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PRELIMINARY DATA ON ATMOSPHERIC AEROSOL OF THE AMAZON BASIN *

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A B S T R A C T

Preliminary distributions of the trace-elements Al, Si, P, S, Cl, K, Ca, Ti, V and Fe in the atmospheric aerosol of the Amazon Basin have been determined through samples collected from August 23 to September 2 of 1980, at a remote place located in the Amazon Forest, about 30 km NE of the city of Manaus. In all, 10 complete cascade impactors of 6-stage, Battelle model, have been exposed but only 8 with success, thus generating 48 samples. From these, 33 samples have been succesfully analyzed by the PIXE method (Particle Induced X-Ray Emission), using - particle beam of the Pelletron Accelerator of the University of São Paulo, and the results revealed that the trace-elements S and K have a noticeable predominance, mainly as fine particle size, relative to the others.

The high correlation factor found between the fine particle concentrations of S and K (0.96) support the assumption of their common airbone transport on the same particulates, originated from the gas-to-particle conversion of gases exuded by the trees of the forest, their only existing sources. Coarse airborne particles, of a probable soil origin, are also present but in unusually small amounts, as it was revelead by the Al, Si, Ca, Ti and Fe size distribution curves.

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INTRODUCTION

Despite the increasing number of experiments which have been performed recently in many remote regions of the world [1,2,3,4], the general knowledge on the distribution of natural trace-components in the atmosphere is still insufficient to support precise evaluations of background concentrations, either for the trace-gases of the atmosphere or for the trace-elements of the natural aerosols.

A particularly important point on this matter is the accumulation of data on the trace-elements that constitute the natural atmospheric aerosol of the Amazon Basin. This is an important matter under both points of view: the determination of the characteristics of this sort of atmospheric aerosol, and the determination of relations between this aerosol and the forest which is the dominant source of certain trace components, since as it is well-known, the living and dead vegetals constitute emission sources for many chemical elements. For instance the exudation from conifer trees has been studied by Curtin et al.[5] and discussed by D.Lawson[6].

A previous experiment for these purposes has already been performed, approximately on the same region, in March 1977, by the Florida State University group. At that time, they ran only two 24-hour impactors for a period of 48 hours[6,7].

In this experiment, although we look practically for all elements with Z>13, only the trace-elements Al, Si, P, S, Cl, K, Ca, Ti, V and Fe have been significantly detected on the different size ranges selected by the operated 6-stage cascade impactor samples. Some trace-elements which are ordinarily part of all urban aerosols, as, for instance Cu, Zn, Br and Pb, have

not been detected, in spite of the uncommonly low detection limit of the PIXE method adopted for the analysis of the samples.

SAMPLING AND ANALYTICAL PROCEDURE

Sampling was performed in August-September 1980, using 6-stage home-made cascade impactor of Battelle model, operating at a flow rate of about 0.7 ℓ/min, discriminating the collected particulate matter in the following size ranges of its aerodynamic diameters: stage-1, from 0.25 μm to 0.5 μm; stage-2, 0.5 - 1 μm; stage-3, 1-2 μm; stage-4, 2-4 μm; stage-5, 4 μm; the so called stage-0 had a nuclepore 0.4 μm filter which retained the $\leq$ 0.25μm particulates.

Substrata for sample collection were carefully prepared in a proper clean laboratory at the IFUSP. Aiming at preventing particulate bounce off in detection, thin mylar coated with vaseline was used in stages 2 to 5, and paraffin in stage 1. On both cases, slides were separated to be used as blanks.

Special care has been taken in all transport and handling operations of the filters throughout the experiment. The sampling place was a remote location called "Estação Duque", an experimental meteorological station (temporarily out of work), inside the jungle, 30 km northeast of the city of Manaus (Amazonas, Brazil), belonging to the "Instituto Nacional de Pesquisas da Amazônia" (INPA), as shown in fig. 1.

The following characteristics relative to the sampling are remarkable: Duque Station is located inside the jungle, without any anthropogenic sources within a radius of about 20 km, except for a road with low traffic situated about 2 km away from the sampling site; there was electric-power available from ordinary power supply lines; the INPA meteorological station, placed near Manaus,

registered dominance of northeast and east winds during the sampling period. Table 1 presents the general data relative to this field sampling.

In all, 10 complete cascade impactors have been collected but 2 have been lost due to failure in air flux measurements. 48 samples (6 for each impactor) have been, therefore, succesfully generated.

We analyzed 33 samples through the PIXE (Particle Induced X-Ray Emission) method: each sample has been irradiated with an α-particle beam of 8 MeV, performing an electric charge accumulated of about 2 μC, from the Pelletron Tamden Accelerator of the University of São Paulo[8,9]. The X-Ray spectrum produced by each sample was first stored in a magnetic tape and then analyzed through special semi-automatic computational program in a PDP-11/60 computer.

The estimated accuracy of the resulting concentrations obtained is of about 30% for the medium Z-elements (K, Ca, Ti, V and Fe), falling down to about 50% for the low Z-elements (Al, Si, P and S).

RESULTS

Tables 2 to 4 present the element concentrations for the elements Al, Si, P, S, Cl, K, Ca, Ti, V and Fe as determined for the atmospheric aerosol of that region of the Amazon Basin, classified according to their size range relative to the state of detection of the cascade impactor samplers used.

On each of the Tables 2, 3 and 4 we present the results of pairs of cascade impactors that ran together and simultaneously in the sampling field, that is: Table 2 is for the pair labeled 2A-2C; Table 3 for 3A-3C; Table 4 for 4A-4C. The very good

consistency generally obtained for the results generated by the two impactors of each pair is an important indication for the quality of the final data.

DISCUSSION AND CONCLUSIONS

First, it should be emphasized that the herein referred field sampling was carried out at the end of the dry season in the Amazon Region, in general with quite good weather, and an almost constant light wind blowing from NE; we believe that these circumstances allow a high representativeness for the obtained mass distributions of the trace-elements detected in the aerosol of the region, during that season.

A better visualization of the trace-element mass distribution among the different sizes of the collected Amazon aerosol may be obtained through the examination of the average size distribution curves shown in figure 2. In fact, in these curves it is quite noticeable, for instance, the dominant behavior of the S and K- curves relative to the other trace-elements: the S-curve, actually a fine-mode (particles with aerodynamic diameter ≤ 2.5 μm) distribution of the mass (since its coarse mode area was estimated as of about 12% of the fine one), while those of K with a bimodal feature but with a clear predominance of the fine mode as compared to the coarse one. The other average-distribution curves show features of coarse mode distributions. (The Al and Si curves, presenting an unexpected growth in the fine particle size region, should be seen with some suspicion since the detection limits and the uncertainty of both elements are usually high in the analytical PIXE method, because of X-Ray absorption problems). P and V curves have not been drawn in fig.2 since these two elements were detected only in a few cases (see tables 2 to 4), with

values certainly close to their detection limits.

An interesting conclusion is suggested by the high value found for the linear correlation factor, 0.96, for the pair of concentrations (S,K), measured at the stages 0 to 2 (that is, the fine particles) of the 6 analyzed impactors (in total, 18 concentration pairs taken from tables 2 to 4): the airborne transportation of S and K in the aerosol investigated might occur on the same particulates, originated from the gas-to-particle conversion process of gases exuded by the trees of the forest, since they are the only existing sources of the region. This conclusion is strengthened by the close accordance found for the S/K mass ratios, both for the vegetals and for the measured fine particle concentrations of, respectively, 1.7 and 2.3.

Finally, we should also mention the generally low concentration values found for the coarse modes of the trace-elements examined (see fig.2). This fact, apparently disagreeing with the previous data published by the FSU group[6,7], might be, probably, due to the absence of soil dust at the sampling site, since a thick grass layer covered all the area until the edge of the forest. On the other hand, the strong correlations found between these coarse modes (for Ti and Fe, 0.84, and Ca and Fe, 0.87) altogether with the ratio values Ti/Fe = 0.59 and Fe/Ca = 1.9 (close to the ones found in the soil, respectively, 0.13 and 2.8[10]) strongly support the assumption of a dust soil origin for them.

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TABLE 1 - GENERAL DATA FROM FIELD SAMPLING AT DUQUE-STATION IN THE AMAZON FOREST (1980)

SAMPLING	DATE OF SAMPLING		DURATION OF SAMPLING (HOURS)	AVERAGE FLOW RATE (P/MIN.)	TOTAL SAMPLED (VOL. M^3)
	STARTED ON DAY/MONTH/TIME	FINISHED ON DAY/MONTH/TIME			
AM6A AM6C	23 AUG 10:33	25 AUG 15:42	53,2	0,63	2.1
AM5A AM5C	25 AUG 16:10	26 AUG 08:30	~ 11*	-	-
AM4A AM4C	26 AUG 16:20	28 AUG 16:50	48,5	0,55	1.6
AM3A AM3C	28 AUG 17:25	02 SEPT 15:20	~ 90*	0,60	3.2
AM2A AM2C	02 SEPT 15:55	04 SEPT 11:55	44	0,56	1.5

* There was power interruption during about 4hs.

TABLE 2 - TRACE-ELEMENTS CONCENTRATIONS DETERMINED BY THE PAIR OF IMPACTOR 4A AND 4C (IN NG/M^3); VOLUME OF AIR SAMPLED: 1.6 M^3

	IC - AM4A							IC - AM4C						
IC STAGE / ELEMENT	0	1	2	3	4	5	Σ (0 to 5)	0	1	2	3	4	5	Σ (0 to 5)
Al			12	22	63		97			4.8		4.1	136	183
Si	25		13		61		99	40		7.4		56	131	235
P				4.2			4.2							
S	27	160	92	23	14	26	342	19	157	132	23	24	20	375
Cl			4.0	13	48	42	106					64	48	112
K	10	63	39	15	45	22	195	5.3	59	74	19	50	18	226
Ca		3.2	3.3	4.1	12	83	106			7.7	6.9	12	53	79
Ti				1.1	4.5	28	33				1.3	3.6	11	15
Fe			2.8	7.0	20	36	66			2.9	8.6	19	33	63
V		3.3	2.4				5.7		3.4	1.5				4.9

TABLE 3 - TRACE-ELEMENTS CONCENTRATIONS DETERMINED BY THE PAIR OF IMPACTORS 3A AND 3C (IN NG/M^3); VOLUME OF AIR SAMPLED: 3.2 M^3

	IC - AM3A							IC - AM3C						
IC STAGE / ELEMENT	0*	1	2	3	4	5	Σ (1 to 5)	0	1	2	3*	4	5	Σ (0 to 5,-3)
Al	-		3.1		2.3		5.4		39		-	1.3		40
Si	-		6.0		6.9	8.2	21	21	6.1		-	8.4	22	57
P	-				4.2		4.2				-	5.0		5.0
S	-	136	57	12	7.8	2.0	215	5.8	96	106	-	8.5	3.0	219
Cl	-			2.8	13	6.8	22				-	13	9.0	24
K	-	58	17	12	32	14	140	6.9	32	40	-	37	17	133
Ca	-	0.8	1.3	1.9	4.5	5.6	14		1.5	3.3	-	5.1	8.9	21
Ti	-			0.5	0.4	0.3	1.3				-	0.8	1.0	2.4
Fe	-	0.8	1.7	4.4	5.1	3.5	16		2.0	2.4	-	6.2	5.6	16
V	-								0.4		-			0.4

* - Samples corresponding to stage 0, IC-AM3A, and stage 3, IC-AM3C, have not been analyzed by PIXE.

TABLE 4 - TRACE-ELEMENTS CONCENTRATIONS DETERMINED BY THE PAIR OF IMPACTOR 2A AND 2C (IN NG/M^3); VOLUME OF AIR SAMPLED: 1.5 M^2

	IC - AM2A							IC - AM2C						
IC STAGE / ELEMENT	0	1	2	3	4	5	Σ (0 to 5)	0*	1	2	3	4	5	Σ (1 to 5)
Al		13				5.5	19	-				0.9	9.3	10
Si	37	17	6.0		27		86	-		7.7		27	44	78
P				4.3			4.3	-			7.4			7.4
S	31	138	48	5.7	12		235	-	127	74	9.3	12	3.0	226
Cl				5.0	24	7.2	36	-			6.9	25	14	46
K	9.4	69	21	12	29	7.8	148	-	58	33	11	32	15	149
Ca		3.7	2.3	4.3	7.1	8.6	26	-	2.4	2.0	3.6	7.9	6.9	23
Ti				0.2	0.7	1.6	2.5	-				1.1	3.7	4.8
Fe			2.9	5.1	15	9.5	33	-		2.0	10	14	16	42
V		0.8					0.8	-						

* - Samples corresponding to stage 0, IC-AM2C, have not been analyzed by PIXE.

FIGURE CAPITONS

FIG. 1 - The geographic location of "Estação Duque" of the "Instituto Nacional de Pesquisas da Amazônia".

FIG. 2 - The average size distribution curves of Al, Si, S, Cl, K, Ca, Ti and Fe.

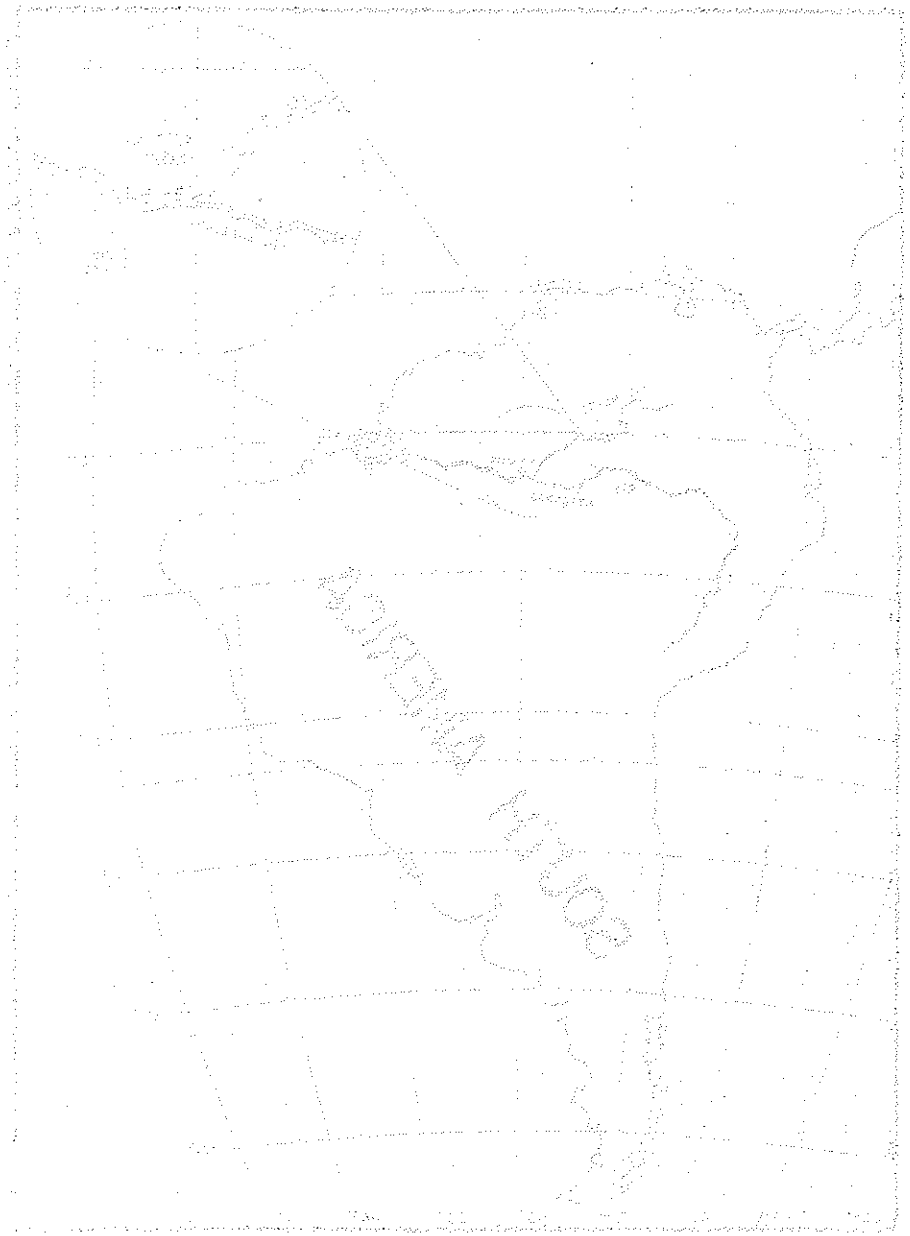

FIGURE 1

FIGURE 2