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PARTITION OF TRANSITION ELEMENTS BETWEEN SOIL AND CAATINGER WOOD GROWN IN NORTH-EAST BRAZIL DETERMINED BY NEUTRON ACTIVATION ANALYSIS

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Seven representative wood species constituting caatinger forest were chosen to analyze Sc, V, Cr, Mn, Fe and Co, as well as Na, Mg and Al, by instrumental neutron activation analysis. In most cases of the soil, the concentration of the element tended to be higher with the increase of depth. Generally, the element partition from soil to root was higher in Mg and Co, whereas V showed higher partition rate from root to bark. The correlation within the elements was higher in the order of soil, root and bark.

INTRODUCTION

Caatinger covers the semi-arid part of North-east Brazil, where the annual rainfall ranges from 400 to 800 mm[1]. Because of the dryness, and shallow and depleted

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soil on hard rocks, the water holding capacity and organic matter content at the area are limited, which results in dominant caatinger vegetation[2]. The growth rate of the tree is slow, showing densely developed annual ring, since only in rainy season is the caatinger able to grow.

Recently, the vegetation of caatinger has been attracting attention based on scientific interest to study the mechanism of environmental tolerance, water deficiency, insufficient nutrients and so on. However, there is hardly any research based on the element partition between wood and soil to study the strategy of the plant adapting to the severe environmental conditions.

The representative wood species constituting caatinger forest were chosen for analyzing the element partition from soil to wood. Instrumental activation analysis was performed to determine the transition elements, Sc, V, Cr, Mn, Fe and Co, as well as Na, Mg and Al in soil along with depth, corresponding to root, the upper part of the wood, i.e. ground level bark and 1 m above, along with annual rings. Then the element partition between soil, root and upper part of the wood was investigated. The correlation of the element concentration between root and soil with respect to the different soil layers, as well as that within the element were also analyzed.

EXPERIMENTAL

The research was performed in the semi-arid area of North-east Brazil, in the suburbs of Juazeiro city in Bahia State. The area was an erosional plain forming Brazilian shield. The altitude was about 400 m from sea level and granite appeared to constitute the main geological rock features. Seven caatinger species, Jureima-branca (*Piptadenia stipulacea*), Faveleira (*Cnidoscolum phyllacanthus*), Jureima-preta (*Mimosa hostilis*), Caatingueira (*Caesalpinia pyramidalis*), Manisoba (*Mannihoteae glaziovii*), Burra-leiteira (*Sapium cicatricosum*) and Umbu (*Phytolacea dioica* L.) were selected, whose ages and diameter at ground level were found to be 8, 3, 3, 5, 3, 10 and 10 years, 14.4, 3.5, 1.4, 8.0, 4.2, 16.5 and 16.5 cm, respectively. Wood disk samples at 1 m above and ground level were cut with a chain saw. To get the soil and root sample from specific soil layers, the soil profile was prepared underneath the place where the tree was downed. After investigation of the soil horizon, soil and root samples at each layer were carefully collected in a vinyl bag.

Soil and plant samples were dried at 60 °C overnight. The soil sample was ground in an agate mortar and sifted with a sieve to get the soil fraction smaller than 2 mm in diameter. Then the sample was doubly sealed, in a well washed polyethylene vinyl bag as flat as possible to avoid air, thereby, to prevent ^{42}Ar formation on activation, whose γ-ray would raise the background in the measurement. Root samples from the corresponding soil layers were wiped well with ethanol and, after treatment with a ceramic coated file, they were sealed in polyethylene vinyl bags in the same way.

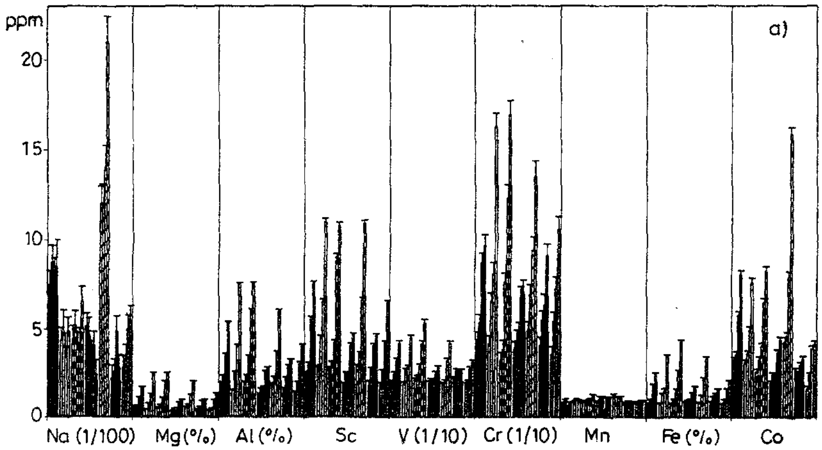
Thin wood disks with 1 cm in thickness were prepared from each wood species, collected from ground level bark and above 1 m from the ground. Then the disk section with 1 cm in width, across the annual ring, including center, was taken out from each wood disk with a fret saw. Each section was further cut into pieces about 1.5 cm in width from sapwood to heartwood to know the element distribution along the xylem. The sectional plane was rasped with a ceramic coated file to eliminate contamination by metal from the saw. Each wood sample was sealed in a polyethylene bag for irradiation in the same way as soil samples.

The samples were irradiated for 30 s to determine ^{27}Mg, ^{28}Al, ^{52}V and ^{56}Mn, and for 24 h for ^{24}Na, ^{46}Sc, ^{51}Cr, ^{59}Fe and ^{60}Co in a Triga Mark II type reactor at the Institute for Atomic Energy, Rikkyo University, with a thermal neutron flux of $1.3x10^{12}$ n $cm^{-2}s^{-1}$. To determine the element content, reference materials, JB3 (Geological Survey of Japan) and orchard leaves (National Bureau of Standards) were irradiated at the same time. After irradiation, the γ-rays emitted from the sample were measured by a Ge(Li) detector. The γ-rays used to determine ^{24}Na, ^{27}Mg, ^{28}Al, ^{46}Sc, ^{52}V, ^{51}Cr, ^{56}Mn, ^{59}Fe and ^{60}Co were, 1.369, 1.014, 1.779, 0.889, 1.434, 0.320, 1.811, 1.099 and 1.173 MeV, respectively.

RESULTS AND DISCUSSION

When the soil profile was prepared, the hard rock material appeared in every soil profile prepared. Four to five soil layers were observed, at each soil profile, from 60 to 85 cm in depth. The soil layer on the hard rock was featured as physically and chemically sterile. The sandy soil contained many nodules consisting mainly from quartz, limiting the water holding capacity and rendering the soil easy to be dried. The other character was the immaturity of the soil derived from highly depleted fumic layer, resulting in indistinct layer differentiation.

Through neutron activation analysis of soil and wood, Na, Mg, Al, Sc, V, Cr, Mn, Fe and Co were determined. Figure 1 shows the element amount of soil (a) and root



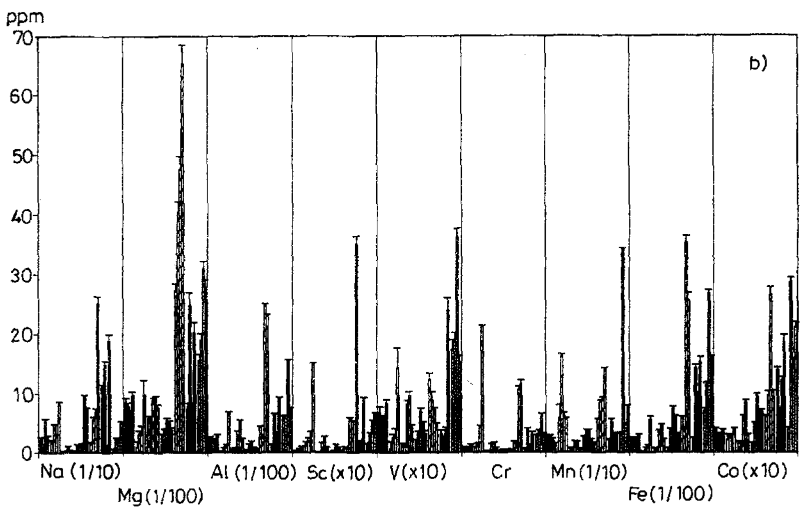


Fig. 1. Concentration of Na, Mg, Al, Sc, V, Cr, Mn, Fe and Co in root (a) and in soil (b). Hundred times lower amounts were plotted for Na and ten times lower amounts for V and Cr. For each element, seven plant species, Jureima-branca (■), Faveleira (□), Jureima-preta (◪), Caatingueira (▦), Manisoba (▧), Burra-leiteira (■) and Umbu (▩), are shown from left to right. In each wood species, four to five columns, from left to right, indicate the samples collected from different soil layers, along the depth. Especially in soil (a), the samples from deeper layers tended to show higher element concentrations within the same wood site

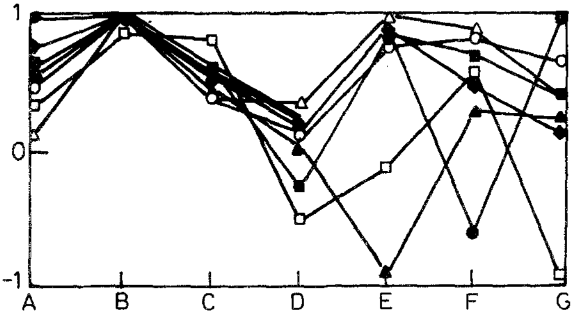


Fig. 2. Correlation factors of elements in root and soil along the depth, at each wood site. The series of notes from A to G correspond to the wood species Jureima-branca, Faveleira, Jureima-preta, Caatingueira, Manisoba, Burra-leiteira and Umbu, respectively. The series of notes from A to G show the wood species plotted. Al (■), Sc (●), V (▲), Cr (◆), Mn (□), Fe (O) and Co (Δ)

(b) in Jureima-branca (A), Faveleira (B), Jureima-preta (C), Caatingueira (D), Manisoba (E), Burra-leiteira (F) and Umbu (G). In all cases of soil profile, the element concentration tended to be higher with the depth, except for Na and Mn. However, in root, a similar tendency could not be observed. Therefore, the correlation of the element concentration in each soil layer to that of the corresponding root was calculated (Fig. 2). In the case of Faveleira (B), the concentrations of all the elements in root from different depths correlated well to those of the soil at the same depth. The correlation factor showed a similar tendency in each wood species except for Mn (□) and Al (■) in Caatingueira (D), Mn (□) and V (▲) in Manisoba (E), Sc (●) in Burra-leiteira (F) and Al (■) and Sc (●) in Umbu (G).

Figure 3 shows the element partition for individual wood species, from soil to root (a), root to ground level bark (b) and from ground level bark to that at 1 m above

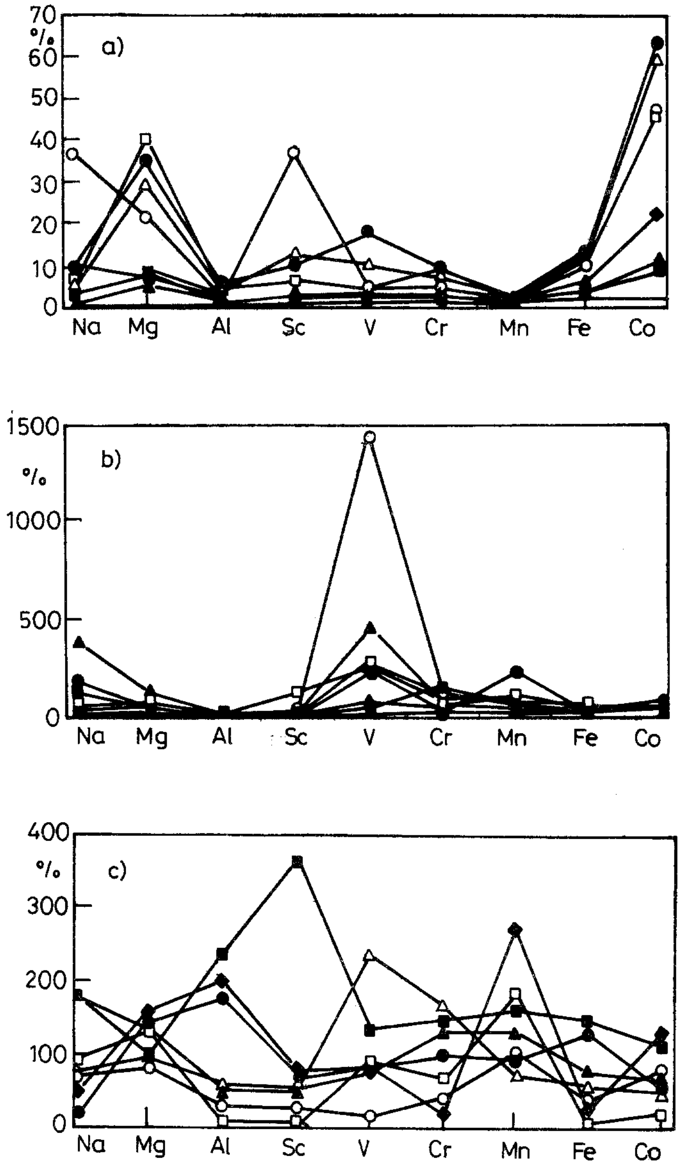


Fig. 3. Element partition ratio from soil to root (a), root to ground level bark (b) and from ground level bark to that 1 m above (c), where the mean value of the element concentration in soil, root and ground level were set as 100%, respectively. Jureima-branca (■), Faveleira (●), Jureima-preta (▲), Caatingueira (◆), Manisoba (□), Burra-leiteira (O) and Umbu (Δ), respectively

the ground (c), where the average amount of the element in soil, root and bark at ground level were set as 100%, respectively. The series of notes from A to G correspond to the wood species, Jureima-branca, Faveleira, Jureima-preta, Caatingueira, Manisoba, Burra-leiteira and Umbu, respectively. In the root, the concentration of all the elements was lower than that in soil (Fig. 3a). From soil to root, Mg and Co tended to be parted to higher degree than the other elements. In the case of Burra-leiteira (O), Na and Sc also showed higher partition. At the ground level bark, in generally, V showed higher concentration than the corresponding root (Fig. 3b). Especially in Burra-leiteira (O), the V concentration was 15 times higher than that in root. In the case of Faveleira (●) and Jureima-preta (▲), Mn and Na also tended to be higher, respectively. Inside the bark, from ground level to 1 m above ground, there was no specific element movement common to all wood species (Fig. 3c).

To find out the correlation within the elements detected, correlation of each element concentration with that of Al was calculated (Fig. 4). The note series from A to G indicate the same wood species as those in Fig. 2. Figure 4a shows the correlation in each soil layer. As is shown in the figure, all of the elements correlated well with each other, except Mn (◆) in soil. Figure 4b shows the correlation of the elements in root collected from different soil layers. In root, though most of the elements correlated well, V (●), Sc (■) and Co (O) did not show a similar behavior to the others in some wood species besides Mn. Figures 4c and 4d show the element correlation in wood bark along with the annual ring, at ground level and 1 m above ground, respectively. In ground level bark (Fig. 4c), there was a great difference

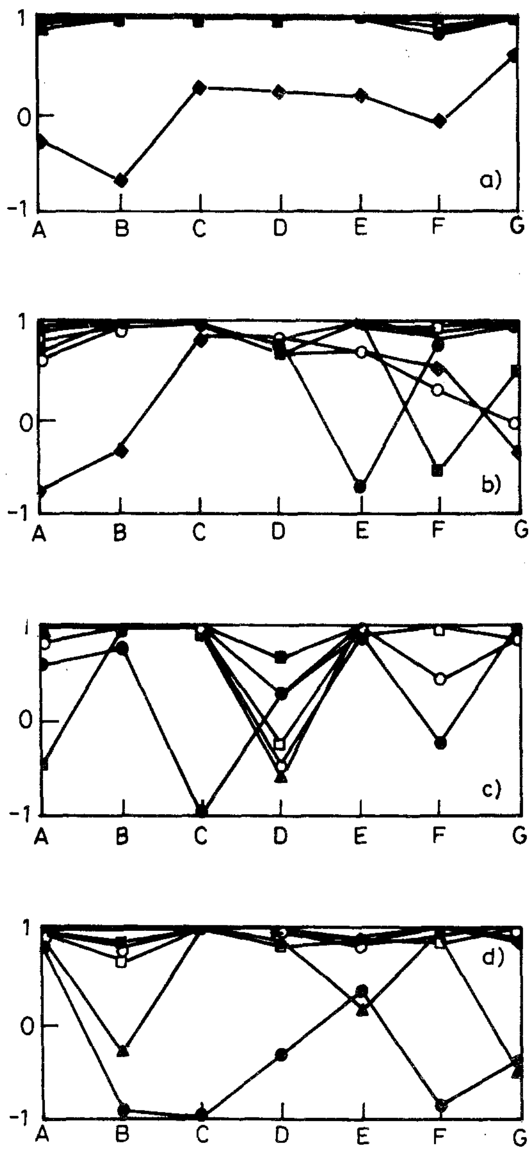


Fig. 4. The correlation factors of each element with Al along the depth in soil (a) and root (b), as well as along the annual ring for ground level bark (c) and that 1 m above ground (d). Sc (■), V (●), Cr (▲), Mn (◆), Fe (□) and Co (O)

in element correlation pattern as a function of wood species. However, it was interesting to say that in the bark at 1 m most of the elements showed better correlation with each other than in ground level bark, except for V (●) and Cr (▲) (Fig. 4d). The strong correlation between the elements indicated in Figs 4b and 4d might suggest that the element concentration in root or bark reflected the nature of that in soil to some extent. Though the correlation of Mn (◆) with the other elements was not so good in root, strong correlation was observed in the bark at 1 m above ground. It is well known that there is a great difference in the element concentration between root and the upper part of the plant. Therefore, weaker correlation between the elements along the annual ring might reflect that selection of the element, from root to bark was different from year to year. Also the weaker correlation of Cr (▲) and V (●) with the other elements at higher bark level (Fig. 4d) suggests an annual difference in the role of these elements.

Since little is known about the element partition from root to bark, the different element partitions found among the wood species might suggest a clue to the strategy of each species to adapt to the environment. In the root of Faveleira (B) and Burra-leiteira (F) a water reserving tissue was found. However, no similarity was found from the element partition or correlation of the elements between the two species.

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REFERENCES

1. T. Nishizawa, M. Tanaka, Arch. Met. Geoph. Biocl., Ser. B, 33 (1983) 107.

2. T. Nishizawa, J.I. Uitto, Fragile Tropics of Latin America, United Nations Univ. Press, 1995.

3. Y. Katayama, N. Okada, S. Iishmaru, M. Nobuchi, H. Yamashita, A. Aoki, Radioisotopes, 35 (1986) 577.