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Litter Production in an Area of Amazonian Terra Firme Forest. Part II. Mineral Nutrient Content of the Litter

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Contents

Abstract

Annually 2.2 P, 12.7 K, 5.0 Na, 18.4 Ca and 12.6 Mg (kg/ha/yr., averages of both years) returned with litter to the soil. Ash content measured 246.8 kg/ha/yr.

Introduction

Subsequently to analyzing organic matter of litter of an evergreen rain forest of the Manaus area, total ash and macro-nutrient contents (P, K, Na, Ca, Mg) of both the annual litter samples of 1963 and the monthly litter fractions of 1964 (KLINGE and RODRIGUES 1968) were determined in the Soils Laboratory at Plön.

Analytical Procedures

Total phosphorus was determined following the method described by ULRICH et al. (1960) using a mixture of hydrochloric, nitric, sulfuric and perchloric acids for oxidation of the organic matter, and molybdenic acid for colour development.

Ash contents were determined gravimetrically after ignition of the samples at 550 °C in a muffle furnace.

Table 1 Nutrients in Litter of

Region	Forest	Litter	O. M.	Nutrients (kg/ha/yr.)				
			t/ha/yr.	P	K	Na	Ca	Mg
Senegal, Casamance (MAHEUT and DOMMERGUES 1960)								
	Teak	Leaf litter, dry	5.8	6	39	—	132	15
	Plantation		4.7	3	31	—	55	18
Congo, Yangambi (LAUDELOUT and MEYER 1955)								
	Mixed forest	Total litter, dry	12.4	7	48	—	105	53
	Brachystegia Forest		12.3	9	62	—	91	44
	Macrolobium Forest		15.3	9	87	—	84	49
	Secondary Forest		14.9	4	104	—	124	43
Ghana, Kade (NYE 1961, NYE and GREENLAND 1960)								
	High forest	Total litter, Oven-dry	10.5	7.3	68	—	206	45
		Leaf litter, Oven-dry	7.0	6.1	70	—	141	38
Colombia (JENNY et al. 1949)								
	Broad-leaved Rain forest	Total litter, Oven-dry	8.5	—	—	—	—	—
	Broad-leaved Forest		10.1	—	—	—	—	—
Amazonia, Manáus (this paper)								
	Terra firme Forest	Oven-dry matter 1963:						
		Leaves	6.4	1.9	11.5	4.9	13.8	11.5
		Wood	1.3	0.3	1.3	0.3	3.7	2
		Fruits	0.2	0.08	0.6	0.08	0.4	0.3
		Total litter	7.9	2.28	13.4	5.28	17.9	13.8
		1964:						
		Leaves	4.8	1.4	8.4	3.7	10.9	8.1
		Wood	1.4	0.3	1.3	0.8	6.6	2.6
		Fruits	0.5	0.3	2.2	0.2	1.1	0.7
		Total litter	6.7	2.0	11.9	4.7	18.6	11.4
Southern Queensland (WEBB 1958)								
	Nothophyll Vine forest	Leaf litter, Oven-dry	6.7	5.6	37	—	75	—
	Simple nothophyll Vine forest		3.4	1.9	12	—	25	—
New Zealand, North Island (WILL 1959)								
	Pinus radiata Plantation	Total litter, dry	5.6	4.1	14.4	3.5	27.2	5.5
	Pinus nigra Plantation		7.9	3.4	17.9	6.4	51.1	7.6
	Pseudotsuga taxifolia Plantation		2.9	2.8	5.3	1.3	26.1	3.1
	Larix decidua Plantation		3.7	2.5	4.5	1.7	21.7	4.2
New Zealand, North Island (MILLER and HURST 1957)								
	Nothofagus truncata stand	Leaf litter, Oven-dry	4.6	3.1	7.6	6.2	44.5	7.9
		Twigs, Oven-dry	1.5	0.6	2	1.1	20.2	2.2
		Total litter, Oven-dry	6.1	3.5	9.5	7.3	65.6	15.7
South Carolina (METZ 1952)								
	Pine stand	Leaf litter, Oven-dry	4.2	—	—	—	20.2	6.8
	Pine-harwood Stand		3.9	—	—	—	49.2	10.8
	Hardwood Stand		4.3	—	—	—	99.5	22.5
North America (LUTZ and CHANDLER 1946)								
	Deciduous Forest		2—3	4	15	—	73	10
	Conifers		2—3	2	7	—	30	5
Central Europe (EHWALD 1957, SCHEFFER and ULRICH 1960)								
	Good Forest Stands	Litter	3.0	4	1.5	—	80	5
U.S.S.R. (SONN 1960, OVINGTON 1962)								
	Picea Forest	Total litter	0.8	2.7	12.3	—	47.8	7.2
				2.4	16.7	—	45.4	5.9

[1]) Calculated on carbon content of 50 per cent.

[2]) Calculated from loss on ignition.

Ratios				Per cent O. M.					Ash	
C/P[1]	N/P	K/Na	Ca/Mg	P	K	Na	Ca	Mg	kg/ha/yr.	per cent O. M.
480	6	—	9	0.1	0.7	—	2.3	0.3	580	10
780	15	—	3	0.06	0.7	—	1.2	0.4	470	10
890	32	—	2	0.06	0.4	—	0.8	0.4	—	—
680	25	—	2	0.07	0.5	—	0.7	0.4	—	—
850	17	—	2	0.06	0.6	—	0.6	0.3	—	—
1,860	35	—	3	0.03	0.7	—	0.8	0.3	—	—
720	27	—	5	0.07	0.7	—	2	0.4	—	—
570	25	—	4	0.09	1.0	—	2.0	0.5	—	—
—	—	—	—	—	—	—	—	—	1,220[2]	14.4
—	—	—	—	—	—	—	—	—	760[2]	7.5
1,680	51	2	1	0.03	0.2	0.08	0.2	0.2	239.9	3.8
2,170	52	4	2	0.02	0.1	0.02	0.3	0.2	28.8	2.2
1,250	23	8	1	0.04	0.3	0.04	0.2	0.2	4.6	2.3
1,750	50	3	1	0.03	0.2	0.07	0.2	0.2	273.3	3.5
1,710	54	2	1	0.03	0.2	0.08	0.2	0.2	168.7	3.5
2,330	49	2	3	0.02	0.09	0.06	0.5	0.2	37.6	2.7
830	21	11	2	0.06	0.4	0.04	0.2	0.1	13.9	2.8
1,680	49	3	2	0.03	0.2	0.07	0.3	0.2	220.2	3.3
600	19	—	—	0.08	0.6	—	1.1	—	—	—
870	19	—	—	0.06	0.4	—	0.7	—	—	—
680	9	4	5	0.07	0.3	0.06	0.5	0.1	—	—
1,160	11	3	7	0.04	0.2	0.08	0.7	0.1	—	—
520	8	4	8	0.1	0.2	0.05	0.9	0.1	—	—
740	11	3	5	0.07	0.1	0.05	0.6	0.1	—	—
740	18	1	6	0.07	0.2	0.1	1	0.2	317.4[2]	6.9
1,000	17	2	9	0.05	0.1	0.09	1.7	0.2	72[2]	4.8
870	16	1	4	0.06	0.2	0.1	1.1	0.3	390.4[2]	6.4
—	—	—	3	—	—	—	0.5	0.2	—	—
—	—	—	5	—	—	—	1.3	0.3	—	—
—	—	—	4	—	—	—	2.3	0.5	—	—
250—375	5	—	7	0.1 —0.2	0.5—0.8	—	2.4—3.7	0.3—0.5	—	—
500—750	13	—	6	0.07—0.1	0.2—0.4	—	1 —1.5	0.2—0.3	—	—
375	13	—	16	0.13	1.5	—	2.7	0.2	—	—
148	19	—	7	0.34	1.5	—	6	0.9	—	—
167	22	—	8	0.3	2.1	—	5.7	0.7	—	—

Alcali and earth-alcali were extracted from the ash with hot ten per cent hydrochloric acid. In these extracts, Na, K and Ca were estimated by flame-photometry. Mg was estimated by atomic absorption. A ZEISS PMQ II apparatus was used for the determinations.

On account of the smallness of original samples, mainly of the 1964 collecting period and, especially, of wood and fruit fractions, all samples or part of them of each year were unified prior to ignition, in the proportion of the original weights of these samples. Some too small samples were left out of consideration.

Because the number of samples in which ash and nutrients were determined were smaller than those of the organic matter determinations, the accuracy of measurements is generally lower than shown for organic matter. No respective calculations were performed.

Values given below are on an oven-dry basis.

Results

The annual return of ash and macro-nutrients to the soil are given in table 1 showing also data on the nutrient content of litter from other forests including tropical ones. It can easily be seen that the annual return of nutrients in the litter of the Amazon forest is much lower than in other forests which is in accordance to its lower litter production. But as to the percentages of nutrients and ash in the litter, the Amazonian forest is also relatively much poorer. This is especially true for phosphorus, potassium and calcium. In turn, it is however relatively rich in magnesium resulting a rather narrow Ca/Mg ratio.

Leaves contain much more ash and nutrients than do wood or fruit, but are poorer than leaves of other tropical forests.

Phosphorus and potassium are highest in fruits, there being small differences between leaves and wood except sodium being very high in leaves. Calcium is higher in wood than in any other litter fraction. Magnesium is equally distributed.

The few data on the ash content appear to indicate that Amazonian forest litter contains much less mineral matter than do other forests ranging between 4.8 and 14.4 per cent. MAHEUT and DOMMERGUES (1960) noted that a value of ten per cent ash in teak litter is exceptionally high.

Differences in ash and nutrient contents of litter fractions of both sampled years are mainly due to the differences in litter production of these years. But there are differences also with regard to their percentage. Wood contained much more sodium and calcium in 1964 than in the preceding year; fruits were richer in calcium, phosphorus and potassium in 1964; leaves had equal contents in both years.

The monthly nutrient and ash return in leaves (expressed as per cent of the total annual yield) is shown in fig. 1. More than fifty per cent of ash and nutrients returned to the soil in the dry season. It cannot be decided whether the differences between humid and dry seasons are due to leaching of litter in the forest or to a real richness of dry season litter.

Fig. 2 shows the oscillations of monthly ash and nutrient return (expressed as a percentage of O. M.) in leaves compared with the respective means. Ash, phosphorus and potassium are lower during the dry season, sodium and earth-alcali are higher. There is no manner to explain exactly this observation which is related to the uptake of nutrients from the soil during both seasons, to return to the trees before the litter-fall and to possible leaching of the litter on the forest floor. It can be concluded, however, that leaching of the litter on the forest floor had not taken place. Otherwise there would be no higher percentages in the humid season.

Monthly return of ash and nutrients in other litter in 1964 cannot be given because only few samples were analyzed.

The poorness of litter in nutrients and ash is supposed to be related to low levels of nutrients in the soil on which the forest grows. But there are no exact data available for the region under discussion which would allow to establish definite relationships between soil and its forest cover (SOMBROEK 1966). SCHWABE (1968), however, when discussing general ecological characteristics of the South American continent striked the importance of low amounts of bioelements circulating in natural ecosystems of this continent.

The fact that the forest of the W. EGLER Forest Reserve is of the mixed type allows the conclusions that its soil offers optimum conditions because under non-optimum conditions single dominant forests grow (RICHARDS 1963).

In connection with this it is mentioned that precipitation is an important factor with regard to the supply of nutrients to the soil (LAUDELOUT 1961), but no data for the Manaus region are available.

The poorness of litter in phosphorus can easily be recognized by the C/P ratios which generally are higher than 1,000 : 1, the ratios for other forests being smaller, and by the N/P ratios as well.

The, by tropical standards, poor quality of the Amazon forest and its litter is indicated not only by a low litter production (see KLINGE and RODRIGUES, Part I), but also by low nutrient contents of the litter. Generalization like that of DOMMERGUES (1963) who wrote: "The actual quantities of the elements involved in the annual cycle is much higher in tropical than in temperate zones, especially as regards nitrogen, magnesium and potassium" seems therefore to be inadequate with regard to the Hylaea.

In addition to macro-elements, the micro-elements Fe, Co, Cu, Mn, Mo and Zn in leaf litter of 1963 (Table 2) were determined following the method described by SCHAUMLÖFFEL (1960, 1962). As there are no data on trace elements of litter of other tropical forests, no evaluation of our data can be given.

Table 2 Some Micro-Elements in Leaf Litter of 1963

	Fe	Co	Cu	Mn	Mo	Zn
g/ha/yr.	1,179.6	1.2	22.2	704.2	1.05	76.4
‰ O. M. . . .	0.18	0.00019	0.0035	0.11	0.00016	0.012

Resumo

Subsequentemente à análise da matéria orgânica da manta vegetal de uma floresta pluvial perenifolia da região de Manaus, tratam os autores neste trabalho das deter-

minações dos conteúdos de cinza total e macro-nutrientes (P, K, Na, Ca, Mg) efetuadas no Laboratório de Solos de Plön tanto das amostras anuais de manta de 1963 como das frações mensais de manta de 1964.

Devido à pequena quantidade de amostras originais, principalmente da coleta de 1964 e das frações de madeira e fruto especialmente, tôdas as amostras ou parte delas de cada ano foram unidas antes da ignição na proporção dos pêsos originais destas amostras. Algumas amostras demasiadamente pequenas não foram consideradas.

Anualmente, 2.2 P, 12.7 K, 5.0 Na, 18.4 Ca e 12.6 Mg (Kg/ha/ano, médias de 2 anos) voltaram ao solo com a manta vegetal. O conteúdo de cinza foi de 246.8 Kg/ha/ano. Na manta vegetal da floresta amazônica, o retôrno anual de nutrientes é muito inferior do que em outras florestas em iguais condições quanto à produção inferior de detritos vegetais. Quanto às porcentagens de nutrientes e cinza na manta, a floresta amazônica é também relativamente muito mais pobre. Isto é exato especialmente para fósforo, potássio e cálcio. Ao contrário, é relativamente rica, entretanto, em magnésio, resultando numa relação Ca/Mg um tanto limitada.

As fôlhas possuem muito mais cinza e nutrientes do que a madeira ou fruto, porém são mais pobres do que as fôlhas de outras florestas tropicais.

Fósforo e potássio são mais elevados nos frutos, havendo pequenas diferenças entre fôlhas e madeira, excluindo o sódio, que é muito elevado nas fôlhas. Magnésio tem distribuição igual.

Alguns dados sôbre conteúdo de cinza parecem indicar que a manta da floresta amazônica possui muito menos mineral do que outras florestas, que estão dentro da faixa entre 4.8 e 14.4%.

Diferenças nos conteúdos de cinza e nutrientes das frações de manta dos 2 anos são motivadas principalmente pelas diferenças na produção de detritos vegetais dêsses anos. Mas há também diferenças quanto à porcentagem. A madeira continha muito mais sódio e cálcio em 1964 do que no ano anterior; os frutos eram mais ricos em cálcio, fósforo e potássio em 1964; as fôlhas possuiam conteúdos iguais nos 2 anos.

Mais de 50% de cinzas e nutrientes retornaram ao solo durante a estação sêca. Não se pode decidir se as diferenças entre as estações úmidas e sêcas são causadas pela lixiviação da manta ou por uma riqueza real da manta na estação sêca.

Cinza, fósforo e potássio são mais baixos durante a estação sêca; sódio e álcali-terroso são mais elevados. Não há como explicar exatamente esta observação que se relaciona à tiragem de nutrientes do solo durante as 2 estações, ao retôrno às árvores antes da queda dos detritos vegetais e à possível lixiviação da manta no chão da floresta. Pode-se concluir, entretanto, que não se deu a lixiviação da manta no chão da floresta. Aliás, não deveria haver porcentagens mais elevadas na estação úmida.

Supõe-se que a pobreza da manta em nutríentes e cinza está relacionada aos níveis baixos de nutrientes no solo em que a floresta se desenvolve. Porém não há dados exatos disponíveis para a região em discursão que permitíssem definir relações entre solo e cobertura florestal.

O fato de ser heterogênea a floresta da Reserva Florestal Walter Egler permíte tirar conclusões de que se deve isto ãs ótimas condições de seu solo porque do contrário se desenvolveriam florestas homogêneas.

Ligado a isto, deve-se mencionar a precipitação como um importante fator relacionado com o suprimento de nutrientes ao solo, porém não há dados disponíveis a êsse respeito para a região de Manaus.

A pobreza da manta em fósforo pode ser fàcilmente reconhecida pelas relações C/P que são geralmente mais elevadas do que 1,000 : 1 e também pelas relações N/P.

Pelos padrões tropicais, a má qualidade da floresta amazônica e de sua manta é devida não só a uma baixa produção de detritos vegetais mas também aos baixos conteúdos de nutrientes da manta.

Complementando os dados sôbre os macro-elementos, êste trabalho apresenta alguns micro-elementos encontrados nos detritos foliares de 1963, determinados pelo método de SCHAUMLÖFFEL. Os valôres dêsses micro-elementos são os seguintes: Fe 1,179.6; Co 1.2; Cu 22.2; Mn 704.2; Mo 1.05; e Zn 76.4 g/ha/ano. Como não há dados comparáveis sôbre êsses elementos na manta de outras florestas tropicais, êsses resultados deíxam de ser avaliados pelos autores.

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