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Assessment of Litter Input, Decomposition and Elements Dynamics in Yatta Tropical Forest in Western Equatoria State, South Sudan

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Abstract: This study characterized soils, assessed litter input, litter decomposition and elements release in Yatta forest, Western Equatoria State, South Sudan during May 2008 and March 2010. The soil was described and sampled. Litter was collected weekly from plots of 16 m^2 under the forest cover with forty replicates. Seventy five litter bags were buried at 15-30 cm soil depth to assess decomposition and elements' release. Twenty fife bags were withdrawn at every 6, 12 months periods Fallen litter, remaining decomposed litter and soil samples were analyzed in the Laboratory of the Department of Soil and Environment Sciences, Faculty of Agriculture, University of Khartoum. The soil was characterized as Oxisols, sandy clay loam, acidic, rich in organic matter, and amply furnished with nutrients. Litter input was 1791 kg/ha/year; with concessive seasonal maxima and minima in dry and wet months. Losses of dry matter were high, ranging of 52.2 % to 96.8 % during the tested periods. The elements K, N, P, Ca, Mg were rapidly released with successive rates ranges of 37 %-62 %, 56 %-72 % and 62 %-90 % during 6, 12 and 18 months observation periods. The results showed a high potential fertility of this natural forest site which will support the sustainability of the growing stock and utilization of the forest for high yielding food crops.

Keywords: Tropical forest, Soil characterization, Litter input and Decomposition, Elements release.

INTRODUCTION

Litter denotes the part of tree-forest stand (foliage, twigs, followers, fruits, pollen grains, bark) that falls and is returned to the soil annually, and as such it is expressed in kg/ha/year (Giweta 2020). It is an indicative of forests' and sites' quality *i.e.* the richer the site the higher the litter production of higher quality and vice versa (Binkley and Menyailo 2005; Krishna and Mohan 2017; Giweta 2020). In this respect, rainforests and those of humid tropical regions are by far the most productive with maximal input of litter annually (Duchaufour 1982; Russell, 1973; Fitzpatrick 1986; Seta *et al*. 2018). Litter quality is refers to its high content of mineral elements, and ameliorative organic compounds and (with low decomposable C/N ratio.) (Swift *et al.* 1979; Duchaufour 1982). The biogeochemical cycling of elements plays a crucial role in production of biomass (litter), turnover, utilization and maintenance in the forested ecosystems (Stanleya and Montagnini 1999; Homann *et al.* 2000; Laclau *et al.* 2010).

Litter input by trees/forests is one of the pathways that they can influence their ecosystems, either positively by *e.g.* ameliorative litter of broadleaves or negatively by acidic litter of conifers (Giweta 2020). Their fore litter to produce that effect must undergo a process of decomposition into secondary organic compounds and mineral elements. Litter decomposition is, however, governed by many factors among which are, litter quality, climatic and soil conditions, biological activity (Vitousek *et al.* 1995). In the warm humid areas, litter decomposition is generally very rapid due to high activity of soil microflora and fauna, and the ensuing products (organic compounds and mineral elements) are readily incorporated into the soil or leached out of it. On the other hand, litter decomposition is very slow in cold areas and it usually tends to accumulate on the soil surface forming an O-layer in most cases (Vitousek *et al.* 1995; Guendehou *et al.* 2014; Krishna and Mohan 2017).

The general objective of this study was to assess the biological cycle of organic matter and elements in a natural forest in a humid tropical region. The specific objectives were characterization of soils under a natural forest; assessment of litter input (quantity) and assessment of litter decomposition and elements' release (quality) under such forest.

MATERIALS AND METHODS

Study site

The study was conducted in Yatta tropical natural forest (lat: 4° 44′ 44″ - 4° 46′ 28″ N and 28° 42′ 25″ - 28° 44′ 33″ E) located in Yambio County, Western Equatoria State, South Sudan.

The climate is of tropical humid type that has a bimodal rain seasons from March to July, with dry spell from second week of July up to first week of August. Then heavy rainfall occurs from August to November. The period of December to February is dry season months. The annual rainfall ranges between 1350 and 1600 mm/yr. The temperature ranges between 24 and 32 °C and the highest temperature is experienced in February and the lowest temperature of about 18 °C in some cases is experienced in August (Kingdon 1989; Smith 1949; Adkins 2015).

The geological formation of the area is composed of Basement Complex and the Nubian Sandstone. The superficial formation is mainly lateritic deposits of ironstone ferruginous red loams, forming a sheet that covers much of western equatorial. Oxisols that have developed from this formation (Soil Survey Staff 2014) are strongly weathered soils, and they have topsoil that can support crop production (Adkins 2015).

The topography is a green belt plateau situated 550 – 700 m *a.s.l.* The area is mainly ironstone plateau, with undulating hills. At the bottom of the hills there are depressions that act as drainage for surface runoff water.

The vegetation is of humid tropical type that is influenced by anthropogenic activities. Natural broad-leaved deciduous trees with open canopy are predominant, *e.g. Combretum sp.*, *Isoberlinia doka*, *Khaya sp. Terminalia sp*. Next to the stream are few riverian species; the height of the trees range between 16 and 36 m. Trees of large girth are rare, big wood climbers are rare, but slender independent tree climbers are frequent. This forest suffers from biotic interferences; most forest fires here are caused by man, to clear land for shifting cultivation to make it easier to collect minor forest products, to smoke honeybees and bush rats.

To some extent forest fires are started by Nilotic cattle keepers to burn the tough old grass and in this way spark fresh shoots with the first rains and also to get rid of tsetse fly. Grass covers of *Aristida adscenious*, *Bidem pilosa*, *Boerhavia diggusa*, *Dactyloctenium aegytuim*, *Eleusine Indica*, *Euphobia hirta*, *Hyparrhenia rufa*, *Imperata cylendrica*, *Panicum maximum*, *Paspalum Commersonii*, *Sporobolus pyramidalis*, *Tridax proculmbens*, are common and well adapted to the environmental conditions (Kingdon 1989; Smith 1949).

Experimental design and Layout

Litter Collection and Quantification

Litter collection was carried out from 1 May 2008 to 30 April 2009; 10 transects of 200 m length, not less than 100 meters apart were traced through the forest. Four sample plots (4x4m) were established on each transect, and their area was overlaid with a plastic sheet to receive fallen litter. The fallen litter was collected on weekly bases; and it was air-dried and weighed and the quantity expressed as kg/ha/yr. Leaves from standing biomass were also collected monthly, air dried, weighed and put into bags.

Litter Decomposition and Nutrient Release

This experiment was carried out from 1 May 2008 to 30 October 2009. Freshly fallen litter was collected from the sites of litter input experiments; the litter was air-dried and thoroughly mixed. Then, 75 composite samples were prepared for litterbags experiments. Litterbags of 30x30 cm with mesh size of 2 mm of Nylon fabric were used (Graca *et al*. 2005). Each of the litterbags was filled with 250 g of litter and buried in the soil at depths of 15–30 cm. Sets of litterbags (25 samples) were withdrawn at intervals of 6, 12 and 18 months of field incubation. After each collection, the nylon mesh bags were carefully brushed out and cleared of foreign materials (soil, roots, seeds and fauna). The withdrawn samples were reweighed and reanalyzed for the remaining matter and mineral content losses were deduced.

Soils Description and Sampling

The soils of the study site were characterized by field description and laboratory analysis. In the field, soil profiles were opened by digging 2 pits (1x1x1.5 m), described according to Soil Survey Staff (2014) and samples were taken for laboratory determinations. Five auger samples were taken from the corresponding horizons demarcated in the profiles; then the samples of the matching horizons were mixed up to form three 3 composite samples for physical and chemical analysis.

Analysis of Organic Materials

Samples of live leaves, litter input and decomposed litter were packed in labelled paper bags of 25 g each and delivered to the Laboratory of the Department of Soil and Environment Sciences, Faculty of Agriculture, University of Khartoum. The samples were air-dried, milled to powder and subjected to wet digestion by heating in presence of conc. H_2SO_4, HNO_3 and $HClO_4$, then following parameters were analyzed according to methods described by Pansu and Gautheyrou (2006) and Estefan, *et al.* (2013): Nitrogen was determined by macro Kjeldahl method; Phosphorus was measured using spectrophotometer after ashing; Potassium was determined by titration with Versenate; Calcium and Magnesium were determined by atomic absorption spectrophotometry; Organic carbon was determined by wet oxidation and the organic matter equaled organic carbon ×1.72.

Soil Analysis

Samples of soil were packed in labelled paper bags of 500 g each and delivered to the Laboratory of the Department of Soil and Environment Sciences, Faculty of Agriculture, University of Khartoum. Upon delivery to the laboratory, the soils were characterized for their general physical and chemical properties. Soil samples were air-dried and sieved to 2 mm mesh size and the following parameters were determined according to Conklin (2005) and Estefan *et al.* (2013): Particle size distribution was obtained using the modified hydrometer method and the textural classes were assigned according to the American system (Soil Survey Staff 2014); Bulk density was determined by the cylinder method; pH was measured by a pH meter equipped with a combined electrode in a soil paste (soil/water = 1:5); Electrical conductivity (ECe) was measured by an ECe meter in a water extract aliquot of the soils; Exchangeable elements were extracted by the international method using ammonium acetate, then Ca and Mg were determined by titration with versenate, Na and K were determined directly using an EEC flame photometer on an appropriate dilute portion of the solution extracts.

Statistical Analysis
The data obtained from the different experiment were statistically analysed. Soil results were presented in tables; while litter input and litter decomposition results were presented in temporal variation curves traced on an excel spread sheet.

RESULTS

Soil Characterization
The soil under the natural forest was red to dusky-red Oxisols (Soil Survey Staff 2014), and the typical profile showed the following horizons and features:

A_1 horizon: thickness: 0–20 cm; colour: reddish-yellowish darkish; texture: sandy loam; structure: aggregate properties present; stability: stable; porosity: prose fractals; humidity: wet; stones: small gravels; concretions: horizontal, varying sizes, coherent and stable; roots: tap and adventitious roots, dense big and small; biological activity: animals and insects are present; boundary: sharp and undulating at certain point.

B horizon: thickness: 20–40 cm; colour: dusty red; texture: sandy clay loam; structure: aggregate properties present; stability: stable; porosity: prose fractals; humidity: wet; stones: small gravels; concretions: horizontal, varying sizes, coherent and stable; roots: few roots; biological activity: low; boundary: undulating.

C horizon: thickness: 40–60 cm; colour: red to yellow-red; texture: sandy; structure: few aggregate; stability: stable; porosity: slightly prose; humidity: wet; concretions: small smooth; roots: nil; biological activity: low; boundary: diffuse and smooth at certain points.

The particle size distribution of the soil under the natural forest showed that sand and silt contents were higher in the surface layer and variable in the deeper layers; while the clay content was lower in the surface and increased in the bottom layer (Table 1). The silt fraction was higher than that of the corresponding sand and clay contents in all the horizons; the difference in the contents of these particle size fractions diminished very much in the deeper layer. The soil texture, therefore, could be classified as sandy clay loam (Soil Survey Staff 2014). The soil had the same values of bulk density throughout the profile and ranged at a medium category bulk density values. The soil reaction was slightly acidic and with similar pH values in all the horizons. The soil electrical conductivity values were identical in the different horizons and amounted to 0.4 dS/m denoting that the soil was not saline.

Chemical composition is presented in Table 1. The exchangeable Ca contents were about 12.8 meq/100 g soil on the average and they increased in the bottom layers. Magnesium contents were the same in all the layers and amounted to a mean value of 4.9 meq/100 g soil. Potassium contents were below unity values in all the layers, they were evenly distributed and amounted to 0.6 meq/100 g soil. Na contents were, however, about 7.9 meq/100 g soil on the average and they increased in the bottom layers of the soil. Organic carbon and organic matter contents were all above unity values and they were higher in the surface horizon than in the subsurface ones. Nitrogen contents were below unity in all the horizons and the surface layer had higher values than the deeper ones. Similarly, phosphorus contents were also below unity but they were evenly distributed within the profile. The C/N ratios in this soil were less than ten, denoting a higher turnover dynamic of the soil organic matter.

Table 1. Physical and chemical characteristics of soils in Yatta natural tropical forest in Western Equatoria State, South Sudan

Depth (cm)	Particle size distribution (%)			Bulk density (g/cm^3)	pH	Ece (dS/m)	Ca^{+2*}	Mg^{+2*}	K^{+*}	Na^{+*}	O.C† (%)	O.M‡ (%)	N (%)	C/N	P (ppm)
	Sand	Silt	Clay												
0-20	32.3	39.0	28.8	1.5	6.1	0.4	11.1	4.9	0.5	6.2	2.0	3.5	0.28	7.1	0.39
20-40	29.9	41.3	28.8	1.4	6.6	0.4	12.3	4.9	0.6	7.4	1.6	2.7	0.24	6.7	0.39
40-60	34.6	34.2	31.2	1.4	6.1	0.4	14.9	4.9	0.6	10.0	1.3	2.8	0.21	6.2	0.40

*Units in meq/100g soil; †O.C: organic carbon; ‡O.M: organic matte.

Assessment of Litter Input
The litter input during the rainy season, May-August, was identical in quantities, 100 Kg/ha per month (Fig.1). From August to November there was a steady increase with monthly increment of 6.3 Kg/ha. From November onwards, there was a sharp increase that reached a peak of 376 Kg/ha, and with mean monthly increment of 83.7 Kg/ha. The litter fall decreased steadily, as from January onwards and returned to the level of rainy season of 100 Kg/ha in April. On the other hand, the total litter input in this natural forest ecosystem amounted to 1791 Kg/ha.

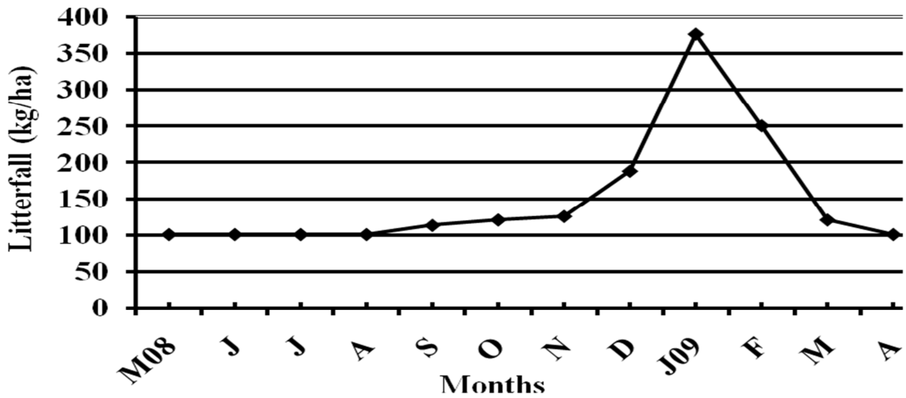

Fig. 1. Temporal variation of litter input in Yatta tropical forest.

The patterns of contents of organic carbon, calcium and magnesium to some extent occurred in a very similar manner to that described for the monthly quantities, *i.e.* low contents during May-August; slightly high increase during August November; very high increase during November-January and a sharp decline afterwards to April (Fig. 2). The pattern contents of these elements also occurred in almost parallel lines with organic carbon content in the upper most parallel level followed by the calcium and magnesium contents.

Nitrogen, phosphorus and potassium contents followed very similarly the temporal variation pattern outlined for litter input quantities, organic carbon and calcium (Fig. 3). Monthly variations of nitrogen and potassium contents in the litter were very close to each other, but identical in most months and occurred in an upper parallel level to that of phosphorus.

The total organic carbon input through litter-fall from this natural forest was estimated to amount to 525.3 Kg/ha which constituted 29.3% of the total litter input. The inputs of the other elements were as follows in a descending order and with their percentage of the total litter shown between brackets, Ca: 227.8 (12.7%) Kg/ha; Mg: 51.3 (2.9%) Kg/ha; K: 48.4 (2.7%) Kg/ha; N: 46.3 (2.6%) Kg/ha and P: 17.2 (~1%) Kg/ha.

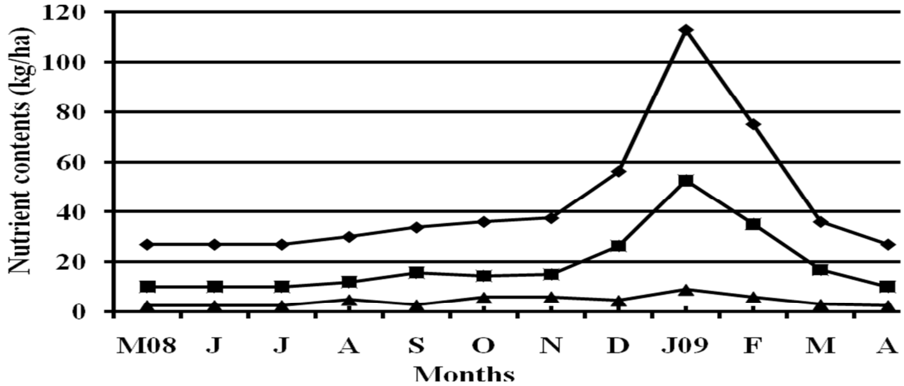

Fig 2. Temporal variation of organic Carbon (♦); Calcium (■) and Magnesium (▲) in litter of Yatta tropical forest.

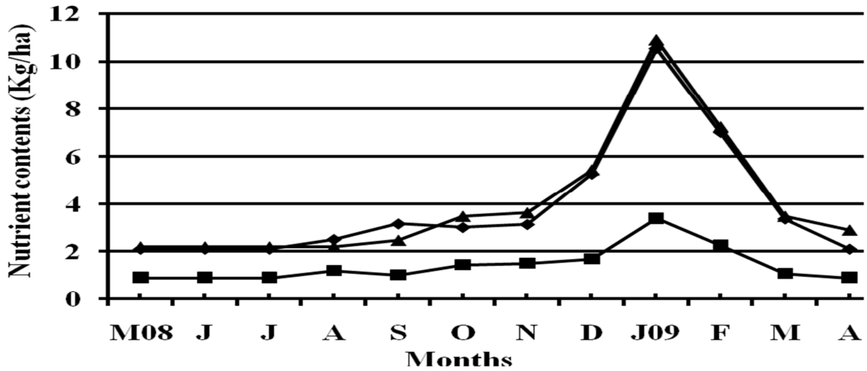

Fig. 3. Temporal variation of Nitrogen (♦); Phosphorus (■) And Potassium (▲) in litter of in Yatta tropical forest.

Assessment of Litter Decomposition and Elements' Release

The litter decomposition was characterized by very strong rate of organic matter loss, so that the reduction rates during the specified periods were, 55.2 % at the end of six months, 83.2 % at the end of twelve's months and 96.8 % at the end of 18th month period. Hence the remaining weights, out of 250 g, at the end of the selected periods were: 112 g, 42 g and 8 g respectively (Fig. 4).

The decomposition rate of the natural forest litter showed very active and strong process. By the end of six months decomposition period, more than 90% of the organic carbon, calcium, potassium and phosphorus were lost from initial quantity of organic matter used (Figs. 5 and 6). The corresponding losses of magnesium and nitrogen were also higher and exceeded 75%. These element losses continued with the same rate during the one-year decomposition period, and by the end of 18th month duration, almost 99 % of these elements were dissipated away. It is worth to note that, phosphorus loss was the most spectacular among these elements, as its losses exceeded 99 % right away at the six months decomposition period. Quantity-wise, the remaining matter from these elements was less than a unity gram, but also traces for some elements like P, K, N and Mg were noted.

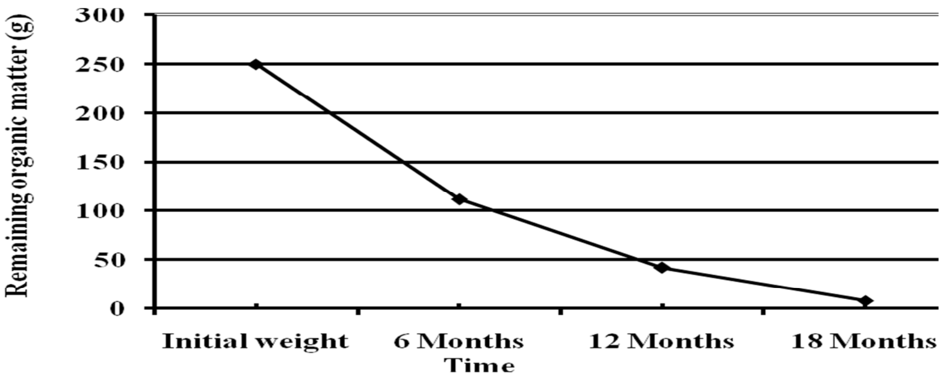

Fig. 4. Remaining organic matter in litter of natural forest after undergoing decomposition process successively at 6, 12 and 18 months periods in Yatta tropical forest.

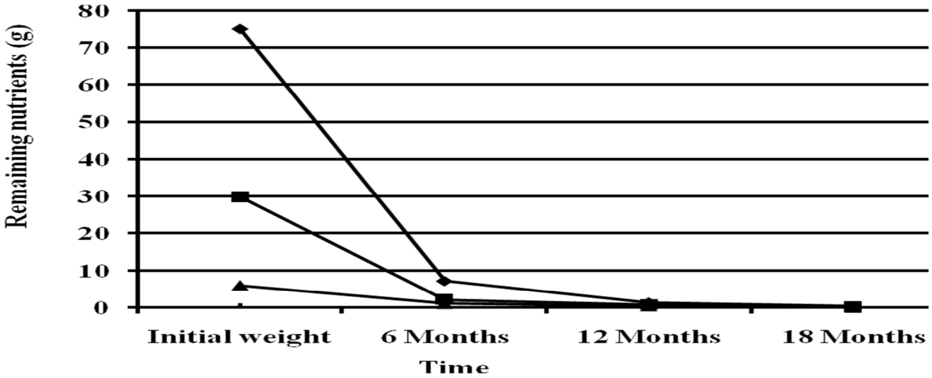

Fig.5. Remaining organic Carbon (♦), Calcium (■) and Magnesium (▲) in litter of Yatta natural forest after undergoing decomposition process successively at 6, 12 and 18 months periods.

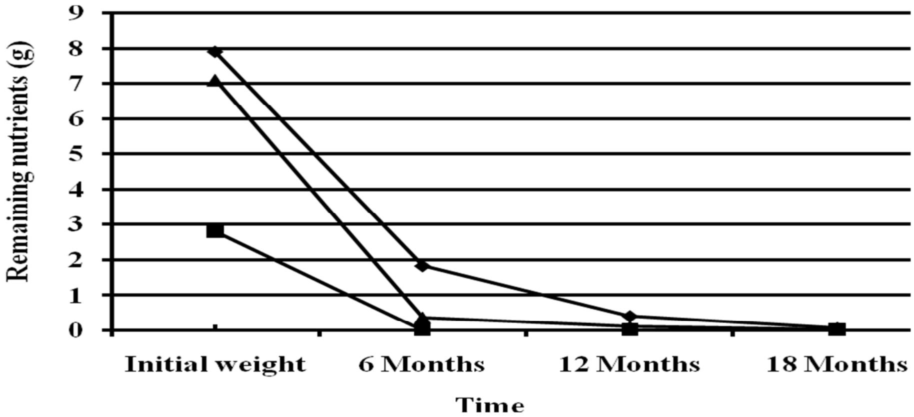

Fig.6. Remaining organic Nitrogen (♦), Phosphorus (■) and Potassium (▲) in litter of Yatta natural forest after undergoing decomposition process successively at 6, 12 and 18 months periods.

DISCUSSION

Soils under the study site of the humid tropical natural forest were Oxisols with typical characteristics (Soil Survey Staff 2014). They were deep, well textured and structured presenting free drainage They were rich in organic matter and amply furnished with basic cations, nitrogen and phosphorus; and they had very low C/N ratio (Young 1990). They were slightly acidic and non-saline. Thus, they were very fertile soils. Nevertheless, their fertility was yet bound to the presence of the tree/forest cover that keeps the fertility in the ecosystem by the mechanism of the biogeochemical cycling of elements (Stanleya and Montagnini, 1999; Homann *et al.* 2000; Laclau *et al.* 2010). As once the tree/forest stands were removed the soil would rapidly lose its fertility through massive decomposition of soil organic matter and leaching of the nutrients released (Duchaufour 1982; Young 1990). Agroforestry is, therefore, the most appropriate utilization type for exploiting these sites, whereby securing adequate output of crops and rationally conserving their soil fertility (Young 1990; Schroth and Sinclair 2003).

Litter input in this forest was continuous all the year round, but its rate and amounts of fall were influenced by seasonality so that maximum litter falls during the dry period as a result of some moisture stress induced to the tress (Parsons *et al*. 2014). The total amount of annual litter input in this forest was 1791 Kg/ha/yr (1.8 t/ha/yr). Amounts of annual litter input in this forest were far less than those reported in literature in similar forests which were: 5.04-8.04 t/ha/yr in tropical Amazonian rainforest, Brazil (Dantas and Phillipson 1989); 6.1 and 10.7 t /ha/yr in tropical rainforest, Congo (Loumeto 2003); and 12.9-14.1 t/ha/yr in tropical rainforest in Cameroun (Songwe *et al.* 1988). These compared litter input values showed that the forest of this study was experiencing a state of serious disturbance of its stand by anthropogenic intrusions. The quality of litter of this forest was reflected in the high amounts of elements, organic C, N, P and basic cations; this indicated in other terms the richness of the site quality (Vitousek *et al*. 1995; Ngaiwi *et al*. 2018).

Litter decomposition in this forest was very rapid so that more than 50 % of dry matter was lost during 6 months and more than 96 % was lost during 18 months period. Likewise the elemental lost was even more rapid such that 90 % of organic carbon, calcium, potassium and phosphorus were lost during 6 months and by the end of 18 months period almost 99 % of these elements were dissipated away. Conducive decomposing conditions of climatic (mesothermic temperature and optimal humidity), edaphic (ambient medium due to good texture and structure), high quality of litter (rich in organic C and N, P and basic cations), and very high biological activity (soil microflora and myriad of fauna) lead to rapid consumption of dry matter and release of elements (Songwe *et al*. 1995; Isaac and Nair, 2005; Xiaogai *et al*. 2013; Krishna and Mohan 2017; Giweta 2020).

Due to the importance of litter input and its decomposition in the functioning of natural tropical forest ecosystems, and to maximize utilization of the forest goods and services that are expected to be yielded and to ascertain findings from this study, we recommend conduction of long-term studies so as to establish inter-annual mean values of these parameters for theoretical and practical end uses.

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REFERENCES

Adkins, B. (2015). *Forestry and Prospects for Stability, Livelihoods and Peace building in the Equatorial States of South Sudan*: *An Initial Assessment*. USAID, South Sudan.

Binkley, D. and Menyailo, O. (eds.) (2005). *Tree Species Effects on Soils: Implications for Global Change*. ©2005 Springer, published in cooperation with NATO Public Diplomacy Division. 362p.

Conklin, A.R, 2005. *Introduction to Soil Chemistry: Analysis and Instrumentation*. Copyright © 2005 by John Wiley & Sons, Inc, Hoboken, New Jersey. www.wiley.com. 241p.

Dantas, M. and Phillipson, J. (1989). Litterfall and litter nutrient content in primary and secondary Amazonian 'terra firme' rain forest. *Journal of Tropical Ecology* 5, 27-36.

Duchaufour, P. (1982). *Pedology: pedogenesis and classification*. Translated by T.R. Paton from French: Pédologie; Pédogenèse et classification (© Masson, Paris, 1977). © George Allen & Unwin (Publishers Ltd), 1982; 40 Museum Street, London WCIA lLU, UK. ISBN-13 978-94-011-6005-6 e-ISBN-13: 978-94-011-6003-2. DOl: 10.1007/978-94-011-6003-2. 475p.

Estefan, G.; Sommer, R. and Ryan, J. (2013). *Methods of Soil, Plant, and Water Analysis: A manual for the West Asia and North Africa region*. International Center for Agricultural Research in the Dry Areas (ICARDA); Copyright © 2013 ICARDA (International Center for Agricultural Research in the Dry Areas) Box 114/5055, Beirut, Lebanon. ICARDA@cgiar.org www.icarda.org. 244p.

Fitzpatrick, E.A. (1986). *Soils: their Formation, Classification and Distribution*. ELSB/Longman, Hong Kong, 353p.

Giweta, M. (2020). Role of litter production and its decomposition, and factors affecting the processes in a tropical forest ecosystem: a review. *Journal of Ecology and Environment* 44, 11, 1-9.

Graca, M.A.S.; Barlocher, F. and Gessner, M.O. (eds.). (2005). *Methods to Study Litter Decomposition*: *A Practical Guide*. ©2005 Springer. 314p.

Guendehou, G.H.S., Liski J.; Toumi, M.; Moudachirou, M.; Sinsin, B. and Mäkipää, R. (2014). Decomposition and changes in chemical composition of leaf litter of five dominant tree species in a West African tropical forest. *Tropical Ecology* 55(2), 207-220. © International Society for Tropical Ecology, ISSN 0564-3295, www.tropecol.com.

Hazelton, P.A. and B.W. Murphy, 2007. *Interpreting Soil Test Results*. CSIRO PUBLISHING, 150 Oxford Street (PO Box 1139), Collingwood VIC 3066, Australia. © NSW Department of Natural Resources 2007, Web site: www.publish.csiro.au. 169p.

Homann, P.S.; McKane, R.B. and Sollins, P. (2000). Belowground processes in forest-ecosystem biogeochemical simulation models. *Forest Ecology and Management* 138, 3-18.

Isaac, S.R. and Nair, M.A. (2005). Biodegradation of leaf litter in the warm humid tropics of Kerala, India. *Soil Biology and Biochemistry* 37, 1656-1664.

Kingdon, J. (1989). *Island Africa: The Evolution of Africa's Rare Animals and Plants*. Princeton University Press. Princeton, NJ, USA.

Krishna, M.P. and Mohan, M. (2017). Litter decomposition in forest ecosystems: a review. *Energy, Ecology Environment* 2(4): 236-249. DOI 10.1007/s40974-017-0064-9.

Laclau, J.P.; Ranger, J.; Gonçalves, J.L.D.; Maquère, V.; Krusche, A.V.; M'Bou, A.T.; Nouvellon, Y.; Saint-Andre, L.; Bouillet, J.P.; Piccolo, M.D.C. and Deleporte, P. (2010). Biogeochemical cycles of nutrients in tropical Eucalyptus plantations: Main features shown by intensive monitoring in Congo and Brazil. *Forest Ecology and Management* 259, 1771–1785.

Loumeto, J.J. (2003). Litterfall and nutrient return in tropical rainforest in the Chaillu area (southwest Congo). *Transactions on Ecology and the Environment* vol 64, 1237-1249. © 2003 WIT Press, www.witpress.com, ISSN 1743-3541.

Ngaiwi, M.E.; Molua, E.L. and Egbe, A.E. (2018). Litter fall and Nutrient Returns in the Rainforest of South western Cameroon: Some Implications for Tropical Forest Productivity. *Environment and Natural Resources Research Vol.* 8, No.3, 25-32.

Pansu, M., and J. Gautheyrou, 2006. *Handbook of Soil Analysis Mineralogical, Organic and Inorganic Methods*. © Springer-Verlag Berlin Heidelberg 2006. 1011p.

Parsons, S.A.; Valdez-Ramirez, V.; Congdon, R.A. and Williams, S. E. (2014). Contrasting patterns of litterfall seasonality and seasonal changes in litter decomposability in a tropical rainforest region. *Biogeosciences* 11, 5047-5056.

Russell, E.W. (1973). *Soil Conditions and Plant Growth*, 10th edition. ELBS/Longman, UK, London, 849p.

Schroth, G. and Sinclair, F.L. (2003). *Trees, Crops and Soil Fertility: Concepts and Research Methods*. ©CAB International 2003, CABIPublishing. 451P.

Seta, T.; Demissew, S. and Zerihun Woldu, Z. (2018). Litterfall dynamics in Boter-Becho Forest: Moist evergreen montane forest of Southwestern Ethiopia. *Journal of Ecology and the Natural Environment Vol.* 10(1), 13-21.

Smith, J. (1949). *Distribution of Tree Species in the Sudan in Relation to Rainfall and Soil Texture*. Ministry of Agriculture, Khartoum, Bulletin No. 4.

Soil Survey Staff, 2014. *Keys to Soil Taxonomy*, 12th ed. USDA-Natural Resources Conservation Service, Washington, DC. 372p. https://www.nrcs.usda.gov.

Songwe, N.C; Fasehun, F.E. and Okali, D.U.U. (1988). Litter fall and productivity in a tropical rain forest, Southern Bakundu Forest Reserve, Cameroon. *Journal of Tropical Ecology* 4, 25-37.

Songwe, N.C.; Okali, D.U.U. and Fasehun, F.E. (1995). Litter decomposition and nutrient release in a tropical rainforest, Southern Bakundu Forest Reserve, Cameroon. *Journal of Tropical Ecology* 11, 333-350.

Stanleya, W.G. and Montagnini, F. (1999). Biomass and nutrient accumulation in pure and mixed plantations of indigenous tree species grown on poor soils in the humid tropics of Costa Rica. *Forest Ecology and Management* 113, 91-103.

Swift, M.J.; Heal, O.W. and Anderson, J.M. (1979). *Decomposition in Terrestrial Ecosystems*. Oxford: Blackwell Scientific Publications, Cambridge, MA.

Vitousek, P.M.; Gerrish, G.; Turner, D.R.; Walker, L.R. and Mueller-Dombois, D. (1995). Litterfall and Nutrient Cycling in Four Hawaiian Montane Rainforests. *Journal of Tropical Ecology* Vol. 11, No. 2, 189-203.

Xiaogai, G.; Lixiong, Z.; Wenfa, X.; Zhilin, H.; Xiansheng, G. and Benwang, T. (2013). Effect of litter substrate quality and soil nutrients on forest litter decomposition: A review. *Acta Ecologica Sinica* 33: 102–108.

Young, A. (1990). *Agroforestry for Soil Conservation*. CAB International; International Council for Research in Agroforestry (ICRAF); ©CAB International 1989; ISBN085198648X. Printed in the UK by BPCC Wheatons Ltd, Exeter. 318p.

تقييم إنتاج و تحلل و ديناميكية عناصر الإنثار في غابة ياتا المدارية بولاية غرب الإستوائية، جنوب السودان

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المستخلص: شخصت هذه الدراسة الترب، إنتاج نثار في غابة طبيعية، تحلل نثار و إطلاق عناصر في غابة ياتا بولاية غرب الإستوائية، جنوب السودان في الفترة من مايو 2008 الي مارس 2010. تم وصف التربة و جمع منها العينات. تم جمع النثار أسبوعياً من مرابيع موزعة تحت غطاء الغابابة مساحة الواحدة منها 16 م^2 و بأربعين مكرر. أستعمل 75 كيس لتقييم تحلل النثار و إطلاق العناصر، و قد دفنت هذه الأكياس في التربة علي أعماق 15 الي 30 سم؛ و قد تم سحب 25 كيس بعد مضي 6 و 12 و 18 شهر من الدفن و التحلل. تم تحليل عينات النثار الساقط و باقي النثار المتحلل و التربة في معمل قسم علوم التربة و البيئة، كلية الزراعة، جامعة الخرطوم. كانت التربة من نوع الأكسيسول، ذات قوام طمي رملي طيني النسجة، حمضي التفاعل، غني بالمادة العضوية، و مزود بوفرة من العناصر الغذائية. بلغ إنتاج النثار 1791 كجم/هك/سنة؛ مع توالي إنتاج عالي و منخفض في الشهور الجافة و الرطبة. كان فقدان المادة الجافة عالياً مع مدي تراوح من

52.2% الي 96.8% في خلال فترة الإختبار. تم تحرير عناصر البوتاسيوم، النيتروجين، الفسفور، الكالسيوم و المغنيسوم سريعاً مع معدلات بلغت 37% – 62%، 56% – 72% و 62% – 90% أثناء فترات 6 و 12 و 18 شهراً من الإختبار. أوضحت النتائج خصوبة عالية لهذه الغابة الطبيعية و التي يمكن أن تدعم إستدامة المخزون النامي لشجارة للموقع و إستغلال الغابة لإعطاء بضائع و خدمات مستهدفة.