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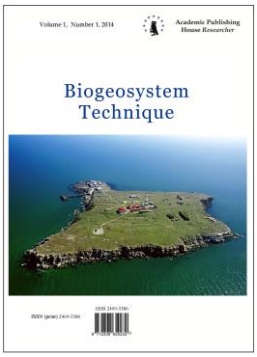

Organic Carbon and Total Nitrogen in Soils of Kon Ka Kinh National Park (Central Vietnam)

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Abstract

The article presents the results of analysis of organic carbon (OC) and total nitrogen (TN) in the soils at the 6 different types of tropical forest: Mixed forest between broad-leaved trees and conifers (*Lagerstroemia calyculata* + *Pinus kesiya*); Bamboo forest (*Bambusa*); Three-needled pine (*Pinus kesiya*); Primary broad-leaf evergreen forest has dominated by Fagaceae; Primary broad-leaf evergreen forest, dominated by Fagaceae, near the streams, can be flooded in the rainy season and Mixed forest between broad-leaved trees and conifers (*Fagaceae* + *Dacrycarpus imbricatus*, *Dacrydium elatum*) of Kon Ka Kinh National Park in Central Vietnam. OC concentrations ranged from 1.1 % in the Primary broad-leaf evergreen forest to 3.5 % in the Mixed forest between broad-leaved trees and conifers (*Fagaceae* + *Dacrycarpus imbricatus*, *Dacrydium elatum*). TN concentrations varied from 0.33 % in the Three-needled pine to 0.04 % in the Bamboo forest. In the Primary broad-leaf evergreen forest has dominated by Fagaceae, OC decreases while TN increases according to the depth of soil. In the Primary broad-leaf evergreen forest, dominated by Fagaceae, near the streams, OC does not change, and TN decreases with soil horizon.

Keywords: organic carbon, total nitrogen, soils, tropical forest, Kon Ka Kinh National Park, Vietnam.

1. Introduction

Organic compounds are very important for the formation of the tropical forest soils (Fridland, 1964; Thai, Nguyen, 2002). The number and the nature of their strong impact to the process of land formation are decided in many branches of Natural Sciences: Physics, Chemistry, Biology and Fertility of soil. Currently, scientists are convinced that one of the main causes of forest degradation, reducing fertility and overall produce of soil biological product is reduced organic matter and decreased humus reserves in soil (Nguyen, 1996; Do, Nguyen, 2001). The soil OC and TN determining is urgent to individualize the location of ecological regions because OC and TN concentrations have a significant influence on the chemical reactions in the soil or sediment (Schumacher, 2002; Okolelova, 2006).

In natural forest, the primary source of organic matter contained in soil includes dead plants, animals and micro-organisms. This supply capacity depends on each status of different forest and species featured plants, domination plants distributed in habitat. This is also not the exception to the Vietnam natural forest ecosystems. In a survey by Vietnam-Russia tropical center held in Gia

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Lai province (Central Vietnam), we have conducted research, identified the OC content and TN in the soils to find out the relationship between them and the habitats which is characterized by different plant species of the Kon Ka Kinh National Park.

2. Study Area

Kon Ka Kinh National Park is located on the Central Highlands of province Gia Lai (Vietnam). Kon Ka Kinh National Park covers an area 41,780 ha. This is the only place in Vietnam that owns mixed forest between broad-leaved trees and conifers (2,000 ha) (Nguyen, Bui, 2018).

In terms of our expedition, conducted research on pedology and some ecological characteristics at the 6 different types of tropical forest in the southwestern part of the Park. Location of research points in Fig. 1.

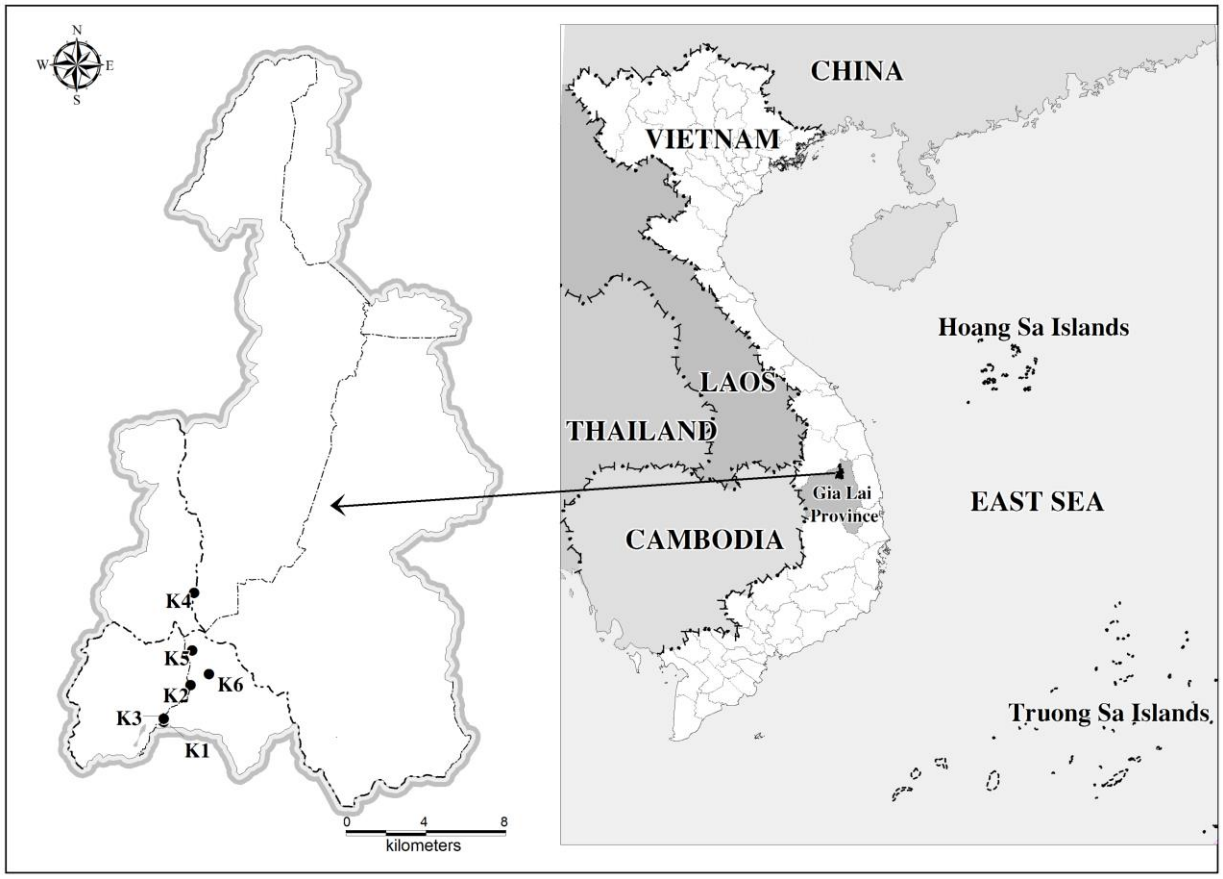

Fig. 1. Location of research points

K1-Mixed forest between broad-leaved trees and conifers (*Lagerstroemia calyculata* + *Pinus kesiya*);

K2-Bamboo forest (*Bambusa*);

K3-Three-needled pine (*Pinus kesiya*);

K4-Primary broad-leaf evergreen forest has dominated by *Fagaceae*;

K5-Primary broad-leaf evergreen forest, dominated by *Fagaceae*, near the streams, can be flooded in the rainy season;

K6-Mixed forest between broad-leaved trees and conifers (*Fagaceae* + *Dacrycarpus imbricatus, Dacrydium elatum*).

3. Materials and methods

The sampling areas: based on the distribution characteristics of plant in the habitat (primary forest, mixed forest, regrowing forest) according to the classification of Thai Van Trung (1978); Anichkin (2011); Kuznetsov, Kuznetsova (2011); Nguyen, Okolelova (2014).

Soil sampling: sample collection, profiles in the ground floor according to Vietnam standard TCVN 7538-2:2005, process templates according to Vietnam standard TCVN 6647:2007. In some

cases, does not determine the ground floor then sampling under the depths of 0–20, 20–40 and 40–60 cm.

The determination of OC to Vietnam standard TCVN 4050-85 is based on the method of Walkley-Black (1934). Oxidisable matter in the soil is oxidised by $K_2Cr_2O_7$ solution. The reaction is assisted by the heat generated when two volumes of H_2SO_4 are mixed with one volume of the dichromate. The remaining dichromate is titrated with ferrous sulphate. The titre is inversely related to the amount of C present in the soil sample (Walkley, Black, 1934; Carter, Gregorich, 2007).

The determination of TN to Vietnam standard TCVN 6498: 1999 is based on the Kjeldahl method: Denitrification of the sample by Dewarda in sulphuric acid is converted to ammonia. Distillation of ammonia released from ammonium sulphate with sulphuric acid and catalyst. The end of the condenser is dipped into a solution of boric acid. The ammonia reacts with the acid and the remainder of the acid is then titrated with a sodium carbonate solution by way of a methyl orange pH indicator (Carter, Gregorich, 2007).

Data processing on software Microsoft Excel 2010.

Preparation of soil samples and analysis were performed in the laboratory of Vietnam–Russia tropical Centre, Ho Chi Minh City, Vietnam.

4. Results and discussion

Characteristics of study areas

K1: Mixed forest between broad-leaved trees and conifers (*Lagerstroemia calyculata* + *Pinus kesiya*). The brown soil, soft, mixing with gravel from 1–3 cm. Stratification not visibly. Litter layer of pine leaf. Position 14°11'12" N, 108°18'10" E, at elevations of 880 m a.s.l.

K2: Bamboo forest (*Bambusa*). The brown land, many bamboo roots. Difficult to distinguish the soil layers. Plants mostly bamboo (*Bambusa*). Litter layer of bamboo leaves. Position 14°12'42" N, 108°18'55" E, at elevations of 902 m a.s.l.

K3: Three-needled pine forest (*Pinus kesiya*), 5–7 m high, steep hills, ferralsol. Layer A1 (0–30 cm) of humus soil, the soil is black and soft. Layer A2 (30–54 cm) the color of soil is back and brown then change to red- yellow in layer B1 (55–70 cm).In A2 and B1, the attributes of soil are flexible and wet. Litter layer of pine leaf. Position 14°11'47" N, 108°18'10" E, at elevations of 897 m a.s.l.

K4: Primary broad-leaf evergreen forest has dominated by Fagaceae. The soil mix with rocks, 3–5 cm diameter. The first layer is humus covers the sandy soil layer below which has pale yellow color. The layer A1 (0–18 cm): humus, black and soft. The layer A2 (18–32 cm), B1 (32–54 cm): sandy soil mixes with a huge gravel and stone, less roots. Position 14°15'13" N, 108°19'01" E, at elevations of 965 m a.s.l.

K5: Primary broad-leaf evergreen forest, dominated by Fagaceae, near the streams, can be flooded in the rainy season. The sandy soil, possible inundated in the rainy season, litter layer of leaves. The layer A1 (0–20 cm), sandy soil, soft. The layer A2 (20–40 cm), B1 (40–60 cm) are golden sand. At elevations of 965 m a.s.l, position 14°13'39" N, 108°18'58" E.

K6: Mixed forest between broad-leaved trees and conifers (*Fagaceae* + *Dacrycarpus imbricatus, Dacrydium elatum*). The layer A1 (0–40 cm), the soil is wet, the color of soil is brown-red. Field texture: medium clay. The layer A2 (40–63 cm), the soil is reddish brown, slightly moist, medium clay, mixes with large tree roots. The layer B1 (63–120 cm) the soil is red, coarse clay, moisture, mixes with large tree roots. Position 14°13'03" N, 108°19'26" E, at elevations of 1,172 m a.s.l.

Content of OC and TN at study areas

The results analyzed at Table 1 indicate the OC content in study areas varies from 1.1 % in the Primary broad-leaf evergreen forest (K5) to 3.5 % in the mixed-leaved forests (K6). The result can be explained as: Although in the K5 is the primary forest, but stay in coastal position which has sandy soils, gravel, litter layer often gets washed by rain and streams so the land should not be sufficiently for biodegradable, additional organic substances for soils. The K6 with high humidity by 1,127 m height, increases decomposition of leaves and plant-body which makes clay in field texture so the ability to accumulate organic matter is better than sandy soils. Consequently, this is the highest level of OC in comparison to other areas, including the depth of the soil horizons.

Table 1. Organic carbon and total nitrogen in soils research

Habitats – Soil types	Soil layer (cm)	OC (%)	TN (%)
K1 Ferralic Acrisols	0–20	3.0	0.26
	20–40	2.8	0.18
	40–60	2.7	0.17
K2 Ferralic Acrisols	0–20	3.2	0.22
	20–40	1.3	0.17
	40–60	1.2	0.04
K3 Xanthic Ferralsols	0–30	2.9	0.33
	30–54	1.7	0.23
	54–70	1.8	0.17
K4 Fluvisols	0–18	3.0	0.06
	18–32	1.6	0.06
	32–54	1.3	0.10
K5 Fluvisols	0–20	1.1	0.24
	20–40	1.1	0.18
	40–60	1.1	0.14
6 Rhodic Ferralsols	0–40	3.5	0.27
	40–63	3.4	0.18
	63–120	3.3	0.12

As shown in Table 1, OC content tended to decrease in depth in 5 habitats (K1, K2, K3, K4, K6) and fluctuated from 3.5 % (K6 habitat) to 2.9 % (K3 habitat). In deeper soil layers, OC change from 3.4 % (K6) to 1.2 % (K2). This is a common feature, due to the surface layer, under the influence of micro-organisms, temperature and humidity, the resolution of organic matter is stronger, the resolution speed of organic matter occurred more powerful, while the lower soil layers, humus formation is quite stable so the resolution speed is slower, resulting in lower OC content. In habitat K5, OC content virtually does not depend on the depth of horizon. This may be due to the place of sampling, the soil component is sand and loamy sand, along with the flow effects of the streams, the organic matter has been washed away, with the lowest content determined, including on the upper ground and forward layers.

Besides the nature of the soil, the types and composition of vegetation in that habitat will be a determining factor for the OC content of the soil. On ferralsols land, the studies of several authors suggest that OC content in the habitats dominated by *Afzelia xylocarpa* reached 2.9 % (Nguyen, 1996); in the rubber forest of Dak Nong Province (Central Vietnam) is about 1.75–3.81 % (Nguyen et al., 2009). While in the Pleiku area, 50 km to the east of study areas, Nguyen V.D. (2013) analyzed the OC content in the ground surface of low-shrub land that is about 2.8%, and in grasslands is 3.2 %.

In Cat Tien National Park and Dong Nai Nature Reserve, OC in the topsoil achieve from 1.71 % in the habitats dominated by *Dipterocarpus alatus* to 5.34 % in the habitats dominated by *Lagerstroemia calyculata*, *Afzelia xylocarpa*, *Tetrameles nudiflora*, while in the habitats dominated by *Ficus*, the OC ranges from 2.15 to 4.75 %, while the bamboo forest (*Bambusa*) is 1.14 to 1.93 % (Okolelova et al., 2014). Thus, as in our analysis, in organic bamboo habitats, OC content is generally lower than in other habitats. In the Evergreen Broad-Leaved forest (Cat Tien National Park, Dong Nai Nature Reserve, South Vietnam) the OC content was higher than our analysis. As for the remaining habitat, the OC content in the soil is equivalent to our analysis.

Analysis of TN content shows that, basically in the topsoil, this value is highest compared to the next layers of the soil profile. This was recorded in 5/6 study areas (except areas K4). In these areas, the TN content was from average or higher than variation in surface layer from 0.22 % (K2 habitat) to 0.33 % (K3) and from 0.04 % (K2) to 0.23 % (K3) in subsequent layers. For the K4, in the upper soil layer, the TN content was 0.06 % but in the down soil layer this number increased 0.1 %.

An analysis of soil properties in some habitats at Cat Tien National Park shows that TN has a large variation, from 0.09 % in *Dipterocarpus alatus*. *D. turbinatus; Bambusa* and *Dipterocarpus alatus* to 4.8 % in *Lagerstroemia calyculata*, *Bambusa* sp., *Calamus* sp. (Okolelova et al., 2014).

In the *Bambusa* (K2) habitat of the study, our analysis also determined that TN was the smallest (0.04 %) compared to all study habitats.

5. Conclusion

The OC content of the soils in the study areas is highest in the topsoil (3.5 % in K6 – Mixed forest (*Fagaceae* + *Dacrycarpus imbricatus, Dacrydium elatum*)) and tends to decrease in depth of the soil layer (1.1 % in K5 – Primary forest, Evergreen Broad-Leaved forest near the stream). Except for K5 – there is almost no change in depth of profile (1.1 %).

TN content was highest in the topsoil (0.33 % in K3 – *Pinus kesiya* forest) and gradually decreased in the soil profile (0.04 % in K2 – Bambusa forest). In Bambusa areas (K2), TN determination was lowest.

Although research land have the same nature as sandy soil and gravel in K4 and K5 areas - Fagaceae) and the same type of evergreen forest, but the OC and TN content recorded are not similar. The OC content of the soil in K4 is higher than K5, while the TN content is opposite.

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