Changes in Temperature Profile and Properties of Organic Soils of Different Initial Moisture Conditions Under External Thermal Impact

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1. Introduction

Forest fires occur throughout the world. Forests play an important role in both carbon sink and conservation of biodiversity. The forest fire alter soil properties and kill roots and soil microbes. To make a forest restoration plan, it is important to estimate how much soil was damaged by fire. However, there are few experimental studies about changes of soil during burning because the fire occurs accidentally. In this study, we simulated forest fire by exerting artificial thermal impacts on the surface of soil columns and measured soil temperature, soil moisture and carbon-nitrogen contents in soils under burns.

2. Method

Soil samples: Andisol, Toyoura sand, Peat-sand mixture which contained total carbon of 4.8%, 0%, 3.9% respectively.

Soil columns: 15 cm in diameter and 5 cm in length, to form 30 cm

Bulk density and initial water content: controlled as showed in Table.1

1. Packed soil samples into columns.
2. Inserted thermocouples at 0, 1, 2, 4, 6, 8, 10, 15, 20 and 25 cm depth below the soil surface to measure soil temperature.
3. Burned charcoal on the soil surface for 6 hours.
4. Cooled soil samples naturally for about 18 hours.
5. Sampled soils for measurements.
6. Measured soil water content.
7. Measured soil carbon and nitrogen content.
8. Measured soil water repellency by WDPT times*. (The classification of intense followed Table.2).

Table.1
Soil bulk density and initial water content

soil	initial water content θ ($m^3\ m^{-3}$)	dry bulk density ($g\ cm^{-3}$)
toyoura sand	0	
	0.15	
	0.23	1.5
andisol	0.15	
	0.32	
	0.39	
	0.45	0.75
peat-sand mixture	0.01	
	0.1	
	0.15	
	0.2	1.0

Table.2
Classification of repellency measured by WDPT times

WDPT times (sec)	class	
-5	hydrophilic	1
5-60	slightly hydrophobic	2
60-600	strongly hydrophobic	3
600-3600	severely hydrophobic	4
3600-	extremely hydrophobic	5

WDPT: Water Drop Penetration Time

Experimental apparatus was showed in Fig.1 and Fig.2.

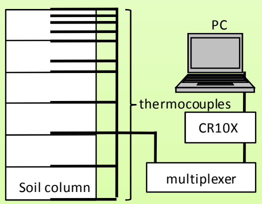

Fig.1 Experimental apparatus

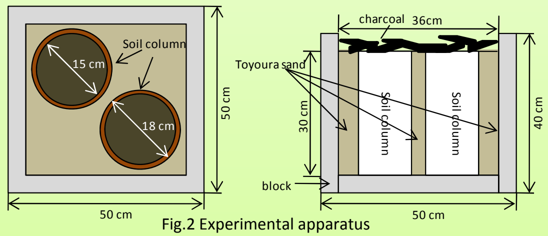

Fig.2 Experimental apparatus

3. Results & Discussions

The temperature of soil surface rose 600-700℃. The temperature of each depth became constant at around 100℃ before increasing over 100℃.

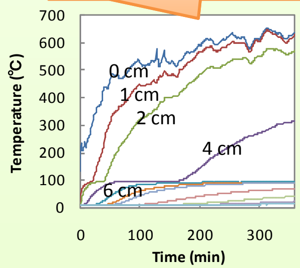

Fig.3 Temperature change (Andisol θ=0.32)

The 100℃-depth was deeper as the initial water content was fewer.It was proportional to square root of the burning time. The relationship between constant of proportional m and initial θ is shown in Fig.5.

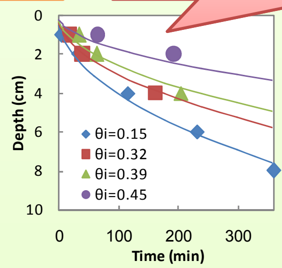

Fig.4 The 100℃-depth vs time (Andisol)

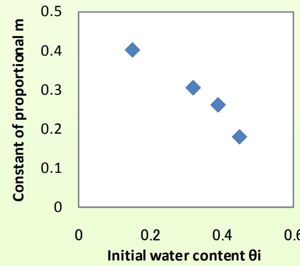

Fig.5 Relationship between m and θi

Temperature change can be divided into 3 zones on reaching 100℃; The high temperature zone which is above 100℃, transaction zone at almost 100℃, low temperature zone which is below 100℃.

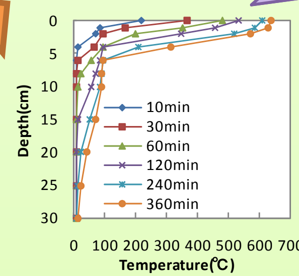

Fig.6 Temperature profile (Andisol θ=0.32)

The high temperature zone was thicker as the initial θ was fewer, but the temperature change deeper than 10 cm is not depend on initial θ.

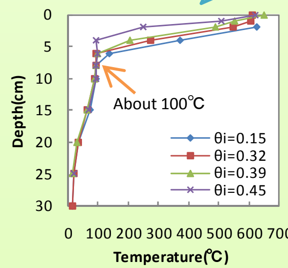

Fig.7 Temperature profile (Andisol t=6 hrs)

The dry front was observed at 6-10 cm depth.

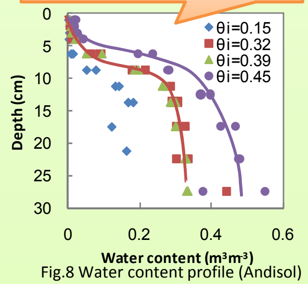

Fig.8 Water content profile (Andisol)

Carbon content was decreased in top soil. Nitrogen showed same trend. The C/N ratio in the top soil increased to be over 20, which is inadequate for plant growth (Fig.10).

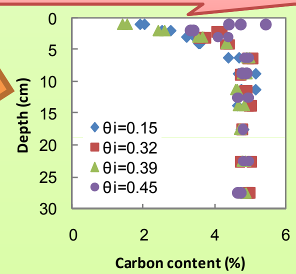

Fig.9 Carbon content profile (Andisol)

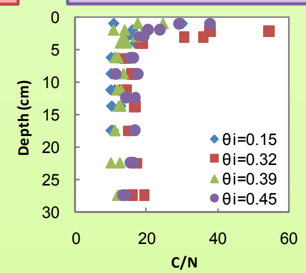

Fig.10 C/N profile (Andisol)

Soil water repellency was appeared only in peat-sand mixture and not in andisol and toyoura sand. Repellency was weak when the soil temperature was below 100 ℃. Repellency becomes strong when the temperature is between 100 and 500℃ but becomes weak again at the temperature is over 500℃.

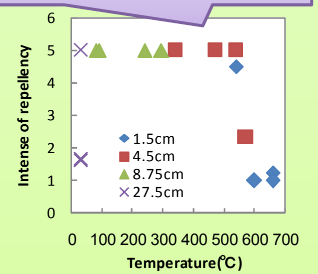

Fig.11 Water repellency (peat-sand mixture)

5. Conclusions

1) The temperature of soil surface rose 600-700℃.
2) The 100℃-depth was proportional to square root of the burning time.
3) Temperature change can be divided into 3 zones on reaching 100℃.
4) C/N ratio in the top soil increased and the value to be over 20.
5) Soil water repellency, which appeared only on peat-sand mixture, differed according to depth and initial water content.

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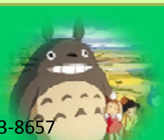

References: ＊Stefan H. Doerr, On standardizing the water drop penetration time and the molarity of an ethanol droplet techniques to classify soil hydrphobicity: a case study using medium textured soils, Earth Surf. Process. Landforms 23. 663-668 (1998)