Increase in Hydrophobicity of Andisol Under Soil Surface Heating

Taku Nishimura, A. Obuchi, Masaru Mizoguchi, H. Imoto and Tsuyoshi Miyazaki (University of Tokyo),
takun@soil.en.a.u-tokyo.ac.jp

ABSTRACT
Soil is often exhibit hydrophobic properties after a forest fire (DeBano et al. 1976, 2000). However, less is known about effects of oxygen atmosphere on morphological changes of organic matter in soil. In this study, we sought to clarify the increase in soil hydrophobicity as well as the changes in carbon and nitrogen content in response to heating of the ground surface in the field and both column and muffle furnace heating in the laboratory. In the muffle furnace burning, soil samples heated under oxygen-deprived conditions exhibited similar carbon and nitrogen dynamics and increased hydrophobicity with temperatures those observed in the field and column experiments. Soil samples under oxygen-deprived condition showed hydrophobicity and some carbon content by heating with 300℃ and higher, while almost no carbon remained after heating with 400℃ under oxygen available condition. Soil C/N ratio increased by heating with higher temperature under oxygen-deprived condition. Limited supply of oxygen could affect to produce soil hydrophobicity under soil surface burning.

Field experiment

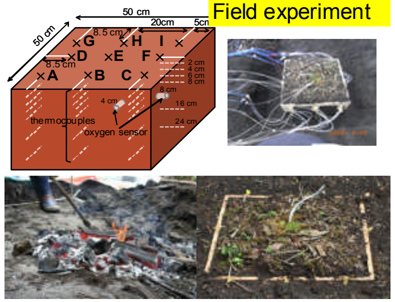

Photo 1 Experimental site at Experimental forest of University of Tokyo in Chichibu, Saitama Japan.

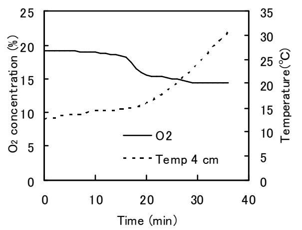

Fig.1 Temperature and oxygen concentration during surface burning.

Column experiment

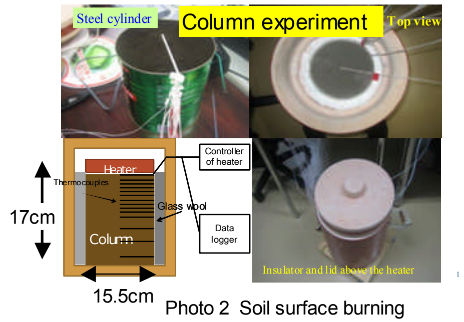

Photo 2 Soil surface burning (laboratory column experiment).

Field experiment

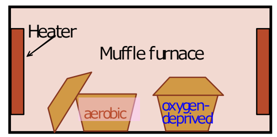

Fig.2 Schematic of aerobic and oxgen-deprived burning in a muffle furnace.

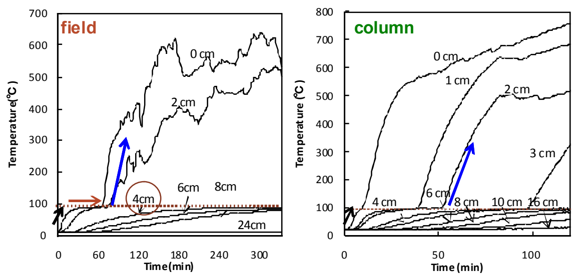

Fig.3 Soil temperature during surface burning

Methods
Field and column experiments: Heating soil surface either charcoal or electric heater. Land cover of the site wa secondary forest (acer, buckeye, dogwood, birch). Soil was Andisol (SL) had total carbon(TC) and nitrogen (TN) of 150-270 g kg^{-1} and 12 g kg^{-1} , respectively.
Soil temperature was monitored by thermocouples connecting CR10 data logger. After the burning, disturbed samples were taken and Total-C and -N analysis (CN-analyzer, Shimadzu Inc.) and water repellency test (WDPT) was conducted.
Muffle furnace burning: Portion of sample was put into crucible with or without lid. The crucible with lid was assumed to be oxygen deprived condition while without lid was aerobic burning. After the burning, analysis same as the column experiment was conducted.

Results and Discussion
1. Trend of temperature variation during surface burning were identical for the field and laboratory experiments.(Fig.3)
2. Field and column experiments gave similar water repellency distribution after the surface burning. (Fig.4)
3. Aerobic muffle furnace burning eliminated water repellency when heating temperature above 300°C, while oxygen-deprived, field and column experiments still produced water repellency under the same heating temperature. (Fig.5)
4. Soils burned by field and column experiments and oxygen-deprived muffle showed high TC for heating temperature of 400 to 700°C. This made C/N ratio of the soil for the same heating temperature. Soil color qualitatively agreed the TC variation. (Fig.5, Photo 3)
5. Oxygen atmosphere during heating may affect carbon and nitrogen behavior in soil and thus controls extent of water repellency.

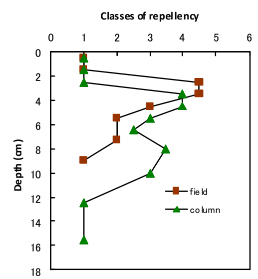

Fig.4 Distribution of water repellency (WDPT, Bisdom et al. (1993)) after surface burning.

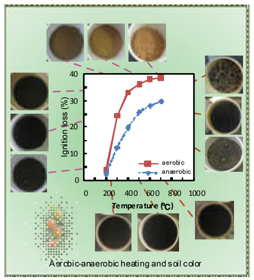

Photo 3 Soil color and ignition loss between aerobic and oxygen-deprived burning with variable heating temperature.

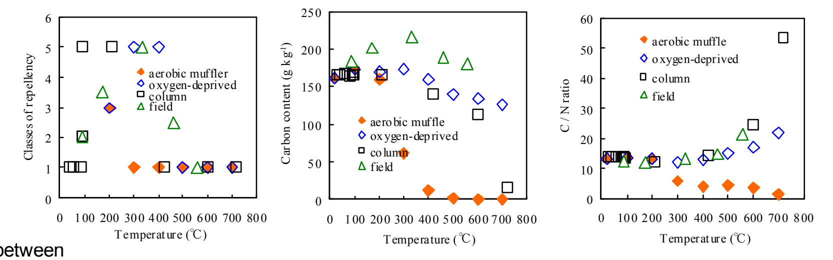

Fig.5 Water repellency, total carbon content and C/N ratio of soils after muffle furnace burning.

CONCLUSION
Oxygen-deprived condition kept high soil TC even soil temperature exceeded 400℃. This fact suggests extent of oxygen supply during surface burning is an important factor in transform of soil organic matters and thus, producing heat induced water repellency of the soil.

REFERENCES
Bisdom et al. (1993) Geoderma, 56: 105-118
DeBano et al. (1976) SSSAJ, 40:799-782
DeBano et al.(2000) J. of Hydrol., 231-232:195-206