Physical properties of Active layer Soil in Siberian wetland

Kunio WATANABE*, Masaru MIZOGUCHI*, Norihumi SATOU** and Yuji KODAMA**
*Faculty of Bioresources, Mie University
**Institute of Low Temperature Science, Hokkaido University

INTRODUCTION

Soil and micro-landform of tundra wetland in Siberian permafrost area were surveyed during the summer of 1997, and physical properties of soil horizons in active layer were measured. In this paper, vegetation map and soil profiles have been reported, and soil genesis of the tundra wetland was discussed on the basis of the survey.

STUDY SITES AND METHODS

The soil survey was carried out at a typical wetland located on a small river running through Tikci, Sakha republic, Russia, from August 12 to September 10, 1997. Figure 1 shows a vegetation and soil map of study area. Solid lines indicate the river and a divide, and arrows indicate slopes. Sedges grew in the area where ground water level was low or the ground was inundated, while mosses grew in the area where ground water level was a few centimeters. Gravels spread at the elevation of higher than 150 m in stead of the vegetations.

Thickness of the active layer, ground temperature and vegetation type were measured along the transit lines which were shown in figure 1 as dashed lines with 25 m intervals. On the transit lines, 30 observation pits with size of 50×50 cm^2 were dug to the frozen ground surface. And horizons, hydraulic conductivity, water content and soil structure were observed directly at the pits.

SOIL PROFILES

Soil of the active layer can be divided into four types according to vegetation and ground water level, and each type of the soil was divided into upper and lower horizons.

Figure 2a shows the soil(a) which was seen in lowland with the water level of between -2 to 10 cm. Although the surface is covered by sedges, the covered rate was low. The upper horizon, consisted of dark brown low moor, had thickness of 20 to 30 cm. A lot of plant residue remained to be decomposed with low density and low viscosity in the upper horizon. On the other hand, the lower horizon consisted of gleyed heavy clay with very high viscosity. There was no clear boundary between the upper and the lower horizons. In this season, the thickness of the active layer was 40 ± 10 cm. Frozen ground, strongly kept feature of mother rock, lay under the active layer. Fine gravels were observed near thawing surface of the frozen ground.

Figure 2b shows the soil(b) which was seen in lowland without inundating. The ground water level was 2 to 8 cm. Living plant layer consisted of mosses 1 to 10 cm in thick, and the upper horizon consisted of brown high moor 10 to 20 cm in thick with very low density, low viscosity and rich humus. Some plant residue remained to be decomposed in the upper horizon. The lower horizon consisted of gray heavy clay with a few board shaped gravels. There was clear boundary between the upper and the lower horizons. The thickness of the active layer was 30±10 cm.

Figure 2c shows soil(c) which was seen in middle-highlands with the ground water level of 2 to 10 cm. Sedges covered the ground densely. The upper horizon was under a few centimeters plant residue layer and consisted of dark brown clayey soil with low density, middle viscosity and rich humus. There are some earthworms and moles. The lower horizon consisted of gray clay with gravels. There was clear boundary between the upper and the lower horizons. The thickness of the active layer was 40±10 cm.

Figure 2d shows soil(d) which was seen in highlands where the elevation was higher than 150 m and the grand water level was lower than 50 cm. There were only piled up gravels under some lichens, and less horizontal soils were observed. The size of the gravels was decreased with depth. The thickness of the active layer was more than 50 cm.

PHYSICAL PROPERTIES OF SOILS

Figure 3 shows profiles of temperature, water content, density and hydraulic conductivity in soil(c). The temperature in the living plant layer was about the air temperature. It decreased with depth and reached 0 degree Celsius at frozen ground surface. Water contents were high in the surface layer and the lower horizon while it was low in the upper horizon. On the other hand, bulk densities were low in the surface layer and the lower horizons, while it was high in the upper horizon. Hydraulic conductivity decreased with depth. Such profiles as soil(c) were also observed in soil(a) and soil(b), but did not observed in soil(d).

Except for soil(d), the surface layers had low densities and high hydraulic conductivity because they had a lot of plant residues and high porosity. Since soil pores keep water, water contents of the surface layers become high. The soil in the upper horizons was compacted and contained rich humus, so that it had high density, low water content and low hydraulic conductivity. Because of disturbance by freeze-thaw effect, balk densities of the soil in the lower horizons are lower than the upper horizons. Since, soil water is restricted to flow by the frozen ground, the water contents of soil in the lower horizons become high. The hydraulic conductivity in the lower horizons increased according to the amount of gravels.

DISCUSSIONS

Mother rocks were found isotropicaly in the study area. Assuming that climatic conditions have been given isotropicaly, these soil feature would be related to only the ground water levels and the vegetations. Upper schematic of figurer 4 indicates relations among elevation, ground water level and thickness of active layers. It is supposed that the difference in the ground water levels depends on the meter-scale difference of micro landform, and the active layer would be thick at the point which has low ground water level or has low elevation. It is also supposed that the thickness of the active layer decreased with increasing the thickness of living plant layer due to adiabatic effects by the plant layer.

Lower schematic of figure 4 indicates vegetations and soil cross section. The amount of peat increased with decreasing the ground water level, and soil organisms were observed at the point which had low ground water level. Soil horizons may be progress along the arrow as shown in figure 4. As a result of frost weathering of the mother rocks and freeze-thaw disturbance, clay which has mother rock feature would spread all over the wetland and gravel-rich condition appear near frozen ground surface.

CONCLUSION

Soil of active layer on tundra wetland was surveyed. Vegetation map and soil cross sections have been reported in the present paper. As the result of the survey, four type of the soils were classified. On the basis of the soil classification, the vegetation and freeze-thaw action, soil formation in tundra permafrost area has been discussed. It is important to understand these actual soil conditions for make practical hydrological model.