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FIELD MEASUREMENT OF THE GROUND WATER FLOW IN THE HIGH MOOR PEAT IN THE SAROBETSU MIRE, HOKKAIDO, JAPAN

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SUMMARY

To clarify the vertical two-dimension groundwater flow, groundwater levels were measured from May 2008 to Oct. 2008. Direct measurement of the groundwater flow was also carried out using groundwater velocimeter. The vertical two-dimension groundwater flow was calculated from the groundwater level distributions. The groundwater in all the depth flowed horizontally from high moor to low moor depending on the ground surface gradient. Only shallow groundwater supports high moor vegetation. We concluded that to save oligotrophic groundwater in the high moor is important as well as to have frequent rainfall on the moss layer because rainfall maintain the discharge from surface moss layer.

KEYWORDS: Groundwater, peat, wetland, moss, water quality

INTRODUCTION

Ground water quantity and quality still plays an important role in maintaining the original diversity of wetland plant species (Iqbal *et al*., 2006b). The purpose of this paper is to investigate the role of groundwater movement in high moor peatlands. The site chosen for this study is Sarobetsu Mire, in northern part of Hokkaido, Japan. The Mire is one of the registered wetlands in the Ramsar Convention, but has problems of disappearing precious vegetation in high moor by the groundwater depletion resulting from the farmland development and other unknown factors. In this study, groundwater observation in the Sarobetsu Mire was carried out to clarify the groundwater movement in the peat soil.

METHODS

Measurement sites setting

The water-sampling stations were set in the special preservation area of the Ministry of the Environment in the Sarobetsu Mire, which is one of the largest mires in Japan. Site E is situated in the hummock surface of the raised bog with high elevation of groundwater and preserved natural bog vegetation. The dominant ground layer cover is *Sphagnum spp*. Site W is located about 180 m from point E on the west direction. Area of this point is transitional area between *Sasa (*dwarf bamboo) area and sphagnum area. In this point, the boundary between the natural and degraded area exists. This site is covered by *Sasa* in sparse on the surface of the ground. Site W' is located about 150 m from site W on the west direction. In this area, the change of hydrological condition is indicated by the gradual change of fluctuating pattern on the ground water level (Inoue et al., 1992). The dominant vegetation is dwarf bamboo (*Sasa*) with the leaf area index (LAI) of 0.6. This site is situated in the high moor bog, but it is covered by dense *Sasa* on the ground. Site WW is situated at the fringe of high moor bog, which is also covered by dense *Sasa* vegetation. The ground height of Site WW is much lower than that of Site W'. Site NC is situated at the head of the small channel which is connected to the Sarobetsu River. Discharging groundwater from the Site NC to the channel after rain is often observed. In each sampling station, pipes made by PVC were installed for water sampling and measuring groundwater level continuously. The number of the pipes was five and their diameter was 67 mm. Each pipe has the 0.2 m long strainer in the different depth of 0.2 m, 0.5 m, 1.0 m, 1.5 m and 2.0 m from the ground. These altitudes of the pipes were measured from the constructed benchmarks by levelling and Global Navigation Satellite System (GNSS) observations. The properties of the water sampling pipes are shown in the Table 1. GNSS observation was made on May 2008. Topcon GB1000 was used to get coordinates. The sampling interval was 30 seconds and measured for over one hour for each benchmarks. The coordinates of the each benchmark were analysed using GPS benchmarks of the Geological Survey Institute of Japan.

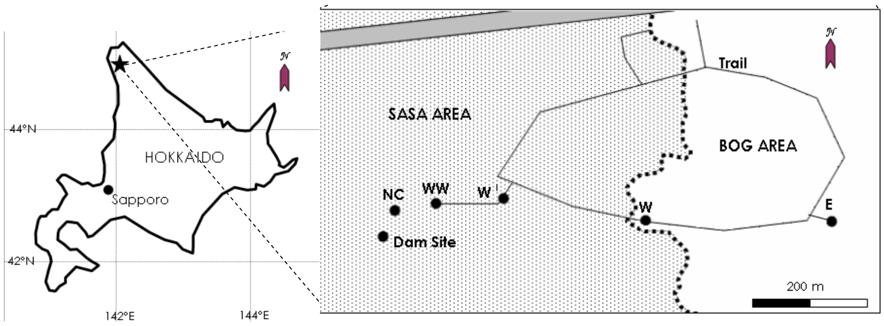

Fig. 1 Sampling stations (Sarobetsu mire, Hokkaido, Japan)

Table 1. The properties of the sampling stations, The coordinates are based on the Japan Plane Rectangular Coordinate System zones 12.

Station	X(m)	Y(m)	Ground level(m)
Sta.W	122843.6	-44426.4	5.914
Sta. W'	122818	-44595.9	5.736
Sta. WW	122771.3	-44712.8	5.236
Sta. NC	122779.3	-44732.9	4.914

Water level observation

Water level loggers (OYO S& DL mini, Onset U-20 and KADEC mizu) were installed to measure groundwater levels continuously. The measurement time intervals of the loggers were 10 min. Water depths were converted to the altitudes of the water level using the results of the surveying. Measurement of the groundwater was started at May 2008 and ended at October 2008. These water levels mean piezometric head by measuring the water levels for different depth of the wells. Water levels were measured manually on May 2008, June 2008 and October 2008.

Hydraulic conductivity of the peat

Hydraulic conductivity was measured by water in situ measuring using well. Evaluation of the hydraulic conductivity was made by below equations, (1) and (2).

$$a = \frac{\log(s_1/s_2)}{t_2 - t_1} \tag{1}$$

$$k = \frac{(2.3de)^2}{8L}\log\left(\frac{2L}{D}\right)a \tag{2}$$

Where, s_1: water level at elapsed time t_1 (m). s_2: water level at elapsed time at t_2 (m), *k*: hydraulic conductivity (m/s), *de*: equivalent diameter (m), *L*: length of the strainer (m), *D*: diameter of the borehole (m) . For the top moss layer, hydraulic conductivity was measured by the column test in the field by circulating water using peristaltic pump and column filled by moss.

RESULTS AND DISCUSSION

Hydraulic Conductivity

Hydraulic conductivities are shown in Table 2. At the top of peat moss layer, they had very high hydraulic conductivity.

Table 2. Hydraulic conductivity of the peat soil in the study site (x 10^{-6} m/s)

Depth (m)	E	W	W'	WW	NC
0.2 (moss layer)	1100	1000	-	-	-
0.5	24	94	0.076	9.3	0.069
1.0	26	24	0.026	0.15	0.18
1.5	-	6.2	0.34	1.3	8.0
2.0	4.5	6.1	0.70	1.0	1.8
2.5	0.92	0.020	0.014	0.15	3.0
3.0	-	0.048	0.033	0.018	0.79

*values are the results of the Jonathan et al, 2010

Vertical two dimension groundwater flow of the groundwater

Fig. 2 shows that vertical 2 dimension isopleth of the piezometric head. Groundwater flows from East (in Fig. 2, left side) to West (in Fig. 2, right side). In high moor bog area, Site E and Site W, there is no obvious vertical component of the groundwater flow. In the fringe of the bog area, Site WW and Site NC, top groundwater tends to spring to the ground. Actually, groundwater upwells around the site. From the Fig. 2, surface groundwater flows horizontally from E to WW. At Site NC, deep ground water also upwells from the layer, whose altitude is 3 m.

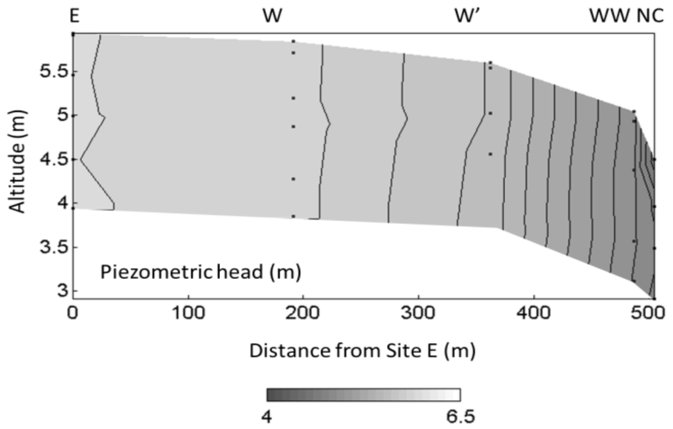

Fig. 2. 2-dimension vertical piezometric head on May 12, 2008.

Groundwater flow rate in the study field

Groundwater flux for Site W was calculated by the equation (4).

$$v = ki\Delta h \tag{4}$$

Where, k: hydraulic conductivity (m/s), i: hydraulic gradient at the same altitude (-), Δh: thickness of the layer. Thickness the corresponding groundwater strainer depth of "0.2 m" , "0.5 m" , "1.0 m", "1.5 m" and "2.0 m" were 0.35 m, 0.4 m, 0.5 m, 0.5 m, 0.5 m, respectively. Hydraulic conductivity k in the 0.2 m depth at Site W was 10^{-3} m/s. Fig. 4 shows that the water flux of the groundwater at the section of Site W. Depending on the high hydraulic conductivity in the surface moss layer, groundwater flux was high in the shallow groundwater. Groundwater flux increases in the dry period. Especially in September 2008, there was scarce rainfall (Total rainfall = 97.5 mm/ 2 month, Fig. 3) . This tendency is very effective for drying of the high moor bog. On the other hand, water flux is low in the wet period, July 2008 (Total rainfall = 90 mm / month) for example. It was clarified that groundwater flux is high in the surface layer and increased in the dry period. At the surface layer of 0.2 m depth, groundwater flux decreased with rainfall.

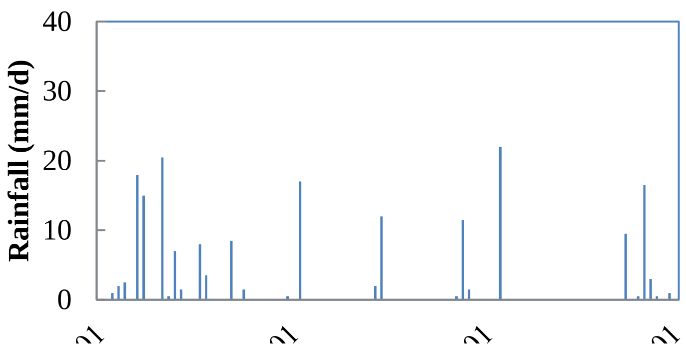

Fig. 3 Daily rainfall at Toyotomi Town, Hokkaido Pref. (Japan Meteorological Agency)

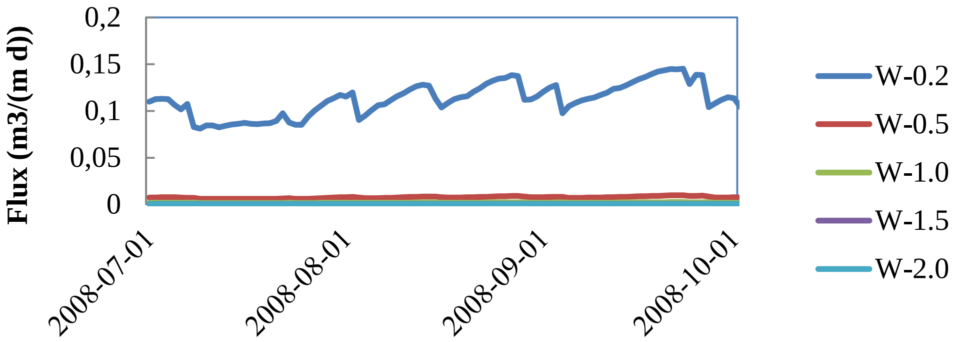

Fig. 4 Estimated groundwater flux for the section of the Site W.

CONCLUSION

In this study, groundwater observation in the Sarobetsu Mire was carried out to clarify the water quality formative mechanisms in high moor peat. The groundwater in all the depth flowed horizontally from high moor to low moor depending on the ground surface gradient. In addition, upward groundwater flow was observed at the natural spring which is located at the downstream of the steep gradient dividing high moor and low moor. Horizontal groundwater flow in high moor means that the mixing of shallow and deep groundwater will not occur in short time scale. We also found that the shallow groundwater was discharged from the thin surface sphagnum or relatively newer peat layer. We concluded that to save the oligotrophic groundwater in the high moor, it is important to maintain groundwater in the thin surface layer which can easily flow to low moor through the surface peat soil or peat moss layer. It is also important to maintain groundwater and inhabit surface groundwater discharge, frequent rainfall to the surface peat is essential.

ACKNOWLEDGEMENTS

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