EFFECT OF ARTIFICIAL FIRE ON THE STREAM WATER CHEMISTRY IN A SMALL MOUNTAINOUS PEATLAND, SOUTH-WESTERN JAPAN

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Abstract: Tadewara mire is a typical volcanic mire that locates in the southwestern Japan and the vegetation has been maintained by the artificial fire. However, the effect of fire on the mire ecosystems as well as its impact on the fresh water ecosystems have not been clarifies. The objective of this study is to clarify the response of mire ecosystem by the fire. We investigated the effect of artificial fire on the chemistry of the stream water in Tadewara mire, southwestern Japan. Artificial fire was conducted on early April in 2007 and 2008, which burned the vegetation: mainly *Moliniopsis japonica, Phragmitesa australis*, and *Sphagnum palustre* - S. fimbliatum communities. Our result showed that the burning had little effect on the chemical characteristics of the streams, except for NH4+. Ammonium concentration was significantly increased after the burning, and showed a 2-hold increase within 24 hours after the burning. This implies that the burning of the vegetation lead to maintain the nutrient-poor environments as well as the nutrient removal from the mire.

Key Words: artificial fire, management, mountainous peatland, stream water chemistry, volcano

INTRODUCTION

Mountainous catchments have a significant key role to play the formation of water chemistry and the source of stream. Stream water is one of the major pathways from the ecosystems. Substantial quantities of mineral nutrients are accumulated in and cycled between vegetation to soil systems, and some of them transported in downstream water. Natural or anthropogenic disturbance of the nutritional pool held in the soil and vegetation also an important mineralizing agent on the nutrient efflux from the catchments. Fire can directly affect nutrient cycling in ecosystems. One significant impact of fire is the transfer to the atmosphere as gases and in the particles of smoke. In particular, peatlands are one of the huge reserves of terrestrial organic carbon, and hence peatlands fire could consume not only the surface vegetation but also the underlying peat soil as CO2 (Page, *et al*., 2002). Peatland fire could promote the mineralization of the organic matter and consequence the nutrient-poor environments. The objective of this study is to clarify the response of mire ecosystem by the fire. In this paper, we report that the effect of artificial fire on the stream water chemistry from the mire with reference to temporal fluctuation following fire.

MATERIAL AND METHODS

Study Site

The study site is located in the Aso-Kuju National Park, the middle part of Kyushu Island, Japan (33º7' N, 131º14' E, Figure 1). Mean annual temperature of the area is 13.9 ºC. Mean annual precipitation is 1,822 mm, and 48 % of an annual precipitation is accounted in the rainy season during June - August (all data is averaged from 1976 to 2007, obtained from the Japan Metrological Agency). The study site is surrounded by several volcanic mountains as much as 1,700 meters high. Mt Hoshou, one of the volcanoes, is still erupting hydrogen sulfide gas in atmosphere. Tadewara Mire (76 ha, 1,015m a.s.l.) is located on the alluvial fan, which consists of the volcanic debris. Its topography slope gently (1.6º). There are two streams and several springs in the Tadewara Mire. Shiramizugawa River runs at the west side of the mire, which has its origin in Mt. Hoshou. Another is Kurogo River, which is the discharge from the spring and runs at the east side of the mire. These streams flow downward, and meet at the terminus of the mire. In the upper part of the mire, which are dominated by Miscanthus sinensis. In the lower part of mire, *Moliniopsis japonica, Phragmitesa australis, and Sphagnum palustre* - S. fimbliatum communities are dominated. In 2005, Tadewara Mire is inscribed as registered wetlands under the Ramsar Convention.

General Description of Artificial Fire at Tadewara Mire

Tadewara mire is burned by an artificial fire, which is conducted only once in the ever spring by the inhabitants of the district. Artificial fire at the Tadewara Mire starts to ignite dry vegetation above the soil, and then most of vegetation burns intensively for a few hours. The burnt area in April 2008 was approximately 46 ha and covered 87 % of whole area. Undamaged area by the fire was swampy area, where were dominated by *Phragmites australis*.

Sample Collection and Chemical Analysis

We investigated the temporal variation in hydro-chemical environments in the river water at the 3 sampling points (Figure 1). P3 is located along Kurogou River, P4 is along Shiramizugawa River, and P5 is the ca. 50 m downstream from the meeting of two rivers. Artificial fire at the Tadewara Mire was carried out on April 8, 2007, and April 5, 2008. Water sampling for chemical analysis at the three points was carried out at 8 times for 27 hours in 2007, and 15 times for 51 hours in 2008 following the fire.

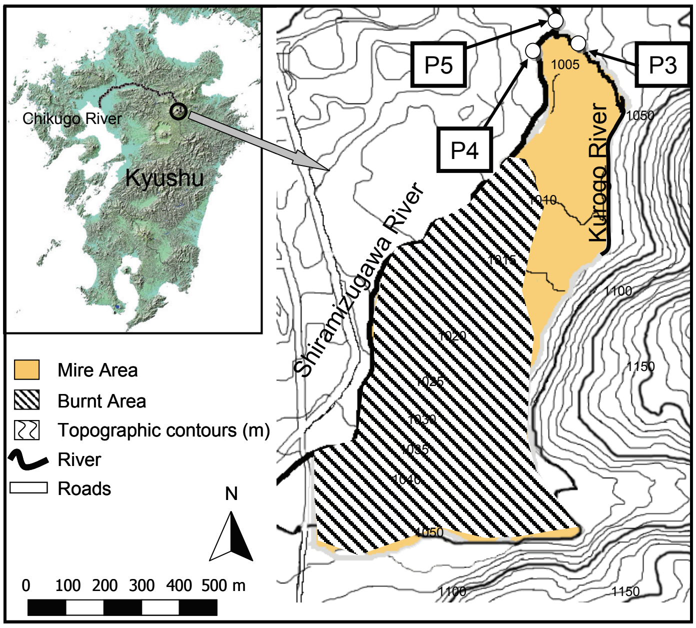

Figure 1. Location of the study site and sampling points (open circles).

Water samples were stored in two 150 ml polyethylene bottles in the field, and kept at < 5 ºC as soon as possible after sampling. Water level at the P5 was measured and recorded at 10-minutes intervals in 2008. In the laboratory, pH and electrical conductivity (EC) of water samples were measured with pH and EC meter (D-54, Horiba). Water samples were then filtered through cellulose acetate membrane filter (0.2μm, Advantec Toyo Co.) and refrigerated before measurement of ion concentrations. Ion concentrations were measured with an ion chromatograph (DX-120, Japan Dionex).

RESULTS AND DISCCUSION

Water Chemical Properties

Chemical characteristics of the stream water are summarized in Table 1. Mean water pH of P4, showing lower than 5.0, was the lowest among the sampling points. Water pH of P3, originate in the spring, was the highest. And P5, located at the meeting of the two rivers, showed the intermediate value between P3 and P4. Ca2+ was the dominant cation, followed by Mg2+, Na+ and NH4+. SO42- was the dominant anion, followed by Cl– and NO3–. Mean SO42- concentrations of P4 was significantly higher than those in P3 and P5. This implies that the chemical environment in the Tadewara Mire affected by the high Ca2+ and SO42– loading from the chemical weathering of the volcanic sediments and the groundwater.

Table 1. Chemical properties of the stream water in the Tadewara Mire. Numbers in the table represents the mean ± SD value.

Chemical parameters	Unit	Sampling point: P3			P4			P5		
pH		6.0	±	0.4	4.8	±	0.7	5.8	±	0.2
Electrical Conductivity	mS/m	41.6	±	5.0	37.4	±	2.7	38.6	±	2.6
Ca2+	mg/L	38.4	±	5.2	36.3	±	6.5	39.1	±	6.0
Mg2+	mg/L	13.6	±	1.8	10.4	±	1.5	12.5	±	1.7
Na+	mg/L	13.3	±	5.9	11.3	±	2.6	12.5	±	3.5
K+	mg/L	2.7	±	1.2	3.3	±	1.0	3.1	±	1.2
NH4+	mg/L	0.3	±	0.2	0.5	±	0.2	0.4	±	0.2
SO42-	mg/L	80.2	±	12.3	123.6	±	14.0	102.7	±	25.0
Cl-	mg/L	34.5	±	11.5	23.2	±	3.0	29.7	±	6.8
NO3-	mg/L	1.3	±	1.1	0.8	±	0.7	0.8	±	0.3

Temporal Changes of the Water Chemistry following Artificial Fire

The temporal changes of the water chemistries with in 2007 and 2008 are shown in Figure 2. The data in 2007 represented the change until 27 hours after ignition. The pH and EC of the river water did not show the temporal change following the fire (data are not presented in Figure 2). Monovalent ion concentrations (Na+, NH4+ and K+) were increased with time, whereas bivalent cation (Ca2+ and Mg2+) concentrations were almost stable. This implies that monovalent cations are vulnerable to leaching compared with the Ca2+ and Mg2+. Chloride and SO42- concentrations did not change following the fire. Nitrate concentrations showed irregularly high value.

The monitoring duration in 2008 was extended to 51 hours following the fire. The temporal fluctuation of chemical properties in river water was shown in Figure 3. Water level and hourly precipitation were also shown in Figure 3. The precipitation data was obtained from Ukenokuchi meteorological station (770 m a.s.l.) which was ca. 4 km away from the Tadewara Mire. During the monitoring, intensive precipitation of 19 mm was recorded after 39 hours following the fire (6:00-11:00 in local time). Maximum water level (0.591m) occurred around the maximum hourly precipitation (9 mm). Mg2+, Ca2+, Cl– and SO42– concentrations showed stable until 39 hours. However, these concentrations decreased at 42 hours, and then increased gradually. Increased discharge water from the upstream mountains following the precipitation might cause the dilute these concentrations.

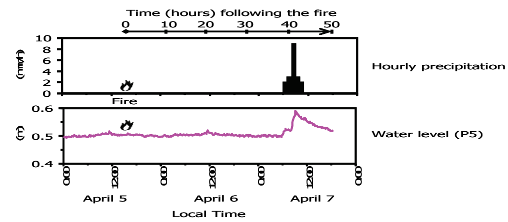

Figure 2. Temporal fluctuations of precipitation and water level of river water at Tadewara Mire (April 5 - 7, 2008)

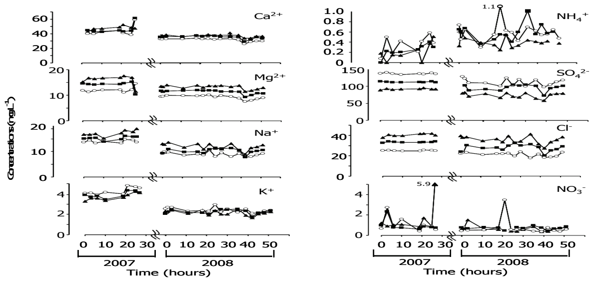

Figure 3. Temporal fluctuations of ion concentrations of the river water following the fire (April 5-6, 2007 and April 5-7, 2008). Closed triangle; P3, Open circle; P4, Closed square; P5.

On the other hands, ammonium, K+ and NO3– did not show clear relationships with the hydrological condition. A sharp increase of NH4+ occurred in the water of P4 (1.0 mg L－1 at 21 hours) and P5 (1.0 mg L–1 at 35 hours), respectively. The ammonium is the primary form of mineralized nitrogen in most flowed wetland soils, although much nitrogen can be tied up in organic forms in highly organic soils (Mitsch, 2007). Chorover, et al. (1994) suggested that increase in NH4+ may be result of thermal decomposition of organic matter or microbial activity. Our results imply that implication of artificial fire in the Tadewara Mire is to promote the mineralization of organic matters and consequently runoff from the mire. In Particular, nitrogen is considered one of the major limiting factors such as coastal ecosystems. Therefore, an understanding of the change in nitrogen dynamics resulting from fire in the peatlands is essential for successful management for watershed ecosystems.

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