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Investigation of Soil Erosion during Typhoon Periods

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1. Introduction

Soil erosion during storm and snow-melting period was strongly correlated with discharges, and studies on sediment concentration-discharge relationship are reviewed for Japanese rivers by Su *et al.* (2002). It showed that the influence of seasonal vegetation cover variation was not taken into account in these studies. In order to investigate this influence, two field surveys were conducted during typhoon periods of August 22nd-23rd, 2001 (Storm A) and October 1st-2nd, 2002 (Storm O). Stream discharges (Q) and suspended solids (SS) were measured in an interval of 1-hour for rising period or 2-hour for recession period of hydrograph at the outlet of a small sub-area #9 in the Kamafusa Dam catchment, Kawasaki town, Miyagi Prefecture (**Fig.1**). This sub-area has the catchment area of 1.56 km^2 and is fully covered with dense forests, which includes 66% deciduous forests and 34% evergreen forests.

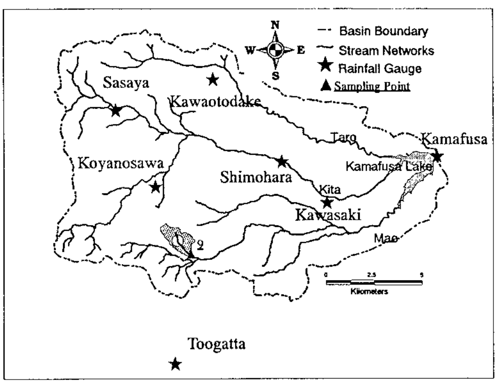

Fig.1 Study sub-area and sampling point #9

2. Methods and Materials

There are several rainfall gauging stations around the sub-area #9 (**Fig. 1**). The inverse-distance-weighted rainfall at center of sub-area #9, which is based on stations of Koyanosawa (3.07km far from the center of sub-area #9), Toogatta (6.38km), Shimohara (6.86km) and Kawasaki (8.10km), was used to represent the average rainfall of this sub-area. The vegetation cover variation was represented using a normalized difference vegetation index (NDVI) data set, which was derived from a time-series Landsat TM data (Su *et al.*, 2002). The statistic data of these two storm events are shown in **Table 1**, which listed the rainfall lasting time, total rainfall, average rainfall, peak values of rainfall intensity, stream discharge, SS concentration and load, and total soil loss during 19 hours' period of these two storm event. The statistic data of vegetation cover variation was shown in **Fig. 2**.

3. Results and Discussion

There are many factors affecting soil erosion during a storm event, such as land use, soil types, topography, rainfall intensity (RI), vegetation conditions and antecedent conditions that determine the potential availability of sediments in a catchment prior to the investigated storm event (Williams, 1989; Romkens *et al.*, 2002). Because the field observations were conducted at outlet of the same sub-area, which is a completely natural catchment covered with forests only, the first three factors of above are same between two investigated storm events. Therefore, the difference in soil erosion between Storms A and O is completely due to other factors.

Table 1 showed that, during the 19 hours' observed period, the total rainfall of Storm A (70.7 mm) was larger than that of Storm O (63.6 mm). However, the storm A lasted 16 hours, which is longer than that of Storm O (10 hours). Therefore, the average rainfall intensity of Storm O (6.3 mm/hr) was higher than that of Storm A (4.4 mm/hr). Also the maximum RI of Storm O (16.7 mm/hr) was higher than that of Storm A (15.4 mm/hr). It meant that the higher RI (both maximum and average) caused higher soil erosion during Storm O than that during Storm A. Furthermore, **Fig. 3** showed that the SS load had approximately exponential relationship with rainfall intensity, which showed that the soil erosion was closely correlated with rainfall intensity during storm event.

To the soil erosion during storm event, the antecedent conditions are also important. Generally, the higher soil erosion would be expected if the availability of sediments prior to an investigated storm is high. For example, if there are no large rainfalls for a long time and there are much sediment deposited in the stream channel beds due to small rainfall events preceded the investigated storm event, it would cause high soil loss in the successive storm event. In order to compare the antecedent conditions of two investigated storms, the rainfall patterns of 30 days prior to the investigated storms were analyzed (**Fig. 4**). There was a storm at 10th day (Storm 1:38mm/d) and 3rd day (Storm 2:49mm/d) prior to storm A and Storm O, respectively. According to general guess, the availability of sediments prior to Storm A should be higher than that prior to Storm O, because part of available sediments prior to Storm O had been washed away by the Storm 2. However, the observed soil loss of Storm O was larger than that of Storm A. The soil loss might be also affected by other factor(s). Besides the factor of rainfall intensity discussed before, it was deduced that the seasonal vegetation cover variation also affected the soil loss to some extent during the investigated storm events.

According to NDVI distribution (**Fig. 2**), the vegetation in August was more prosperous than October. By plotting soil loss of two investigated storm events with mean NDVI of sub-area #9 in August and October, a negative relationship was shown (**Fig. 5**). It showed that the higher mean NDVI of sub-area #9, the lower soil loss yielded in this sub-area. The dotted line is the expected variation pattern of soil loss dependent on vegetation cover variation.

4. Conclusions

This study tried to analyze the influence of vegetation cover variation on soil erosion during storm periods. Although only two storm events were investigated, the results showed that: 1) the rainfall intensity was a very important factor in the soil erosion, and 2) vegetation cover variation had negative influence on soil erosion.

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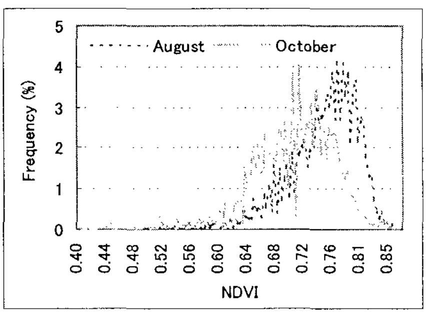

Fig. 2 Frequency of NDVI distribution in August and October

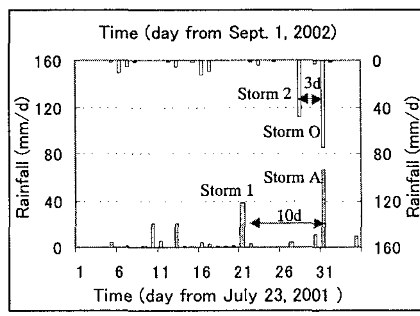

Fig. 4 Rainfall pattern at the Kawasaki Station during 30 days prior to investigated storms A and O

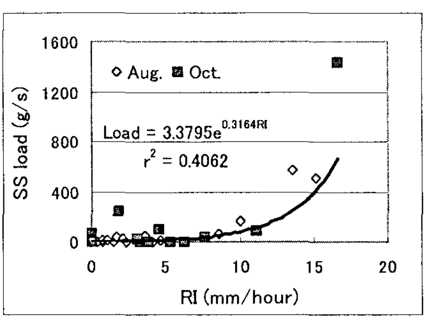

Fig. 3 Relationship of SS load and rainfall intensity

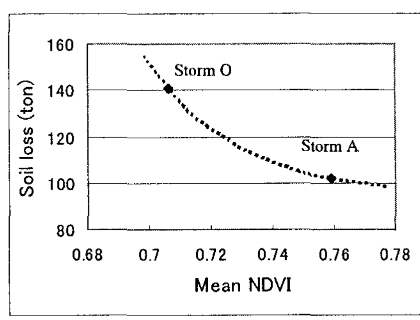

Fig. 5 Relationship of soil loss and vegetation cover variation

Table 1 Statistic data of two investigated storm events during 19hours' period

Storm Event	Rainfall Lasting Time (hour)	Total Rainfall (mm)	RI_{avg} (mm/hr)	RI_{max} (mm/hr)	Q_{max} (m^3/s)	$Conc_{max}$ (mg/l)	$Load_{max}$ (g/s)	Soil Loss (ton)
Storm A (Aug. 22nd-23rd, 2001)	16	70.7	4.4	15.4	1.14	561	575*	102
Storm O (Oct. 1st-2nd, 2002)	10	63.6	6.4	16.7	1.91	750	1432	141

*-Discharge peak occurred 1 hour later than concentration peak (positive hysteresis)