043 Rainfall and debris flow discharge in the Nojiri River, Sakurajima

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1. Introduction

Precipitation and total volume of the solid material mobilized as debris flow are two main variables that contribute to define the intensity of debris flow event. The rainfall plays a fundamental role to trigger debris flow event whereas volume of debris flow plays a fundamental role in the evaluation of the degree of the risk zones potentially affected by transit and deposition of the transported solid material.

For the prediction of rainfall-triggered debris flow, the concept of hydrological debris flow-triggering thresholds is important to be developed. This paper aims to examine the relations between rainfall characteristics and debris flow occurrence at local scale, focusing on a small Nojiri basin where rainfall intensity and debris flow discharge are intensively monitored.

2. Field observation

Sakurajima volcano is one of the most active volcanos in Japan and erupts nearly 100 to 200 times a year. The eruptions give ash deposit around the source areas of ravines on slope of the volcano. When heavy and continuous rain occurs in upstream areas over a period of time, the ash deposited is carried down river by runoff water as debris flows.

Nojiri River is located in the southwestern part of Sakurajima volcano where the most frequent debris flow occurs (more than 20 times per year).

The monitoring system on the river which was installed in 1974 to record the passage of debris flow wave is based on ultrasonic sensor installed in mid fan area, ground vibration, wire sensor and 10 cameras installed from Nojiri Dam 7 (NO7) to the river mouth (NOK) (Fig. 1a). Precipitation is measured by a telemeter rain gauge installed at side of Nojiri Dam 5 (NO5).

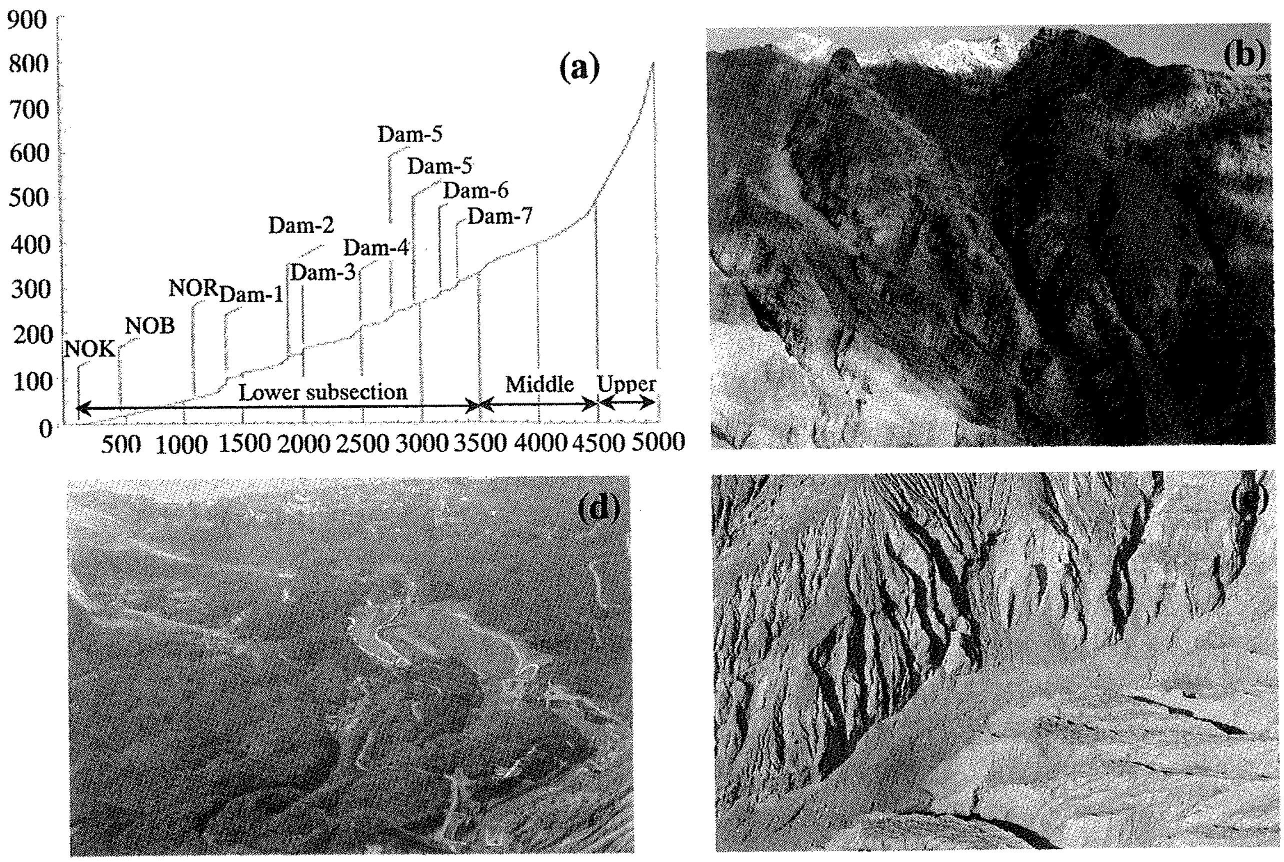

Figure 1. Nojiri River, (a) longitudinal section, (b) upper subsection, (c) middle subsection and (d) lower subsection

Channel of Nojiri River can be divided 3 subsections, that is the lower, middle and upper subsections, where distance from the sea are 0 – 3500 m, 3500 – 4500 m and 4500 – 5000 m as well as slope gradient 3 – 5°, 6 – 12° and more than 20°, respectively (Fig. 1a). The lower subsection has been constructed dam 1 to 7, sand pocket, and a lot of observation instruments. Sources of ash deposit located in upper subsection as well as left and right side of river bank at the middle subsection (Figs. 1b, c and d).

3. Rainfall data and debris flow discharge

The following variables were selected for the analysis of rainstorms and discharges in the Nojiri Basin: total rainfall (mm), maximum rainfall intensity (mm/10minute), total discharge (mm) and maximum discharge rate (mm/10minute).

Rainfall data recorded from 1992 to 1995 were considered in this study. During this period, 15 debris flow events were selected, for which the hydrographs were well recorded by cameras which are located at NO5, NOR, and NOB. The maximum discharge of debris flow occurred in correspondence to the maximum rainfall intensity in 12 out of 15 cases; time differences between peak of rainfall and discharge were from 2.5 to 20 minutes.

Annual numbers of explosive eruptions in 1992, 1993, 1994 and 1995 were 152, 88, 126 and 215 times, respectively. The spread of ash deposit is determined by the ejection strength of the volcano and wind velocity in the free atmosphere. The amount of volcanic ash ejected in each year was estimated to be 16.8, 3.7, 2.9 and 3.5 millions tons, respectively, by Sakurajima Volcanological Observatory (SVO) of Kyoto University. At the same time, Ohsumi Work Office of Ministry of Land, Infrastructure and Transport observed ash deposit at 260 m above sea level (asl), along Nojiri River where the volume of deposit was 42.7, 8.2, 30.6 and 13.7 kg/m^2 year in 1992, 1993, 1994 and 1995, respectively, at the same time number of debris flow outbreaks by the river was 24, 14, 11 and 10, respectively.

4. Result and Discussion

Figure 2 shows relationship between total rainfall and total discharge for each rainfall event. The area of plot distribution is between 5% and 100% line boundaries where most of plot around 25% line boundary. Figure 3 shows the relationship between maximum rainfall intensity and maximum discharge rate. The maximum rainfall intensity greater than 6 mm/10 minute and total rainfall more than 13.5 mm are probably required for initiation of debris flow event (Figs. 2 and 3).

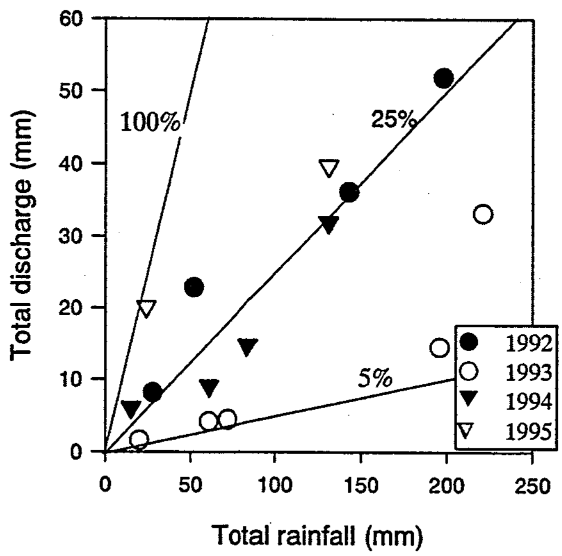

Figure 2. Relationship between total storm rainfall and total discharge

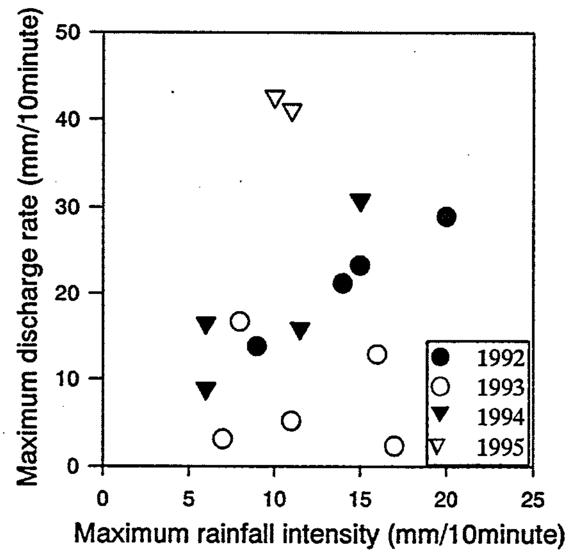

Figure 3. Relationship between maximum rainfall intensity and maximum discharge rate

Both of figures show substantially different plot distribution among the year. In 1993, the plot distribution are in lower area, which is due to the few ash deposit (8.2 kg/m^2 year). In 1992 and 1994 the volume of ash deposit were 42.7 and 30.6 kg/m^2 year, respectively and the plot distributions are in middle area. In 1995, the plot distributions are in upper area although volume of ash deposits 13.7 kg/m^2 year. The large of total and maximum discharge rate in 1995 were probably due to the rain storm event after the volcano eruption (Figs. 2 and 3).

Based on the observations mentioned above it can be stated that the amount of ash deposit in upstream of the catchment area is one of main factors to certain threshold of rainfall-triggered debris flow and volume of debris flow discharge.

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