Sediment discharge from mountain catchment in volcanic area, Japan

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INTRODUCTION

Sediment discharge from mountain catchments is temporally and spatially variable, depending on frequency and magnitude of sediment production and various agents of transport. Although several studies reveal affected periods of landslide triggered by heavy rainfall and earthquake events on catchment-scale sediment dynamics, only few studies reveal that by other sediment production events (e.g. huge debris avalanche and volcanic eruption). In this study, sediment discharge characteristics in volcanic area were examined by estimating affected periods of past volcanic eruptions. Debris flow associated with volcanic products repeatedly occurs immediately after volcanic eruption and sometimes causes disasters in residential areas downstream. Countermeasures after volcanic eruptions are taken not only for such sediment disaster prevention, but also for subsequent volcanic products discharge control. Estimation of affected period of volcanic products on sediment discharge is expected to provide useful information for sediment control planning after volcanic eruption.

MATERIALS AND METHODS

Site description

The Agatsuma River catchment in the Gunma prefecture, Kanto district, with a watershed area of 267 km2 was selected as the study site. This site, where a few typhoons produced heavy rainfall in September 2011, has two active volcanoes: the Asama and Kusatsu-Shirane volcanoes. The Asama volcano erupted repeatedly over the course of recorded history with outstanding volcanic eruptions in a few hundred years. Although outstanding volcanic eruptions in the Kusatsu-Shirane have not occurred recently, an episodic volcanic eruption occurred BP 8.5 ka.

Data acquisition

Water level and bedload sediment discharge of the catchment was measured. Bedload sediment discharge was monitored using a hydrophone based on an acoustic method and the data is available from 2011 to 2012 for the catchment. The acoustic method for calibrating sound pressure data, which are obtained through hydrophones, with the volume of bedload transport was checked the accuracy by comparing direct measurement data and estimation results in previous study.
Sediment discharge characteristics were derived through a comparison of fluctuations in bedload sediment discharges and hydrological data. In the Agatsuma River catchment, landslides in past ca. 50 years were interpreted using aerial photographs, and sediment production in the watershed area was investigated through a field survey.

RESULTS AND DISCUSSION

Characteristics of sediment discharge

In the Agatsuma River catchment, stream power and sediment discharge corresponded before and after a typhoon event (Fig.1). Trend of sediment discharge remained constant before and after the event, and high sediment discharge continued for several years. These results suggest that the amount of stored sediment, which can be discharged with rainfall, in the Agatsuma River catchment is potentially large, and formed transport-limited geomorphic system. Although high sediment discharge is known to occur after landslides, from the interpretation of aerial photographs, there were no major landslide scars in the past ca. 50 years and almost all upper areas were mainly covered with forest and farm land except around craters.

Effects of volcanic eruption on sediment discharge

Sediment production by landslides affects sediment dynamics and sediment yield on interdecadal time

scales. In the Agatsuma River catchment, few sediment productions originated from landslides in the past ca. 50 years, and high-sediment discharge in recent years is unlikely to originate from sediment production associated with landslides. The past volcanic eruptions form a part of the geology of the catchment, and friable volcanic rocks are distributed in the upper area. In particular, the Asama volcano located at the edge of southern watershed border experienced large-scale volcanic eruptions with pyroclastic flow in 1783 (total amount of magma from volcanic eruptions is of 10^8 m^3 order). Types of bedload materials were surveyed at site of the hydrophone, and ca. 15 % of that was eruptive products originated from the 1783 eruption. Previous studies reported that eruptive products affect sediment dynamics on a catchment scale after episodic volcanic eruptions. Thus, in the Agatsuma River catchment, there was abundant sediment production from eruptive products, and high sediment discharge was assumed to be consistent with stream power for over a hundred years.

CONCLUSION

In the Agatsuma River catchment, high sediment discharge in recent years assumed to be originated from past volcanic eruptions. The results suggest that past volcanic eruption affected catchment-scale sediment dynamics for over a hundred years. Thus, evaluation of the effect of volcanic eruption by investigating past volcanic eruption events and surveying geology at upper areas of catchment as sources of sediment production is necessary for sediment control planning in a volcanic area that experienced large-scale volcanic eruptions. In addition, when countermeasures for sediment control after large-scale volcanic eruptions are taken, it is important to consider prolonged impact of volcanic eruption on sediment transport.

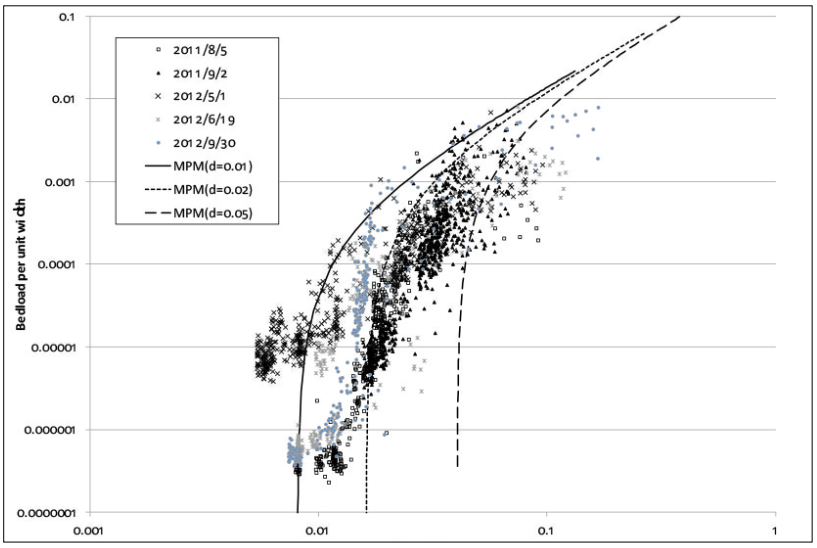

Figure 1. Relationship between bedload per unit width and stream power.

KEYWORDS

sediment discharge; sediment dynamics; hydrophone; volcanic area; volcanic eruption

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