Characteristics of Fine Sediment Transport from Hillslopes in Steep Headwater Catchments

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INTRODUCTION

Fine sediment, which is consisted by fine sand (0.063~2 mm), silt (0.002~0.063 mm), and clay (< 0.002 mm), is transported from hillslopes to stream channels and affects sediment dynamics in channels. Movement of fine sediment on hillslopes is generally associated with various factors such as rainfall intensity, vegetation and litter ground cover, soil characteristics and hillslope topography (Morgan, 1986). For instance, Nanko et al. (2008) showed that 1.2 times greater amount of rainfall induced 2.3 times greater soil detachment rate in 26.3° hillslopes covered by Japanese cypress plantation. Miyata et al. (2009) showed that hillslopes covered by 100 % of vegetation was 78.3 % less soil erosion than that on hillslopes covered by less than 5 % of vegetation in 1 x 2 m plots in Japanese cypress plantation forest. Fine sediment transport also differs depending on season due to the differences of mechanisms of sediment movement. Based on 2 – 3 m width x 200 m length plots, Imaizumi et al. (2015) showed that summer sediment transported by raindrop splash and overland flow has 60 to 91 % less soil erosion than that in winter by freezing and thawing. Although most of the previous studies examined characteristics of total sediment transport, differences of mobility of sediment among particle size were not examined (Sklar et al., 2017). Transport of fine sediment (≤ 2 mm) can possibly vary depending on the mechanisms of soil erosion. Therefore the objective of this study is to identify the characteristics of the fine sediment transport on hillslopes located adjacent to channels in temperate forested headwater catchments.

STUDY SITE AND METHODOLOGY

We monitored fine sediment transport in four plots located in No.3 (7 ha, elevation: 435 to 655 m) and No.4 (5 ha, elevation: 470 to 655 m) headwater catchments in the Oborasawa watershed (35°28’N, 139°12’E), in Mt. Tanzawa, Japan. The areas located 100 km of southwest of Tokyo metropolitan. Annual precipitation and mean air temperature is 3000 mm and 12°C, respectively. Most precipitation occurs from June to October and snow occasionally occurs from the end of January to early March (Hiraoka et al., 2015). Underlined geology of the catchments is Cenozoic sedimentary rock. Hillslope is generally steep near valley with mean gradient of 36°. Overstory vegetation is consisted by a mixture of 20-to-30 years old conifer trees (*Cryptomeria japonica* and *Chamaecyparis obtusa*) and broadleaf trees (*Cercidiphyllum japonicum* and *Aesculus turbinate*). We established four plots with 1m in width and from 19 to 42 m in length, in July 2010 (**Figure 1**). All plots are characterized as planar slopes. Sediment and litter collected in the plots was sampled every one to two months. Sediment and litter

Figure 1 Overview of study plots

were separated by washing in buckets. Sediment was settled down at the bottom, while litter was floated on the surface of water. Both litter and sediment was dried with 105° for 24 hours for measuring weight. Sediment was sieved using 40, 25, 9.52, 4, 2, 1, and 0.59 mm in diameter. Then, amount of total and fine sediment (< 2 mm) was estimated.

RESULTS AND DISCUSSION

The mean annual fine sediment transport for 7 years, monitored from 2010 to 2016, ranged from 1.2 to 23.7 g/day with the highest of Plot P4-1 followed by plot P3-2 (4.7 g/day) (**Figure 2a**). Percentages of mean fine sediment to the total transported sediment was also the high within plot P4-1 (35.5 %), followed by plot P3-1 (11.3 %), plot P4-2 (7.9 %), and plot P3-2 (6.1 %). Because P4-1 had sparse ground cover and high slope gradient among the plots, soil was detached by rain splash and mobilized on hillslope (Nanko et al., 2008). Litter transport for the plot was also the highest in plot P4-1(5.1 g/day) followed by plot P3-2 (4.3 g/day), plot P3-1 (2.9 g/day), and plot P4-2 (2.2 g/day) (**Figure 2b**). Because high soil erosion also reduces the availability of litter cover on hillslope (Li et al., 2014), the greatest amount of soil erosion was elevated in plot P4-1.

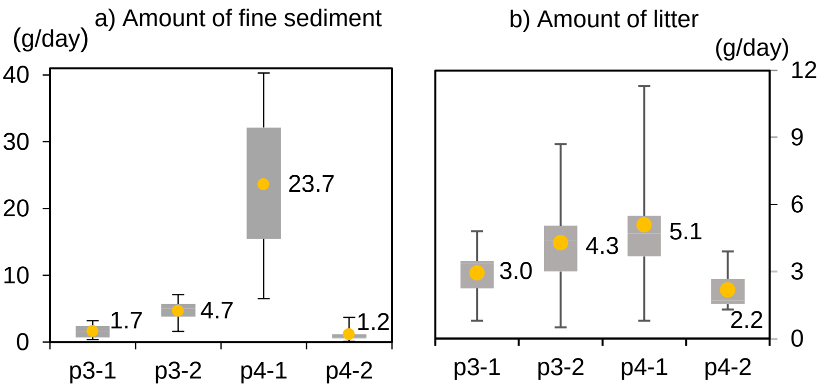

Figure 2 a) Amount of fine sediment transport and b) litter transport from the plots

Fine sediment transported in summer month (from June to October) was 1.3 to 4.8 times greater than that in winter. Percentages of fine sediment to total sediment became 6.0 to 43.6% in summer compared to that was 3.3 to 31.5 % in winter. In summer period, the highest daily precipitation level was 259.9 mm/day (16 Jul, 2015) followed by 245.0 mm/day (22 Aug, 2016). By comparing the two periods, fine sediment transport during the period including in 16 Jul, 2015 was 84.7 g/day, while sediment transport in the second highest precipitation occurred in 22 Aug, 2016 was 37.8 g/day. Differences of fine sediment transport in summer possibly related to short term rainfall intensity such as 1 hr rainfall (Vandaele and Poesen, 1995).

Our monitoring showed that fine sediment transport was associated with interaction among factors of soil erosion and soil surface conditions. The result suggested that litter is an important factor controlling the process of fine sediment transport. In general, most of the forest management considers only overstory and/or understory vegetation. Hence findings of this study indicated that litter cover was a key factor affecting fine sediment transport. Therefore, maintaining litter cover on soil surface is important for watershed management for soil conservation.

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