Particle size and sources of suspended sediment from mountain to coastal area

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1. INTRODUCTION

Extensive human activity and climate change have given great impacts on the sediment balance and connectivity between fluvial and coastal systems, causing sediment-related problems such as sedimentation in reservoir, coastal erosion and water pollution by prolonged turbid water. The dynamics of suspended sediment is one of the most important issues in watershed and coastal management. Suspended sediment load transported to ocean by a river commonly represents a mixture of sediments delivered from different locations and source types within the contributing catchment. Recently, sediment fingerprinting studies have been focused to elucidate suspended sediment sources within a catchment based on the quantitative interpretation of multivariate tracers (Collins et al., 1998; Yeager et al., 2002; Mizugaki et al., 2012). Information on suspended sediment source causing prolonged sediment runoff represents a key requirement from the management perspective, since identification of suspended sediment sources is a key precursor to the design of effective sediment management and control strategies (Walling, 2005). The objective of this study is to investigate the particle size and sources of suspended sediment from mountain to coastal area. To achieve this objective, sediment samples were collected in river channels with various watershed scales, a dam reservoir and a coastal area. For the collected sediment samples, fingerprinting was conducted using natural radionuclide tracers.

2. STUDY SITE

The study site was across a couple of adjacent watersheds, the Saru River and Mu River watersheds, draining from the Hidaka mountain range in central Hokkaido, northern Japan, to the Pacific Ocean (Fig. 1). The catchment areas of the Mu River and Saru River at the river mouth are 1270 km^2 and 1350 km^2, respectively. Annual precipitation ranges from 975 mm in the downstream to 1353 mm in the upstream area of the Saru River watershed. The 85% of both watersheds are covered by forest, and agricultural land (5.5%) and residential area (9.4%) stretch along the river channel and in the downstream area. Dominant geology of the study area consists of plutonic rock in the upstream area, Cretaceous sedimentary rock and accretionary complex from the upstream to midstream area, and Neocene sedimentary rock in the downstream area (Fig. 1). Basalt block in the accretionary complex and metamorphic rock of sedimentary rock and serpentinite are found in the midstream area (Fig. 1).

3. MATERIAL AND METHODS

To collect the suspended sediment during storm events, time-integrated suspended sediment samplers (ex., Phillips et al., 2000) were installed at each outlet of the 13 sub-catchments (0.7-27.2 km^2) and 12 stream channels with mid- to large-scaled watershed areas (17-1333 km^2; Fig. 1). Deposited sediment samples were also collected at the Nibutani Dam reservoir, which is located in the midstream of the Saru River (Fig. 1). Coastal sediment samples were collected from 17 sites along the coastal line of 25 km including the outlets of the Mu and Saru Rivers (Fig. 1). Sediment sampling for suspended sediment and coastal sediment was conducted periodically from 2009 to 2010, in total 138 and 203 samples, respectively. Sediment sampling across the dam reservoir was conducted June and November of 2010, in total 48 samples. In this study area, Mizugaki et al. (2012) indicated that the potential source areas of suspended sediment can be discriminated into 6 geological units shown in Fig. 1 by three natural radionuclides (^{212}Pb, ^{228}Ac and ^{40}K), which are available as tracers

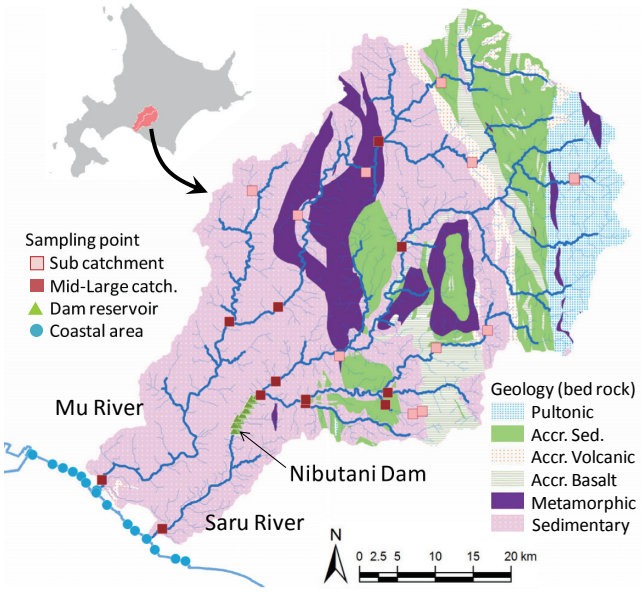

Fig. 1 Location and geology of study area and sampling site

to calculate the contributions of six source areas to suspended sediment. For the collected sediment samples, gamma-ray spectrometry was conducted to determine the activities of ^{212}Pb (238 keV), ^{228}Ac (911 keV) and ^{40}K (1461 keV) using a well type HPGe gamma detector (Ortec; GWL-120-15) coupled with a multichannel analyzer (SEIKO EG&G MCA7600) at our laboratory in the CERI, PWRI (Mizugaki et al., 2012). For each sediment sample, contributions of six source areas were calculated according to Mizugaki et al. (2012). Specific surface areas of the sediment samples were estimated using particle size distribution and the spherical approximation of the particles in each class. Particle size distribution was measured by sieving the dam deposits and coastal sediment and using a laser diffraction method for the suspended sediment.

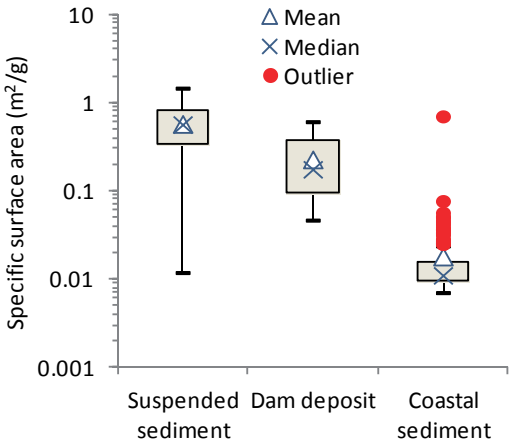

Fig. 2 Differences in specific surface area among suspended sediment, dam deposit and coastal sediment (finer than 0.5 mm).

4. RESULTS AND DISCUSSION

Specific surface area of the sediment showed significant differences among suspended sediment, dam deposit and coastal sediment (Fig. 2). This result indicates that the particle size composition can be controlled by sorting effects. Spearman correlation analysis was conducted among the contributions of each source area to the sediment and specific surface area (Fig. 3). For sedimentary rock and metamorphic rock, contribution to suspended sediment showed significant positive correlations, suggesting that finer sediment particles can originate in these geological areas, which are located mainly mid- to downstream area in the Mu and Saru River watersheds. Meanwhile, significant negative correlations were found for plutonic rock and accretionary sedimentary rock, suggesting that coarser fraction in suspended sediment can originate in the upstream area of the study site. These results indicate that the sources of fluvial sediment can depend on particle size so that the source area to be managed may be different according to the sediment focused on.

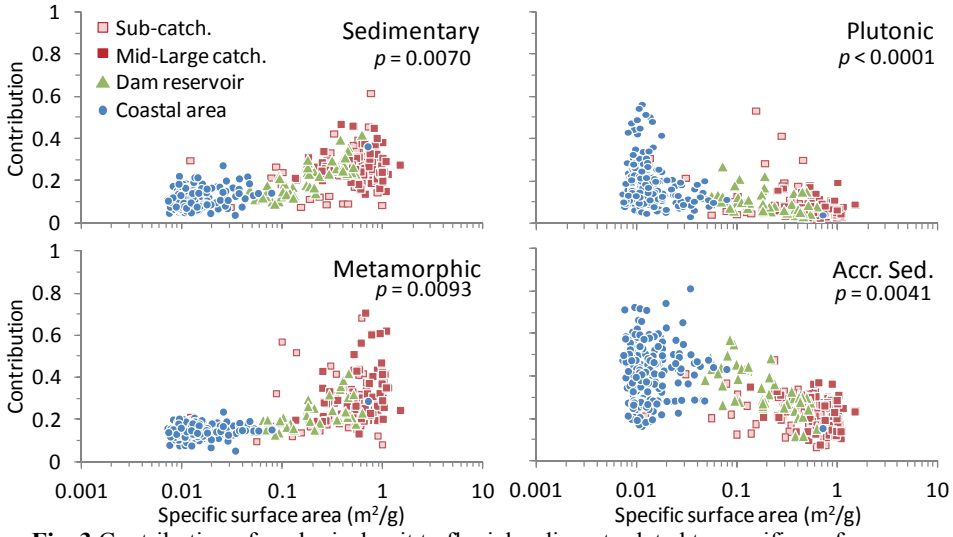

Fig. 3 Contribution of geological unit to fluvial sediment related to specific surface area

5. ACKNOWLEDGEMENT

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Keywords : suspended sediment, particle size, fingerprinting, natural radionuclide, watershed scale

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