Hillslope erosion and sedimentation in lake catchments in South Korea

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1. Introduction

An important source of sediments in lake basins is soil particles detached from hillslope surfaces. Eroded soil particles from a given catchment accumulate on the bed of the lake together with mineral sediments containing environmental indicators such as chemical pollutants and fallout radionuclides. Consequently, sediments deposited on lake bottoms can be used as primary tracers for the estimation of erosion rates on slope surfaces, sediment delivery ratio and sedimentation rates, which in turn are related to differences in soil properties, rainfall intensity, slope steepness and catchment area.

2. Study methods

The present study aimed to estimate erosion and sedimentation rates in two of the lake catchments, by investigating a number of surface soil erosion and sedimentation lacustrine indicators in the Yeongcheon lake underlain by sedimentary rock (Se lake) and the Seondong lake underlain by granite rock (Gr lake) in South Korea. The lacustrine sedimentations were measured with sediment traps and cores. In order to determine the seasonal variations for sedimentation in the lakes, the sediment traps were set in the deeper parts of the lakes so as to respond sensitively to the deposit of sediments from the hillslopes. The lake sediments have been sampling with sediment traps in each month since July, 2004 in both lakes. Core samples of 21 cm depth in the Gr lake and 13 cm depth in the Se lake were obtained in July, 2004 from central parts of these lakes. Rainfall was measured with a tipping-bucket rain gauge placed near the lake and water level was measured with a floating type of water level gauge. Physical properties (mineral content, organic matter, biogenic silica, water content, grain size and grain density, etc) of the trap and core sediments were analyzed as basic indicators in order to estimate the hillslope erosions and sedimentations in lake catchments.

3. Results

The results of surface soil erosion on the hillslopes and sediment deposition in lake bottoms showed that both the Se lake and the Gr lake have been characterized by different geomorphic factors (bedrock, slope and catchment area). Two years of observations of sedimentation in the Seondong and Yeongcheon lake catchments have revealed the relationship between sedimentation and catchment area and sedimentation and rainfall amounts.

The average monthly sedimentation rate for a year as measured in the traps indicates that there is a distinct difference between the Gr and Se lakes, in particular during the early stage of irrigation. It should be noted that the monthly sedimentation rate does not represent the average sedimentation rate, but that of the most sensitive areas of the lakes. The most intensive sedimentation rate occurred in the Gr lake due to easy erodibility of the surface soil.

The results from the traps indicated that soil erosion, sediment transportation and sediment deposition rates in the lakes are related to differences in soil properties, rainfall intensity and catchment area. For example, a high sedimentation rate occurred in the Gr lake catchment partly due to its steep slopes and low catchment area. This was confirmed by the sediment yields deposited in the traps within the lake. In the Gr lake catchment, the soil cover on hillslopes around the lake is influenced by human activity and land use, and this fact may have influenced the high soil loss and transportation into lake. Sedimentation rate is also related to grain density and mineral content. The sedimentation intensity indicates that the distinct difference between the two lakes is due mainly to the catchment factor. Sedimentation rates in each month in the Gr lake were higher than those in the Se lake, which suggests that sediments produced within the Gr catchment are more easily moved by overland flow into the lake than in the Se catchment.

Thus, the sedimentation processes in the lakes are mainly related to three factors: first, the catchment's morphological conditions, such as relief, catchment area and slope steepness second, the lake's internal conditions, such as water level and bed morphology; and third, the erosion conditions such as erodibility of the surface soil and rainfall erosivity.

4. Sedimentation rates using ^{137}Cs radionuclide

The sedimentation rates in the two lakes using ^{137}Cs inventories indicated several differences, as follows:

1. For the bulk and core sediments, sediment yields were more highly deposited in the Gr lake, and contained more organic matter, biogenic silica and coarse materials, but lower mineral content and grain density, than sediments in the Se lake.
2. The sedimentation rate and erosion intensity were estimated using the vertical distributions of the radionuclide ^{137}Cs inventory, which is strongly absorbed into sediments and eroded materials in the Gr and Se lake catchments. The peak ^{137}Cs inventories occurred at 14.5 Bq/cm^3 at 6cm depth and 12.1 Bq/cm^3 at 9cm depth in the Se and Gr lakes, respectively.
3. Comparing average ^{137}Cs inventories within the sediments of the Gr and Se lakes, the highest sedimentation rate was 0.22 cm/yr in the Gr lake, compared to 0.15 cm/yr in the Se lake. The higher sedimentation rate in Gr lake was associated with high rainfall intensity, low catchment area and intensive vulnerability to erosion by water during heavy rainfall events.

5. Conclusions

The sediment yields highly deposited in the Gr lake are caused by high rainfall intensity and extreme surface flow erosion. Consequently, higher erosion and sedimentation rates occurred in the Gr lake than those in the Se lake during the observation period. A sedimentation rate was weakly related to catchment area to lake ratio in both lakes. Over the short term period, the results show that intensive erosion and sedimentation rates in the Gr lake were affected by heavy rainfall events, low catchment area and extreme vulnerability to soil erosion by surface flow, compared to the Se lake catchment. In general, sediment properties, such as high content of organic matter in the Gr lake indicated that surface soil was severely stripped and eroded by surface flow in the Gr catchment. Sediment property such as high content of fine mineral in the Se lake indicated that soil may be eroded by subsurface flow in the Se catchment.

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