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Sedimentation in the lake catchments in South Korea

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Abstract: This study discusses the soil erosion on hillslopes and sediment deposition in lakes within catchments in South Korea. In order to determine seasonal variations of sedimentation in Yeongcheon and Seondong lakes, the sediment traps were set in the deep part of both lakes and lake sediments have been sampledmonthly from July 2004 to August 2005. Some properties such as highmineral content, fine particle size and high particle density in the Yeongcheon Lake indicate intensive soil erosion, sediment transportation and deposition throughout the catchment for a long time. The high sediment yield in the Seondong Lake is related with higher weathering intensity and extreme soil erosion by running water due to higher seasonal rainfall amount. Rates of erosion and sedimentation in the Seondong Lake are estimated to be higher than those of the Yeongcheon Lake, suggesting that the Seondong Lake is associated with higher precipitation, smaller catchment area, and extreme soil vulnerability to ephemeral erosion by overland flow during the heavy rainfall event. Consequently, both catchments are characterized by different erosion and sedimentation processes, as well as different geomorphic factors (bedrock, soil structure, rainfall intensity and catchment area).

Key words: erosion, sedimentation, lake catchment

1. INTRODUCTION

An important source of sediments in stream channels or lake basins is soil particles delivered from slope surface (Orkhonselenge et al., 2004). Consequently the lake bottom sediments can be the primary objects for the evaluation of the erosion rate in the slope surface, sediment delivery ratio and sedimentation rate within catchments (Marco et al., 2001; Terrence et al, 2002). The soil erosion, sediment transportation and sediment deposition rates are related with soil properties, bedrock weathering intensity and characteristics of catchment area (Boardman, 1996 Kashiwaya et al., 1997; 2004; Steiger et al., 2001). The sedimentation process in lake, sea, reservoir and stream is very important to reveal the long term global environmental changes andmajor climato-limnological fluctuations during glaciation and interglaciation cycles (Barlow and Thompson, 2000; Keith, 1986).many studies using lake sediments have been progressed in field of the hillslope geomorphology, such as surface soil erosion, massmovement and landform changes. massmovement in the form of soil detachment occurs on steep hillslopes that

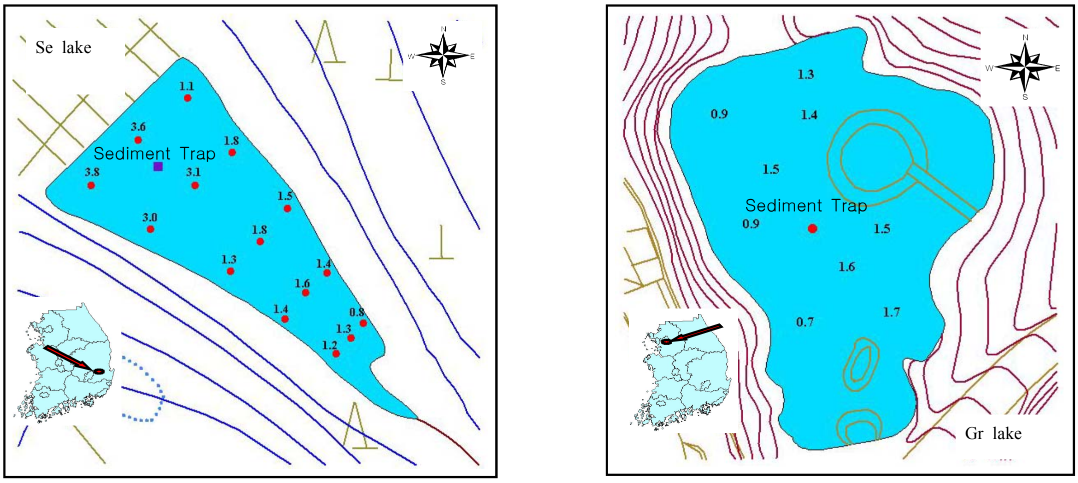

Fig. 1 Location maps showing the geographic locations of the Yeongcheon Lake (Se lake: left) and the Seondong Lake (Gr lake: right). Water depths are shown in the locationmap and the sediment trap is set in the deeper parts in two lakes.

receive large amounts of rainfall enough to saturate the upper soil layer and reduce soil strength. Themassmovement delivers sediments directly to the stream channel (Renard et al., 1997), resulting in high sediment yields in the stream. Another important sediment source in undisturbed forests is slip, which transports soils to stream channels or lake basins (Kirkby andmorgan, 1980).

The goal of this study is to examine the surface erosion and sedimentation processes in small lakes (Yeongcheon and Seondong lakes: Fig. 1) from Korea and to compare the erosion and sedimentation rates in different bedrock lakes such as the Yeongcheon lake underlain by Sedimentary rock (Se lake) and the Seondong lake underlain by the Granite rock (Gr lake).

2. STUDY AREA

The sedimentation rate wasmeasured using sediment traps in two lakes; one is underlain by sedimentary rocks (the Yeongcheon Lake) and the other is underlain by granite (the Seondong Lake) (Fig. 1). The Yeongcheon Lake underlain bymesozoic sedimentary rocks is located in north-western side (N 36° 32′, E 129° 38′) of Kuemomountain (411m in height) in southeastern Korea (Fig. 1). Themean altitude is of the lake 110m above sea level (Table 1). The climate can be characterized as a low humid zone, with an annual rainfall of 900~1000mm (Table 1). The vegetation is dominated by deciduous-tree forest. The Yeongcheon Lake is a hydrologically open lake, however small ephemeral streams flow into the lake. The lake is impounded by Cretaceous sedimentary rocks. The average depth of the lake is 1.92m, with maximum depth of 3.88m. The catchment area of the lake covers 67500㎡, the lake has a surface area of 4400㎡ (Table 1).

The Seondong Lake (N 37° 35′, E 127° 02′) is located in south-western side of the Go-Huangmountain (150m high) in northeastern Seoul (Fig. 1). Themean of

Table 1. Morphological characteristics of the Seondong and Yeongcheon lake catchments

Number	Parameter	Yeongcheon Lake	Seondong Lake
1	Mean annual precipitation, P	991.9	1399.6
2	Maximummeanmonthly precipitation, p	260	510
3	$p^{2/P}$	1.83	2.27
4	Lake perimeter	270	240
5	Catchment area,m^2	67500	35000
6	Log catchment area	4.82	4.54
7	Lake area,m^2	4400	3564
8	Catchment area/lake area ratio	15.34	9.82
9	River lengths	115	50
10	Lake altitude	110	45
11	Mean catchment altitude	145	75
12	Soil erodibility	0.077	0.016
13	Vegetation	Deciduous Tree	Deciduous Tree
14	Slope gradient	30	32
15	Slope length	275	135

the lake altitude is 45m above sea level (Table 1). The average depth of lake is 1.26m, withmaximum depth of 1.67m (Table 1). The climate is semi-humid with an average yearly precipitation of 1200~1400mm (Table 1). The vegetation is dominated by deciduous-tree forest. The lake has no outlet and is a hydrologically open lake, however small ephemeral streams flow into the lake. The lake is impounded bymesozoic granitic rocks (the Jurassic Daebo Granite) (KIGAM, 1999). The catchment area of the lake covers $35000m^2$ and the lake has a surface area of $3564m^2$ (Table 1).

3. METHODS ANDMATERIALS

The lake sediments have been collected during the time interval between July 2004 and August 2005. Lake sediments were sampled with sediment traps once amonth. Sediment traps were set on small concrete squares resting on the lake bed. Traps were located in the deep parts in two lakes (Fig 1). The lake sediments from traps were examined with respect tomineral content, biogenic silica content, water content, particle size and particle density, all of which are helpful in determining the general characteristics of the lake sediments. The sediment samples were analyzed at Institute of Nature and Environmental Technology in Kanazawa University, Japan. Precipitation wasmeasured with a tipping-bucket rain gauge. The OWL2pe data logger rain gauge of typed on ONSET was installed in each catchment.

4. RESULTS AND DISCUSSIONS

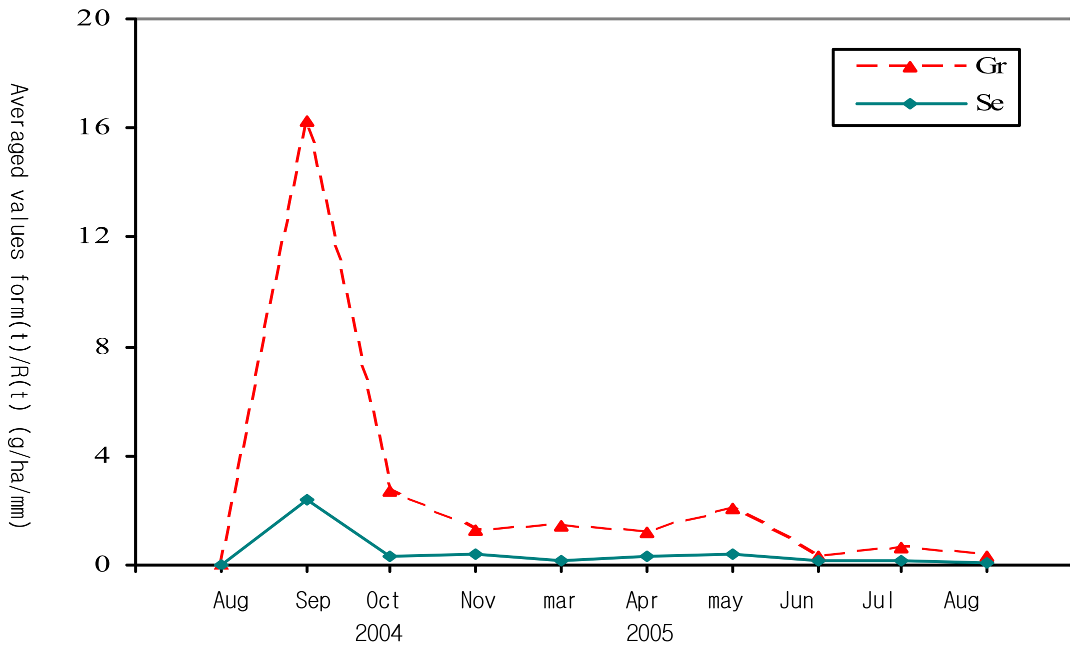

Fig. 2 The soil erodibility in the catchments, M(t)/R(t). Se means the Yeongcheon and Gr represents the Seondong Lake.

During the observation period, larger amount of sediments were deposited in the Seondong Lake than in the Yeongcheon Lake. The annual amount of sediments per square km is 0.35 ton/㎢/year and 0.019 ton/㎢/year in the Seondong and Yeongcheon lakes, respectively. The sediment yields were 0.69 g/㎡ in the Seondong Lake and 0.58 g/㎡ the Yeongcheon Lake, respectively. The higher sedimentation rate in the Seondong Lake implies that sediment yields are strongly related with larger rainfall amounts. Alternatively, higher sedimentation rate results frommuch sediments deposited during the summertime. Lower sediment yields in the Yeongcheon Lake reflect smaller rainfall amounts during the observation period. The lowest sediment yields in the Yeongcheon Lake demonstrate that sediment yields are not dependent solely on precipitation amount. Instead rainfall intensity likely plays on important role in sediment yields. For the rainfall amounts, the average rainfall amounts were 130.1mm in August, 246mm in September, 31mm in October, 67.5mm in November and 24mm in December in 2004, respectively.

Mineral Content: The averagemineral content is 75.83% and 83.7% in Seondong and Yeongcheon lakes, respectively. The averagemineral content of sediment in the Yeongcheon Lake is higher than that of the Seondong Lake. It denotes that the soils around the Yeongcheon Lake are eroded by throughflow as well as rainfall erosion.

Organicmatter: The average content of the organicmatter is 15.93% and 10.95% in Seondong and Yeongcheon lakes, respectively. The average content of organicmatter in the Yeongcheon Lake is lower than that of the Seondong Lake. Organicmatter whatever its origin has little effect on sedimentation patterns. The accumulation rate of organicmatter shows little variation with time, hence organicmattermerely increases the total sediment yield by a value that is relatively small and nearly constant. Consequently, the potential production of organicmatter within the lake creates little uncertainty about sediment yield from the catchment.

Biogenic Silica: Biogenic silica is an indicator of bio−productivity of lakes and/or sediment discharge (SiO_2) in the catchments. The average content of biogenic silica is 6.95% and 3.24% in Seondong and Yeongcheon lakes, respectively. The biogenic silica content in some lakes often occupies a great part of sediments; about 50% in Lake Baikal and 20~30% in Lake Hovsgol in interglacial periods, whereas it is not so large and ranges from 5 to 10% in Korean ponds and/or lakes (Kashiwaya, 2003).

Mineral Particle Size: Sediments in the Seondong Lake aremostly coarser than those of the Yeongcheon Lake. The average particle size is about 6.3 ϕ (Seondong Lake) and 8.2 ϕ (Yeongcheon Lake), respectively. The average particle size tends to be coarser in the wintertime. The sediments of the Seondong Lake show high content of sand and silt (3.14% and 76.9%, respectively) and low content of clay (19.96%), whereas the sediments of the Yeongcheon Lake are characterized by low content of sand and silt (0.4% and 43.5%, respectively) and high content of clay (56.1%).

Sediment Yield and Sedimentation Rate: The lake area in the Yeongcheon catchment is larger than that of the Seondong catchment. In association with lake area scale, larger sediments deposited in Yeongcheon catchment than Seondong catchment during observation period.

The sedimentation rates in the lake catchments were 0.35 t/km^2/year and 0.019 t/km^2/year in Seondong and Yeongcheon lakes, respectively. For the Yeongcheon Lake, the lowest sedimentation rate was observed in June, in association with decreation of the water level about 1m in lake for cultivation irrigation. The sediment yield were 0.1 and 0.06 t/ha yr in Seondong and Yeongcheon lakes, respectively. Calculations of sedimentation rates depending on rainfall events show that the Seondong Lake has larger sedimentation rate than that of the Yeongcheon Lake. It demonstrates that soils in the Seondong catchment were extremely eroded by ephemeral runoff, and that large amounts of erodedmaterials accumulated on the bottom of lake (Fig. 2). Lake sediment fluxes were 1.25 and 0.65 t/yr in Yeongcheon and Seondong lakes, respectively. The larger sediment flux in the Yeongcheon Lake indicates that soils in Yeongcheon catchment are located under the influence of perennial erosion.

CONCLUSIONS

The study of sedimentation processes in Seondong and Yeongcheon lakes indicates that large amounts of eroded surfacematerials in catchments were transported into the lakes. Physical properties of sediments in two lakes are very different from each other and such differencesmay be influenced by different bedrock characteristics. The larger amounts of sediments were deposited in the Seondong Lake than that in the Yeongcheon Lake during observation period, indicating higher rates of surface soil erosion in the former. In the Seondong Lake, themajority of sediments were deposited during heavy rainfall events or summer season, suggesting that soils in this catchment were highly vulnerable to ephemeral erosion. Erosion and sedimentation rates in the Seondong Lake are thought to have been higher than those in the Yeongcheon Lake. The lake water froze in January and February, then deposited sediments in the Yeongcheon Lake was larger than in the Seondong Lake inmarch Consequently, itmay be concluded by that soils in the Yeongcheon catchment is located under influence of perennial erosion, confirmed by higher contents ofminerals and clay-sized sediments in the Yeongcheon Lake.

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