Hortonian overlandflow generation mechanism in semiarid Mongolian catchments

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1. Introduction

In Mongolia, soil erosion is considered to be generated by overgrazing. To resolve this problem, it is necessary to elucidate the runoff process, quantitatively. The field monitoring of runoff is very important for understanding the erosion mechanism. But, very few studies about runoff process have been done in Mongolia semiarid catchments based on field monitoring. Therefore, the present study elucidated the mechanism of Hortonian overlandflow through the field experiment to monitor runoff in the two measured catchments in Kherelen river drainage basin in Mongolia.

2. Measured catchments and Methodology

2.1. Measured Catchments

The measured two catchments are located in the Kherlen river drainage basin with the distance of about 100km to the east of Ulaanbaatar (Fig.1). One drainage basin is located at Kherlenbayan-Ulaan (KBU), and the otheris located at Baganuur (BGN) (Fig.1). The annual rainfall over the past 11 years (1993-2003) in BGN and KBU is 213 mm and 181 mm, respectively with very wide annual variation (Sugita et al., 2006). The vegetation of two catchments is grassland with scattered angular gravels.The grassland of BGN occurs more densely than that of KBU. The geology of BGN and KBU is granite and sandstone, respectively. The drainage basin areas of BGN and KBU are 0.069 km^2 and 0.076 km^2, respectively. The reliefs of BGN and KBU are 160 m and 100 m, respectively.

2.2. Methodology

6-inch Parshall flumes and sediment traps (60 cm wide, 100-cm long, and 80-cm high) were installed at the outlets of the catchments. The water level was monitored by water level logger (WT-HR500, Trutrack, NewZealand). The water level data were recorded at 10-min intervals in 2003 and 5-min intervals in 2004. Rainfall was measured by rain gauge. Raindrop energy sensors (Model V11A, Sensit, California, USA) connected to data loggers (OWL 2e, EME Systems, California, USA) monitored the cumulative raindrop impact (counted 5 s per min) and raindrop number. Each of these parameters was recorded at 10-min intervals.

2.3. Plot studies

The plots surrounded by a 20-cm-high concrete wall, in each area; from March 2003, one plot was surrounded by a fence for protection from grazing pressure. To minimize the spatial variability of the infiltration rate, we established large plots (25 m × 50 m).The hillslope gradient in each plot was 15.

The discharge flow in the plots was monitored by 3-in Parshall flumes.

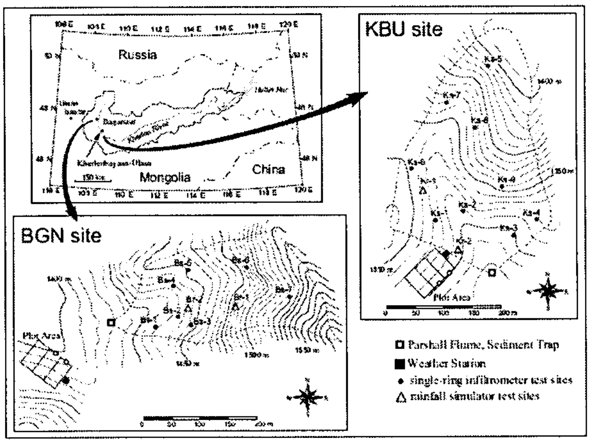

Fig.1 Topographic map of measured catchments

3. Results

3.1. BGN Site

Since Mongolia has a semiarid climate, only a few storm events were monitored in each watershed throughout the years of 2003 and 2004. The annual rainfall in 2003 and 2004 were 246.6 mm and 187.9 mm, respectively, in the BGN AWS site, and the corresponding BGN rain data (Jun.1 to Sep. 30) were 192.8 mm and 112.2 mm, respectively. The hyetograph of the rainfall and runoff between 2003 and 2004 is shown in Fig. 2. For 12 rainfall events, the recorded rainfall was greater than 10 mm/day, but only 3 runoff events were observed; this suggests that the daily rainfall is not the controlling factor of surface runoff generation.

In the BGN catchment, two storm events were monitored in 2004; however, no runoff events were detected in 2003. The first rainfall event occurred on June 30, 2004, and it led to a rainfall of 13 mm (B-1 event). The peak discharge-recorded as 62.8 l/s- dissipated within 15 min. The runoff ratio was calculated as 7.8%.

The second rainfall event occurred on July 26, 2004, and it led to a rainfall of 15 mm (B-2 event). The peak discharge was recorded as 80.4 l/s and it dissipated within 10 min. The runoff ratio was calculated at 3.9%.

The third rainfall event occurred on June 30, 2003, and it led to a rainfall of 8.8 mm (B-3 event). Although sediment was detected in the sediment trap, no flow was detected in the Parshall flume. This may be because the runoff peak was extremely short and the water level could not redcorded during the 10-min interval logging time. Field investigation was carried out the day after the storm event; however, there was barely any evidence of the surface runoff, suggesting that the peak runoff of this storm event was very small.

3.2.KBU site

In 2003, the rainfall atthe KBU site (Jun. 1 to Sep. 30) was 162.2 mm, and in 2004, it was 112.2 mm. The hyetograph and hydrograph are shown in Fig. 2. For 6 rainfall events, the recorded rainfall was greater than 15 mm/day; however, only 3 runoff events were observed, suggesting that the daily rainfall is also not controlling factor in the KBU catchment.

The biggest rainfall event occurred on June 21, 2003, and it led to a rainfall of 7.4 mm (K-1 event). The peak discharge-recorded as 66.8 l/s-dissipated within 10 min.The runoff ratio was calculated as 7.7%. The raindrop impact for the event was very strong; its magnitude was 108 J/m^2/min.

The second rainfall event that also occurred on June 21, 2003, led to a rainfall of 8.2 mm (K-2 event). The peak discharge was recorded as 1.27 l/s and the runoff ratio was 0.1%. The third rainfall event occurred on July 26, 2004, and it led to a rainfall of 16 mm (K-3 event). The peak discharge was recorded as 37.7 l/s and the runoff ratio was 1.0%.

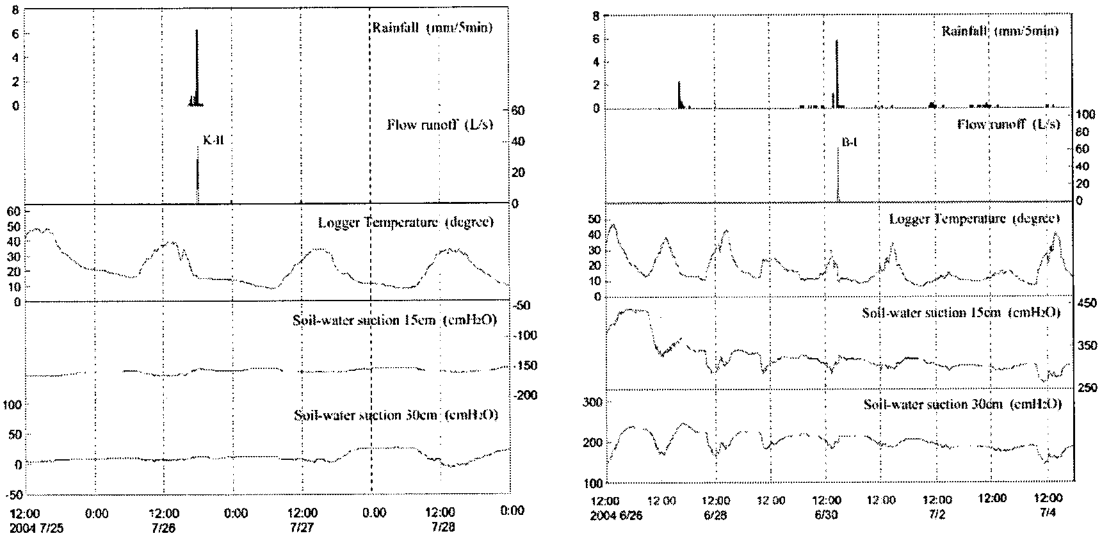

Fig. 2 Examples of Event Hydrograph of KBU and BGN

3.3.Infiltration capacity and raindrop impact

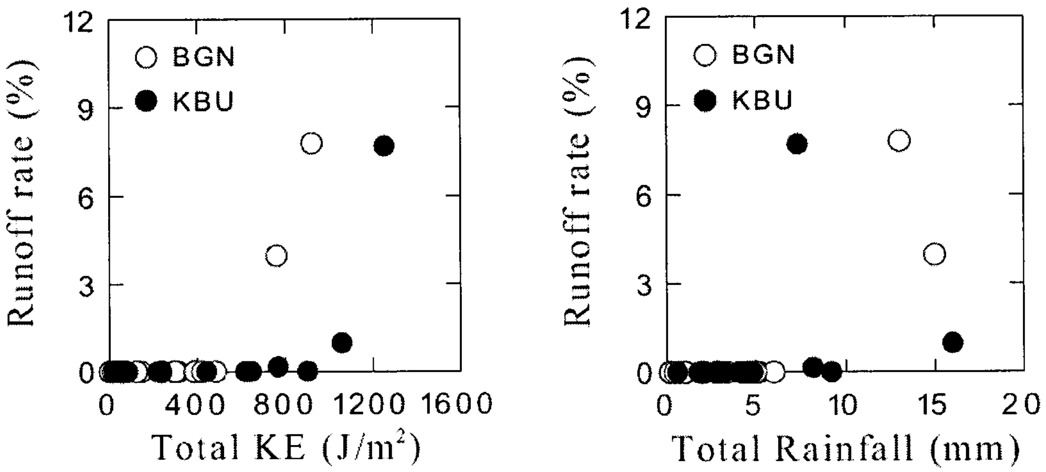

Fig.3 Relationships between Runoff rate, Total KE and Total rainfall

The hydrograph of the peak discharge shows very steep rising and declining limbs disappeared within 15 min associating with rainfall events in two catchments. But the soil water suctions 15 cm and 30 cm did not show distinct response to rainfall events. The observation of soil after rainfall event shows that the rain fall water infiltrated to only 10cm depth. The results imply that the runoff generation occurred only by surfaceflow not by subsurface flow. The infiltration capacitiesmeasured by single-ring infiltrometer show 115.8-217.2 mm/h in BGN and 186.8-484.3 mm/h in KBU. Most of rainfall water can infiltrate into the soil in BGN and KBU based on the infiltration capacity measured by single-ring infiltrometer. But the infiltration capacities measured by oscillating rainfall simulator show the lower values than those measured by single-ring infiltrometer; 15.7-21.7 mm/h in BGN and 21.4-21.7 mm/h in KBU(Table 1) . The relations between runoff rate and the 10-min peak raindrop impact shows that the runoff occurs at raindrop impact of about 400 $J/m^2/10min$, and the runoff rate increases with peak raindrop impact (Fig.3).

Table Infiltration capacity measured by oscillating rainfall simulator

Measuring point	Infiltration rate (mm h^{-1})
Baganuur	
Br-1	15.7
Br-2	21.7
Kherlen-bayan Ulaan	
Kr-1	21.7
Kr-2	21.4

4. Conclusions

Hortonian overlandflow occurs by the reduction of infiltration capacity of surface soils. The reduction of infiltration capacity is caused by raindrop impact. The threshold of runoff generation is about 400 $J/km^2/10min$.

Acknowledgements This study was supported by the CREST project (The Rangelands Atmosphere-Hydrosphere-Biosphere Interaction Study Experiment in Northeastern Asia) of the Japan Science and Technology Agency (JST).