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Field measurement of infiltration rate using an oscillating nozzle rainfall simulator in the cold semiarid grassland of Mongolia

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In arid and semiarid rangelands, the process of desertification due to overgrazing has been described in terms of changes in surface vegetation cover and reduction in infiltration rate. Infiltration rate is one of the key indicators of overland flow generation and soil erosion; therefore, detecting reduction in infiltration rate is essential to assess land degradation of rangeland. Mongolia is located in northeastern Asia, and approximately 75 percent of its total land area consists of cold, semiarid grassland that is subjected to grazing throughout the year. Recent intensive grazing in Mongolia may be significantly reducing the infiltration rate of rangeland; however, very few data on the infiltration rate are currently available in this region.

In this study, a new light-weight oscillating nozzle rainfall simulator was developed to generate the simulated rainfall with large raindrops and raindrop kinetic energy based on the design of existing rainfall simulators. We carried out a series of field infiltration tests for various surface cover conditions using the modified rainfall simulator and small plots (1 m^2) in Mongolia. The objectives of this study were to elucidate the fundamental relationships between surface vegetation cover and infiltration rate in cold semiarid grassland. The results of field infiltration tests indicated that dense surface vegetation cover increased the infiltration rate significantly; however, a statistically significant correlation was found between the total surface cover (including rock fragment cover) and steady state infiltration rate, suggesting that surface cover by rock fragments also increased the infiltration rate to some extent.

In general, steady state infiltration rate observed in the simulated rainfall experiment increases with increasing rainfall intensity until all parts of the plot are saturated (Murai and Iwasaki, 1975; Hawkins, 1982). The infiltration rates observed in simulated rainfall experiment is apparent infiltration rate under certain rainfall intensity experimental condition, and the maximum spatially averaged infiltration rate for the whole plot attained can be observed when the entire plot is contributing surface runoff (Dunne et al., 1991). We used the mathematical relationships between rainfall intensity and infiltration rate represented by using hyperbolic tangent curve (Tanaka and Tokioka, 2007) to estimate the maximum spatially averaged infiltration rate for the observed steady state infiltration rates. The relationships between surface cover and the calculated maximum spatially averaged infiltration rate for the Mongolian grassland were compared to those in various other regions. The relationships between the surface vegetation cover and the infiltration rate showed approximate correspondence to the different grassy hillslopes. The high consistency in these relationships suggested rather common effects of surface cover on the infiltration rate throughout grass-covered hillslopes in semiarid environments.

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