Field measurement of infiltration rate using an oscillating nozzle rainfall simulator in semi-arid area of Mongolia

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In Mongolia, increasing number of live stock has been considered to affect surface vegetation cover and resulting intensive soil erosion may cause of land degradation on grazing grassland. However the present state of soil erosion and overland flow generation on grassland have not been sufficiently understood because very few field data is currently available in this region. Although semi-arid environment is a crisscross region of water and wind processes, only a few studies has focused on the effects of aeolian processes on water infiltration under semi-arid environment. The objective of this study is to investigate water infiltration characteristics on various ground surface conditions under semi-arid environment of Mongolia, by means of field infiltration tests using an oscillating nozzle rainfall simulator. Two study areas are selected, one site is in Kherlen river basin, where is a typical steppe with tall-grass prairie. The other site is in Mandal Gobi in Dund Gobi province, where is a desert steppe with short-grass and shrubs. Although wind erosion occurs in early spring from March to May in Mandal Gobi region, no evidence of wind erosion was found at the study sites in Kherlen river basin. Fourteen sites with different surface conditions were selected for simulated rainfall experiments. A modified oscillating nozzle rainfall simulator based on the design of Mayer and Harmon (1979) was used for field infiltration tests. A simulated rain with intensity of 170-180 mm h^{-1} by using single Veejet 80150 spray nozzle (Spraying systems Ltd., U.S.A.) was applied onto small experimental plot (1 m^2) for 15 to 25 minutes. The rain kinetic energy of 44 J m^{-2} min^{-1} is equal to the raindrop impact which can generate overland flow on Mongolian grassland (Onda et al., 2006). Measurement included surface runoff rate from the experimental plot at one minute interval and infiltration rate was calculated by subtracting surface runoff rate from applied rainfall intensity. The observed infiltration rates ranged 25.9-99.9 mm h^{-1} for steppe grassland and 5.2-88.6 mm h^{-1} for desert steppe. In steppe grassland, high infiltration rate (more than 80 mm h^{-1}) was observed at the site with dense vegetation cover, in contrast, low infiltration rate (less than 50 mm h^{-1}) was observed at the site where had large percentage cover of bare ground surface (more than 40%). In desert steppe area, although surface vegetation covers of the experimental plot were generally low, high infiltration rate more than 80 mm h^{-1} was observed. Very low infiltration rate (less than 20 mm h^{-1}) was observed regardless the percentage of surface vegetation cover on shrubland. These data suggested that surface vegetation cover increase soil infiltration rate on steppe grassland, however such relationship was not found in desert steppe area. In desert steppe area, soil hardness varied among the sites, where even only very small differences on surface vegetation cover were found. Sandy aeolian deposits were considered to be the cause of low soil hardness at the sites where has patchy distributions of surface vegetation. In contrast, soil crust formation may result in high soil hardness at the site with almost no surface vegetation covers. This indicated that relatively high infiltration rate was observed at the site with low soil hardness where accumulated aeolian sand. However unexpectedly very low infiltration rate was observed at shrub site where sandy microdunes were formed at the base of plant. We attributed this low infiltration rate to water repellency of nebkha dune because dry soil was found beneath surface soil after the application of simulated rainfall. A series of simulated rainfall experiments suggested that surface vegetation cover has an important role on soil infiltration capacity on steppe grassland, whereas on aeolian landforms, the accumulations of sandy aeolian deposits may affects soil infiltration characteristics.