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Impacts of Different Soil Texture and Organic Content on Hydrological Performance of Bioretention

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The land development and increase in urbanization in a watershed has adverse effects such as flooding and water pollution on both surface water and groundwater resources. Low Impact Development (LID) Best Management Practices (BMPs) such as bioretentions, vegetated rooftops, rain barrels, vegetative swales and permeable pavements have been implemented in order to diminish adverse effects of urbanization. LID-BMP is a land planning method which is used to manage storm water runoff by reducing peak flows as well as simultaneously improving water quality. The aim of this study is developing a functional experimental setup called as Rainfall-Watershed-Bioretention (RWB) System in order to investigate and quantify the hydrological performance of bioretention. RWB System is constructed on the Istanbul University Campus and includes an artificial rainfall system, which allows for variable rainfall intensity, drainage area, which has controllable size and slope, and bioretention columns with different soil ratios. Four bioretention columns with different soil textures and organic content are constructed in order to investigate their effects on water quantity. Using RWB System, the runoff volume, hydrograph, peak flow rate and delay in peak time at the exit of bioretention columns may be quantified under various rainfalls in order to understand the role of soil types used in bioretention columns and rainfall intensities. The data obtained from several experiments conducted in RWB System are employed in establishing a relation among rainfall, surface runoff and flow reduction after bioretention. Moreover, the results are supported by mathematical models in order to explain the physical mechanism of bioretention. Following conclusions are reached based on the analyses carried out in this study: i) Results show that different local soil types in bioretention implementation affect surface runoff and peak flow considerably. ii) Rainfall intensity and duration affect peak flow reduction and arrival time and shape of the hydrograph. iii) A mathematical representation of the relation among the rainfall, surface runoff over the watershed and outflow from the bioretention is developed by incorporating kinematic wave equation into the modified Green-Ampt Method. The rainfall intensity in modified Green-Ampt method is represented by the inflow per unit surface area of bioretention which may be obtained from kinematic wave solution using the measured rainfall data. Variable rainfall cases may be taken into account by using the modified Green-Ampt method. Thus, employing the modified Green-Ampt method helps significantly in understanding and explaining the hydrological mechanism of a bioretention cell where the Darcy law or the classical Green-Ampt method is inadequate which works under constant rainfall intensities. Consequently, the rainfall is directly related with the outflow through the bioretention. This study discusses only the water quantity of bioretention.