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Using SWMM as a tool for hydrologic impact assessment

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Abstract

Hydrologic impact assessment is necessary for a planned development area in designing detention storage for urban drainage systems to minimize the effect of urbanization. It also has strong implication on pollutant loads from urban areas. For such assessment, single or two hydrologic models can be paired for pre- and post- development conditions. Typical pairings are the use of synthetic hydrograph methods for both conditions or synthetic hydrograph for pre-development and urban hydrology model for post-development condition. The former has the difficulty of accounting for drainage structure for post-development condition and the latter can run into erratic evaluation as the error can be introduced due to different model conceptualizations and parameterizations. In order to overcome the aforementioned shortcomings, the use of Storm Water Management Model (SWMM) for both pre- and post-development conditions is proposed in this study. The SWMM was applied to four planned development areas in Korea. The comparison of the results with previous assessments done for the same sites showed that the new approach can resolve the irrationalities that can occur with the combination of two different models such as smaller peak flow and longer time to peak for post-development condition. It is thought that the proposed method improves the accountability of the hydrologic impact assessment on planned development areas.

Keywords: Hydrologic impact; Natural watershed; SWMM; Synthetic hydrograph; Uncalibrated runs; Urbanization effect

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1. Introduction

Urbanization has occurred in Korea over several decades with the growth of Korean economy. This inevitably led to the increase of impervious areas and the installment of drainage structures which means that more surface water is available and they are routed faster than pre-development condition resulting in classical urbanization effect on the hydrograph of a watershed — higher peak flow and shorter time to peak [1–4]. This caused the inundation problem at the low-lying areas and undesirable load to the downstream areas.

To compensate the negative impact of urbanization on the hydrology of a watershed, Korea has embarked on the regulation starting 1996 that requires the assessment of the impact of development on hydrology and corresponding abatement plan for reducing the peak flow down to the same level as was in pre-development condition. Typical abatement plan is to construct a detention pond at the outlet of the watershed to provide storage to reduce the peak flow.

The practice of hydrologic impact assessment in Korea is based on the guideline published by the National Emergency Management Agency [5] and it proposes to evaluate the urbanization impact as follows: (1) For pre-development condition, application of synthetic hydrograph techniques [6] such as Soil Conservation Service (SCS) method and Clark method is suggested as such an area is typically not gauged, (2) for post-development condition, it is suggested that urban hydrology models such as SWMM [7,8] and Illinois Urban Drainage Area Simulator (ILLUDAS) [9,10] are used to evaluate the urbanized conditions. Nevertheless, the majority of early applications opted for the use of synthetic hydrograph techniques for both pre- and post-development conditions with the use of SCS curve number (CN) method to estimate effective rainfall due to the simplicity of its use and guaranteed outcome of increase of peak flow and shorter time to peak expected of post-development condition because of the increase of CN number for urbanized condition. However, this approach was faced with the criticism that synthetic hydrograph method cannot deal with urbanized condition of drainage structure adequately.

The step-up of the use of synthetic hydrograph technique was then to apply the synthetic hydrograph for pre-development condition and to apply the urban hydrology model to post-development condition. However, this seemingly logical choice sometimes led to ironical assessment of smaller peak and longer time to peak for urbanized condition making the assessment result to be excluded in determining the peak flow used for the design of detention pond. We think this occasional irony of urbanization effect is due to the use of two different models for the assessment even though the models that are supposed to describe each of those two conditions best were used, and also due to the fact that models have to be run uncalibrated (not calibrated) as pre-development area is typically ungauged. Different models have different conceptualizations and associated parameters. Especially, the synthetic hydrograph method highly depends on empirical formula derived for a specific regional context so the outcome can only be hoped to resemble the actual hydrology when the model is applied to other geographical region. When such a method is combined with more physically based urban hydrology model for hydrologic assessment, their application to the conditions where they are supposed to be applied to does not necessarily yield the expected outcome. We think this shortcoming can be overcome by the use of the same model to both pre- and post-development conditions.

There can be two ways to do that. The one is earlier practices of applying synthetic hydrograph method to both conditions but it was criticized for its inability to model the urban drainage structure explicitly. Harris County [11] has developed an empirical method that can indirectly incorporate urban features such as % development and