Case Study of the Integrated Model for Estimation of Sediment Load in Artificial River Channel

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Abstract: Sedimentation is one of the most important factors affecting stream channel stability. A proposed model was developed to estimate the sediment load of an artificial channel by the integration of the revised universal soil loss equation (RUSLE) and Watershed Assessment of River Stability and Sediment Supply (WARSSS). The developed model was tested in the channelized portion of the Hocking River near Athens, Ohio. It was estimated that the gross erosion from the watershed was 7.29×10^{10} kg/year, of which 96.64% resulted from surface erosion and 3.36% from bank erosion. A field measurement of total sediment yield in the channel, assumed to be the sum of suspended sediment and bedload, was conducted. The total annual sediment yield was estimated as 8.09×10^{9} kg, of which 98.29% was suspended sediments and 1.71% bedload sediments. It was concluded that the sediment delivery ratio of the studied watershed was estimated to be 11.11%, which is consistent with those of the watersheds having similar sizes in the region. Based on these results, the authors believe that the proposed model can reasonably well estimate the sediment load in the studied portion of the Hocking River. **DOI: 10.1061/(ASCE)HE.1943-5584.0001642.**

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Introduction

Sedimentation is regarded as one of the leading environmental problems, specifically for artificial river channels. It plays a critical role in shaping the landscape and river morphology (Vanoni 2006). Sedimentation has greatly influenced water resources system; the deposition of sediments affects flood control and navigation. Moreover, the accumulation of sediment in stream channels results in a decrease or reduction of flood-carrying capacity (USEPA 2007). Not only has sedimentation become a nuisance to navigation channels, it is hazardous to flood control and public safety (Vanoni 2006). Overflows from floodplains occur frequently as a result of unwanted sedimentation. To solve this problem, efforts have been made to reduce sedimentation, including changing vegetation covers from shrub or woody riparian to herbaceous or leaf plants; transforming land uses from developed and barren areas to forests (Bakker et al. 2008; Feng et al. 2010; Van Rompaey et al. 2002); conducting soil conservation projects such as terraces, check dams, and reservoirs (Nyssen et al. 2004; Xin et al. 2012); and modifying the channels by channelization and confinement of river systems.

The estimation of soil erosion and sedimentation at the scale of watersheds is complex. A large amount of fieldwork is required, such as measurements of suspended and bedload sediments, recordings of physical parameters, and soil sampling. Not only is the process labor intensive, most of the present results are semi-quantitative in the optimal situation (Van Rompaey et al. 2002). Indeed, there have been no unreliable direct measurements to quantitatively analyze geomorphic responses to land use changes. To this end, numerical modeling is introduced to simulate the response. Numerical models can be used to quantitatively assess the interactions between different factors. They can be categorized into lumped and distributed models (Aksoy and Kavvas 2005; Merritt et al. 2003). The lumped model represented by the revised universal soil loss equation (RUSLE) assumes that hillslope is homogeneous and the erosion process is lumped within the watershed (Renard et al. 1997; Chang and Bayes 2013; Chang et al. 2016). The distributed model represented by the Watershed Assessment of River Stability and Sediment Supply (WARSSS) uses spatially distributed variables to study eroded areas (Rosgen 2006a). Geographical information systems (GISs) have been extensively applied to the distributed model for spatial variation analysis of soil erosion. However, a high volume of data is required as input for simulation. If the available data are limited, the distributed model will not perform effectively. Simplified long-term geomorphic models can help address the issue, where soil erosion, sediment yield, and sediment transport are three key components.

In this study, an integrated model is developed to estimate sediment supply and determine influencing factors in the channelized portion of the Hocking River near Athens, Ohio. The proposed model based on the integration of the RUSLE and WARSSS models is to estimate the gross erosion of the watershed using the former and the sediment yield in the channel by the latter. Not only can the proposed model simplify the estimation process of watershed erosion and channel sediment loads, it can analyze and determine channel stability and influencing factors.

Proposed Model and Artificial Channel

The Athens area in Ohio, including a major portion of the Ohio University campus, has frequently been flooded by the Hocking River in the past. The tremendous economic loss caused by the flooding each year has driven debates and attempts for flood

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