

集水區土砂生產和運移動態模擬

Dynamic Modeling of Sediment Production and Transport at Watershed Level

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摘要

颱風豪雨引起山區大量土砂生產和搬運，經常直接危害人命與財產安全，也改變河床地形，威脅水利和水資源工程設施。為評估颱風豪雨造成的土砂生產和運移之動態變化，本研究整合崩塌潛勢模式、土砂生產模式與土砂運移模擬，建立一套集水區土砂生產和運移動態模式。首先，由水筒模式模擬降雨期間的土壤水指數變化，結合二元迴歸模式分析邊坡崩塌潛勢；再利用崩塌體積-面積經驗式，計算崩塌土砂量，以及通用公式計算土壤沖蝕量；最後，根據地表逕流和邊坡土砂生產量，模擬土砂受到逕流沖刷和土石流流動的運移現象。並以石門水庫集水區的白石子集水區為測試案例，結果顯示崩塌潛勢分析的成功率介於 0.74~0.79，逕流量的效率係數為 0.82，土砂入流量也有一定的合理性。而在極端降雨情境的模擬結果顯示，崩塌為集水區主要土砂來源，並造成 2~5 公尺的河床淤積。顯示本模式能夠應用於模擬山區集水區的土砂生產和運移之動態變化，提供下游水庫淤積和河防安全評估之依據。

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Abstract

Sediment production and transport triggered by typhoon precipitation are critical issues in Taiwan. These natural phenomena usually cause direct damages on the human's life and properties and change river bedform threaten the hydraulic and water resources facilities. To evaluate the dynamic of sediment production and transport triggered, an integrated model was developed which couples landslide susceptibility, sediment production from landslides and soil erosion, and sediment transport models. The model first used soil water index from tank

model as a triggering factor of logistic regression to model the landslide susceptibility. Second, sediment production from landslides was simulated based on the landslide susceptibility and an empirical relation of landslide volume-area, and the Universal Soil Loss Equation was used to calculate the soil erosion rate. Third, the sediment transports induced by the forces of water and gravity was simulated based on the runoff from tank model and Hunt's model. Then, the model was applied and tested in the Shihmen Reservoir watershed. The results show acceptable performances in predicting the landslide susceptibility ($AUC = 0.74\sim 0.79$), runoff (coefficient of efficiency = 0.82), and sediment discharge. Under an extreme rainfall scenario, landslides are the major source of sediment resulting approximately 2~5 m of sediment accumulation occurred on the upstream. The test confirmed that the model is capable of modeling the dynamic of sediment production and transport at watershed level and providing the useful information for evaluating the sedimentation in reservoir and river.

Keywords: landslides, soil erosion, sediment transport, Shihmen Reservoir watershed