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論文名稱: 集水區土砂脈衝動力行為之研究

英文論文名稱: Dynamic behaviors of pulsing sediment for watersheds

【中文摘要】

台灣位處地殼運動頻繁之板塊交界帶，又由於每年颱風過境攜帶豐沛的豪雨，塑造了特殊及多樣的地形景觀，亦形成不少地質災害如山崩、土石流等事件，公部門長期在集水區管理上投入工程建設以控制土砂運移。九二一地震後，產官學界中興盛起生態工程之概念，重新檢視對生態環境的態度及調整對自然災害的防治策略，惟現階段較少考量能量累積效應對集水區生態系統之影響。

爰本研究乃分析自然事件所產生之破壞能量與系統間之交互作用，並以自然崩塌事件為例，應用系統生態學之理論與能量分析方法，建立集水區土砂脈衝能量系統生態模型，分析能量流動特性對系統演替之影響，作為應用生態工程整災之理論基礎探討。

經文獻分析與案例觀察，由生態能量觀點可知集水區受到颱風或地震等外力引起之崩塌現象，為土砂外部脈衝動力行為，衍生之生態效應為促進坡面土體養份循環之能量代謝作用；另由模擬結果顯示 1. 土砂脈衝能量與系統各環節之能流進、出量有關。 2.土砂能量從生產、儲存、轉換等過程皆

與其他組成份彼此交互作用，並影響下一時間之發展。3. 流入系統之外部能量愈高，系統之生產力愈大，亦使系統有較高之破壞能量。4.防砂壩控制土砂能流之運移，其能量積蓄效應引起土砂內部脈衝動力行為，所產生崩塌之總土砂脈衝能量激增及脈衝型態不規則等現象，實增加防災管理之困難度。有關集水區之整體治理策略，依研究分析結果，茲建議如下；

1. 減低土砂脈衝能量：可在安全場址及安全時期分階段釋放集水區自然產出之土砂量，避免「零存整付」之脈衝現象。

2. 增加回饋機制、強化集水區之彈性與抗性：經自然外力事件所產生之崩落土石，對系統之生態效益為一種能量津貼，不僅補充中、下游流域經平日淘刷所失去之土砂，另可提供洪水平原、濱溪植生帶等植群自然生長所需之土壤與養份，成為系統面對未來之災難事件最佳之防護。

3. 維持自然河道之輸砂機制：河道設計應考量可隨著大自然之脈動儲存額外之能量並達沖淤平衡。彎曲之河道為最佳之設計可維持自然河道之輸砂機制。

4. 改變防災思維，以減災、避災為導向：由於人類無法改變颱風、豪雨或地震等外部能量流入系統，因此災害防不勝防，惟可透過能流分析與管理，以減輕、迴避土砂脈衝能量為導向，實為人類因應自然外力之最佳策略。

【英文摘要】

Diversities of the terrains and landscapes incorporated with annual typhoon events, Taiwan suffers serious geologic hazards, such as landslide, debris flow and flooding, the concepts and measurements of ecological engineering are mainly adopted for the hazards treatment and/or risk management after the impact of the catastrophic 921 Earthquake. It is important to evaluate the effects of energy accumulation on the behaviors of ecosystem for watersheds.

This study attempts to establish a pulsing model, which uses the Systems Ecology approach to discuss the natural hazard and its interactive behaviors with the system energy. The pulsing energy patterns of the landslide events are described in the model. The results can be used to depict the principle of ecological engineering in the watershed hazard treatment.

According to the literatures review and case studies, the phenomenon of a landslide can be considered as a dynamic behavior of external pulsing, which contributes watershed nutrient recycle and energy metabolism. The model simulation shows that: 1). the magnitude of pulsing sediment has a close relationship between the energy inflows and/or outflows; 2). the interaction of sediment energy with the system components occurred in the whole process of production, storage and transformation is interactive; and the outcomes also affect the trend of system development; 3). the more external energy flow the higher production of the system, and it then increase the potential destruction energy; 4). check dam simulation shows that there exist a phenomenon of energy accumulation. The dynamic behavior of internal pulsing yields the failures of the engineering construction. The abrupt increasing of total pulsing energy and the irregular pulsing patterns make it difficult to handle the hazards management. To solve the above problem, the strategies of integrated management for a watershed are recommended as follows:

1. Reducing sediment pulsing energy: considering how energy accumulation can be abated, watershed sediment should be released at the right time and space to avoid huge pulse.
2. Increasing feedback mechanism and strengthening the resilience and resistance of watershed: landslide caused by natural external force is one kind of energy subsidy for ecological system. It not only can supply

sediment materials for downstream and nourish flood plain, riparian vegetation zone, but also can provide the best protection against natural hazard events in the future.

3. Maintaining natural mechanism of sediment transport: the design with considering natural pulse on river should store extra energy and reach the balance condition of sediment erosion and deposition. Wandering channel can be an appropriate design to meet the mechanism.

4. Shifting the concept of preventing natural hazards: this study suggests the best strategy is stressed on abating or/and shunning the hazards, then human can coexist peacefully with nature.