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# Runoff erosion process on different underlying surfaces from disturbed soils in the Three Gorges Reservoir Area, China

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ABSTRACT

Disturbed soil accumulation caused by all man-made activities during the producing and constructing process of large-scale projects is the main landform occurred artificial water and soil loss. Because of its different producing sources and soil-rock ratios, the underlying surfaces from disturbed soil accumulation often characterize a unique soil erosion process under same runoff scouring condition. Taking the ubiquitous purple soil deposits and yellow sand deposits associated with different soil-rock ratio as examples, the study aimed to explore the difference in both hydraulic properties and sediment yield characteristics on disturbed soils. Some field scouring experiments were conducted in Chongqing, China. These results indicate that: (i) Runoff regime on all underlying surfaces from disturbed soils often manifest as turbulent and subcritical flow during runoff scouring process. (ii) For rocky disturbed soils from purple soil, sediment production rate shows continuously waving variations, and the average sediment production rates are 0.28, 11.65, 33.69, 73.00, and 177.37 g/($m^2$·min), respectively, when flow discharge increase from 5 to 25 L/min gradually; the collapse on gully wall caused by its gravity from underlying surfaces is the important cause for the fluctuating variations of the sediment production rate. (iii) The influencing degree of hydrodynamic parameters on sediment yield is in such order as $\gamma_Q > \gamma_P > \gamma_v > \gamma_\tau > \gamma_f$. These study results could be used to control artificial erosion caused by production and construction projects and to provide some important parameters for soil and water loss predicting in the Three Gorges Reservoir Area of Chongqing.



## 1. Introduction

Artificial water and soil losses caused by production and construction activities are more and more serious recently (Cao et al., 2014; Cerdà, 2007; Cheng et al., 2013; Rodrigues and Silva, 2012; Tømmervik et al., 2012). Production and construction projects are always increasing or diversifying both in numbers and in types in the Three Gorges Reservoir Area which is one of the most serious soil erosion regions in China. Such many man-made activities as urban relocation, agriculture exploitation and road construction in the reservoir area not only largely change the original landform but also produce massive disturbed soil accumulation. These special artificial landforms have been proved to cause large soil and water loss, which is due to its bare soil, lowest vegetation cover, loose structure and heavy rain (Beullens et al., 2014; Gilley et al., 1997). Such severe soil loss not only cause land degradation and ecological destruction but also pose a great threat to the long-term benefit and safe operation of the Three Gorges Project, and so do the security for downstream area. *Soil and Water Conservation Law of the People's Republic of China*, executed in 2011, clearly defined that sand, stones, dusts, gangues, tailings or solid wastes generated or discharged in construction should be subjected to soil and water conservation measures to ensure that no new hazards will be generated (People's Congress Standing Committee, 2011). The disturbed soil accumulation is a comprehensive mixture of soil and rock fragments with uneven material composition, so its erosion features are very different from the original landform (Atucha et al., 2013; Li et al., 2014; Miao et al., 2012; Xu et al., 2012; Yang et al., 2012).

Since disturbed soil accumulation is the major sources for man-made accelerated erosion, it is necessary to analyze the hydraulic properties of overland flow and the mechanism of sediment production from disturbed soils, which can help to make effective measures for controlling soil and water loss. Many studies have focused on the types, mechanism and control techniques of soil erosion for industrial and mining area at home and abroad currently (Hancock et al., 2003; Li et al., 1996; Nicolau, 2003; Nyssen and Vermeersch, 2010), and the mines and quarries are the focus (Milder et al., 2013; Raizada and Juyal, 2012). In addition, many researchers also have paid attention to roadside erosion (Dong et al., 2012; Jiang and Zhang, 2008; Shi, 2006; Ramos Scharrón, 2010; Luo et al., 2013;) and its bioengineering

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techniques as re-establishing vegetation cover (Jimenez et al., 2013; Lee et al., 2013), and some have studied and are concerned with urban erosion during construction process (Pan and Zhao, 2007). Many authors have studied the hydraulic properties of overland flow during slope erosion process in recent years, which mainly involved the following: hydraulic properties of shallow flow (Pan et al., 2006; Zhang, 2002), hydro-dynamic mechanism of sheet erosion process (Liu et al., 2012) and hydrodynamic characteristics of runoff in rill erosion on original lands (Giménez and Govers, 2001; Li et al., 2008; Rafael and Gerard, 2008). But few studies have concentrated on soil erosion principles and hydraulic properties on underlying surfaces from disturbed soils, especially for the hydraulic properties on underlying surfaces with different soil-rock ratio from disturbed soils. So it is necessary to carry out those studies on hydraulic properties on disturbed soil accumulation with different soil–rock ratio, which has a scientific meaning for revealing hydro-dynamic mechanism and sediment transporting characteristics during runoff erosion process for construction and production projects.

This study represents an initial effort to analyze runoff erosion process on underlying surfaces from disturbed soils containing different soil-rock ratio from the view of hydraulic process on overland flow. Hence, the study specifically aims to: (1) measure and analyze hydrodynamic parameter variation on overland flow during runoff erosion process; (2) analyze the production mechanism of runoff and sediment on underlying surface with different soil-rock ratio; and (3) evaluate the contribution effects of hydrodynamic parameters to sediment production and establish sediment prediction equations for different underling surfaces. The study results could provide some important parameters on disturbed soil accumulation from production and construction projects, which are applications important for predicting soil and water loss accurately, and for arranging reasonable measures for soil and water conservation.

## 2. Materials and methods

### 2.1. Experiment sites and materials

Field scouring experiments were conducted on experimental plots from August to November 2012 at the Soil Erosion Experiment Site for production and construction projects in Southwestern University, Chongqing (Fig. 1). The experimental plots were filled with disturbed soils which were designed to different soil–rock ratio and mixed and flattened fully with a iron rake before beginning every experiment (Fig. 2). Experimentally disturbed soils were collected from urbanization construction project in the Three Gorges Reservoir Region of Chongqing. The parent rock of purple soil deposits is $J_{2s}$ (in Chinese soil parent material) and that of yellow sand deposits is Brown Siltstone. Based on several field surveys and indoor analyses on the material composition of disturbed soil, field scouring experiments were conducted on some ubiquitous underlying surfaces: partial disturbed soils (soil–rock ratio is 4:1) and rocky disturbed soils (soil–rock ratio is 3:2). Particle-size distribution of those disturbed soils was described in Fig. 3. Some soil samples in experimental plots were collected and their bulk density, moisture content and particle size distribution were determined before every scouring experiment.

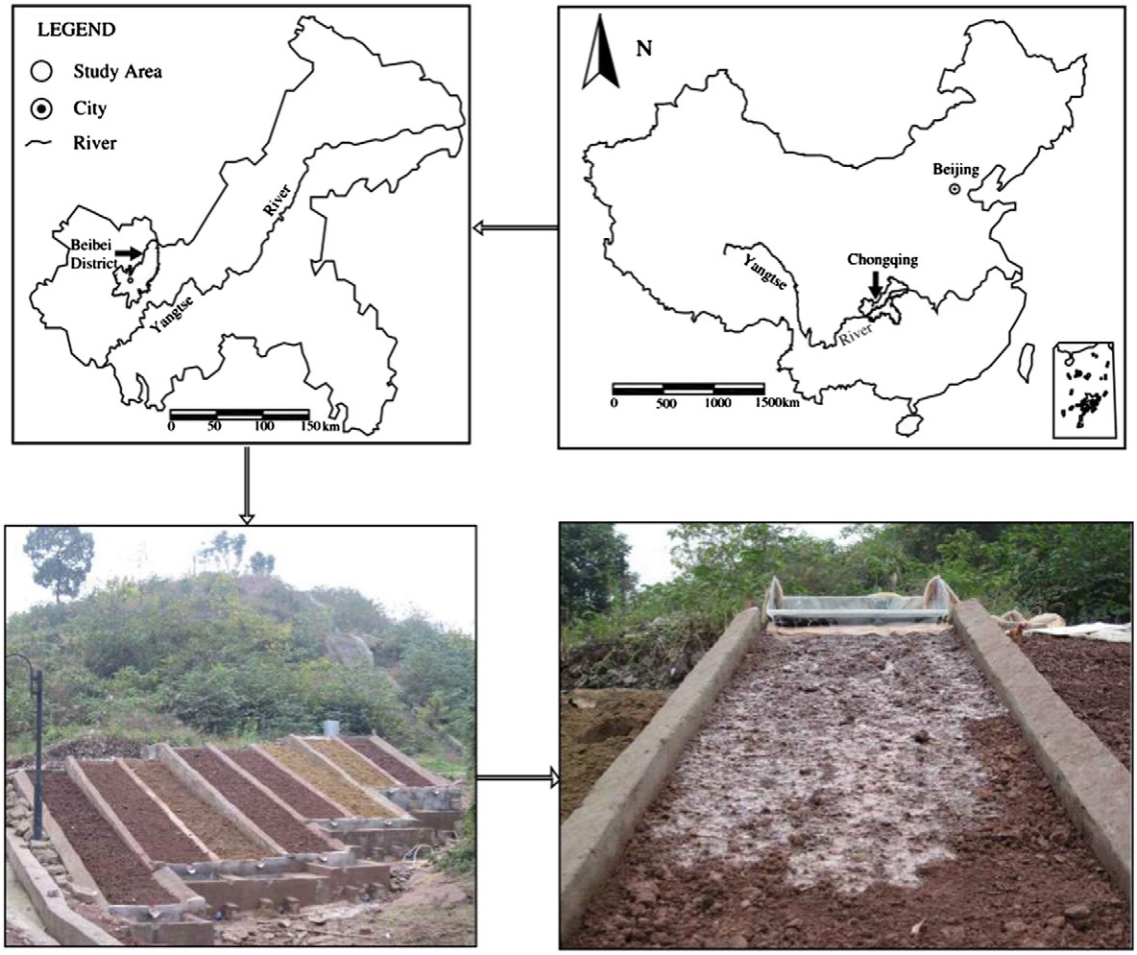


**Fig. 1.** Layout of the experiment plots at Southwest University, Chongqing.