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RESEARCH ARTICLE

Effects of land uses on soil physic-chemical properties and erodibility in collapsing-gully alluvial fan of Anxi County, China

DENG Yu-song[1], XIA Dong[1], CAI Chong-fa[1, 2], DING Shu-wen[1, 2]

[1] *College of Resources and Environment, Huazhong Agricultural University, Wuhan 430070, P.R.China*

[2] *Key Laboratory of Arable Land Conservation (Middle and Lower Reaches of Yangtze River), Ministry of Agriculture, Wuhan 430070, P.R.China*

Abstract

As a special kind of soil erosion that severely deteriorates the qualities of soil in granite regions, collapsing gully is widely distributed in the tropical and subtropical areas of South China. In particular, collapsing-gully erosion produces a large amount of sediment deposited on the plough layer of alluvial fan farmland and causes increase of desertification, great reduction of nutrients and rapid enhancement of erodibility in the soil. This study was designed to evaluate the effects of different land uses on the soil physic-chemical properties and erodibility of collapsing-gully alluvial fan. Our results show that the physical properties of soil in alluvial fan were greatly improved with smaller bulk density, increased soil porosity, strengthened water holding capacity and a higher particulate matter content. The chemical properties of soil were also significantly improved, including pH, cation exchange capacity, and the contents of organic matter, total and available nitrogen, potassium and phosphorus. All the land uses were proved to improve the soil properties, especially in the tea garden, vegetable land and paddy field. The results of correlation analyses among the properties demonstrate that the physical and chemical properties were significantly correlated, indicating that improving the soil physical properties is an effective method to increase the soil nutrient in the farmland of collapsing-gully alluvial fan. In addition, the application of land uses included grass land, eucalyptus forest land, vegetable land, tea garden, sweet potato land, and paddy field reduced the erodibility of the soil compare to bare land. The erodibility *K* values of soils in grass land, eucalyptus forest land, vegetable land, tea garden, sweet potato land, and paddy field were 14.43, 16.97, 45.45, 33.12, 18.94, and 34.01% lower than those of bare land, respectively. The results of multiple linear regression analysis show that the soil erodibility had a significant correlation with the physic-chemical properties, especially the soil texture and the content of organic matter. In conclusion, our results demonstrate that different land use patterns are effective to improve the quality of the soil in collapsing-gully alluvial fan, including the improvements of the soil structure, nutrients and anti-erosion ability. Our findings provide important implications for the soil improvement in the farmland of collapsing-gully alluvial fan.

Keywords: land use, soil physic-chemical properties, soil erodibility, collapsing gully, alluvial fan, Anxi

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DENG Yu-song, Tel: +86-27-87288249, E-mail: Dennyus@163.com; Correspondence DING Shu-wen, Tel: +86-27-87282137, E-mail: dingshuwen@mail.hzau.edu.cn

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1. Introduction

Collapsing gully is a serious type of soil erosion widely distributed in southern China, which is formed in the hill slopes covered by thick granite weathering mantle (Zeng

1960; Xia *et al.* 2015). Collapsing gully was first proposed by Zeng (1960), which is a composite erosion formed by hydraulic scour and gravitational collapse. Monitoring data show that collapsing gully is widely distributed in the regions with granitic red clay soils in China, including Guangdong, Jiangxi, Hubei, Hunan, Fujian, Anhui, and Guangxi. Since 2000, the Monitoring Center of Soil and Water Conservation of China has reported more than 239 000 collapsing gullies (Zhang *et al.* 2010). Collapsing gully consists of (1) upper catchment, where a large amount of water is pooled; (2) collapsed wall, where mass soil wasting, water erosion and gravity erosion are serious; (3) collapsed slope, where the residual materials are deposited; (4) channel, usually deep and narrow, where sediments are accumulated and transported; and (5) alluvial fan, the zone below the gully mouth, where sediments transported out of the channel are deposited (Xu *et al.* 1996; Sheng and Liao 1997) (Fig. 1). Collapsing-gully erosion is characterized by fast development and strong burst, which makes it more threatening than common soil erosion, and sometimes a rainstorm can expand the collapsing erosion area to approximately twice (Deng *et al.* 2015). Consequently, collapsing gully causes severe damages to land resources. However, no effective method is available to prevent such damages at present. From 1950 to 2005, erosion and gulley collapse affected 1 220 km^2 of red granitic clay soils area, and caused the loss of more than 60 Mt of soil and 380 000 ha of farmland (Zhang *et al.* 2010), especially the farmland of alluvial fan. Alluvial fan is a sedimentary region of collapsing gully erosion. When collapsing gully occurs, the cultivation layer of alluvial fan farmland will be covered by a large amount of sediments, which seriously affects the physic-chemical properties of the soil and further reduces the crop yield (Deng *et al.* 2014, 2015).

A number of researches have been done to investigate the collapsing gully in China (Liang *et al.* 2009; Li *et al.* 2013; Deng *et al.* 2015). Most of the studies are focused on the formation mechanism and governance of collapsing gully (Luk 1997; Feng *et al.* 2009; Chen *et al.* 2013; Ren *et al.* 2013). These studies investigated the causes of gully erosion by analyzing the dominant factors and observing the erosion processes. Some researches proposed a new ecological economics approach to control collapsing gully, which can protect the ecosystems and dramatically improve the soil and conservation, vegetation restoration and sustainable socioeconomic development (Zhong *et al.* 2013). However, only the corresponding problems were put forward concerning the threats of collapsing gully to farmland, and no solution was proposed for governance improvement. In most areas of South China, many sloped areas susceptible to erosion have been converted to farmland because of population pressure. More recently, the physical and chemical properties of the collapsing alluvial fan were studied, such as the composition of soil particles, bulk density, soil porosity, water-holding capacity, nutrients, and the relationships among them were analyzed. The spatial variation law of the soil physic-chemical properties in dilapidated granite alluvial fan farmland was also studied, which not only benefits agricultural land use planning, but also provides a theoretical basis for the soil improvement of the collapsing alluvial fan farmland (Deng *et al.* 2014, 2015). We also investigated the effects of different fertilization methods on the modified farmland in alluvial fan area. The results show that fertilizer, farmyard manure and biogas manure effectively improve the physical and chemical properties of alluvial fan farmland soil, especially farmyard manure (Deng *et al.* 2014). Through these studies, we found that there is almost no research focusing on the effects of land uses on the soil quality of the farmland in collapsing-gully alluvial fan. Land use affects soil properties through the direct effect of soil management practices, especially in the case of agricultural lands (Kosmas *et al.* 1996). The land use and the changes in soil management practices have profound influences on the physical and chemical environments, thereby affecting the fertility and productivity of soils (George *et al.* 2013; Gonnety *et al.* 2013). Studying the effects of land uses on agroecosystem is of global importance (Saurette *et al.* 2008). Some studies have shown that soil erodibility and soil properties are closely related. Therefore, land use patterns will inevitably have an impact on soil erodibility (Zhang

Fig. 1 Collapsing gully erosion and alluvial fan that worsen the quality of farmland.