A simplified and rapid technique to determine an aggregate stability coefficient in coarse grained soils

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1. Introduction

Soil aggregate stability is an important soil property since stable aggregates promote the stability of soil structure (e.g. Amezketa, 1999; Horn et al., 1994). Consequently, soil aggregate stability can be seen as an indicator for soil quality (e.g. Amezketa, 1999; Nichols and Toro, 2011). Soil aggregates play important roles in many biotic and physicochemical processes within the soil system, like soil carbon storage, water and gas exchange, nutrient cycling, and erosion prevention (Bast et al., 2014; Le Bissonnais et al., 2007; Siddiky et al., 2012; Six et al., 2004; Tisdall and Oades, 1982). Some authors also postulate a positive correlation between aggregate stability and soil shear strength parameters, which include angle of internal friction Φ and cohesion c' (Fattet et al., 2011; Frei et al., 2003; Graf et al., 2009). Since shear strength is a major control of mass movements, the stability of aggregates can be a valuable measure to determine near-surface slope stability (Bast et al., 2014). This topic is of special interest in soil eco-engineering, where living plants are used to accomplish engineering functions based on the development of a close and dense vegetation cover (Mitsch, 2012; Morgan and Rickson, 1995; Schiechtl and Stern, 1996). Eco-engineering measures gain more and more in importance for the restoration of degraded slopes, but in contrast to technical constructions, standardized techniques for quantifying the stabilizing effect of vegetation are still lacking (Bast et al., 2014).

Following Nimmo (2013), soil aggregates are clods or a group of primary soil particles, showing stronger coherence to each other than to those particles surrounding them. Soil aggregates are formed through the interdependency of aggregation and fragmentation, and chemical as well as physical forces are acting in manifold processes (Amezketa, 1999; Kemper and Rosenau, 1986; Nimmo, 2013; Six et al., 2004). To facilitate the measurement of aggregate size distribution or aggregate stability, aggregates need to be separated from each other without being destroyed. The technique and force needed to separate the aggregates should be adapted to the environmental conditions of the respective study site to have a practical relevance. In dry regimes, where aeolian processes dominate and erosion is mainly caused by wind, an analysis of dry aggregates is performed (Broersma et al., 1997; Chepil,
2. Material and methods

2.1. Study site

The study site Patjänna Rüfe (46°53′43.41 N, 9°44′30 E) is located in the Arieschbach catchment, Prättigau, Eastern Swiss Alps (Fig. 1a). The climate of the area is characterized as sub-oceanic (Ott et al., 1997) with a mean annual air temperature of 4.6°C and a mean annual precipitation of 1170 mm/year (Bast et al., 2014). The local bedrock, the Prättigau Flysch, is covered by Quaternary sediments, in particular moraine-derived material, providing the parent material for the Cambisols, Luvisols and Regosols typically developed in this area (Ott et al., 1997). The natural vegetation cover is dominated by fir-spruce forests (Abies alba Mill. and Picea abies (L.) H. Karst).

The coarse grained, low-density deposits covering the Prättigau Flysch are particularly prone to erosion and superficial landslides. Torrential rains, frequently occurring within the region, led to high erosion rates and mass movements and, hence, to vast vegetation-free and steep talus slopes with Leptosols as typically occurring soil types. Since the 1990s extensive joint technical (e.g. debris retention dams, concrete check dams etc.) and soil eco-engineering measures (e.g. hedge brush layers) were applied in the catchment area to stabilize the slopes and minimize erosion and landslide processes.

The Patjänna Rüfe is an ENE-exposed talus slope, ranging in elevation between 1220 m and 1400 m a.s.l. and in inclination between 37° and 50°. The Leptosol developed on this slope has an average grain size composition (soil depth: 0–35 cm; n = 6; sampled in May 2010) of 792 ± 19 g kg⁻¹ of gravel, 140 ± 14 g kg⁻¹ sand, 49 ± 5.2 g kg⁻¹ silt and 19 ± 2.9 g kg⁻¹ clay (mean ± standard error) (Bast et al., 2014). Following the Unified Soil Classification System (USCS) all soil samples were classified as poorly graded gravel with silt (GP-GM) (ASTM-D422-63, 2000; ASTM-D2487-00, 2000) (Fig. 1b).

In May 2010 a soil eco-engineering experiment was established (Bast et al., 2014). One control and two treatments (in the following also myco and non-myco) were selected (Fig. 1b). The two treatments were stabilized (~700 m²) with saplings of alder (Alnus spp.) (n = 1200), willow

![Fig. 1. a) Map of Switzerland, highlighting the study site Arieschbach catchment, Fideris, Eastern Swiss Alps. b) Photograph of the experimental site. The white dashed lines are contour lines (m a.s.l.). One of the treatments (myco) is outlined (white rectangle). The coarse grained material of the soil is clearly visible at the surface, indicating the harsh properties of the environment and the difficulty to use soil standard procedures.](image-url)