Available online at www.sciencedirect.com
ScienceDirect
Procedia Earth and Planetary Science 16 (2016) 89 – 97
Procedia
Earth and Planetary Science

The Fourth Italian Workshop on Landslides

Effect of the soil organic content on slurries involved in mudflows

Claudia Carotenuto*, Mario Minale

Dipartimento di Ingegneria Industriale e dell'Informazione, Seconda Università di Napoli, Via Roma 29, Aversa (Caserta) 81031, Italy

Abstract

The effect of the soil organic content on the stability of a soil involved in a rapid mud flow is here experimentally investigated. The soil is collected form a site where a catastrophic landslide took place (Cervinara – AV) and it is chemically treated to selectively remove different aliquots of its original organic carbon. In particular, The Dissolved Organic Carbon (*i.e.* the carbon soluble in water)results the 6% of the soil organic carbon and it is removed with a mild chemical treatment to obtain the DOC 6 sample, the 77% and 89 % of the Total Organic Carbon (*i.e.*the pool of oxidizablesoil organic carbon)is removed with a strong chemical treatment to obtain the TOC 77 and TOC 89 sample, respectively. The stabilizing effect of the organic carbon is investigated by following the evolution of the particle size distribution of soils induced by a mild mixing of diluted slurries and we showed that the particle size distribution of the original soil sample is unaffected by the slurry mixing, while those of DOC 6,TOC 77 and TOC 89 evolve during time, revealing the breakup of soil aggregates. Our findings highlight the stabilizing effect of SOC in the investigated liquid slurries and, furthermore, they suggest that the organic carbon quality, more than its quantity, plays a crucial role in the soil stability. Indeed, it is enough to remove the Dissolved Organic Carbon to register a soil disaggregation process comparable to that observed for TOC 77 and TOC 89 samples.This suggests that Dissolved Organic Carbon is the fundamental organic fraction stabilizing the slurry microstructure.

Peer-review under responsibility of the organizing committee of IWL 2015

Keywords: Rheology; Viscosity; Yield stress; Particle size distribution; Soil stability.

1. Introduction

Trigger and evolution of a mudflow are influenced by several factors acting on different *length scales*: i) the morphological characteristics of the site and its vegetation cover, at *macro-scale*; ii) the geopedological and hydraulic properties of the soil, at *meso-scale*; iii) the particle shape, the size distribution and the chemical composition of the soil, *at micro-scale*. This work regards the micro-scale and, in particular, it investigates the possible effect of the soil organic carbon (SOC) content on triggering and evolution of rapid mudflows.

* Corresponding author. Tel.: +39-081-5015410; fax: +39-081-5010204.
*E-mail address:*claudia.carotenuto@unina2.it

Peer-review under responsibility of the organizing committee of IWL 2015
doi:10.1016/j.proeps.2016.10.010

SOC originates from plants, animals and microorganisms, and their exudates.[1] The frequent addition of easily decomposable organic residues leads to the synthesis of complex organic compounds that bind soil particles into structural units called aggregates. These aggregates help to maintain a loose, open, granular condition. SOC, which stabilizes microaggregates, is incorporated in the small pore spaces, is protected from microbial attack, and persists for long time; for this reason, it is considered an "old" SOC. Conversely, SOC that stabilizes the larger aggregates is constantly renewed by crop growth and is readily accessible to microbial attack;[2] for this reason, it is considered a "young" SOC. Hierarchical theory of aggregation thus proposes that larger aggregates are composed by more stable microaggregates.[1,3]

The large majority of the works dealing with the role of SOC is related to the study of soil structure and its alteration due to land use and soil/crop management practices[4-6]and, thus, principally refers to dry or wet samples.[7-10] These studies show that SOC contributes to the stability of the soil and also highlight that this stabilizing effect tends to increases from dry to wet samples. The case of larger water contents, *i.e.* of liquid soil slurries, is less investigated, but this is the typical condition encountered in mudflows, reached after long and/or intensive rainfall.

Recently, Carotenuto et al.[11] demonstrated the stabilizing effect of the soil organic carbon also on liquid slurries made of 40% of soil in water. The soil was taken from a site involved in a catastrophic fast landslide (Cervinara, Avellino, South Italy) and the slurry rheology was investigated as a function of the SOC content. A decrease of viscosity and yield stress was measured by reducing the amount of the organic matter and, in particular, they observed that it is enough to remove a small fraction of organic carbon, *i.e.* the "young" one, to significantly destabilize the slurry. The young organic matter is usually easily removed and restored in the soil. This can be very relevant in the landslide trigger forecast, since, this organic fraction can be removed by a water soil washing,[4,12]like that occurring during rainfall events. Since fast landslides are typically triggered by intense rainfalls,[13] we can hypothesize that this aspect is a factor concurrent to the overall trigger, especially if a "soil washing" is shortly followed by another significant rainfall. If this happens, the system maynot have the time to restore the organic fraction washed out.

The decrease of viscosity and yield stress with decreasing SOC content was ascribed to a change of the intensity of the attractive interparticle interactions, which induces a change of the clustering ability of the slurry.[3]We aim at confirming what discussed by Carotenuto et al.[11]from another point of view:The soil aggregative capability of the organic matter is investigated by following the evolution of the soil particle size distribution (PSD) when the soil is dispersed in water and stirred at a constant velocity. It is indeed known that when a laser granulometry measurement wants to be performed, one of the major experimental issues is to have a nicely dispersed sample without aggregates. To this end the suspensions is stirred and often subjected to sonication. We here approach the problem on the other way round; we focus on the unavoidable aggregated soil, initially dispersed in water, and follow its disaggregation kinetics as a function of the SOC content.

2. Material and Methods

2.1. Materials

The soil was collected from the site of Cervinara (Avellino, South Italy), which was affected by a catastrophic landslide in 1999.[14,15] The soil evolved on a slope covered by pyroclastic deposits pumice-cineritic affected by erosion, landslide, accumulation of material and burial of the oldest surfaces. In particular, the sample was taken from a specific pedological profile (figure 1.a), which shows the horizons succession O-A-Bw-2C-3Ab-3Btb (figure 1.b), defined according to the system of soil classification proposed by the USDA-NRCS (United States Department of Agriculture Natural Resources Conservation Service); the profile is classified as an AndicHumudepts, mesic, ashy-pumiceous. We collected the soil sample from the Bw horizon located at a depth of 50-80 cm from the surface mineral soil. In this horizon, the volcanic materials (pumices, ashes) lost the physical characteristics of the original parent material mainly for mechanical disruption rather than by chemical alteration. However, the process of structuring (aggregation of soil materials) is already started in this horizon. This phenomenon is closely related to the process of soil formation and is caused by cementation of colloids of mineral and organic origin. The Bw horizon is chosen because it is richer of organic matter than the deeper horizons and its SOC is more structured than that of shallower horizons.