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Plastic properties of some Alpine topsoils and bottomsoils

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Flash-flood phenomena, namely sudden intense precipitations, are very common in Alpine areas and they can result in conspicuous soil losses by water erosion and aggregate failure.

The structure of surface soil aggregates can be destroyed by intense runoff, releasing fine particles easily transported by water. Moreover, solifluxion and liquefaction phenomena can occur when soil is saturated by water, depending on soil plastic properties.

Soil plastic and liquid properties, and therefore soil strength, can be quantified through the Atterberg limits, and particularly the liquid limit (LL) and the plastic limit (PL), describing the behaviour of soils depending on the water content. In facts, soil samples with a high liquid limit can absorb a considerable amount of water before beginning to behave as a liquid. Also the plastic behaviour of soils can affect their stability, and the difference between liquid and plastic limit is defined as the Plasticity Index (PI), describing a range of water contents characterized by a plastic behaviour in soils. The Atterberg limits are commonly determined with standard procedures, and the LL can be obtained with two methods, i.e. the Casagrande device and the cone penetrometer.

The purpose of this work was twofold: a) comparing the LL obtained with the Casagrande and the penetrometer methods; b) comparing the strength properties of soils at different depths in order to assess the potential occurrence of liquefaction/solifluxion events.

The study area is located in Valle d'Aosta (Western Italian Alps) and it covers a watershed affected by a flood in the year 2000, characterised by widespread instability phenomena (debris flow, slope failures, solifluxions). The soils were chemically and physically characterised. LL and PL were determined on a set of samples (n=18), at two different depths corresponding to surface and bottom horizons, using the Casagrande device and the cone penetrometer, and PL was obtained with a standardised method.

The two determination methods gave different LL values ($p<0.001$), lower for the Casagrande device, and a systematic deviation was observed among the results which were strongly related ($r=0.983$, $p<0.001$).

Both top and bottomsoils were classified as non-plastic or poorly plastic according to the PI value, which is consistent with the limited development of mountain soils. However, topsoils showed higher LL and PL ($p<0.001$), which can be explained by the differences observed in soil aggregation. The liquid and plastic limits showed good correlations with different aggregating agents depending on soil depths: while LL and LP in topsoils were strongly related to organic C and clay aggregation, inorganic aggregating agents (Fe oxides) played a major role in the case of bottomsoils.

In the study area the methods used for LL determination gave slightly different results but the two indexes showed a predictable linear relation, and the degree of plasticity expressed by the PI was not affected by such differences. Soil plastic and liquid properties reflected different aggregation types for topsoils and bottomsoils, generally evidencing scarce soil plasticity and consistent differences in strength between surface and bottom horizons. Such heterogeneity indicates that liquefaction and solifluxion phenomena may occur also in subsurface horizons after intense precipitation, and therefore the study area requires a careful soil management.