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Triggering and evolution of sinkholes in non-karst terrains. Examples from the Po Plain (Italy)

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Natural sinkhole phenomena which are not connected to karst processes are relatively frequent. This paper deals with particular phenomena and related landforms, recently formed in the Po Plain in a non-karst environment. These processes have periodically produced shallow sinks, up to 2 m wide and deep, that disrupted agricultural works and exposed farm equipment to risk, requiring costly remedial measures. In some cases, the land productivity itself was impaired.
On the basis of literature information, as well as available geological, geomorphological and geotechnical data, the possible triggering factors and the evolution of these phenomena are described.
An inventory carried out some years ago shows that these phenomena tend to develop in different geological settings, from the apex of the alluvial fans down to the lower alluvial plain, generally within relatively short distances from streams and artificial channels. In most cases, the affected soils have silty-sandy textures, related to recent alluvial ridges which are composed by sandy channel fills, bounded by levees of mixed sand and silt, which pass outwards to finer silts and clays of interchannel zones.
On the basis of Cone Penetration Tests (CPTs), some of the affected areas have been characterized with reference to lithology, stratigraphy and relevant geotechnical parameters and described in typical cross-sections. Under a surficial overconsolidated cohesive unit, with sufficient clay fraction to form and retain shrinkage cracks in the active zone, at a depth in the order of 6 meters, a sandy unit can be typically found, that has shown to be susceptible of liquefaction as a consequence of natural or artificial causes (seismic shaking, water table sudden drawdown, heavy vehicles transit etc.). The liquefaction and subsequent packing of loose sediments leads to the development of proto-chambers, that reveal as sinkholes when their roofs suddenly collapse.
In the proposed conceptual model, triggering and evolution of these phenomena depend on the grain size of sediments, and on specific hydraulic conditions related to the distal sectors of alluvial ridges in a recent alluvial plain.