Subsidence due to peat oxidation and its impact on drainage infrastructures in a farmland catchment south of the Venice Lagoon

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Abstract: Large agricultural areas reclaimed in the past century south of the Venice Lagoon have experienced significant land subsidence due to oxidation of peat reach histosols. The present communication provides a brief overview of the problem with important information on its most recent evolution.

Key words: land subsidence, peat oxidation, drainage infrastructures, flood risk, Venice Lagoon catchment

Introduction

Land subsidence due to oxidation of organically reach soils (histosols) in drained agricultural catchments can enhance local flood hazards and significantly impact on the maintenance and operational cost of the existing hydraulic infrastructures, e.g., ditches, levees, and pumping stations (Deverel & Rojstaczer, 1996).
Large agricultural areas located south of the Venice Lagoon and characterized by soils with high organic content (peat) were reclaimed from 1892 to 1967. At present they lie almost entirely below mean sea level. The organic fraction, where peat generally exceeds 50 %, is subject to oxidation with CO_2 release into the atmosphere, loss of sediment mass and related land subsidence. The release of CO_2 depends on the agricultural practices and is primarily controlled by soil temperature and depth to the water table. The latter is regulated by a complex network of ditches and pumping stations which discharge the drainage water into the Venice Lagoon or the Adriatic Sea with flooding from the sea and the lagoon prevented in normal conditions by levees.
The maintenance of a given water table depth, as is dictated by the agricultural requirements, has caused the lowering of the inlet shaft of the drainage pumping stations and the simultaneous increase of the pumping head. As a major consequence the efficiency of the pumps has decreased and the drainage cost increased. Moreover the risk of flooding during exceptionally severe storms cannot be ruled out as well as the occurrence of adverse event such as the saltwater contamination from the nearby rivers, the lagoon and the sea. Hence the sustainable development of the area as a cereal farmland is becoming increasingly expensive.

Scientific paper

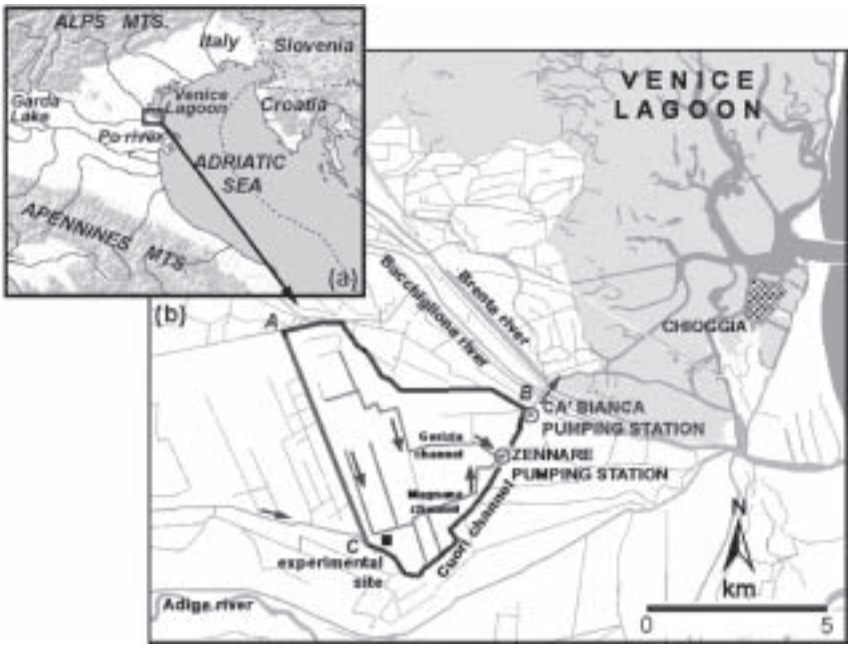

Figure 1. a) Map of the north-eastern Italy with the location of b) the Zennare Basin

A 23 km^2 closed catchment south of the Venice Lagoon, the Zennare Basin, has been selected to study the process (Figure 1). The site, reclaimed during the 1930's, has been instrumented with the purpose of measuring the ongoing land settlement, collecting the main hydrologic variables, which control the peat oxidation (namely depth of the water table, rainfall, soil temperature and moisture) and quantifying the CO_2 fluxes into the atmosphere (FORNASIERO ET AL., 2002; 2003).

The present communication describes briefly the area involved in the process with emphasis on the hydraulic infrastructures whose efficient operativity is of paramount importance for the correct implementation of the agricultural practices and the mitigation of the adverse environmental consequences.

EVIDENCE OF LAND SUBSIDENCE AND IMPACT ON CATCHMENT INFRASTRUCTURES

Land subsidence has been estimated from 1965 to 1983 by the reclamation authority with the aid of elevation maps of the area. Over less than a 20 year period a maximum settlement of about 1 m was measured close to both the north-western and south-western boundaries. As an example Figure 2 shows the practical consequences of the land settlement that has affected the area surrounding a hydraulic infrastructure. The foundation of the bridge, originally constructed for a road intersecting a channel, prevents the regular water flow. The latter is recently restored by a lower drainpipe shown in the left end corner of the figure.

An indirect evidence of the magnitude of the occurrence is provided by the Zennare pumping station (Figure 1b) that drains off the surplus water from the study basin. The shaft level

of the pumping station has been continuously lowered from the original 1930 elevation to conform to the subsiding ground elevation of the surrounding area. The water elevation shows an overall average lowering on the order of 1.5 m (Figure 3).

Figure 2. In situ evidence of the land subsidence that has turned a bridge into a useless structure. The left drainpipe helps convey the water of the channel originally flowing through the protruding infrastructure

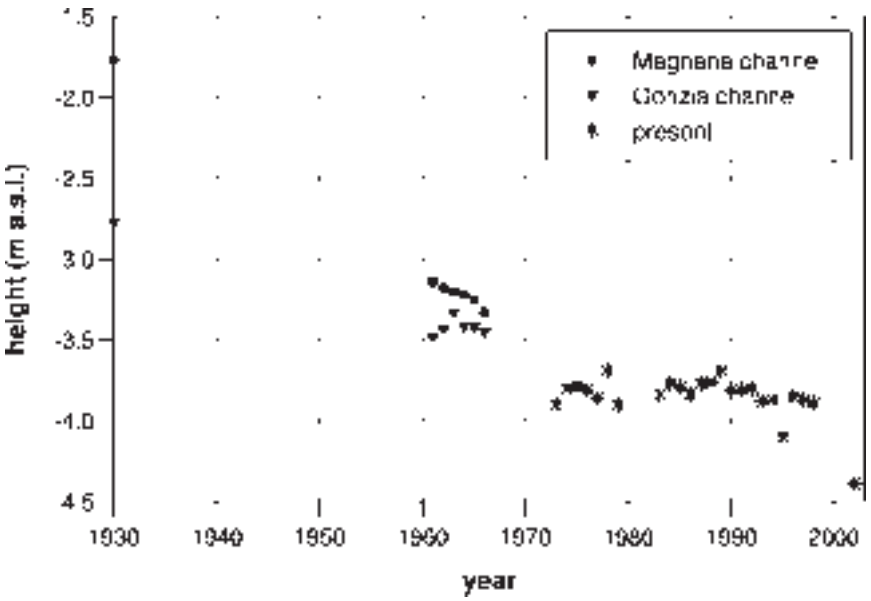

Figure 3. Water level (m.a.s.l.) in the Magnana and Gorizia channels at the Zennare pumping station from 1930 to 2000. The channels are united and flow together into the station since 1970

An evidence that land subsidence is still occurring in the south-western area of the basin has been obtained by comparing the ground elevation as derived from a DEM based on an aerial photographic survey performed in 1983 and a kinematic DGPS (Differential Global Positioning System) survey carried out in March 2002. The results show a subsidence rate ranging from 0.02 to 0.05 m/year where peat outcrops while the sandy zones turn out to have been much more stable.

CONCLUSIONS

Peat oxidation in the southern catchment of the Venice Lagoon, particularly in the Zennare Basin, and land subsidence are strictly correlated. Maximum land settlements between 1.5 and 2 m over the past 70 years have been observed. This has created a number of problems to the drainage system and has exposed the area, which lies almost entirely below sea level down to as much as -4 m, to the hazard of flooding during severe storm events. A test site within the Zennare Basin has been selected for a pilot study (Figure 1). The site has been instrumented in 2002 to measure the ongoing land subsidence, the major hydraulic variables (i.e., depth of the water table, precipitation rate, soil temperature and moisture) and the CO_2 fluxes from ground surface into the atmosphere. The data thus collected will be used as input data to a numerical model for a reliable prediction of the land subsidence trend over the next decades.

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