Effects of irrigation and ditch seepage on soil salinization with shallow brackish groundwater table in low-lying area of Po river delta (Emilia-Romagna, Italy)

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INTRODUCTION

The interaction between open channel surface water, shallow groundwater and irrigation water, in low-lying areas of coastal zone, can affect the salt loads to surface water (Pauw, 2014) and to rooted zone of soil. The mixing process between shallow fresh and deep brackish groundwater, in low-land areas, may develop the freshwater lens (Eeman, 2011). The seasonal and annual dynamics of freshwater-lens and the effects on lens of irrigation and tile drainage, in Mediterranean and sub-humid climate, are not well know. In low-lying agricultural area, the mixing zone between fresh and brackish groundwater is located in vadose layer (de Louw, 2011), so far, in irrigated field it is strong related to irrigation water quality, irrigation method, irrigation practice (e.g. leaching technique) and effectiveness of tile drainage system (Hinesly at al. 1966).

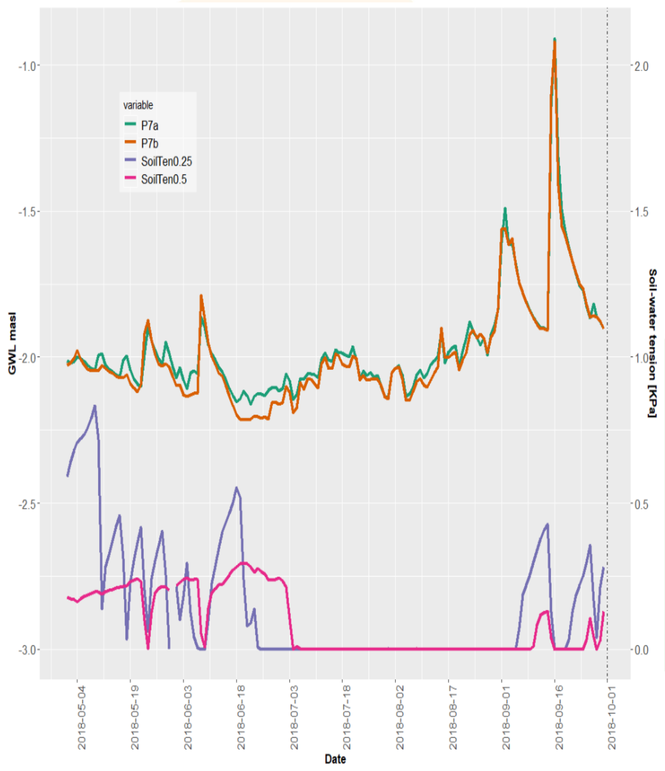
Many authors solved the problem of drain spacing in presence of upward seepage groundwater with analytical method in transient (Abdel-Dayem at al. 1984) and steady-state conditions (Hinesly at al. 1966; Bazaraa et al., 1986). The rainfall and evapotranspiration, with seasonal and inter-seasonal pattern, can affect the natural process. In irrigated areas, the irrigation water application, the irrigation method and, mainly, the water level control in drainage ditches, managed by land reclamation Consortia have the major effects. Hinesly and Kirkham (1966) developed an analytical method to calculate the tile-drain spacing to remove the surplus upward water flux of artesian groundwater. Analytical formulation of the problem presented previously allows a preliminary understanding of soil-water flow and transport processes in low lying area.

OBJECTIVES

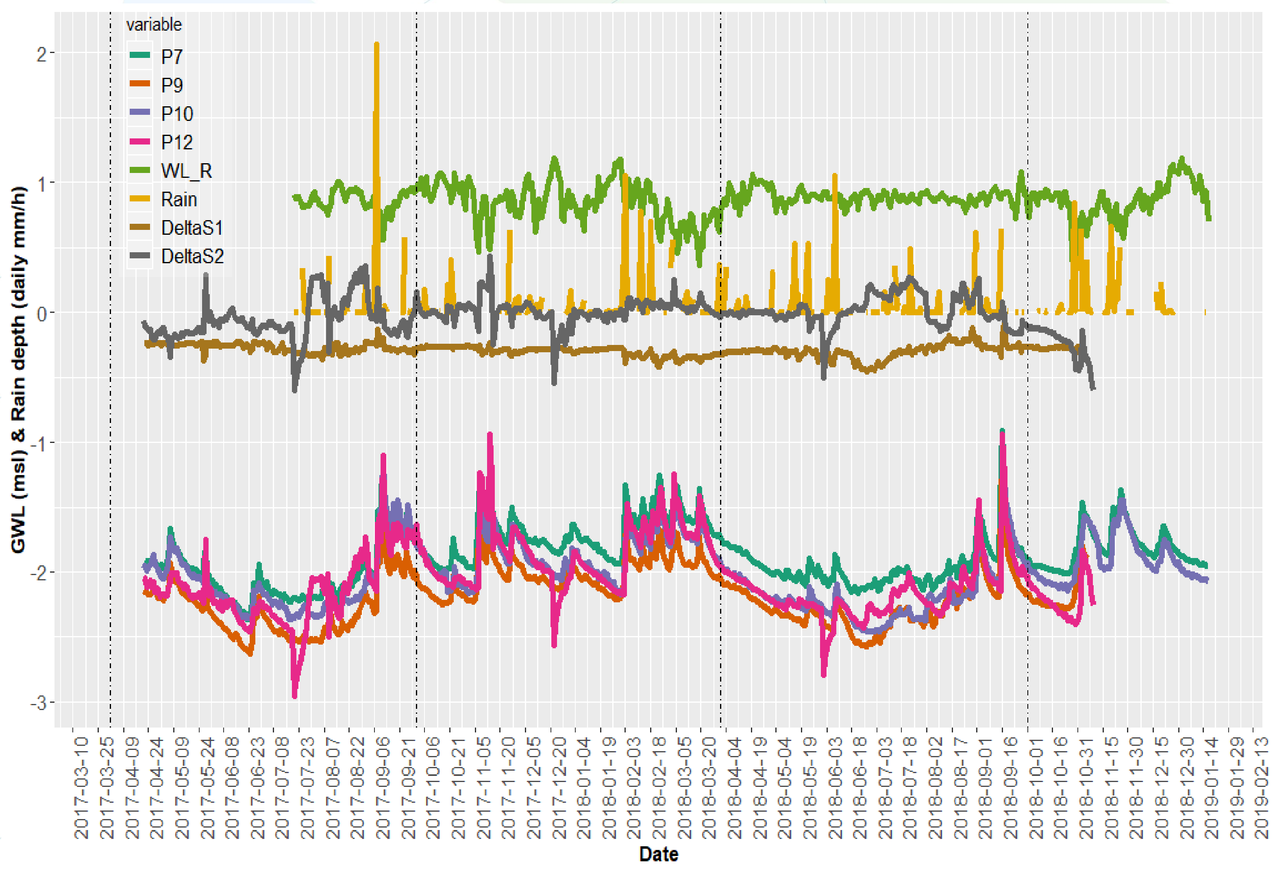
We present the results of two-year monitoring for the evaluation of combine effects on soil salinisation, in complex hydrogeological condition, of river downward seepage with variable salinity water, deep brackish groundwater interaction with shallow fresh-water, irrigation water and tile-drainage. The study area is a low-lying irrigated parcel of about 15 hectares located at about -0.5 meter below sea level (mBSL), at few meters from 'Po di Volano' river bank. The lithology is result of alluvial deposition and, late, earthworks and grading of the land surface, that produces complex inter-bedded distribution and layer stratification of soil.

MAIN RESULTS

- The groundwater table level (GWL), at 150 meters far from the River, is always lower with few variations along the year. The piezometer P12 shows a different geo-hydrological response respect to the others monitoring points.
- The tile-drainage system is located at -1,5 meters below ground level (mBGL). Only for short period the GWL overtops the drains level and the abrupt decline of water level (e.g. 02-03/2018) should be related to the activation of drainage system.
- Between July and September, the irrigation water, applied to leach the soil salinity, reached the groundwater table increasing the GWL of about 0,3 m. Until September, the GWL never reached the tile-drained depth, so the salt leached from rooted-zone was not removed from soil layers.



Soil-water tension at depth of 25 and 50 cm below ground level and GWL measurement – mBSL - for piezometers 7b and P9b for irrigation season 2018.



Time-series of GWT measurements (P7b, P9b, P10, P12), water level in 'Po di Volano' Po River (WL_R), average hourly rainfall (mm), difference between P7 and P9 (Delta S1 transect) and difference between P10 and P12 (Delta S2 transect). Vertical line allows to evaluate the transition between irrigation season and winter season.

General view of study area with details of piezometer location and river 'Po di Volano'. Red line is delimiting the trail plot. Blue points are the location of the piezometers. WL_R is the location of surface water level sensor in river. Orange circle is aerial photo with evidences of bright/dark color due to different soil type.

CONCLUSIONS

- The effectiveness of leaching technique is linked to drainage efficiency: the leaching of salt from rooted-zone could increase the GWL and capillary fringe, with upward unsaturated soil-water movement, could increase the soil salinization processes. The continuous application of irrigation water can reduce the unsaturated upward movement from shallow groundwater table that should affects the rooted-zone, decreasing the soil-water potential gradient and so far, the mass flux.
- The irrigation water, applied during the summer season, allows to reduce and control the salinity build-up in soil and, in the rain season, the tile-drainage operation system allows salt removal. A seasonal fluctuation of water electrical-conductivity in piezometers could represents the effect of different climate condition on geo-hydrological dynamics: climate impacts on soil-water processes are strong and water movement, in clayey soil, are more complex (Velstra et al. 2011) so far, the surface water level control in river and ditches, managed by land reclamation authority, could have strong consequence on soil salinization processes more than previously thought. The seepage from river impacts on salinization of shallow groundwater system, while good quality irrigation water allows the control of soil salinization during dry season.