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Baseline

Assessment of factors enabling halite formation in a marsh in a humid temperate climate (Ajó Marsh, Argentina)

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ABSTRACT

The formation of evaporites associated with the final stages of the precipitation sequence, such as the case of halite, is frequent in marshes in arid areas, but it is not to be expected in those humid climates. This work, by means of the study of the hydrological, climatic and land use conditions, identifies the factors that allow the formation of saline precipitations in a marsh located in a humid climate area. The results obtained show that the exclusion of the marsh as a result of the embankment is the main reason for the presence of halite. It is to be expected that in the future the growth of the embanked marsh areas, together with the climatic and tidal condition tendencies recorded, will favour a higher rate of formation of evaporite salts. The identification of these factors makes it possible to set basic sustainable management guidelines to avoid soil salinisation.

Salt marshes occur worldwide, particularly in middle to high latitudes. Thriving along protected shorelines, they are a common habitat in estuaries. The formation of salt precipitates in marshes is controlled by the tidal flows, which contribute saline water, and the characteristics of the climate; the latter are related to the predominance of evapotranspiration over rainfall in the water balance. This is the reason why the formation of evaporites associated with the final stages of the precipitation sequence, such as halite, is restricted to marshes developing in arid areas (Butler, 1969; El-Omla and Aboulela, 2012; Aref Mahmoud et al., 2014; Alvarez et al., 2015).

The littoral of the outer Río de la Plata estuary (Argentina) constitutes an area which has a humid temperate climate (Carol et al., 2013) and in which there is an extensive marsh that reaches its greatest extent at the southern end (Fig. 1). In this sector, the tide enters the marsh along a large tidal channel referred to as Ajó River, which also receives the contribution of continental water from groundwater discharge and surface runoff; the latter is regulated by floodgates. Even though the estuary has a semidiurnal microtidal regime, the low topography of the marsh makes it possible for the tide to reach the most continental sectors periodically (Carol et al., 2012). Within the marsh, there are approximately ten farms whose main activity is livestock farming. The development of this activity modifies the marsh hydrologically, due to the construction of embankments for internal access roads to the farms and to contain the tidal flow in order to reclaim land for livestock (Carol et al., 2014).

Salt precipitates are frequently found covering the surficial sediments in different sectors of the marsh. Although their spatial development is not important, their presence in a marsh within a humid climate area is noteworthy. The objective of this work is to identify the composition of the salt precipitates, their source and the factors conditioning their formation, in order to set basic sustainable management guidelines to avoid soil salinisation.

QuickBird satellite images from 2014 (Software Google Earth) were used in order to identify areas with similar hydrological patterns, which were then verified in field surveys. The hydrological characterisation of the area was carried out taking into consideration climate and tidal data. The annual and seasonal variations in the rainfall and temperature regime, as well as their influence on the real estimated evapotranspiration as suggested by Thornthwaite and Mather (1957), were analysed using historical climate data of the General Lavalle station from the 1956–2014 period. The tidal regime was studied on the basis of the hourly observed tidal heights (astronomical tide plus weather effects) of the General Lavalle port recorded by the Prefectura Naval Argentina (Argentine Coast Guard). Salt precipitates samples were extracted from the most surficial sediments, stored hermetically in order not to alter the humidity conditions and examined under a binocular magnifying glass, an X-ray diffraction (Philips X'Pert PRO diffractometer) and a scanning electron microscope (JEOL JSM 6360 LV microscope). In order to assess the hydrological and climatic conditions in which the

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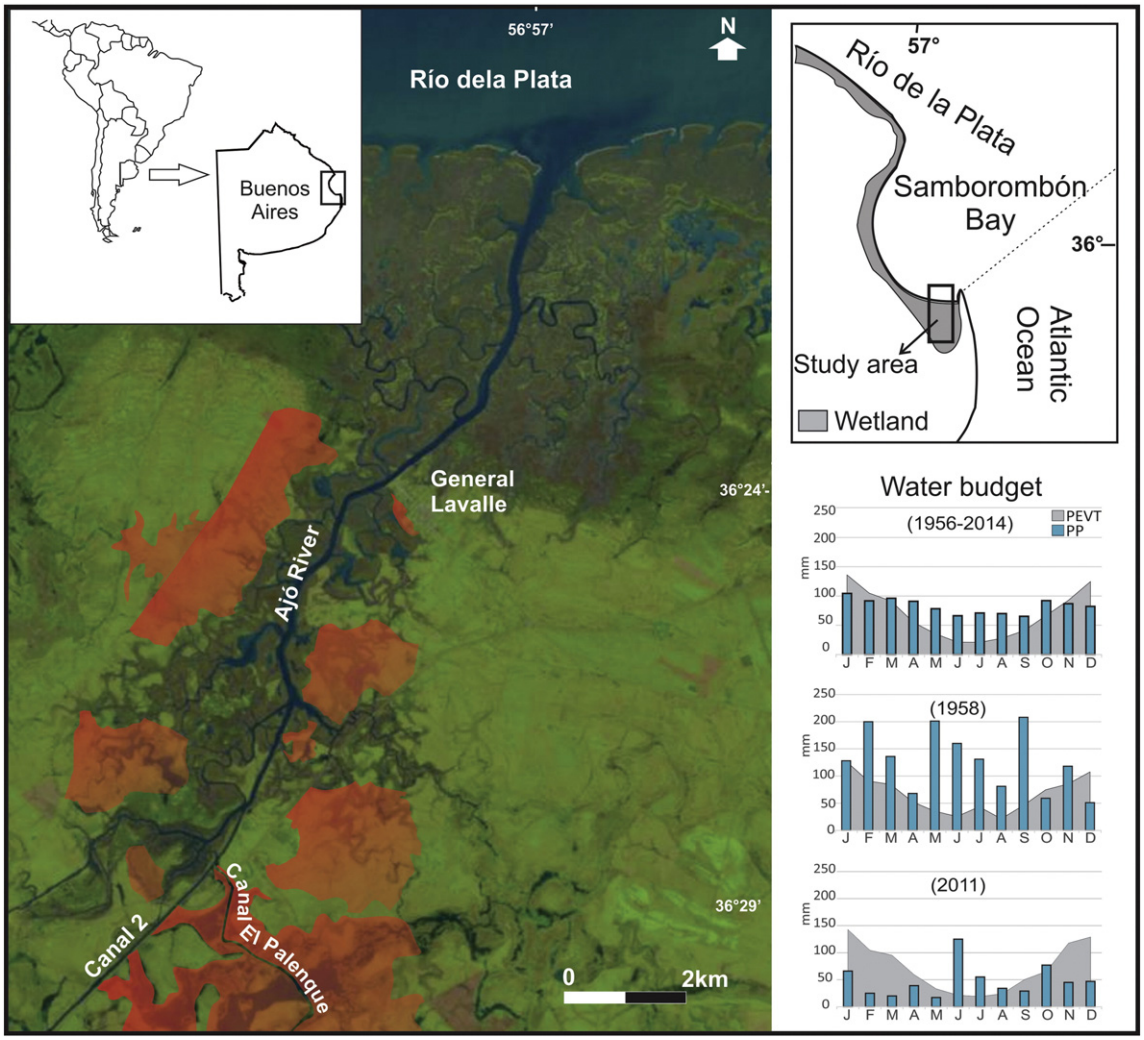

Fig. 1. Location and water balances of the study area. In the map, sites affected by anthropogenic modifications are shown in red. Balances correspond to the historical mean (1956–2014), wettest year (1958) and driest year (2011) of the entire period analysed. PP: Precipitation; PEVT: Potential evapotranspiration.

salt precipitates were formed, tide time, daily precipitation, relative humidity and mean daily temperature data from the days prior to the sampling were analysed. Besides, tidal water samples were obtained from the Ajó River to determine the major ion concentration (Fig. 1). The hydrochemical data were used to estimate the possible salts that may precipitate due to tidal water evaporation by modelling using PHREEQC (Parkhurst and Appelo, 1999). In order to do so, a total evaporation of the tidal water sample of a sequential type was modelled and the ion activities and saturation indices of the evaporites were estimated.

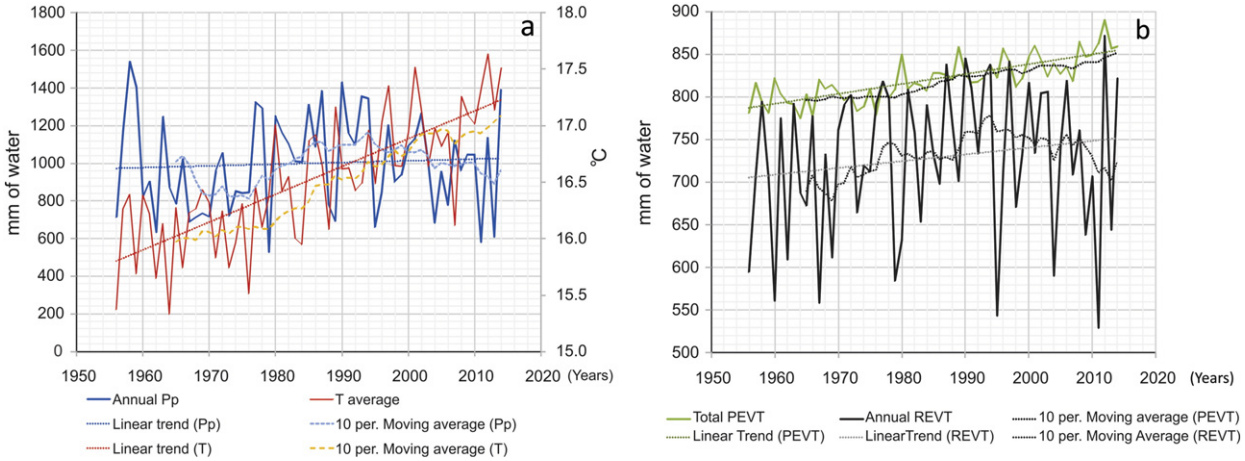

Fig. 2. Historical trend for (a) precipitation and temperature, and (b) potential (PEVT) and real evapotranspiration (REVT) during the last 60 years.