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Changes in soils due to polderization in coastal plain estuaries. (North coast of Spain)

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The drainage of salt marshes is a common practice in Europe that causes important changes in soil properties mainly due to carbonate salts surface wash, changes in pH, solubility of metals, etc. These induced changes have always been considered as being improvements to the productive capacity of the soils. However, although the salt wash and lack of daily floods make these soils suitable for farming or cattle grazing, drainage causes changes in the electrochemical characteristics and a loss of the high natural value of these zones. Hence it may be necessary to restore the natural conditions of some of these reclaimed soils.

In natural conditions, salt marsh soils have organic rich surface layers, they tend to have a basic pH and they are flooded periodically with seawater, which is rich in salts and cations like iron, manganese or zinc. Under drained conditions, the soil's geochemistry is altered by oxidation and precipitation of metal compounds which, when the concentration is excessive, can be harmful.

The North Coast of the Iberian Peninsula (Spain) is a steep coast in which estuaries are infrequent and cover a small area. They have all undergone anthropogenic alterations without exception. The process of reclaiming wetland to convert them into pastures, crops or urban zones have led, (in some cases) to the complete destruction of salt marshes. In spite of the transformation, some soil properties remain unaltered; the estuarine origin of the drained soils can be found from these properties. In order to know which soil properties have changed in Cantabrian estuarine soils due to human intervention, we selected *Ría de Villaviciosa* as the experimentation area. This area is about 691 ha and at least two thirds of its surface has been reclaimed over the last 150 years.

A morphodynamic classification of the Villaviciosa estuary had been elaborated. Two classes have been differentiated according to flood frequency: i-The low terrace (LT) which is inundated twice a day at high tide. ii- The high terrace (HT) which are only flooded by high water spring tides or strong storms.

Many profiles were sampled in LT and HT reclaimed soils for all the study area. We also sampled profiles in natural soils from these two terraces. In each profile the genetic horizons were identified. In addition to the morphological description the following physical and chemical properties for each horizon sample were analyzed: texture, pH, total organic carbon; %carbonates; CIC; exchangeable cations; trace elements and electrical conductivity.

From a morphological point of view, the most visible changes appear in the low terrace (LT). In natural conditions, the soils which are flooded at each high tide do not show differentiation in genetic horizons and the Redox change takes place in the surface. After drainage, these soils continue to be flooded twice a day but its profile has undergone great changes. Under these new conditions, the soil profiles develop at least three genetic horizons: one upper horizon of organic matter accumulation which has variable thickness; a medium reddish horizon which shows clear evidence of oxidation and finally the deepest grey horizon that is permanently under reduced conditions. The depth at which the Redox change occurs is related to the distance to the dykes and tidal channels.

Morphological changes imply changes in soil properties. Metal oxidation under acidic conditions causes important accumulations of Fe, Mn, Cu and Zn in the oxidized soils horizons. Accumulation of organic matter also increases, because the maturing of these soils due to reclaimed land process enables them to be colonised by vascular plants and therefore the surface horizon is enriched in amorphous organic matter caused by the decomposition of *Juncus maritimus*.

The reclaimed soils in the high terrace (HT) show a different evolution in morphological properties than in the LT. The accumulation of amorphous organic matter is not present in them; nevertheless they give a horizon of humic organic matter which is very similar to continental soils. The other genetic horizons, (oxidized and reduced horizons), are separated by an evident change in colour which marks the change in the Redox conditions. This change is also observed in the natural soils of the high terrace, but at a lower depth than in the polder soils. In oxidized horizon, carbonate washes are very intense and the pH level can decrease to 3.5. This does not happen in natural soils which give very high salinity and % of carbonates values in the oxidez horizon. This acidification is caused by profiler washing but also by the oxidation of metallic cations that are precipitated as red nodules inside soils. It is also possible to find elevated concentrations of copper and manganese in these reclaimed soils. With HT soil drainage, the rate of aerobic biological oxidation of organic matter is multiplied and therefore the accumulated organic carbonate decreases. In the reduced horizon, the pH values are neutral or basic and the electrical conductivity is elevated. This fact seems to indicate that in spite of the dykes, the saline wave can be found at deeper levels.

In spite of these changes, the drained soils of salt marshes continue to retain some common characteristics of natural soils which make them identifiable. These characteristics are mainly: high amounts of mud in textures and the presence of organic remains like bivalve shells and rushes. The presence of change in Redox conditions at variable depths caused by tidal influence is also a good indicator of the estuarine origin of these soils. This change is found in the coloration of the profile which turns from intense red in the oxidised zone to clear greys in the reduced zone. The presence of all these morphological characteristics indicates quite clearly that the origin of these soils is estuarine in spite of intense transformations