# Experimental evidence of rainwater lens dynamics in natural and agro-ecosystems in the Scheldt river region

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## ABSTRACT

The presence of shallow saline groundwater in the Scheldt river region in the Netherlands and Belgium may adversely affect agricultural production, but may also lead to the development of interesting natural saline vegetations. Since little is known about the spatiotemporal dynamics of this delicate shallow water system overlying saline groundwater, we monitor the fresh/salt dynamics at two agricultural sites and a natural grassland. These on-going field campaigns include monitoring of groundwater levels, hydraulic heads, electrical conductivity and composition of groundwater and soil moisture. Upward seepage of saline groundwater is particularly prominent in the cold seasons at the nature area in Belgium that is not artificially drained. Water quality parameters appear to also reveal a seasonal trend, although this variation differs for the three sites.

## INTRODUCTION

The Scheldt region has been subjected to several transgressions during the Holocene. Seawater submerged the area and infiltrated and salinized the soil and aquifer. This “fossil” seawater is present at less than 5 meters depth (de Louw, 2008). Nowadays, thin rainwater lenses are found in drained agricultural areas that are in dynamic balance with precipitation, evapotranspiration, drainage and seepage. These rainwater lenses are important for crop production as fresh surface water is not available for irrigation during summer. However, spatiotemporal dynamics of rainwater lenses have remained underexposed in research.

Also for the development and composition of natural vegetations, root zone conditions are a determinant factor. Saline seepage as found in the Scheldt region offers good opportunities for the development of saline natural vegetations. In this paper, the spatiotemporal dynamics of two agricultural fields and a natural vegetation location are monitored to gain more insight in the system dynamics and underlying processes.

## METHODS

The two agricultural fields (Location 1: 51° 43’ 42”N, 3° 47’ 58”E and 2: 51° 42’ 04”N, 3° 51’ 33”E) are located at the peninsula of Schouwen-Duiveland near Zierikzee (province of Zeeland, the Netherlands). The locations are bordered by ditches with managed water levels. Drains are present at distances of about 10 m. At location 1, a sand ridge is present at one side of the field. At both locations, measurement sites (Figure 1) are in between two drains, and at location 2, two sites are positioned above a drain. A measurement site consists of a group of 6 piezometers (depths: 1, 1.3, 1.6, 2, 3 and 4 m) where hydraulic heads (divers) were monitored and electrical conductivities (EC) measured every month. Rhizons were installed at depths: 10, 25, 40, 55 and 70 cm to obtain soil moisture samples for EC. Near-continuous monitoring of soil moisture and salinity was done by TriScans (Sentek). Furthermore the amount of drainage and the corresponding EC were monitored continuously.

The natural saline grassland is located in an embanked creek system near Watervliet, Belgium (51° 17' 6"N, 3° 36' 22"E). A gradient from fresh water dependent vegetation (former upper salt marsh) to halophytic vegetation (former creek) is observed over a distance of 100 m (de Moor & van de Velde, 1994). Measurement sites were installed along the fresh to saline vegetation gradient and include a piezometer to monitor groundwater levels and EC. Four Rhizons were installed at depths: 10, 25, 50 and 75 cm below the soil surface. Obtained soil moisture samples were analyzed for EC, T, pH, macro-nutrients (N, P, S, K, Mg) and Ca, Na, Cl.

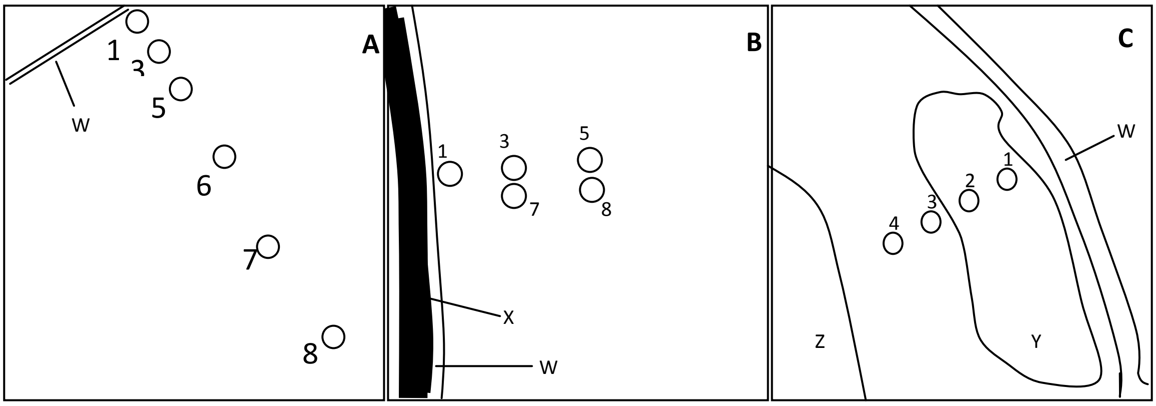


**Figure 1 Overview of the different locations with the measurement sites. A: Location 1; B: Location 2; C: Natural vegetation location. W= Ditch/creek, X =Road, Y= Saline area and Z= former high tidal flat.**

## RESULTS

### *Agricultural locations*

Monitoring revealed the presence of saline conditions near the ditch (s1) at location 1, where EC at 2 m depth is 45 mS/cm (Figure 2 and W in Figure 1). Towards the center of the field (s6 and s8) conditions change from saline to brackish, the EC decreases from 30 to 5 mS/cm at 2 m depth. These profiles clearly show a mixing zone of saline seepage with fresh rainwater for depths < 2m. This corresponds with the location of the sand ridge, where water can infiltrate more easily. The profiles prove to be consistent throughout the year for depths >1.5 m. For the unsaturated zone, measurements indicate a completely fresh profile by the end of February. In summer, too little soil moisture was present to enable sampling. At location 2, all measurement sites show an increase of EC with increasing depth (Figure 2). A horizontal spatial gradient in decreasing EC towards the center of the field is not observed. In general we find higher salinities at shallower depth above the drain. A vertical gradient is present i.e. the upper two piezometers show a decrease in EC compared to the deeper piezometers, indicating the presence of a mixing zone. Temporal dynamics between summer and winter are limited. At site 6 conditions are slightly less saline in winter. Samples from the unsaturated zone show fresh water conditions in the upper meter for site 5, whereas sites 7 and 1 show a strong increase in EC from 40 cm onwards. Remarkable is that at these sites often higher EC's are measured than in the piezometers.

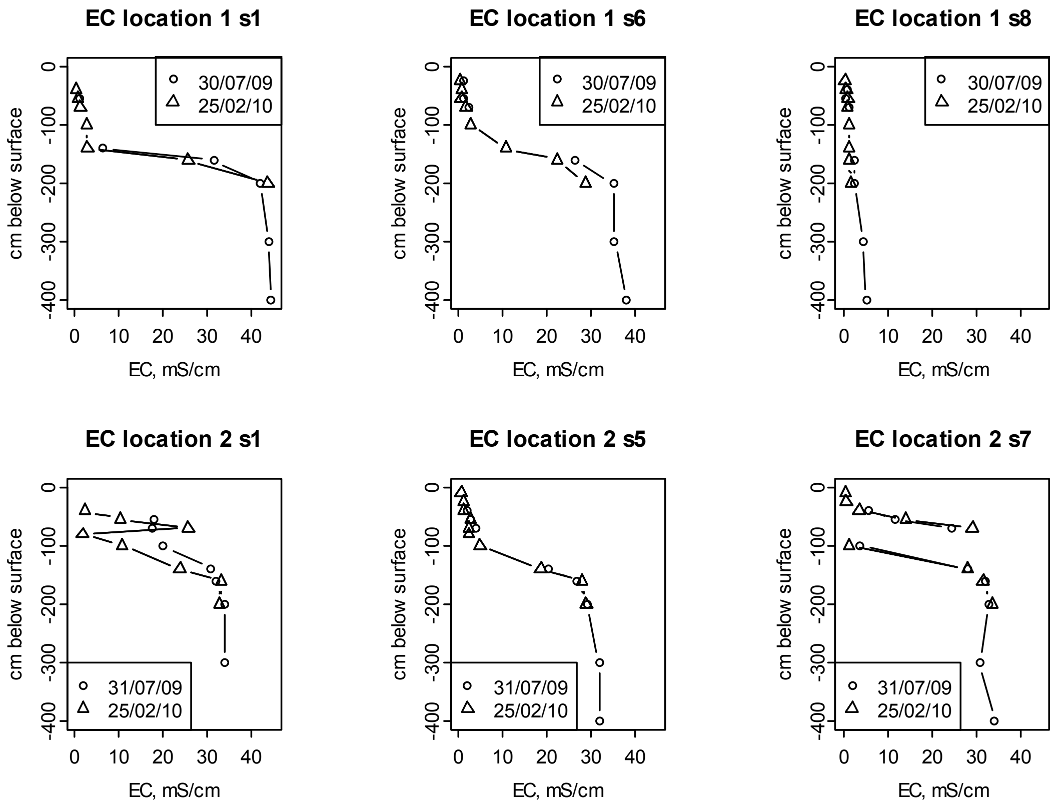


**Figure 2 EC profiles at locations 1 and 2, in the summer and in the winter. The s-numbers correspond to the numbers in Figure 1.**

### *Natural vegetation location*

EC measurements (not shown) confirm the observed vegetation gradient with salinities increasing from 1.5 to 21 mS/cm from fresh to saline vegetations. EC soil moisture measurements show little temporal dynamics at 50 and 75 cm depth. In summer, a strong increase in EC occurs for the upper part of the soil. During winter, observed groundwater levels have increased more than a meter compared to summer conditions due to a combination of precipitation surplus and little retention possibilities in the area.

## DISCUSSION AND CONCLUSIONS

Our measurements show that rainwater lenses, if present, are very shallow and thin, partly depending on geomorphic landscape elements and drainage. Temporal dynamics, as a result of changes in precipitation and evapotranspiration in these systems seem to be limited to the upper meter of the soil profile, where rainwater dynamics cause larger changes in the unsaturated zone. Differences in EC measurements between Rhizon and piezometer samples suggest a porosity effect. It is likely that due to the vacuum during sampling via Rhizons, water is extracted from smaller pores that are less in contact with flowing water. Apparently these pores contain water of higher salinity than the more regularly flushed pores contributing to the water measured in the piezometers. At the natural vegetation location, evapotranspiration may be an important factor in determining the salinity profile. Data collected this spring should give more insight in these dynamics and the influence of evapotranspiration on the salinity distribution in the soil profile.

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