# Surface and subsurface water continuous monitoring to quantify nitrate leaking to groundwater from maize plots


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## 1. Introduction

Nitrogen losses from agricultural sources have been recognised as one of the most serious threats in industrialised and emerging countries, determining ecosystem eutrophication and groundwater nitrate contamination (Fig.1). This issue has recently become a priority within the European Community Framework Directive for water protection (WFD) which has established a list of measures and limitations to be applied in areas declared "vulnerable to nitrate from agricultural sources". An example is the Ferrara Province (Northern Italy), an intensively cultivated area affected by serious nitrate pollution since decades. To deal with potential groundwater contamination by fertilizers loading is essential to understand which processes are important in N transformation and at which rate they occur. For this purpose a surface and subsurface monitoring have been performed to quantify N-species fate in a site representative of the Ferrara Province loamy soils.

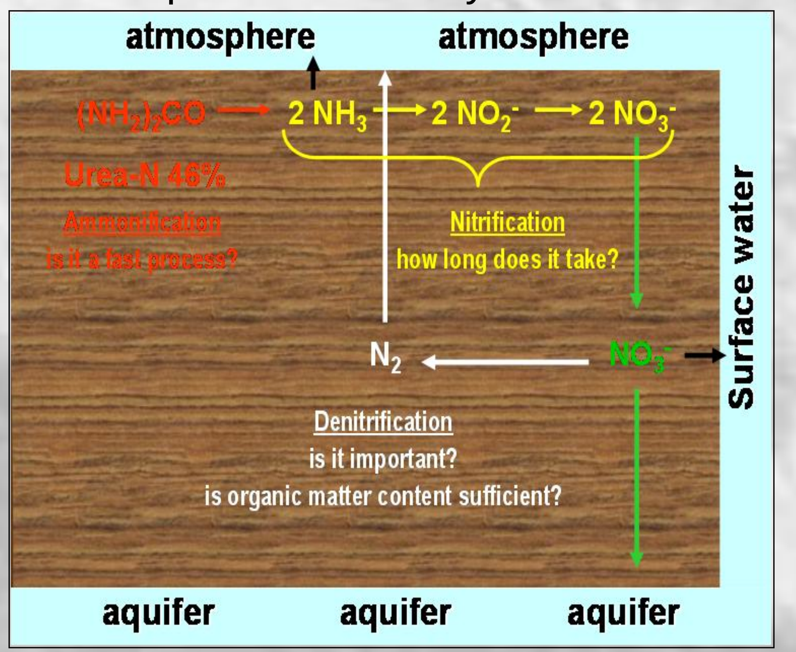


**Fig.1: Representation of nitrogen fluxes**

## 2. Materials and Methods

An experimental plot cultivated with maize and fertilized with 300 Kg/ha of urea, was selected to represent Ferrara Province loamy soils. The surface area of the plot in each site was 1 ha, its slope was less than 0.5% (and mostly less than 0.05%). The field site was equipped with: Irrometer tensiometers and Watermark soil moisture probes for daily monitoring of soil water potential in the unsaturated zone; a meteorological stations recording rainfall, wind speed, solar radiation, temperature and humidity. Drains and suction cups were installed to collect water samples for anions and cations analysis; Core logs down to 2 m b.g.l. were collected to define soil water content, soil texture, organic matter content and bulk density; piezometers (2.5 cm inner diameter) screened from 1.5 to 5 m b.g.l., were installed and monitored to quantify the presence and degradation of nitrogen dissolved species in the shallow unconfined aquifer. Monitoring of all parameters started in February 2008 and is still active.

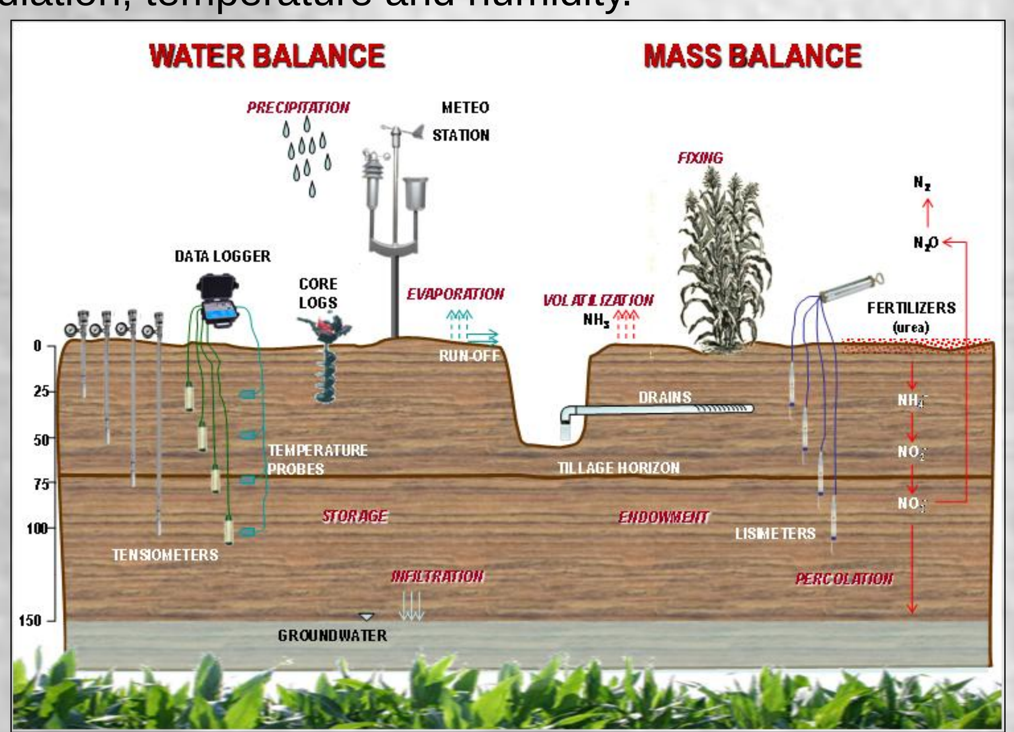


**Fig.2: Representation of the field equipment**

## 2. Soil water fluxes monitoring

The matric potential measured at different depth in at the site (Fig. 3) shows that during the autumn/winter seasons the upper and the lower horizons are near the saturation state. This implies that recharge is taking place especially during the late winter season, where the saturation state is reached in all the measuring point concomitantly. Conversely, from the sowing to the harvest of maize (May to September 2009) the soil became very dry in the upper horizon since the evapotranspiration is very high (Mastrocicco et al., 2010).

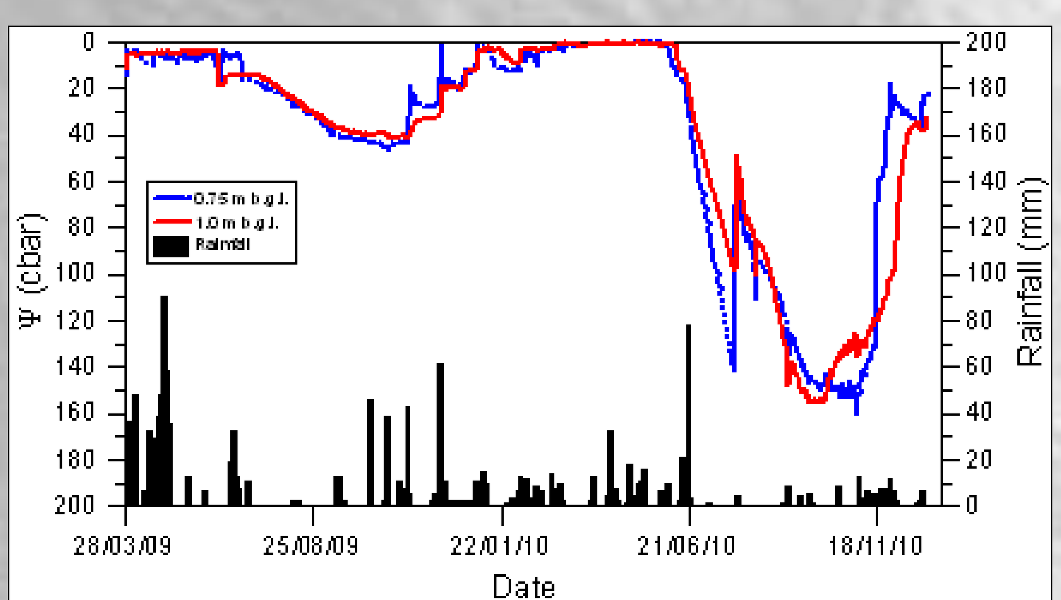


**Fig. 3: rainfall and matric potential recorded at the site at different depth, 0.75 and 1.0 m b.g.l.**

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Note that for rotation needs, in May 2010 beetroots were sowed instead of maize at the site and the soil became dry also in the lower horizon, since the rooting system of the beetroot is deeper than in maize (Christiansen *et al.*, 2006). In addition Figure 1 shows a clear temporal shift during the wetting cycle, from the sensor located at 0.75 m b.g.l. and the one located at 1.0 m b.g.l.; this is due to the low permeability of these soils which do not allow fast vertical transfer of water.

## 3. Dissolved species monitoring

Figure 4 shows a largely variable groundwater table in the loamy site, where the groundwater flow is linked with canals level. In particular, the sharp peak recorded the 21/06/2010 was due to a flood event that rose the level of the nearby canal of 2.5 m, but the soil moisture sensor placed at 1m b.g.l. was not in saturation condition (Figure 3).

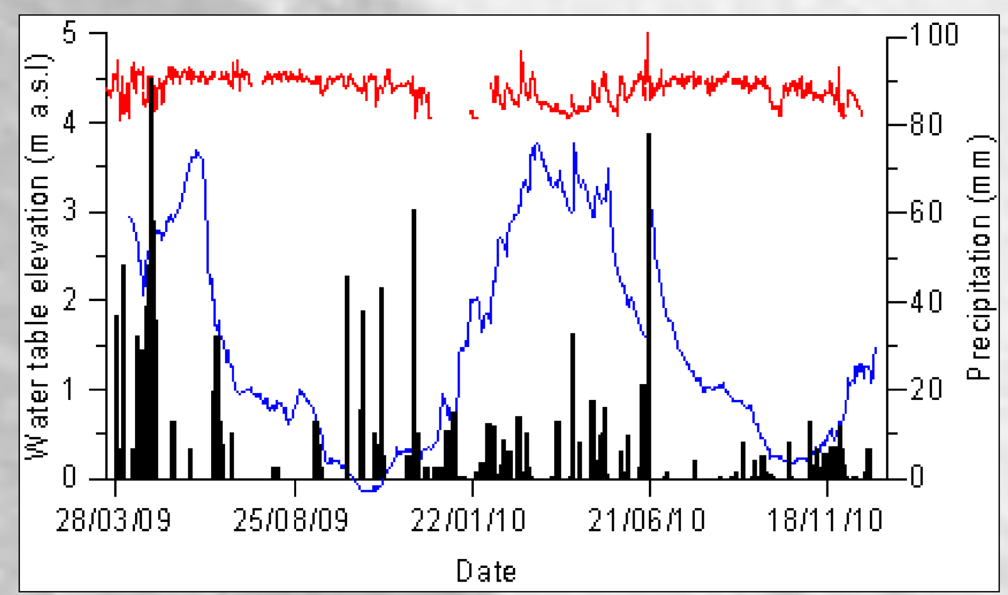


**Fig. 4: rainfall and water level recorded at the site in the canal (red line) and in the piezometer (blue line)**

At the site nitrate mass transfer to the unconfined aquifer was slow as shown in Figure 5 and concentrated at the end of the winter season, when the water table rose and brought in solution the available $NO_3^-$.The $NO_3^-$ concentration in surface water was generally comprised between 8 and 15 mg/l, but displays peaks of even 80 mg/l during flood events, when the canal is used as floodway and collect water coming from the Apennine hills. For comparison with $NO_3^-$ in Figure 6 is plotted the EC recorded in the piezometer and in the canal, is evident that the EC of the surface water is always lower than the EC of the groundwater. The EC in the canal is oscillating during the year with maximum values in winter and minimum in summer, groundwater is also oscillating but with more peaks during the year. The groundwater EC is generally increasing when the water table rises, since it dissolved the salts accumulated in the vadose zone. While during the summer seasons EC decreases because groundwater is replaced by canal water that have lower EC.

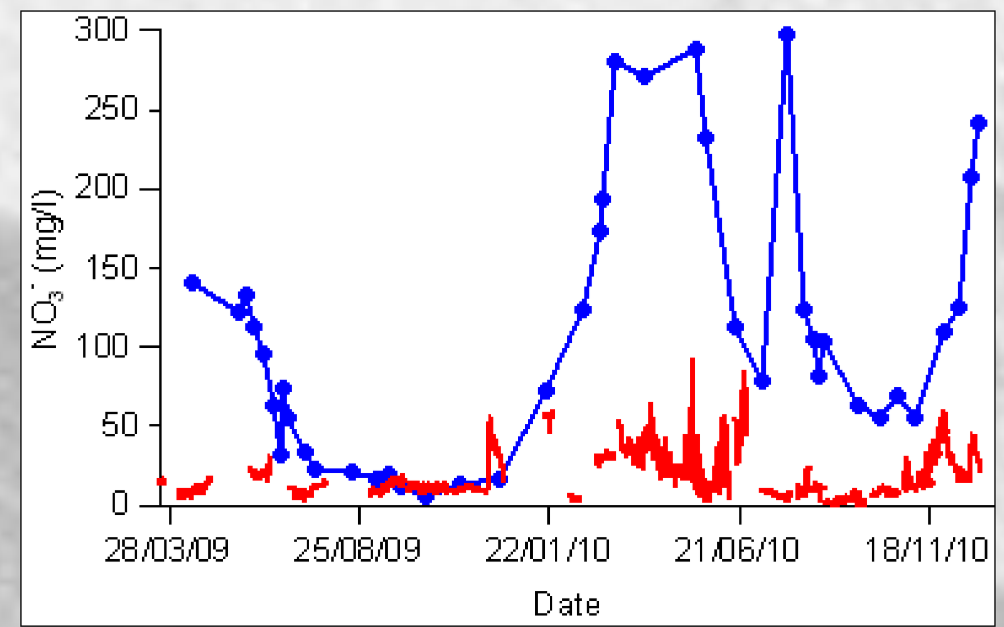


**Fig. 5: $NO_3^-$ recorded at the site in the canal (red line) and in the piezometer (blue line)**

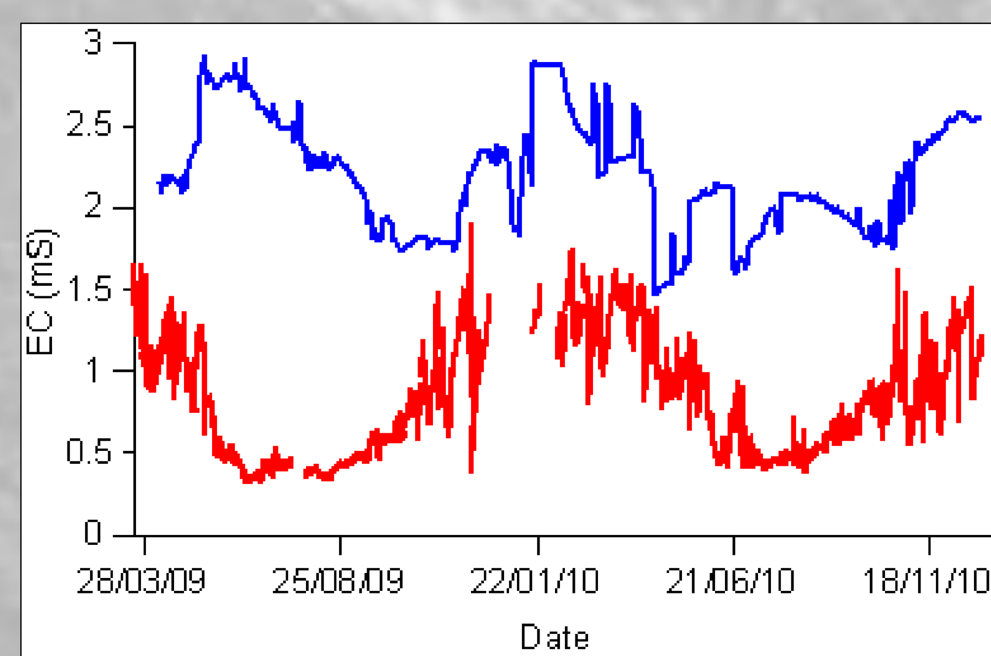


**Fig. 6: EC recorded at the site in the canal (red line) and in the piezometer (blue line)**

## 4 . Conclusions

Results highlight the importance of a continuous monitoring to fully understand connections between surface and groundwater in alluvial environments and the need to integrate it with detailed estimates of biogeochemical processes when quantifying nitrogen export from agricultural soils to groundwater.

## 5 . References


Christiansen J S, Thorup-Kristensen K and Kristensen H L (2006) Root development of beetroot, sweet corn and celeriac, and soil N content after incorporation of green manure. J Horticult Sci & Biotech 81 (5): 831–838

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