

# Groundwater flow and Nitrate content in the shallow and unconfined aquifer of the upper plain of the Province of Modena

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## INTRODUCTION

Due to the widespread of intense agricultural activities, nitrate pollution is one of the main causes of groundwater quality deterioration.

In Emilia Romagna Region, high amount of nitrates are commonly detected along the upper part of the Po plain, where infiltration processes from the ground-surface could become more active through the coarse deposits of the alluvial fans. In the case of the Taro, Enza, Tiepido, Sillaro shallow aquifers, this phenomenon is so severe that NO<sub>3</sub> content can exceed the maximum limit for safe drinking water law (50 mg/l) up to reach 140 mg/l (Marcaccio 2008).

The aim of this work is to improve the knowledge on the groundwater flow and quality characterising the shallower and phreatic aquifers. Field activities has been done between autumn 2010 and summer 2011 (2 campaigns) and they focused on 53 wells spread over the Tiepido alluvial fan (Province of Modena).

They consisted of groundwater levels monitoring and physical analyses (temperature, pH, electrical conductivity), while waters were sampled for chemical in-lab characterization (major ions and NO<sub>3</sub>).

Results allowed to provide several thematic maps which could be useful for further groundwater vulnerability studies: groundwater level; overview of the chemical quality state; distribution of pH, electrical conductivity, NO<sub>3</sub>, SO<sub>4</sub>, Cl.

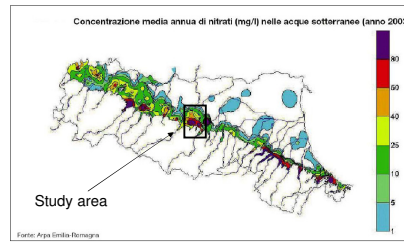
## HYDROGEOLOGICAL SETTING

The study area is located in the upper portion of the plain of the Province of Modena. The area coincides with the alluvial fans of the Secchia and Tiepido rivers, close to the foothills, and it has an extension of about 85 km<sup>2</sup>.

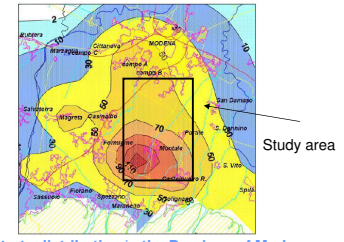
The stratigraphy is composed by 150 meters of alluvial continental sediments (Plio-Pleistocene age). It is made up of gravely and sandy horizons (aquifer; permeability up to 10<sup>-4</sup> m/s) separated by silty clayey levels (aquiclude-aquitard) (Gasperi et al. 2005).

In the research only the first 20 meters in depth of the unconfined aquifer were characterized. This portion was identified as A0 by Emilia Romagna Geological, Seismic and Soil Survey. Laterally A0 is not always continuous and in some cases it is closed by aquicludes, giving rise to springs. Moreover it is characterized by perched aquifers. A0 is recharged directly by the rainfall and by the surface water bodies. Geological Survey has identified below the A0 aquifer the unconfined A1 aquifer. In some cases the two aquifers are directly connected; in other cases they are separated by aquitards, which allow low vertical exchanges of groundwater between A0 and A1.

In the current research, only wells with maximum depth in the order of 10-20 meters have been taken into account. As proposed by the Geological, Seismic and Soil Survey of Emilia Romagna region, they match to A0 aquifer (the shallowest one).



Nitrate distribution in the Emilia Romagna Region (ARPA)



Nitrate distribution in the Province of Modena (ARPA and Pr. Modena)

## RESULTS

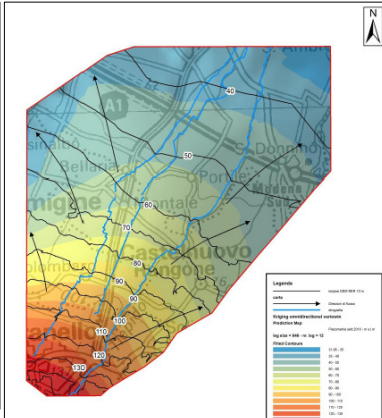
Wells placed in municipality of Maranello and Formigine were completely dried. In the other ones, the groundwater table depth ranged between 0.50 and 15 meters.

No substantial difference, was detected between the two campaigns if we exclude few wells where the water table decreased of some meters. This phenomenon seems related to the intense crop irrigation.

The interpolation of water table levels shows as the shallow aquifer is connected and recharged by the Tiepido river. Moreover, local intense pumping were highlighted in Formigine and Maranello municipality.

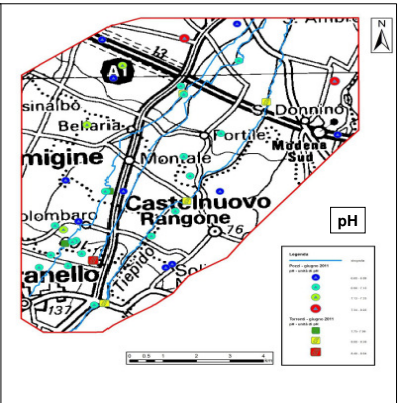
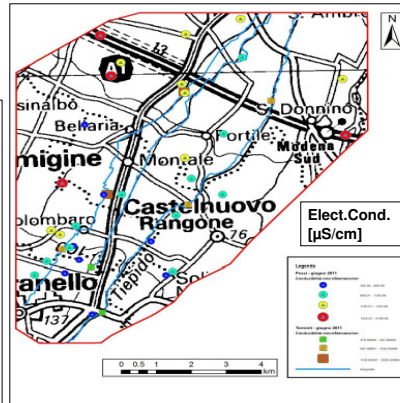
For the chemical point of view, groundwater is Ca-HCO<sub>3</sub> while pH is between 6.60 and 8.20. The electrical conductivity varies from 590 (foothills area) up to 2190 µS/cm (distant part of the alluvial fan). Cases of agricultural or human pollution have been detected; some samples were characterized by high NO<sub>3</sub> contents (4 wells exceeded 50 mg/l, max. value 146 mg/l) and in some samples, NO<sub>3</sub> was associated to remarkable level of Na (max. 151 mg/l), K (max. 10 mg/l), Mg (max. 60 mg/l), Cl (max. 368 mg/l), SO<sub>4</sub> (max. 191 mg/l).

In the local rivers, the electrical conductivity of the water is in the range 378 and 2020 µS/cm, instead the pH is in the range of 7.75 - 8.94. In the Tiepido the amount of NO<sub>3</sub> is in the range 1 - 20 mg/l. The direct recharge from the river to groundwater, together with the low concentration in NO<sub>3</sub>, favours a dilution in the amount of NO<sub>3</sub> in the A0 aquifer.

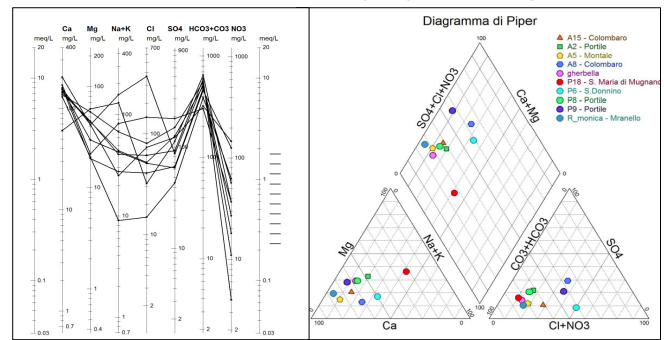


Investigate wells (maximum depth 20 meters). Red points absence of groundwater; Cyan points groundwater depth range 0-20 m

Water table level map for the shallow aquifer



Groundwater Electrical Conductivity and pH in the investigate wells

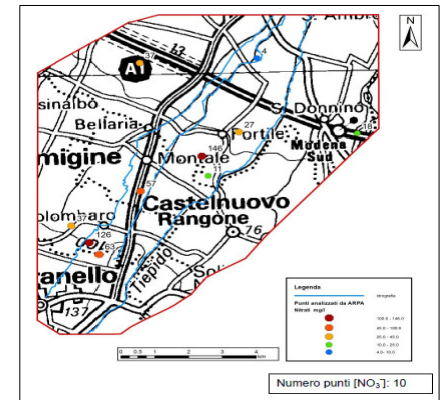
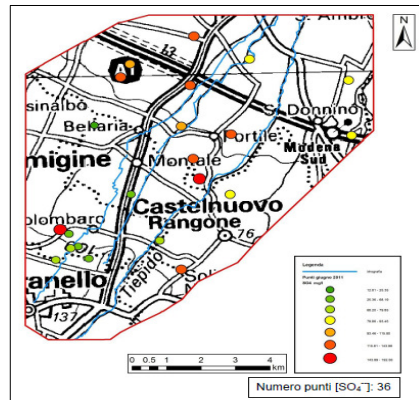
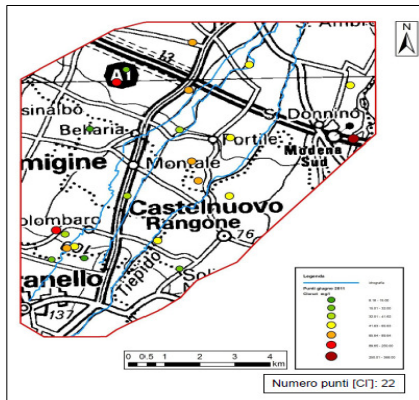


Groundwater chemical analysis plots for 10 selected wells

## CONCLUSION

The work has permitted to elaborate a first groundwater level map of the shallowest aquifer hosted inside the alluvial fan of the Tiepido river. The interpolation showed an important recharging process from the Tiepido river. At north-westward of the study area, instead, it shows as the groundwater level was lowered by the agricultural and industrial water supplies and/or by the drainage action caused by the near Secchia river's alluvial fan (which is characterized by high hydraulic conductivity and by high thickness of gravely sediments).

The physical and chemical measures highlighted cases of pollution by human activities, probably agricultural. In some wells, the nitrates content exceeded 100 mg/l and high concentration of K, Mg, Cl was found.



Concentration of Cl - SO<sub>4</sub> - NO<sub>3</sub> in the investigate wells