RECHARGING THE PHREATIC AQUIFER IN THE UPPER FRIULI PLAIN, ITALY, BY A LARGE INFILTRATION BASIN

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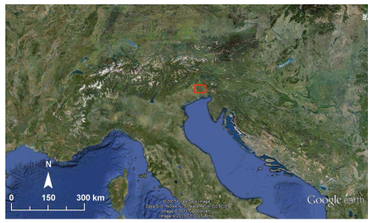
1 - BACKGROUND



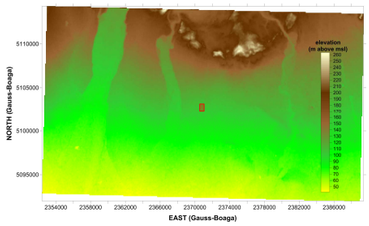


Fig. 1 – Location and DEM of the study area

Even though the Friuli Region, northern Italy (Fig. 1), is one of Italy's rainiest areas with an average yearly rainfall that ranges between 1300 mm along the cost up to 3000 mm at the Alps foothills, the groundwater level is continuously decreasing over the last years. To cope with this reduction of water availability and increase the subsurface storage of high-quality surficial waters that usually are lost during winter flowing into the northern Adriatic Sea, an artificial recharge project is ongoing within the WARBO LIFE+ Project funded by EU.

WARBO is aimed at implementing large-scale use of artificial recharge in Italy where water directives still strongly limit its application. The project involves regional authorities and public and private stakeholders operating in the field of water management and treatment with the aim of guaranteeing the future application of the defined methods and the development of specific experimental protocols to overcome the boundaries posed by the current legislation.

2 – EXPERIMENTAL SITE

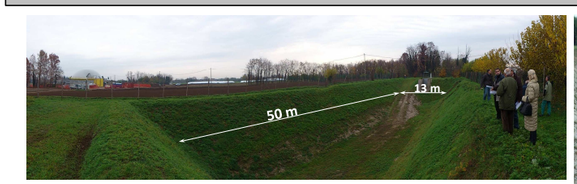


Fig. 2 – Photo and dimensions of the infiltration pond in Mereto di Tomba

In this context, the Mereto di Tomba recharge site (Fig. 2) selected in the upper Fruili plain is emblematic. Here a large infiltration basin, about 5 m deep and 50×7 m^2 wide, was built in the early 2000s but the use was prohibited by law soon after the construction. Only recently, within the WARBO Project, the possibility of implementing the recharge has been allowed. The site is characterized by an elevation of 105 m above msl and the depth to the water table averages 50 m. A 1-month infiltration experiment is planned for April-May 2013, whereas the full-scale recharge will occur each year over the autumn-winter season when the surficial water derived from the Tagliamento river are not used for irrigation. The depth to the water table averages 50 m.

3 - PRELIMINARY INVESTIGATIONS

In-situ tests and geophysical investigations have been carried out to characterize the vadose zone and the unconfined aquifer in the study area:

- detailed lithostratigraphy in six 70-m deep boreholes (Fig. 3). The typical geology of the upper Friuli plain consists of a thick non-differentiated layer of coarse alluvial sediments. However, a log stratigraphy analysis in the wells within a range of 6 km showed a certain heterogeneity degree with the presence of some intercalating layers of gravel, conglomerate and clay;
- infiltration tests: it was carried out in the pond and the calculated vertical hydraulic conductivity (in the non-saturated mean) was 10^{-4} m/s;
- an DEM of the pond: a LIDAR survey was performed to accurately characterize the basin geometry (Fig. 4). A volume versus height curve has been consequently derived;
- grain-size distribution curve (Fig. 5): the characterization of a shallow sample has been carried out using the ASTM D422 procedure. According with USCS, the deposit is classified as poorly-graded gravel (gravel: 75%; sand: 18%; silt and clay: 7%). Grain-size distribution and volume-mass properties are used to define the soil-water characteristic curve used in the numerical simulations;
- geophysical surveys: the results of a couple of electrical resistivity topographies (ERT) performed from the pond bottom (Fig. 7) have displayed some heterogeneity, at least in the upper meters (Fig. 8).

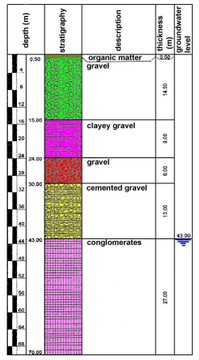


Fig. 3 – Representative lithostratigraphy

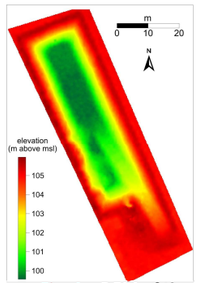
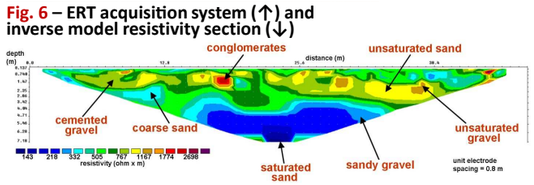


Fig. 4 – DEM of the infiltration pond

Fig. 6 – ERT acquisition system (↑) and inverse model resistivity section (↓)



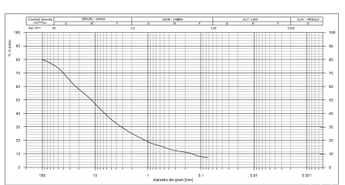
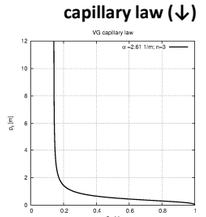


Fig. 5 – Grain-size distribution curve (↑) and associated Van Genuchten capillary law (↓)



4 - MODELLING: PRELIMINARY RESULTS

A preliminary investigation has been carried out with the aim of assessing the radius of influence of the pond infiltration. Two analytical solutions were used (Fig. 7):

- Todd, for a steady-state condition;
- Bear, for a transient condition (6 month of recharge).

A 3D FE code solving the Richards equation is applied to the experimental site. The 3D mesh (Fig. 8) accurately accounts for the actual DEM and lithostratigraphy. Preliminary simulations in homogeneous conditions (Fig. 9) shows that few days suffice to the infiltrated water to reach the water table. After 1 month a ~250 m influence radius is computed.

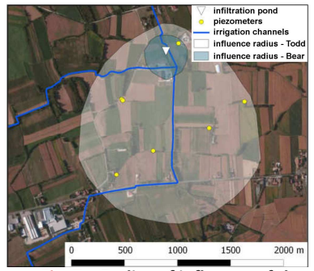


Fig. 7 – Radius of influence of the Mereto di Tomba infiltration pond (steady-state and transient conditions) with the location of piezometers established at the date

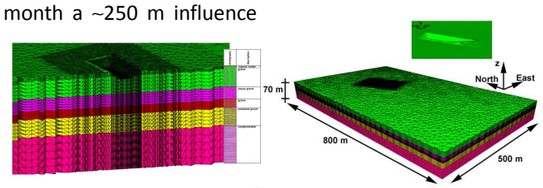


Fig. 8 – Perspective view and section of the 3D FE mesh (246'948 nodes, 1'416'225 elements)

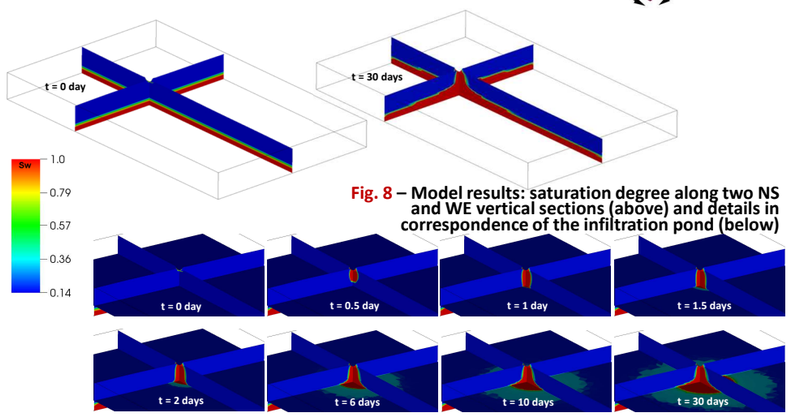


Fig. 8 – Model results: saturation degree along two NS and WE vertical sections (above) and details in correspondence of the infiltration pond (below)

5 - CONCLUSIONS

The results of these investigations will greatly reduce the hydrogeological knowledge gaps and will be used to fine tune the recharge program and to define the monitoring concept. More detailed geophysical investigations (both HR seismic surveys and TL-ERT) will be performed to calibrate the numerical model. The final aim of the study will be to provide a multi-disciplinary methodology for the implementation of managed aquifer recharge programs using existing structures.

Acknowledgments: the research is carried out within the EU LIFE+ Project "WATER RE-BORN - Artificial Recharge: Innovative Technologies for the Sustainable Management of Water Resources"

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