## A3-6 Orale Quaranta, Nicola

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**MULTI-DISCIPLINAR APPROACH AND APPLICATION OF GROUNDWATER FLOW-TRANSPORT SIMULATION MODELS FOR REHABILITATION OF A COASTAL ALLUVIAL AQUIFER AFFECTED BY NITRATE POLLUTION.**

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*Key terms: nitrates pollution; aquifer modelling; nitrates reduction*

The aim of this study is the caractherization of the alluvial acquifer of the Metauro Plain in order to compare solutions to reduce the nitrate contamination of groundwater for human use.
The study area (about 5000 hectares) is located in the Metauro alluvial plain in the municipality of Fano (Pesaro Urbino district, Marche, Italy), between the Torno Falcineto site and the shoreline; land use is featured by diffuse urbanisation, industrial plants, commercial centers and motorways, with important gravel quarries; intensive agricultural practices are widely diffused.
During most of the year, the water demand for human use is satisfied by diversion from the Metauro river (trough purification plants); in the summer period, increasing water demand due to touristic pressure coupled with low-flow conditions in the river requests groundwater uptake; artificial recharge system installed by the water managing society (ASET) at the Torno potabilization plant is composed by lines of iniection wells inflowing Metauro's freshwaters already in the early spring, in order to lower high concentration of nitrates (> 100 mg/l) caused by infiltration and transport of fertilizers in agriculture.
The Metauro Plain unconfined aquifer (gravel and sands) lies upon a Pliocenic Clay Formation (bedrock) at depth of 20-40 meters below ground surface. The top of the bedrock could be encountered along the right bank of the Metauro river, because of the effects of neotectonic tilting.
The piezometric monitoring network has been set-up with on-site selection of private and human use wells oriented to obtain optimal density with geostatistic tests.
Positioning the monitoring wells has been supported by high precision GPS surveys based on a dual frequency RTK system; the GPS survey has been hooked up to IGM points in the GIS environment.
In order to evaluate the groundwater geochemical features, two monitoring survey have been scheduled, representative of different hydrological conditions (winter time and summer season).
The samples from has been analyzed in ASET specialized laboratory in order to evaluate the main composition of groundwater and distribution of geochemistry facies (Piper and Schoeller diagrams, statistical methods "cluster analysis").
Moreover, the areal distribution of the main measured hydrochemical parameters concentration in the groundwater has been represented through iso-concentration maps, in order to identify the processes of recharge and diluition by freshwaters into the acquifer.
Pumping tests in the well-field of Torno site have been performed in order to evaluate the hydrodynamic parameters of the aquifer system (hydraulic conductivity, transmissivity, specific storage) using both extraction and two observation wells over a time period of 48 hours with a data logger automathized system. Distribution of hydrodynamic parameters in the aquifer has been evaluated also by correlation between transmissivity and specific discharge (defined with step-test).
Aquifer vulnerability has been evaluated also in terms of potential risk of pollution by nitrates, using the IPNOA distributed model for the identification of the agricultural sources of N-inflow.
Numerical models (MODFLOW) has been setup at the intermediate scale (well-field and surrounding areas), calibrating on the monitoring data, in order to reproduce and evaluate the efficiency of the artificial recharge techniques since now used and suggest improving solutions.
Particle-tracking technique allows to define the protection zones of the wells, defining safety times and consequent measures to be respected in the agricultural practices in the nearby of groundwater uptakes.
Alternative solutions can be searched in the direction of reactive permeable barriers, actually in phase of preliminary identification and modelling.

## A3-7 Orale Mottola, Adolfo

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**HYDROGEOLOGICAL MODELLING IN GIS ENVIRONMENTAL: EVALUATION OF ARCHYDRO GROUNDWATER PLUG-IN CAPABILITY FOR A WELL-FIELD DESIGN LOCATED ON SARNO RIVER PLANE (SALERNO, ITALY)**

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*Key terms: Groundwater Modeling; Gis; Hydrogeological Modelling; Modflow; RadMod*

Groundwater flow and contaminant fate and transport modeling is an important component of most aquifer remediation studies and it begins to obtain an intense utilization by environmental government agencies and environmental consultant associations. This task becomes extremely time consuming, when the modeler is required to analyze complex heterogeneous aquifers and faces manipulation of large amounts of input and output data structures, which are model specific.
Geographic Information Systems (GIS), on the other hand, provide a platform in which layered, spatially distributed databases can be manipulated with ease, thereby simplifying the implementation of data management tasks of model building and model calibration significantly. MODFLOW (USGS) graphical interfaces (pre-post processing) have been created, tested extensively and used in numerous field applications since 1990. In later revisions these programs were upgraded to WINDOWS'95 platform, while significantly increasing the graphics capabilities and the capacity of the software. In the present work, in an effort to aid modelers, a GIS integrated groundwater flow and contaminant fate and transport modeling platform is developed using Arc Hydro Groundwater plug-in, which connects MODFLOW to ArcGIS®. The GIS platform facilitates the time consuming task of preparation of data input and output structures for multilayer groundwater flow and contaminant fate and transport simulation codes. Utilizing the GIS platform, the user may develop groundwater flow and contaminant fate and transport modeling applications with relative ease. The purpose of this work is to evaluate the capability-limits of this new GIS-Modelling software by well-field design located on Sarno River plane (Salerno, Italy).

## A3-8 Orale Preziosi, Elisabetta

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**COUPLING GROUND WATER MODELING AND GIS: A DECISION MAKING TOOL FOR GROUNDWATER MANAGEMENT TO SUPPORT AN IRRIGATION SYSTEM. A CASE STUDY IN MOROCCO**

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*Key terms: GROUND WATER MODELING; GIS; INTEGRATED WATER RESOURCES MANAGEMENT; MONITORING NETWORK*

In the framework of the EC FP6 Integrated Project "AquaStress" (www.aquastress.net), Tadla irrigated perimeter in Morocco has been selected as a test sites representative of water stress in the agricultural sector in the Mediterranean climate. In Tadla perimeter, located in the Oum Er Rbia basin, 200 km northeast of Marrakech, irrigation is currently sustained mainly by surface waters coming from the local irrigation system via an important network of canals. Recently ground waters are becoming more and more exploited by private wells in order to support agriculture especially during droughts. Irrigation return constitutes the main recharge to the underlain phreatic aquifer and has caused in the past an excessive uprise of the water table leading to the degradation of soil and water quality. Conversely, during periods of intense droughts, the aquifer has suffered from strong drawdown enhanced by the overexploitation of groundwater by means of private wells.
In this communication a water stress mitigation option which has been implemented in collaboration with local stakeholders such as ORMVAT (local water supplier for irrigation) and ABHOER (Oum Er Rbia river basin authority) is described. It aims at providing the water managers with a "easy to use" decision support tool, which could be able to give advise on how to control excessive water table fluctuations when they exceed defined thresholds; this task is carried out producing scenarios arising from different management options, by means of a ground water flow model which is grounded on the piezometric data coming from the monitoring network activities. The water managers are given the possibility to choose the most suitable management option comparing the simulated scenario with a target piezometric situation.
The "Tadla Groundwater Management Tool" (TGMT) is a GIS application in which data, models and user interfaces are integrated in the GIS environment (ArcGis 9.2) in a "tight coupling" approach. The numerical flow model has been implemented with the finite differences code MODFLOW. The operator is given the possibility to produce an interpolation of the heads measured in the local monitoring networks, identify the critical situations and elaborate possible scenarios in relation to different management options.
The tool has been specifically designed for Tadla aquifer and its irrigation system and cannot be applied "tout court" to other similar situations; however the architecture of the tool and the GIS environment can be easily adapted to other sites, providing the existence of analogous data bases.

## A3-9 Orale Tarragoni, Claudia

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**PROPOSED METHOD FOR GROUNDWATER MODELLING OF FRACTURED SYSTEM IN RUMPLED AREA**

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*Key terms: Groundwater modelling; Transmissivity; Rapresentative Elementary Volume; Fractured system*

A parameterization of the transmissivity of lower Fiastrone Scaglia calcarea Complex is developed.
The NEWSAM program, used to simulate porous aquifers, has been applied to a fractured system of the Apennine belt area; therefore the simulation was simplified accordingly by taking into account:
- Exclusion of flood phenomena (representation of stationary regime);
- Partial representation of aquifer (exclusion of sectors with turbulent regime);
- Assumption of equivalent continuous medium (when supported by the observation on discharge regime).
Moreover, the Representative Elementary Volume (significantly larger than fracture volume, therefore that it is possible to consider it as a continuous volume with homogeneous properties) has been considered to minimize the scale effect of karstic medium.
The first step was to analyse stratigraphic, sedimentological and tectonic data, identifying the main hydrogeological units of the area. The complex hosting the aquifer has been modelled using a grid.
The second step was to identify and quantify the springs, their regime and mean discharge value (a detailed analysis of base flow was carried out through hydrogeological survey directly performed in the rivers).
Subsequently the attention was drawn on the detailed three-dimensional reconstruction of the spatial pattern of the aquiclude (a detailed analysis of structural setting was carried out through geological sections normal to the analysed structure).
The following example is based on a simulated aquifer with dimension 5000 m x 6000 m. The grid has 17 rows and 12 columns (188 cells), with first order cell dimensions of 500 m x 500 m and second order cell dimension of 250 m x 250 m.
Each cell has been provided of water input (based on hydrogeological balance) and transmissivity value; the cells corresponding to linear spring have been defined as draining cells and they have been provided of mean altitude value. Only the mean discharge value has been used in the inverse procedure for

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