A COMPARISON BETWEEN TWO STOCHASTIC APPROACHES TO ASSESS GROUNDWATER PCE DIFFUSE POLLUTION IN MILANO FUNCTIONAL URBAN AREA

Luca ALBERTI [1], Loris COLOMBO [1], Giovanni FORMENTIN [2]

[1] Department of Civil and Environmental Engineering, Politecnico di Milano, Piazza Leonardo da Vinci 32-20133, Milan, Italy, luca.alberti@polimi.it
[2] Tethys srl, Viale lombardia 11-20133, Milan, Italy, giovanni.formentin@tethys.srl

Contamination of groundwater resources in highly urbanized areas has become, over the last two decades, one of the most important environmental issues at both European and National level. In Italy, the Po plain, and in particular the Lombardy Region, is one of the most populated European areas where human activities have caused a high impact on groundwater quality. Recently, the new National and Regional regulations consider the necessity to develop plans for the remediation and management of the most industrialized urban areas, affected by groundwater contamination due to both point sources (PS, associated with medium-large sources dimensions, i.e. hot-spots) and multiple point sources (MPS, constituted by a series of unidentifiable small sources clustered in a large area, that cause a diffuse contamination). Due to the European relevance of the topic, the EU project AMIIGA (Interreg. Central 2016-19) has recently started with the aim to set up a common methodology to assess MPS diffuse groundwater contamination in European Functional Urban Areas (FUA).
Because of the uncertainty related to the exact position and strength of MPS, it is complex to implement a numerical model able to simulate the fate and transport of a diffused contamination. Nevertheless, such kind of models are requested by Public Authorities as a tool to manage the groundwater resource and plan the necessary actions to improve water quality. To overtake this problem, a numerical stochastic model (code MODFLOW/MT3DMS) was implemented in a pilot area north-east of the Milano FUA. The proposed methodology allows to consider the uncertainties linked to diffuse contamination sources (MPS) using a Monte Carlo (MC) procedure. Several calibrated models were generated considering the effect of some parameters governing groundwater flow and transport (namely hydraulic conductivity, heterogeneity, and mass released by unknown sources).
Two different stochastic approaches were developed and compared:

- Particle backtracking (BT) through 400 MC realizations varying the distribution of hydraulic conductivity. Using MODPATH, placing particle starting points where a PCE was measured in low concentrations linked to diffuse contamination, it was possible to highlight the cells most frequently crossed by particles, interpreting them as the cells most probably hosting a MPS.
- Clustered MPS through 100 MC realizations considering the variability of contaminant mass released into the shallow aquifer. Using MT3D, for each domain sector it was possible to assess, in a probabilistic way, the distribution of MPS contaminant and the frequencies of mass inflow occurrence into the model domain.

The results of the two approaches were compared in order to collect information about those

areas that most likely host sources of the observed diffuse contamination. In most of the cases, the identified areas match. Some improvements are necessary though, mostly in areas near the boundary conditions of the models.
Regarding the computational aspects, it is possible to affirm that particle BT is faster than the clustered MPS approach. Moreover, the latter requires several information to implement the inverse problem.
Concluding, the study shows that mathematical models within a probabilistic framework have a high potentiality and can represent a powerful tool for groundwater management planning in FUAs susceptible to diffuse contamination.