5. Conclusions

The research area of these three years has focused on the study and modeling of pollutants in groundwater. More specifically, a bibliographic research and a subsequent in-depth study of 1D,2D and 3Ddimensional ADE models and their applications were conducted to examine the state of the art and possible development points.

The research carried out has allowed the development of new one-dimensional models in semi-finite domain for a reacting solute subject to first order decay and linear equilibrium sorption: third and first type boundary conditions were considered by modelling simultaneous production and decay at the source, finite release at the source by Heaviside function, and consecutive reaction decay.

Model have been tested using literature data. A subsequent comparison with known solutions was done.

Analytical solutions here proposed can be suitable to describe contaminant release due to failures in underground tanks or pipelines.
The source in fact is expressed, in one of the solutions proposed in Chapter 3, as a combined production-consumption time-dependent function.
An initial small leakage, with an increment in concentration is usually observed in underground tank failure. This phenomenon at the source is due to the enlargement of the failure. A further concentration decrease happens when the tank is empty.
The proposed model can also describe NAPL pools degradation as PCE to TCE or radioactive first order decay series at the source.

A three-dimensional solution starting from the new one-dimensional solution with simultaneous source decay and production subject to Dirichelet boundary conditions was developed on the base of Green Function Method hypothesis.
The three dimensional solution has an integral expression that needs to be evaluated numerically.
An approximated closed form was then derived on the base of Domenico approximation (Domenico, 1987).
Both the approximated closed form and the integral open one were analyzed by performing simulations. Tests were performed by varying values of some significant parameters such as source production and decay constants. Relative error diagrams were created in order to test the precision of the approximated closed form with respect to the integral one. Concentration contours were generated in order point out similarities and differences between the two models. Another important comparison was done by performing simulations at different time steps and along the x axis centerline.

Another three-dimensional approximated closed form solution with source decay only has been modelled.

It was compared with the exact integral solution already present in BIOCHLOR-AT. Relative error diagrams, concentration profiles, longitudinal sections and transverse sections are given, they confirm that the closed form solution makes acceptable errors in the central area of a width at least equal to the source width. Some simulation at different simulation time were performed: high errors appear for high simulation time but in region of very low concentration.

For both approximated solution found, the closed and the open form models give different results far from the centerline but in regions where concentration values are very low while they are really accurate in areas of great importance such as along the centerline.

Another study, presented in Chapter 2, focused on differences between three-dimensional problems with plane and volumetric sources, finding out that the former represent the limit solution of the latter if the thickness of the volumetric source tends to zero along x axes.
In particular, we considered the three-dimensional problem with plane source put as boundary condition and subject to first order source decay and the three-dimensional problem with volumetric source put inside the domain. We found out, both analytically and numerically, that the limit for x tending to x_0 of the latter is totally equivalent to the former.
Finally, 3D analytical solutions considering a volumetric source inside the domain or a plane source as a boundary condition of the first or of the third type were found to be equivalent at the limit.