A methodology for the assessment of soil and groundwater contamination in a refinery

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The main objective of this study was a preliminary assessment of the soil and groundwater contamination inside the limits of a refinery, with an associated petrochemical complex, with more than 40 years of uninterrupted activity, located in the Atlantic seashore. The first phase in the methodology was the physical characterization of the site. The topography of both the surface and the bedrock was modulated and the structure of the soil and the aquifer was characterized using three-dimensional stratigraphic models. The bedrock topography clearly evidenced the existence of a valley originating preferential flows for the groundwater.

For the construction of three-dimensional stratigraphic models we used data obtained by seismic refraction, while for the aquifer model we used local piezometric data obtained in the same period of the year – a typical month of November.

The second phase was the characterization of the space distribution of the contaminations. To reach that purpose, we used data produced both by the analysis of the soil gas and from the samples of groundwater collected from the local piezometers. For each variable we built a semivariogram (either spheric or Gaussian) and we selected the corresponding fitting parameters (nugget effect, contribution and range) so that an ordinary or a universal kriging could be applied. We could than infer lines of iso-concentration.
In the next phase of our methodology, we applied several multivariate statistical methods to the concentration data of several classes of contaminants obtained from samples that were taken collected in each hole. We used principal component analysis, R-mode factor analysis, with and without factor rotation, Q-mode Factor Analysis and Correspondence Analysis. The statistical study allowed an unequivocal definition of four different contamination profiles.

Finally a new campaign allowed the collection of 40 soil samples, located at different depths and selected from criteria induced by the original preliminary data analysis. In each sample a broad set of parameters was determined: density, moisture, pH, organic matter, total organic carbon, grain size, texture, TPH and BTEX and concentrations in nitrogen and phosphor and 20 different heavy metals.

Finally, in the last phase of the methodology, the global interpretation of all the information allowed to define a first integrated strategy for a future remediation of the site, both during industrial activity and in an eventual future after closure.