



## **Isotopes content analysis in saturated-unsaturated transition area and in the groundwater to support the investigation of nuclear underground events**

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Unexpected CH<sub>4</sub> and CO<sub>2</sub> releases from the underground and noble and conventional gases in groundwater could be favored by the mechanical stress induced by an underground nuclear explosion. A suitable monitoring protocol could aim to detect gases in the soil, focusing the investigation in the transition area between saturated and unsaturated. By means of an appropriate monitoring network, it is therefore possible to identify sampling areas for capture of gases conventionally present in the soil, such as methane and CO<sub>2</sub>, and of noble gases and conventional gases dissolved in groundwater. The method proposes to verify possible correlations between underground nuclear events and anomalies in the concentrations of gases from the ground, in order to correlate the fluctuations of atmospheric conditions with endogenous contributions and to verify if there is a correlation with gases anomalies in the aquifers solution. This method allows to overcome local geological factors and to be able to analyze even non-investigable areas. Combining the saturated-unsaturated level of the anomalous emanations of some relevant noble gases (Xenon-133 and Argon-37) with the activity of the same gases in solution in the aquifers, it is possible to verify possible relationships to define the diffusion and release models. These models could be validated by comparison with measurements performed on naturally occurring gases in the waters solution such as Rn, Th, H isotopes, O isotopes, CO<sub>2</sub>, CO, SO<sub>2</sub>, CH<sub>4</sub> etc.,. These correlations could be useful for verifying anomalies in the reference background contents of dissolved gases, present in the solution of multi-aquifer systems.