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Detection and monitoring of volatile and semivolatile pollutants in soil through different sensing strategies

Fabrizio De Cesare (1,2) and Antonella Macagnano (2)

(1) Department for Innovation in Biological, Agro-food and Forest systems (DIBAF), University of Tuscia, Viterbo, Italy (decesare@unitus.it), (2) Institute for Microelectronics and Microsystems (IMM), National Research Council (CNR), Rome, Italy (antonella.macagnano@artov.imm.cnr.it)

Pollutants in environments are more and more threatening the maintenance of health of habitats and their inhabitants. A proper evaluation of the impact of contaminants from several different potential sources on soil quality and health and then on organisms living therein, and the possible and sometime probable related risk of transfer of pollutants, with their toxic effects, to organisms living in different environmental compartments, through the trophic chain up to humans is strongly required by decision makers, in order to promptly take adequate actions to prevent environmental and health damages and monitor the exposure rate of individuals to toxicants. Then, a reliable detection of pollutants in environments and the monitoring of dynamics and fate of contaminants therein are of utmost importance to achieve this goal. In soil, chemical and physical techniques to detect pollutants have been well known for decades, but can often drive to both over- and underestimations of the actual bioavailable (and then toxic) fraction of contaminants, and then of the real risk for organisms, deriving from their presence therein. The use of bioindicators (both living organisms and enzyme activities somehow derived from them) can supply more reliable information about the quantification of the bioavailable fraction of soil pollutants. In the last decades, a physicochemical technique, such as SPME (solid phase microextraction) followed by GC-MS analysis, has been demonstrated to provide similar results to those obtained from some pedofaunal populations, used as bioindicators, as concerns the bioavailable pollutant quantification in soil. More recently, we have applied a sensing technology, namely electronic nose (EN), which comprises several unspecific sensors arranged in an array and that is capable of providing more qualitative than quantitative information about complex air samples, to the study of soils contaminated with semivolatile (SVOCs) pollutants, such as polycyclic aromatic hydrocarbons (PAHs). The EN device set up on purpose involved suitable sensors and it was demonstrated to be capable of supplying information related to the whole soil environment as well as to the presence of contaminants and their dynamics, such as their biodegradation by soil microorganisms and the contemporary increase of CO_2 release. These results were also somehow related to those obtained through SPME-GC/MS analyses, since a list of substances could be identified to be responsible for the different classification of contaminated and uncontaminated soil samples obtained through EN. Presently, we also have got evidences that more complex sensing devices can be used for in situ monitoring of contaminated soils. We have designed and fabricated a multi-parametric hybrid sensing system, based on the assembly of several different sensors and sensing systems (i.e. single sensors and a sensor array), some of which are commercially available, while some others were created by design in laboratory and tested for their specificity. The main target of such a hybrid sensing device was to be capable of measuring various soil parameters and volatile pollutants (VOCs) in soil, such as BTEX (benzene, toluene, ethylbenzene and xylene), in order to relate the quantification and behaviour of contaminants in soil (e.g. solubility, volatility, phase partitioning, adsorption and desorption, etc.) to the relative environmental conditions, by measuring physical (temperature and moisture) and chemical (pH) parameters, which can affect such processes. Furthermore, a suitable procedure was set up on purpose to provide VOCs quantifications actually related to the bioavailable fraction of pollutants (passive vs. active sampling). That sensing system was also set up for a wireless communication of the recorded values to a data-collecting centre. Such a tool was designed to be used as a proper probe to insert into soil for in situ monitoring of contaminated sites in order to provide semi-continuous information about soil pollution conditions and evolutions, suitable for unskilled employees, on the basis of three different levels of contaminations and alarms. That probe might be then a suitable tool for decision makers about environmental risk assessment. Finally, an EN device has also been recently applied to detect microbial activity and biomass in soil. Then, the described sensing strategies might be successfully used to both monitor the presence of pollutants and their dynamics during and after remediation processes, in order to validate the effectiveness of the specific techniques applied in contaminated sites, and evaluate the recovery of soil metabolic activities and active microbial biomass.