

Application des Biomarqueurs et Bioindicateurs dans le cadre des évaluations des risques sur des sites pollués. Exemple du programme "Bioindicateurs"

The use of biomarkers and bio-indicators for risk assessment at polluted sites. Exemple of the "Bioindicators Programme."

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Soil can be considered as a non-renewable resource that must be protected because it is essential to our economic activities (it provides food, drinking water, biomass and raw materials) but its degradation is still accelerating (e.g. erosion, contamination, compaction). Thus protecting and managing soils require a set of indicators able to judge about degradation and/or remediation of its properties and functions. Within the large battery of indicators, bioindicators and more recently biomarkers, have emerged and seemed to be relevant in ecological risk assessment of soil contamination. The discrimination between bioindicators and biomarkers is based on the investigation level: biomarkers are related to below organism level and correspond to biological responses to an environmental constraint (e.g pollution); bioindicators are related to organism level (part of organism or population or community) and inform on the state and the functioning of ecosystem.

In order to develop and test the relevance of several biological indicators for risk assessment at polluted sites, a national research programme has been set up supported by ADEME (2006-20012). The main objectives of this "BioIndicator programme" are to (i) develop methods for measuring soil biodiversity and soil functions, (ii) use soil bioindicators to monitor soil quality and (iii) identify relevant bioindicators or endpoints for ecological risk assessment of soil contamination. The first step of this programme (finished in 2008) aimed to develop and to test 60 bioindicators, involved in 19 programmes and based on the following biological organisms:

- Bacteria and fungi (indicators based on the diversity and activity),
- Collembola and Nematodes (indicators based on the diversity),
- Earthworms and total macrofauna (indicators based on the diversity, activity, bioaccumulation and biomarkers),
- Snails (indicators based on the bioaccumulation),
- Birds and micrommalls (indicators based on bioaccumulation and biomarkers)
- Plants (indicators based on the diversity, bioaccumulation and biomarkers).

This step, due to multivariate analysis approaches, ended with the selection of 40 relevant indicators.

The 2<sup>nd</sup> step, started in 2009, aims to calibrate the different selected bioindicators (variability caused by soil use, by contamination or caused by climate change), to compare them each together (relevance in terms of sensitivity, accessibility, applicability) and to validate these bioindicators. The strengths of this programme are i) to test a large number of bioindicators (40), in a large panel of situations (51 sites) combining different soil types, land uses and practices (forest, pastures, organic farming, contaminated soils), ii) to apply standardised sampling protocols managed by only one sampling team, thus ensures a high quality of biological data acquisition, iii) to manage high number of data (100.000) by using a common database thus facilitates the data analysis.

The data mining of the results will select relevant bioindicators able either to monitor soil quality and to assess risks to ecosystems due to soil contamination. In parallel, this program provides a better understanding of soil biodiversity, notably by initiating the development of a national reference database, and related ecosystem services.