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BIOMARKERS IN ECOTOXICOLOGY OF SOIL INVERTEBRATES – SUITABLE TOOL IN ENVIRONMENTAL PROTECTION?

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Abstract: *Biomarkers in soil invertebrates are regarded as rapidly developing field in ecotoxicological research. They are used to both qualification and quantification of exposure and adverse effect of various environmental pollutants. Generally, they are considered to be more sensitive indicators of chemical stress than lethal or sublethal effects. This report provides critical overview of most examined and widely used as well as some prospective novel parametres in ecotoxicology of soil invertebrates, e.g. metallothioneins, stress proteins, cholinesterases, detoxification enzymes, parametres of oxidative stress and others. These selected markers are compared together with special attention to their characteristics crucial to practical use in environmental protection.*

Keywords: biomarkers, soil invertebrates, ecotoxicology, usage in environmental protection

In last years there has been an increasing interest in the use of biomarkers in soil invertebrates for the assessment of the potential adverse effects of chemicals on soil ecosystems. According to Scott-Fordsmand and Weeks (2000), the major reasons for that interest were limitations the classical approach to environmental toxicology, when serious adverse organism effects (such as mortality, reproduction, or growth) were directly related to chemical concetrations. However, under various environmental conditions the availability of the toxicant may differ, especially in soils, rendering it difficult to extrapolate laboratory toxicity data to variable field conditions. Thus biomarkers may provide more sensitive sub-lethal responses or enable quantifying the bioactive fraction of the pollutants. They may also integrate exposure or effects of complex pollution, various physical stresses or properties of real matrixes. These methods may be applicable under both laboratory and field conditions. If there is link between the observed biomarker response and deleterious changes to the organisms or its reproductive output, biomarkers may function as early warning indicators at higher levels of biological organisation.

Soil invertebrates offer meaningful targets becouse they play major role in the functioning of the soil ecosystem by enhancing soil structure and the decomposition of organic materials. Furtermore, these invertebrates represent a

major component of all animal species in soils and often are present in high population densities; thus, samples can be taken for analysis without significantly affecting population dynamics or ethical and legal limitations (Kammenga et al. 2000). These popular testing organisms belong to different taxonomic groups, i. e., nematodes (*Caenorhabditis elegans*), oligochaetes (earthworms *Eisenia fetida*, *Apporectodea caliginosa* and *Lumbricus terrestris*, enchytraeids *Enchytraeus albidus* and *E. buchholzi*), acarids, crustaceans (*Oniscus asellus*, *Porcellio scaber*), gastropods (snail *Helix pomatia*), collembolas (*Orchesella cincta*, *Folsomia candida*) and other insects. In connection to biomarkers, soil invertebrates have the advantage that they are in direct contact with soil pore water or food exposure, in contrast to many vertebrates exposed only through the food chain.

For a biomarker, or a battery of such, to be used in risk assessment some basic understanding is needed. The most basic requirement is that the biomarker can be measured in an organism relevant for investigated ecosystem. Knowledge is required about the range of hazards that elicit a biomarker response. To estimate the magnitude of the problem, a dose-response relationship between the exposure level and a biomarker response is essential. This need not to be straightforward as the biomarker response reflects only the bioactive fraction, which may or may not increase or decrease in the same way as the external dose of pollutant. To reflect *in situ* pollution, the biomarker response should have low inherent variability with a low, or at least a known, dependence on physiological and physiochemical conditions. Also, there should be known the induction time and the persistence of the biomarker response to estimate the likelihood and significance of detecting a response in field samples.

In ecotoxicology of soil invertebrates, there exist a range of biomarkers of toxic compound, including biomarkers from the molecular to the organismal level. Our report provides critical overview of most examined and widely used as well as some prospective novel parametres, e. g. DNA alterations, metallothioneins and other metal binding proteins, stress proteins, cholinesterases, detoxification enzymes, parametres of oxidative stress, lysosomal membrane integrity, imunological and histopathological responses, behavioural changes and many others. These selected markers are compared together with special attention to their characteristics crucial to practical use in environmental protection. This comparison emphasizes advantages and disadvantages in points as selectivity, methodology, influences and limitations, used tested organisms and inter-species diversity, seasonal variability etc.

In reported biomarker studies, the main emphasis has been devoted to identification of the mechanisms involved in these responses and possible dose-response relationships. Fewer studies have been concerned with temporal aspects, variability in responses or linkages to population-level effects. Moreover, these experiments have been performed under very different conditions. A broad range of chemicals have been tested in respect to biomarker response in soil invertebrates; however, for each biomarker the main emphasis historically has been placed on only a few chemicals. This lack of uniformity

makes comparison difficult and gives little indication of such biomarker responses under natural conditions. In some studies, i.e. Itziou and Dimitriadis (2011, in press), biomarker responses have been tested under field or semifield conditions.

For risk assessment purposes, according to Kammenga et al. (2000), it is recommended to rank biomarker responses on a defined scale in which the predicted „lowest impact index“ represents control conditions (no observable biomarker response) and the „highest impact index“ refers to conditions inducing maximum biomarker responses. The rating of scales must be adjusted for every investigated marker individually. Based on this approach, a standartized protocol of such biomarker response can provide information on the toxic potential connected to specific exposure (field) conditions.

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