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Mini Review

Earthworm Glutathione-Glutathione-S-Transferase: A Biomarker in Ecological Risk Assessment

Sulata Maity[1]* and Shibani Chaudhury[2]

[1]*Department of Botany, University of Calcutta, India*

[2]*Department of Environmental Studies, Visva-Bharati Santiniketan, India*

***Corresponding author:** GCS Negi, GB Pant National Institute of Himalayan Environment and Sustainable Development, Kosi-Katarmal, Almora, Uttarakhand, India

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Introduction

Modernization of human society generates numerous chemical from different sources and stimulate serious hazard to the ecosystem. Consequently, people are exposed to thousands of chemicals on daily basis by food, air, water, soil, dust, or the products we use without knowing their harmful effect. It's not easy for people to identify if those chemicals are risky to their wellbeing or not. These encountered problems require immediate scientific attention to find appropriate and cost effective solutions. Most ecological risk assessments are based on chemical residue analysis of environmental parameters, such as surface water, sediments and soils in addition to determination of species diversity and density of wildlife, though the biological significance of measured chemical concentrations are not so specific and quantitative [1]. Chemical analysis cannot predict actual bio available chemicals, assumed that it is 100% as obtained from analysis of environmental matrix.

Also the field assessment of individual survival and reproductive success cannot speculate the xenobiotics induced alteration in behavioural, biochemical, physiological or toxic responses in the organisms/ species, could affect the stability of a population. As a result, environmental modelling is unable to state real effect of the chemicals in people because of the large difference in predicted levels with respect to the actual levels of chemicals in the living organisms. To evaluate environmental health as well as effects of contaminants on organisms there is need of a biological approach as physicochemical analyses are unable to provide proper information on the biological status of ecosystems. Consequently, bio monitoring is most health relevant way of assessing exposure of environmental chemicals in organism to avoid errors in interpretation of environmental levels (measured in air, soil, water and food). In the course of bio-monitoring, biomarkers are the observable properties of an organism and are vital for the exposure assessment during direct measurement process. In true sense, Biologic markers or biomarkers may be used as the early warning indices of biologic effect and as quantitative measures of chemical exposures and biologically effective doses [2,3]. Biomarkers can provide us the evidence of exposure, the route and pathway of exposure, finally the effects of one or more chemical exposure. Biomarkers also have the ability to identifying priority exposures, recognizing time trends in exposure, identifying at risk populations (Large biomarker studies can distinguish exposure differences among racial, geographic or socio-economic groups), providing integrated dose measurements (biomarker analysis provides a direct assay of body burden that integrates exposure from all sources, even ones that hard to measure) and finally evaluating exposure prevention efforts [4]. For this solicitation, three specific types of biomarkers will be considered [5].

A. Biomarkers of exposure- Measure xenobiotics, metabolite(s) or the obtained products after interaction of a chemical with the cells or target molecules within an organism.

B. Biomarkers of effects- Assessable changes within an organism, which depends on the magnitude of exposure, can signify potential or recognized health impairment.

C. Biomarkers of susceptibility- Markers of inherent or acquired properties of an organism that make an individual more susceptible upon exposure to a specific chemical.

Continuous addition of foreign chemicals by urban communities and industries to the environment make people aware of the potential long-term adverse effects of these xenobiotics in general and their potential risks for aquatic and terrestrial ecosystems in particular. To maintain a healthy terrestrial food web, the sustainable use of soils is essential. The presence of a xenobiotic compound in a segment of a terrestrial ecosystem does not, by itself, indicate injurious effects. There should have established correlation between exposure levels, bio-accumulation of contaminants and early adverse effects.

In an environmental context, biomarkers offer promise as sensitive indicators demonstrating that toxicants have entered organisms, have been distributed between tissues, and are eliciting

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a toxic effect at critical targets [6]. Consequently, the development and subsequent application of sensitive laboratory bioassays, based on the biomarkers responses, such as the Glutathione (GSH), Glutathione-S-transferase (GST), Metallothionein (MT), Acetyl cholinesterase (AchE) responses [7-12] are important aspect of environmental research. Bioassays offer many advantages for comparing the relative toxicity of specific chemicals or specific effluents.

Earthworms have universally attracted considerable attention as one of the most suitable and representative animals to be used for ecotoxicity testing of industrial wastes disposed as land fillings and field applications of pesticides [13-18], by the European Economic Community (EEC), the Organization for Economic Co-operation and Development (OECD), the Food and Agriculture Organization of the United Nations (FAO), the American Society for Testing Materials [19,20], by many national pesticide registration authorities including the US EPA [21], and environmental pollution committees [22]. Earthworms have been regarded as an alternative to in vivo rodent bioassays [23,24]. Because they are readily available and easy to handle in laboratory and also in field condition. Earthworms are important component of terrestrial food web because of their contribution in enhancing overall soil productivity by changing soil properties like decomposition of organic litter, increasing soil porosity, water drainage, and aeration and enhancing microbial activities of soil. These features enhance their popularity to consider them as an excellent bio indicators of soil pollution [25,26]. Thus, earthworms provide the society a predictive tool of ecosystem quality as biomarker of chemical contamination [27,28]. This helps us to develop an experimental model that can assess ecotoxicological risk within an ecosystem. Pesticides can exert both direct toxicity against earthworms or produce latent effects on their growth, histology and fertility. In addition, metals and pesticide-contaminated earthworms are a source of contamination to higher members of the food web, e.g. birds or mammals.

All living organisms contain enzymes and bio molecules with antioxidant capabilities to protect them against the adverse effects of reactive oxygen species (ROS) and xenobiotics [29]. GSH and GST of the phase II biotransformation system have been considered as biomarkers of environmental pollution because of their major role in cellular defence mechanisms [30]. GSTs and glutathione interact perfectly in protecting cells from electrophilic xenobiotics and endogenous toxic compounds. They are also involved in hormone metabolism and intercellular signal cascades [31]. The enzyme class shows a high flexibility and represents the starting point of well-developed metabolic pathways in the degradation and excretion of xenobiotic conjugates [32].

The cytosolic as well as the microsomal GSTs of most species are dimeric enzymes (consisting of subunits of the same or similar size between MW 23 and 30kDa) that have extensive ligand binding properties in addition to their catalytic role in detoxification [33,34]. The determination of subunit size is in most cases deduced from SDS-PAGE separation and migration [31]. The ubiquitous distribution of GSTs and glutathione in animals and plants assume their joint co-evolution. However, so far, little is known about the oxidative stress and antioxidant defences in earthworms. [35,36], reported the existence of glutathione (GSH)-glutathione-S-transferase (GST) involved operating system in six species of Lumbricidae. Maity et al. [8] recorded a significant perturbation in GSH-GST and other enzymes (glutathione peroxidise and glutathione reductase) involved in antioxidant defence systems in Lampito mauritii against Pb and Zn treatment. A recent report of [37] noted that a combined effect of different trace elements induces GST activity and reduces cellular GSH level in earthworm Aporrectodea caliginosa, sampled from different heavy metal polluted sites of eastern Slovakia. According to the earlier investigations [38,39], the coupled reaction of GSH consumption and GST activation is essential to retain homeostasis of the cellular internal environment. Also reported that GST-GST responses depend on the dose and duration of metal exposure and the species of earthworm. In response to organic and inorganic pollutant perturbations of glutathione concentration, activity of glutathione-S-transferases, glutathione reductase and glutathione peroxidase have been reported in earthworm [40-45], recorded induction in GST activity of earthworm (Pheretima posthuma) exposed to three insecticides (aldrin, endosulphan or lindane) with subsequent decline to control level due to the biotransformation and elimination of pesticides [46]. Also reported induction in GST activity of Apporectodea caliginosa exposed to organophosphate pesticides (chlorpyrifos and diazinon) [47]. The biochemical/molecular biomarker like GST responses in earthworms could have an ecological meaning when they can be related directly to behavioural responses with significant ecological impact. However, very little research has demonstrated such a relationship. In light of the above discussion we can conclude that at the present time we need extensive research associating earthworm biomarkers as the biomarker is increasingly becoming a suitable tool for soil contamination survey for assessing the progress of remediation actions in contaminated soils.

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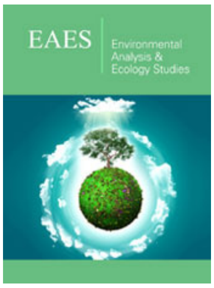

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