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IMPACT OF AGROCHEMICALS ON THE SOIL FERTILITY AND BIODIVERSITY OF SOIL ARTHROPODS

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Abstract: *The soil is home to a large proportion of the world's genetic diversity. The linkages between soil organisms and soil functions are observed to be incredibly complex. The interconnectedness and complexity of this soil 'food web' means any appraisal of soil function must necessarily take into account interactions with the living communities that exist within the soil. The biomass of the soil fauna of the earth is approximately 20 times the biomass of the human beings living on the earth. It is an established fact that no soil is healthy unless it harbours soil organisms. A great variety of fauna inhabit soil. The soil as a complex environment affords high degree of protection from predators, protection from physical factors and provides access to large quantities of living plant material as food supply for soil arthropods which is the largest phylum of the animal kingdom. About 95% of all insects spend at least part of their life cycle within the soil. Some of these enter the soil merely to rest such as cut worm larva, may enter the soil for winter hibernation and a large proportion enter the soil for pupation.*
Keywords: *Soil, Environment, Protection and Animal.*

Introduction: Among soil fauna, fungi-/detritivores such as Collembola, oribatid mites (Acari: Oribatida), earthworms and enchytraeids (Oligochaeta: Enchytraeidae) take part in important ecosystem functions such as decomposition, nutrient mobilisation, soil mixing and aggregate formation [1,2]. Moreover, predatory soil fauna–mesostigmatid mites (Acari: Mesostigmata) and larger arthropods such as beetles, spiders and ants–may through predation regulate the populations of other faunal groups [3,4] and thereby possibly influence decomposition processes. In spite of their role in decomposition and the fact that soil organisms make up a substantial part of the global biodiversity [5], many of these species remain poorly known. Even the functional specificity of many common soil organism species is unclear. It is likely that, for example, many of the fungi- and detritivorous animals have similar functions, but the enchytraeid *Cognettia sphagnetorum* [2] and some oribatid mites and collembolans [6,7] may be functionally specific under certain conditions. Avoiding severe declines in the diversity of soil communities can therefore be seen as an insurance against possible disturbances of ecosystem functions. However, on a community level we know that soil fauna respond to many different environmental variables, and because they can indicate environmental stress through changes in species or community structure [8,9], they can also be used as important indicators.

Soil organisms contribute a wide range of essential services to the sustainable functioning of all ecosystems. They act as the primary driving agents of nutrient cycling, regulating the dynamics of soil organic matter, soil carbon sequestration and greenhouse gas emissions; modifying soil physical structure and water regimes, enhancing the amount and efficiency of nutrient acquisition by the vegetation and enhancing plant health. These services are not only essential to the functioning of natural ecosystems but constitute an important resource for sustainable agricultural systems. Direct and indirect benefits of improving soil biological management in agricultural systems include economic, environmental and food security benefits:

Economic benefits: Soil biological management reduces input costs by enhancing resource use efficiency (especially decomposition and nutrient cycling, nitrogen fixation and water storage and movement). Less fertilizer may be needed if nutrient cycling becomes more efficient and less fertilizer is leached from the rooting zone. Fewer pesticides are needed where a diverse set of pest-control organisms is active. As soil structure improves, the availability of water and nutrients to plants also improves. It is estimated that the value of "ecosystem services" (e.g. organic waste disposal, soil formation, bioremediation, N_2 fixation and biocontrol) provided each year by soil biota in agricultural systems worldwide may exceed US$ 1,542 billion.

Environmental protection: Soil organisms filter and detoxify chemicals and absorb the excess nutrients that would otherwise become pollutants when they reach groundwater or surface water. The conservation and management of soil biota help to prevent pollution and land degradation, especially through minimizing the use of agro-chemicals and maintaining/enhancing soil structure and cation exchange capacity (CEC). Excessive reduction in soil biodiversity, especially the loss of keystone species or species with unique functions, for example, as a result of excess chemicals, compaction or disturbance, may have catastrophic ecological effects leading to loss of agricultural productive capacity.

Food security: Soil biological management can improve soil health, crop yield and quality, especially through controlling pests and diseases and enhancing plant growth. Below-ground biodiversity determines resource use efficiency, as well as the sustainability and resilience of low-input agro-ecological systems, which ensure the food security of much of the world's population. In addition, some soil organisms are consumed as an important source of protein by different cultures and others are used for medicinal purposes. At least 32 Amerindian groups in the Amazon basin use terrestrial invertebrates as food, and especially, as sources of animal protein - a strategy that takes advantage of the abundance of these highly renewable elements of the rainforest ecosystem.

Apart from these benefits, several species of soil arthropods are associated with many agricultural crops from sowing to harvesting and sometimes causing considerable damage to their crops. Due to the subterranean habits and sporadic attacks, these soil pests have not received sufficient attention of the economic entomologists. The members of Diplopoda, Symphyla, Crustacea, Arachnida and Insecta are known to cause damage to a wide variety of crops.

Impact of Plant Protection Inputs: Anthropogenic activities such as indiscriminate use of fertilizers and pesticides, disposal of industrial and domestic effluents, municipal sewage sludge and solid waste cause undesirable changes in the physical, chemical and biological parameters of the soil. Of the soil pollutants, effects of pesticides and particularly the effects of insecticides on soil fauna have been investigated to certian extent. However comparatively less information is available on their effects on soil arthropod populations. Relatively few field studies of pesticide side-effects have investigated beneficial arthropods' population recovery responses, though recovery may be ecologically more important than the initial effect. Detection of long-term effects and the subsequent recovery of populations, communities or ecosystems depends on adequate temporal scales of study. This is because effects of repeated applications of pesticides may develop slowly [10] or persist over more than one season, whilst sporadically-occurring species, rare events or cyclic phenomena could be missed in a short-term study. Even a single pesticide application may lead to ecological changes over several years, e.g. in the abundance of microarthropods [11]. Such 'transient dynamics' are difficult to foresee and endorse the need for long-term ecological studies [12].

When chlorpyrifos an cypermethrin were used frequently in plant protection, effects of chlorpyrifos on arthropod abundance and taxonomic richness were consistently negative whereas effects of cypermethrin were negative for predatory arthropods but positive for soil surface Collembola. Pirimicarb effects were marginal, primarily on aphids and their antagonists, with no effect on the Collembola community. Collembola-predator ratios were significantly higher following cypermethrin treatment, suggesting that cypermethrin-induced increases in collembolan abundance represent a classical resurgence. Observations in other studies suggest Collembola resurgences may be typical after synthetic pyrethroid applications. Collembola responses to insecticides differed among species, both in terms of effect magnitude and persistence, suggesting that coarse taxonomic monitoring would not adequately detect pesticide risks. These findings have implications for pesticide risk assessments and for the selection of indicator species [13].

When foliar and soil insecticide applications on collembolan density and community structure were investigated in vegetable fields, both insecticides dimethoate and chlorpyriphos were lethal to Collembola and insecticide applications and resulted in a strong decline in the density of total Collembola. Application of chlorpyrifos reduced collembolan density to a greater extent than dimethoate; the effect of the combined application on total collembolan numbers was similar to that of chlorpyrifos only. Collembolan numbers recovered after the insecticide applications in 1999, but in the treated plots populations were still reduced in March 2000 before the re-application of insecticide treatments in that year. The insecticide applications changed the dominance structure of the collembolan community, but had no effects on species composition. Use of herbicides like atrazine also had a deleterious effect on the population of collembola. Well documented that the chitin synthesis inhibitors also have undesirable effects on the collembolan diversity and abundance at higher concentrations [14].

Managing and Restoring Soil Biological Activity: The goal of managing the soil biological community is to improve biological functions, including forming and stabilizing soil structure, cycling nutrients, controlling pests and disease, and degrading or detoxifying contaminants. Research shows that management practices and disturbances impact soil biological functions because they can enhance or degrade the microbial habitat, add to or remove food resources and directly add or kill soil organisms. Although management practices are known to impact soil biology, there is limited knowledge to support the development of detailed management strategies. A particular practice may have the desired result in one situation but have little effect in another because biological communities respond to the interaction of multiple factors including food sources, physical habitat, moisture, and impacts of historical land use. Soil biota eat, grow and reproduce within the soil environment. They need food, a conducive soil habitat and, in the cases of symbionts, a host organism, to survive. The ecological principles behind soil biological management that need to be understood and practiced are as under.

(i) Supply of Organic Matter for Food: Each type of soil organism occupies a different niche in the web of life and favours a different substrate and nutrient source. Thus a rich supply and varied source of organic matter will generally support a wider variety of organisms. Organic matter may come from crop residues at the soil surface, root and cover crops, animal manure, green manure, compost and other sources. Increased supply of organic matter such as straw litter resulted in increased activity of earthworm *Dichogaster bolaui* with desirable CN ratio. Further, various earthworm species were abundant in cultivated soils supplied with rich organic matter [15].

(ii) Increased Plant Diversity: Crops should be mixed and their spatial-temporal distribution varied to create a greater diversity of niches and resources that stimulate soil biodiversity. Each crop contributes a unique root structure and type of residue to the soil. A diversity of soil organism can help control pest populations, and a diversity of cultural practices can reduce weed and disease pressures. Several strategies could indirectly or directly contribute to creating different habitats to support complex mixes of soil organisms, for example: i) landscape diversity, over space and time, can be increased by using buffer strips, small fields, contour strip cropping, crop rotation, and by varying tillage practices; ii) a changing vegetation cover and sequence increases plant diversity and the types of insects, micro-organisms and wildlife that live on the farm; and iii) crop rotations encourage the presence of a wider variety of organisms, improves nutrient cycling and natural processes of pest and disease control.

(iii) Protecting the Habitat of Soil Organisms: Soil biodiversity can be stimulated by improving soil living conditions such as aeration, temperature, moisture and nutrient quantity and quality, for example through: reducing tillage and maximizing soil cover, minimizing compaction, minimizing the use of pesticides, herbicides and fertilizers and improving drainage.

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