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The Effect of Soil Organisms and Macro-Invertebrates In Physical and Chemical Conditions of Soil

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ABSTRACT

The living ecosystem soils full with microscopic and bigger organisms that perform many dynamic functions including converting dead and decaying organic matter as well as minerals to plant nutrients. Different soil organisms feed on different organic substrates. Their biological activity depends on the organic matter supply. Nutrient exchanges amongst organic matter, waterand air are essential to soil fertility and need to be continued for sustainable production. The soil is exploited for crop production without keeping the organic matter and nutrient contents, the nutrient cycles are broken, soil fertility declines and the balance in the agro-ecosystem is destroyed. Soil organic matter - the product of on-site biological decomposition - affects the chemical and physical properties of the soil and its overall health. Soil ecosystem supports a complex of animal communities of which soil arthropods were of prime importance since they constitute the major component of soil mesofauna in all types of soils. The soil arthropods includes a variety of mites, collembolans, pseudoscorpions, centipedes, millipedes, symphylans, diplurans, proturans, hymenopterans, coleopterans etc. they play an important role in releasing nutrients and improve productivity within the forest ecosystem (less disturbed ecosystem) by decomposition process. Mostly they are present with numerically abundant in the undisturbed, natural forest. Among the soil arthropod Acarina and Collembola are the most diverse as well as abundant group. The present article reviews the research work done in this field with reference to India.

Keywords: Soil fauna, soil Acarines, Collembola, soil ecology, soil fertility.

INTRODUCTION

The soil is one of the most valuable resources for the existence of mankind.It is a complex and fragile amalgamation of minerals and organic matter. Almost 50 percent of the volume of any soil contains of pore spaces containing air and water, while the other 50 percentis primarily the mineral, comprised of weathered parent bedrock and deposited minerals. It is complex living body that breaths, assimilates organic and inorganic elements, breakdowns and mineralizes organic matters of biological origin, and stores reserves as organic matter. These functions are gifted by organisms dwelling through their metabolism. These actions of soil organisms transform and regenerate the soil components. The rate of decomposition of soil is governed mainly by the microbial biomass. The contamination of soil by inorganic elements and/or organic compounds that can significantly change manner the activity of the microbial pool and other indispensable organisms ensuring that soil remains a living ecosystem. The biologically diverse habitat and wide varieties of living components in the form of flora and fauna on earth is supported by soil. The most diverse phylum of living organismsthere can be representatives of about 20 different lineages of Arthropoda among the faunal components. Arthropods in soil encompass a broad range of guilds, including specialised and polyphagous predators, parasites, phytophages, fungivores, microbivores, saprophages, detritivores, and omnivores. Arthropods in soil act as “driving variables” indirectly affecting pathways of energy transfer in soil at levels that are orders of magnitude greater than direct faunal contributions to nutrient

and energy fluxes (,1988) In addition to the arthropod fauna, other soil organisms ranged from the myriad of invisible microbes, bacteria and fungi to the more familiar macro fauna such as earthworms, beetles, centipedes, termites etc. Plants roots can also be considered as soil organisms in view of their symbiotic relationship and interactionswith other soil components. These diverged organisms interact with one and other with the various plants and animals in the ecosystem forming a complex web of biological activities. Environmental factors, such as temperature, moisture and acidity as well as anthropogenic actions, in particular management practices, affect soil biological community and their functions to their different extents (Frampton et al.,2002, Siira-Pietikäinen et al. 2001).The interacting functions of soil organisms and the effects of human activities in managing land for agriculture and forestry affect soil health and quality to sustain plant and animal production, maintain or enhance water and air quality and support human health and habitation. The concept of soil health includes the ecological attributes of the soil, which have implications beyond its quality or capacity to produce a particular crop. The soil quality and health are chiefly associated with the soil biota: its diversity, its food web structure, its activity and the range of functions it performs. Therefore, soil biodiversity and abundance may not be a soil property critical for the production, but it is a property that may be vital for the continued capacity of the soil to support the production. In tropical countries like India where population growth is high and soil tends to be highly weathered besides having low fertility, the role of soil fauna becomes very important. This biodiversity in soil organisms, especially the beneficial ones, play an important role in maintaining and improving soil fertility (Warren and Zou,2002)

The activities of macro fauna such as earthworms and termites affect soil structure through mixing soil horizons and organic matter and increases porosity. This directly related to soil erosion and availability of the soil nutrients to plants. The soil meso- and micro-fauna may contribute to decomposition of complex organic matter by breaking the larger plant components into small pieces, thereby increasing their surface area, or even by decomposing the plant biomass directly. Some soil borne pathogens and nematodes may be detrimental to plant growth, for example, the build up of nematodes or disease under certain cropping practices. The activities of certain organisms determine the carbon cycle- the rate of carbon sequestration and gaseous emissions and soil organic matter transformation. Plant roots, through their interactions with other soil components and symbiotic relationships, especially Rhizobium bacteria and Mycorrhiza, play key role in the uptake of nutrients and water, and contribute to the maintenance of soil porosity and organic matter content, through their growth and biomass. Soil organisms can also be used to reduce or eliminate environmental hazards resulting from accumulations of toxic chemicals or other hazardous wastes. The plant litter decomposition is a key process in global carbon and nutrient cycling (Bradford et al., 2002, Shaw and Harte,2001The litter decay is governed by a number of biotic and abiotic factors and their interactions. The activity of the decomposition processes depends on the soil contents of organic matter, conditions of soil drainage, temperature of the upper soil horizon).(Striganova et al. 2000)and soil organisms (Swift , Heal and Anderson,1979.(Soil fauna have a great influence in functioning of the decomposer flora as a result of their feeding activities (Santos and Whitfortd,1981) They are the primary agents for the release of nutrients immobilized by the soil microflora (Cortet et al.,2003) Litter arthropods are mostly members of the detritus based “brown” food web (BFW). BFWs are responsible for the recycling of nutrients and releasing the energy locked in all plant tissues (Coleman,et al., 2004, Bardgett,2005, Bardgett , Usher and Hopkins ,2005).They also constitute half or more of arthropod diversity in a tropical forest (Stork and Grimbacher,2006. Litter arthropods are assumed to be generalists because leaf litter and litter arthropods do not coevolve (Scheu and Setälä,2002, Wardle,2005, Ayres, Dromph and Bardgett,2006).

Unlike aboveground herbivore assemblages (Coley and Barone,1996) litter arthropods do not interact directly with living plants, but harvest nutrients from dead plant material and the microbes decomposing the litter (Seastedt,1984, Moore , Walter . and Hunt, 1988).

Role of soil fauna in soil fertility

Soil represents one of the most important reservoirs of biodiversity. It reflects ecosystem metabolism since all the bio-geo-chemical processes of the different ecosystem components are combined within it; therefore soil quality fluctuations are considered to be a suitable criterion for evaluating the long-term sustainability of ecosystems(Hazra A.K.,1991).Within the complex structure of soil, biotic and abiotic components interact closely in controlling the organic degradation of matter and the nutrient recycling processes. Soil fauna is an important reservoir of biodiversity and plays an essential role in several soil ecosystem functions; furthermore, it is often used to provide soil quality indicators. Although biodiversity was one of the focal points of the Rio conference, in the 1990s virtually no attention was paid to activities for the conservation of soil communities. However, with the new millennium, the conservation of soil biodiversity has become an important aim in international environmental policies(Menta C.,2012).

Studies on the role of soil fauna in ecosystem functioning require accurate characterization of the soil community food web, identifying the potentially important species and groups as well as the interactions among them (De Ruiter, Neutel and Moore ,1997).Proper understanding on the contribution of different faunal groups to the ecosystem process are required for developing environmentally sound management practices and strategies to safeguard the biodiversity and soil fertility. It has been proposed that a varied and abundant fauna maintains and even enhances soil fertility and thus high productivity (Edwards , Reichle and Crossley,1970). Most of the information in this context from India and elsewhere is from natural systems where nutrient cycle is tight and there is no major biomass removal from this site (Seastedt,1984, Harding and Stuttard,1974, Palacios-Vargas,2002, Bisht,2002, Dazzi et al.,2002, Massa et al.,2002, Eaton,2004, Sanyal,2004)..The greatest effect of such microarthropods fauna is reported in forest ecosystem with well developed litter layers (Warren and Zou, 2002, Kumssa, Aarde and Wassenaar,2004) and grassland ecosystems (Reynolds et al. 2003, Curry J.P.,1994,) . A few studies have also been conducted to determine the role of soil micro and meso fauna in agro forestry/ silvi-pasture systems and in crop/fodder production systems (Hubert and Tuckova, 2003, Costa, de-Costa and Gunasena, 2009, Roy, Srivastava and Roy,1998, Roy, Srivastava and Roy,2005, Krebs,1972).

Ecological Study of Soil Fauna

A natural habitat such as soil in undisturbed forest ecosystem provides a diverse group of arthropod fauna. In undisturbed soil, interactions among animals and between animals and microarthropods form an integrated system for the decomposition of organic matter and recycling of mineral nutrients(Seastedt,1984,Wallwork,1970).The animals in the soil participate in numerous processes of soil formation and affect the usefulness of soils. The classical role of the soil fauna is in the breakdown of dead plants and animals, which are returned to the soil. Accompanying this decaying process is the release of nutrients from the organic body of plants and animals into the soil. Effects of animals in and on soil result in changes in soil fabrics, i.e., size, shape, arrangement of soil components and changes in soil composition. There are at least twelve kinds of activities by which soil animals affect the soil (Ferguson and Joly,2002).These activities include mounding, mixing, forming voids, back-filling voids, forming and destroying peds, regulating soil erosion, regulating movement of water and air in soil, regulating plant litter, regulating animal litter, regulating nutrient cycling, regulating biota, and

producing special constituents through the processes of regurgitation, mixing of saliva or excreta with soil materials. Soil arthropod biodiversity is an indicator of soil quality. The biomass of fauna is a relatively small proportion of the total soil mass, particularly in a mineral soil, yet the activity of these animals is important in moving material upward against the forces of gravity and of the flow of fluids, in altering soil fabric and micro-topography, in changing distribution patterns of soil materials and plant nutrients and in relating processes and assemblages of materials and organisms.

Effect of Climatic Factors on Soil Ecology

Soil systems are heterogenous and adjacent microhabitats may possess various physical, chemical and biological properties(Wood,1967). These various biotic and a biotic factors of soil have influence on the distribution of soil animal. The biotic components of soil such as source of food and vegetation cover are the important factors which impacts on the population of soil fauna. The soil fauna depend on microorganisms like bacteria, fungi, algae, etc. for their food material. The physical and chemical abiotic factors are important in determining the population distribution pattern and species composition of soil microarthropods in the soil ecosystems. The physical factors affecting the soil which form part of the environment of soil arthropod include soil structure, soil moisture, porosity, soil temperature and humidity of soil etc. Among the physical abiotic factors soil moisture takes vital roles in the distribution, abundance and various activities of many soil organisms of their environment. The soil moisture content is of vital importance to the soil fauna(Kevan, 1982).Vertical distribution of soil fauna is mainly influenced by soil moisture (Alicata et al.,1973, Hassall, et al. 1986). Wall work (Alicata et al., 1973) also considered, within a climatic region, the main factors determining the abundance of soil microarthropods include: (1) type and quantity of decomposing organic residues and their effects on the micro floral population, (2) structural stability of the soil and resulting porosity, and (3) soil water regime.

Soil varies from place to place depending upon the percentage contribution of the sand, silt and clay. Sandy soils are light and warm and pore spaces are large. These soils are well drained, aerated and loose in texture. The clay soils are heavy, wet and badly drained. Soil structure determines soil porosity. The soil porosity decrease progressively with depth and it is parallel by a succession of species in which larger size of soil animals are confined to the surface layer of the profile, while smaller groups present at the lower levels. The various abiotic chemical substances play important roles in the life cycle of soil arthropods. These abiotic factors include organic carbon, pH, nitrogen and phosphorus and their relationship with the soil fauna have been studied by several workers(Mukharji. and Singh,1970, Banerjee,1974 & 1976 Sharon, Degani and Warburg , 2001). However, among these chemical factors, soil organic carbon is the major constituent of organic matter and it takes better role in determining the character of the soil. High status of organic matter is maintained in the soils by the fall of huge amount of litter on the soil surface and its rapid decomposition due to favourable conditions like moisture and temperature(Singh , Borah and Boruah,1995) . Thus, decomposition represents an ecological service for the whole ecosystem, as 60-90% of terrestrial primary production is decomposed in the soil (Giller, 1996). Moreover, the organic carbon content of the soil is an important factor in determining the composition of soil fauna (Giller, 1996). Soil rich in organic matter are generally rich in nutrients. Organic matter decomposition in soil is performed by a dynamic system of microflora and invertebrate fauna and their synergistic interactions play a very important role in enhancing the nutrient release. Soil pH seemed to have little influence on the distribution of soil arthropods though most of the Collembola and mites prefer slightly acidic soil.

Conclusion

Soil is a living, dynamic ecosystem. Healthy soil is

packed with microscopic and larger organisms that perform many vital functions including converting dead and decaying matter as well as minerals to plant nutrients. Different soil organisms feed on different organic substrates. Their biological activity depends on the organic matter supply. Nutrient exchanges between organic matter, water and soil are essential to soil fertility and need to be maintained for sustainable production purposes. Where the soil is exploited for crop production without restoring the organic matter and nutrient contents and maintaining a good structure, the nutrient cycles are broken, soil fertility declines and the balance in the agro-ecosystem is destroyed. Soil organic matter - the product of on-site biological decomposition - affects the chemical and physical properties of the soil and its overall health. Its composition and breakdown rate affect: the soil structure and porosity; the water infiltration rate and moisture holding capacity of soils; the diversity and biological activity of soil organisms; and plant nutrient availability.

Soil ecosystem supports a complex of animal communities of which soil arthropods were of prime importance since they constitute the major component of soil mesofauna in all types of soils. The soil arthropods includes a variety of mites, collembolans, pseudoscorpions, centipedes, millipedes, symphylans, diplurans, proturans, hymenopterans, coleopterans etc. they play an important role in releasing nutrients and improve productivity within the forest ecosystem (less disturbed ecosystem) by decomposition process. Mostly they are presenting with numerically abundant in the undisturbed, natural forest. Among the soil arthropod Acarina and Collembola are the most diverse as well as abundant group. Ecological investigation of soil arthropods helps in understanding, describing and studying the distributional pattern of these animals and also major role in soil formation, nutrient cycling etc. For understanding the importance of soil animals, information on the distribution, abundance as well as interaction with various abiotic factors is also necessary.

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