

**Population dynamics on soil insects in Greater  
Kolkata, West Bengal: A review**

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**Abstract**

Soil is the natural habitat for microorganisms, plants and animals. Insects are the most diverse groups of organisms on earth and have adapted a wide range of habitats. Soil is the weathered surface of the earth's crust which mixed with organic material and in which organisms live and plants grow. The soil insects play a significant role in soil ecosystem. They decompose dead materials, thereby help in nutrient cycling into the ecosystem and also act as an important bio-indicator of environmental changes. Different anthropogenic activities not only affect the soil insect communities but also create a diversified effect on other soil organisms and the soil as a whole. In Kolkata, the uncontrolled urbanization and industrialization affect the soil ecosystem. Particularly the vehicular exhaust containing the heavy metal lead cause enormous changes in the soil insect communities. An understanding of the deleterious effect of urbanization and industrialization on soil insects and of the importance of these organisms to soil ecology is still in its infancy. The present article is a review on the facts related with soil insect communities and the research work done in this field with reference to greater Kolkata.

**Keywords:** Deleterious effects, soil fertility, soil insects, research works, urbanization.

**Introduction**

The word soil is derived from the Latin word 'solum' meaning earthy material in which plants grow. The science which deals with the study of soil is called soil science, Pedology (Pedos = earth) or Edaphology (Edaphos = soil). Soil can be defined as the mixture of minerals, organic matter, gases, liquids, and

countless organisms that together support life on earth. Insects are the most diverse groups of organisms on earth and have adapted a broad range of habitats successfully enjoying their own niche (Booth et al., 1979; Jana et al., 2014a). According to Jana et al., 2006; insects have the ability to differentiate in the more

polluted load of air pollution from the non polluted one. Insects, the most abundant and diversified faunal group (Williams and Feltmate, 1992) acts as an important bio-indicator of environmental changes (Jana et al., 2014b). They also decompose dead materials: thereby help nutrient cycling into the ecosystem.

Exponential growth of human population; uncontrolled and rapid urbanization and industrialization have resulted into production of numerous effluents in the form of solid wastes, liquid discharges, as well as obnoxious gases. Many of those are either dumped or get settled on the soil and interfere with the natural processes, both physicochemical and biogeochemical, which in turn affect the biotic components of the ecosystem (Ghosh et al., 2007). In the urban areas the vehicular emission contain the heavy metal lead, that remain admixed in the motor fuel as tetraethyl lead, which acts as antiknock compound and get deposited on the road side soil. The lead pollution of the soil may cause enormous changes in the bionomics of the soil arthropod population has already been demonstrated by Krzysztofiak (1986) and Wuorenrinne (1989).

The soil quality and health are chiefly associated with the soil biota, its diversity, its food-web structure, its activity and the range of function it performs. This biodiversity of soil organisms play an important role in maintaining and improving soil fertility (Warren and Zou, 2002). The research development in soil fauna from Darwin to the current holistic view that tends to link the diversity and functions of the aboveground and belowground communities was nicely reviewed (Huhta, 2007). The current knowledge on the role of soil biota, their diversity, and various components has accumulated mainly during the last 30 years, resulting in the modern view of soil fauna as a

part of ecosystem (Huhta, 2007). The study of soil animals has been neglected field for a long time particularly in India (Kumar and Singh, 2016). Little attention has been given to ecological studies of the soil insects, particularly on their seasonal occurrence, site specific diversity/ distribution, species diversity, population dynamics, community structure and effect of population on the population or community of the soil insects (Ghosh et al., 2007).

Considering the vehicular congestion in Kolkata it is expected that lead, emitted through vehicular exhausts and deposited on the roadside soil, has its effects on the community of soil insects (Ghosh et al., 2007). As demonstrated by Ghosh et al., 2007, the soil ant fauna is maximum at Kolkata where the lead pollution is minimum and the ant population is minimum in Kolkata where lead pollution is maximum, thereby suggesting a negative effect of lead on the soil ant community. So, further investigation is required to study the population dynamics of soil insects to monitor the loss of biodiversity of soil insects in future due to urbanization in Kolkata.

#### **Soil insects and other soil living arthropods**

Soil represents one of the most important reservoirs of biodiversity. Soil ecosystem supports a complex of animal communities of which soil arthropods were of prime importance since they constitute the major component of soil fauna in all types of soils. Among the arthropods the class Insecta is the largest group of animals. The tremendous adaptive diversity of insects has enabled them to survive in virtually every habitat. They are perhaps the most successful of all the invaders of the terrestrial habitat. The space between fallen leaves and bit of decomposing vegetation on a forest floor is the home of an

incredibly rich assemblage of various soil insects and other groups of arthropods.

The diversity of soil comprises of large number of terrestrial insects including many ground dwelling insects those are functionally important to the biodiversity. The soil include a variety of hymenopterans, orthopterans, dermapterans, coleopterans, isopterans, proturans, diplurans, microcoryphia, thysanura, zoraptera and larval forms of many other orders( Kumar and Singh, 2016; Ruppert and Barnes, 2001). They have been reported to occur in varied soil conditions in different ecosystems. Other soil arthropods are mites, collembolans, centipedes, millipedes, symphylans, acarids etc. Some of them are temporary soil inhabitants while others are permanent and some live under surface debris and some are burrowing forms. The species composition and the geographical location, climate, physical and chemical properties of the soil, type of vegetation cover , nature and depth of the litter and humus and a variety of other environmental factors(Kumar and Singh, 2016). Mostly they are present with numerically abundant in the undisturbed natural forest. Filser and Seatala, 1999; described that soil animals are directly associated with the soil structure through fecal deposition and drilling of pores .

#### **Role of soil insects in soil productivity**

Soil is the natural habitat for microorganisms, plants and animals. The soil quality and health are chiefly associated with the soil biota, its diversity, its food web structures, its activity and the range of function it performs. A large portion of soil micro, meso and macro fauna is comprised of soil arthropods. Macrofauna contribute to improve soil structure, aeration, and water infiltration. They predate on soil organisms and help to maintain biological equilibrium in soil. Mesofauna are important plant

pathogens. Microfauna are important predators of bacteria and algae, thus regulating their population in soil.

Arthropods function on two of the three broad levels of organization of soil food web: they are plant litter transformers or ecosystem engineers. Litter transformers fragment of comminute and humidify ingested plant debris, which is deposited in feces for further decomposition by microorganisms. The ecosystem engineers alter soil structure, mineral and organic matter composition and hydrology. The burrowing by arthropods such as ants and termites particularly the subterranean network of tunnels and galleries improves soil porosity providing adequate aeration and water- holding capacity belowground. Also the movement of particles from lower horizons to the surface by ants and termites aids in mixing the organic and mineral fractions of the soil. Soil organisms are also responsible for nutrient cycling, formation of soil, degradation of wastes and harmful chemicals. Soil insects have been recognized as important in the functioning of soil ecosystems and a vast literature accordingly has accumulated, principal roles played by arthropods in the soil fertility have been nicely reviewed by Culliney, 2013 and Bagyaraj et al., 2016. These organisms interact with one another with the various plants and animals in the ecosystem forming a complex web of biological activities.

Ants, termites are also ecosystem engineers, since they modify or create habitats for smaller soil organisms. In this way, they also regulate the availability of resources for other soil organisms. Other soil insects like crickets, grasshoppers and grubs of scarabid beetles and caterpillar of moths and butterflies etc., also play an important role in maintaining soil fertility, structure and texture and in rendering the soil porous. Soil

arthropods also act as bioindicator. Among the arthropods oribatid mites and collembolans have a great potential as bioindicators of environmental conditions (Migliorini et al., 2005, Bispo et al., 2009) and land use identification (Ponge et al., 2003).

In Kolkata where the population growth is high and soil tends to be highly weathered besides having low fertility, the role of soil fauna becomes very important. However, there is some lacuna in our knowledge about the role of these soil fauna in ecosystem and we need more advanced research to enrich our knowledge.

#### **Anthropogenic causes affecting soil insect's population**

An exponential growth of human population; rapid urbanization and industrialization have resulted into production of numerous effluents in the form of solid wastes, liquid discharges, as well as obnoxious gases. With rapidly advancing technology, man's impact upon the world's natural resources is beginning to prove overwhelming. Rapid urbanization, with the consequent increase in population and building construction, has resulted in the reduction of land for the wastes to be deposited. Kolkata is one of India's major metro city, which is on the edge of the Bay of Bengal and has attracted millions of migrants. Today, the city appears to be at its bursting point. A growing population is bringing with it a growing problem of domestic waste. A study conducted by the Centre for Quality Management System (CQMS) at Jadavpur University says that several areas in the city have been affected by toxic wastes. Solid waste disposal comprised of non-biodegradable materials such as plastic, electronic wastes, batteries, metal cans, glass, medicine foils and construction waste that don't mix with soil but settle down, batteries

for instance break open and carbon and adhesive spill out, these substances then interfere with the natural processes both physicochemical and biogeochemical, which in turn effect the biotic components of the soil ecosystem (Ghosh et al., 2007). Therefore it destroys soil fertility and affects the soil fauna.

On the other hand industrial landfills are sources of soil pollution in that area and the city as a whole due to the generation of large quantity of industrial dumps from mining, metallurgical, chemical, mechanical, other engineering and technological processes. Million tones of total mass of residues such as pyrite ferric, chromium, lead, zinc, cadmium and other associated metals arsenic, antimony, mercury and silver are dumped in landfills. As per geographical information system (GIS) reports reveal that Kolkata is surrounded by toxic industrial wastes. So within a least radial distance from the waste area are heavily polluted mostly from highly toxic elements such as iron, chromium, lead etc (Gurumurthy, 2011).

In Kolkata with the growing number of vehicles mainly in the urban areas the deposition of heavy metal lead in soil emitted from vehicular exhaust is getting a striking problem today. The heavy metal lead (Pb), remain admixed in the motor fuel as tetraethyl lead, which acts as an antiknock compound and get deposited on the road side soil. The lead pollution of the soil may cause enormous changes in the bionomics of the soil arthropod population has already been demonstrated by Krzysztofiak (1986) and Woureninne (1989). Considering the vehicular congestion and as demonstrated by Ghosh et al., 2007 that there is a negative effect of lead on the soil ant community, it is expected that lead emitted through vehicular exhausts and deposited on the road side soil,

has its effect on the community of other soil insects.

#### **Effect of anthropogenic pollutants on soil insects**

Many pollutants of anthropogenic origin either dumped or get settled on the soil and interfere with the natural processes which in turn affect the biotic components of the soil ecosystem (Ghosh et al., 2007). Not unexpectedly, soil contaminants can have significant deleterious consequences on the ecosystem.

Soil pollutants can negatively affect the metabolism of microorganisms, and arthropods, which can destroy some layers of the primary food chain and have a harmful effect on predator animal species. Also, some small life forms that may consume harmful chemicals in the soil which may then be passed up to the food chain to larger soil fauna, which may lead to increased mortality rates and even animal extinction. Accumulation of heavy metals in the litter and upper soil horizons of natural forest ecosystem has resulted in the hypothesis that litter decomposition and nutrient cycling may be reduced in soils with excessive heavy metal input. Reduction of general microbial activity in soils polluted with heavy metals has been documented (Bhuiya and Cornfield, 1972). It is reasonable to speculate, however, that the rate of decomposition of soil organic matter may be reduced in the soil compartment of the immediate roadside environment. As the soil fauna are interlinked together through multiple food chains deleterious effect at one level may affect the others also.

The impact of roadside soil lead (Pb) on element of soil fauna, including insects (Smith, 1976) has been examined. Ants may have particularly high lead (Pb) burdens (Fangmeyer and Steubing, 1986). Ghosh et al., 2007; demonstrated that heavy metal lead

has negative effect on the soil ant community. Krzysztofiak, 1986 and Wuorenrinne, 1989, demonstrated that lead pollution of the soil may cause enormous changes in the bionomics of the soil arthropod population. It is reported that some insects accumulate large amount of metals in their bodies and result in physiological toxicity. Furthermore, heavy metals would be transported to organisms on the higher position from insects along food chains (Zhang et al., 2009)

Despite our considerable awareness of the amount and localization of lead (Pb) in the roadside area and other waste products such as domestic and industrial effluents products we remain quite ignorant regarding its chemistry, function and effect on soil organisms.

#### **Research and development on soil insect**

The vast majority of scientific literature on soil fauna, both taxonomy and ecology, have been mostly from the European and North American soils. Some important works are by Kevan (1955), Kevan (1962), Farb (1959), Macfadyen (1957), Doeksen et al., (1963), Burges et al., (1967), Graff et al., (1967), Wallwork (1976), Lebrun et al., (1983), Huhta (2007) etc. Smith in 1976 demonstrated the effect of lead contamination of the roadside ecosystem. There is an extraordinary amount of literature on this important topic. Due to space constraints this review is representative rather than comprehensive. There are available excellent recent reviews that deal with one or more aspect of the topic (Lagerwerff, 1974 ; Vallee and Ulmer, 1972 ; Knutsson et al., 1974 ; Ewing and Pearson, 1974 ; Haar, 1975 ; Hankin, 1972; Blokker, 1972; Warren, 1974 )

In India, Systemic survey of literature on Indian soil Zoology is difficult as they are distributed in obscure journals. Scanty literature on the subject speaks of its poor

attention received from Indian Pedologists (Singh, 1978). Added to this, there is growing evidence of interest from Indian workers (Singh, 1978; Edwards and Veeresh, 1978; Veeresh, 1981; Veeresh and Rajagopai, 1983; Veeresh et al., 1991) signaling the gradual maturity of soil faunal studies in India. But the knowledge is yet insignificant compared to its vast landscape variation and severe pressures on fragile soils (Kumar and Singh, 2016). Ghosh et al., 2005, compared the diversity of ant species in polluted area (divider of a busy road) and that of nearby unpolluted area (inside a lake of national importance) and observed the diversity of species was less in polluted area in comparison to the other. Recently a publication was made by Gosh et al., 2007 on roadside soil inhabiting ants (Hymenoptera: Formicidae) of Kolkata with reference to the effects of lead emitted through automobile exhaust and by Maity et al., 2016 on "Insect faunal diversity of Salt Lake city – an urbanized area to Kolkata".

### **Conclusion**

Soil is the natural habitat of plant, animals and microorganisms. Healthy soil is characterized by its flora and faunal components and the range of function they perform. Living organisms in the soil both fauna and flora are very essential in the process of degradation and synthesis of humus. These organisms are essential for the numerous biochemical changes and help to stabilize the structure of the soil. Among the soil fauna soil arthropods were of prime importance since they constitute the major components of the soil fauna in all types of soils. The soil arthropods comprised of insects, millipedes, centipedes, collembolans, symphylans, acarids, mites etc. Among them the class insect has the ability to survive in virtually every habitat because of their

tremendous adaptive diversity. They are perhaps the most successful of all the invaders of the terrestrial habitat.

Kolkata is one of India's major urban hubs. Like the other urbanized city in Kolkata rapid and uncontrolled urbanization and industrialization produce numerous soil pollutants in huge amount. These pollutants have deleterious effects on soil fauna. And the roadside soil is polluted by the deposition of heavy metal lead from vehicular exhausts, which has enormous effects on the community of soil insects.

Study of soil animals has been neglected field for a long time particularly in India (Kumar and Singh, 2016). Though there is a growing evidence of interest from Indian workers, an understanding of the deleterious effects of urbanization and industrialization on soil insects and of the importance of these organisms to soil ecology is still in its infancy and the effect of lead to the roadside biota is apparently subtle and undoubtedly complex and worthy of continued investigation. So, further investigations are required to record the soil insects and other soil fauna and understand their importance to prevent the loss of biodiversity and ecological imbalance.

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