Impact of Land Use Patterns on Soil Invertebrate Abundance and Diversity at GKVK Campus, Bengaluru, India

Abstract

At the University of Agricultural Sciences, GKVK, Bengaluru, a study analyzed soil invertebrate macrofauna across four land use types: roadside soil, forest ecosystem, paddy ecosystem, and botanical garden. Sampling involved 12 units across these categories using Berlese-Tullgren funnels. A total of 55 individuals were collected, with ants and spiders found in all land use types, but earthworms and Collembola were absent from paddy ecosystems. Forests showed the highest macrofauna abundance (49.09%), followed by botanical gardens (29.09%). Spiders (45.4%) and Collembola (23.63%) were the most abundant, indicating that natural environments support richer macrofauna communities. Intensive agriculture alters these communities' abundance and diversity.

Keywords Soil macrofauna, Berlese-Tullgren funnel, land use type, abundance and diversity

Introduction

“Soil macro-invertebrates are animals which inhabit different soil layers, including litter and soil surface, and which are visible to the naked eye, with a body length of >1 cm and a body width >2 mm1. Taxonomically, they are heterogeneous and predominantly belong to the phyla Mollusca, Annelida, and Arthropoda. Their effect on the soil ecosystem is indispensable, they physically alter the soil matrix by creating burrows which increases aeration and drainage, they promote litter decomposition, and by interacting with microorganisms, they contribute to nutrient cycling2. Macro-invertebrates living in the soil are mainly detritivores and predators, they can be classified into various functional guilds based on their feeding habits3, and are as such parts of extremely complex soil food webs4” [18-19].

Soil macrofauna diversity, abundance, and community composition are all impacted by land use type (Guerra et al., 2020). Changes in land use and intensification have an influence not just on plant communities but also on soil food webs and the connections between above- and below-ground populations (Wardle *et al.*, 2004; Sohlstrom et al., 2022). Annual cropping techniques don't provide permanent soil cover, it will disturb the soil and reduce the diversity and abundance of soil fauna communities (Barrios, 2007; Rossi *et al.*, 2010). Soil macro-fauna are also impacted by unsustainable land management techniques such as overgrazing, fire, deforestation, pollution, soil erosion, and fertility depletion (Bignell *et al.*, 2005). The development of soil macrofauna is facilitated by forest land and garden fields, which have more soil cover and less soil disturbance. These characteristics are absent from grazing areas and crop-cultivated fields, which leads to greater soil compaction, deterioration, and a lack of food and cover that are necessary for the survival of soil macrofauna (Moreira *et al.*, 2008).

It is well established that residue inputs and soil management techniques affect the distribution, abundance, and diversity of Soil Invertebrate Macro-Fauna (SIMF) (Manhaes et al., 2013). SIMF play a crucial role in maintaining ecosystem health. However, the effects of various land management techniques on SIMF are not fully understood, particularly in local contexts. Previous studies conducted at the UAS, GKVK, campus in Bangalore have identified a knowledge gap regarding SIMF assemblages in different land use categories. This study aims to investigate the influence of land use changes on the abundance and diversity of SIMF in GKVK, Bangalore. By analyzing SIMF communities across various land use types, we seek to identify specific impacts and inform sustainable land management practices.

Materials and Methods

Description of the study area

The study was carried out in four primary land use types: roadside soil; botanical garden; forest ecosystem; and paddy ecosystem ZARS at UAS, GKVK, Bangalore, which is situated in the northern region of the Bangalore district; Geographically, the region is located between Latitude: 13° 04' 55.92" N and Longitude: 77° 34' 34.57" E.

Sampling Methods and Experimental Design:

Sampling was carried out in May 2021, during the beginning of light rainfall, when soil macrofauna activity is normally heightened. Every category of land use (Plate 1) has 3 sampling locations. Using an excavator tool soil was dug to a depth of 25 × 25 × 30 cm at 10-meter intervals along a transect perpendicular to the slope and with randomly placed starting points. Three sample monoliths were taken from each type of land use to create a total of twelve sampling points. Using Berlese funnels (Muvengwi *et al.,* 2018) (Plate 2), the macro-fauna was separated from the soil, collected in vials with 70% alcohol and then identified and counted. After the extraction of macrofauna, the extracted soil was put back in its original location to reduce soil disturbance in selected land use types.

Identification of soil macro-fauna

The collected soil invertebrates were identified and counted. According to Eaton and Kaufman (2007), identification keys and visual aids such as photographs were used in the laboratory to identify species of SIMF. Four different land use categories were evaluated for macro-fauna abundance (Table 1). The abundance and diversity of each macrofauna within the four land use groups were calculated.

Results

A total of 55 SIMF individuals were collected across four land use categories. Ants and spiders were ubiquitous, found in all land use types. However, earthworms and Collembola were absent from paddy ecosystems, suggesting their sensitivity to intensive agricultural practices.

The abundance of SIMF varied significantly among land use types. Forest land exhibited the highest abundance (49.09%), followed by botanical gardens (29.09%), while paddy fields and roadside soil had lower densities. This pattern indicates that more natural or less disturbed environments, such as forests and botanical gardens, provide more suitable conditions for SIMF.

Spiders were the most abundant macrofauna group across all land use types, constituting 45.4% of the total. Collembola were the second most abundant group, representing 23.63%. These findings highlight the importance of spiders and Collembola in maintaining soil ecosystem health in the study area (Table 2)

Discussion

“The SIMF community clearly responded to the environmental disturbance induced by unsustainable land use management. These groups of SIMF living in forest and botanical garden fields were favored, possibly via the large production, and/or better quality of litter. This owing to the fact that high organic matter content under forest and homestead garden fields which provided substrates for the soil organisms, likely reduces the negative effects of soil acidity on soil organisms" (Ayuke et al., 2011). "Also, the paddy-cultivated fields had higher soil acidity concentrations and low organic matter content considered to be "not convenient" for many SIMF". (Bufebo et al., 2021). "Botanical garden fields and forest lands had more species diversity explaining the fact that unregulated agricultural expansion into forest land had a negative impact on SIMF species diversity. Diversity decreased gradually with an increasing intensification of land use in the system. The density of SIMF communities varied significantly in relation to the land use. In our study, an increase in density of SIMF in the forest and botanical garden fields was largely accounted by variations in litter quality and /or abundance, occurrence of vacant niches, good pH, and moisture content at the soil surface" (Bufebo et al., 2021). "This may be attributed to the variation of disturbance level in the habitats within these land use types on the community composition of SIMF" (Ayuke et al., 2011)

Botanical garden and forest land had more species abundance explaining that the fact that unregulated agricultural expansion into forest land had a negative impact on the abundance of SIMF species. The abundance of SIMF was dramatically affected by Road site human activities and crop cultivated outfields. Similarly, (Decaens et al., 1994) reported that "the abundance of soil macro-fauna tends to decrease to low levels in crop cultivated lands. The higher the vegetation diversity, so the ability to provide energy and food source for soil macro-fauna would be high". "The higher the availability of energy and nutrients for soil macro-fauna, so growth and activity of soil macro-fauna would be better" (Negasa et al., 2017). "As intensification occurs in crop cultivated outfields, losses and stresses imposed by chemical contamination through use of herbicides and pesticides and chemical imbalances through soil acidification resulted in a gradual decrease in SIMF diversity" (Elias, 2016). "Moreover, continuous cultivation of the study area led to soil degradation through nutrient depletion and compaction impaired soil biological functioning" (Bufebo & Elias, 2020). Similarly, (Muchane et al., 2012) reported that "agricultural activities significantly affected the composition of macro-fauna community". Consistent with findings by Bufebo et al. (2021), "soil macro-fauna abundance tends to decrease to low levels in crop-cultivated lands".

Conclusion

The findings of this study indicate that intensive cultivation of land leads to quantitative alterations in the abundance and diversity of SIMF communities. These changes are attributed to specific management practices that result in habitat destruction and the removal of organic substrate, consequently diminishing the availability of food sources for associated SIMFs. Among the four land use classes examined, Forest land, characterized by minimal disturbance and greater soil cover, supports the highest SIMF abundance. Conversely, paddy fields and roadside soil, subject to intensive agricultural practices and human disturbance, exhibit lower SIMF densities. The results highlight the importance of preserving natural and less disturbed land use types to maintain healthy soil ecosystems. Sustainable land management practices that minimize soil disturbance, promote organic matter inputs, and reduce the use of agrochemicals are crucial for conserving SIMF populations and ensuring their continued contributions to soil health and ecosystem resilience. Therefore, it is advisable to adopt sustainable cropping systems that uphold acceptable levels of SIMF abundance while minimizing human disturbances. Achieving this goal necessitates incorporating knowledge of biological processes into the design of land management systems. Additionally, further in-depth studies are crucial to identifying the optimal combination of land use and varying management practices across different land types, ensuring the most effective sustainability of SIMF populations.

Table 1: Composition and distribution of SIMF in different land use types at GKVK, Banglore

Taxa	Distribution			
Earthworm	Paddy Ecosystem ZARS	Botanical Garden	Forest Ecosystem	Roadside Soil
Collembola	-	+	-	+
Spider	-	+	+	-
Ant	+	+	+	+
Millipede	+	+	+	+

+ indicates present, − indicates absent

Table 2: Abundance of each taxon in different land use types

Land use types	Earthworm	Collembola	Spider	Ants	Millipede	Total % of arthropods
Paddy ecosystem	0	0	5	2	0	12.72%
Botanical garden	3	4	8	1	0	29.09%
Forest ecosystem	0	9	11	4	3	49.09%
Roadside soil	2	0	1	1	2	10.90%
Total % of arthropods	9.09%	23.63%	45.45%	14.54%	9.09%	

 

(a)

 

(b)

 

(c)

Plate 1: Collection of Soil Sample from (a) Paddy field, (b)Forest ecosystem, (c) Roadside soil

Plate 2: Setting of Berlese Funnel for the Estimation of Soil Invertebrate population from collected samples

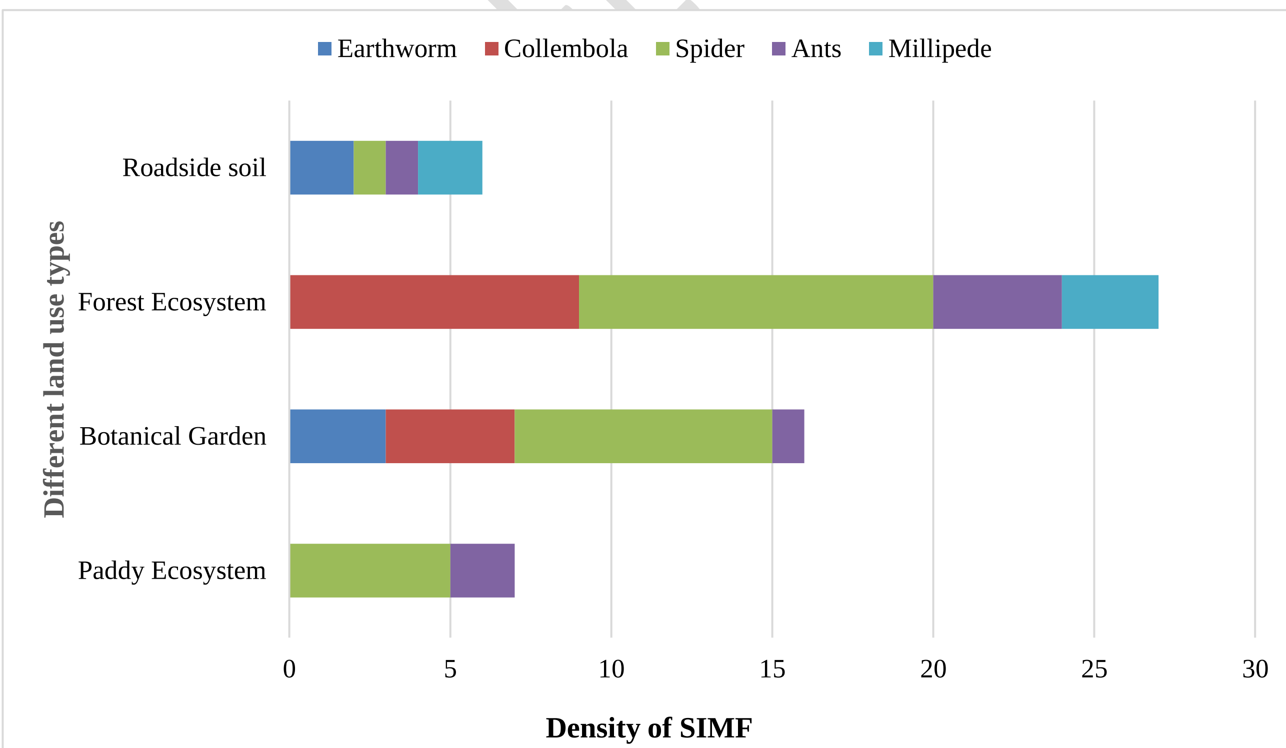

Fig.1. Density of SIMF in different land use types at GKVK, Bangalore

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