STUDIES ON SOIL ARTHROPODS IN RELATION TO SOIL QUALITY IN PUNJAB

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By

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DECLARATION

I, hereby declared that the presented work in the thesis entitled “**Studies on Soil Arthropods in relation to Soil Quality in Punjab**” in fulfilment of degree of Doctor of Philosophy (Ph. D.) is outcome of research work carried out by me under the supervision **Dr. JOYDEEP DUTTA**, working as Professor, in the Department of Zoology/School of Bioengineering and Biosciences of Lovely Professional University, Punjab, India. In keeping with general practice of reporting scientific observations, due acknowledgements have been made whenever work described here has been based on findings of other investigator. This work has not been submitted in part or full to any other University or Institute for the award of any degree.

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CERTIFICATE

This is to certify that the work reported in the Ph. D. thesis entitled "**Studies on Soil Arthropods in relation to Soil Quality in Punjab**" submitted in fulfillment of the requirement for the reward of degree of Doctor of Philosophy (Ph.D.) in the Department of Zoology, School of Bioengineering and Biosciences, is a research work carried out by **Ruby Angurana**, **11719572**, is bonafide record of his/her original work carried out under my supervision and that no part of thesis has been submitted for any other degree, diploma or equivalent course.

2/5/23

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Abstract

The terrestrial soil of our planet supports a wide array of living organisms, including both plant and animal species. The soil fauna constitutes a significant proportion of the terrestrial ecosystem and plays a vital role in soil fertility through their decomposition activities. Soil microarthropods are among the most commonly occurring types of soil fauna that inhabit soil and litter. The present study aimed to assess the population and diversity of soil microarthropods, particularly Collembolans and Acarina (mites), across four distinct research sites located in Punjab, encompassing both agricultural and non-agricultural land of Jalandhar, Punjab over a period of two years, spanning from January to December. The Berlese-Tullgren apparatus was utilized to extract soil-dwelling arthropods and fluctuations in the population of soil microarthropods was observed based on seasonal changes. Consequently, one of the objectives of this study was to investigate the monthly variations in soil arthropod populations. The study considered several factors, namely the abundance, standard deviation, density, and monthly population fluctuations of soil arthropods. These factors were chosen due to their ability to represent the notable changes in population that transpired within a span of two years. Edaphic soil variables, such as soil temperature, pH and EC at the soil surface, and soil moisture content, can influence the abundance of soil arthropods. The present study investigated the impact of edaphic conditions on the soil arthropod population. Hence, organisms from different sites in Punjab were collected, and assessments of the chemical parameters of the soil, including organic carbon, nitrogen, phosphate, and potash, along with other edaphic factors, were conducted at four distinct research sites located in Jalandhar, Punjab. A significant correlation was observed between the soil microarthropod populations and edaphic elements. The present discovery implies that alterations in the environment and soil properties throughout various seasons have an impact on the arthropod populations inhabiting the soil. The statement suggests that the population dynamics of Collembola and Acarina are influenced by seasonal fluctuations in environmental factors such as temperature, moisture content, pH, and electrical conductivity. The rise in arthropod population during the pre-winter and winter seasons can potentially be attributed to favorable environmental conditions. During these seasons, it is possible that lower temperatures

and increased moisture content of the soil may create favorable conditions for the growth and reproduction of certain organisms. Conversely, the reduction in populace observed in the summer season could be attributed to less propitious circumstances. The arthropods may experience decreased survival rates or limited resources due to elevated temperatures and arid soil conditions during the summer season. The QBS approach was utilized to assess the biological condition of soil through the examination of soil arthropods. The findings indicate that the biological quality of the soil was relatively consistent across the study sites, with values exceeding 100, which is indicative of favorable soil quality. However, an exception was observed in the case of AG4, where the value was recorded as 87. Agricultural management techniques have the potential to affect the population of soil microarthropods. Consequently, our investigation focused on the impact of management practices on the diversity of soil microarthropods in the subsequent objective. In addition to conducting molecular characterization through the use of COX 1 genes, diversity indices were calculated during the population analysis. DNA barcoding has emerged as a prominent method for the identification of various species, including arthropods. Currently, DNA barcoding efforts are primarily focused on arthropod taxa. This approach was utilized to ascertain a multitude of species in light of the aforementioned global phenomenon. The identification protocol employed a combination of DNA barcoding and scanning electron microscopy techniques. Based on the results of the study, it has been determined that the region of Punjab exhibits a significant diversity of arthropod taxa such as *Folsomia quadrioculata, Isotomidae* sp., *Bethylidae* sp., *Poecilochirus carabi, Sperchonopsis ecphyma,* and *Demodex folliculorum.* This discovery has facilitated access to a valuable genomic asset that can be utilised for future investigations into the comparative genomics of arthropods in soil and its evolutionary chronicle. The cuticle, which functions as the outermost protective layer of the bodies of Collembola and Acarina populations in the study, was probably analyzed using SEM. In arthropods, the cuticle serves as a protective barrier against a variety of environmental stressors, including physical damage and desiccation. In addition, the SEM analysis have focused on specific anatomically significant regions, such as the furcula and the skin ornamentation of the organisms. The furcula is a distinctive anatomical structure found in certain Collembola taxa, also known as springtails. The furcula is located ventrally

on the abdominal region and is utilized for jumping and somersaulting. Utilizing SEM analysis, it was observed that the structural characteristics of the furcula and the skin pattern, which includes unique adaptations or characteristics that contribute to its exceptional functionality have yielded significant results regarding the surface morphology of the organisms, allowing researchers to examine the cuticle, furcula, and other intricate anatomical features. This information may facilitate comprehension of the structural modifications and operational characteristics exhibited by these invertebrates. The data obtained from both agricultural and non-agricultural regions reveals minimal differences, suggesting that these arthropods are relatively less affected by human activities with a cumulative count of 15653 organisms/m^2 during the period of two years. The statistical analysis indicated that there were no statistically significant differences observed between the sites during the two-year period, encompassing all sites. In summary, the study provides evidence that the presence and characteristics of habitats and soil have a notable impact on the prevalence and spatial arrangement of arthropods in soil. Through comprehending these patterns, researchers can acquire knowledge about the ecological dynamics of arthropod populations in ecosystems of soil.

Keywords: arthropods; soil fertility; cox I; identification; DNA sequences

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Abbreviations

PSFs	Plant soil feedbacks
CO_2	Carbon dioxide
H_2O	Water
NO_3-	Nitrate
mm	millimeter
DOM	Dissolved organic matter
SOM	Soil organic matter
QBS ar	Soil biology quality index for arthropods
cm	Centimeter
°F	Fahrenheit
°C	Degree celsius
DPX	Dibutylphthalate Polystyrene Xylene
v/v	Volume/volume
COI	Cytochrome C oxidase subunit 1
µL	Microlitre
PCR	Polymerase chain reaction
DNA	Deoxyribonucleic acid
TBE	Tris base, boric acid and EDTA
w/v	Weight/volume
BLAST	Basic Local Alignment Search Tool
FESEM	Field emission scanning electron microscopy
EC	Electrical Conductivity
Temp.	Temperature
IRGA	Infrared gas analyzer
Org C	Organic Carbon
N	Nitrogen
P	Phosphorus
K	Potassium
S	Species count
T	Taxa
µg	Microgram
µM	Micromolar
Mg	Milligram
mM	Millimole
1-D	Simpson diversity Index
H	Shannon Weiner Index
J	Equitability Index
EMI	Eco morphological Index
AG1	Agriculture Site 1
NAG1	Non-agriculture Site 1
AG2	Agriculture Site 2
NAG2	Non-agriculture Site 2
AG3	Agriculture Site 3
NAG3	Non-agriculture Site 3
AG4	Agriculture Site 4
NAG4	Non-agriculture Site 4
ds/m	Deci-siemens/meter
Kg/h	Kilogram per hectare
ppm	Parts per million
df	Degree of freedom
N	Number
min	Minimum
max	Maximum

Std error	Standard error
Stand. Dev.	Standard deviation
Fam.	Family
Ord.	Order

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Chapter 1 Introduction

1.1 Agriculture and the soil

The relationship between soil and agriculture is a crucial aspect of sustainable food production. The quality and health of soil directly impact the growth and yield of crops, as well as the overall health of the ecosystem. Therefore, understanding the complex interactions between soil properties, such as nutrient availability and soil structure, and agricultural practices, such as tillage and crop rotation, is essential for maintaining soil health and productivity. Our country economy is based on agricultural production, and agri-products. Agro-industries generate 54.6% employment (Kataria, 2021) and the agricultural sector of India has a long and illustrious history (Dandage et al., 2017) dependent on the soil, but the soil in agroecosystems contains most biodiversity, making it the most complex and diverse ecosystem on Earth. In addition to being the second-largest consumer of cereals in the world, modern agriculture is based on a commercial production model, which has resulted in the widespread use of agricultural chemicals, such as fertilizers and pesticides, by farmers (Gulati & Juneja, 2022). India contributes one of the most significant amounts to global food production through its agricultural output. The country produces the second most wheat and rice in the world (Bakthavatchalam et al., 2022). The amount of agricultural pollution has increased significantly over the last few decades, with most of it due to the use of chemical fertilizers and pesticides on agricultural fields (Jiang et al., 2020). The world’s population is pushing for increased agricultural production to combat diseases and pests by using intensive land use, large quantities of agrochemicals, and cultivating disease-resistant cultivars (Chávez-Dulanto et al., 2021). To increase food production, many developing nations agricultural development programs rely heavily on imported inputs from developed countries, such as mechanization and agrochemicals (Marambe et al., 2020). Agrochemicals are used more frequently to control pests, weeds, and diseases. Because of such traditional approaches-biological, cultural, and mechanical control (Rawat et al., 2021; Sener, 2022) the quality of soil is being depleted day by day thus, need to rely on more on natural systems. In addition to other important aspects, agrochemicals can also be used to increase plant growth and yield (Kah & Kookana, 2020). However, long-term use of agrochemicals, in excessive quantity, has been linked to reduction of organisms in the soil and soil fertility loss (Baweja et al., 2020).

The soil biota is a crucial component of various ecological services that hold significant importance for the sustained well-being of both natural and cultivated ecosystems. According to research, soil arthropods have been found to constitute up to 85% of the total species present in the soil. Soil organisms play a crucial role in maintaining soil health and quality, while also providing various environmental services. Soil arthropods primarily contribute to the soil ecosystem by facilitating the decomposition of organic matter and enhancing soil moisture levels. Nevertheless, through the process of ingestion, they may also facilitate the decomposition of nutrients in the soil by microorganisms. Arthropods play a significant role in altering the structure of soil. This process is achieved through the incorporation of soil mixing, creation of pores and holes, and the formation of soil aggregates. The soil medium serves as a naturally occurring home for living organisms and plays a crucial role in the establishment and sustenance of diverse ecosystem functions. According to Garibaldi et al., 2019, it occupies multiple ecological niches beneath the surface. The involvement of arthropods residing in soil litter is significant in the facilitation of soil nutrient cycles through the processes of nutrient mineralization and litter feeding. Additionally, these organisms play a crucial role in the formation of soil structures by means of soil mixing, creation of soil openings, and production of soil aggregates (Nsengimana, 2018; Sofo et al., 2020). Also, some arthropods are important predators on the surface of the soil and in the litter layer, which helps keep pest numbers in control (Akunne et al., 2013). Conversely, certain individuals consume primary decomposers and contribute towards regulating the composition and functioning of soil microorganisms. Arthropods are frequently employed as indicators of soil quality due to their significant contribution to the soil's biological processes (Gonçalves et al., 2021).

1.2 Soil biota and its role

Soil biota is a comprehensive term utilized by soil scientists to refer to the entirety of soil organisms that inhabit and interact within the soil environment. Ritz et al., 2004 characterized soil biota as the primary biological force that propels and alters various physical, chemical, biological, and ecological mechanisms across soil worldwide. The survival of all living species on earth is fundamentally dependent on soil. Life and daily activities in its usual form cannot be imagined without a planet, even if there were none. Living organisms can be affected by the soil's characteristics in a variety of circumstances, either directly or indirectly (Hooper et al., 2005). In consequence, all living things have a diversity determined by the types, compositions, and environmental conditions of the soil in which they grow. Excessive and stressful environmental conditions as well as diversity and density of subsurface fauna can affect soil metabolism, growth, and reproduction in a direct or indirect way (Holt & Miller, 2011). Changes in soil conditions, which may stem from natural environmental climatic factors or artificially imposed factors, have a significant impact on the biological communities of organisms that are born in the soil and live in the soil in natural environments (Jaisankar et al., 2018). As a varied and extremely dynamic system, soil allows for the emergence of a diverse variety of ecological niches that are ideal for high-density human development. It provides a home for a variety of living species and performs vital functions for the overall ecosystems well-being (Haines-Young & Potschin, 2010). Microorganisms, such as bacteria and fungi, are the most common types of organisms found in soil (Delgado-Baquerizo et al., 2020), followed by a diverse range of animals, including nematodes, arthropods, enchytraeids, and earthworms, which are also common (Zanella et al., 2018). They can improve soil structure while concurrently enhancing soil horizon mixing, soil pore space, soil aeration, and soil moisture content because of the reduction in bulk density (McCalla, 1950). Further research has demonstrated that it can expedite the breakdown of litter and the creation of soil aggregate structure (Bucka et al., 2019).

In addition to providing sustenance for the plants, the soil also provides as a natural habitat for invertebrates and bacteria in the surrounding environment (Figure 1:1) (Prather et al., 2013). Top soil is covered with humus, which is the result of several physical and chemical processes that have taken place in the soil. It is this humus that serves as a habitat for a varied spectrum of mesofauna species (Brussaard & Juma, 1996). When it comes to plant growth, soil is often thought of as a straightforward substrate. The soil, on the other hand, not only provides excellent support for plants, but it also serves as a reservoir for water and organic matter, as well as a source of biological and pedologically significant components. The breakdown of organic matter in the soil, nutrient cycling, the transformation and movement of soil constituents, and the development and maintenance of healthy soil are all activities (Figure 1:2) that soil organisms have a considerable influence on soil (Johns, 2017).

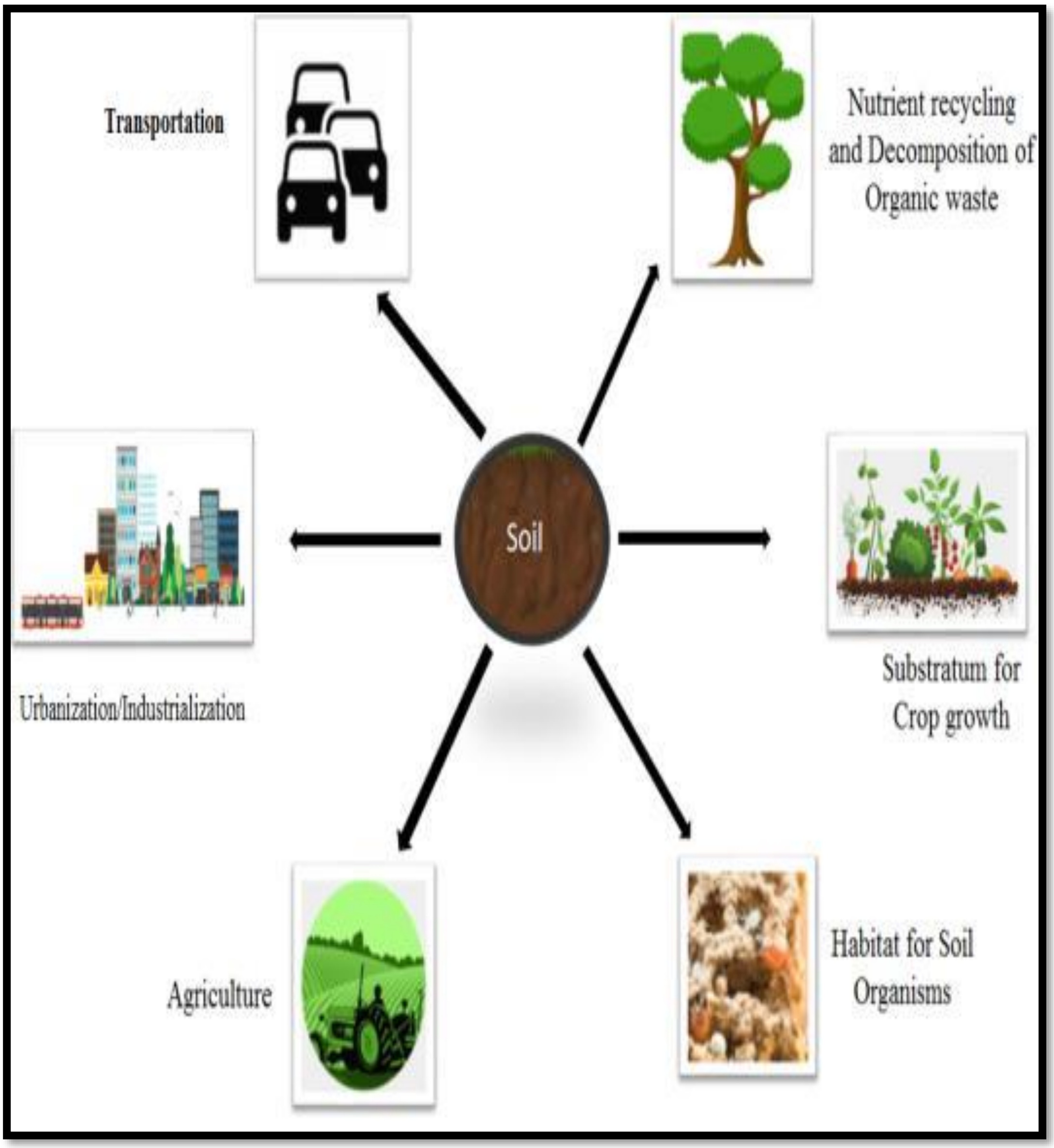


Figure 1:1 Soil as natural habitat for all living organisms

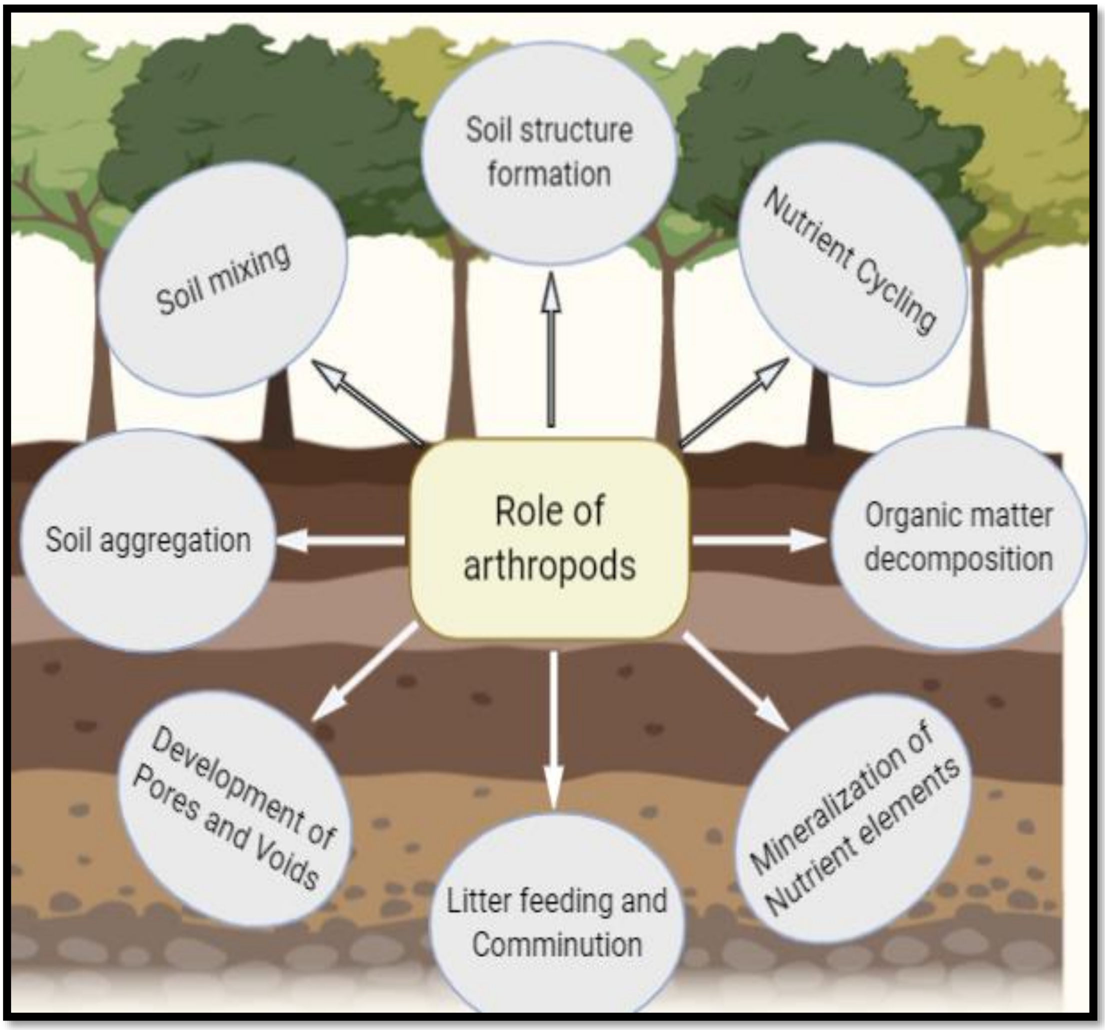


Figure 1:2 Role of soil arthropods in soil

Therefore, soil organisms should not be disregarded as an asset in the management and maintenance of agriculture, as well as in the preservation of the subsurface ecosystem (Bender et al., 2016). When we have a biologically sound soil, we can find a varied range of animals, including bacteria, fungus, protozoans, nematodes, springtails, mites, ants, termites, and larval forms of ground beetles, among other things. In addition to boosting nutrient availability and discharging chemicals that promote plant development, the majority of them are advantageous to plants in a variety of ways (Coleman & Wall, 2015). A fertile soil produces a diverse range of crops with the least number of external inputs and with little or no negative environmental implications, compared to a deficient soil. There are several advantages to it in terms of biological, physical, and chemical features (Liebman & Davis, 2000).

Soil microarthropods are arthropods that are microscopic in size, measuring between 0.1mm and 2mm in length, and they burrow their way deep into the soil to reproduce (Franzluebbers, 2009). Apterygote (wingless arthropods such as Collembolans, Diplurans, Proturans, and so on) and Pterygote (winged arthropods such as Collembolans, Diplurans, and so on) are the two principal groupings of arthropods classified (winged arthropods like Coleopterans, Isopterans, Dipterans, Hymenopterans etc) (Labandeira, 2019). Soil microarthropods have an important role in the movement of energy and the cycling of nutrients in humid to semi-arid regions of the planet, primarily at the herbivore and decomposer levels, as well as in the flow of nutrients (Roy et al., 2018). In the same way that other creature's ecological relevance is proportional to the density and biomass of their population, the intensity of their ecological importance is proportionate to the density and biomass of their population. The ability of various soil fauna, including microarthropods, to impact essential ecosystem processes such as decomposition of organic matter and nutrient mineralization, as well as to promote plant development, has long been recognized (Menta, 2012). When soil-dwelling animals are active, they have a significant impact on the soil's ability to retain fertility. It is defined as soil that provides essential nutrients for crop production and crop growth, facilitates the development of a diverse and productive biotic community, exhibits the characteristics of typical soil structure, and allows for the unhindered decomposition of organic matter in the agricultural setting (Lavelle et al., 1992).

Soil arthropods play an important part in litter decomposition by devouring and fragmenting litter as well as stimulating microbial sources to further simplify organic and inorganic matter (Ravn et al., 2020; Bokhorst and Wardle, 2013; Deng et al., 2022). The presence of microarthropods shows the health and quality of the soil (Palacios-Vargas et al., 2007). The deposition of organic matter and nutritional resources in the soil is caused by a slow rate of decomposition. Plant litter, along with root exudates, is the principal source of SOM. Organic materials can enter the soil as dissolved organic matter (DOM) because of root turnover or bioturbation. Approximately a quarter of litter-derived carbon is metabolized to CO_2, with the remainder remaining in the soil and becoming sequestered during millennium and centennial periods. Because litter decomposition, SOM production, and soil texture are all interrelated, any change in the soil texture will have an impact on the patterns of litter decomposition and SOM creation (Angst et al., 2021).

Plants, on the other hand, benefit from rapid breakdown rates since they aid in the provision of enough nourishment. Seasonal fluctuations, rainfall, and temperature can all have an impact on the performance of bacteria and numerous other soil faunas, ultimately altering decomposition rates (Krishna and Mohan, 2017). Soil is a multi-component, multi-purpose system that interacts with the abiotic environment through the interactions of numerous soil-dwelling species to regulate the structure and composition of habitats (Neher and Barbercheck, 2019). Besides air and water, soils constitute one of the three essential elements of the environment (Bünemann et al., 2018). In terms of quality, air and water pollution have a negative impact on natural ecology, animal nutrition, and human wellbeing (Balali-Mood et al., 2016). In the context of soil, the label quality is defined as Within the ecosystem, the soil primarily maintains the air and water quality, promotes animal and plant health, and sustains biological productivity (Cardoso et al., 2013). During soil formation and accumulation, there is a series of events that mark the economic and environmental succession stages leading to the establishment of biotic ecosystems (Liu et al., 2016). There are several biotic, chemical, and physical reactions involved in the formation of soil (Bagyaraj et al., 2016). As a result of their interactions between five major factors, soil properties enhance: climate, topography, biota, parent material, and time (Schaetzl and Thompson, 2015). The physical weathering is the first step in the formation of soil of rocks (Eisenbeis and Wilfried Wichard, 1987), which results in cracks and fragmentation into granular materials (Egli et al., 2018). Metabolic processes and other by-products may increase nutrient availability from soil over the next few decades, as well as the structure of the soil and the connectivity between the organisms and the mineral components (Lavelle et al., 2016). By the end of the process, organic material aggregation is controlled by nutrient cycles and breakdowns that are nearly too close together (Harris, 1997). Consequently, natural soils are composed of biological and clastic origins. There is a wide variety of living elements found on the soil, indicating a high level of soil quality (Mursec, 2011). A diverse range of organisms may be found in healthy soils in both controlled and uncontrolled conditions, supporting the ecosystems multi-functionality and emphasising that soil biodiversity is a critical regulator of ecosystems (Bowker et al., 2010). Microarthropods make up a large component of the soil fauna and play an important role in nitrogen cycling and litter transformation. Acari and Collembola are the most prevalent soil microarthropods identified in both the mineral soil profile and the litter. Microarthropods can be found in practically all terrestrial ecosystems (Korboulewsky et al., 2016). Litter diversity has an effect on the behaviour of soil organisms and the activities of these species during decomposition (Chomel et al., 2016). At the same time, some writers define soil health and quality as a soil's ability to work within its potential within the normal or regulated ecosystem limitations in order to improve soil quality and plant and animal sustainability (Bone et al., 2010). Because of the diverse spectrum of soil qualities and functions, determining soil quality has always been a difficult undertaking. There are currently no universally acknowledged procedures for determining the quality of soil at this time (Rosa, 2005). There is a great deal of evidence that tillage practises have an impact on the biological, chemical, and physical features of soil's (Audette et al., 2021).

The existence of mesofauna in agricultural soil is widespread, but much more has to be learned about their role in soil characteristics and how they interact with one another (Barrios, 2007). The fact that they are sensitive to agricultural chemicals has prompted some to speculate that they may even have potential as biological indicators of the impact of agricultural chemicals on ecosystems (Koehler, 1992). Some soil macrofauna (for example, spiders and ants) are involved in pest species predation, but others tend to play a role that is similar to mesofauna, in that their food contains both primary and secondary consumers, as well as processing organic matter and making a positive contribution to soil structure (van Straalen, 1997, Doube and Schmidt, 1997). In the case of a specific leaf type under favourable climate circumstances, it has been hypothesised that the management of biota is the most important aspect of the breakdown process (Lavelle et al., 1993). Because of this, it is possible to deduce that soil fauna (mostly soil microarthropods) may have a major impact on the rate at which organic matter decays. For examples, notable families such as mites (Acari) and springtails (Collembola) are represented in soil microarthropods, which collectively account for around 90% of the overall microarthropod population in the vast majority of soil environments. In addition to having indirect effects on these process steps through interactions with other soil organisms, particularly microbes, microarthropods also have direct effects on these process steps through fragmentation of litter and the production of nutrient-rich excreta (Peterson et al., 1998). Microarthropods are the most abundant group of soil organisms in boreal soil's (Peterson et al., 1998) and have both indirect and direct effects on these process steps through interactions with other soil organism (Thakur and Geisen, 2019). The impact of land usage has a considerable impact on the creature's that live in the soil environment. It is the quick conversion of forests into farmland and agricultural sectors that is the primary cause of soil degradation and change, which has a negative impact on the creature's that live on these grounds. Plant biodiversity is affected both directly and indirectly by agricultural inputs such as ploughing and other agricultural practices (Emmerson et al., 2016). Agronomic techniques have an immediate impact on arthropod diversification by modifying habitats, causing body injury, and altering nutrition availability (Médiène et al., 2011). A few examples of indirect effects include changes in soil structure, loss of organic matter in the soil, decreased complexity and diversity in carbon inputs, disruption of trophic interactions due to selective pressure on target and non-target organisms, and toxicity caused by pesticide residues and biocides breakdown products (Gessner et al., 2010). Increased forest disturbance levels, as a result of forest conversion to agroforestry and agricultural systems, have resulted in decreased soil arthropod abundance and species richness in ecosystem services (Steffan-Dewenter et al., 2007). In many cases, pesticides cause soil contamination, which has a long-term influence on soil fertility and can endure for several decades (Chen et al., 2015). Many of the chemicals used in pesticides cause soil contamination. The fact that the bigger the amount of organic matter present in the soil, the better the soil's ability to hold water, is solid confirmation of this fact (Pettit, 2004). Farm crop yields can be increased by as much as 20-40 percent when organic farms produce yields that are 20-40 percent greater than those produced by conventional farms, which is beneficial in times of severe drought (Lim et al., 2015). A decrease in the amount of organic matter present in the soil increases the amount of pesticide that will be released from the region following treatment because organic matter binds to pesticides and aids in their breakdown

(Durán-Lara et al., 2020). The application or extensive usage of agro-chemicals on agricultural farms has resulted in a significant reduction in the amount of organic matter in the soil's organic matter (Rasul and Thapa, 2004). As a result, the soil community is one of the most diverse components of a terrestrial ecosystem, ranking second only to vegetation (Lal et al., 2019). A wide range of arthropods are found on earths soil, and they are among the most popular and well-known animals (Scheffers et al., 2012). Soil Arthropods are dominating groups of organisms found in the soil that include dominant groups of species of great ecological value as stated by Menta and Remelli, 2020. Arachnids, Chilopoda, Crustaceans, Diplopoda and Insecta (sometimes known as Hexapoda) are the five major classes of arthropods (Smarandache-Wellmann, 2016). Whereas in the terrestrial ecosystem's food chain and food webs, the key groups of soil arthropods that are noteworthy include Myriapods, Acarina, Collembola, Symphyla and arthropods (Potapov et al., 2017). Wallwork (1970) discovered that the Collembola and Acarina contain 90 percent of total soil organisms, while Hopkins (1997) stated that soil creatures are categorised into organism size-based main groups (Walter et al., 2013), dietary preferences, manner of locomotion, and position in the soil depending on depth of the soil (Bardgett et al., 2005).

In history, much emphasis has been placed on the contribution of earthworms in the soil; nevertheless, in terms of their variety, diversity, and quantity of niches, the phylum arthropods, as well as the variety of niches that they occupy, play a significant role in the environment (Thomas et al., 2020; Elmquist et al., 2023). We investigated the importance of the arthropod group as a bioindicator (Zayadi et al., 2013) of soil quality for each taxon. Furthermore, because arthropods live, consume, and reproduce in soil, some species are immensely vulnerable to variations in soil properties and have adjusted well to specific soil quality (Menta and Remelli, 2020). In accordance with extant research, human activities, as well as the soil's biodiversity, have an impact on soil and its communities. Yet such studies are rare in India, and there is a significant lack of knowledge on the subject, particularly in the northern half of the country, which has a diverse climate and a diverse range of animal species. Baardsen et al., 2021 have reported that arthropods exhibit negligible effects in response to pollutants, urbanisation, industry, change, and habitat loss, owing to their high reproductive rate and diversity. The current state of knowledge regarding the abundance and diversity of soil-dependent arthropods in the Jalandhar region is inadequate. The present study aimed to gain an in-depth knowledge of the seasonal fluctuations in the quantity and variety of soil arthropods in Jalandhar, India, considering the aforementioned factors.

Chapter 2 Review of literature

2.1 Soil arthropods-Overview

Soil is a mixture of solid, liquid, and gaseous components essential in ecosystem processes and biogeochemical cycles. In addition, the soil itself is a vital resource for agriculture production because it provides nutrients for plant growth. As a result, soil fauna is incredibly divergent, with organisms spanning a wide spectrum of fauna and flora as well as soil and litter arthropods, accounting for up to 85% of all soil fauna (Nsengimana et al., 2018). In soil-living ecosystems, soil arthropods are critical contributors to soil quality and health and ecosystem services. Soil arthropods are responsible for organic matter transport, decomposition, nutrient cycling, soil structure formation, and, as a result, water management (Mishra and Singh, 2020). Soil arthropods are the essential herbivore and detritivore of the terrestrial system. Soil arthropods play a vital role in litter decomposition by consuming and fragmenting litter and stimulating microbial sources for further simplifying organic and inorganic mass (Ravn et al., 2020; Bokhorst and Wardle 2013). The presence of microarthropods indicates soil health and quality (Palacios-Vargas et al., 2007). The deposition of organic matter and nutrient resources in the soil results from a slow decomposition rate. Plant litter is the primary source of SOM, along with root exudates. Organic matter may enter the soil as dissolved organic matter (DOM) from root turnover or bioturbation. Approximately a quarter of litter-derived C is mineralized to CO_2, while the remainder is retained in the soil and becomes sequestered during millennium and centennial periods. Because litter decomposition, SOM production, and soil texture are all interconnected, any change in the soil texture will impact the patterns of litter decomposition and SOM formation (Angst et al. 2021). On the other hand, plants benefit from fast decomposition rates because they help them achieve adequate nutrition. Seasonal changes, rainfall, and temperature can affect microbe’s performance and several other soil faunas, directly affecting decomposition rates (Krishna and Mohan, 2017). Soil is a multi-component, multi-purpose system that interacts with the abiotic environment through the interactions of various soil-dwelling organisms to regulate the structure and composition of habitats (Neher and Barbercheck, 2019). A wide range of species lives in healthy soils in both controlled and unmanaged environments, supporting the multi-functionality of the ecosystem, implying that soil biodiversity is a crucial regulator of ecosystems (Hasan et al., 2020). Microarthropods make up a significant portion of the soil fauna and play an essential role in nutrient cycling and litter transformation. Acari and Collembola are the most common soil microarthropods found in both the mineral soil profile and litter. Microarthropods are found in nearly all terrestrial habitats (Culliney, 2013). The behaviour of soil organisms and their activities during decomposition is influenced by litter diversity (Hättenschwiler et al., 2005). At the same time, some authors define the health and quality of the soil as a particular soil's ability to work within its capability within the normal or regulated ecosystem limits (Doran and Zeiss, 2000) to enhance soil quality and plant and animal sustainability (Schoenholtz et al., 2000). Assessing soil quality has always been a challenging task due to the wide range of properties and functions. There are currently no internationally accepted methodologies for determining soil quality (Zalidis et al., 2002). There is considerable evidence that tillage procedures have an impact on the biological, chemical, and physical characteristics of soil's (Audette et al., 2021). The maintenance of a particular ecosystem structure is contingent upon the interplay between biotic and abiotic factors, which engender the emergence of species exhibiting characteristic patterns of abundance, seasonality, and biomass. Numerous global studies have demonstrated the significance of soil biota in preserving soil health and promoting the efficacy and viability of vegetation growth. This has sparked interest in investigating the interplay between soil biota components, soil parameters, and plant productivity (Verhoef and Brussard, 1990). According to De Deyn et al., 2003, the presence of invertebrates in soil contributes to the improvement of grassland succession and its diversity. The moisture content, temperature, and population dynamics of soil arthropods exhibit a correlation that is influenced by seasonal variations. According to Choudhuri and Roy, 1972 and Mukharji and Singh, 1970, the highest populations of Collembolans were observed in the period spanning from November to January in the uncultivated land of West Bengal. According to Cassange et al., 2003, there exists a direct correlation between the physiological structure of humus and Collembolans. The process of humus formation is primarily attributed to the activities of soil biota. This, in turn, has a significant impact on the interactions between terrestrial plants and soil organisms, thereby playing a pivotal role in the functional diversity of the terrestrial ecosystem (Cassange et al., 2006). According to Wong et al., 1977, there was a significant presence and variety of Collembolan's and Acarian's in soil with a higher concentration of organic matter. The impact of Collembola on soil microorganism ecology and fertility is significant. Their influence on microorganisms affects the decomposition and nutrient cycling processes involved in soil formation, as noted by Culik et al., 2003. Their lifespan is typically short. According to Behan-Pelltier, 2003, these organisms consume fungal hyphae and decomposing plant matter, playing a crucial role in soil formation through nutrient cycling and decomposition processes. Springtails have been observed to facilitate the proliferation of mycorrhizae and exhibit potential in managing fungal infections in plants. Collembolans have been acknowledged for their potential value as biological indicators of soil quality and ecosystem health. Consequently, understanding Collembola is beneficial for the formulation of conservation strategies and monitoring of natural and human-impacted regions (Culik et al., 2003). The interactions that take place between micro arthropods and fungi serve as the fundamental process for soil decomposition (Cortet et al., 2003) and nutrient cycling (Bonowski et al., 2000). The preeminent decomposers of soil are soil micro arthropods, including Collembola and Acari. This organism inhabits the soil pores and exhibits a preference for consuming dark pigmented fungi, as well as decomposed organic matter and mineral particles derived from plants. This information is supported by the findings of Bengtsson and Rundgren, 1983 and Kaneko et al., 1998. The significance of arthropods in soil is a topic of great importance in the field of ecology. The community of soil arthropods constitutes a significant constituent of the soil ecosystem. Soil organisms play a crucial role in the formation of humus in the soil, which in turn facilitates important soil functions such as the creation of pores and voids necessary for vegetation and decomposition processes (Hasegawa et al., 2009; Bagyaraj et al., 2016). Soil microorganisms, including bacteria, fungi, and protozoa, serve as the chemical engineers of soil, playing a crucial role in the decomposition process by breaking down plant organic matter into essential nutrients. A diverse array of diminutive invertebrates, including mites, springtails, and nematodes, function as biological regulators by preying upon plants. According to Bagyraj et al., 2016, invertebrates of considerable size, such as arthropods, ants, termites, and earthworms, serve as ecosystem engineers by primarily contributing to the modification of habitats for smaller organisms. Soil fertility refers to the state in which soil possesses the capacity to meet the nutritional requirements of plants for root growth and nutrient absorption. The role of soil arthropods is to transform litter, while the abundance of micro arthropods in the soil is determined by the amount of litter present in agricultural lands. This relationship has been established in previous studies conducted by Fujii and Takeda, 2017 and Gill, 1969.

According to Watanabe's research in 1968, it was observed that the populations of soil arthropods, specifically Springtails and Mites, decreased in number as the depth of the soil increased. This phenomenon can be attributed to a reduction in porosity, as well as an increase in carbon-dioxide and carbon contents within the soil. Soil arthropods serve as highly valuable bioindicators within ecosystems due to their significant contributions towards maintaining soil quality, regulating invertebrate populations, and facilitating soil formation through direct and indirect means. The soil harbours a greater amount of carbon in contrast to the atmosphere, and serves a significant function in the carbon cycle, as evidenced by studies conducted by Rocha et al., 2010 and Frouz, 2017. Certain species of apterygotes have been observed to impact soil fertility by facilitating the growth and proliferation of microbial populations and fungi, which serve as crucial primary colonisers of plant litter (Bagyraj et al., 2016). The primary source of sustenance for a majority of arthropods is derived from plant matter and its associated detritus, which constitutes a significant biotic component. The observation of population dynamics, seasonal variations, and distributions in a given area is facilitated by the influence of biotic and abiotic factors on the distribution, diversity, and abundance of soil arthropods, as noted by Wang and Tong (2012). The primary functional role of litter transformers is the decomposition of plants, which involves breaking down plant litter into basic energy. Various modified techniques have been employed to extract these litter transformers from the soil litter, as documented by (Culliney, 2013) and Bagyaraj et al., 2016. Singh et al., 2002 have reported that the fertility of soil can be enhanced by plant vegetation, which is triggered by a range of ecological and physiochemical modifications in the soil. Surprisingly, there is a dearth of information regarding the interactions among soil decomposers and their role in soil formation. The interdependence of the food web within the soil ecosystem remains a significant topic of inquiry. Nonetheless, the process of decomposition is largely influenced by a multitude of biotic factors, including litter decomposition, as well as a diverse array of abiotic factors, such as soil physico-chemical properties (Wright and Coleman, 2002; Fiera, 2009). The dispersion of arthropods is regulated by multiple factors, including atmospheric conditions, availability of nutrients, and accessibility to shelter. The presence of a variety of plant species and their associated vegetation results in the accumulation of litter, which primarily serves as a habitat for a diverse range of organisms that inhabit litter (Lussenhop, 1992). Apart from the atmosphere, the vegetation of plants, and soil properties such as soil texture, organic matter, and soil pH, the soil food web plays a crucial role in regulating the rate of litter degradation, breakdown, nutrient cycling, and decomposition process of forest litter (Cortet et al., 2003). The tropical forest ecosystem is characterised by the deposition of litter, which facilitates the return of dead organic matter and its associated nutrients to the soil. This process leads to the formation of humus, and the litter on the soil surface serves as a primary source of nutrients through the process of decay. Consequently, this mechanism plays a crucial role in regulating nutrient cycling within the ecosystem (Sundarapandian and Swamy, 1999). The generation of litter and its subsequent decomposition play a significant role in preserving soil fertility. The litter, which descends from plant vegetation, serves to retain the nutritional elements of the soil. The presence of nutrients in soil fertility is crucial for the development of crops and plants, and it also sustains a varied community of arthropods inhabiting the soil (Madar et al., 2003; Culliney, 2013; Bagyaraj et al., 2016). The process of litter fall plays a significant role in the recycling of nutrients, as it facilitates their return to the soil surface and thereby contributes to the maintenance of soil fertility. The process of organic production and decomposition is crucial for the upkeep of soil ecosystems. The decomposition process facilitates the return of essential nutrients to the soil surface, thereby preserving the soil ecosystems integrity. This phenomenon has been documented in various studies (Garkoti and Singh, 2000; Meentemeyer et al., 1982; Odiwe and Muoghalu, 2003; Rajendraprasad et al., 2000; Rai and Srivastava, 1982). The process of litter fall decomposition plays a crucial role in the formation of humus and serves as an energy source for various microflora groups. This, in turn, promotes microbial diversity by providing them with energy and nutrient sources. The process of decomposition has an impact on other soil processes, including mineral soil weathering and nutrient provision to plant components (Berg and McClaugherty, 2003). Fungi are integral to the decomposition process in terrestrial ecosystems, working in conjunction with soil micro arthropods. Specifically, they serve as the primary decomposers of plant materials such as leaf litter, roots, and twigs. Saprophytic fungi possess the ability to break down cellulose and lignin, thereby facilitating the decomposition of plant litter and its byproducts (Dix and Webster, 1995; Rodin and Basilevic, 1967 and 1968).

The soil serves as a natural environment for all living organisms and plays a crucial role in facilitating a multitude of ecological niches underground, thereby enabling the execution of various vital processes within the ecosystem. The role of soil in facilitating vegetation growth, supplying water and nutrients, and supporting the root system for optimal ecosystem functioning has been noted by Bender et al., 2016. According to Gribet and Edgecombe, 2019, arthropods represent the most abundant and diverse phylum of organisms on the planet. The phylum of soil arthropods is the most extensive in the animal kingdom, encompassing over one million species that have adapted to various habitats (Ojeda and Gasca-Pineda, 2019). The presence of arthropods within soil litter plays a crucial role in regulating the stability and functioning of soil ecosystems (Nsengimana et al., 2017). These organisms contribute to the nutrient cycling process of soil through their involvement in nutrients mineralization and litter feeding. Additionally, they aid in the development of soil structures by mixing soil, forming soil openings, and constructing soil aggregates (EI Mujtar et al., 2019). Soil arthropods are recognised as ecosystem engineers or litter transformers due to their significant role in creating, maintaining, and modifying habitats, as well as regulating resource availability for other species such as fungi and bacteria (Bagyaraj et al., 2016). As a result, the nutrients and minerals from decomposing organisms are made accessible for plant uptake in the soil. The microorganisms found in soil play a crucial role in improving soil health and quality by facilitating the decomposition and decay of deceased plants, which serves as a fundamental source of sustenance for animals, plants, and humans (Raj et al., 2019). Hence, these arthropods hold significant importance in the process of decomposing intricate organic matter and upholding the productivity and fertility of the soil. The population and variety of soil arthropods are impacted by fluctuations in vegetation quantity and quality, in addition to physical and chemical properties of the soil. The diversity of soil arthropod species associated with various types of vegetation, such as trees, crops, or plants, plays a crucial role in determining species diversity and serves as a significant ecological factor in investigations of biotic processes and relationships that are essential for the preservation of biodiversity (Bouraoui et al., 2019). The soil species diversity is subject to significant variation, as it is impacted by a multitude of factors, including but not limited to habitat diversity, abundance, biochemical composition, geographical range, physical and biological factors (such as rainfall and temperature), productivity, and biological interactions. The Phylum Arthropoda is known for its high reproductive capacity and diversity, which renders its communities somewhat vulnerable to anthropogenic activities such as pollution, urbanisation, industrialization, transformation, and habitat loss (Menta, 2012). It is widely recognized that soil is one of the three most significant elements of the environment along with air and water (Bünemann et al., 2018). In terms of quality, air and water pollution adversely affect natural ecology, animal nutrition, and human wellbeing (Ghorani-Azam et al., 2016). Specifically, in the context of soil, soil quality is defined as the maintenance of air and water quality, the promotion of animal and plant health, and the maintenance of biological productivity (Cardoso et al., 2013). There is a succession of economic and environmental events that result in soil formation and accumulation leading to biotic ecosystem formation. The formation of soil is a result of several biotic, chemical, and physical reactions that take place as part of the overall process (Bagyaraj et al., 2016). In soil climate, topography, biota, parent material, and time interact to increase soil properties (Schaetzl and Thompson, 2015). It is the physical weathering of rocks that leads to soil formation (Eisenbeis and Wichard, 1987), causing cracks and fragmentation into granular materials (Egli et al. 2018). It is probable that metabolic processes and other by-products will increase the availability of nutrients from the soil as well as the connectivity between organisms and mineral components in the next few decades (Lavelle et al. 2016). A nutrient cycle and breakdown close to each other determine how organic material aggregates at the end of the process (Harris, 1997). As a consequence, natural soils are formed by combining biological and clastic elements. The presence of many living organisms in these soil's indicates a high level of soil quality (Mursec, 2011). It has been widely recognized that earthworms contribute greatly to the soil throughout history; yet, the phylum arthropods, along with the variety of niches they occupy, play an imperative role in the environment in terms of their variety, diversity, and quantity. For each taxon, it has been examination of the importance of arthropods as bioindicators of soil quality (Zayadi et al., 2013). Because arthropods live, consume, and reproduce in soil, some species are very susceptible to soil quality variations and have adapted well to them. Among the most popular and well-known animals on earth are arthropods, which are found in a wide range of soils. A report by Menta and Remelli, 2020 emphasized that soil arthropods were the dominant group of organisms that are found in the soil, and included the dominant group of species of significant ecological importance. The five major classes of arthropods are the Arachnids, the Chilopods, the Crustaceans, the Diplopods, and the Inescta (also called Hexapoda). For instance, when it comes to the terrestrial ecosystem's food chain and food webs, the key groups of soil arthropods that are noteworthy in regard to their significance are the Myriapoda, Acarina, Collembola, Symphyla, and arthropods (Potapov et al., 2017). It has been reported that 90% of soil organisms are composed of Collembola and Acarina (Wallwork, 1970), while Hopkins (1997) stated that soil creatures are divided into main groups based on their size (Walter et al., 2013), dietary preferences, locomotion styles, and positions within the soil in accordance with the depth of the soil (Bardgett et al., 2005).

2.2 Soil fauna

Overview of Soil fauna (Figure 2:1)

The word soil fertility refers to a soil ability to meet plant demands for nutrients (including water) and a physical matrix suitable for proper root growth, both of which are affected significantly by biological processes. Arthropods are litter transformers or ecosystem engineers on two of the three general levels of the organizational hierarchy of the soil food web. Litter transformers, from which microarthropods are a significant component, fragment and humidify ingested plant litter, enhancing its consistency as a medium for decomposition processes and encouraging microbial population growth and dispersal. Ecosystem engineers physically alter the habitat, controlling food distribution to other species either directly or indirectly (Culliney, 2013). Soil invertebrates are divided into three groups based on their size: microfauna, mesofauna, and Macrofauna.

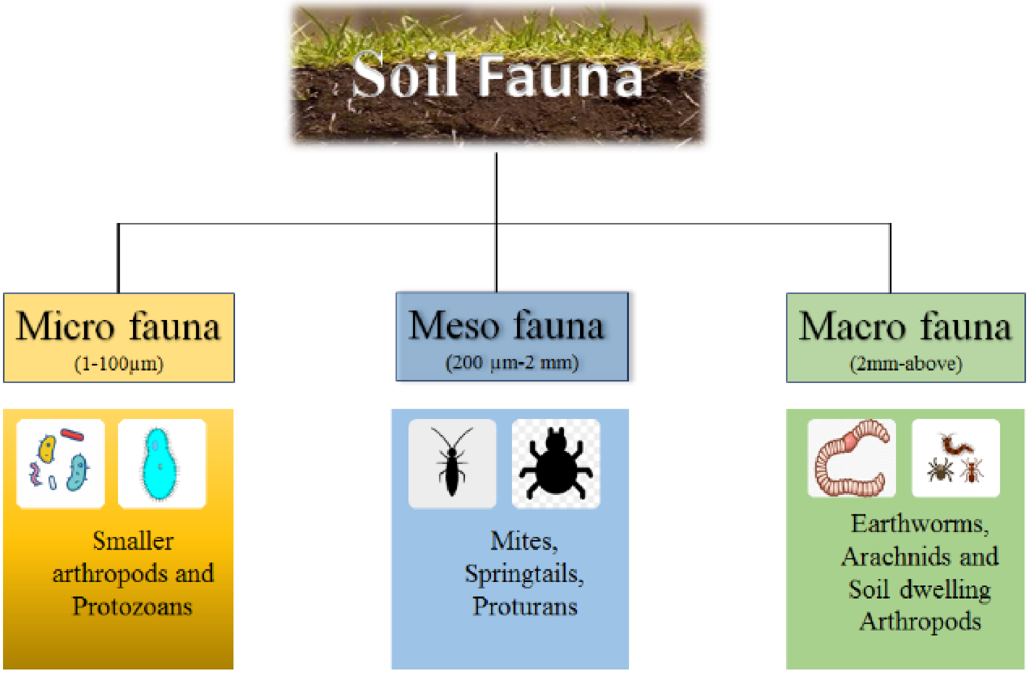


Figure 2:1 Types of Soil Fauna

A. **Micro fauna**: It consists of animals living in water films, burrows on the earth's surface, and soil particles ranging in size from 1 to 100 micrograms. The most abundant soil microfauna consists of protozoa and nematodes; the latter feed on bacteria mainly, while the former feed on microbes mainly. In general, nematode species can be divided into two types: Phyto parasitic nematodes which feed on roots as well as microbivorous nematodes, which feed on microbes. The number of soil microflora is often many times higher in the rhizosphere than in the non-rhizosphere since bacteria, Rotifers, Yeast, Ciliates, and other organisms are all part of the microfauna. Therefore, microfauna regulates soil populations by predating on algae and bacteria (Darby and Neher, 2016; Wale & Yesuf, 2022).

B. **Mesofauna**: Typically, soil microfauna can be found in litter or soil. They typically range in size from 0.2 to 2 millimeters in length. It is the mites and springtails that can dynamically control the cycling of nutrients based on their regular predation on protozoa, fungi, and nematodes, as well as their predation on protozoa and fungi. Generally, the interactions between mesofauna and microbes are mutualistic because these organisms break and soften plant debris, which is eventually expelled as fecal pellets. This kind of pellet is colonized by chemioorganotrophic microbes when it is exposed to soil, and they release ions of ammonium and other minerals that plants can take advantage of (Zagatto et al. 2019). As an example, insect larvae, isopods, nematodes, Collembola, and other organisms can be found in the environment (Elmquist et al., 2023).

C. **Macro-fauna**: Throughout the world, there is a vast range of earth arthropods that live in holes and burrows that are larger than 2 mm in diameter and have a diameter and size wider than 2 mm. Examples of these are Coleoptera, millipedes, flea larvae, centipedes, and other arthropods. A macrofaunal species is an ecosystem engineer, capable of altering the soil’s physical structure, soil composition, organic matter and mineral content, and hydrology, influencing the distribution of nutrients, and bridging the food chain between the leaves and the soil (Bagyaraj et al., 2016). The main contribution made by Macrofauna in the soil is that it eats or feeds on microorganisms in the soil that aid in the maintenance of the biological equilibrium of the soil, as well as playing an important role in improving soil structure, water infiltration and aeration (Sofo et al., 2020: Deng et al., 2022).

Soil biota plays an essential role in the function of soil as it participates in processes such as organic materials decomposition, humus formation and the cycling of many elements (carbon, nitrogen, sulphur) (Uzoh et al., 2021). Edaphic fauna furthermore affects the porosity and aeration of organic substances within the soil horizons and the infiltration and production. The soil fauna ecosystem services are one of the primary motivations for edaphic biodiversity conservation. Organic matter decomposition by soil organisms is critical to the working of an ecosystem because it has a significant function in providing plant growth and primary products to the ecosystem (Menta, 2012).

2.3 Dynamics and different class of Soil arthropods

Soil biota plays a vital role in the functioning of the soil because it performs processes such as the breakdown of organic materials, the production of humus, and the cycling of elements (carbon, nitrogen, sulphur). In addition to regulating the porosity of soil horizons and the aeration of organic compounds, edaphic fauna also contributes to infiltration and production in soil horizons. Moreover, soil fauna plays an important role in sustaining edaphic biodiversity due to its ecological benefits (Wang et al., 2020). As a result, the breakdown of organic matter by soil arthropods is essential to the ecosystems functioning since it is necessary for the development of plants as well as the production of basic products (Menta, 2012). Soil arthropods play a significant role in soil-living communities since they play a crucial role in preserving soil health and quality in addition to providing ecological functions (Santos et al., 2007). It is well established that soil arthropods perform a number of important roles in a variety of activities, including organic material transfer, breaking, decomposition, cycling nutrients, soil structure, and temperature regulation (Behan-Pelletier, 1993). Additionally, because some organisms live in the soil, eat, and reproduce there, and because they are highly adapted to specific soil conditions, they are especially vulnerable to changes in soil quality (Vilardo et al., 2018). In the Kingdom Animalia, the phylum Arthropods encompasses crabs, mites, and arthropods, which is the largest group of animals in the kingdom. Arthropods constitute 85 percent of the soil's fauna according to Culiney (2013), and by recycling organic matter produced by above-ground plants, the soil fauna plays a crucial role in the soil food web. The soil fauna is a part of the soil food web and plays a crucial role in soil ecology. The phylum covers an extremely large part of the soil meso- and macro-fauna, with body lengths that are up to 16 cm or even greater. As a result, of the eu-edaphon and hem-edaphon species, most of which dwell in the humus or litter or at a lower level in the soil environment, are divided into five groups: Acari, Isopoda, Insecta, Collembola, and Myriapoda. Species such as Diplura, Protura, and Pauropoda play a relatively small role in the soil community and have a relatively minor impact on soil formation processes (Menta, 2012). Soong and Nielsen, 2016 found several species of minute arthropods in the soil food web, referred to collectively as microarthropods.

Microarthropods

There are three main taxa in this grouping: the Collembola and Acarina taxa, and the Oribatida taxa. In order to understand microarthropods better, a number of different soil types are analyzed, such as grass, freezing ice, and rough deserts (Culliney, 2013), ranging from the poles to the equator, humid tropical climates to temperate climates, grasses to freezing ice, and rough deserts. The microarthropod, a member of the mesofauna that resides at various trophic levels of the soil’s food web, serves both as prey and as a predator, thereby maintaining the balance between the soil microflora and soil microfauna, which enables energy transfer from the soil microflora to the soil macrofauna (Çakır and Makineci, 2018).

Mites *(Acari)*

In soil ecosystems, Acari are omnipresent and display a vast taxonomic diversity with a wide variety of feeding habits and features of life history, according to (González-Macé and Scheu, 2018). As a result, they can inhabit a variety of environments regardless of the type of environment they are in. There is, however, a common understanding that the negative correlation between the physical and chemical disturbances occurring in agricultural soils and the low levels of organic matter found there are, in fact, negatively correlated. There are many species of arthropods that feed on microflora and detritus, like bacteria and fungi, which is the reason why acari are the most numerous and diverse groups of arthropods. Prostigmata and Mesostigmata species, on the other hand, mainly consume microfauna and mesofauna components (Mbuthia et al., 2012). The mite is considered to be an ecological bio-indicator that has been studied for many years. There is no doubt that Oribatida are highly sensitive to all kinds of soil disturbance due to their long-lived nature, gradual growth, low fertility and dispersion, all indications of the condition of the ecosystem. In farmland and forest soil, Oribatida (*Cryptostigmata*) are amongst the most commonly involved Acari species, influencing soil composition by consuming decaying organic matter as well as fungi, influencing decomposition (by shredding and eating on decaying organic matter as well as fungi) as well as soil composition by producing faecal pellets, which are an essential component of soil composition (Manu et al., 2019). It has been documented that Oribatida populations have been documented in coniferous soils with 10^5-10^6 individuals per metre square in numerous forests that have a higher density of Oribatida than those in deciduous soils. The Oribatida are thought to be some of the most diverse and effective soil arthropods in the world, with almost 172 families out of the 9000 species living in the soil of the litter system. The organic matter, on the other hand, has a lower percentage and a lower population density. The organic matter, on the other hand, has a lower proportion and a lower population density. Decomposition and mineralization are crucial to the preservation of agro-ecosystems, so they play an important role in this process. They are considered to be one of the most effective soil arthropods on the planet. There is a wide range of feeding methods used by oribatid mites, from degraded plant products to decaying feces. However, most are either mandatory fungivores or optional fungivores (Culliney, 2013). Acari, as well as other small soil invertebrates (enchytraeids, collembola, oribatids, insect larvae), play an indirect role in decomposition and, consequently, influence soil productivity and fertility (Madal et al., 2019). They also play a key role in regulating the population of other soil invertebrates, which also play a vital role in regulating soil productivity. There are a large number of species that prefer environments that are high in organic matter, high in soil moisture content, high in average soil temperature, and with low pH, because these are environments that are favored by them. It has been shown that soil mites are very useful soil bioindicators as a result of their ecological requirements and high sensitivity to ecological and anthropogenic disturbances (Manu et al., 2021).

Springtails (*Collembola)*

Collembola are the small wingless creatures and it is the largest species that attains a length up to 17 mm (Bellinger et al. 2007; Fox et al., 2007) among the arthropods. They are widely distributed in every habitat, and large number of density and diversity can be seen in the soil rich in organic matter and humus. By decreasing fungal biomass and thus creating too much resources available to bacterial populations, Collembola grazing on mycorrhizal fungi may promote soil bacteria growth (Filho et al., 2021). Mostly Collembola are characterized by the presence of tube-like structure (collophore) found on the ventral surface of the first section of appendage and a distinctive character of furca (jumping purpose) which resulted from the basal combination of the two appendages at the 4th segment of abdomen. At the distal end of ventral tube, an eversible vesicle pair is present. Collembola feeds upon fungi, actinomycetes, bacteria and algae (Devi et al., 2019). Collembola helps in nutrient cycling (Cuchta et al., 2019), degradation of organic matter and interaction of microbes with soil fungi (Ding et al., 2019). They help in the formation of humus by the process of fragmentation of leaf litter as they are the food source for various predators existing in the soil (Kumar et al., 2020). They are the bioindicators of quality of soil. Collembola is abundant in number as they are present in both modified and disturbed habitats (agriculture land) (Dirilgen et al., 2018), which shows that the species of the collembola lives in numerous habitats at various depth of the soil (Joimel et al., 2018) and it has a dynamic role in the several ecological activities of soil with other microarthropods (Coulibaly et al., 2019). Collembola acts as a decomposer in the food chain and supports the processing of decomposition of microbes through mixing along with aerating the soil, thus generating catalysed effects on nutrients process and movement of energy indirectly, maintaining the size of the population of soil arthropods. They generally feed on fungi, mosses, spores, organic waste, bacteria, and decaying matter (Bahrndorff et al., 2018). There are 9000 species published worldwide. Collembolan fossils from Devonian (400 million years ago) are among the world's oldest wildlife records. These species are found all over the world system, ancient and thus, are one of the most successful arthropod generations. Collembola plays an important part in the food web below ground (Wurst et al., 2012). Regardless of the fact that species-specific feeding requirements exist, they are classified as feeders that are not specialised because they consume a diverse variety of materials such as bacteria, fungi decomposition of organic plants debris (dos Reis Ferreira et al., 2020). Their feeding process contributes to the organic matter decomposition in the soil (Salem et al., 2013). Collembola pellets of faeces, which are usually 30 to 90 meters in diameter, are thought to contribute to soil aggregation, according to Lussenhop (1992) and a recent experimental study has demonstrated that they can improve soil macroaggregation (Siddiky et al., 2012).

Diplura

Diplurans are among the three entognaths hexapod groups that can be found in almost any cave, soil, or further void subsoil area. With around 900 articles published since Linnaeus Systema Naturae (1761–67), this order has received little attention in the scientific literature (Sendra et al., 2021). Diplura is the insect's close relative and therefore the most common closely related of the three basic hexapods (Collembola, Protura). Diplura lives in moist, shaded areas, primarily in leaf litter and soil, and also beneath the stones and wood, where they eat other soil organisms (Sendra et al., 2020).

Conehead (*Protura*)

Protura is a Hexapoda Class with a small and less known population. They are soil-dwelling and their body size is about 0.5-2.5mm. Instead of antennas, wings, and eyes, Protura has a set of pseudocelli on its head and a pair of fully developed sensilla bearing forelegs and they are projected to the front and act as principal sense systems. Throughout their entire lives, they live in soil layers and leaf litter (Galli et al., 2021). Protura can only be found in humid environments, primarily in acidic soil and occasionally in decaying wood, a member of a group of decomposers that facilitate the decomposition and recycling of organic resources. They are often seen under trees in fallen leaves and mosses, where they could graze upon fungi (Galli et al., 2021).

Termites *(Isoptera)*

Termite is an endogenous exopterygote insect belonging to the Isoptera order and is one of the many species that occupy the soil. Depending on vegetation and land use, the composition and abundance, hence their influence on processes of soil differs greatly. Termite typically thrives by eating material from detritus and creating mounds in which it manages its environment. The mounds take on a range of types and sizes depending on the species of termites and the ecosystem around them. Such mounds demonstrate how termites are suitable for the climate. Termites are used as soil indicators due to their important properties such as soil texture and soil profiling, dispersing plant nutrients and organic matter (Enagbonma and Babalola, 2019). The foraging activity of termites creates an encouraging environment for the microbe’s community for the mineralization of nutrients (Culliney, 2013). Higher concentrations of calcium, potassium, magnesium, ammonium, inorganic phosphorus, total nitrogen, chlorides, sulfate anions, available phosphorus, and bicarbonates are observed in the soil modified by termites with higher microbial activities (Nsengimana, 2018). Organic debris or living plant tissue is accumulated during the time of occupation of the mound, often over vast foraging areas, transferred to mounds, and subjected to extreme degradation as the termite is digested. In the plant-soil environment, plant nutrients and organic matter that they produce are removed from circulation until they eventually die.

Therefore, termite behavior in the soil influences the dynamics of nutrients and organic matter, and soil structure. Through carbon sequestration, nutrient cycling and soil texture, such improvements in soil characteristics have a profound effect on ecosystem productivity (Jouquet et al., 2007). Termites are the utmost effective soil residing ecosystem engineers, altering the availability of resources for other species through biogenic structures (soil sheetings, nests, foraging holes, and so on). By bioturbation, they integrate plant litter as well as crop residues further into soil, modifying physiological, biological, and chemical soil aspects that influence materials and energy flow. As a result, they change the soil habitat of other biotas (Khan et al., 2018). Soil-dwelling termites create underground nests that have a main consequence on the soil ecosystem. Termite activity can make a significant contribution to the accumulation of organic matter in the soil as well as the improvement of nutrients and minerals (Sofo et al., 2020).

Ants *(Formicidae)*

In Hymenoptera, the most common, dominant, and ecologically important group is ants (Formicidae) which are present on the terrestrial ground (Bagyaraj et al., 2016). Ants have a broad geographical range and are vulnerable to different features, such as soil chemical and physical characteristics. In the soil ecosystem, ants are responsible for the functioning of leaf and litter fragmentation, soil porosity, soil aeration, soil texture, soil mixing, collection and dispersal of seeds, vegetative cropping, and controlling of other groups of soil organisms was stated by Menta and Remelli (2020). They also contribute their role in the nutrient transport and relationship with certain other micro-organisms at different soil depths. Moreover, vegetation affects myrmecofauna in multiple ways, causing negative impacts on specific species in cooler-closed areas, and positive impact on particular species in higher warmer-opened areas. Furthermore, increased complexity of vegetation contributes to greater variety and group abundance of these organisms. The ability of ants to increase aeration, soil drainage and amount of nutrients makes them important ecosystem engineers, thereby leading to low ecological impact farming practices (Cammeraat and Risch 2008). When ants dig galleries for their nests, they help to ventilate the soil and enhance the porosity property of soil, which affects water penetration and thus decreases erosion risks. Ants also increase the amount of energy available to plants and microorganisms (Sofo et al., 2020). During nest construction and preservation, ants remove the vegetation from the surface soil and mobilise large quantities of the underground soil. Their diet is often dominated by organic material, and they produce a great deal of organic waste, which is deposited in specific chambers within the nest or on the soil surface. According to (Farji-Brener and Werenkraut, 2017), ant nest soil exhibit unique physical as well as chemical properties that have a consequence on the surrounding vegetation.

Coleoptera

The Coleoptera are the most numerous orders i.e., about 40% of the Insecta class. They are found in a variety of trophic levels (e.g., scavengers, predators, and phytophagous) in the soil macro arthropods community (Rivard, 1966). There are more than 300,000 different species of beetles in the world (Elias, 2010). Agricultural plants and stored goods are commonly damaged by beetles. Inorganic nutrients are decomposed and recycled by scavengers and wood-boring beetles. Aphids and scale arthropods are controlled biologically by lady beetles (Evans, 2009).

2.4 Ecological significance of soil arthropods (Figure 2:2)

Soil arthropods hold considerable ecological significance due to their crucial contribution towards preserving soil fertility and overall well-being.

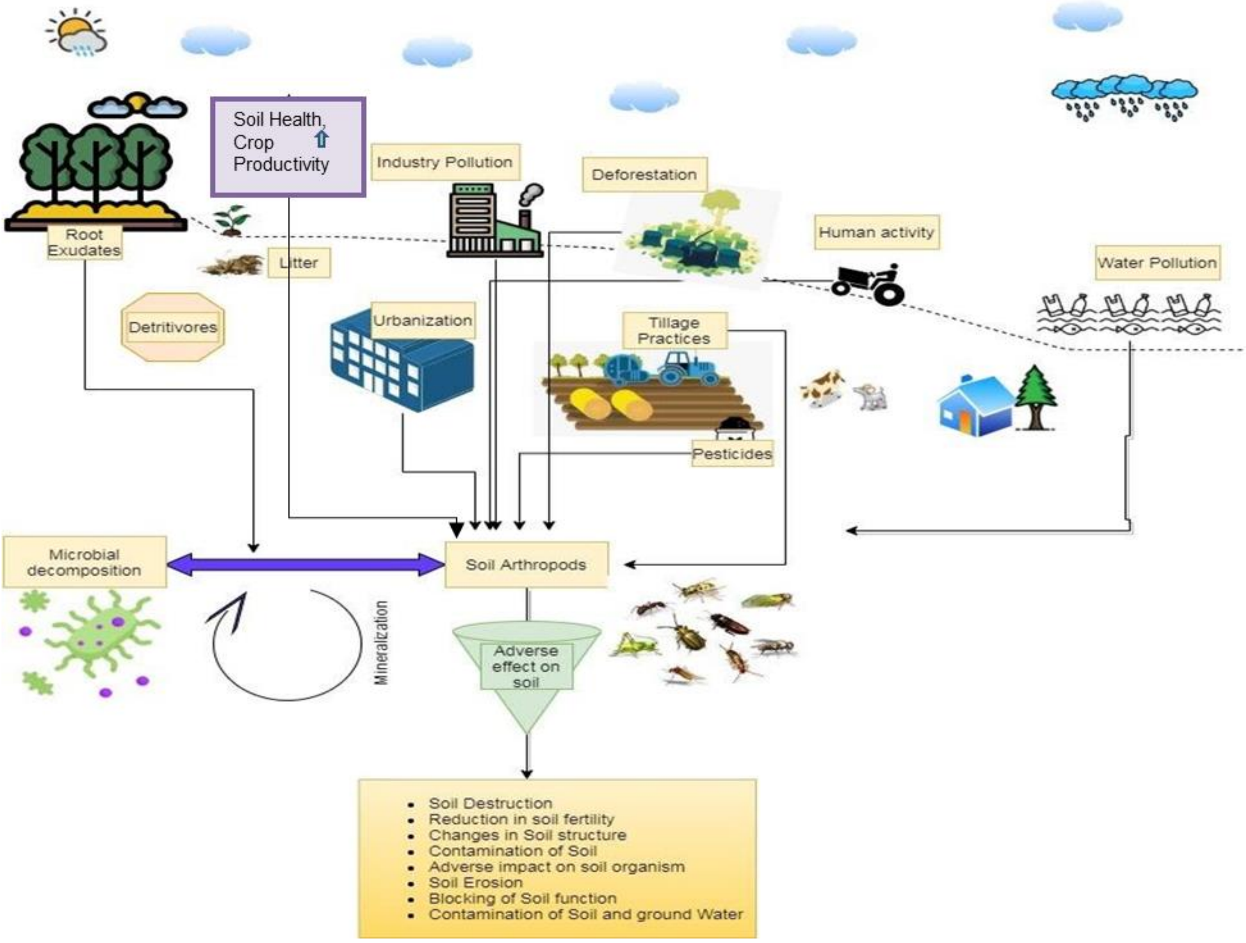


Figure 2:2 Ecological significance of soil arthropods

Arthropoda play two major roles in the soil food web: they act as ecosystem engineers and as plant litter transformers (Figure 2:3). It works by crushing or fragmenting and moistening the waste of consumed plants, which is then accumulated in the feces for additional decomposition by microbes, which then encourages microbial populations to grow and spread. The soil arthropod community is clearly linked to the organic material available in the soil, and as the organic materials in the soil increases, so does the soil arthropod community (Meitiyani and Dharma, 2018). Termites can process a large portion of the annual litter input, for example, termites can handle up to 60 percent of the entire litter input. The mineralization process converts the organic substances into simplified inorganic substances that are accessible to the trees and shrubs by converting the fragmentary plant material in the faeces into an expanded substratum that is attacked by the microbial species (Li and Brune, 2007). It is known that ecosystem engineers influence resource availability and alter ecosystems of other species (Lavelle et al., 2016). The soil structure, hydrology, organic matter and mineral composition are changed by these engineers. Termites and ants not only help transport soil fragments to the surface, but also help combine organic and mineral ingredients (Bourguignon et al., 2015). Arthropod feces are an important source of humus and soil aggregates necessary for the physical stabilization of the Soil and increasing its nutrient storage capacity are essential (Lakshmi et al., 2020). With changing soil properties, they can have a reflective impact on the soil flora, its ecology and its taxa. Soils with good organic matter content, low contamination and low soil disturbance, such as by mechanical tillage, usually have a well-developed and diverse soil fauna (Soong et al., 2016).

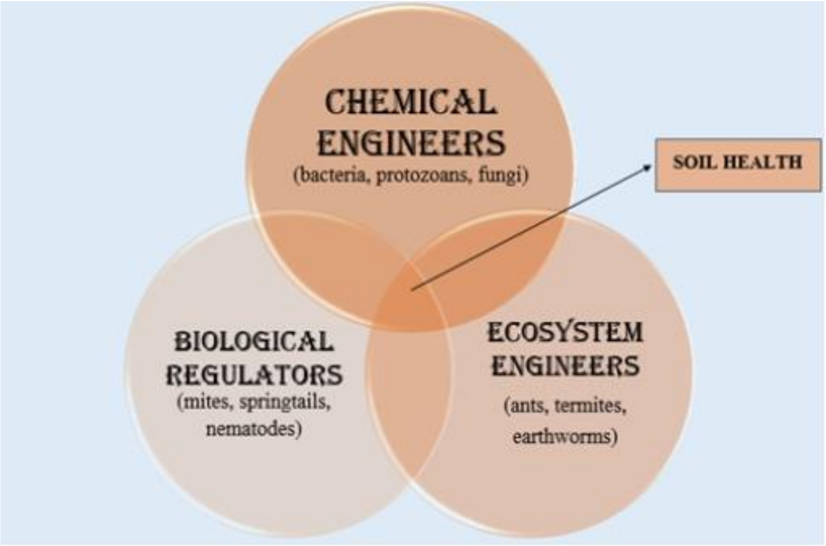


Figure 2:3 Functional Grouping of Soil biodiversity

Its functions include soil formation, pest management, waste breakdown, nutrient retention, and the production of secondary products such as fuel, fiber and food.

- **Influence of Soil arthropods in Nutrient cycling and organic matter decomposition**

Nearly 90 percent of total terrestrial primary production reaches the detritus food web, where it is degraded and reprocessed. The decomposition as well as recycling process begins with woody materials and leaves that fall to the soil surface (Figure 2:4) (Wale and Yesuf, 2022). Arthropods and other microbes in the soil contribute to the breakdown of the organic matter (Palacios-Vargas et al., 2007) by consuming litter and breaking it down directly or indirectly into tiny particles in an opening in a porous structure for decomposition processes, which also play a significant role in humus formation. The process of decomposition of litterfall has a vital role in the formation of humus, supporting the diversity in microbial populations and soil arthropods was stated by (Garg et al., 2022). Decomposition influences the soil process for instance weathering of soil minerals and the involvement of the nutrients to the plants part (Dincher et al., 2020). Litterfall is one of the important routes through which nutrients return to the soil surface thus maintaining the fertility and integrity of the soil (da Silva et al., 2018). Litter feeding promotes the activity of microbe's community and increasing the process of mineralization of organic compounds converting into inorganic compounds (Findlay, 2021).

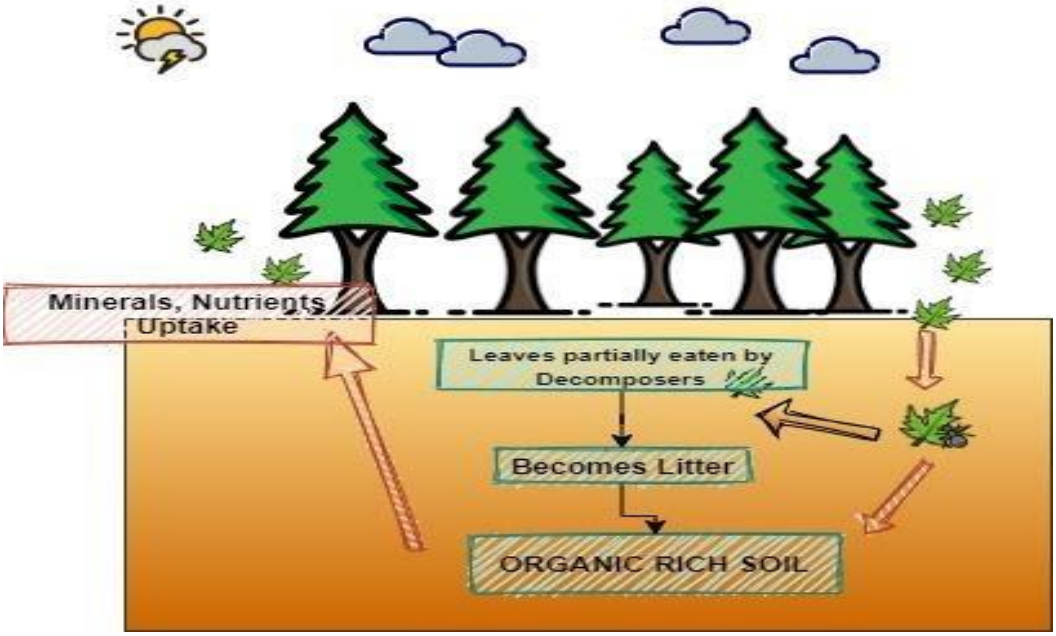


Figure 2:4 Conceptual diagram of Nutrient Cycling

- **Mineralization of Nutrient elements in soil**

Organic nutrients are present in the soil and can be taken by the plant roots (Figure 2:5). Mineralization involves the catabolic conversion of organic elements into inorganic forms, particularly by decomposing organisms, such as the production of Carbon dioxide in carbohydrate respiration and the degradation of amino acids are converted into ammonium and finally nitrate (NO3-). In the processing of plant litter, the direct or indirect activities of arthropods, which may be nutritious deprived or decompositionresistant, enhances the required nutrient concentration in the soil was stated by (Garcia-Pausas and Paterson, 2011). Organisms efficiently convert plant litter, including the structural polymers in cell walls, into living tissue, which provides consumers with a rich source of nutrients at a relatively low metabolic cost. According to (Gray and Dighton, 2006), a significant part of the nutrients is concentrated in the litter system and temporarily deposited in microbial biomass before they are released in the faeces and after death in consumers, especially microarthropods. Arthropods grazing can stimulate the microbial mineralization of nutrients. Various studies have shown that Collembola grazing has a significant stimulatory influence on the growth and respiration of fungus (Culliney, 2013).

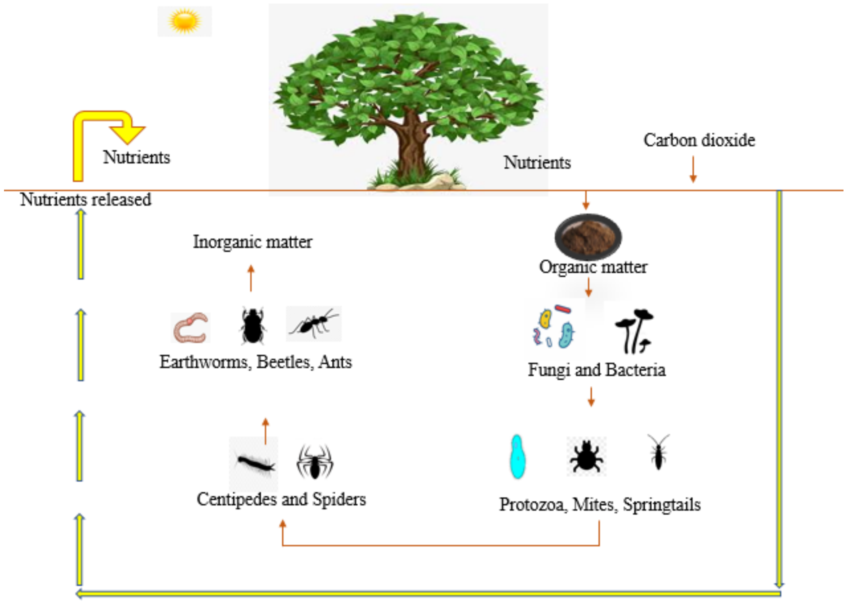


Figure 2:5 Conceptual diagram of mineralization

- **Activities of litter arthropods in the soil environment**

Soil is an essential component of habitats, and they are made fertile mainly due to the activities of their biota (Figure 2:6). The capacity of a soil to provide plants determines its fertility with not just the essential nutrients for development and growth and a physical matrix that promotes respiration and growth of roots while also preserving the soil's structural stability against erosive factors. Arthropods have two significant effects on soil fertility (Murphy, 2015). The word soil fertility refers to a soil ability to meet plants demand for water and nutrients, as well as provide a physical condition favourable for root growth (Stockdale et al., 2006).

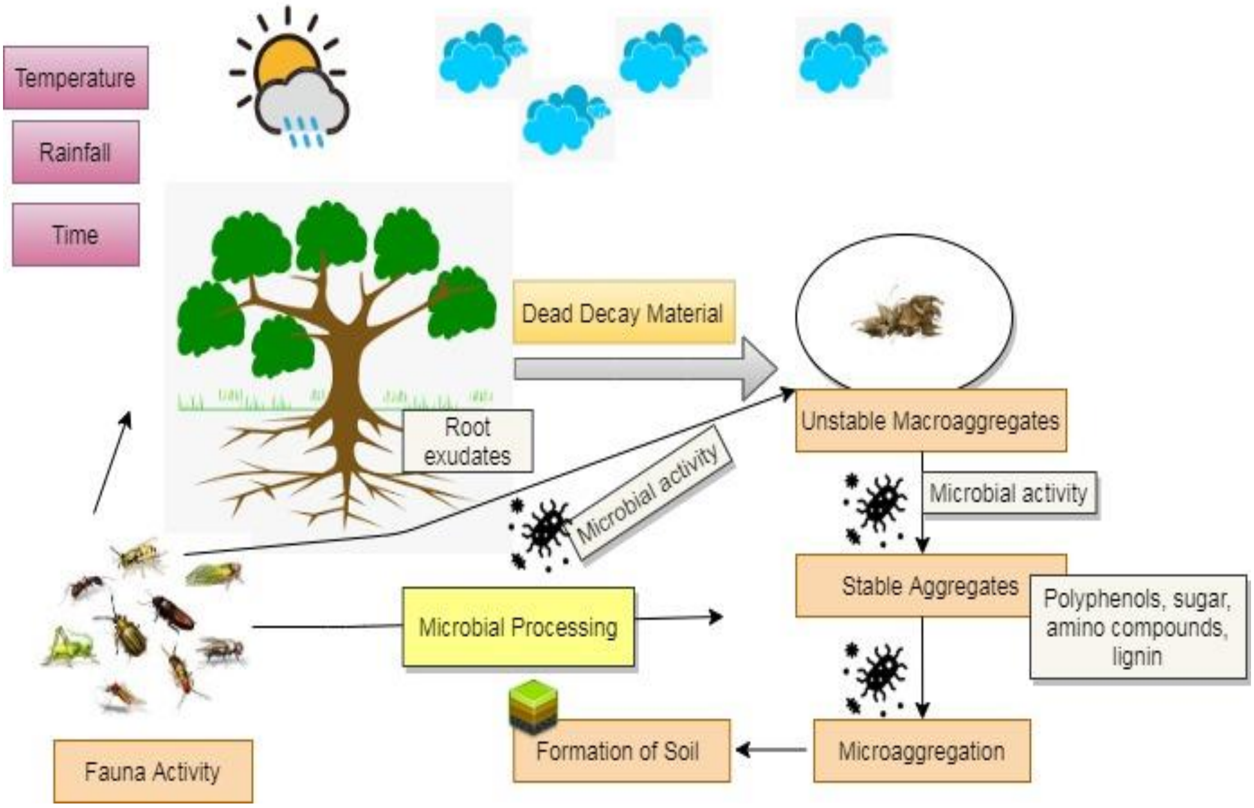


Figure 2:6 Role of Soil fauna in soil formation

Initially, they facilitate leaf litter breakdown by physical and chemical means, directly and indirectly converting it into substances that can be decomposed further (Zhou et al., 2020). Termites increased assimilation efficiency instantly transforms a higher proportion of the litter into biomass than other terrestrial arthropods. In contrast, Oribatida, Collembola, Isopoda, and Myriapoda contribute indirectly to nutrient cycling as secondary decomposers (Bagyaraj et al., 2016), which maintain the litters through passage and comminution through the soil (Briones, 2014). Arthropod feeding on microbial species may also help regulate nutrient availability to plants, maintain that nutrients are released in a regulated and systematic way, and minimise root system failures (Altieri, 1999). The second way arthropods contribute to soil health protection is through their influence on the physical soil structure. Termite and ant activities trigger pedoturbation, which brings significant quantities from the subsoil to the top surface, raising the mineral content of topsoil and creating ion exchange sites in the root zone. In addition, arthropod burrowing and tunnelling generate air and water penetration pathways and mix organic matter into the top layer of soil (Culliney, 2013).

Arthropod faeces act like particles to accumulate soil aggregation and essential components of soil structure (Moore et al., 1988). It is vital for preserving stability, is a crucial component in humus development, and aids in maintaining water and soil nutrients (Bagyaraj et al., 2016). Soil fauna performs various functions, including soil structure formation, pest management, toxic chemical and waste degradation, nutrient cycling, and the production of beneficial secondary products such as fibres, food, and fuel. Soil arthropods are one of the essential components of soil-living organisms. They play a crucial role in developing and maintaining the soil structure, soil quality and health, and ecosystem services (Menta and Remelli, 2020). They contribute to the development of soil structural properties in a variety of ways. The structural distribution of the soil particles, voids and pores among them, the arrangement of the soil particles into soil aggregates, and the stability of the aggregate in the water are the more biologically significant features of the soil (Almendro-Candel et al., 2018). As a result, the soil good structure promotes root penetration, aeration, nutrient retention, and water retention ability and prevents topsoil erosion and crusting (Rabot et al., 2018).

- **Impact of agriculture and forest land on soil arthropods**

The impact of land use has a significant effect on soil organisms. The primary cause of soil degradation and modification is the rapid transformation of forests to farmlands and agricultural sectors, impacting the organisms living there. Agricultural inputs such as ploughing have a direct and indirect impact on above and below-ground biodiversity (Ghosh et al., 2019). Habitat modification, body damage and changes in nutrient availability are all immediate consequences of farming practices on arthropod diversification. Changes in soil structure, loss of organic matter in the soil, decreased complexity and diversity of carbon inputs, disruption of trophic interactions due to selective pressure on target and non-target organisms, and toxicity from pesticide residues and biocides breakdown products are all examples of indirect effects (Kibblewhite et al., 2008). Reduced soil arthropod abundance and species richness in ecosystem services have resulted from increased forest disturbance levels due to forest conversion to agroforestry and agricultural systems.

2.5 Factors affecting soil arthropods

Pesticides

Many chemical pesticides and fertilizers, such as fungicides, herbicides, and insecticides, as well as biocontrol agents and growth regulators enhancing organisms, are used in modern agriculture (Bünemann et al., 2018). While these manufactured additions can be helpful but are also thought to be the primary source of loss of biodiversity in the land (Power, 2010). Pesticides are often used to protect crops from pests in agricultural regions. These insecticides and fertilizer treatments have an impact on the arthropod community in the soil. Crop production mostly relies on the application of pesticides, fertilizers, and tillage for crop development and yield; however, these practices have an impact on soil biological diversity. Continuous use of agricultural practices, alters the soil environment, consequential in a disruption of the arthropod community in the soil, as well as a loss in nutrient cycling and crop yields (Chen et al., 2020). In agricultural fields, insecticides are used to promote agricultural productivity as they are associated with enhancing agricultural production and assisting in yield losses due to insect infestations. Even after their significant role, pesticides have an adverse impact such as harmful residues in water, food, atmosphere, and land, insect pest reappearance and susceptibility, and consequences on non-target species (Sánchez-Bayo, 2021). Insecticides have the potential to affect an insect's immune system. This capability might be reduced or increased depending on the insecticide used (Zibaee and Malagoli, 2020). The functions of important arthropods are impacted when herbicides/pesticides are administered in farming areas so the numbers and species diversity of these beneficial arthropods are reduced. Pesticides have an indirect impact by lowering the number of micro-organisms which provide nourishment for many other beneficial organisms. Herbicides have the capacity to redefine ecosystems by changing the morphology of vegetation, resulting in a decline in important arthropods. Pesticides decrease the survivability of a variety of life cycle phases, lower reproductive capability, alter the viability of the host for parasitizing or predation, reduces the development of parasitoids from contaminated eggs mineralization, and cause immediate fatality (Hu et al., 2020). The use of pesticides in the lawn and garden area in most cases reduces the diversity and number of organisms (Jaganmohan et al., 2013). However, the excessive use of pesticides and fertilizers degrades soil fertility since the soil is a reservoir for all kinds of chemical applications, including pesticides used to control crop predatory arthropods. Insecticides have a detrimental effect on the size of an insect community's population, diminishing variety (Eisenhauer et al., 2010). These insecticides harm a wide range of non-target organisms in the soil, many of which are economically important.

Human Activity

Human beings are now disturbing the populations of soil biota through plowing, tractors, utilizing axes, deforestation, livestock grazing, and fire, among other agricultural inputs (Osman, 2014). The decline in arthropod biodiversity is due to the extensive use of pesticides, fertilizers, and the implications of modern agricultural techniques. Continuous tillage activities in agricultural lands frequently damage habitat structure and increase soil erosion, resulting in the isolation of insect species, which further diminishes population size (Menta, 2012). Human actions are frequently responsible for the bulk of arthropods habitat destruction and environmental degradation, which results in biodiversity loss as well as species extinction, disrupting ecological functions. As a result, there is an urgent need to protect soil organisms, which have been neglected for a long time (Cardoso et al., 2020). Tillage operations in agricultural fields continue to disrupt soil-dwelling arthropods (Kelly et al., 2023). Degradation and changes in the functional process of the soil occur because of human disturbances (de Oliveira et al., 2021), reducing the diversity of soil arthropods. Tillage alters the habitat structure of the soil in agricultural regions, increasing energy loss, soil erosion, and other factors, isolating arthropods, and limiting population number (Loranger et al., 1998). Habitat structure is the driving force behind many ecological forms and activities because it maintains community structure by providing shelter, nutrients, and a tunneling place for soil species (Turbé et al., 2010). Changes in habitat structure can have an impact on communities and ecological forms, and these changes are primarily due to development, which is mostly caused by anthropogenic activities (Roy et al., 2018) such as converting deserts and forests into major cities, industries zones, and many more. This type of habitat arrangement is frequently found in urban areas (Zipperer et al., 2020). According to Onyeka and Alex, 2013, continuous agricultural input reduces the diversity of arthropod populations in conventionally managed farmlands. Tillage has been shown to affect H_2O content, temperature, and decaying agricultural residues, as well as the abundance and diversity of soil arthropods. With the dominance of human urbanized areas, many natural habitats have been replaced by arthropods, resulting in the loss of biodiversity (Tóth et al., 2021). The presence of human interventions can lead to the degradation and alteration of soil functional processes, resulting in a reduction in the diversity of soil arthropods. The disturbance of soil habitat structure caused by tillage in agricultural lands has been found to result in increased energy loss and soil erosion. This, in turn, leads to the isolation of insect species and a subsequent reduction in population size (Loranger et al., 1998). The consistent implementation of tillage techniques in agricultural land leads to the disruption of the arthropod population inhabiting the soil, as noted by Rodriguez et al., 2006. Urbanisation, primarily driven by human activities such as the conversion of forests and deserts into shopping complexes and industrial areas, is a major contributor to changes in habitat structure. The habitat structure is frequently produced within urbanised regions, as noted by Kaye et al., 2006 and Byrne, 2007. The arthropod populations of the soil are significantly impacted by the natural terrestrial ecosystem, which serves as a critical component in the nutrient cycle, organic matter decomposition, and enhancement of soil quality. House, 1985 has reported that the properties of soil can be enhanced by the soil arthropod community, which is an integral component of the agroecosystem, particularly in the absence of tillage. The practise of tillage has a direct impact on soil invertebrates, including ants, earwigs, centipedes, and millipedes, resulting in a decrease in their population. The diminished Figures indicate that soil tillage results in the demise of invertebrates through the processes of burial and mechanical actions. Therefore, it can be inferred that the practise of tillage results in the disturbance and reduction of the population of advantageous invertebrates, as suggested by Sharley et al., 2008). Research has revealed that the absence of tillage in each location is associated with a greater abundance of soil arthropods when compared to an area subjected to tillage. Thus, it is imperative to preserve these invertebrates, as they play a crucial role in promoting sustainable agricultural practises (Dubie et al., 2011). In contrast to carbamate or organophosphate insecticides, it has been observed that the arthropod community is significantly impacted by rotation and tillage practises. Stinner et al., 1986 reported that there was no statistically significant variation in the quantity of arthropods that were subjected to the disintegration patterns of insecticides and tillage treatment. The practise of tillage has been observed to have an effect on various factors such as water content, temperature, and the decomposition of crop residues. This, in turn, has an impact on the composition and population of soil arthropods, as noted by Cardoza et al., 2015. Pesticides are frequently utilised within agricultural settings as a means of safeguarding crops against pest infestations. The application of pesticides and fertilisers has an impact on the subterranean insect community. The cultivation of crops is heavily dependent on the application of pesticides, fertilisers, and tillage practises to promote crop growth and enhance yield. However, these practises can have adverse effects on the soil's biological diversity. The persistent implementation of agricultural techniques results in alterations to the soil environment, leading to disruption of the subterranean insect community, decreased nutrient cycling, and reduced crop yields. This phenomenon has been documented in various studies (Attwood, 2017; Bardgett and Vander Putten, 2014; Bender and Heijden, 2015; Giller et al., 1997; Lundgren and Fausti, 2005; Mader et al., 2002; Triafouli et al., 2015; Wagg et al., 2014). The decline in insect biodiversity can be attributed to the intensive utilisation of pesticides and fertilisers, as well as the implementation of contemporary agricultural techniques. Frequent tillage practises in agricultural areas can cause disturbance to the habitat structure and lead to elevated soil erosion rates. This phenomenon can result in the isolation of insect species and ultimately lead to a reduction in population size. The application of insecticides has been observed to have deleterious impacts on the population dynamics of insect communities, leading to a reduction in their overall diversity. According to Pimentel et al., 1993, the application of insecticides can have negative impacts on various non-target organisms in the soil that hold significant economic value. Human activities are a significant contributor to the destruction of arthropods habitat structure and environmental degradation (Figure 2:7). This phenomenon results in the loss of biodiversity and species, ultimately disrupting ecological services. The conservation of soil arthropods has been neglected for a considerable duration, as noted by Kim (1993), and therefore requires immediate attention. The excessive utilisation of harmful chemicals and human-induced inputs have resulted in the degradation of habitat structure, thereby posing a growing threat to the population of beneficial soil arthropods (Losey and Vaughen, 2006). Arthropods play a crucial role in sustaining human populations, particularly as agricultural practises rely heavily on their ecological processes and functions. The rapid growth of human populations, the cultivation of plants in soil is highly dependent on the presence and contributions of arthropods within the ecosystem. The excessive application of fertilisers and agrochemicals has been found to result in the depletion of soil-dwelling beneficial arthropods (Jankielsohn, 2018). The phenomenon of urbanisation has been observed to result in a reduction in the biodiversity of insect fauna. This can be attributed to the displacement of natural habitats that serve as the dwelling places for these arthropods, which is a consequence of the prevalence of human urbanised areas. (Maity et al., 2016). The application of insecticides and pesticides in the lawn and garden area has been found to typically result in a decrease in both the diversity and abundance of insect species, as reported by Jaganmohan et al., 2013.

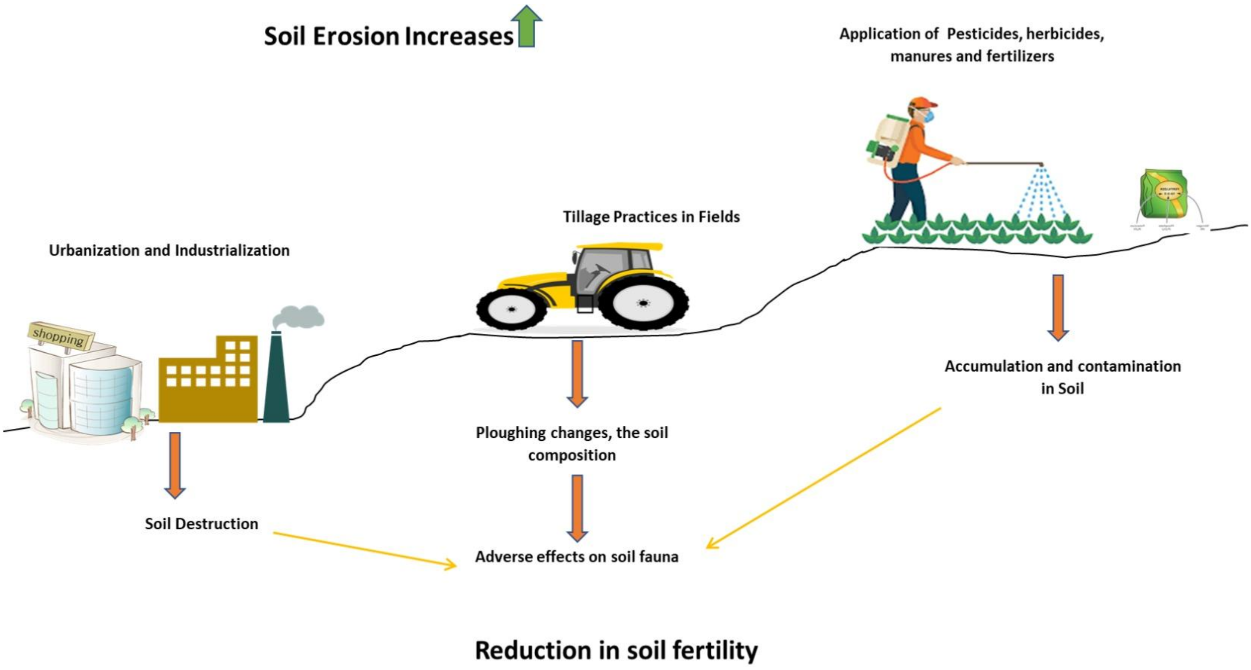


Figure 2:7 Impact of Human activities

Cover Crops

Cover crops provide habitat for both pest and beneficial arthropod populations. Cover crops increase the soil health and enhance the performance of natural processes to generate beneficial service to meet human requirements, such as improving soil fertility, reducing overflow from farmland into surface waters, and weed control through plant competition (Kremer, 2021). The introduction of Cover crops in an agroecosystem promotes plant diversity that might attract both pests and pollinating organisms (Adetunji et al., 2020). The application of a cover crop to a field promotes plant diversity (Alyokhin et al., 2019). Non-crop species that are planted before or intercropped with a cash crop are known as cover crops. Reduced soil and nutrient loss, as well as weed suppression, are all advantages of using a cover crop (Rouge et al., 2020).

- **Impact of climate change on Soil arthropods**

Arthropod diversity is suffering because of climate change. Climate change profoundly impacts arthropod diversity, modifying ecological circumstances by reducing decomposers, predators, and pathogens and increasing nutrient availability. The impact of climate change is not just an increase in temperatures, but it also increases the frequency of extreme weather events such as prolonged drought and significant flooding. Further problems arise from higher land-use intensities (which contribute to overgrazing and lower agricultural yields), mining, and pollution (Schloter et al., 2018). As arthropod communities change, farmers have noticed a decrease in soil fertility and agricultural output (Prasannakumar et al., 2016). Changes in resource availability and the nature of the soil food web can affect the quantity and composition of microarthropod soil communities both directly and indirectly. Warming and changes in precipitation, for example, can directly impact soil temperature and moisture, which are critical factors in microarthropod reproduction and development (Kardol et al., 2011).

2.6 Litter Decomposition by arthropods

Litter quantity and quality decide the forest ecosystems functioning for healthy ecosystem processes. Nutrient release, net adsorption, and net secretion are the three main stages of decomposing leaves in the tropics. The decomposition rate of litter is affected by various factors, including leaf litter quality and soil conditions (Giweta, 2020). The primary contribution of soil arthropods is humification and decomposition by comminuting plant debris. The breakdown of the leaf cuticle exposes the cells contents, increasing water storage, exposure to sunlight, and downward movement of soluble compounds and particulate matter.

Litterfall is an essential mechanism for returning nutrients to the soil in terrestrial ecosystems (Figure 2:8). In forestry, leaf tissue represents more than a 70 percent of sub-surface litter, with stems, small twigs, and vegetative composition contributing to the remaining. The amount of carbon dioxide released and the compound discharged, which contains both nutrients and carbon compounds, is referred to as decay or litter mass loss. Litter decomposition is essential for nutrient budgeting of the soil and encompasses a comprehensive breakdown of organics to CO_2 and nutrients physical, chemical, and biological activities. Heterotrophic breakdown of organic matter of the litter results in Litter decomposition (Krishna and Mohan, 2017). Litter is the surface of decaying plant material on the ground or dead plant matter separated from a living plant. The mineral layer and the litter strata will vary; however, this is not the case for the surface containing identifiable plant matter and organic content layer (Gilliam, 2014). There is no standard for when litter that has separated from a living plant begins to decompose. For example, before a tree falls to the ground, a dead crown branch may have degraded to its partial live body weight, and a trees heartwood may also die and decompose entirely (Krishna and Mohan, 2017).

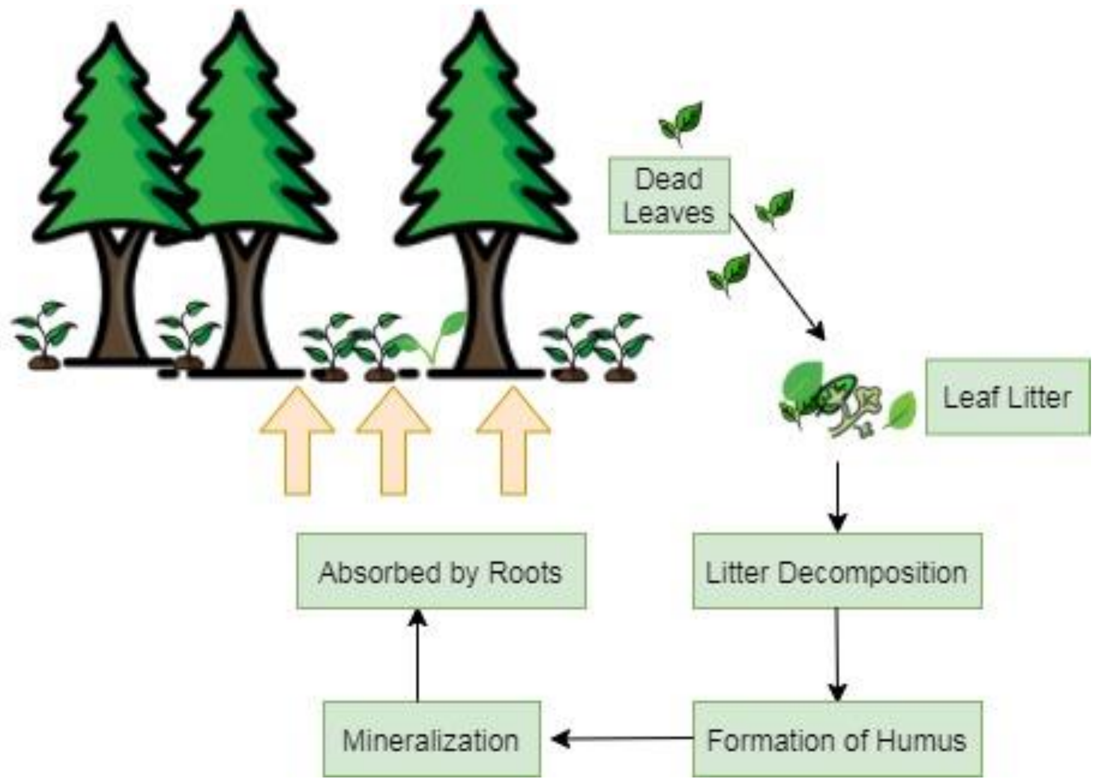


Figure 2:8 Diagrammatic representation of Litter Decomposition

The nutrient consumption of a forest area relies heavily on litter decomposition, with nutrient recycling from plant litter having the most significant impact on the flora. Litter decomposition involves organic matters physical, biological, and chemical breakdown to produce CO_2 and nutrients. The heterotrophic respiration of soil animals and microorganisms returns carbon to the environment in the form of CO_2. Arthropods increase the concentration of nutrients in the soil, either directly or indirectly, during litter decomposition. Litter decomposition is divided into two stages:

(a) Microorganisms mineralise and humify cellulose, lignin, and other substances, and

(b) Soluble compounds are leached into the soil, where nitrogen and carbon are gradually mineralised (Krishna and Mohan, 2017).

Microorganisms in the soil turn plant litter, such as polymer structures forming cell walls, into living tissue with more acceptable carbon: nutrient ratios and more excellent nutrition value for another biota, providing a rich nutrient value source to the consumer a low metabolic rate. Most nutrients in soil litter are extracted and temporarily stored or immobilised in the biomass of microbes and then absorbed by consumers, mainly in the soil arthropods (Bardgett, 2005). These processes use abiotic variables such as temperature and humidity and biotic characteristics such as litter chemical composition and soil species. As a result, the three most important factors that affect litter decomposition are the physical and chemical environment, litter quality, and the distribution of the decomposer community (Prescott, 2010). Temperature is a significant factor in deciding litter decomposition rates, with decomposition being more sensitive to temperature than primary production. The rate of increase in soil microbial activity is proportional to the temperature of the soil (Petraglia et al., 2019). A few studies have suggested that the chemical structure of the litter and environment play a role in decomposition. Soil macro and microfauna benefit from the availability of fresh leaf litter (Frouz, 2018). Litter quality influences the decomposition process leading to a shortage of easily accessible carbon and the deposition of compounds (Ge et al., 2013; Liu et al., 2018). The chemical and physical properties of the soil affect litter decomposition. It is the most significant since texture affects nutrient and water dynamics, porosity, permeability, and surface area. The essential chemical properties are pH, ion exchange capacity, organic carbon content, and nutrients. Organic matter, which affects physiochemical factors, including density and pH, is the most critical soil property influencing litter decomposition. The population density of soil microorganisms can also be increased by adding organic matter, essential for litter mixing and decay (Verma and Jayakumar, 2012).

2.7 Impact of Arthropods in the litter decomposition

Soil biota contributions to the decomposition of organic matter include substrate absorption, increased surface area by degradation, and rapid microbial inoculation of materials. In forest habitats, soil microarthropods have also been shown to improve litter decomposition, nutrient uptake, and ecosystem processes by digesting and breaking down litter, stimulating microbial growth, and transporting bacteria fungal propagules (Wang et al., 2018). Soil fauna may affect the composition or biomass of microbial organisms, influencing the decomposition and nutrient cycle rate (Wang et al., 2009). The decay of the organic materials in ecosystems affects plant healthy growth and development, species composition, and carbon storage (Khatoon et al., 2017). Litter decomposition and organic matter in the soil stabilization can influence other soil properties such as pH, nutrient availability, redox potential, sorption, and capacity to store water. These soil resources support various essential ecosystem services such as the plants growth, hygienic water, flood control, and climate protection, directly or indirectly (Neher and Barbercheck, 2019).

Furthermore, fragmentation of litter and passage by microarthropods guts facilitate the establishment of soil microbial populations. Detritus is fragmented or comminuted by detritivorous microarthropods, resulting in smaller particles with more surface area available for microbial colonisation and increased moisture content in the substrate (Culliney, 2013), which stimulates microorganism development (Coleman and Wall, 2015). The possibility of nutrient loss from agroforestry systems is minimised by regulating the microbial decomposition process in a regulated and continuous manner (Bagyaraj et al., 2016).

Various microarthropod groups significantly affect the absorption of many soil nutrients due to certain relations between below-ground trophic interactions and ecological processes (Wang et al., 2009). Microarthropods can also change soil nutrient uptake, and plants can modify biomass distribution patterns based on the type and availability of soil nutrients. Microarthropods changing the availability of soil nutrients can influence the root-to-shoot ratio of plants. Microarthropods consume living plant parts, litter, and adhering organisms, converting nutrients into biomass and unassimilated matter into faeces (Neher and Barbercheck, 2019).

2.8 Impact of Arthropods on soil microbiota and mineralisation

Fungi, bacteria, protozoa, archaea, and viruses are all microorganisms that are important in the biogeochemical cycling of soil nutrients. (Wurst et al., 2012). Microorganisms break down organic materials in the soil, releasing essential inorganic plant nutrients. Leaching from litter is the first step during organic matters breakdown process at the start of the decomposition process. The leached compounds are often quickly metabolised, thus stimulating the growth of microbes (Bokhorst and Wardle, 2013). They play a critical role in the regulatory process of soil nitrate with the help of nitrification, phosphate via phosphorus mineralization and sulfate through sulphur oxidation, and many other nutrient cycling mechanisms such as nitrogen fixation, oxidation, and ammonification (Fageria, 2012). They even play a significant role in carbon processing by carbon storage and nutrients in the biomass after cell death (Condron et al., 2010).

On the other hand, soil fauna, including annelids, nematodes, and microarthropods, can modify the soil microbial community composition and biomass (Bahrndorff et al., 2018). Soil fauna also mixes soil organic matter with minerals and affects water infiltration and aeration. Soil microarthropods play an essential role because they work mechanically on soil's organic matter until it is degraded chemically by bacteria and fungi (Fig 5). In other terms, they make the organic matter more available, appealing to microorganisms, and hasten the rate of mineralisation (Bagyaraj et al. 2016). The activities of bacterial and fungal communities in the soil largely determine how the organic materials are converted into inorganic forms. Thus, arthropod and microbial interaction are essential when assessing the faunal impact on the nutrient dynamics of litter (Figure 2:9) (Seastedt and Crossley, 1984). The effect of fungivorous Collembola *Tomocerus minor* and the detritivorous isopod *Philoscia muscorum* studied on microbial respiration and exchangeable macronutrients. The results show that both the microarthropods significantly improved microbial activities and the concentration of exchangeable nitrate, ammonium, and phosphate (Teuben and Roelofsma, 1990). Such synergistic effect of soil arthropod and microbe could be observed in the microbial decomposition of litter result in the release of potassium which is enhanced by arthropod activity with the significant increase in the level of organic carbon. However, when soil fauna is removed from heterotrophic decomposition systems, the activity of microbes may decrease, leading to reduced carbon and nitrogen mineralisation (Pramanik et al., 2001). The arthropod-microbe interaction on nutrient mineralisation depends upon the feeding behaviour of arthropods over microorganisms. Oribatid mite stimulates fungal growth by grazing on senescent hyphae. Still, its effect can also be negative on microbial growth, which depends on its foraging intensity. It was also reported that microbial respiration is inhibited when the collembolans density is outnumbered (González, 2002). Vast quantities of annual litter input can be processed; for example, termites can handle up to 60% of litter input. Mineralisation increases the surface area of fragmented plant matter in the faeces, which is invaded by microbes, turning organic substrates into simpler inorganic substrates that are more readily available to the plants (Culliney 2013).

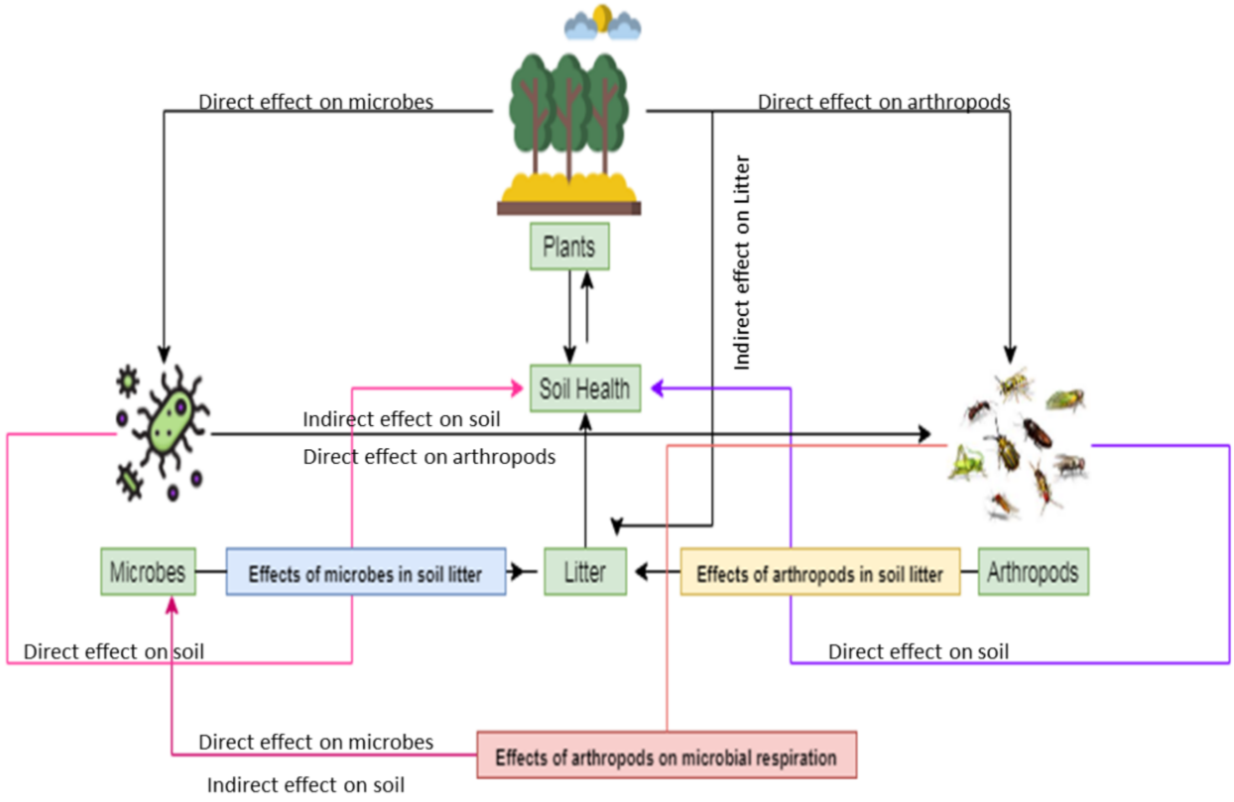
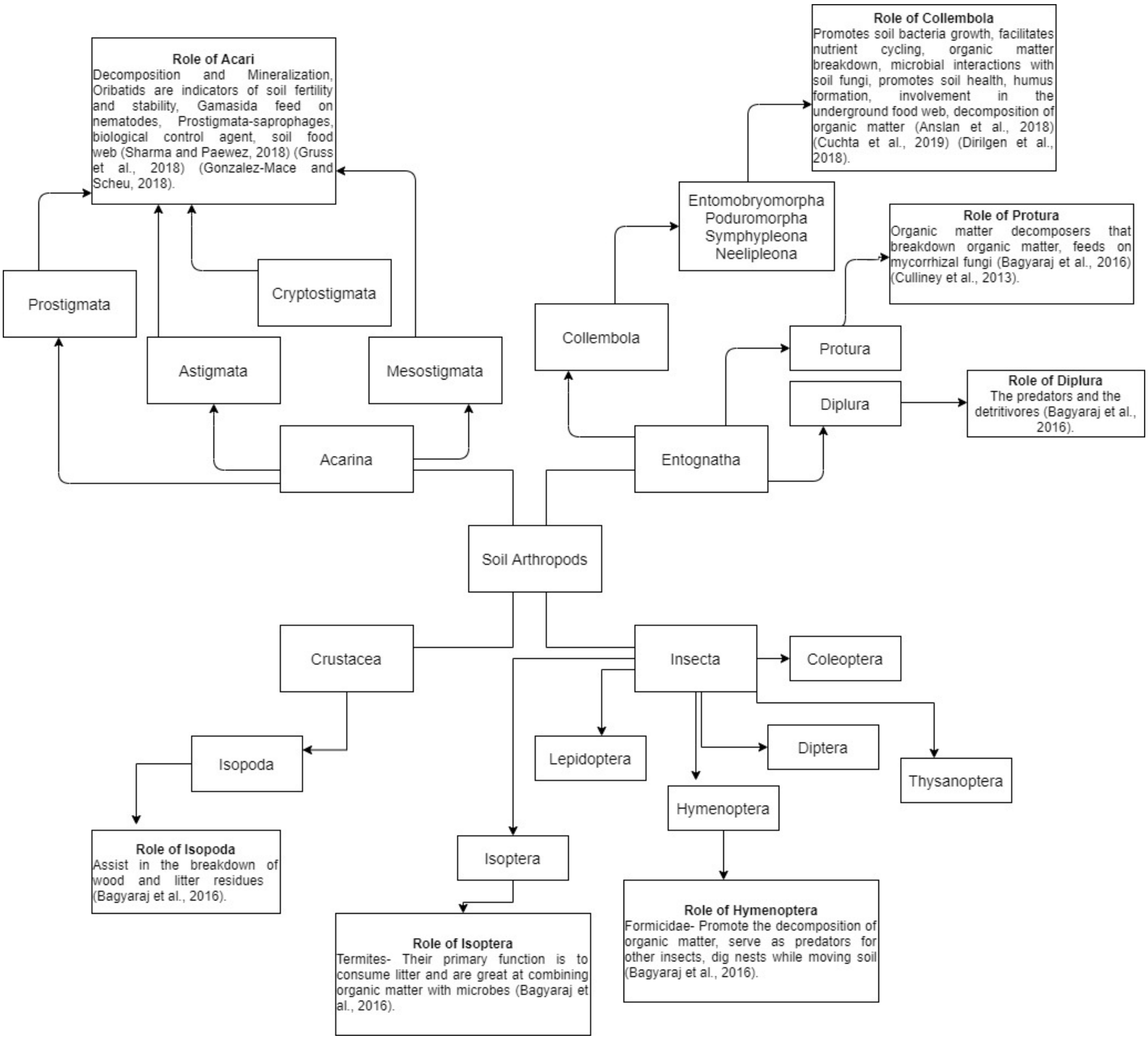


Figure 2:9 Interaction between Plants, Arthropods and Microbes.

Direct effect	Indirect effect
Direct effects on decomposition	Indirect effects on decomposition
Through Food	Through faeces production
Digestion and assimilation	Change in Microbes
Assimilation efficiency	Activity of Microbes
	Rate of mass loss in feaces
	Incorporation of feaces into the soil

Microarthropods also affect soil porosity and thus aeration by creating macropores and turning residue of plants into forms that are more available to microorganisms (Sung et al. 2017). In ecosystem conservation, soil microarthropods play a crucial role. Soil microarthropods live in various habitats, including trees, vegetation, deserts, and agroforestry (Menta and Remelli, 2020). For the sake of food security and other ecological functions, proper management of these ecosystems is necessary. Since soil microarthropods play an essential role in ecosystem management (Figure 2:10), they can maintain the soil ecosystem to enhance consistent and efficient nutrient cycling (Costantini et al., 2015). The application of soil litter to improve soil fertility would have been the most critical management choice. Microarthropods can work on the leaves to release nutrients, so adding them to the soil is a great thing (Sayer, 2006). Microarthropods have a direct impact on nutrient cycles through feeding organic matter or litter.

In contrast, soil mixing, soil channeling, selective grazing, defecation, and microfloral activation by feeding senescent hyphae impact the soil (Wolters, 1991). Pedoturbation and Bioengineering, in which microarthropods and other soil fauna play an important role, recycle nutrients in soils continuously. In most cases, these three biogeochemical processes (Cycles of Carbon, Nitrogen, and Phosphorus) are associated with maintaining a stable soil ecosystem. On the other hand, the lack of microarthropods has substantially affected the decomposition of organic components (Lakshmi et al., 2020).



Role of Acari
Decomposition and Mineralization, Oribatids are indicators of soil fertility and stability, Gamasida feed on nematodes, Prostigmata-saprophages, biological control agent, soil food web (Sharma and Paewez, 2018) (Gruss et al., 2018) (Gonzalez-Mace and Scheu, 2018).

Role of Collembola
Promotes soil bacteria growth, facilitates nutrient cycling, organic matter breakdown, microbial interactions with soil fungi, promotes soil health, humus formation, involvement in the underground food web, decomposition of organic matter (Anslan et al., 2018) (Cuchta et al., 2019) (Dirilgen et al., 2018).

Role of Protura
Organic matter decomposers that breakdown organic matter, feeds on mycorrhizal fungi (Bagyaraj et al., 2016) (Culliney et al., 2013).

Role of Diplura
The predators and the detritivores (Bagyaraj et al., 2016).

Role of Isopoda
Assist in the breakdown of wood and litter residues (Bagyaraj et al., 2016).

Role of Isoptera
Termites- Their primary function is to consume litter and are great at combining organic matter with microbes (Bagyaraj et al., 2016).

Role of Hymenoptera
Formicidae- Promote the decomposition of organic matter, serve as predators for other insects, dig nests while moving soil (Bagyaraj et al., 2016).

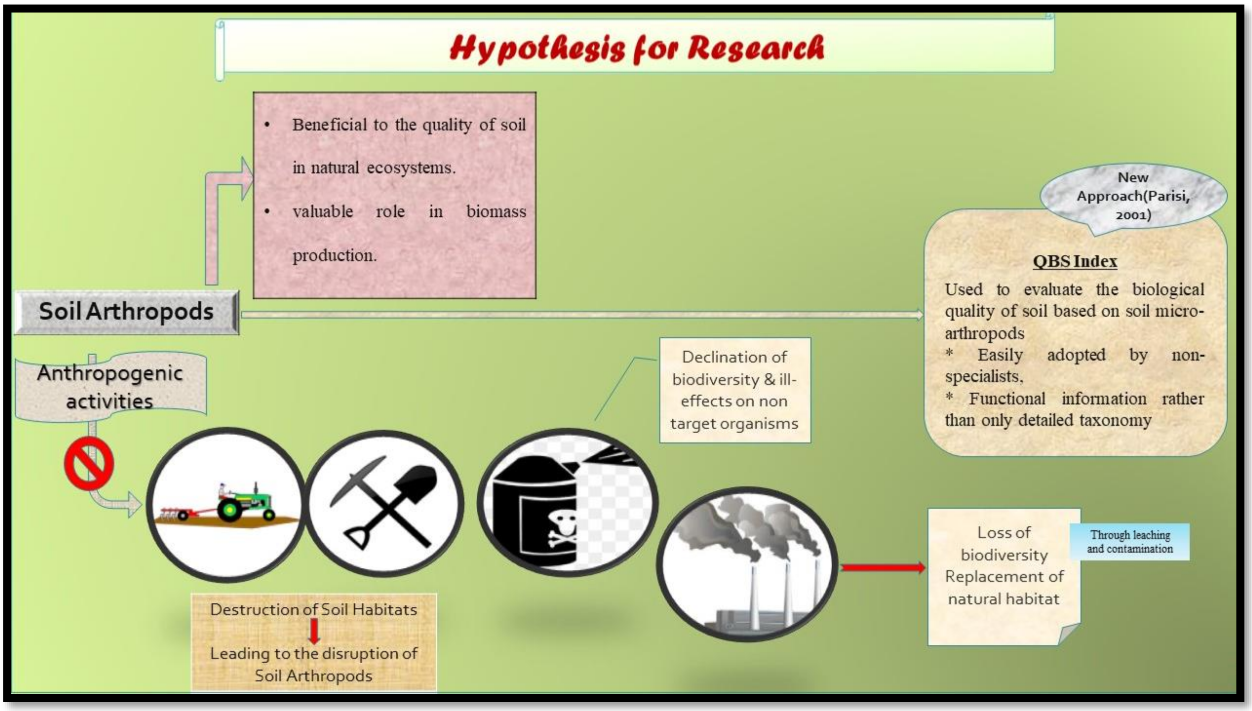
Figure 2:10 Ecosystems in the soil and their functions

2.9 The effects of Plant Litter on Plant-Soil Feedbacks

The investigation of plant-soil feedback (PSF) has focused on the interplay between plant species, abiotic factors (e.g., soil nutrients), and rhizosphere communities (e.g., mutualists, pathogens). The reciprocal interactions between plants and soil, commonly known as plant-soil feedbacks, exert significant influence on growth conditions, plant physiology, community structure, and ecosystem processes. The regulation of Provision of Ecosystem Services (PSFs) may play a crucial role in enhancing the sustainability of agroecosystems. The impact of plant and rhizosphere communities on plant-soil feedbacks (PSFs) has been acknowledged for some time, as have the indirect effects of interactions between plant along with decomposer communities facilitated by litter inputs. The impact of plant litter on the soil environment in agricultural as well as natural ecosystems has been extensively studied, particularly in relation to crop residues. Nevertheless, there has been a relatively lower focus on biological pathways in research on plant-soil feedback mediated by litter (Facelli and Pickett, 1991). The process of plant litter decomposition results in the release of a diverse array of chemical compounds that may have either advantageous or detrimental effects on the reproductive achievement of plants. The chemical pathway has the potential to enhance litter-mediated plant-soil feedbacks (PSFs) by facilitating the transfer of plant nutrients, secondary metabolites, or genetic material from decomposing litter. The community responsible for the fragmentation of litter comprises of several organisms such as myriapods, earthworms, diplopods, millipedes, and diverse insect larvae. These organisms play a crucial role in converting a significant proportion of plant litter into faeces, thereby augmenting the surface area accessible to microbial decomposition. This process leads to an accelerated breakdown of litter. The process of litter shredder decomposition can be significantly influenced by the natural selection of specific litter types or chemicals by decomposers. Plant root-mediated plant-soil feedbacks (PSFs) are a result of the direct interactions between living plant roots and either mutualistic or pathogenic microorganisms in the rhizosphere. In order to induce litter-mediated plant-soil feedbacks, scholars will employ either physical-chemical or biotic pathways (such as alterations in soil community composition, biotic interactions, or home-field advantage effects). The potential effects of litter-mediated plant-soil feedbacks (PSFs) may be influenced by species-specific effects on seedling germination or plant growth. These impacts may include variations in litter layer density or the availability of light beneath litter layers, which operate through the physical pathway. The chemical channel may be responsible for the litter-mediated consequences resulting from the release of primary as well as secondary compounds from disintegrating leaf litter, which in turn may elicit reactions from plants. Ultimately, alterations in the biotic makeup and functioning of decomposer communities can potentially lead to changes in the rates at which they impact the breakdown and recycling of plant debris, thereby driving litter-based plant-soil feedbacks. The rhizosphere and litter play a significant role in the mediation of Plant-Soil Feedbacks (PSFs). This is achieved through various interactions, such as direct competition for nutrients and available space among pathogens, mutualists, and saprotrophs. Additionally, biota immobilize nutrients that are released from waste in the rhizosphere, while pathogen and mutualist responses are triggered by chemical and physical modifications in the soil caused by litter (Veen et al., 2019).

Chapter 3 Hypothesis of the Research

Soil constitutes a crucial constituent of ecosystems, and their fecundity is predominantly impacted by the actions of the fauna inhabiting them. Soil fertility is determined by its ability to provide plants with both essential nutrients for growth and reproduction, as well as a physical matrix that facilitates root development and respiration, while simultaneously maintaining structural integrity against erosive forces. The presence of soil fauna is imperative for the maintenance of soil health and long-term sustainability. Arthropods crucial functions as facilitators of essential ecological processes, particularly those related to the decomposition and rejuvenation of organic matter, are often not fully comprehended. The goal of this work is to establish and underscore the significance of arthropods as crucial constituents of soil fauna and to investigate the population dynamics of soil arthropods in the agro-ecosystem and their contribution to improving soil agro-ecological processes, which may have direct or indirect advantages for both the environment and human well-being. Unfortunately, there is a scarcity of scholarly literature on underground arthropods and their agricultural ramifications in various parts of India. Moreover, it is apparent that undertaking research in the Punjab region is crucial. This study aims to investigate the multifaceted functions fulfilled by soil arthropods and their influence on soil productivity and health. By doing so, it seeks to expand our comprehension of the essentiality of different soil arthropods in preserving soil quality in natural ecosystems and their substantial role in biomass generation. The utilization of soil micro-arthropods has a significant impact on the assessment of soil biological quality, as indicated by the QBS index. This further highlights the importance of arthropods in soil ecosystems. Human activities, including the application of fertilisers, use of hazardous chemicals such as pesticides, tillage practises, and urbanisation of industrial operations, have been found to disrupt the habitats of beneficial soil organisms, leading to their destruction. Therefore, it is crucial to understand the importance of these arthropods in terms of conservation efforts, as they play a vital role in nutrient cycling, soil moisture enhancement, and soil aeration augmentation. The hypothesis of research work is shown as Figure 3:1.



Hypothesis for Research

- Beneficial to the quality of soil in natural ecosystems.
- valuable role in biomass production.

Soil Arthropods

New Approach(Parisi, 2001)

QBS Index

Used to evaluate the biological quality of soil based on soil micro-arthropods

* Easily adopted by non-specialists.

* Functional information rather than only detailed taxonomy

Anthropogenic activities

Declination of biodiversity & ill-effects on non target organisms

Destruction of Soil Habitats

Leading to the disruption of Soil Arthropods

Loss of biodiversity Replacement of natural habitat

Through leaching and contamination

Figure 3:1 Hypothesis of the research work

Chapter 4 Objectives

1. To study the population dynamics of Soil arthropods.
2. To study the impacts of agricultural and non-agricultural activities on Soil arthropods.
3. To assess the soil quality through QBS index.

Chapter 5 Materials and Methodology

5.1 To study the population dynamics of Soil Arthropods.

Study Site and collection of Soil sample

This investigation was carried out in different fields of Jalandhar, Punjab as arthropods vary in the habitat requirement and tolerance to various biotic and abiotic environmental factors, seasonality fluctuations etc.

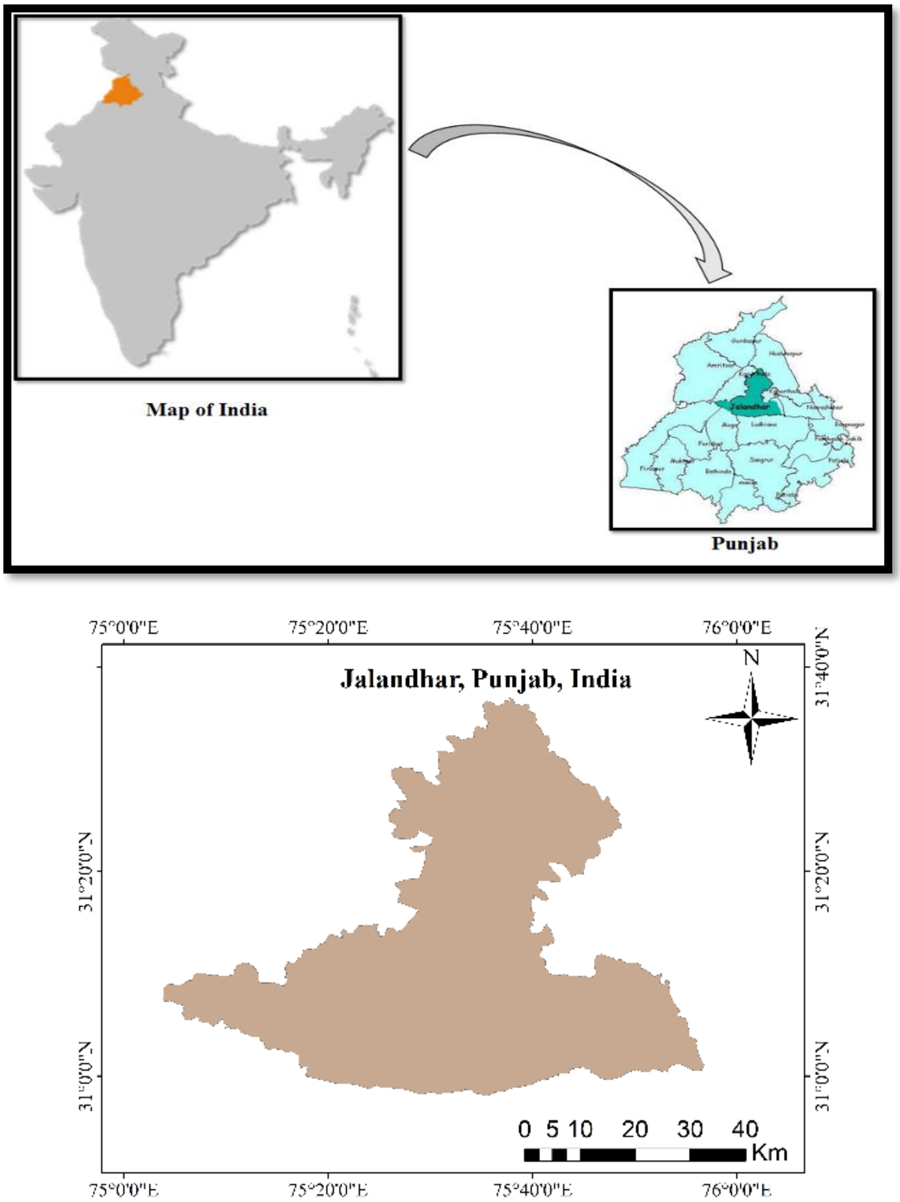


Figure 5:1 Study site location

Description of Sampling Sites

- Site 1- The present investigation was conducted in the Adampur region of Punjab, India, encompassing both agricultural and non-agricultural land. The geographical coordinates of the location with Latitude- 31^{o} 25´ 58´´ N and Longitude- 75^{o} 43´ 3´´ E, with an average elevation of 233 metres. The location of this place is centrally located within the region of Punjab. The study area exhibits a temperate and warm climate, characterised by a higher amount of precipitation during summers in comparison to winters, with an average of 816 mm of rainfall.
- Site 2- Bhogpur is situated at Latitude- 31^{o} 33´ 0´´ N and Longitude- 75^{o} 37´ 59.99´´ E, with a usual elevation of 232 meters. Summers in Bhogpur are hot, humid, and clear, while winters are mild, dry, and generally clear. Throughout the year, temperatures range from 41°F to 103°F, with temperatures seldom dropping below 36°F or exceeding 110°F.
- Site 3- Kartarpur is located at Latitude- 31^{o} 26´ 24´´ N and Longitude- 75^{o} 29´ 59´´ E, with a 235-meter average elevation. The summers are humid and hot, while the winters are mild. Summer lasts from April to June, and winter lasts from November to February. In July - August, a short period of southwest monsoon rain impacts the climate. Approximately 70 cm of precipitation falls each year.
- Site 4- Lambra is located at Latitude- 31^{o} 36´ 20.52´´ N and Longitude- 75^{o} 47´ 56.5´´ E. The local climate, terrain, and the ways in which land is used all play a role in determining the patterns of rainfall and the types of flora that grow there. The months of April through June bring with them the scorching heat of Lambra summer, while the months of July through September usher in the region’s monsoon season. The months of November through February usher in the regions pleasant winter season. The Jalandhar district receives approximately 600 millimeters of precipitation on an annual basis, with the majority of the precipitation falling during the time of the monsoon.

5.1.1 Sampling and Extraction

In order to assess the diversity of soil arthropods, soil samples were obtained from various fields at varying depths (up to 45 cm) using a soil corer with a sample size of up to 10cm in height and 5 cm in diameter (Figure 5:1 made by ARCGIS software), as described by Borah and Kakati (2014). The minimum number of times the sampling was conducted was three. The methodology employed for acquiring the soil samples in this study involved the utilisation of a rectangular steel corer that was pressed into the soil. The instrument is composed of a rectangular steel tube with dimensions of 10 cm in length and an inner area of 5 square centimetres. A metallic rod, measuring 15 cm in length, was affixed to the upper part of the cylindrical container to function as a grip. In order to facilitate a seamless and efficient ingress into the terrestrial environment, the inferior extremity of the cylinder was enhanced. Upon each instance of sampling, the corer was inserted into the soil and up to 45 cm segment was extracted through the application of pressure. The aggregate amount of soil that was gathered at each sampling location during the temporal span of January through December in both 2019 and 2021.

- **NO SAMPLING WAS DONE IN 2020 DUE TO COVID CIRCUMSTANCES.**

Figure 5:2 Sampling process and extraction using Berlesse-Tullgren funnel

Precautions

The process of gathering soil and fauna specimens entailed the utilisation of labelled polyethylene bags to mitigate moisture loss and minimise disruptions to soil arthropods during transit from the field to the laboratory (Figure 5:2). The technique of gathering data has been previously recorded by Parisi et al., 2005 with the aim of conducting analysis and extraction.

A monthly quantitative sampling was carried out to assess the diversity of soil arthropods between January and December in 2019 and 2021. A total of five soil samples were collected per field, on a monthly basis, from both agricultural and non-agricultural sites. A comprehensive set of 288 soil samples were procured from designated sites in a year. Each individual sample was accurately arranged into appropriately labelled zip lock bags and subsequently conveyed to the laboratory for subsequent extraction and analysis.

Monthly soil samples were collected from each plot at each site over a period of two years. The methodology encompassed the arbitrary sampling of five cores from each plot, which were subsequently blended with precision and consistency to produce a composite Soil Sample (Figure 5:2). The designated site yielded a total of 288 samples on an annual basis being procured from each plot. The specimens were collected during the early morning hours, precisely between 8:00 and 10:00 a.m. Sampling was avoided on days characterised by dense fog and following periods of intense precipitation. The investigation of edaphic factors involved a two-year period of sampling (Figure 5:3), extraction, and analysis, specifically in the years 2019 and 2021, as previously indicated.

Extraction

The extraction of soil-living organisms from soil is considered a noteworthy and intricate obstacle within the realm of soil zoology. Various techniques and methodologies have been utilised by soil zoologists to gather soil fauna from soil samples obtained over a period of time. It is important to acknowledge that the extraction process has not been shown to be 100% effective by any of the aforementioned methods or techniques. The extraction process was carried out using the Berlese- Tullgren funnel method (Figure 5:2), which was outlined by Crossley and Blair in 1991. The Berlesse-Tullgren funnel, originally conceptualised by Berlese

(Fenton, 1947), is utilised to extract soil arthropods from soil specimens. A 60-Watt electric bulb was employed as a source of both light and heat for a period of six to seven days. The collected specimens were preserved in vials containing a solution consisting of 70% ethanol and a small amount of glycerol. The samples were separated and mounted in DPX medium, then examined using a stereo zoom microscope according to the methodology outlined by Nsengimana et al., 2017, Wang and Tong, 2012), and Borah and Kakati (2014).

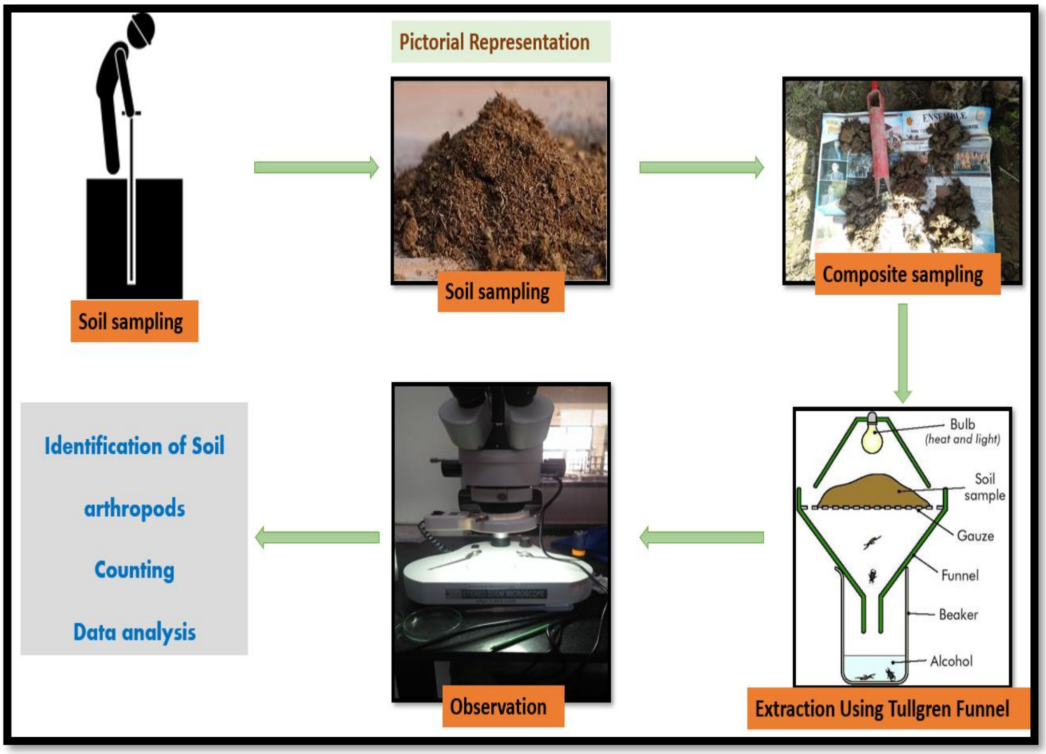


Figure 5:3 Pictorial representation of the work

Identification of arthropods

The taxonomic analysis of soil arthropods involved the utilisation of a standard protocol for preparing extracted materials. This protocol entailed soaking the arthropods in a solution composed of 70% alcohol along with lactic acid (v/v), as proposed by Balogh (1972). For the temporary microscopic observation, following the mounting procedure, lactic acid was utilised. After conducting a necessary microscopic analysis, the specimens were transferred to small glass containers containing a solution of 70% alcohol and a small amount of glycerin in order to prevent dehydration. The collected specimens underwent analysis utilising a Stereozoom Microscope to ascertain their fundamental attributes. Taxonomic keys, as described by Bellinger et al., (1996-2023) were utilised to conduct identification up to the order or family level.

The remaining arthropods that were gathered were also appropriately preserved in a solution consisting of 70% alcohol. The specimens, which were either preserved in alcohol or placed on slides, were dispatched to the Zoological Survey of India, accompanied by appropriate labelling and essential details, for the purpose of identification and molecular characterization using COX1 genes.

5.1.2 Molecular Characterization of Arthropods using COX 1 genes

Molecular characterization of the Organisms

DNA Isolation

DNA was isolated from the 20 specimens of every similar group of organisms (Vials containing the samples with labelling), and the Qiagen mini kit was used to isolate DNA, following the manufacturers guidelines. DNA was eluted in 20.0 µL of elution buffer. DNA was checked on gel (2.0 µL) and 2.0 µL was used to assess the quality by PCR. Two primers (Forward and Reverse primer) were used.

COIUF 5'- TYTCAACAAAYCAYAARGATATTGG-3'

COIUR 5'-TAAACTTCWGGRTGWCCAAARAATCA-3'

DNA PCR

The mtDNA COI gene was amplified by using forward and reverse primers that are specific to the COI gene (Chahartaghi et al., 2009). The PCR uses amplicons that are about 500 bp long. The following mixture was made to make a PCR reaction mix for one DNA sample (Table 5:1). With two primers, a PCR reaction was done on each sample. Finally, each reaction had a volume of 25.0 µL. The reaction mix was made and put into 200 µL PCR tubes for each sample. The genomic DNA was then added to each tube (Thunnisa et al., 2021).

For PCR, the following thermal cycling program was used (Table 5:2):

Table 5:1 The following mixture was used to set up a PCR reaction for a DNA sample.

Materials	Volume (uL)
Genomic DNA	5.00
PCR Mix	12.5
10 pmole Primers (LCO1490 & HCO2198)	1.0
Nuclease Free water	6.5

Table 5:2 The thermal cycling program listed below was utilized for PCR.

Stage	Temperature (ºC)	Time (min:sec)	Cycles
Initial denaturation	95	5:00	
Denaturation	95	0:30	35 cycles
Annealing	54	0:45	
Extension	72	1:00	
Final extension	72	7:0	
Hold	4	hold	

Agarose Gel Electrophoresis of PCR product

On agarose gels, PCR products were analyzed using standard 0.5X TBE gel electrophoresis buffer and 2% (w/v) agarose gel electrophoresis.

PCR product Purification

Excess dNTPs and primers were removed from the reaction mixture in order to prepare PCR amplicons for sequencing. 10 µL of PCR product were utilized for ExoSAP purification. Enzymatic cleaning of the amplified PCR product was accomplished using Thermo Fisher’s ExoSAP-ITTM PCR Product Cleanup Reagent. In a single procedure, additional primers and nucleotides were hydrolyzed. Samples that have been ExoSAP-IT purified were appropriate for use, including DNA sequencing. The ExoSAP-IT reagent protects PCR amplicons, obviates the requirement for tube, well, or column transfer steps, and reduces the likelihood of cross-contamination. No additional processing was needed. A total of 7l of a post-PCR reaction product and 2 l of ExoSAP-

IT reagents were used for the reaction. To degrade leftover primers, the reaction was incubated at 37°C for 60 min.

DNA sequencing of PCR products

The PCR products DNA was sequenced using both the aforementioned primers and an Applied Biosystems BigDye Terminator V3.1 Cycle sequencing kit. The sequencing products were placed on the automated DNA sequencing device, the Applied Biosystems 3130 Genetic Analyzer. Sequences were examined using the sequencing machines Sequencing Analysis 5.1 software. These sequences were duplicated and processed with ChromasPro version 1.34. Forward and reverse sequences were matched to construct the contig with the best sequence calls; thus, one contig was generated for each sample containing two sequences (forward and reverse).

The ChromasProV3.1 sequence assembly software was utilized in order to piece together the 16S region sequences obtained from the test sample. The assembled sequences were put through a BLAST analysis, in the NCBI database. Based on the results of the BLAST search, phylogenetic analysis was performed on ten distinct strains. Further investigation into the phylogenetic connection between the reference and query sequences was carried out.

SEM characterization of the organisms

JEOL FESEM JSM-7610F-PLUS was used to study the detailed images of Organisms (Field emission scanning electron microscopy). Five species were attached (of each organism) to an aluminum stub with carbon tape and later coated with gold for SEM examination.

5.1.3 Physiochemical Analysis of Soil

Standard procedures were used to determine soil physicochemical parameters. For the examination of physicochemical characteristics, soil samples will be collected in a similar manner from the adjacent sampling area of the soil arthropods. These physicochemical analyses such as soil temperature, soil moisture, soil pH etc will be done by standard laboratory method during sampling period in order to check the impact of these factors on the populations of soil arthropods (Wang and Tong, 2012; Sharma and Paewez, 2017; Borah and Kakati, 2014). The field sampling was conducted with three replications, each of which was sampled twice. One sampling group was dedicated to the analysis of physico-chemical factors, while another group was focused on the seasonal collection of faunal specimens. The various physico-chemical factors that were documented or approximated are enumerated below:

- Soil temperature was measured during each sampling event using a soil thermometer (Model number- Qzep: 677880995667) with an accuracy of 1^{o}C.
- The pH (Labtronics LT-49) and electrical conductivity of soil were measured through the use of an electronic pH metre and conductivity metre in a 2:5 soil and water suspension (Smith & Doran, 1997). The percentage of soil moisture was ascertained by subjecting 20 grams of fresh soil to oven (Hot air oven- Digital Make Lab Fit) drying at a temperature of 105°C for a period of 24 hours or until a state of constant weight was achieved (Wilke, 2005).
- The percentage of organic carbon was estimated using the Walkley Black method (Janitzky, 1986). The quantification of soil organic carbon relies on the utilisation of the Walkley-Black chromic acid wet oxidation technique. The oxidizable organic matter present in the soil undergoes oxidation when treated with a 1 N potassium dichromate ($K_2Cr_2O_7$) solution. The reaction is facilitated by the exothermic heat released upon combining two volumes of H_2SO_4 with 1 volume of the dichromate.
- The quantification of Total Nitrogen (%), in this context, was conducted through the utilisation of the Kjeldahl method (Sáez-Plaza et al., 2013). The Kjeldahl method for the determination of nitrogen involves the utilisation of wet digestion, a procedure designed to convert organic nitrogen compounds into ammonium ions (NH_{4+}). The procedure entails the identification of the chemical element nitrogen (N) and subsequently determining its quantity.
- The extraction process for Phosphorus estimation involves subjecting soils to a 0.5M sodium bicarbonate solution with a soil to solution ratio of 1:100, which is adjusted to pH 8.5 and left for a duration of 16 hours. Subsequently, the sample is subjected to acidification and assessed through colorimetric means.

The quantification of potassium is accomplished through the utilisation of atomic absorption spectroscopy (Allen et al., 2001). The potassium content is quantified through mineralization using a dry process and subsequent analysis using atomic absorption spectrometry. In order to prevent the ionisation of potassium, it is imperative to incorporate a spectral buffer, such as cesium chloride.

5.1.4 Data Analysis

The focus of the population study was on arthropod communities, specifically their seasonal patterns and diversification. A number of analyses were considered to analyse population trends and species diversity. To better comprehend seasonal population dynamics, the study evaluated the annual mean density of arthropods, which provides a general assessment of their abundance. This metric can be used to compare population sizes across seasons. The seasonal variation in the pattern of arthropod populations was analyzed to identify any recurring patterns or yearly changes. This information sheds light on the seasonal abundance and changes in arthropods in the area under study. It was necessary to determine the profile distribution of arthropods in order to comprehend their spatial distribution at the study site. This involves tracking the presence and abundance of multiple arthropod species in different areas or habitats, which assists in identifying any special preferences or associations. To determine the relative importance of various arthropod groups within the community as a whole, the percentage contribution made by distinct faunal groups was evaluated. This study sheds light on the form and ecological significance of numerous taxa of arthropods. Several diversity indices were employed to assess the biodiversity of arthropods.

The species count (S) represents the number of diverse arthropod species discovered within the study area. Dominance is a measurement of the quantity and dominance of the most prevalent species. Simpsons diversity index (1-D) assesses the species richness of arthropods, with greater values indicating greater species diversity. The Shannon Weiner diversity index (H) takes into account both species richness and evenness to provide a comprehensive measure of biodiversity. Evenness is a measure of the distribution of species abundances that indicates whether a community is evenly or unevenly distributed. The Margalef Index measures species diversity by combining the number of species (S) and the total number of individuals. Equitability (J) assesses the comparability of species abundances, revealing whether the arrangement of organisms is proportional or unbalanced. Numerous faunal groups and abiotic characteristics were investigated using correlation analysis. This research contributes to a greater understanding of how conditions in the environment affect the abundance and distribution of diverse arthropod species. A one-way analysis of variance (ANOVA) was also used to determine whether there were significant differences between seasons or habitats in terms of population metrics or biodiversity indices. This statistical test contrasts group means in order to identify any significant differences. For statistical analysis and correlation analysis, the PAST 4.03 software was utilised, as it provided the necessary capabilities to perform calculations, visualise data, and interpret the results. Utilising these methods, the study seeks to provide complete understanding into the seasonal patterns, species composition, and population density of arthropods in the study area.

The main important factors which were considered during the work are as follows:

a. Identifying the number of different organisms present in the sample taken,
b. Counting the total number of each organism present in the sample,
c. Using the numbers to estimate the various measures of biodiversity.

Shannon-Weiner Index (H) - To measure the species diversity in a sample is based on a theory which was given by Shannon and Weiner in 1949 (Balakrishnan *et al*., 2014; Rotimi and Uwagbae, 2014; Harianja *et al*., 2016; Rohyani and Ahyadi, 2018).

$$H = -\sum_{i=1}^{S} Pi \text{ Log } Pi$$

Where H = Measure of Shannon and Wiener diversity

S = Total number of species in a sample

Pi = Proportion of the total number of individuals occurring in species i.

To calculate the maximum possible diversity of H or H max, this will be calculated by using the formula [H max = Log2S; Where, S = Number of species]

Evenness or Equitability Index (Pielou, 1969) - It is denoted by J and also referred as Relative diversity, calculated by using the formula as follows:

$J = H/ H \max$

Here, H = Shannon-Weiner function/Mac-Arthur index of diversity (Borah, 2015).

5.2 To study the impacts of agricultural and non-agricultural activities on Soil arthropods

The objective of this investigation is to assess the impact of pesticides, fertilisers, tillage, and industrialization/urbanization on soil arthropods across various types of land. The Berlesse-Tullgren funnel process was employed to gather arthropods from the soil. Subsequently, the soil arthropods were gathered, classified, evaluated, and identified in a laboratory setting utilising the statistical methods previously mentioned. The minimum number of times the sampling was conducted was on monthly basis (Esenowo *et al*., 2014; Lee and Kwon, 2015; Simony *et al*., 2013).

5.3 To assess the soil quality through QBS index

This study aimed to validate the simple index QBS-ar based on the either presence or absence of various categories of soil arthropods and how they adapt to soil habitats. The acronym QBS, which stands for Qualita Biologica del Suola in Italian, refers to a novel approach utilised in Italy for the first time in 2001. This approach involves the biological evaluation of soil quality and is aimed at studying the same. The QBS index is associated with a notion that a positive correlation exists between soil quality and the abundance of soil organisms that are well-suited to the soil niche. Popovic et al., 2022 employ indices that rely on soil invertebrates to evaluate the consistency and prevalence of populations. Nonetheless, the execution of these methods is frequently impeded by difficulties in categorization and the procurement of a suitable specimen. The limitations mentioned earlier have led to the development of a simplified eco-morphological index that eliminates the requirement for taxonomic identification of organisms. This has resulted in an increased range of applicability for these methodologies, as reported by Dickinson et al., 2005. Parisi proposed the integrated QBS index, also referred to as Qualità Biologica del Suolo, which is based on the eco-morphological index principle. The QBS-ar index is formulated based on the empirical observation that a positive correlation exists between the amplification of soil quality and the proliferation of microarthropod groups that are specifically adapted to soil habitats, as reported by Galli et al., 2014. The QBS-ar technique is employed for the assessment of the level of acclimatisation of soil microarthropods to their soil environment. According to Galli et al., 2014, the physical characteristics that indicate an organisms adaptation to soil habitats consist of diminished or non-existent pigmentation and visual organs, a sleek body structure with condensed appendages (e.g., hairs, antennae, and legs), and a decrease or lack of adaptations for activities such as flying, jumping, or running. Parisi outlines the various essential stages involved in the QBS-ar application, which include sampling, microarthropod extraction, specimen preservation, determination of biological forms, and QBS-ar index calculation.

The process of determining QBS entails a series of process:

Sampling: Soil samples were obtained from various locations in the fields. In order to determine QBS, it is necessary to collect a sample from soil that is moist. It is recommended to refrain from sampling immediately following periods of heavy rainfall. Monthly sampling was conducted at each of the selected sites, as reported by Parisi et al., 2005.

The Berlesse-Tullgren funnel method was employed in the laboratory to extract soil species within 48 hours of sampling. The arthropods present in the soil were extracted and subsequently conserved in a preservative solution for future investigations, as reported by Parisi et al., 2005.

The preservation of specimens involves placing them in a vial with a preservative liquid consisting of 75% ethanol and glycerol in a 2:1 ratio. This process is typically carried out under a stereomicroscope at low magnification, as described by Parisi et al., 2005 and Aspetti et al., 2010.

The identification of the morphological type and the computation of the QBS index are crucial in determining the adaptation levels of various specimens within a group. This enables the recognition of the distinct biological form or morphology exhibited by each specimen, and an EMI score is assigned to each group based on this classification. The Eco-Morphological Index (EMI) is a metric used to assess the ecological and morphological characteristics of a given environment. The classification of soil-dwelling organisms is based on their depth of habitation and EMI values. Eu-edaphic organisms are characterised by their deep soil dwelling and have an EMI value of 20. Hemi-edaphic organisms are an intermediate form, while Epi-edaphic organisms live on the surface and have an EMI value of 1. The aggregation of all the gathered clusters from the specimen constitutes the overall QBS score. The statistical analysis of all results was conducted (Parisi et al., 2005), Menta et al., (2008, 2012, 2018), Santorufo et al., 2012, Yan et al., 2012, Begum et al., 2013, Blasi et al., 2013, Galli et al., 2014, Constantini et al., 2015, and Lakshmi and Joseph (2016).

Chapter 6 Results and Discussion

6.1 Overview of Site 1

This research was conducted in different fields of Punjab since arthropods differ in their habitat requirements and tolerance to various biotic and abiotic environmental conditions, seasonality changes, and other factors as given in Table 6:1.

Table 6:1 Study Site description of agriculture and non-agriculture land (Site 1)

LOCATION	The present investigation was conducted in the Adampur region of Punjab, India, encompassing both agricultural and non-agricultural land. The geographical coordinates of the location area Latitude- 31^{o} 25´ 58´´ N and Longitude- 75^{o} 43´ 3´´ E, with an average elevation of 233 meters. The location of this place is centrally located within the region of Punjab. The study area exhibits a temperate and warm climate, characterized by a higher amount of precipitation during summers in comparison to winters, with an average of 816 mm of rainfall.	
VEGETATION COVER	AGRICULTURE (AG1)	NON-AGRICULTURE (NAG1)
	The region surrounding Adampur is primarily distinguished by agricultural land, with a focus on the cultivation of crops such as wheat, rice, maize and sugarcane.	The area adjacent to non-agricultural land exhibited a dense vegetation cover comprising of a diverse range of trees, along with numerous herbs, shrubs, climbers, and grasses.
SOIL AND ENVIRONMENTAL CONDITION	The soil displays typical alluvial traits, characterized by a high clay content and favorable water retention capacity in relation to their environmental attributes. The prevailing climatic conditions in the area are classified as humid subtropical, which are characterized by warm summers and chilly winters. The precipitation regime within the area is distinguished by a notable aggregation of rainfall during the monsoon period, which conventionally extends from the month of July to September. The mean yearly precipitation in the region is approximately 700 millimeters. The study of soil quality and population dynamics of soil arthropods in Adampur, due to its geographical location in an agricultural region, has the potential to provide valuable insights into the well-being and efficiency of the agricultural systems in the locality.	

Site1- Agriculture land (AG1)

6.1.1 Edaphic factors

In July of 2019 and 2021, the soil temperature was measured at its highest level of 33 degrees Celsius, and in January of 2019 and 2021, it was recorded at its lowest level of 12 degrees Celsius. The percentage of moisture found in the soil had reached its highest level more than 12% in the month of December 2021, while it had dropped to its lowest level less than 0.8% in the month of June, July and August in both the year (2019 and 2021). The pH values of the soils in all the sampling plots ranged from 7 to 8 in both 2019 and 2021, indicating that the soil's had a neutral to acidic in nature. The changes in pH were in between 7 to 8, and they occurred in a manner in different months. According to Table 6:2, the percentage of organic materials discovered to be present ranged from its highest point (0.9%) in July 2019 to its lowest point (0.05%) in April 2019.

The Table 6:2 represents data collected over a one-year period (2019) on environmental variables, and abundance of Collembola, Acari, and other arthropods. Environmental variables were temperature (degrees Celsius), pH, electrical conductivity (Deci siemens per meter), moisture content (%), carbon content (%), nitrogen content (%), potassium content (kilograms per hectare), and phosphorus content (ppm). The data shows that the temperature varied throughout the year, with the lowest (12°C) and highest (33°C) occurring in January and July, respectively. The soil environment was mildly acidic to mildly alkaline, as shown by the pH values, which ranged from 6.26 in March to 7.98 in December. From 0.11 in August and September to 0.27 in March, the electrical conductivity values varied, with the greatest value suggesting a relatively high salt concentration in the soil. The moisture content exhibited temporal variability, with the maximum value (11.48%) being observed in December and the minimum value (0.6%) being recorded in June and July. The carbon content exhibited a fluctuation between 0.05% in April and 0.9% in July, whereas the nitrogen content demonstrated a range of 0.004% in April to 0.069% in September. The study revealed that the potassium levels exhibited a fluctuation between 27 kg/h in May and 48 kg/h in February and March, while the phosphorus levels ranged from 2 ppm to 3 ppm. Regarding arthropod abundance, the data indicates that Collembola exhibited the highest level of abundance, with the maximum count recorded in March (78 individuals) and the minimum in May (2 individuals). The abundance of Acari and other arthropods was comparatively lower, with the maximum count recorded in January (68) and November (10), respectively.

In 2021, the carbon, nitrogen, and phosphorus content in the soil remains constant over the time. The mean carbon content (0.36%), mean nitrogen content (0.03%) and the mean phosphorus content (37.75 ppm). Temporal fluctuations significantly impact the population density of Collembola, Acari, and other arthropods. The data (Table 6:3) reveals that the month of January has the highest abundance of collembola, with a count of 86, while the month of February exhibits the highest count of acari (64) and

December for other arthropods (15). The arithmetic average of the number of collembola was 40.6. The mean count of acari is reported to be 29.9. In comparison, the mean count of other arthropods was observed to be 7.25. The data indicates a positive correlation between temperature and the occurrence of arthropods across all three categories. The months with higher temperatures showed the highest numbers of arthropods. The study revealed a negative correlation between the moisture content and the abundance of arthropods. Specifically, the arthropod counts were found to be lowest during months with higher moisture content. The results indicate that there is no significant correlation between the pH levels, electrical conductivity, or the concentrations of carbon, nitrogen, and phosphorus, and the incidence of arthropods.

Table 6:2 The number of arthropods in relation to soil factors at AG1 during 2019

Month, 2019	**Temp. (^oC)**	**pH**	**E.C (ds/m)**	**Moisture (%)**	**C (%)**	**N (%)**	**K (Kg/h)**	**P (ppm)**	**Collembola**	**Acari**	**Other arthropods**
n	12	12	12	12	12	12	12	12	12	12	12
Min	12	6.26	0.11	0.6	0.05	0.004	27	2	2	2	1
Max	33	8	0.27	11.48	0.9	0.069	59	3	78	68	10
Sum	265	88.8	1.93	55.1	4.01	0.2233	474	32	439	344	67
Mean	22.08±2.20	7.4±0.15	0.16±0.01	4.59±1.2	0.33±0.08	0.01±0.005	39.5±2.7	2.6±0.1	36.5±8.3	28.6±7.0	5.5±0.7
Variance	58.26	0.29	0.002	17.28	0.086	0.0003	89.72	0.24	830.2	603.3	6.81
Stand. dev	7.63	0.53	0.05	4.15	0.29	0.019	9.47	0.49	28.81	24.56	2.60
Median	20.5	7.5	0.13	2.92	0.20	0.01	38	3	27.5	23.5	6

Table 6:3 The number of arthropods in relation to soil factors at AG1 during the year 2021

Month, 2021	**Temp. (^oC)**	**pH**	**E.C (ds/m)**	**Moisture (%)**	**C (%)**	**N (%)**	**K (Kg/h)**	**P (ppm)**	**Collembola**	**Acari**	**Other arthropods**
n	12	12	12	12	12	12	12	12	12	12	12
Min	12	7.1	0.1	0.6	0.06	0.005	27	2	10	6	0
Max	33	7.9	0.3	12.5	0.8	0.068	48	3	86	64	15
Sum	267	90.1	2.05	55.66	4.33	0.368	453	32	488	359	87
Mean	22.2±2.2	7.50±0.08	0.17±0.01	4.63±1.1	0.36±0.07	0.03±0.006	37.75±2.1	2.6±0.14	40.6±7.8	29.9±6.8	7.25±1.1
Variance	62.2	0.08	0.003	16.9	0.06	0.00045	54.75	0.24	746.6	558.08	15.29
Stand. dev	7.88	0.29	0.05	4.12	0.25	0.021	7.39	0.49	27.32	23.62	3.91
Median	22	7.6	0.16	3.05	0.275	0.02	35.5	3	35	22.5	6

6.1.2 Population dynamics

A comprehensive collection of arthropods was obtained, comprising 3020 individuals/m^2 from 3 distinct classes and 5 different orders. Arthropods were observed in both agricultural and non-agricultural land, and the number of arthropods was documented for each land type annually.

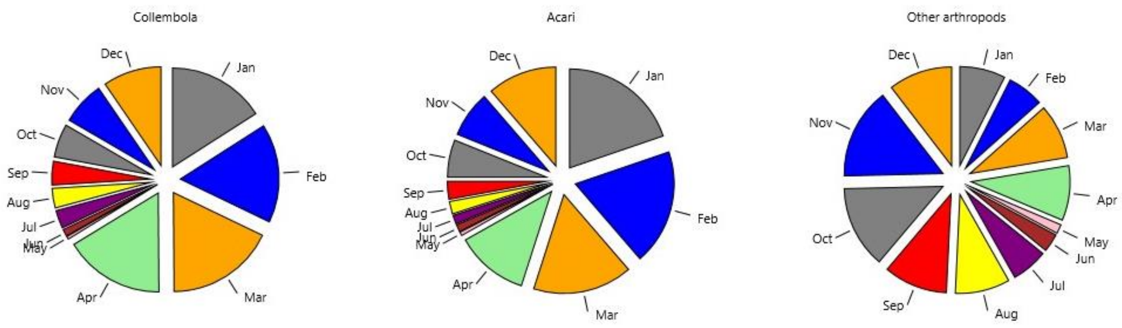


Figure 6:1 The number of Collembola, Acari, and other arthropods in month-wise presenting in AG1 during year, 2019.

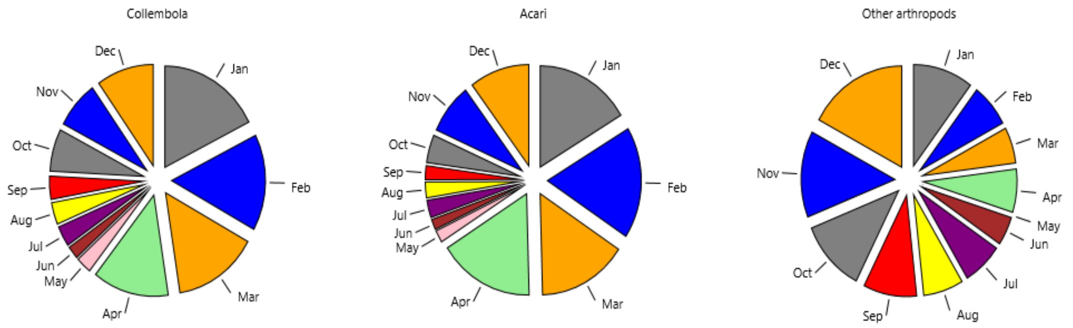


Figure 6:2 The number of Collembola, Acari, and other arthropods in month-wise presenting in AG1 during year, 2021.

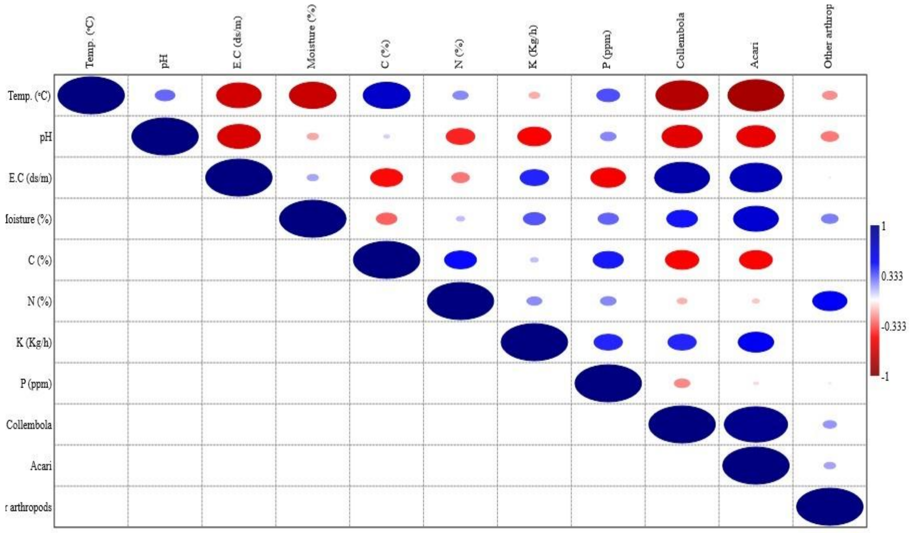
Based on the information provided in the Tables (6:2 and 6:3) the number of arthropods observed in agricultural land was 850 in 2019 and 934 in 2021. The number of arthropods observed in non-agricultural land was 583 in the year 2019 (Table 6:2), while in 2021, the count increased to 653 (Table 6:3). Additionally, the data indicates that there was a seasonal fluctuation in the arthropod population, with the greatest abundance occurring in the winter months and the least abundance occurring in the summer months. The aforementioned pattern was observed in both years of the conducted study (Figure 6:1 and Figure 6:2). This study offers valuable insights into the diversity and distribution of arthropods in both agricultural and non-agricultural land, as well as their seasonal population fluctuations. The data can be utilized to apprise land management methodologies and conservation endeavors to guarantee the safeguarding of arthropod populations and their significant ecological functions. The prevailing taxonomic group in Agricultural land was Collembola, accounting for 51.64% of the total, followed by Acari at 40.4%. Pseudoscorpions, Ground Beetle, and Ants were the least represented groups, with a combined total of 7.8%, as indicated in Table 6:2 for year 2019. However, in year 2021, Collembola accounting for 52.2% of the total, followed by Acari at 38.4% and others arthropods for 9.31% as indicated in Table 6:3.

The present study reports on the arthropod species composition of agricultural land, where a total of 1784 individuals/m^2 were collected in both years in agricultural land. Among the collected species, Collembola exhibited the highest dominance with 439 and 488 species, followed by Mesostigmatids and Oribatids mites with 344 and 359 species in year 2019 and 2021, respectively. In contrast, others arthropods were found to be the least represented, with approximately 67 and 87 species in year 2019 and 2021, respectively. The arthropod community was found to be dominated by Collembola, which accounted for 51.9% of the total population (1784). The numerical dominance of the Family *Isotomidae*ae of Collembola was observed. The population of Acari, which accounted for 40.4% of the total, ranked second in terms of numerical abundance. The Acari community was primarily composed of the Mesostigmata and Prostigmata, which were the dominant species within this group. The proportionate prevalence of the remaining taxa, including coleopterans, diplurans, pseudoscorpions, isopods, and Hymenoptera, was found to be below 7.8%. The soil arthropod population peaked during the winter months when the organic carbon content was greater than 0.2%, the moisture content was moderate, and the temperature was relatively low. In the months of May through August, when humidity levels were low and temperatures were relatively high, it attained its lowest point. In the post-monsoon or pre-winter period, when soil parameters such as temperature, moisture, and organic carbon were relatively moderate, there was also an upward trend in the population of soil arthropod fauna. The observed fluctuation of the total population at this site was primarily attributable to two major groups, namely Collembola and Acari and remaining were identified as other arthropods.

6.1.3 Correlation analysis

Correlational study between edaphic factors and arthropod population at the AG1 in 2019

The correlational data shows that that there was no statistically significant impact of environmental factors on the species count (Figure 6:3). The findings of the correlation analysis indicate a negative correlation between soil temperature and the abundance of arthropod species, specifically Collembola and other arthropods. However, a positive correlation was observed between soil temperature and Acari, with a value of 0.84. The pH levels exhibited a negative correlation with all the organisms taken in the study with r values of -0.60, -0.58, and -0.26, respectively. There was a negative correlation observed between the percentages of Carbon and Nitrogen and the abundance of Collembola and Acari, while a positive correlation was noted with other arthropod species. Additionally, a positive correlation was observed between the abundance of Potassium and Collembola as well as Acari, while a negative correlation was found between Potassium and other arthropods.



2019

Figure 6:3 Correlation analysis between Edaphic factors and arthropods populations in AG1 during year, 2019.

Correlational study between edaphic factors and arthropod population at the AG1 in 2021

The Figure 6:4 displays the correlation coefficients that exist between various edaphic factors, including environmental factors and three distinct categories of arthropods, namely Collembola, Acari, and other arthropods, at AG1 over the course of the year 2021. Upon examination of data, it is evident that temperature exhibits a feeble negative correlation with Collembola (r=-0.87) and a weak negative correlation with other arthropods (r=-0.38). The pH levels exhibit a feeble negative correlation with the three arthropod categories. Among these, the Collembola category shows the most robust negative correlation with a coefficient of -0.44. The data indicates that there exists a weak negative correlation between EC and temperature, with a correlation coefficient of -0.38. Additionally, there is a weak positive correlation between EC and both Collembola and Acari, with correlation coefficients of 0.58 and 0.51, respectively. The presence of moisture exhibits a significant inverse relationship with the three arthropod classifications. On the other hand, there is a strong positive correlation between C and N, with a correlation coefficient of 0.99, and a weak negative correlation with Collembola and Acari. Additionally, K displays a weak positive correlation with other arthropods.

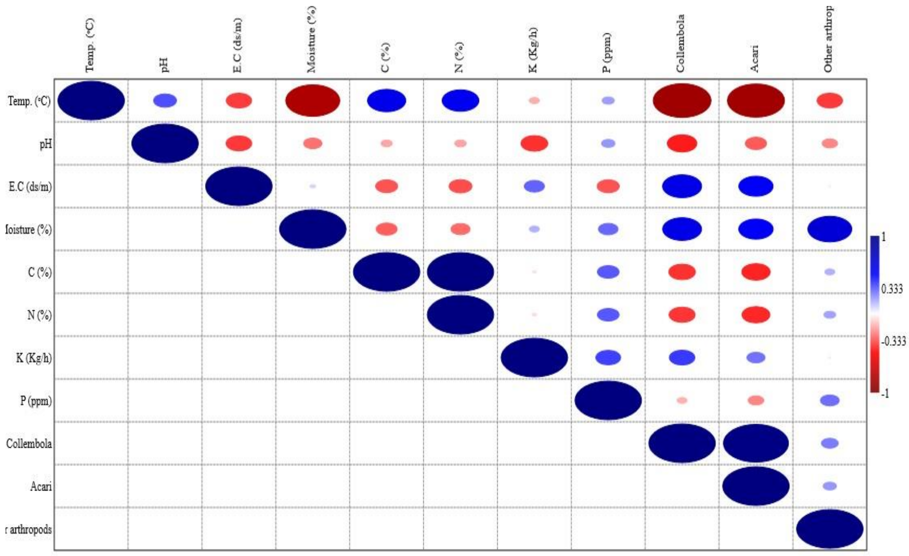


Figure 6:4 Correlation analysis between Edaphic factors and arthropods populations in AG1 during year, 2021.

6.1.4 Diversity Indices

The seasonal variations in the count, diversity, and equitability of Collembola, Acari, and other arthropods in AG1 during the years 2019 and 2021 are depicted in Table 6:4. The data exhibits a seasonal pattern, with a rise in Figures during the pre-winter phase, as demonstrated by the maximum value being documented in winter and the minimum value being documented in summer and autumn. The winter season exhibited the highest number of species observed. The investigation revealed that the Simpsons diversity (1-D) indices exhibited variability across distinct arthropod categories. Specifically, Collembola displayed a value of 0.869, Acari exhibited a value of 0.860, and other arthropods manifested a value of 0.9 in the year 2019. In the year 2021, Collembola demonstrated a value of 0.88, Acari displayed a value of 0.869, and other arthropods exhibited a value of 0.89. The Dominance (D) values exhibited variation across different taxa. Specifically, in 2019, Collembola demonstrated a value of 0.130, Acari exhibited a value of 0.139, and other arthropods displayed a value of 0.1. In 2021, Collembola exhibited a value of 0.117, Acari demonstrated a value of 0.131, and other arthropods displayed a value of 0.105. The data suggests a decline in diversity during the autumn season, which was subsequently followed by an upswing in diversity during the winter season. Furthermore, Collembola demonstrated a comparable Simpsons diversity index when compared to Acari and other arthropods. The study conducted by Shannon Weiner on Collembola revealed that the diversity values (H) exhibited a seasonal trend, with discernible peaks in diversity occurring during specific months. In 2019, the H values demonstrated variability, with Collembola exhibiting a range of 2.17, Acari exhibiting a range of 2.12, and other arthropods exhibiting a range of 2.37. In 2021, the H values continued to exhibit variability, with Collembola exhibiting a range of 2.27, Acari exhibiting a range of 2.18, and other arthropods exhibiting a range of 2.32. In 2019 and 2021, the Evenness metric demonstrated a slightly higher value of 0.89 and 0.92 in other arthropods as opposed to Collembola and Acari, respectively. The Equitability (J) metric exhibited a comparatively elevated value of 0.95 and 0.96 in other arthropods during the years 2019 and 2021, respectively. The Margalef index was found to exhibit values within the ranges of 1.8 to 2.6 and 1.7 to 2.23 during the years 2019 and 2021, correspondingly. Upon comparing the arthropod population indices from 2019 and 2021, it is evident that there exist certain variations in the arthropod populations over the given period. In 2021, the number of observed arthropod taxa was slightly lower than that of 2019, with 11 taxa observed in 2021 and 12 in 2019. The aggregate count of individuals has increased in 2021 as compared to 2019. The Simpson (1-D) and Shannon (H) indices indicate a higher level of diversity in the arthropod populations in 2021 as compared to 2019. Alternative indices, such as Evenness and Equitability (J), indicate a more uniform dispersion of arthropod populations across various taxa in 2021 as opposed to 2019. In general, these indices offer a valuable method for measuring and contrasting the biodiversity of arthropod populations across different periods.

Table 6:4 Diversity indices of arthropods from AG1 in year 2019 and 2021

	2019			**2021**		
Index	**Collembola**	**Acari**	**Other arthropods**	**Collembola**	**Acari**	**Other arthropods**
Taxa (S)	12	12	12	12	12	11
Individuals	439	344	67	488	359	87
Dominance (D)	0.1307	0.1394	0.1	0.1178	0.131	0.1056
Simpson (1-D)	0.8693	0.8606	0.9	0.8822	0.869	0.8944
Shannon (H)	2.177	2.122	2.372	2.273	2.187	2.323
Evenness (EVNS)	0.735	0.6959	0.8929	0.8094	0.742	0.9274
Margalef	1.808	1.883	2.616	1.777	1.87	2.239
Equitability (J)	0.8761	0.8541	0.9544	0.9149	0.8799	0.9686

[S for Taxa; D for Dominance; H for Shannon Diversity; EVNS for Evenness and J for Equitability]

6.1.5 One-way ANOVA

For AG1 (2019)

Test for equal means

The presented data appears to be indicative of the results obtained from a unidirectional analysis of variance (ANOVA) test, which is employed to assess the statistical significance of differences in means across multiple groups. The statistical analysis indicates a notable disparity in averages among the cohorts, as evidenced by the p-value of 0.004218. The analysis of variance reveals that approximately 31% of the overall variability can be attributed to inter-group dissimilarities, while the omega2 coefficient, which is a gauge of the magnitude of the effect, has a value of 0.2335. The output additionally encompasses assessments for homogeneity of variance, which hold significance in verifying the assumptions of the ANOVA examination. The findings suggest that there exist notable variations in variance among the groups, as determined by both means and medians. This implies that the concept of homogeneity of variance may have been contravened. The output additionally presents outcomes of a Welch F-test, a variant of the ANOVA procedure that is applicable in cases where there exist unequal variances among groups. The findings of this examination demonstrate a noteworthy distinction between the cohorts (p = 0.0009455).

For AG1 (2021)

Test for equal means

One-way ANOVA is a statistical method used to compare the means of many groups to determine if there are statistically significant differences between them. In 2021, we put the data from AG1 through the test. Results from a single-factor analysis of variance are shown in the Table 6:6. The p-value is extremely small at 3.31×10^{-23}, and the F-statistic is 22.44. This indicates that there are substantial differences in the groups means. The ICC value of 0.641185 indicates that group differences account for 64.12% of the total variance, as shown in the Components of Variance section. The low p-values for both tests described in the section on Levene's test suggest that there is a statistically significant difference in the group variances. The Welch F test section shows that the differences between the means are statistically significant, with a modest p-value, even though the variances are not the same.

6.1.6 Seasonal fluctuation of soil organisms

Month-wise arthropod population atAG1 in 2019 and 2021

In 2019 and 2021, arthropods were collected on monthly basis and the details of the organisms are given below in Table 6:5 and Table 6:6 respectively:

Table 6:5 Arthropod community species and month-wise population in AG1 in 2019.

Name of the Species/Family/Order	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Collembola												
Fam.*Isotomidae*	07	08	07	08	01	02	02	02	02	03	04	06
Cryptopygus sp.	08	06	08	09	0	0	01	02	02	02	03	06
Isotoma sp.	06	07	09	06	0	01	02	01	02	02	03	05
Isotomiella sp.	07	07	08	07	0	02	01	02	03	03	03	04
Isotomurus sp.	07	05	07	08	0	0	01	01	01	02	03	03
Folsomia quadrioculata	08	06	08	06	0	0	01	01	02	02	03	03
Hypogastrura sp.	04	06	06	07	0	0	01	01	01	03	02	04
Lepidocyrtus sp.	09	09	08	05	0	0	01	01	01	02	03	03
Entomobrya sp.	05	06	06	06	1	0	01	01	01	02	03	02
Sminthrus sp.	04	06	05	06	0	0	01	01	01	02	02	02
Fam.*Katiannidae*	05	05	06	04	0	0	01	01	01	01	02	04
Acari												
Fam.*Acaridae*	08	07	06	05	0	01	01	01	01	03	04	05
Fam.*Laelapidae*	08	08	06	04	0	01	01	02	02	02	02	04
Fam.*Cunaxidae*	07	07	06	03	0	0	01	01	01	02	03	03
Ord. *Cryptostigmata*	06	07	06	02	0	0	01	01	01	02	02	02
Fam.*Phytoseiidae*	06	07	07	04	0	0	0	0	01	02	03	04
Poecilochirus carabi	07	06	05	03	01	01	0	0	01	02	02	03
Sperchonopsis ecphyma	06	05	05	03	0	0	0	0	01	03	03	03
Acari juveniles	06	06	04	05	0	0	0	0	0	02	02	05
Fam.*Rhodacaroidea*	08	07	06	06	0	0	01	02	02	02	03	04
Demodex folliculorum	06	05	05	06	01	01	0	0	0	01	02	06
Other arthropods												
Cortinicara sp. (Fam.*Latridiidae*)	01	01	01	01	0	0	01	01	01	01	01	0
Anthicidae species	01	0	01	0	0	0	01	0	01	01	01	01
Fam.*Carabidae*	01	0	01	0	0	01	0	0	0	01	01	01
Hymenoptera	01	01	01	01	0	0	0	01	0	01	0	01
Psocoptera	0	01	01	0	0	0	0	01	01	0	01	01
Diplura	01	01	01	02	01	01	01	02	01	03	04	03
Diptera	0	0	0	01	0	0	01	01	02	01	01	0
Pseudoscorpions	0	0	0	01	0	0	0	0	01	01	01	0
N	29	29	29	29	29	29	29	29	29	29	29	29
Min	0	0	0	0	0	0	0	0	0	0	0	0
Max	09	09	09	09	01	02	02	02	03	03	04	06
Sum	143	140	140	119	05	11	22	27	34	54	67	88
Mean	4.93	4.82	4.82	4.10	0.17	0.37	0.75	0.93	1.17	1.86	2.3	3.04
Std. error	0.54	0.53	0.51	0.49	0.07	0.11	0.10	0.13	0.13	0.14	0.19	0.33
Variance	8.70	8.29	7.79	7.02	0.14	0.38	0.33	0.49	0.50	0.62	1.07	3.24
Stand. dev	2.95	2.87	2.79	2.65	0.38	0.62	0.57	0.70	0.71	0.78	1.03	1.80
Median	06	06	06	04	0	0	01	01	01	02	02	03

Table 6:6 Month-wise arthropod population atAG1 in 2021.

Name of the Species/Family/Order	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Collembola												
Fam.*Isotomidae*	10	08	07	08	01	02	02	02	02	03	04	07
Cryptopygus sp.	12	10	09	09	02	0	01	02	02	02	03	07
Isotoma sp.	06	07	09	06	01	01	02	01	02	03	03	05
Isotomiella sp.	07	07	08	07	01	02	01	02	03	04	04	04
Isotomurus sp.	08	05	08	07	02	0	02	01	01	03	05	03
Folsomia quadrioculata	10	06	07	06	01	01	02	01	02	02	03	03
Hypogastrura sp.	06	06	07	06	02	01	01	02	01	04	03	04
Lepidocyrtus sp.	11	09	06	05	0	01	02	03	02	03	04	05
Entomobrya sp.	05	06	04	04	01	0	01	01	01	03	03	02
Sminthrus sp.	05	06	04	04	01	01	01	01	01	03	02	02
Fam.*Katiannidae*	06	05	02	02	01	01	01	01	01	03	03	06
Acari												
Fam.*Acaridae*	07	07	06	07	01	01	01	01	01	03	04	06
Fam.*Laelapidae*	07	08	06	04	0	01	01	02	01	01	02	05
Fam.*Cunaxidae*	05	07	06	07	0	01	01	01	01	01	03	03
Ord. *Cryptostigmata*	04	07	06	05	01	0	01	01	01	01	02	02
Fam.*Phytoseiidae*	06	07	07	04	0	0	01	0	01	02	03	04
Poecilochirus carabi	05	05	05	06	01	01	01	0	01	01	02	03
Sperchonopsis ecphyma	06	05	05	07	01	0	02	01	01	02	04	04
Acari juveniles	05	06	04	05	0	0	01	0	0	02	03	06
Fam.*Rhodacaroidea*	08	07	06	07	02	01	01	02	01	02	04	02
Demodex folliculorum	06	05	04	07	01	01	0	01	0	01	02	02
Other arthropods												
Cortinicara sp. (Fam.*Latridiidae*)	01	01	01	01	0	0	01	01	01	01	01	02
Anthicidae species	01	01	01	0	0	0	01	0	01	01	01	01
Fam.*Carabidae*	01	0	01	0	0	02	0	0	0	01	01	02
Hymenoptera	01	01	0	01	0	0	01	01	0	01	01	02
Psocoptera	01	01	01	0	0	0	01	01	02	01	02	02
Diplura	01	01	01	02	0	02	01	02	01	03	04	03
Diptera	02	0	0	01	0	0	01	01	02	01	01	01
Pseudoscorpions	01	01	0	01	0	0	0	0	01	01	01	02
N	29	29	29	29	29	29	29	29	29	29	29	29
Min	01	0	0	0	0	0	0	0	0	01	01	01
Max	12	10	09	09	02	02	02	03	03	04	05	07
Sum	154	145	131	129	20	20	32	32	34	59	78	100
Mean	5.3	05	4.51	4.44	0.68	0.68	1.10	1.10	1.17	2.03	2.68	3.44
Std. error	0.59	0.54	0.53	0.50	0.13	0.13	0.10	0.14	0.13	0.18	0.21	0.32
Variance	10.36	8.5	8.33	7.47	0.50	0.50	0.31	0.59	0.50	1.03	1.36	3.11
Stand. dev	3.21	2.91	2.88	2.73	0.71	0.71	0.55	0.77	0.71	1.01	1.16	1.76
Median	06	06	05	05	01	01	01	01	01	02	03	03

Collembola

Table 6:5 and 6:6 illustrates the seasonal population dynamics of Collembola species in AG1 (2019 and 2021). The *Isotomidae* family was observed to have a presence of

Cryptopygus, Isotoma, Isotomiella, Isotomurus, Isotomidae, and *Folsomia quadrioculata* throughout all seasons, with the exception of May and June. The family Hypogastruridae was found to have a single species, specifically identified as *Hypogastrura sp*. This species was observed to be present throughout all seasons, with the exception of summer and the rainy season. *Hypogastrura sp*. demonstrated a seasonal pattern of population variation, with the highest population levels occurring during the winter season and lower levels observed from May to September. The family *Entomobryidae* was observed to have a presence of two distinct species, namely *Lepidocyrtus sp*. and *Entomobrya sp*. These species were found to be present throughout the year, with the exception of the months between May and September. The population dynamics of both species followed the typical pattern of exhibiting higher numbers during the winter season. The family Sminthuridae was comprised of a solitary species, namely *Sminthrus sp.* This species was documented to be present during the period spanning from December to April, with a decrease in numbers during the summer and autumn seasons. The family *Katiannidae* was observed during the months of December through April, with lower occurrences noted during the summer and autumn seasons.

Acari

Table 6:5 and 6:6 depicts the seasonal fluctuations of the Acari population in AG1 in both years. The presence of *Acaridae* family was noticed across all seasons, except for the months of May and June. The Lealapidae family was observed to be present during all seasons, except for the summer and rainy seasons. The Lealapidae species exhibited a seasonal fluctuation in population, wherein the winter season recorded the highest population levels, while the period from May to September witnessed a decline in population. The study reports the occurrence of the *Cunaxidae* family and its species throughout the year, except for the period spanning from May to September. The population fluctuations for *Cryptostigmata*, *Poecilochirus carabi*, and *Sperchonopsis ecphyma* species conform to the standard pattern of displaying elevated numbers during the winter season. The presence of the *Rhodacaroidea* family was recorded during the period ranging from December to April, with a decline in observations during the summer and autumn months. The observation of *Demodex folliculorum* and Acari juveniles was noticed between December and April, with reduced incidences being recorded during the summer and autumn months.

Other arthropods

The research investigated the fluctuations in population of arthropods during different seasons (Table 6:5 and 6:6). Collembola and Acari were excluded from the study, and the identified arthropods were classified into the group of other arthropods at the order level. The Order Hymenoptera was observed to have a significantly low population count during various months, while Psocoptera, Diplura, Diptera, and Pseudoscorpions displayed a consistent trend of having low numbers throughout all seasons.

6.1.7 Diversity indices of arthropods in month-wise from AG1

The following Table 6:7 illustrates the monthly fluctuations in the quantity, diversity, and evenness of Collembola, Acari, and other arthropods in AG1 for the years 2019 and 2021. The data displays a recurring monthly pattern, wherein there is an increase in number during the pre-winter and winter phases. This is evidenced by the highest recorded value occurring during the winter season (143 individuals) in January 2019, and the lowest recorded value occurring during the summer (5 individuals) in May and autumn of the same year. The season of winter demonstrated the greatest quantity of observed organisms. The findings of the investigation indicate that there was variability observed in the Simpsons diversity (1-D) indices across different categories of arthropods. During the months of May and June, the observed values ranged from 0.8 to 0.876, with a consistent pattern of approximately 0.9 throughout the remaining months. Variation in Dominance (D) values was observed across various taxa, with a recorded value of 0.2 in May of 2019. According to the research conducted by Shannon Weiner, the diversity values (H) displayed a seasonal pattern, with distinct peaks in diversity observed during certain months, as evidenced by the analysis of monthly data. The H values exhibited variability in 2019, with a range of 3.26 observed in October and a range of 1.6 observed in May. The Evenness metric exhibited a marginal increase to a value of 1 in May 2019, while in the remaining months it ranged between 0.8 and 0.9. The metric of Equitability (J) demonstrated a relatively higher value of 1 during the month of May, and a range of 0.9 in the remaining months of the year 2019. During the year 2019, the Margalef index displayed values ranging from 6.8 in September to 2.4 in May.

Furthermore, the diversity indices in 2021 reveal that the winter season (January) had the highest recorded value of 154 individuals, while the summer season (May) and autumn of the same year had the lowest recorded value of 20 individuals. The results suggest a consistent pattern in the Simpsons diversity (1-D) indices across various months, with values ranging from 0.93 to 0.95. Variability in the values of Dominance (D) was noted among different taxonomic groups, ranging from 0.04 to 0.07. The Shannon Weiner’s (H) exhibited a seasonal trend, with discernible peaks in diversity observed during specific months, as demonstrated by the examination of monthly data. In 2021, the H values demonstrated fluctuation, with the month of October exhibiting a range of 3.246, while the months of May and June displayed a range of 2.718. The Evenness metric demonstrated values ranging from 0.8 to 0.9. The Equitability metric (J) exhibited a comparable range of values, ranging from 0.94 to 0.97. In the year 2021, the Margalef index exhibited a fluctuation in values, with the highest value of 7.213 observed in July, and the lowest values of 5.007 observed in May and June.

Table 6:7 Diversity indices of all arthropods in month-wise from AG1 in year 2019 and 2021

Diversity Indices												
2019	**Jan**	**Feb**	**Mar**	**Apr**	**Mar**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Taxa (S)	26	25	27	26	5	9	20	21	25	28	28	26
Individuals	143	140	140	119	5	11	22	27	34	54	67	88
Dominance(D)	0.04	0.04	0.04	0.04	0.2	0.12	0.05	0.05	0.04	0.04	0.04	0.04
Simpson (1-D)	0.95	0.95	0.95	0.95	0.8	0.8	0.94	0.94	0.95	0.95	0.95	0.95
Shannon (H)	3.12	3.1	3.14	3.1	1.6	2.14	2.96	2.98	3.14	3.26	3.25	3.14
Evenness (EVNS)	0.87	0.9	0.86	0.86	1	0.94	0.96	0.94	0.92	0.93	0.92	0.89
Margalef	5.03	4.8	5.26	5.23	2.485	3.33	6.14	6.06	6.80	6.76	6.42	5.58
Equitability(J)	0.95	0.96	0.95	0.95	1	0.97	0.98	0.98	0.97	0.97	0.97	0.96
2021												
Taxa (S)	29	27	26	26	16	16	26	23	25	29	29	29
Individuals	154	145	131	129	20	20	32	32	34	59	78	100
Dominance(D)	0.04	0.04	0.04807	0.04705	0.07	0.07	0.042	0.0	0.046	0.042	0.040	0.043
Simpson (1-D)	0.95	0.95	0.95	0.95	0.93	0.93	0.95	0.94	0.95	0.95	0.95	0.95
Shannon (H)	3.16	3.14	3.10	3.12	2.71	2.71	3.20	3.05	3.14	3.24	3.26	3.24
Evenness (EVNS)	0.81	0.86	0.86	0.87	0.94	0.94	0.94	0.92	0.92	0.88	0.90	0.88
Margalef	5.55	5.22	5.12	5.14	5.00	5.00	7.21	6.34	6.80	6.86	6.42	6.08
Equitability (J)	0.94	0.95	0.95	0.95	0.98	0.98	0.98	0.97	0.97	0.96	0.97	0.96

6.2 Site 1-Non-Agriculture land (NAG1)

6.2.1 Edaphic factors

In July of 2019 and 2021, the soil temperature was measured at its highest level of 33 degrees Celsius, and in January and December of 2019 and 2021, it was recorded at its lowest level of 12 degrees Celsius. The percentage of moisture found in the soil had reached its highest level more than 12.6% in the month of February 2019 and December 2021, while it had dropped to its lowest level less than 0.9% in the month of July, 2019. The pH values of the soils in all the sampling plots ranged from 6.2 to 8 in both 2019 and 2021, indicating that the soil's had an alkaline to acidic in nature. The soil arthropod faunal population peaked in the winter of 2019 and 2021, when the organic carbon content was between 0.2 and 0.8, the moisture content was moderate, and the temperature was low. It attained its lowest point from May to August, when moisture content was low and temperatures were relatively high. Post-monsoon or pre-winter, when soil parameters such as temperature, moisture, and organic carbon were relatively moderate, an upward trend in soil arthropod populations was also observed. The population fluctuation observed at this site was primarily attributable to the behavior of two major groups: Collembola and Acari. The 2019 values of edaphic variables and the arthropod population are shown in the Table 6:8. The statistics show a wide variety of temperatures, from 12 degrees Celsius in January to 33 degrees Celsius in July, which may explain why arthropod populations appear to be larger in the spring and summer. Soil pH varied from 6.3 to 8.0 over the course of a year, making it mildly acidic to mildly alkaline. Arthropod populations and distributions may have been affected because some species are better adapted to certain pH ranges. Soil EC readings between 0.12 and 0.26 ds/m are consistent with the presence of dissolved minerals. Some arthropod species require either particularly nutrient-poor or nutrient-rich soils for survival, thus this may have affected both. From July to February, the soil's moisture content changed from 0.9% to 12.6%. As some arthropod species are better suited to wetter or drier soil, seasonal changes in soil moisture levels may have altered arthropod abundance and dispersion. Arthropod populations may have fluctuated due to seasonal changes in the soil's carbon, nitrogen, and phosphorus content. The percentage of organic materials discovered to be present ranged from its highest point 0.2% to 0.8% in April 2019. In May, for instance, despite a high concentration of carbon, nitrogen, and phosphorus in the soil, very few arthropods were found. In contrast, soil arthropod populations increased in October despite decreasing nutrient levels. By far the most common type of arthropod all through the year was the Collembola (springtails), followed by the Acari, and then Other Arthropods. The edaphic conditions in the soil may have contributed to seasonal shifts in the abundance of these groupings. For instance, high temperatures and poor soil moisture may have contributed to the lack of arthropods observed in May. As a whole, the table gives a good overview of the connection between edaphic parameters and arthropod populations at NAG1 in 2019. As this study only presents one year’s worth of data from one specific area, and that the interactions between edaphic conditions and arthropod populations can be intricate and highly context-dependent. Table 6:9 provides a summary of the edaphic parameters and arthropod populations at NAG1 in the year 2021. The data can be used to evaluate the impact of soil conditions on arthropod populations and to predict ecological shifts. From January and December’s average temperatures of 12 degrees Celsius to Julys sweltering temperatures of 33 degrees Celsius, there is a large range of data. From March to December, the pH level rose from 6.26 to 7.7. Between January and August, the electrical conductivity varied between 0.1 and 0.26 ds/m. Moisture levels were lowest in July, at 1.6%, and greatest in December, at 12.2%. From February to March, the carbon concentration ranged between 0.1% and 0.81 %. From February to March, potassium concentrations ranged from 27 kg/h in June to 48 kg/h in January and February, and nitrogen concentrations ranged from 0.009% to 0.060%. Phosphorus concentration never varied from 3 ppm throughout the year. The arthropod population fluctuated on a monthly basis.

Table 6:8 The number of arthropods in relation to soil factors at NAG1 during the year 2019

Month, 2019	**Temp. (^{o}C)**	**pH**	**E.C (ds/m)**	**Moisture (%)**	**C (%)**	**N (%)**	**K (Kg/h)**	**P (ppm)**	**Collembola**	**Acari**	**Other arthropods**
N	12	12	12	12	12	12	12	12	12	12	12
Min	12	6.3	0.12	0.9	0.11	0.009	27	2	3	2	1
Max	33	8	0.26	12.6	0.8	0.068	53	3	60	48	8
Sum	266	88.69	2.03	62.83	5.28	0.447	436	33	298	232	53
Mean	22.16	7.39	0.16	5.23	0.44	0.037	36.33	2.75	24.83	19.33	4.41
Std. error	2.22	0.14	0.012	1.16	0.07	0.006	2.45	0.13	5.63	4.57	0.6
Variance	59.42	0.26	0.002	16.22	0.07	0.0005	72.6	0.2	380.8	250.7	4.44
Stand. dev	7.7	0.51	0.04	4.02	0.26	0.02	8.52	0.45	19.51	15.83	2.1
Median	20.5	7.5	0.165	4.6	0.4	0.03	34	3	21.5	16	4.5

Table 6:9 The number of arthropods in relation to soil factors at NAG1 during the year 2021

Month, 2021	**Temp. (^{o}C)**	**pH**	**E.C (ds/m)**	**Moisture (%)**	**C (%)**	**N (%)**	**K (Kg/h)**	**P (ppm)**	**Collembola**	**Acari**	**Other arthropods**
N	12	12	12	12	12	12	12	12	12	12	12
Min	12	6.26	0.1	1.56	0.11	0.009	27	2	6	5	2
Max	33	7.9	0.26	12.6	0.81	0.06	48	3	58	52	14
Sum	267	88.5	1.94	64.56	4.39	0.37	450	34	305	272	76
Mean	22.25	7.37	0.16	5.38	0.36	0.03	37.5	2.83	25.41	22.66	6.33
Std. error	2.27	0.13	0.012	1.07	0.07	0.006	1.98	0.11	5.27	4.38	1.08
Variance	62.2	0.22	0.001	13.78	0.06	0.0005	47.18	0.15	334.08	230.97	14.06
Stand. dev	7.88	0.47	0.04	3.71	0.26	0.022	6.86	0.38	18.2	15.19	3.74
Median	22	7.45	0.14	5.55	0.26	0.02	37	3	23.5	22	5

6.2.2 Population dynamics

The prevailing taxonomic group in non-agriculture land was Collembola, accounting for 51.11% of the percentage abundance, whereas Acari constituted the smallest proportion at 39.79%, and other arthropods for 9.09% for year 2019. However, in year 2021, Collembola accounting for 46.7% of the total, followed by Acari at 41.65% and others arthropods for 11.63%. The occurrence of arthropods in two different years are given below in Figure 6:5 and Figure 6:6.

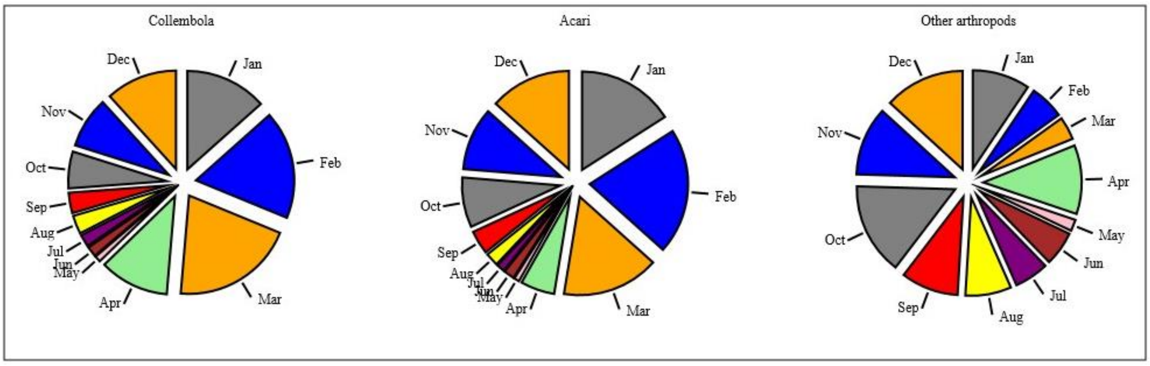


Figure 6:5 The number of Collembola, Acari, and other arthropods in month-wise presenting in NAG1 during year, 2019

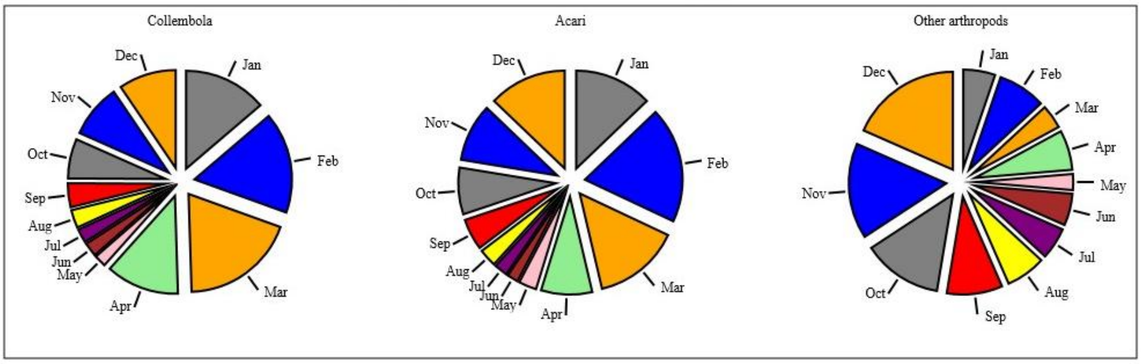


Figure 6:6 The number of Collembola, Acari, and other arthropods in month-wise presenting in NAG1 during year, 2021

A total of 1236 individuals/m^2 soil arthropods were gathered from non-agricultural land, with Collembola being the most prevalent species, comprising 298 and 305 specimens, followed by Acari with 232 and 272 specimens, followed by other arthropods with 53 and 76 in year 2019 and 2021, respectively. Collembola comprised 48.78% of the total population of 1236, demonstrating numerical superiority over other groupings. It was observed that the Family *Isotomidae* was numerically dominant. In terms of numerical abundance, the Acari population ranked second, comprising 40.77 percent of the total. Mesostigmata and Prostigmata, which were the dominant species within this group, constituted the majority of the Acari community. The proportional prevalence of the remaining taxa, such as coleopterans, diplurans, pseudoscorpions, isopods, and Hymenoptera, was determined to be less than 10.4%. The number of Collembola ranged from six in May to fifty-eight in March. From June to February, the Acari population ranged from 5 to 52 individuals. Between May and September, the range of other arthropods was between 2 and 14.

6.2.3 Correlation analysis

Correlational study between edaphic factors and arthropod population at the NAG1 in 2019

The correlation Figure (6:7) displays the correlation coefficients for the calendar year 2019 between the edaphic variables and the arthropod populations (Collembola, Acari, and other arthropods) at NAG1. Correlation coefficients, which range from -1 to 1, are statistical measures of the intensity of the relationship between two variables. A value of -1 represents perfect negative correlation, while a value of 1 represents perfect positive correlation. The Table indicates that temperature has a weakly positive correlation with carbon (0.69), nitrogen (0.69), and a moderately positive correlation with moisture (0.70). In addition, it exhibits a slight positive correlation (0.18 with other arthropods). Most edaphic parameters, including temperature (-0.32), electrical conductivity (-0.64), and moisture (-0.23), as well as the populations of Collembola (-0.66) and Acari (-0.5), have a weakly negative relationship with pH. The association between EC and Acari populations (-0.55), moisture (-0.44), and temperature (-0.65) is modestly negative. Moisture has a significant positive correlation with Collembola (0.79) and Acari (0.79) populations, a mild positive correlation with electrical conductivity (-0.44), and a moderately negative correlation with pH (-0.22). Carbon and nitrogen have a strong positive correlation (0.99) with pH and a moderate negative correlation (-0.44) with EC. In addition, they have a strong negative correlation with the populations of Collembola (-0.76 and -0.74) and Acari (-0.86 and 0.84). K has a strong positive correlation with the populations of Collembola (0.76), Acari (0.70), and a moderately negative correlation with temperature (-0.74). P has a mildly negative association (-0.02) with pH and a weakly negative correlation (-0.26) with the arthropod population. In conclusion, this correlation provides useful information regarding the relationships between edaphic elements and arthropod populations at NAG1 in 2019.

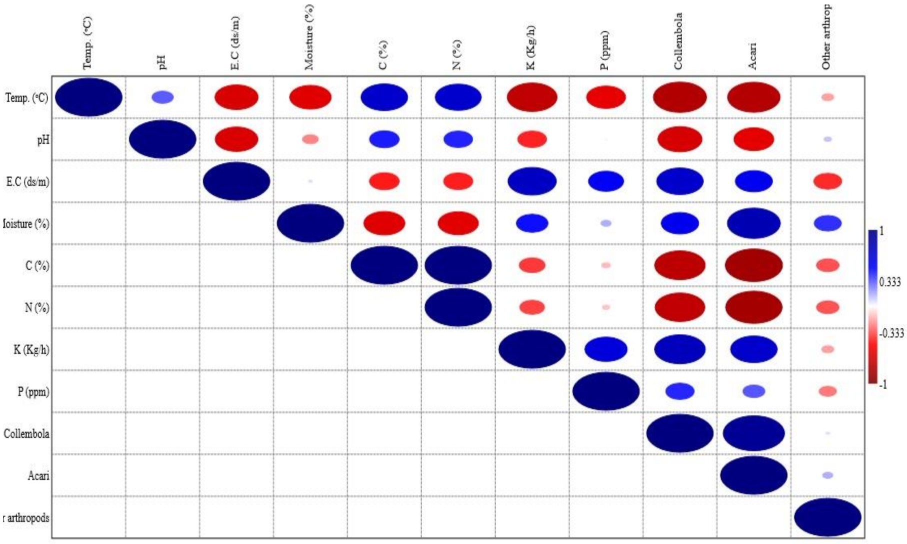


Figure 6:7 Correlation analysis between Edaphic factors and arthropods populations in NAG1 during year, 2019

Correlational study between edaphic factors and arthropod population at the NAG1 in 2021

The Figure 6:8 presents the Pearson correlation coefficients that were computed to establish the relationship between different edaphic factors and the populations of three distinct arthropod groups, namely Collembola, Acari, and other arthropods, at NAG1 during the year 2021. A moderately positive correlation can be observed between the temperature (Temp.) and pH, with a correlation coefficient of 0.50. The data indicates a significant positive correlation between temperature and the populations of Collembola (r=0.91) and Acari (r=0.88), implying that an increase in temperature is associated with a rise in the abundance of these arthropods. Nonetheless, the association with other arthropods exhibits only a moderate level of correlation (r = 0.27). The pH levels exhibit a moderate positive correlation with Collembola (r=0.79) and Acari (r=0.64) and a strong positive correlation with other arthropods (r=0.64). This suggests that arthropod populations exhibit a positive correlation with higher pH levels in their respective habitats. The arthropod populations of Collembola and Acari exhibit a weak negative correlation (r=-0.26 and r=-0.16, respectively) with electrical conductivity (E.C.). This suggests that an increase in E.C. results in a decrease in the populations of these arthropods. The data indicates a moderate positive correlation (r=0.31) between moisture and Collembola, as well as a strong positive correlation (r=0.60) between moisture and Acari. This suggests that the abundance of these arthropods is higher in soil with higher moisture levels. The carbon (C) and nitrogen (N) exhibit a robust positive correlation (r=0.99), suggesting that they assess comparable facets of soil quality and possess a high degree of correlation. The Potassium (K) exhibits a modest positive correlation (r=0.27) with Other Arthropods, while displaying a modest negative correlation (r=-0.40) with Collembola and Acari (r=-0.34). The Phosphorus (P) exhibits a robust positive correlation (r = 0.75) with pH and a moderate positive correlation (r = 0.22) with Other Arthropods. However, it does not demonstrate any significant correlation with Collembola or Acari. In general, the correlation coefficients provide insight into the associations between soil-related factors and arthropod communities at NAG1.

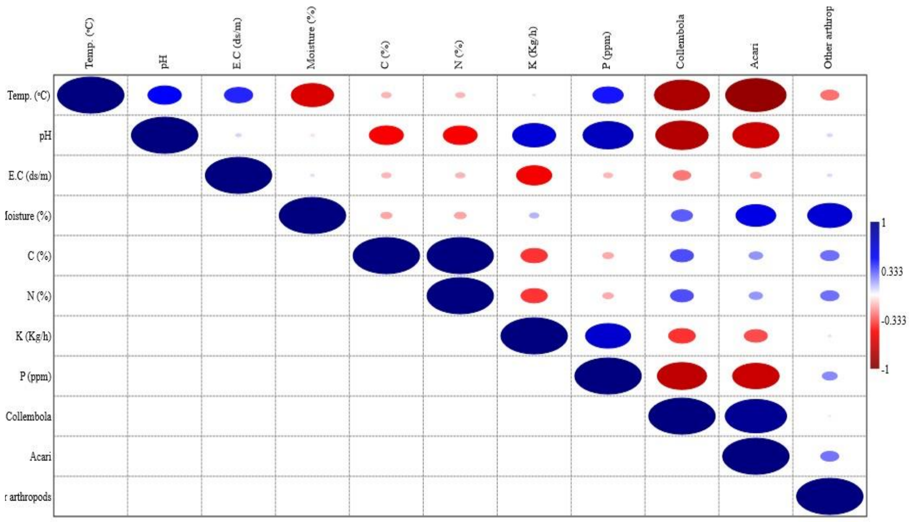


Figure 6:8 Correlation analysis between Edaphic factors and arthropods populations in NAG1 during year, 2021

6.2.4 Diversity Indices

The Table 6:10 includes the Taxa which represents the total number of unique species found in the dataset. The number of arthropod taxa in 2019 and 2021 was the same: 12. The sum of all the people in the sample is represented by this index. There were 305 Collembola in 2019, up from 298 in 2020 and 297 in 2021. The Dominance indicator shows the degree to which a single species or small group of species predominates over other species in the sample. In both years, Collembola were the most common, with values between 0.1177 and 0.1346 for Acari. This index measures how likely it is that any two given individuals in the sample are of the same species. More varied values point to a more diverse population. The Simpson index ranged from 0.8772 to 0.8899 in 2019, and from 0.8654 to 0.8901 in 2021. In 2019, the Shannon index fluctuated between 2.242 and 2.336, and in 2021, it was in the range of 2.158 and 2.373. This index measures how evenly individuals of different species are scattered. A wider range of values between 0 and 1 indicates more even dispersion. The distribution of evenness was 0.7847 to 0.8619 in 2019, and 0.7208 to 0.8939 in 2021. Species richness is measured by this index, which considers both the total number of species and the total number of individuals in the sample. More varied values point to a more diverse population. The margin of error for the Margalef index was 1.923–2.54 in 2019 and 1.931–2.771 in 2021. The equitability (J) index evaluates how evenly individuals are distributed among species, taking into consideration the total number of species present in the sample. A wider range of values between 0 and 1 indicates more even dispersion. Equitability index values fluctuated between 0.8683 and 0.9549 over the course of both years. The data show that in 2021, there were fewer individuals than in 2019, yet there was little change in the total number of species. There was a modest decline in diversity from 2019 and 2021, as measured by the Simpson index. However, between 2019 and 2021, the Shannon index showed a little rise in diversity. The Evenness indicator showed reduced evenness in 2021 compared to 2019. The Acari clade was the most numerous in both years, though the values for dominance changed. The Margalef index showed that the number of species present in 2021 was higher than in 2019. There was a little decrease in equality between 2019 and 2021, as measured by the Equitability index.

Table 6:10 Diversity indices of arthropods from NAG1 in year 2019 and 2021

Index	**2019**			**2021**		
	Collembola	**Acari**	**Other arthropods**	**Collembola**	**Acari**	**Other arthropods**
Taxa (S)	12	12	12	12	12	12
Individuals	305	272	76	298	232	53
Dominance (D)	0.122	0.117	0.110	0.130	0.134	0.100
Simpson (1-D)	0.877	0.882	0.889	0.869	0.865	0.899
Shannon (H)	2.242	2.271	2.336	2.189	2.158	2.373
Evenness (EVNS)	0.784	0.807	0.861	0.744	0.720	0.893
Margalef	1.923	1.962	2.54	1.931	2.02	2.771
Equitability (J)	0.902	0.914	0.940	0.881	0.868	0.954

{Table details (Abbreviation): Taxa-S; Dominance-D; Simpson (1-D), Shannon (H); Evenness (EVNS); Equitability (J)}

6.2.5 One-Way ANOVA

For NAG1 (2019)

Test for equal Means

The results of a one-way ANOVA (Analysis of Variance) exhibit various variables and statistical measures, such as the sum of squares (SS), degrees of freedom (df), mean square (MS), F-value, and p-value. The variability among groups is denoted by the sum of squares for intergroup associations, while the variability within groups is indicated by the sum of squares for intragroup associations. The statistical analysis reveals that the p-value associated with the outcome 1.48 x 10^{12}, while the F-value is 25.79. This finding suggests a statistically significant disparity in the median values among the various groups. There exists a disparity between the mean values of at least one dataset and the mean values of the remaining datasets. The outcome displays a couple of variance components, namely group variance and error variance. The interclass correlation coefficient (ICC) value of 0.67 indicates that 67% of the variance can be attributed to differences between groups, while the remaining 33% can be attributed to variation within groups. In addition to that, the output encompasses the effect size metric omega squared (2). The obtained value of 2 = 0.6525 suggests the presence of statistically significant disparities between the group means. In addition, the output incorporates the outcomes of Levene's examination for homogeneity of variance. The statistical analysis indicates that both p-values are statistically significant at a level of 0.05, leading to the rejection of the null hypothesis that the variances are equal. The Welch F-test is presented as a suitable option due to the plausible assumption of non-equal variances. The statistical significance of the p-value is 3.931E-38, whereas the difference in group means is indicated by the Welch F-value of 301.

For NAG1 (2021)
Test for equal means

The one-way ANOVA performed on NAG1 data in 2021 found that the variation between the means of the compared groups is represented by the sum of squares between groups (19987.3), whilst the variance within each group is represented by the sum of squares within groups (7730.1). The total sum of squares (27517.5) is the sum of the square sums between and within groupings. The sum of squares between groups has ten degrees of freedom (df), which is equal to the number of groups minus one. The df for the sum of squares within groups is 121, which equals the total number of observations minus the number of groups. The df of the sum of all squares is equal to the number of observations minus 131. Dividing the total number of squares by the degrees of freedom to get the between-group mean square (1978.74). The mean square reflects the average amount of variation between the means of the groups under consideration. By dividing the mean square between groups by the mean square within groups, the F-value (30.97) is determined. The F-value is used to determine whether or not the difference between two groups means is statistically significant. The p-value for the sum of squares between groups is 7.83 x 10^{-9}, which is less than 0.05. This suggests that the norms of the two groups differ statistically significantly. The random effect variance components are supplied. The group variance is 159.571, while the error variance is 63.88. The intraclass correlation coefficient (ICC) is 0.71, indicating that between-class variation accounts for 71.41 percent of the variation. The omega squared number (0.69) represents the percentage of total variance explained by the sum of squares between groups. The Levene's test for variance homogeneity is used to examine whether or not the variances between groups are equal. The p-value for the test based on means is 6.90E-22, while the p-value for the test based on medians is 3.04E-21. Because both p-values are less than 0.05, the variances between the categories are not equal. When uneven variances are present, the Welch's F-test is used, yielding an F-value of 358 with 45.55 degrees of freedom and a p-value of 7.84E-40. This shows that there is a statistically significant difference between the comparing category means.

6.2.6 Seasonal fluctuations of Soil organisms

Month-wise arthropod population atNAG1 in 2019

Table 6:11 shows the monthly population and species count of the arthropod community at NAG1 for the year 2019. According to the study period, 29 different species were observed throughout the year. The species are classified as Acari and Hexapoda (Insecta) in terms of taxonomic categorization. Hexapoda includes multiple orders, including Collembola (also known as springtails), Diptera (flies), Hymenoptera (which includes ants, bees, and wasps), and *Pseudocoptera* (also known as booklice). Acari includes families such as *Acaridae*, *Laelapidae*, and *Phytoseiidae*. Over the course of the year, the monthly count of observed individuals varies. In terms of frequency of sightings, February had the highest number of organisms (104), followed by March (99) and January (82). The month of December had the (73), while November (55) and October (45) organisms followed suit with fewer sightings. The results show that there is a temporal fluctuation in the population of arthropod species at NAG1, with the largest population recorded during the spring season and the lowest population observed during the winter season. *Isotomidae* sp. had the largest population density of any arthropod species throughout the year, followed by *Isotoma* sp. and *Isotomurus* sp. *Cryptopygus* species and *Folsomia quadrioculata* were also common. Several other arthropod species, including *Cortinicara* sp. *(Latridiidae*), *Anthicidae*, *Carabidae*, *Hymenoptera*, *Psocoptera*, *Diplura*, *Diptera*, and *Pseudoscorpions*, were observed in smaller quantities. To summarise, based on the data available, NAG1 in 2019 was home to 29 arthropod species belonging to two separate classes. Furthermore, it was discovered that the population size of these species varied seasonally throughout the year.

Table 6:11 Month-wise arthropod population atNAG1 in 2019

Name of the Species/Family/Order	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Collembola												
Fam.*Isotomidae*	05	05	05	02	01	02	01	01	01	02	03	06
Cryptopygus sp.	03	04	06	04	0	0	0	01	01	02	03	06
Isotoma sp.	05	03	07	03	0	01	01	01	01	01	02	05
Isotomiella sp.	04	02	05	04	0	02	0	01	01	02	02	02
Isotomurus sp.	05	05	07	05	01	0	01	01	01	02	03	03
Folsomia quadrioculata	01	05	06	06	0	0	0	01	0	01	02	03
Hypogastrura sp.	02	06	06	03	0	0	01	0	01	02	01	02
Lepidocyrtus sp.	05	07	07	02	0	0	01	01	01	01	03	01
Entomobrya sp.	05	06	04	01	01	0	0	0	01	02	02	02
Sminthrus sp.	03	05	04	02	0	0	01	01	01	02	02	02
Fam.*Katiannidae*	02	05	03	02	0	0	0	01	01	01	02	03
Acari												
Fam.*Acaridae*	05	05	02	01	0	01	01	01	01	01	04	03
Fam.*Laelapidae*	05	03	04	02	0	01	01	01	01	02	02	04
Fam.*Cunaxidae*	07	02	03	01	0	0	0	01	01	02	01	03
Ord. *Cryptostigmata*	02	07	06	02	0	0	0	01	01	02	02	02
Fam.*Phytoseiidae*	03	07	04	01	0	0	0	0	01	02	03	02
Poecilochirus carabi	07	02	05	01	01	01	0	0	01	02	02	03
Sperchonopsis ecphyma	01	05	05	01	0	0	0	0	01	03	03	03
Acari juveniles	03	05	02	01	0	0	0	0	0	02	02	01
Fam.*Rhodacaroidea*	02	07	02	01	0	0	01	01	02	02	03	04
Demodex folliculorum	02	05	04	02	01	01	0	0	0	01	02	06
Other arthropods												
Cortinicara sp. (Fam.*Latridiidae*)	01	01	00	01	0	0	0	0	01	01	0	0
Anthicidae species	01	0	0	0	0	01	01	0	0	01	01	01
Fam.*Carabidae*	01	0	0	0	0	01	0	0	0	01	01	01
Hymenoptera	01	0	01	01	0	0	0	01	0	01	0	01
Psocoptera	0	01	0	0	0	0	0	01	01	0	01	01
Diplura	01	01	01	02	01	01	01	01	01	02	01	03
Diptera	0	0	0	01	0	0	01	01	01	01	01	0
Pseudoscorpions	0	0	0	01	0	0	0	0	01	01	01	0
N	29	29	29	29	29	29	29	29	29	29	29	29
Min	0	0	0	0	0	0	0	0	0	0	0	0
Max	07	07	07	06	01	02	01	01	02	03	04	06
Sum	82	104	99	53	06	12	12	18	24	45	55	73
Mean	2.8	3.5	3.4	1.8	0.20	0.4	0.4	0.6	0.8	1.5	1.8	2.5
Std. error	0.38	0.45	0.45	0.26	0.07	0.11	0.09	0.09	0.08	0.11	0.18	0.32
Variance	4.29	6.03	5.89	2.07	0.16	0.39	0.25	0.24	0.21	0.39	0.95	2.97
Stand. Dev	2.07	2.45	2.42	1.44	0.41	0.62	0.50	0.49	0.46	0.63	0.97	1.72
Median	2	5	4	1	0	0	0	1	1	2	2	2

Month-wise arthropod population at NAG1 in 2021

The Table 6:12 details the 2021 Arthropod Community at NAG1, including the species present and the monthly population. The 12 columns represent the months of the year, while the 29 rows list the many arthropod species, families, and orders. Monthly sums for each arthropod species are shown in the Table. There are 12 columns totaling the population count for each month of the year, starting with January and ending in December. The first column specifies the numerous arthropod species, families, or orders. In total, 29 distinct arthropod species, families, or orders were found at NAG1, as shown in the Table below. Some of the most frequent types of arthropods are the springtails, Acari, and other arthropods. The monthly population count varies for each species, with some indicating higher numbers at certain times of the year. The maximum number of *Cryptopygus* sp. and *Isotomurus* sp. was recorded in March, whereas the lowest number of *Sminthrus* sp. was recorded in June to September. Moreover, numerous species showed consistently low population counts across all months, including Psocoptera and Pseudoscorpions. Collembola, Acari, Hymenoptera, Diptera, and many more are just some of the orders and families into which arthropods can be placed. Most species can be found in the Collembola order, followed by the Acari. A total of two or three species from the other orders are represented in the Table. The highest monthly population count for any specific species of arthropod is 7. The population fluctuates between 16 and 109 per month. The average monthly population is anything from 0.55 and 3.76. The monthly variation in population is reflected in the standard error figures. Each column’s minimum and maximum values, as well as their sum, mean, and standard error, are summarised in the Table. These aggregate statistics shed light on the long-term trends in the abundance of each species. This Table contains important information for ecological research and conservation efforts about the arthropod community at NAG1 in 2021.

Table 6:12 Month-wise arthropod population at NAG1 in 2021

Name of the Species/Family/Order	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Collembola												
Fam.*Isotomidae*	05	04	05	02	01	02	01	01	01	03	03	06
Cryptopygus sp.	04	04	06	04	0	01	0	01	01	02	03	02
Isotoma sp.	05	03	05	04	01	01	01	01	01	01	02	03
Isotomiella sp.	04	02	05	04	0	02	0	01	02	02	03	02
Isotomurus sp.	05	05	07	05	01	0	01	01	01	02	03	03
Folsomia quadrioculata	02	05	06	06	0	0	01	01	01	02	02	03
Hypogastrura sp.	02	06	06	04	01	0	01	0	01	02	02	02
Lepidocyrtus sp.	05	06	07	02	0	01	01	01	01	01	03	01
Entomobrya sp.	05	06	04	02	01	0	0	0	01	02	02	02
Sminthrus sp.	03	05	04	02	0	0	01	01	01	02	02	02
Fam.*Katiannidae*	02	05	03	02	01	0	0	01	01	01	02	03
Acari												
Fam.*Acaridae*	05	05	02	02	01	01	01	02	02	02	04	04
Fam.*Laelapidae*	03	03	04	02	01	01	01	01	02	02	02	04
Fam.*Cunaxidae*	07	03	04	01	01	0	0	01	01	02	01	03
Ord. *Cryptostigmata*	02	07	06	02	0	01	01	01	01	02	03	02
Fam.*Phytoseiidae*	03	07	04	03	01	0	01	01	01	02	03	03
Poecilochirus carabi	07	05	05	04	01	01	01	01	01	02	03	04
Sperchonopsis ecphyma	01	05	05	03	0	0	0	0	01	03	03	03
Acari juveniles	03	05	03	03	01	0	0	0	01	02	02	01
Fam.*Rhodacaroidea*	02	07	02	01	01	0	01	01	02	02	03	05
Demodex folliculorum	02	05	04	02	01	01	0	0	02	02	02	06
Other arthropods												
Cortinicara sp. (Fam.*Latridiidae*)	01	01	0	01	0	01	01	01	01	01	01	01
Anthicidae species	01	01	0	0	0	01	01	0	0	01	02	02
Fam.*Carabidae*	01	01	01	0	01	01	0	0	01	01	01	02
Hymenoptera	0	01	01	01	0	0	0	01	01	01	01	01
Psocoptera	0	01	0	0	0	0	0	01	01	01	02	01
Diplura	01	01	01	01	01	01	01	01	01	02	02	03
Diptera	0	0	0	01	0	0	01	01	01	02	02	02
Pseudoscorpions	0	0	0	01	0	0	0	0	01	01	01	02
N	29	29	29	29	29	29	29	29	29	29	29	29
Min	0	0	0	0	0	0	0	0	0	01	01	01
Max	07	07	07	06	01	02	01	02	02	03	04	06
Sum	81	109	100	65	16	16	17	22	33	51	65	78
Mean	2.79	3.75	3.44	2.24	0.55	0.55	0.58	0.75	1.13	1.75	2.24	2.68
Std. error	0.38	0.41	0.4	0.28	0.09	0.11	0.09	0.0	0.08	0.10	0.14	0.25
Variance	4.24	4.97	5.25	2.33	0.25	0.39	0.25	0.26	0.19	0.33	0.61	1.86
Stand. Dev	2.05	2.23	2.29	1.52	0.50	0.63	0.50	0.51	0.44	0.57	0.78	1.36
Median	02	05	04	02	01	0	01	01	01	02	02	02

6.2.7 Diversity indices of arthropods in month-wise from NAG1

The tabulated data (Table 6:13) presents diversity indices pertaining to arthropods observed at NAG1 during the months of 2019 and 2021. In the year 2019, the distinct species count which is referred as Taxa (S) exhibited a range between 23 to 28, with the highest count being recorded in the month of September. The sample size varied between 6 and 104 individuals, with the highest frequency observed in the month of February. The range of Dominance (D), which represents the proportion of the most dominant species, varied from 0.04 to 0.16. The highest value was observed in the month of May. The Simpsons Diversity Index (Simpson: 1-D) exhibited a range of 0.83 to 0.96, with the minimum value being observed in the month of May. The Shannon (H) index exhibited a range of values between 1.79 and 3.03. Notably, the highest value was observed in the month of September. The metric of Evenness of species exhibited a range of values between 0.86 and 1, with the highest value being observed during the month of May. The month of September yielded the highest Margalef index value. During the month of May, the Equitability (J) index, which takes into account both species richness and abundance, exhibited a range of values between 0.943 and 1. The highest value was observed in the month of April. The year 2021 witnessed a fluctuation in the count of distinct taxa (Taxa S), ranging from 24 to 29, with the highest count being recorded during the months of October and November. The sample size varied between 16 and 109 individuals, with the highest count being observed during the month of May. The range of Dominance (D) was observed to be between 0.038 and 0.07. The highest value was documented in the month of June. The Simpsons Diversity Index (Simpson: 1-D) ranged from 0.92 to 0.96. The minimum value of the index was observed in the month of May. The Shannon (H) index, exhibited a range of values from 2.59 to 3.03. The highest value was observed in the month of October. The metric of Evenness of species exhibited a range of values between 0.85 and 1, with the highest value being observed during the month of May. During the month of September, the Margalef index demonstrated its highest values, which varied between 4.68 and 7.722. During the month of May, the Equitability (J), a metric that takes into account both the number of species and individuals, exhibited a range of values between 0.956 and 1. Notably, the highest value was observed in the month of April. Overall, the diversity indices of arthropods at NAG1 in 2021 exhibited similarities to those documented in 2019, although with certain fluctuations on a monthly basis. Throughout both years, there was variability in the quantity of species and individuals observed, with certain months demonstrating greater values than others. The distribution of dominant species exhibited a modest proportion in both years, suggesting a relatively equitable distribution of species.

Table 6:13 Diversity indices of all arthropods in month-wise from NAG1 in year 2019 and 2021

Diversity Indices												
2019	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Taxa (S)	26	24	23	26	6	10	12	18	23	28	27	26
Individuals	82	104	99	53	6	12	12	18	24	45	55	73
Dominance(D)	0.05	0.05	0.05	0.05	0.16	0.11	0.08	0.055	0.045	0.04	0.043	0.05
Simpson (1-D)	0.94	0.94	0.94	0.94	0.83	0.88	0.91	0.94	0.95	0.96	0.95	0.94
Shannon (H)	3.07	3.06	3.03	3.07	1.79	2.25	2.48	2.89	3.12	3.27	3.21	3.11
Evenness (EVNS)	0.83	0.88	0.90	0.83	1	0.95	1	1	0.98	0.94	0.91	0.86
Margalef	5.67	4.95	4.78	6.29	2.79	3.62	4.42	5.88	6.92	7.09	6.48	5.82
Equitability(J)	0.94	0.96	0.96	0.94	1	0.97	1	1	0.99	0.98	0.97	0.95
2021												
Taxa (S)	25	27	24	26	16	14	17	21	28	29	29	29
Individuals	81	109	100	65	16	16	17	22	33	51	65	78
Dominance(D)	0.05	0.04	0.04	0.049	0.06	0.07	0.058	0.049	0.039	0.038	0.038	0.043
Simpson (1-D)	0.94	0.95	0.95	0.95	0.93	0.92	0.94	0.95	0.96	0.96	0.96	0.95
Shannon (H)	3.06	3.15	3.07	3.11	2.77	2.59	2.83	3.02	3.28	3.31	3.30	3.24
Evenness (EVNS)	0.85	0.86	0.90	0.86	1	0.96	1	0.98	0.95	0.94	0.93	0.88
Margalef	5.46	5.54	4.99	5.98	5.41	4.68	5.647	6.47	7.722	7.121	6.70	6.42
Equitability (J)	0.95	0.956	0.967	0.955	1	0.98	1	0.994	0.986	0.984	0.98	0.96

6.3 Overview of Site 2

Table 6:14 Study Site description of agriculture and non-agriculture land (Site 2)

LOCATION	Bhogpur is located at Latitude- 31^{o} 33´ 0´´ N and Longitude- 75^{o} 37´ 59.99´´ E, and 232 metres above sea level. Summers in Bhogpur are hot, muggy, and clear, while winters are comfortable, dry, and frequently clear. Throughout the year, temperatures range from 41°F to 103°F, rarely falling below 36°F or exceeding 110°F.	
	AGRICULTURE (AG2)	NON-AGRICULTURE (NAG2)
VEGETATION COVER	The area in the surrounding region of Bhogpur is predominantly characterised by agricultural activities, with an emphasis on the farming of crops including wheat, rice, maize.	It was densely vegetated with a variety of trees, herbs, shrubs, climbers, and grasses in the vicinity of non-agricultural land.
SOIL AND ENVIRONMENTAL CONDITION	Bhogpur agriculture is supported by its predominantly alluvial soil, which is composed of sediment deposited by rivers. Because Bhogpur alluvial soil is generally nutrient-dense, especially in terms of nitrogen and phosphorus, a wide variety of crops can be cultivated there. However, soil conditions in Bhogpur and its environs can vary based on land, climate, soil type, and human activity. Overall, the soil conditions in Bhogpur are favourable for agriculture, but the land must be managed sustainably to preserve soil health and prevent degradation. Bhogpur ecology is influenced by various things, including weather, topography, water resources, and human actions. The area experiences hot summers and mild winters, typical of a semi-arid climate. Between June and September, the region experiences its annual monsoon season, when heavy downpours are the norm. However, droughts can occur due to water constraint and erratic rainfall patterns.	

6.3.1 Edaphic factors

The parameters data, which were measured throughout a year, is given as follows:

The mean temperature in January was recorded as 12 °C, whereas in July, it was noted as 33 °C. The recorded temperature range spanned from 12 to 33 degrees Celsius. The annual mean temperature was recorded at approximately 22.17 degrees Celsius. The pH values were analyzed and found to have a mean of 7.17, with a range of 6.9 to 7.5. The pH values serve as a measure of the level of acidity or alkalinity present in each environment. The mean electrical conductivity was determined to be 0.1775 ds/m, with a range of values spanning from 0.14 to 0.22 ds/m. The electrical conductivity of soil is positively associated with the quantity of ions that are present within it, as it is a metric that gauges the soil's ability to conduct an electrical current. The percentage of moisture present. The soil's moisture content exhibited a range of 0.8% to 11.2%, with an average value of 5.44%. The soil's carbon content exhibited a range of 0.06% to

0.6%, with a mean value of 0.26% in the C (%) measurement. Carbon is an essential constituent of soil fertility and plays a crucial role in the nutrient cycling process. The variables N (%), K (Kg/h), and P (ppm) represent the respective proportions of nitrogen, application rate of potassium in kilograms per hectare, and concentration of phosphorus in parts per million presents in the soil. The columns, namely Collembola, Acari, and Other Arthropods, exhibit the numerical representation of diverse Arthropod taxa that inhabit the soil. The arthropods Collembola, Acari, and Others are distinct subgroups of diminutive organisms that inhabit soil. The data (Table 6:15) indicates that the temperature varied throughout the year, with January and July recording the lowest (12°C) and highest (33°C) temperatures, respectively. The pH values indicated that the soil environment was faintly acidic to mildly alkaline, ranging from 6.9 to 7.5. The electrical conductivity values varied from 0.14 in October to 0.22 in March, with the highest value indicating a relatively high salt concentration in the soil. Moisture content showed temporal variation, with the highest value (11.2%) observed in February and the lowest value (0.8%) recorded in July. The carbon content fluctuated between 0.06% and 0.6% in August and September, whereas the nitrogen content fluctuated between 0.005% and 0.051% in August and September. The study revealed that potassium levels fluctuated between 27 kg/h in October and 48 kg/h in February, July, and August, while phosphorus levels fluctuated between 2 ppm and 3 ppm. Collembola exhibited the highest level of abundance among arthropods, with the greatest count recorded in February and March (81 individuals) and the lowest count recorded in June (11 individuals). Comparatively fewer Acari and other arthropods were observed, with the highest counts occurring in April and November, respectively. In 2021 (Table 6:16), The lowest temperature recorded for the year was 12^{o}C in January, and the highest was 33^{o}C in July. A difference of 21^{o}C between winter and summer temperatures is rather noticeable. There isn’t much variation in pH levels throughout the year, with readings staying within a range of 7.0 to 7.15. The average pH throughout the year is at 7.066, indicating a pH that is slightly acidic to neutral. pH values vary very little from one another, with a standard deviation of only 0.061. The E.C values in August and September are 0.13 ds/m, while the values in May are 0.22 ds/m. Throughout the year, an E.C. value of 0.167 ds/m is somewhat typical. There is a fair amount of dispersion among E.C. values, as measured by a standard deviation of 0.035 ds/m. The moisture content can be as low as 0.9% in July and as high as 11.6% in February. About 5.3% humidity is typical throughout the year. There is a lot of fluctuation in measured moisture levels, as evidenced by the 3.79 standard deviation. The carbon percentage, nitrogen %, and potassium input rate may all be calculated from these values. The lowest carbon content is in June and July at 0.14%, and the highest is in November at 0.42%. From June to November, the nitrogen level shifts from 0.12% to 0.42%. From June through March, the potassium inflow fluctuates between 12 and 82 kg/h. The average percentage of carbon, nitrogen, and potassium are 0.26 percent, 0.02 percent, and 42 kg per hectare. For all three parameters, the standard deviations are 0.081 for carbon, 0.007 for nitrogen, and 7.59 for potassium. The phosphorus concentration in the months of May, June, and July varies between 2 ppm and an undisclosed value.

Table 6:15 The number of arthropods in relation to soil factors at AG2 during the year 2019

Month, 2019	**Temp. (^{o}C)**	**pH**	**E.C (ds/m)**	**Moisture (%)**	**C (%)**	**N (%)**	**K (Kg/h)**	**P (ppm)**	**Collembola**	**Acari**	**Other arthropods**
N	12	12	12	12	12	12	12	12	12	12	12
Min	12	6.9	0.14	0.8	0.06	0.005	27	2	11	7	3
Max	33	7.5	0.22	11.2	0.6	0.051	53	3	81	82	13
Sum	266	86	2.13	65.3	3.07	0.258	495	33	520	441	95
Mean	22.16	7.16	0.177	5.44	0.25	0.02	41.25	2.75	43.33	36.7	7.91
Std. error	2.22	0.06	0.008	1.11	0.051	0.004	2.35	0.13	8.16	7.74	0.97
Variance	59.42	0.044	0.0009	14.92	0.031	0.0002	66.56	0.20	800.42	719.2	11.35
Stand. Dev	7.70	0.21	0.03	3.86	0.17	0.014	8.15	0.45	28.29	26.8	3.36
Median	20.5	7.1	0.17	4.75	0.2	0.017	43	3	39.5	31	8

Table 6:16 The number of arthropods in relation to soil factors at AG2 during the year 2021

Month, 2021	**Temp. (^{o}C)**	**pH**	**E.C (ds/m)**	**Moisture (%)**	**C (%)**	**N (%)**	**K (Kg/h)**	**P (ppm)**	**Collembola**	**Acari**	**Other arthropods**
N	12	12	12	12	12	12	12	12	12	12	12
Min	12	7	0.13	0.9	0.14	0.012	33	2	12	6	2
Max	33	7.15	0.22	11.6	0.42	0.036	59	3	82	79	12
Sum	266	84.8	2.01	63.7	3.12	0.264	504	31	528	469	90
Mean	22.16	7.066	0.167	5.3	0.26	0.022	42	2.58	44	39.08	7.5
Std. error	2.18	0.017	0.01	1.09	0.023	0.002	2.19	0.14	8.1	7.92	0.9
Variance	57.24	0.0037	0.0012	14.42	0.006	4.90E-05	57.63	0.26	787.81	752.99	9.72
Stand. Dev	7.56	0.061	0.035	3.79	0.081	0.007	7.59	0.51	28.06	27.44	3.11
Median	21	7.1	0.15	4.6	0.24	0.02	40	3	40	32	7

6.3.2 Population dynamics

A complete collection of arthropods comprising 4,106 individuals/m^2 from three distinct classes and five distinct orders was obtained. The number of arthropods was recorded annually for both agricultural and non-agricultural land. The number of arthropods observed on agricultural land was 1056 individuals/m^2 in 2019 and 1087 individuals/m^2 in 2021. In 2019, a total of 1,012 arthropods/m^2 were recorded on non-agricultural land; by 2021, that number will have increased to 951 specimens. In addition, the data suggests that the arthropod population fluctuated seasonally, with the highest abundance occurring during the winter months and the lowest abundance occurring during the summer months. In 2019, the predominant taxonomic group in Agricultural land (AG2) was Collembola, which accounted for 49.24% of the total, followed by Acari at 41.76% and other arthropods, which accounted for 8.99% of the total. In 2021, however, Collembola account for 48.57 percent of the total, followed by Acari at 43.14 percent and other arthropods at 8.27 percent. The present analysis describes the species composition of arthropods in AG2, where a total of 2143 species were collected in both years. Collembola dominated the collected species with 520 and 528 species in 2019 and 2021, respectively, followed by Acari with 441 and 469 species in each year. Other arthropods, in contrast, were determined to be the least abundant, with approximately 95 and 90 species in 2019 and 2021, respectively. Collembola were found to constitute 48.9% of the total population (2143), making up the majority of the arthropod community. Nonetheless, it was observed that the same species of AG1 Collembola were present throughout the entire sampling period. The Acari population, which accounted for 42.4% of the total, ranked second in terms of numerical abundance, and a community comparable to that of AG1 was discovered. It was determined that the proportional prevalence of the remaining taxa, including coleopterans, diplurans, pseudoscorpions, isopods, and Hymenoptera, was less than 8.6%. Figure 6:9 and 6:10 depicts a comparable pattern of arthropod population occurrence in different months in relation to edaphic factors when compared to Site 1 (AG1).

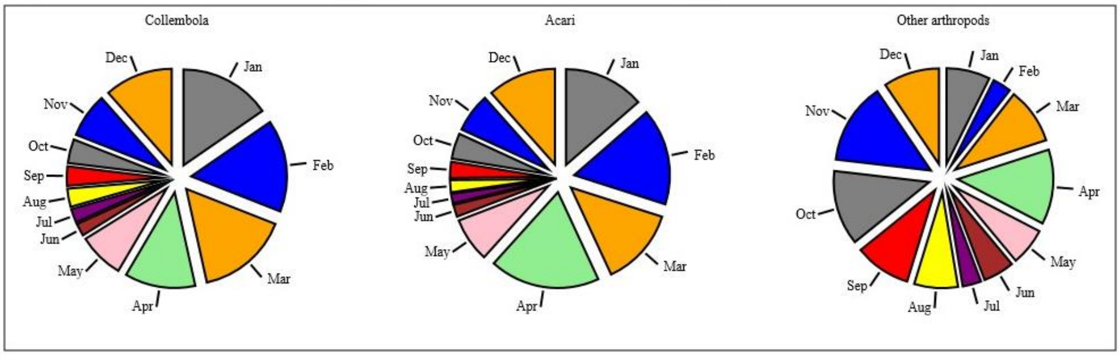


Figure 6:9 The number of Collembola, Acari, and other arthropods in month-wise presenting in AG2 during year, 2019.

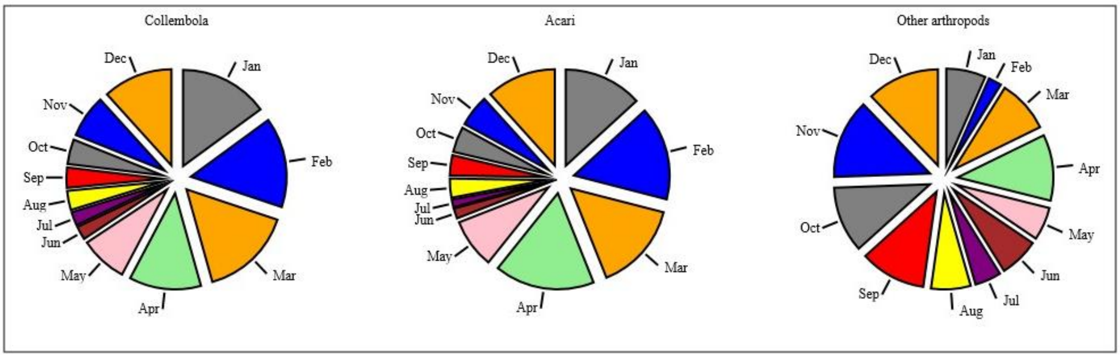


Figure 6:10 The number of Collembola, Acari, and other arthropods in month-wise presenting in AG2 during year, 2021.

6.3.3 Correlation Analysis

Correlational study between edaphic factors and arthropod population at the AG2 in 2019

The 2019 information (Figure 6:11) provides a matrix depicting the relationships between variables in a dataset. The degree and direction of a linear relationship between two variables can be evaluated using correlation coefficients. Both moisture content and carbon (%) are positively correlated with temperature. It is only moderately correlated with pH (0.17194). Its mildly inverse relationship with E.C (ds/m) is -0.57229. E.C (ds/m) (0.038629) and Moisture (%) (0.86746) are positively correlated with this variable. Both C (%) and N (%) are mildly negatively correlated with it (-0.37188 and -0.37077, respectively). Electrical Conductivity is positively correlated with Moisture (%) (0.91144). It is inversely related to temperature by a small amount (-0.6013). The coefficient of determination between E.C (ds/m) and moisture is 0.91 81%. It has a -0.64856 correlation with colder temperatures. There is a very weak positive association between carbon content and N (%) (2.47E-14). There is a slight positive correlation between it and Temperature (0.4545). The correlation between temperature in degrees Celsius and nitrogen is moderately positive (0.44972). It is moderately positively correlated with C (%), at 0.99874. Potassium content is slightly negatively correlated with temperature (-0.37219). Phosphorus concentration tends to go down as the temperature goes up (-0.56062). There is a negative association between temperature and Collembola (-0.90314). Acari has a significant inverse association with temperature (-0.84931). There is a moderately negative relationship between temperature and the presence of other arthropods (-0.27238). This linearity between variables is represented by the correlation coefficients.

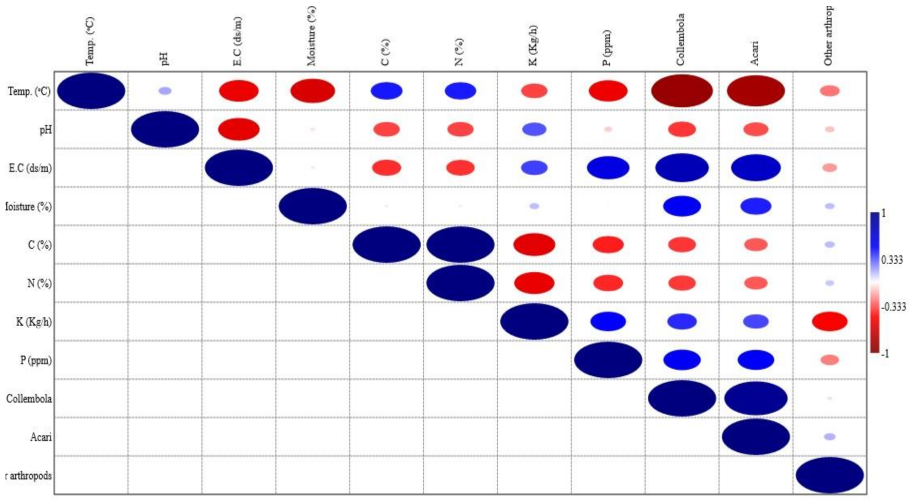


Figure 6:11 Correlation analysis between Edaphic factors and arthropods populations in AG2 during year, 2019.

Correlational study between edaphic factors and arthropod population at the AG2 in 2021

The Figure 6:12 displays the correlation coefficients between the various dataset parameters. The study demonstrates a significant positive correlation between pH and temperature (r = 0.74513). In contrast, negative correlations exist between temperature and electrical conductivity (r = -0.58552), moisture (r = -0.6808), carbon (r = -0.094013), nitrogen (r = -0.10442), potassium (r = -0.56819), and phosphorus (r = -0.47058). The present findings indicate that an increase in temperature correlates positively with an increase in pH, while a decrease in temperature correlates negatively with electrical conductivity, moisture content, carbon, nitrogen, potassium, and phosphorus levels. The data indicates a strong positive correlation (r = 0.74513) between pH and temperature, whereas negative correlations are observed between pH and E.C, moisture, carbon, nitrogen, potassium, and phosphorus (r = -0.52462, r = -0.31563, r = -0.19864, r = -0.21043, and r = -0.047809). The data suggests a negative correlation between the increase in pH and the concentrations of E.C, moisture, carbon, nitrogen, potassium, and phosphorus. Carbon, nitrogen, and potassium all have a positive correlation with E.C. Temperature and pH have a -0.58552 and -0.52462 negative correlation, respectively. Also exhibiting a negative correlation with a value of 0.110762 is moisture. Observed relationships indicate that an increase in E.C is accompanied by an increase in carbon, nitrogen, and potassium levels, while temperature, pH, and moisture levels decrease. Moisture is positively correlated with carbon (0.14015), nitrogen (0.115445), and potassium (0.6119), but negatively correlated with temperature (-0.6808) and pH (-0.31565). The observed relationships indicate a correlation between an increase in humidity and a decrease in temperature and pH levels, as well as an increase in carbon, nitrogen, and potassium concentrations. There is a highly significant positive correlation (0.99906) between carbon and nitrogen in organic matter due to their close relationship. There is a negative correlation between carbon and nitrogen concentrations and temperature, pH, and moisture. Potassium is moderately positively correlated with phosphorus (r = 0.65113), electrical conductivity (r = 0.54098), and soil moisture (r = 0.6119). Phosphorus has a weak positive correlation with nitrogen (0.028303), but strong positive correlations with both water content and potassium. Collembola, also known as springtails, and Acari, also known as mites, exhibit negative correlations with carbon, nitrogen, potassium, and phosphorus, in addition to temperature, pH, E.C, and other elemental factors. Moisture and other arthropods have a weak negative correlation of -0.054867, while carbon and nitrogen have weak positive correlations of -0.62717 and -0.61875, respectively.

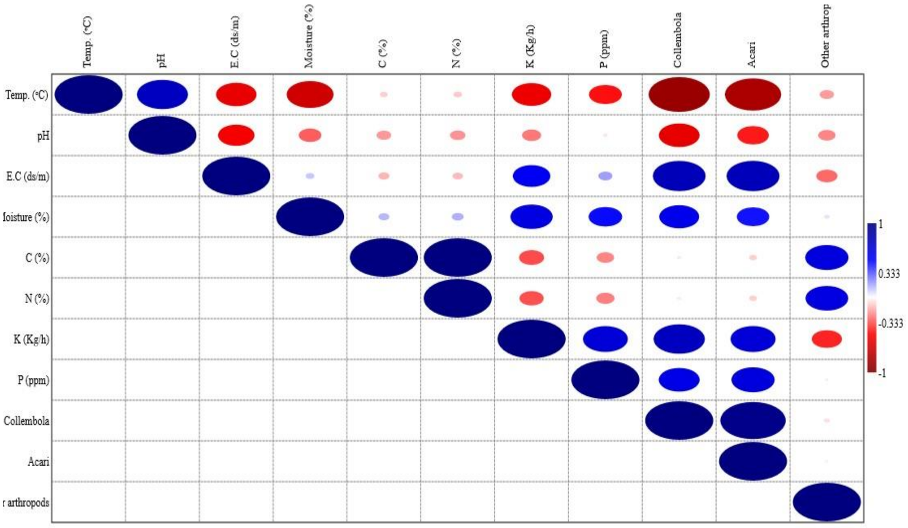


Figure 6:12 Correlation analysis between Edaphic factors and arthropods populations in AG2 during year, 2019.

6.3.4 Diversity Indices

The diversity indices (Table 6:17) of both 2019 and 2021, 12 distinct arthropod taxa are identified in the sample. This suggests that the species diversity remained stable over the duration of the two years. In 2021, 528 arthropods were tallied in the sample, a slight decrease from the 520 counted in 2019. This indicates that the population of arthropods in AG2 remained relatively stable over the period of two years. The dominance index in 2019 was dominated by Acari, Collembola, and other arthropods (0.124, 0.1159, and 0.09717, respectively). Acari remained the dominant group in 2021 (0.121), followed by Collembola (0.1144) and Other Arthropods (0.09654). The dominance values demonstrate a relatively consistent pattern of abundance between the two years. In 2019 and 2021, the Simpson indices are relatively high, indicating a high probability of encountering the same type of arthropod. The values are as follows: 2019 (0.8841) and 2021 (0.8856). The Shannon index values were 2.279 and 2.288, the Shannon indices for 2019 and 2021 are comparable. This indicates that over the span of two years, the diversity and distribution of arthropods remained relatively stable. In both years, the evenness scores are comparatively high, indicating an even distribution of arthropod species within the population. The values are 2019 (0.8136) and 2021 (0.821). The Margalef index measures species with respective values of 1.759 and 1.755, the Margalef values for 2019 and 2021 are similar. According to population size, this indicates a stable level of species diversity. In both years, the ratings for equitability are quite high, indicating a reasonably even distribution of species. 2019 is rated at 0.917, while 2021 is rated at 0.9206. Statistics indicate that the AG2 arthropod population remained relatively stable between 2019 and 2021. Despite minor variations in the number of individuals and the dominance of arthropod groups, the diversity indices indicate a consistent level of species richness, diversity, and evenness over the two-year period.

Table 6:17 Diversity indices of arthropods from AG2 in year 2019 and 2021

Index	**2019**			**2021**		
	Collembola	**Acari**	**Other arthropods**	**Collembola**	**Acari**	**Other arthropods**
Taxa (S)	12	12	12	12	12	12
Individuals	520	441	95	528	469	90
Dominance (D)	0.11	0.12	0.09	0.11	0.12	0.09
Simpson (1-D)	0.88	0.87	0.90	0.88	0.87	0.90
Shannon (H)	2.27	2.22	2.39	2.28	2.24	2.39
Evenness (EVNS)	0.81	0.77	0.91	0.82	0.78	0.91
Margalef	1.75	1.80	2.41	1.75	1.78	2.44
Equitability (J)	0.91	0.89	0.96	0.92	0.90	0.96

{ Taxa-S; Dominance-D; Simpson (1-D), Shannon (H); Evenness (EVNS); Equitability (J)}

6.3.5 One-Way ANOVA

For AG2 (2019)

Test for equal means

The outcomes of a unidirectional analysis of variance (ANOVA) that was carried out in AG2 during the year 2019, states that between-group sum of squares is 36362.7, and it has been computed with 10 degrees of freedom. The computation of the mean square involves the division of the sum of squares by the degrees of freedom, yielding a value of 3636.27. The statistical analysis reveals that the F-value is 23.92, and the p-value is 2.88E-24, indicating a significant result with a negligible probability of occurrence. The within-group sum of squares is 18395.1, and it is associated with 121 degrees of freedom. The computation of the mean square involves the division of the sum of squares by the degrees of freedom, yielding a value of 152.025. The aggregate sum of squares is 54757.7, accompanied by a cumulative count of 131 degrees of freedom. The analysis of variance (ANOVA) findings indicates a statistically significant distinction among the groups in AG2 during the year 2019. The statistical analysis reveals that the F-value of 23.92 denotes a substantial disparity among groups in contrast to the variability within groups. Furthermore, the remarkably low p-value of 2.88E-24 indicates that the observed disparity is of great statistical significance. In brief, the ANOVA examination reveals a statistically significant variation in the arthropod data among the AG2 groups during the year 2019.

For AG2 (2021)

The results of a one-way analysis of variance (ANOVA) in AG2 for 2021 are shown in the Table below. The sum of squares between the groups, which is 38734.2, has 10 degrees of freedom. When you divide the sum of squares by the number of degrees of freedom, you get 3873.42, which is the mean square. This means that the F-value is 25.36 and the p-value is 2.89E-25, which is very close to 0. Each group has 121 degrees of freedom, and the total number of squares is 18481.3. When the total number of squares is divided by the number of degrees of freedom, the mean square is found to be 152.738. All of the squares add up to 57215.5, and there are 131 degrees of freedom. In AG2, the ANOVA results for 2021 show, like those for 2019, that there is a big difference between the groups. The F-value of 25.36 shows that the difference between groups is much bigger than the difference within groups. The p-value of 2.89E-25 also shows that the difference seen is statistically very important. In short, the ANOVA study for 2021 shows that the crab data in AG2 are significantly different. As with the 2019 results, the differences that have been seen may reflect real differences between crustacean groups in AG2. This suggests that these differences are not just random.

6.3.6 Seasonal fluctuations of soil organisms

Arthropods organisms and month wise populations at AG2 in 2019

The monthly number of recorded organisms exhibits fluctuations throughout the year 2019 as shown in Table 6:18. Regarding the quantity of observed organisms, February and April exhibited the highest count (156), succeeded by March (148), and January (147). The period spanning from May to October exhibited a lower abundance of organisms in contrast to the winter season. The data indicates that the arthropod species population at AG2 exhibits temporal fluctuations. Furthermore, the organisms observed throughout the study period were comparable to those observed at Site 1, with only variations in their respective populations.

Table 6:18 Month-wise arthropod population at AG2 in 2019

Name of the Species/Family/Order	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Collembola												
Fam.*Isotomidae*	10	10	15	12	04	02	02	02	02	02	04	08
Cryptopygus sp.	13	14	10	08	02	05	01	01	01	02	03	09
Isotoma sp.	15	03	10	03	04	01	01	03	02	02	04	07
Isotomiella sp.	04	12	05	04	04	02	01	02	02	02	02	02
Isotomurus sp.	15	05	07	08	01	0	01	01	01	02	03	05
Folsomia quadrioculata	01	08	06	06	05	01	01	01	01	02	04	03
Hypogastrura sp.	02	06	06	08	05	0	01	01	02	02	04	04
Lepidocyrtus sp.	08	07	07	05	05	0	01	02	01	02	07	05
Entomobrya sp.	07	06	08	04	05	0	02	01	02	02	02	07
Sminthrus sp.	03	05	04	02	01	0	01	01	01	02	04	07
Fam.*Katiannidae*	02	05	03	02	04	0	0	01	02	01	02	03
Acari												
Fam.*Acaridae*	08	08	08	10	08	01	01	02	02	01	09	08
Fam.*Laelapidae*	09	09	08	09	03	01	01	01	01	02	02	07
Fam.*Cunaxidae*	08	08	09	09	05	01	01	01	01	02	01	08
Ord. *Cryptostigmata*	09	09	09	08	02	01	01	01	01	02	02	08
Fam.*Phytoseiidae*	08	07	04	09	03	01	01	01	01	02	03	02
Poecilochirus carabi	07	08	05	09	07	01	01	01	01	02	02	03
Sperchonopsis ecphyma	04	06	05	09	02	01	0	01	01	03	03	01
Acari juveniles	03	05	04	09	03	0	0	0	01	02	02	04
Fam.*Rhodacaroidea*	02	07	02	08	0	01	01	01	02	02	03	04
Demodex folliculorum	02	05	04	02	01	01	0	0	01	01	02	06
Other arthropods												
Cortinicara sp. (Fam.*Latridiidae*)	01	01	01	02	01	01	0	01	01	02	02	02
Anthicidae species	01	0	01	01	01	01	01	02	01	02	02	01
Fam.*Carabidae*	01	0	01	02	01	01	0	0	01	01	02	01
Hymenoptera	01	0	01	02	01	01	0	01	01	01	02	01
Psocoptera	01	01	01	01	01	0	0	01	02	02	02	01
Diplura	01	01	02	02	0	01	01	01	01	02	01	03
Diptera	01	0	01	01	0	0	01	01	01	01	01	0
Pseudoscorpions	0	0	01	01	01	0	0	0	01	01	01	0
N	29	29	29	29	29	29	29	29	29	29	29	29
Min	0	0	01	01	0	0	0	0	01	01	01	0
Max	15	14	15	12	08	05	02	03	02	03	09	09
Sum	147	156	148	156	80	25	22	32	38	52	81	120
Mean	5.06	5.37	5.1	5.37	2.75	0.86	0.75	1.10	1.31	1.79	2.79	4.13
Std. error	0.83	0.71	0.66	0.65	0.39	0.18	0.10	0.12	0.08	0.09	0.32	0.52
Variance	20.13	14.67	12.73	12.31	4.61	0.98	0.33	0.45	0.22	0.24	3.02	7.98
Stand. Dev	4.48	3.83	3.56	3.5	2.14	0.99	0.57	0.67	0.47	0.49	1.73	2.82
Median	03	06	05	05	02	01	01	01	01	02	02	04

Arthropods organisms and month wise populations at AG2 in 2021

The investigation into the arthropod species population at AG2 in 2021 revealed significant temporal fluctuations in the observed individuals (Table 6:19). The monthly displays exhibited variability, with March exhibiting the maximum number of observations (160), followed in close succession by February (156), April (153), and

January (147). By way of contrast, the frequency of observations exhibited a decline from the month of May to November, thereby suggesting a reduction in the number of individuals present during this period. The study’s results indicate a clear seasonal trend in population dynamics, wherein the highest population density is observed during the winter months and the lowest population density is recorded during the summer months. This contributes to our comprehension of the time-related patterns of the arthropod assemblage and emphasize the influence of seasonal variations on the populace quantities at AG2.

Table 6:19 Month-wise arthropod population at AG2 in 2021

Name of the Species/Family/Order	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Collembola												
Fam.*Isotomidae*	09	08	09	08	08	04	02	03	03	03	08	08
Cryptopygus sp.	08	09	09	07	07	01	01	03	04	03	07	07
Isotoma sp.	09	09	09	05	05	01	01	02	02	01	04	08
Isotomiella sp.	09	09	08	06	04	02	01	02	02	02	03	08
Isotomurus sp.	09	08	08	08	07	01	01	02	01	02	03	07
Folsomia quadrioculata	08	09	08	04	07	01	01	01	01	02	02	05
Hypogastrura sp.	09	06	08	05	02	01	01	01	01	02	02	07
Lepidocyrtus sp.	09	06	08	07	0	01	01	01	01	02	03	05
Entomobrya sp.	05	06	08	08	01	0	01	0	01	02	02	02
Sminthrus sp.	03	05	04	04	0	0	01	01	01	02	02	02
Fam.*Katiannidae*	02	05	03	02	01	0	01	01	01	01	02	03
Acari												
Fam.*Acaridae*	08	09	05	09	09	01	01	02	02	01	03	07
Fam.*Laelapidae*	07	07	06	09	09	01	01	03	02	02	02	08
Fam.*Cunaxidae*	09	07	05	08	08	01	0	03	02	02	01	08
Ord. *Cryptostigmata*	02	08	07	07	05	01	01	03	02	02	03	08
Fam.*Phytoseiidae*	07	09	08	08	04	01	01	02	01	02	03	03
Poecilochirus carabi	05	08	08	08	01	01	01	01	01	02	03	06
Sperchonopsis ecphyma	08	08	08	08	0	01	0	0	01	03	03	03
Acari juveniles	07	06	07	07	01	0	0	0	01	02	02	01
Fam.*Rhodacaroidea*	06	07	08	08	01	0	01	01	02	02	03	05
Demodex folliculorum	03	05	08	07	01	01	0	0	02	02	02	06
Other arthropods												
Cortinicara sp. (Fam.*Latridiidae*)	01	0	01	03	01	01	01	01	02	01	01	01
Anthicidae species	01	0	01	01	01	01	01	01	02	01	02	01
Fam.*Carabidae*	01	01	01	01	01	01	0	0	01	01	01	02
Hymenoptera	01	01	01	01	01	01	0	01	01	01	01	01
Psocoptera	01	0	01	01	0	01	0	01	01	01	02	01
Diplura	01	0	01	01	01	01	01	01	01	02	02	01
Diptera	0	0	01	01	0	0	01	01	01	02	02	02
Pseudoscorpions	0	0	01	01	0	0	0	0	01	01	01	02
N	29	29	29	29	29	29	29	29	29	29	29	29
Min	0	0	01	01	0	0	0	0	01	01	01	01
Max	09	09	09	09	09	04	02	03	04	03	08	08
Sum	147	156	160	153	86	26	22	38	44	52	75	128
Mean	5.06	5.37	5.51	5.27	2.96	0.89	0.75	1.31	1.51	1.79	2.58	4.41
Std. error	0.63	0.64	0.58	0.55	0.58	0.14	0.09	0.18	0.13	0.11	0.29	0.51
Variance	11.6	11.93	10.04	8.92	9.96	0.59	0.26	1.007	0.54	0.38	2.46	7.67
Stand. Dev	3.4	3.45	3.16	2.98	3.15	0.77	0.51	1.003	0.73	0.61	1.57	2.77
Median	06	06	07	07	01	01	01	01	01	02	02	05

6.3.7 Diversity indices of arthropods in month-wise from AG2

The following Table 6:20 exhibits the diversity indices computed for the years 2019 and 2021 in order to assess the diversity of the arthropod species inhabiting AG2. In 2019, between 19 and 29 species were recorded per month on average, with a range of 25.6 species. The monthly totals varied from 22 to 156 individuals, with an average of

73.7. The index ranges from 0.03 to 0.07, which indicates the prevalence of the most abundant species in a given community. The Simpson index ranges between 0.92 and 0.96, whereas the Shannon index ranges between 2.78 and 3.32. The range of the Margalef index is 4.55 to 7.69, while the range of Evenness values is 0.70 to 0.96. The range of equitability values was between 0.89 and 0.98. In 2021, the observed species ranged from 21 to 29, with an average of 26.7 species per month. The monthly totals varied between 22 and 160 individuals, with an average of 80.8 per month. The dominance measure (D) ranges from 0.038 to 0.072. The Simpson diversity index in a single dimension displayed values between 0.9278 and 0.9615, which were comparable to those observed in 2019. The Shannon index ranges from 2.8 to 3.308, which is comparable to 2019 values. Additionally, the values of evenness expressed as range from 0.71 to 0.94, which are comparable to the values observed in 2019. The Margalef index ranges from 4.357 to 7.399, values comparable to those observed in 2019. The equitability values ranged from 0.938 to 0.9946, which is comparable to the values observed in 2019.

Table 6:20 Diversity indices of all arthropods in month-wise from AG2 in year 2019 and 2021

Diversity Indices												
2019	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Taxa (S)	28	24	29	29	26	19	20	25	29	29	29	27
Individuals	147	156	148	156	80	25	22	32	38	52	81	120
Dominance(D)	0.06	0.05	0.05	0.04	0.05	0.07	0.05	0.04	0.03	0.03	0.04	0.05
Simpson (1-D)	0.93	0.94	0.94	0.95	0.94	0.92	0.94	0.95	0.96	0.96	0.95	0.95
Shannon (H)	2.98	3.04	3.12	3.14	3.04	2.78	2.96	3.14	3.30	3.32	3.21	3.10
Evenness (EVNS)	0.70	0.87	0.78	0.79	0.81	0.85	0.96	0.92	0.94	0.96	0.85	0.82
Margalef	5.41	4.55	5.60	5.54	5.70	5.59	6.14	6.92	7.69	7.08	6.37	5.43
Equitability(J)	0.89	0.95	0.9	0.93	0.9	0.94	0.98	0.97	0.98	0.98	0.95	0.94
2021												
Taxa (S)	27	23	29	29	23	22	21	23	29	29	29	29
Individuals	147	156	160	153	86	26	22	38	44	52	75	128
Dominance(D)	0.049	0.04	0.04	0.04	0.07	0.05	0.04	0.05	0.042	0.038	0.046	0.047
Simpson (1-D)	0.95	0.95	0.95	0.95	0.92	0.94	0.95	0.94	0.957	0.96	0.95	0.95
Shannon (H)	3.09	3.06	3.16	3.17	2.8	2.99	3.02	3.02	3.26	3.30	3.22	3.15
Evenness (EVNS)	0.81	0.93	0.81	0.82	0.71	0.9	0.98	0.89	0.9	0.94	0.86	0.81
Margalef	5.21	4.35	5.51	5.56	4.93	6.44	6.47	6.04	7.39	7.08	6.48	5.77
Equitability (J)	0.93	0.97	0.94	0.94	0.89	0.96	0.99	0.96	0.97	0.98	0.95	0.93

6.4 Site 2-Non-Agriculture land (NAG2)

6.4.1 Edaphic factors

The following Table 6:21 presents an overview of the arthropod populations and environmental parameters observed at NAG2 during the year 2019. The temperature range observed spanned from 12 to 33 degrees Celsius, with an average temperature of 22.25 degrees Celsius. The study yielded a mean pH value of 7.24, alongside a minimum pH of 7.1 and a maximum pH of 7.5. The electrical conductivity (EC) values ranged from 0.14 ds/m to 0.22 ds/m, with an average EC of 0.17. The maximum level of moisture detected was 12.3%. The mean moisture content ascertained was 6.56%. The mean carbon concentration was determined to be 0.27%, with a range of 0.45% as the lowest and highest values. The study found that the minimum concentration of nitrogen was 0.02%, while the maximum concentration was 0.038%. The average concentration of nitrogen was calculated to be 0.023%. The data indicates that 38 Kg/h, 58 Kg/h, and an average of 47.83 Kg/h of potassium value were recorded. The concentration of phosphorus exhibited a range between 2 ppm and 3 ppm, with a mean value of 2.83ppm. The minimum count of Collembola observed was 11, while the maximum count was 79, with a corresponding mean value of 41.91. The present study reports on the 2019 observations of Acari, commonly known as mites, at NAG2. The dataset under consideration exhibits a range of values from a minimum of 7 to a maximum of 78. The central tendency of this dataset is represented by the mean value of 35.16. In 2019, other arthropods populations, comprised with a range of counts between 2 and 12, with a mean number of 7.25. The present tabular representation offers a comprehensive summary of the environmental factors observed at NAG2 during the year 2019. The parameters include temperature, pH, electrical conductivity, moisture content, carbon and nitrogen content, and the count of diverse arthropod species.

The tabulated data (Table 6:22) presents the arthropod population count at NAG2 during the year 2021, in relation to different soil parameters. The temperature range observed was between 12 and 33 degrees Celsius, with 12 representing the minimum temperature and 33 representing the maximum temperature. The mean annual temperature was 22.08 degrees Celsius. The pH values observed in the study ranged from 7.1, which was the minimum, to 7.5, which was the maximum. The mean pH value for the given time period was 7.28. The electrical conductivity values varied between 0.13 dS/m as the minimum and 0.22 dS/m as the maximum. Throughout the entire year, the mean electrical conductivity was recorded as 0.166 deciSiemens per metre. The moisture content measurements exhibited a range of 0.9% at the minimum point to 12.3% at the maximum point. Throughout the duration of the year, the mean level of moisture content was recorded to be 6.06%. The carbon content exhibited a range of 0.2% to 0.45% across the samples. Throughout the duration of the year, the mean carbon concentration was 0.30%. The nitrogen proportion in the sample was observed to range between 0.038% for both the minimum and maximum values. The mean nitrogen concentration on a yearly basis was 0.025%. The minimum recorded potassium levels were 33 kg per hectare, while the maximum levels were 53 kg per hectare. Throughout the duration of the year, the mean potassium level was recorded as 43.58 kg per hectare. The study recorded the levels of phosphorus, which ranged from a minimum of 2 ppm to a maximum of 3 ppm. The annual mean value of phosphorus was 2.75 parts per million (ppm). The observed abundance of Collembola, commonly known as springtails, at NAG2 during the year 2021. The minimum count recorded was 10, while the maximum count was 80. The mean annual count of Collembola was 41.41. The quantification of Acari (mites) observed at NAG2 during the year 2021. The minimum count recorded was 6, while the maximum count was 71. On average, Acari has been subjected to 32 measurements annually. The arthropods were enumerated with a minimum count of 3 and a maximum count of 9. On an annual basis, the average number of arthropods was 5.83. The data provides a complete overview of soil variables and population counts of several arthropod species at NAG2 in 2021.

Table 6:21 The number of arthropods in relation to soil factors at NAG2 during the year 2019

Month, 2019	**Temp. (^{o}C)**	**pH**	**E.C (ds/m)**	**Moisture (%)**	**C (%)**	**N (%)**	**K (Kg/h)**	**P (ppm)**	**Collembola**	**Acari**	**Other arthropods**
N	12	12	12	12	12	12	12	12	12	12	12
Min	12	7.1	0.14	0.9	0.2	0.02	38	2	11	7	2
Max	33	7.5	0.22	12.3	0.45	0.03	58	3	79	78	12
Sum	267	86.9	2.15	78.8	3.27	0.27	574	34	503	422	87
Mean	22.2	7.24	0.17	6.56	0.27	0.02	47.83	2.83	41.91	35.16	7.25
Std. error	2.19	0.05	0.008	1.24	0.02	0.001	1.88	0.11	8.00	7.5	0.82
Variance	57.84	0.03	0.0008	18.73	0.005	3.9	42.6	0.15	769.1	680.6	8.20
Stand. Dev	7.6	0.19	0.028	4.32	0.075	0.006	6.53	0.38	27.7	26.09	2.86
Median	20.5	7.1	0.17	6.5	0.25	0.02	50.5	3	39	30	7

Table 6:22 The number of arthropods in relation to soil factors at NAG2 during the year 2021

Month, 2019	**Temp. (^{o}C)**	**pH**	**E.C (ds/m)**	**Moisture (%)**	**C (%)**	**N (%)**	**K (Kg/h)**	**P (ppm)**	**Collembola**	**Acari**	**Other arthropods**
N	12	12	12	12	12	12	12	12	12	12	12
Min	12	7.1	0.13	0.9	0.2	0.02	33	2	10	6	3
Max	33	7.5	0.22	12.3	0.45	0.038	53	3	80	71	9
Sum	265	87.45	2	72.8	3.64	0.31	523	33	497	384	70
Mean	22.08	7.28	0.166	6.06	0.303	0.025	43.5	2.75	41.41	32	5.83
Std. error	2.24	0.054	0.009	1.21	0.027	0.002	1.90	0.130	7.948	7.30	0.57
Variance	60.6	0.035	0.001	17.8	0.009	6.31E-05	43.7	0.204	758.0	640.3	3.96
Stand. Dev	7.78	0.188	0.032	4.22	0.095	0.007	6.61	0.452	27.53	25.30	1.99
Median	12	12	12	12	12	12	12	12	12	12	12

6.4.2 Population dynamics

In 2019, the predominant taxonomic group in Non-agricultural land (NAG2) was Collembola, which accounted for 49.70% of the total, followed by Acari at 41.69% and other arthropods, which accounted for 8.59% of the total. In 2021, however, Collembola account for 52.26 percent of the total, followed by Acari at 40.37 percent and other arthropods at 7.36 percent. The present analysis describes the species composition of arthropods in NAG2, where a total of 1963 species were collected in both years. Collembola dominated the collected species with 503 and 497 species in 2019 and 2021, respectively, followed by Acari with 422 and 384 species in each year. Other arthropods, in contrast, were determined to be the least abundant, with approximately 87 and 70 species in 2019 and 2021, respectively. Collembola were found to constitute 48.9% of the total population (2143), making up the majority of the arthropod community. Nonetheless, it was observed that the same species of Site 1 in which, Collembola were present throughout the entire sampling period. The Acari population, which accounted for 41.05% of the total, ranked second in terms of numerical abundance, and a community comparable to that of Site 1 was discovered. It was determined that the proportional prevalence of the remaining taxa, including coleopterans, diplurans, pseudoscorpions, isopods, and Hymenoptera, was less than 7.99%. Figure 6:13 and Figure 6:14 depicts a comparable pattern of arthropod population occurrence in different months in relation to edaphic factors when compared to Site 1 (NAG1).

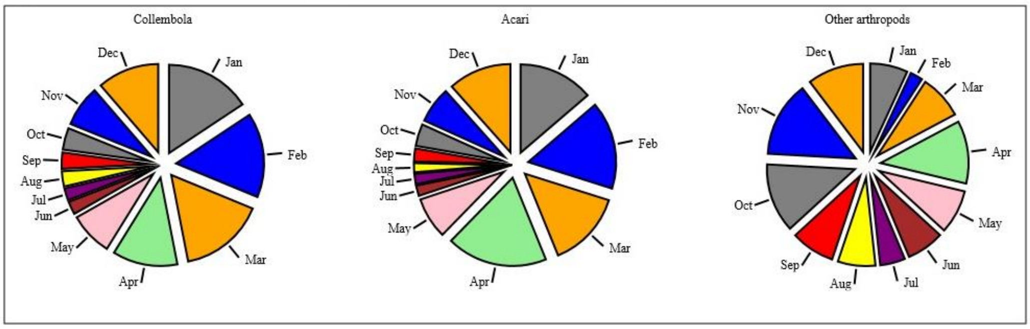


Figure 6:13 The number of Collembola, Acari, and other arthropods in month-wise presenting in NAG2 during year, 2019.

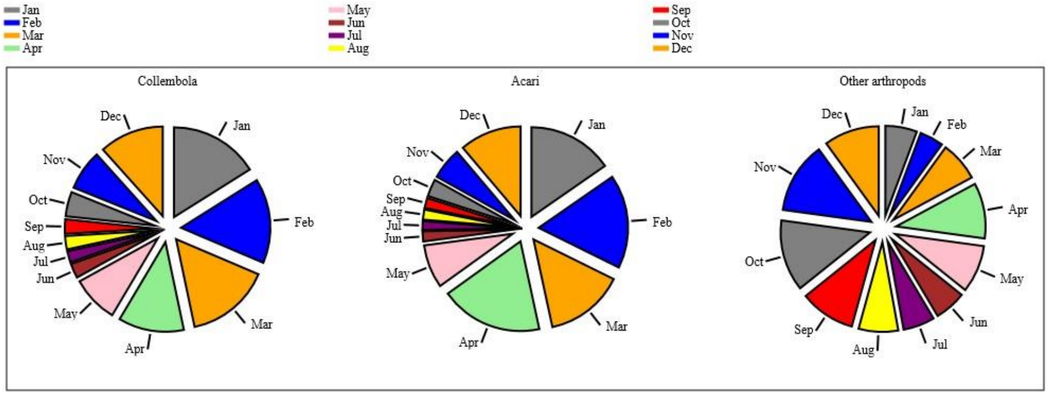


Figure 6:14 The number of Collembola, Acari, and other arthropods in month-wise presenting in NAG2 during year, 2021.

6.4.3 Correlation Analysis

Correlational study between edaphic factors and arthropod population at the NAG2 in 2019

The data presented (Figure 6:15) includes correlation coefficients between edaphic parameters and the populations of Collembola, Acari, and Other arthropods. The number of collembola exhibits a negative correlation with temperature (-0.90844), pH (-0.17428), and the number of other arthropods (-0.10271). An increased pH level is indicative of a larger Collembola population. The growth of Collembola populations exhibits a positive correlation with elevated levels of E.C. (0.7946) and moisture (0.73292), while displaying a negative correlation with carbon content (-0.23181) and nitrogen content (-0.21134). A positive correlation (r = 0.41227) has been observed between elevated potassium concentrations and increased abundance of Collembola. The data suggests an inverse relationship between the population of Acari and both temperature (R=-0.85881) and the number of other arthropods (R=-0.0030412), indicating a tendency for population decline as these factors increase. The results indicate a significant correlation between pH (0.26752), E.C. (0.83891), and moisture (0.53863), implying that a rise in any of these factors is typically accompanied by an increase in the Acari population. The abundance of Acari exhibits a positive correlation with both carbon and nitrogen concentration, with correlation coefficients of -0.29626 and -0.22827, respectively. The findings suggest that an increase in temperature and phosphorus concentration may have a negative impact on the population of Other arthropods, with respective correlation coefficients of -0.17423 and -0.20384. There exists a positive correlation between the carbon content (0.62037) and nitrogen content (0.68997). The abundance of arthropods classified as Other exhibits a positive correlation with elevated levels of carbon and nitrogen. The associations between soil variables and the population dynamics of Collembola, Acari, and other arthropods findings indicate that the prevalence of diverse arthropod taxa within the studied ecosystem may be influenced by environmental factors.

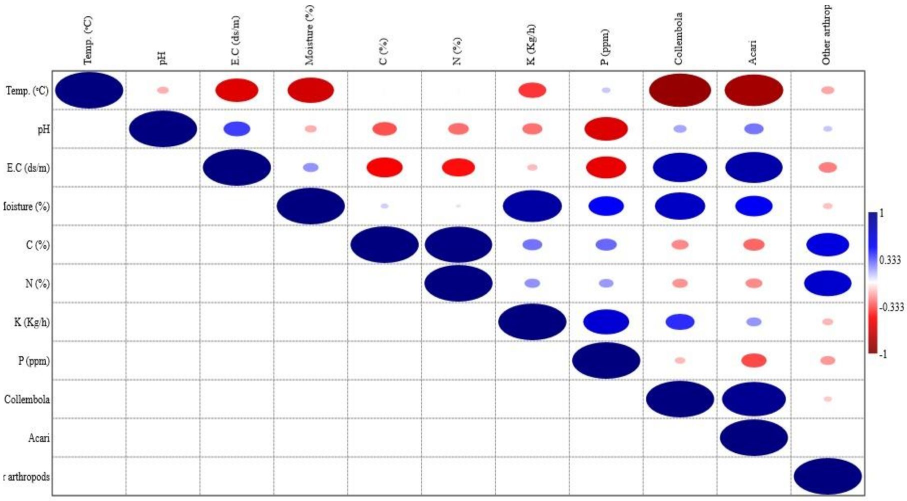


Figure 6:15 Correlation analysis between Edaphic factors and arthropods populations in NAG2 during year, 2019.

Correlational study between edaphic factors and arthropod population at the NAG2 in 2021

The information includes population estimates of Collembola, Acari, and other arthropods as well as correlation coefficients between those estimates and other environmental parameters. According to the Figure 6:16, there is an inverse relationship between temperature (-0.91017), pH (-0.33444), and the presence of other arthropods (-0.224). According to the results, the number of Collembola decreases as temperature, pH increases. The data show that electrical conductivity (E.C.) (r = 0.88731), moisture (r = 0.74561), and potassium levels (r = 0.17704) are all positively correlated with the Collembola population. However, carbon and nitrogen levels were shown to be negatively correlated with the Collembola population (r = -0.56299 and -0.56055, respectively). According to these results, higher concentrations of E.C., moisture, and potassium are all associated with higher Collembola populations. However, it is possible that an increase in Collembola population might result from a decrease in carbon and nitrogen concentration. Collembola and Acari populations were positively correlated (r = 0.9474), suggesting that a rise in one population is accompanied by an increase in the other. Temperature (-0.85585), pH (-0.40701), and the presence of other arthropods (-0.20555) all negatively correlate with the Acari population. A lower Acari population appears to correlate with rising temperatures, acidity, and the presence of other arthropods. Electrical conductivity (E.C.) was shown to have a positive link with Acari populations by a coefficient of 0.9483, moisture by a coefficient of 0.57819, and potassium by a coefficient of 0.25418. In contrast, a negative connection (r = -0.61984) was found between the Acari population and carbon content, while a negative correlation (r = -0.58404) was found between the Acari population and nitrogen content. These results imply that higher levels of E.C., moisture, carbon content, nitrogen content, and potassium are all linked to larger Acari populations. There is a highly substantial positive connection (r = 0.9474) between the abundance of Acari and Collembola, suggesting that higher Acari abundance predicts higher Collembola abundance. Temperature (-0.010743), pH (-0.0060532), and phosphorus concentration (-0.20555) all negatively correlate with the number of Other arthropods. This suggests that the population of Other arthropods decreases with increasing temperature, pH, and phosphorus content. Both moisture (-0.10873) and nitrogen content (0.34283) are positively correlated with the number of Other arthropods. More specifically, higher levels of moisture and nitrogen are linked to a rise in the number of Other arthropods. The data shows that there is a -0.1065 association between E.C. and the number of Other arthropods. It appears that a decrease in the number of Other arthropods is associated with increasing E.C. values. Our findings suggest that environmental factors such as temperature, pH, moisture, and nutrient concentrations may influence the abundance of the arthropod taxa within the studied ecological system.

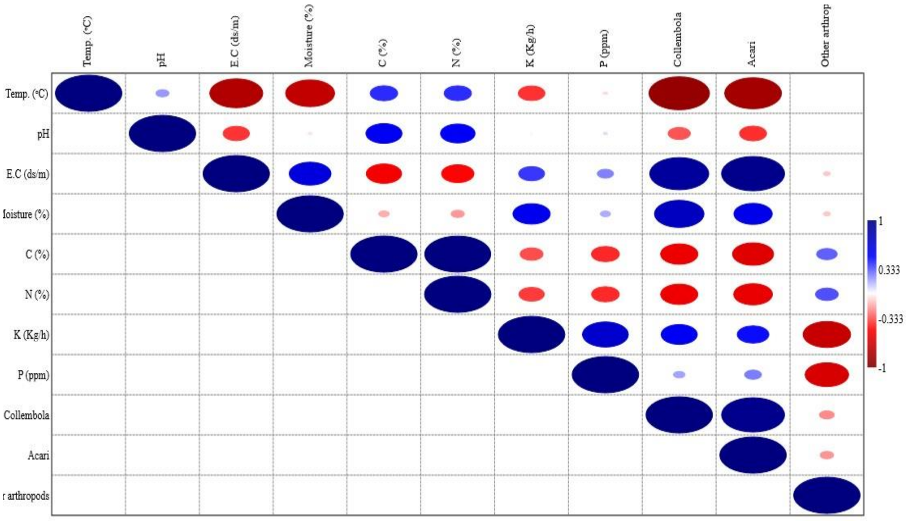


Figure 6:16 Correlation analysis between Edaphic factors and arthropods populations in NAG2 during year, 2021

6.4.4 Diversity Indices

The arthropod diversity indices obtained from NAG2 between 2019 and 2021 provide useful information about the composition and characteristics of the arthropod population (Table 6:23). The taxonomic count remained stable between years, with a total of 12 unique arthropod categories found, indicating a steady degree of species diversity. In terms of abundance, the total population decreased somewhat between 2019 and 2021. Collembola had the highest population count in 2019, with 503 organisms, followed by Acari (422 organisms), and Other arthropods (87 organisms). The Collembola taxonomic group had 497 individuals in the year 2021, while the Acari taxonomic group had 384 individuals. In addition, 70 specimens were discovered in the Other arthropods taxonomic category. Acari was the most dominant taxon in both years studied, followed by Collembola and other arthropods. Despite slight fluctuations in dominance values over the years, the overall ranking remained steady. During both years, the arthropod groups had Simpson diversity values that were near to one another. This shows that the communities had a diversified composition and a rather uniform species distribution. The three groups displayed a rather high level of diversity in both years, as demonstrated by Shannon indices ranging from 2.179 to 2.431. The statement suggests that arthropod populations have a diverse and equitable species distribution. Arthropods had the highest amount of evenness in 2019, with Collembola and Acari close behind. In the year 2021, it was discovered that among diverse arthropods, some had the highest evenness, while Acari had the lowest evenness. The statistics show a shift in the equitability of species dispersal between the years specified. Increased species diversity is indicated by higher Margalef index values. The arthropods had the highest Margalef index in both years, with Acari and Collembola close behind. The data for the year 2021 showed a small increase when compared to the data for 2019, indicating a possible increase in species diversity. Greater equity scores imply a more equitable distribution of individuals across species. Arthropods had the highest equitability in both years, followed by Collembola and Acari. During the period from 2019 to 2021, the values followed a fairly constant pattern. To summarise, the NAG2 arthropod population maintained a consistent level of species richness and diversity between 2019 and 2021. While there were slight differences in the quantity and frequency of discrete arthropod taxa throughout the two years, the overall variety and equitable dispersion of species remained stable.

Table 6:23 Diversity indices of arthropods from NAG2 in year 2019 and 2021

Index	**2019**			**2021**		
	Collembola	**Acari**	**Other arthropods**	**Collembola**	**Acari**	**Other arthropods**
Taxa (S)	12	12	12	12	12	12
Individuals	503	422	87	497	384	70
Dominance (D)	0.1168	0.1254	0.09526	0.1171	0.1311	0.09224
Simpson (1-D)	0.8832	0.8746	0.9047	0.8829	0.8689	0.9078
Shannon (H)	2.273	2.216	2.408	2.268	2.179	2.431
Evenness (EVNS)	0.8088	0.7643	0.9259	0.8051	0.7367	0.948
Margalef	1.768	1.82	2.463	1.772	1.849	2.589
Equitability (J)	0.9146	0.8918	0.969	0.9127	0.877	0.9785

[S for Taxa; D for Dominance; H for Shannon Diversity; EVNS for Evenness and J for Equitability]

6.4.5 One-Way ANOVA

For NAG2 (2019)

One-way ANOVA was used in 2019 to evaluate the changes of diversity indices among several arthropod groups in NAG2. The estimated sum of squares between groups is 39098.1, showing statistically substantial variation among the arthropod groups. The sum of squares in each group, 17353, serves as a measure of variance within each group.

The degrees of freedom (df) within a group are 10 while the degrees of freedom (df) between groups are 121. The mean square is calculated by dividing the total of squares by the number of degrees of freedom involved. The variation between groups is divided by the variance within groups when computing the F-value. The statistical study yields an F-value of 27.26, indicating that there is statistically significant variance in diversity indices among arthropod taxa in NAG2 in 2019.The p-value is a statistical indicator used to determine the significance of the F-value. The study's p-value is 1.58E-26, which is extremely near to zero. This finding provides significant support for the null hypothesis that diversity indices do not differ amongst arthropod groups. As a result, the diversity indices of arthropod taxa within NAG2 in 2019 differ dramatically. The ANOVA results show that there are significant differences in diversity indices between arthropod groups, which could be due to differences in species composition, abundance, or other variables affecting arthropod communities in NAG2 during 2019.

For NAG2 (2021)

The study conducted a unidirectional analysis of variance (ANOVA) to investigate the diversity indices variations among different arthropod categories within NAG2 during the year 2021.The computed sum of squares between groups is 34638.5, indicating a statistically significant level of diversity among the arthropod groups. The sum of squares within groups is 16773.5, which represents the degree of variability that exists within each group. The degrees of freedom (df) associated with the between groups and within groups are 10 and 121, respectively. The process of calculating the mean square involves the process of dividing the sum of squares by the corresponding degrees of freedom. The F-value may be characterized as the ratio of the inter-group variance to the intra-group variance. The F-value of 24.99 that was obtained indicates a statistically significant level of variation in diversity indices among the arthropod groups present in NAG2 during the year 2021.The p-value is a measure of the statistical significance of the F-value. The calculated p-value of 5.19E-25 is indicative of strong evidence against the null hypothesis, which posits the absence of diversity index variation among arthropod groups. It can be inferred that a significant difference in diversity indices exists among the arthropod taxa found in NAG2 in the year 2021. The information presented is deficient in terms of providing explicit particulars concerning the diversity indices and arthropod taxa. The results of the ANOVA analysis reveal significant variations in the diversity index among the arthropod taxa, suggesting potential differences in species distribution, population size, or other factors that influence the arthropod communities in NAG2 during the year 2021.

6.4.6 Seasonal fluctuations of soil organisms

Arthropods organisms and month wise populations at NAG2 in 2019

As depicted in Table 6:24, the number of organisms recorded each month fluctuates throughout 2019. February and April had the highest number of observed organisms (148), followed by March (145) and December (143). In comparison to the winter season, the period from May to October had a lower organism abundance. According to the data, the arthropod species population at NAG2 fluctuates over time. In addition, the organisms observed throughout the study period were analogous to those observed at Site 1, with the exception of variations in the populations of each species.

Table 6:24 Month-wise arthropod population at NAG2 in 2019

Name of the Species/Family/Order	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Collembola												
Fam.*Isotomidae*	10	9	9	5	3	1	1	2	1	2	5	9
Cryptopygus sp.	9	7	8	7	4	1	1	2	2	2	4	8
Isotoma sp.	7	6	7	6	5	1	1	1	1	1	4	9
Isotomiella sp.	8	5	6	7	4	1	1	1	1	3	3	7
Isotomurus sp.	5	7	5	5	5	1	1	2	1	3	5	8
Folsomia quadrioculata	5	6	6	5	6	1	1	1	2	1	2	3
Hypogastrura sp.	6	9	6	4	3	1	1	2	1	2	2	2
Lepidocyrtus sp.	7	8	9	5	2	1	1	1	1	1	3	2
Entomobrya sp.	7	8	9	6	2	1	1	0	1	2	3	3
Sminthrus sp.	8	7	9	7	3	1	1	1	3	2	3	3
Fam.*Katiannidae*	7	6	5	3	3	2	1	1	1	1	4	3
Acari												
Fam.*Acaridae*	7	8	7	4	4	1	1	1	1	1	4	7
Fam.*Laelapidae*	8	8	6	7	4	1	1	1	1	2	2	4
Fam.*Cunaxidae*	7	9	7	9	4	0	0	1	1	2	2	5
Ord. *Cryptostigmata*	5	9	7	9	5	1	1	1	1	2	2	3
Fam.*Phytoseiidae*	6	7	9	9	3	1	1	0	1	1	5	5
Poecilochirus carabi	8	3	5	8	5	1	1	1	1	2	2	6
Sperchonopsis ecphyma	4	6	4	7	3	1	0	1	1	3	4	4
Acari juveniles	5	7	3	8	2	1	1	0	1	1	2	3
Fam.*Rhodacaroidea*	4	6	6	9	1	0	1	1	2	2	3	5
Demodex folliculorum	4	5	5	8	1	1	1	0	0	1	2	7
Other arthropods												
Cortinicara sp. (Fam.*Latridiidae*)	1	1	2	1	0	0	0	1	1	1	2	1
Anthicidae species	1	0	1	3	1	1	0	0	1	1	2	1
Fam.*Carabidae*	1	0	1	2	1	2	0	0	1	1	2	1
Hymenoptera	1	0	1	1	2	1	1	0	1	1	1	1
Psocoptera	0	0	1	0	1	0	1	2	1	1	1	1
Diplura	1	1	1	1	1	1	1	1	0	2	2	3
Diptera	0	0	0	1	1	1	1	1	1	3	1	0
Pseudoscorpions	1	0	0	1	0	0	0	1	1	1	1	1
N	29	29	29	29	29	29	29	29	29	29	29	29
Min	0	0	0	0	0	0	0	0	0	1	1	0
Max	10	9	9	9	6	2	1	2	3	3	5	9
Sum	143	148	145	148	79	26	23	27	32	48	78	115
Mean	4.9	5.10	5	5.10	2.72	0.89	0.79	0.93	1.10	1.65	2.68	3.96
Std. error	0.55	0.61	0.55	0.53	0.30	0.09	0.07	0.12	0.10	0.13	0.22	0.49
Variance	8.99	11.0	9.07	8.45	2.77	0.23	0.16	0.42	0.31	0.51	1.50	7.17
Stand. Dev	2.99	3.33	3.01	2.9	1.66	0.48	0.41	0.65	0.55	0.72	1.22	2.67
Median	5	6	6	5	3	1	1	1	1	2	2	3

Arthropods organisms and month wise populations at NAG2 in 2021

The study conducted on the arthropod species population at NAG2 in 2021 has indicated noteworthy temporal variations in the observed individuals, as presented in Table 6:25. The monthly displays demonstrated fluctuation, with February presenting the highest number of observations (144), closely followed by January (143), April (137), and March (136). In contrast, there was a decrease in the frequency of observations from May to November, indicating a potential decline in the population size during this time frame. The findings of the study demonstrate a distinct seasonal pattern in the dynamics of the population, whereby the winter months exhibit the highest population density and the summer months exhibit the lowest population density. This finding enhances our understanding of the temporal distribution patterns of the arthropod community and underscores the impact of seasonal fluctuations on population densities at NAG2.

Table 6:25 Month-wise arthropod population at NAG2 in 2021

Name of the Species/Family/Order	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Collembola												
Fam.*Isotomidae*	10	9	8	4	4	1	1	2	1	2	5	9
Cryptopygus sp.	9	7	8	7	4	1	1	2	2	2	4	8
Isotoma sp.	7	6	7	6	5	1	1	1	1	1	4	9
Isotomiella sp.	9	5	6	7	4	1	1	1	1	3	3	7
Isotomurus sp.	5	7	5	5	6	2	0	1	1	2	4	8
Folsomia quadrioculata	5	6	6	5	6	1	1	1	1	2	2	3
Hypogastrura sp.	6	7	6	4	3	1	1	1	1	2	2	3
Lepidocyrtus sp.	7	8	7	5	2	1	1	1	1	2	3	2
Entomobrya sp.	7	8	9	6	2	1	1	0	1	2	3	3
Sminthrus sp.	8	7	6	7	3	1	1	1	2	2	3	3
Fam.*Katiannidae*	7	6	8	3	3	2	1	1	1	2	3	3
Acari												
Fam.*Acaridae*	7	8	6	4	4	1	1	1	1	1	4	5
Fam.*Laelapidae*	8	8	6	5	4	1	1	1	1	2	2	4
Fam.*Cunaxidae*	7	9	7	9	4	0	0	1	1	1	2	5
Ord. *Cryptostigmata*	5	9	7	6	5	1	1	1	1	2	2	2
Fam.*Phytoseiidae*	7	6	7	6	3	1	1	0	1	1	3	5
Poecilochirus carabi	8	3	5	8	4	1	1	1	1	1	2	5
Sperchonopsis ecphyma	4	5	4	8	2	0	0	1	0	1	2	4
Acari juveniles	5	6	3	8	2	1	0	0	0	1	2	3
Fam.*Rhodacaroidea*	4	6	5	9	1	0	0	1	1	1	2	5
Demodex folliculorum	4	5	5	8	1	1	1	0	0	1	1	5
Other arthropods												
Cortinicara sp. (Fam.*Latridiidae*)	1	1	2	1	0	0	1	1	1	1	1	1
Anthicidae species	1	0	1	2	1	1	0	0	1	1	1	1
Fam.*Carabidae*	1	0	1	1	1	1	0	1	0	0	1	1
Hymenoptera	0	1	0	1	1	0	1	1	1	1	1	1
Psocoptera	0	0	1	0	1	0	0	0	1	1	1	1
Diplura	0	1	0	0	1	1	1	1	2	2	2	1
Diptera	0	0	0	1	1	1	1	0	0	2	1	0
Pseudoscorpions	1	0	0	1	0	0	0	1	1	1	1	1
N	29	29	29	29	29	29	29	29	29	29	29	29
Min	0	0	0	0	0	0	0	0	0	0	1	0
Max	10	9	9	9	6	2	1	2	2	3	5	9
Sum	143	144	136	137	78	24	20	24	27	43	67	108
Mean	4.93	4.96	4.68	4.72	2.68	0.82	0.68	0.82	0.93	1.48	2.31	3.72
Std. error	0.58	0.59	0.53	0.52	0.32	0.10	0.08	0.10	0.09	0.11	0.21	0.48
Variance	9.99	10.1	8.15	8.13	3.00	0.29	0.22	0.29	0.28	0.40	1.29	6.70
Stand. Dev	3.16	3.18	2.85	2.85	1.73	0.53	0.47	0.53	0.529	0.633	1.13	2.58
Median	5	6	6	5	3	1	1	1	1	1	2	3

6.4.7 Diversity indices of arthropods in month-wise from NAG2

The Table 6:26 depicts the diversity indices of arthropods in NAG2 across the months spanning from January to December in the years 2019 and 2021. The monthly taxa observed in the year 2019 displayed a variation between 23 and 29. Throughout the year, the population size exhibited fluctuations ranging from 143 to 148 individuals. The range of values for the index of dominance was observed to be between 0.0408 and 0.0507. The Simpson diversity index, which is the reciprocal of the dominance index, displayed a spectrum of values ranging from 0.9513 to 0.9592. The Shannon diversity index exhibited a range of values between 3.039 and 3.279. The range of the index of evenness was observed to be between 0.9047 and 0.9738. The Margalef index displayed a spectrum of values spanning from 4.402 to 7.502. The range of values observed for the equitability index was between 0.93 and 0.99. The monthly taxa observed in the year 2021 displayed a variation between 20 and 29. Throughout the year, the population under observation demonstrated a fluctuation between 136 and 144 individuals. The observed range of the dominance index was between 0.040 and 0.050. The Simpson diversity index manifested a spectrum of values ranging from 0.951 to 0.959. The Shannon diversity index exhibited a range between 2.99 and 3.26. The values of the evenness index ranged between 0.8114 and 0.9719. The Margalef index displayed a spectrum of values spanning from 4.62 to 7.17. The computed equity ratio is 0.9373 to 1. The diversity indices employed in this investigation offer an understanding of the degrees of richness, evenness, and dominance demonstrated by arthropod species in NAG2 over the selected intervals.

Table 6:26 Diversity indices of all arthropods in month-wise from NAG2 in year 2019 and 2021

Diversity Indices												
2019	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Taxa (S)	27	23	27	28	27	24	23	22	27	29	29	28
Individuals	143	148	145	148	79	26	23	27	32	48	78	115
Dominance(D)	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.042	0.04	0.04	0.04
Simpson (1-D)	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.94	0.95	0.95	0.95	0.95
Shannon (H)	3.13	3.05	3.14	3.17	3.15	3.15	3.13	3.03	3.23	3.27	3.26	3.13
Evenness (EVNS)	0.85	0.92	0.85	0.85	0.86	0.97	1	0.94	0.93	0.91	0.90	0.81
Margalef	5.23	4.40	5.22	5.40	5.95	7.05	7.01	6.37	7.50	7.23	6.42	5.69
Equitability(J)	0.95	0.97	0.95	0.95	0.95	0.99	1	0.98	0.98	0.97	0.97	0.93
2021												
Taxa (S)	25	24	25	27	27	22	20	22	24	28	29	28
Individuals	143	144	136	137	78	24	20	24	27	43	67	108
Dominance(D)	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.04	0.04	0.04	0.04	0.05
Simpson (1-D)	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.94
Shannon (H)	3.09	3.07	3.11	3.14	3.13	3.06	2.99	3.06	3.14	3.26	3.25	3.12
Evenness (EVNS)	0.88	0.90	0.89	0.85	0.85	0.97	1	0.97	0.96	0.93	0.89	0.81
Margalef	4.83	4.62	4.88	5.28	5.96	6.60	6.34	6.60	6.97	7.17	6.65	5.76
Equitability (J)	0.96	0.96	0.96	0.95	0.95	0.99	1	0.99	0.98	0.98	0.96	0.93

6.5 Overview of Site 3

This research was conducted in different fields of Punjab since arthropods differ in their habitat requirements and tolerance to various biotic and abiotic environmental conditions, seasonality changes, and other factors as given in Table 6:27.

Table 6:27 Study Site description of agriculture and non-agriculture land (Site 3)

LOCATION	Kartarpur is located at 31°26´24´´ N and 75° 29´ 59´´E, with a 235-meter average elevation. The summers are humid and hot, while the winters are mild. Summer lasts from April to June, and winter lasts from November to February. In July - August, a short period of southwest monsoon rain impacts the climate. Approximately 70 cm of precipitation falls each year.	
VEGETATION COVER	AGRICULTURE (AG3)	NON-AGRICULTURE (NAG3)
	The region encircling Kartarpur is dominated by agricultural land, with an emphasis on the cultivation of grains such as wheat, rice, maize, and sugarcane.	The area neighboring non-agricultural land exhibited a high density of vegetation comprising a diverse array of trees, herbs, shrubs, climbers, and grasses.
SOIL AND ENVIRONMENTAL CONDITION	The soil has typical alluvial characteristics, including a high silt content and a favorable water retention capacity in relation to its environmental characteristics. The predominant climate in the region is classified as humid subtropical, which is characterized by mild summers and cold winters. During the monsoon season, which typically lasts from July to September, there is a significant accumulation of precipitation in the region. The region receives roughly 70 cm of precipitation annually on average. Due to its location in an agricultural region, the study of soil quality and population dynamics of soil arthropods in Kartarpur has the potential to shed light on the health and productivity of the local agricultural systems.	

Site 3- Agriculture land (AG3)

6.5.1 Edaphic factors

The following Table 6:28 is a 2019 analysis of the arthropod abundance at AG3 in relation to soil factors:

The lowest temperature recorded was 12 degrees Celsius, while 33 degrees Celsius was the maximum. The annual average temperature was 22.08 degrees Celsius. The pH varied between 7 and 7.5, with a mean of 7.24. The E.C values varied between 0.14 and 0.22 ds/m, with an average of 0.178 ds/m. The soil’s moisture content ranged from 0.6% to 11.6%, with a mean of 5.49%. The carbon content ranged between 0.06% and

0.6%, with an average of 0.2%. The nitrogen content ranged from 0.005% to 0.051%, averaging 0.021%. The potassium concentration ranged from 28 to 51 kg/h on average, with a mean of 40.41 kg/h. The phosphorus concentration varied between 2 ppm and 3 ppm, with a mean of 2.66 ppm. The observed Collembola population ranged from 10 to 82 individuals, with a mean of 43.91. The observed range of Acari was eight to seventy-one, with an average of 37.33 individuals. The number of other arthropods ranged from 3 to 13, with an average of 8 individuals. These values provide information about the soil conditions and the abundance of arthropods, specifically Collembola, Acari, and other arthropods, at AG3 in 2019.

The Table 6:29 below details the number of arthropods relative to soil characteristics at AG3 in 2021. 12 degrees Celsius was the lowest temperature recorded, while 33 degrees Celsius was the highest. The yearly mean temperature was 22.16 degrees Celsius. The pH values ranged from 7 to 7.5, with a mean of 7.28. The average E.C value was 0.178 ds/m, ranging from 0.14 to 0.22 ds/m. The range of soil moisture content was between 1.2% and 11.8%, with an average of 5.6%. The carbon content ranged from 0.08% to 0.45%, with a mean value of 0.25%. The nitrogen content ranged from 0.006% to 0.038%, averaging 0.021%. The potassium concentration ranged from 33 to 53 kg/h on average, with a mean of 42.66 kg/h. The phosphorus concentration ranged between 2 ppm and 3 ppm, averaging 2.75 ppm. Collembola (springtails) ranged from 8 to 90 individuals with an average of 44.83 individuals. The observed range of Acari (mites) was between 5 and 76 individuals, with an average of 39.91 individuals. Other arthropods were observed in numbers ranging from four to eighteen, with an average of 8.33. These values reveal the soil conditions and abundance of arthropods, including Collembola, Acari, and other arthropods, at AG3 in 2021.

Table 6:28 The number of arthropods in relation to soil factors at AG3 during the year 2019

Month, 2019	**Temp. (^{o}C)**	**pH**	**E.C (ds/m)**	**Moisture (%)**	**C (%)**	**N (%)**	**K (Kg/h)**	**P (ppm)**	**Collembola**	**Acari**	**Other arthropods**
N	12	12	12	12	12	12	12	12	12	12	12
Min	12	7	0.14	0.6	0.06	0.005	28	2	10	8	3
Max	33	7.5	0.22	11.6	0.6	0.051	51	3	82	71	13
Sum	265	86.9	2.14	65.9	3.12	0.262	485	32	527	448	96
Mean	22.08	7.241	0.178	5.491	0.26	0.021	40.4	2.66	43.91	37.3	8
Std. error	2.247	0.066	0.009	1.122	0.050	0.004	2.05	0.14	8.44	7.45	0.93
Variance	60.62	0.053	0.001	15.12	0.031	0.0002	50.8	0.24	855.7	666.2	10.5
Stand. Dev	7.786	0.231	0.032	3.889	0.176	0.0148	7.12	0.49	29.25	25.81	3.24
Median	20.5	7.1	0.17	4.9	0.2	0.017	42.5	3	38.5	31	8

Table 6:29 The number of arthropods in relation to soil factors at AG3 during the year 2021

Month, 2021	**Temp. (^{o}C)**	**pH**	**E.C (ds/m)**	**Moisture (%)**	**C (%)**	**N (%)**	**K (Kg/h)**	**P (ppm)**	**Collembola**	**Acari**	**Other arthropods**
N	12	12	12	12	12	12	12	12	12	12	12
Min	12	7	0.14	1.2	0.08	0.006	33	2	8	5	4
Max	33	7.5	0.22	11.8	0.45	0.038	53	3	90	76	18
Sum	266	87.4	2.14	67.2	3.1	0.261	512	33	538	479	100
Mean	22.1	7.2	0.178	5.6	0.258	0.021	42.66	2.75	44.83	39.9	8.33
Std. error	2.21	0.06	0.009	1.109	0.033	0.002	1.70	0.13	8.94	8.19	1.25
Variance	59.06	0.05	0.001	14.76	0.01	9.68E-05	34.96	0.20	959.96	806.0	18.78
Stand. Dev	7.68	0.22	0.032	3.84	0.11	0.009	5.91	0.452	30.98	28.39	4.33
Median	20.5	7.3	0.17	3.7	0.24	0.02	42	3	39.5	35	6.5

6.5.2 Population dynamics

The total number of organisms observed from both the agricultural and non-agricultural land in Site 3 was 4220. In 2019, the predominant taxonomic group in Agricultural land (AG3) was Collembola, which accounted for 49.47% of the total, followed by Acari at 41.54% and other arthropods, which accounted for 8.97% of the total. In 2021, however, Collembola account for 48.16 percent of the total, followed by Acari at 42.88 percent and other arthropods at 8.95 percent. The present analysis describes the species composition of arthropods in AG3, where a total of 2164 species were collected in both years. Collembola dominated the collected species with 518 and 538 species in 2019 and 2021, respectively, followed by Acari with 435 and 479 species in each year. Other arthropods, in contrast, were determined to be the least abundant, with approximately 94 and 100 species in 2019 and 2021, respectively. Collembola were found to constitute 48.79% of the total population (2164), making up the majority of the arthropod community. Nonetheless, it was observed that the same species of Site 1 in which, Collembola were present throughout the entire sampling period. The Acari population, which accounted for 42.23% of the total, ranked second in terms of numerical abundance, and a community comparable to that of Site 1 was discovered. It was determined that the proportional prevalence of the remaining taxa, including coleopterans, diplurans, pseudoscorpions, isopods, and Hymenoptera, was less than 8.96%. Figure 6:17 and Figure 6:18 depicts a comparable pattern of arthropod population occurrence in different months in relation to edaphic factors when compared to Site 1 and Site 2.

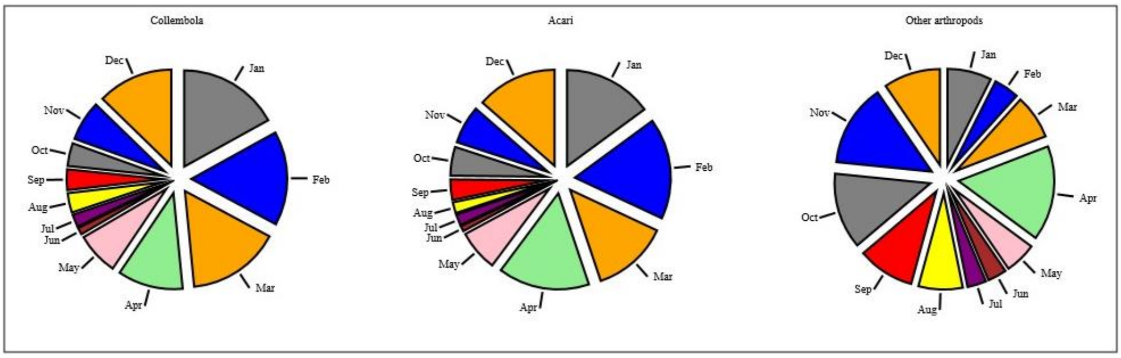


Figure 6:17 The number of Collembola, Acari, and other arthropods in month-wise presenting in AG3 during year, 2019

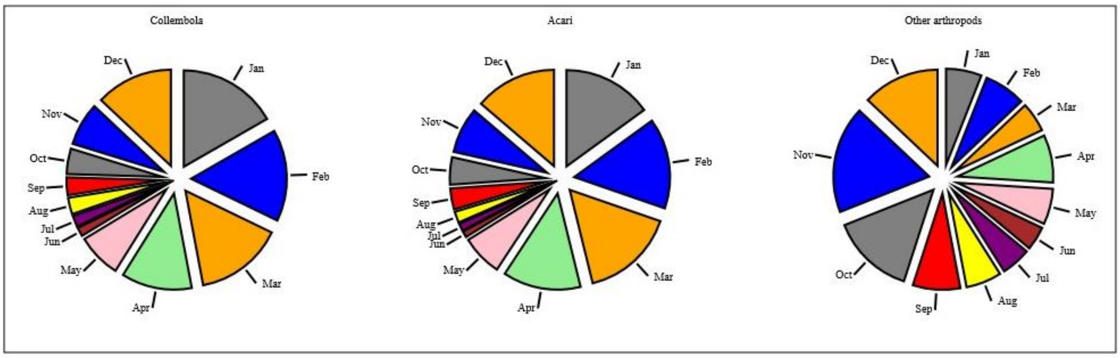


Figure 6:18 The number of Collembola, Acari, and other arthropods in month-wise presenting in AG3 during year, 2021.

6.5.3 Correlation Analysis

Correlational study between edaphic factors and arthropod population at the AG3 in 2019

The Figure 6:19 below depicts the correlation between diverse soil attributes and the abundance of arthropods in AG3 during the year 2019. The correlation between temperature and arthropod abundance exhibits a slightly positive association with a coefficient of 0.0786. There exists a moderate negative correlation (-0.5835) between the abundance of arthropods and pH. The correlation coefficient between electrical conductivity and arthropod abundance indicates a moderate negative association (-0.6378). There exists a positive correlation of slight amount (0.2863) between the abundance of arthropods and the moisture content. The correlation between carbon concentration and arthropod abundance exhibits a modest positive association (r = 0.2783). The correlation between nitrogen content and arthropod abundance exhibits a negative association, albeit with a weak strength of -0.4413. The correlation between the concentration of potassium and the abundance of arthropods exhibits a negative association of weak strength, with a coefficient of -0.3952. There exists a strong inverse relationship (-0.8882) between the abundance of arthropods and the phosphorus content. There exists a strong inverse correlation (-0.8786) between the abundance of Collembola arthropods and the total arthropod population. There exists a moderate negative correlation (-0.3325) between the abundance of Acari arthropods and the overall arthropod abundance. There is a limited degree of overlap observed among other arthropod species. In general, the aforementioned correlations indicate that the variables pH, electrical conductivity, phosphorus content, and the abundance of Collembola and Acari arthropods exhibit the most strong relationships with the overall arthropod abundance at AG3 during the year 2019.

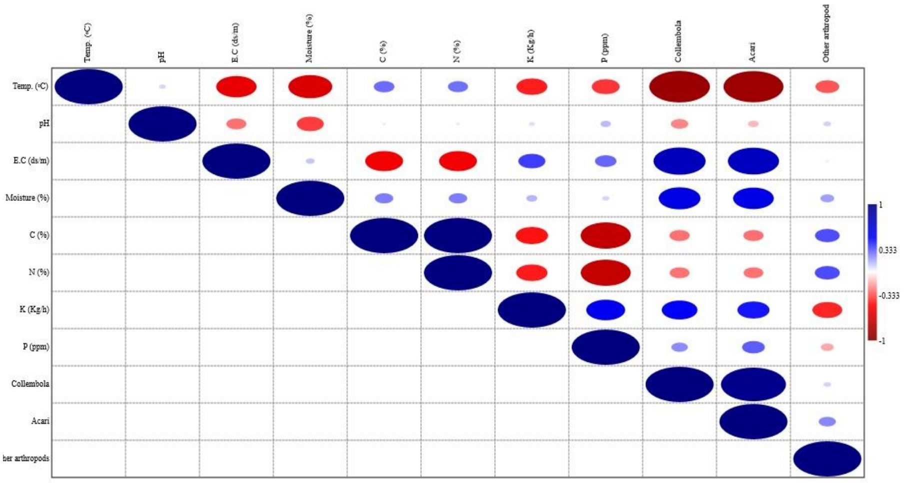


Figure 6:19 Correlation analysis between Edaphic factors and arthropods populations in AG3 during year, 2019.

Correlational study between edaphic factors and arthropod population at the AG3 in 2021

The Figure 6:20 shows the correlation between soil characteristics and arthropod density in AG3 in 2021. There is a marginal (0.0327) relationship between temperature and the number of arthropods present. The abundance of arthropods has been found to have a weakly positive connection with pH (r=0.1525). Weakly negative (-0.6013) is the relationship between electrical conductivity and the number of organisms present. The abundance of arthropods has a moderately negative connection with moisture levels (-0.6911). The carbon concentration is marginally positively correlated (0.3242) with the number of arthropods present. Weak positive (0.3277) association exists between nitrogen concentration and arthropod abundance. The abundance of arthropods has a moderately negative connection with potassium content (-0.6388). There is a moderately negative relationship between phosphorus levels and arthropod populations (-0.4316). Collembola arthropod abundance is significantly inversely related to overall arthropod abundance (r=-0.9135). Acari arthropod abundance is significantly inversely related to total arthropod abundance (-0.9145). No significant similarities to other arthropods can be found. The number of Collembola and Acari arthropods in 2021 appears to be related to the temperature, pH, electrical conductivity, moisture content, carbon content, nitrogen content, potassium content, and phosphorus content seen at

AG3. There are significant relationships between the quantity of Collembola and Acari arthropods and the abundance of other arthropods.

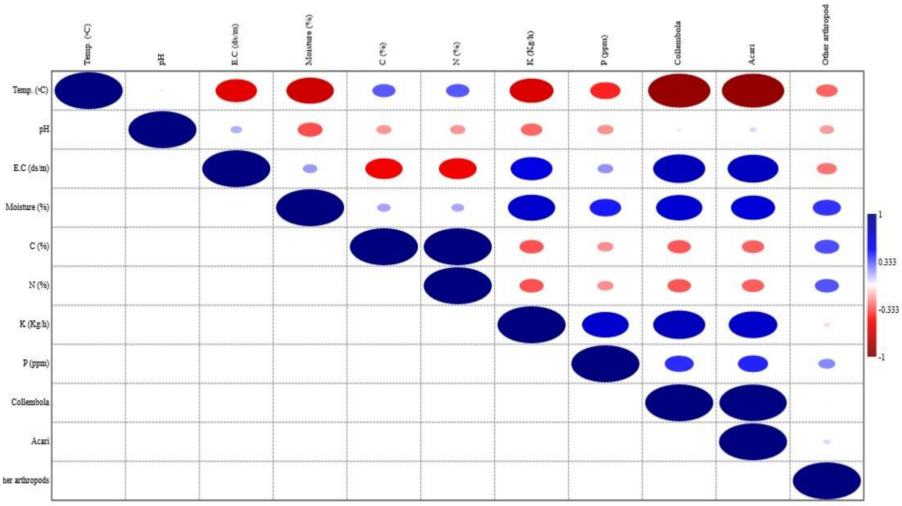


Figure 6:20 Correlation analysis between Edaphic factors and arthropods populations in AG3 during year, 2021.

6.5.4 Diversity Indices

The data in Table 6:30 reflects the diversity indices of AG3 arthropods for 2019 and 2021. Both 2019 and 2021 observed the identification of 12 taxa (families) of arthropods at AG3. This indicates that there were the same number of distinct arthropod groups in both years. In 2019, a total of 518 individuals were documented, 435 of which belonged to the Acari group and the remaining 94 to the Other arthropods group. In 2021, a total of 538 individuals were documented, 479 of which were Acari and 100 of which were Other arthropods. Dominance denotes the relative affluence of the most populous group in the community. In both 2019 and 2021, the Dominance values for all three groups (Collembola, Acari, and Other arthropods) were relatively similar, indicating a similar distribution pattern of dominance among the groups. The values of Simpson index (1-D) for all three categories were relatively high in both years, indicating a relatively high diversity of arthropods at AG3. In 2019 and 2021, the Shannon index (H) values for all three categories were comparable, indicating an equal amount of diversity. In both years, the evenness values were fairly high for all three categories, indicating a balanced distribution of organisms among the taxa. In both years, the Margalef values for all three categories were comparable, indicating an equivalent amount of species diversity. In both years, the equitability values for all three categories were relatively high, indicating an almost equitable distribution of organisms among the taxa. Between 2019 and 2021, the diversity of arthropods at AG3 maintained comparatively stable, according to the data. In both years, the number of taxa and the diversity and evenness indices exhibited similar values. This indicates that the diversity and composition of the arthropod community remained stable during the study period.

Table 6:30 Diversity indices of arthropods from AG3 in year 2019 and 2021

Index	**2019**			**2021**		
	Collembola	**Acari**	**Other arthropods**	**Collembola**	**Acari**	**Other arthropods**
Taxa (S)	12	12	12	12	12	12
Individuals	518	435	94	538	479	100
Dominance (D)	0.1207	0.1231	0.1025	0.1198	0.122	0.104
Simpson (1-D)	0.8793	0.8769	0.8975	0.8802	0.878	0.896
Shannon (H)	2.247	2.222	2.369	2.249	2.223	2.374
Evenness (EVNS)	0.7883	0.7687	0.8906	0.7896	0.7694	0.8952
Margalef	1.76	1.811	2.421	1.749	1.782	2.389
Equitability (J)	0.9043	0.8942	0.9534	0.9049	0.8945	0.9554

[S for Taxa; D for Dominance; H for Shannon Diversity; EVNS for Evenness and J for Equitability]

6.5.5 One-Way ANOVA

For AG3 (2019)

Test for equal means

The sum of squares between groups (35477.3) denotes the extent of variation that can be ascribed to dissimilarities among the groups under comparison in AG3. The sum of squares within groups (19135.5) explains the variance present within each group, and this is not attributable to dissimilarities between the groups. The statistical analysis reveals that the F-value of 22.43 is indicative of a considerable ratio between the mean square of the between-groups and the within-groups. This finding suggests that there exist noteworthy distinctions between the means of the groups in AG3 during the year 2019. The F-value obtained through calculation is 22.43, and the associated p-value is 3.37E-23 (or nearly 0). The data suggests that there exists a statistically significant disparity between the means of the groups in AG3 during the year 2019. In summary, the outcomes of the one-way ANOVA indicate that there exist noteworthy dissimilarities among the AG3 groups in the year 2019, with respect to the scrutinized dependent variable.

For AG3 (2021)

In the year 2021, the value of the sum of squares between groups in AG3 is 39888.7. This metric serves as an indicator of the extent to which the observed variation can be attributed to differences between groups. The inter-group variability can be attributed to the sum of squares (20833), which represents the variation that is present within each group but cannot be attributed to differences between groups. The statistical analysis reveals that there exist significant variations between the group means in AG3 for the year 2021, as indicated by the F-value of 23.17. This value is derived from the ratio of the mean square between-groups to the mean square within-groups. The statistical significance of the observed differences between group means is supported by the p-value of 9.86E-24, which is close to zero. This suggests that the likelihood of these differences occurring by chance alone is highly improbable, thus providing further support for the rejection of the null hypothesis. The statistical analysis of the one-way ANOVA conducted in AG3 for the year 2021 indicates that there exist significant differences among the groups concerning the dependent variable under consideration.

6.5.6 Seasonal fluctuations of soil organisms

Arthropods organisms and month wise populations at AG3 in 2019

As depicted in Table 6:31, the number of organisms recorded each month fluctuates throughout 2019. January and February had the highest number of observed organisms (160), followed by March (144), April (139) and December (134). In comparison to the winter season, the period from May to October had a lower organism abundance. According to the data, the arthropod species population at AG3 fluctuates over time. In addition, the organisms observed throughout the study period were analogous to those observed at Site 1 and Site 2 as previously discussed, with the exception of variations in the populations of each species.

Table 6:31 Month-wise arthropod population at AG3 in 2019

Name of the Species/Family/Order	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Collembola												
Fam.*Isotomidae*	10	9	8	7	4	1	1	2	1	2	5	9
Cryptopygus sp.	9	7	8	5	4	1	1	2	2	2	3	9
Isotoma sp.	7	7	7	5	3	1	1	1	1	1	4	8
Isotomiella sp.	9	7	6	6	4	1	1	1	2	2	3	8
Isotomurus sp.	6	7	8	5	6	0	1	3	2	2	4	7
Folsomia quadrioculata	7	8	6	5	3	1	1	1	2	2	2	5
Hypogastrura sp.	8	7	8	4	3	0	1	1	2	1	2	6
Lepidocyrtus sp.	8	8	7	5	2	0	1	1	1	2	3	3
Entomobrya sp.	8	9	8	6	2	0	1	3	2	2	3	3
Sminthrus sp.	8	7	7	6	3	0	1	1	2	2	3	4
Fam.*Katiannidae*	8	6	8	3	3	1	1	1	1	2	3	4
Acari												
Fam.*Acaridae*	7	8	6	4	4	1	1	1	1	2	4	5
Fam.*Laelapidae*	8	8	6	6	4	0	1	1	2	2	2	7
Fam.*Cunaxidae*	7	9	5	7	3	0	0	1	1	4	2	7
Ord. *Cryptostigmata*	6	9	8	6	6	1	1	1	1	2	3	6
Fam.*Phytoseiidae*	7	8	5	5	3	0	1	0	1	1	3	5
Poecilochirus carabi	8	6	5	8	4	1	1	1	1	3	3	5
Sperchonopsis ecphyma	6	7	6	7	2	0	0	1	2	2	3	6
Acari juveniles	5	7	5	9	2	0	2	0	2	2	2	6
Fam.*Rhodacaroidea*	5	6	5	7	1	0	0	2	1	2	2	6
Demodex folliculorum	6	6	5	8	1	1	1	0	3	1	4	6
Other arthropods												
Cortinicara sp. (Fam.*Latridiidae*)	1	1	2	1	0	0	1	1	1	1	1	1
Anthicidae species	1	0	1	2	1	1	0	0	1	1	2	2
Fam.*Carabidae*	1	0	1	2	1	1	0	1	1	2	1	1
Hymenoptera	2	1	1	3	1	0	1	1	1	1	1	1
Psocoptera	1	1	1	3	0	0	0	1	1	2	3	1
Diplura	0	1	1	2	0	0	0	1	2	2	2	1
Diptera	0	0	0	1	1	1	1	1	1	2	2	1
Pseudoscorpions	1	0	0	1	1	0	0	1	1	1	1	1
N	29	29	29	29	29	29	29	29	29	29	29	29
Min	0	0	0	1	0	0	0	0	1	1	1	1
Max	10	9	8	9	6	1	2	3	3	4	5	9
Sum	160	160	144	139	72	13	22	32	42	53	76	134
Mean	5.51	5.51	4.965	4.79	2.48	0.44	0.75	1.10	1.44	1.82	2.62	4.62
Std. error	0.58	0.60	0.519	0.41	0.30	0.09	0.09	0.13	0.10	0.12	0.18	0.48
Variance	9.83	10.75	7.820	5.09	2.68	0.25	0.26	0.52	0.32	0.43	1.02	6.95
Stand. Dev	3.13	3.280	2.796	2.25	1.63	0.50	0.51	0.72	0.57	0.65	1.01	2.63
Median	7	7	6	5	3	0	1	1	1	2	3	5

Arthropods organisms and month wise populations at AG3 in 2021

The study conducted on the arthropod species population at AG3 in 2021 has indicated noteworthy temporal variations in the observed individuals, as presented in Table 6:32. The monthly displays demonstrated fluctuation, with January presenting the highest number of observations (168), closely trailed by February (163), March (161), and December (149) and April (135). In contrast, there was a decrease in the frequency of observations from May to November, indicating a potential decline in the population size during this time frame. The findings of the study demonstrate a distinct seasonal pattern in the dynamics of the population, whereby the winter months exhibit the highest population density and the summer months exhibit the lowest population density. However, similar pattern of organisms was found in site 1 and site 2 except the variations in numbers. This finding enhances our understanding of the temporal distribution patterns of the arthropod community and underscores the impact of seasonal fluctuations on population densities at AG3.

Table 6:32 Month-wise arthropod population at AG3 in 2021

Name of the Species/Family/Order	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Collembola												
Fam.*Isotomidae*	10	9	8	7	4	1	1	2	1	2	5	9
Cryptopygus sp.	9	7	8	5	4	1	1	2	2	2	4	9
Isotoma sp.	7	7	7	5	6	1	1	1	1	1	4	8
Isotomiella sp.	9	7	6	6	4	1	1	1	2	2	3	8
Isotomurus sp.	6	7	8	5	6	0	1	3	2	2	4	7
Folsomia quadrioculata	7	8	6	6	3	1	1	1	2	2	2	9
Hypogastrura sp.	9	7	8	4	3	2	0	1	2	1	2	6
Lepidocyrtus sp.	8	8	7	6	2	0	1	0	0	3	3	3
Entomobrya sp.	8	9	8	6	2	0	1	2	1	3	3	3
Sminthrus sp.	8	7	7	6	3	0	1	1	2	3	6	4
Fam.*Katiannidae*	9	7	7	8	3	1	1	1	1	2	3	4
Acari												
Fam.*Acaridae*	7	8	9	4	4	1	1	1	1	2	4	7
Fam.*Laelapidae*	9	8	6	6	4	0	1	1	2	2	2	7
Fam.*Cunaxidae*	7	9	8	7	3	0	0	1	1	4	2	7
Ord. *Cryptostigmata*	9	9	8	6	6	1	1	1	1	2	4	6
Fam.*Phytoseiidae*	9	8	8	5	3	0	1	0	2	2	6	7
Poecilochirus carabi	9	5	8	8	4	1	1	1	1	3	3	5
Sperchonopsis ecphyma	6	7	7	7	4	0	0	1	2	2	4	7
Acari juveniles	5	7	8	6	3	1	0	1	2	2	4	7
Fam.*Rhodacaroidea*	5	6	7	7	1	0	0	2	2	2	4	5
Demodex folliculorum	6	6	7	7	1	1	1	0	3	1	4	8
Other arthropods												
Cortinicara sp. (Fam.*Latridiidae*)	1	1	1	1	0	0	1	1	1	1	1	2
Anthicidae species	1	0	1	1	1	1	0	0	1	1	2	2
Fam.*Carabidae*	1	1	1	1	1	1	1	0	0	3	1	1
Hymenoptera	1	2	1	1	1	0	1	1	1	1	2	1
Psocoptera	1	2	0	1	0	0	0	1	1	2	4	3
Diplura	0	1	1	1	1	1	1	1	2	2	2	2
Diptera	0	0	0	1	1	1	1	1	1	2	2	1
Pseudoscorpions	1	0	0	1	1	0	0	1	1	2	4	1
N	29	29	29	29	29	29	29	29	29	29	29	29
Min	0	0	0	1	0	0	0	0	0	1	1	1
Max	10	9	9	8	6	2	1	3	3	4	6	9
Sum	168	163	161	135	79	17	21	30	41	59	94	149
Mean	5.79	5.62	5.55	4.65	2.72	0.58	0.724	1.034	1.41	2.03	3.24	5.13
Std. error	0.63	0.58	0.59	0.46	0.32	0.10	0.084	0.126	0.12	0.13	0.24	0.50
Variance	11.6	9.88	10.1	6.16	2.99	0.32	0.206	0.463	0.46	0.53	1.68	7.48
Stand. Dev	3.41	3.14	3.18	2.48	1.72	0.56	0.454	0.680	0.688	0.73	1.29	2.73
Median	7	7	7	6	3	1	1	1	1	2	3	6

6.5.7 Diversity indices of arthropods in month-wise from AG3

The data presented in Table 6:33 comprises the diversity indices of arthropods in AG3 during the months of 2019 and 2021. Every month, a varying number of arthropod taxa ranging from thirteen to twenty-nine are observed. The monthly aggregate count of arthropods observed exhibits fluctuations ranging from 13 to 160. The community values of taxon dominance fall within the range of 0.038 to 0.076. The Simpson values exhibit a range from 0.92 to 0.96. The Shannon values range between 2.56 and 3.307. The Evenness values exhibit a range spanning from 0.827 to 1. The Margalef indices exhibit a range of values spanning from 4.67 to 7.491. The range of Equitability values falls between 0.946 to 1. The diversity indices observed in 2021 exhibit a comparable trend to those of 2019, albeit with certain fluctuations in monthly values. During both years, there was a notable level of species richness and diversity observed, however with some variability in the distribution and abundance of arthropods across different months. The indices of evenness are indicative of differing levels of balance in the dispersion of arthropod taxa.

Table 6:33 Diversity indices of all arthropods in month-wise from AG3 in year 2019 and 2021

Diversity Indices												
2019	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Taxa (S)	27	25	27	29	26	13	21	25	29	29	29	29
Individuals	160	160	144	139	72	13	22	32	42	53	76	134
Dominance(D)	0.045	0.046	0.045	0.041	0.049	0.076	0.049	0.048	0.039	0.038	0.039	0.045
Simpson (1-D)	0.95	0.95	0.955	0.958	0.951	0.923	0.950	0.951	0.960	0.961	0.960	0.95
Shannon (H)	3.153	3.111	3.159	3.246	3.118	2.565	3.028	3.13	3.296	3.307	3.292	3.186
Evenness (EVNS)	0.86	0.89	0.87	0.88	0.86	1	0.98	0.91	0.93	0.94	0.92	0.83
Margalef	5.12	4.7	5.23	5.67	5.84	4.67	6.47	6.92	7.49	7.05	6.46	5.71
Equitability(J)	0.95	0.9	0.95	0.96	0.95	1	0.99	0.97	0.97	0.98	0.97	0.94
2021												
Taxa (S)	27	26	26	29	27	16	21	24	27	29	29	29
Individuals	168	163	161	135	79	17	21	30	41	59	94	149
Dominance(D)	0.046	0.0449	0.045	0.04	0.047	0.06	0.047	0.04	0.042	0.03	0.039	0.043
Simpson (1-D)	0.95	0.9551	0.954	0.95	0.952	0.93	0.952	0.95	0.957	0.96	0.960	0.956
Shannon (H)	3.1	3.148	3.133	3.197	3.143	2.752	3.045	3.10	3.227	3.305	3.287	3.21
Evenness (EVNS)	0.85	0.89	0.88	0.84	0.858	0.97	1	0.93	0.933	0.93	0.922	0.854
Margalef	5.07	4.9	4.92	5.70	5.95	5.294	6.569	6.76	7.001	6.86	6.163	5.596
Equitability (J)	0.95	0.96	0.96	0.94	0.953	0.99	1	0.97	0.979	0.98	0.976	0.953

6.6 Site 3- Agriculture land (NAG3)

6.6.1 Edaphic factors

The following is a 2019 (Table 6:34) analysis of the arthropod abundance at NAG3 in relation to soil factors. The lowest temperature recorded was 12 degrees Celsius, while 33 degrees Celsius was the maximum. The annual average temperature was 22.08 degrees Celsius. The pH varied between 7 and 7.5, with a mean of 7.18. The E.C values varied between 0.14 and 0.21 ds/m, with an average of 0.1575 ds/m. The soil's moisture content ranged from 1.2% to 11.8%, with a mean of 5.625%. The carbon content ranged between 0.06% and 0.6%, with an average of 0.26%. The nitrogen content ranged from 0.005% to 0.051%, averaging 0.021%. The potassium concentration ranged from 28 to 51 kg/h on average, with a mean of 40.41 kg/h. The phosphorus concentration varied between 2 ppm and 3 ppm, with a mean of 2.66 ppm. The observed Collembola population ranged from 6 to 79 individuals, with a mean of 41.75. The observed range of Acari was 4 to 71, with an average of 34 individuals. The number of other arthropods ranged from 4 to 12, with an average of 7.66 individuals. These values provide information about the soil conditions and the abundance of arthropods, specifically Collembola, Acari, and other arthropods, at NAG3 in 2019.

The Table 6:35 below details the number of arthropods relative to soil characteristics at NAG3 in 2021. 12 degrees Celsius was the lowest temperature recorded, while 33 degrees Celsius was the highest. The yearly mean temperature was 22.16 degrees Celsius. The pH values ranged from 7 to 7.5, with a mean of 7.316. The average E.C value was 0.178 ds/m, ranging from 0.14 to 0.22 ds/m. The range of soil moisture content was between 0.9% and 12.3%, with an average of 5.708%. The carbon content ranged from 0.08% to 0.45%, with a mean value of 0.25%. The nitrogen content ranged from 0.006% to 0.038%, averaging 0.02175%. The potassium concentration ranged from 33 to 53 kg/h on average, with a mean of 42.66 kg/h. The phosphorus concentration ranged between 2 ppm and 3 ppm, averaging 2.75 ppm. Collembola (springtails) ranged from 7 to 80 individuals with an average of 42.25 individuals. The observed range of Acari (mites) was between 6 and 73 individuals, with an average of 38.08 individuals. Other arthropods were observed in numbers ranging from 4 to 13, with an average of 7.58. These values reveal the soil conditions and abundance of arthropods, including Collembola, Acari, and other arthropods, at NAG3 in 2021.

Table 6:34 The number of arthropods in relation to soil factors at NAG3 during the year 2019

Month, 2019	**Temp. (°C)**	**pH**	**E.C (ds/m)**	**Moisture (%)**	**C (%)**	**N (%)**	**K (Kg/h)**	**P (ppm)**	**Collembola**	**Acari**	**Other arthropods**
N	12	12	12	12	12	12	12	12	12	12	12
Min	12	7	0.14	1.2	0.06	0.005	28	2	6	4	4
Max	33	7.5	0.21	11.8	0.6	0.051	51	3	79	71	12
Sum	265	86.2	1.89	67.5	3.12	0.262	485	32	501	408	92
Mean	22.0	7.18	0.157	5.62	0.26	0.021	40.41	2.66	41.75	34	7.66
Std. error	2.24	0.05	0.005	1.13	0.050	0.004	2.05	0.14	8.322	7.56	0.74
Variance	60.6	0.03	0.0004	15.3	0.031	0.00021	50.8	0.24	831.1	686.5	6.60
Stand. Dev	7.78	0.19	0.02	3.92	0.176	0.014	7.12	0.49	28.82	26.20	2.57
Median	20.5	7.1	0.15	4.9	0.2	0.017	42.5	3	39	26.5	7

Table 6:35 The number of arthropods in relation to soil factors at NAG3 during the year 2021

Month, 2021	**Temp. (°C)**	**pH**	**E.C (ds/m)**	**Moisture (%)**	**C (%)**	**N (%)**	**K (Kg/h)**	**P (ppm)**	**Collembola**	**Acari**	**Other arthropods**
N	12	12	12	12	12	12	12	12	12	12	12
Min	12	7	0.14	0.9	0.08	0.006	33	2	7	6	4
Max	33	7.5	0.22	12.3	0.45	0.038	53	3	80	73	13
Sum	266	87.8	2.14	68.5	3.1	0.261	512	33	507	457	91
Mean	22.16	7.31	0.17	5.70	0.25	0.021	42.66	2.75	42.25	38.0	7.583
Std. error	2.218	0.06	0.009	1.15	0.03	0.002	1.707	0.13	8.74	7.83	0.829
Variance	59.06	0.05	0.001	16.1	0.01	9.68E-05	34.96	0.20	917.	736.9	8.265
Stand. Dev	7.685	0.22	0.032	4.01	0.11	0.009	5.913	0.45	30.2	27.14	2.874
Median	20.5	7.5	0.17	3.7	0.245	0.02	42	3	39.5	32.5	6.5

6.6.2 Population dynamics

The total number of organisms observed from non-agricultural site was 2056 individuals/m^2, the predominant taxonomic group in Agricultural land (NAG3) 2019, was Collembola, which accounted for 50.04% of the total, followed by Acari at 40.75% and other arthropods, which accounted for 9.19% of the total. In 2021, however, Collembola account for 48.05 percent of the total, followed by Acari at 43.31 percent and other arthropods at 8.62 percent. Collembola dominated the collected species with 501 and 507 species in 2019 and 2021, respectively, followed by Acari with 408 and 457 species in each year. Other arthropods, in contrast, were determined to be the least abundant, with approximately 92 and 91 species in 2019 and 2021, respectively. Collembola were found to constitute 49.02% of the total population, making up the majority of the arthropod community. Nonetheless, it was observed that the same species of Site 1 in which, Collembola were present throughout the entire sampling period. The Acari population, which accounted for 42.07% of the total, ranked second in terms of numerical abundance, and a community comparable to that of Site 1 was discovered. It was determined that the proportional prevalence of the remaining taxa, including coleopterans, diplurans, pseudoscorpions, isopods, and Hymenoptera, was less than 8.9%. Figure 6:21 and Figure 6.22 depicts a comparable pattern of arthropod population occurrence in different months in relation to edaphic factors when compared to Site 1 and Site 2.

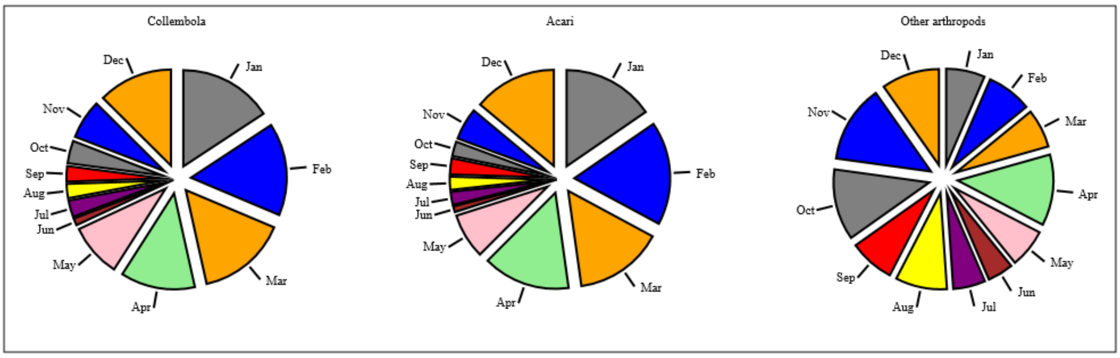


Figure 6:21 The number of Collembola, Acari, and other arthropods in month-wise presenting in NAG3 during year, 2019

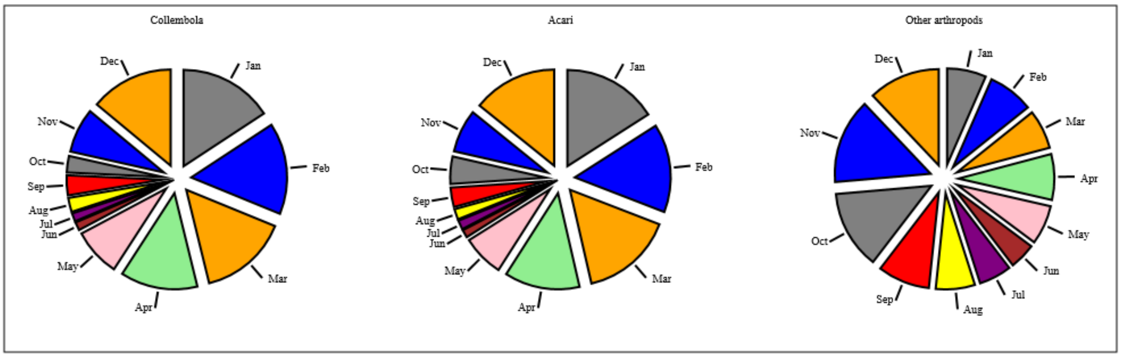


Figure 6:22 The number of Collembola, Acari, and other arthropods in month-wise presenting in NAG3 during year, 2021

6.6.3 Correlation Analysis

Correlational study between edaphic factors and arthropod population at the NAG3 in 2019

An analysis of the correlation coefficients between the pertinent variables can be conducted to assess the correlation between arthropods and edaphic parameters is given in Figure 6:23. The variables that exhibit the most robust negative correlations, indicating a significant negative relationship, are temperature (-0.88276) and pH (-0.868). Furthermore, the percentage of moisture displays a moderately favourable correlation coefficient of 0.53435. The Acari species displays a notable negative correlation with both pH (-0.868) and temperature (-0.868). Moisture (percent) exhibits a moderate positive correlation (0.54183). There exists a negative correlation (-0.32555) of low magnitude between temperature and other arthropods, which is comparatively less significant. According to the data, temperature and pH exhibit the most pronounced adverse associations with both Collembola and Acari. Arthropods and moisture content display moderately favourable correlations. Typically, there exists a lower degree of association between various arthropods and soil-related factors.

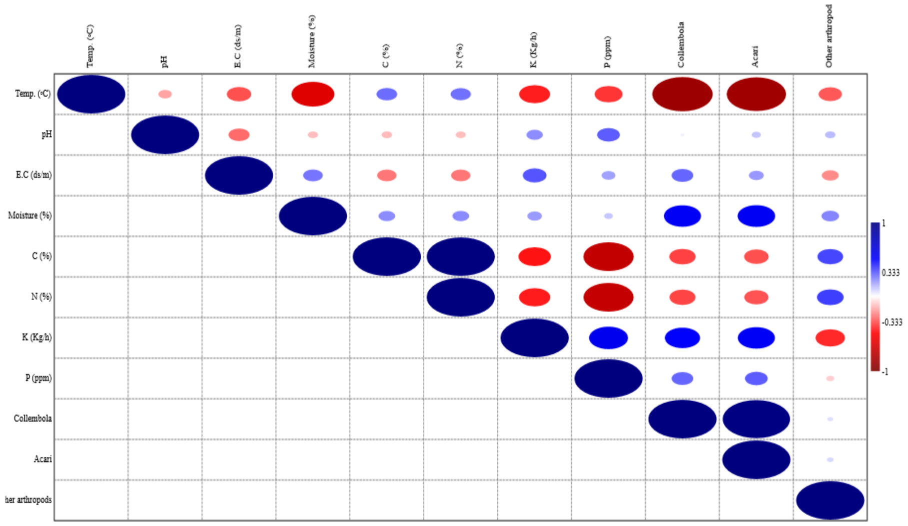


Figure 6:23 Correlation analysis between Edaphic factors and arthropods populations in NAG3 during year, 2019

Correlational study between edaphic factors and arthropod population at the NAG3 in 2021

The Figure 6:24 presents correlation coefficients that establish the relationship between diverse arthropods and other associated factors. The data suggests a significant negative correlation (r = -0.92321) between the abundance of Collembola and temperature (^{o}C), implying that an increase in temperature is associated with a decrease in the occurrence of Collembola. The aforementioned variables exhibit positive correlations with each other, as evidenced by their respective correlation coefficients: pH (0.37825), E.C (ds/m) (0.75951), Moisture (%) (0.62009), K (Kg/h) (0.69749), P (ppm) (0.37667), Acari (0.99262), and Other arthropods (0.061867). The data indicates a significant negative correlation (r = -0.91425) between Acari and temperature (^{o}C), suggesting that an increase in temperature is associated with a decrease in the presence of Acari. The aforementioned variables exhibit positive correlations with the given factors: pH (0.34638), electrical conductivity (ds/m) (0.7332), moisture content (%) (0.64855), potassium (Kg/h) (0.72672), phosphorous (ppm) (0.4387), Collembola (0.99262), and Other arthropods (0.11114). The data indicates a negative correlation between temperature (^{o}C) and the presence of other arthropods, with a coefficient of -0.29694. This suggests a minor reduction in the abundance of other arthropods as temperature increases. The data indicates that there exist positive correlations between the variable in question and the following factors: Moisture (%) (0.43029), C (%) (0.41812), N (%) (0.40748), and P (ppm) (0.19227). The data reveals a noteworthy correlation between Collembola (0.061867) and Acari (0.11114), suggesting a potential linkage between the existence of other arthropods and the occurrence of Collembola and Acari. The correlation coefficients offer valuable insights into the associations between arthropod populations and environmental variables. The indicators demonstrate the potential impact of alterations in the variables on the prevalence or population density of the arthropods.

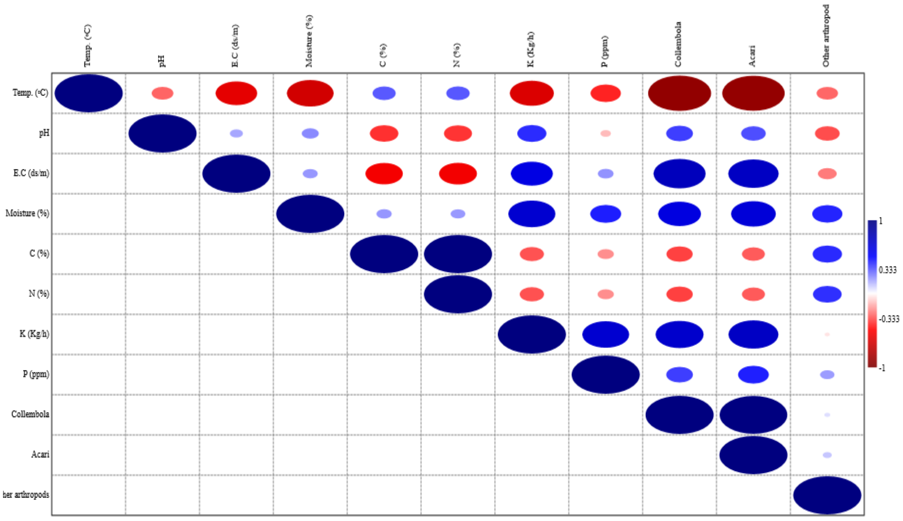


Figure 6:24 Correlation analysis between Edaphic factors and arthropods populations in NAG3 during year, 2021

6.6.4 Diversity Indices

The data in Table 6:36 reflects the diversity indices of NAG3 arthropods for 2019 and 2021. Both 2019 and 2021 observed the identification of 12 taxa (families) of arthropods at NAG3. This indicates that there were the same number of distinct arthropod groups in both years. In 2019, a total of 501 Collembola were documented, 408 of which belonged to the Acari group and the remaining 92 to the Other arthropods group. In 2021, a total of 507 individuals were documented, 457 of which were Acari and 91 of which were Other arthropods. Dominance denotes the relative affluence of the most populous group in the community. In both 2019 and 2021, the Dominance values for all three groups (Collembola, Acari, and Other arthropods) were relatively similar, indicating a similar distribution pattern of dominance among the groups. The values of Simpson index (1-D) for all three categories were relatively high in both years, indicating a relatively high diversity of arthropods at NAG3. In 2019 and 2021, the Shannon index (H) values for all three categories were comparable (more than 2), indicating an equal amount of diversity. In both years, the evenness values were fairly high for all three categories, indicating a balanced distribution of organisms among the taxa. In both years, the Margalef values for all three categories were comparable, indicating an equivalent amount of species diversity. In both years, the equitability values for all three categories were relatively high, indicating an almost equitable distribution of organisms among the taxa. Between 2019 and 2021, the diversity of arthropods at NAG3 maintained comparatively stable, according to the data. In both years, the number of taxa and the diversity and evenness indices exhibited similar values. This indicates that the diversity and composition of the arthropod community remained stable during the study period.

Table 6:36 Diversity indices of arthropods from NAG3 in year 2019 and 2021

Index	**2019**			**2021**		
	Collembola	**Acari**	**Other arthropods**	**Collembola**	**Acari**	**Other arthropods**
Taxa (S)	12	12	12	12	12	12
Individuals	501	408	92	507	457	91
Dominance (D)	0.1198	0.1287	0.09192	0.1226	0.1222	0.09431
Simpson (1-D)	0.8802	0.8713	0.9081	0.8774	0.8778	0.9057
Shannon (H)	2.245	2.189	2.434	2.222	2.226	2.423
Evenness (EVNS)	0.7869	0.7438	0.9504	0.7687	0.7723	0.9398
Margalef	1.769	1.83	2.433	1.766	1.796	2.439
Equitability (J)	0.9035	0.8809	0.9795	0.8942	0.896	0.975

{Taxa-S; Dominance-D; Simpson (1-D), Shannon (H); Evenness (EVNS); Equitability (J)}

6.6.5 One-Way ANOVA

For NAG3 (2019)

For One-Way ANOVA in NAG3 during the year 2019, the value of 33463.5 for the sum of squares between groups represents the degree of variability that can be attributed to differences among the groups being compared in the context of NAG3. The intra-group sum of squares (18165.2) accounts for the variability that exists within each group, and this cannot be attributed to differences between the groups. Based on the statistical analysis conducted, it can be inferred that the F-value of 22.29 signifies a significant ratio between the mean square of the between-groups and the within-groups. This discovery implies that significant differences exist between the averages of the NAG3 groups in the year 2019. The calculated F-value is 22.29, with a corresponding p-value of 4.30E-23 (or approximately zero). Based on the data analysis, it can be concluded that there is a notable difference between the means of the groups in NAG3 for the year 2019, which is statistically significant. In brief, the results of the one-way ANOVA reveal significant differences among the NAG3 groups in 2019, in relation to the examined dependent variable.

For NAG3 (2021)

The result of a unidirectional analysis of variance (ANOVA) conducted in NAG3 during the year 2021. In the year 2021, the value of the sum of squares between groups in NAG3 is 37230.6. This metric serves as an indicator of the extent to which the observed variation can be attributed to differences between groups. The inter-group variability can be attributed to the sum of squares (19500.8), which represents the variation that is present within each group but cannot be attributed to differences between groups. The statistical analysis reveals that there exist significant variations between the group means in NAG3 for the year 2021, as indicated by the F-value of 23.1. This value is derived from the ratio of the mean square between-groups to the mean square within-groups. The p-value of 1.10E-23 in this instance is notably diminutive, signifying compelling evidence contradicting the null hypothesis of negligible disparities. Thus, it can be inferred that there exist significant statistical variations in the diversity indices of arthropods across the groups in NAG3 for the year 2021.

6.6.6 Seasonal fluctuations of soil organisms

Arthropods organisms and month wise populations at NAG3 in 2019

As depicted in Table 6:37, the number of organisms recorded each month fluctuates throughout 2019. January (148) and February (156) had the highest number of observed organisms, followed by March (143), April (134) and December (129). In comparison to the winter season, the period from May to October had a lower organism abundance. According to the data, the arthropod species population at NAG3 fluctuates over time.

In addition, the organisms observed throughout the study period were analogous to those observed at Site 1 and Site 2 as previously discussed, with the exception of variations in the populations of each species.

Table 6:37 Month-wise arthropod population at NAG3 in 2019

Name of the Species/Family/Order	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Collembola												
Fam.*Isotomidae*	9	7	8	6	5	1	1	2	1	2	5	7
Cryptopygus sp.	7	7	8	6	4	1	1	2	2	1	2	7
Isotoma sp.	7	7	7	4	5	0	2	1	1	1	4	8
Isotomiella sp.	7	7	6	6	5	1	2	1	2	2	3	8
Isotomurus sp.	5	7	8	5	6	0	2	1	1	2	4	7
Folsomia quadrioculata	6	6	6	6	5	1	1	1	1	2	1	7
Hypogastrura sp.	5	7	8	5	5	1	2	1	1	1	2	5
Lepidocyrtus sp.	8	7	5	6	2	0	0	0	0	1	1	3
Entomobrya sp.	8	9	6	7	2	0	1	1	1	2	1	3
Sminthrus sp.	8	7	7	6	3	0	1	1	2	3	6	4
Fam.*Katiannidae*	9	7	7	6	3	1	1	1	1	2	4	4
Acari												
Fam.*Acaridae*	7	8	9	4	4	1	1	1	1	1	2	7
Fam.*Laelapidae*	9	8	6	6	4	0	1	1	1	1	2	5
Fam.*Cunaxidae*	7	9	8	7	3	0	0	1	1	1	2	7
Ord. *Cryptostigmata*	9	9	3	6	6	1	1	1	1	1	1	6
Fam.*Phytoseiidae*	6	8	4	5	3	0	1	0	1	1	1	5
Poecilochirus carabi	6	5	5	5	4	1	1	1	1	1	2	3
Sperchonopsis ecphyma	6	7	7	7	3	0	2	1	1	1	2	7
Acari juveniles	3	7	5	6	2	0	1	1	1	1	1	7
Fam.*Rhodacaroidea*	4	4	7	7	1	0	0	2	1	1	5	5
Demodex folliculorum	6	6	7	7	1	1	1	0	2	1	4	5
Other arthropods												
Cortinicara sp. (Fam.*Latridiidae*)	1	1	1	1	0	0	1	1	1	1	1	2
Anthicidae species	1	0	1	1	1	1	0	1	2	1	1	1
Fam.*Carabidae*	1	1	1	1	1	1	1	1	0	2	1	1
Hymenoptera	1	2	1	2	1	0	1	1	0	1	1	1
Psocoptera	1	2	0	1	0	0	0	1	1	1	3	1
Diplura	0	1	1	2	1	1	1	1	1	1	1	1
Diptera	0	0	0	1	1	1	1	1	1	2	2	1
Pseudoscorpions	1	0	1	2	1	0	0	1	1	2	2	1
N	29	29	29	29	29	29	29	29	29	29	29	29
Min	0	0	0	1	0	0	0	0	0	1	1	1
Max	9	9	9	7	6	1	2	2	2	3	6	8
Sum	148	156	143	134	82	14	28	29	31	40	67	129
Mean	5.10	5.37	4.93	4.62	2.82	0.48	0.96	1	1.06	1.37	2.3	4.44
Std. error	0.57	0.56	0.54	0.40	0.34	0.09	0.11	0.08	0.098	0.10	0.27	0.46
Variance	9.52	9.24	8.56	4.81	3.36	0.25	0.39	0.21	0.28	0.31	2.15	6.32
Stand. Dev	3.08	3.04	2.92	2.19	1.83	0.50	0.62	0.46	0.52	0.56	1.46	2.51
Median	6	7	6	6	3	0	1	1	1	1	2	5

Arthropods organisms and month wise populations at NAG3 in 2021

The study conducted on the arthropod species population at NAG3 in 2021 has indicated noteworthy temporal variations in the observed individuals, as presented in Table 6:38. The monthly displays demonstrated fluctuation, with January presenting the highest number of observations (159), closely trailed by February (153), March (153), and December (147) and April (131). In contrast, there was a decrease in the frequency of observations from May to November, indicating a potential decline in the population size during this time frame. The findings of the study demonstrate a distinct seasonal pattern in the dynamics of the population, whereby the winter months exhibit the highest population density and the summer months exhibit the lowest population density. However, similar pattern of organisms was found in site 1 and site 2 except the variations in numbers. This finding enhances our understanding of the temporal distribution patterns of the arthropod community and underscores the impact of seasonal fluctuations on population densities at NAG3.

Table 6:38 Month-wise arthropod population at NAG3 in 2021

Name of the Species/Family/Order	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Collembola												
Fam.*Isotomidae*	9	8	8	6	5	1	1	2	1	2	5	7
Cryptopygus sp.	7	8	8	6	4	1	1	2	2	1	2	7
Isotoma sp.	6	9	7	4	5	1	1	1	1	1	4	9
Isotomiella sp.	6	9	8	7	3	1	1	1	2	1	3	7
Isotomurus sp.	6	8	7	5	4	1	1	1	1	1	4	7
Folsomia quadrioculata	4	6	8	6	4	1	1	2	1	1	3	7
Hypogastrura sp.	9	7	9	5	5	1	0	0	1	1	3	5
Lepidocyrtus sp.	9	7	5	6	2	0	0	1	2	1	2	7
Entomobrya sp.	8	6	6	7	2	0	0	0	3	2	2	3
Sminthrus sp.	8	4	5	6	3	0	0	1	2	1	6	5
Fam.*Katiannidae*	8	6	5	8	4	0	1	1	1	2	4	7
Acari												
Fam.*Acaridae*	8	8	9	4	4	1	1	1	1	2	2	8
Fam.*Laelapidae*	8	8	6	6	4	0	1	1	1	2	3	6
Fam.*Cunaxidae*	9	9	8	7	3	0	0	1	1	2	3	8
Ord. *Cryptostigmata*	9	8	7	5	5	1	1	1	2	1	3	6
Fam.*Phytoseiidae*	8	8	7	7	3	1	1	0	1	1	3	6
Poecilochirus carabi	5	5	7	5	4	1	1	0	2	2	3	6
Sperchonopsis ecphyma	7	5	7	7	4	0	0	1	2	1	4	7
Acari juveniles	7	5	7	5	2	0	1	1	2	1	3	7
Fam.*Rhodacaroidea*	7	6	6	5	2	1	0	2	1	5	5	5
Demodex folliculorum	5	6	7	7	1	1	1	0	2	4	4	6
Other arthropods												
Cortinicara sp. (Fam.*Latridiidae*)	1	1	1	1	0	0	1	1	1	1	1	2
Anthicidae species	1	0	1	1	1	1	0	1	2	1	1	1
Fam.*Carabidae*	1	1	1	1	1	1	1	1	0	2	1	1
Hymenoptera	1	2	1	0	1	0	1	0	0	1	1	1
Psocoptera	1	2	0	1	0	0	0	0	2	2	3	1
Diplura	0	1	1	1	1	1	1	1	1	1	2	3
Diptera	0	0	0	1	1	1	1	1	1	2	2	1
Pseudoscorpions	1	0	1	1	1	0	0	1	1	2	2	1
N	29	29	29	29	29	29	29	29	29	29	29	29
Min	0	0	0	0	0	0	0	0	0	1	1	1
Max	9	9	9	8	5	1	1	2	3	5	6	9
Sum	159	153	153	131	79	17	19	26	40	47	84	147
Mean	5.48	5.27	5.27	4.51	2.72	0.58	0.65	0.89	1.37	1.62	2.89	5.06
Std. error	0.60	0.56	0.56	0.45	0.29	0.09	0.08	0.11	0.12	0.17	0.23	0.48
Variance	10.4	9.42	9.13	6.11	2.56	0.25	0.23	0.38	0.45	0.88	1.59	6.70
Stand. Dev	3.23	3.06	3.02	2.47	1.60	0.50	0.48	0.61	0.67	0.94	1.26	2.59
Median	7	6	7	5	3	1	1	1	1	1	3	6

6.6.7 Diversity indices of arthropods in month-wise from NAG3

The data presented in Table 6:39 comprises the diversity indices of arthropods in NAG3 during the months of 2019 and 2021. In both years, 27 arthropod species were recorded each month. Between the two years, there was a difference in the number of individual arthropods. In 2019, 14 to 156 individuals were tallied, while in 2021, 17 to 159 individuals will be counted. In general, the number of individuals in 2021 appears to be greater than in 2019. The dominance value of an arthropod species indicates the abundance of that species relative to other species. In both years, dominance values exhibited insignificant variations, with no major distinctions. A Simpson index for arthropods measures the likelihood that two randomly selected individuals pertain to distinct species. In both years, Simpson index values range between 0.928 and 0.960, and between 0.941 and 0.959 in 2021. The species diversity and distribution appear comparable between years. The Shannon diversity index considers both species richness and species evenness. There are minor differences between the Shannon index values of the two years, but they remain within the same range overall. As of 2019, values range from 2.63 to 3.295, whereas they will range from 2.83 to 3.27 in 2021. Differences in Shannon index values in 2021 indicate a modest increase in species diversity. The distribution of arthropod species among evenness values is uniform. The values of evenness have varied between the two years. However, the overall distribution pattern suggests a relatively balanced distribution of species. To quantify species diversity, the Margalef index is utilised. The values for 2019 are higher than those for 2021, with minor variations between the years. The 2019 species diversity appears to be marginally greater. The equivalence value is used as a measure of species abundance. There is no significant difference between the equity values from one year to the next. Despite some discrepancies between 2019 and 2021, the patterns of all arthropods in NAG3 were relatively similar. There are no significant differences in the number of taxa, dominance, or equitability values; however, there are minor differences in the number of diversity indices. Arthropod abundance and diversity may have fluctuated between the two years, but the patterns of arthropod diversity do not appear to have changed substantially.

Table 6:39 Diversity indices of all arthropods in month-wise from NAG3 in year 2019 and 2021

Diversity Indices												
2019	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Taxa (S)	27	26	27	29	27	14	23	26	26	29	29	29
Individuals	148	156	143	134	82	14	28	29	31	40	67	129
Dominance(D)	0.04	0.04	0.04	0.04	0.04	0.07	0.04	0.04	0.04	0.04	0.04	0.04
Simpson (1-D)	0.95	0.95	0.95	0.95	0.95	0.92	0.95	0.95	0.95	0.96	0.95	0.95
Shannon (H)	3.13	3.14	3.14	3.23	3.13	2.63	3.08	3.22	3.21	3.29	3.18	3.18
Evenness (EVNS)	0.85	0.89	0.85	0.87	0.84	1	0.95	0.96	0.95	0.92	0.83	0.83
Margalef	5.20	4.95	5.23	5.71	5.9	4.92	6.60	7.42	7.28	7.59	6.65	5.76
Equitability(J)	0.95	0.96	0.95	0.96	0.95	1	0.98	0.98	0.98	0.97	0.94	0.94
2021												
Taxa (S)	27	26	27	28	27	17	19	22	27	29	29	29
Individuals	159	153	153	131	79	17	19	26	40	47	84	147
Dominance(D)	0.04	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.04	0.04	0.04	0.04
Simpson (1-D)	0.95	0.95	0.95	0.95	0.95	0.94	0.94	0.94	0.95	0.95	0.95	0.95
Shannon (H)	3.13	3.14	3.14	3.17	3.16	2.83	2.9	3.04	3.22	3.23	3.273	3.21
Evenness (EVNS)	0.85	0.88	0.86	0.85	0.87	1	1	0.95	0.93	0.87	0.91	0.85
Margalef	5.12	4.97	5.16	5.53	5.95	5.64	6.1	6.44	7.04	7.27	6.31	5.61
Equitability (J)	0.95	0.96	0.95	0.95	0.95	1	1	0.98	0.97	0.96	0.97	0.95

6.7 Overview of Site 4

This research was conducted in different fields of Punjab since arthropods differ in their habitat requirements and tolerance to various biotic and abiotic environmental conditions, seasonality changes, and other factors as given in Table 6:40.

Table 6:40 Study Site description of agriculture and non-agriculture land (Site 4)

LOCATION	Lambra is situated at the geographic coordinates of Latitude- 31° 36´ 20.52´´ N and Longitude- 75° 47´ 56.5´´ E. The precipitation patterns and vegetation distribution in a given area are influenced by various factors such as the regional climate, topography, and land use practices. The period spanning from April to June is characterized by the intense heat of Lambra summer, whereas the months from July to September mark the onset of the monsoon season in the area. The period spanning from November to February marks the advent of the agreeable winter season in the area. The Jalandhar district experiences an average annual precipitation of around 600 millimeters, with much of the rainfall occurring during the monsoon season.	
VEGETATION COVER	AGRICULTURE (AG4)	NON-AGRICULTURE (NAG4)
	The region encircling Lambra is dominated by agricultural land, with an emphasis on the cultivation of grains such as wheat, rice, maize, potato, and sugarcane.	The area neighboring non-agricultural land exhibited a high density of vegetation comprising a diverse array of trees, herbs, shrubs, climbers, and grasses.
SOIL AND ENVIRONMENTAL CONDITION	The soil exhibits typical alluvial features, such as a high proportion of silt and a favourable capacity for water retention in accordance with its environmental attributes. The prevailing climatic conditions in the area are categorized as humid subtropical, featuring moderate summers and chilly winters. The region experiences a notable accumulation of precipitation during the monsoon season, which typically spans from July to September. The geographical placement of Lambra in an agricultural zone renders it a promising site for investigating the soil quality and population dynamics of soil arthropods. Such research endeavors have the capacity to provide valuable insights into the well-being and efficiency of the nearby agricultural systems.	

6.7.1 Edaphic factors

Site 4- Agriculture land (AG4)

The following (Table 6:41) is a 2019 analysis of the arthropod abundance at AG4 in relation to soil factors:

The 2019 dataset AG4 provides important insights into the prevailing environmental conditions and the quantity of arthropods within the selected study area. The monthly temperature data shows a range of values, with the lowest temperature recorded at 12°C and the highest at 33°C, resulting in an approximate mean temperature of 22.08°C. The pH values measured in the study ranged from 7.0 to 7.5, indicating a slightly acidic to neutral environment. The average pH value measured was 7.24. The electrical conductivity (E.C) values observed in the study ranged from 0.15 to 0.22 ds/m, indicating the ability of the environment to carry electrical current. The moisture content ranged from 0.8% to 11.6%, with a mean moisture level of around 4.03%. The dataset provides useful information about the numerous components of the surrounding environment. Carbon (C) percentage ranged from 0.06% to 0.6%, with a mean value of 0.22%. Nitrogen (N) content ranged from 0.005% to 0.051%, with an average of 0.019%. Potassium (K) was applied at a rate ranging from 28 to 51 Kg/h, with an average of 42.25 Kg/h. Phosphorus (P) concentrations ranged from 2 to 3 parts per million (ppm), with an average of 2.75 ppm. The dataset comprises counts for three types of arthropods: Collembola (springtails), Acari (mites), and other arthropods. Collembola abundance ranged from 8 to 85 individuals, with an average count of 43.67. The number of Acari ranged from 5 to 75, with an average of 38.75. The number of other arthropods ranged from 2 to 19, with an average of 8.83. In summary, the dataset provides a detailed account of environmental conditions and arthropod groups, providing important insights into the workings of the researched ecological system throughout 2019.

The Table 6:42 below details the number of arthropods relative to soil characteristics at AG4 in 2021. In this year, 12 degrees Celsius was the lowest temperature recorded, while 33 degrees Celsius was the highest. The yearly mean temperature was 22.16 degrees Celsius. The pH values ranged from 7 to 7.5, with a mean of 7.28. The average E.C value was 0.178 ds/m, ranging from 0.14 to 0.22 ds/m. The range of soil moisture content was between 1.2% and 11.8%, with an average of 5.6%. The carbon content ranged from 0.08% to 0.45%, with a mean value of 0.25%. The nitrogen content ranged from 0.006% to 0.038%, averaging 0.02175%. The potassium concentration ranged from 33 to 53 kg/h on average, with a mean of 42.66 kg/h. The phosphorus concentration ranged between 2 ppm and 3 ppm, averaging 2.75 ppm. Collembola (springtails) ranged from 10 to 92 individuals with an average of 45.66 individuals. The observed range of Acari (mites) was between 6 and 79 individuals, with an average of

41.6 individuals. Other arthropods were observed in numbers ranging from 4 to 19, with an average of 8.75. These values reveal the soil conditions and abundance of arthropods, including Collembola, Acari, and other arthropods, at AG4 in 2021.

Table 6:41 The number of arthropods in relation to soil factors at AG4 during the year 2019

Month, 2019	**Temp. (^{o}C)**	**pH**	**E.C (ds/m)**	**Moisture (%)**	**C (%)**	**N (%)**	**K (Kg/h)**	**P (ppm)**	**Collembola**	**Acari**	**Other arthropods**
N	12	12	12	12	12	12	12	12	12	12	12
Min	12	7	0.14	1.2	0.08	0.006	33	2	10	6	4
Max	33	7.5	0.22	11.8	0.45	0.038	53	3	92	79	19
Sum	266	87.4	2.14	67.2	3.1	0.261	512	33	548	500	105
Mean	22.166	7.283	0.178	5.6	0.25	0.021	42.66	2.75	45.66	41.66	8.75
Std. error	2.218	0.066	0.009	1.10	0.03	0.002	1.707	0.130	9.005	8.394	1.38
Variance	59.06	0.052	0.001	14.76	0.01	9.68E-05	34.96	0.204	973.15	845.5	22.9
Stand. Dev	7.685	0.22	0.032	3.84	0.11	836	5.913	0.452	31.19	29.07	4.78
Median	20.5	7.3	0.17	3.7	0.24	0.02	42	3	41	37.5	7

Table 6:42 The number of arthropods in relation to soil factors at AG4 during the year 2021

Month, 2021	**Temp. (^{o}C)**	**pH**	**E.C (ds/m)**	**Moisture (%)**	**C (%)**	**N (%)**	**K (Kg/h)**	**P (ppm)**	**Collembola**	**Acari**	**Other arthropods**
N	12	12	12	12	12	12	12	12	12	12	12
Min	12	7	0.14	0.9	0.08	0.006	33	2	7	6	4
Max	33	7.5	0.22	12.3	0.45	0.038	53	3	80	73	13
Sum	266	87.8	2.14	68.5	3.1	0.261	512	33	507	457	91
Mean	22.16	7.316	0.17	5.70	0.25	0.021	42.66	2.75	42.25	38.08	7.58
Std. error	2.218	0.066	0.009	1.15	0.03	0.002	1.707	0.130	8.74	7.836	0.82
Variance	59.06	0.052	0.001	16.12	0.013	9.68E-05	34.96	0.204	917.1	736.9	8.26
Stand. Dev	7.685	0.22	0.032	4.01	0.114	0.009	5.913	0.452	30.28	27.14	2.87
Median	20.5	7.5	0.17	3.7	0.245	0.0205	42	3	39.5	32.5	6.5

6.7.2 Population dynamics

In the year 2019, a total of 2248 organisms/m^2 were recorded from an agricultural site. The taxonomic group that was found to be most prevalent in the Agricultural land

(AG4) was Collembola, comprising 47.85% of the total count. This was followed by Acari, accounting for 42.46% of the total count, while the remaining arthropods constituted 9.68% of the total count. As of 2021, the proportion of Collembola in the overall count amounts to 47.52 percent, whereas Acari accounts for 43.36 percent and other arthropods constitute 9.10 percent of the total count. In both 2019 and 2021, Collembola were the most abundant species collected, with 524 and 548 species, respectively. The second most abundant group was Acari, with 465 and 500 species in 2019 and 2021, respectively. In contrast, it was found that other arthropod species exhibited the lowest levels of abundance, with an estimated count of approximately 106 and 105 in the years 2019 and 2021, respectively. The arthropod community was predominantly composed of Collembola, which accounted for 47.68% of the total population (2248). However, it was observed that the identical species found at Site 1, Site 2, and Site 3 exhibited the presence of Collembola throughout the entirety of the sampling period. The population of Acari, comprising 42.92% of the aggregate, secured the second position in numerical abundance. A community of similar size to that of Site 1, 2, and 3 was identified. The study concluded that the relative abundance of the remaining taxa, such as coleopterans, diplurans, pseudoscorpions, isopods, and Hymenoptera, was below 9.38%. Figure 6: 25 and Figure 6:26 depicts a comparable pattern of arthropod population occurrence in different months in relation to edaphic factors when compared to Site 1, Site 2 and Site 3.

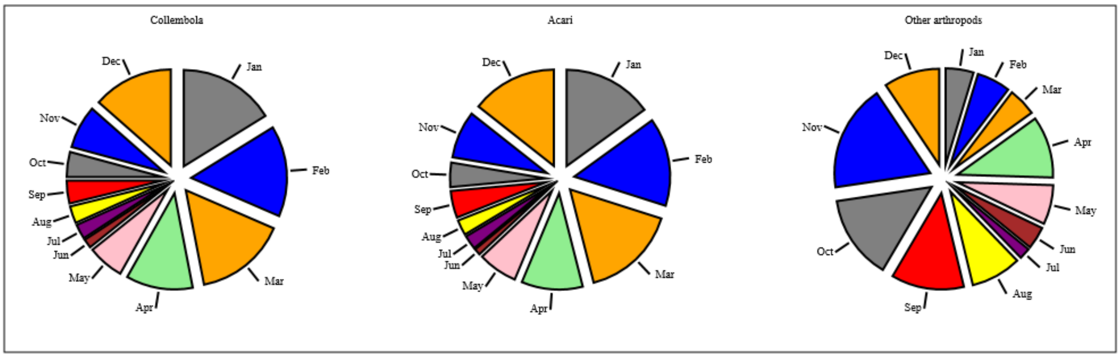


Figure 6:25 The number of Collembola, Acari, and other arthropods in month-wise presenting in AG4 during year, 2019

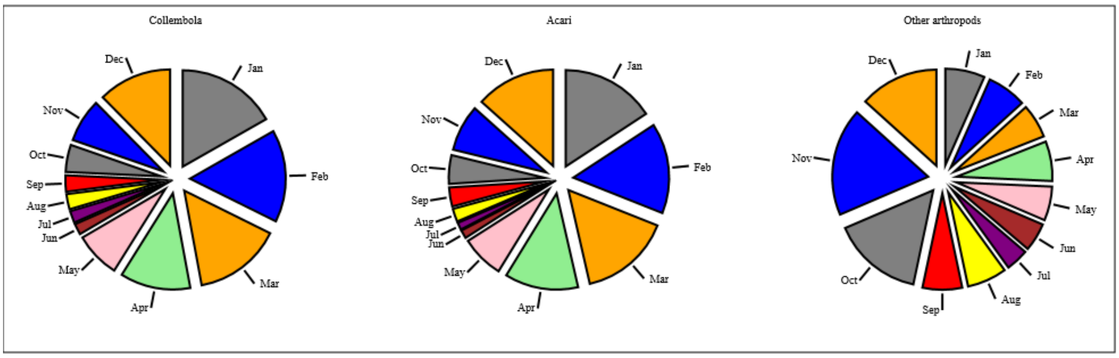


Figure 6:26 The number of Collembola, Acari, and other arthropods in month-wise presenting in AG4 during year, 2021

6.7.3 Correlation Analysis

Correlational study between edaphic factors and arthropod population at the AG4 in 2019

The Figure 6:27 displays correlation matrix that establishes a relationship between environmental factors and the abundance of arthropods. The results of the study suggest that there exists a significant positive correlation (r = 0.75068) between the abundance of Collembola and moisture content. This indicates that higher levels of moisture are positively associated with a greater abundance of Collembola. The data indicates the presence of significant negative correlations between the abundance of Collembola and various environmental factors, including temperature (-0.90278), pH (-0.23933), and other arthropods (-0.14152). The findings indicate that the abundance of Collembola exhibits a negative correlation with rising temperatures, increasing alkalinity of pH levels, and a higher count of other arthropods. A correlation of moderate positivity (0.21900) has been observed between the abundance of collembola and nitrogen content. The data implies that elevated levels of nitrogen within the surrounding ecosystem could potentially be a contributing factor to the augmentation of Collembola population. The findings indicate a robust positive correlation between Acari abundance and moisture content (0.71022), implying that higher levels of moisture are linked to a greater abundance of Acari. The data indicates the presence of significant negative correlations between acari abundance and temperature (-0.90506), pH (-0.23609), and other arthropods (-0.099222). The data indicates that there is an inverse relationship between Acari population density and temperature elevation, alkalinity escalation of pH levels, and an increase in the number of other arthropods. The correlation coefficient of 0.2263 indicates a moderate positive association between the abundance of Acari and the nitrogen content, implying that higher levels of nitrogen may be a contributing factor to the increased abundance of Acari. The findings indicate a moderate positive correlation (r = 0.71022) between the abundance of other arthropods and the moisture content, as well as a weak positive correlation (r = 0.089872) with the carbon content. These results suggest that higher levels of moisture and carbon may facilitate an increase in the abundance of other arthropods. The study reveals the existence of negative correlations between the abundance of other arthropods and electrical conductivity (-0.75728) as well as pH (-0.13488). This implies that higher levels of electrical conductivity and alkalinity in pH may be linked to a decrease in the abundance of other arthropods. These correlations provide insight into the connections between environmental variables and the prevalence of arthropods within the given dataset.

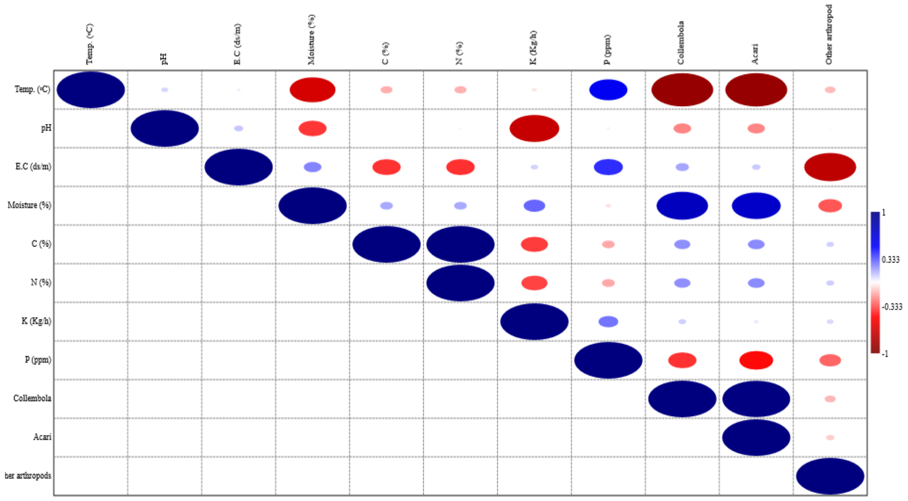


Figure 6:27 Correlation analysis between Edaphic factors and arthropods populations in AG4 during year, 2019

Correlational study between edaphic factors and arthropod population at the AG4 in 2021

The present study reveals that in the year 2021, Temperature exhibited negative correlations with Collembola abundance (-0.90907), Acari abundance (-0.92198), and other arthropods (-0.31249), as depicted in Figure 6:28. This implies that elevated temperatures could potentially have an adverse impact on the population density of said arthropods. Based on the data, it appears that there is a lack of significant associations between pH levels and arthropod populations. The pH value exhibits a modest inverse relationship with other arthropods, with a correlation coefficient of -0.2363. There is no significant correlation between arthropods and electrical conductivity. The results indicate that there exists a positive correlation between the abundance of Collembola (0.66738), Acari (0.66278), and other arthropods (0.4313) with the moisture content. This suggests that elevated levels of moisture could potentially facilitate a greater prevalence of said arthropods. The correlation between carbon content and arthropods is not significant, except for a minor positive correlation observed with other arthropods (0.33792). The correlation analysis indicates that there is no significant association between nitrogen content and arthropods, except for a minor positive correlation with other arthropods (0.32859). There is no significant correlation between the application rate of potassium and arthropods. There is no significant correlation observed between arthropods and the content of phosphorus. In general, the data indicates that the abundance of arthropods, specifically Collembola, Acari, and other arthropods, is significantly influenced by temperature and moisture content. Increased temperatures have a deleterious effect on the population density of arthropods, whereas augmented moisture levels have a tendency to foster their occurrence. The data provided does not exhibit significant associations between arthropod abundance and various factors including pH, electrical conductivity, carbon content, nitrogen content, potassium application rate, and phosphorus content.

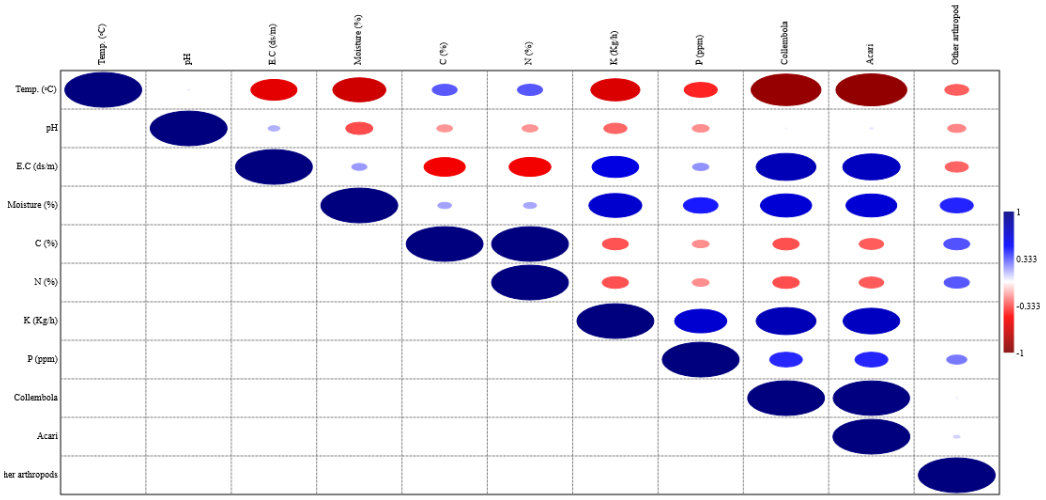


Figure 6:28 Correlation analysis between Edaphic factors and arthropods populations in AG4 during year, 2021

6.7.4 Diversity Indices

The data in Table 6:43 reflects the diversity indices of AG4 arthropods for 2019 and 2021. Both 2019 and 2021 observed the identification of 12 taxa (families) of arthropods at AG4. This indicates that there were the same number of distinct arthropod groups in both years. In 2019, a total of 524 Collembola were documented, 465 of which belonged to the Acari group and the remaining 106 to the Other arthropods group. In 2021, a total of 548 individuals were documented, 500 of which were Acari and 105 of which were Other arthropods. Dominance denotes the relative affluence of the most populous group in the community. In both 2019 and 2021, the Dominance values for all three groups (Collembola, Acari, and Other arthropods) were relatively similar, indicating a similar distribution pattern of dominance among the groups. The values of Simpson index (1-D) for all three categories were relatively high in both years, indicating a relatively high diversity of arthropods at AG4. In 2019 and 2021, the Shannon index (H) values for all three categories were comparable (more than 2), indicating an equal amount of diversity. In both years, the evenness values were fairly high for all three categories, indicating a balanced distribution of organisms among the taxa. In both years, the Margalef values for all three categories were comparable, indicating an equivalent amount of species diversity. In both years, the equitability values for all three categories were relatively high, indicating an almost Equitable distribution of organisms among the taxa. Between 2019 and 2021, the diversity of arthropods at AG4 maintained comparatively stable, according to the data. In both years, the number of taxa and the diversity and evenness indices exhibited similar values. This indicates that the diversity and composition of the arthropod community remained Stable during the study period.

Table 6:43 Diversity indices of arthropods from AG4 in year 2019 and 2021

Index	**2019**			**2021**		
	Collembola	**Acari**	**Other arthropods**	**Collembola**	**Acari**	**Other arthropods**
Taxa (S)	12	12	12	12	12	12
Individuals	524	465	106	548	500	105
Dominance (D)	0.1184	0.1179	0.1079	0.119	0.1205	0.1062
Simpson (1-D)	0.8816	0.8821	0.8921	0.881	0.8795	0.8938
Shannon (H)	2.263	2.26	2.338	2.256	2.235	2.364
Evenness (EVNS)	0.8013	0.7987	0.8635	0.795	0.7791	0.8861
Margalef	1.757	1.791	2.359	1.744	1.77	2.364
Equitability (J)	0.9108	0.9096	0.9409	0.9077	0.8995	0.9513

{Taxa-S; Dominance-D; Simpson (1-D), Shannon (H); Evenness (e H/S); Equitability (J)}

6.7.5 One-Way ANOVA

For AG4 (2019)

For One-Way ANOVA in AG4 during the year 2019, the value of 38483.3 for the sum of squares between groups represents the degree of variability that can be attributed to differences among the groups being compared in the context of AG4. The intra-group sum of squares (18666.7) accounts for the variability that exists within each group, and this cannot be attributed to differences between the groups. Based on the statistical analysis conducted, it can be inferred that the F-value of 24.95 signifies a significant ratio between the mean square of the between-groups and the within-groups. This discovery implies that significant differences exist between the averages of the AG4 groups in the year 2019. The calculated F-value is 24.95, with a corresponding p-value of 5.54E-25 (or approximately zero). Based on the data analysis, it can be concluded that there is a notable difference between the means of the groups in AG4 for the year 2019, which is statistically significant. In brief, the results of the one-way ANOVA reveal significant differences among the AG4 groups in 2019, in relation to the examined dependent variable.

For AG4 (2021)

In the year 2021, the value of the sum of squares between groups in AG4 is 41443.6. This metric serves as an indicator of the extent to which the observed variation can be attributed to differences between groups. The inter-group variability can be attributed to the sum of squares (21457.3), which represents the variation that is present within each group but cannot be attributed to differences between groups. The statistical analysis reveals that there exist significant variations between the group means in AG4 for the year 2021, as indicated by the F-value of 23.37. This value is derived from the ratio of the mean square between-groups to the mean square within-groups. The p-value of 7.05E-24 in this instance is notably diminutive, signifying compelling evidence contradicting the null hypothesis of negligible disparities. Thus, it can be inferred that there exist significant statistical variations in the diversity indices of arthropods across the groups in AG4 for the year 2021.

6.7.6 Seasonal fluctuations of soil organisms

Arthropods organisms and month wise populations at AG4 in 2019

As depicted in Table 6:44, the number of organisms recorded each month fluctuates throughout 2019. March (161) and January (160) had the highest number of observed organisms, followed by and February (155), December (148) and April (118). In comparison to the winter season, the period from May to October had a lower organism abundance. According to the data, the arthropod species population at AG4 fluctuates over time. In addition, the organisms observed throughout the study period were analogous to those observed at Sites 1, 2 and 3 as previously discussed, with the exception of variations in the populations of each species.

Table 6:44 Month-wise arthropod population at AG4 in 2019

Name of the Species/Family/Order	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Collembola												
Fam.*Isotomidae*	9	7	8	7	4	1	1	2	1	2	5	9
Cryptopygus sp.	9	7	8	6	4	1	1	2	2	2	3	9
Isotoma sp.	7	7	7	5	3	1	1	1	2	2	4	8
Isotomiella sp.	8	7	6	6	2	1	1	1	2	2	4	8
Isotomurus sp.	6	7	8	5	3	0	1	2	2	2	4	9
Folsomia quadrioculata	7	8	6	5	3	1	2	1	2	2	2	5
Hypogastrura sp.	7	7	8	5	3	0	1	1	2	2	4	9
Lepidocyrtus sp.	8	8	7	5	2	1	1	1	2	2	3	3
Entomobrya sp.	8	9	8	6	2	0	2	2	2	2	3	3
Sminthrus sp.	8	7	7	6	3	1	1	1	2	2	3	4
Fam.*Katiannidae*	8	6	8	3	3	1	1	1	1	2	3	4
Acari												
Fam.*Acaridae*	7	6	9	4	5	1	1	1	3	2	4	8
Fam.*Laelapidae*	8	8	9	3	4	0	1	1	2	2	4	7
Fam.*Cunaxidae*	8	7	8	3	3	0	1	1	2	2	4	7
Ord. *Cryptostigmata*	8	6	8	4	6	1	1	1	2	4	5	8
Fam.*Phytoseiidae*	7	9	8	3	3	0	1	2	2	1	6	8
Poecilochirus carabi	8	7	7	5	4	1	1	1	2	1	3	5
Sperchonopsis ecphyma	8	7	7	4	2	1	1	1	2	2	3	6
Acari juveniles	5	7	8	7	2	0	2	1	2	2	2	6
Fam.*Rhodacaroidea*	5	6	6	7	1	0	1	2	1	2	2	6
Demodex folliculorum	6	6	5	8	1	1	1	1	3	1	4	6
Other arthropods												
Cortinicara sp. (Fam.*Latridiidae*)	1	1	1	1	0	0	1	1	1	2	3	1
Anthicidae species	1	1	1	1	1	1	0	1	2	1	3	2
Fam.*Carabidae*	1	1	1	2	1	1	0	1	2	2	1	2
Hymenoptera	1	1	0	1	1	0	0	2	2	2	3	1
Psocoptera	0	1	1	2	1	0	0	1	1	2	3	1
Diplura	0	0	1	2	2	1	0	1	2	2	3	1
Diptera	0	0	0	1	1	1	0	1	1	2	2	1
Symphyla	1	1	0	1	0	0	1	1	2	2	1	1
N	29	29	29	29	29	29	29	29	29	29	29	29
Min	0	0	0	1	0	0	0	1	1	1	1	1
Max	9	9	9	8	6	1	2	2	3	4	6	9
Sum	160	155	161	118	70	17	26	36	54	56	94	148
Mean	5.51	5.34	5.5	4.06	2.41	0.58	0.89	1.24	1.86	1.93	3.24	5.10
Std. error	0.59	0.55	0.59	0.39	0.26	0.09	0.10	0.08	0.09	0.09	0.20	0.54
Variance	10.4	8.94	10.3	4.49	2.10	0.25	0.31	0.18	0.26	0.28	1.26	8.73
Stand. Dev	3.22	2.99	3.22	2.12	1.45	0.50	0.55	0.43	0.51	0.52	1.12	2.95
Median	7	7	7	4	2	1	1	1	2	2	3	6

Arthropods organisms and month wise populations at AG4 in 2021

The study conducted on the arthropod species population at AG4 in 2021 has indicated noteworthy temporal variations in the observed individuals, as presented in Table 6:45. The monthly displays demonstrated fluctuation, with January presenting the highest number of observations (178), closely trailed by February (168), March (164), and December (149) and April (134). In contrast, there was a decrease in the frequency of observations from May to November, indicating a potential decline in the population size during this time frame. The findings of the study demonstrate a distinct seasonal pattern in the dynamics of the population, whereby the winter months exhibit the highest population density and the summer months exhibit the lowest population density. However, similar pattern of organisms was found in site 1 and site 2 except the variations in numbers. This finding enhances our understanding of the temporal distribution patterns of the arthropod community and underscores the impact of seasonal fluctuations on population densities at AG4.

Table 6:45 Month-wise arthropod population at AG4 in 2021

Name of the Species/Family/Order	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Collembola												
Fam.*Isotomidae*	10	9	8	6	4	1	1	2	1	2	5	9
Cryptopygus sp.	8	8	8	7	4	1	1	2	2	2	3	7
Isotoma sp.	9	7	6	4	6	1	1	1	1	2	5	8
Isotomiella sp.	8	7	8	5	5	1	1	1	2	2	4	8
Isotomurus sp.	7	7	7	6	6	1	1	2	1	2	4	7
Folsomia quadrioculata	8	8	8	4	3	1	1	1	2	2	2	9
Hypogastrura sp.	7	7	7	6	3	2	1	1	2	2	2	6
Lepidocyrtus sp.	9	8	7	7	2	1	1	0	0	3	3	3
Entomobrya sp.	9	9	8	6	3	0	1	2	1	3	3	3
Sminthrus sp.	8	8	7	6	3	0	1	1	2	3	6	4
Fam.*Katiannidae*	9	7	7	8	3	1	1	1	1	2	3	4
Acari												
Fam.*Acaridae*	7	8	9	4	4	1	1	1	1	3	4	8
Fam.*Laelapidae*	9	8	6	6	4	0	1	1	2	3	3	7
Fam.*Cunaxidae*	8	9	8	7	3	0	0	1	1	4	3	8
Ord. *Cryptostigmata*	9	9	8	6	6	1	1	1	1	2	4	6
Fam.*Phytoseiidae*	9	8	8	5	3	0	1	0	2	2	6	6
Poecilochirus carabi	9	7	8	8	4	1	1	1	1	3	3	5
Sperchonopsis ecphyma	7	7	7	7	4	1	0	1	2	2	4	7
Acari juveniles	7	7	8	6	3	1	0	1	2	2	4	7
Fam.*Rhodacaroidea*	7	7	8	6	3	1	0	2	1	2	4	5
Demodex folliculorum	7	6	7	7	2	1	1	2	3	1	4	8
Other arthropods												
Cortinicara sp. (Fam.*Latridiidae*)	1	1	1	1	1	1	1	1	1	2	1	2
Anthicidae species	1	0	1	1	1	1	0	1	0	2	2	2
Fam.*Carabidae*	1	1	1	1	1	1	1	1	0	3	2	2
Hymenoptera	1	2	1	1	1	0	1	1	1	1	2	1
Psocoptera	1	1	1	1	0	0	0	1	1	2	4	3
Diplura	1	1	1	1	1	1	1	1	2	2	2	2
Diptera	0	0	0	0	0	1	0	0	1	2	3	1
Symphyla	1	1	0	1	1	0	0	1	1	2	3	1
N	29	29	29	29	29	29	29	29	29	29	29	29
Min	0	0	0	0	0	0	0	0	0	1	1	1
Max	10	9	9	8	6	2	1	2	3	4	6	9
Sum	178	168	164	134	84	22	21	32	38	65	98	149
Mean	6.137	5.82	5.65	4.62	2.89	0.75	0.72	1.10	1.31	2.24	3.3	5.13
Std. error	0.633	0.58	0.58	0.47	0.31	0.09	0.08	0.10	0.13	0.11	0.2	0.49
Variance	11.62	9.86	9.94	6.52	2.88	0.26	0.20	0.31	0.50	0.40	1.45	7.05
Stand. Dev	3.409	3.14	3.15	2.55	1.69	0.51	0.45	0.55	0.71	0.63	1.20	2.65
Median	7	7	7	6	3	1	1	1	1	2	3	6

6.7.7 Diversity indices of arthropods in month-wise from AG4

The data presented in Table 6:46 shows a various trends and contrasts that may be observed when comparing the diversity indexes between 2019 and 2021. 29 taxa were reliably recorded each month in 2019, which is a relatively stable Figure for the species richness. In contrast, taxa varied somewhat in 2021, with 26 to 29 species every month. Throughout both years, the population fluctuated, with 2019 generally having larger counts than 2021. 2019 showed greater populations in the months of January to April and October to November. Both years showed a similar range when looking at the dominance values, which represent the abundance of the most dominating species. In 2019 and 2021, the dominance values were 0.036 to 0.058 and 0.037 to 0.049, respectively. These results point to a roughly equal distribution of species in both years communities. Species diversity was found to be high according to Simpsons diversity index for both 2019 and 2021. In 2019 the readings varied from 0.9412 to 0.963, while in 2021 they varied from 0.9504 to 0.9572. Close to 1 value indicate diverse ecosystems in both years. Species richness and evenness are taken into consideration by Shannon diversity index, which changed over the course of months and years. The values fell between 2.833 and 3.332 in 2019 and 3.028 and 3.329 in 2021. More even distributions throughout communities and increased species richness are both indicated by higher Shannon values. In 2019 and 2021, the evenness values varied from 0.8285 to 1 and 0.8424 to 1, respectively. These numbers point to an evenly distributed species population in both years. The Margalef index showed fluctuations over the course of months and years. In 2019 the numbers varied from 4.92 to 7.814 and in 2021 from 5.068 to 7.213. The range of equitability values was 0.9441 to 1 in 2019 and 0.9485 to 1 in 2021. These numbers show that in both years, there was a fairly equal distribution of individuals among the various species. In conclusion, when comparing the diversity indices between 2019 and 2021, the overall trends show that both years had reasonably high diversity. Although the number of taxa varied slightly, there were typically more people in 2019. High Shannon and Simpson index values in both years demonstrated wealthy and diversified communities. The Margalef score indicated moderate to high species richness, whereas the evenness values suggested a reasonably even distribution of species. Equitability values showed that people were distributed among species fairly. These results offer important new understandings of the ecological processes and variety of the time-varying communities under study.

Table 6:46 Diversity indices of all arthropods in month-wise from AG4 in year 2019 and 2021

Diversity Indices											
2019	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Taxa (S)	26	27	26	29	27	17	23	29	29	29	29	29
Individuals	160	155	161	118	70	17	26	36	54	56	94	148
Dominance(D)	0.045	0.04	0.04	0.04	0.046	0.058	0.04	0.038	0.03	0.036	0.038	0.045
Simpson (1-D)	0.954	0.95	0.95	0.95	0.953	0.941	0.95	0.961	0.96	0.963	0.961	0.9543
Shannon (H)	3.128	3.15	3.12	3.22	3.168	2.833	3.09	3.314	3.32	3.332	3.306	3.179
Evenness (EVNS)	0.877	0.86	0.87	0.86	0.879	1	0.96	0.948	0.96	0.965	0.940	0.828
Margalef	4.92	5.15	4.92	5.86	6.12	5.64	6.75	7.814	7.01	6.956	6.163	5.603
Equitability(J)	0.96	0.95	0.96	0.95	0.961	1	0.98	0.984	0.98	0.989	0.9818	0.9441
2021												
Taxa (S)	28	27	27	28	27	21	21	26	26	29	29	29
Individuals	178	168	164	134	84	22	21	32	38	65	98	149
Dominance(D)	0.04	0.04	0.04	0.04	0.045	0.049	0.047	0.042	0.04	0.03	0.038	0.04
Simpson (1-D)	0.95	0.95	0.95	0.95	0.954	0.950	0.952	0.95	0.95	0.96	0.961	0.95
Shannon (H)	3.16	3.16	3.15	3.17	3.169	3.028	3.045	3.20	3.18	3.32	3.305	3.22
Evenness (EVNS)	0.84	0.87	0.86	0.85	0.880	0.983	1	0.94	0.93	0.96	0.939	0.86
Margalef	5.21	5.06	5.09	5.51	5.868	6.47	6.569	7.21	6.87	6.70	6.107	5.59
Equitability (J)	0.94	0.96	0.95	0.95	0.961	0.994	1	0.98	0.97	0.98	0.981	0.95

6.8 Site 4-Non-Agriculture land (NAG4)

6.8.1 Edaphic factors

A study was conducted in 2019 at location NAG4 to examine the correlation between the number of arthropods and various soil variables (Table 6:47). The recorded temperatures on a yearly basis ranged from 12 to 33 degrees Celsius, with a mean value of approximately 22 degrees Celsius and a standard deviation of 7.79 degrees Celsius. The soil exhibited a pH mean of approximately 7.21, accompanied by a standard deviation of 0.17. The pH values ranged from 7.1 to 7.5. The electrical conductivity

(E.C) values, which serve as an indicator of soil fertility, exhibited a range of 0.13 to 0.22 ds/m. The mean value of E.C was approximately 0.17 ds/m, with a standard deviation of 0.03. The soil moisture content exhibited a range of values spanning from 0.9% to 12.3%. The mean value of the soil moisture content was approximately 6.26%, while the standard deviation was 4.26. The soil's carbon (C%) content exhibited a mean value of approximately 0.315% and a standard deviation of 0.19, with a range of 0.06% to 0.6%. The nitrogen content of the sample had a mean value of approximately 0.026% with a standard deviation of 0.016. The range of nitrogen levels observed in the sample was from 0.005% to 0.051%. The potassium (Kg/h) concentrations exhibited a range of 28 to 53 Kg/h, with a mean value of approximately 40.83 Kg/h and a standard deviation of 7.78. The phosphorus (ppm) concentrations in the soil exhibited a consistent pattern, with values ranging between 2 to 3 ppm. The mean concentration of phosphorus was 2.67 parts per million (ppm), with a corresponding standard deviation of 0.49. The investigation placed particular emphasis on arthropod populations, including but not limited to Collembola, Acari, and other arthropods. The Collembola arthropod count was observed to vary between 8 and 75, with a mean count of approximately 41.75 and a standard deviation of 27.20. In a comparable vein, the Acari arthropods were observed to range in population size from 6 to 70 individuals, exhibiting a mean count of approximately 36.08 and a standard deviation of 26.42. The arthropod population exhibited a range of 5 to 14, with a mean value of approximately 8.58 and a standard deviation of 2.94. In general, the data presented provide insights into the variability and dispersion of soil constituents and arthropod communities at location NAG4 during the year 2019.

Table 6:48 provides a summary of the edaphic parameters and arthropod populations at NAG4 in the year 2021. The data can be used to evaluate the impact of soil conditions on arthropod populations and to predict ecological shifts. From January and December's average temperatures of 12 degrees Celsius to Julys sweltering temperatures of 33 degrees Celsius, there is a large range of data. The pH level rose from 7 to 7.5. The electrical conductivity varied between 0.14 and 0.22 ds/m. Moisture levels were lowest at 0.9%, and greatest at 12.3%. The carbon concentration ranged between 0.08% to 0.45%. The potassium concentrations ranged from 33 kg/h in June to 53 kg/h, and nitrogen concentrations ranged from 0.006% to 0.038%. Phosphorus concentration varied from 2-3 ppm throughout the year. The arthropod population fluctuated on a monthly basis as given in the Table for 2021.

Table 6:47 The number of arthropods in relation to soil factors at NAG4 during the year 2019

Month, 2019	**Temp. (^{o}C)**	**pH**	**E.C (ds/m)**	**Moisture (%)**	**C (%)**	**N (%)**	**K (Kg/h)**	**P (ppm)**	**Collembola**	**Acari**	**Other arthropods**
N	12	12	12	12	12	12	12	12	12	12	12
Min	12	7.1	0.13	0.9	0.06	0.005	28	2	8	6	5
Max	33	7.5	0.22	12.3	0.6	0.051	53	3	75	70	14
Sum	265	86.55	2.07	75.1	3.78	0.316	490	32	501	433	103
Mean	22.08	7.21	0.17	6.258	0.315	0.0263	40.83	2.66	41.75	36.08	8.58
Std. error	2.247	0.05	0.009	1.229	0.055	0.0046	2.245	0.14	7.85	7.628	0.84
Variance	60.62	0.03	0.001	18.14	0.036	0.0002	60.51	0.24	739.8	698.2	8.62
Stand. dev	7.786	0.17	0.033	4.260	0.191	0.016	7.779	0.49	27.20	26.42	2.93
Median	20.5	7.12	0.16	6.4	0.25	0.021	41	3	42	32	7.5

Table 6:48 The number of arthropods in relation to soil factors at NAG4 during the year 2021

Month, 2021	**Temp. (^{o}C)**	**pH**	**E.C (ds/m)**	**Moisture (%)**	**C (%)**	**N (%)**	**K (Kg/h)**	**P (ppm)**	**Collembola**	**Acari**	**Other arthropods**
N	12	12	12	12	12	12	12	12	12	12	12
Min	12	7	0.14	0.9	0.08	0.006	33	2	9	6	3
Max	33	7.5	0.22	12.3	0.45	0.038	53	3	74	73	15
Sum	266	87.8	2.14	68.5	3.1	0.261	512	33	491	444	87
Mean	22.166	7.31	0.17	5.70	0.25	0.021	42.66	2.75	40.91	37	7.25
Std. error	2.218	0.06	0.009	1.15	0.03	0.002	1.707	0.130	7.751	7.860	1.09
Variance	59.06	0.05	0.001	16.1	0.01	9.68E-05	34.96	0.204	720.9	741.4	14.3
Stand. dev	7.68	0.22	0.032	4.01	0.11	0.009	5.913	0.452	26.85	27.22	3.79
Median	20.5	7.5	0.17	3.7	0.245	0.0205	42	3	32.5	27.5	6.5

6.8.2 Population dynamics

The prevailing taxonomic group in non-agriculture land was Collembola, accounting for 48.31% of the percentage abundance, whereas Acari constituted the smallest proportion at 41.75%, and other arthropods for 9.93% for year 2019. However, in year 2021, Collembola accounting for 48.04% of the total, followed by Acari at 43.44% and others arthropods for 8.65%. The occurrence of arthropods in two different years are given below in Figure 6:29 and Figure 6:30.

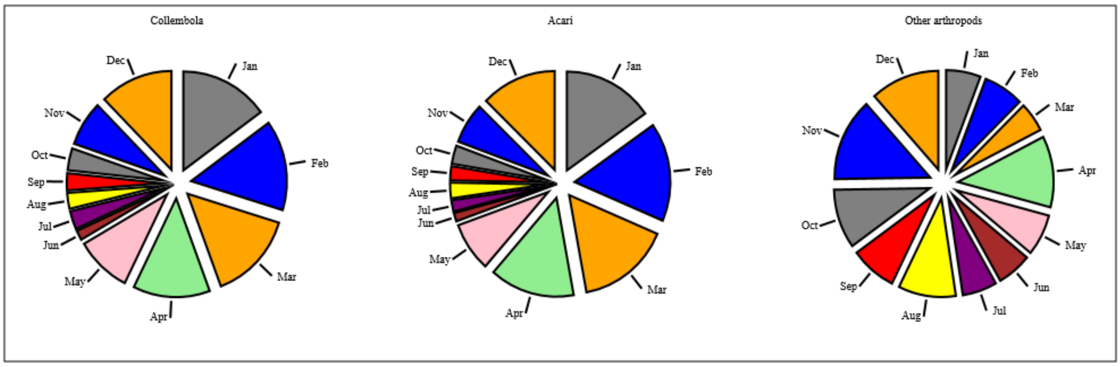


Figure 6:29 The number of Collembola, Acari, and other arthropods in month-wise presenting in NAG4 during year, 2019.

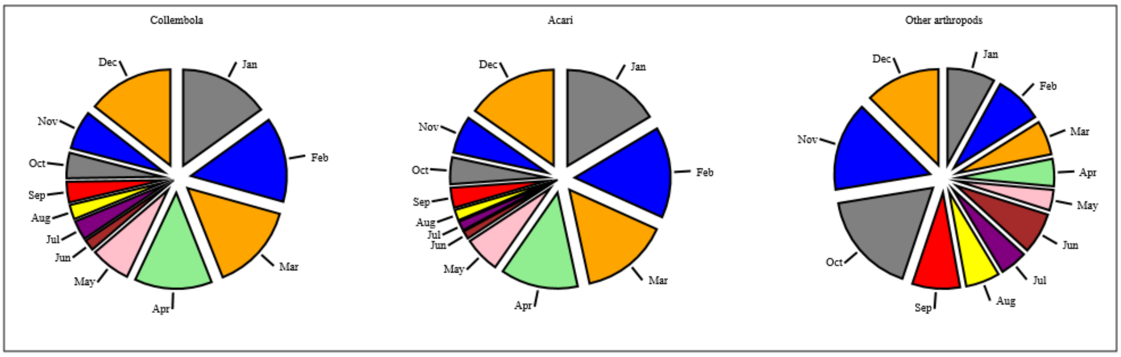


Figure 6:30 The number of Collembola, Acari, and other arthropods in month-wise presenting in NAG4 during year, 2021.

A total of 2059 soil arthropods/m^2 were gathered from non-agricultural land, with Collembola being the most prevalent species, comprising 501 and 491 specimens, followed by Acari with 433 and 444 specimens, followed by other arthropods with 103 and 87 in year 2019 and 2021, respectively. Collembola comprised 48.17% of the total population of 2059, demonstrating numerical superiority over other groupings. It was observed that the Family *Isotomidae* was numerically dominant. In terms of numerical abundance, the Acari population ranked second, comprising 42.59 percent of the total. Mesostigmata and Prostigmata, which were the dominant species within this group, constituted the majority of the Acari community. The proportional prevalence of the remaining taxa, such as coleopterans, diplurans, pseudoscorpions, isopods, and Hymenoptera, was determined to be less than 9.22%.

6.8.3 Correlation analysis

Correlational study between edaphic factors and arthropod population at the NAG4 in 2019

The Figure 6:31 displays the correlation coefficients observed between various soil variables and arthropod populations that were documented at NAG4. The correlation coefficient between temperature (^{o}C) and pH is -0.2281, indicating a mild negative association. The correlation analysis reveals a weak negative association between pH and electrical conductivity (E.C), as evidenced by the correlation coefficient of -0.2105. The correlation coefficient between moisture content and electrical conductivity (E.C) is 0.4171, indicating a moderately positive relationship. The soil elements carbon (C%) and nitrogen (N%) exhibit a robust positive correlation coefficient of 0.9981, which suggests a highly positive association between them. The correlation coefficient between the percentage of carbon and moisture is -0.4471, suggesting a negative correlation between the two variables. The correlation between the percentage of nitrogen (N%) and moisture (%) is negative, with a coefficient of -0.4486, suggesting a somewhat unfavorable relationship. The correlation coefficient between potassium (Kg/h) and E.C is 0.4789, indicating a moderately positive association. The correlation analysis reveals that there exists a negative correlation between the levels of phosphorus (P ppm) and temperature (^{o}C), with a coefficient of -0.5612. This suggests that the association between the two variables is somewhat unfavorable. The significant correlation coefficients suggest that there exist considerable positive interactions among the arthropod populations, including Collembola, Acari, and other arthropods.

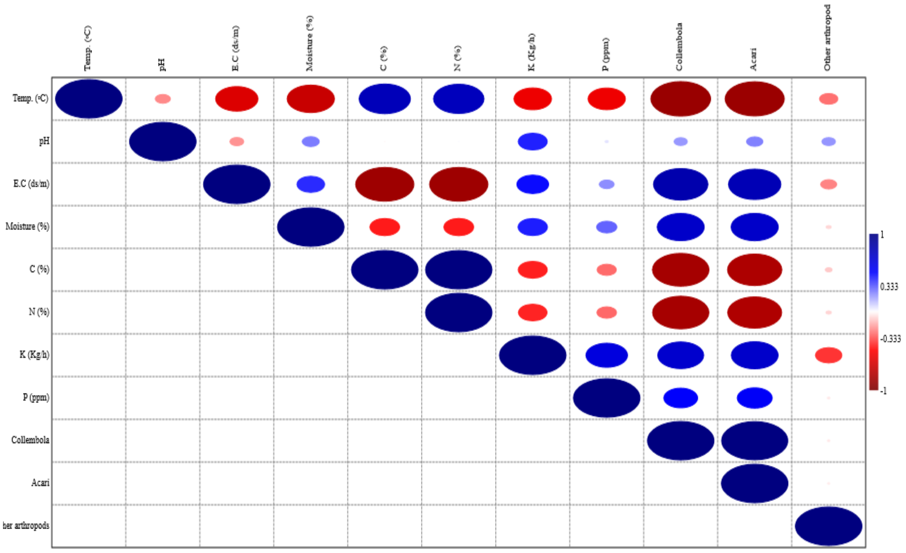


Figure 6:31 Correlation analysis between Edaphic factors and arthropods populations in NAG4 during year, 2019

Correlational study between edaphic factors and arthropod population at the NAG4 in 2021

The Figure 6:32 presents the correlation coefficients observed between various soil variables and arthropod populations documented at NAG4. The correlation coefficient between temperature (ᵒC) and pH is -0.3014, indicating a negative association of weak strength. The Pearson correlation coefficient between the pH and electrical conductivity (E.C) variables is 0.1725, signifying a positive correlation of weak strength. The correlation coefficient between moisture (%) and E.C is 0.2026, suggesting a positive association of weak magnitude. The soil elements carbon (C%) and nitrogen (N%) exhibit a robust positive correlation coefficient of 0.9996, signifying a highly positive association between them. The correlation analysis indicates a positive association between the percentage of carbon and moisture, with a coefficient value of 0.2056. The correlation coefficient between nitrogen (N%) and moisture (%) is 0.1987, suggesting a weak positive correlation. The correlation coefficient between potassium (Kg/h) and E.C is 0.6075, indicating a moderately positive association. The data reveals a correlation coefficient of -0.4316 between phosphorus (P ppm) and temperature (ᵒC), suggesting a negative association between the two variables. The significant correlation coefficients suggest that there exists a considerable positive association between the arthropod populations that are exemplified by Collembola, Acari, and other arthropods.

It is imperative to acknowledge that the correlation between soil parameters and arthropod populations at NAG4 does not necessarily imply causation. Additionally, there may be other unaccounted variables that could potentially influence the observed associations.

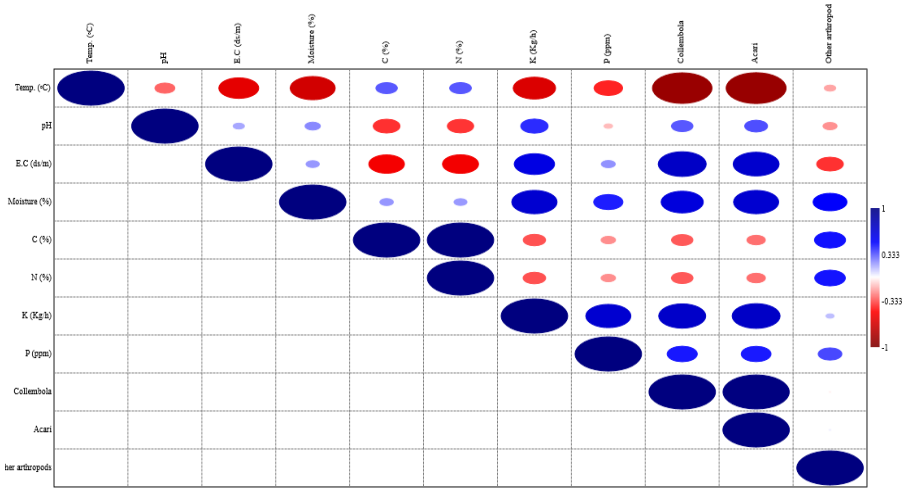


Figure 6:32 Correlation analysis between Edaphic factors and arthropods populations in NAG4 during year, 2021

6.8.4 Diversity Indices

The following Table 6:49 presents the diversity indices of arthropods collected from NAG4 during the years 2019 and 2021. The number of arthropod taxa identified remained consistent at 12 across both years. The data suggests that there was no significant alteration in the diversity of species between the years 2019 and 2021. The total count of individuals identified within each arthropod group exhibits some variation between the two years. The arthropod population in the year 2019 comprised of 501 Collembola, 433 Acari, and 103 individuals belonging to other taxa. The year 2021 witnessed a rise in the populations of Collembola, Acari, and other arthropods, with the numbers reaching 491, 444, and 87, respectively. These variations indicate slight changes in the size of the population. There was a slight variation in the dominance levels of different arthropod groups between the two years. In 2019, Collembola exhibited a dominance value of 0.1158, while Acari demonstrated a value of 0.1243. Additionally, other arthropods displayed a dominance value of 0.09228. The dominance values of Collembola, Acari, and other arthropods were recorded as 0.1162, 0.1247, and 0.1042, respectively, in the year 2021. The Simpson diversity index values

(1 - Dominance) for each arthropod group exhibit similar patterns in both years. The Collembola taxonomic group exhibited a value of 0.8842 in 2019, which decreased slightly to 0.8838 in 2021. The value of Acari in 2019 was recorded as 0.8757, whereas in 2021, it was noted as 0.8753. The arthropods in question exhibited a value of 0.9077 in 2019, which decreased to 0.8958 in 2021. The aforementioned indices serve as a measure of the probability that two individuals selected at random from a given population belong to different species. Higher values of these indices are indicative of a greater level of diversity within the population. There is a slight fluctuation observed in the Shannon diversity index values between the two years. The Collembola exhibited a value of 2.271 in 2019, which increased slightly to 2.276 in 2021. The data indicates that the values for Acari remained constant at 2.215 for both years. The arthropod taxa received a rating of 2.433 in 2019, which decreased to a value of 2.369 in 2021. These indices take into account not only the number of species present in a given community, but also the degree of evenness in their distribution. The Collembola exhibited a value of 0.8072 in 2019, which increased to 0.8114 in 2021. Acari had consistent 0.7638 results in both years. The arthropod category exhibited a value of 0.9491 in 2019, which decreased to 0.8905 in 2021. Greater evenness scores indicate a more equitable distribution of individuals across various species. The Margalef index for the Collembola species exhibits a value of 1.769 in 2019, which has increased to 1.775 in 2021. The value of Acari in 2019 was recorded as 1.812, while in 2021 it was noted as 1.805. The arthropod taxa received a rating of 2.373 in 2019, which increased to 2.463 in 2021. Higher Margalef scores suggest a greater diversity of species. The Collembola exhibited a Equitability value of 0.9138 in 2019, which increased to 0.9159 in 2021. Acari has a 2019 value of 0.8916 and a 2021 value of 0.8915. In 2019 and 2021, other arthropods exhibited values of 0.979 and 0.9533, respectively. Higher equitability ratings suggest that people are distributed more evenly among species.

In summary, there are slight shifts in population sizes, dominance values, and various diversity measures when comparing the diversity indices between 2019 and 2021. Nonetheless, the aggregate count of species richness remains invariant, and the diversity patterns of the community exhibit a substantial degree of constancy.

Table 6:49 Diversity indices of arthropods from NAG4 in year 2019 and 2021

Index	**2019**			**2021**		
	Collembola	**Acari**	**Other arthropods**	**Collembola**	**Acari**	**Other arthropods**
Taxa (S)	12	12	12	12	12	12
Individuals	501	433	103	491	444	87
Dominance (D)	0.1158	0.1243	0.09228	0.1162	0.1247	0.1042
Simpson (1-D)	0.8842	0.8757	0.9077	0.8838	0.8753	0.8958
Shannon (H)	2.271	2.215	2.433	2.276	2.215	2.369
Evenness (EVNS)	0.8072	0.7638	0.9491	0.8114	0.7638	0.8905
Margalef	1.769	1.812	2.373	1.775	1.805	2.463
Equitability (J)	0.9138	0.8916	0.979	0.9159	0.8915	0.9533

[S for Taxa; D for Dominance; H for Shannon Diversity; EVNS for Evenness and J for Equitability]

6.8.5 One-Way ANOVA

For NAG4 (2019)

As per the findings of the 2019 NAG4 one-way ANOVA, there exist statistically significant variations among the groups under investigation. The statistical analysis reveals that the F-value of 23.86 denotes a noteworthy distinction between the variance observed among categories and the variance observed within them. This illustrates that the matter under investigation exerts a noteworthy influence on the gathered data. The statistical analysis reveals a significantly low p-value (3.16E-24), which indicates strong evidence to reject the null hypothesis that there are no significant differences between the groups. Consequently, the likelihood of chance alone accounting for the significant variations observed between the groups is exceedingly low. Thus, based on the statistical analysis, the null hypothesis can be confidently rejected, indicating that there exist significant differences among the categories. The concept of sum of squares encompasses two distinct components, namely between and within groups, which serve to evaluate the overall variability in the dataset. The value of 34410.9 for the sum of squares between groups represents the extent of variability that can be ascribed to dissimilarities among the groups. The within-group sum of squares, amounting to 1,7449.7, signifies the unexplained heterogeneity within each group. To summarise, based on the ANOVA analysis, it can be inferred that the variable under investigation exerts a significant impact on the NAG4 data for the year 2019. The statistical analysis reveals that the F-value is significant and the p-value is low, suggesting that there exist significant variations among the groups and that the observed differences are not attributable to chance occurrences.

For NAG4 (2021)

Test for equal means

The results of the 2021 ANOVA conducted in NAG4 indicate the presence of statistically significant differences among the groups. The obtained F-value of 24.86 and the p-value of 6.36E-25 provide significant evidence to reject the null hypothesis, which assumes the absence of any differences between the groups. The results indicate that the component under analysis has a significant impact on the observed data of NAG4 in the year 2021. The between-groups sum of squares, which quantifies the variability that can be attributed to differences among groups, is equal to 35870.2. The sum of squares among groups has been determined to be 17459.9 due to an unexplained fluctuation. The mean square for between groups indicates that there exists an average of 3587.02 points of dissimilarity between groups. The mean square, which serves as a metric for the degree of randomness present within each group, has an average value of 144.296. Both inter-group and intra-group analyses possess a combined total of 121 degrees of freedom. The degrees of freedom pertain to the count of unique variables employed in approximating each component of the entirety. To summarize, the results of the 2021 ANOVA analysis on NAG4 indicate that the variable being examined has a statistically significant impact on the observed data. The statistical analysis indicates that the F-value is significant and the p-value is low, which implies that the observed distinctions among the groups are not attributable to chance occurrences. Additional evidence supporting the presence of significant intergroup disparities can be observed in the magnitude of the differences between the groups, which surpasses the magnitude of the differences within the groups. The findings suggest that the studied variable exerts a significant impact on the NAG4 Figures for the year 2021.

6.8.6 Seasonal fluctuations of Soil organisms

Month-wise arthropod population atNAG4 in 2019

Table 6:50 shows the monthly population and species count of the arthropod community at NAG4 for the year 2019. According to the study period, 29 different species were observed throughout the year. The species are classified as Acari and Hexapoda in terms of taxonomic categorization. Hexapoda includes multiple orders, including Collembola (also known as springtails), Diptera (flies), Hymenoptera (which includes ants, bees, and wasps), and *Psocoptera* (also known as booklice). Acari includes families such as *Acaridae*, *Laelapidae*, and *Phytoseiidae*. Over the course of the year, the monthly count of observed individuals varies. In terms of frequency of sightings, February had the highest number of organisms (151), followed by March (146) and January (147). The month of December had the (129), while November (80) and October (45) organisms followed suit with fewer sightings. The results show that there is a temporal fluctuation in the population of arthropod species at NAG4, with the largest population recorded during the spring season and the lowest population observed during the winter season. To summarise, based on the data available, NAG4 in 2019 was home to 29 arthropod species belonging to two separate classes. Furthermore, it was discovered that the population size of these species varied seasonally throughout the year.

Table 6:50 Month-wise arthropod population at NAG4 in 2019

Name of the Species/Family/Order	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Collembola												
Fam.*Isotomidae*	9	7	8	6	5	1	1	2	1	2	5	7
Cryptopygus sp.	7	7	8	6	4	1	1	2	2	1	2	7
Isotoma sp.	7	7	7	4	5	0	2	1	1	1	4	8
Isotomiella sp.	7	7	6	6	5	1	2	1	2	2	3	8
Isotomurus sp.	5	7	8	5	6	0	2	1	1	2	4	7
Folsomia quadrioculata	6	6	6	6	5	1	1	1	1	2	2	6
Hypogastrura sp.	5	7	8	5	5	1	2	1	1	1	2	5
Lepidocyrtus sp.	8	7	5	6	1	1	1	1	1	1	3	3
Entomobrya sp.	7	6	6	7	4	1	1	1	1	2	4	3
Sminthrus sp.	7	6	5	8	4	0	1	1	2	2	4	4
Fam.*Katiannidae*	7	7	6	6	3	1	1	1	1	2	4	4
Acari												
Fam.*Acaridae*	7	9	9	6	5	1	1	1	1	1	3	7
Fam.*Laelapidae*	9	7	6	6	5	0	1	1	1	1	2	5
Fam.*Cunaxidae*	7	9	8	7	4	0	0	1	1	1	4	7
Ord. *Cryptostigmata*	9	8	6	6	6	1	1	1	1	1	1	6
Fam.*Phytoseiidae*	7	7	6	5	3	1	1	2	1	2	3	5
Poecilochirus carabi	6	5	5	5	4	1	1	1	1	1	2	3
Sperchonopsis ecphyma	7	7	7	7	3	0	1	1	1	2	2	7
Acari juveniles	3	7	5	6	2	1	1	1	1	2	3	5
Fam.*Rhodacaroidea*	4	5	9	7	2	0	0	2	1	1	5	5
Demodex folliculorum	7	6	7	7	1	1	1	0	1	1	4	5
Other arthropods												
Cortinicara sp. (Fam.*Latridiidae*)	1	1	1	1	1	1	1	2	2	1	1	2
Anthicidae species	1	0	1	2	1	1	1	2	2	1	2	2
Fam.*Carabidae*	1	1	1	1	1	1	1	1	0	1	2	2
Hymenoptera	1	2	1	2	1	1	1	1	0	1	1	2
Psocoptera	1	2	0	1	0	0	0	1	1	1	3	1
Diplura	0	1	1	2	1	1	1	1	1	1	1	1
Diptera	0	0	0	1	1	1	1	1	1	2	2	1
Pseudoscorpions	1	0	0	2	1	0	0	1	1	2	2	1
N	29	29	29	29	29	29	29	29	29	29	29	29
Min	0	0	0	1	0	0	0	0	0	1	1	1
Max	9	9	9	8	6	1	2	2	2	2	5	8
Sum	147	151	146	139	89	20	29	34	32	41	80	129
Mean	5.068	5.20	5.034	4.79	3.068	0.689	1	1.172	1.103	1.413	2.75	4.448
Std. error	0.559	0.53	0.555	0.41	0.347	0.087	0.099	0.086	0.090	0.093	0.22	0.428
Variance	9.066	8.31	8.963	4.95	3.495	0.221	0.285	0.219	0.238	0.251	1.40	5.327
Stand. Dev	3.011	2.88	2.993	2.22	1.869	0.470	0.534	0.468	0.488	0.501	1.18	2.308
Median	7	7	6	6	3	1	1	1	1	1	3	5

Month-wise arthropod population at NAG4 in 2021

The Table 6:51 details the 2021 Arthropod Community at NAG4, including the species present and the monthly population. The 12 columns represent the months of the year, while the 29 rows list the many arthropod species, families, and orders. Monthly sums for each arthropod species are shown in the Table. There are 12 columns totaling the population count for each month of the year, starting with January and ending in December. The first column specifies the numerous arthropod species, families, or orders. In total, 29 distinct arthropod species, families, or orders were found at NAG4, as shown in the Table below. Some of the most frequent types of arthropods are the springtails, Acari, and other arthropods. The monthly population count varies for each species, with some indicating higher numbers at certain times of the year. Moreover, numerous species showed consistently low population counts across all months, including Psocoptera and Pseudoscorpions. Collembola, Acari, Hymenoptera, Diptera, and many more are just some of the orders and families into which arthropods can be placed. Most species can be found in the Collembola order, followed by the Acari. A total of two or three species from the other orders are represented in the Table. Each column’s minimum and maximum values, as well as their sum, mean, and standard error, are summarised in the Table. These aggregate statistics shed light on the long-term trends in the abundance of each species. This Table contains important information for ecological research and conservation efforts about the arthropod community at NAG4 in 2021.

Table 6:51 Month-wise arthropod population at NAG4 in 2021

Name of the Species/Family/Order	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Collembola												
Fam. *Isotomidae*	7	7	8	6	3	1	1	2	1	2	3	7
Cryptopygus sp.	6	7	8	6	4	1	1	2	2	1	2	7
Isotoma sp.	5	7	7	4	3	1	1	1	1	1	2	9
Isotomiella sp.	6	7	8	6	3	1	1	1	2	3	3	7
Isotomurus sp.	5	8	6	5	4	1	2	1	1	3	2	7
Folsomia quadrioculata	4	5	8	6	4	1	1	2	1	1	3	7
Hypogastrura sp.	8	7	6	5	3	1	3	1	1	3	3	5
Lepidocyrtus sp.	9	6	5	6	2	0	3	0	2	1	2	7
Entomobrya sp.	8	6	6	7	2	2	0	0	3	3	2	3
Sminthrus sp.	8	4	5	6	3	0	2	1	2	1	6	5
Fam. *Katiannidae*	8	6	5	7	2	0	1	1	1	2	4	7
Acari												
Fam.*Acaridae*	8	8	9	4	3	1	1	1	1	2	2	8
Fam.*Laelapidae*	8	8	6	6	2	0	1	1	1	1	1	6
Fam.*Cunaxidae*	9	9	8	7	3	0	0	1	1	2	2	6
Ord. *Cryptostigmata*	9	8	7	5	5	1	1	1	2	1	2	7
Fam.*Phytoseiidae*	8	8	5	7	3	1	1	0	1	1	2	7
Poecilochirus carabi	5	5	7	5	2	1	1	0	2	2	3	6
Sperchonopsis ecphyma	7	5	5	7	4	0	0	1	2	1	4	8
Acari juveniles	7	5	7	5	2	0	1	1	2	1	3	9
Fam.*Rhodacaroidea*	7	6	5	5	2	1	0	2	1	5	5	5
Demodex folliculorum	5	6	7	7	1	1	1	0	2	4	4	6
Other arthropods												
Cortinicara sp. (Fam.*Latridiidae*)	1	1	1	1	0	0	1	1	1	1	1	2
Anthicidae species	1	0	1	0	1	1	0	1	2	1	1	1
Fam.*Carabidae*	1	1	1	0	0	1	1	1	0	2	1	1
Hymenoptera	1	2	0	0	1	1	1	0	0	2	1	1
Psocoptera	1	2	0	0	0	0	0	0	2	2	3	1
Diplura	1	1	1	1	1	3	1	1	1	5	2	3
Diptera	0	0	0	1	0	0	0	0	0	0	2	1
Pseudoscorpions	1	0	1	1	0	0	0	1	1	2	2	1
N	29	29	29	29	29	29	29	29	29	29	29	29
Min	0	0	0	0	0	0	0	0	0	0	1	1
Max	9	9	9	7	5	3	3	2	3	5	6	9
Sum	154	145	143	126	63	21	27	25	39	56	73	150
Mean	5.31	5	4.93	4.34	2.17	0.72	0.93	0.86	1.34	1.93	2.51	5.17
Std. error	0.57	0.52	0.54	0.47	0.26	0.13	0.14	0.11	0.13	0.22	0.22	0.49
Variance	9.43	8.14	8.56	6.59	2.00	0.49	0.63	0.40	0.51	1.49	1.47	7.21
Stand. Dev	3.07	2.85	2.92	2.56	1.41	0.70	0.79	0.63	0.72	1.22	1.21	2.68
Median	6	6	6	5	2	1	1	1	1	2	2	6

6.8.7 Diversity indices of arthropods in month-wise from NAG4

From 2019 to 2021, an analysis was conducted to compare and contrast the diversity indices of arthropods in NAG4 (Table 6:52). The column labelled taxa denote the quantity of unique arthropod taxa that were recorded on a monthly basis. The taxonomic categories exhibited a range of 26 to 29 in the year 2019, while in 2021, the range was observed to be between 24 to 29. The maximal taxa observed in both years were comparable; however, the total number of taxa recorded in 2019 was greater than that of 2021.The monthly tally of arthropod individuals in their entirety. The data indicates that in 2019, the observed range of individual counts ranged from 20 to 151, whereas in 2021, the range was found to be between 21 and 154. The monthly totals exhibited variability in both 2019 and 2021; however, the Figures for the latter year were slightly higher on average. Upon comparing the two years, it was observed that the values pertaining to dominance exhibited a certain degree of consistency, albeit with a marginal increase in the values recorded in 2021. Both observed years demonstrated relatively elevated Simpson values, which suggest a profusion of arthropod species. The values exhibited a degree of consistency across the two years, with minor fluctuations observed on a monthly basis. The Shannon index is utilised to measure the diversity and distribution of arthropods on a monthly basis. The Shannon values exhibited a range of 2.996 to 3.308 in 2019, and a range of 2.822 to 3.261 in 2021. Comparable trends were observed in both year's, however, the Shannon values were generally greater in 2019. No significant disparity or discernible pattern was observed in the evenness values between the two years. Across both years, the Margalef values exhibited minor monthly fluctuations, yet consistently maintained a comparable range. The equitability values were relatively high in both years, suggesting that there was an Equitable distribution of species abundances. In summary, although there are variations in the diversity indices observed between the years 2019 and 2021, the trends in diversity and uniformity of arthropod populations at NAG4 exhibit a degree of consistency. Both years demonstrated a notable degree of biodiversity, with a marginal increase in the number of taxa and individuals observed in 2019. The indices of dominance, Simpson, and evenness exhibited similar trends in both years, while the Shannon values demonstrated a slightly elevated level in 2019.

Table 6:52 Diversity indices of all arthropods in month-wise from NAG4 in year 2019 and 2021

Diversity Indices												
2019	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Taxa (S)	27	26	26	29	28	20	25	28	27	29	29	29
Individuals	147	151	146	139	89	20	29	34	32	41	80	129
Dominance(D)	0.046	0.044	0.046	0.041	0.046	0.05	0.044	0.03	0.04	0.038	0.040	0.043
Simpson (1-D)	0.953	0.955	0.9537	0.958	0.953	0.95	0.956	0.96	0.95	0.961	0.95	0.956
Shannon (H)	3.139	3.153	3.127	3.24	3.16	2.99	3.176	3.28	3.24	3.308	3.27	3.22
Evenness (EVNS)	0.854	0.900	0.877	0.880	0.842	1	0.95	0.95	0.95	0.942	0.91	0.86
Margalef	5.21	4.98	5.01	5.67	6.01	6.3	7.12	7.65	7.50	7.54	6.39	5.76
Equitability(J)	0.952	0.967	0.959	0.962	0.948	1	0.98	0.98	0.98	0.982	0.97	0.95
2021												
Taxa (S)	28	26	26	25	24	18	21	21	26	28	29	29
Individuals	154	145	143	126	63	21	27	25	39	56	73	150
Dominance(D)	0.045	0.045	0.046	0.046	0.048	0.065	0.058	0.052	0.04	0.047	0.04	0.04
Simpson (1-D)	0.954	0.954	0.953	0.9539	0.951	0.934	0.941	0.947	0.956	0.95	0.95	0.95
Shannon (H)	3.157	3.147	3.128	3.119	3.091	2.822	2.949	2.997	3.188	3.18	3.26	3.20
Evenness (EVNS)	0.839	0.894	0.878	0.905	0.916	0.933	0.908	0.953	0.9323	0.85	0.89	0.85
Margalef	5.36	5.023	5.037	4.962	5.551	5.584	6.068	6.213	6.824	6.70	6.52	5.58
Equitability (J)	0.947	0.965	0.960	0.969	0.972	0.976	0.968	0.984	0.9785	0.95	0.96	0.95

6.9 Molecular analysis of Soil arthropods using COX 1 Genes

Identification of soil arthropods using COX1 genes

6.9.1 Agarose gel electrophoresis

The following gel pictures (Figure 6:33; 6:35; 6:37; 6:39; 6:41; 6:43) was taken after running the Agarose gel for 30 min at 5v/cm. The First lane in the gel image is a DNA marker with a standard size of 100-1000 bp. The remaining wells are loaded with PCR products for the samples amplified using COI primers. The size of the amplicons generated by this primer pair is ~500 bp, as is also evident from the gel picture below

6.9.2 Barcoding

The results of a bootstrap analysis (Figure 6:34; 6:36; 6:38; 6:40; 6:42; 6:44) were used to determine the confidence values of the branches (500 replicates). The evolutionary history was framed together through the use of a method called Neighbor-Joining (Saitou and Nei, 1987; Felsenstein, 1985; Kimura, 1980). The Kimura 2-parameter method was utilized in the computation of the evolutionary distances, and the results are expressed in terms of the number of base substitutions that occurred at each site. In this particular analysis, there were thirteen nucleotide sequences involved. For each sequence pair, every ambiguous position was cleaned up and removed (pairwise deletion option). The completed dataset contained a grand total of 668 bp (*Folsomia quadrioculata*), 708 bp (*Poecilochirus carabi*), 668 bp (*Bethylidae* sp.) and 679 bp (*Isotomidae* sp.) in different positions. MEGA11 was used to perform analyses of the evolutionary process (Tamura et al., 2021). Our sequence submitted to the database has similarities to those from Serbia, Greece, and Italy, along with many other countries. Following the discovery of conspecific sequences as shown below for every organism, while conducting a BLAST nucleotide search, the sequences were uploaded to the NCBI database under the Accession Number ON935721.1, ON854091.1, ON936061.1, ON936062.1.

- *Folsomia quadrioculata*

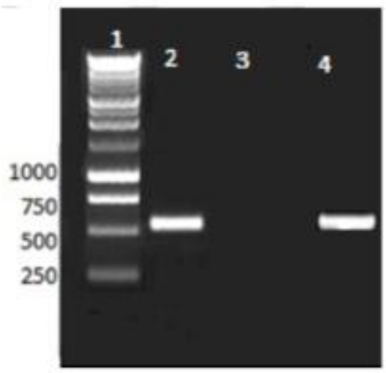


Figure 6:33 Agarose gel electrophoresis of *Folsomia quadriculata*

Consensus sequence of *Folsomia quadrioculata*

GAATCAAAATAAATGTTGATACAGAATAGGGTCTCCACCTCCTGCTGGGTCGAAAAAAGATGTGTTTAAGTTAC

GATCTGTTAGAAGTATAGTAATAGCTCCTGCTAACACCGGGAGAGATAGTAAAAGTAAAATAGCAGTTAAAAAT

ACGGATCAAACAAATAAAGGTGTGCGGTCTCAAGACATCCCCACAGTTCGTATGTTAATAATTGTTGTAATAAA

ATTTACAGCCCCTAAAATAGATCTGGCCCCGGCTAAATGTAATCTAAAAATTGATAGGTCTACGGATGCACCCG

CGTGGGCGATCCCTGAGGATAAAGGAGGGTAAACTGTTCATCCTGTCCCGGCCCCTCTTTCAACCAACCCTCCG

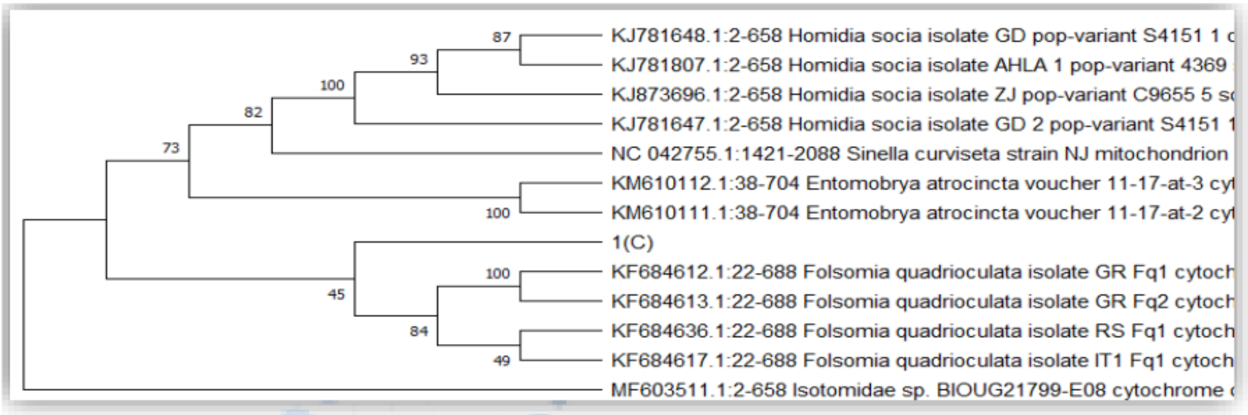
GTGAGAAGCAGGATTAGAGATGGGGGTAGTAGTCAAAAACTTATATTATTTATTCGGGGGAAGGCCATGTCAGG

GGCCCCGATTATTAAAGGTACTAACCAATTACCGAATCCTCCGATTATAATAGGTATAACTATAAAGAAAATTA

TAATAAAGGCGTGGGCAGTCACCATTACATTATAAATTTGGTCGTCTCCAATAAATGAACCCGGTTGTCCGAGC

TCTAAACGGATAAGCACTCTAAAAGCAGTGCCCACTATTGCTGATCAAACTCCGAAAATAAGATATAAAGTCCC AA

Phylogenetic tree (Figure 6:34):



- *Sperchonopsis ecphyma*

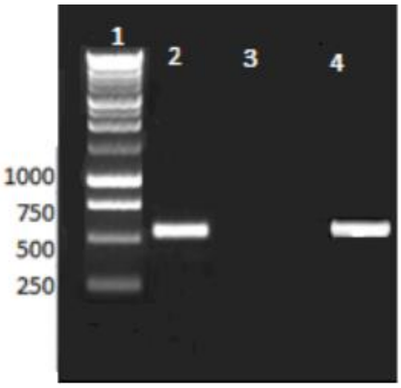


Figure 6:35 Agarose gel electrophoresis of *Sperchonopsis ecphyma*

Consensus sequence of *Sperchonopsis ecphyma*:

AATCAAAATAAATGTTGATATAAAATTGGGTCTCCTCCTCCCGCAGGATC
AAAAAATGATGTATTAATATTTCG
ATCGGTTAAAAGTATAGTAATAGCTCCTGCTAAAACAGGCAATGAAAGTA
ATAGTAAAATAGCTGTAATTACAA
CTGATCAAACAAATAAAGGTATTCGATCTAATGTTATTCCTTCTGGTCGTA
TATTAATTACTGTAGTAATAAAA
TTAATAGCACCTAAAATAGAAGAAATTCCAGCTAAATGTAAACTAAAAAT
AGCTAAATCTACTGAAGATCCCCC
ATGTGCAATATTTGATGATAAGGGAGGATAAACTGTTCAACCAGTTCCTG
CCCCATTTTCTACGATTCTTCTTA
TTAATAAAAATCTTAAAGATGGGGGTAAAAGTCAAAATCTTATATTATTT

ATTCGGGGGAAAGCTATATCTGGT

GCTCCTAATATTAAAGGTACTAGTCAATTTCCAAATCCTCCAATTATAAAA

GGTATAACTATAAAAAAAATTAT

AACAAATGCATGAGCTGTAACAATAACGTTATAAATTTGGTCATCACCAA

TTAATGAACCTGGAGTCCCTAATT

CAGTTCGAATTAATAAACTTAGAGAAGTTCCTACTATTCCGGATCATGCTC

CAAAAATAAAGTATAGAGTTCCA ATATCCT

Phylogenetic tree (Figure 6:36):

- *Poecilochirus carabi*

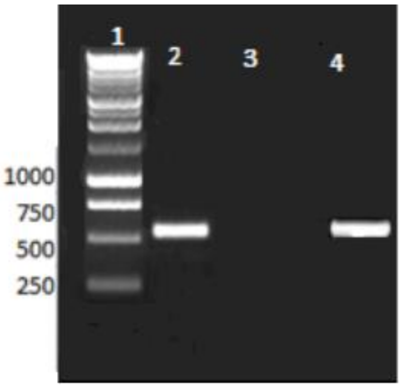


Figure 6:37 Agarose gel electrophoresis of *Poecilochirus carabi*

Consensus sequence of *Poecilochirus carabi*:

TCGATTAGTCTTTCGCCCCTATACCCAGATCAGATTATCGATTTGCACGTC

AGAAAAACTTCAGACATCCACCA

GAGTTTCCTCTGGCTTCATCTTGACTAGGCATAGATCACCATCTTTCGGGT

CTCAAACGACACGCTTGTAGTCT

ACAAATGCCTGAAAGCACTAGTAGCTTATCATTTTTTCGTGAAAAAACAC

AAATAACAATACGCTCGCATTTCA

CTTCGCCTTTGGATTACTAAACCCAATGACTCGCGTGCCATTTGAACTCCT

TGGTCCGTGTTTCAAGACGGGTC

AAATAACTAATACATAATCATTAAACAAAAGATACAAACCAGAACAACG

TGATAGCCACAAACAAGAACTAACC

CGTCTGCTAGGCATACACGTCACCCAGGTTTTAAGTACCTCGGGCTAAAG

TAATCTCAGCCAAGCTGAACAATC

ATAATGCACAACCTGCTACTTGGCACAATGTGCAAACTGCAGCAAGCCTC

TGCATAGATCATAAAGCTTCTTAA

TGATAGGAAATGCATCAAATCACAGATACTGCCAGCTATCTATGCGCAAG

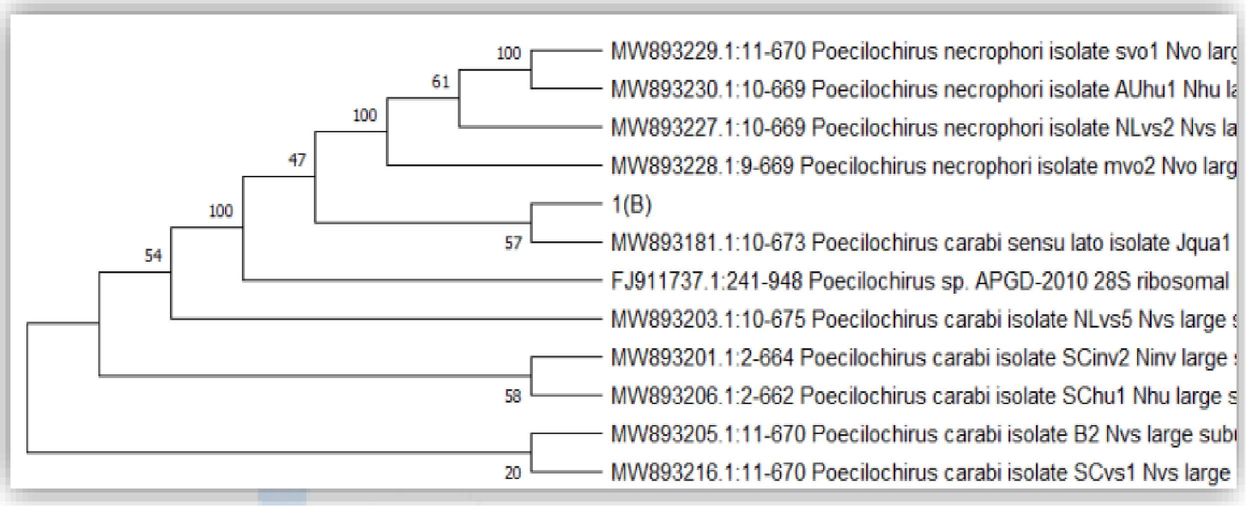
AATTTTGCTGAAAAACAGCTAATT

CTCGCACACTCGATAACCGCCACTAACTATTGAAAAGCATTTCACAAAAA

AGTACAGTTATCCGTTTTACTCAT

TATGGTTTCACGTACTATTGAACTCTCTCTTCAGAGTTCTTT

Phylogenetic tree (Figure 6:38):



- *Isotomidae* sp.

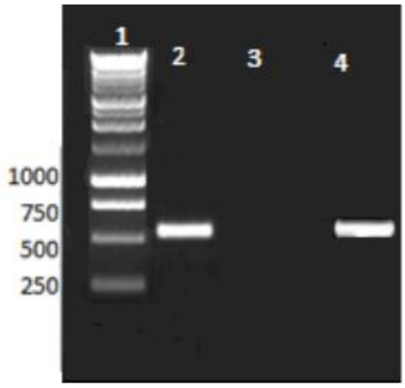
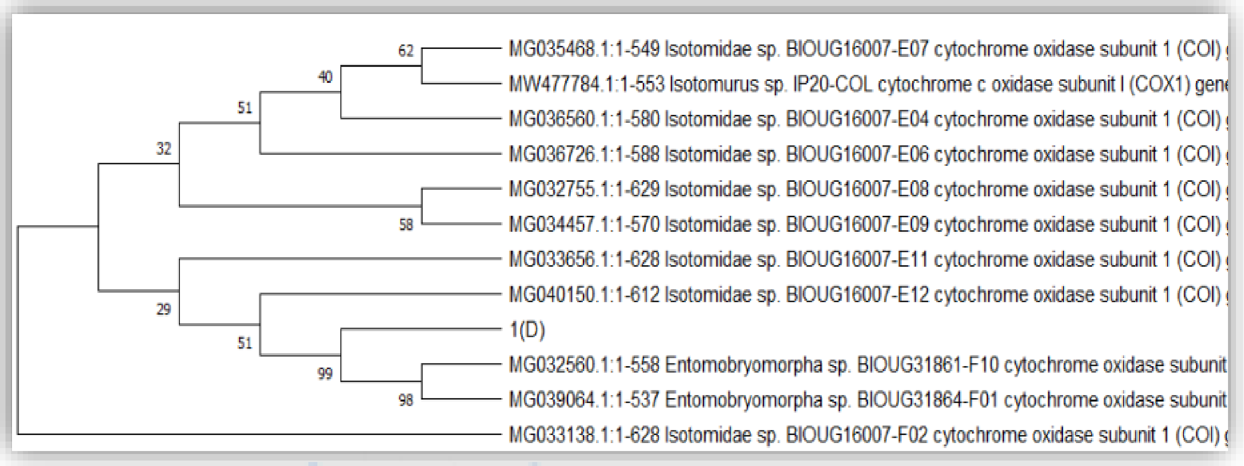


Figure 6:39 Agarose gel electrophoresis of *Isotomidae* sp.

Consensus sequence of sample *Isotomidae* sp.:

GGTGTCCAAAGAATCAGAATAAATGCTGGTATAAAATAGGATCCCCTCCC
CCCGCAGGATCGAAAAAAGAGGTG
TTTAGGTTCCGGTCTGTTAGCAGTATAGTGATGGCTCCTGCAAGTACAGGT
AAAGACAGAAGAAGAAGGATTGC
TGTTAGGAATACTGACCACACAAATAAAGGTGTGCGGTCTCATGTTATTC
CAGGTGTTCGCATATTAATAATAG
TTGTAATAAAATTTACGGCACCTAAAATTGAAGATGCGCCCGCCAAGTGG
AGACTGAAAATAGATAGGTCTACC
GAAGCTCCGGCATGGGCTACTCCTGAAGATAGAGGGGGATAAACTGTTCA
TCCTGTTCCAGCTCCTCTTTCTAC
TAGCCCTCCTGCAAGTAACAGGGTTAAAGATGGGGGTAAGAGTCAAAATC
TCATATTATTTATTCGGGGGAAAG
CCATGTCTGGGGCCCCAATTATCAGAGGTACTAGTCAATTTCCGAAACCTC
CAATTATAATGGGTATGACTATA
AAGAAAATTATAATAAAAGCATGCGCTGTCACTATTACATTGTAAATTTG
ATCGTCCCCAATAAATCTTCCTGG
TTGTCCTAATTCTAGCCGGATTAGTACTCTAAAAGCTGTTCCTACTATAGC
TGACCACACCCCAAAAATTAAAT ATATTGTGCCAAT

Phylogenetic tree (Figure 6:40):



- *Demodex folliculorum*

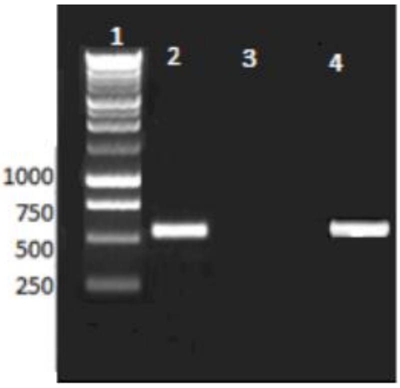


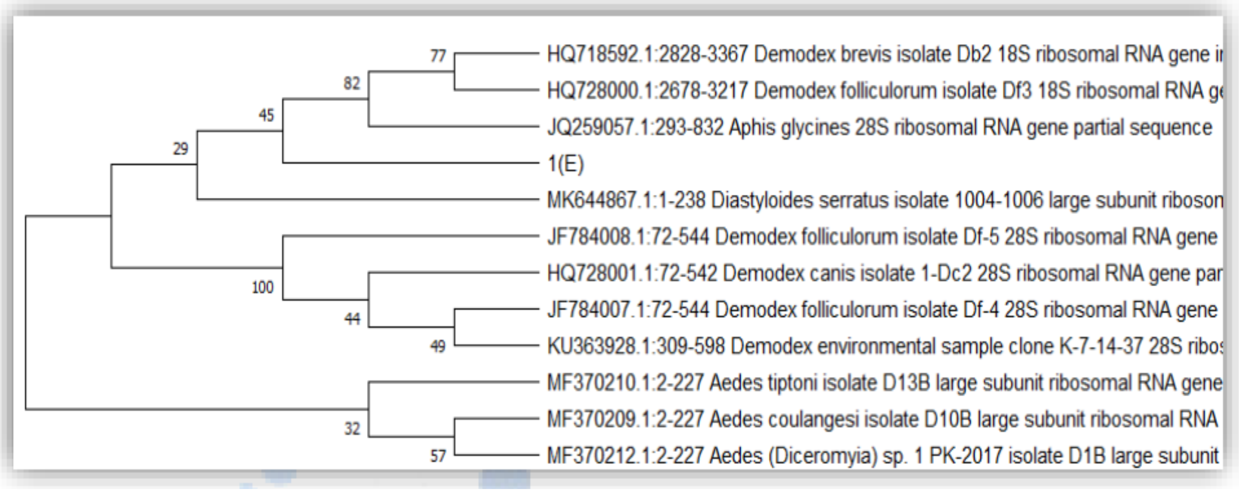
Figure 6:41 Agarose gel electrophoresis of *Demodex folliculorum*).

Consensus sequence of *Demodex folliculorum*:

GATCGATTTGCACGTCAGAACCGCTGCGAGCCTCCACCAGAGTTTCCTCTG
GCTTCGCCCTATTCAGGCATAGT
TCACCATCTTTCGGGTCCCAACATATATGCTCTTACTCAGACCCATCCCAG
AACATCAGGGCCGGTCGATGGTG
CTCCTTGCGGATCCCACCTGCATTCACTTTCATTACGCTCATGGGTTTGCC
ACCCAAAAACTCGCACACATGTT
AGACTCCTTGGTCCGTGTTTCAAGACGGGCCACTTAAAGCCATTACGCCA
GCATCCTAAGTGTGAAGGTGTCCG
AAGACCCGCCCAGAGGGCACACTGCGTTCCTTGGTCTACGTCGTCGTATC

CTGCACAGGGCTATAACACATCCG
AGGAGGCCACATTCCCCATGCGCTTCTCCGACGACCCAAACCAATGCTGG
CTTGCCACCGAGAAATACACCAAG
CAAAAGCCAGGCGGAGTCTCTCGCAGCACGGCTGACTTCAAGTGCTTCCC
TTTCGACAATTTCACGTACTTTTA ACTCTCTTTCCAAAGAGCTCTTC

Phylogenetic tree (Figure 6:42):



- *Bethylidae* sp.

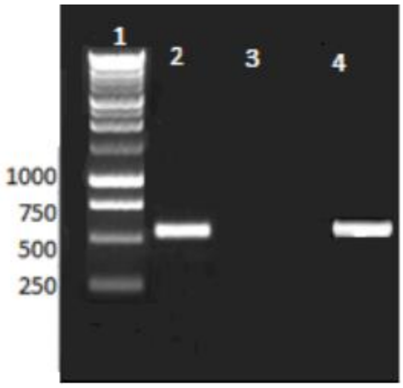


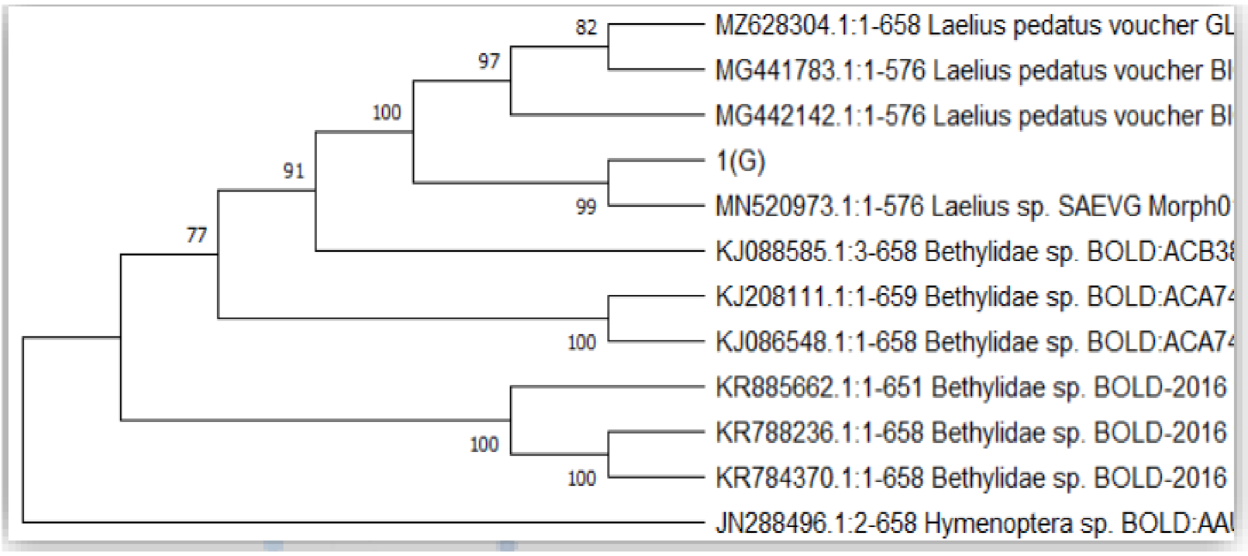
Figure 6:43 Agarose gel electrophoresis of *Bethylidae* sp.

Consensus sequence of *Bethylidae* sp.:

GGTATACTTTATTTTATTTTTGGTATATGATCTGGAATAATTGGATCTTCTA
TAAGTGTTTTAATTCGTTTAGA
ATTAAGAACACCATCCTCTTTTATTAAAAATGATTTAATTTATAATTCATT
AATTACAAGACATGCTTTAATTA

TAATTTTTTTTATAGTTATACCATTTCTAATTGGAGGATTTGGAAATTGATT
AATTCCTTTAATATTAGGAGCT
CCTGATATAGCTTACCCACGAATAAATAATATAAGTTTTTGACTTTTACCA
CCTTCTATTTCTCTTCTAATTTT
AAGTAGATTAATCAACAAAGGTGTAGGAACAGGATGAACAGCATACCCT
CCTTTATCATCTAACTTAAGACAAA
TAGGTTCTTCTATAGATTTTGCAATTTTTTCTTTACATATTGCTGGTTTATC
TTCAATTATAGGAGCAATTAAC
TTTATTTCAACTATTTTAAATTTATTTAATAAAAATTTAAAAATTGAAAAT
TTAACTCTTTTTTCTTGATCTGT
TTTAATTACAACTATTCTTCTTCTTCTTTCCTTACCAGTTCTAGCTGGAGCA
ATCACAATATTATTAACAGATC
GAAATTTAAATACATCATTTTTTGATCCTATAGGAGGAGGAGATCCAATTT
TATACCAACATTTATTTTGATTC TT

Phylogenetic tree (Figure 6:44):



Abundance of all arthropods:

The study recorded a total arthropod abundance of 15,653 individuals/m^2 species over the entire observation period. Specifically, 7,681 arthropods/ m^2 were collected in 2019, while 7,972 arthropods/ m^2 were collected in 2021 as shown in Table 6:53 and Figure 6:45. They belong to Collembola, Acari and other arthropods. The taxa of Collembola such as *Isotomidae* sp., *Cryptopygus* sp., *Isotoma* sp., *Isotomiella* sp., Isotomurus sp. *Folsomia quadrioculata*, *Hypogastrura* sp., *Lepidocyrtus* sp., *Entomobrya* sp., *Sminthrus* sp., *Katiannidae* were common in all sites. Acari such as *Acaridae*, *Laelapidae*, *Cunaxidae*, *Cryptostigmata*, *Phytoseiidae*, *Poecilochirus carabi*, *Sperchonopsis ecphyma*, Acari juveniles, *Rhodacaroidea*, *Demodex folliculorum* were present in all sites. In addition to, other arthropods such as *Cortinicara* sp. (*Latridiidae*), *Anthicidae* species, *Carabidae*, Hymenoptera, Psocoptera, Diplura, Diptera, Pseudoscorpions and Symphyla were present in all sites.

Table 6:53 The overall count of arthropod species presents at each location.

SITE DESCRIPTION	YEAR		2019 (individuals/ m^2)	2021 (individuals/ m^2)	TOTAL (individuals/ m^2)
	SITE 1	AG1	850	934	1784
		NAG1	583	653	1236
	SITE 2	AG2	1056	1087	2143
		NAG2	1012	951	1963
	SITE 3	AG3	1047	1117	2164
		NA3	1001	1055	2056
	SITE 4	AG4	1095	1153	2248
		NAG4	1037	1022	2059
		TOTAL	7681	7972	15653

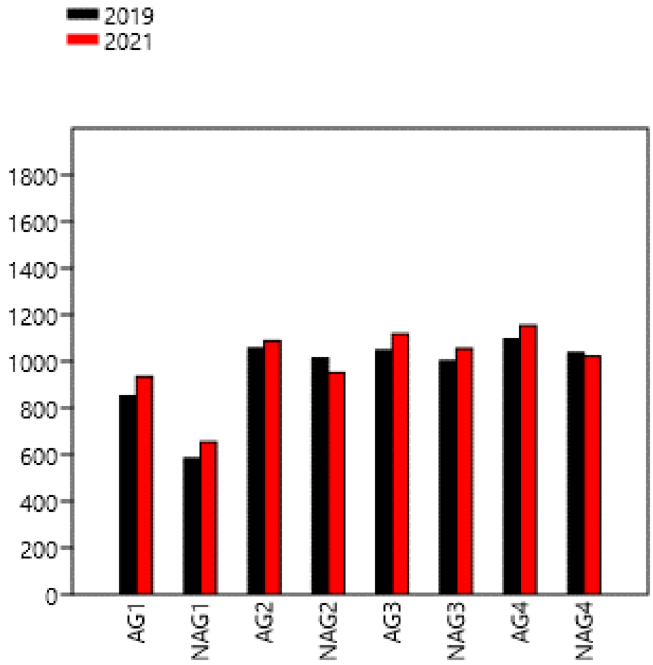


Figure 6:45 Bar chart of the total abundance of arthropods in 2019 and 2021

The Collembolans and Acari exhibited a high level of abundance. The prevalence of soil-dwelling arthropods at ground level can be attributed to the taxonomic classification of arthropods (Bagyaraj et al., 2016). The orders of Collembolans (Figure 6:47; 6:48) and Acari (Figure 6:49) were found to be highly prevalent

across all fields of the Sites. This can be attributed to the fact that these orders constitute a significant proportion, i.e., 80%, of the soil arthropod population (Culliney, 2013). The dissimilarities in the prevalence of both individual soil arthropods and species can be attributed to a variety of factors, including the diversity of vegetation, prevailing environmental conditions, and the abundance of litter present within the respective regions. The prevalence of Coleopterans (Figure 6:50) in these regions can be attributed to the ample availability of food resources. The diversity of soil arthropods was assessed across different land use types Figure 6:51 and the SEM characterization of the organisms were also used in the identification of Organisms Figure 6:52.

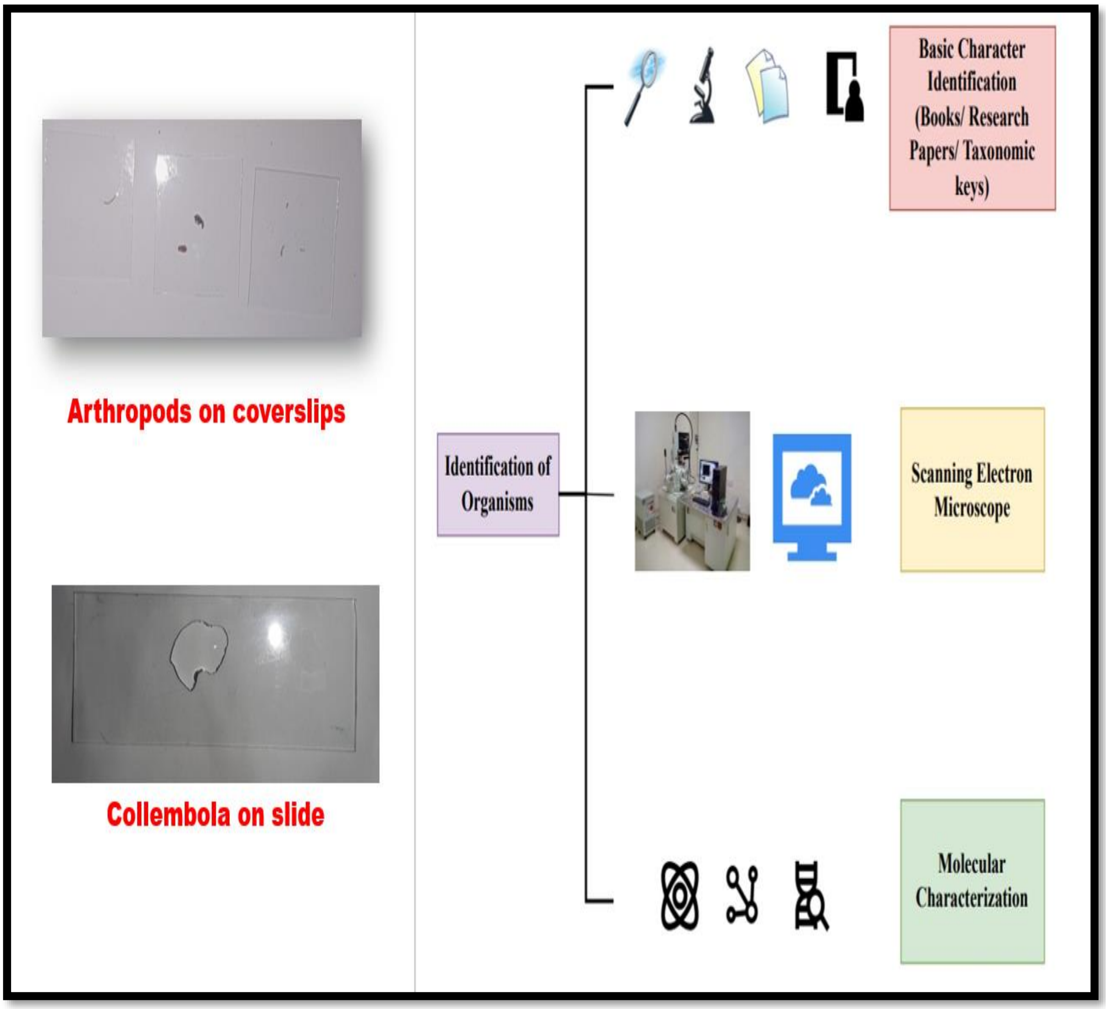


Figure 6:46 Pictorial representation of the Identification of Organisms

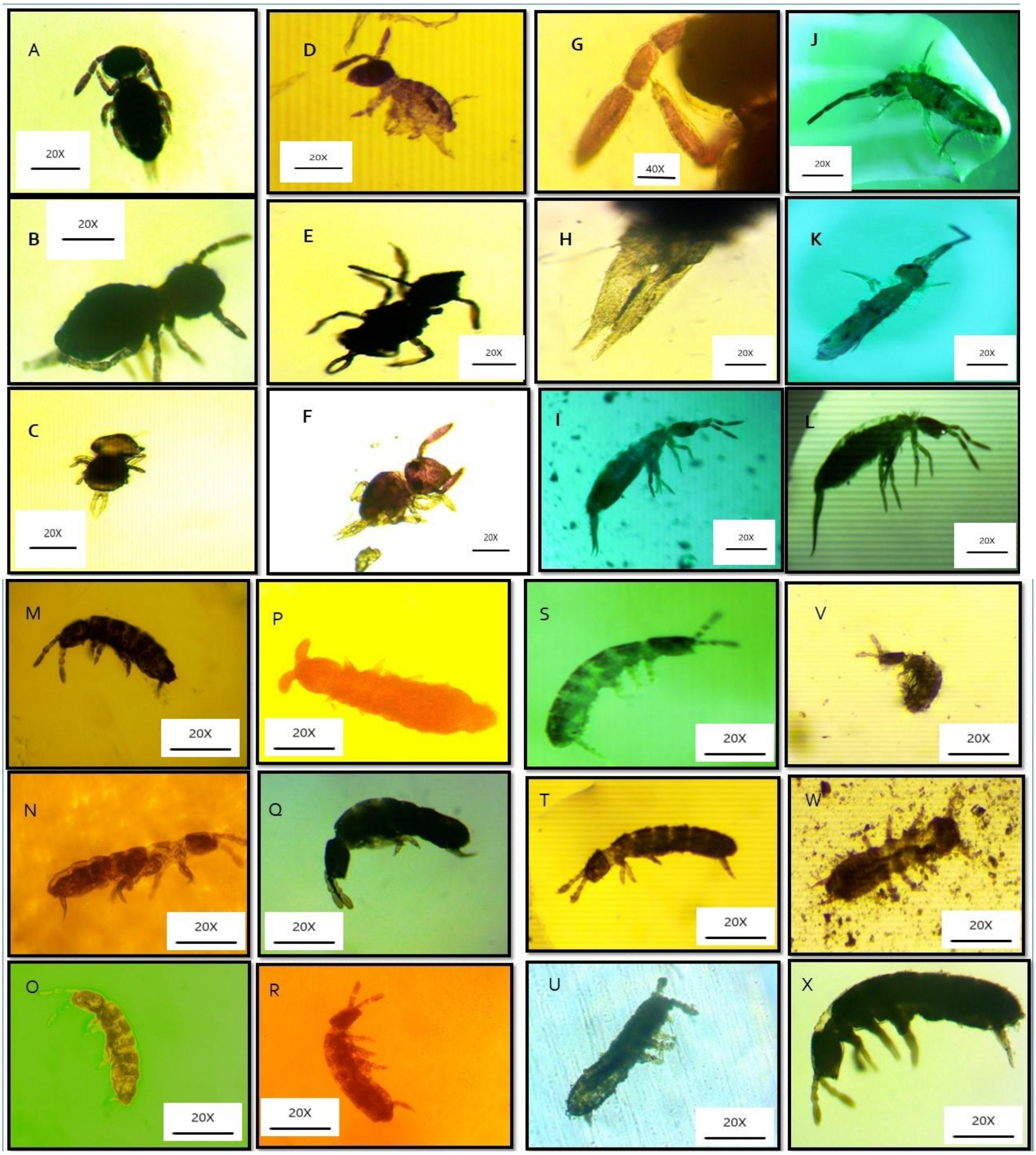


Figure 6:47 Collembolans come in a variety of shapes, colors, and sizes. Some of the species found in this thesis Sites, with information regarding the diversity and occurrence are provided in brackets (A-H *Symphyleona*; I-L *Entomobryomorpha*; M-O *Lepidocyrtus* sp.; P *Poduromorpha*, Q-X *Isotomidae*)

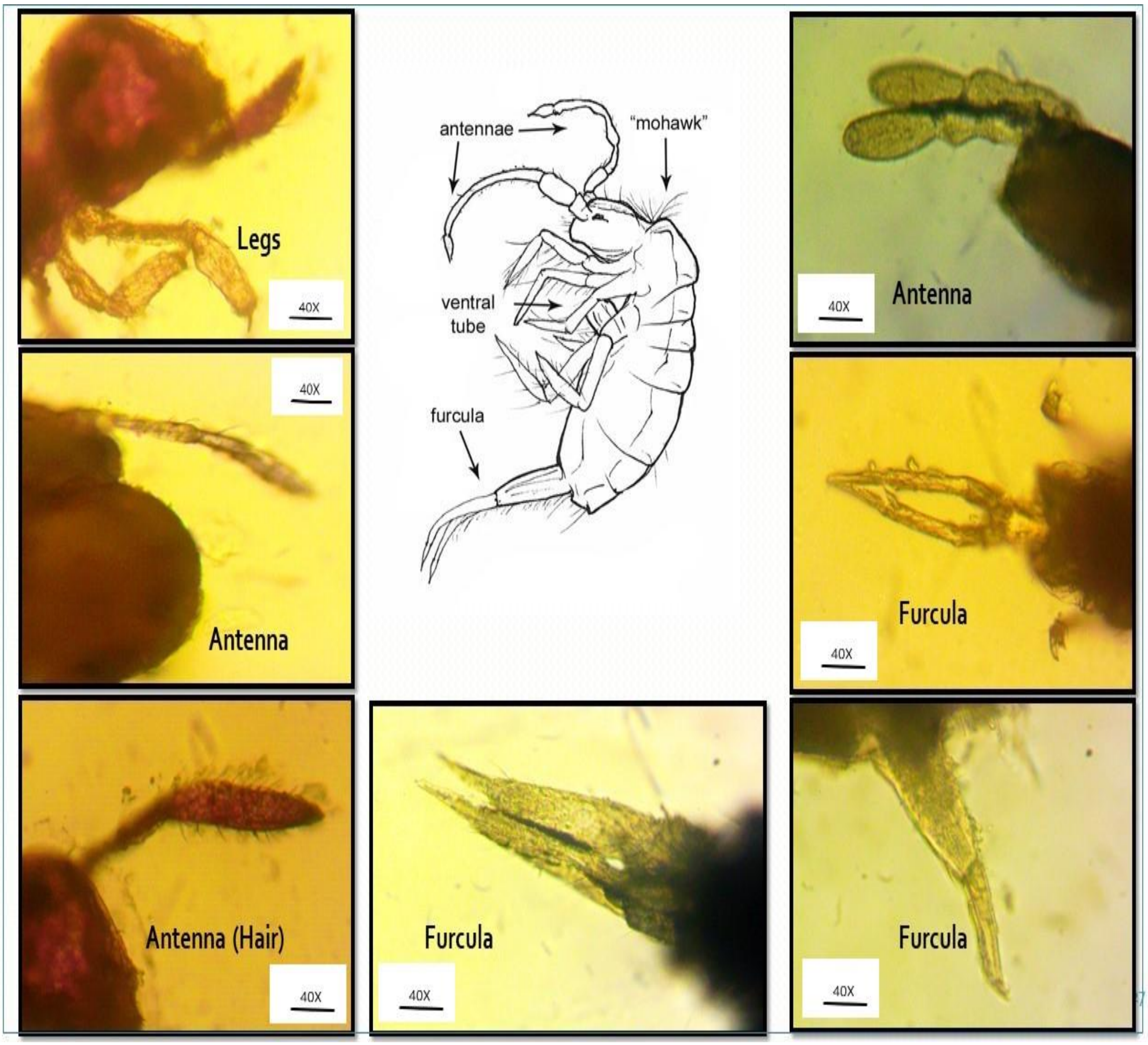


Figure 6:48 Different body parts of Collembola including Legs, Antenna, Hair, Furcula

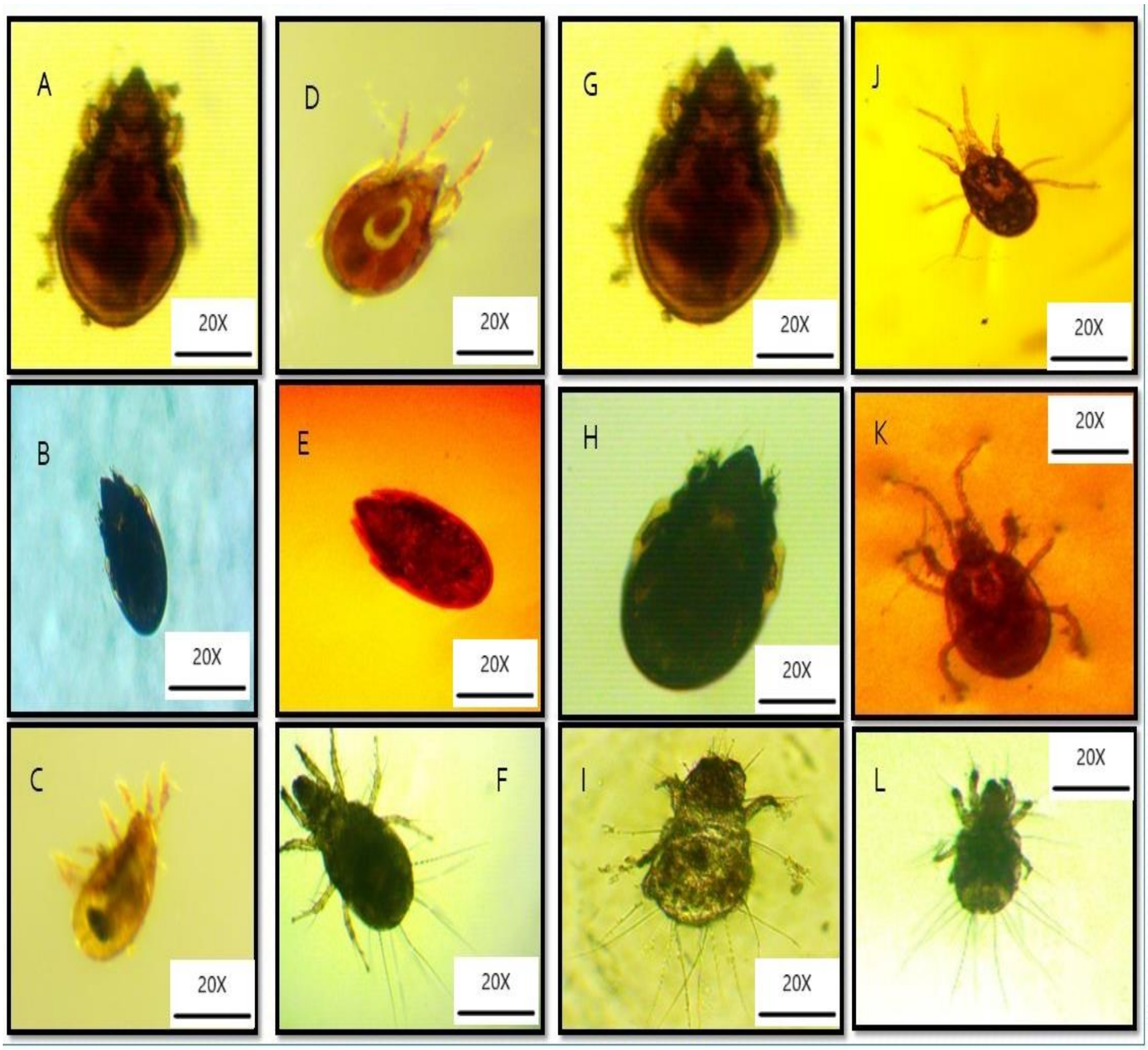


Figure 6:49 Different types of Acari observed during the study period (A-E, G, H Oribatida; F, I-L Mites)

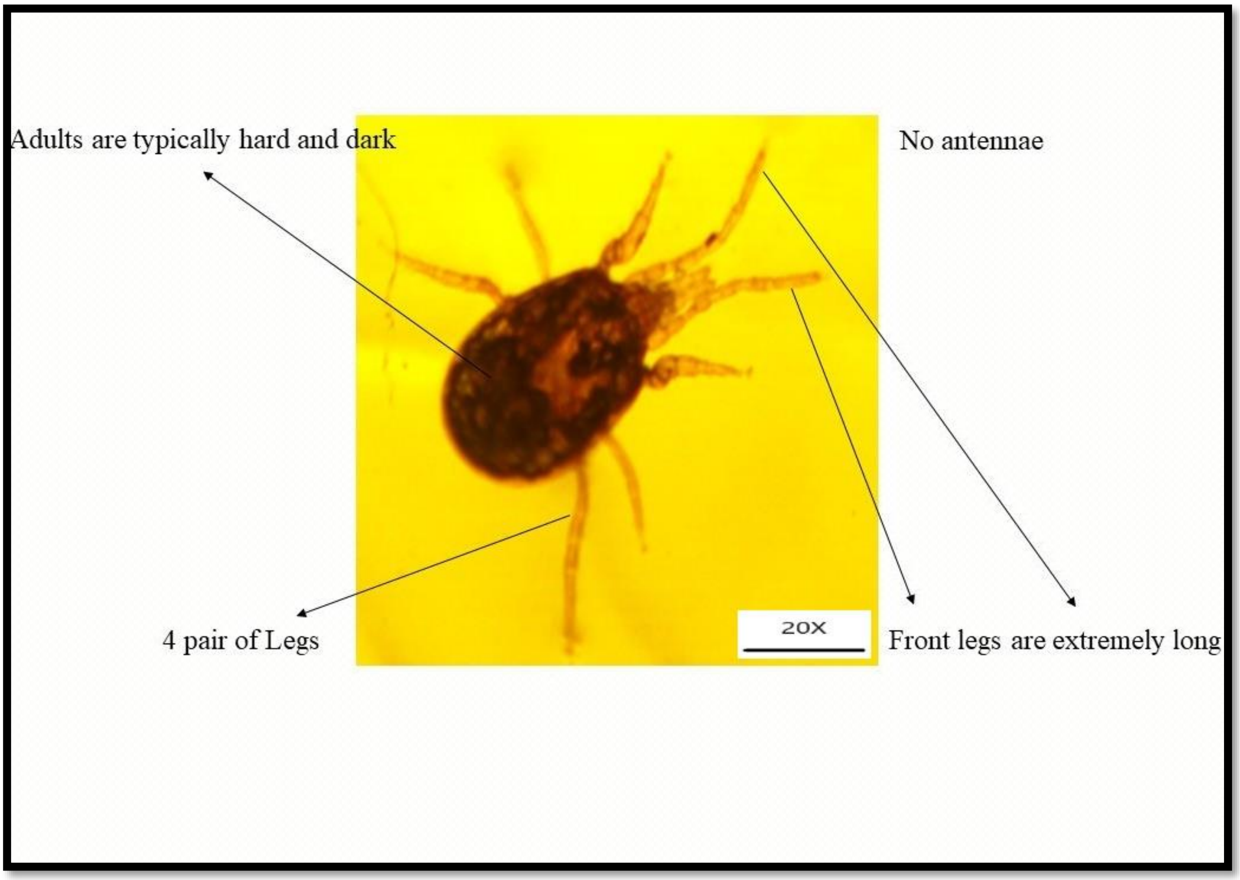


Figure 6:50 Different body parts of Mites including Legs, Front Legs and Hard Skeleton

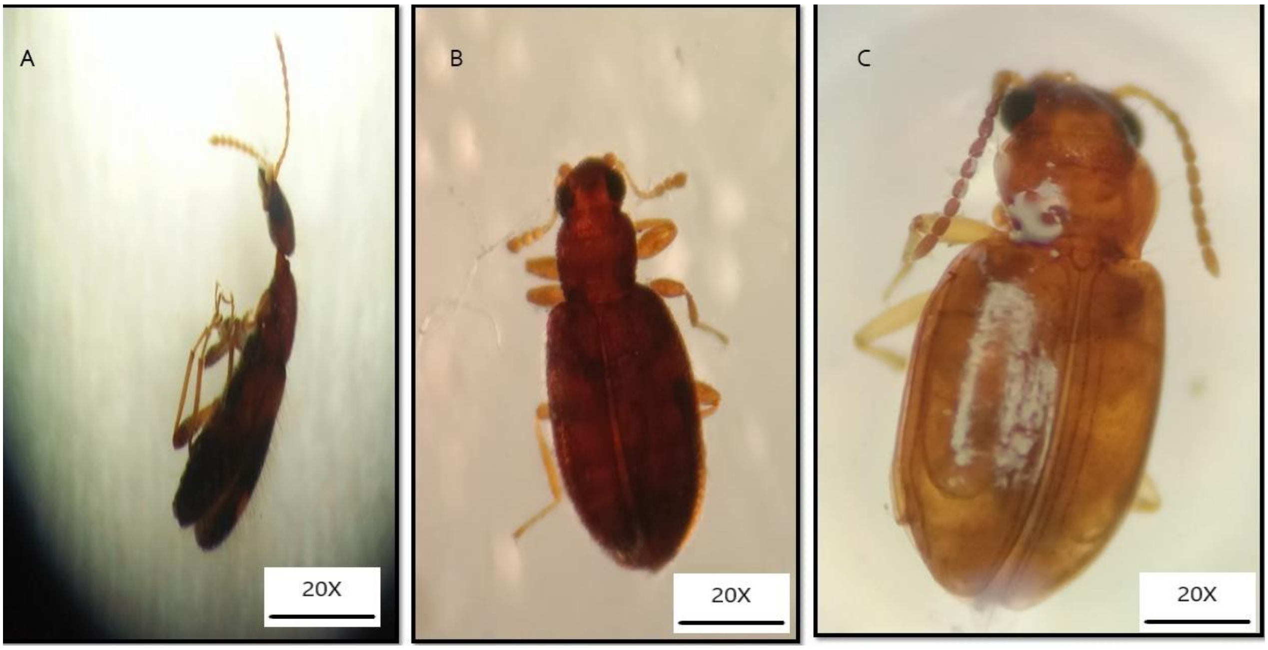
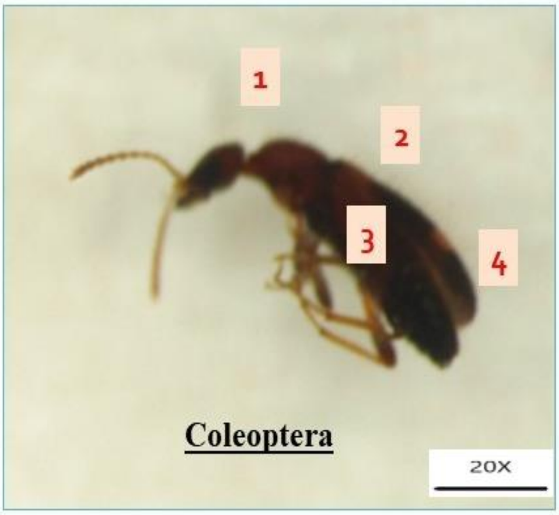


Figure 6:51 Coleoptera families obtained during the study period A- *Anthicidae* species; B- *Cortinicara* species; C- Family *Carabidae*



1. Gap at neck and waist
2. Large wing covering
3. Dark colored insects
4. Pair of wings forming a hard covering (Elytra)

Figure 6:52 Different body parts of Coleoptera

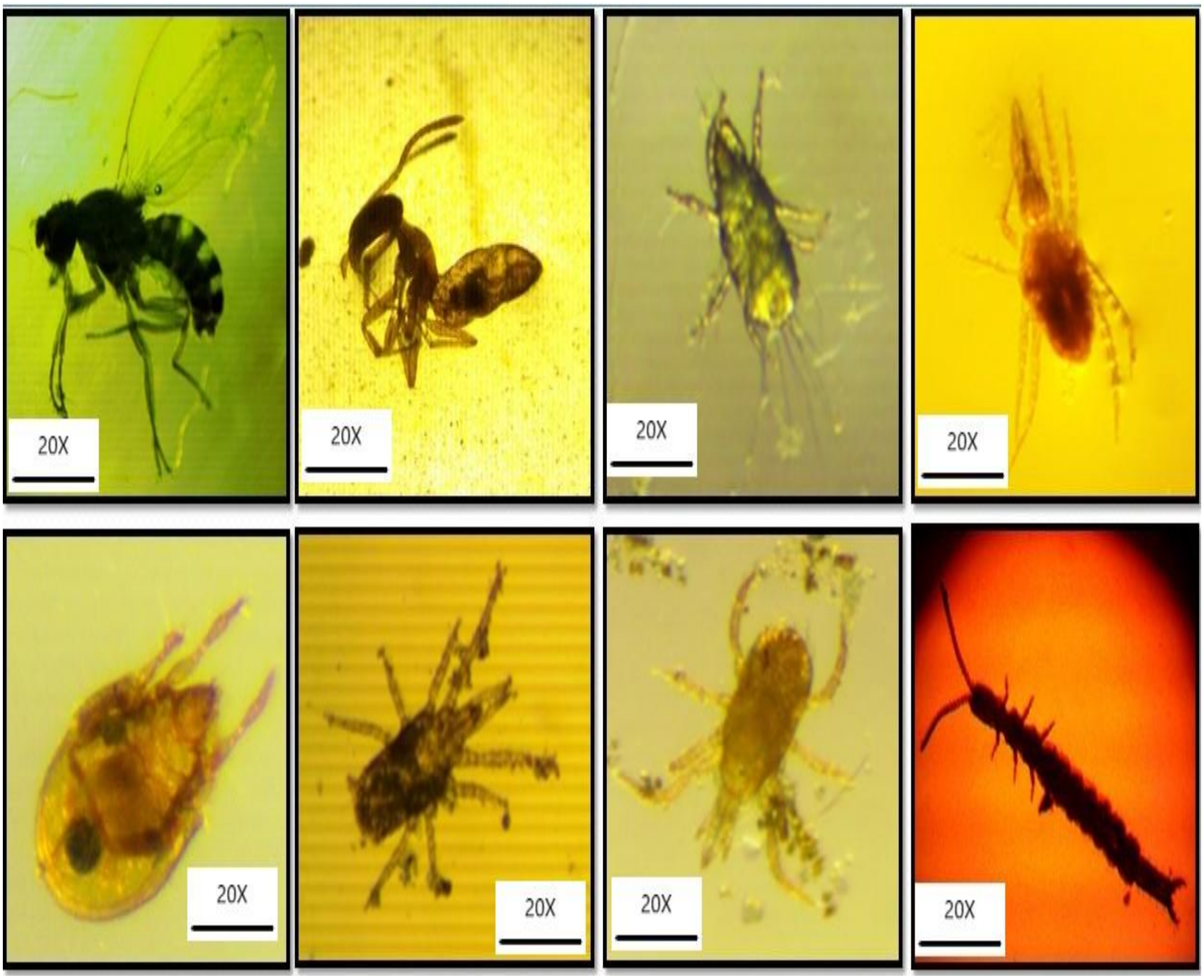


Figure 6:53 Arthropods including Ants, Flies, Mites, and Diplura in the study period 2019-2021

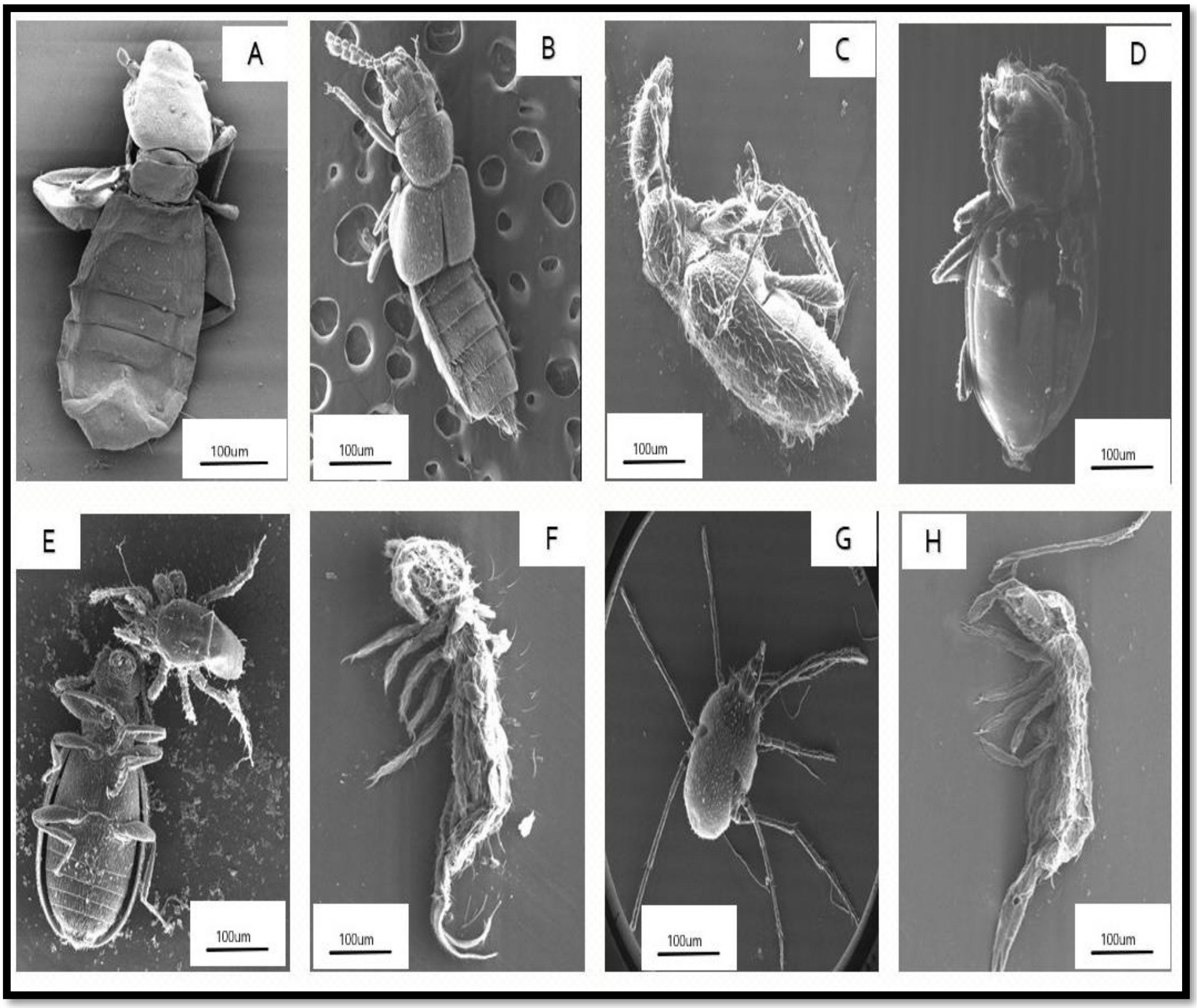


Figure 6:54 SEM characterization of the arthropods upto 140X (A- Psocoptera, B- Earwig; C, D- Coleopterans; E- Coleoptera with Mite; F- Collembola; G-Bethyliade sp.; H-Collembola)

6.10 Impact of Agriculture and Non-agriculture activities on Soil arthropods

The findings obtained from the analysis of the data collected at Site 1, 2, 3, and 4 demonstrate the existence of a periodic monthly trend in the population of soil arthropods. This trend is marked by a surge in the number of observed organisms during the pre-winter and winter periods, while the frequency of occurrences is lower during the summer and rainy seasons. At Site 1, there was an observed increase in the population of soil arthropods from 850 (individuals/ m^2) in 2019 to 934 (individuals/ m^2) in 2021 with a 9.88% increase, leading to a cumulative count of 1784 organisms in AG1. Likewise, the NAG1 exhibited a rise from 583 arthropods in 2019 to 653 in 2021, with a 12% increase, resulting in a cumulative count of 1236 organisms (individuals/ m^2). In 2019, AG2 exhibited a population of 1056 (individuals/ m^2) soil arthropods, which experienced a marginal increase of 2.93% to 1087 in 2021, resulting in a cumulative count of 2143 (individuals/ m^2). Conversely, NAG2 displayed a count of 1012 arthropods in 2019, which decreased (6.02%) to 951 in 2021, yielding a total of 1963 organisms. The arthropod population in AG3 exhibited an increase (6.68%) from 1047 (individuals/ m^2) in 2019 to 1117 (individuals/ m^2) in 2021, resulting in a cumulative population of 2164 (individuals/ m^2). The NAG3 population of arthropods exhibited a numerical increase (5.39%) from 1001 in 2019 to 1055 in 2021, resulting in a total population of 2056 organisms. In 2019, AG4 exhibited a population of 1095 arthropods, which increased (5.29%) to 1153 in 2021, resulting in a cumulative count of 2248 individuals. Conversely, NAG4 displayed a population of 1037 arthropods in 2019, which decreased (1.44%) to 1022 in 2021, resulting in a total count of 2059 organisms. In 2019, the number of soil arthropods totaled 7681 (individuals/ m^2), which subsequently increased by 3.78% to 7972 (individuals/ m^2) in 2021, resulting in a cumulative count of 15653 (individuals/ m^2) across all sites. The findings of the investigation indicate that there was variability observed in the Diversity indices across different categories of arthropods in different sites. The current investigation suggests that a wide range of factors exert an impact on the richness and population size of arthropods, with a particular emphasis on soil microarthropods. Organisms inhabiting environments with abundant nutrient availability, optimal soil moisture, and favorable environmental conditions exhibit a tendency towards higher population densities. The gradual loss of specific species due to harsh climatic conditions can have unpredictable impacts on ecosystem processes. This phenomenon may result in process response patterns towards alterations in diversity that are analogous to those witnessed in communities that have been assembled randomly. The diverse characteristics of Collembola, Acari, and other arthropod communities have been observed in our experimental investigations conducted in both agricultural and non-agricultural locations. It is noteworthy that the stable climatic conditions appear to have a positive impact on fostering a diverse range of arthropods. The number and variety of soil arthropods in both the land can be impacted by a range of factors, such as the quality and quantity of external inputs, quality of habitat, edaphic properties, and regional climatic challenges. The data collected from both agricultural and non-agricultural lands indicate negligible disparities, indicating that these arthropods are comparatively less impacted by human activities. The results of our study indicate that temperature exhibited a negative correlation with faunal diversity, whereas moisture content demonstrated a significant positive association with species richness and availability. The correlation between lower temperatures and higher faunal species diversity indicates a preference for cooler environments. Conversely, an increase in moisture content was found to be positively correlated with a greater diversity and abundance of fauna populations. It is possible that certain species exhibit a preference for cooler climates, and as a result, the occurrence of these species may be favored in habitats with lower temperatures. This may be attributed to the observed negative correlation between temperature and faunal diversity. This phenomenon could potentially be attributed to physiological mechanisms that are influenced by temperature or species-specific modifications that have evolved in response to colder environments. Conversely, the observed correlation that exists between faunal diversity and abundance and moisture content indicates that optimal moisture levels are conducive to the sustenance, propagation, and accessibility of resources for faunal communities. Sufficient atmospheric moisture can facilitate the growth of vegetation and provide suitable habitats and nourishment for various animal species, thereby augmenting their population size and variety. The findings emphasize the importance of considering temperature and moisture levels in the analysis and management of faunal communities. The authors highlight the complex interplay between climatic factors and animal communities, emphasizing the criticality of maintaining optimal moisture levels to support diverse and thriving fauna populations. The results of our study indicate that the implementation of superior agricultural management techniques can yield a favorable outcome in terms of the abundance of different taxa and the overall diversity of soil microarthropods. Conversely, suboptimal agricultural management practices may have an adverse impact on the diversity of soil microarthropods.

The implementation of sustainable and eco-friendly methods, such as organic farming, comprehensive pest management, along with soil conservation regulations in the management of agricultural lands has been found to create a more conducive habitat for soil arthropods. These agricultural techniques facilitate the enhancement of soil health, conservation of soil structure and fertility, and mitigation of the application of detrimental chemicals. Consequently, the well-managed agricultural systems provide a conducive environment for the flourishing of microarthropods in terms of their diversity and abundance.

On the other hand, agricultural management techniques that prioritize environmental sustainability may have a positive impact on soil microarthropods, whereas those that prioritize other factors, such as the overuse of pesticides, fertilizers that are synthetic, and intensive tillage, may have adverse effects on them. The aforementioned practices have the potential to disturb the inherent equilibrium of the soil ecosystem, deteriorate the quality of soil, and inflict damage upon the populace of advantageous arthropods. The degree of agricultural management is a critical factor in ascertaining the diversity and abundance of soil microarthropods. Agricultural management techniques that prioritize the health of the soil and biodiversity conservation have been observed to promote greater variety of microarthropod taxa. On the contrary, when lower-level management practices fail to prioritize environmental sustainability, it can lead to a decline in the variety and quantity of soil arthropods. The results underscore the significance of adopting sustainable agricultural methodologies in safeguarding and augmenting the diversity of soil microarthropods. Through the implementation of soil health-promoting practices, reduction of chemical inputs, and preservation of natural habitat features, farmers can establish agricultural landscapes that facilitate the growth of a diverse and thriving community of soil microarthropods. Consequently, this can make a valuable contribution to the holistic operation and adaptability of agricultural ecosystems.

6.11 QBS Index

The QBS-ar values were calculated and the soil quality classes were defined using Parisi et al., (2005) recommended Table. The Eco-Morphological Index (EMI) was utilized to assign a value to each micro-arthropod species found in the soil across all Sites. These values were then combined based on the corresponding orders and life forms of the species. Table 6:54 presents the recorded summed electromagnetic interference (EMI) value, specifically the QBS-ar, for all arthropod taxa.

Table 6:54 Mean and Standard Deviation of the numbers of arthropods with ecomorphological index occurring at the study sites in both years.

Fauna Species	**AG1**	**NAG1**	**AG2**	**NAG2**	**AG3**	**NAG3**	**AG4**	**NAG4**
Collembola	20	20	20	20	20	20	20	20
Acari	20	20	20	20	20	20	20	20
Coleoptera	20	20	20	20	20	20	20	20
Hymenopetra	5	5	5	5	5	5	5	5
Psocoptera	1	1	1	1	1	1	1	1
Diplura	20	20	20	20	20	20	20	20
Diptera	1	1	1	1	1	1	1	1
Pseudoscorpions	20	20	20	20	20	20	0	20
Symphyla	0	0	0	0	0	0	10	0
Total QBS	107	107	107	107	107	107	87	107
Mean	13.37	13.37	13.37	13.37	13.37	13.37	12.12	13.37
Std. error	3.26	3.26	3.26	3.26	3.26	3.26	3.13	3.26
Stand. dev	9.22	9.22	9.22	9.22	9.22	9.22	8.87	9.22

The tabulated data presents the prevalence of diverse arthropod taxa across multiple research location (AG1, NAG1, AG2, NAG2, AG3, NAG3, AG4, and NAG4). The Table enumerates various arthropod taxa, namely Collembola, Acari, Coleoptera, Hymenoptera, Psocoptera, Diplura, Diptera, Pseudoscorpions, and Symphyla. The frequency of occurrence of every taxonomic group is exhibited for every research location. The tabulated data denotes the aggregate count of individuals observed for every taxonomic group across all research sites. All taxonomic groups exhibit equal abundance, with a total of 20 individuals recorded across all study locations. However, it is worth noting that Pseudoscorpions were not observed in AG4. The Table presents supplementary statistical information pertaining to the abundance data, including the QBS, mean, standard deviation, and standard error. The QBS is a method employed in the field of biomonitoring to assess the ecological status of a given ecosystem by analyzing the prevalence and relative abundance of particular taxonomic groups. The statistical measures commonly employed to describe the central tendency and dispersion of abundance data are the mean, standard error, and standard deviation. Each of the study locations exhibits an identical Total QBS value of 107 and in AG4 the QBS index was 87. The Table presents summary statistics of the data, including the mean, standard deviation, and standard error. The mean abundance of each study site, which varied between 12.125 and 13.375, indicates that the average abundances across the locations are largely comparable. The standard error and standard deviation values provide an indication of the variability exhibited by the abundance statistics. The Table presents abundance data for various arthropod species across different study locations, highlighting the prevalence of high abundance values across most taxa and study locations. However, all the correlation coefficients are 1, indicating that each pair of research sites has a perfect positive association. This implies that the variables evaluated in the correlation analysis demonstrate a strong positive association between the various study sites. The QBS value of 107 denotes the overall quality of the biological soil in all the study sites. The assessment of the biological aspect of the soil ecosystem is determined by considering the various organisms present and their respective roles in maintaining soil health and functionality. The QBS index of 87 at Location AG4 is distinct to that particular site. This metric serves as an indication of the caliber of the biological soil in the particular region. The QBS index analysis indicates that the biological soil at AG4 exhibits a slightly inferior quality in comparison to the other study sites, with a Total QBS value of 87, as opposed to 107. The QBS index is formulated through an assessment of the abundance, variety, and distribution of diverse biological indicators present in the soil, encompassing a range of entities such as arthropods, bacteria, fungi, and other microorganisms. These indicators are frequently assigned a numerical value owing to their ecological significance and their role in promoting the health of the soil ecosystem. The QBS index is computed by calculating the EMI from the data, which serves as a metric for the comprehensive excellence of the biological soil. The findings indicate that the biological quality of soil is generally similar among the study sites, albeit with a slightly lower value observed in AG4.

6.12 Discussion

Over the last 20 years, advancements in soil ecological investigation methodologies have contributed to the development of the field of ecological research on soil arthropods. It is crucial to acknowledge that the implementation of novel methodologies must not disregard the interdependence of soil arthropod populations on edaphic variables. The issue of climate change is of utmost importance in the field of ecology, given the widely acknowledged role of climate as a precursor for all forms of terrestrial animal life. Therefore, it is apparent that the rate of species modification is dependent on their ability to adapt to the current environmental conditions. Any modification in the climate possesses the capability to influence the corresponding species. The rate of climatic oscillations has the potential to influence the rate of alterations in species that may arise through natural means. The correlation among climatic oscillations, their consequences on the pertinent organisms, and the endurance of the impacted species are intricately interconnected. Typically, if a species resistance capacity is insufficient to withstand the impact, its condition may be altered or impacted. On the other hand, when the capacity to resist is equal to the impact, it can be considered as a favorable environment that is distinguished by the absence of modified conditioning. In the event that the capacity for resistance surpasses the impact, it can be deemed an optimal habitat for living organisms. The modified condition may refer to physiological, anatomical, or morphological facets. The stochastic nature of species modification cannot be ascertained in light of the persistent dynamic fluctuations experienced by the climate. As aforementioned, the aggregate count of arthropods inhabiting soil's exhibits variability within a given ecosystem. The influence of environmental factors on the population dynamics of soil arthropods is widely recognized. Thus, a hypothesis was formulated that the alteration of soil fauna species is dependent on climatic disturbance. The research employed a method of multiple correlation analysis to assess the influence of environmental factors on the population dynamics of arthropods residing in soil. The findings of the correlation analysis suggest that the arthropod groups were primarily impacted by precipitation, temperature, and moisture levels. The population and diversity of soil arthropods are greatly influenced by edaphic factors. Edaphic factors, including soil temperature, moisture, pH, and organic carbon content, exerted varied effects on the density and abundance of soil microarthropods. The relationship between the rates of dispersal of different species of soil arthropods and their response to soil temperature, moisture, and organic matter in terms of population has been documented. Edaphic factors have the potential to induce fluctuations in the soil arthropod population, specifically in Collembola and Acari(mites). The research locations recorded a statistically significant rise in the populace of Collembola and Acari(mites) in the spring and winter seasons, succeeded by a noteworthy decline in the summer season. The etiology of this phenomenon remains uncertain; however, it is plausible that the reduction in soil arthropod populace during the winter season can be ascribed to the amalgamation of low temperatures and moderate humidity. The findings of our study indicate a negative correlation between soil microarthropod population and temperature elevation. Thus, it can be argued that a significant correlation exists between temperature ranges and population dynamics. Hence, it can be hypothesized that the wide spectrum of soil temperatures may have an adverse influence on the populace of soil microarthropods, leading to noteworthy consequences on their kinetics and overall viability. The main motive of this research was to examine the variety and quantity of arthropods present in both agricultural and non-agricultural terrain across various regions of Punjab. The findings indicate that there exists no statistically significant association between diverse soil characteristics, including pH levels, electrical conductivity, and carbon, nitrogen, and phosphorus concentrations, and the prevalence of arthropods. The total number of arthropods collected during the whole study period was 15653 (individuals/ m^2). Arthropods were observed in both agricultural and non-agricultural land, and their counts were recorded on an annual basis for each respective land type. In 2019, the recorded count of arthropods was 7681 (individuals/ m^2) whereas in 2021 the count went to 7972 (individuals/ m^2). Furthermore, the data has indicated a periodic variation in the arthropod populace, exhibiting maximal prevalence in the winter season and minimal prevalence in the summer season. The analysis of species composition in agricultural land revealed a maximum abundance over the course of two years. The taxonomic groups of Collembola, Mesostigmatids, and Oribatids mites were collected and analyzed, with Collembola demonstrating the greatest degree of dominance, followed by Mesostigmatids and Oribatids mites. In both years, there was a lower representation of other arthropod species. The findings of the study revealed a negative correlation between the abundance of arthropod species, including Collembola and other arthropods, and soil temperature as determined through correlation analysis. The H values exhibited inter-annual variability during the years 2019 and 2021, wherein Evenness was observed to be marginally higher in other arthropod taxa as opposed to Collembola and Acari. Upon conducting a comparison of arthropod population indices between the years 2019 and 2021, it was noted that there was a reduction in the number of taxa in 2021. However, there was an increase in the overall count of individuals. The results of the ANOVA analysis indicated significant variance variations among the groups in 2019, suggesting notable differences in means. The *Isotomidae* family manifested a distribution of diverse genera across all seasons, with the exception of the months of May and June. The population dynamics of Collembola and Acari exhibited a conventional trend of elevated numerical abundance during the winter season. To summarize, the research emphasized the variances in arthropod diversity and abundance between agricultural and non-agricultural terrain in the region of Punjab. The occurrence of arthropods was not significantly influenced by soil properties. The findings highlight the significance of incorporating land management practices and seasonal fluctuations into comprehending the ecological dynamics of arthropod populations.

Soil arthropods are affected by a variety of factors, including climate change, soil pollution, tillage practices, herbicides and pesticides, and various grazing management strategies. Mahdi et al., 2017 posit that soil arthropods serve as indicators of soil fertility and health, and exert a significant influence on plant productivity. Several studies have demonstrated that the diversity and abundance of soil arthropods are influenced by the richness and variety of soil habitat (Esenowo et al., 2017). It can be inferred that agricultural regions exhibit a greater abundance of soil arthropods and offer a favorable habitat, as evidenced by the observed discrepancies in the quantities of soil arachnids between all sites. The taxonomic groups with the highest prevalence in agricultural landscapes were Collembola, followed by Acari, Beetles, and Ants. Fusaro et al., 2018 have reported that Collembola serves as a significant bioindicator for assessing soil health and is highly susceptible to alterations in soil habitat. According to Fusaro et al., 2018, the greater part of collembola exhibit a carnivorous feeding behavior, consuming decomposing organic matter, deceased subterranean organisms, and fungal hyphae. According to Liu et al., 2016, Collembola and Acari are ubiquitous in various trophic levels of subterranean organic matter food webs, and thus comprise the majority of soil-dwelling arthropods. The present investigation revealed that Collembola exhibited the highest population density and prevalence compared to other soil microarthropods such as Acari, Coleoptera, Hymenoptera, and other taxa. The Collembola and Acari species exhibit a consistent and comparable pattern of seasonal fluctuations, as evidenced by various studies (Bhagawati et al., 2018; Bhagawati et al., 2020; Esenowo et al., 2017; Fusaro et al., 2018). The abundance of soil arthropods is subject to various factors such as soil temperature, pH, and food availability, as reported by Abbas and Parwez (2020) and Bhagawati et al., 2020. Research conducted on soil arthropods has demonstrated that population abundance and diversity are influenced by edaphic variables and seasonal fluctuations. According to Esenowo et al., 2017, a greater diversity of Collembolan species was observed in agricultural areas across all seasons, suggesting the presence of a finely distributed population of multiple species. The study conducted by Bhagawati et al., 2018 suggests that there was a notable rise in the diversity of Collembolans and Acari from January to April in comparison to May and June 2019 (Bhagawati et al., 2018; Bhagawati et al., 2020). This phenomenon can be attributed to the presence of elevated levels of moisture content and temperature, which expedite the process of organic material and litter decomposition and create a more favorable environment. The microbial community is affected both directly and indirectly by changes in the organic matter and moisture content of the soil, which can be achieved through methods such as enhancing interaction with the soil, observing humification, and promoting the development of macro- and microflora. The arthropod diversity exhibited a monthly variation, with the highest density observed during the winter along with pre-winter phases, and the lowest density observed during the summer. The soil-litter arthropod community exhibited reduced diversity and richness during the summer season, as evidenced by the collected soil samples. The management of land use has been found to have a potential correlation with reduced levels of biodiversity and abundance. It was determined that the weather conditions posing the greatest risk during the field data collection period in May and June were characterized by high temperatures and low humidity levels. The research carried out by Santos et al., 2007 was executed in the summertime. The biological regulation and ecological significance of Collembola are widely acknowledged. According to Kaneda and Kaneko (2008), it is widely recognized that they have a diet that includes bacteria, fungi, mineral soil particles, organic matter, protozoa, and nematodes. Additionally, their presence has been shown to enhance soil respiration and expedite nitrogen mineralization (Kaneda and Kaneko, 2008). Oribatid mites were found to be the second most prevalent species. The ecological roles of Oribatid mites are analogous to those of Collembola, as they serve as decomposers of organic matter and play a significant role in nutrient cycling. According to Krantz, (1978), these organisms subsist on expired or expiring tissues, as well as yeasts, bacteria, and algae. Wilson, (2005) notes that certain species of ants include these organisms in their dietary regimen. The assemblage of predatory arthropods in the olive groves was predominantly comprised of *Carabidae*, Staphylinidae, Elateridae, Formicidae, and Araneae, with variations in their respective abundances across. Araneae and Staphylinidae were identified as significant groups, the Araneae species primarily consume insects, as noted by Riechert and Lockley, (1984). On the other hand, the majority of Staphylinidae species feed on fungi, algae, and decomposing plant matter, with some also feeding on various arthropods, as reported by Klimaszewski et al., 1996. Low captures of other arthropods and beetles were also obtained by Morris and Campos, (1999).

The application of fertilizer is a critical factor in enhancing agricultural productivity. However, it has been observed that this practice can significantly affect soil properties by modifying the levels of biodiversity and leaf litter. Consequently, this alteration can lead to changes in the abundance and diversity of soil fauna populations. Soil-litter arthropods are vulnerable to alterations in soil physicochemical composition caused by chemical fertilizers, owing to their intimate association with soil nutrient levels. The soils at the sampling sites exhibited a high abundance of collembola and acari. The dietary patterns of subterranean invertebrates exert a noteworthy influence on the efficacy of the decomposer microbiota. Waste materials are primarily decomposed and their nutrients are released through the utilization of these as the principal means. The taxonomic group of soil arthropods encompasses a variety of organisms, such as Collembola, Mites, Millipedes, Pseudoscorpions, Isopods, Centipedes, Symphyla, Diplura, Protura, Hymenoptera, and larvae belonging to numerous other orders. Acarina and Collembola are dominant in terms of both the quantity and variety of arthropods across all continents, as stated by Liu et al., 2016, Chown and Convey (2016), and Schuster et al., 2019. Scientists attribute Acari's dominance in the soil to their physiological and morphological adaptive adaptations. Acari mites exhibit a prolonged lifespan, with an average longevity ranging from several months to two years, starting from the moment of hatching until reaching adulthood. In addition, these organisms possess exoskeletons that are sclerotized, exhibit a diverse array of dietary preferences, and exhibit a prolonged lifespan. Due to their rapid reproductive rate and ability to produce multiple generations within a single year, springtails are frequently observed in soil environments, as noted by Abbas and Parwez, (2020) and Shakir and Ahmed, (2014). The temperature of the soil exerts an influence on the locomotion of soil-dwelling arthropods. According to Menta and Remelli's (2020) study, an increase in temperature prompts soil arthropods to relocate to deeper layers of the soil profile, resulting in a reduction in the population of soil microarthropods. According to Shakir and Ahmed (2014), there was a rapid reduction in soil arthropods with an increase in soil warmth and moisture. Mites and collembolans are considered noteworthy arthropods with substantial potential as bioindicators of present-day environmental conditions, particularly with regards to the intensification of land use. Kumar and Singh, (2016) reported that the arthropod composition in Indian soil's is dominated by mites and collembolans, accounting for a range of 72-97% of the observed arthropods. The study revealed that the aggregate proportion of mites and collembolans exceeded 80%. Acari exhibit diverse morphological and ecological characteristics, encompassing parasitoids, predators, fungi, parasites, dead plant feeders, algal feeders, root feeders, bacterial feeders, scavengers, and omnivores. Acarina possess the ability to decompose organic matter and stimulate microbial processes within the soil, while also exhibiting a diverse dietary range encompassing various species within the surrounding ecosystem. The process of decomposition and nutrient cycling is reliant upon the presence of acarine. Collembola plays a pivotal role in the decomposition of organic matter, nutrient cycling, soil formation, and fungal regulation. Collembolans and oribatids exhibit certain similarities, albeit with distinct ecological functions. According to Menta and Remelli, (2020), Collembolans exhibit a greater capacity for adapting to environmental changes compared to oribatids. This could be attributed to their predominant consumption of fungi and detritus. In contrast to the abundant presence of collembola and acari, the remaining two groups were infrequent and mostly absent in the specimens collected during several months. The aforementioned observation is supported by the research conducted by Abbas and Parwez, (2020), Bhagawati et al., 2016 Chown and Convey, (2016), Dey and Hazra, (2021), Kaur and Sangha, (2020), Krishnapriya and Binoy (2020), Kumar and Singh, (2016), Liu et al., 2016, Menta and Remelli, (2020), Shakir and Ahmed, (2014), and Uthappa and Devakumar, (2021).

As per the research conducted by Ferguson and Joly, (2002), the populations of Collembola and Acari were primarily regulated by competition for food, and secondarily by temperature in relation to climate, as evidenced by earlier studies. Pedobiologist’s study a range of soil-related factors, such as temperature, which can experience notable variations throughout different seasons and sudden, extreme changes during prevailing weather patterns or seasons. The present study provides support for the results obtained by Maclagen, (1932) regarding the influence of soil temperature, moisture content of the soil, and soil pH on the development, growth, and fecundity of Collembola, which is consistent with our own findings. Jucevica and Melecis, (2006) have reported that the community responses of Collembola population are significantly regulated by temperature and precipitation. The present study offers corroboration for the conclusions drawn by Dowdy, (1944) with respect to the influence of temperature on the vertical movement behaviors exhibited by subterranean microarthropods inhabiting diverse soil compositions and regions that have experienced substantial anthropogenic interference. The study demonstrates that temperature fluctuations elicit diverse responses in invertebrates. Dowdy, (1965) has observed the correlation between habitat and arthropod lifespan, as well as its potential to enhance population diversity.

The level of soil moisture is an essential edaphic parameter that has a substantial impact on the survival and growth of soil biota. The fluctuation in soil moisture levels holds noteworthy consequences for the populace densities of soil-dwelling arthropods. An increase in soil moisture facilitates the spread of fungi, which act as a main source of sustenance for ants, collembolans, and mites. Parwez et al., 2011 assert that the abundant vegetation promotes a habitat for a plethora of subterranean species and expedites the decomposition of litter, as well as the accrual of humus in the upper stratum of soil. The study revealed that agricultural sites exhibited a higher and more consistent density and abundance of soil arthropods in comparison to unarable sites. There exists a correlation between the distribution of varieties of vegetation and the variability in soil moisture levels. The present investigation employs the term available moisture to denote the amount of moisture necessary for the initiation and maintenance of vegetation in agricultural locations. The elevated population of Collembola in agricultural sites may be attributed to specific factors in contrast to non-agricultural sites. The moisture gradient can display a sudden or a gradual shift. The correlation between the gradual increase in soil moisture levels and the population of soil arthropods, specifically collembolans, is a significant observation. However, it is widely acknowledged that the correlation between moisture levels and annual precipitation is not always consistent, whereas the availability of moisture gradient is consistently associated with the existence of vegetation. The correlation between soil temperature and soil moisture levels indicates a rapid reduction in the latter as the former increases. The soil moisture levels beneath the uneven topography displayed seasonal variations, wherein the minimum levels were observed during the summer season and the maximum levels were observed during precipitation events. Davis, (1963) posits that the seasonal fluctuations in arthropod populations within the soil are predominantly impacted by soil moisture, which is deemed the most salient factor. According to the findings of the study, there is a notable increase in soil moisture stability during the winter months, which results in a more pronounced and uniform presence of soil arthropods. The aforementioned phenomenon can be ascribed to the propitious soil moisture conditions that facilitate the sustenance of said arthropods. The present study’s results indicate that the diversity and quantity of soil arthropods can be ascribed to multiple factors, with fluctuations in soil organic content being the most probable explanation. Körschens et al., 1997 have suggested that a correlation can be established between the concentrations of soil organic carbon and the abundance and density of soil arthropods. This relationship can be attributed to the intimate association of soil carbon with all chemical, physical, and biological soil properties.

As per the findings of Vreeken-Buijs et al., 1998, Collembolans demonstrate a predilection for environments that provide a steady supply of organic material. The influence of moisture levels on soil arthropods is predominantly indirect, as it is primarily contingent on the consequent vegetation type and density, which subsequently fosters the augmentation of soil organic matter. The presence of soil organic matter served a twofold purpose by serving as a source of nourishment and influencing the accessibility of habitat for subterranean fauna. The correlation between the augmentation of microarthropod population and the escalation of organic matter in soil has been documented in earlier research conducted by Haarlov, (1960), Christensen (1970), Davis, (1963), Singh, (1970), Darlong & Alfred, (1982), and Huhta & Milkkonen, (1982). The documentation of a substantial abundance of mites in soil surfaces that exhibit a high level of organic matter has been recorded. The underlying cause of this phenomenon can be attributed to the existence of organic matter and its associated microorganisms on the surface, which play a pivotal role as a substrate for mites. The importance of organic matter in soil, whether it occurs naturally or is introduced through biotic activity, is a subject of great interest due to the pivotal role played by soil microarthropod populations in the process of decomposition. The microarthropods are accountable for the decomposition of leaf litter and the provision of vital nutrients to the soil. Soil arthropods demonstrate enhanced resistance under circumstances of heightened temperature and humidity. The viability of soil-dwelling arthropods is often impeded by the optimal balance between temperature and moisture. According to Choi et al., 2006, the population dynamics of Collembola are significantly influenced by soil moisture, while previous research has indicated that temperature plays a critical role in regulating different aspects of their life (Christiansen, 1964; Butcher et al., 1971; Hopkins, 1997). The elevated temperature had an impact on the Collembola community. The current investigation is consistent with prior research that has indicated a correlation between springtail density and various factors, including soil water content, pH, temperature, and food resources (Chagnon et al., 2000; Olejniczak, 2000; Hasegawa, 2001). It is important to emphasize that under the specific conditions of the field experiment, the population of soil arthropods experiences a negative impact as a result of increased soil temperatures, as opposed to a positive one. The aforementioned result is associated with the effects of evaporation and the decline in soil moisture, as previously indicated by Kautz et al., 2005. The research community has widely recognized the effects of low humidity on soil microarthropods, which include migration, decreased reproductive rates, and elevated mortality rates, as observed by Butcher et al., in 1971. Pflug and Wolters, (2001) have suggested that the presence and diversity of Collembola may be reduced due to stress caused by drought. The present investigation is fully consistent with the observation that was discovered. The results of the investigation were incongruous with the preliminary hypotheses, as the recorded levels of soil microarthropods did not demonstrate an upsurge despite notable fluctuations in soil moisture and temperature throughout all the scrutinized locations. The prevailing negative correlation between soil microarthropods and pH levels in most cases implies that their abundance is not primarily determined by acidic conditions, under the present circumstances. In 1997, van Straalen and Verhoef reported notable variations in the pH inclinations of diverse soil microarthropod species. As per the research conducted by Butcher et al., in 1971, it was observed that collembolans exhibited a pH tolerance range of 6.0 to 8.0, with an optimal pH range of 7.2 to 7.5. Our findings are consistent with this observation. The pH levels within the near neutral range have the potential to exert an influence on the populations of Collembola. The experimental fields were found to exhibit a predominance of pH values at 7. The results of the study suggest that Collembolans exhibited a higher prevalence than other taxa across all of the investigated sites. The occurrence of Collembola and Acari in non-agricultural sites was found to be prevalent, with a rate exceeding 88% in both years. This observation may be attributed to the comparable pattern of incidence in both sites, regardless of human activities. On the other hand, a negative correlation was detected between the prevalence of Phosphorus and arthropods. The presented data exhibits the correlation coefficients between different edaphic factors and the population of three specific arthropod categories, namely Collembola, Acari, and other arthropods, at AG1 over the course of the year 2019. The findings suggest the presence of a direct association between temperature and moisture, C, and N, whereas an inverse relationship is apparent between temperature and pH, E.C., P, Collembola, Acari, and other arthropods.

The pH levels demonstrate an inverse relationship with arthropod groups, electrical conductivity, and phosphorus, while exhibiting a low correlation with moisture. A positive correlation has been observed between E.C. and K, as well as all arthropod groups. Conversely, a negative correlation has been noted between E.C. and pH and P. The presence of moisture is positively correlated with all arthropod groups and exhibits a weak correlation with carbon and nitrogen. Conversely, moisture displays a negative correlation with temperature. A positive correlation has been observed between C and moisture, as well as all arthropod groups. Conversely, a negative correlation has been identified between C and pH. The variable N demonstrates a weak positive correlation with both moisture and all arthropod groups, while exhibiting a negative correlation with pH. A positive correlation has been observed between K and E.C. in addition to all arthropod groups. The variable P demonstrates an inverse relationship with E.C. and exhibits a low correlation with all arthropod groups. It is generally apparent that there are complex relationships between soil-related factors and arthropod populations, and these relationships are not always straightforward. The data suggests that specific variables, namely moisture, E.C., and K, display a positive association with arthropod populations, while other variables, such as pH and P, exhibit a negative association. The implementation of correlation coefficients facilitates the identification of the most noteworthy variables in forecasting or clarifying the prevalence of specific arthropod categories at AG1 in the year 2019. In 2021, a weak positive correlation was observed between the variable P and Other Arthropods. The data provides a comprehensive summary of the correlation that exists between moisture levels, pH values, temperature, and arthropod populations. The results suggest that there is a significant association between the presence of moisture and the abundance of arthropod communities, particularly Collembola and Acari. Furthermore, there were weaker correlations detected among pH, temperature, and arthropod populations. The correlation between arthropod populations and edaphic factors, including carbon, nitrogen, potassium, and phosphorus, is relatively weak.

The impact of human management practices on the ecosystem is a well-recognized phenomenon. These practices, which include mechanical or manual tilling, plant sampling, utilization of fertilizers and pesticides, and irrigation during harvesting periods, have been found to cause disturbances to the ecosystem. The soil-dwelling arthropod population is susceptible to alterations resulting from a range of grazing management techniques, alongside environmental factors such as climate change, soil contamination, tillage practices, herbicide application, and pesticide usage. According to the research conducted by Mahdi et al., 2017, soil arthropods are considered to be significant indicators of soil health and fertility. Their presence can have a notable impact on crop yields. Numerous investigations have indicated that the prevalence and variety of soil arthropods are impacted by the opulence and diversity of soil habitats (Esenowo et al., 2017). The dissimilarities in soil arthropod populations between the two land types suggest that agricultural areas provide a more favorable habitat for soil arthropods. The present results are consistent with the study carried out by Bhagawati et al., 2018, indicating that the existence of increased moisture levels and temperature circumstances can expedite the breakdown of organic matter and debris, generating a conducive milieu that could explain the increased diversity of Collembolans and Acari recorded between January and April. This trend exhibits a noteworthy distinction when juxtaposed with the corresponding months of May and June in both aforementioned years. On the other hand, the significant increase in the diversity of soil microarthropods, particularly Collembola, in agricultural areas compared to non-agricultural areas can be attributed to the adoption of management strategies. The reason for this is that implementation of superior management practices can foster a milieu that is favorable for the improved viability of soil arthropods. The precipitation levels have a significant influence on the diversity and distribution of soil-dwelling arthropods. The present study has demonstrated that the population of soil-dwelling arthropods exhibited a relatively lower abundance during months characterized by precipitation. Currently, the etiology is undetermined. The matter of concern pertains to the potential impact of flooding on the survival and diversity of soil arthropods. The inundation may lead to the partial filling of air-filled soil pores with water. In light of these conditions, it is possible for the respiratory process to be impeded as a result of a decrease in the oxygen concentration present in the soil's aqueous pores. The survival of soil arthropods has the potential to significantly impact the diversity of soil arthropod populations, potentially leading to disturbances and subsequent reductions in diversity. On the other hand, changes in temperature are currently leading to adjustments in the hydrologic cycle, impacting the timing and intensity of precipitation occurrences in diverse ecological systems. The alteration of precipitation patterns in combination with increased soil surface temperatures has the capability to enhance the occurrence, duration, and intensity of drought occurrences. The exacerbating aridity conditions possess the capability to induce an increase in the fatality proportion of soil microarthropods, which are presently undergoing physiological dehydration in regions characterized by arid and semi-arid climates. The correlation between soil arthropod species richness and ecological variables may exhibit variability, as the mere presence of arthropods in the studied locations does not necessarily guarantee a consequential increase in richness. The potential extinction of species due to particular soil conditions is not a stochastic process, and its impact will not be evenly spread among different functional categories. The potential consequences of the gradual reduction in soil arthropod species resulting from abiotic or edaphic factors exceeding their tolerance thresholds should be taken into account, as it could result in indiscriminate losses in soil arthropod diversity. The aforementioned scenario may have consequential effects on soil-dwelling arthropods, potentially leading to disturbances in soil productivity. Hence, it is crucial for managers and farmers to acquire knowledge pertaining to the probable influence of edaphic factors on the variety of soil arthropods in agricultural soil ecosystems.

According to recent research, DNA Metabarcoding has been found to produce comparable assessment outcomes, making it a viable and dependable approach for identifying invertebrates in bioassessment of ecosystems. Furthermore, it offers a significant advantage over morphological identification by enabling identification of taxonomic groups that are difficult to identify using routine protocols (Elbrecht et al., 2017; Valentini et al. 2009). DNA barcoding enables the acquisition of a collection of autonomous characteristics that can be readily compared among various species and populations in a straightforward manner.

The results of our study indicate that the utilization of COI sequencing data has the potential to overcome the taxonomic limitations in identifying soil invertebrate species. The results of our study indicate that the utilization of COI sequence data is a viable approach for the identification of Collembola within soil-dwelling invertebrates. The utilization of DNA barcodes facilitates the execution of comprehensive investigations that necessitate a substantial volume of customary identifications. Previous studies have demonstrated the utility of DNA barcodes in the identification of Collembola. The taxonomic impediment that impacts most soil taxa can be overcome by utilizing molecular taxonomy techniques, such as DNA barcoding, which offer a suitable solution for the prompt, efficient, and accurate identification of these species. This assertion holds particular relevance for taxonomic groups that exhibit diminutive size and have been subject to limited scientific inquiry, such as Collembola. DNA barcoding has the potential to make a substantial contribution, considering the vast availability of reference libraries and the swift expansion of capacity for those that are still deficient. The Collembola species presents a valuable case for the identification and quantification of macroscopic taxa. Moreover, this presents an opportunity to monitor a plethora of taxonomic categories that are seldom sampled in conventional surveys. Prior research has demonstrated that the sequencing of mitochondrial genes is a viable approach for discriminating between closely related Collembola species. Our own research has provided evidence to support these claims. Novel approaches are necessary to promptly evaluate the local and global conditions of soil biota, owing to insufficient taxonomic proficiency and data on particular taxa. It is imperative to devise novel methodologies. Molecular systematics, which encompasses the use of DNA barcoding, has the potential to facilitate the detection and classification of various plant and animal taxa. The prioritization of COI over other mitochondrial genes is due to the exceptional specificity and reliability of COI primers, which demonstrate the utmost accuracy in retrieving the 5 end of target DNA. The prioritization of COI is attributed to this rationale. The implication of this statement is that the utilization of COI sequences has the potential to aid in the identification of the genus, contingent upon the comprehensiveness of the pertinent database. In the event that the sequence of a given species is untraceable in the NCBI database, a thorough exploration of the corresponding family will be conducted until the most analogous match is identified. The present study provides support for the effectiveness of mitochondrial DNA sequencing as a means of distinguishing closely related Collembola species, which is consistent with prior research in this area (Angurana et al., 2023). The utilization of soil microarthropods as indicators of soil quality in agroecosystems has been widely acknowledged (Stork and Eggleton, 2009). Among the various indices available, the QBSar is considered to be one of the most dependable as it is based on the microarthropods adaptation to the soil habitat (Parisi et al., 2005). The findings of Menta et al., 2011 confirm that the soil quality of field margins and grasslands is superior to that of arable fields. The results indicate that there is a positive correlation between field margins and invertebrate biodiversity, as well as soil quality. Arthropods serve significant functions in agro-ecosystems as food, predatory creature's, pollinators, and parasites. Therefore, the species richness, abundance, and geographic distribution of arthropods have a substantial impact on the sustainability of the ecosystem (Bagchi et al., 2014; Rana et al., 2019; Maqsood et al., 2020). Jacobsen et al., 2019 and Torma et al., 2019 have both recognized the importance of maintaining and improving levels of abundance and biodiversity in the development of sustainable agricultural practices. The findings of our study indicate a significant dissimilarity in the arthropod communities between the two research sites. These variations in the sites can be attributed to the abiotic factors. Suheriyanto et al., 2019 have asserted that the distribution of faunal communities across various ecological regions is significantly influenced by environmental gradients. A previous study conducted by Andrew, 2013 revealed that the distribution of arthropod communities in an ecosystem is influenced by climatic factors and humidity. Barberi et al., 2010 emphasize the importance of studying the various interactions between the arthropod population and vegetation types, in order to gain a comprehensive understanding of the negative impacts on ecosystem sustainability. The findings of our study indicate a notable disparity in arthropod abundance between the agriculture and non-agriculture regions, with the former exhibiting a higher abundance and the latter a lower abundance. The findings indicate that the distribution of fauna is greater in agriculture land as a result of the highly favorable environmental conditions for arthropod distribution, in comparison to other regions. One plausible hypothesis is that the observed phenomenon could be attributed to the higher levels of precipitation and cooler weather in the aforementioned region. According to Knapp et al., 2008, Blankinship et al., 2011, Sylvain et al., 2014, and Caruso et al., 2019, humidity is considered a crucial factor in determining the productivity of terrestrial ecosystems. This factor has a significant impact on the diversity, species richness, and abundance of soil arthropods. According to several studies (Landesman et al., 2011; Turnbull and Lindo, 2015; Torode et al., 2016; Cesarz et al., 2017), a greater abundance of ground-dwelling arthropods was observed in areas with higher levels of precipitation. The recent shift in attention towards the impact of precipitation on the abundance and diversity of arthropods has resulted in a change in emphasis from temperature to local climatic factors as a determining factor (Leckey et al., 2014). Stephanie and Rasmont, (2012) and Mcglynn et al., 2019 have posited that arthropod populations may decline in hot and xeric climates due to the requirement of moderate temperatures for optimal growth and production of soil arthropod fauna. The studies conducted by Xu et al., 2013 and de Sassi et al., 2012 have revealed that humidity has a significant impact on faunal abundance. Conversely, regions characterized by dry climatic conditions tend to exhibit a more uniform diversity of arthropods. The findings of our study indicate that, in addition, the region characterized by a warm climate exhibited a reduced presence of fauna. The present findings are consistent with prior research conducted by Hamblin et al., 2017 and Majeed et al., 2020, which posited that elevated temperatures within a given habitat can lead to a reduction in arthropod diversity within the corresponding ecosystem. The aforementioned proposition is further supported by Joose's, 1981 assertion that in a setting that is comparatively more stable and advantageous, biotic factors assume a more immediate function. The author noted an increased likelihood of predation in *Orchesella cinecta*, as well as the occurrence of interspecific competition among multiple species of Collembola. The members of Coleoptera and Hymenoptera have been observed to utilize the abundant soil microarthropods as a food source. These microarthropods are preyed upon by the aforementioned insects, and they also consume plant materials and dead microarthropods, as postulated by Raw, 1956. Collembolans exhibit a high prevalence in the uppermost soil layer, relative to the overall population of soil microarthropods, owing to their vertical distribution. According to Kaczmarek's (1993) findings, a majority of Collembola, exceeding 90%, are present in the uppermost 10 cm of soil. Consequently, it was determined that soil cores with increased depth were adequate soil specimens for the majority of the soil arthropod community. Numerous scholarly investigations have documented a reduction in the prevalence of collembolans as depth increases. These studies include Poole, 1959; Davis, 1963; Christenson, 1964; Mc Millan, 1969; Chaudhury and Roy, 1970; Takeda, 1976;

Darlong and Alfred, 1982; and Mallow et al., 1985. During the investigation period, Acarina (mites) were observed in moderate quantities across all three suborders in all sites. The observed moderate population of mites suggests that the agricultural site is unsuitable due to inadequate levels of vegetation, moisture, and organic matter. The population of mites experiences a decrease due to the predation of Dipterans and Coleopterans larvae, which utilize them as a source of sustenance. The presence of mites is contingent upon the lack of human intervention, including but not limited to tillage, manuring, ploughing, or chemical spraying, which leads to an environment that remains undisturbed. The phenomenon of multiple peaks in soil mites is a rare occurrence. As per Badejo's, 1990 findings, a significant proportion of mite genera demonstrate a unimodal distribution, which is indicative of a particular season. The population trend of Apterygotes displayed significant variability, particularly in relation to the population of Collembola across all the examined sites. The five families were observed to exemplify the order. However, the *Isotomidae* family displayed significant peaks during the months of January, February, and March, predominantly across all sites, for two consecutive years. In contrast, the samples collected from non-agricultural land exhibited a relatively lower population density when compared to those obtained from agricultural sites. The observed populations potential causes may be ascribed to both edaphic and biotic factors. The temporal distribution of collembolans manifests fluctuations in the zenith and nadir of populace densities among diverse locations and taxa, as antecedently noted by Hale, 1966. Collembolans display a behavioral adaptation wherein they temporarily migrate from their habitat to avoid desiccation. As a result, the population of Collembolan exhibits a substantial decrease during periods of aridity. This can be attributed to the absence of vegetation, which serves as a source of shade, and the increased atmospheric temperature that reduces the soil surface. The influence of seasonal or periodic changes on the functioning and diversity of ecosystems is dependent on the response patterns. Gradual depletion of species caused by abiotic conditions exceeding tolerance limits can result in a loss of diversity in soil microarthropods, which may have arbitrary impacts on soil functional ability. The capacity of soil to function effectively is commonly dependent on its functional groups, which are interrelated domains that rely on their competency and ability to survive. The inherent mutual reliance between different components of the soil system is a pivotal determinant of its overall efficacy. The survival and biodiversity of soil arthropods may be negatively impacted by exposure to extreme weather conditions that occur during seasonal fluctuations. The present investigation has identified a pair of fundamental factors that have been attributed to the population oscillations of soil microarthropods. The initial factor pertained to the amalgamation of soil temperature and relative humidity, whereas the subsequent factor was associated with diminished soil moisture. The aforementioned factors are of paramount importance, not solely for the proliferation of flora, but also for the enhancement of soil management methodologies in the field of agriculture. Acknowledging soil moisture as a critical constraining factor is essential in situations where soil moisture conditions remain stable and temperatures are within normal ranges. The combination of heightened soil temperature and augmented relative humidity has been observed to exert an adverse influence on the microarthropod communities inhabiting soil that is abundant in nutrients. The aforementioned factors are subject to the influence of climatic fluctuations, which are predominantly dictated by the length of the seasons. Hence, the significance of seasonal interference on the population of soil microarthropods cannot be overstated. The conservation of soil microarthropod diversity is imperative for the preservation of agricultural vegetation or ground cover, as viewed from a managerial standpoint. The reason behind this phenomenon is that the preservation of such habitats can function as a sanctuary during winter for diverse microarthropod predators. The noteworthy aspect pertains to the inclusion of every type of soil microarthropod within a more extensive collection, whereby the absence of any one species is expected to immediately affect the intricacies and population densities of other subterranean organisms. Soil arthropods that possess crucial ecological functions are designated as keystone species, and their absence is thought to lead to the collapse of the surrounding ecosystem.

Chapter 7

CONCLUSION AND SUMMARY

The significance of soil as a constituent of ecosystems is noteworthy, and its productivity is predominantly impacted by the actions of the arthropods inhabiting it. Soil fertility is determined by its ability to provide plants with essential nutrients for growth and reproduction, as well as a physical matrix that facilitates root development and respiration, while simultaneously maintaining structural integrity against erosive forces. The presence of soil fauna is imperative for the maintenance of soil health and the achievement of long-term sustainability. Various human activities have an impact on arthropods, and these organisms have demonstrated a degree of sensitivity to these anthropogenic factors. The influence of specific strategies on distinct taxa remains ambiguous, which is crucial for monitoring the overall productivity of crops and the health of soil. Arthropods have a direct impact on soil organic matter through the fragmentation of detritus. They also have an indirect effect by influencing microbial activity and altering the flow of organic matter among various soil pools through multi-channel grazing. The absence of arthropods and their associated activities and processes would undoubtedly result in a disadvantageous state for soil. In certain regions of the world, where significant fauna such as microorganisms are scarce or non-existent, soils may only sustain highly simplified communities. The biota presents in the soil, which sustains its fertility, is considered a crucial element of ecosystems. For a soil to be deemed fertile, it is necessary for it to furnish nutrients and a physical structure that facilitates root growth and respiration, while also upholding its structural stability against erosion. Arthropods contribute to the enhancement of soil fertility through two distinct mechanisms. The presence of litter within the tissues of organisms leads to their direct contribution to the process of breakdown, as well as an indirect contribution through the conversion of said litter into substrates that are more readily degradable. Termites exhibit a superior ability to convert ingested litter into biomass as compared to other soil arthropods, owing to their heightened absorption efficiency. The Collembola, Acari, and other arthropods play a significant role in nutrient cycling as secondary decomposers. They prepare litter for further breakdown by the microflora through gut fragmentation, thereby contributing directly to the process. The nests of termites and ants, along with their accompanying faecal matter, waste disposal, and fungal proliferation, serve as fertile substrates for the microbial decomposition and mineralization of organic substances. These processes lead to the conversion of intricate organic compounds into uncomplicated inorganic forms that are capable of being utilized by plants. The utilization of arthropods for consuming microbes can serve as a means of managing the availability of nutrients to plants. Arthropods play a significant role in maintaining soil productivity by affecting the physical structure of the soil. The excrement of arthropods plays a crucial role in the formation of soil aggregates, which are fundamental components of soil structure and essential for its stability. Additionally, arthropod faeces are a significant constituent in the production of humus, which aids in the retention of water and nutrients in the soil.

- The objective of this study was to establish and underscore the significance of arthropods as crucial constituents of soil fauna. The public may exhibit a deficiency in their cognizance of such matters. Arthropods crucial roles as carriers of essential ecological processes, particularly in the context of the decomposition and regeneration of decaying matter, are often not fully known. While certain trends have been noted regarding the influence of maintenance activities on litter arthropods, further investigation is necessary. Unfortunately, there is lack of research concerns pertaining to underground arthropods and their agricultural implications in diverse regions of India. Furthermore, it is evident that conducting research in the Punjab region holds significant importance. The objective of this research is to enhance our understanding of the significance of specific soil arthropods in maintaining soil health in natural environments and their significant contribution to biomass generation. The objective of this study is to conduct an analysis of the diverse range of functions carried out by soil arthropods and their impact on the overall productivity and health of the soil.
- The utilization of the Berlesse-Tullgren funnel method was implemented to isolate microorganisms from soil specimens collected from both agricultural and non-agricultural regions. The QBS index, a novel technique developed by Parisi et al., 2005 that employs soil micro-arthropods, was utilized to evaluate the biological quality of the soil. The

taxonomic keys and molecular characterization via COX1 genes were utilized to identify fundamental characters up to the order or family level. Statistical analysis was performed using the PAST 4.03 software.

- This study aimed to investigate and emphasize the importance of arthropods as essential components of the soil fauna that contribute to productivity. Ultimately, the findings support the notion that arthropods play a crucial role in maintaining soil health and ecosystem functioning. Arthropods in the soil were observed in all of the surveyed locations, but they exhibited relatively lower vulnerability to human-induced disturbances. The crucial function of arthropods as providers of ecosystem services, specifically in the decomposition and recycling of organic matter, has been insufficiently comprehended. Therefore, comprehending the distribution pattern of a systems keystone organisms and the functional characteristics of the majority of taxonomic groups and their interrelationships is imperative. Contemporary approaches and methodologies are necessary to delineate the species constitution and incorporate their heterogeneity in empirical community interventions. The loss of arthropods and their associated behaviors and mechanisms will inevitably lead to soil degradation. In areas where key fauna, such as earthworms, are scarce or absent, soil fertility may be compromised. Arthropods are acknowledged to exert a beneficial influence on the soil quality in ecological systems, while also playing a crucial role in the generation of biomass. Therefore, they are regarded as highly significant in the preservation of soil productivity and the facilitation of robust soil health.

The soil arthropods in this study were influenced by edaphic conditions. Consequently, a collection of organisms from various locations in Jalandhar, Punjab was made, and an evaluation of soil chemical parameters was analysed. There was a significant correlation observed between edaphic elements and populations of soil microarthropods. This observation implies that fluctuations in environmental and soil conditions throughout different seasons have an impact on the populations of soil-dwelling arthropods. The statement suggests that variations in temperature, moisture levels, pH, and electrical conductivity have an impact on the population dynamics of Collembola and Acarina. The observed increase in arthropod population during the pre-winter and winter seasons could potentially be attributed to environmental factors. Certain species may experience enhanced development and reproductive success during specific seasons due to the presence of lower temperatures and increased soil moisture. The decline in summer population may be attributed to unfavourable circumstances. The survival and availability of resources for arthropods may be negatively impacted by high summer temperatures and dry soil conditions. The study focused on the analysis of soil arthropods through the utilisation of the QBS method, which served as a means to assess the biological condition of the soil. The study sites exhibited biological quality ratings exceeding 100, thereby signifying favourable soil quality. The value of AG4, however, was 87. The implementation of agricultural practises has the potential to modify the composition and abundance of soil microarthropods. The subsequent objective of our study focused on investigating the impact of management practises on the diversity of soil microarthropods. The population analysis encompassed the utilisation of diversity indices and molecular characterization of the COX 1 gene. The utilisation of DNA barcoding is extensively employed for taxonomic identification purposes, encompassing arthropods. The research methodology of DNA barcoding primarily centres on the taxonomic classification of arthropods. In light of the extensive prevalence of this phenomenon, the utilisation of this method facilitated the identification of numerous species. The identification process involved the utilisation of both scanning electron microscopy (SEM) and DNA barcoding techniques. The research conducted in Punjab identified the presence of *Folsomia quadrioculata, Isotomidae* sp.*, Bethylidae* sp.*, Poecilochirus carabi*, *Sperchonopsis ecphyma,* and *Demodex folliculorum*. The aforementioned discovery provides researchers with a vital genetic resource for the purpose of studying the genomes and evolution of soil arthropods. The cuticles of Collembola and Acarina populations were potentially analysed using scanning electron microscopy (SEM), as a means of studying the protective structures surrounding their bodies. The cuticles of arthropods serve as a protective barrier against both physical injury and desiccation. SEM studies have also been directed towards examining the furcula and skin ornamentation of various organisms. The furcula is an anatomical characteristic that is distinctively observed in specific taxa of Collembola, commonly referred to as springtails. The ventral abdominal furcula is utilised in the execution of jumping and somersaulting movements. The application of SEM analysis has provided valuable insights into the structural characteristics of the furcula and the unique adaptations of the skin pattern, which contribute to its exceptional functionality. These findings have yielded significant results in understanding the surface morphology of the organisms, enabling researchers to investigate intricate anatomical features such as the cuticle and furcula. This may serve to elucidate the structural modifications and behavioural patterns exhibited by these invertebrates. The data reveals a cumulative count of 15653 organisms/m^2 over a span of two years in both agricultural and non-agricultural zones. This observation implies that the arthropod population remains largely unaltered by human activities. Over the course of the two-year timeframe, it was observed that there were no statistically significant differences across all sites. In summary, the abundance and distribution of soil arthropods are influenced by both habitats and soil conditions. These patterns facilitate the comprehension of population dynamics of arthropods in soil ecosystems by researchers.

Future Work

The utilisation of fertilisers and pesticides in a soil ecosystem may have an adverse impact on the soil microarthropod population. The impact of fertilisers and their frequency of application on the soil arthropod population can be assessed. The impact of pesticides and other anthropogenic activities, as well as their frequency of application or incorporation into the soil, on the abundance and variety of soil arthropods, can also be assessed. The process of extracting and quantifying the population of soil arthropods can be a difficult and challenging task, particularly when dealing with species for which a suitable taxonomic framework is lacking or inadequate. Under such circumstances, novel methodologies may be necessary for the retrieval and measurement of said entities. The utilisation of molecular techniques has the potential to augment comprehension of the variety of patterns and ecological characteristics of soil arthropods, thereby constituting a prospective avenue of research.

Chapter 8

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Conferences

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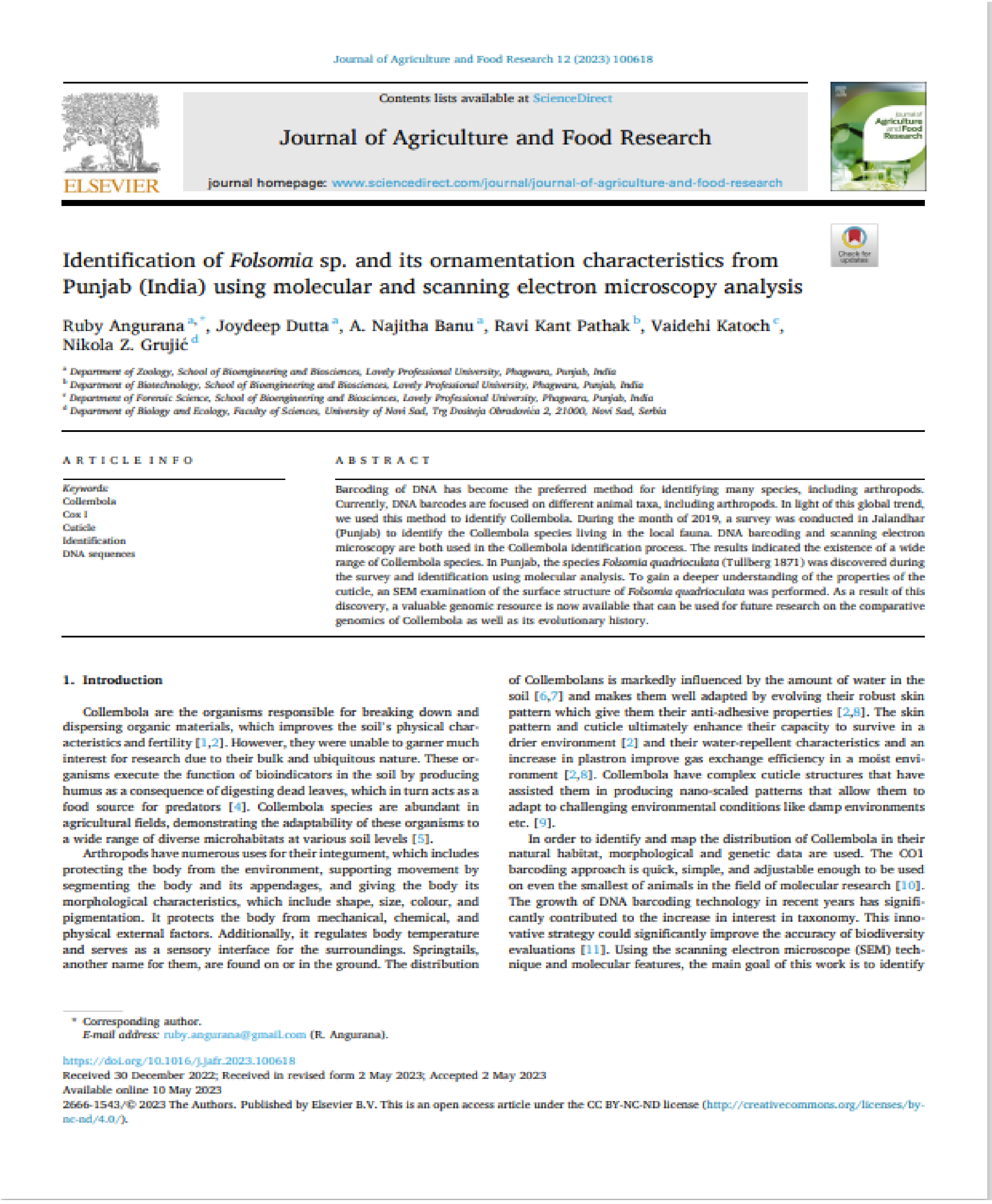

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Identification of *Folsomia* sp. and its ornamentation characteristics from Punjab (India) using molecular and scanning electron microscopy analysis

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ABSTRACT

Barcoding of DNA has become the preferred method for identifying many species, including arthropods. Currently, DNA barcodes are focused on different animal taxa, including arthropods. In light of this global trend, we used this method to identify Collembola. During the month of 2019, a survey was conducted in Jalandhar (Punjab) to identify the Collembola species living in the local fauna. DNA barcoding and scanning electron microscopy are both used in the Collembola identification process. The results indicated the existence of a wide range of Collembola species. In Punjab, the species *Folsomia quadrioculata* (Tullberg 1871) was discovered during the survey and identification using molecular analysis. To gain a deeper understanding of the properties of the cuticle, an SEM examination of the surface structure of *Folsomia quadrioculata* was performed. As a result of this discovery, a valuable genomic resource is now available that can be used for future research on the comparative genomics of Collembola as well as its evolutionary history.

1. Introduction

Collembola are the organisms responsible for breaking down and dispersing organic materials, which improves the soil's physical characteristics and fertility [1,2]. However, they were unable to garner much interest for research due to their bulk and ubiquitous nature. These organisms execute the function of bioindicators in the soil by producing humus as a consequence of digesting dead leaves, which in turn acts as a food source for predators [4]. Collembola species are abundant in agricultural fields, demonstrating the adaptability of these organisms to a wide range of diverse microhabitats at various soil levels [5].

Arthropods have numerous uses for their integument, which includes protecting the body from the environment, supporting movement by segmenting the body and its appendages, and giving the body its morphological characteristics, which include shape, size, colour, and pigmentation. It protects the body from mechanical, chemical, and physical external factors. Additionally, it regulates body temperature and serves as a sensory interface for the surroundings. Springtails, another name for them, are found on or in the ground. The distribution of Collembolans is markedly influenced by the amount of water in the soil [6,7] and makes them well adapted by evolving their robust skin pattern which give them their anti-adhesive properties [2,8]. The skin pattern and cuticle ultimately enhance their capacity to survive in a drier environment [2] and their water-repellent characteristics and an increase in plastron improve gas exchange efficiency in a moist environment [2,8]. Collembola have complex cuticle structures that have assisted them in producing nano-scaled patterns that allow them to adapt to challenging environmental conditions like damp environments etc. [9].

In order to identify and map the distribution of Collembola in their natural habitat, morphological and genetic data are used. The CO1 barcoding approach is quick, simple, and adjustable enough to be used on even the smallest of animals in the field of molecular research [10]. The growth of DNA barcoding technology in recent years has significantly contributed to the increase in interest in taxonomy. This innovative strategy could significantly improve the accuracy of biodiversity evaluations [11]. Using the scanning electron microscope (SEM) technique and molecular features, the main goal of this work is to identify

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