JURNAL ONLINE
PERTANIAN TROPIK

Correlation Between Soil Macrofauna and Soil Chemical Properties in Smallholder Palm Oil Plantations

Raharya Pratama* , Sulakhudin, Leony Agustine
Department of Soil Science, Faculty of Agriculture, Tanjungpura University, Pontianak 78112, Indonesia
*Corresponding Author: arya07@student.untan.ac.id

ARTICLE INFO
Article history:
Received: 23 September 2024
Revised: 24 April 2025
Accepted: 10 Augustus 2025
Available online:
https://talenta.usu.ac.id/jpt

E-ISSN: 2356-4725
P-ISSN: 2655-7576

How to cite:
Raharya P., Sulakhudin & Agustine L. (2025). Correlation of Soil Macrofauna and Several Soil Chemical Properties in People's Palm Oil Plantations. Jurnal Online Pertanian Tropik, 12(2), 1-10

https://doi.org/10.32734/jpt.v12i2.18252

ABSTRACT
Writing

This study aimed to determine the relationship between soil macrofauna communities and soil chemical properties in smallholder oil palm plantations. Field sampling and laboratory analyses were conducted at five observation points arranged diagonally. Soil macrofauna were collected using two methods: the pitfall trap method for surface-dwelling organisms and the monolith method for subsurface organisms. Observed parameters included population abundance, species diversity and richness, organic carbon (C-organic), total nitrogen (N-total), available phosphorus (P), and exchangeable potassium (K-dd). Data were tested for normality and linearity prior to correlation analysis. The results from the pitfall trap method showed that pygmy grasshoppers (Tetrigidae) were strongly correlated with C-organic (r = 0.757) and N-total (r = 0.677), while termites (Termitidae) also showed strong correlations with C-organic (r = 0.612) and N-total (r = 0.553). Carpenter ants (Formicidae) exhibited negative correlations with all soil nutrients, whereas black garden ants (Formicidae) showed a strong positive correlation with available P (r = 0.604). Only one species was found using the monolith method; therefore, no further analysis was conducted. Overall, macrofauna diversity and species richness showed very strong correlations with C-organic and N-total (r > 0.94), and strong correlations with K-dd (r = 0.860). These findings indicate that the availability of organic carbon, nitrogen, and potassium plays a crucial role in shaping soil macrofauna community structure in smallholder oil palm plantations.
Keywords: chemical properties, oil palm plantation, soil macrofauna. C organic

ABSTRAK
Hasil analisis menunjukkan bahwa melalui metode *pitfall trap*, belalang kerdil (Tetrigidae) memiliki korelasi kuat dengan C-organik (r = 0,757) dan N-total (r = 0,677), sedangkan rayap (Termitidae) juga berkorelasi kuat dengan C-organik (r = 0,612) dan N-total (r = 0,553). Sebaliknya, semut tukang kayu (Formicidae) menunjukkan korelasi negatif terhadap seluruh unsur hara, sementara semut hitam kebun (Formicidae) memiliki korelasi positif kuat dengan P tersedia (r = 0,604). Pada metode monolit hanya ditemukan satu spesies, sehingga tidak dilakukan analisis lanjutan.Secara keseluruhan, keanekaragaman dan kekayaan jenis makrofauna menunjukkan korelasi sangat kuat dengan kandungan C-organik dan N-total (r > 0,94), serta korelasi kuat dengan K-dd (r = 0,860). Temuan ini menegaskan bahwa ketersediaan karbon organik, nitrogen, dan kalium merupakan faktor utama yang memengaruhi struktur komunitas makrofauna tanah di perkebunan kelapa sawit rakyat.
Kata Kunci: sifat kimia, perkebunan kelapa sawit, makrofauna tanah, C organik

1. Introduction

Soil is one of the main components of the ecosystem that plays a crucial role in supporting the life of plants and other organisms. In agricultural contexts, particularly in oil palm plantations, soil quality is a key factor determining agricultural productivity and sustainability. Oil palm, as one of Indonesia's most important commodities, requires special attention to soil health and fertility to achieve optimal yields (Sun et al., 2020).

Soil health is influenced by various factors, including chemical properties such as organic carbon (C-organic), total nitrogen (N-total), available phosphorus (P-available), and exchangeable potassium (K- exch). These chemical properties not only directly affect plant growth but also interact with biological components of the soil, such as soil macrofauna. The presence of soil macrofauna can influence carbon and nitrogen dynamics, which are essential for soil fertility and productivity (Dungait et al., 2019). Understanding the interactions between soil macrofauna and soil chemical properties is therefore crucial for sustainable soil management. Changes in macrofauna communities can reflect the condition of soil health and affect the biogeochemical processes that maintain soil fertility.

Research on the correlation between soil macrofauna and soil chemical properties in oil palm plantations can provide valuable insights into the condition and dynamics of soils in such environments. A deeper understanding of the interactions between soil biota and chemical characteristics can contribute to the development of more sustainable soil management practices (Lehmann & Kleber, 2020).

2. Materials And Methods

The study was conducted on Inceptisol soil in a smallholder oil palm plantation located in Sungai Keran Village, Sungai Raya Kepulauan District, Bengkayang Regency, and soil analyses were carried out in the laboratory. Observation points were determined using a diagonal system with a total of five points in a nine-year-old oil palm plantation. Soil samples for chemical analysis were collected from the palm circle area at a depth of 0–30 cm at each observation point. Soil macrofauna samples were collected using the pitfall trap method for surface-dwelling macrofauna and the monolith method for subsurface macrofauna, with five plots at each observation point. The research parameters included population abundance, species diversity, species richness, organic C, total N, available P, and exchangeable K (K-exch). Data on population abundance, species diversity, and species richness were correlated with organic C, total N, available P, and exchangeable K using Pearson's correlation analysis with the assistance of Microsoft Excel and SPSS software.

3. Results And Discussion

3.1. Chemical Soil

The results of the analysis of several chemical properties of the soil in the Chemistry and Fertility Laboratory of the Faculty of Agriculture, Tanjungpura University at the research location are presented in Table 1.

Table 1. Results of analysis several soil chemical properties in oil palm plantation located in Sungai Keran Village, Sungai Raya Kepulauan District, Bengkayang Regency.

Location point	C-organic		N-total		P-available		K-exchangable	
	(%)	Criteria	(%)	Criteria	(ppm)	Criteria	(cmol(+)kg^{-1})	Criteria
A1	2.67	Medium	0.34	Medium	14.85	Low	0.28	Low
A2	2.06	Medium	0.26	Medium	55.88	Very high	0.17	Low
A3	1.52	Medium	0.20	Medium	17.05	Medium	0.14	Low
A4	2.03	Medium	0.26	Medium	15.47	Low	0.19	Low
A5	2.31	Medium	0.31	Medium	204.78	Very high	0.26	Low

The results of soil organic C analysis at each location (Table 1) were tested for normality, and the data were found to be normally distributed. The highest organic C content was recorded at location A1 (2.67%), while the lowest was at location A3 (1.52%). The description in Table 1 shows that the organic C value at point A3 was lower than at other points, which corresponds to the field conditions. Location A1 was dominated by grasses and oil palm fronds placed around the base of the palm trees and left to decompose naturally, whereas location A3 had fewer leaf litter and woody debris. This finding is consistent with Bakri *et al.* (2016), who stated that plant residues such as twigs, leaves, stems, and roots provide raw materials for microbial decomposition containing about 50% carbon.

The variation in soil organic C content can influence the abundance of soil macrofauna populations. Soil organic matter serves as a direct food source for macrofauna such as earthworms, decomposer insects, and other soil organisms. According to Suin (2012), soil organic matter greatly determines the population density of soil organisms; the higher the organic matter content, the greater the diversity of soil fauna within an ecosystem. Hanafiah (2013) further emphasized that higher organic matter content increases soil fauna activity, as organic materials serve as energy and nutrient sources essential for their survival.

The results of soil total N analysis at each location (Table 1) were tested for normality, and the data were found to be normally distributed. The highest total N content was observed at location A1 (0.34%), while the lowest was at location A3 (0.20%). The low total N content at location A3 was associated with the lowest soil organic matter content (Table 1). This is because most of the nitrogen in soil originates from the decomposition of organic matter; therefore, the amount of soil organic material affects the availability of nitrogen for plants. The correlation between soil organic C and total N is consistent with the findings of Lusi (2023), who stated that organic matter is the main source of nitrogen in soil, as it releases N through the decomposition process.

The availability of total N in the soil is influenced by organic matter through the nitrogen cycle. Grikin and Cooper (2022) stated that organic matter plays a vital role in the nitrogen cycle within soil ecosystems. Nitrogen transformation involves the mineralization of organic nitrogen into forms that can be absorbed by plants, such as ammonium and nitrate, followed by nitrification and denitrification processes.

The results of soil available P analysis at each location (Table 1) were tested for normality, and the data were found to be normally distributed. The highest available P content was recorded at location A5 (204.78 ppm), while the lowest was observed at location A1 (14.85 ppm). The variation in soil available P among locations was mainly due to uneven fertilizer application. In particular, the very high available P content at location A5 resulted from the application of rock phosphate fertilizer (28% P_2O_5) at a rate of 2 kg per tree, applied four times a year, along with the use of rice husk as an organic amendment. Rice husk contains 18–22.3% silica (Si), and the addition of Si is known to enhance soil phosphorus availability. Lusi (2023) stated that Si can improve plant physical properties and increase the solubility of P in the soil.

These findings are consistent with the previous study by Lusi (2023) conducted in the same oil palm plantation, which reported the highest available P value of 188.19 ppm and the lowest of 17.13 ppm. Our results further confirm the high levels of available phosphorus in the plantation soil. According to Lusi (2023), uneven applications of rock phosphate (28% P_2O_5) and rice husk contribute to high P concentrations at certain points. Compared to nitrogen, phosphorus becomes available more rapidly but is easily bound by soil cations and fixed on positively charged soil colloid surfaces (Hanafiah, 2007). The results of soil exchangeable K (K-exch) analysis (Table 1) were tested for normality, and the data were found to be normally distributed. The exchangeable K values at all observation points were classified as low. The highest K-exch value was recorded at observation point A1 (0.28 cmol(+)kg^{-1}), while the lowest was at point A3 (0.14 cmol(+)kg^{-1}).

The results also showed that K-exch values at each observation point were consistent with the levels of soil organic C (Table 1). This is because organic C can increase the cation exchange capacity (CEC), allowing K^+ ions to be retained by soil colloids, thereby reducing leaching losses. As shown in Table 1, the organic C levels ranged from moderate to low, which made K^+ more susceptible to leaching. Moreover, the study area experiences high rainfall, which, according to Pardon et al. (2016), increases the risk of nutrient leaching in tropical oil palm plantations.
In addition, Inceptisol soils in Indonesia generally contain low levels of potassium. The potassium content in Inceptisols typically ranges from 0.1 to 0.3 cmol(+)kg^{-1}, which is considered low (Nursyamsi & Suprihati, 2005). These authors also reported that Inceptisol and Oxisol soils are dominated by kaolinite clay minerals and/or oxihydroxides with low cation exchange capacities, causing potassium nutrients to be easily lost through leaching processes.

3.2. Population Abundance Pitfall Trap Method

The results of observations of soil macrofauna using the Pitfall Trap method found a total of 359 individuals, 9 species are presented in Table 2.

Table 2. Population abundance of soil macrofauna by pitfall trap method in palm plantation located in Sungai Keran Village, Sungai Raya Kepulauan District, Bengkayang Regency.

Location point	No	Type of macrofauna	Individual	Abundance of population (%)
A1	1	Big Black Ant	12	15%
	2	Small Black Ant	25	32%
	3	Termite	36	46%
	4	Dwarf Grasshopper	3	4%
	5	Tiger Beetle	1	1%
	6	Wolf Spider	1	1%
	7	Cricket	1	1%
		Total	79	100%
A2	1	Big Black Ant	12	18%
	2	Small Black Ant	28	43%
	3	Termite	23	35%
	4	Dwarf Grasshopper	1	2%
	5	Cricket	1	2%
		Total	65	100%
A3	1	Big Black Ant	13	20%
	2	Small Black Ant	32	48%
	3	Termite	21	32%
		Total	66	100%
A4	1	Big Black Ant	10	14%
	2	Small Black Ant	25	36%
	3	Termite	32	46%
	4	Dwarf Grasshopper	2	3%
		Total	69	100%
A5	1	Big Black Ant	8	10%
	2	Small Black Ant	39	49%
	3	Termite	28	35%
	4	Dwarf Grasshopper	1	1%
	5	Long-legged spider	3	4%
	6	Leaf Beetle	1	1%
		Total	80	100%

The correlation between population abundance and several soil chemical properties is presented in Table 3.

Table 3. Correlation of soil macrofauna population abundance with several soil chemical properties in oil palm plantation located in Sungai Keran Village, Sungai Raya Kepulauan District, Bengkayang Regency.

No	Type of macrofauna	Correlation Coefficient			
		C-organic	N-total	P-available	K-exchangable
1	Dwarf Grasshopper	0.757	0.677	-0.373	0.555
2	Termite	0.612	0.553	-0.405	0.499
3	Big Black Ant	-0.622	-0.699	-0.721	-0.756
4	Small Black Ant	-0.581	-0.489	0.604	-0.390

The observation of soil macrofauna on the soil surface was carried out using the pitfall trap method. At the observed points, four dominant soil macrofauna species were identified: the pygmy grasshopper (Family Tetrigidae), termite (Family Termitidae), carpenter ant (Family Formicidae), and black garden ant (Family Formicidae). These species were analyzed for their correlation with several soil chemical properties. The population abundance data were tested for normality and found to be normally distributed, while the linearity test indicated a linear relationship.

3.2.1. Dwarf Grasshopper

The Pearson correlation coefficient analysis for the population abundance of pygmy grasshoppers with soil organic C showed a correlation value of 0.757, indicating a strong positive relationship. The high correlation between pygmy grasshopper abundance and soil organic C is supported by Guo et al. (2023), who stated that herbivorous insects can alter root exudates and litter composition, thereby influencing microbial activity and the rate of soil organic carbon mineralization.

For total N, the correlation coefficient was 0.677, also indicating a strong positive relationship. Grasshoppers are generally herbivorous and influence nitrogen dynamics in ecosystems through their feeding activities, which can affect plant biomass and, consequently, soil nitrogen content. Zheng et al. (2023) reported that the presence of grasshoppers can indirectly affect soil nitrogen content through their impact on plant biomass and decomposition rates.

For available P, the correlation coefficient was –0.373, categorized as a weak negative correlation. The absence of a strong relationship between pygmy grasshopper abundance and available P is likely due to the complex interactions of phosphorus in soil, which are influenced by physical and chemical soil properties, microbial activity, and agricultural practices. In the studied oil palm plantation, the application of rock phosphate fertilizer (28% P_2O_5) and rice husk likely affected the amount of available phosphorus in the soil.

For exchangeable K, the correlation coefficient was 0.555, indicating a moderate positive correlation. The relationship between herbivores such as grasshoppers and soil properties, including exchangeable K, is highly complex and variable. Herbivores can influence soil microbes and nutrient cycling depending on plant production levels and species composition (Kelsey et al., 2023).

3.2.2. Termite

The Pearson correlation coefficient for the population abundance of termites with soil organic C was 0.612, indicating a strong positive correlation. This result is supported by Amrullah (2019), who reported a positive correlation (r = 0.701) between Coptotermes sp. abundance and soil organic C, suggesting that higher organic C content corresponds to greater termite abundance. This finding aligns with Jones (1998) in Panggabean (2001), who stated that termite abundance is associated with the availability of organic matter derived from accumulated litter. For total N, the correlation coefficient was 0.553, categorized as a moderate correlation. This relationship can be explained by the fact that organic matter contains nitrogen that is released into the soil through decomposition processes (Lusi, 2023). Termites indirectly influence total soil nitrogen by contributing organic material during decomposition, which explains the moderate correlation value. Amrullah (2019) noted that members of the Termitidae family play an important role in the decomposition of organic matter, serving as key mediators in ecosystem processes and nutrient cycling, and are among the soil organisms most responsive to land condition changes.

For available P, the correlation coefficient was –0.405, indicating a weak negative correlation. This negative relationship may reflect the complex interactions affecting phosphorus availability in soil, including physical and chemical soil properties, microbial activity, and agricultural practices. The direct contribution of termites to soil phosphorus availability is likely difficult to separate from these other influencing factors.

For exchangeable K, the correlation coefficient was 0.499, indicating a moderate correlation. Kaschuk et al. (2006) reported that termite activity increases the concentrations of K, P, Ca, Mg, and organic C in termite mounds, thereby affecting soil properties and nutrient cycling. Similarly, Umeh et al. (1999) stated that soil transport activities during mound construction modify the physical and chemical structure of soil, influencing overall nutrient levels.

3.2.3. Big Black Ant

The Pearson correlation coefficient for the population abundance of carpenter ants with soil organic C was –0.622, indicating a moderate negative correlation. Generally, carpenter ants (Camponotus sp.) act as predators that regulate the populations of other insects, particularly herbivorous pests. This finding is supported by Ummah (2021), who reported a very strong negative correlation (r = –0.98874) between ants of the Camponotus genus and soil organic C content.

For total N, the correlation coefficient was –0.699, also indicating a moderate negative correlation. This result is consistent with Ummah (2021), who found a strong negative correlation (r = –0.7604) between Camponotus ants and soil nitrogen content. For available P, the correlation coefficient was –0.721, categorized as a strong negative correlation. Similar findings were reported by Ummah (2021), who found a strong negative correlation (r = –0.83773) between Camponotus ants and soil phosphorus levels. These results suggest that carpenter ants do not directly influence soil chemical properties but rather function as predators that regulate the abundance and distribution of other soil and surface-dwelling insects. For exchangeable K, the correlation coefficient was –0.756, indicating a strong negative correlation. This finding aligns with Ummah (2021), who reported a moderate negative correlation (r = –0.65625) between Camponotus ants and soil potassium levels.

3.2.4. Small Black Ant

The Pearson correlation coefficient for the population abundance of black garden ants with soil organic C was –0.581, indicating a moderate negative correlation. This negative correlation can be explained by the fact that both the black garden ant and the carpenter ant belong to the Formicidae family; therefore, both species exhibited negative correlation values. The analysis of total N also showed a negative correlation, with a coefficient value of –0.489, categorized as a moderate negative correlation.

For available P, the correlation coefficient was 0.604, indicating a strong positive correlation. This strong relationship is likely due to the complex interactions affecting soil phosphorus availability, which are influenced by various factors, including soil physical and chemical properties, microbial activity, and agricultural practices. The direct contribution of soil macrofauna to phosphorus availability may be difficult to separate from other influencing factors, particularly considering that rock phosphate and rice husk fertilizers were applied in the study area, both of which can increase available P in the soil. The Pearson correlation coefficient for the population abundance of black garden ants with exchangeable K was –0.390, indicating a weak negative correlation.

3.3. Population Abundance Monolith Method

The results of the abundance of soil macrofauna populations found in the soil surface using the monolith method revealed only one species, namely earthworms (Family Lumbricidae). The lack of species found using this method makes correlation calculations for several chemical properties ineffective.The low diversity of soil macrofauna obtained through the monolith method may be influenced by several environmental factors, such as soil moisture, temperature, and organic matter content. According to Lavelle et al. (2006), earthworms are highly sensitive to microclimatic changes and organic matter availability, which directly affect their survival and activity levels. In this study area, the limited presence of litter and relatively compact soil structure may have restricted habitat availability and movement of subsurface macrofauna, resulting in the dominance of a single species.

Additionally, agricultural management practices, including fertilization and periodic tillage, may have contributed to the reduced diversity of below-ground macrofauna. Continuous fertilizer application, especially inorganic fertilizers, can alter soil pH and nutrient balance, indirectly affecting the composition and abundance of soil biota (Paoletti, 2018). The dominance of earthworms indicates that they play a significant ecological role in the decomposition of organic matter and nutrient cycling, although further studies are needed to evaluate their population dynamics and contribution to soil fertility in oil palm plantation ecosystems.

3.4. Diversity of Pitfall Trap Methods

The results of the diversity of soil macrofauna species (H’) above the ground surface using the pitfall trap method are presented in Figure 1.

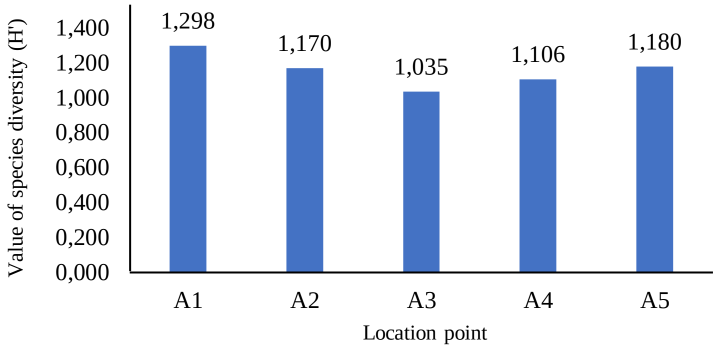

Figure 1. The value of species diversity (H') using the pitfall trap method in oil palm plantation located in Sungai Keran Village, Sungai Raya Kepulauan District, Bengkayang Regency.

The results of observations of the diversity of soil macrofauna species above the ground surface using the pitfall trap method in Figure 1 show the highest species diversity in A1, namely H' = 1.298 with moderate criteria. Meanwhile, the lowest species diversity in A3, namely H' = 1.035 with moderate criteria.

Table 4. Correlation of species diversity (H') with several soil chemical properties

Biological Parameters	Pearson Correlation Coefficient Value			
	C – organic	N – total	P – available	K – dd
Diversity of Species (H')	0.966	0.940	0.138	0.860

The Pearson correlation coefficient for species diversity was tested for normality and linearity, and the data were found to be normally distributed and linear. The correlation between species diversity and soil organic C showed a coefficient value of 0.966, indicating a very strong correlation. The high correlation between species diversity and soil organic C is also supported by Eisenhauer et al. (2015), who stated that soil macrofauna species diversity is positively correlated with soil organic carbon accumulation. High macrofauna diversity enhances organic matter decomposition and humus formation, leading to increased carbon sequestration in the soil ecosystem. For total N, the correlation coefficient was 0.940, also indicating a very strong correlation. This high level of correlation is reinforced by Eisenhauer et al. (2012), who reported that soil macrofauna species diversity contributes to the resilience and function of soil ecosystems, including nutrient cycling processes such as nitrogen mineralization and turnover. High macrofauna diversity is associated with an increased rate of nitrogen cycling and availability in the soil, as different species play complementary roles in decomposition and nutrient release (Wall et al., 2012). Available P, the correlation coefficient was 0.138, categorized as a very weak correlation. This very weak correlation is likely due to the complex interactions of phosphorus in soil, which are influenced by various factors, including soil physical and chemical properties, microbial activity, and agricultural practices.

According to the Table 4, For exchangeable K, the correlation coefficient was 0.860, indicating a strong correlation. This strong relationship is supported by Bardgett and Van der Putten (2014), who stated that soil macrofauna diversity can influence potassium availability by affecting nutrient cycling processes through nutrient-rich excreta such as nitrogen, phosphorus, and potassium, enhancing decomposition rates by fragmenting organic materials, and improving soil structure through burrowing activities that increase aeration and water infiltration.

3.5. Diversity of Monolith Method Types

The results of the diversity of soil macrofauna species found in the soil surface using the monolith method revealed only one species, namely the earthworm (Family Lumbricidae). The lack of species found using this method makes it impossible to calculate the diversity of species, therefore correlations with several chemical properties will also not yield results.

The low species diversity recorded in this study may be attributed to several environmental and ecological factors. Soil characteristics such as high bulk density, low organic matter content, and reduced aeration can restrict the habitat and movement of soil-dwelling organisms, resulting in lower macrofaunal diversity. Earthworms, which are generally more tolerant of compact and nutrient-poor soils, are often among the few species capable of surviving under such conditions. Similar findings were reported by Lavelle et al. (2006), who emphasized that soil compaction and limited organic inputs significantly reduce the abundance and diversity of soil macrofauna communities.

In addition to soil physical constraints, management practices in oil palm plantations may also influence subsurface macrofauna diversity. Continuous fertilizer application, minimal crop residue return, and infrequent organic matter inputs can lead to reduced soil biological activity and biodiversity. Earthworms, while being the dominant species found, play a critical ecological role in enhancing soil structure, aeration, and nutrient cycling. However, the absence of other macrofauna groups indicates a simplified soil ecosystem, which may affect long-term soil health and sustainability. Therefore, promoting better organic matter management and reduced soil disturbance could help enhance macrofauna diversity and ecosystem function in oil palm plantation soils.

3.6. Wealth of Pitfall Trap Method Types

The results of the species richness (R') of soil macrofauna above the ground surface using the pitfall trap method are presented in Figure 2.

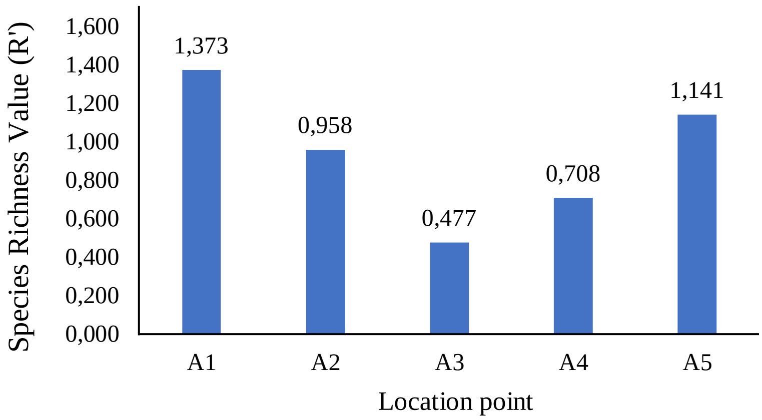

Figure 2. Species Richness Value (R’) by pitfall trap method in oil palm plantation located in Sungai Keran Village, Sungai Raya Kepulauan District, Bengkayang Regency.

The results of the species richness of soil macrofauna found above the ground surface using the pitfall trap method are shown in Figure 51, showing the highest value in A1, namely R' = 1.373 with a low criterion. Meanwhile, the lowest species richness was in A3, namely R' = 0.477 with a low criterion.

Table 5. Correlation of Species Richness (R’) with Several Soil Chemical Properties

Biological Parameters	Pearson Correlation Coefficient Value			
	C – organic	N – total	P – available	K – dd
Species Richness Value (R’)	0.9667	0.9666	0.3446	0.9101

The Pearson correlation coefficient for species richness was tested for normality and linearity, with the data showing a normal distribution and remaining linear. The correlation between species richness and organic C was 0.9667, a very strong correlation. Soil macrofauna species richness can influence soil organic matter by increasing organic matter decomposition, biological activity, and soil structure (Eisenhauer et al., 2015).

Total N obtained a correlation coefficient of 0.9666, a very strong correlation. Soil macrofauna species richness can influence total soil nitrogen by increasing organic matter decomposition, nitrogen mineralization, and biological activity (Eisenhauer et al., 2015). Available P obtained a correlation coefficient of 0.3446, a weak correlation. These weak correlations suggest a complex interaction between soil phosphorus and various factors, including soil physical and chemical properties, microbial activity, and agricultural practices. The direct contribution of soil macrofauna to phosphorus availability may be difficult to separate from the contributions of these other factors. K – dd obtained a correlation coefficient value of 0.9101 with very strong correlation criteria. The richness of soil macrofauna species can influence the capacity of potassium exchange in soil by increasing biological activity and nutrient cycling (Eisenhauer. et al, 2015).

3.7. Wealth of Monolith Method Types

The results of the richness of soil macrofauna species found in the soil surface using the monolith method revealed only one species, namely the earthworm (Family Lumbricidae). The lack of species found using this method makes it impossible to calculate the richness of the species, and therefore correlations with various chemical properties will also not yield results.

4. Conclusions

The population abundance of dominant species showed varying correlation patterns with soil chemical properties. The pygmy grasshopper (Tetrigidae) exhibited a strong correlation with both soil organic C and total N, a weak negative correlation with available P, and a moderate correlation with exchangeable K (K-dd). Termites (Termitidae) demonstrated a strong correlation with soil organic C, a moderate correlation with total N and K-dd, and a weak negative correlation with available P. The carpenter ant (Formicidae) showed a moderate negative correlation with soil organic C and total N, a strong negative correlation with available P, and a strong negative correlation with K-dd. Meanwhile, the black garden ant (Formicidae) exhibited a moderate negative correlation with soil organic C and total N, a weak negative correlation with K-dd, and a strong positive correlation with available P. The species diversity of soil macrofauna obtained using the pitfall trap method showed a very strong correlation with soil organic C and total N, a very weak correlation with available P, and a strong correlation with K-dd. In contrast, the species diversity results of soil macrofauna obtained using the monolith method could not be correlated with soil chemical properties due to insufficient data for statistical testing. The species richness of soil macrofauna based on the pitfall trap method showed a very strong correlation with soil organic C, total N, and K-dd, while a weak correlation was observed with available P. However, the correlation analysis for species richness obtained from the monolith method could not be conducted due to the limited data available.

5. References

Amrullah, A. (2019). Hubungan keanekaragaman makrofauna tanah dengan kandungan C-organik pada lahan reklamasi bekas tambang kapur di Kabupaten Tuban [Undergraduate thesis, Institut Teknologi Sepuluh Nopember]. Fakultas Sains, Surabaya.

Bakri, I., Abdul, R. T., & Isrun. (2016). Status beberapa sifat kimia tanah pada berbagai penggunaan lahan di DAS Poboya Kecamatan Palu Selatan. e-Jurnal Agrotekbis, 4(5), 512–520.

Bardgett, R. D., & Van der Putten, W. H. (2014). Belowground biodiversity and ecosystem functioning. Nature, 515(7528), 505–511.

Dungait, J. A. J., Warren, G. P., Stockdale, E. A., & Watson, C. A. (2019). Soil organic matter turnover is governed by accessibility, not recalcitrance. Global Change Biology, 25(2), 725–740.

Eisenhauer, N., Bowker, M. A., Grace, J. B., Powell, J. R., & Raubuch, M. (2015). From patterns to causal understanding: Structural equation modeling (SEM) in soil ecology. Pedobiologia, 58(3), 65–72.

Eisenhauer, N., Reich, P. B., Isbell, F., & Van der Putten, W. H. (2012). Macroparasite effects on plant–plant interactions and plant performance. Journal of Ecology, 100(3), 551–557.

Grikin, T. N., & Cooper, H. V. (2022). Nitrogen and ammonia in soils. Encyclopedia of Soils in the Environment, 2(1), 142–151.

Guo, J., Xiong, W., Qiu, J., & Wang, G. (2023). Linking soil organic carbon mineralization to soil physicochemical properties and bacterial alpha diversity at different depths following land use changes. Ecological Processes, 12(39), 1–15.

Hanafiah, K. A. (2007). Dasar-dasar ilmu tanah. Jakarta: PT Raja Grafindo Persada.

Hanafiah, K. A. (2013). Dasar-dasar ilmu tanah. Jakarta: PT Raja Grafindo Persada.

Kaschuk, G., Santos, J. C. P., Almeida, J. A. D., Sinhorati, D. C., & Berton-Junior, J. F. (2006). Termite activity in relation to natural grassland soil attributes. Scientia Agricola, 63(6), 583–588.

Kelsey, S., Malacrino, A., Marrero, M., Snyder, K., Alabyadh, W., Bingman, J., Borrero, I., Bryan, R., Chappidi, C., Darling, D., Fulton, V., Harris, K., Huynh, C., Lin, X., Moore, B., Heinze, J., & Bennett,

A. (2023). Herbivory in the feedback phase promotes more negative plant–soil feedbacks particularly for legumes and forbs. Authorea, 3(2), 44–59.

Lavelle, P., Decaëns, T., Aubert, M., Barot, S., Blouin, M., Bureau, F., Brown, G., Deregnaucourt, S., Dubs, F., Grimaldi, M., & Jiménez, J. J. (2006). Soil invertebrates and ecosystem services. European Journal of Soil Biology, 42(1), S3–S15. https://doi.org/10.1016/j.ejsobi.2006.10.002

Lehmann, J., & Kleber, M. (2020). The contentious nature of soil organic matter. Nature, 528(7580), 60–68.

Lusi. (2023). Status hara N, P, dan K tanah pada lahan kelapa sawit rakyat di Desa Sungai Keran Kecamatan Sungai Raya Kepulauan Kabupaten Bengkayang [Undergraduate thesis, Universitas Tanjungpura Pontianak]. Fakultas Pertanian, Pontianak.

Nursyamsi, D., & Suprihati. (2005). Sifat-sifat kimia dan mineralogi tanah serta kaitannya dengan kebutuhan pupuk untuk padi (Oryza sativa), jagung (Zea mays), dan kedelai (Glycine max). Buletin Agronomi, 33(3), 40–47.

Panggabean, M. (2001). Inventarisasi rayap tanah di perkebunan kelapa sawit PT. Sawit Mas Sejahtera Musi Banyuasin [Undergraduate thesis, Universitas Sriwijaya]. Fakultas Matematika dan Ilmu Pengetahuan Alam, Inderalaya.

Paoletti, M. G. (2018). Soil invertebrates in cultivated and uncultivated soils. Agriculture, Ecosystems & Environment, 256, 123–133. https://doi.org/10.1016/j.agee.2018.01.002

Pardon, L., Cecile, B., Paul, N. N., Bernard, D., Jean, O., Raphael, M., Jean, P. C., & Benoit, G. (2016). Key unknowns in nitrogen budget for oil palm plantations: A review. Agronomy for Sustainable Development, 36(1), 1–21.

Suin, N. M. (2012). Ekologi hewan tanah. Bandung: Bumi Aksara.

Sun, H., Wu, L., & Huang, S. (2020). The impact of soil health on oil palm productivity: A review. Journal of Soil Science and Plant Nutrition, 20(3), 897–912.

Umeh, V. C., Ivbijaro, M. F., & Ewete, F. K. (1999). Relationship between characteristics of Macrotermes spp. mound materials and their surrounding soils. International Journal of Tropical Insect Science, 19(2), 251–255.

Ummah, M. (2021). Keanekaragaman serangga permukaan tanah pada berbagai umur perkebunan kelapa sawit di Desa Muara Fajar Timur Kecamatan Rumbai Barat Kota Pekanbaru [Undergraduate thesis, Universitas Islam Negeri Maulana Malik Ibrahim]. Fakultas Sains dan Teknologi, Malang.

Wall, D. H., Bardgett, R. D., Behan-Pelletier, V., Herrick, J. E., Jones, H., Ritz, K., Six, J., Strong, D. R., & Van der Putten, W. H. (2012). Soil ecology and ecosystem services. New York: Oxford University Press.

Zheng, W., Lan, R., Zhangzhong, L., Yang, L., Gao, L., & Yu, J. (2023). A hybrid approach for soil total nitrogen anomaly detection integrating machine learning and spatial statistics. Agronomy, 13(2669), 1–20.