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Community structure of soil microarthropods in active and passive zones of Ngronggo landfill Salatiga

Psn Masruri Sulistiyanto Ari[1], Rully Rahadian[1,*], Udi Tarwotjo[1]

[1]*Department of Biology, Faculty of Science and Mathematics, Diponegoro University*
Jl. Prof. Soedharto, SH, Tembalang, Semarang 50275, Indonesia

A B S T R A C T

Soil microarthropods play a key role in decomposing organic materials. The objectives of this study were to compare the structure of soil microarthropods communities in the active and passive zones of Ngronggo landfill Salatiga. The sampling of ten soil samples in each active and passive zones was performed for soil microarthropods extraction and soil physical-chemical analysis. Soil microarthropods were extracted using modified Barlese-Funnel. Soil microarthropods data were analyzed to determine abundance, diversity, and similarity. Physical-chemical factors were measured, including soil texture, heavy metal content (Pb, Cd, Cu, Zn, and Hg) and organic matter. The results show that all attributes of structure of soil microarthropods communities in active zone are higher than in passive zone, i.e., the density, the species richness, the species diversity, and the evenness. In both zones, the composition of soil microarthropods tend to be different.. Organic matter is likely the most important soil physicochemical factors to form the microarthropod structure in active and passive zones. This study contributes a new information about the role of soil microarthropods in decomposing the disposal waste of material and it would be benefit for developing a bioindicator of waste decomposition in landfill area.

Keywords: *Microarthropods, landfill, heavy metal*

I. Introduction

Monitoring of polluted environment is generally performed by physical and chemical parameters, but recently biological monitoring using soil fauna arose to be a promising alternative. This is because the soil fauna is sensitive to soil changes and can be found abundant in the soil. Meanwhile, aside from having a direct effect on soil fauna, the soil physical and chemical properties are also more likely to inform the state of the soil only at the time of measurement. Soil microarthropods are one of the soil fauna group that has an important role in the soil, especially in decomposing organic matter and their ability in maintaining and restoring soil productivity (Agustina, Tarwotjo, & Rahadian, 2019). So that, microarthropods can be used as bioindicators of soil quality.

The city of Salatiga has a waste landfill in Ngronggo Village. This place is the only landfill in Salatiga where located near residential areas and holds garbage throughout the Salatiga area. Waste in landfill can be a source of pollutants that can affect the quality of the surrounding environment (Hakami, 2016). Research on the structure of soil microarthropods in landfill land has not been widely carried out. The abundance of organic and inorganic pollutants in the landfill is interesting to study and related to the microarthropod community structure. The determination of the community structure provides important information about the status of the land (Çakır & Makineci, 2018; Wu et al., 2014; Zhu & Zhu, 2015). The objective of this study is to compare the community

*Corresponding author
E-mail addresses: rully.rahadian@live.undip.ac.id

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structure of microarthropods in the Ngronggo Salatiga landfill, specifically in the active zone which still contains fresh organic and inorganic waste, and in the passive zone that the decomposition of organic matter has already occurred.

II. Material and Methods

This research was conducted in March 2017 in the active and the passive zone of the Ngronggo landfill, Kumpulrejo District, Salatiga City. The extraction and identification process was conducted at the Laboratory of Ecology and Biosystematics, Department of Biology, Diponegoro University. The analysis of soil physical-chemical was carried out at the Environmental Laboratory and Soil Mechanical Laboratory, Diponegoro University.

The sampling station was determined randomly in both the active and passive zone. Sampling was carried out using a 5 x 5 m^2 square plot. The sample was taken from each corner of the plot and the middle part of the plot which was the diagonal line intersection, so totally there were 5 sample points (Figure 1).

From each sample point, two soil samples were taken for identification of microarthropods and soil physicochemical analysis. Soil samples were taken using a small shovel covering 10 x 10 cm (10 cm depth and 10 cm in diameter). The soil samples were immediately put into a cotton bag to keep the soil microarthropods alive until they are extracted in the laboratory.

Microarthropod extraction was carried out using a modified Berlese funnel (Chelinho et al., 2014). The soil samples were placed on the funnel which coated their bottom surface with mesh. The samples then heated by a 40-watt bulb. Under the funnel, bottles containing 70% alcohol were set up to trap and to preserve the microarthropods. The extraction process was carried out for 7 x 24 hours. The identification and sortation of taxa were carried out by observing the morphology of microarthropods under the Olympus stereo microscope and the Olympus binocular microscope. Identification of microarthropods was carried out until the possible taxa.

The analyzed physical-chemical parameters of soils were pH, humidity, temperature, soil texture, soil porosity, soil aeration, organic matter, and heavy metals (Pb, Cd, Cu, Zn, Hg). Measurement of pH, temperature, and soil moisture was performed in three replication. Analysis of soil organic matter and soil heavy metals (Pb, Cd, Cu, Zn, Hg) were carried out at the Environmental Engineering Laboratory, Diponegoro University. While the soil texture, water hold content and soil porosity were analyzed at the Soil Mechanical Laboratory, Diponegoro University.

Data were analyzed using Microsoft Excel to determine relative abundance index, Shannon-Wiener diversity index, evenness index, and Sorensen similarity index. The difference of diversity of microarthropods in active and passive zones was analysed statistically using t-Hutcheson test. The similarity of microarthropods community in active and passive zones was determined using Sorenson analysis.

III. Results and Discussion

The findings from two stations in the Ngronggo Salatiga landfill found seven families soil microarthropods in the active zone and eight families in the passive zone (Table 1). Total microarthropods found in the active zone were more abundant than in the passive zone e.i., 840 and 740 individual, respectively. The species composition in each zone was varied. Some species belonging to the Piophilidae (Diptera) and Hypogasturidae (Colembolla) families were found in both sampling zones.

In the active zone, 840 individuals were found. They were divided into 13 species from 6 families (Drosophilidae, Piophilidae, Acrididae, Cicadellidae, Hypogasturidae, and Labiduridae) and five orders (Diptera, Orthoptera, Homoptera, Colembolla, and Dermaptera).

Table 1. The composition and species diversity of soil microarthropods in the active and passive zone of Ngronggo landfill, Salatiga.

Sub Ordo & Ordo	Family	Genus	Species	Active Zone		Passive Zone	
				K (m^2)	Di (%)	K (m^2)	Di (%)
Acariformes	Acaridae	*Sancassania*	*Sp17*	0	0	60	8.1^{sd}
Coleoptera	Curculionidae		*Sp14*	0	0	60	8.1 ^{sd}
	Staphylinidae	*Thyreocephalus*	*Sp 18*	0	0	40	4.7 ^{sd}

Collembola							
	Hypogasturidae	*Xynlla*	*Sp 6*	140	16.3[d]	20	2.3[r]
			Sp13	40	4.7[sd]	40	4.7[sd]
			Sp 19	0	0	40	4.7[sd]
Dermaptera	Labiduridae	*Labidura*	*Sp 7*	20	2.3[r]	0	0
Diptera	Drosophilidae	*Drosophilia*	*Sp 1*	160	18.6[d]	0	0
	Piophilidae		*Sp 2*	60	7.0[sd]	80	9.3[sd]
			Sp 9	120	14.0[d]	40	4.7[sd]
			Sp 10	40	4.7[sd]	20	2.3[r]
	Larvae		*Sp 16*	20	2.3[r]	0	0
Hemiptera	Cydnidae		*Sp 20*	0	0	20	2.3[r]
Homoptera	Cicadelidae	*Chlorotetix*	*Sp 4*	80	9.3[sd]	0	0
		Macrostele	*Sp 5*	40	4.7[sd]	0	0
		Macrostele	*Sp 8*	60	7.0[sd]	0	0
		Scaphoideus	*Sp 11*	40	4.7[sd]	0	0
Hymenoptera	Formicidae	*Mimrica*	*Sp 12*	0	0	300	40.5[d]
Isoptera	Termitidae	*Microtermes*	*Sp 15*	0	0	20	2.7[r]
Orthoptera	Acrididae		*Sp 3*	20	2.3[r]	0	0
	Total density, n			840		740	
	Species richness, S			13		12	
	Shannon diversity index, H'			2.34		2.04	
	Evenness index, e			0.89		0.82	

Criteria Di (%) = (**d**) Dominant (>10%), (**sd**) Sub-dominant (3.2%-9.9%),
(**r**) Recedent (1.0%-3.1%), (**sr**) Sub-recedent (0.32%-0.99%), (**s**) Sporadic (<0.99%)

Some microarthropods species were only found in the active zone, i.e., Sp 1 (Diptera: Drosophilidae), Sp 3 (Orthoptera: Acrididae), Sp 7 (Dermaptera: Labiduridae), and Sp 4, 5, 8, 11 (Homoptera: Cicadellidae). In the passive zone, 12 species were found which consist of 8 families (Curculionidae, Staphylinidae, Piophilidae, Formicidae, Cydniydae, Hypogasturidae, Termitidae, Acaridae). These families were included in 7 orders (Coleoptera, Diptera, Hymenoptera, Hymenoptera, Collembola, Isoptera, and Acari) (Figure 1). Some existed species in the passive zone were Sp 17 (Acariformes: Acaridae), Sp 15 (Isoptera: Termitidae), Sp 14 (Coleoptera: Curculionidae), Sp 18 (Coleoptera: Staphylinidae) and Sp 12 (Hymenoptera: Formicidae) (Table 1).

The Shannon-Wiener index of soil microarthropods in the active zone and passive zone were 2.34 and 2.04, respectively (Table 2). These soil microarthropods diversity indexes are categorized in the medium level. The diversity of soil microarthropods in the active zone is greater than 0.3 (Table 2) compared to the passive zone. This is likely to be influenced by how long the passive zone was abandoned so that the organic material in the soil is less than the active zone (Table 4). Differences in diversity can also occur due to competition between species in each of the different zones, such as inactive zones which have dominant species decomposers will experience more even competition than in passive zones whose species are more varied due to less organic material and the emergence of pioneer plants (Amelinda, Rahadian, & Hadi, 2017).

The diversity of soil microarthropods was statistically analyzed using the t-Hutcheson test to determine whether there were differences in the level of diversity in the two zones. The t-Hutcheson test showed that soil microarthropod diversity in active and passive zones was not significantly different because it had a t-test value (0.062) smaller than the t-table value (1.99). Evenness index analysis (e) showed that the active zone was higher than the passive zone. Evenness index in the active zone (0.89) was almost the same as the passive zone (0.82) (Table 2). This result shows that the evenness of the two zones is still fairly even. Based on Sorensen's analysis, both landfill zones have a similarity index value of 40% (Table 2). Similarity index value of 40% indicates soil microarthropods composition in the active and passive zones of Ngronggo landfill is

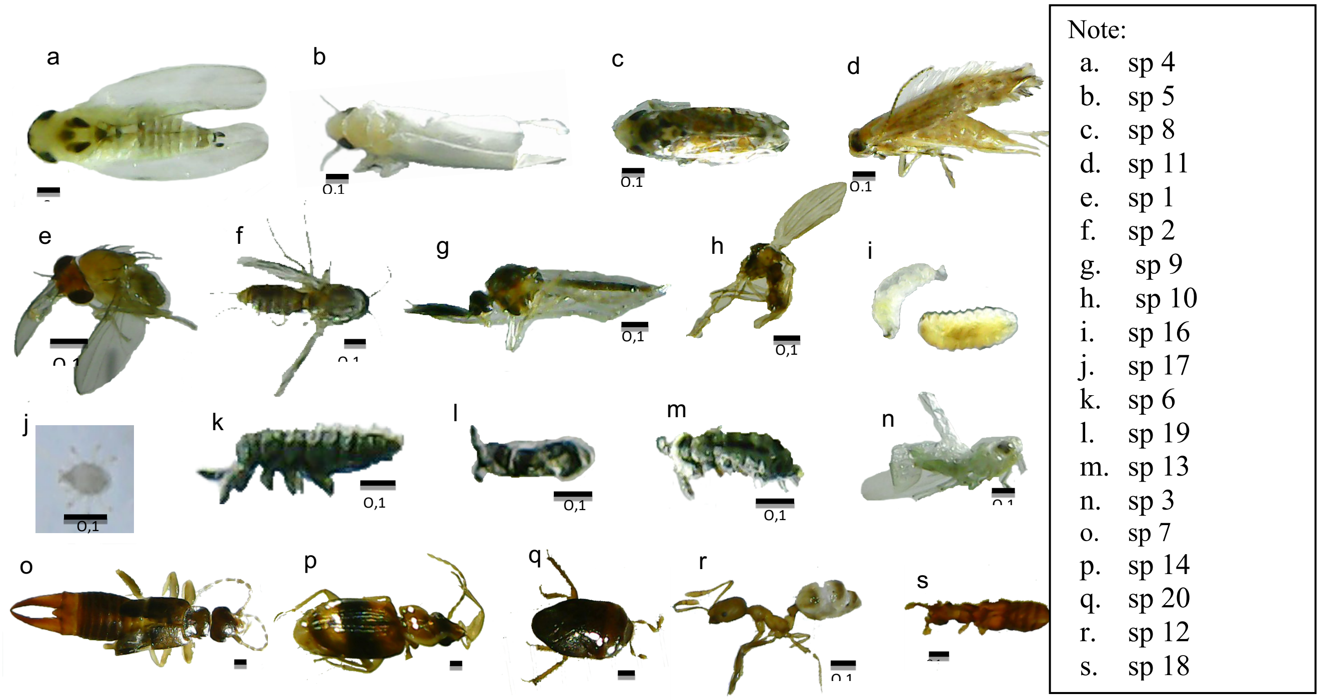

Figure 1. Soil microarthropods found in active and passive zones of Ngronggo landfill.

quite different. This is likely due to the process occurs in both zones where the active zone continues to experience the addition of waste and sand every 10 cm solid thickness while in the passive zone that has not undergone any process from the outside makes similar species found low. The structure of the microarthropods community cannot be separated from other factors that influence each other both abiotic and biotic, physical and chemical (Husna, Hadi, & Rahadian, 2017). Physical factors of soil consisting of temperature, humidity, light intensity, moisture content, soil texture, porosity. Soil chemical factors include heavy metals (Pb, Cd, Cu, Zn, Hg), Ph and Organic Materials.

Table 2. Number of species, Shannon-wienner diversity index, and evenness of soil microarthropods in each zone.

Index	Active Zone	Passive Zone
Number of Species, S	13	12
Shannon-wiener diversity index, H’	2.34	2.04
Evenness, e	0.89	0.82
Similarity index, IS	40%	

The soil texture of the active zone and passive zone consists of silt with a percentage of 46.58% and 35.5% (Table 3). Sand soil texture in the active zone is 39.32% and in the passive zone is 39.84%. The percentage of sand is divided into fine sand and coarse sand. The second zone is dominated by fine sand (Table 3). Other textures of the landfill are found in the lower zone of the active zone. The clay is found in the active zone in the minimum amount which is only 1%, while the clay in the passive zone is not found at all (Table 3).

Table. 3. Physical soil parameter in active zones and passive zones of Ngronggo landfill Salatiga.

Parameter	Active Zone	Passive Zone
Soil temperature, ^{0}C	19 ± 1.16	24 ± 0.58
Soil humidity, %	100 ± 0	83 ± 5.77
Light intensity	24747 ± 7886.6	29300 ± 692.8
Soil water content (w), %	48.31	40.60
Soil texture		
- Sand, %	13.10	24.64
- Coarse sand, %	16.71	19.24
- Fine sand, %	22.61	20.60
- Silt, %	46.58	35.50
- Clay, %	1.00	0
Soil porosity (n), %	58.66	55.83

The value of porosity in the Ngronggo landfill soil exceeds 50% with the difference between the active zone and the passive zone reaching 2.83% (Table 3). The soil temperature in the active zone and the passive zone is low because the location of the Ngronggo TPA is located at an altitude of 809 meters above sea level which causes the soil temperature in the active zone to reach 19^{0}C and in the passive zone of 24 ^{C}C (Table 3). In addition to physical factors, environmental factors that influence the structure of soil microarthropods are soil chemical factors, namely the content of heavy metals and soil organic matter, as well as chemical factors that affect, among others, Pb, Cd, Cu, Zn, Hg and percentage of organic matter (Table 4) .

Table 4. Chemical soil parameter in active zones and passive zones of Ngronggo landfill Salatiga

Chemical Parameter	Active zone	Passive zone
Pb (µg/g)	0.105	0.13
Cd (µg/g)	<0.001	<0.001
Cu (µg/g)	0.016	0.497
Zn (µg/g)	1.679	4.776
Hg (µg/g)	0.003	0.008
Organic matter (%)	3.2	2.4
Soil pH	6.2 ± 0	6.5 ± 0.4

Heavy metal content in Ngronggo landfill does not reach the average content of natural soil heavy metals according to (Austruy et al., 2016) which mentions the levels of heavy metals naturally including Pb: 10 µg/g, Cd: 0.06 µg/g, Cu: 20 µg/g, Zn: 50 µg/g, Hg: 0.03 µg/g. The results obtained at Ngronggo landfill are all below the natural content of the soil in general. This shows that the heavy metals in the Ngronggo landfill have not polluted the environment around the landfill. This is possible because of the lack of existing factory waste and the City of Salatiga in the dominance of home industries which on average produce organic waste. Compared to Jatibarang TPA Semarang which has a high level of heavy metals to close to the level of natural heavy metals in the soil such as Pb levels: 3,92-7,26 µg/g, Cu: 0-30,1 µg/g, Zn: 0-234 µg/g, Hg: 1.08-0.87 µg/g respectively from the active zone to the passive zone.

In contrast to the organic material in the Ngronggo landfill, the active zone results are higher than the passive zone (Table 4). Organic material is a food source for soil microarthropods or mesofauna will be more widely found in areas that have organic material as a source of food (Gergócs & Hufnagel, 2016). The statement is in accordance with the results obtained where the active zone has more organic material (Table 4) and the community structure is higher (Table 1) than the passive zone.

Soil microarthropods in the active zone of the Ngronggo Salatiga landfill have total species density (860 individuals/m2), richness (14 species from 6 families) and evenness (0.908) higher than in passive zones which have total species density (740 individuals/m2), richness (12 species from 8 families) and evenness (0.819). active zone diversity (H '= 2,396) and passive zone (H' = 2,035) have similar level of similarity (40%). The density and abundance of soil microarthropods are directly proportional to the content of organic matter in the soil where the more soil organic matter, the more density and abundance of soil microarthropods.

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