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ABSTRACT

Soil fauna has played an important role in ecosystem functioning, especially as ecosystem engineers which contribute to soil fertility in tropical environment. A tailing deposition area is one habitat that has several types of soil fauna to live and growth as well as involves in the decomposition of organic matter. The objective of this study was to examine the number and distribution of soil fauna in the tailing area of Freeport Indonesia Mining and Gold Company, Timika. The study was located in some inactive tailing deposition areas in between Double Levee of the lowland area of ModADA (Modification Ajkwa Deposition Areas). Samples were taken from inactive tailing as 198 of ModADA for soil and soil fauna, the Kuadran Method was used to collecting soil fauna on the soil surface and in the soil. There were 17 types/ordo of soil fauna in the study area and the highest number was a group of ants (Hymenoptera/Formicidae). Population density (PD) and relative density (RD) of soil fauna (Formicidae) ranged from 0.03-2.41 Individu m^{-2} (PD) and 0.07-6.50% (RD). Both PD and RD were likely to increase as the number of soil fauna increase. The distribution of most soil fauna were found as a clump, while Pulmonata (Gastropods) were distributed normally in the tailing areas. The number and types (ordo) of these soil fauna had showed that inactive tailing deposition areas were considered a good habitat for soil fauna.

Key words: Distribution, population, soil fauna, tailing

INTRODUCTION

Soil fauna are the most important organisms which can be found both on the soil surface and in the soil and as a part of soil ecosystem. They play an important role in ecosystem functioning, especially as ecosystem engineers which contribute to soil fertility in tropical environment. These organisms interact in the soil enhancing its fertility, promoting primary production and creating acomplex food web in the soil ecosystem that serve to sustain life within the soil and on the surface (Sackett *et al*. 2010). In forests ecosystem, the soil fauna is numerous and forms diverse communities (De Ruiter *et al*. 2002; Fitter *et al*. 2005). A tailing deposition area is one habitat that has several types of soil fauna to live and growth as well as involves in the decomposition of organic matter. Their growth and development are mainly depended on the physical and chemical properties of soil (Suin 2003).

Wallwork (1970) has classified soil fauna into four different groups (1) according to their body size (*i.e* macro fauna, meso fauna and microfauna), (2) frequency of occurence in the soil (*i.e* transient, temporary, periodic and permanent group), (3) based on their habitat (*i.e*. epigeon, hemiedafon and euedafon), and (4) based on their food consumption (*i.e*. herbivore, saprovore, fungivore and predator). Brussard (1998) has also classified the soil organisms into three functional groups such as root organisms, decomposer and ecosystem engineer. Furthermore, Sugiyarto (2000) has classified soil macrofauna based on their dominant activity living *i.e*. the group of soil macrofauna which are active on the soil surface and in the soil.

The existence of soil fauna are most depended on their specific living habitat, forest is the most likely good ecosystem and high variability of soil fauna because forest soil contains high organic matter and nutrients both on the surface and in the soil. The highest population of soil fauna had been found on the forest floor of Borneo which consisted of Collembola, Arachnida, Coleoptera, Hymenoptera and other groups (Suin 2003). While in West Java,

the highest population of soil fauna on the forest floor are mainly Acarina, Collembola, Hymenopthera, Sumphyla, Diplura and Psocoptera (Adianto 1993). Collembola and Acarina are considered as a main component of soil mesofauna in all terrestrial ecosystems, *Collembola* has played an important role in the decomposition process and formed micro structure on the soil (Rusek 1998). Collection of baseline data on the density, diversity and distribution of soil fauna is essential in order to utilize this community as biological indicators of soil health and monitor changes indisturbed ecosystems (Behan-Pelletier 1999).

Soil fauna on the mine tailing areas have been studied previously *e.g*. Battigeli (2011); Shao *et al*. (2008); Picaud and Petit (2007), however those studies have focused on the specific soil fauna. The research on biodiversity of soil fauna in the tailing deposition areas of Freeport Indonesia Mining Company has not been done previously. The tailing deposition area was covered about 230 km^2 until at the end of mining activity. Most of this area has also been grown with some types of plants and also dominated by primary natural succession which more likely became a secondary forest. Therefore, the information about the bodiversity of soil organisms especially soil fauna were needed as a data base to inform Freeport Indonesia about the effectiveness of soil fauna especially their diversity, number and distribution in the tailing area. It was expected that, this information could be used by Freeport Indonesia to make a decision and consideration of tailing management and conservation, as well as to improve the healthy tailing ecosystem.

The objective of this study was to determine the number and distribution of soil fauna which consisted of their population density, relative density, and frequency of occurence of soil fauna in some tailing areas of Freeport Indonesia, Timika-Papua.

MATERIALS AND METHODS

Sampling Location

Soil and soil fauna sampling were taken across ModADA (inactive tailing) areas of PT Freeport Indonesia work area project at Timika, Mimika region. Most of the sampling location were dominated by flat areas (Figure 1). Soil sample was taken compositely in the depth of 0-20 cm by using a soil auger in each 200 m interval, but in the location which its width was smaller than the distance between points, was 50 – 100 m. In each point, sample was taken as many as 10 augers with 1 meter distance circularly in order to get composite sample from each point. The number of the whole samples taken was 198 points, or as many as 1980 composited auger samples. Soil pH and moisture content were analyzed for all sampling points.

Sampling Technique of Soil Fauna

Sampling of soil fauna was taken using Kuadran Method with two techniques *i.e*. (1) direct collection of soil fauna which occured on the soil surface, and (2) soil monolith technique of 25×25×30 cm^3 (Anderson and Ingram 1993) on each sampling point with "handsorting insitu"collection method. The collection was put in the sampling bottle, counted and identified the type of soil fauna based on the soil fauna identification handbook. Total of soil monolith accross the study areas was 198 monolith.The population of one type or groups of soil fauna were counted and expressed in the number or biomass per wide areas, or per volume with the formula (Suin 2003):

$$\text{Population of A} = \frac{\text{Number of individual A type}}{\text{Number of Sample Unit/areas/volume}}$$

Relative Density was counted by comparison the density of a type of soil fauna with all soil fauna density which found in the unit of sampling by using the formula of (Suin 2003):

$$\text{RD of A type} = \frac{\text{Density of A type}}{\text{Total Density of all types}} \times 100$$

RESULTS AND DISCUSSIONS

Soil Characteristics (pH and Moisture content)

Data on soil pH and moisture content in the tailing areas is presented in Table 1. In general, the range of soil pH in the tailing areas was 4.61 to 8.67 with the mean of 7. While the moisture content ranged from 2.40 to 62% with the mean of 20.13%. Soil pH and moisture content were factors that affected the number and distribution of soil organism in the soil.

Most of the tailing areas have high value of soil pH, however only few location have had lower soil pH (4.61-4.9). In contrast, only few areas in Mile 21 and 23 have >45.7 % of soil moisture content. This might be caused by high level of rain and the areas were located nearby river.

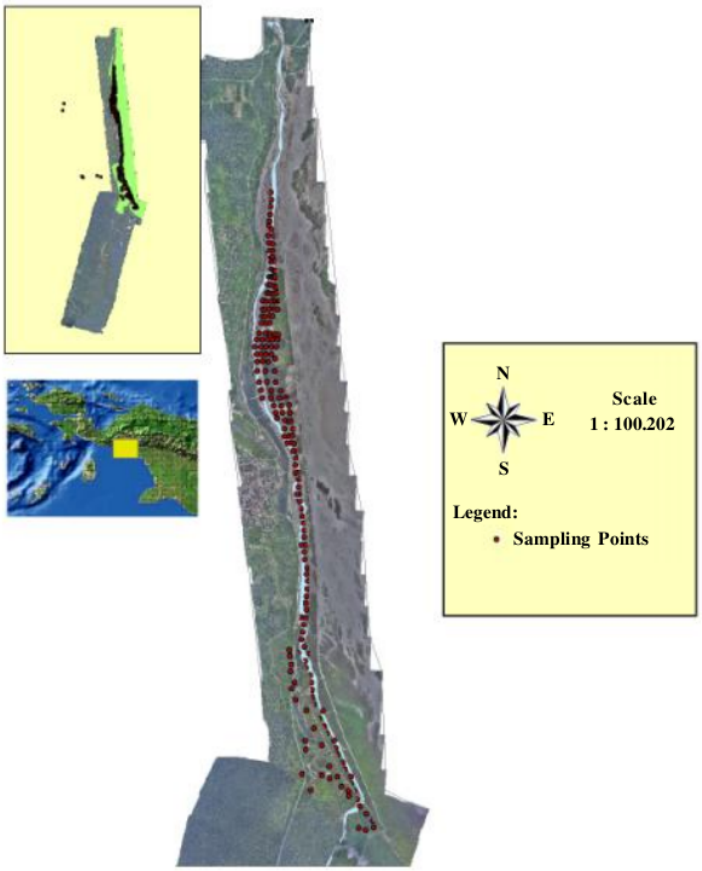

Figure 1. Research Location and Sampling Points in the Tailing ModADA Areas of Freeport Indonesia Timika.

Soil Fauna

The number, PD, RD, distribution and type of soil fauna which found in the tailing areas are presented in Table 2. There were 17 types (ordo) of soil fauna found in the tailing deposition areas, the highest number of soil fauna in total was a group of soil ants (Hymenoptera/*Formicidae*) which consisted of *Tapinoma* (564), P. *hauxwelli* (163) and D. *bituberculatus* (135), followed by the highest of PD and RD of these group *i.e* 2.41 Individu m^{-2} and 6.50, respectively, while the lowest soil fauna were the group of Chilopoda, Collembola, Dipthera, and Protura. Population density and RD were likely to follow the pattern of the number of soil fauna found in tailing areas, which were the highest number of soil fauna in the soil the PD and RD are also high. Most of the soil fauna was found in the tailing deposition areas were distributed as a clump and very rare of them was found in individual, however a type of Pulmonata (Gastropod) was distributed normally.

Suin (2003) has reported that most of soil fauna were distributed as a clump, they preferred to choose and live in the suitable habitat for themselves, both suit based on the physical and chemical characteristics of soil and food availability.The population and distribution of soil organisms both for soil flora and fauna are varied in the soil depend on soil characteristics, soil cultivation, and type of vegetation grown on the soil. Hanafiah *et al*. (2005) has noted that there are three main factors which

Table 1. Soil pH and moisture content in the tailing deposition areas.

Variable	Mean	Median	Standard Deviation	Kurtosis	Skewness	Min	Max	CV
Soil Moisture Content (%)	20.13	17.95	11.05	0.40	0.81	2.40	62.00	54.92
pH H_2O (1:2)	7.00	7.42	1.13	-0.93	-0.64	4.61	8.67	16.09

Note: Min= Minimum, Max= Maximum, CV= Coefficient of Variation

Table 2. Total number, Mean, Population Density (PD), Relative Density (RD) and the Distribution of Soil Fauna in the Tailing Deposition Areas of PT Freeport Indonesia.

No.	Type of Soil Fauna (Ordo)	Mean	Min	Max	Total	PD (Individu m^{-2})	RD (%)	Distribution	
								Value	Criteria
1	Acarina	0.07	0	2	13	0.35	0.95	V>M	Clump
2	Acari (Eriophydae)	0.03	0	2	5	0.14	0.37	V=M	Random
3	Araneida	0.07	0	3	13	0.35	0.95	V>M	Clump
4	Chilopoda	0.01	0	1	2	0.05	0.15	V=M	Random
5	Coleoptera	0.35	0	8	68.5	1.85	5.005	V>M	Clump
6	Collembola (Arthropleona)	0.01	0	1	1	0.03	0.07	V=M	Random
7	Dermapthera	0.04	0	2	7	0.19	0.51	V>M	Clump
8	Dipthera	0.01	0	1	1	0.03	0.07	V=M	Random
9	Diplopoda	0.1	0	5	20	0.54	1.46	V>M	Clump
10	Entomobryomorpha	0.05	0	3	10	0.27	0.73	V>M	Clump
11	Hemiptera	0.12	0	2.67	24	0.65	1.75	V>M	Clump
12	Hymenoptera	0.45	0	8.27	89	2.41	6.50	V>M	Clump
13	Megadrilacea (Lumbricina)	0.15	0	10	30	0.81	2.19	V>M	Clump
14	Opliones	0.02	0	1	4	0.11	0.29	V=M	Random
15	Orthoptera	0.09	0	2	18	0.49	1.31	V>M	Clump
16	Protura	0.01	0	1	1	0.03	0.07	V>M	Clump
17	Pulmonata	0.02	0	1	3	0.08	0.22	V<M	Normally

affected the population and distribution of soil organisms *i.e* (1) weather, especially rainy season and moisture; (2) soil condition/characteristics *i.e* acidity, soil moisture content, temperature and nutrient availability; and (3) type of vegetation/land cover *i.e* forest, shrubs and grass land. Among the soil fauna found in the tailing deposition areas, the group of soil ants (Hymenoptera/Formicidae) were abundant. Wallwork (1976), the group of ants (*Formicidae*) raised about 70% of the soil fauna population in the tropical soils, therefore these groups were higher than other soil organisms while the lowest number was Collembola, Dipthera and Protura groups. Djuuna *et al*. (2008) has also reported that the group of ants were dominated among the population of soil fauna under different type of forest vegetation in Gunung Meja secondary forest in Manokwari.

In general, the numbers of soil fauna which found in the tailing deposition were considered medium, however their types were hihgly varied which were dominated by ants and other soil insects. Most of the soil fauna found in the tailing deposition areas were in the group of insects, while the earthworm (Megadrilacea, Lumbricina) was found in the cultivated land of mile point (MP) 21, reclamation and biodiversity research areas. This because that soil condition and type of vegetation in the reclamation areas were suited for earthworm to growth, they prefered to live in soil with high organic matter. Some ecological factor which could influenced this earthworm were soil pH,

temperature, organic matter, soil types and nutrients supply (Hanafiah *et al*. 2005). Earthworms can growth better in the soil which had pH 7.0, however some of them could also lived in the soil with low pH. The average value of soil pH in the tailing areas ranged from 6,0-8,0 (neutral to alkaline), this was not followed by the highest number of earthworm. This might be caused by low number of soil organic matter in the tailing areas as well as the llimited type of vegetation. According to Hanafiah *et al*. (2005), organic matter distribution in the soil could influenced the number and activity of earthworms. Based on the field observation, the litter or fresh organic matter on the soil surface in some tailing deposition areas were thicked enough especially under forest vegetation, however this source of organic matter are low to be decomposed, therefore it affected the number of earthworm in this area. Most of that, inactive tailing deposition areas are considered good habitat for soil fauna to live and growth.

CONCLUSIONS

The total number of soil fauna in the tailing deposition areas were considered high for a group of Hymenoptera (Formicidae), while the lowest number was from a group of Collembola, Dipthera and Protura. Most of these organisms were distributed as a clump. The high variability of soil fauna in the tailing areas is considered that tailing is also a good habitat for growth and development of soil fauna.

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