Species diversity and dominance of Oligochaeta in copper and cadmium polluted soil

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Abstract. The aim of this study was to determine the dominance and species diversity of oligochaeta were studied in copper and cadmium polluted soil. This location is used for the garbage disposal of Jatibarang Landfill Semarang City residents, Central Java. Oligochaeta were collected from 5 research sites. The research method used is field experiment. Oligochaeta sampling was carried out based on a random sampling method. Oligochaeta sampling in Jatibarang Landfill was carried out at a depth of 25 cm. Analysis of oligochaeta diversity includes species diversity using the index formula Shannon-Wiener and dominance with the index formula Simpson. The species diversity (Shannon-Weiner Index) showed value of 0.191 (site 1), 0.411 (site 2), 0.539 (site 3), 0.137 (site 4), 0.443 (site 5) and the dominance calculated was 0.207 (site 1), 0.024 (site 2), 0.279 (site 3), 0.045 (site 4), 0.031 (site 5) which indicates that the diversity and the dominance were inversely related. The population density (individuals/m²) of the Oligochaeta species at 5 research sites showed variations. The total density of L. terrestris recorded was 280.66 (site 1), 59.66 (site 2), 130.33 (site 3), 136.66 (site 4), 62 (site 5), and the total density of Pheretima sp 14 (site 1), 10 (site 2), 39 (site 3), 4.33 (site 4), 12 (site 5). Two species of Oligochaeta showed high richness whereas some were sparsely populated.

1. Introduction

Soil fauna is one of the components of the soil ecosystem that plays a role in improving soil structure through weight-loss types, the increase in pore spaces, aeration, drainage, water storage capacity, the decomposition of organic materials, mixing the soil particles, The spread of microbes, and improvements to the structure of the soil aggregates [1]. The influence of soil and organic matter decomposition are indirectly, but soil fauna can be seen as a regulator of the occurrence of the process of physical, chemical or biochemical on the ground [2]. Soil macrofauna role in determining the fertility of the ground. The decline in the quality of the soil affects on the changes of regulation of
decomposition biology and the availability of nutrients in the soil, which can eventually affect the diversity of soil macrofauna [3]. One of the soil macrofauna is oligochaeta. Oligochaetas help soil aeration, process of humification, mixing and stabilizing organic soil pH [4]. Macro pore soil influenced by soil texture, organic soil, ingredients and macrofauna activity [5].

Oligochaeta is an important component of soil ecosystem, because it contributes to the process of humification, improve aeration, cultivate organic material and stabilize the degree of soil acidity. In general which can be seen as a regulator of the onset of the process on the ground, in other words Oligochaeta play a role in determining soil fertility in the level of soil health in an area of farms. Macro soil pores, soil texture and soil organic material content are influenced by diversities of living creatures around it such as existing oligochaeta activity. From the results of Sudarmi’s research it is known that three species of oligochaeta that have characteristics of life on a market organic waste heap are Megascolex sp, Peryonix sp, and Drawida sp [6]. Research by [7] also found seven species of oligochaeta in a Landfill and household Landfills in several districts of Medan Municipality, namely Megascolex sp1, Megascolex sp2, Peryonix sp, Fridericia sp, Drawida sp, Pontoscolex corethrurus and Pheretima sp [8].

Oligochaeta fulfill the requirements to be selected as bioindicators, sensitive to pressure and environmental changes, oligochaeta have high abundance and are easily surveyed/observed, exposed to the environment, and have a strong relationship with the wider community or do not have a strong relationship with the component of pressure. Oligochaeta makes contact with pollutants in this compartment with the movement and consumption of soil or leaf litter contaminated with Cu and Cd. Oligochaeta are grouped into three groups based on their habitat, living in litter, and consumption of plant residues. Oligochaeta dig narrow channels and eat a mixture of soil and crop residues. Oligochaeta is capable of digesting the litter and throwing back to the ground. The aim of this study was to determine the dominance, diversity of oligochaeta were studied in Cu and Cd polluted soil.

2. Method

2.1. Study area

Research site at Jatibarang Landfill. This location is used for the garbage disposal of Semarang, Central Java, Indonesia (Fig. 1).

Figure 1. Location of Jatibarang Landfill in Semarang City Central Java
The research method used is field experiment. Samples were taken from the population at 5 research sites. The research site was determined based on the results of a preliminary study by looking at differences in environmental conditions in the Jatibarang Landfill, especially the difference in Cu and Cd concentration in the soil and 5 research sites were determined. (Fig. 2).

Figure 2. Location of Sampling Site

2.2. Field sampling
Oligochaeta sampling was carried out based on a random sampling method. Oligochaeta sampling in Jatibarang Landfill was carried out at a depth of 25 cm [9]. Oligochaeta samples and were taken from the same 5 sites. The area is divided into small areas for individual (sampling units). The tools used are squared frame size 0.5 × 0.5 m², plastic bags, plastic containers, tweezers, bottle sample, the meter, the magnifier, and coring. Oligochaeta were collected by the diluted formaldehyde complemented with digging using quadratic 0.5 × 0.5 m quadrates and hand sorting method. The specimens were killed in 70% ethanol, fixed in 4% formalin solution and 96% ethanol, then transferred into 75% ethanol [10]. Collection of samples brought to laboratorium oligochaeta identified with a lup and microscope binoculars. Characteristics of the essentials used in the process of identification include: number of segments, size, shape and color of the body; The type seta; The location and the form of clitellum, tuberculapubertatis (TP) and genital tumescence (GT). Identification is done up to the level of the genus by using reference literature: [11, 12, 13, 14, 15, 16, 17]. The number and type of individual oligochaeta used for the analysis of the quantitative i.e the density [18]. Analysis of diversity of species by using the Shannon-Wiener formula, equity with the Evenness index [19] with the formula Simpson index [20]. Soil sampling, carried out together with Oligochaeta sampling. Measurement of soil samples conducted in-situ i.e. soil texture, soil pH, soil moisture, and soil organic matter. Other parameters is carried out analysis in the laboratory. Size (weight) of each soil samples needed 100 g soil per sample.

3. Results and discussion
One of the potential locations for oligochaeta living is a landfill area. Oligochaeta is one component of soil ecosystem that plays a role in improving soil structure through decreasing specific gravity, increasing pore space, aeration, drainage, water storage capacity, decomposition of organic matter,
mixing soil particles, microbial dispersion, and improving soil aggregate structure. The effect of Oligochaeta on soil formation and decomposition of organic matter is indirect, but Oligochaeta can be seen as a regulator of physical, chemical and biochemical processes in the soil. Oligochaeta plays a role in determining soil fertility. Declining soil quality has an impact on changes in biological decomposition regulations and the availability of nutrients in the soil, which can ultimately affect the diversity of Oligochaeta. Oligochaeta help the humification process, improve soil aeration, mix organic material and stabilize soil pH. Oligochaeta through their activities can affect the formation of soil macro pores. Soil macro pore is influenced by the diversity of Oligochaeta, soil texture, soil organic matter content, and soil digging Oligochaeta activity. In general, oligochaeta can be seen as regulating the occurrence of processes in the soil, in other words soil fauna plays a role in determining soil fertility and even some types of oligochaeta can be used as indicators of the level of soil health in an agricultural area.

Oligochaeta living on organic stack of materials at ground level, the increase in litter input can improve the content of soil organic matter. A lot of organic that material found on has soil moisture is high. The composition of the difference is allegedly caused by the complexity and climate of the microhabitat. Habitat complexity will add microhabitat to add to the number of types that can live in it. The soil contains the total total carbon organic cause of the amount of soil that contained little [8]. Soil has a high sand content, generally not preferred by oligochaeta because have grain rough so not able to store water to the needs of oligochaeta [21]. Ecological factors that affect oligochaeta include: soil pH, soil moisture, soil temperature, organic materials and soil texture (Table 1).

**Table 1. Ecological Factors in the Jatibarang Landfill**

| ECOLOGICAL FACTORS | SITE I | SITE II | SITE III | SITE IV | SITE V |
|--------------------|-------|--------|----------|--------|--------|
| Soil temperature (°C) | 35    | 35     | 35       | 35     | 35     |
| Soil pH             | 5,4   | 4,4    | 4,1      | 5      | 5,3    |
| Organic matter (%)  | 29,45 | 34,95  | 13,86    | 38,48  | 27,77  |
| Soil moisture (%)    | 35,37 | 29,31  | 34,01    | 41,79  | 46,19  |
| Soil texture        | Clays sandy clay | Clays sandy clay | Clay | Clays sandy clay | Sandy clay |
| Cu (ppm) in soil    | 7,89  | 15,87  | 9,16     | 10,68  | 6,74   |
| Cd (ppm) in soil    | 0,037 | 0,032  | 0,035    | 0,037  | 0,031  |

Site 1, 2, 4 and 5 in Jatibarang Landfill are included in the texture type of sandy clays. Oligochaeta is a soft animal capable of living well in sandy clay areas. Site 3 in Jatibarang Landfill is included in the type of clay texture. Site 3 The value of the smallest organic material because it has the highest percentage of the clay fraction compared to other sites, that capable of living soft both in sandy clay and clay area. It can be due to have high ability adaptation. [21] stated that soil with a high content of sand, is generally disliked by oligochaetas because it has rough grains so it is unable to store sufficient amounts of water for the needs of oligochaetas. the greater the value of uniformity indicates a large type of uniformity, meaning that the density of each type can be said to be the same and tends not to be dominated by a particular type.

Environmental conditions of Jatibarang Landfill with pH slightly acidic (<6) and organic matter levels are categorized as high (> 1%) (Table 1). Oligochaeta prefers environmental conditions with a slightly acidic pH (<6) with relatively high organic content [6, 7]. Soil organic matter is enormous influence on the development of populations of oligochaetas since the organic material is found in soil is very necessary to continue his life. Organic matter also affects physical and chemical issues of soil and organic matter of the oligochaetas. Organic matter in site 3 Jatibarang Landfill has the most small organic matter because it has the highest percentage of the clay fraction compared to other sites. Soil organic matter has a huge influence on the development of oligochaeta populations because organic
matter found in the soil is indispensable to continue its life. Organic matter also affects the physical-chemical properties of soil and organic matter is a source of feed to produce energy and oligochaeta body formation compounds [22]. According [23] states that epigeic worms live and eat in piles of organic matter at ground level. It is proven to be found genera Pheretima sp. Pheretima sp are classified as epigeic live on piles of organic matter at ground level. According to [24] that increased litter input can increase the content of soil organic matter. [25] added that organic matter is widely found in soils that have high humidity. The difference in the composition of oligochaeta is thought to be due to the complexity and climate of microhabitats. [26] stated that increasing the complexity of habitats will increase microhabitats thus increasing the number of species that can live in them. Soils containing low total organic carbon cause fewer oligochaetas to be found [8]. The existence of organic matter can come from nature or from household and industrial activities. In natural soil, what acts as a source of organic matter is the decay of dead plants and animals. Naturally the process of decomposition of organic matter depends on the amount of organic matter, the presence of bacteria, pH, temperature, oxygen, time and others.

Figure 3. Oligochaeta Distribution in Jatibarang Landfill

Table 2. Composition, Density, Shannon-Wiener Index (H'), Simpson's Dominance Index (D), and (E) the Evenness Index Oligochaeta in Jatibarang Landfill Semarang

| Species       | Depth (cm) | Site I     | Site II    | Site III   | Site IV    | Site V     |
|---------------|------------|------------|------------|------------|------------|------------|
| Lumbricus terestris | 0-30       | 280,66     | 59,66      | 130,33     | 136,66     | 62         |
| Pheretima sp   | 0-30       | 14         | 10         | 39         | 4,33       | 12         |
| Total          |            | 294,66     | 69,66      | 169,33     | 140,99     | 74         |
| H'             |            | 0,191      | 0,411      | 0,539      | 0,137      | 0,443      |
| D              |            | 0,207      | 0,024      | 0,279      | 0,045      | 0,031      |
| E              |            | 0,276      | 0,593      | 0,777      | 0,095      | 0,639      |

Based on table 2, Simpson dominance index (D) in the range of 0 < D < 0.5 for all sites means that no genus dominates in Jatibarang Landfill, community structure is in a stable state and there is no ecological pressure on oligochaeta in the habitat. Oligochaeta distribution in Jatibarang Landfill of
each species is not the same (Fig 3) and in the ecosystem there is a tendency to occur with the species dominance due to the instability of the environmental and population factors. Almost no individual dominates and is usually followed by a Evenness index. The larger the value of uniformity of large type shows, which means that the density of each type can be said to be the same and likely not dominated by certain types. In accordance with [27], if the value of type dominance is close to 1 then in that community there is a type that dominates and in a state of labile and high ecological pressure. For Shannon Wienner index value (H’) in Jatibarang Landfill has a value of less than 1 means that the diversity of species in Jatibarang landfill is low for all sites. The composition of the Oligochaeta is highest at the site 1 while the lowest in site 2. L. terestris has the highest density while the lowest of Pheretrima sp. The highest kind of diversity is on site 3 (H’ = 0.539) because it has a varied vegetation and meetings. The lowest diversity was found in site 4 (H’ = 0.137). While the Evenness Index (E) values for site 1 and site 4, low E values mean unstable communities, while site 3 and site 5 have high E values means that stable communities, individuals of the same species. Jatibarang Landfill is relatively suitable for the growth and development of each oligochaeta. According to [26], diversity tends to be higher in areas with diverse habitat conditions than in uniform habitats and the diversity of a community type is determined not only by the number of types, but also by the density and evenness of each species.

4. Conclusion
Based on the research that has been done, it can be concluded that the types of oligochaeta in Jatibarang Landfill consist of 2 species, Lumbricus terestris and Pheretrima sp. The highest density of Lumbricus terestris located on Site 1 is 280.66 individuals/m², the lowest density for Lumbricus terestris contained in site 5, which is 62 individuals/m². While the highest density for Pheretrima sp contained in the site 3, 39 individuals/m², and the lowest density for Pheretrima sp contained in the site 4, 4.33 individuals/m².

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