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# Identification of Termite House Cementation as an Effort to Make Synthetic Cementation for Soil Conservation

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**ABSTRACT**

*Termites are social insects that have strong and hard nests. The purpose of this study was to identify the cementation material for termite nests which makes termite nests sturdy so they are resistant to rain or erosion. Sampling was carried out by random sampling method in three different districts, namely Gunung Kidul, Kulon Progo and Bantul. Parameters observed for the identification of cementation materials were pH, C-organic, organic matter, texture, protein and fat. In general, the parameters in the termite nest have a higher value than the soil around the termite nest. C-organic termite nests in Gunung Kidul by 2.82%, Kulon Progo 3.05% and Bantul 3.46%. While the organic matter content in the soil of Gunung Kidul is 2.06%, Kulon Progo is 2.21% and Bantul is 3.00%. The protein content in termite mounds is 0.17% in Gunung Kidul, 0.19% in Kulon Progo, and 0.15% in Bantul. The protein content in the soil around the nests was 0.10% in Gunung Kidul, 0.12% in Kulon Progo and 0.10% in Bantul. The texture of the termite nest and the soil around the nest is loamy and loamy loam. Based on the results of the analysis obtained, the construction of termite nests is dominated by clay material with adhesive or cementation of organic matter and protein produced from termite saliva. Soil conservation can be done by adding organic matter and protein to stabilize and strengthen soil aggregates.*

## 1. INTRODUCTION

Nowadays population growth is very fast. The rapid population growth has also resulted in an increase in the necessities of life, both in quantity and quality. Increasing necessities of life such as food will encourage wider land use, while the availability of resources is increasingly limited and decreasing. These conflicting things put greater pressure on land resources. On the one hand, land is expected to produce very high yields, but on the other hand, land use conversion has occurred from productive land into residential land (Arifin, 2010).

Land use such as cultivation in the highlands has a high risk and limiting factors such as relatively steep slopes, high sensitivity of the soil to erosion, and landslide potential. Therefore, inappropriate management and utilization of resources in the highlands can cause biophysical damage, decrease soil fertility and water availability. Damage to these resources is not only felt by the upstream community but also by the downstream community (Idjudin, 2011).

About 45% of Indonesia's territory is in the form of highlands, both hills and mountains. The practice of agricultural cultivation in the highlands has a strategic position for the national agricultural development program. Utilization of land in the highlands apart from providing benefits to many farmers, also plays an important role in maintaining the environmental functions of watersheds (DAS) and buffer areas in the downstream (DEPTAN, 2006).

Despite having great opportunities for land use in the highlands for agricultural cultivation activities, hilly and mountainous land is also vulnerable to erosion and landslides due to relatively steep slopes and relatively high or heavy rains, and unstable soil. The danger of erosion and landslides becomes a major threat if the use of resources in the highlands is not carried out properly and prioritizes conservation aspects for environmental sustainability. Apart from being influenced by slope factors and high rainfall, erosion and landslides in the highlands are influenced by cultivation techniques and agricultural systems in the region (DEPTAN, 2006). Therefore, a strategy or action is needed in handling erosion in the area.

One of the actions that can be taken to reduce the level of erosion and landslides in the highlands as an effort in soil conservation activities is to add soil cementation so that the soil aggregate becomes strong and the soil structure becomes stable so that it is resistant to raindrops and the influence of heavy surface runoff during rainfall. Several types of cementation commonly used in soil are organic matter, protein and fat obtained from microorganisms. One example of cementation on soil that can be adopted is cementation on termite houses (Subekti, 2012).

Termite nests are made of mineral materials such as clay, clay, humus and termite saliva which function as adhesives to produce a hard and strong building. The salivary fluid in termite mounds is a mixture of secretions from the submaxillary, sublingual, parotid and cheek glands. Termite nest buildings are generally made of organic materials and soil. In addition, in the soil termites make tunnels (Lee *et al*., 2007). These activities result in better soil aeration, root and water penetration, and soil resistance to erosion. The cementation of the termite mounds is able to make the soil more stable and resistant to erosion so it is necessary to know and develop the contents of the termite mounds such that it can be mass produced and used for soil conservation activities in the highlands to prevent erosion.

Based on research (Subekti, 2012) termite nests are composed of clay particles carried by termites from the surrounding soil. The clay particles are then arranged into nests and glued together with their saliva or saliva. Termite houses have very strong strength so that they are resistant to rainwater blows so as to minimize erosion and destruction. The results of the analysis showed a high content of organic matter and protein in termite houses. Organic materials and proteins act as cementation materials in the construction or manufacture of termite houses. Therefore, in this study, tests will be carried out on the chemical content of the termite nests and the soil around the nests to determine the fractions contained and cementation materials, both organic matter and saliva from these termites, which are useful for soil cementation in conservation activities. After knowing the content of saliva or saliva can be used whether the content can be mass produced and in large quantities. The use of termite saliva or saliva as an adhesive or cementation agent in termite houses.

## 2. RESEARCH METHOD

### 2.1. Time and Location of Research

This research was carried out in April - November 2022 located in Bantul, Gunung Kidul, and Kulon Progo. Termite house sampling was carried out by random sampling in teak plantations in those three districts in order to have uniform samples. Sampling locations can be seen in Figure 1. The samples used were termite houses and soil samples around the termite houses were taken from the Bantul, Gunung Kidul, and Kulon Progo areas which were analyzed at the General Soil Laboratory, Soil Department, Faculty of Agriculture, Universitas Gadjah Mada (UGM), Yogyakarta.

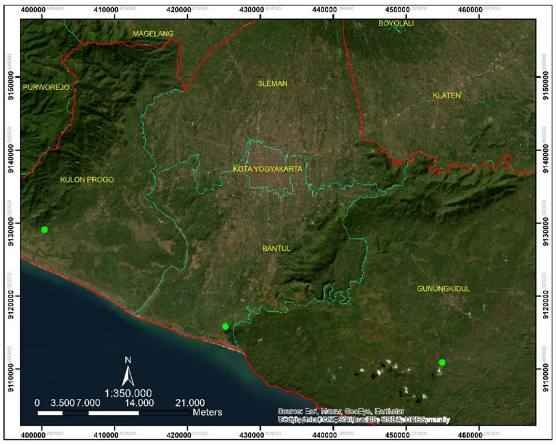


**Figure 1.** Locations for sampling of termite mounds were marked with green dots ( ● )

### 2.2. Tools and Materials

The tools used are hoes, shovels and stationery, sieves and laboratory equipment at the Soil Physics Laboratory, General Soil Laboratory and Soil Chemistry and Fertility Laboratory, Soil Department, Faculty of Agriculture, UGM. The materials used were soil samples around termite houses, termite house samples, and chemical materials for analysis of the chemical and physical properties of the soil and termite houses.

### 2.3. Sampling and Preparation

Sampling of soil and termite nest samples was carried out in 3 different areas to determine the characteristics formed. Samples in each district were taken as many as 3 points as a replication in teak plantations. Soil samples were taken around the termite house and termite house samples were taken randomly and then composited per area. Samples of soil and termite houses were prepared and sieved with a diameter of 2 mm which was used for laboratory analysis and protein and fat analysis.

### 2.4. Physical and Chemical Analysis

Analysis of the physical and chemical properties of the soil was carried out on the prepared samples. The parameters to be analyzed were pH ($H_2O$) and pH (KCl) by the electrometric method and read by a pH meter (Balittanah, 2005), C-Organic by the Walkley and Black method (Balittanah, 2009), N-total by the Kjedahl method

(Balittanah, 2009), KPK with ammonium acetate pH 7 (Balittanah, 2009), Moisture content using the gravimetric method (Balittanah, 2009), Soil texture using the pipetting method.

*2.4.1. Protein Analysis of Termite Nest*

Protein content was analyzed using the Weende method. Dry sample of 0.5 g was introduced into a 100 ml Kjeldahl flask and 0.5 g of selenium and 3 ml of concentrated $H_2SO_4$ were added. Then do the destruction (heating in a boiling state) for 1 hour until the solution is clear. After cooling, 50 ml of distilled water and 20 ml of 40% NaOH were added and then distilled. The distillation results were collected in an Erlenmeyer flask containing a mixture of 10 ml of 2% $H_3BO_3$ and 2 drops of the pink Bromine Cresol Green-Methyl Red indicator (pink color). The volume of the distillate became 10 ml and has a bluish green color, the distillation was terminated and the distillate was titrated with 0.1 N $H_2SO_4$ until it turns pink. The same treatment was also applied to blanks. The protein content was calculated using the following equation:

$$Protein\ content = \frac{(S-B) \times N \times 14}{W \times 1000}\ x\ 100\% \tag{1}$$

where *S* is the volume of titrant (ml), *B* is the volume of blank titrant (ml), *N* is the normality of $H_2SO_4$, and *W* is dry weight of sample (mg).

*2.4.2. Fat Analysis of Termite Nest*

Fat content was also analyzed using the Weende method. As much as 2 g of dry sample was spread on cotton which was lined with filter paper and was then rolled to form a thimble, then put it into a Soxhlet flask. Then extraction was carried out for 6 hours using a fat solvent in the form of hexane as much as 1150 ml. The extracted fat was then dried in an oven at 100 $^oC$ for one hour. Fat content was calculated according to the following equation:

$$Fat\ content = \frac{Weight\ of\ extracted\ fat}{Weight\ of\ dry\ sample}\ x\ 100\% \tag{2}$$

## 3. RESULTS AND DISCUSSION

### 3.1. Termite Nests

Termites in the soil play an important role in the circulation or cycle of nutrients derived from decaying plant material. Termite swarms are often found in protective structures known as termite house or termite nest. Termite mounds are generally made of mineral matrices mixed with the deposition of clay particles or plant material, C-organic, and feces or saliva, depending on the species and the formation of special habitats for soil microbes based on different physical and chemical properties (Ervany *et al*., 2019). There are three types of termite nests that are commonly found, namely mound nests (Figures 2a and 2b), cardboard nests (Figure 3), and nests that form underground. The type of nest built by termites is based on the feeding habits of the termite species. Termite nests at the study site are types of nests on the ground and termite nests in trees. There are two types of termite mounds with different structures. Termite mounds found at the study site were termite mounds in termite colonies without fungus (Vesala *et al*., 2019). Although climate is one of the factor influences on mound size, the type of soil in the nest environment is a stronger influence on the shape of the mounds produced by termites.

**Figure 2.** Mound nest of termites found in Kulon Progo (left), and Gunung Kidul (right)

**Figure 3.** Cardboard nests of termites found in in Bantul

### 3.2. Termite Genus

Based on the research that has been carried out, we found examples of termites dominated by the genera Microtermes and Globitermes (Figures 4). From morphological observations, the genus microtermes has characteristics such as a bright yellow body with a body length of a large soldier of 5.9 mm, head length with mandible 1.6 mm, antenna 15 segments, found in termite nests that were destroyed at the study site. Types of microtermes are small, between 2.75-4.75 mm, depending on the type of termite caste. The mandible is thin, the base is concave, the antennae are 15 segments, the species has a small size, soldier termites are smaller than worker termites (Kadarsah, 2005). Apart from the microtermes genus, the type of termite found at the study site is globitermes. This species has a white body, a round yellow head and has 13 antenna segments with a body length of 4.4 mm, mandibles are rounded and have marginal teeth in the middle. When these termites feel disturbed, they are able to secrete a milky white liquid from their mouths which is found in weathered wood and buried in the ground (Sornnuwat *et al*., 2004).

**Figure 4.** Termite genus: microtermes (left) and globitermes (right)

### 3.3. Characteristic of Termite Nest and Surrounding Soil

Table 1 summarizes the characteristic of termite nest and the surrounding soil in the three different locations, namely Gunung Kidul, Kulon Progo, and Bantul. Important properties are discussed in the following sections.

**Tabel 1.** Characteristic of termite nest and the surrounding soil

| Parameter | Unit | Gunung Kidul | | Kulon Progo | | Bantul | |
|---|---|---|---|---|---|---|---|
| | | Soil | Nest | Soil | Nest | Soil | Nest |
| pH | | 6,55±0,04 | 6,14±0,02 | 6,17±0,02 | 6,70±0,03 | 6,60±0,03 | 6,36±0,04 |
| KL | % | 9,43±0,03 | 28,57±0,07 | 10,43±0,05 | 16,90±0,05 | 14,47±0,02 | 18,13±0,07 |
| C org | % | 2,08±0,02 | 2,82±0,03 | 2,21±0,01 | 3,05±0,04 | 3,00±0,09 | 3,46±0,06 |
| N tot | % | 0,27±0,05 | 0,23±0,04 | 0,15±0,03 | 0,24±0,04 | 0,20±0,03 | 0,25±0,01 |
| P tot | % | 0,02±0,01 | 0,024±0,01 | 0,017±0,01 | 0,022±0,01 | 0,021±0,01 | 0,023±0,20 |
| K tot | % | 0,66±0,03 | 0,76±0,04 | 1,00±0,04 | 1,41±0,06 | 0,91±0,07 | 0,93±0,08 |
| OM | % | 3,56±0,04 | 4,86±0,03 | 3,81±0,06 | 5,26±0,08 | 5,18±0,05 | 5,97±0,02 |
| Protein | % | 0,10 | 0,17 | 0,12 | 0,19 | 0,10 | 0,15 |
| CEC | Cmol(+)/ kg | 18,38±0,03 | 16,46±0,04 | 32,69±0,04 | 37,88±0,70 | 28,85±0,10 | 33,55±0,03 |
| Texture | | | | | | | |
| Sand | % | 50,27 | 53,49 | 30,59 | 36,93 | 75,75 | 90,65 |
| Silt | % | 47,04 | 45,45 | 39,82 | 41,63 | 15,87 | 6,47 |
| Clay | % | 2,69 | 1,06 | 29,59 | 21,44 | 8,38 | 2,88 |
| | | Clay | Clay | Clayey Loam | Clayey Loam | Clay | Clay |

#### *3.3.1. Moisture Content*

The water content in each termite house and the soil around the termite nest has different results. In general, the moisture content in termite mounds is higher than in the soil around termite mounds. Moisture content in Gunung Kidul termite nests was 28.57%, Kulon Progo 16.90% and Bantul 18.13%. Meanwhile, the moisture content of the soil around termite nests ranged from 9.41% in Gunung Kidul, 10.43% in Kulon Progo and 14.47% in Bantul. Yáñez *et al*. (2004) stated that the high moisture content in termite nests is due to the cellulose content secreted by termites in the nest. The high cellulose content affects the absorption and storage capacity of water in termite houses which is higher than the moisture content in the soil around the nest. In addition, the high content of organic matter and clay can affect the moisture content in the nest to be higher than the soil around the nest.

*3.3.2. Soil pH*

The results of the analysis conducted on the pH of termite mounds and soil around the nests showed that the pH of termite mounds tended to be neutral, ranging from 6.14 in Gunung Kidul, 6.17 in Kulon Progo, to 6.36 in Bantul. While the pH of the soil around the nests was 6.55 in Gunung Kidul, 6.70 in Kulon Progo, and 6.60 in Bantul. Soil pH is influenced by the content of organic matter contained in termite nests which can neutralize the pH of termite nests compared to the soil around the nest without the role of termites in the decomposition process of organic matter. The results of the soil pH analysis that has been carried out, termite nests tend to have a lower soil pH value than the soil samples around the nests. This is because the biogenic products produced by termites will have a lower pH and generally the biogenic products produced by termites have a better fertility rate than the soil around the nest (Lestari *et al*., 2019).

*3.3.3. Organic Carbon (C)*

The results of the analysis of C-organic content in termite nests and soil around the nests varied. The organic matter content in termite nests is higher than that in the soil around termite nests. The organic matter content of termite nests in Gunung Kidul is 2.82%, Kulon Progo is 3.05% and Bantul is 3.46%. While the organic matter content in the soil of Gunung Kidul is 2.06%, Kulon Progo is 2.21% and Bantul is 3.00%. Based on research conducted by Mulyani *et al*. (2012), the C-organic content is included in the low category if <2%, the medium category is 2-3%, the high category is >3%. In general, the C-organic content of termite nests is in the high category, that is, the C-organic content is >3%. This is influenced by the accumulation carried out by termites and other nutrients into the soil or mounds of nests that have been made (Sintoso *et al*., 2021). The walls of termite nests have a higher C-organic content than the soil around the nest, this is due to the high C-organic content derived from feces and excretion of termite saliva as the main component in nest construction. The high C-organic content will be used as a source of food and energy for microbes resulting in an increase in nutrients in the soil (Jimènez & Decaëns, 2006).

*3.3.4. Total Nitrogen*

The results of nitrogen analysis that has been carried out on termite nests and soil around the nests show different values. The nitrogen content in termite nests in Gunung Kidul is 0.23%, Kulon Progo is 0.24%, and Bantul is 0.25%. The nitrogen content of the soil around the nests is 0.20% for Gunung Kidul, 0.15% for Kulon Progo and 0.20% for Bantul. In general, the nitrogen content in termite nests and soil around the nests is in the low category. Nitrogen has a role in plant vegetative growth, while nitrogen can be sourced from organic matter in the soil that has been decomposed by soil microbes which have a major role in improving the physical, chemical and biological properties of the soil (Sintoso *et al*., 2021).

*3.3.5. Cation Exchange Capacity*

The results of the analysis of cation exchange capacity (CEC) carried out on termite nests and the soil around the nests varied. The CEC values of termite nests were 16.46 Cmol(+)/kg in Gunung Kidul, 37.88 Cmol(+)/kg in Kulon Progo and 33.55 Cmol(+)/kg in Bantul. Cation exchange capacity values in the soil around the nests were 18.38 Cmol (+)/kg in Gunung Kidul, 32.69 Cmol(+)/kg in Kulon Progo, and 28.85 Cmol(+)/kg in Bantul. The values of CEC in the nest and in the soil is influenced by several factors such as the content of organic matter and the content of clay minerals in the soil. High clay mineral content can increase CEC compared to soils with low clay mineral content, especially 2:1 clay minerals and low organic matter content. The CEC value in the soil or in the nest affects the availability of nutrients in it. The nutrient content will be higher if a soil has a high CEC value (Sudaryono, 2009). The nutrients in termite nests are used by termites as energy and a source of nutrition when building nests. The high CEC in termite nests is influenced by the texture of the clay and the high organic matter content.

*3.3.6. Phosphor*

The content of P nutrients in termite nests and soil around the nests showed various results. The P content in termite nests was 0.024% in Gunung Kidul, 0.022% in Kulon Progo, and 0.023% in Bantul. The content of element P in the soil around the nest is 0.019% in Gunung Kidul, 0.017% in Kulon Progo and 0.021% in Bantul. The content of element P in termite nests is generally higher than the content of element P in the soil around the nest. Element P will be available in large quantities in neutral soil pH conditions. Under acidic pH conditions P will be bound by Fe and Al elements so that it is insoluble and not available to plants, whereas if the pH is alkaline it will bind to Ca and Mg elements to form compounds that are insoluble either and not available to plants (Sudaryono, 2009). According to (Buckman & Brady, 1982), the optimal pH for the availability of P in the soil is pH 6 to 7. Element P plays a role in plant root growth, stem cell division, and seed growth and ripening so that P is an essential element for plants.

*3.3.7. Potassium*

The results of elemental K (potassium) analysis in termite mounds and soil around termites showed varied results. The K content in termite nests is 0.76% in Gunung Kidul, 1.41% in Kulon Progo, and 0.93% in Bantul. Meanwhile, the K content of the soil around termite nests was 0.66% in Gunung Kidul, 1.00% in Kulon Progo, and 0.91% in Bantul. The element K in the soil plays an important role in the photosynthetic activities of plants, the formation of carbohydrates and proteins. Potassium is one of the essential nutrients besides N and P. The element K in termite nests is higher than the K content in the soil around the nest due to the decomposition of organic matter carried out by termites thereby increasing the potassium content in the termite nest. According to Lingga & Marsono (2003) the decomposition of organic matter from animal manure will increase the nutrient content in the soil, especially in termite nests.

*3.3.8. Texture*

Texture is the ratio of the proportions of the constituent fractions of the soil. Soil constituent fractions consist of sand, clay, and silt. Texture plays a role in plant growth, especially in the supply of water and the growth of plant roots. Textures with clay predominance will be higher in retaining water than sand-dominated textures. The dominance of clay will affect the ability to grow plant roots. Plant roots will not grow optimally if they grow on heavy textures. Based on the results of the analysis, the texture of the termite nest and the soil around the termite nest is clay. This is because generally termites will form nests of clay, sand, humus and glued together with termite saliva. The bonding of the forming material with saliva will produce a hard building (Subekti, 2012). Termites build nests by hoarding various modified soil minerals and clay content from the environment around the nest into the nest. Termites will transport fine soil particles such as clay and glue them together using saliva to form a biogenic structure resulting in a change in soil texture. The large size of the soil aggregate in termite nests indicates that the soil has the ability to bind water and pass water well, thereby helping to control surface runoff and erosion (Decaëns, 2001).

*3.3.9. Protein*

Protein is one of the substances contained in termite nests. Based on the results of the analysis that was carried out on termite nests and soil around termite nests, various results were obtained. The protein content in termite mounds is 0.17% in Gunung Kidul, 0.19% in Kulon Progo, and 0.15% in Bantul. The protein content in the soil around the nests was 0.10% in Gunung Kidul, 0.12% in Kulon Progo and 0.10% in Bantul. Substances such as protein as one contained in termite nests must be broken down into simple forms, namely monomeric sugars, amino acids, and fatty acids. The breakdown of carbohydrates begins in the oral cavity with the help of amylase enzymes contained in saliva and ends at the brush border of the intestinal mucosa (Contour-Ansel *et al*., 2000). The protein contained in termite nests is the amylase enzyme which has catalytic activity.

*3.3.10. Soil Conservation*

Soil conservation is an action to reduce the loss of soil particles by water or other agents. Soil conservation on agricultural land is important because intensive tillage activities destroy soil aggregates (Ishak, 2016). Soil particles that are easily carried away by water are clay particles. There are many methods that can be carried out for soil conservation activities, one of which is the chemical method by providing soil conditioners to glue and strengthen soil aggregates against rainwater blows and surface runoff so that they are resistant to erosion (Kertonegoro, 1981). As an example in a termite house, clay particles as a building block are cemented using organic materials and proteins derived from their saliva. Based on research by Corrêa *et al*. (2014) termite saliva will cause flocculation and cementation of the clay particles that make up the termite house, causing it to be hydrophobic and have cohesive properties. Organic matter containing protein can be used as a soil conditioner to stabilize and bind aggregates between soil particles so that they can be used in soil conservation activities, especially on agricultural land that has a clay texture.

## 4. CONCLUSION

The cementation materials obtained from the identification of termite nests in three districts were organic matter and protein content. In general, the parameters for moisture content, C-organic, organic matter, cation exchange capacity, potassium, phosphorus in termite mounds were higher than those in the soil around termite mounds. The type of soil used as nest-forming material is clay soil so that the small clay particles will be glued together with cementation materials such as organic matter, humus with termite saliva which contains protein. Cementation that can be carried out in agricultural land conservation activities is by adding organic matter and protein such as those contained in saliva or termite saliva. with the addition of these materials, the soil aggregate becomes stable, resistant to rainwater blows, and resistant to water flow and resistant to erosion.

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