Determination of Ammonium and Nitrate Ions on Degraded Peat Soil by Termites Activities in Tanjung Leban, Bengkalis Regency

Sofia Anita, Fransisca, and Tengku Ariful Amri

***Abstract*—Indonesia, especially Riau Province has struggled with forest fire since 1997 which causes degradation of peat soil. Nowadays, peat soil in the Bengkalis District, Riau Province, has been partially degraded by repeated fires and land clearing so that the fertility decline. Therefore, it is necessary to improve the fertility of peat land. The aim of this research was to study the effect of the presence of the termite nest to the ecosystem degraded peat lands in the village of Tanjung Leban, Bengkalis Regency. Parameters measured were the content of ammonium and nitrate ions in soil samples around the termite nests using Auto-analyzer. The results of analysis of 10 termite nests showed that the ion content of NH_4^+ (H_2O), NH_4^+ (KCl), and NO_3 (H_2O and KCl) found in soil samples S2, S8 and S10. Based on the results, it can be concluded that the termite nests found in this study site in general no significant impact on the increase of nitrogen in the soil using analysis of variance (ANOVA) and Duncan test at $\alpha = 0.05$.**

***Index Terms*—Ammonium, auto-analyzer, nitrate, peat, termites.**

I. Introduction

Peatlands have a low fertility rate because of the relatively high acidity with a pH range of 3-5, as well as poor nutrient content, both macro and micro [1]. The mineral content of peat in Indonesia is generally less than 5% and the rest is organic matter [2]. Based on fertility, peat is less favorable for agriculture. However, the limitations of mineral soils cause the peat soil used for agriculture and plantation. Today, peat is used for many agricultural commodities, such as palm tree. Soil is a natural body derived from a mixture of organic and inorganic materials weathering results so as to provide water, air and nutrients for plants [3]. There are several types of soil found in Indonesia, such as humus soil, volcanic, alluvial, and peat.

According to [2], Indonesia is a country that has the largest tropical peat swamp land in the world, which is about 20.6 million hectares [4]. The peat lands are mostly found in the lowlands along the east coast of the island of Sumatra, especially in Riau is a province with the largest peat lands, namely 4,360,740.2 hectares, spread in 12 districts. [1], Bengkalis, the second largest area of peat land, has about 803,891.1 acres of rubber, sago, and pineapples, so that increasing fertility is needed.

The use of fertilizers require an additional cost and may adversely affect the environment. The alternative is to burn plant litter and partially dried peat layer to produce ash that can improve soil productivity. However, it also had a negative impact because it can trigger a forest fire that eventually it will decrease soil fertility [2]. Using termites is a solution to increase environmentally friendly fertility without disrupting the continuity of the ecosystem. Termites are macrofauna soil that can survive in the acidic environment [5], such as peat. Habits of termites build nests with modifying organic material causes an increase in organic matter in the soil. The accumulation of organic matter will improve soil fertility in the nest location and surroundings. Termites affect the nitrogen cycle in the ecosystem for building the structure of biogenic-rich nutrients, especially inorganic nitrogen that can be used by plants [6].

Numerous studies have been done on termite nests, especially in areas of poor soil mineral nutrients. Research in Venezuela [7], Colombia [8], and Brazil [9] showed the content of NH_4^+ and NO_3 in termite nests. However, research on nitrogen content in termite nests on peat soil, which also nutrient-poor, has not been studied in Tanjung Leban, Bengkalis Regency, Riau Province. This land generally has suffered repeated fires, causing degradation. Therefore, this study was conducted to determine the effect of the termite nest to increase the nitrogen content in the area. Research is done in degraded peatland fires in 2002, 2004 and 2007 in the village of Tanjung Leban.

II. Experimental Method

The instruments were used in this study were digital scales (Hanke YF - MB BL - 01), oven, desiccator, cup aluminum, centrifuge (AS ONE HSIANGTAI), tube centrifuge plastic size 50 mL (IWAKI, Japan), 12 mL syringe, the filter paper (GF / F , 0.7 µm ; Whatman, UK), disposable syringe filter unit 0.45 µm (Cellulose acetate, ADVANTEC), filter holder (Polysulfone aseptic, ADVANTEC), automotive test & bleed kit (MODEL MV8000), Auto-analyzer (QuAAtro2-HR, BLTEC). Materials were a soil sample taken from degraded peatland in Tanjung Leban, Bengkalis Regency, KCl (p.a.), NH_4Cl, Na_2EDTA, NH_4OH, TX10, $C_6H_8N_2O_2S$, H_3PO_4 concentrated, $C_{12}H_{14}N_2.2HCl$, $KNaC_4H_4O_6.4H2O$, $(CH_2COONa)_2.H_2O$, H_2SO_4 concentrated, C_6H_5OH, NaOH,

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NaOCl, $Na_4[Fe(CN)_6NO_2]._{10}H_2O$,$CuSO_4$ $_5H_2O$, HCl, $(NH_4)_2SO_4$, $CHCl_3$, KNO_3, Milli-Q water.

This study was conducted in one of the degraded peatland (0°44'-1°11'N and 100°11'-102°10'E) in Tanjung Leban, Bengkalis Regency. The land chosen as the study site was originally a peat used as oil palm plantations. Those plantations have been burned three times, namely in 2002, 2004 and 2007, causing land degradation. Sampling technique used is purposive sampling. A termite nest on the transect observed, then immediately do the soil sampling. Then, soil samples around the termite nest is taken and put in a ziplock bag. Soil samples on the transect do not have a termite nest is also taken as control. Three replicates were taken or each termite nests and control. Soil solution samples to be analyzed must be removed from the freezer and thawed prior to analysis. The time required for the liquefaction process depends on the number and volume of samples, usually around 1.5 hours. After melting, the sample is poured into the cup auto - analyzer. Each cup be filled with 1N HCl then be inhaled by the probe. After that, the cup filled with Milli-Q water and sucked bac out. Each stage is repeated 2 times.

Ammonium ion analysis carried out by Berthelot reaction. The formation of complex compounds is accelerated by heating it in a heating bath set at 37 ℃. Further, the complex compounds formed indophenol blue flowed into photocolorimeter which has been set at a wavelength of 630 nm. Recorder is also regulated by the speed chart 5 cm/min. Analysis of nitrate ions, samples are drawn into the system unloaded speed of 0.32 mL/min to 0.1 mL/min. Reduction of nitrite ions results then flowed out the column and reacted with Sulfanilamide under acidic conditions to form a diazo compound. After that, the diazo compound binds to N-(1-naphthyl)- ethylenediamine dihydrochloride to form a reddish purple azo dyes. These complex compounds absorb color at a wavelength of 550 nm so that the filter colorimeter set at these wavelengths and the chart recorder speed 5mm/min. The content of nitrite ions were measured a combination of nitrate and nitrite ion content in the samples. Data were analysed using ANOVA.

III. Results and Discussion

Results of the sampling are presented in Table I. In transect of 100 m x 2 m made as sampling sites, found 10 nests of termites. It can be observed that the section of the transect can have more than one nest of termites, section 8 , 9 , and 10. In addition, there are three types of termites found ten nests, which *Schedorhinotermes sp.*, *Coptotermes sp.*, and *Parrhinotermes sp*.

The content of ammonium and nitrate ions are extracted with deionized water and 1.372 N KCl solution for each soil sample are presented in Table II. It shows that the highest content of ammonium ions are extracted with a ($NH4^+$ (H_2O)) were obtained from soil samples S2, ie 5.4275 ± 6.51 mg/kg. These results are in contrast to the content of ammonium ions extracted using a solution of KCl (NH_4^+(KCl)) for the same soil sample. The highest content of NH_4^+ ions (KCl) were from to 45.4467 ± 8.91 mg/kg, found in soil samples S8 (Table II and Fig. 1). Both the soil samples contain ammonium ions are significantly different at $\alpha = 0.05$ with the majority of other samples of ammonium ion content in each solvent extraction.

TABEL I: Location and Termites Types Found in the Peat Soil at Tanjung Leban

Nest Number	Code	Location	Termites Types
1	S_1	*Section* 2	*Schedorhinotermes* sp.
2	S_2	*Section* 6	*Coptotermes* sp.
3	S_3	*Section* 7	*Schedorhinotermes* sp.
4	S_4	*Section* 8	*Schedorhinotermes* sp.
5	S_5	*Section* 8	*Schedorhinotermes* sp.
6	S_6	*Section* 9	*Schedorhinotermes* sp.
7	S_7	*Section* 9	*Schedorhinotermes* sp.
8	S_8	*Section* 10	*Schedorhinotermes* sp.
9	S_9	*Section* 10	*Schedorhinotermes* sp.
10	S_{10}	*Section* 16	*Parrhinotermes* sp.

TABLE II: Ammonium and Nitrate Ions (Mean ± Standard Deviation, n=3) and Its Control

Code	Water content (%)	NH_4^+ (mg/kg)	
		H_2O	KCl
S_1	27,43	0,6504 ± 0,09^{b}	6,4824 ± 3,52^{bc}
S_2	29,20	**5,4275 ± 6,51^{a}**	24,8023 ± 17,47^{l}
S_3	31,33	0,5359 ± 0,09^{b}	5,9534 ± 1,79^{bc}
S_4	41,30	3,2391 ± 1,08^{ab}	19,6570 ± 6,82^{bc}
S_5	41,30	0,8949 ± 0,28^{b}	8,1863 ± 10,74^{l}
S_6	33,17	0,8219 ± 0,53^{b}	4,7960 ± 1,82^{c}
S_7	33,17	0,6464 ± 0,13^{b}	4,4169 ± 2,39^{c}
S_8	28,87	0,6223 ± 0,13^{b}	**45,4467 ± 8,91^{a}**
S_9	28,87	0,4460 ± 0,22^{b}	12,5622 ± 16,47^{l}
S_{10}	27,07	0,6764 ± 0,05^{b}	15,8609 ± 6,34^{bc}
K_1	18,94	0,7150 ± 0,46^{b}	13,0160 ± 14,44^{l}
K_2	20,68	-	-

Code	NO_3^- (mg/kg)	
	H_2O	KCl
S_1	0,0367 ± 0,06^{c}	0,3271 ± 0,37^{d}
S_2	2,9379 ± 2,25^{bc}	5,5819 ± 1,80^{bc}
S_3	0,0543 ± 0,05^{c}	0,4272 ± 0,43^{d}
S_4	6,4963 ± 1,91^{ab}	8,2180 ± 0,35^{ab}
S_5	0,0000 ± 0,00^{c}	0,1545 ± 0,14^{d}
S_6	0,0080 ± 0,01^{c}	0,4828 ± 0,43^{d}
S_7	1,9431 ± 2,54^{c}	5,3626 ± 0,78^{bc}
S_8	0,8885 ± 1,46^{c}	1,0234 ± 0,79^{d}
S_9	1,2146 ± 1,03^{c}	3,3289 ± 2,52^{cd}
S_{10}	**9,2101 ± 1,99^{a}**	**11,8902 ± 2,56^{a}**
K_1	-	-
K_2	3,6173 ± 4,34^{bc}	6,6519 ± 5,13^{bc}

K_1 = mean of control NH_4^+ ion
K_2 = mean of control NO_3^- ion

The content of nitrate ions which extracted with deionized water ($NO_3(H_2O)$) showed that the highest values in 1soil samples S10, namely 9.2101 ±1.99 mg/kg (Table II and Fig. 1). Meanwhile, in soil samples S5 was not measured any ions NO_3 (H_2O). Soil samples S10 not only show the highest nitrate ion content in the extract deionized water, but also on the extract solution of KCl, which ranged from 11.8902 ± 2.56 mg/kg (Table II and Fig 2. Based on Duncan test, nitrate ions content in soil samples S10, whether extracted with deionized water or KCl solution, differs significantly ($\alpha = 0.0$) with most of the nitrate ion content of more soil samples.

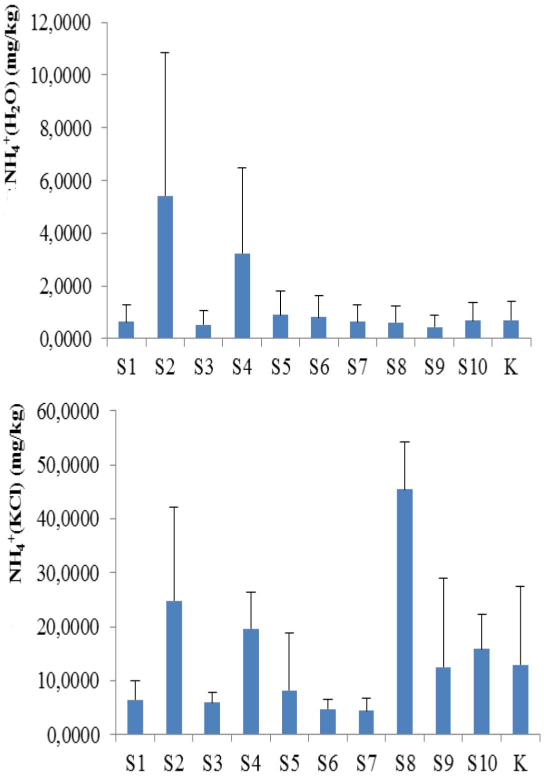

Fig. 1. The mean of NH4+(KCl) (left) and NH4+(KCl) (right) concentrations (n=3) on termites nest and its control.

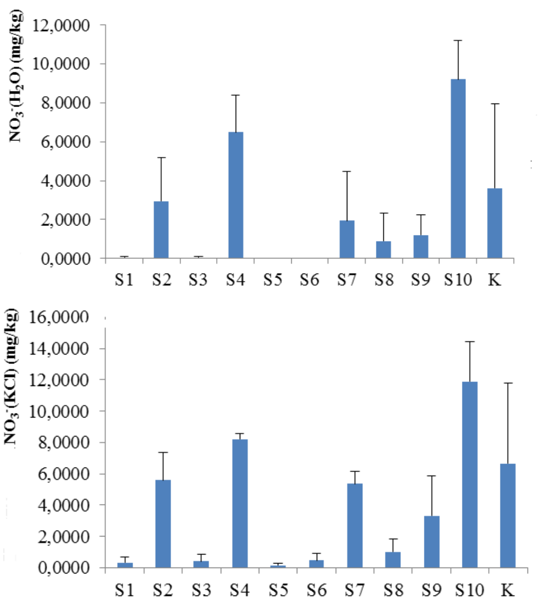

Fig. 2. The mean of NO3-(H2O) (left) and NO3- (KCl) (right) concentrations (n=3) on termites nest and its control.

The content of ammonium ions contained in soil samples around the termite nests are found on the whole did not differ from controls. Based on Duncan test, only the content of ion NH_4^+ (H_2O) in soil samples S2 (5.4275 ±6.51 mg/kg), which has significant differences to the control at $\alpha = 0.05$. Similar results were also shown by the content of NH_4^+ ions (KCl). Soil samples S8 is the only one that showed significant differences to the control. Each soil sample analyzed contains NH_4^+ (H_2O) ion (KCl) which is much higher than the NH_4^+ (H_2O)). This is because the positively charged ammonium ions which are generally tied strongly with negatively charged soil colloids [10] so, deionized water can not be extracted. However, the content of ions NH_4^+ (H_2O)) measured shows that most of the ammonium ion is in a free state in the country even though its concentration is low. In contrast, KCl solution has a potassium ion is also positively charged so as to extract the ammonium ions are bound in the soil through cation exchange reaction. The reason of choosing KCl as a solvent extractor is because potassium and ammonium ion size almost the same so that the cation exchange will be more apt to occur [11].

The content of nitrate ions derived from most soil samples around the nests of termites also showed no significant difference against the control. S10 soil samples containing ions NO_3 (H_2O) and NO_3 (KCl) each by 9.2101±1.99 mg/kg and 11.8902 ± 2.56 mg/kg did not differ significantly (α=0,05) with the control. Meanwhile, the nitrate ion content in all the other soil samples did not have significant differences with the control. The pattern of nitrate ion content of each sample was ground together with the ammonium ion content, the content of ions NO_3 (H2O) is lower than the ion NO_3 (KCl). The results obtained are not consistent with the fact that the nitrate ion which is usually in the form of free land should be extracted only by using deionized water. This is likely due to time shaking long enough so that not all of nitrate ions in soil samples that were extracted out. Meanwhile, the positively charged potassium ions in KCl solution will also facilitate the extraction process due to an ionic bond with the nitrate ions are negatively charged. Nevertheless, almost all soil samples, except S7 and S10, has a nitrate ion content lower than the ammonium ion, which indicates that ammonification and denitrification is higher than the nitrification in the soil [7].

Results obtained in this study are generally lower than studies in the area of mineral soil. [12] in the Colombian jungle show that the ion content of NH_4^+ and NO_3 in the soil within 20 cm from the edge of the mound *Nasutitermes sp*. row is about 45g/g and 40 mg/g. Meanwhile, research on termite nests *Nasutitermes ephratae* in Sabana Venezuela by [7] concluded that the soil around the nest of termites have NH_4^+ ion content of 29.5 g/g. Based on this data, only soil samples S8 which contains NH_4^+ ion equivalent or higher than the research [7] and [12]. The low content of ammonium and nitrate ions are measured in this study may be due to the limited termite species that can live in conditions of acid soils. Termites are found at the study site consists of *Schedorhinotermes sp.*, *Coptotermes sp.*, and *Parrhinotermes sp*. The types of termites belong to the wood-eating group that also make nests in wood, vary with the type of termites in other studies that make mounds. Nesting inside the timber causes nutrients accumulate in the nest difficult to move into the surrounding soil. Therefore, the types of termites were less contribute to the increased content of ammonium and nitrate ions into the ground.

Termites are decomposing organisms that contribute significantly to the nutrient cycle in tropical ecosystems [9]. In the mineral soil, termites make a tunnel that will increase groundwater recharge [6] decomposing plant litter, and build mounds through translocation will enrich soil nutrients [13]. Research conducted by [12] against *Nasutitermes sp*. revealed that termite mounds can act as a source of nitrogen for plants runoff in the savanna ecosystems that poor nutrition. The content of ammonium and nitrate ions obtained in this study are generally quite low. According [14], nitrate ion content in the range of 0.0000 to 11.89 mg/kg were in the criteria is very low (<5 ppm) to low (5-15 ppm). In addition, the content of ammonium and nitrate ions are measured as a whole did not differ from controls so that the role of termites to increase the nitrogen content in degraded peat soil at the site of research yet to be seen.

Set of termite found in this study site only from Rhinotermitidae family consisting of three genera, namely *Schedorhinotermes*, *Coptotermes*, and *Parrhinotermes.* All types of termite found a diet of wood and termites nesting in the wood are thus the pest termites that actually have a negative impact on the environment. The low abundance of species of termites in the study site can be caused by disturbances during the clearing process or multiple fires that caused the death of another termite species that are susceptible to interference. Disturbance on degraded peat lands may have reduced termite functional groups, such as *Macrotermes* and *Nasutitermes*, which is important in improving soil nutrient. Peat soil is acidic limiting organisms that can live there. Earthworms as one of the decomposing organisms that have the same role with the termites are very sensitive to acidic pH conditions, anaerobic, and other disorders [15] so it is hardly found in degraded peat lands. Meanwhile, ground-eating termite studies in Sabana Colombia revealed that the group is more important termites in the improvement of soil nutrients than ants [8]. Therefore, termites seen as decomposing organisms that can be used efficiently in the peat soil. However, it is necessary to take measures to increase the abundance of species of termites are functional and reduce termite pest so that the role of termites on soil fertility can be improved.

IV. Conclusion

Termite nests were found at the study site in general no significant impact on the increase of nitrogen in the soil around by analysis of variance (ANOVA) and Duncan test using SPSS at $\alpha = 0.05$.

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