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RESEARCH ARTICLE

THE CHANGE OF NUTRIENTS IN TIDAL SWAMP SOIL AND PALM OIL PLANT DUE TO SEVERAL DOSAGES APPLICATION OF PALM OIL MILL EFFLUENT ON PLANTING MEDIA

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ABSTRACT

The change of several soil nutrients in tidal swamp area due to addition of palm oil mill effluent (POME) on soil media. The research objective was to determine the effect of different dosages application of palm oil mill effluent on nutrient changes within planting media. This experiment was conducted in a plastic house by using 8 month ages of plants consisting of 9 pots combined with 6 levels of BOD treatment (*Biological Oxygen Demand*) concentrations as follows: 20.000 mg/l (L_5), 15.000 mg/l (L_4), 10.000 mg/l(L_3), 5.000 mg/l (L_2), 2.500 mg/l (L_1) and water only (L_o). The plants were grown for six months from December 2014 to June 2015. The variables observed were pH (H_2O), pH KCl, C-Organic, N-Total, P-Bray I (ppm), K- dd, Na, Ca, Mg, Cation Exchange Capacity, Al-dd and H-dd as well as N, P and K nutrients of crop tissues. The results showed that addition of palm oil mill effluent increased soil pH and availability of soil N, P, K, Ca and Mg. Meanwhile nutrients content of N, P and K in tissues were not increased significantly by given POME with BOD up to 20.000 mg/l.

Keywords: Palm oil mill, effluent (POME), soil nutrients, tidal swamp, and BOD

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INTRODUCTION

Dry land utilization as a plantation area is becoming limited due to exploitation of the existing land for several activities such as seasonal crops cultivation, development of new paddy field area, settlement area, husbandry and mining activities. Furthermore, population number is steadily increasing causing the need for plantation land by company is directed toward the lowland swamps and tidal lowland areas. The utilization of lowland swamp and tidal lowland require relatively high investment especially in term of water management. In this regards the use of lowland as plantation area has a beneficial effect for social aspect of community primairly avoiding the land ownerships conflict.

Lowland area used as a plantation area, especially for palm oil plantation, have advantage such as water availability for whole year, thus growth and production of oil palm plants have no stagnant condition such as occurred on dry land. The main constraints of tidal swamps were flooding, pyrite and fire hazards during dry season especially on peat soil (Widjaja-Adi *et al.*, 1992). According to Eelart (2004), key success for tidal lowland management was water table control at macro, meso and micro levels within cultivation crop. The controlled water table can maintain water availability during wet season without flooding condition and no dryness during dry season so that fire hazards can also be controlled.

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Water resources derived from tidal lowland and swamp lowland are originated from rainfall and tidal sea water. Tidal lowland area is suitable for oil palm plantation cause of water availability. Other fact showed that during construction stage for preparation of planting of oil palm plant, there were plant blocks and drainage channels development activities in order to achieve aerobe condition within soil which help plants growth within rooting zone of about 40 cm (Russel, 1977).

Generally soil of tidal lowland have characteristics which are acidic condition, low nutrients content of phosphate, nitrogen, potassium, calcium and magnesium as well as high content of organic matter especially in peat condition. According to Khalid *et al.,* (1999), availability of nutrients and water have linear correlation with growth and production of oil palm. Nutrients will be affecting root distribution of plants which concentrated at 30 cm above soil layer and it will decrease beyond the depth. Water requirement for oil palm plants can be fulfilled by rainfall and tidal sea water as well as water addition from palm oil mill effluent or known as land application. The advantage of palm oil mill effluent is supporting the some nutrients required by plants.

The palm oil mill effluent contains nutrients required by plant with composition as follows : water 95 %, oil 1.0 %, TSS 2.0 % and TDS 2.0 % (Igwe *et al.,* 2007). According to PPKS (1996), palm oil mill effluent containeds several nutrients which were 500 mg/l N, 90 ml/l P, 400 mg/l K and 2,000 mg/l Ca. Hidayat *et al.,* (2007) showed that addition of palm oil mill effluent had effected on plant growth for seedling media with plant age of 6 to 10 months.

The objective of this research was to determine the effect of different doses application of palm oil mill effluent to support the nutrients change on lowland soil as soil media for plant and Nitrogen, Phosphate, and Potassium of plant.

MATERIALS AND METHODS

Materials used in this study were palm oil mill (POME) effluent originated from anaerobe pond 1, soil media from tidal lowland area taken from Gasing, Banyuasin District, oil palm plants with 8 months of age. The other material is chemical ingredients for laboratory analysis. This study was conducted from period of December 2014 up to June 2015.

Sampling for palm oil mill effluent was done by using purposive sampling from anaerobe pond. The depth of waste treatment installation pond (anaerobe pond) was 4 m, water sampling was taken from one third of pond depth and on pond base which was subsequently mixed or composited as samples. Sampling of liquid waste was done by using water sampler, followed by placing the sample into glass bottles which was subsequently put into sample box added with ice as the cooling agent.

Analysis of palm oil mill effluent was conducted at Industrial Council Laboratory in Palembang. Acidity (pH) was done by direct measurement in the field, whereas analyses of BOD_5, COD, N, P, K, Ca, Mg as well as oil and lipid were done in laboratory of Soil Science Department, Faculty og Agriculture, Sriwijaya University.

Working Procedures: 1). Preparation of oil palm plants having age of 8 months. (2). Preparation of soil media from tidal lowland area of Gasing, Banyuasin District. 3). Soil media was air dried, ground and sieved using 2 mm sieving device. 4).The sieved soil media was poured by water in order to determine the water content at field capacity. 5). Preparation of plant media from tidal lowland soil and placed this media into pot having no hole that function as the *weighing lysimeter*.

6). Soil used as media and pot were weighed with magnitude of 30 kilograms at field capacity condition. 7). Treatments application of water and palm oil mill effluent were conducted by using different concentrations of BOD (*Biological Oxygen Demand*) which consisted of 20.000 mg/l (L_5), 15.000 mg/l (L_4), 10.000 mg/l(L_3), 5.000 mg/l (L_2), 2.500 mg/l (L_1) and without palm oil mill effluent or water (L_0). The weighing was done for every 3 days by maintaining soil weight at field capacity condition. Different concentrations were achieved by diluting of BOD taken from anaerobe pond having concentration of 20.000 mg/l. 8). Soil samples were collected at the end of experiment period (six months after treatments application). 9). Composite samplings were conducted amongst similar treatments (three replications for each treatment). 10). Soil samples before and after treatments were analyzed at Laboratory of Soil Department, Faculty of Agriculture, Sriwijaya University. This research was conducted within plastic house from December 2014 to June 2015. Treatment combinations were consisted of 9 pots of oil palm plants with 6 waste concentrations yielding total of 54 pots.

The observed variables of soil were soil pH (potentiometric method, C-organic (Wakley and Black method), cation exchange capacity (NH4OAc pH 7 method), and Nitrogen (Kjeldahl method), P (Bray-1 method), K, Mg, Fe, and Al (NH4 OAC, pH 7.0 method). Plant samples were taken from the 4th midrib from upper part and 7th leaves which were subsequently composited for each replication and followed by Nitrogen, Phosphate, and Potassium analyses in laboratory.

Data processing were done by using tables and graphs in relation to increase or decrease of nutrients which was compared to nutrients sufficient status based on CSR (Centre For Soil and Agroclimate Research, 1994) without any statistical analysis.

RESULTS AND DISCUSSIONS

Soils taken used as a planting media in pot experiments were originated from tidal lowland area which were dominated by growth of grasses and ferns. Analysis results showed that soil pH was very acidic with pH of 3.38, very high C-organic content with value of 3.70 %, low total-nitrogen 0.18 % and very low phosphate of 8.70 ppm. Cationic bases elements were low to medium, medium K-exch content of 0.32 me/100g, low Na content of 0.22 me/100g, very low Ca content of 0.28 me/100g and very low Mg content of 0.05 me/100g, whereas cation exchange capacity was classified as high with value of 26.10 me/100g (Table 2 and Table 3). Soils at tidal lowland area of Gasing had been reclaimed for ten years ago with provision of drainage channel into Rengit river. Drainage channels and embankments had been built currently in this land which make high tidal water can not enter into this land anymore. High level of C-organic content was the results of organic matters pile up and delayed decomposition process due to anaerobe condition. The concentration of other nutrients was also low due to acidic soil reaction so that pH dependent nutrients were in unavailable condition or fixed in clay soil minerals.

Soils from tidal lowland taken at depth of 0 cm - 40 cm layers had not received nutrients enrichment causing the fertility was low. Palm oil mill effluent used in this study was originated from anaerobe pond 1 with high pH value of 7.03 (Table 1). This condition was occurred because it had been delivered through cooling pond and acidifying pond. The addition of lime and NaOH were done in acidifying pond resulting in the pH of palm oil mill effluent increased.

Table 1. Characteristics of Palm Oil Mill Effluent Used in this experiment

No.	Variable	Values
1	pH	7.3
2	BOD-5 (mg/l)	24,820.20
3	COD (mg/l)	54,258.80
4	Oil and Lipid (mg/l)	635,090
5	Nitrogen (mg/l)	650.2
6	Phosphate (mg/l)	25.2
7	Natrium (mg/l)	295.1
8	Magnesium (mg/l)	67.9
9	Calcium (Ca) (mg/l)	1.7

Source: Bakri *et al*., (2015)

Treatment without palm oil mill effluent showed the increase of pH and nutrients of C-organic, N-total and phosphate (Table 2 and Figure 1). High increment was occurred in phosphate nutrient from very low concentration up to very high concentration with increment of 79.45 ppm. The addition of phosphate nutrient from supply of palm oil mill effluent was able to decrease the requirement of phosphate nutrient from inorganic fertilizer.

The addition of palm oil mill effluent at concentrations of 2.500 mg/l (L_1) and 5.000 mg/l (L_2) showed the occurrence of nutrients concentration increment, especially for nitrogen and phosphate. This nutrients concentration increment was due to nutrients accumulation from palm oil mill effluent.

The characteristics of palm oil mill effluent derived from anaerobe pond 1 showed that this effluent was neutral pH and having macro nutrients required by crops such as Nitrogen, Phosphate, Potassium, Magnesium and Calcium. If these macro nutrients together with water were given to plants, they had three functions consisting of water availability maintenance, addition of soil nutrients which reduce inorganic fertilizer usage as well as waters environment protection because this palm oil mill effluent was not directly discharged into environment as waste or it has environmental friendly characteristics. According to Igwe *et al.* (2007), effluent compositions from Crude Palm Oil processing are consisted of 95 percent of water, 1.0 percent of oil, Total Soluble Solid (TSS) of 2.0 percent and Total Dissolved Solid (TDS) of 2.0 percent, respectively. Minardi *et al.*, (2014), the treatment of balance between organic and inorganic fertilizer (75 : 25)%, it is significantly different than inorganic fertilizer.

Soil acidity showed that soil after POME treatment increasing soil pH 3.38 unit with value more than 4.0. The pH increment was related to addition of palm oil mill effluent which had pH of 7.30 resulting in pH value of media was increased. The value of C-organic in soil at initial condition was 3.70 and it was increased due nutrients addition from application of palm oil mill effluent.

Table 2. Average Values of Soil pH, C-organic, N – total and P-Brey 1 before and after application of palm oil mill effluent.

Treatment	pH H_2O	C-Organic (%)	N-total (%)	P-Brey 1 (ppm)
Before treatment	3.38 sm	3.70 st	0.18 sr	8.70 sr
L_0 (water/control)	3.81 sm	3.71 st	0.19 sr	88.45 st
L_1 (BOD 2.500 mg/l)	4.07 sm	3.74 st	0.21 s	92.70 st
L_2 (BOD 5.000 mg/l)	4.21 sm	3.74 st	0.22 s	95.60 st
L_3 (BOD 10.000 mg/l)	4.17 sm	3.76 st	0.27 s	99.15 st
L_4 (BOD 15.000 mg/l)	4.43 sm	3.76 st	0.26 s	99.40 st
L_5 (BOD 20.000 mg/l)	4.98 m	3.79 st	0.26 s	91.73 st

Remarks: Djainudin *et al*., (1994).; sm: very acid; r: low; m: acid t: high; sr : very low st: very high

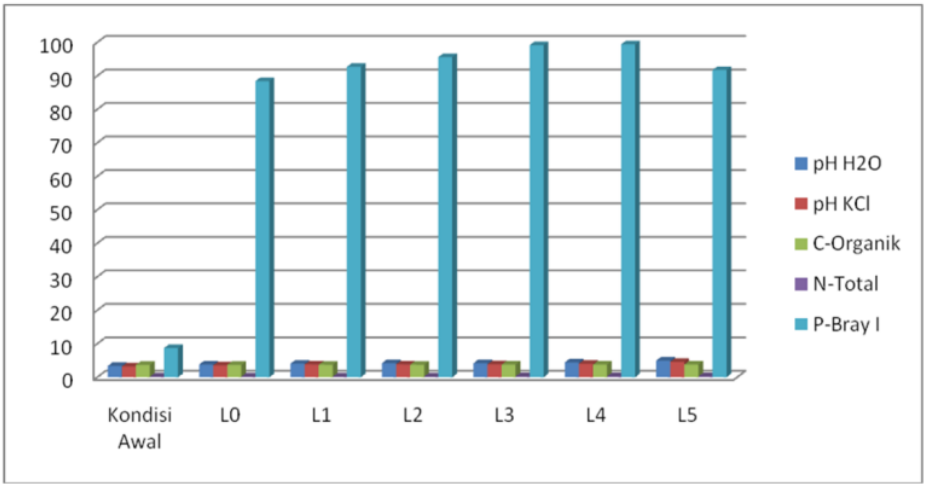

Figure 1. The change of soil pH, C-organic, N – total and P-Brey 1 before and after applications of palm oil mill effluent.

High increasing of soil nutrients was occurred in soil media, i.e. Nitrogen and Phosphate, which showed that addition of palm oil mill effluent was able to increase soil nutrients. These results were alsmot similar with study results by Syamshudin *et al.,* (1992) and Yunindanova *et al.,* (2013), which stated that addition of palm oil mill effluent was able to increase soil pH from 4.3 into 5.0. If palm oil mill effluent and rock phosphate applied together were able to increase Ca and Mg nutrients and other nutrients becaming available.

The mean values of K-exch and Na before and after treatment applications were very high, whereas Ca nutrient was changed from very low status to low due to nutrient supply from palm oil mill effluent (Table 2 and Figure 2).

Nutrients content of Ca and Mg were classified low, whereas cation exchange capacity of soil was high before treatment. The increase of Ca nutrient was started to occur at BOD treatment of 5.000 mg/l (L_2), whereas increment of Mg nutrient was occurred at BOD treatment of 15.000 mg/l (L_4) and 20.000 mg/l

Table 3. Average Values of K-dd, Na, Ca, Mg, CEC, Al-dd and H-dd before and after application of palm oil mill effluent.

Treatment	K-exch	Na	Ca	Mg	CEC
			cmol (+) kg^{-1}		
Before treatment	0.32 s	0.22 r	0.28 sr	0.05 sr	26.10 t
L_0 (water/control)	6.21 st	3.71 st	0.81 sr	0.24 sr	21.03 s*
L_1 (BOD 2.500 mg/l)	9.53 st	9.62 st	1.,70 sr	0.25 sr	27.55 t
L_2 (BOD 5.000 mg/l)	9.04 st	6.83 st	2.10 r	0.37 sr	24.65 s
L_3 (BOD 10.000 mg/l)	11.24 st	9.69 st	2.54 r	0.37 sr	33.35 t
L_4 (BOD 15.000 mg/l)	15.26 st	7.98 st	2.76 r	0.58 r	30.45 t
L_5 (BOD 20.000 mg/l)	19.15 st	9.84 st	3.55 r	0.64 r	36.25 t

Remarks: Djainudin *et al.*(1994); sm: very acid; r: low; m: acid; t: high; sr : very low; st: very high

*. Decrease occurrence

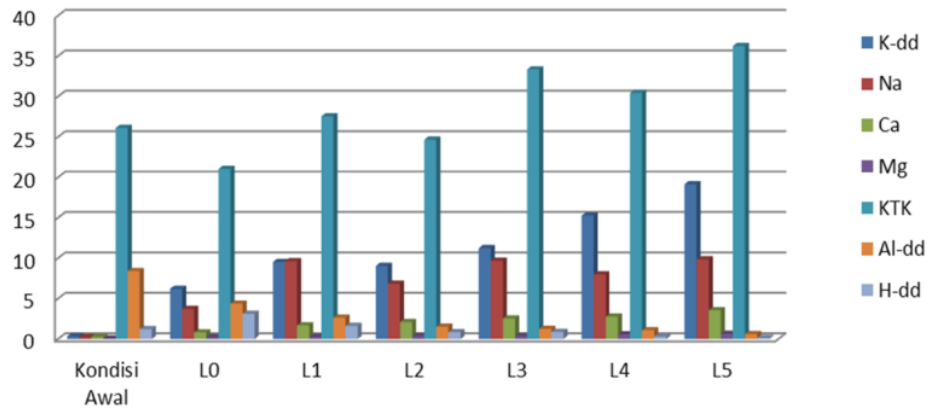

Figure 2. The change of soil K-dd, Na, Ca, Mg, CEC and Al-dd before and after applications of palm oil mill effluent.

(L_5). Cation exchange capacity of soil was increased except for control treatment although at the same status of soil fertility (Table 2 and Figure 2). These comparable results were found by Okwute *et al.* (2007) which stated that addition of palm oil mill effluent had significant effect on soil pH, water holding capacity, C-organic, N total, Potassium, Magnesium and Calcium. In addition, Chuan *et al.* (2011) showed that pH, C-organic, N, P and K were increased on agro-ecosystem of oil palm plantation with balance fertilization.

Nutrients content on leaves showed that the highest Nitrogen nutrient was found in BOD concentration treatment of 5.000 mg/l (L_2), the highest Phosphate nutrient was obtained in BOD concentration treatment of 2.500 mg/l (L_1), whereas the highest Potassium nutrient was reached in BOD concentration treatment of 20.000 mg/l (L_5). Results of study showed that increase in treatment levels was not followed by nutrients increment in leaves (Table 4) because treatments in this study had short period of six months.

Results of this study were merely similar with results by Banua and Pulung (2008) which showed that application of palm oil mill effluent on soil had no effect on nutrients content of Nitrogen, Phosphate and Potassium within plant tissues. Results of study by Budianta *et al.* (2010) showed that the use of organic matter as mulch from empty fresh bunches of oil palm had effect on soil pH, Mg and N, but had no effect on P, K, C-Organic, CEC, Al and Fe.

Table 4. Average Values of Nitrogen, Phosphate and Potassium (K) in leaves

Treatment	N (%)	P (%)	K (%)
L_0 (water/control)	2.16	0.29	0.88
L_1 (BOD 2.500 mg/l)	2.24	0.31 *	0.88
L_2 (BOD 5.000 mg/l)	2.29 *	0.26	0.96
L_3 (BOD 10.000 mg/l)	2.24	0.24	0.79
L_4 (BOD 15.000 mg/l)	2.19	0.23	0.96
L_5 (BOD 20.000 mg/l)	2.16	0.14	1.00**

Remarks: * the highest value

CONCLUSIONS

Based on the research results, it can be concluded that application of palm oil mill effluent can increase soil pH as well as availability of N, P, K, Ca and Mg nutrients within soil. Unfortunately the N, P and K nutrients content in plant tissue did not showed increase until the given dose level was equal to BOD 20.000 mg/l.

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