IOSR Journal of Agriculture and Veterinary Science (IOSR-JAVS)
e-ISSN: 2319-2380, p-ISSN: 2319-2372. Volume 13, Issue 7 Ser. II (July 2020), PP 29-32
www.iosrjournals.org

Long-term POME Application Effect on Soil Acidity and Stability in Oil Palm Plantations

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Abstract: *The development of oil palm plantations has resulted in the increasing of palm oil mills that produce CPO as its main products as well as solid waste and liquid waste (POME). Liquid waste contains floating solids that have the potential to become pollutants. One of its alternative-utilization is land application from primary anaerobic ponds with BOD 3500-5000 mg/l. The land application starts at ± 4 years old, continuously until plants are ± 25 years old. This study aims to obtain data on the effect of long-term POME application on soil acidity and stability (compaction or dispersion). The data reported is the result of laboratory analysis in the 9th and 16th years. The results showed that the application of POME had the potential to reduce soil pH and there was no potential for damage to soil stability due to dispersion by Na^{+} elements or cementation by Ca^{++} elements.*

Keywords*: Palm oil, Palm Oil Mill Effluent (POME), Suspension, BOD. Dispersion, Cementation*

Date of Submission: 13-06-2020 Date of Acceptance: 28-07-2020

I. Introduction

The development of oil palm plantations in Indonesia contributes to employment, improving the lives of the regional economy, fulfilling domestic cooking oil needs and non-oil and gas exports. The total area of Indonesian oil palm plantations [1] is ± 11.6 million ha with CPO production of ± 40 million tons. With the increase in area, resulting in an increase in processing units, that is palm oil mills. According to Singh [2], each processing of 1 ton of FFB in the Palm Oil Mill produces the main products that are 200-220 kg Crude Palm Oil (CPO), 60 kg of palm kernel and waste consisting of ± 230 kg of oil palm empty fruit bunches (OPEFB), 30 kg of mesocarp fiber, 30 kg in kernel cake, and ± 1.5 m3 (670 kg) palm oil mill effluent (POME).

POME is an accumulation of residual diluted water, golden-yellow color, containing oil, protein and other impurities. Fresh POME has a very high BOD (Biological Oxygen Demand) value, which is 25,000-60,000 ppm which has the potential as a pollutant [3].

Oil Palm Mill processing capacity is generally at 60 tons of FFB/hour, the continuous accumulation of POME is a problem because it requires a WWTP (Wastewater Treatment Plant) within a large area, expensive cost and a long time (retention) between 90-120 days. Based on these problems, alternative waste management oriented to 1E, 4R (Eliminated, Reduce, Reuse, Replace, Recycling) is done by shortening the processing retention time of the POME that is for land applications.

The POME used for land applications originated from a primary anaerobic pond with a retention time of 40 days, the BOD has dropped to 3500-5000 mg/l [4]. POME is generally applied continuously in the phase of mature plants from 3 years to 25 years. The impact of long-term application is important to consider in sustainable management. This study aims to determine the impact of long-term POME application on the value of soil acidity and soil stability in oil palm plantations.

II. Material And Methods

This research was conducted at Bukit Maradja Estate, PT. SIPEF Sumatera Utara Province, Indonesia. The sample observation was conducted in July 2010 (the 9th year after POME application) and July 2017 (the 16th year after application) by collecting soil samples in the depth 0-20 cm, 21-40 cm, 41-60 cm, 61-80cm and analysis the samples in PT. Asian Agri Laboratory, Tebing Tinggi, Indonesia.

Reasearch Design: The research design used a descriptive design, describing observational parameters in sample blocks, comparison with laboratory standards and index numbers:

- Block 97, 16 A ± 18 ha with (+) POME application treatment, and
- Block 97, 27 A ± 21 ha without (-) POME application treatment.

The research blocks are separated by the harventing road (block road).

Research Location: The sample/research block is located in the division I of Bukit Maradja Estate (PT Eastern Sumatra Indonesia SIPEF group) located in Simalungun Regency, Sumatera Utara at the coordinates ... and ...

.The type of soil is *Typic Dystropept* (Inseptisol ordo) flat topography with a texture of sandy clay soil, soil structure with angular blocky with the average rainfall of 1700-2100 mm/year.

Study Duration: The sample observation was conducted in July 2010 (the 9th year after POME application) and July 2017 (the 16th year after application) for collecting samples and laboratory analysis.

Sample size: 5 samples for each layer (0-20 cm; 21-40 cm; 41-60 cm; 61-80 cm).

Subjects & selection method: The type of oil palm plant is the Dura x Pisifera Costa Rica, planted in 1997 with an equilateral triangular planting system of 130 trees/ha. The POME application began in 2001 until the plants were 4 years old. Observations were made at a time lag of ± 10 years, namely in 2010 (plant age 13 years or 9 years after application) and in 2017 (plant age 20 years or 16 years after POME application).

Research Stages:

Things explained at this stage of the research are the POME application that applied in the Bukit Maradja Estate (SIPEF group), that are as follows:

a. The source of POME comes from primary anaerobic ponds with BOD values of 3500-5000 mg/l (ppm).
b. POME is distributed to oil palm plant blocks in a trench or long bed system that has been designed in advance.
c. The amount of POME is according with frequency guideline; that is 3 times/year, a dose of 250 m^3/ha/application or a total of 750 m^3/ha/year.
   The application was conducted when the plant is 4 years old (2001) until the end of one plant cycle which is estimated to be 25 years old.

Observation Paramaters: Sampling was from the edge of the circle (plant disc) of around ± 2.5 m and vertically at a depth of 0-20 cm, 21-40 cm, 41-60 cm and 61-80 cm. The number of sample points is 5 with a distance of ± 2 rows of plants (± 16 m) samples collected in a composite. Determination of pH by water dilution (1: 5); CEC, Na and Ca with NH_4OAc extraction pH 7.0

III. Result and Discussion

a. POME Quality

The quality of POME that is flowed periodically is monitored hence it still meets the quality requirements, especially pH and BOD with the following results:

Table 1. Analysis of POME pH and BOD Value

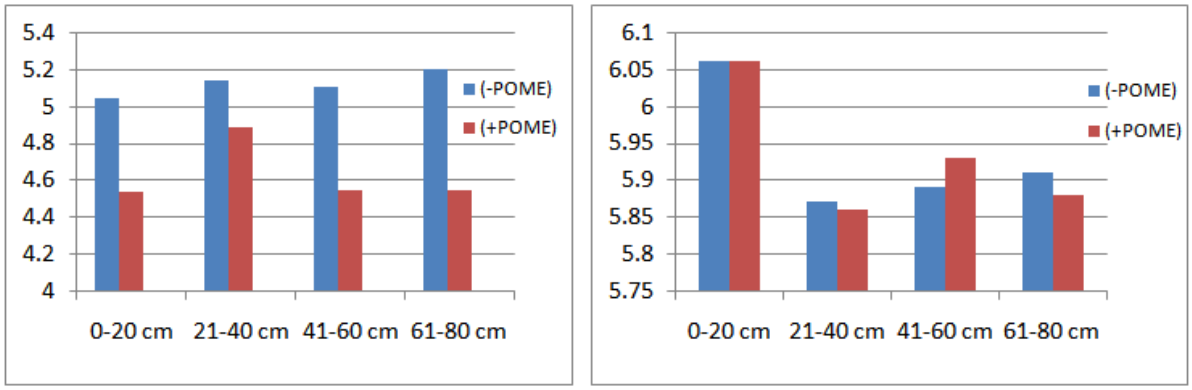
Application Year (to)	pH	BOD (mg/l)
9	7,42	753
16	7,53	803
Company Standards	6-9	3500-5000

The quality of POME that was used had fulfilled the provisions, namely the BOD value which was quite low (≤ 1000 mg/l), indicating that the or decomposition that occurred in the primary anaerobic pond had been able to take place properly. According to Nursanti [5] floating material or suspended solids in POME consist of 8.20% protein, 11.90% fiber and other matters that are soluble in esters as much as 31.60%.

The decomposition in primary anaerobic ponds is carried out by the activity of microorganisms which are mainly *mesophilic* and *thermophilic* bacteria from the methanogen group which will produce methane gas. The process that occurs consists of hydrolysis, *acidogenesis*, *acetogenesis* and *metagenesis* [6].

b. Soil Acidity

The observation results of soil pH values are in the picture below:



(A) (B)

The figure 1. Soil pH, 9 years (A) and 16 years (B) Applications

In the 9th year, the pH values in all observed layers were included in the acidic category with a pH standard of 4.5-5.5. The POME application treatment reduced soil pH by an average of decreased from 5.14 to 4.53. Soil acidity needs to be considered because it plays an important role in the dynamics or processes that occur in the soil [7]. A pH value of 5.0 to 6.0 is the optimum pH condition. At that pH the nutrient elements are in the available form hence they are easily absorbed by plants. The decrease in pH in the POME treatment application can be caused by the activity of microorganisms in the soil in which it produces organic acids (acetate, malate, lactate, etc.) which resulted in a decrease in the pH value of the soil.

Hanafiah [7] suggested that the result of the decomposition process is CO_2 gas, which if accumulated can react with water to form H_2CO_3 (weak acid) but if dissociated into HCO^-_3 and H+ can acidify the soil or reduce soil pH. Iyakndue *et al* [8] also reported a similar matter that is along with the increasing amount of POME applied it would reduce the soil pH even though it was not significant.

Soil types at the study site include as the Inceptisol, which is a newly developing and relatively fertile soil formed by the eruption of Toba with the secondary mineral kaolinitic clay. Furthermore, Hakim *et al* [9] suggested that further weathering conditions can result in the dissociation of clay minerals in which released H+ resulted in a decrease of soil pH.

Even though the POME used has experienced a retention time of ± 40 days it turns out there are still organic compounds (oil, fat or protein) that have not been degraded. Oil/fat levels contained in POME need to be analyzed to ensure that their quality complies with the standard of ≤ 3000 mg/l. The decreased pH value due to the POME application can potentially reduce the productivity of oil palm plants [10]. Sutedjo [11] claimed that the pH value affects the development and activity of soil microorganisms.

In the 16^{th} year, the POME application observed pH value in all layers were included in the slightly acidic category with an average pH of 5.93 (-POME) and 5.96 (+POME) which is an ideal condition for oil palm plants. An increase in pH value in the 16^{th} year was also caused by the contribution of the dolomite CaMg $(CO_3)_2$ and Rock Phosphate Ca_3 (PO_4) fertilizer application as a source of fertilizer for old plants aged ≥ 20 years. According to Erningpraja *et al* [12] Ca nutrients that play a role in increasing pH in POME application has the least amount compared to the elements of N, P, K and Mg. This is in line with Madaki and Seng [13] who reported that the POME application of 4.5 x 10^6 l/ha contains several nutrients which are equivalent to 36 kg of ZA, 7 kg of RP, 52 kg of KCl and 18 kg of Kieserite. The most common element in POME is Potassium (K) and the least is Ca (Calcium).

c. Soil Stability

Another impact that often gets attention due to the application of waste and high-dose chemicals is the disruption of soil stability (soil structure) in the form of compaction by "cementing agents" such as lime elements and the destruction caused by "dispersing agents" namely by the Na element. To support the following study the analysis of Cation Exchange Capacity (CEC) analysis and composition, Na and Ca are presented.

Table 2. Observation of CEC, Na and Ca

Depth	CEC (ml/100 gr)		Na (ml/100gr)		Ca (ml/100gr)	
	-POME	+POME	-POME	+POME	-POME	+POME
0-20 cm	6,35	8,19	0,04	0,04	1,27	2,06
21-40 cm	6,99	9,29	0,05	0,05	1,37	1,22

41-60 cm	6,76	6,53	0,05	0,05	1,10	1,96
61-80 cm	7,37	6,53	0.04	0.04	1,57	2,04
Average	6,60	7,63	0,05	0,05	1,33	1,82
%	100%	115%	100%	100%	100%	137%
Category	SR	SR	SR	SR	SR	SR

Note: SR (Very low). % value comparison between +POME treatment with -POME treatment.

The CEC value of soil with POME applications increased by an average of 15%; the increase mainly occurs in the 0-20 cm and 21-40 cm layers with an increase of 29% and 33%, it means that the benefits of POME as a source of organic matter show good benefits. Sakiah and Wahyuni [14] have reported positive benefits of POME application in the same place that is an increase in N, C-organic, P and K. The increase in CEC showed that the space in the clay mineral lattice is more open and this can provide benefits among others; the stability of nutrient exchange mechanisms and increased fertilizer efficiency [9].

Na element analysis results in treatment with and without POME application included in the very low category, no adverse effects were found. The Na element has the potential to damage the soil structure due to its ability to disperse such as the occurrence of soil damage due to intrusion by seawater, Iyakndue *et al* [8] also reported the impact of POME application on Na element with initial Na analysis was 0.05 ml/100 gr and after POME application at 8^{th} week, it became 0.13 ml/100 gr although it was still classified as a very low category.

The research location is ± 30 km from the coast hence it is estimated that there is no influence of seawater intrusion which can deposit salts, especially NaCl. Nwoko and Ogunyemi [15] suggested the importance of Na analyzing because, in conditions of increased salt Na+ content, it can disrupt the life of microorganisms. Djajadi and Murdiyati [16] suggested that the normal standard of Na is 0.03 ml/100 gr. Excess Na in the soil will cause the soil to disperse and erode.

POME application increases Ca^{+2} easily by 37%; in the 0-20 cm layer an increase of 63% occurred. Although Erningpradja *et al* [12] suggested that although the Ca content in POME were very low, they were able to repair and bind Ca in the soil sorption complex even though it was still in the very low category. In this condition, Ca^{++} is not a "Cementing Agent" nor does it precipitate other anions such as SO^{4-} or Cl hence the soil hardens [17]. The availability of Ca is expected to increase the adequacy of nutrients for oil palm plants.

IV. Conclusion

POME application in oil palm plantations in the long term has the potential to reduce soil pH from slightly acidic to acidic criteria. There is no indication of a negative effect on soil damage due to the dispersion by the Na+ element or cementation by the Ca++ element. Monitoring the quality of POME for soil applications is important to note.

References

[1]. Ditjenbun 2016. Statistik Perkebunan Indonesia (Plantation Statistic of Indonesia). 2016 – Kelapa Sawit. Departemen Pertanian.
[2]. Singh G. 1994. Management andc Utilization of Palm Oil Products. The Planter 71 NO 833, p 361-886.
[3]. Naibaho P.M 1998. Teknologi Pengolahan Kelapa Sawit. PPKS Medan
[4]. Pamin K, Darnoko dan P. Guritno 1995. Strategi Pengelolahan Limbah Perkebunan Kelapa Sawit di Indonesia (Palm Oil Plantation Waste Management in Indonesia). Warta PPKS Vol 3(2) : 47-53 PPKS Medan.
[5]. Nursanti I. 2013. Karakteristik LCPKS Pada Proses Pengolahan Anaerob dan Aerob (POME Characteristic in Aerobic and Anaerobic Decomposition). Journal Ilmiah Universitas Batang Hari Jambi Vol 13(4) :67-74.
[6]. Rizal T A, Mahidin dan M. Ayub. 2015. Pengembangan Anaerobic Digester Untuk Produksi Biogas dari LCPKS (The Development of Aerobic Digester for Biogas Production from POME). Journal Ilmiah JURUTERA Vol 2(2) : 8-19.
[7]. Hanafiah K.A. 2012. Ilmu Tanah (Soil Science). Medyatama Sarana Perkasa Jakarta.
[8]. Iyakndue M L, A.A. Unimke and B E Agbo 2017. Effect of Palm Oil Mill Effluent on Soil Microflora and Fertility in Colabor-Nigeria. Asian Journal of Biologi 2(3) : 1-11.
[9]. Hakim, et al..1986. Dasar-Dasar Ilmu Tanah. Lampung (Basic of Soil Science). Penerbit Universitas Lampung.
[10]. Corley R.H.V. and P.B. Tinker. 2003. The Oil Palm, Fourth Edition. Blackwell Science Ltd.
[11]. Sutedjo, M., dkk. 1996. Mikrobiologi Tanah Soil Microbiology). Jakarta: Penerbit Rineka Cipta
[12]. Erningpradja L, Z. Poeloengan dan P.L Tobing 1996. Prospek Pemanfaatan Limbah Cair Pabrik Kelapa Sawit Untuk Perkebunan Kelapa Sawit (The Prospect of POME Utility for Oil Palm Plantation). Prosiding Kongres VI HITI
[13]. Madaki Y S and L. Seng. 2013. Palm Oil Mill Effluent (POME) From Malaysia Palm Oil Mills : Waste or Resources International Journal of Science Environment and Technology Vol 2(6) : 1138-1155.
[14]. Sakiah and Wahyuni 2018. Analysis Of C organic, Nitrogen, Phosphorus and Pottasium in Application Areas and Without Application of Palm Oil Mill Effluent IOSR. Journal of Agriculture and Veterinary Science (IOSR-JAVS) VOL II (4) : 23-27.
[15]. Nwoko C O and S. Ogunyemi 2010. Effect of Palm Oil Mill Effluent (POME) on Microbial Characteristics in a Humid Tropical Soil Under Laboratory Conditions. International Journal of Environmental Science and Development Vol I(4) : 307-314.
[16]. Djajadi dan Murdiyati A S 2000. Hara dan Pemupukan Tembakau Temanggung. Balai Penelitian Tanaman Tembakau dan Serat (Plant Nutrient and fertilizer for *Solanum tobacco*). Malang.
[17]. Tisdale, S.L. and W.L. Nelson. 2016. Soil Fertility and Fertilizer 8^{th} Edition. Potash and Phosphate Institute. Canada.