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Utilization of palm oil mill effluent on plantation land

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ABSTRACT

The purpose of this study was to determine the Utilization of Palm Oil Mill Effluent on plantation land. Samples of wastewater coming from an outlet of Wastewater Treatment Plant channeled through a pipe leading to the *Land Application*. The results showed that almost no significant changes from the first semester and second semester on soil porosity with an average of 47, 72% and 51, 36%, so that there was no change in the physical properties of the soil due to the utilization of palm oil wastewater on the soil. The high value of P-available in the rorac and between-rorac (0-20 cm and 20-40 cm, even> 40 cm), because the palm oil waste water that is given contains the element P.Furthermore, Ca-dd, Mg-dd, and Na-dd values in the soil fluctuate, especially in the control location. Soil fertility is increasing after palm oil waste water is applied to oil palm plantations.

Key words*: Palm oil wastewater, Soil*

Introduction

The development of an oil palm processing factory will give an impact on environmental conditions in and around the plantation area, therefore is needed for an integrated management of palm oil processing plants that are environmentally friendly. The utilization of palm oil mill wastewater/effluent is referred to as the Land Application. Managing wastewater that is effective and safe for the environment is by the Land Application technique, namely channeling the palm oil mill effluents to the channel created in oil palm plantations so that it can be fully utilized for the needs of oil palm plants. Before applied to oil palm plantations, it must first be tested (Sutarta *et al.*, 2003). Waste water assessment on the soil is carried out because of the potential accumulation of pollutants in the soil and the ability of the soil to neutralize wastewater is limited and depends on the characteristics of the soil (Tisdale 1990; Brazauskiene *et al*., 2008; Akpor and Muchie, 2010; Dhal *et al*., 2013; Ahmad *et al*., 2014;).

Land Application is a system applied in the mill industry and oil palm plantations that changes processes that have been linear (open) to cycle processes (closed), so that waste originating from the processing of oil palm fruit in oil palm mills will be re-utilized in oil palm lands to increase nutrient content which needed for the growth of oil palm plants (Epstein, 1972; Wu *et al*., 20009, Comte *et al*., 2012; Tan *et al*., 2019; Putro *et al*., 2019). Land Application activities are in line with the implementation of the Near Waste (Zero Discharge) program, which expects palm oil plantation companies able not to dispose of environmental waste by composting and Land Application.

Land Application study activities in the plantation and oil palm industries aim to realize the Act

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No. 32 of 2009 on Environmental Protection and Management clause 1 section 2 which states that environmental management is an integrated effort to preserve the function of the environment including policies on the arrangement, utilization, development, maintenance, recovery, supervision and control of the environment. Section 5 which states that the preservation of environmental functions is in a series of efforts to maintain the sustainability of the bearing capacity and the carrying capacity of the environment. The purpose of the implementation of the use of wastewater in the soil and oil palm plants is to find out how much nutrient content contained in the wastewater/effluent, and also to find out how much the needs and absorption capacity of oil palm plants on the wastewater/effluent that will be applied by PT. Sawit Graha Manunggal.

Methods and Data Analysis

The research time 12 months from July 2015 to June 2016 at palm oil plantations Sawit Graha Manunggal. The wastewater/effluent sample comes from the outlet pool of the Waste Water Treatment Plant which is channeled through a 4 inch pipe to the land for the assessment and utilization of wastewater (Land Application). Soil sampling locations are set at 3 (three) locations, i.e. irrigation ditches (rorac), between ditches and plants (between rorac), and in control land at six depths as follows : (a) 0 – 20 cm; (b) 20 – 40 cm; (c) 40 – 60 cm; (d) 60 – 80 cm; (e) 80 – 100 cm; and (f) 100 – 120 cm.Soil sampling in an irrigation ditch (rorac) and longbed required two types of samples, namely samples of the disturbed soil and undisturbed soil samples.

Results and Discussion

The land area for the study and utilization of palm oil mill effluent for fertilization through Land Application in the initial stage is Block H3 and H4 with an area of ± 100 ha with the coordinates of the study area S = 02^0 04.04.4' and E = 115^0 03.83.7' which refers to and guided by Minister of Environment Decree No.28 and No. 29 of 2003.

Utilization of wastewater on the soil uses a long bed system. Long bed channel to store palm oil waste water has a length of 5-10 m, width 2 m, depth 0.5 m. The distance between one long bed channel and the other is 18 m. Then the pipe used is a PVC pipe with a size of 4 inches. The dosage of

Table 1. Periodic Data of the Waste Water Outlet Qualityat Palm Oil PlantationsUtilized in the Land Application

No	Parameter	Quality Standard*	Results of IPAL/ WWTP Outlet Wastewater Analysis											
			Jul- 15	Agt- 15	Sept-15	Oct- 15	Nov-15	Dec-15	Jan-16	Feb-16	Mar-16	Apr-16	May-16	June-16
1.	Temp (°C)		33.3	34.1	32.5	34.7	37.6	36.5	31	32.4	33.1	33.7	33.7	30
2.	pH	6-9	5.14	6.7	5.8	4.5	7.3	8.2	7	7.1	7.1	7.1	7.1	7.0
3.	DO (mg/L)	-	0.16	0.14	0.35	0.20	0.20	0.49	0.16	0.34	0.44	0.24	0.24	5.5
4.	BOD (mg/L)	250	2.403	8.378	28.370	78.002	8.552	7.326	2.364	6.752	8.552	1.591	2.101	1.651
5.	COD (mg/L)	500	8.340	21.700	61.000	192.000	28.800	22.200	46.000	22.200	24.600	4.320	9.067	7.620
6.	TSS (mg/L)	-	700	1.003	1.534	21.115	1.789	1.030	2.039	1.261	2.683	1.507	1.662	1.065
7.	TDS (mg/L)	-	2.580	5.002	5.278	7.400	6.052	5.818	3.360	3.750	3.200	2.810	2.810	3.260
8.	NH_3 (mg/L)	20.0	57.72	19.82	43.30	109.10	274.0	12.59	97.45	199.2	83.60	72.64	161.5	86.70
9.	Zn (mg/L)	-	0.085	0.438	Tt	0.087	0.692	0.066	0.302	0.418	0.734	tt	tt	tt
10.	Cu (mg/L)	-	tt	0.026	Tt	Tt	0.083	0.04	Tt	0.218	0.221	1.158	tt	tt
11.	Pb (mg/L)	-	tt	Tt	Tt	Tt	Tt	Tt	Tt	<0.004	Tt	0.02	tt	tt
12.	NO3 (mg/L)	-	28.72	439.6	606.8	1.011	68.17	536.2	598.3	199.6	35.40	18.03	201.0	179.9
13.	SO4 (mg/L)	-	26.77	640.1	306.1	67.87	1.848.5	287.8	264.1	408.3	85.97	21.57	8.75	205.1
14.	Oil and Fat (mg/L)	30.0	3.5	7.0	2.0	7.5	5.5	2.5	5.5	<1.9	3.0	3.7	5.3	<1.9

wastewater applied to the soil is 1.000 m^3 per year/ ha. Whereas liquid waste water discharge is the processing capacity of palm oil plant multiplied by the ratio of wastewater production toward the production of Fresh Fruit Bunches/Tandan Buah Segar namely 250.000 tons FFB/ year x 0.8 = 200,000 tons. The location needs for land application 200.000 tons divided by 1,000 m^3 is an area of 200 ha. Rotation of the utilization of palm oil mill effluent is 6 times per year or once in 2 months. Periodic data of the wastewater outlet pool quality of palm oil plantations used in the Land Application (Table 1), the tendency of palm oil industry wastewater used in Land Application (Figure 1).

Table 1 shows the trend of changes in the concentration of wastewater at the outlet for 12 months observation. The parameters of BOD, COD, Zn, Cu, Pb, SO_4 had decrease in concentration until the end of the observation.

The results of laboratory analysis the impact of the utilization of wastewater on the soil on soil physical and chemical parameters tend to increase in value. The parameter that tends to increase in rorak soil samples namely land near the canal, because the soil is soaked with palm oil mill wastewater that is piped into the channel (longbed).

Soil Physical Properties – The physical properties of the soil are closely related to the feasibility of use in the soil. Robustness and supporting strength, drainage and water storage capacity, plasticity, then easy penetrated by the root, aeration, and storage of plant nutrients are closely related to soil physical conditions (Mengel and Kirkby, 1992; Alam, 1999; Antolín *et al*., 2005; Wang, *et al*., 2019; Peters *et al*., 2019; Chin *et al*., 2013). The results of the analysis of the physical properties of the soil in the laboratory indicate that the condition of volume weight/ berat volume (BV), specific gravity/berat jenis (BJ), and Total Porosity on observations is presented in Table 2.

Table 2 showes that almost no significant changes from the first semester and second semester on soil porosity with an average of 47, 72% and 51, 36%, so that there was no change in the physical properties of the soil due to the utilization of palm oil wastewater on the soil (Sanchez, 1976).

Soil permeability indicates fast or slow the water seep into the soil through soil pores, both horizontally and vertically (the ability of the soil to absorb water). Soil permeability is influenced by soil texture, soil structure, soil porosity, fluid viscosity, gravity, volume weight/berat volume (BV) and specific gravity/berat jenis (BJ). The physical properties of the soil at the study site in the form of volume weight/berat volume (BV), specific gravity/ berat jenis (BJ), and porosity indicate a relationship with soil permeability. The results of laboratory analysis on the soil permeability presented in Table 3.

Table 2. Results of Analysis of Soil Physical Properties of Land Application at Palm Oil Plantations

No	Sample Code/ Depth (Cm)		Volume Weight (g/cm^3)		Specific gravity (g/cm^3)		Porosity(%)	
			Semester I	Semester II	Semester I	SemesterII	Semester I	Semester II
1.	Rorac	0-30	1.15	1.00	2.08	2.01	44.58	50.37
		30-60	1.21	1.13	2.25	2.15	46.03	47.52
2.	Between Rorac	0-30	1.13	0.98	2.41	2.33	53.04	57.98
		30-60	1.25	1.10	2.46	2.42	49.19	54.62
3.	Control	0-30	0.99	0.96	1.89	1.96	47.81	51.04
		30-60	1.26	1.12	2.33	2.10	45.67	46.61
	Average		1.17	1.05	2.24	2.16	47.72	51.36

Table 3. Results of Laboratory Analysis on Soil Permeability at the Land Application

No	Sample Code		Permeability (cm/hour)	
			Semester I	Semester II
1.	Rorac	0-30 cm	8.49 (Rather fast)	8.49 (Rather fast)
		30-60 cm	8.49 (Rather fast)	8.49 (Rather fast)
2.	Between Rorac	0-30 cm	3.06 (Medium)	8.15 (Rather fast)
		30-60 cm	8.49 (Rather fast)	8.49 (Rather fast)
3.	Control	0-30 cm	3.74 (Medium)	2.72 (Medium)
		30-60 cm	4.76 (Medium)	4.08 (Medium)

Table 3 shows that soil permeability at the depth of 0-30 cm and 30-60 cm in semester I and semester II is medium. Then at the location of the rorac and between rorac at both depths of land and the same semester is moderate - rather fast.Soil texture is the size of soil particles, which refers to the fineness or roughness of the soil. More typically, texture is a relative comparison of sand, dust and clay. The results of soil texture measurements at the study location are presented in Table 4.

The results of measurements of soil texture are 0.60 - 86.84% (clay, loamy sand, sand, sandy clay loam, loam, dusty loam, dusty clay loam, and sandy clay). Fine-sized fraction dominates all soil layers (0-120 cm). In connection with the holding capacity of water and nutrients this type of soil has greater ability. Sand-textured soil, then each unit of weight has a smaller surface area so that it cannot absorb (hold) water and nutrients. Clay textured soil, then each unit of weight has a greater surface area so that the ability to hold water and provide nutrients higher.

Soil Chemical Properties **-** Based on the results of soil analysis from the laboratory shows that the chemical properties of the soil, especially soil pH, C-organic content, N-total, P-available, K-available, base saturation/kejenuhan basa (KB), and soil bases (Ca, Na, and Mg) presented in Table 5.

The high value of P-available in the rorac and between-rorac (0-20 cm and 20-40 cm, even> 40 cm), because the palm oil waste water that is given contains the element P, and in the decomposition process can release P into the soil solution. Furthermore, Ca-dd, Mg-dd, and Na-dd values in the soil fluctuate, especially in the control location. Soil fertility is increasing after palm oil waste water is applied to oil palm plantations.

Conclusion

The results showed that almost no significant changes from the first semester and second semester on soil porosity with an average of 47, 72% and 51, 36%, so that there was no change in the physical properties of the soil due to the utilization of palm oil wastewater on the soil. The high value of P-available in the rorac and between-rorac (0-20 cm and 20-40 cm, even> 40 cm), because the palm oil waste water that is given contains the element P. Furthermore, Ca-dd, Mg-dd, and Na-dd values in the soil fluctuate, especially in the control location.

Table 4. Results of Soil Texture Analysis of Land Application of Palm Oil Plantations

No	Sample Code / Depth (Cm)		Soil Texture (%) of Semester I and Semester II					
			Sand		Dust		Clay	
			I	II	I	II	I	II
1.	Rorac	0-20	8.03	13.84	39.66	34.25	52.32	51.92
		20-40	3.74	9.73	31.77	38.58	64.48	51.69
		40-60	1.11	18.78	35.72	80.34	63.17	0.88
		60-80	1.65	2.35	32.98	44.47	65.37	53.18
		80-100	4.02	0.60	35.23	31.31	60.75	68.07
		100-120	1.37	2.74	39.10	28.65	59.52	68.61
	Average	3.32	8.01	35.74	42.93	60.94	49.06	
2.	Between Rorak	0-20	86.84	45.47	2.80	19.87	10.36	34.65
		20-40	84.94	41.41	6.71	46.70	8.35	11.89
		40-60	54.88	57.02	16.11	20.56	29.01	22.42
		60-80	59.48	45.64	16.12	14.21	25.40	40.14
		80-100	51.07	32.38	18.37	23.69	30.56	43.94
		100-120	42.27	34.00	10.53	12.75	47.20	53.25
	Average	63.25	42.65	11.77	22.96	25.15	34.38	
3.	Control	0-20	13.76	12.07	58.64	39.32	27.61	48.61
		20-40	26.44	23.73	44.58	35.01	28.99	41.26
		40-60	18.63	16.39	27.87	15.70	53.51	67.92
		60-80	2.47	17.13	42.29	12.36	55.24	70.51
		80-100	2.28	17.26	38.91	8.52	58.81	74.21
		100-120	2.05	10.17	81.49	6.02	16.46	83.81
	Average	10.94	16.13	48.96	19.49	40.10	64.39	

Table 5. Results of Soil Chemical Properties Analysis at Palm Oil Plantations

No	Sample Code		Variable In Semester															
			pH		C-org (%)	N-total (%)	KB (%)		P-available		K-dd (me/100g)		Ca-dd (me/100g)		Mg-dd (me/100g)		Na-dd (me/100g)	
			I	II	I	I	I	II	I	II	I	II	I	II	I	II	I	II
1	Rorac	0-20	4.62	5.18	1.62	0.29	3.29	3.16	33.80	54.95	0.09	0.03	0.20	0.44	0.23	0.05	0.01	0.01
		20-40	4.32	5.05	0.17	0.23	2.11	2.62	26.66	57.40	0.05	0.02	0.25	0.37	0.03	0.08	0.03	0.01
		40-60	4.34	5.11	0.11	0.17	1.77	1.92	13.27	26.19	0.05	0.01	0.22	0.33	0.03	0.06	0.00	0.01
		60-80	4.33	5.06	0.09	0.21	1.94	2.24	12.86	63.21	0.07	0.02	0.33	0.32	0.02	0.05	0.01	0.01
		80-100	3.66	5.12	0.14	0.22	2.34	1.83	12.08	58.49	0.05	0.00	0.34	0.31	0.01	0.04	0.01	0.02
		100-120	3.50	5.13	0.12	0.20	2.27	1.92	13.08	71.38	0.06	0.02	0.36	0.29	0.01	0.03	0.01	0.02
	Average	**4.13**	**5.11**	**0.38**	**0.22**	**2.29**	**2.28**	**18.63**	**55.27**	**0.06**	**0.02**	**0.28**	**0.34**	**0.06**	**0.05**	**0.01**	**0.01**	
2	In Rorac	0-20	4.24	4.49	3.94	0.22	2.84	3.33	23.34	49.09	0.13	0.01	0.33	0.48	0.13	0.03	0.02	0.01
		20-40	4.57	4.65	2.03	0.25	2.26	2.65	12.79	18.55	0.06	0.03	0.31	0.34	0.04	0.12	0.02	0.01
		40-60	4.40	4.63	1.28	0.22	1.26	1.89	12.55	25.17	0.06	0.03	0.15	0.30	0.02	0.04	0.01	0.01
		60-80	4.21	4.83	0.60	0.21	2.03	1.81	20.55	19.31	0.06	0.02	0.31	0.27	0.01	0.03	0.01	0.02
		80-100	4.42	4.88	0.36	0.19	2.97	1.69	15.06	11.37	0.05	0.01	0.40	0.27	0.01	0.02	0.01	0.01
		100-120	4.21	4.84	0.17	0.17	2.73	1.88	11.68	18.34	0.06	0.02	0.38	0.30	0.02	0.04	0.01	0.01
	Average	**4.34**	**4.72**	**1.40**	**0.21**	**2.35**	**2.21**	**16.00**	**23.64**	**0.07**	**0.02**	**0.31**	**0.33**	**0.04**	**0.05**	**0.01**	**0.01**	
3	Control	0-20	4.22	5.09	9.00	0.20	1.90	2.38	25.98	15.08	0.14	0.04	0.12	0.30	0.11	0.04	0.03	0.03
		20-40	4.23	5.08	4.18	0.22	2.56	1.80	16.62	6.27	0.08	0.01	0.40	0.27	0.03	0.03	0.02	0.02
		40-60	4.25	5.23	0.59	0.23	2.58	1.79	11.54	9.19	0.07	0.01	0.35	0.27	0.01	0.03	0.02	0.01
		60-80	4.08	4.98	0.50	0.17	2.41	2.18	11.82	9.83	0.07	0.04	0.35	0.28	0.02	0.03	0.02	0.01
		80-100	4.31	4.88	0.54	0.17	2.37	1.67	12.23	5.92	0.07	0.01	0.35	0.27	0.01	0.02	0.02	0.02
		100-120	4.04	4.56	0.48	0.18	2.74	2.09	12.77	5.75	0.07	0.02	0.39	0.28	0.01	0.02	0.02	0.03
	Average	**4.19**	**4.97**	**2.55**	**0.20**	**2.43**	**1.99**	**15.16**	**8.67**	**0.08**	**0.02**	**0.33**	**0.28**	**0.03**	**0.03**	**0.02**	**0.02**	

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