The Impact of Palm Oil Mill Wastewater on the Soil Properties of Paddy Fields

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The Impact of Palm Oil Mill Wastewater on the Soil Properties of Paddy Fields

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***Abstract*—A paddy field is a wetland area which always muddy and constantly flooded by irrigation. This land possesses impermeable layers, hence the irrigation water quality ought to be maintained, to prevent changes in its properties, as well as the paddy field features. Furthermore, wetland pollution by the palm oil mill wastewater PT BSS was experienced in June 2018, characterized by a lowered quality of water in the fields of Manggopoh Village, Agam District, West Sumatra. The purpose of this study, therefore, is to determine the effect of PT BSS palm oil mill wastewater on the quality of paddy fields, using a survey method to obtain samples through random sampling techniques. This research was conducted downstream, based on the direction of flow along the irrigation channel as well as on the uncontaminated fields upstream. Furthermore, a ring and ground drill was used in the collection process, and analysis for physical and chemical properties was conducted in the Soil laboratory of the faculty of Agriculture, Andalas University. Subsequently, the evaluation involved averaging the soil data, followed by a comparison with the criterion level of damage, and ANOVA was used to estimate the difference between sample point locations, at a significance level of 0.05%. The results obtained indicate the absence of any changes in soil properties, in contrast with the water characteristics that can cause damage because the paddy soil is in a saturated state. Thus, wastewater is unable to permeate the soil matrix. Hence, it does not change the properties, since the values obtained passed the threshold criteria for soil.**

***Keywords*— wastewater; paddy field; rice; polluted; palm oil.**

I. INTRODUCTION

The high interest of farmers in oil palm has led to rapid development and expansion of its plantations, due to its high economic value, and the propensity to significantly increase income. Furthermore, the production of fresh bunches (FFB) often exceeds the capacity of palm oil mills, triggering the establishment of new sites, which unfortunately does not follow land use designations. Besides, several of them were created in paddy fields, and one of which was the palm oil mill company termer PT BSS, with processing ponds situated only 100 m from the community. In addition, the leakage of WWTP aerobic pond that occurred in May 2018, caused pollution to the surrounding, therefore, the high organic acids led to a brown pigmentation of the water, which subsequently mixed with irrigation and rainwater.

Similar phenomena can cause soil damage /degradation, characterized by a decline in its function as a plant growing, and biomass-producing media, filter, buffer, transform (water, nutrients, and pollutants), biological habitat, and genetic resources. Arsyad stated the possibility of a reduction in the efficiency at plant roots, storing groundwater, and providing necessary nutrients [1].

Soil damage occurs in varying typologies of land use, including paddy soil, which is used to grow rice throughout the year, or in rotation with secondary crops. Besides, this specific term is not included in taxonomy, as it serves in general applications, as seen in forest, plantation, and agricultural land, etc. It is, therefore, possible to use all types of terrains with water sufficiency as rice fields, and a variety of rice is obtained through the climate; thus, it is one of the plants with the most types [2].

Paddy soil degradation is characterized by a reduction in productivity, C-organic content, and macronutrients (P and K), as well as silting of the topsoil layer. This occurrence is particularly attributed to industrial waste and the uncontrolled use of agrochemical materials, including fertilizers and pesticides, modifying its physical, chemical and biological properties.

Palm oil liquid waste is used as fertilizers and as irrigation water in oil palm plantations, with the specification of having a COD <10,000 mg/L, and pH between 6 - 9 [3]. Therefore, they need to be initially treated, to reduce the pollution load, and its utilization subsequently reduces waste processing costs. In addition, the properties obtained include pH 3.3-4.6; BOD 24.884-27.421 mg / l; COD 47.165-49.765 mg / l; TS 16,580-94,106 mg / l; TSS 1,330-50,700 mg / l [4].

In line with ascertaining the possibility of palm oil liquid waste changing the nature of flooded soils, [5]. Stated that the pore matrix of these soils is covered by water molecules, with adhesion bonds that enhance the difficulty of wastewater entrance. This means that there is no significant modification to its properties. However, there was a community assumption of possible field damages; hence, they requested for land reclamation. The purpose of this study was to determine the effect of PT BSS palm oil mill wastewater on the quality of paddy fields

II. MATERIALS AND METHODS

A. Materials

The research was conducted in the soil field in Mangopoh Village, Agam District, West Sumatra, Indonesia at June-August 2018 as in Figure 1. Materials and equipment used include mineral soil drill (auger Belgium), Munsell book, GPS, sampling ring, and plastic samples. Figure 1 below shows the paddy soil which is contaminated by palm oil wastewater.

Fig. 1 Paddy soil contaminated by palm oil mill wastewater in Manggopoh Village, Agam District

The physical and biological properties were analyzed in the laboratory of the Land Department, Faculty of Agriculture, Andalas University, while the chemical analysis was performed at the Soil Laboratory, BPTP, Sukarami. Soil samples were taken from six locations that were thought to be affected by oil palm liquid waste spills from PT BSS aerobic ponds, two months earlier. The field survey was conducted on August 8, 2018.

B. Methods

1) Soil sampling. This was conducted using purposive random sampling method, taken from five contaminated locations, while the comparative sample was obtained from an uncontaminated paddy site, at a depth of 0-20 cm.

TABLE I
LOCATION OF SOIL SAMPLING AT PT. BSS

No	Location code	Description	GPS coordinate
1	BSS 1	Rice fields that are not contaminated with oil palm waste are located upstream of contaminated ones	S 00° 20'21,9'' - E 99°57' 49,8"
2	BSS 2	Paddy soil closest to the source of waste	S 00° 20' 11,9" – E 99° 57' 48,5"
3	BSS 3	Paddy soil and downstream area of the second point	S 00° 20' 13,1" – E 99° 57' 40,2"
4	BSS 4	Paddy soil downstream of the second point	S 00°19' 52,2" – E 99° 57' 17,8"
5	BSS 5	Paddy soil downstream of the third point	S 00°19' 52,2" – E 99° 57' 17,8"

Fig.2 Location of rice field sampling contaminated by palm oil mill wastewater

The first sample was from the undamaged field upstream, while the second was from the contaminated rice field area, through land leveling from the closest point to the spill source, down to the furthest, in the direction of irrigation flow. The analysis of physical properties was performed on the uncontaminated unit, while chemical and biological evaluation was conducted on the supposed polluted filed.

2) Analysis Method in Soil Laboratory. The soil samples were analyzed in the soil laboratory of Andalas University, and the Institute for Agricultural Technology Assessment (BPTP) Sukarami. Therefore, the parameters assessed include soil texture, volume, weight, permeability, pH (H_2O; KCl), C-organic, Total Nitrogen, Phosphor, K-interchangeable, CEC, and DHL content. The details of the analysis parameters and methods are presented in Table 1.

TABLE II
SOIL OBSERVATION AND ANALYSIS IN THE LABORATORY

No	Analysis parameters	Methods
1	Texture (%)	Pipette
2	Volume weight (BV) g / cm^3	Gravimeter
3	Permeability (cm / hour)	Permeameter of Darcy's Law
4	pH	Potentiometer
5	C-Organic (%)	Walkley and Black
6	N-Total (%)	Kjeldahl
7	P-available (ppm)	Bray II
8	CEC (me / 100 g soil)	Ammonium Acetate
9	K total (me / 100 g soil)	Ammonium acetate
10	Electrical Conductivity of Soils (DHL) ms / m	Electrical resistance with EC meter

The determination of oil palm wastewater influence at each sampling point was conducted with one-way ANOVA analysis at $\alpha = 5\%$. Furthermore, the first assumption was the varied effects on each paddy field, and the second was the propensity to affect soil nature. Therefore, on instances where the mean, median value is significantly different, a Tukey's pairwise comparison test is performed to identify the disparity between each sequence.

III. RESULTS AND DISCUSSION

A. *Control Location (Uncontaminated)*

The results showed the soil samples with rice aged around 1.5, were planted, was obtained at S 00° 20' 21.9' - E 99°57' 49.8." These were not affected by the palm liquid waste spill, thus used as a comparison. Besides, they were further contrasted with the standard criteria [6], [7] which showed the land to be within the threshold. However, this analysis also showed high DHL in soil solution (with electrical conductivity/DHL considered critical in cases where it was higher than 9 mS/cm). This is thought to be due to the excessive use of chemical fertilizers, including KCl, Urea, etc. The availability of groundwater influences the high conductivity of electricity [8]. In contrast, there was also low phosphorus content, supposed to be caused by a decline in the amount of P which is partially bound by organic matter and aluminum [9]), subsequently increasing the pH [10].

B. *The location of the contaminated soil sample*

The properties of paddy soil obtained in areas 2, 3, 4, and 6 was characterized by contamination with oil palm waste, as shown in Table 3, and no significant difference was observed in contrast with location 1. Also, the fat present did not affect its matrix, thus, this minimal impact was due to the flooded condition of the paddy soil.

The macro and micropores of the saturated soil were filled, and the matrix was covered with water, hence, the inability to receive more. Furthermore, a different density was observed after irrigation, indicating a reduced tendency to enter the saturated matrix. All pores with adhesive and cohesive bonds that were filled with irrigation and wastewater no longer could accept more liquid after flooding [11]. This addition moves laterally from superior to lesser energy, or from high to low [5]. Therefore, soil saturation inhibits vertical movement, as the soil turned into mud, while [12] reported paddy soil to possess a plow layer (A and B, with a depth of 20-25 cm), which is dominated by micropores.

TABLE III
SOIL PROPERTIES OF LOCATION 1 THAT WERE NOT CONTAMINATED BY PALM OIL MILL WASTEWATER

No	Parameter	Critical Threshold (PP 150/2000 and LPT 1983)	Analysis results	Critical /not critical
1	Faction Composition	< 18 % colloid; > 80% quarzitic sand	57.06 % 0.28 %	Not critical
2	Volume weight *	> 1.4 g/cm^3	0.35 g/cm^3	Not critical
3	Permeability *	< 0.7 cm/hour; 8.0 cm/hour	0.42 cm/hour	Not critical
4	pH (H2O) 1: 2.5	< 4.5; > 8.5	5.2	Not critical
5	Electrical Conductivity / DHL	> 4.0 mS/cm	9 mS/cm	Critical
6	Total Nitrogen	< 0.10 %	1.12 %	Not critical
7	Phosphorus is available	< 10 ppm	4.60 ppm	Critical
8	K- inter changeable (Cmol / kg)	< 1 Cmol/kg	0.58 Cmol/kg	Not critical
9	CEC (cm / kg)	< 5 Cmol/kg	31.62 Cmol/kg	Not critical
10	C-organic	< 1 %	2.84 %	Not critical

It is also caused by gravitational water when it is minimal because the soil of the rice field has a waterproof plow layer. Consequently, the movement of water to the underground layer is very small. This causes the soil to become saturated and floods and then the water flows downstream along with the flow of irrigation water. Based on this condition, the intrusion of palm oil mills is minimal in its influence on the soil matrix. Therefore, the impact of oil palm water does not affect changing the nature of rice fields.

TABLE IV
THE MEANS OF PADDY SOIL PROPERTIES AT FIVE LOCATIONS BASED ON THE DISTANCE FROM THE WASTE SOURCE

Variable of soil										
No location	Clay	BV	C- org	Permeability	pH	CEC	DHL	N	Phosphor	K
	%	g/cm^3	%	cm/h		me	Sm/cm	%	ppm	me
1	57.06	0.351	2.84	3.91	5.5	31.62	95	1.12	4.6	0.58
2	37.08	0.506	1.68	0.42	5.26	23.54	40	0.58	4.9	0.58
3	26.67	0.708	0.55	0.85	5.18	13.45	17	0.1	0.23	0.58
4	35.34	0.461	1.65	1.94	5.5	22.24	48	0.6	1.61	0.69
5	45.97	0.483	0.75	1.12	5.33	22.57	63	0.53	2.07	0.36

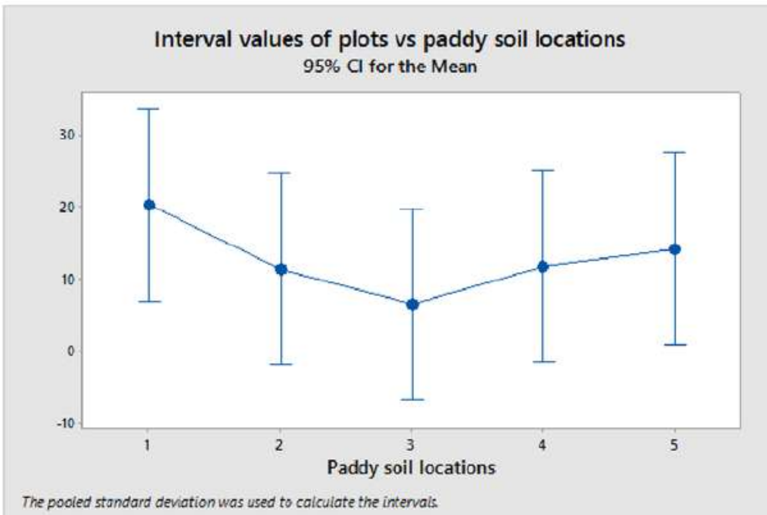

Fig. 3. The means value of soil properties at the research locations.

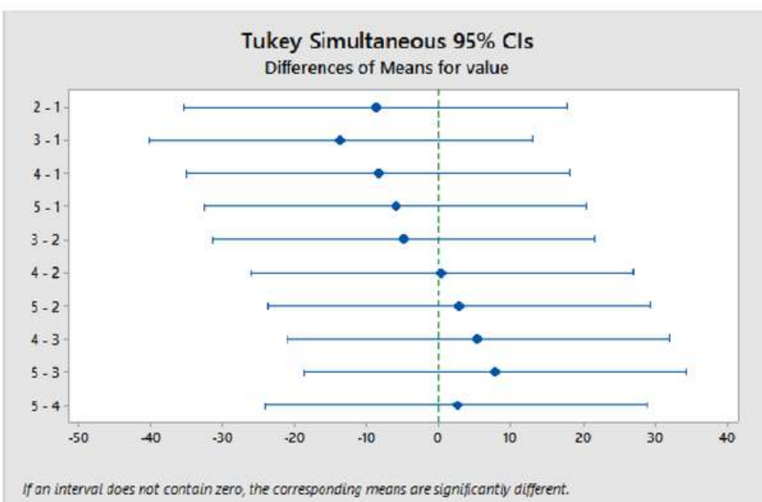

Fig. 4 Grouping the middle value of soil properties based on Fisher's exact test with 95% independency

TABLE V
ANALYSIS OF VARIANCE

Source	DF	Adj SS	Adj MS	F Value	P Value
Location	4	997.2	249.2	0.57	0.684
Error	45	19609.1	453.6		
Total	49	20606.2			

Besides, differences in land properties at each location were identified through one-way ANOVA, as seen in Table 5. This was subsequently followed by Tukey's comparison test, as seen in Table 6, which did not show any significant variations between the uncontaminated (control) and the contaminated fields.

TABLE V
TUKEY'S TEST FOR PAIRWISE COMPARISON OF PADDY FIELDS

Locations	N	Means	Group
Control field 1	10	20.3	A
Location 2	10	14.22	A
Location 3	10	11.80	A
Location 4	10	11.45	A
Location 5	10	6.53	A

The results of the analysis did not indicate any significant differences and influence on the control and the contaminated locations were due to land saturation and water circulation. This was as a result of irrigation and rain. Figure 3 shows the highest value was recorded at location 1 (control), while the lowest mean was at location 3, which was within the 200 m range of the waste pond. The graph of means grouping using Fisher's test shows palm wastewater did not significantly affect soil properties. Figure 4. show group of average value from Fisher's test; the value of the nature of the high ground is more likely to be in the positive zone. Meaning the change in soil properties is not too full due to palm waste. Besides, several studies have reported its capacity to be used as organic fertilizer, and Figure 5 shows the effect on the growth of rice for 2 months.

Fig. 5 Rice growth affected by wastewater spill palm in Manggopoh Village after 2 months.

Organic fertilizers can improve the chemical, physical, and biological properties of soil; hence, manure and compost increase the macro and micronutrient content needed by plants [13]. Organic fertilizers increase soil organic matter content, provide and increase N accumulation, and increase rice production [14], [15]. Organic fertilizer increases soil biological activity and increases plant biomass [16]. Furthermore, they also promote the ability of the root area to provide a better growing medium and increase microorganism activities, which is very useful in the supply of nutrients [17]. Organic compost extends root life and increases leaf photosynthesis [18]. Organic fertilizer reduces total reactive nitrogen loss and increases soil organic carbon uptake [19].

The utilization of oil palm wastewater reduces the need for chemical forms of fertilizers, thus, improving environmental cleanliness through a marked decline in waste accumulation. Agricultural waste tends to be rich in organic matter, which is beneficial for plant growth [20]. The fat content of palm oil wastewater leads to the difficulty of penetration into water-saturated soil matrices; hence, this parameter does not significantly affect the paddy field. Palm oil waste increases soil fertility and increases plant height and number of leaves [21].

IV. CONCLUSION

Field survey and laboratory analysis showed the insignificant effect of wastewater on the properties of soil obtained from Manggopoh village: (1) There was no change of the soil properties for the paddy field that crosses the threshold of the criteria; (2) There was no reduction in the quality of the soil of paddy fields from each sample point location and (3) There was no significant difference between the sample point location, due to changes in soil properties.

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