Pertanika J. of Trop. Agric. Sci. 16(1): 25-29(1993)

ISSN: 0126-6128

Leaching Losses and Nutrient Build-Up in the Soil through Application of Raw and Digested Palm Oil Mill Effluent (POME)

S. PALANIAPPAN
Perbadanan Khidmat Pertanian FELDA
Jalan Maktab, Kuala Lumpur
Malaysia.

ABSTRAK

Kehilangan nutrien melalui larut lesap dari penggunaan effluen kilang kelapa sawit (POME) yang mentah dan juga yang dihadamkan secara anaerobik, telah diuji dalam lysimeter dengan Tanah Siri Segamat sedalam 75sm. POME mentah telah ditabur pada kadar 1.78 mm persamaan hujan (rey)/taburan selama 1175 hari sementara POME yang dihadam telah ditabur pada kadar 3.54 rey/taburan untuk selama 475 hari. Purata penaburan untuk setahun adalah masing-masing sebanyak 463 mm dan 936 mm setara hujan untuk POME mentah dan POME hadam. Kadar kehilangan nutrien Ca, K dan Mg melalui larut lesap dari penaburan POME mentah adalah masing-masing sebanyak 49.8%, 37.7% dan 7.7% manakala dari penaburan POME yang dihadam secara anaerobik pula adalah masing-masing sebanyak 30.7%, 16.3% dan 11.5%. Larutan lesap N dan P dari kedua-dua jenis effluen tersebut adalah kecil.

ABSTRACT

The leaching losses as a result of application of nutrient rich raw and anaerobically digested palm oil mill effluent (POME) onto Segamat Soil Series were studied using lysimeters of 75 cm soil depth. Raw POME was applied at a rate of 1.78mm rain equivalent per year (rey)/application over 1175 days while anaerobically digested POME was applied at a rate of 3.54 rey/application over 475 days. The average yearly application amounted to 463 mm and 936mm rain equivalent for raw and digested POME respectively. The percentage of nutrients leached as a result of applying raw POME was 49.8% for Ca, 37.7% for K and 7.7% for Mg, while for anaerobically digested POME it was 30.7% for Ca, 16.3% for K and 11.5% for Mg. For both effluent types there was very little leaching of total N and P.

Keywords: Palm oil mill effluent (POME), leaching, lysimeter

INTRODUCTION

Palm oil mill effluent (POME) is a by-product in the processing of oil plam fresh fruit bunches (ffb) to produce crude palm oil. About 0.5 - 1.0 tonne of waste-water is produced for every tonne of ffb processed. The raw POME, a golden brownish liquor, is nutrient rich apart from containing carbohydrates, proteins and oil. Untreated fresh POME has a Biochemical Oxygen Demand of about 20,000 ppm making the liquid a strong pollutant if discharged into the water ways in its raw form. With the introduction of the Environmental Quality Act in 1974, the discharge of raw POME into rivers was disallowed. The Environment Quality Regulation (Prescribed Premises) (Crude Plam Oil) 1977 prescribed permissible standards of the water quality which can be discharged.

As an option to dischaging POME into waterways, land application of the effluent both raw (untreated) and anaerobically digested POME have been investigated by many workers (Wood 1981, Tan *et al.* 1982, Lim *et al.*1983, Tan 1983, Lim *et al.* 1983, Tajuddin dan Zakaria 1984, Dolmat 1985).

Little imformation exists on the impact of land application of POME, either raw or anaerobically digested, on the soil and its influence on underground water (Lim 1987, Dolmat *et al.* 1987). To add some understanding in this area, a study on leaching of certain nutrients was conducted at Pusat Perkhidmatan Pertanian Tun Razak, Sg Tekam using lysimeter. Information on nutrient build-up in the soil was also obtained.

MATERIALS AND METHODS

Simple lysimeters were constructed using 200 liter drums of diameters 58.4 cm. The lysimeters were sheltered from the rain. The base of each lysimeter was curved outward and an outlet using a hollow metal rod welded to the base was constructed. This was designed to help in easy collection of the leachate. The base of the lysimeters were filled with stones and pebbles to a depth of about 9cm. Segamat Series Soil (Haplic Acrorthox) a deep friable, heavy textured well drained soil, was selected for this study and it was back filled layer by layer with the lowest profile dug going first into the lysimeter. The depth of each layer was 15 cm and after each layering it was irrigated to facilitate soil settling. The entire soil depth of the lysimeter was 75 cm.

Water was irrigated for a month at a rate of 5370 ml three times a week. This was to help stabilise the soil before the start of the study. Two lysimeters were used for the raw POME application study of which one was used as a control. The study was initiated in August of Year 1. To the treatment lysimeter, 1.78 mm rain equivalent per year (rey) or 456 ml of raw POME was applied each time. To the control, the same volume of water was applied. The amount of raw POME applied per year was 46.3 cm rain equivalent. For land disposal of raw POME, studies by Pillai *et al.* (1978) have shown that application of 480 rain equivalent mm/yr could be applied on land. This high rate was selected for this study. To simulate rainfall, 5370 ml water was applied twice weekly or 2159 rem per year, to both the lysimeters. The leachate was collected the following day and volume recorded. The leachate was stored in a glass container kept in a dark room. Formic acid was added to prevent microbial growth. Fortnightly, samples of water from, both treatment and control leachate were sent for chemical analysis of total-N, P, K Mg and Ca concentrations. The study was terminated in December Year 4 after 1175 days. For every 15 cm depth, a bulk soil sample was taken from each of the four lysimeters at the end of the study. Two sub-samples from each bulk sample were analysed for pH, total-N, available P, and exchangeable K, Mg and Ca. However only the top (0-15 cm) and bottom (61-75 cm) depths are reported. Samples at other depths were used for computing the nutrient bulid-up.

Two more lysimeters were constructed and soil filled in as described earlier. To one, anaerobically digested POME was irrigated at a rate of 3.56 mm rey or 912 ml per application and the same quantity of water was applied to the other which served as a control. As an average the amount of digested POME applied per year was 936 mm rain equivalent. The amount is twice that applied for raw POME. One of the problems attributed to high rates of raw POME application was the rapid build-up of solids. In digested POME the suspended solids are only about 30% of that of raw POME. In view of this the double rate of raw POME application was selected for this study. As before 5370 ml of water was irrigated twice weekly to simulate rainfall. The study was terminated after 475 days. The same procedure was followed for collection of leachate and soil and their analysis.

RESULTS AND DISCUSSION

The data have been analysed and presented on a calendar year basis. For the amount of water applied, only about 40-60% was collected as leachate after each irrigation over the 4 years.

The raw and digested POME vary greatly in the nutrient contents. The amount of nutrients present depends on a number of factors e.g. dilution as a result of water usage during processing, nutrient content in oil palm fresh fruit bunches, etc. As such only an average figure was computed for use in calculations. Table 1 gives the nutrient content of raw and digested POME.

The volume of raw POME added over 4 years (1175 days) was 382 litres while for digested POME 312 l were applied over 2 years (475 days). Table 2 give the total quantity of

TABLE 1
Certain characteristics of raw and anerobically* digested (Supernatant) POME

	Raw POME (ppm)	Digested POME (ppm)
N	380	227
P	70	31
K	990	1542
Mg	242	247
Ca	330	256
Total solid	34260	12408
Suspend solid	19990	5456
BOD	20790	2240
pH	4.0	7.0

* 20 days retention time in a tank digester.

TABLE 2
Quantity of nutrients added in lysimeter through raw and digested POME application

POME	Volume Applied (l)	Nutrient Content (g)				
		N	P	K	Mg	Ca
Raw	382	152.8	24.3	378.1	92.4	126.0
Digested	312	70.8	9.7	480.7	77.0	79.8

Note: Raw POME applied over 1175 days and digested POME over 475 days.

nutrients added over the peroid of study through application of raw and digested POME. The amount of nutrients applied in order of descending quantity for raw POME was K > N > Ca > Mg > P and for digested POME it was K > Ca > Mg > N > P. It is most probable that Ca and Mg had leached out faster from the organic matter into the liquid fraction of the anaerobically digested POME than for N where mineralisation could have been slow.

Table 3 gives the total amount of nutrients leached out from the lysimeters as a result of raw and digested POME application. The amount of POME nutrients leached out is computed by

TABLE 3
Total quantity of nutrients leached through application of raw* and digested** POME over the period of study

POME	Nutrient Content Leached (mg)				
	N	P	K	Mg	Ca
Raw	550	60	142410	7080	62750
Digested	650	50	78380	8850	24460

* Period of study 1175 day, Volume applied 382 1
** Period of study 475 days, Volume applied 312 1

TABLE 4
Percentage of nutrients leached as compared to amount added via raw POME application

(Year)	% Leached Period				
	N	P	K	Mg	Ca
1	Neg	1.4	1.2	1.7	22.4
2	Neg	0.1	13.1	8.4	34.9
3	0.6	0.4	74.8	13.3	43.6
4	0.7	0.3	39.5	3.3	48.5
Over 4 years*	0.4	0.2	37.7	7.7	49.8

*1175 days

TABLE 5
Percentage of nutrients leached as compared to amount added via digested POME application

Period (Year)	% Leached				
	N	P	K	Mg	Ca
1	1.1	0.2	2.9	2.9	28.5
2	0.9	0.7	22.2	15.3	31.6
Over 2 years*	0.9	0.5	16.3	11.5	30.7

* 475 days

subtracting the control leacheate from the treatment leacheate on a yearly basis. For the raw and digested POME treatments the nutrient content leached in descending order was the same i.e K > Ca > Mg > N > P. This order was similar to the amount of nutrients applied via digested POME but differed from raw POME application where N content was substantially higher.

Tables 4 and 5 give the percentage nutrient leached as compared to the amount of nutrients applied through raw and digested POME applications, respectively. For raw POME the first two years showed no traces of N leached although the remaining two years showed only neglible leaching. In the case of P, the amount leached was generally less than N over 4 years. In digested POME application, the N and P leached were also low although the percentages were higher than in raw POME application. The lower leaching of P is expected as its mobility through the soil is slow. Phosphorus is generally fixed in acidic soils. The bulk of N, especially in raw

POME, could have been immobilised as it is probably organically bound. The mineralisation rate of N as a result of POME application has been reported to be slow (V. M. Palaniappan and S. Palaniappan 1980).

The nutrient that leached most over the 1175 days of raw POME application was calcium (49.8%), follwed by potassium (37.7%) and to a lesser extent magnesium (7.7%). For digested POME aplication over the 475 days the same order of leaching prevailed with Ca (30.7%), K (16.3%) and Mg (11.5%).

Table 6 gives the soil nutrient status of the top 15 cm of soil and the lower most 15 cm depth (61-75 cm) for control and POME treated lysimeters. For the 0-15 cm depth, marked increases as compared to control were noted in pH (70%), total-N (76%), available P (340%) and exchangeable K (140%), exchangeable Ca (270%) and exchangeable Mg (270%) for raw POME application. For digested POME the changes were pH (55%), N (18%), available P (230%), exchangeable K (110%), exchangeable Ca (160%) and cxchangeable Mg (150%) for the top 15 cm. For soil treated with raw POME over 1175 days, the 61-75 cm soil depth also showed significant increases in all parameters measured. However, to digested POME applied over 475 days this was not apparent.

Table 7 gives an extrapolation of the nutrient bulid-up in the 75 cm soil profile as a result of raw and digested POME appplication using the same rates over 1 ha. The extrapolation was based on converting the extra nutrient content (treated soil content - control soil content) for each 15 cm soil depth over a hectare basis. The value for each nutrient for the five 15 cm depths was added to give the total nutrient build-up over the 75 cm soil profile. It can be observed that at these rates of application the nutrient accumulation in the soil can be significant over time. The abundance of 'excess' nutrients in the soil through raw and digested POME application was the same following the order K > N > Mg > Ca > P.

The enrichment of the soil through POME application (raw or digested) can be observed

TABLE 7
Amount of nutrients (kg/ha) accumulated in the 75 cm soil depth as a result of raw and digested POME application*

Nutrient	Nutrients Accumulated (kg/ha)	
	Raw POME Applucation	Digested POME Application
N	5400	2620
P	1000	360
K	8800	15030
Mg	3190	2550
Ca	2360	2070

*Equivalent to - 14,258,914 l/ha of raw POME applied over 1175 days
- 11,646,024 l/ha of digested POME applied over 475 days.

TABLE 6
Some chemical analysis of Segamat series soil at 0-15 cm and 61-75 cm depth treated with raw and digested POME application

Soil Depth (cm)	pH	Total N (%)	Available P (ppm)	Exchangeable (meq/100g soil) K	Mg	Ca
Control						
0-15	4.7	0.17	23	2.25	1.68	2.29
61-75	5.0	0.15	4	0.19	0.20	5.62
Raw POME Application						
0-15	8.0	0.30	102	5.48	6.24	8.54
61-75	6.0	0.20	25	2.44	2.13	7.42
Digested POME Application						
0-15	7.3	0.20	75	4.75	4.24	5.96
61-75	4.3	0.14	8	0.20	0.21	1.42

by studies on responses to growth and yield of plants (S. Palaniappan and V.M. Palaniappan 1981, Yeow and Zin 1981, Palaniappan and Rusdi 1986). Nevertheless differential build-up and leaching of nutrients in the soil over long periods of application, could lead to an imbalance of nutrients for plant uptake. The high K build-up could lead to a suppression of Mg uptake. High Ca could in turn affect K and Mg uptake. The increase in Ca would reduce phosphate availability through the formation of calcium phosphates. Nevertheless with close monitoring of POME (raw or digested) application on land, through regulated quantities, an imbalance situation could be minimized. Futhermore if some imbalances persist they can be rectified through the use of inorganic fertilisers to amend the situation. Application of POME onto land not only helps overcome the disposal of the polluting waste water but its ulitisation in the field would help improve yield and cut down production cost.

ACKNOWLEDGEMENTS

The author wishes to acknowlegge the assistance of Mr. Rusdi Embong and is grateful to the General Manager, FELDA Agricultural Services Corporation for permission to publish this paper.

REFERENCES

LIM, C.H., T.C. P'NG, K.W. CHAN, and S.Y. CHOOI. 1983. Land application of digested POME by sprinkler system. *Proc. Seminar on Land Application of Palm Oil and Rubber Factory Effluents.* MSSS, Kuala Lumpur.

LIM, K.H. 1987. Trials on long-term effects of application of POME on soil properties, oil palm nutrition and yields. Presented at the *1987 International Oil Palm/Palm Oil Conference.* PORIM, Kuala Lumpur.

LIM K.H., B.J. WOOD, A.L. LAI, W. SULAIMAN and M. SUHAIMI. 1983. Land application of digested POME supernatant on oil plam using a flatbed system. *Proc. Seminar on Land Application of Palm Oil and Rubber Factory Effluent.* p. 90-103. MSSS, Kuala Lumpur.

MOHD. HASHIM TAJUDDIN and Zin Z. ZAKARIA. 1984. Present status of land application of POME. *Proc. Workshop on Review of POME Technology vis-a-vis DOE Standard.* PORIM, Kuala Lumpur.

MOHD. TAYEB HJ. DOLMAT. 1985. Land application of POME; Efficacy of methods used. *Proc. National Symposium on Oil Palm By-Products for Agro-Based Industries.* PORIM, Kuala Lumpur.

MOHD. TAYEB HJ. DOLMAT, K.H. LIM, ZIN Z. ZAKARIA and A. HALIM HASSAN. 1987. Recent studies on the effects of land application of POME on oil palm and the environment. Presented at the *1987 International Oil Palm/Palm Oil Conference.* PORIM, Kuala Lumpur.

PALANIAPAN, S. and V.M. PALANIAPPAN. 1981. Potentials of palm oil mill effluent (POME) as a manure for plant growth. *Proc. UNESCO Regional Symposium/Workshop on Biotechnology in the Utilisation of Renewable Resources.* Kuala Lumpur.

PALANIAPPAN, S. and RUSDI EMBONG. 1986. Penggunaan sisa kilang sawit (POME) bagi tanaman kontan. *Kemajuan Penyelidikan* **7(1):** 7-10.

PALANIAPPAN, V.M. and S. PALANIAPPAN. 1980. Utilisation of palm oil mill effluents as source of nitrogen. *Proc. Conf. on Soil Science and Agricultural Development in Malaysia.* Kuala Lumpur 12th - 14th May, 1980.

PILLAI, K.R. CHOOI SIEW YUEN and B.J. WOOD. 1978. A review of practical experiences in dealing with POME. *Symp. on Malaysian Environ.* RESCAM. Complex. Penang Sept.

TAM T.K., K.H. YEOW and Y.C. POON 1982. Land application of POME H & C experience. *Proc. PORIM Regional Workshop on Plam Oil Mill Technology and Effluent Treatment.* Kuala Lumpur.

TAN K.S. 1983. Land application of digested POME to mature oil palm on inland soils. *Proc. Seminar on Land Application of Palm Oil and Rubber Factory Effluents.* MSSS, Kuala Lumpur.

WOOD B.J. 1981. KGSB experience with POME control–by land application raw or after anaerobic digestion. *Proc 3 MOPGC Symposia on Treatment and Disposal of POME.* Kuala Lumpur.

YEOW, K.H. and Zin, Z. ZAKARIA. 1981. MOPGC/PORIM progress report on palm oil mill effluent utilisation. *Proc. PORIM National Workshop on Oil Palm by Product Utilisation.* Kuala Lumpur.

(Received 24 July 1992)