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Comparative Study of Rubber Effluent and an Inorganic Fertiliser as Sources of Plant Nutrients for Hevea *and Their Effects on Soil Properties*

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Leachate collected from soils to which rubber effluent was applied contained consistent levels of ammonium nitrogen (NH_4-N), whereas the amount of NH_4-N in leachate from fertiliser-treated soils fluctuated, at times being significantly higher than those from effluent-treated soils. Leachate from effluent-treated soils had higher levels of potassium (K), magnesium (Mg) and calcium (Ca) compared to those from fertiliser-treated soils. The frequency of effluent application affected only the level of NH_4-N in the leachate and application at a lower frequency produced leachate with lower concentrations. Soils treated with rubber effluent had higher nutrient contents than fertiliser-treated soils but rubber seedlings grown on fertiliser-treated soils had higher leaf nitrogen contents than those grown on effluent-treated soils. There was no significant difference in latex yield produced by the effluent-treated seedlings and the fertiliser-treated seedlings.

Application of rubber factory effluent to the land has been shown to be an environmentally acceptable and economically viable alternative treatment for the effluent[1-6]. Studies have also indicated the potential of the effluent as a source of fertilisers and water for crops[4-10]. However, the effects of its application to soil, plant and the groundwater compared to fertiliser application need to be investigated. This study was carried out to obtain some information on the effects of rubber effluent applied as a fertiliser in these areas.

TABLE 1. SOME PHYSICO-CHEMICAL CHARACTERISTICS OF RENGAM SERIES SOIL[11]

Chemical property	Depth 0–10 cm	Depth 10.1–74 cm
pH	4.01	4.46
N (%)	0.171	0.075
Exch. K (m-equiv./100 g)	0.24	0.10
Exch. Ca (m-equiv./100 g)	0.23	0.10
Exch. Mg (m-equiv./100 g)	0.47	0.44
CEC (m-equiv./100 g)	8.46	3.51

Permeability: Moderate

Particle size distribution:

	0–10 cm depth	10.1–74 cm depth
Coarse sand	37.9%	32.9%
Fine sand	9.8%	7.4%
Silt	10.8%	6.7%
Clay	41.8%	54.2%

MATERIALS AND METHODS

The study was carried out using lysimeters (75 cm height; 30 cm internal diameter) under glasshouse conditions. The lysimeters were filled with air-dried soil (34 kg) of Rengam Series (Typic Paleudult). Some characteristics of Rengam Soil Series are shown in *Table 1.* Three germinated seedlings (three-week-old GT 1) were planted in each lysimeter. After three weeks, two plants of the same vigour were selected for the experiment.

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The details of the treatments in this experiment are listed in *Table 2*. For each treatment, three replications were carried out. All the lysimeters received 600 ml liquid (effluent/water) per day. Chemical properties of the rubber factory effluent applied in the experiment are shown in *Table 3*. The fertiliser was applied at two months' intervals split into six applications.

Leachates from the lysimeters were collected in Winchester bottles which were connected by glass-tubing to a hole drilled at the bottom of each lysimeter. Leachates which accumulated were periodically collected and analysed for NH_4-N, total N, NO_3-N, K, Ca, Mg, Zn, P and BOD contents. Chemical analysis of the leachates was carried out according to the methods described earlier[12].

After six and ten months of growth of the seedlings, foliar analyses (N content) of the second whorl leaves of the seedlings were carried out. Nitrogen content was determined using the auto-analyser method[13].

Rubber yields of the seedlings were also obtained after six and ten months of growth using micro-tapping as the exploitation method.

TABLE 2. DETAILS OF TREATMENTS APPLIED IN GLASSHOUSE LYSIMETRIC STUDIES

Treatment	Rate of N application (g/pot/year)	Source (amount/pot/year)	Application
E_0 (control)	—	Water only	600 ml per day
F_1	20	95.24 g sulphate ammonia 95.0 g CIRP 28.6 g KCl 19.24 g $MgSO_4$	6 split applications
F_2	30	142.86 g sulphate ammonia 142.50 g CIRP 42.99 g KCl 28.86 g $MgSO_4$	6 split applications
E_1F_1	20	40 litres raw rubber effluent 77.78 g CIRP 8.66 g KCl 11.54 g $MgSO_4$	Effluent applied 5 times per week at 160 ml per application Fertiliser applied in 6 split applications
E_1F_2	20	40 litres raw rubber effluent 77.78 g CIRP 8.66 g KCl 11.54 g $MgSO_4$	Effluent applied at 2 times per week at 400 ml per application Fertiliser applied in 6 split applications
E_2F_1	30	60 litres raw rubber effluent 116.67 g CIRP 12.99 g KCl 17.31 g $MgSO_4$	Effluent applied at 5 times per week at 160 ml per application Fertiliser applied in 6 split applications
E_2F_2	30	60 litres raw rubber effluent 116.67 g CIRP 12.99 g KCl 17.31 $MgSO_4$	Effluent application at 2 times per week at 400 ml per application Fertiliser applied in 6 split applications

TABLE 3. CHARACTERISTICS OF THE RUBBER EFFLUENT APPLIED IN THE LYSIMETRIC STUDY

Parameter	Range	Mean
pH	5.10 - 7.98	5.64
BOD	750 - 5 800	2 195
COD	1 561 - 16 846	5 507
Total N	152 - 1 620	676
Ammoniacal N	123 - 642	331
Nitrate	0 - 5	1
P	20 - 70	43
K	12 - 375	173
Mg	<1 - 47	16
Ca	<1 - 75	27
Zn	<1 - 101	7

All parameters are expressed in milligrammes/litre except pH

At the end of twelve months, soils from each lysimeter were sampled at three different depths, *viz.* 0 - 12.5 cm, 12.6 - 30 cm and 30.1 - 52.5 cm. The soils were analysed for total N, total P, total K, exchangeable K, total Ca, exchangeable Ca, total Mg and exchangeable Mg contents; pH of the soils was also determined[14].

RESULTS AND DISCUSSION

Characterising the leachate produced during the application of rubber effluent as a source of plant nutrients is important in determining the would-be effect of the application on the groundwater quality. *Figure 1* shows the NH_4-N concentration of leachates collected from the lysimeters at various periods of the study. Concentration of NH_4-N was negligible during the first two-and-a-half months of experimentation. This could be due to the

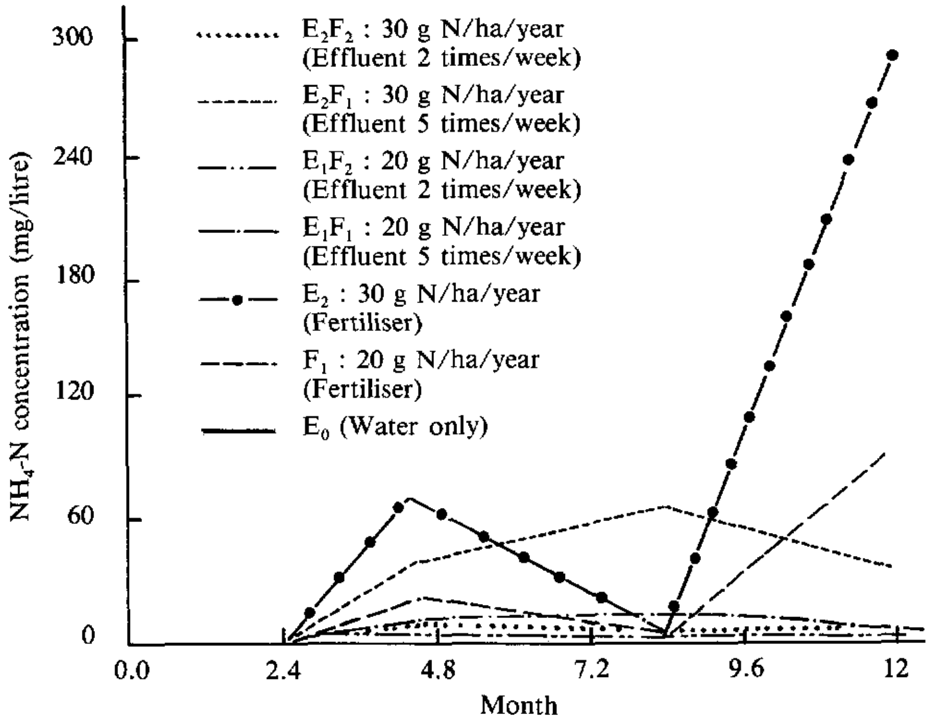

Figure 1. Ammoniacal nitrogen concentration of leachates collected from lysimeters at various periods.

NH_4-N in the effluent applied undergoing fixation in the soil, nitrification, uptake by the plants, denitrification and volatilisation.

NH_4-N in the leachates from all the lysimeters except from that receiving twice-weekly application at the rate of 20 g N per year, was noticeable only after four-and-a-half months. This treatment produced leachate with negligible concentration of NH_4-N throughout the period of study.

Leachates collected from the effluent-applied lysimeters contained consistent levels of NH_4-N after four-and-a-half months of application whereas fluctuations of NH_4-N levels were observed in leachates from the fertiliser-applied lysimeters. Consistent application of NH_4-N in the form of effluent throughout the study could be the cause for effluent-applied lysimeters to produce leachates with consistent levels of NH_4-N whereas fertiliser-applied lysimeters were applied with NH_4-N once in two months. Significant differences in the NH_4-N content between treatments were observed for leachates collected at four-and-a-half, eight-and-a-half and twelve months after treatment *(Table 4)*. For the earlier collections, there were no significant differences in the NH_4-N content of the leachates. Leachates collected from the fertiliser-applied lysimeters at twelve months contained higher NH_4-N than those from the effluent-applied lysimeters. Leachates from lysimeters with fertiliser applied at the rate of 30 g N per year had higher contents of NH_4-N compared to the rest of the treatments *(Table 5)*. Leachates from lysimeters with effluent applied twice-weekly contained lower NH_4-N compared to leachates from lysimeters with effluent applied at a frequency of five times per week *(Table 5)*. Application of effluent twice-weekly provided dry and wet periods in the soil environment which favoured nitrification and denitrification processes thus reducing the NH_4-N content of leachates from the lysimeters.

Figure 2 shows the NO_3-N concentration of leachates collected from the lysimeters at various time intervals. Leachates from all the lysimeters showed high concentrations of NO_3-N at the beginning of the experiment, indicating that the nitrification process had taken place in the soils before they were placed in the lysimeters. After four-and-a-half months, NO_3-N levels in the leachates from all the lysimeters started to decrease. Nitrification could still be occurring during this period but the nitrate formed could have undergone denitrification. Denitrification requires an anaerobic condition. Mohd. Tayeb *et al.*[3] reported that an anaerobic condition could have been created in the soil as application of rubber effluent to soil increased the bulk density of the soil and reduced its total porosity. Furthermore, the presence of a high concentration of carbon in the effluent encouraged the growth of denitrifiers in the soil. In this regard, up to eight-and-a-half months after treatment, there were no significant differences between treatments in the NO_3-N contents in the leachates from all the lysimeters *(Table 4)*. At twelve months, however, leachates from the fertiliser-applied lysimeters had significantly higher NO_3-N content than those from the effluent-applied lysimeters *(Table 5)*.

Figure 3 shows the total nitrogen contents of leachates from all the lysimeters. These values are similar to those shown for NH_4-N contents in *Figure 1*.

Figure 4 shows K concentration of leachates collected from the lysimeters during the study. Significant differences in K concentration between treatments were observed for leachates collected at four-and-a-half, eight-and-a-half and twelve months after treatment *(Table 4)*. At twelve months, K concentrations from effluent-applied lysimeters were significantly higher than those from the fertiliser-applied lysimeters *(Table 5)*. This could be due to the soil having reached its saturation point in absorbing K.

Figure 5 shows the concentrations of Ca in leachates at various periods during the study. Differences between treatments were observed at eight-and-a-half and twelve months. At twelve months, Ca concentrations in the leachates from effluent-applied lysimeters were significantly higher than those from fertiliser-applied lysimeters *(Table 5)*. Effluent application five times per week produced leachates with

TABLE 4. EFFECTS OF VARIOUS TREATMENTS ON CHARACTERISTICS OF LEACHATE (ANALYSIS OF VARIANCE)

Time (months)	Parameter (mean squares)								
	Total-N	NH_4-N	NO_3-N	K	Ca	Mg	Zn	BOD	P
0	0.5556 $P<0.1$	0.9841 NS	262.555 NS	8.1905 NS	0.0000 NS	0.0000 NS	—	3.6349**	—
1.0	0.2222 NS	0.2063 NS	653.2069 NS	11.9365 NS	120.1905 NS	0.0000 NS	0.3175 NS	1.6349	—
2.5	0.4286*	0.0000 NS	574.9053 NS	18.9048 NS	0.4048*	0.0714 NS	1.0000 $P<0.1$	0.8730 NS	—
4.5	1929.1108***	1901.7141***	26890.1593 NS	444.1111**	6.1587 NS	1.4921 NS	3.1111**	4.9841 NS	0.0952 NS
8.5	2330.7974***	1611.5393***	1415.6348 $P<0.1$	7587.7139***	7004.7627*	1013.7461*	1.5238 NS	2.5288 NS	0.3810 NS
12.0	50326.6484***	34351.9922***	377.5555***	4508.7783***	676.9364*	875.0476*	1.0952 NS	1.3333 NS	1.9683 NS

TABLE 5. EFFECTS OF VARIOUS TREATMENTS ON CHARACTERISTICS OF LEACHATES (DUNCAN'S MULTIPLE RANGE TEST, 5% LEVEL)

Treatment	At 2.5 months		At 4.5 months		At 8.5 months		At 12.0 months	
	Treament	Mean	Treatment	Mean	Treatment	Mean	Treatment	Mean
Total nitrogen	E_0	3.0000	E_0	4.0000	E_1F_2	3.0000	E_0	6.0000
	F_1	3.5000	E_1F_2	7.3333	E_0	4.0000	E_1F_1	11.0000
	E_2F_1	3.5000	E_1F_1	17.0000	F_1	6.3333	E_1F_2	14.3333
	E_2F_2	3.5000	E_2F_2	17.0000	E_2F_2	12.3333	E_2F_2	17.6667
	F_2	4.0000	F_1	28.0000	E_1F_1	19.3333	E_2F_1	42.3333
	E_1F_1	4.0000	E_2F_1	43.6667	F_2	46.5000	F_1	106.6667
	E_1F_1	4.0000	F_2	76.6667	E_2F_1	77.3333	F_2	363.0000
Ammonical-N			E_0	0	E_1F_2	1.0000	E_1F_2	1.6667
			E_1F_2	0.6667	E_0	1.3333	E_0	2.3333
			E_2F_2	12.0000	F_1	4.3333	E_1F_1	6.6667
			E_1F_1	14.6667	E_2F_2	6.3333	E_2F_2	9.6667
			F_1	25.0000	F_2	11.0000	E_2F_1	36.3333
			E_2F_1	39.6667	E_1F_1	15.6667	F_1	97.3333
			F_2	71.0000	E_2F_1	66.3333	F_2	294.0000
Nitrate-N							E_0	0
							E_1F_2	1.0000
							E_2F_1	1.6667
							E_2F_2	2.6667
							E_1F_1	6.6667
							F_1	15.6667
							F_2	30.6667
Potassium			E_0	0	E_0	0.6667	F_1	3.0000
			E_1F_1	11.0000	E_1F_2	0.6667	F_2	4.3333
			E_2F_2	12.3333	F_1	15.0000	E_0	15.6667
			F_1	16.6667	E_1F_1	52.0000	E_1F_2	49.0000
			F_2	17.0000	E_2F_2	53.3333	E_1F_1	57.0000
			E_1F_2	17.0000	F_2	55.0000	E_2F_1	64.0333
			E_2F_1	40.3333	E_2F_1	145.6667	E_2F_2	110.0000
Magnesium					E_1F_2	0	E_1F_2	0
					F_1	13.6667	F_1	1.6667
					E_0	26.3333	F_2	10.6667
					E_1F_1	26.3333	E_0	21.0000
					F_2	34.6667	E_1F_1	21.0000
					E_2F_2	48.0000	E_2F_1	40.6667
					E_2F_1	52.3333	E_2F_2	42.3333
Calcium					E_1F_2	12.0000	F_1	10.0000
					E_0	14.6667	F_2	20.6667
					F_1	42.3333	E_0	31.3333
					E_1F_1	86.3333	E_1F_2	35.3333
					E_2F_1	96.3333	E_2F_2	45.6667
					E_2F_2	107.6667	E_1F_1	46.0000
					F_2	136.6667	E_2F_1	51.6667

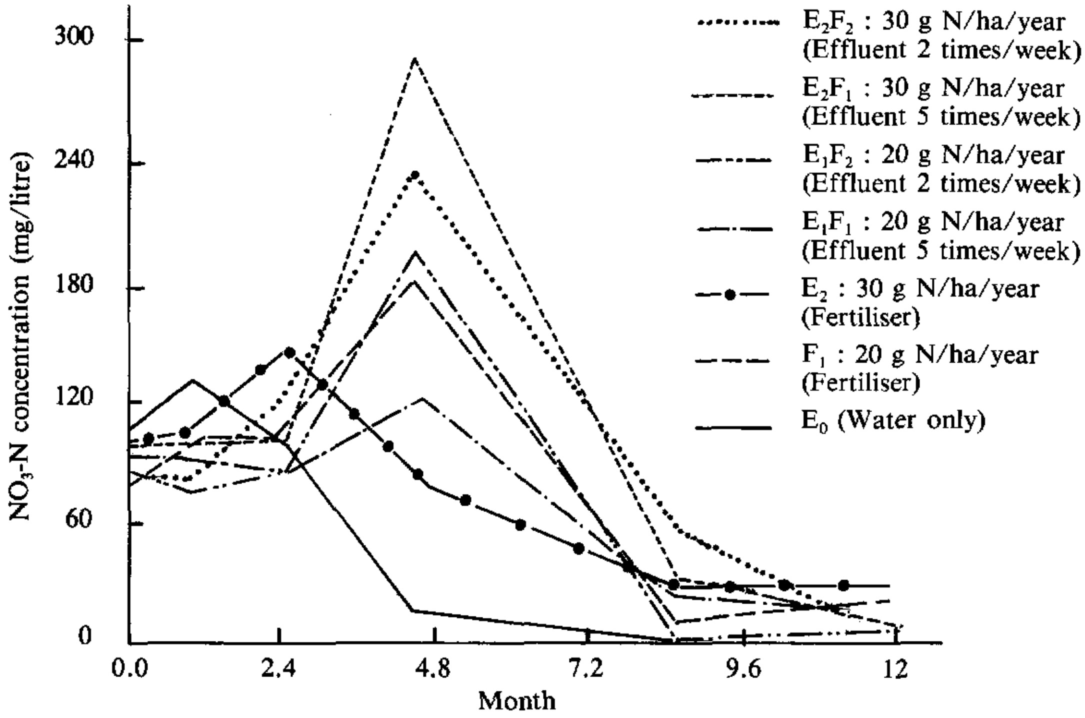

Figure 2. Nitrate nitrogen concentration of leachates collected from lysimeters at various periods.

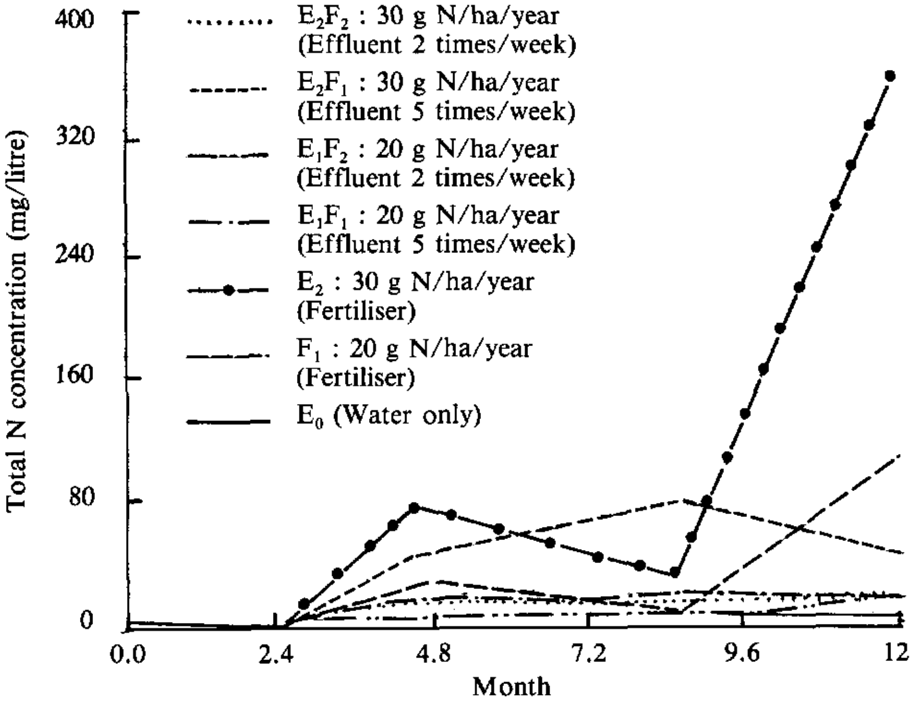

Figure 3. Total nitrogen contents of leachates from all the lysimeters.

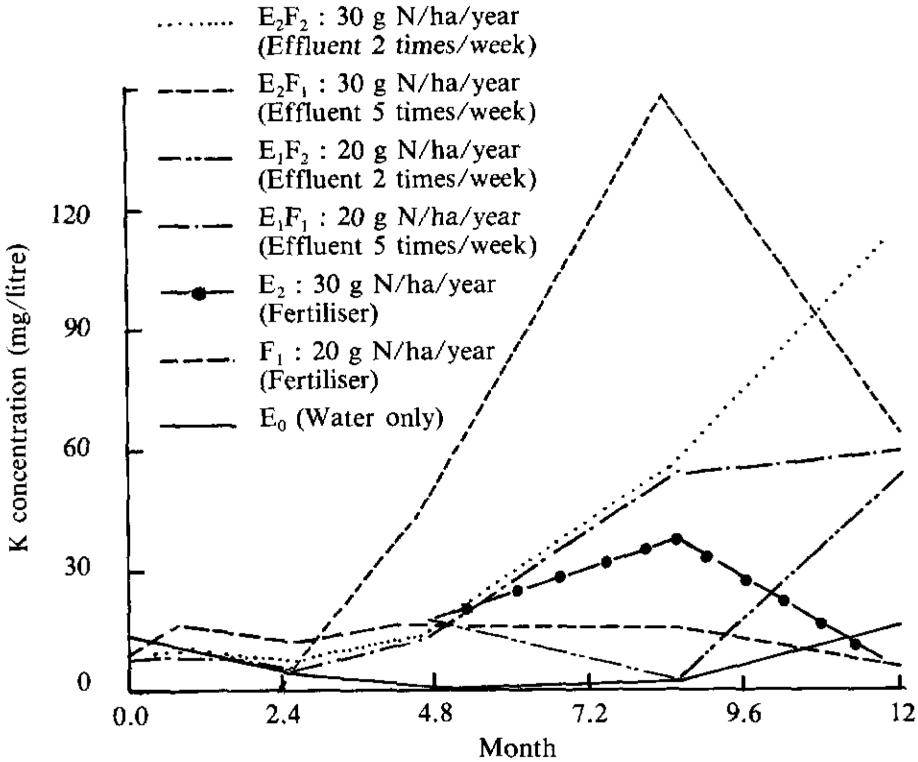

Figure 4. Potassium concentration of leachates collected from lysimeters during the study.

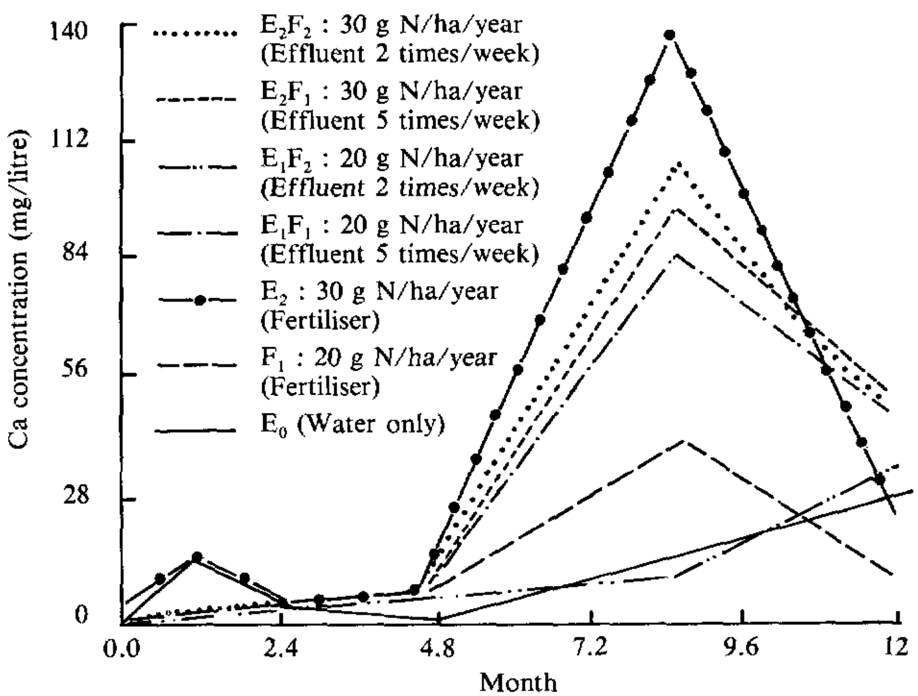

Figure 5. Calcium concentration of leachates collected from lysimeters during the study.

higher concentrations of Ca than twice-weekly application *(Table 5)*.

Figure 6 shows Mg concentrations in the leachates from the lysimeters at various periods of the study. Negligible concentrations of Mg were observed from lysimeters with effluent applied twice-weekly at the rate of 20 g N per year but Mg leaching was observed when the frequency of effluent application was increased to five times per week. Mg leaching was also observed when the rate of effluent application was increased to 30 g N per year. Differences between treatments were observed at eight-and-a-half and twelve months after treatment *(Table 4)*. At twelve months after treatment, effluent application produced higher concentrations of Mg in the leachates compared to fertiliser application *(Table 5)*.

The levels of Zn, P and BOD of leachates from all the lysimeters were very low *(Table 6)*. Application of effluent to the soil was observed to give good removal of BOD in the rubber effluent. The United States Environmental Protection Agency[15] also reported similar experiences in treatment of effluent from municipal waste. There were no significant differences between treatments in the concentrations of Zn, P and BOD in the leachates from all the lysimeters *(Table 4)*.

Chemical properties of the soils in the lysimeters after the application of fertiliser and rubber effluent are shown in *Table 7*. No differences were observed in the N content in the soils treated with fertiliser and those treated with rubber effluent; this is expected since in both treatments the soils received about similar rates of nitrogen. However, effluent-treated soils contained higher concentrations of total P, total K, total Ca and total Mg than fertiliser-treated soils and application of effluent five times per week was more effective than the twice-weekly application. Soil pH was not affected by the application of effluent.

The N contents of the leaves of the rubber seedlings after six and ten months of growth are shown in *Table 8*. Application of effluent

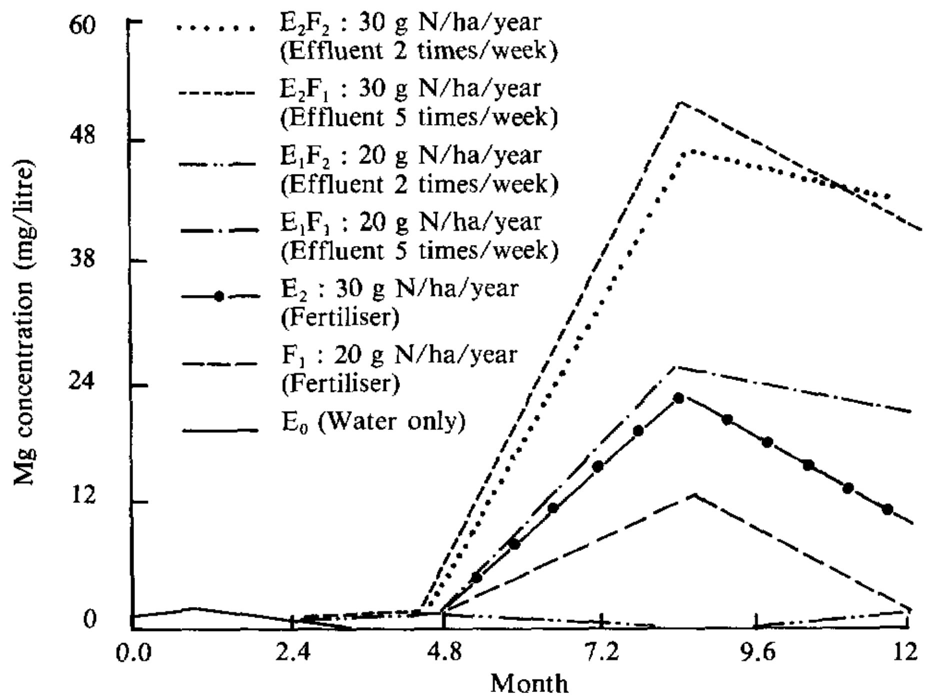

Figure 6. Magnesium concentration of leachates collected from lysimeters during the study.

TABLE 6. CONCENTRATIONS OF BOD, ZINC AND PHOSPHORUS IN LEACHATES

Time (months)	Treatment																				
	E_0			F_1			F_2			E_1F_1			E_1F_2			E_2F_1			E_2F_2		
	BOD	Zn	P	BOD	Zn	P	BOD	Zn	P	BOD	Zn	P	BOD	Zn	P	BOD	Zn	P	BOD	Zn	P
0	1	—	—	0	—	2	0	—	2	0	—	2	1	—	1	3	—	1	1	—	1
1.0	3	<1	—	1	<1	—	1	<1	—	2	<1	—	2	1	—	1	1	—	1	1	—
2.5	3	<1	—	1	2	1	2	1	4	1	<1	1	2	1	1	2	2	<1	1	<1	<1
4.5	<1	<1	1	0	2	1	0	3	1	1	1	1	1	2	1	1	3	1	0	3	1
8.5	3	<1	<1	0	<1	1	3	2	1	5	1	1	2	<1	1	2	2	1	4	1	1
12.0	1	<1	1	2	<1	1	3	1	1	0	<1	1	1	<1	3	1	<1	1	3	1	1

E_0 = Water only
F_1 = *Fertiliser applied at 20 g N/year*
F_2 = Fertiliser applied at 30 g N/year
E_1F_1 = Effluent applied at 20 g N/year, 5 times per week
E_1F_2 = Effluent applied 20 g N/year, 2 times per week
E_2F_1 = Effluent applied 30 g N/year, 5 times per week
E_2F_2 = Effluent applied 30 g N/year, 2 times per week

TABLE 7. SELECTED CHEMICAL PROPERTIES OF SOIL SAMPLES TREATED WITH FERTILISERS AND RUBBER EFFLUENT

Parameter	Depth (cm)	Treatment						
		Control	F_1	F_2	E_1F_1	E_1F_2	E_2F_1	E_2F_2
pH	0.0 - 12.5	4.30	3.80	3.90	4.00	4.00	4.20	4.10
	12.6 - 30.0	4.40	3.90	3.80	4.10	4.10	4.00	4.10
	30.1 - 52.5	4.40	4.00	4.00	4.00	4.00	4.00	4.00
Total N (%)	0.0 - 12.5	0.10	0.11	0.13	0.11	0.13	0.13	0.13
	12.6 - 30.0	0.10	0.11	0.11	0.10	0.10	0.11	0.10
	30.1 - 52.5	0.12	0.11	0.12	0.11	0.10	0.10	0.11
Total P (p.p.m.)	0.0 - 12.5	171	1 096	1 636	1 165	1 323	2 064	1 721
	12.6 - 30.0	168	304	432	548	436	925	714
	30.1 - 52.5	169	267	352	500	394	674	516
Total K (m-equiv./100 g)	0.0 - 12.5	0.18	0.50	0.65	0.66	0.53	0.77	0.75
	12.6 - 30.0	0.21	0.44	0.86	0.56	0.47	0.88	0.81
	30.1 - 52.5	0.16	0.46	0.86	0.48	0.40	0.81	0.67
Exchangeable K (m-equiv./100 g)	0.0 - 12.5	0.06	0.39	0.50	0.53	0.39	0.58	0.57
	12.6 - 30.0	0.04	0.29	0.67	0.43	0.35	0.66	0.58
	30.1 - 52.5	0.03	0.36	0.67	0.43	0.29	0.69	0.52
Total Ca (m-equiv./100 g)	0.0 - 12.5	0.34	7.40	11.14	7.90	6.67	12.42	8.35
	12.6 - 30.0	0.27	1.97	3.13	3.54	2.50	6.85	5.91
	30.1 - 52.5	0.27	1.54	2.91	2.53	2.46	5.23	4.02
Exchangeable Ca (m-equiv./100 g)	0.0 - 12.5	0.22	1.05	1.54	1.05	1.10	1.37	1.11
	12.6 - 30.0	0.16	0.59	0.90	0.82	0.76	1.22	0.97
	30.1 - 52.5	0.22	0.90	1.27	0.92	0.84	1.22	0.93
Total Mg (m-equiv./100 g)	0.0 - 12.5	0.36	0.58	0.67	0.78	0.57	0.93	0.80
	12.6 - 30.0	0.20	0.79	0.93	0.73	0.65	1.04	1.25
	30.1 - 52.5	0.22	0.83	1.47	0.66	0.65	1.13	0.94
Exchangeable Mg (m-equiv./100 g)	0.0 - 12.5	0.04	0.35	0.54	0.64	0.44	0.67	0.63
	12.6 - 30.0	0.04	0.38	0.75	0.50	0.47	0.88	0.79
	30.1 - 52.5	0.04	0.59	1.18	0.62	0.51	0.97	0.74

five times per week resulted in leaves with higher N contents compared to application twice per week. Application of N at higher frequencies enhanced its uptake by the plants probably due to sustained increased availability of the nutrient. The N contents of leaves of

TABLE 8. NITROGEN CONTENT OF SECOND-WHORL LEAVES FOR FIRST PLANT (SIX MONTHS' OLD) AND SECOND PLANT (TEN MONTHS' OLD)

Treatment	N concentration (%)	
	1st plant[a]	2nd plant[a]
F_1	3.80	3.78
F_2	4.94	4.25
F_1F_1	4.46	3.40
E_1F_2	3.54	2.97
E_2F_1	4.74	4.02
E_2F_2	4.25	3.51
Mean of squares (Anova)	0.8776 NS	0.6283**

F_1 = Fertiliser applied at 20 g N/year
F_2 = Fertiliser applied at 30 g N/year
E_1F_1 = Effluent applied at 20 g N/year, 5 times per week
E_1F_2 = Effluent applied at 20 g N/year, 2 times per week
E_2F_1 = Effluent applied at 30 g N/year, 5 times per week
E_2F_2 = Effluent applied at 30 g N/year, 2 times per week
[a]Mean of three replicates

TABLE 9. CUMULATIVE RUBBER YIELDS BY MICROTAPPING FOR FIRST PLANT (SIX MONTHS' OLD) AND SECOND PLANT (TEN MONTHS' OLD)

Treatment	Rubber yield (g/plant)	
	1st plant[a]	2nd plant[b]
F_1	0.346	0.866
F_2	0.296	0.501
F_1F_1	0.296	1.040
E_1F_2	0.244	0.675
E_2F_1	0.226	0.646
E_2F_2	0.282	0.692
Mean of squares (Anova)	0.0054 NS	0.1052 NS

F_1 = Fertiliser applied at 20 g N/year
F_2 = Fertiliser applied at 30 g N/year
E_1F_1 = Effluent applied at 20 g N/year, 5 times per week
E_1F_2 = Effluent applied at 20 g N/year, 2 times per week
E_2F_1 = Effluent applied at 30 g N/year, 5 times per week
E_2F_2 = Effluent applied at 30 g N/year, 2 times per week
[a]Total of six tappings
[b]Total of seven tappings

plants treated with fertiliser-N sampled at ten months were higher than those from effluent-treated plants. This was probably due to greater availability of the nitrogen.

The accumulative yields of the seedlings from the various treatments are shown in *Table 9*. There was no significant difference in the yields produced between fertiliser-treated seedlings and effluent-treated seedlings.

CONCLUSION

The study showed that NH_4-N concentrations of leachates from the effluent-applied lysimeters was more consistent than those from the fertiliser-applied lysimeters. At times, leachates collected from the fertiliser-applied lysimeters contained significantly higher NH_4-N than those from the effluent-applied lysimeters but this was not sustained. After a long duration of application, leachates from the effluent-applied lysimeters showed higher contents of K, Mg and Ca than those from the fertiliser-applied lysimeters. However, no differences in Zn, P and BOD concentrations were observed between the effluent-applied and the fertiliser-applied lysimeters.

Twice-weekly application of effluent produced leachate with lower NH_4-N compared to application five times per week. For the other parameters, no clear pattern of the effect of frequency of application on their concentration in the leachates was observed.

With proper control in the application of effluent to the land, NH_4-N concentration of the groundwater would not be affected. This study also showed that leachates produced from the effluent-applied lysimeters contained very low BOD and P concentrations indicating that the application of the effluent to land would not affect these properties of the groundwater.

However, care should be taken with K, Mg and Ca since their levels in leachates from the effluent-applied lysimeters were significantly higher than those from the fertiliser-applied lysimeters.

Soils from the effluent-applied lysimeters showed higher nutrient contents. Plants treated with fertiliser had leaves with higher N content compared to those treated with rubber effluent. Plants treated with effluent at higher frequency had leaves with higher N content. However, there was no significant difference in latex yield from effluent-applied and fertiliser-applied seedlings.

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