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Full Length Research Paper

Influence of pharmaceutical effluent on some soil chemical properties and early growth of maize (*Zea mays* L)

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A greenhouse experiment was conducted at the University of Benin, Benin City, Nigeria to determine the effect of pharmaceutical effluent on some soil chemical properties and early growth rate of maize (*Zea mays* L) in an experiment laid out in a completely randomized design with three replicates. Five rates of the effluent- 0, 25,000, 50,000, 75,000 and 100,000 l/ha were used. Results of the effluent analysis revealed that it is rich in some plant nutrients and the effluent also had effect on some soil chemical properties as well as the growth of maize. The organic carbon, N, P, K, Ca, Mg, Na and ECEC were raised whereas the exchangeable acidity and C/N ratio decreased. There were no drastic changes in the soil texture class. Also the nutrient uptake by the maize plant, the collar girth, leaf area were enhanced while the plant height as well as the number of leaves were depressed compared to control. The chlorophyll content of the maize plant however, was enhanced at low effluent concentration.

Key words: Pharmaceutical effluent, soil chemical properties, maize growth, chlorophyll content.

INTRODUCTION

Pharmaceutical effluents are waste generated by pharmaceutical industry during the process of drugs manufacturing. The steps involved in the compounding of drugs (which may include extraction, processing, purification and packaging) generate air emission, liquid wastes and solid wastes (Duon, 1993). Some pharmaceutical effluents are known to contain high concentration of organic compounds and total solids, mercury, cadmium, isomers of hexachlorocylohexane, 1,2-dichloroethane and solvent. The biochemical oxygen demand (BOD), chemical oxygen demand (COD), suspended solids as well as phenol and pH of pharmaceutical effluent is however not consistent, depending on the product manufactured, materials used and the processing details (Anon 1993).

The utilization of industrial waste as soil amendment has generated interest in recent times. Swamenathan and Vaidhee-swaran (1991) reported that waste water produced continuously could cater for the needs of irrigated crops. Thus this will not only prevent waste from being an environmental hazard but also serves as an additional potential source of fertilizer for agricultural use. The addition of sewage sludge to a coarse textured sandy and calcareous soils was reported to have improve the water holding capacity, cation exchange capacity, increase the availability of N, P, K, Cu, Zn, Fe, Mn, Na but with reduced biochemical oxygen demand (BOD) (Badary and El-Moitaium, 1999). Yeow and Zin (1981) reported that controlled application of rubber effluent on land caused changes in soil properties and improved in soil water retention while Lim and P'ng (1983) recorded increase in pH, K, Ca, Mg and organic matter content with the application of palm oil mill effluent. Valdes et al. (1996) observed an increase in the soil organic matter by 1% with sugar factory effluent applied to soils in Cuba taking into account the deficiency in the humic matter of the soil.

Kumar and Bhargava (1998) cautioned on the deleterious effects of higher concentration effluent by

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Table 1. Analysis of pharmaceutical effluent used.

Parameters	Value
PH E	8.38
Org C %	2.05
N	11.25
P	1.85
K	138.86
Ca	342.66
Mg	51.08
Na	319.92
COD	1,488.00
BOD	909.00
Total Solids	2820
Electrial Conductivity (µs)	1700

decreasing the growth of crop. Somasheka and Siddaramaiah (1997) (using soap and detergent effluent), Dutta and Boisgya (1997) (paper mill effluent) and Karunyal et al. (1993) (tannery effluent) observed suppressed germination of *Pennissetum tyhoides* and *Pisum savitum*, rice seeds and decrease in chlorophll content of *Lycopersicon esculentum*, respectively, at various high effluent concentration. Mather and Davis (1987) also recorded a decrease in shoot and root length with increase in the concentration of palm oil mill effluent.

The objective of this work was to assess the effect of pharmaceutical effluent on some soil chemical properties as well as some agronomic character of early growth of maize (*Zea mays* L).

MATERIALS AND METHODS

This experiment was conducted in a greenhouse at Faculty of Agriculture, University of Benin, Benin City Nigeria. The pharmaceutical effluent was obtained from Nomagbon Pharmaceutical Company in Benin City while the maize DMR-Y variety was obtained from Moore plantation, Ibadan. The soil used was collected from top 15 cm of an uncultivated field left to fallow for two years after seven years of continuous maize production. The soil was bulked, mixed thoroughly and air dried and then sieved to remove debris. A 2 kg of the composite soil was weighed into polythene bags measuring 23.5 x 23.3 cm in size.

The experiment was laid out in a completely randomized design using 5 treatments with 3 replicates and each replicate containing 20 polythene bags with 4 bags per treatment making a total of 60 bags. The pharmaceutical effluent was applied at the following rates 0, 25,000, 50,000, 75,000 and 100,000 l/ha, mixed thoroughly with the soil and left for 2 weeks before sowing to allow for effluent mineralization. Growth parameters measured started 2 weeks up to 8 weeks after sowing. Thereafter the plant top were harvested, oven-dried at 72°C for 72 h to a constant weight used to determine the nutrient uptake using method of Pal (1991).

The soil analysis was carried out before and after the experiment while the pharmaceutical effluent and plant analysis were carried out before and after the trial respectively. Soil particle size was determined using the hydrometer method of Bouyoucos (1951).

The soil pH was determined in a 1:1 soil to water ratio using the glass electrode pH meter while the pharmaceutical effluent pH was read directly. The electrical conductivity of the effluent was read directly from a model 230HT conductivity meter. The organic carbon was determined using the chromic acid wet oxidation procedure as described by Jackson (1962) whereas the total nitrogen of soil, effluent and plant were individually determined by micro-kjeldal method as described by Jackson (1962). Available phosphorus was extracted using Bray No1 P solution (Bray and Kurtz, 1945) and the P in the extract was assayed colorimetrically by the molybdenum blue colour method of Murphy and Riley (1962). The exchangeable bases were extracted using I N neutral ammonium acetate solution. Calcium and magnesium content of the extract were determined volumetrically by EDTA titration procedure (Black, 1965). The calcium, potassium and sodium determined by flame photometry. Magnesium content was obtained by the difference. The exchangeable acidity was determined by the KCl extraction and titration method of Mclean (1965). The ECEC was calculated as the sum of exchangeable bases and exchangeable acidity. The total solids in the pharmaceutical effluent was analysed by the method of Ademoroti (1996). The chlorophyll content of the maize plant was determined using method of Amon (1949).

RESULTS

Properties of pharmaceutical effluent used

The pharmaceutical effluent used was milky in colour, alkaline and have the following components; N, P, K Ca, Mg Na, organic C, electrical conductivity, COD, BOD and solids as shown in Table 1.

Influence of pharmaceutical effluent on some physico-chemical properties of the soil

The addition of the pharmaceutical effluent increased the soil pH from 4.10 to 7.15 in 75,000 l/ha effluent treatment. The N, P, K, Mg, Ca, Na, organic carbon and ECEC were also raised from 0.07%, 3.89 ppm, O.13 Cmolkg^{-1}, 0.16 Cmolkg^{-1}, 0.48 Cmolkg^{-1}, 0.06%, 1.27 Cmolkg^{-1}, 4.25 Cmolkg^{-1} to 0.14%, 6.34 ppm, 0.51 Cmolkg^{-1}, 0.06 Cmolkg^{-1}, 20.07 Cmolkg^{-1}, 1.52%, 1.42 Cmolkg^{-1} and 42.07 Cmolkg^{-1} in the 100,000 l/ha effluent treatment, respectively. The exchangeable acidity and the C/N ratio decreased from 3.42 and 18.14 to 0.01 Cmolkg^{-1} and 10.66 in 100,000 l/ha and 75,000 l/ha effluent treatments, respectively. There were no drastic changes recorded in the soil textural class. The soil was texturally sandy (Table 2).

Effect of pharmaceutical effluent on the growth and chlorophyll content of maize

There were no significant difference among the treatments throughout the period of trial in plant height (Table 3), number of leaves (Table 4) and stem girth

Table 2: Soil chemical properties before and after the experiment.

Treatment (l/ha)	PH	Org C (%)	N (%)	C/N	P (ppm)	K	Mg	Ca	Na	Ea	ECEC	Sand	Silt	Clay
						←		$Cmolkg^{-1}$			→	%	%	%
Before the soil amendment	4.80	1.27	0.07	18.14	3.89	0.13	0.16	0.48	0.06	3.42	4.25	87	4	9
After the trial														
0	5.98	1.00	0.06	16.66	3.07	0.41	0.02	0.07	0.05	0.06	0.61	90.05	0.95	9
25,000	7.11	1.40	0.12	11.66	4.08	0.41	10.08	10.06	0.71	0.02	21.28	90.20	0.8	9
50,000	7.08	1.50	0.13	11.53	4.77	0.37	10.08	10.06	1.10	0.02	21.63	90.20	0.8	9
75,000	7.15	1.28	0.12	10.66	6.00	0.32	20.08	10.06	1.10	0.02	31.58	90.30	0.7	9
100,000	1.12	1.52	0.14	10.85	6.34	0.51	20.06	20.07	1.42	0.01	42.07	90.20	0.8	9

Table 3. Effects of pharmaceutical effluent on plant height (cm).

Treatment (L/ha)	Weeks after planting			
	2	4	6	8
Control	31.50	56.80	86.13	126.06
25,000	33.60	53.10	81.16	117.43
50,000	30.70	55.05	88.53	116.07
75,000	32.53	60.67	88.70	113.37
100,000	32.66	56.46	88.13	118.27
LSD(0.05)	NS	NS	NS	NS

Table 4. Effect of pharmaceutical effluent on leaf number of maize plant.

Treatment (L/ha)	Weeks after planting			
	2	4	6	8
Control	3.92	3.92	3.33	4.50
25,000	3.73	3.50	3.42	4.33
50,000	4.00	3.67	3.75	4.33
75,000	4.50	4.17	3.67	4.33
100,000	4.08	3.42	4.58	4.42
LSD(0.05)	NS	NS	NS	NS

Table 5. Effect of pharmaceutical effluent on stem girth of maize (cm).

Treatment (L/ha)	Weeks after planting			
	2	4	6	8
Control	6.27	8.97	9.43	11.80[a]
25,000	6.23	8.17	9.40	11.57[a]
50,000	6.33	8.57	10.10	12.27[a]
75,000	6.90	9.53	11.07	13.43[a]
100,000	6.90	9.20	10.33	12.37[a]
LSD(0.05)	NS	NS	NS	NS

Table 6. Effect of pharmaceutical effluent on leaf area (cm^2) of maize.

Treatment (L/ha)	Weeks after planting			
	2	4	6	8
0	96.89[b]	312.58[a]	499.16	608.43
25000	118.72[a]	172.48[b]	574.16	623.37
50000	97.77[b]	299.66[a]	604.05	676.40
75000	105.18[a]	365.210[a]	707.11	730.68
100000	122.81[a]	318.13[a]	597.26	685.97
LSD (0.05)	22.25	171.24	NS	NS

number of leaves while 75,000 l/ha effluent treatments had the highest value in stem girth. In leaf area (Table 6), 25,000, 75,000 and 100,000 l/ha were significantly

Table 7. Effect of pharmaceutical effluent on maize plant chlorophyll.

Treatment (L/ha)	Chlorophyll content (mg/g fresh weight)
Control	0.19
25,000	0.30
50,000	0.21
75,000	0.21
100,000	0.26
LSD	0.58

($p<0.05$) better than control and 50,000 effluent treatments at 2 WAP, whereas at 4 WAP the control, 50,000, 75,000 as well as 100,000 l/ha effluent treatments were significantly ($p<0.05$) better than 25,000 l/ha effluent treatments. At 6 and 8 WAP no significance difference in leaf area occurred among the treatment but 75,000 l/ha treatment had the highest value at 8 WAP. There were also no significant differences among the treatments in chlorophyll content (Table 7) of the maize plant. However, treatment 25,000 l/ha concentration had the highest value of chlorophyll content.

Effect of pharmaceutical effluent on nutrient uptake

The maize nutrient uptake was not consistent in all the treatments. The uptake of Mg was significantly ($P<0.05$) better at 25,000 l/ha while N and P uptake were significantly higher at 100,000 l/ha treatment, whereas the uptake of Ca was significantly better at 50,000 l/ha. Treatments 25000 l/ha and 50,000 l/ha were not significantly different from each other but better than other treatments including control in K uptake. Also in Na uptake, 25,000, 50,000, 75,000 and 100,000 l/ha were not significantly different from one another but were better than control (Table 8).

DISCUSSION

The result of the pharmaceutical effluent analysis showed that the effluent was high in some plant nutrient while the initial analysis of the soil used revealed that the soil was an ultisol and low in nutrient components. The soil analysis result is similar to the report of Buol et al. (1973), Agboola and Ogunkule (1993), Orhue et al. (2005a,b). The increase in soil pH and decrease in exchangeable acidity is attributed to the higher Ca and Mg component of the pharmaceutical effluent used. The increase in Ca, Mg, Na, K, and N in the soil at the end of the trial is due to the high constituent of these elements in the effluent. This report is similar to finding of Poon (1982) and Seneviratne (1997) with palm oil mill and rubber effluent, respectively.

Table 8. Effect of pharmaceutical effluent on maize nutrient uptake.

Treatment (l/ha)	Mg	N	P	K	Na	Ca
		←		Mg/g	→	
0	11.52^{c}	204.92^{e}	12.08^{c}	41.59^{d}	0.01^{b}	3.30^{d}
25,000	43.02^{a}	391 .29^{c}	17.48^{b}	263.31^{a}	0.03^{a}	4.30^{c}
50,000	27.27^{b}	333.94^{d}	17.51^{b}	263.14^{a}	0.04^{a}	5.71^{a}
75,000	27.69^{b}	414.83^{b}	18.59^{b}	172.83^{b}	0.05^{a}	4.74^{b}
100,000	26.74^{b}	437.68^{a}	24.46^{a}	137.62^{c}	0.04^{a}	4.64^{b}

Figures with the same letters in the column are not significantly different from one another at 5% level of probability.

The higher component of P in the soil could be as a result of fixation attributed to high pH brought about by the Ca, Mg and Na in the soil. The increased organic carbon was as a result of high total solid present in the effluent, which may have mineralized while the decrease in C/N ratio may be due to the occurrence of high microorganisms activities, which assisted in the reduction of the C/N ratio. This report on C/N ration is however contrary to the report of Orhue et al. (2005b) with brewery effluent.

The high nutrient content in the effluent did not reflect in the general growth of maize plant. Similar finding have earlier been reported by Ogboghodo et al. (2003) that cassava mill effluent enhanced soil properties but the effects were not reflected in maize growth. The lack of response by the test crop may be due to non-availability of some nutrients, which may have been fixed in the soil. Tisdale et al. (1985) reported for instance that the availability of magnesium decreased as the pH approaches neutrality. Sanchez (1976) and Orhue et al. (2005b) reported that increase in Na may lead to Na toxicity in plants.

The variation in nutrient uptake may have been influenced by certain features such as temperature, aeration, plant age, concentration of competing ions and nutrient interaction. All these according to Clinton and William (1981) may have differential effect upon nutrient uptake rate and subsequent different nutrient component. According to Loos et al. (1979), reduced nutrient uptake in the presence of effluent could take place due to the strong adsorption or degradation in the soil and that the extent of adsorption or degradation did not only depend on the properties of the effluent but on the properties of site, soil types, type of soil organisms and climatic conditions.

The increase in chlorophyll content at 25,000 l/ha effluent treatment suggested that the synthesis of chlorophyll is accelerated at low concentration. Similar findings have earlier been reported by Srivastava and Sahai (1987), Karunyal et al. (1993) and Orhue et al. (2005b). The increase in chlorophyll content may be distributed to lack of heavy metals in the effluent and probably the availability of Fe/Mg for the synthesis of chlorophyll. Excess concentration of heavy metals such as Co, Cu and Cr according to Orhue et al. (2005b) decrease chlorophyll concentration by inhibiting electron transports. Cu according to Sandmamnn and Roger (1980) decomposes the chloroplast membrane of plant

From the foregoing, there is evidence that the pharmaceutical effluent altered the soil properties as well as the some planr growth parameters. The organic carbon, N, P, K, Ca, Mg, Na and ECEC were increased while the exchangeable acidity and C/N ration decreased. Although there were no consistent nutrient uptake in amended soil, it was certainly better than control. The plant height and number of leaves were depressed while stem girth and leaf area were enhanced. Chlorophyll content of the maize plant was also enhanced at low effluent concentration. Based on this study and to further investigate the fertilizer potential of this pharmaceutical effluent, it is suggested that more trial in greenhouse and field be carried out.

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