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Full Length Research Paper

Growth of maize (*Zea mays* L.) and changes in some chemical properties of an ultisol amended with brewery effluent

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A greenhouse studies was conducted at the University of Benin, Benin City, Nigeria to evaluate the effect of brewery effluent on some soil chemical properties and growth of maize. The experiment, which was organised in a completely randomised design, had three replications with 0, 25, 50, 75 and 100% effluent concentration in a 2 kg soil. Results showed that organic carbon, N, P, Na, and Mg concentration in the soil were reduced while K, Ca, C/N ratio, soil pH were increased. There were no changes observed in the soil textural class. The growth of maize plant as well as chlorophyll content was enhanced with brewery effluent treatments when compared with the control.

Key words: Brewery effluent, concentration, soil, maize.

INTRODUCTION

Brewery effluent is the resulting liquid flow from a wastewater treatment system of the brewery factory. The quality of brewery effluent can fluctuate significantly as it depends on various different processes that take place within the brewery and that the organic components in brewery effluent are generally easily biodegradable since these mainly consists of sugars, soluble starch, ethanol, volatile fatty acids as well as solids which are mainly spent grains, waste yeast and trub (Driessen and Vereijeken, 2003). The World Bank (1997) reported that untreated brewery effluent typically contained suspended solids (10 – 60 mg/L), Biological Oxygen Demand (BOD) (1000 – 1500 mg/L), Chemical Oxygen Demand (COD) (800 – 3000 mg/L), nitrogen (30 –100mg/L) and phosphorus (10 – 30 mg/L). However, not all of the organic materials are dissolved in the effluent hence some organic materials will remain as particulate (Grolsch Brewery, 2000).

Generally, the effects of effluent quality upon the receiving soil may range from behaving as a clean water input to that causing serious sodicity/salinity levels in soil or clogging the soil micropores with solids and that decisions about monitoring are based upon a clear understanding of the interaction between the effluent and the soil (Patterson, 1999). Chemical compounds introduced into soils can be adsorbed by soil constituents, transformed by soil organisms, taken up by plants, washed out by rain or irrigation water or evaporated in gaseous form (Grover, 1975; Walker and Smith, 1979; Herzel and Schmitt, 1979; Roseberg and Alexander, 1980).

Yeop and Poop (1983) observed that land application of palm oil mill effluent improves soil fertility and has no adverse effect on the environment. Sugar factory effluent applied to soil in Cuba, taking into account the general deficiency in humic matter of Cuba soils increased the soil organic matter content by 1% (Valdes et al., 1996) while cassava mill effluent applied to the soil increased the nitrate content as reported by Vieities and Brinkoli (1998). The soils treated with tannery effluent were rich in Mg, Mn, Fe, Na, and K ions as reported by Karunyal et al. (1993).

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The growth of various crops has been reported to be influenced by different types of effluents. Napier grass production have been observed to increase significantly with rubber effluent application (Tan et al., 1979) while tannery effluent caused an increased in leaf area, biomass, chlorophyll content and total protein of *Gossypium hirstum, Vigna mungo*, *Vigna unguiculata* and *Lycopersicum esculentus* over control as observed by Karunyal et al. (1993). Treated effluent of chemical industry was found to be effective in promoting germination, growth, chlorophyll and protein content of *Mungo* (Chidaunbalam et al., 1976). Rajni and Chanchan (1996) using tannery effluent and Dutta and Boissya (1997) using paper mill effluent, however, observed a significantly reduction in germination percentage, root length and total biomass in almost all varieties of *Hordeum vulgare* and *Oryza sativa*, respectively.

The objective of this study therefore was to evaluate the influence of brewery effluent on some soil chemical properties and growth of maize (*Zea mays* L) plant.

MATERIALS AND METHODS

Maize seeds were planted in a green house into polythene bags filled with 2 kg soil earlier air-dried and sieved to remove debris. Soil used was a surface soil collected from the floor of *Gmelina arborea* plantation at a depth of 0 – 15 cm. The total number of polythene bags used was 45, each labelled for the various treatments. The experiment was laid out in a completely randomized design (CRD) with three replicates. Each replicate had 15 polythene bags with 3 polythene bags per treatment. The brewery effluent was applied at the following rates of 0, 25, 50, 75 and 100% concentration per 2 kg soil and then left for 2 weeks to allow for mineralization before sowing the maize seeds. Four seeds were initially sown and later thinned to one plant per polythene bag 2 weeks after planting (WAP). The plants were watered every other day with deionized water.

Growth parameters were observed and measured every 2 WAP. This was done for 8 weeks after which the plants were harvested, dried in the oven at 105°C for 48 h to a constant weight in order to determine the top dry weight. The growth parameter measured were plant height, leaf area, stem girth, number of leaf and chlorophyll content of the fresh leaf. The chlorophyll content was determined according to the method of Arnon (1949).

Soil analysis was carried out before and after the experiment while the brewery effluent was analysed before application. The soil pH was determined at soil:water ratio of 1:1 using glass electrode pH meter. The particle size analysis of the soil was by the method of Bouyoucos (1951) as modified by Day (1965) whereas the organic carbon content of both soil and effluent were analysed by chromic acid wet oxidation method of Jackson (1962). The nitrogen was determined by microkjeldal procedure as described by Jackson (1962). The available phosphorus was extracted with Bray and Kurtz solution 1 (Bray and Kurtz, 1945). Exchangeable acidity was determined by the KCl extraction and titration methods of Maclean (1965). The total dissolved solids and suspended solids in the brewery effluent were analysed by the method of Ademoroti (1996). The alkalinity was determined by the method of Larson and Henley (1955). The electrical conductivity was determined using the model 230HT CORNING conductivity meter. The Biological Oxygen Demand (BOD) and Chemical Oxygen demand (COD) were determined using the method of Ademoroti (1996).

Table 1. Properties of brewery effluent used in the trial.

Parameter	Value
PH	4.34
Total nitrogen mg/L	13.62
Available P (PPM)	5.46
Potassium mg/L	40.16
Magnesium mg/L	6.56
Calcium mg/L	182.09
Sodium mg/L	15.12
Biochemical Oxygen Demand (BOD) mg/L	1069
Chemical Oxygen Demand (COD) mg/L	12.96
Electrical Conductivity μ s	780
Alkalinity mg/L	12.90
Suspended Solids (SS) mg/L	996
Total Dissolved Solids (TDS) mg/L	420

RESULTS AND DISCUSSION

The analysis of brewery effluent used revealed that it is an acidic, turbid, colourless liquid with slight odour and suspended particles. It contained N, P, organic carbon, K, Mg, Na and Ca (Table 1). The electrical conductivity is low. This result agrees with the report of Driessen and Vereijken (2003). In area of particulate, Grolsch Brewery (2000) reported that not all the organic material is dissolved in effluent hence some organic materials remain as particulate.

The soil used is an Ultisoil as revealed by its low percentage base saturation (less than 35%) which distinguished it from an Alfisol (Buol et al., 1973). It has relatively low pH of 5.1 and the particle size analyses showed that the soil is loamy sand. Some of the chemical components before effluent application showed that N, P, K, Ca, Mg, Na and organic carbon were of low value, which revealed that the soil is low in fertility.

The soil particle size analysis result depicted that the soil is loamy sand and no drastic change in soil texture occurred with the application of brewery effluent throughout the period of the trial. The soil pH rose from 5.10 in control to 6.50 at 75% effluent concentration treatment. This increase in pH may be attributed to the high Ca content of the brewery effluent. This result agrees with report of Orhue et al. (2005) using rubber effluent as an amendment in an ultisol. There was a decrease from 1.32% in control to 1.20% at 100% effluent concentration in organic carbon content of the soil. This decrease may be as a result of the presence of biological activities in the polluted soil. This result however, disagreed with the report of Lim et al. (1983) and Valdes et al. (1996) but agrees with that of Orhue et al. (2005). The total N decreased from 0.05% to 0.02% in 75% and 100% effluent treatment. The C/N ratio was however lower in 50% effluent concentration but higher in

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

Treatment (% Conc/2 kg Soil)		pH	Organic Carbon (%)	N (%)	P (mg/kg^{-1})	K	Na	Mg	Exch. acidity	C/N	Clay (%)	Silt (%)	Sand (%)
						($Cmol/kg^{-1}$)							
Before effluent application		5.10	1.32	0.05	4.71	0.04	1.39	0.39	0.08	26.40	3.10	3.80	93.10
After the expt.	**0**	5.88	1.00	0.03	4.70	0.03	0.57	0.56	1.01	25.64	5.10	3.50	91.40
	25	6.07	0.64	0.03	10.52	1.40	0.60	0.40	1.33	18.28	3.60	3.50	92.90
	50	6.34	0.42	0.03	9.33	1.52	0.58	0.16	0.38	13.12	4.60	2.30	92.10
	75	6.50	1.10	0.02	9.35	1.34	0.63	0.40	0.90	55.00	3.10	3.50	93.40
	100	6.42	1.20	0.02	9.88	1.60	0.75	0.72	0.83	66.00	3.10	3.50	93.40

Table 3. Effect of brewery effluent on Leaf Area (cm^2) of maize plant.

Treatment	Weeks after planting (WAP)			
% concentration	2	4	6	8
0	13.17^{a}	94.82^{a}	107.87^{a}	106.66^{b}
25	15.96^{a}	109.45^{a}	110.84^{a}	109.16^{b}
50	16.53^{a}	97.51^{a}	159.86^{a}	219.30^{ab}
75	16.12^{a}	105.56^{a}	154.92^{a}	251.70^{a}
100	16.89^{a}	126.28^{a}	172.61^{a}	253.01^{a}

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

the treatment of 100% effluent concentration. The presence of higher C/N ratio in 100% effluent concentration butress the presence of higher N content in the effluent. Also, the use of N by microoganisms for metabolic activities did not in anyway reduce the C/N ratio below that of control. Vieities and Brinkoli (1983) using cassava effluent reported an increase in soil nitrate.

The available P increased from 4.71 $mgkg^{-1}$ in control to 11.52 $mgkg^{-1}$ at 25% effluent concentration treatment. The reduced available P at 50, 75 and 100% effluent concentration treatment may be due to higher P uptake resulting from favourable soil pH range as shown in Table 2. The brewery effluent applied also influenced exchangeable cations. The K and Ca increased from 0.04 and 0.01 $Cmolkg^{-1}$ in control to 1.60 and 8.00 $Cmolkg^{-1}$ in the 100% effluent treatment, respectively. Whereas Na and Mg deceased from 1.39 $Cmolkg^{-1}$ and 1.39 $Cmolkg^{-1}$ in control to 0.75 and 0.72 $Cmolkg^{-1}$ at 100% effluent concentration, respectively. The exchangeable acidity increased from 0.08 in control up to 50% effluent treatment and then declined as from 75% effluent concentration probably due to the presence of higher Ca and Mg in the brewery effluent used.

Significant difference was not recorded in leaf area (Table 3) at 2, 4 and 6 WAP among the treatments, except at 8 WAP when 50, 75 and 100% effluent treatments were significantly ($P<0.05$) better than other treatments including control. In stem girth (Table 4), the various treatments were not significantly different from one another at 2 and 8 WAP whereas at 4 and 6WAP, 50, 75 and 100% effluent treatments were significantly ($P< 0.05$) better than other treatments.

At 2 and 4 WAP, there was no significant difference among the treatments in plant height (Table 5) except at 6 and 8 WAP when 50, 75 and 100% effluent concentration treatments were significantly better than other treatments. There were no significant differences recorded among treatments in number of leaf (Table 6) throughout the period of the trial. Treatments 50, 75 and 100% concentration were not significantly different from one another in total dry weight (Table 8) but significantly ($p<0.05$) better than treatment 25% effluent concentration and control.

The chlorophyll content (Table 7) of plant treated with 25% brewery effluent concentration had the highest value of 96.37 mg/g^{-1}. This result indicates that brewery effluent

Table 4. Effect of brewery effluent on stem girth (cm) of maize plant.

Treatment % Concentration	Weeks after planting (WAP)			
	2	4	6	8
0	1.18^{a}	2.06^{b}	2.46^{bc}	2.48^{a}
25	0.94^{a}	1.99^{b}	2.30^{c}	2.32^{a}
50	1.27^{a}	2.33^{b}	3.19^{ab}	3.12^{a}
75	1.23^{a}	2.52^{a}	3.31^{ab}	3.37^{a}
100	1.26^{a}	2.64^{a}	3.52^{a}	3.29^{a}

Mean with the same letter are not significantly different from one another at 5% level of probability.

Table 5. Effect of brewery effluent on plant height (cm) of maize plant.

Treatment % Concentration	Weeks after planting (WAP)			
	2	4	6	8
0	9.30^{a}	12.80^{a}	15.81^{b}	22.08^{b}
25	8.25^{b}	12.38^{a}	14.85^{b}	19.82^{b}
50	10.05^{a}	14.68^{a}	20.82^{a}	27.73^{a}
75	9.62^{a}	14.98^{a}	20.41^{a}	27.65^{a}
100	10.12^{a}	16.19^{a}	21.66^{a}	29.41^{a}

Mean with the same letter are not significantly difference from one another at 5% level of probability.

Table 6. Effect of brewery effluent on leaf number of maize plant.

Treatment % Concentration	Weeks After Planting (WAP)			
	2	4	6	8
0	2.77^{a}	2.77^{a}	5.99^{a}	6.77^{a}
25	2.52^{a}	2.83^{a}	5.99^{a}	6.51^{a}
50	2.61^{a}	3.66^{a}	6.08^{a}	7.33^{a}
75	2.66^{a}	3.77^{a}	7.77^{a}	7.88^{a}
100	2.77^{a}	3.97^{a}	6.77^{a}	7.99^{a}

Mean with the same letter are not significantly difference from one another at 5% level of probability.

stimulates the synthesis of chlorophyll and the synthesis is accelerated at low concentration of the effluent. Similar observations have been reported by Srivastava and Sanhai (1987) and Karunyal et al. (1993). At 25% brewery effluent concentration treatment, the stimulation was over 600% compared to control. The increase in chlorophyll content may be due to lack of heavy metals in the effluent and the availability of Fe/Mg for the synthesis of Chlorophyll. Bohner et al. (1980) reported that excess concentration of some heavy metals such as Co, Cu, and Cr decrease chlorophyll concentration by inhibiting electron transport. While Cu has been reported by Sandmann and Roger (1980) to decompose the chloroplast membrane of plant.

Table 7. Chlorophyll content of fresh leaf samples of maize plant.

Treatment % Concentration	Chlorophyll content (mg/g fresh weight)
0	14.77
25	96.37
50	69.85
75	56.85
100	23.54

Table 8. Dry weight of maize plant at 8 WAP under the effluence of brewery effluent.

Treatment % Concentration	Dry weight (g)
0	9.92[b]
25	10.51[b]
50	23.90[a]
75	28.16[a]
100	30.24[a]

Mean with the same letter are not significantly difference from one another at 5% level of probability.

In conclusion, the brewery effluent altered the soil properties. The values of organic carbon, N, P, Na and Mg were reduced whereas K, Ca, exchangeable acidity and soil pH increased. However, there was no definite pattern of nutrient concentration among the effluent treatments but 25, 50, 75 and 100% effluent concentration were better than control in nutrient accumulation. The growth of maize and chlorophyll content were enhanced. This may have been prompted by high nutrient uptake, synthesis and translocation. Therefore, brewery effluent has some organic nutrients needed by maize plant. As a result of the foregoing there is the need to carry out series of greenhouse and field trials to ascertain the fertilizer potentials of this effluent for maize plant.

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