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Ameliorative effect of sodium carbonate on phytotoxicity of palm oil mill effluent

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Abstract

This study aims to evaluate the impact of palm oil mill effluent treated with sodium carbonate on the growth of maize. The experiment consisted of eight treatments of concentrations of palm oil mill effluent viz 1.0%, 2.0%, 3.0%, 4.0%, 5.0%, 6.0%, 7.0% and 8.0%. The treatment was carried out on potted maize plants with six replications. Four kilograms of soil was weighed into each pot. Six pots were labelled as control with untreated palm oil mill effluent added to them. Eight other groups consisting of six pots each were treated with 1.0%, 2.0%, 3.0%, 4.0%, 5.0%, 6.0%, 7.0% and 8.0% concentrations of the effluent. The maize seeds were planted one in each pot to avoid overcrowding. The pots were transferred to greenhouse and moistened daily with the effluent. The growth rate, plant height and leaf length of the maize plants were thereafter determined. The 8.0% concentration of sodium carbonate in the effluent had the highest expected effect on the parameters whereas the control gave the lowest expected effect. The effects increased as the concentration of sodium carbonate in the effluent increased, indicating that increased concentration of sodium carbonate recorded significant increase in growth rate, height and leaf length of maize. The analysis of variance for the obtained data showed that the effects of the different concentrations were significantly different. This study provides an alternative and cost effective method of ameliorating the toxicity of palm oil mill effluent to plants.

Keywords: Sodium carbonate; Maize growth; Palm oil mill effluent; Treatment

1. Introduction

The large scale production of palm oil, a high quality oil used popularly and primarily for cooking in developing countries, is carried out in palm oil mills. Most palm oil mills use large quantities of water during the extraction of palm oil from the mesocarp of oil palm fruits. As a result, a considerable amount of wastewater known as Palm Oil Mill Effluent (POME) is generated from the mills [1]. Palm oil mill effluent is a toxic industrial liquid waste capable of causing serious harm to the ecosystem including plants. The discharge of raw palm oil mill effluent on land results in clogging, water logging of the soil and kills the vegetation on contact [2]. The raw effluent also affects the movement of soil microorganisms [3] and causes deterioration of soil physicochemical properties and increases soil acidity [4].

Several innovative treatment methods have been developed for palm oil mill effluent [5]. These technologies and processes include biological, physical and chemical techniques aimed at reducing the biodegradable component of palm oil mill effluent. However, researchers have expressed concern over the problems associated with the existing treatment technologies for palm oil mill effluent. [6]. The methods are expensive and difficult to operate. In most developing countries, this problem causes operators of palm oil mills to discharge the effluent on the surrounding lands without

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treatment. The discharged effluent causes serious harm to crops and other plants growing on the affected lands. This ugly development calls for an alternative means of treating palm oil mill effluent that is cheap and easy to handle which will ameliorate its harmful effect on crops.

In view of the above fact, the study was conducted to evaluate the effect of palm oil mill effluent treated with sodium carbonate, an affordable chemical substance, on the growth of maize.

2. Material and methods

The sodium carbonate was bought from a scientific shop in Owerri, Nigeria. The effluent was collected in five-liter plastic containers from effluent storage tank. Certified seeds of maize were used for the experiment.

2.1. Physicochemical characterization of palm oil mill effluent

The physicochemical characterization of palm oil mill effluent involve the estimation of the biological oxygen demand, chemical oxygen demand, oil and grease, total suspended solids, pH, phosphate, sulphate, nitrate, chloride, salinity, alkalinity and metals. Effluent sample to be analyzed for metals were preserved with 2% nitric acid. The determinations were done using standard analytical methods [7].

2.2. Treatments, Treatment Applications and Procedure

The experiment was consisted of eight treatments of concentrations of palm oil mill effluent viz 1.0%, 2.0%, 3.0%, 4.0%, 5.0%, 6.0%, 7.0% and 8.0% obtained by treating 8 sets of 1000mL of the effluent with 10g, 20g, 30g, 40g, 50g, 60g, 70g and 80g of sodium carbonate respectively. The treatment application was carried out on potted maize plants with six replications. Four kilograms of soil was weighed into each pot. Six pots were labelled as control with untreated palm oil mill effluent added to them. Eight other groups consisting of six pots each were treated with 1.0%, 2.0%, 3.0%, 4.0%, 5.0%, 6.0%, 7.0% and 8.0% concentration of the effluent. The maize seeds were planted one in each pot to avoid overcrowding. The pots were transferred to greenhouse and each pot was moistened daily with the specified concentration of the palm oil mill effluent.

2.3. Determination of growth rate, plant height and leaf length

The growth rate was measured 21 days after sowing seeds in the pots. The meter rule was set at the base of the plant (ground level) and the heights were determined by measuring the plants from their base to the highest points. The values were written down in a chat with both the dates and the heights recorded. This activity was repeated at an interval of three days. The average daily growth rates were determined as suggested in scientific literature [8].

The plant height was measured with meter rule from the surface of the soil to the top of the tallest leaf 28 days after sowing the seeds in the pots. A random sampling of five leaves per plant was chosen for measurement of leaf length. The values were added and divided by the number of measurements taken. The effects of the treatments were ascertained from the analysis of variance for the data obtained.

3. Results and discussion

3.1. Physicochemical properties of palm oil mill effluent

Table 1 shows the results of the physicochemical analysis of palm oil mill effluent. The results of the various determinations showed that the raw palm oil mill effluent had pH 4.8, Biological Oxygen Demand (BOD_5) was 29500 mg/L, chemical oxygen demand was 42200 mg/L and oil and grease was 7200 mg/L.

The high biological oxygen demand and oil and grease values as well as high acidity of the effluent indicate that the effluent needed to be treated before it is discharged on the surrounding environment. This agrees with the findings of previous researchers that palm oil mill effluent characteristics were above environmental guidelines with potential negative consequences for the ecosystem [9, 10]. The acidity of the effluent was removed after treatment with sodium carbonate. The use of sodium carbonate as pH adjuster in various treatment processes for palm oil mill effluent is well established in scientific literature [11, 12, 13].

Table 1 Physicochemical characteristics of raw and treated POME

Parameter	Raw POME (mg/L)	Treated POME (at 8.0 %w/v)
pH	4.8	9.8
Total Dissolved Solids	715	
Chloride	<0.0018	
Salinity	<0.001	
Dissolved Oxygen	68	
Sulphate	98.18	96.52
Alkalinity	0.02	
Phosphate	29.74	27.62
Total Organic Carbon	269.94	
Total Suspended Solids	100	
Nitrate	0.174	0.16
Chemical Oxygen Demand	42,200	320
BOD_5	29,500	206
Oil and Grease	7,200	102
Sodium	1.275	1.60
Chromium	<0.01	
Calcium	17.00	
Iron	13.5	
Copper	<0.01	
Potassium	305	304
Magnesium	693	682
Zinc	0.07	
Lead	0.03	

3.2. Effect of palm oil mill effluent on the growth rate, plant height and leaf length of maize

The different concentrations of sodium carbonate with palm oil mill effluent on growth rate, plant height and leaf length of maize yielded varying means effect. The 8.0% concentration had the highest expected effect on all the parameters whereas the control (untreated effluent) gave the least expected effect. The effects increased as the concentration of sodium carbonate in the effluent increased, indicating that increased concentration of sodium carbonate recorded significant increase in growth rate, plant height and leaf length. The 2.0%, 3.0%, 5.0%, 7.0% and 8.0% concentrations gave mean growth rates of 22.50 $mmday^{-1}$, 22.86 $mmday^{-1}$, 24.28 $mmday^{-1}$, 24.66 $mmday^{-1}$ and 27.66$mmday^{-1}$ respectively. The maize height and leaf length also increased as the concentration of sodium carbonate in the effluent increased. The untreated effluent gave reduced mean growth rate, plant height and leaf length. The analysis of variance (ANOVA) for growth rate, plant height and leaf length measurements show that the between groups (treatment effects) were significantly different, $p<0.005$ with the corresponding calculated f values of 2.612, 9.920 and 11.115 respectively.

This study recorded reduced growth of maize with untreated palm oil mill effluent as the control. The inhibitory effect of untreated palm oil mill effluent on crops after application to soil is established in scientific literature. Previous researchers have evaluated the growth of maize on palm oil mill effluent contaminated soil and observed that an increase in concentration of the raw effluent was associated with a decrease in the performance of the maize growth [14]. This observation and the report of Oikeh EI et.al., [15] that untreated palm oil mill effluent is detrimental to plant

growth agree with the findings of this present study. It is, therefore, clear that the reduced growth recorded with the untreated effluent in this study was as a result of its toxicity to crop. The toxic component of the effluent was not investigated because of limitation of fund.

Table 2 Effect of palm oil mill effluent treated with sodium carbonate on growth rate, height and leaf length of maize

Sodium carbonate Concentration	Growth rate (mm day-^{1})	Maize height (mm)	Leaf length (mm)
0.0%	16.50	138.6	94.8
1.0%	17.50	227.5	202.5
2.0%	22.50	243.0	205.8
3.0%	22.86	230.8	179.1
4.0%	22.86	229.0	179.4
5.0%	24.28	234.2	184.4
6.0%	23.41	223.2	173.2
7.0%	24.66	302.5	240.6
8.0%	27.66	341.1	266.8
SEM±	5.467	9.929	8.35
F test (5%)	Sig	Sig	Sig
CD 5%	43.6	50.05	40.98

Note: All values represent mean of six replications

It is evident from this study that sodium carbonate had an ameliorative effect on the toxicity of the effluent. Organic and inorganic ameliorants have been reported to be effective in improving nutrient availability and crop yield [16]. Sodium carbonate induced salinity-alkalinity in agricultural soil has been reported to increase protein profile and activities of plant enzymes [17]. It is also recorded in this study that the treatment of palm oil mill effluent removed the acidity of the effluent which may affect nutrient availability to crops [18] and consequently reduce growth if the effluent is applied to soil without treatment. This also might be responsible for the positive effect recorded with the treated effluent. It is, therefore, not unlikely that the use of this substance in the treatment of palm oil mill effluent accounted for the reduced phytotoxicity of the effluent recorded in the study.

4. Conclusion

The use of sodium carbonate, an affordable chemical substance, in the treatment of palm oil mill effluent significantly increased the height, growth and leaf length of maize whereas the untreated effluent had negative effect on the growth of the plant. This study, therefore, provides an alternative and cost-effective method of ameliorating the toxicity of palm oil mill effluent to plants.

Compliance with ethical standards

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Disclosure of conflict of interest

The authors declare that no competing interests exists.

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