SHORT NOTE
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Influence of Paper Mill Effluent Irrigated Soil Characteristics under Laboratory and Field Conditions

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ABSTRACT

Background: The solid wastes and the wastewater (effluent) generated in the pulp and paper industry can be used to improve the soil fertility. However, the cation concentration in these residues can influence the bioavailability of some nutrients and soil properties. The objective of this study is to experiment the availability of the cations namely Ca, Mg, Na and K in laboratory (column) and the field.

Methods: An experiment with PVC column was carried out in the laboratory to study the availability of cations as influenced by 13 irrigations with papermill effluent *vis-à-vis* in a field experiment in the Department of Environmental Sciences, Tamil Nadu Agricultural University, Coimbatore during 2019-2020.

Result: The pH, EC and the concentration of the cations were higher in the field soil compared to the column soil barring magnesium. This may be due to the clogging of pores resulting in decreased infiltration in field soil.

Key words: Biosludge, Flyash, Papermill effluent, Pressmud, Soil column.

INTRODUCTION

The application of wastewater to irrigate soils may be an attractive option for paper mills, as the effluents provide nutrients to plants, however there could be negative environmental impacts which need to be monitored as wastewater, contains dissolved solids (chlorides and sulphates of Na, Ca) and varying amounts of suspended organic materials. Significantly higher values of EC, organic carbon, available K, exchangeable cations (Ca^{2+}, Mg^{2+}), exchangeable anion (Cl^-, HCO^{3-}) along with micro-nutrient (Cu^{2+}) have been reported in soils being irrigated with paper and pulp industry effluents (Singh *et al.* 2007). According to Carreiro *et al,* (2017), effluent application changed the soil SPE composition and caused an increase in EC, pH, Na+ and SAR values, which can be directly associated with effluent's chemical properties. The present investigation was undertaken to examine the soil cationic concentration as influenced by the application of effluents and solid wastes from paper and pulp industry and under column (laboratory condition) and field condition.

MATERIALS AND METHODS

Column experiment

The column experiment was carried out using PVC pipes of 55 cm height (bottom two portions of 15 cm height and top portion of 25 cm height, joined and leak proofed) with an internal diameter of 7 cm. The bottom portion of each column was covered with 1 cm sand layer, wire mesh, Whatman No. 1 filter paper and a muslin cloth. Buckner funnel was attached to the base of each column and secured with rubber washers. The column was divided into three equal portions (each 15 cm height) based on bulk density of soil (packed) and individual layers were separated using filter papers The bottom portion was filled with 649 g of soil to maintain a bulk density of 1.53 Mg m^{-3}, middle portion with 632 g of soil to maintain a bulk density of 1.49 Mg m^{-3}, the top portion was filled with the mixture of 555 g soil (bulk density 1.31 Mg m^{-3}) and irrigatedas per treatments. Each treatment had two replications. The treatments were T_1- (Control) ; T_2- (bio sludge 12 t ha^{-1}); T3- (Fly ash 10 t ha^{-1} + bio sludge 6 t ha^{1}); T_4 - Press mud 12 t ha^{-1} . Initially the columns were saturated with treated effluent and then effluent was applied to each column daily to maintain an irrigation loading of 5 cms. After 13 irrigations with the effluent , the soils from each column were removed and analysed for pH, EC and exchangeable Ca, Mg, K and Na as per the procedures.

Field trial

The treatments were T_1- Control ; T_2- Bio sludge 12 t ha^{-1}, T_3- Fly ash 10 t ha^{-1} + Bio sludge 6 t ha^{-1}, T_4 - Press mud 12 t ha^{-1}, with sugarcane varied, C086032 as test crop. Each plot was irrigated with secondary treated paper mill effluent. Soil samples were collected after 13 irrigations and analyzed.

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Table 1: pH, EC, Ca and Mg of the soils in the column experiment and the sugarcane field trial.

Treatment details	Column experiment soil pH	Sugarcane field soil pH	Column experiment soil EC (dS m^{-1})	Sugarcane field soil EC (dS m^{-1})	Column experiment soil exchangeable calcium (c mol p^{+} kg^{-1}) -	Sugarcane field soil exchangeable calcium (c mol p^{+} kg^{-1})	Column experiment soil exchangeable magnesium (c mol p^{+} kg^{-1})	Sugarcane field soil exchangeable magnesium (c mol p^{+} kg^{-1})
T_1- Control	7.45	7.52	0.06	0.08	7.44	7.58	4.16	3.30
T_2- Bio sludge 12 t ha^{-1}	7.55	7.86	0.07	1.19	7.83	8.44	4.35	3.77
T3- Fly ash 10 t ha^{-1} + Bio sludge 6 t ha^{-1}	7.66	7.89	0.09	1.37	7.73	8.49	4.30	3.81
T4- Press mud 12 t ha^{-1}	7.48	7.83	0.07	1.26	7.77	8.36	4.27	3.74

Table 2: Exchangeable sodium and potassium of the soils from the column experiment and the sugarcane field.

Treatment	Column experiment soil exchangeable sodium (c mol p^{+} kg^{-1})	Sugarcane field soil exchangeable sodium (c mol p^{+} kg^{-1})	Column experiment soil exchangeable potassium (c mol p^{+} kg^{-1})	Sugarcane field soil exchangeable potassium (c mol p^{+} kg^{-1})
T_1- Control	0.67	1.83	0.48	1.12
T_2- Bio sludge 12 t ha^{-1}	0.72	2.51	0.50	1.40
T_3- Fly ash 10 t ha^{-1} + Bio sludge 6 t ha^{-1}	0.65	2.45	0.51	1.27
T_4- Press mud 12 t ha^{-1}	0.68	2.34	0.48	1.43

Table 3: Per cent increase over control under treatment T_3- (ash 10 t ha^{-1} + Bio sludge 6 t ha^{-1}).

Parameters	Column (control)	Column T_3-Fly ash 10 t ha^{-1} + bio sludge 6 t ha^{-1}	Per cent increase over control	Field (control)	Field T_3-Fly ash 10 t ha^{-1} + bio sludge 6 t ha^{-1}	Per cent increase over control
pH	7.45	7.66	2.81	7.52	7.89	4.9
EC	0.06	0.09	50	0.08	1.37	1612
Ca	7.44	7.73	3.9	7.58	8.49	12
Mg	4.16	4.30	3.3	3.30	3.81	15.45
Na	0.67	0.65	-2%	1.83	2.45	33.9
K	0.48	0.51	6%	1.12	1.27	13.4

RESULTS AND DISCUSSION

The pH and EC values were high in treatment, having T3-fly ash 10 t ha^{-1} + bio sludge 6 t ha^{-1} . The pH and EC values were found to be high in the field soil compared to column soil in all the treatments (Table 1). The treatment compromising of fly ash 10 t ha^{-1} + bio sludge 6 t ha^{-1} had higher concentration of cations the field soil compared to column soil except for magnesium (Table 1 and 2). Roy *et al.* (2008) and Singh *et al.* (2013) reported increased pH value, the electrical conductivity (ECe) and exchangeable sodium percentage (ESP) in soils irrigated with waste water.

The EC, organic carbon, available K, exchangeable cation (Cu^{2+} and Mg^{2+}) were found to be significantly higher in treated treatments than control. The per cent increase of pH, EC and all the cations over the control was higher in the field condition compared to the column (Table 3). This may be due to the clogging and reduced infiltration of salts in the field soil due to the accumulation of organic or suspended materials present in the effluent.

Bardhan *et al.* (2016) reported decreased in infiltration rate due to clogging of soil pores by suspended materials present in the treated wastewaters (Viviani *et al.* (2004); Taywade and Jagdish Prasad 2008).

CONCLUSION

The results suggest that paper mill effluents can be used for soil irrigation with caution. However, Effluent application increased soil pH, EC, organic carbon and cations (Ca, K, Na) barring Mg. The increase in the cations may cause clogging of the soil pores necessitating a continuous soil quality monitoring program.

Conflict of interest: None.

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