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ASSESSMENT OF POST-BIOMETHANATED DISTILLERY EFFLUENT MOVEMENT ON GROUND WATER QUALITY USING PIEZOMETERS

B. ANANDAKRISHNAN, M. BASKAR, M. SOUNDARRAJAN, M. SHEIK DAWOOD, S. JEBARAJ AND M. MURUGESAN*

Anbil Dharmalingam Agricultural College and Research Institute,
Tamil Nadu Agricultural University, Trichy 620 009, T.N., India.
*EID Parry (I) Ltd., Nellikuppam, 607 105, India

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ABSTRACT

To monitor the downward movement of post bio-methanated distillery effluent (PME) and possible ground water contamination, piezometers were installed at different depths viz., 0.5, 1.0, 1.5 and 2.0 m in the long term sugarcane field experiments being conducted at EID Parry (I) Ltd., Cane farm, Edayanvelli, Tamil Nadu. The piezometers were installed in pre-plant undiluted PME (5 lakh litres ha^{-1}) applied field, diluted PME (1:10 times) applied field and in control plot (without PME application). Three replications were maintained for each treatment. Piezometers were examined for the presence of leachate every month. The leachate samples were analyzed for pH, EC, cations, anions, sodium adsorption ratio (SAR), residual sodium carbonate (RSC), biological oxygen demand (BOD) and chemical oxygen demand (COD). The analysis of the leachate samples revealed no change in color at all the depths. The BOD and COD of the leachate from PME plots when compared to the control plots were not affected significantly at all the depths. There was not any significant difference observed in the pH, EC, cations like Ca, Mg and K and anions like Cl, CO_3, HCO_3 and SO_4 in the leachate collected beyond 1.5m depths in treated plots when compared to the control plots. The SAR calculated at 0.5m and 1.0m depths of treated plots has stood below the control values. The higher Ca and Mg in the leachate supplied by the PME applied have significantly decreased the SAR of

the leachate at these depths. The SAR of leachate collected at 2.0 m depths in the treated plots did not show any significant difference from the control plots. The RSC calculated was found to be lesser than the control plots till 1.0m depths this is due to the higher Ca and Mg found in the leachate. The results reveal that the PME application has not influenced the leachate collected at 1.5m and 2.0m depths in the treated plots and this clearly indicates that PME applied at the highest concentrations has not influenced the ground water and there is no possibility of pollution by the PME application at these doses.

INTRODUCTION

At present, there are 319 distilleries in the India with an installed capacity of 3.25 billion litres of alcohol (Uppal, 2004). The cane-growing states of Uttar Pradesh and Maharashtra have the highest installed capacity constituting more than 40% of the total installed capacity followed by Madhya Pradesh (14.2%) and Tamil Nadu (9.7%) (Uppal, 2004). The disposal of wastes from industrial sources is becoming a serious problem throughout the world. Most of the distilleries are concentrated in the states of Maharashtra, U.P, Andhra Pradesh, Madhya Pradesh, Tamil Nadu and Karnataka. The post biomethanated distillery effluent (PME) released by the distilleries is generally characterized by high levels of biological oxygen demand (BOD), chemical oxygen demand (COD) and electrical conductivity. Owing to its high nutrient potential and organic carbon it is widely recycled for augmenting crop production in the sugar industries command area (Joshi *et el.* 1996). However, indiscriminate disposal of this PME has resulted in adverse impact on soil and environmental health in various areas. Ground water contamination by effluent with high BOD and salt content near the lagoon side in the most of the distilleries has been reported widely. In some cases, particularly in Maharashtra the color problem in groundwater is so acute that distilleries have to provide separately potable water to surrounding villages (Nemade, 2002). Hence a study was initiated to monitor the downward movement of PME and possible ground water contamination.

MATERIALS AND METHODS

To monitor the downward movement of PME and possible ground water contamination, piezometers were installed at different depths viz., 0.5, 1.0, 1.5 and 2.0 m in the long term field experiments (sandy loam soil) being conducted at EID Parry (I) Ltd., Cane farm, Edayanvelli, Tamil Nadu. The piezometers were installed in the treatments of the long-term experiments that received pre-plant undiluted PME @ 5 lakh litres ha^{-1}, diluted PME @ 1:10T (4 Lakh litres ha^{-1}) and in control plot (without PME application). Piezometers were installed in three replicates in their respective treatmental units.

Piezometer installation

Four nested piezometers of different lengths (0.5m, 1.0m, 1.5m, and 2.0m) were installed in the long-term experimental plots to measure the shallow and deep ground water to confirm the nutrient distribution. A hand augur was used to dig holes for each piezometer. The piezometers were made from slotted PVC pipes that were covered with mesh at the base, and then inserted into the augured holes. The space around the tubes were backfilled with sand till the level of holes and then with white cement and followed by clay to prevent preferential flow pathways developing around the outsides of the PVC tubes. PVC tubes extend above the soil surface for 1m to avoid surface water flow entering the piezometers. They were end capped to avoid rain filling the tubes shown in Fig 1. The designs of the piezometers are prepared based on the models of nested piezometers by Aarons *et al.* (2004).

Sampling and analysis

Piezometers were examined for the presence of leachate every month. However leachate got collected in the piezometers only during the rainy months (only after heavy rains). The leachate samples were analyzed for pH, EC, cations, anions, SAR, RSC, BOD and COD. Analysis was done according to standard water analytical procedures (APHA, 1998). The analyzed results data were statistically scrutinized (Gomez and Gomez, 2000).

RESULT AND DISCUSSION

Influence on pH and EC

The pH and EC of the leachate collected at 0.5m and 1.0m depths in the PME plots has shown a slight increase over the control plots, indicating the PME influence on the leachate at these depths (Table 1). The leachate at 1.5m, and 2.0 m depths has not shown any significant difference from control plots indicating that there is no significant downward leaching of soluble salts below 1.0m depths. Electrical conductivity is an indirect measure of soil and soil pore water salinity. The electrical conductivity of the subsurface generally depends on the soil texture, soil chemistry, water content, soil porosity and pore water quality (MacMillan, 2001).

Influence on cation concentrations

The leachate collected was analysed for cations like Ca, Mg, Na and K. The analysed calcium content of the leachate has revealed that there is a significant increase in calcium levels upto 1.0m depths in the treated plots when compared to the control plots. This might be the influence of applied PME. The calcium content of the leachate collected from the 2.0m depths of PME plots has not shown any significant difference from the control plot values implying that there is no impact by the applied PME.

The magnesium and sodium content of the leachate analysed has shown significant difference from the control plots only at 0.5m and 1.0m depths in the treated plots and there is no significant difference observed at 1.5m and 2.0m depths in treated plots suggesting the impact of applied PME only till 1.0m depths.

The leachate analyzed for potassium content at different depths for the two doses has revealed that the potassium content of the leachate from PME plots

Table 1

Influence of distillery effluent on ground water quality

Parameters	0.5 m depth C	1:10	5 lakh L/ha	1.0 m depth C	1:10	5 lakh L/ha	1.5 m depth C	1:10	5 lakh L/ha	2 m depth C	1:10	5 lakh L/ha	Bore well water	CD (0.05)
Colour	No change in color													
pH	8.38	8.34	8.31	8.38	8.36	8.36	8.39	8.37	8.38	8.42	8.41	8.41	8.44	NS
EC(dSm^{-1})	0.89	1.08	1.1	0.89	0.89	0.88	0.86	0.87	0.87	0.84	0.84	0.85	0.83	0.07
Ca^{2+} ($me.l^{-1}$)	0.76	1.49	1.47	0.75	1.15	1.16	0.82	0.83	0.85	0.83	0.82	0.82	0.73	0.10
Mg^{2+}($me.l^{-1}$)	2.43	3.19	3.15	2.48	2.86	2.86	2.24	2.23	2.24	2.23	2.24	2.73	2.24	0.19
Na^{+} ($me.l^{-1}$)	4.38	4.32	4.30	4.24	4.31	4.35	4.38	4.32	4.34	4.36	4.38	4.37	4.36	NS
K^{+} ($me.l^{-1}$)	0.17	0.54	0.52	0.18	0.30	0.31	0.16	0.19	0.18	0.13	0.13	0.12	0.08	0.04
Cl^{-} ($me.l^{-1}$)	2.18	3.06	3.11	2.17	2.60	2.57	2.17	2.20	2.21	2.24	2.24	2.24	2.1	0.16
CO_3^{2-}($me.l^{-1}$)	0.21	0.20	0.20	0.20	0.20	0.20	0.40	0.20	0.20	0.40	0.20	0.20	0.40	0.08
HCO_3^{-}($me.l^{-1}$)	5.28	5.78	5.80	5.15	5.19	5.21	4.72	4.70	4.66	4.44	4.60	4.64	4.86	0.21
SO_4^{2-} ($me.l^{-1}$)	0.34	0.56	0.58	0.30	0.42	0.44	0.34	0.34	0.38	0.28	0.32	0.32	0.27	0.08
SAR	3.47	2.82	2.83	3.34	3.04	3.07	3.54	3.49	3.49	3.52	3.54	3.28	3.58	NS
BOD ($mg\ l^{-1}$)	11.8	12.6	13.1	8.5	8.6	8.3	8.6	8.5	8.5	8.1	8.2	8.3	8.21	0.48
COD ($mg\ l^{-1}$)	19.2	20.1	20.3	15.8	16.5	15.5	16.1	14.3	15.5	14.2	14.8	14.2	13.5	0.60

at 0.5m and 1.0m depths was found to be significantly higher than the control plots. The higher value suggests that the PME with its high K content has enriched the surface layers and the potassium from the surface layers has leached down till 1.0m depths. The K content of the leachate obtained at 1.5m and 2.0m depths in treated plots has revealed that the K has not leached more than 1.0m depths and thereby has not influenced the water quality more than 1.0 m depths. The K movement in the soil water was reported by van Noordwijk (1999).

Influence on anion concentrations

The leachate was analyzed for anions like chloride, carbonate, bicarbonate and sulphate. The leachate from PME plots has shown a higher chloride content at 0.5m and 1.0m depths than the control plots. While the chloride content at 1.5m and 2.0m depths has not shown significant difference from the control plots. Dawes *et al.* (2001) has used chloride concentration as an indicator of effluent movement because it is

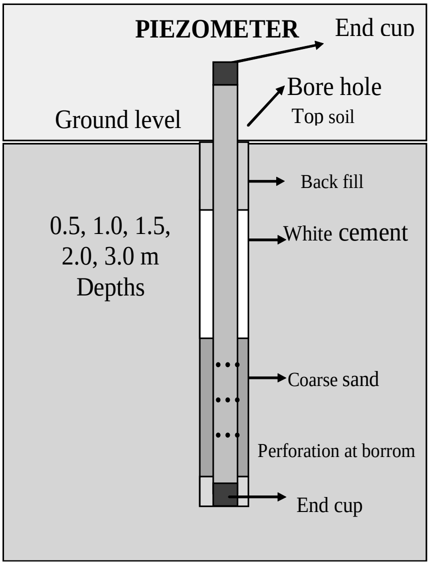

Fig. 1 Piezometer Pictorial Representation

highly mobile in soil systems and undergoes limited soil adsorption and no biochemical transformation.

The carbonate content of the leachate from PME plots has not shown much difference from the control plots and was under safer limits in all the samples collected at different depths. The bicarbonate content of the leachate at 0.5m depths of PME plots stood above the control plot values confirming the leaching of bicarbonates as Ca and Mg bicarbonates. The higher Ca and Mg at this depths correlates with the observations. The bicarbonate levels at 1.0m, 1.5m and 2.0m depths have not shown significant difference from the control.

The sulphate content of the leachate at 0.5m and 1.0m of PME plots stood higher than the control plot values and there was not much difference observed at 1.5m and 2.0m depths when compared with the control plot.

Influence on sodium adsorption ratio and residual sodium carbonate sodium adsorption ratio

The SAR calculated for the leachate samples collected from the piezometers at different depths revealed that there is significant influence by the applied PME till 1.5m depths. The SAR calculated at 0.5m, 1.0m, and 1.5 m depths has stood below the control. The higher Ca and Mg in the leachate supplied by the PME applied have significantly decreased the SAR of the leachate at these depths. The SAR of leachate collected at 2.0 depths did not show any significant influence by the PME this is evident from the values of the control and the treatment samples.

Residual sodium carbonate

The Residual Sodium Carbonate calculated revealed that the calcium and magnesium leached from the surface layers from PME applied plots till 1.0m depths has decreased the residual sodium carbonate of the leachate from these plots when compared to the control. The calcium and magnesium has not leached significantly below 1.0m depths and this is evidenced from the calculated calcium and magnesium contents and from the calculated RSC from the leachate at 1.5m and 2.0m depths.

Influence on BOD and COD

The leachate analyzed for the BOD and COD revealed that the PME applied has not significantly affected BOD and COD of the leachate when compared to the control at all the depths.

CONCLUSIONS

The intensive water sampling and the piezometer data demonstrated elevated nutrient levels in the leachate collected at 0.5m and 1.0m depths of treated plots, also there was no impact of the PME on the leachate observed beyond 1.5m depths of treated plots. The results of monitoring at the highest dose has clearly evinced that the recommended dose of 1:10T dilution treatments as fertigation and 1.25 lakh litres per hectare as preplant application of post biomethanated distillery effluent is the optimal dose and they do not pose any possibility of pollution of ground water in near future.

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