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Original Research Paper

Impact of One Time Application of Distillery Spent Wash on the Groundwater Quality

K. Suganya, G. Rajannan*and K. Valliappan*
Deptt. of Soil and Environment, Agriculture College and Resarch Institute, Madurai-625 104, T. N., India
*Deptt. of Environmental Sciences, Tamil Nadu Agricultural University, Coimbatore-641 003, T. N., India

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ABSTRACT

A field experiment was conducted with different irrigation doses of distillery spent wash along with inorganic N and P fertilizer without K using maize variety COH (M)-5 as test crop and groundnut as residual crop. In order to assess the quality of groundwater due to distillery spent wash application, piezometers of 1 m depth were installed in five treatments *viz*., 25, 50, 75,100 kL/ha and in the control. Piezometer water samples were collected at regular intervals and analysed for various water quality parameters. The leachate study with piezometer of 1m depth indicated that the pH, EC, cations, anions, BOD, TDS, SAR and RSC of the leachate were slightly increased in distillery spent wash applied treatments, compared to control. However, in the leachate collected after fourth and fifth leachings, the levels of cations, anions, BOD, TDS, SAR and RSC were decreased.

INTRODUCTION

The distillery spent wash is a dark coloured, acidic (pH< 4.0), high BOD (40,000 to 80,000 mg/L) liquid consisting primarily of biodegradable organics and some inorganic constituents. Spent wash is a rich source of organic matter and nutrients like nitrogen, phosphorus, potassium, calcium and sulphur. In addition, it contains sufficient amount of micronutrients such as iron, zinc, copper, manganese, boron and molybdenum. Every cubic meter of distillery spent wash contains 1 kg of N, 0.2 kg of phosphorus oxide and 10 kg of potassium. Most of these nutrients are in soluble forms and are easily available to plants. Suspended and dissolved organic matter is a source of food for microorganisms.

Through large number of experiments, it has been found that the spent wash is very useful in increasing the yield of several crops and improving the soil characteristics like pH, EC and nutrient availability. However, the effect of pre-sown and post-sown application of distillery spent wash on produce quality, soil fertility status and groundwater quality are lacking. Hence, the present investigation was attempted to assess the salt movement in groundwater due to distillery spent wash application through piezometer study.

MATERIALS AND METHODS

Field experiments were conducted at Research and Development Farm, M/s Sakthi Sugars Limited, Sakthi Nagar, Tamil Nadu in order to study the effect of distillery spent wash application on the physico-chemical properties, microbial dynamics and enzyme activities of soil, plant growth parameters, yield and quality of maize (main crop) and groundnut (residual crop) The treatment details consist of two factors, Factor A and B. The factor A is method of application of distillery spent wash, which comprises of M_1-pre-sown application of distillery spent wash (DSW) (before planting) and M_2-post-sown application of distillery spent wash (DSW) (30 days after planting along with irrigation water). The factor B is dosage of distillery spent wash application with NPK management and has seven treatments namely, T_1-Control + recommended dose of NPK, T_2-application of 25 kL/ha of DSW + RD of NP, T_3-application of 50 kL/ha of DSW + RD of NP, T_4-application of 75 kL/ ha of DSW + RD of NP, T_5-application of 100 kL/ha of DSW + RD of NP, T_6-application of 75 kL/ha of DSW + 75 % RD of NP , T_7-application of 100 kL/ha of DSW + 75 % RD of NP. To assess the quality of groundwater, the piezometers were installed in the field during the experiment. Before the application of treated distillery spent wash, the piezometers at the depth of 1m were installed in all the treatments except T_6 and T_7.

Installation of piezometers: Piezometers of depth 1.0 m were installed in the experimental field to measure the shallow and deep groundwater to confirm the nutrient distribution. A hand operated piling 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 in-

serted into the holes. The space around the tubes was backfilled with sand up to 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 extended above the soil surface for 0.5m is as to avoid the surface water flow entering the piezometers. Finally they were end capped to avoid rain filling the tubes. The design of the piezometers is prepared on the models of nested piezometers by Aarons et al. (2004).

Piezowater samples were collected at five different intervals *viz.*, 30, 60, 120, 150 and 180 days after the application of spent wash (DASW) as both pre-sown (M_1) and post-sown (M_2) and analysed for pH, EC, BOD and COD immediately after the collection. The water samples were preserved safely for further analysis. The characteristics of distillery spent wash are presented in Table 1.

Table 1: Characteristics of distillery spent wash (DSW).

Characteristics	Values
pH	7.65
EC (dS/m)	38.2
Total suspended solids (mg/L)	6,750
Total dissolved solids (mg/L)	48,120
Organic carbon (mg/L)	28,500
BOD ((mg/L)	8,900
COD (mg/L)	38,300
Total N (mg/L)	1,800
Total P (mg/L)	460
Total K (mg/L)	12,100
Soluble anions (meq/L)	
CO_3^-	Absent
HCO_3^-	52.13
Cl^-	250.72
SO_4^{2-}	77.35
Soluble cations (meq/L)	
K^+	237.25
Na^+	34.25
Ca^{2+}	52.65
Mg^{2+}	60.70

RESULTS AND DISCUSSION

pH: The pH of the leachate collected at 30 (L I), 60 (L II), 120 (L III), 150 (L IV) and 180 (L V) days after spent wash (DASW) application to the crop varied between 7.31 and 7.92 in M_1 (Fig. 4). The highest pH was recorded in the treatment T_5 with values of 7.75, 7.79, 7.84, 7.88 and 7.92 in L I, L II, L III, L IV and L V respectively, and lowest pH was registered in the control with pH of 7.31, 7.35, 7.39, 7.42 and 7.46 respectively, at the above mentioned leachings. The leachates collected at all five leachings due to post-sown application of spent wash ranged between 7.35 and 7.93.

In general, the pH of the leachate collected at 180 days after spent wash (DASW) application was increased in spent wash applied treatments over control (Fig. 1). There was a slight increase in pH from first to fifth leachings. The slight increase in pH might be due to alkaline nature of spent wash and continuous release of exchangeable bases *viz.*, Ca, Mg, Na and K into the soil solution and subsequent leaching. Corroborative results were reported by Sridharan (2007) who stated that application of distillery spent wash to maize gradually increased the pH of the leachate as the number of leachings increased. Saliha (2003) also reported the increase in pH with increase in leaching events in the sodic soil treated with organics and distillery spent wash. However, the pH values were within the safe limit of 7.31 to 7.92 which indicated that the groundwater is suitable for both irrigation and recreational purposes as per Indian Standards for industrial effluent discharge (IS: 2490-1982).

EC: The EC of the leachate collected in the pre-sown (M_1) application of distillery spent wash during first leaching was highest in T_5 (2.17 dS/m) and lowest in T_1 (0.66 dS/m) (Fig. 2). As the number of leachings increased, the EC value was decreased in T_5 and T_1, registering the value of 1.25 and 0.31 dS/m respectively. The post-sown application of distillery spent wash registered the EC value of 0.69 dS/m (T_1) and 2.20 dS/m (T_5) in the first leachings, later it got decreased to 0.33 to 1.30 dS/m in the fifth leachings.

A significant reduction in EC was observed after first leaching to fifth leaching in all the treatments (Fig. 2). The spent wash applied treatments recorded the higher EC than control in all leachings of both pre-sown and post-sown application of spent wash. However, the EC value did not exceed the critical limit of 2.0 dS/m for any water system. The EC content gradually decreased with the increase in number of leachings and got reduced from 2.17 to 1.25 dS/m in the plot that received distillery spent wash @ 100 kL/ha. Reduction in EC might be ascribed to the dilution of the salts through the irrigation water given to the crop and the spent wash was applied as one time application to the crops. Hence, the possibility of increase in the salt content of groundwater is very limited under field conditions when distillery spent wash is applied as one time land application up to 100 kL/ha. These findings are in line with Valliappan (1998).

Cations: The cations *viz.*, Ca^{++}, Mg^{++}, Na^+ and K^+ in the leachates varied considerably due to the application of distillery spent wash. The Ca^{++} content ranged from 1.81 to 10.06 meq/L and 1.86 to 10.78 meq/L in the leachates of M_1 and M_2 (Fig. 3). The treatment T_5 recorded the highest calcium content of 10.06 meq/L and the lowest Ca content was recorded in the treatment T_1 (2.63 meq/L) in the first leaching. Similar trend was observed in post-sown (M_2) application. The Mg^{++} content of the leachate collected during first leaching in M_1 was highest in T_5 (6.02 meq/L), and the minimum

Table 2: Effect of distillery spent wash application on the anions (Cl^-, SO_4^{2-}, HCO_3^-) contents of the groundwater.

Method of application / Treatments	M1					M2				
	LI	LII	LIII	LIV	LV	LI	LII	LIII	LIV	LV
					Sulphate (SO_4^{2-})					
T1	3.12	2.85	2.36	2.01	1.66	3.17	2.88	2.42	2.11	1.68
T2	4.24	3.62	2.84	2.41	2.12	4.32	3.65	2.92	2.5	2.21
T3	5.98	4.68	3.71	3.06	2.68	6	4.72	3.8	3.19	2.81
T4	6.94	6.13	4.55	4.12	3.66	7.12	6.2	4.61	4.21	3.79
T5	8.96	7.12	5.23	4.88	4.14	8.96	7.22	5.3	4.92	4.17
					Bicarbonate (HCO_3^-)					
T1	1.18	0.99	0.86	0.62	0.5	1.24	1.06	0.92	0.71	0.56
T2	1.86	1.61	1.3	1.18	0.98	1.97	1.72	1.41	1.31	1.06
T3	2.54	2.31	2.04	1.53	1.24	2.63	2.42	2.18	1.71	1.31
T4	3.64	3.26	2.84	2.06	1.72	3.78	3.37	2.98	2.12	1.82
T5	4.85	4.09	3.39	2.54	2.06	4.91	4.2	3.51	2.72	2.2
					Chloride (Cl^-)					
T1	3.54	3.36	2.56	2.06	1.85	3.6	3.42	2.87	2.31	1.74
T2	4.36	3.82	2.83	2.32	2.08	4.42	3.91	2.72	2.41	2.11
T3	6.64	5.65	3.64	3.06	2.54	6.75	5.74	3.76	3.19	2.6
T4	8.02	7.24	4.78	4.18	3.59	8.13	7.43	4.86	3.94	3.63
T5	10.8	8.28	5.1	4.26	3.91	11.2	8.36	5.15	4.38	3.89

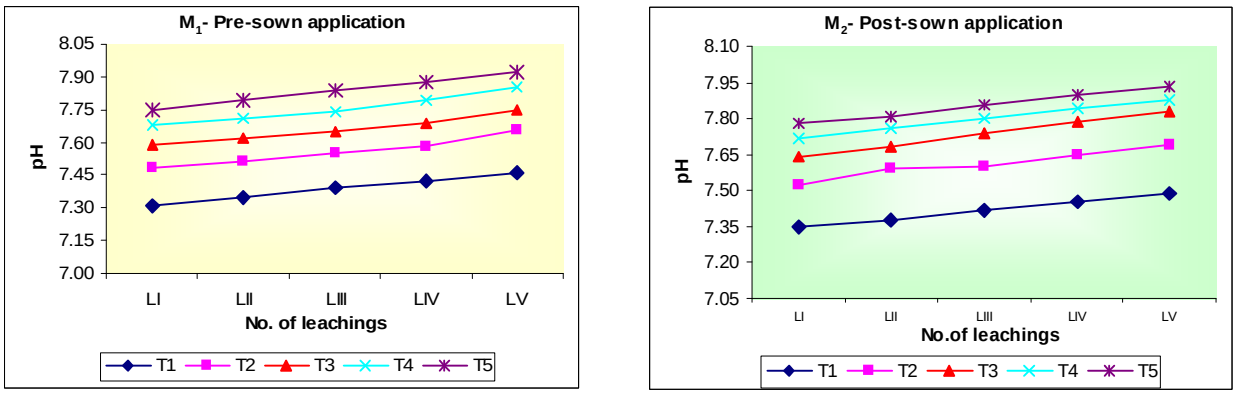

Fig. 1. Effect of distillery spent wash on pH of the leachate collected during the cropping period.

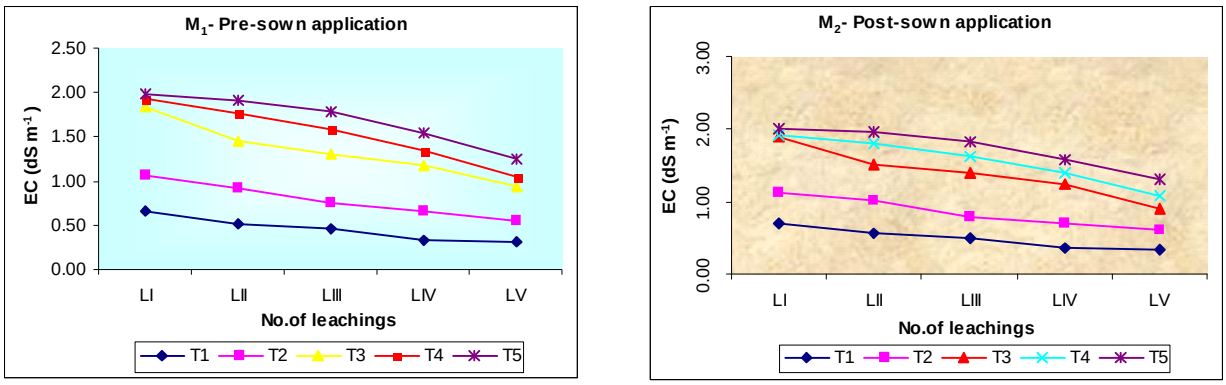

Fig. 2. Effect of distillery spent wash on EC of the leachate collected during the cropping period.

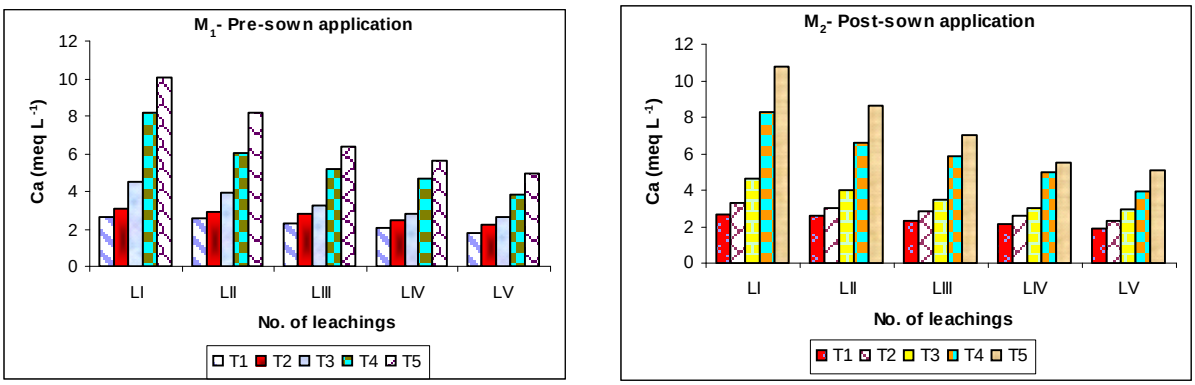

Fig. 3. Effect of distillery spent wash on calcium of the leachate collected during the cropping period.

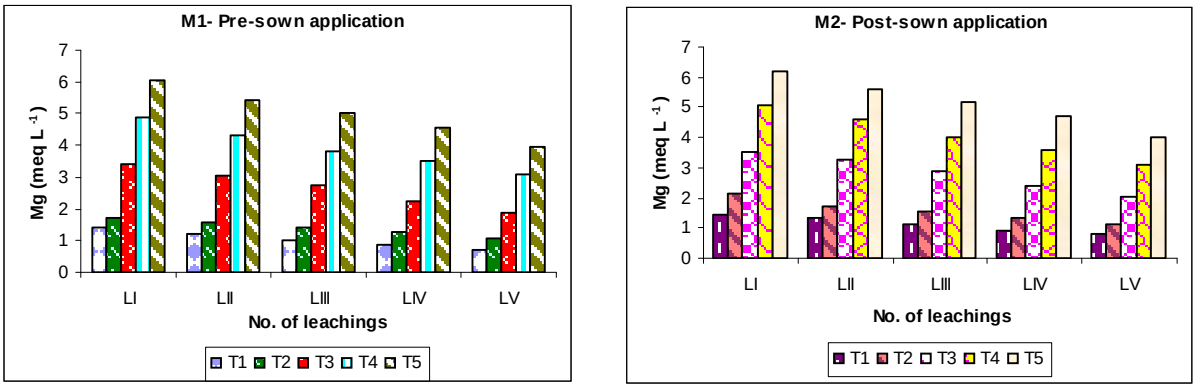

Fig. 4. Effect of distillery spent wash on magnesium of the leachate collected during the cropping period

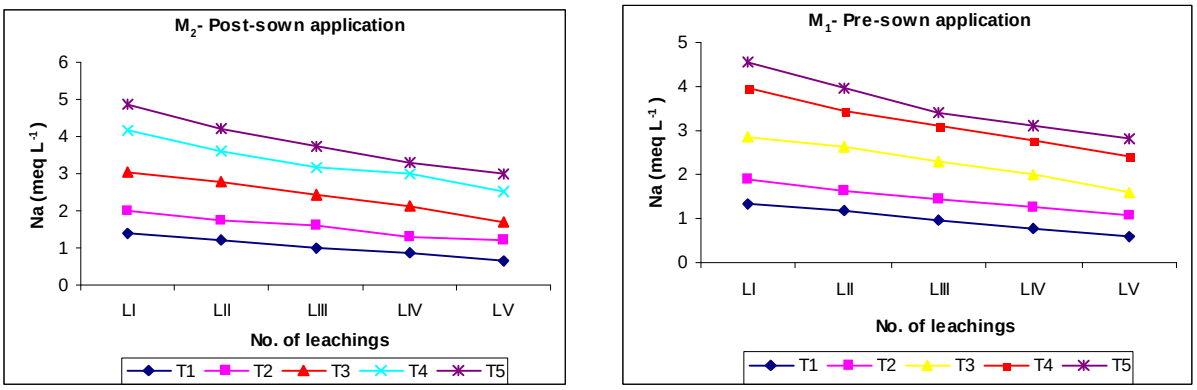

Fig. 5. Effect of distillery spent wash on sodium of the leachate collected during the cropping period.

was recorded in T_1 (1.43 meq/L) (Fig. 4). As the number of leachings increased, the Mg^{++} content got decreased in T_5 and T_1, registering the value of 3.98 and 0.71 meq/L respectively. In M_2, the Mg^{++} content ranged from 1.45 meq/L (T_1) to T_5 (6.21 meq/L) in the first leachate and later decreased to 0.81 to 4.01 meq/L for T_5 and T_1 respectively, in the fifth leachings.

The Na^+ and K^+ content of the leachate (Figs. 5 and 6) collected during first leaching recorded the highest value of 4.56 (T_5) and 3.86 (T_5) respectively, and lowest values of 1.34 (T_1) and 0.39 (T_1) meq/L were recorded in M_1, for Na^+ and K^+ respectively. M_2 registered the highest Na^+ and K^+ contents of 4.85 meq/L (T_5) and 4.21 meq/L (T_1) respectively, during first leaching. The Na and K contents decreased with

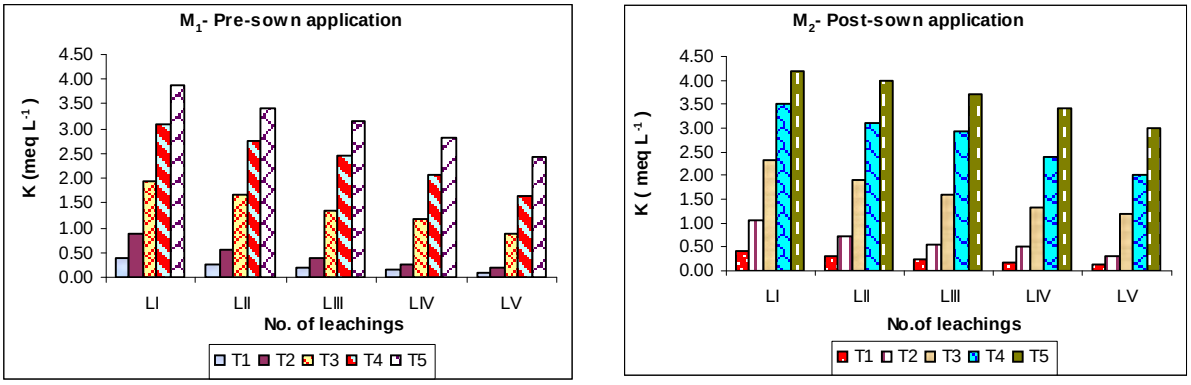

Fig. 6. Effect of distillery spent wash on the potassium of the leachate collected during the cropping period.

the progressive increase of the leaching events. Application of distillery spent wash resulted in considerable amounts of cations *viz.*, Ca^{++}, Mg^{++}, Na^{+} and K^{+} in the leachate collected from piezometer of 1m depth (Figs. 3, 4, 5 & 6). This might be due to higher amount of cations present in spent wash applied to the experimental field. Corroborative results were given by Nunes et al. (1982) who reported the contents of Ca^{++}, Mg^{++} and K^{+} in each percolate volume tended to increase with increasing rates of vinasse. However, there was a decrease in value of cations with the increase in number of leachings. This is in line with the findings of Malathi (2002) who also reported that amount of cations in the leachates decreased with the increase in leaching events.

Anions: The anions *viz.*, Cl^{-}, SO_4^{2-} and HCO_3^{-} varied due to the application of distillery spent wash. In the pre-sown and post-sown application of distillery spent wash, the HCO_3^{-} ranged from 1.18 to 4.85 and 1.24 to 4.91 meq/L respectively, in the first leaching (Table 2). The HCO_3^{-} content got decreased to 2.06 meq/L from 4.85 meq/L in the treatment T_5 as the leaching events pronounced from first to fifth leaching in M_1. Among the treatments, M_2 followed the trend of M_1. The Cl^{-} content of the five leachates ranged from 1.85 to 10.8 meq/L and 1.74 to 11.2 meq/L in the pre-sown (M_1) and post-sown (M_2) application of distillery spent wash, respectively (Table 2). The highest Cl^{-} content in first leachings was recorded in T_5 (10.8 meq/L) and (11.2 meq/L) in the M_1 and M_2, respectively, and the lowest being recorded in T_1 (3.54 and 3.60 meq/L in M_1 and M_2, respectively). Similar trend was observed for other leachates collected at four different intervals.

The leachate collected at five different leachings recorded the SO_4^{2-} content ranging from 1.66 to 8.96 meq/L in M_1 and 1.68 to 8.96 meq/L in M_2 (Table 2). The SO_4^{2-} content was higher in T_5 (8.96 meq/L), followed by T_4 (6.94 meq/L) and the lower SO_4^{2-} content was registered in T_1 (3.12 meq/L) in the leachate collected at first leaching in M_1. Similar trend was observed in the remaining leaching events. In seeing M_2, the variation among the treatments followed the similar trend as that of pre-sown application of distillery spent wash.

In general, the Cl^{-}, SO_4^{2-} and HCO_3^{-} contents of the leachate collected from 1.0 m depth piezometer increased with application of distillery spent wash to the crop (Table 2). As the leaching events progressed from first to fifth leaching, the level of chloride reduced from 10.8 to 3.91 and 11.2 to 3.89 meq/L in pre-sown and post-sown application of distillery spent wash, respectively. The high Cl^{-} content of spent wash and soil might have facilitated greater leaching of Cl^{-} ions. In most of the soil amended with spent wash, large accumulation of salts followed by greater amount of leaching were reported by Singh et al. (1980). However, the chloride content in the leachate collected at fourth and fifth leachings were well within safer limit of < 4 meq/L.

In general, EC, anions and cations of the leachate collected at fourth and fifth leachings were reduced compared to first leachate collected. This might be due to the fact that distillery spent wash was applied to crop field as only one time application to the crop and also the salt load present in the spent wash may get diluted through the irrigation water supplied throughout the cropping period. Thus, the results indicated that the pH, EC, cations and anions of the leachate were slightly increased in distillery spent wash applied treatments, compared to control. Also, pH, EC, cations and anions of the leachate were slightly increased during first leaching, and were tremendously decreased during fourth and fifth leachings, only when distillery spent wash was applied as one time application for one year.

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