Effect of different doses of distillery spentwash on leaching using column study

D. JANAKI AND V. VELU

Introduction

Application of distillery spentwash results in the accumulation of large amounts of potassium (K), sodium (Na), calcium (Ca) and magnesium (Mg) as major cations and chloride (Cl), sulphate (SO₄), nitrate (NO₃) and phosphate (PO₄) as the associated anions besides small amounts of carbonate (CO₃) and bicarbonate (HCO₃) salts in the soil. Presence of excess salts affects the plant growth due to specific ion toxicity, high osmotic pressure of soil solution, low physiological availability of water to plants and complex interaction between ions leading to imbalances. Hence, leaching of salts from the soil, particularly from the root zone, is a prerequisite for crop production whenever the distillery spentwash is applied.

The distillery industrial waste water is non toxic, biodegradable, purely of plant origin and contains large quantities of soluble organic matter and plant nutrients, which may be utilized by the plants for their growth and yield. However, the only problem with distillery effluent is its high BOD, COD and salt content being observed as non ecofriendly (Rajukkannu and Manickam, 1997) and because of which disposal is a problem for sugarcane growing countries where distilleries has recently expanded (Jadhav et al., 2005). Leaching is the process of downward movement of water through the soil. Because salts movement with water, groundwater contamination depends on the extend of leaching of these salts from the spentwash amended soils. The amounts of salts that are leached out and retained in the soil were determined through column experiment.

Resources and Research Methods

Soil column experiment was conducted under laboratory conditions to examine the mobility and transport of salts and nutrients in the soil under spentwash application. Cylindrical poly vinyl chloride tubes of 30 cm height with an internal diameter of 6 cm were used. At the bottom, a layer of filter paper (Whatman No. 1) and nylon mesh (<0.2mm) were placed and secured tightly for the free flow of water without soil displacement. Calculated quantity (1.056 kg) of soil (<2mm)
was gently tapped in the column from the bottom to the top to a height of 25 cm leaving 5 cm at the top (above the soil surface) for the application of spentwash and water. A uniform bulk density of 1.42 Mg m\(^{-3}\) was maintained throughout the column.

The columns were mounted on the plastic funnels provided with glass jars for the collection of leachates. Spentwash at the rate of 0, 25, 50 and 100 m\(^3\) ha\(^{-1}\) was applied uniformly and mixed thoroughly in the top 10 cm. Each treatment was replicated thrice and the columns were arranged in a Completely Randomized Design. After two weeks of spentwash application, leachate was collected by allowing water from the reservoir to pass through the column at the rate of 1ml/min. The leaching was carried out based on pore volume. After 15 days of spentwash application, the column was leached with distilled water and the leachate samples were analyzed for various parameters like pH, EC, cations and anions at periodical intervals. At the end of experiment, the column was dismantled and the soil was analyzed for various chemical properties.

Research Findings and Discussion

The experimental findings of the present study have been presented in the following sub heads:

**pH of the leachate:**

pH of the leachate varied from 7.60 to 8.60 in L\(_1\)T\(_1\) and L\(_3\)T\(_3\), respectively. Control soil had a pH of 7.85 whereas the pH of the soil that received the highest dose of DSW (100 m\(^3\) ha\(^{-1}\)) was 8.33. The pH of the leachates collected from the control soil ranged from 7.34 to 7.96 (Table1). Among the leaching events, sixth leaching event recorded the highest value of pH (8.64) followed by L\(_3\) and L\(_5\) which were at par among themselves and these were followed by L\(_2\) and L\(_4\) which in turn were at par among themselves while the control recorded the lowest.

Among the levels of spentwash, the treatment T\(_4\) recorded the highest pH (8.33) followed by T\(_3\) and then T\(_2\) while the control T\(_1\) recorded the lowest (7.85). The pH of the leachates showed an increasing trend with increasing number of leaching events which might be attributed to the continuous release of exchangeable bases (Ca\(^{2+}\), Mg\(^{2+}\), K\(^{+}\) and Na\(^{+}\)) into soil solution. Similar result was reported by Rajukannu and Manickam (1997), Malathi (2002) and Shenbagavalli (2007).

**EC of the leachate:**

The leachate from the control soil (no spentwash) application recorded lower values of EC (0.21–0.79 dS m\(^{-1}\)) at all the leaching events. Higher rate of spentwash application (100 m\(^3\) ha\(^{-1}\)) resulted in higher EC of the leachates at all leaching events and the lowest EC values were obtained from the control soil (Table 2). As regards to the leaching events, L\(_1\) recorded

<table>
<thead>
<tr>
<th>Table 1: Effect of different levels of spentwash on pH of the leachate (Mean of three replications)</th>
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</thead>
<tbody>
<tr>
<td>Treatments</td>
</tr>
<tr>
<td>T(_1)-Control</td>
</tr>
<tr>
<td>T(_2)-25 m(^3) ha(^{-1})</td>
</tr>
<tr>
<td>T(_3)-50 m(^3) ha(^{-1})</td>
</tr>
<tr>
<td>T(_4)-100 m(^3) ha(^{-1})</td>
</tr>
<tr>
<td>Mean</td>
</tr>
<tr>
<td>S.E.(\pm)</td>
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<tr>
<td>C.D. (P=0.05)</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 2: Effect of different levels of spentwash on EC (dS m(^{-1})) of the leachate (Mean of three replications)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatments</td>
</tr>
<tr>
<td>T(_1)-Control</td>
</tr>
<tr>
<td>T(_2)-25 m(^3) ha(^{-1})</td>
</tr>
<tr>
<td>T(_3)-50 m(^3) ha(^{-1})</td>
</tr>
<tr>
<td>T(_4)-100 m(^3) ha(^{-1})</td>
</tr>
<tr>
<td>Mean</td>
</tr>
<tr>
<td>S.E.(\pm)</td>
</tr>
<tr>
<td>C.D. (P=0.05)</td>
</tr>
</tbody>
</table>

Leaching event (L) | 0.09 |
Treatment (T) | 0.18 |
L x T | 0.28
the highest EC of 12.8 dS m\(^{-1}\) which got drastically reduced to 2.92 dS m\(^{-1}\) at L\(_2\) and 2.02 dS m\(^{-1}\) at L\(_3\), and thereafter it got further reduced to 0.58 – 0.25 dS m\(^{-1}\) at L\(_4\) to L\(_8\) which in turn were at par among themselves. Among the levels, increasing doses of DSW application markedly increased the EC of the leachate with T\(_4\) recording the highest (3.94 dS m\(^{-1}\)) while the control T\(_1\) recorded the lowest (0.47 dS m\(^{-1}\)). The results indicated that application of spentwash at higher rates might lead to build up of salts in the soil as claimed by Devarajan and Oblisami (1995), Chinnusamy et al. (2001) and Malathi (2002).

**Potassium content of the leachate:**

The K content of the leachate varied from 10.0 mg l\(^{-1}\) in L\(_8\)T\(_1\) to 360 mg L\(^{-1}\) in L\(_4\)T\(_4\). A steady and marked increase in the K content of the leachate from L\(_1\) (133 mg L\(^{-1}\)) to L\(_4\) (215 mg L\(^{-1}\)) was observed and thereafter it got drastically decreased at every leaching event to 74.7 mg L\(^{-1}\) at L\(_8\). Among the doses of spentwash, T\(_4\) recorded the highest (207.5 mg L\(^{-1}\)) followed by T\(_2\) while the control recorded the lowest (26.3 mg L\(^{-1}\)) (Fig. 1). The K and Na content got increased upto 4\(^{th}\) leaching event and thereafter it showed a decreasing trend. Similar results were noticed by Nunes et al. (1982) who reported that the contents of K\(^+\) in the percolate volume of the leachate tend to increase with increasing rate of spentwash. This is in close agreement with the findings of Saliha (2003).

**Sodium content of the leachate:**

Sodium content of the leachate varied from 8.0 in L\(_8\)T\(_2\) to 32.0 in L\(_4\)T\(_4\). The sodium content was the highest in 4\(^{th}\) leaching event (29.3 mg L\(^{-1}\)) followed by L\(_3\) and then L\(_2\) and L\(_5\) while L\(_8\) recorded the lowest (Fig. 2). Among the levels of spentwash, the treatment T\(_4\) recorded the highest followed by T\(_3\) and then T\(_2\) while control (T\(_1\)) recorded the lowest. At all leaching events, application of spentwash @ 100 m\(^{3}\) ha\(^{-1}\) resulted in higher amounts (12 to 32.0 mg L\(^{-1}\)) of Na in the leachate.

**Calcium content of the leachate:**

The amount of Ca leached from the soil varied significantly and ranged from 64 in L\(_8\)T\(_1\) to 492 mg L\(^{-1}\) in L\(_1\)T\(_4\). The Ca content was highest in 4\(^{th}\) leaching event (514 mg L\(^{-1}\)) followed by L\(_4\) while L\(_8\) recorded the lowest (Table 3). Among the levels, T\(_4\) recorded the highest (435 mg L\(^{-1}\)) while T\(_1\) recorded the lowest (136 mg L\(^{-1}\)). The amount of Ca leached...
Table 4: Effect of different levels of spentwash on Mg\(^{2+}\) (mg L\(^{-1}\)) content of the leachate

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Leaching events</th>
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<th></th>
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<th></th>
<th>Mean</th>
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<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>T(_1)-Control</td>
<td>18.0</td>
<td>20.0</td>
<td>25.9</td>
<td>28.5</td>
<td>25.8</td>
<td>18.3</td>
<td>13.3</td>
<td>12.4</td>
</tr>
<tr>
<td>T(_2)-25 m(^3)ha(^{-1})</td>
<td>23.1</td>
<td>25.4</td>
<td>33.3</td>
<td>36.0</td>
<td>33.3</td>
<td>27.5</td>
<td>21.4</td>
<td>19.6</td>
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<tr>
<td>T(_3)-50 m(^3)ha(^{-1})</td>
<td>35.3</td>
<td>40.0</td>
<td>42.9</td>
<td>45.1</td>
<td>42.9</td>
<td>37.2</td>
<td>30.5</td>
<td>28.4</td>
</tr>
<tr>
<td>T(_4)-100 m(^3)ha(^{-1})</td>
<td>43.8</td>
<td>52.1</td>
<td>61.0</td>
<td>62.9</td>
<td>61.0</td>
<td>53.5</td>
<td>47.7</td>
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<td>Mean</td>
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<td>34.4</td>
<td>40.8</td>
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<td>34.1</td>
<td>28.2</td>
<td>25.7</td>
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</tbody>
</table>

Leaching event (L): 1.98
Treatment (T): 1.44
L x T: 4.06

Table 5: Effect of different levels of spentwash on SO\(_4^{2-}\) (mg L\(^{-1}\)) content of the leachate

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<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th>Mean</th>
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<td>4</td>
<td>5</td>
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<td>7</td>
<td>8</td>
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<tr>
<td>T(_1)-Control</td>
<td>1.9</td>
<td>2.8</td>
<td>3.6</td>
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<td>5.2</td>
<td>5.0</td>
<td>2.4</td>
<td>2.0</td>
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<tr>
<td>T(_2)-25 m(^3)ha(^{-1})</td>
<td>4.5</td>
<td>7.3</td>
<td>9.3</td>
<td>12.4</td>
<td>9.7</td>
<td>5.7</td>
<td>3.6</td>
<td>2.2</td>
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<tr>
<td>T(_3)-50 m(^3)ha(^{-1})</td>
<td>5.2</td>
<td>7.4</td>
<td>12.2</td>
<td>14.0</td>
<td>10.4</td>
<td>7.9</td>
<td>6.2</td>
<td>4.2</td>
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<tr>
<td>T(_4)-100 m(^3)ha(^{-1})</td>
<td>4.2</td>
<td>13.1</td>
<td>14.2</td>
<td>19.3</td>
<td>10.3</td>
<td>10.6</td>
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<td>8.9</td>
<td>7.3</td>
<td>4.3</td>
<td>3.4</td>
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</table>

Leaching event (L): 0.51
Treatment (T): 0.20
L x T: 0.71

Table 6: Effect of different levels of spentwash on Cl\(^-\) (mg L\(^{-1}\)) content of the leachate

<table>
<thead>
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<th>Treatments</th>
<th>Leaching events</th>
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<th></th>
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<th></th>
<th></th>
<th>Mean</th>
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<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>T(_1)-Control</td>
<td>3.7</td>
<td>5.5</td>
<td>6.3</td>
<td>6.6</td>
<td>6.3</td>
<td>7.8</td>
<td>7.0</td>
<td>3.7</td>
</tr>
<tr>
<td>T(_2)-25 m(^3)ha(^{-1})</td>
<td>53.7</td>
<td>62.5</td>
<td>132.3</td>
<td>158.6</td>
<td>146.0</td>
<td>127.6</td>
<td>74.3</td>
<td>34.3</td>
</tr>
<tr>
<td>T(_3)-50 m(^3)ha(^{-1})</td>
<td>77.3</td>
<td>86.5</td>
<td>135.7</td>
<td>185.3</td>
<td>172.7</td>
<td>168.7</td>
<td>82.0</td>
<td>61.3</td>
</tr>
<tr>
<td>T(_4)-100 m(^3)ha(^{-1})</td>
<td>194.0</td>
<td>207.4</td>
<td>229.3</td>
<td>285.7</td>
<td>256.0</td>
<td>233.3</td>
<td>86.3</td>
<td>58.7</td>
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<tr>
<td>Mean</td>
<td>82.1</td>
<td>90.4</td>
<td>125.9</td>
<td>159.1</td>
<td>145.2</td>
<td>134.3</td>
<td>62.4</td>
<td>39.5</td>
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<td>S.E.</td>
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<td>2.08</td>
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<td>C.D. (P=0.05)</td>
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<td></td>
<td></td>
<td></td>
<td>1.40</td>
</tr>
</tbody>
</table>

Leaching event (L): 2.14
Treatment (T): 1.76
L x T: 4.81

Table 7: Characteristics of spentwash applied soil after eighth leaching event

<table>
<thead>
<tr>
<th>Treatments</th>
<th>pH</th>
<th>EC</th>
<th>OC</th>
<th>K(^+)</th>
<th>Na(^+)</th>
<th>Ca(^{2+})</th>
<th>Mg(^{2+})</th>
<th>Cl</th>
<th>SO(_4^{2-})</th>
<th>KMnO(_4)-N</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>T(_1)-Control</td>
<td>6.0</td>
<td>0.06</td>
<td>0.21</td>
<td>72.0</td>
<td>45.0</td>
<td>28.0</td>
<td>12.0</td>
<td>10.0</td>
<td>12.0</td>
<td>92.0</td>
<td>8.0</td>
</tr>
<tr>
<td>T(_2)-25 m(^3)ha(^{-1})</td>
<td>6.8</td>
<td>0.09</td>
<td>0.48</td>
<td>96.0</td>
<td>78.0</td>
<td>264.0</td>
<td>176.0</td>
<td>32.0</td>
<td>38.0</td>
<td>129.0</td>
<td>12.0</td>
</tr>
<tr>
<td>T(_3)-50 m(^3)ha(^{-1})</td>
<td>7.2</td>
<td>0.12</td>
<td>0.63</td>
<td>121.0</td>
<td>98.0</td>
<td>282.0</td>
<td>180.0</td>
<td>45.0</td>
<td>63.0</td>
<td>186.0</td>
<td>16.0</td>
</tr>
<tr>
<td>T(_4)-100 m(^3)ha(^{-1})</td>
<td>7.6</td>
<td>0.76</td>
<td>0.76</td>
<td>190.0</td>
<td>102.0</td>
<td>299.0</td>
<td>192.0</td>
<td>59.0</td>
<td>79.0</td>
<td>220.0</td>
<td>26.0</td>
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<tr>
<td>S.E.d.</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
<td>0.08</td>
<td>0.42</td>
<td>2.08</td>
<td>1.40</td>
<td>0.34</td>
<td>0.48</td>
<td>0.93</td>
<td>0.13</td>
</tr>
<tr>
<td>C.D. (5%)</td>
<td>0.02</td>
<td>0.02</td>
<td>0.02</td>
<td>2.14</td>
<td>1.04</td>
<td>5.10</td>
<td>3.42</td>
<td>0.83</td>
<td>1.17</td>
<td>2.29</td>
<td>0.31</td>
</tr>
</tbody>
</table>
increased rapidly up to 4th leaching event and thereafter decreased. At all leaching events, Ca leaching was greater (492 to 246 mg L\(^{-1}\)) in the soil amended with 100 m\(^3\) ha\(^{-1}\) of spentwash (T\(_4\)).

**Magnesium content of the leachate:**
Mg content of the leachate varied from 12.4 to 62.9 mg L\(^{-1}\) in L\(_8\) T\(_1\) and L\(_4\) T\(_4\), respectively (Table 4). Among the leaching events, L\(_3\), L\(_4\), L\(_5\) being on a par recorded higher Mg content followed by L\(_2\) and L\(_6\) while L\(_8\) recorded the lowest. Among the doses of spentwash, T\(_4\) recorded the highest followed by T\(_3\) while T\(_1\) recorded the lowest. Increasing levels of the spentwash, increased the amount of Mg leached and the application of spentwash at 100 m\(^3\) ha\(^{-1}\) resulted in larger amounts of Mg leached out in the soil. Ca and Mg content in the leachate increased up to 4th leaching event and thereafter decreased. Similar trend of results was reported by Malathi (2002).

**Sulphate content of the leachate:**
The amount of sulphate leached varied significantly due to the application of spentwash. Sulphate content of the leachate varied from 1.9 in L\(_1\) T\(_1\) to 19.3 mg L\(^{-1}\) in L\(_4\) T\(_4\). Among the treatments, L\(_4\) recorded the highest (193.8 mg L\(^{-1}\)) while the control recorded the lowest (583 mg L\(^{-1}\)) (Table 5). However, the Cl\(^{-}\) content of the leachate was found to increase up to 4th leaching event and thereafter it got decreased. However, in most of the treatments, the concentration of Cl\(^{-}\) and SO\(_4^{2-}\) in the leachate were within the safer limits of 600 to 1000 mg L\(^{-1}\), respectively prescribed by the ISI for the disposal of effluent into inland surface water and land for irrigation.

**Chloride content of the leachate:**
Increasing levels of spentwash application markedly increased chloride content in the leachate. The Cl\(^{-}\) content varied from 3.7 in L\(_1\) T\(_1\) to 285.7 mg L\(^{-1}\) in L\(_4\) T\(_4\). Among the treatments, T\(_4\) recorded the highest (193.8 mg L\(^{-1}\)) while the control recorded the lowest (583 mg L\(^{-1}\)) (Table 6). However, the Cl\(^{-}\) content of the leachate was found to increase up to 4th leaching event and thereafter it got decreased. However, in most of the treatments, the concentration of Cl\(^{-}\) and SO\(_4^{2-}\) in the leachate were within the safer limits of 600 to 1000 mg L\(^{-1}\), respectively prescribed by the ISI for the disposal of effluent into inland surface water and land for irrigation.

**Characteristics of soil after eighth leaching:**
Application of spentwash at different levels had a significant effect on the residual pH of the soil. The residual EC of soil after 8th leaching showed that all the soils had EC <1 dS m\(^{-1}\). The Ca and Mg content in the soil increased with increasing dose of spentwash application where the highest value was recorded in T\(_4\) (100 m\(^3\) ha\(^{-1}\)) (Table 7). The residual Cl\(^{-}\) and SO\(_4^{2-}\) in the soil after eighth leaching varied from 10 to 59 and 12 to 79 mg kg\(^{-1}\) in the soil, respectively. The residual available phosphorus and K content varied from 8 to 26 mg kg\(^{-1}\) and 72 to 190 mg kg\(^{-1}\), respectively. Similarly, the organic carbon content of the soil had also registered more than three fold increased for the application of the highest dose of DSW @ 100 m\(^3\) ha\(^{-1}\).

**Literature Cited**


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