Investigating The Viability and Performance Of The Pilot Scale Fly Ash/Lime Filter Tower For Onsite Greywater Treatment

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Water Scarcity

• Increase in urbanisation – Increase in water demand.

• South Africa is a water scarce country.

• Alternatives are required - e.g. Greywater, Rainwater harvesting etc.

• Innovative approaches are needed to mitigate water scarcity.
The use of greywater has become a common practice.

Greywater can be used for non-potable purposes [24].

Environmental feasibility [14].

Economic feasibility [18].
Greywater

• The US, Australia and the Middle East have accepted the use of greywater for irrigation [17,18].

• Reduces the demand for water supply [6].

• Reduce the demand for high quality potable water for non-potable uses [3,6].

• Reduce energy demands and carbon footprint of water services [6].
Greywater in South Africa

• Some areas in South Africa lack proper sanitation facilities [1].

• Greywater disposal is a major sanitation problem [1].

• Greywater is often disposed outside the houses.

• The ponded greywater creates environmental and health risks [1,4].

• Microorganisms are likely to proliferate, causing diseases in humans and animals [5].
Fly Ash/ Lime Filter Tower (FLFT)

- On-site treatment.
- Low cost material.
  - Avoid theft.
- Easy to operate.
- Coupled to a drip irrigation system.
FLFT

- **Fly Ash**
  - By-product of coal combustion [5].
  - Made up of different elements e.g. Al,
  - Where most of the greywater treatment occurs.

- **Water Hyacinth** (*Eichhornia crassipes*).
  - Invasive species [10].
  - High absorptivity [10].
  - Used for pH stability.

Image adapted from http://www.painetworks.com/previews/gj/gj0690.html
Methodology

Greywater Characterization
- Microbial constituents
  - Faecal Coliforms
  - Total Bacteria
- pH
- Turbidity
- Chemical Oxygen Demand (COD)
- Nitrates
- Phosphates
- Chlorides
- Ammonium

Environmental Impact Studies
- Faecal coliforms
- Total bacteria (Anaerobic and aerobic)
- Bulk density
- Particle size density
- Loss on ignition
- Metal analysis
- pH
- Plant analysis - Data not available
Greywater Characterization

• *Microbial analysis*

• **Faecal coliforms**
  – Influent = ~ 65 - 110 CFU/100 ml
  – Effluent = ~ 20-50 CFU/100 ml

• **Total bacteria**
  – Influent = ~3.0 x 10^7 CFU/ml
  – Effluent = ~6.0 x 10^6 CFU/ml
Table 1: The physico-chemical components of the greywater before and after treatment with the FLFT. (Grahamstown East).

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Fingo</th>
<th></th>
<th>Extension 1</th>
<th></th>
<th>Extension 9</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Influent</td>
<td>Effluent</td>
<td>Influent</td>
<td>Effluent</td>
<td>Influent</td>
<td>Effluent</td>
</tr>
<tr>
<td>pH</td>
<td>8.92 ± 0.5</td>
<td>6.87 ± 0.5</td>
<td>7.63 ± 0.7</td>
<td>6.91 ± 0.5</td>
<td>7.22 ± 0.6</td>
<td>7.19 ± 0.5</td>
</tr>
<tr>
<td>Turbidity (ntu)</td>
<td>748 ± 213.4</td>
<td>430 ± 411.1</td>
<td>691 ± 98.8</td>
<td>368 ± 97.3</td>
<td>1032 ± 55.5</td>
<td>598 ± 276.9</td>
</tr>
<tr>
<td>COD (mg/l)</td>
<td>2116.2 ±108.1</td>
<td>392.2 ±23.0</td>
<td>2994.5 ± 653.3</td>
<td>411.7 ±69.5</td>
<td>2978.3 ±129.2</td>
<td>376.5 ±96.4</td>
</tr>
<tr>
<td>NO₃⁻ (mg/l)</td>
<td>96.54 ± 87.9</td>
<td>45.58 ± 21.9</td>
<td>71.61 ± 50.8</td>
<td>24.43 ± 17.4</td>
<td>78.95 ± 7.4</td>
<td>44.84± 10.8</td>
</tr>
<tr>
<td>PO₄⁻ (mg/l)</td>
<td>1.87 ± 0.6</td>
<td>0.78 ± 0.7</td>
<td>8.08 ± 3.2</td>
<td>2.14 ± 1.8</td>
<td>3.71 ± 2.2</td>
<td>2.45 ± 1.9</td>
</tr>
<tr>
<td>NH₄⁺ (mg/l)</td>
<td>3.25 ± 1.9</td>
<td>1.73 ± 1.4</td>
<td>6.93 ± 3.1</td>
<td>3.392 ± 2.6</td>
<td>2.55 ± 1.8</td>
<td>1.30 ± 1.8</td>
</tr>
<tr>
<td>Cl⁻ (mg/l)</td>
<td>7.80 ± 3.1</td>
<td>4.43 ± 2.0</td>
<td>15.15 ± 6.3</td>
<td>7.9 ± 3.1</td>
<td>6.0 ± 3.1</td>
<td>3.86 ± 1.9</td>
</tr>
</tbody>
</table>
Table 2: The physico-chemical components of the greywater before and after treatment with the FLFT. (Grahamstown West).

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Town 1</th>
<th>Town 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Influent</td>
<td>Effluent</td>
</tr>
<tr>
<td>pH</td>
<td>7.23 ± 0.6</td>
<td>6.94 ± 0.5</td>
</tr>
<tr>
<td>Turbidity (ntu)</td>
<td>986 ± 282.6</td>
<td>26.2 ± 6.5</td>
</tr>
<tr>
<td>COD (mg/l)</td>
<td>1509.7 ± 260.9</td>
<td>291.3 ± 95.1</td>
</tr>
<tr>
<td>NO₃⁻ (mg/l)</td>
<td>35.10 ± 10.7</td>
<td>23.40 ± 8.4</td>
</tr>
<tr>
<td>PO₄⁻ (mg/l)</td>
<td>1.60 ± 0.6</td>
<td>0.88 ± 0.2</td>
</tr>
<tr>
<td>NH₄⁺ (mg/l)</td>
<td>2.95 ± 1.7</td>
<td>1.53 ± 1.6</td>
</tr>
<tr>
<td>Cl⁻ (mg/l)</td>
<td>3.31 ± 1.7</td>
<td>1.9 ± 0.8</td>
</tr>
</tbody>
</table>

There is a significant decrease in the turbidity.
**Figure 2**: Percentage removal of the chemical content of the greywater after treatment with the Fly Ash/Lime Filter Tower treatment system to check the efficiency of the system with respect to the sites.
Soil Analysis

Table 1: Soil analysis of the initial samples (untreated) and treated samples (irrigated with greywater treated using the FLFT system over a period of time. (Grahamstown East)

<table>
<thead>
<tr>
<th></th>
<th>Fingo</th>
<th>Extension 1</th>
<th>Extension 9</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Initial</td>
<td>After</td>
<td>Initial</td>
</tr>
<tr>
<td>pH</td>
<td>6.50±0.3</td>
<td>7.53±0.16</td>
<td>5.76±0.02</td>
</tr>
<tr>
<td>Bulk density (g/cm³)</td>
<td>0.79±0.01</td>
<td>0.81±0.12</td>
<td>0.84±0.01</td>
</tr>
<tr>
<td>Particle size density (g/cm³)</td>
<td>2.10±0.1</td>
<td>2.11±0.03</td>
<td>2.2±0.2</td>
</tr>
<tr>
<td>Loss on ignition (%)</td>
<td>10.81±0.02</td>
<td>13.95±1.32</td>
<td>11.33±0.03</td>
</tr>
</tbody>
</table>
Table 2: Soil analysis of the initial samples (untreated) and treated samples (irrigated with greywater treated using the FLFT system over a period of time (Grahamstown West).

<table>
<thead>
<tr>
<th></th>
<th>Town 1</th>
<th></th>
<th>Town 2</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Initial</td>
<td>After</td>
<td>Initial</td>
<td>After</td>
</tr>
<tr>
<td>pH</td>
<td>6.60±0.04</td>
<td>7.38±0.14</td>
<td>6.13±0.02</td>
<td>7.31±0.20</td>
</tr>
<tr>
<td>Bulk density (g/cm³)</td>
<td>0.15±0.002</td>
<td>0.75±0.02</td>
<td>0.116±0.004</td>
<td>0.89±0.03</td>
</tr>
<tr>
<td>Particle size density(g/cm³)</td>
<td>2.48±0.02</td>
<td>2.23±0.06</td>
<td>2.31±0.1</td>
<td>2.27±0.06</td>
</tr>
<tr>
<td>Loss on ignition (%)</td>
<td>13.05±0.04</td>
<td>14.52±3.79</td>
<td>13.89±0.02</td>
<td>15.33±1.19</td>
</tr>
</tbody>
</table>
Soil Analysis

Table 2: Metal analysis of soil after irrigation with greywater from the Fly Ash/Lime Filter Tower.

<table>
<thead>
<tr>
<th>Sites</th>
<th>Mn</th>
<th>Cu</th>
<th>Pb</th>
<th>Cd</th>
<th>Mg</th>
<th>K</th>
<th>Al</th>
<th>Fe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fingo</td>
<td>8.4</td>
<td>0.63</td>
<td>3.22</td>
<td>0.0</td>
<td>75.18</td>
<td>45.34</td>
<td>142.70</td>
<td>133.90</td>
</tr>
<tr>
<td>Ext 1</td>
<td>20.60</td>
<td>0.73</td>
<td>2.10</td>
<td>0.0</td>
<td>31.38</td>
<td>25.18</td>
<td>139.52</td>
<td>182.80</td>
</tr>
<tr>
<td>Ext 9</td>
<td>32.30</td>
<td>1.12</td>
<td>2.29</td>
<td>0.0</td>
<td>41.48</td>
<td>71.00</td>
<td>149.02</td>
<td>222.24</td>
</tr>
<tr>
<td>Town 1</td>
<td>18.59</td>
<td>0.41</td>
<td>0.40</td>
<td>0.0</td>
<td>34.20</td>
<td>31.29</td>
<td>168.15</td>
<td>207.00</td>
</tr>
<tr>
<td>Town 2</td>
<td>18.69</td>
<td>0.42</td>
<td>0.0</td>
<td>0.0</td>
<td>82.99</td>
<td>23.02</td>
<td>134.20</td>
<td>174.22</td>
</tr>
</tbody>
</table>

Samples were analysed using ICP/OES
Water and Plant samples
Conclusion

• The project was part of a civic engagement to address the community’s urgent needs.
  – food security.
  – Improvement of sanitation.

• Aimed at the development of a socially responsive biotechnology and healthcare professional.

• Decrease in the concentration of the tested parameters: COD, turbidity and pH.

• Decrease in pH: Water hyacinth incorporated into the tower.

• The FLFT was efficient:
  – producing an effluent compliant with greywater quality guidelines in South Africa.
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Thank you