Comparative Analysis of Hydrocotyle umbellata, Pistia stratiotes & Eichhorina crassipess for the Removal of Contaminants in Domestic Wastewater

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Abstract

The aim of the present study was to determine the performance of aquatic macrophytes in the treatment lagoons at NARC, Islamabad. The analytical procedure given by APHA (2005) was followed for the determination of physical parameters (pH, EC and TDS) and chemical parameters (Cl\textsuperscript{-1}, SO\textsubscript{2}\textsuperscript{-1} and NO\textsubscript{3}\textsuperscript{-1}) of the domestic wastewater. Rhizofiltration efficiency of the experimental plants was in sequence as Pistia stratiotes>Eichhornia crassipess>Hydrocotyle umbellatta at average temperature of 33\degree C while Pistia stratiotes and Eichhornia crassipess showed maximum removal efficiency at 31\degree C whereas Hydrocotyle umbellatta at 35\degree C. This biologically treated domestic wastewater can be used for irrigating farmlands and parks.

Keyword: Hydrocotyle umbellata, Pistia stratiotes, Eichhorina crassipess, contaminants, domestic, wastewater

Introduction

Domestic waste containing household effluent and human waste is either discharged directly to sewer system, natural drain, water body, a nearby field or an internal septic tank. Pakistan, an agriculture-based country once had surplus water, is currently a water deficit country as per capita water availability in 1951 was 5300 m\textsuperscript{3} but recently reduced to 1105 m\textsuperscript{3}, just touching the water scarcity level of 1000 m\textsuperscript{3} (SOER, 2005). Out of the total available fresh water 88% alone is used for irrigation (Gleick, 2000). Pakistan has a total of 77 million acres of land suitable for irrigation out of which 71% is already cultivated, but the remaining 29% can become dynamic if water made available for irrigation (PIDAT, 2003). Therefore, the country is in dire need to sustainably use and conserve this precious resource. The 3R principle of reuse, recycle and reduce may be helpful in achieving the objectives as ten large urban centers of Pakistan produces more than 60% of the total urban wastewater including household, industrial and commercial wastewater (WB-CWRAS, 2005) out of which only 8% is treated in municipal treatment plants (Feestra et al., 2005).

Domestic waste water contain various chemicals may affect transplants and sensitive crops at the initial growth stage (WHO, 2004). Serious public health problems rose due to the use of wastewater. Wastewater carries a wide range of pathogenic organisms posing a risk to agriculture workers, crop handlers and consumers. High level of nitrogen in wastewater results in nitrate pollution of groundwater, which could lead to adverse effects on human health (Blumenthal et al., 2001).

Chloride helps plants to metabolize. The accumulated chloride concentration in leaves exceeds the crop's tolerance, injury symptoms develop in the form of leaf burn. This starts at the tips of leaves and progresses from the tip back, along the edges, as the severity increases. In extreme cases chloride toxicity manifests itself in early leaf drop. Crop quality is affected by chloride-induced leaf injury in plants whose leaves are the marketed product, or where fruit size and appearance are affected by chloride-induced yield decreases (Imran, 2005).

Sulfate is used for protein synthesis, enzyme reaction and energy transfer. A plant injured by excessive sulfate first displays mottled leaves or yellowed tissue between the veins of leaves. This is followed by leaves that are dead at their tips, at their margins, and in areas between their veins. Excessive sulfate concentration may lead to laxative effect and it affects the alimentary canal (Purushotham et al., 2011).

Hydrocotyle umbellatta common name is pennywort belongs to family Apiaceae. It is free-floating aquatic plant. It reproduces from fragments and seeds and can spread across the soil or water in large mats (Afrous et al., 2010). Pistia stratiotes common name is water lettuce belongs to family Araceae. It is...
free-floating aquatic plant. It is a free-floating plant that is capable of forming dense mats on the surface of lakes, ponds, rivers and other bodies of water (Moore, 2005). *Eichhornia crassipess* common name is water hyacinth belongs to family Pontederiaceae. It is free-floating aquatic plant. Cold-damaged leaves then fold down and protect the meristem, which grows at or immediately below the surface of the water (Hussain *et al.*, 2010).

**Methodology**

**Sampling:** The experiment was carried out in an aerobic treatment lagoons in natural environment, sample of wastewater was collected from all bio-treatment ponds. From each pond, samples were collected three times. Water samples were collected directly from inlet and outlet of each pond during subsequent days, 10, 20 and 31 days. Mechanism of treatment is exclusively based on bio-remediation i.e. using indigenous plants and microbes. Table (i) shows the dimension and water storing capacity of different ponds.

<table>
<thead>
<tr>
<th>Plants</th>
<th>Length (ft)</th>
<th>Width (ft)</th>
<th>Depth (ft)</th>
<th>Storage Capacity (m.gal)</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Pistia stratiotes</em></td>
<td>97</td>
<td>83</td>
<td>6.5</td>
<td>0.40</td>
</tr>
<tr>
<td><em>Eichhornia crassipess</em></td>
<td>98</td>
<td>80</td>
<td>6.5</td>
<td>0.40</td>
</tr>
<tr>
<td><em>Hydrocotyle umbellatta</em></td>
<td>98</td>
<td>82</td>
<td>6.5</td>
<td>0.40</td>
</tr>
</tbody>
</table>

**Wastewater sampling and physio-chemical analysis:** For sample collection the bottles were washed with hot water followed by distilled water. During collection bottles were filled, rinsed with the sample water 2-3 times, tightly capped and properly labeled (APHA, 2005). Physical parameters of collected water samples were studied immediately, which were collected in replicates from all the bio-treatment ponds. In physical parameters analysis pH, EC and TDS were studied. While Chloride, Sulfate and Nitrate were the chemical parameters which were studied. Analytical procedure given by APHA (2005) used for water analysis. The pH of the wastewater determine by pH meter (WA-2015). Electric conductivity determined by conductivity meter (WA-2015). Total Dissolved Solids determined by TDS Meter (WA-2015). Chloride determined by titration method given by APHA.

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Cl^- = \frac{\text{ml of titrant used} \times N \times 35.5 \times 1000}{20}
\]

The UV-visible method used for the rough estimate of Nitrate. It determined the absorption of nitrate ion at 220 nm. UV/VIS spectrophotometer (Lambda 3B) used for analysis. The UV-visible method used for the rough estimate of Sulfate. It determined the absorption of nitrate ion at 420 nm. UV/VIS spectrophotometer (Lambda 3B) used for analysis.

**Results & Discussion**

Each parameter is analyzed 3 times, results shown in Table (ii). Sample was collected from Bio-remediation Orchard. Efficiency of these macrophytes in scavenging contaminants designate that the presence of these macrophytes was vital constituent for the removal of contaminants in the wastewater. Following are the different results shown by macrophytes. pH decreased by *Pistia stratiotes* 3.7%, 5% and 6.3%. *Eichhornia crassipess* also decreased pH by 1.3%, 2.5% and 5%. *Hydrocotyle umbellatta* increased pH by 5%, 2.5% and 2.1%.

*Pistia stratiotes* show better results at 31 °C as compare to 33 °C and 35 °C. EC decreased by *Pistia stratiotes* by 5.3% at 31 °C. *Eichhornia crassipess* showed comparatively good results at 31°C. *Eichhornia crassipess* decreased EC by 1.6% at 31 °C. EC decreased by *Hydrocotyle umbellatta* by 1.5%, at 35 °C.

Greater accumulation of TDS showned by *Pistia stratiotes* and decreased TDS by 4% at 31 °C rather than 1.3% decreased at 35 °C. *Eichhornia crassipess* decreased TDS by 3% at 31 °C. But *Hydrocotyle umbellatta* decreased TDS by 2.2% at 35 °C.

Nitrates decreased by *Pistia stratiotes* by 26% at 31 °C respectively. *Eichhornia crassipess* decreased Nitrates by 16% at 31 °C. *Hydrocotyle umbellatta* decreased Nitrates concentration by 12% at 35 °C.

Sulfate decreased 13% by *Pistia stratiotes* at 31 °C. *Eichhornia crassipess* decreased Sulfate by 26% at 35 °C. *Hydrocotyle umbellatta* decreased Sulfate by 22% at 35 °C, 33 °C and 31 °C.

Chloride decreased by 10% by *Pistia stratiotes* at 35 °C. *Eichhornia crassipess* decreased Chloride by 13.4% at 31 °C respectively. *Hydrocotyle umbellatta* decreased Chloride by 9.7% at 35 °C.

Averages of all the percentages decreased by *Pistia stratiotes* at temperature 35 °C was 7.3, 33 °C was 8.9 and at 31 °C was 9.45. This showed that its best performance at 31 °C as compare to other temperature. So overall performance of *Pistia stratiotes* comparatively higher than *Eichhornia crassipess* and *Hydrocotyle umbellatta*.

Averages percentages decreased by *Eichhornia crassipess* at 35 °C, 33 °C and 31 °C was 2.97, 5.27 and
10.8. This showed that likewise *Pistia stratiotes*, *Eichhornia crassipess* showed maximum accumulation at 35 °C. But overall performance of *Eichhornia crassipess* in month July is less than *Pistia stratiotes* but higher than *Hydrocotyle umbellatta*.

*Hydrocotyle umbellatta* showed maximum accumulation at 35 °C but other species showed maximum accumulation at 31 °C. Averages of percentages showed that 8.7, 5.78 and 3.79 decreased by *Hydrocotyle umbellatta* at temperature 35 °C, 33 °C and 31 °C respectively. And its performance is at least as compare to both of other plants.

Analysis of all these species indicates that accumulation of *Pistia stratiotes* is greater than other, then *Eichhornia crassipess* and least accumulates done by *Hydrocotyle umbellatta*.

**Conclusion**

Presently Pakistan is facing a scarcity of freshwater resources and per capita water availability which was 5300 m³ in 1951 had reduced to 1105 m³. However, Agriculture is the single largest user of fresh water in the world, in Pakistan nearly 88% fresh water used for irrigation. This study will help to make better choice of wastewater plant system for other cities of Pakistan because this technology is not expensive and easy to adopt. The ponds are suitable as fish farms and we can use this water for crops and farming.

The main reasons for declining water availability are rapid growth and pollution/contaminants of existing water resources due to discharge of untreated industrial and sewage effluents into streams/rivers. Deterioration of water quality of lakes, rivers and groundwater aquifers has resulted in increased waterborne diseases and other health impacts.

**Recommendations**

The demand for increased water supply in the city continues day by day due to continued growth of population and also due to development programs for a better socio-economic standard. The Government so far has failed to meet the short fall in water supply for both domestic and industrial purposes. The cost of water that is already in short supply is also increasing thereby increasing the cost of production. Water should be regarded as a gift of God and nature and must be handled with extreme care and never be misused. However, it is the most misused commodity on earth. Due to continued shortage of water and ever increasing cost it is logical to recycle it wherever possible/feasible.

Phytoremediation can occur naturally, it is more effective when good design, planting, and site management processes are carried out properly. Treated water has some of organic compounds and also micronutrients which are required for better crop yield, it is good for soil.
### Table (ii). Physico/Chemical Analysis of Wastewater in the Month July at Bio-remediation Orchard

<table>
<thead>
<tr>
<th>Date/Temp</th>
<th>Plants</th>
<th>Physical Parameters</th>
<th>Chemical Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>pH</td>
<td>EC (dS/m)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>In/Out/Diff</td>
<td>In/Out/Diff</td>
</tr>
<tr>
<td>9th July, 2012 (35°C)</td>
<td>Water Lettuce</td>
<td>8.0/7.7/3.7*</td>
<td>1.13/1.09/3.5*</td>
</tr>
<tr>
<td></td>
<td>Water Hyacinth</td>
<td>7.6/7.5/1.3*</td>
<td>1.091/1.089/0.2*</td>
</tr>
<tr>
<td></td>
<td>Water Pennywort</td>
<td>7.5/7.9/2*</td>
<td>1.098/1.081/1.5*</td>
</tr>
<tr>
<td>19th July, 2012 (33°C)</td>
<td>Water Lettuce</td>
<td>8.0/7.6/5*</td>
<td>1.16/1.11/4.3*</td>
</tr>
<tr>
<td></td>
<td>Water Hyacinth</td>
<td>7.8/7.6/2.5*</td>
<td>1.052/1.037/1.4*</td>
</tr>
<tr>
<td></td>
<td>Water Pennywort</td>
<td>7.5/7.7/2.5*</td>
<td>1.052/1.042/0.9*</td>
</tr>
<tr>
<td>30th July, 2012 (31°C)</td>
<td>Water Lettuce</td>
<td>8.1/7.58/6.3*</td>
<td>1.162/1.10/5.3*</td>
</tr>
<tr>
<td></td>
<td>Water Hyacinth</td>
<td>7.9/7.5/5*</td>
<td>1.109/1.091/1.6*</td>
</tr>
<tr>
<td></td>
<td>Water Pennywort</td>
<td>7.7/7.9/2.1*</td>
<td>1.098/1.091/0.7*</td>
</tr>
</tbody>
</table>

* = %
In = Inlet
Out = Outlet
Diff = Difference

A permissible limit of agriculture for pH is (6.5-8.5), EC is (0-3 dS/m), TDS is (0-2000 NTU), Cl$^{-1}$ is (0-1065 ppm), NO$_3^{-1}$ is (0-30 ppm) and SO$_4^{2-}$ is (0-960 ppm) given by United States Department of Agriculture (APHA).
Literature Cited


