VETIVER SYSTEM

FOR ENVIRONMENTAL PROTECTION

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INTRODUCTION

• The Vetiver System (VS) is based on the use of vetiver grass (*Vetiveria zizanioides* L.) for a wide range of applications. VS was first developed by the World Bank for soil and water conservation and now being used in over 100 countries.

• In Australia the Vetiver System is based on the use of Monto Vetiver which is sterile, non invasive, it flowers but set no seeds hence no weed potential.

• R&D conducted by the author showed that Monto vetiver is tolerant to the most adverse conditions, high levels of pesticides and herbicides and also to a wide range of heavy metal toxicities. Therefore VS has been successfully used for environmental protection purposes in Australia, Asia, Africa and Europe.

• Monto Vetiver was derived from south India, therefore genetically identical to most cultivars grown around the world, including the cultivar from South Africa.
UNIQUE PHYSIOLOGICAL CHARACTERISTICS

Tolerant to:

• Drought and flood
• Acidity, alkalinity, salinity and sodicity
• Heavy metals
• Various soil types and conditions
Saline threshold level is at $EC_e = 8 \text{ dsm}^{-1}$, and vetiver can survive at $47.5 \text{ dsm}^{-1}$ under dryland salinity conditions.
Salt tolerance level of Vetiver grass as compared with some crop and pasture species grown in Australia.

<table>
<thead>
<tr>
<th>Species</th>
<th>Soil EC_{se} (dSm^{-1})</th>
<th>Saline Threshold</th>
<th>50% Yield Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bermuda Grass (<em>Cynodon dactylon</em>)</td>
<td>6.9</td>
<td></td>
<td>14.7</td>
</tr>
<tr>
<td>Rhodes Grass (C.V. Pioneer) (<em>Chloris guyana</em>)</td>
<td>7.0</td>
<td></td>
<td>22.5</td>
</tr>
<tr>
<td>Tall Wheat Grass (<em>Thynopyron elongatum</em>)</td>
<td>7.5</td>
<td></td>
<td>19.4</td>
</tr>
<tr>
<td>Cotton (<em>Gossypium hirsutum</em>)</td>
<td>7.7</td>
<td></td>
<td>17.3</td>
</tr>
<tr>
<td>Barley (<em>Hordeum vulgare</em>)</td>
<td>8.0</td>
<td></td>
<td>18.0</td>
</tr>
<tr>
<td>Vetiver grass (<em>Vetiveria zizanioides</em>)</td>
<td>8.0</td>
<td></td>
<td>20.0</td>
</tr>
</tbody>
</table>
Vetiver growing among mangrove seedlings on a tidal creek near Brisbane
In Fiji vetiver growing next to a coastal mangrove swamp
EXTRAORDINARY PHYSIOLOGICAL CHARACTERISTICS

Tolerant to adverse soil conditions:

• High acidity, pH 3.0-12.5

• Aluminium and Manganese toxicities.
Highly erodible acid sulfate soil in coastal Queensland
One year after planting
### Threshold levels of heavy metals to vetiver growth as compared with other species

<table>
<thead>
<tr>
<th>Heavy Metals</th>
<th>Threshold levels in soil (mgKg⁻¹)</th>
<th>Threshold levels in plant (mgKg⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Vetiver</td>
<td>Other plants</td>
</tr>
<tr>
<td>Arsenic</td>
<td>100-250</td>
<td>2.0</td>
</tr>
<tr>
<td><strong>Cadmium</strong></td>
<td>20-60</td>
<td>1.5</td>
</tr>
<tr>
<td>Copper</td>
<td>50-10</td>
<td>Not available</td>
</tr>
<tr>
<td><strong>Chromium</strong></td>
<td>200-600</td>
<td>Not available</td>
</tr>
<tr>
<td>Lead</td>
<td>&gt;1 500</td>
<td>Not available</td>
</tr>
<tr>
<td><strong>Mercury</strong></td>
<td>&gt; 6</td>
<td>Not available</td>
</tr>
<tr>
<td>Nickel</td>
<td>100</td>
<td>7-10</td>
</tr>
<tr>
<td>Selenium</td>
<td>&gt;74</td>
<td>2-14</td>
</tr>
<tr>
<td>Zinc</td>
<td>&gt;750</td>
<td>Not available</td>
</tr>
</tbody>
</table>
EXTRAORDINARY PHYSIOLOGICAL CHARACTERISTICS

• High percentage removal of N and P from polluted water

• High percentage removal of N, P, COD and Chloride from landfill leachate
**N and P removal:** With high capacity of removing N and P in polluted water, vetiver cleaned up blue green algae in 4 days.

Sewage effluent infested with Blue-Green algae due to high Nitrate (100mg/L) and high Phosphate (10mg/L)

Same effluent after 4 days after treating with vetiver, reducing N level to 6mg/L (94%) and P to 1mg/L (90%)

08/12/00
Vetiver roots thrive in high N and P sewage effluent under hydroponics conditions.
## Reduction of Pollutants from Domestic Effluent under Hydroponics Treatment

<table>
<thead>
<tr>
<th></th>
<th>Total N (mg/L)</th>
<th>Total P (mg/L)</th>
<th>COD</th>
<th>E. coli (org/100 mL)</th>
<th>EC (dS/m)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Initial</strong></td>
<td>66.0</td>
<td>12.4</td>
<td>252</td>
<td>&gt;1600</td>
<td>963</td>
</tr>
<tr>
<td><strong>Day 14</strong></td>
<td>20.3</td>
<td>6.5</td>
<td>93</td>
<td>50</td>
<td>634</td>
</tr>
<tr>
<td><strong>Reduction %</strong></td>
<td>76</td>
<td>59</td>
<td>63</td>
<td>97</td>
<td>34</td>
</tr>
<tr>
<td><strong>Reduction per bin</strong></td>
<td>8002 (mg)</td>
<td>1165 (mg)</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>
## Removal rates of pollutants from polluted water in China (Zheng et al. 1997)

<table>
<thead>
<tr>
<th>Pollutants</th>
<th>River 1*</th>
<th>River 2**</th>
<th>Tap water</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total N</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Concentration (mg/L)</td>
<td>13.8</td>
<td>10.5</td>
<td>0.1</td>
</tr>
<tr>
<td>Removal %</td>
<td>71.0</td>
<td>58.1</td>
<td></td>
</tr>
<tr>
<td><strong>Total P</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Concentration (mg/L)</td>
<td>0.94</td>
<td>1.03</td>
<td>ND</td>
</tr>
<tr>
<td>Removal %</td>
<td>99.3</td>
<td>93.7</td>
<td></td>
</tr>
</tbody>
</table>

*After 3 weeks
** After 2 weeks
ND Not detectable
## Removal rates of pollutants from landfill leachate (*Xia et al. 2000*)

<table>
<thead>
<tr>
<th>Pollutants</th>
<th>Reduction %</th>
<th>High concentration leachate</th>
<th>Low concentration leachate</th>
</tr>
</thead>
<tbody>
<tr>
<td>COD</td>
<td>Reduction %</td>
<td>69.0</td>
<td>61.9</td>
</tr>
<tr>
<td>Carbonate + Bicarbonate</td>
<td>Reduction %</td>
<td>80.6</td>
<td>59.0</td>
</tr>
<tr>
<td>Total N</td>
<td>Reduction %</td>
<td>79.4</td>
<td>71.10</td>
</tr>
<tr>
<td>Total P</td>
<td>Reduction %</td>
<td>70.0</td>
<td>65.0</td>
</tr>
<tr>
<td>Chloride</td>
<td>Reduction %</td>
<td>21.5</td>
<td>7.9</td>
</tr>
<tr>
<td></td>
<td>Removal (mg/pot)</td>
<td>232.1</td>
<td>255.4</td>
</tr>
<tr>
<td></td>
<td>Removal (mg/pot)</td>
<td>7.63</td>
<td>4.66</td>
</tr>
<tr>
<td></td>
<td></td>
<td>321.9</td>
<td>207.8</td>
</tr>
</tbody>
</table>
HYDRAULIC CHARACTERISTICS

- Reducing flow velocity
- Trapping sediment containing nutrients, herbicides and pesticides
Large silt fan trapped by this hedge on a sugarcane farm.
Trapping herbicides on cotton farms in central Queensland

Note: Vetiver filter strips located at 0 and +10 m
Trapping pesticides on cotton farms in central Queensland

![Graph showing pesticide trapping with Vetiver Hedges at 0 and +10 m from the filter strip.](image)
APPLICATION OF THE VETIVER SYSTEM FOR DOMESTIC EFFLUENT DISPOSAL

- Sewage effluent seepage from septic systems
Vetiver was most effective in absorbing effluent discharge from a toilet block at Beelarong Community demonstration centre in Brisbane.
Effectiveness of vetiver in reducing N level in domestic blackwater

**Entry:** Total N level at 95.2mg/L

2 rows of vetiver plants

**Monitoring wells**

**Exit:** Total N level at 16mg/L or a reduction of 83%

5 rows of vetiver plants

**Monitoring wells**

**Entry:** Total N level at 95.2mg/L

2 rows of vetiver plants

**Monitoring wells**

**Exit:** Total N level at 1.2mg/L or a reduction of 99%
## Effectiveness of Vetiver in Removing N and P from Blackwater Effluent

<table>
<thead>
<tr>
<th></th>
<th>Total Nitrogen (mg/L)</th>
<th>Total Nitrate (mg/L)</th>
<th>Total Phosphorus (mg/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Original Levels</strong></td>
<td>95.2</td>
<td>92.8</td>
<td>1.3</td>
</tr>
<tr>
<td><strong>After 2 vetiver rows</strong></td>
<td>16.0</td>
<td>16.7</td>
<td>0.24</td>
</tr>
<tr>
<td><strong>Reduction (%)</strong></td>
<td>83</td>
<td>82</td>
<td>82</td>
</tr>
<tr>
<td><strong>After 5 vetiver rows</strong></td>
<td>1.2</td>
<td>0.7</td>
<td>0.20</td>
</tr>
<tr>
<td><strong>Reduction (%)</strong></td>
<td>99</td>
<td>99</td>
<td>85</td>
</tr>
</tbody>
</table>
APPLICATION OF THE VETIVER SYSTEM FOR LANDFILL LEACHATE TREATMENT
(Land irrigation)

- Tweed Shire, NSW
Diagrammatic cross section of the mound at Stotts Creek Landfill, Muwillumbah
Space planting
Irrigated with leachate after planting each day
One year after planting
Fourteen months after planting
VETIVER SYSTEM

FOR

INFRASTRUCTURE PROTECTION
UNIQUE MORPHOLOGICAL CHARACTERISTICS

- Erect and stiff stems, which slow flow velocity
- Forming thick hedges when planted close together, which can divert flows and trap sediments
Forming a thick hedge when planted in row
Strong current flattened the native grass but not vetiver on this waterway.
UNIQUE MORPHOLOGICAL CHARACTERISTICS

- Deep, extensive and penetrating root system
China: One year old with 3.3m deep root system
(These roots have a tensile strength equivalent to 1/6 mild steel reinforcement)

Thailand: One year old, 3.3m long
Vietnam: The different root systems between vetiver grass and native vetiver

Vetiveria zizanioides

Vetiveria nemoralis

PC: PHD Phuoc
Root size distribution and tensile strength

These roots have a tensile strength equivalent to 1/6 mild steel reinforcement.
Soil stabilisation mechanism by vetiver

Vetiver hedgerows

Vetiver roots

slipping zone on slopes usually 0~2 m depths

Diti Hengchaovanich
Australia: After 400mm of rain in 10 days in northern Queensland
New batter, severely eroded within weeks in the wet season
Three months after planting
Completely stabilised seven months after planting
Hydromulching three months after planting
Three weeks after planting
Eight months after planting
Highly tolerant to fire: One month after a severe wildfire
Two months after fire
Bridge abutment: Ten weeks after planting
Malaysia: East West highway
Vietnam: Ho Chi Minh Highway
The best trial, where the first sod was planted by the President. It is lucky because it is internally stable, though still having problem at its toe.
China: Fancy cement-concrete works, imagine the cost
Beautiful when new, but...
But do not always stay up when old or typhoon affected
CONCLUSIONS

- Vetiver hedge can be rapidly established in arid conditions and poor soils with little if any nutrients.
- Once established vetiver hedges are maintenance free and withstand arid and dry season conditions including bush fires.
- Provides protection to steep cuts and fill batters resulting in substantial savings in earthwork costs.
- Encourages sheet flow and reduced water run-off velocities resulting in natural vegetation re-growth and prevention of erosion.
- Eliminates undermining of hard rock structures
- Effective alternative to hard rock check dams
- Effective prevention of gully erosion

- Very cost effective, with savings ranging from 73% for culvert protection to 64% for table drain and is miscellaneous protection works and 60% for road shoulder protection.

- In highly erodible soils, the most important advantage of vetiver technology over conventional structures is that rock structures themselves are not stable and require constant maintenance to protect the road works which will add to the overall operating costs of infrastructure in the long term.
Thank You