"Vicoria zizaniodes (L.) Nash in a densely tufted, narrow, very fluffy perennial grass. The plant grows in large clumps from a much branched root stock with erect culms 0.3-1.5 m high."

Economic Flora of the World

"Vicoria grass is widely used throughout the tropics for planting on the contour as an anti-wash measure, for protective partitions in terraced fields, and as a border for roads and gardens...

Proceedings, 5th IVM 1935
Regional Centre, University of the South.

Vicoria grass is widely used throughout the tropics for planting on the contour as an anti-wash measure, for protective partitions in terraced fields, and as a border for roads and gardens..."
VETIVER FOR LANDFILLS

Extensive research, development and application have established that Vetiver grass (Chrysopogon zizanioides L.) possesses unique attributes that make it exceptional for environmental protection and rehabilitation.

When applied to landfill projects, Vetiver addresses a multitude of needs:

- Leachate and Wastewater Treatment
- Slope Stabilisation and Erosion Control
- Infrastructure Protection
- Silt Fencing and Sediment Control

VETIVER FOR LEACHATE and WASTEWATER TREATMENT

WHY VETIVER:

When applied to leachate and wastewater, Vetiver acts to treat and absorb nutrients and pollutants, such as heavy metals, reduce or eliminate the volume of wastewater, and as a form of phytoremediation for contaminated water and land. In fact, Vetiver is the most effective treatment and disposal method for landfill leachate, and domestic and industrial effluent.

It is Vetiver’s unique combination of characteristics that make it exceptionally effective at addressing the requirements of leachate and wastewater treatment.
WHY VETIVER: STRUCTURAL CHARACTERISTICS

• Stiff and erect stems withstand high velocity flows
• Thick stem growth create barriers to trap fine and course sediment
• Deep, extensive and interlocking root system reduce deep drainage
• Dense and finely structured root system improves nutrient uptake and stimulates microbiological processes in the rhizosphere (area around the roots)

WHY VETIVER: PHYSIOLOGICAL CHARACTERISTICS

• Tolerant to adverse soil conditions; high soil acidity and alkalinity, saline, sodic and magnesic, aluminium toxicities and manganese toxicities
• Tolerant to elevated levels of heavy metals: arsenic, cadmium, copper, chromium, lead, mercury, nickel, selenium and zinc
• Tolerant to agrochemicals and excess nutrients
• Breaks down organic compounds associated with agrochemicals
• High capacity to remove N & P in dry, wetland and hydroponic conditions
• Tolerant to adverse climatic conditions; frost, inundation, flood, drought and heat waves
• High water usage (uses more water than wetland plants, uses 7.5 times more water than Typha. Estimated that Vetiver would use 6.86L/day per 1kg of dry biomass)
• Fast growth with high yield dry matter
Vetiver’s tolerance to elevated and toxic levels of salinity, alkalinity, and acidity, and its ability to tolerate and absorb pesticides, herbicides, heavy metal contaminants and elevated nutrient levels, combined with its capacity to produce fast growth and high yield dry matter, make it the perfect plant to use for leachate and wastewater treatment.

Table 3 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 (mg kg⁻¹)</th>
<th>Threshold levels in plant (mg kg⁻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>Cadmium</td>
<td>20-60</td>
<td>1.5</td>
</tr>
<tr>
<td>Copper</td>
<td>50-100</td>
<td>Not available</td>
</tr>
<tr>
<td>Chromium</td>
<td>200-600</td>
<td>Not available</td>
</tr>
<tr>
<td>Lead</td>
<td>&gt;1500</td>
<td>Not available</td>
</tr>
<tr>
<td>Mercury</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>

*Available elements

Table 4 Salt tolerance level of vetiver grass as compared with some crop and pasture species grown in Australia (Truong et al., 2002)

<table>
<thead>
<tr>
<th>Plant Species</th>
<th>Saline Threshold</th>
<th>Soil EC₅₀ (dSm⁻¹)</th>
<th>50% Yield Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bermuda Grass (Cynodon dactylon)</td>
<td>6.9</td>
<td>14.7</td>
<td></td>
</tr>
<tr>
<td>Rhodes Grass (C.V. Pioneer) (Chloris gayana)</td>
<td>7.0</td>
<td>22.5</td>
<td></td>
</tr>
<tr>
<td>Tall Wheat Grass (Thynopyron elongatum)</td>
<td>7.5</td>
<td>19.4</td>
<td></td>
</tr>
<tr>
<td>Cotton (Gossypium hirsutum)</td>
<td>7.7</td>
<td>17.3</td>
<td></td>
</tr>
<tr>
<td>Barley (Hordeum vulgare)</td>
<td>8.0</td>
<td>18.0</td>
<td></td>
</tr>
<tr>
<td>Vetiver (Vetiveria zizanioides)</td>
<td>8.0</td>
<td>20.0</td>
<td></td>
</tr>
</tbody>
</table>
METHODS OF VETIVER APPLICATION:

Vetiver can be applied in a multitude of ways to address leachate and effectively facilitate its transformation and disposal, including:

- Land irrigation systems
- Hydroponics by floating pontoons
- Lining leachate pond edges
- Lining channels and bases of embankments around landfill
- To establish constructed wetlands at discharge locations
- Planted on water banks and in poor soil
HOW VETIVER ADDRESSES LEACHATE and WASTEWATER

The Vetiver System addresses landfill treatment and disposal in two ways, by reducing the volume or completely eliminating the leachate, and by improving the quality of the wastewater.

REDUCING THE VOLUME or ELIMINATING LEACHATE and WASTEWATER
- Land irrigation
- Wetlands (natural or constructed)
- Seepage control

IMPROVING WASTEWATER QUALITY
- Trapping debris, sediment and particles
- Absorbing pollutants, nutrients and heavy metals
- Detoxification of industrial and agrochemicals in wetlands

HOW VETIVER CONTROLS LEACHATE

Vetiver is best suited to leachate disposal due to its high water usage, nutrient absorption rates, and tolerance to elevated levels of nutrients, salt and other toxicities. When applied to landfill leachate, Vetiver acts to:
- Prevent pollution of underlying and surrounding soil
- Prevent the pollution of ground and surface water
- Control the ‘bioreactor’ by containing and treating surface or underground egresses
- Treat leachate through irrigation methods
- Stabilise dam walls
- Control seepage
ADVANTAGES OF VETIVER SYSTEM LEACHATE APPLICATION

SIMPLE: Only requires standard land preparation for planting and weed control in the establishment phase.

LOW COST: Costs a fraction of conventional methods.

MINIMAL MAINTENANCE: When properly established, the VS requires practically no maintenance to keep it functioning. Harvesting two or three times a year to export nutrients and to remove top growth for other usages is all that is needed.
VETIVER FOR SLOPE STABILISATION AND EROSION CONTROL

The application of Vetiver as a bioengineering tool in land and water based situations, for stabilisation, protection and disaster mitigation, has been used across the world. Extensive research and development has resulted in the Vetiver System, which plants Vetiver in rows, forming strong and dense hedges. It is the application of Vetiver hedgerows and the unique characteristics of Vetiver grass which make it exceptional for erosion control and stabilisation.

HOW THE VETIVER SYSTEM WORKS

ROOTS

Vetiver's unique attributes, the root and stem system, combine to work both above and below ground to ensure erosion control, soil and water conservation and steep slope stabilisation.

Below the surface the dense, deep and penetrating root system of Vetiver grass can reach vertical depths of 5+ metres, binding and reinforcing soil sheer strength by up to 45%. The roots are extremely strong with a tensile strength of 75 MPa, which is approximately 1/6th of mild steel reinforcement.

When planted in Vetiver System hedgerows, the roots of the plants interlock creating vast underground, dense and strong root wall systems, which protect against erosion, instability and flood disasters.
STEMS

The strong, thick and stiff stems create above ground hedges, which dissipate wind and water energy, slow down water flow, trap sediments and control water runoff. These hedges act to protect the topsoil, ensuring that it remains in place, halting erosion.

RESILIENCE

A resilient and adaptable grass, Vetiver is disease and pest resistant, can recover after fires, and withstands prolonged periods of flooding and drought, surviving in air temperatures of -15°C to 55°C. Vetiver can grow and thrive in a variety of soils: sandy, saline, waterlogged, acidic, alkaline and toxic (from pH 3.3 – 12.5). Most importantly, Vetiver grass is sterile, which means it has NO WEED POTENTIAL, allowing for Vetiver to be shaped and applied for specific use without the threat of it spreading or competing with other vegetation.

The protective effects of Vetiver System hedgerows for erosion and sediment control can clearly be seen in the above image of Vetiver road batter stabilisation and protection in Mackay, Queensland. The Vetiver hedgerows successfully reinforced and protected the soil against erosion.
ADVANTAGES OF VETIVER

- Sustainable
- Non-invasive
- Low maintenance
- Gets stronger over time (strength of the grass increases as it grows)
- Environmentally harmonious
- Low establishment costs (compared to hard-engineering methods)

SILT FENCING and SEDIMENTATION CONTROL

TRAPPING DEBRIS, SEDIMENT AND PARTICLES:
The combination of the stiff and erect stems and their creation of a thick barrier allows Vetiver to be highly effective in trapping particulate-bound nutrients, agrochemicals and other toxic substances.

Vetiver is unique in comparison to other silt fencing, as it can not only be designed as a permanent barrier to protect watercourses and neighbouring properties from contaminants but also acts to remediate and store these contaminants, removing them from the environment, rather than just trapping them behind a fence.

For landfill sites, Vetiver fencing provides an effective trapping and remediation tool to ensure environmental standards are met.
WHY NOT USE NATIVE PLANTS

As environmental awareness has evolved, the desire to utilise indigenous plants where possible has developed. However, local native plants are mostly adapted to a low fertility, unpolluted and clean Australian environment. Therefore, they generally cannot be used for phytoremediation purposes of treating highly contaminated sites, as those mentioned above, as they do not have the unique attributes of Vetiver, such as:

- Tolerance to extremely adverse growing environments:
  - High soil salinity, acidity and alkalinity conditions
  - Heavy metal contaminants and agrochemicals such as weedicides and soil amendments
  - Prolonged drought and inundation
- Penetrating, long and extensive root system
- Highly adaptable to various soil types, from beach sand, to heavy clay and decomposing rocks

Vetiver is a **sterile grass**, it has no above or underground runners, which means it has **no weed potential** and cannot self-spread. Therefore, it poses no threat to the environment and other vegetation, both native and introduced species.

BENEFITS OF USING VETIVER IN LANDFILL APPLICATIONS

- On-site leachate treatment and disposal
- Multiple methods of application – including seepage control, pontoons, irrigation systems and hydroponically
- Low establishment costs
- Environmentally harmonious
- Sustainable
- Low maintenance
- Multifaceted – can address wastewater treatment, leachate disposal, infrastructure protection, land rehabilitation, and erosion and sediment control
- Highly tolerant to adverse conditions
- High capacity to remove excess nutrients
- Tolerant to adverse toxicities and pollutants
- High water usage
- Fast growth rate
CASE STUDY: STOTTS CREEK LANDFILL, NSW

THE ISSUE:

At the time (2003), Stotts Creek was a 20 year old landfill site where dry and wet wastes were dumped together, compacted and then covered with a thin layer of clay. This process had seen the dump grow to 35 metres high and 300 metres long, consisting of many layers of waste and clay.

The treatment process saw leachate and surface water separated, in order to reduce leachate volume. The surface water was discharged into local streams via an artificial wetland, which had been constructed to improve the water quality as it left the site. The leachate was stored in a dam and irrigated onto sections of the landfill, allowing for evaporation into the atmosphere. However, this limited the amount of leachate that could effectively be disposed of, especially during high rainfall periods. To comply with the Environmental Protection Agency regulations, during heavy rainfall periods excess leachate had to be transported off-site for disposal, which was inefficient and expensive.

With a growth in population predicted, it was anticipated the landfill facility would need to be expanded, requiring a more efficient and cost effective method for leachate treatment. A Vetiver System phytoremediation approach was adopted.

THE VETIVER SYSTEM SOLUTION

The Vetiver System phytoremediation approach for leachate control and wastewater disposal needed to address the leachate pollutants, which included high levels of pH, chloride and sulphate salts, and excess nutrients, particularly nitrogen. In addition, it was necessary for the solution to possess a high water capacity, to be capable of dealing with the amount of water present, especially during heavy rainfall periods. Vetiver is exceptionally capable, with an estimated water usage rate of 6.86L/day per 1kg of dry shoot biomass.
AN INNOVATIVE APPROACH TO LEACHATE DISPOSAL

Although the Vetiver System had already been effectively used to address leachate disposal, its application had only been utilised for seepage control, whereby the roots are exposed to leachate. The design for the Stotts Creek Landfill took the treatment and disposal one step further, combining a seepage control application with an irrigation system.

**VETIVER APPLICATION AND PLANTING**

The planting process began with capping of the waste dump with impervious clay, followed by topsoil and mulch. The Vetiver was planted on the surface of the mound, with thick contour hedges of 10 plants per metre to control seepage, erosion, and spread runoff and irrigation water. Additional Vetiver plants were placed between the hedges, at a density of between 5 and 8 plants per square metre, for erosion control and leachate disposal. An overhead irrigation system was then installed, which sprayed leachate onto the shoots of the Vetiver grass. This system has the capacity to deliver 1300L per minute. The overhead spray irrigation was applied immediately after planting each day and then twice daily thereafter.
THE RESULT

The Vetiver System phytoremediation leachate disposal applied was extremely effective. Despite the highly polluted, saline and alkaline leachate, the Vetiver established at a 90-95% success rate. In fact, the growth was exceptional with the Vetiver Grass reaching up to 3 metres tall within 15 months. The high salt and other contaminants did not adversely affect the plant growth and due to the irrigation process the grass continued to grow in the winter months. The Vetiver Grass Installation successfully disposed of all leachate and run off generated at Stotts Creek during the dry season.
13 months after planting

2nd Summer over 3m tall

Growing in polluted leachate pool

Flowering at 15 months
EXPERIENCE

Veticon is the industry leader in the research, development and application of Vetiver System (VS) solutions for wastewater treatment and disposal. Veticon designs and implements VS wastewater treatment solutions to address industrial and municipal sewage and effluent, landfill leachate disposal, agrochemical pollution, industrial wastewater and polluted waters purification.

AUSTRALIAN PROJECTS:
• Judy Holt Park, Redland Shire, Brisbane, QLD (Landfill Leachate)
• Stotts Creek landfill, Tweed Shire, NSW (Landfill Leachate)
• Toogoolawah Sewage treatment Plant, Esk Shire, QLD (Sewage Effluent)
• Boonah Sewage treatment Plant, Boonah Shire, QLD (Sewage Effluent)
• Gelatine Factory, Beaudesert Shire, QLD (Industrial Effluent)
• Beef Abattoir, Beenleigh, QLD (Industrial Effluent)

INTERNATIONAL PROJECTS:
• Biloxi landfill, Mississippi, USA (Landfill Leachate)
• Desotto landfill, Florida, USA (Landfill Leachate)
• Fort Bend landfill, Alabama, USA (Landfill Leachate)
• San Antonio landfill, Texas, USA (Landfill Leachate)
• Leon landfill, PASA, Mexico (Landfill Leachate)
• Costa Rica landfill, PASA, Mexico (Landfill Leachate)
• Beer Brewery, Caracas, Venezuela (Industrial Effluent)
• Oil refinery, Medellin, Colombia (Industrial Effluent)
• Fazenda Deflor, Belo Horizonte Brazil (Sewage Effluent)

For more information and case studies please visit www.veticon.com.au