

Vetiver System

A
System
To
Mitigate
Storm
Damage
and
Control
Water
Pollution

Below: Vetiver grass roots, after 12 months of growth, showing the difference between the infertile, non-invasive vetiver grass, *Chrysopogon zizanioides* (long root system), and a fertile species native to Southeast Asia, (short roots).



The Vetiver System's Role In the Gulf Coast Region: Infrastructure Protection & Comprehensive Water Pollution Control

The **Vetiver System** is an effective, low cost bioengineering technology that protects infrastructure and wetlands by enhancing control over the management of soil and water. Vetiver grass (*Chrysopogon zizanioides* Roberty, formerly *Vetiveria zizanioides* L) is an erect, deep-rooted tropical clump grass recognized by USDA as non-invasive. The concept behind the Vetiver System is that barriers, or *hedges*, of vetiver grass, planted in geometric or natural patterns, such as chevrons or contour hedges, reinforce the dynamic processes of water flow and sediment deposition. Global experience, including during Hurricane Mitch in Central America in 1998 confirms that the Vetiver System is effective in protecting vital infrastructure in the face of extreme weather events. Refer to: http://www.vetiver.org/LAVN_disaster.htm.

Several applications of the Vetiver System are relevant to mitigating hurricane damage in the Gulf region and could play a role in strategies for recovery. Water pollution control is another relevant application: buffer strips of vetiver grass around crops trap sediment and sediment-borne agrochemicals, while constructed wetlands of vetiver grass polish pre-treated wastewater effluents. The recently published **Technical Reference Manual** for Vetiver System Applications may be downloaded from the following link: <http://www.esnips.com/nsdoc/9057fcb9-75b5-4af1-b9a9-793da6d087c9/?action=forceDL>



Vetiver hedges on river dike in Vietnam with mangrove ferns at waterline



The Vetiver Network International (TVNI) is an international nonprofit 501(c)(3), non-government organization chartered as a foundation in the US state of Virginia. Since 1989, TVNI's mission has been to support vetiver grass research and demonstration of its many applications, to document the uses of vetiver grass and to disseminate that information widely through its website www.vetiver.org. More than forty national level vetiver networks are affiliated with TVNI. In recent years, TVNI has expanded its scope of activity to include applying the Vetiver System (VS) to specific problems. Technical advisers are available from TVNI to assist in project design and implementation. Contact TVNI for information.



S. China landfill before treatment



S. China landfill after vetiver treatment

Vetiver grass has special characteristics that lend themselves to protection of infrastructure and control of water-related pollution:

- The sterile “Sunshine” cultivar of vetiver grass embodies a wide spectrum of properties that are rarely combined in a single species. The result is uncommon versatility and hardness;
- Vetiver grass has stiff, erect stems that form a dense hedge that can stand up to high velocity water flows. That porous barrier prevents scouring of the soil on sloped land; The stems and leaves form a “filter strip” that traps soil particles and agrochemicals such as pesticides that are adsorbed onto the particles;
- Vetiver hedges need little maintenance over an open-ended working life;
- Fine, dense, penetrating roots anchor the soil profile up to four meters deep, preventing wind and water erosion and forming an underground barrier to water flow down the slope;
- Constructed wetlands of vetiver grass are biological sinks that assimilate residual N and P and other pollutants from pre-treated wastewater effluents;
- Vetiver grass tolerates saline soils (50% yield reduction at 20 dS/m; lethal at 45 dS/m); vetiver hedges are effective in stabilizing coastal dunes and levees, beaches and barrier islands; and
- Vetiver grass is a perennial, infertile, non-invasive plant that is incapable of migrating from its planting site; it is cleared for use in the United States, including Hawaii and Puerto Rico by USDA and widely available through commercial nurseries;

The *Vetiver System* is comprised of a set of applications that addresses several important soil and water conservation issues. This document discusses those applications that appear to be most relevant to the problems faced by the US littoral states of the Gulf of Mexico and guides the reader to supporting documents.



Bridge infrastructure solidly protected

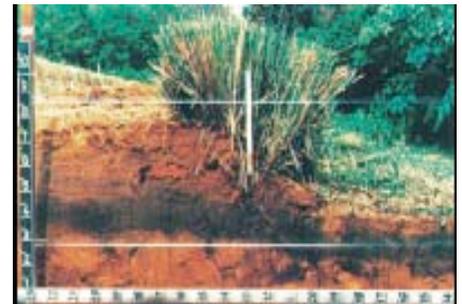
Comprehensive water pollution control: Vetiver hedges planted as “buffer strips” around crops, such as cotton or sugar cane, trap soil particles and sediment-borne agrochemicals, preventing this *nonpoint source* of pollution from migrating offsite. http://www.vetiver.com/PRVN_IVC2_19.PDF

Constructed wetlands of vetiver grass are biological filters that “polish” *point source* pollution, such as pre-treated wastewater effluents. See http://www.vetiver.com/ICV3-Proceedings/AUS_sewage.pdf Even landfill leachate, normally toxic to most plants, can be intercepted and treated by vetiver hedges. http://www.vetiver.com/ICV3-Proceedings/AUS_Landfill.pdf This remarkable plant can help reduce water pollution *across the entire spectrum of sources*.

Protection of embankments: Hedges of vetiver grass planted on the contour lines of sloped land protect the banks of canals and rivers and coastal levees against soil erosion from wave action and lateral scouring from a river current. How does vetiver do all this? Vetiver’s massive root system can not be dislodged by moving water, and it anchors the upper three to four meters of the soil profile. Vetiver roots have an average tensile strength of 75 MPa (about 1/6 that of mild steel), which increases the average shear strength of the surrounding soil by 30% to 40%. The effect is to stabilize the levee, dam or other soil structure against scouring by water or wind. Refer to: http://www.vetiver.com/VNN_truong_jan2005.pdf

Protection of civil works: When vetiver grass is planted at the interface between soil, concrete structures (culverts, drains, bridge supports) and moving water it prevents undermining and loss of structural integrity. After years of testing, the ministries of transportation of five southern provinces of China have standardized on the Vetiver System as a more effective and lower cost alternative to conventional civil works, such as bench terracing, gabions and rip-rap. The Vetiver System stabilizes the third steepest railroad in the world in Madagascar, so that it now survives regular cyclonic storms without significant interruption of service to the farmers who depend on it. Refer to: http://www.vetiver.com/ICV3-Proceedings/MAD_rail_stab.pdf2.pdf

Stabilization of coastal dunes, barrier islands and wetlands: Vetiver grass is at home in a marsh environment and in littoral areas, including either dry or saturated soils. It can survive prolonged inundation in fresh or brackish waters. Eroding dunes, barrier islands and brackish marshes can be stabilized by systematic deployment of vetiver hedges. Vetiver serves as pioneer plants to assist native to plants establish themselves, giving way to those plants over time. Refer to dune stabilization documentation at: http://www.vetiver.com/ICV3-Proceedings/VNN_sanddune.pdf



Profile of a vetiver contour hedge

Image above: To the left of this three year old hedge in Malaysia, more than 40 cm of soil has been trapped behind the hedge. The original soil level is indicated by the black subsoil band. The vertical white marker indicates the original site on the contour line of the slope where vetiver was transplanted.



Polishing of wastewater effluent in China



Coastal dune stabilization in Viet Nam



Waterway bank protection in Vietnam

Special characteristics of Vetiver Grass

What makes vetiver grass special? The answer is found in the roots, in the plant's physiological and ecological characteristics and in its inherent ability to grow without becoming a weed and without attracting pests.

Vetiver grass has a massive, finely structured root system that is unique among grasses. It has neither *rhizomes* nor *stolons* that make it possible for a plant to spread laterally; vetiver roots grow only *straight down* in a mass as dense as the amount of leaves it produces above the ground. The roots average less than one mm in diameter and penetrate three to four meters into the soil. New roots and shoots develop from germ plasm located in the *root crown* just below the surface of the soil and from nodes on the stems when they are buried by trapped sediment. Vetiver grass will continue to grow and fill in at the face, or "upslope" side of the hedge, where the new ground level eventually forms a terrace at the face of the hedge. The result is a natural terrace that alters the original geometry of the slope.

Vetiver grass has other special characteristics that are exploited to manage waterborne pollutants in surface water runoff and urban wastewater effluents. Vetiver grass tolerates anoxic conditions around the roots and high concentrations of toxic substances such as heavy metals and ammonia that will kill most plants. Vetiver grass may be used in constructed wetlands to "polish" pre-treated wastewater by stripping the nutrients, nitrogen (Vetiver can tolerate nitrogen levels of up to 10,000 kg N per ha) and phosphorus, which eutrophy surface water, or as hedges to intercept and treat highly toxic leachates from landfills or "brownfields" sites.

Physiological characteristics

Vetiver grass is a "climax plant," that survives environmental conditions that kill most other plants. It will tolerate prolonged drought, fire, flood, submergence and extreme ambient temperatures from -15°C to 55°C. Vetiver grass is able to regenerate quickly after being affected by drought, fire, frost, salt and adverse soil conditions. Vetiver grass can withstand an exceptionally wide range of pH: it can survive in soils with an acidity of 3.0 and alkalinities with a pH as high as 10.5 to 11. Vetiver can tolerate a high level of soil salinity, soil sodicity, and acid sulfate, defining it as a uniquely hardy plant. Refer to: www.vetiver.com/AUS_Salt%20Tolerance.pdf

"Sunshine" vetiver is a traditional, non-fertile Louisiana cultivar (variety) that was introduced to the Gulf region in the French colonial era over 200 years ago. In principle, non-native plants intended for use in environmental protection or agriculture must be investigated for their potential to become weeds or to act as intermediate hosts for pests that affect economically important crops. *Sunshine vetiver was officially released from observation by the USDA Golden Meadows Plant Material Center, in Louisiana in 1995.* Refer to <http://plant-materials.nrcs.usda.gov/lapmc/releases.html> The South Eastern Exotic Pest Plant Council, declared in May 2001 that Sunshine vetiver is acceptable for use in the region. Refer to: www.se-eppc.org/fslist.cfm. More recently, the **Pacific Island Ecosystem at Risk** (PIER) Project carried out a risk assessment of non-fertile vetiver grass cultivars from South India (Sunshine, US and Monto, Australia). A rating of +1 means that the plant species is "low risk" for invasiveness. *Vetiver grass was rated negative eight (-8).* The very low risk rating is based on the Australia/New Zealand weed risk assessment protocol, modified for Hawaii by the USDA and other cooperators. The link to the PIER risk assessment for vetiver grass is: http://www.vetiver.org/USA_PIER.htm

Ecological characteristics

The Vetiver System has been used extensively across a wide range of ecological conditions in regions with tropical, subtropical and Mediterranean climates to rehabilitate degraded land and to protect infrastructure against erosion and the effects of extreme weather events. Because of its special characteristics, vetiver grass functions as a "nurse" plant on disturbed soils and on chemically extreme soils, where it may be the *only* plant that is able to survive and grow. A series of vetiver contour hedges stabilizes erodible slopes and creates a micro-climate that favors the re-establishment of native plants after a fire or clear-cut. Over time, native plant species will re-establish themselves on these sites, and the trees and shrubs will shade the vetiver hedges, replacing them as the stabilizing agent, since vetiver grass does not tolerate full shade. Therefore, vetiver is highly regarded as a versatile, non-invasive pioneer plant in interventions to rehabilitate degraded land and to arrest land degradation on individual land holdings or throughout the landscape.

The Vetiver System in the Gulf Region: Infrastructure Protection and Comprehensive Water Pollution Control

The image to the right shows the massive, finely structured roots of an 18 month old clump of vetiver grass from Southern China. Note that the roots are fine, fibrous, vertical in orientation and without lateral roots.

The leaves and stems have been cut off the top. The clump itself is composed of several hundred individual "slips", or sprigs, that grow side by side to make up the clump.



When planted in hedges along the contour lines of sloped land, the massive, finely structured root mass creates underground barriers as deep as four meters in addition to the dense above-ground hedge.

Vetiver is not invasive, does not produce viable seeds, and has no rhizomes or stolons. This means that vetiver hedges remain in the same place year after year. With only minimal maintenance, vetiver hedges last for generations

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Right image:
Flume trial by USDA-ARS
in 1991 showing 30 cm of
water backed up behind
the hedge, demonstrating
the effect of stiff stems
on the flow of water



Before hedges

Drainage canal in
Quang Ngai, Vietnam,
before and after protection
with vetiver hedges



After hedges

