Global and Regional Applications of the Vetiver System

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Abstract

Vetiver grass technology (VGT) is the basis of every application that are known collectively as the Vetiver System (VS). VS covers many applications and include: soil and water conservation, land rehabilitation and gully control, slope stabilization, disaster mitigation, improvement of the interface of water and structures, water quality, remediation of polluted sites, agricultural uses, and other applications that are unrelated to the forgoing. VS applications are used to remedy past problems and prevent new problems re-occurring. The paper provides some general detail about the applications, their region of use, and supporting research.

Key words: Vetiver grass technology, Vetiver Systems, soil and water conservation, slope stabilization, disaster mitigation, water quality improvement, pollution control.

Introduction

Vetiver grass technology (VGT) can be applied to a wide range of needs with many forms of application. We call these applications as whole "The Vetiver System". The core of the Vetiver System (VS) is vetiver grass – Vetiveria zizanioides – that is the base component of VGT as described in my previous paper today. This paper addresses VS as applied globally.

As background VS was first used for soil and water conservation purposes probably by Indian farmers in Mysore District of India's southern state of Karnataka. There it had been used for centuries for conservation purposes. Likewise it has been used (in this case Vetiveria nigritana) for more than 100 years in Nigeria's northern city of Kano as a boundary demarcation for household plots and as a windbreak. Its first modern use for conservation purposes was probably in the West Indies (St. Lucia, St. Vincent) and then in Fiji where John Greenfield introduced the technology to protect steep hillsides that were being planted to sugar cane. The current vetiver initiative, developed by John Greenfield[1] and myself, at a time when we were working in India during the latter part of the 1980's, in the beginning focused primarily on soil and water conservation.

Vetiver grass has been used for millennia for the extraction of an aromatic oil, oil of vetiver, from its roots, prior to 1985 most of the research on vetiver had focused on vetiver oils. Indian research stations (G. Bharad) were the first to undertake serious soil conservation related work from 1987, closely followed by Malaysia's Rubber Research Institute (P.K/Yoon) and Thailand's Royal Project's Development Board at the insistence of the King of Thailand. By this time research was moving into new areas including vetiver's use for highway stabilization and handicrafts. In the early 1990's work was initiated in Australia by Paul Truong who undertook vetiver research relating to flood mitigation, heavy (toxic) metal tolerance, water quality improvement, and constructed wetlands. Chinese researchers headed by Xia Hanping followed up on Truong's work and carried out extensive research on the use of vetiver for water quality improvement and at the same time undertook large scale applications of VGT to highway, railroad and landfill stabilization. Currently a new and large vetiver program is developing in Vietnam for a wide range of applications backed by research and data collection.

India, Malaysia, Thailand, Australia, China and Vietnam have or are the big centers of research and development. Even so there are many other initiatives taking place that are important and less dramatic in other parts of the world. Today over 100 tropical and subtropical countries around the world are fairly serious users of vetiver. In addition special niche environments such as California and some Mediterranean countries are developing techniques to use Vetiver Systems to mitigate problems that impact their infrastructure. Some of this is backed by local research, but much development and VS used is now being undertaken on the basis of research done elsewhere and the use of vetiver grass cultivars that are related to those of south India. Such cultivars include: Karnataka, Sunshine, Hoffman, and Monto. Combine the two and one can expect good results if applied correctly.

VGT for Soil and Water Conservation.

Soil and water conservation issues affect most of the world's farmers. Vetiver is one solution that is cheap and effective. There is conclusive evidence from many countries that VGT reduces soil loss by up to 90%, reduces run off by as much as 70%. Increases crop yields, acts as a drought proofing system, and provides byproducts that are effective mulches, improve soil organic matter, act as alternative hosts to crop pests (and in the process reduce insect damage to adjacent crops), and recycle nutrients, particularly nitrates and phosphates that are normally unavailable to the crop. The demand for VGT for these purposes has not been as great as one would have expected. This is due to a number of complex reasons – social, economic and technical. However the most important limitation has been the generally ineffective marketing of the technology to farmers. Where enlightened government agencies and active and progressive NGOs have been involved there has generally been a good response from farmers. A number of cases come to mind including: export orientated small vegetable farmers in Zambia, a large number of maize farmers in Malawi, tea growers in India and Sri Lanka, community based projects in Indonesia, Philippines and Mexico, sugar cane farmers in Fiji, Madagascan irrigation and upland farmers, farmers in Cameroon, large commercial farmers in Queensland, Australia, and South Africa, and a range of farmers in Central America, China, and Thailand. In every case VGT comprises of vetiver hedgerows planted across the slope on an average contour with a vertical interval of about two meters between hedgerows.

VGT for Land Rehabilitation and Gully Control.

Vetiver grass is one of the few really good species that act as a pioneer plant for land rehabilitation. There are many good examples where VGT has been applied for such purposes. In China there is a classic example in Guangdong Province where vetiver was used to reclaim the "Red Desert" - a hilly area completely eroded to the "C" horizon where no plant would grow. Vetiver was planted as hedgerows across this 500 ha site and then interplanted with eucalypts and other tree species. The hedgerows resulted in improved moisture conditions and more stable soils and within 5 years the area was totally reforested. Other degraded sites including mining areas in Australia, China, South Africa, Indonesia, and Venezuela – all affected by heavy and toxic metals have been rehabilitated using VGT. In China VGT has also been used to rehabilitate stone quarries. Extensive information on land rehabilitation can be found in the Proceedings of the second and third International Vetiver Conferences[2]

There are some good examples of gully reclamation from Fiji in the 1950's, Australia, Ethiopia, India, Malaysia, South Africa, and Zimbabwe in the 1990's; and most recently new work ongoing in the Congo. In all cases the technology is based on hedgerows planted across the bottom and sides of gullies. Over time the grass barriers silt up with sediment so that eventually a series of natural terraces develop down the gully. It is essential that steep sided gullies are correctly shaped before the planting of vetiver,

VGT for Slope Stabilization

VGT has been used by farmers to stabilize slopes long before the 1980's. However in the early 1990s P.K.Yoon and Diti Hengchaovanich working in Malaysia started to serious look as to how vetiver might be used to stabilize the Malaysian highway system that was being seriously affected by tropical storms and the resultant collapse of road cut and fill. Yoon first showed how vetiver could be used to stabilize plantation roads on steep hillsides then he moved into the highway system. Hengchaovanich undertook a series of studies on the tensile strength of vetiver and its impact on shear strength of soil. The results were spectacular. The average root strength of vetiver grass is about 75 MPa

Table 1: Tensile Strength of Roots of Some Plants

Botanical name	**Common name**	**Tensile strength (MPa)**
Salix	Willow	9-36*
Populus	Poplars	5-38*
Alnus	Alders	4-74*
Pseudotsuga	Douglas fir	19-61*
Acer sacharinum	Silver maple	15-30*
Tsuga heterophylia	Western hemlock	27*
Vaccinum	Huckleberry	16*
Hordeum vulgare	Barley Grass, forbs Moss	15-31* 2-20* 2-7kPa*
Vetiveria zizanioides	Vetiver grass	40-120 (Average 75**)

* After Wu (1995)
** After Hengchaovanich and Nilaweera (1998)

Vetiver's dense and massive root system offers better shear strength increase per unit fiber concentration (i.e. 6~10 kPa per kg of root per m3 of soil) compared to 3.2 - 3.7 kPa per kg of root/m3 of soil for tree roots[3] Shear strength of soil in the first half meter may increase by as much as 30%.

The fact that vetiver roots grow vertically on steep slopes (more than 150%), grows fast, and provides more reinforcement to the soil makes it a better candidate for slope stabilization than other plants. Another less known characteristic that sets it apart from other tree roots is its power of penetration. Its strength and vigor enables it to penetrate hard pans, between boulders, and fractures between rock layers. Vetiver roots behave like 'living' soil nails or dowels of 2 - 3 m depth, the latter are commonly used in alternative 'hard approach' slope stabilization work.

As a result of this work engineers were more confident to apply the technology for the stabilization of high cost infrastructure. In recent years there have been many applications of VGT to highways and railroads in Australia, Central America, China, Italy, Madagascar, South Africa, Thailand, Venezuela, and Vietnam. The results were generally very good leading to much better stability, lower construction and maintenance costs, and site beautification.

Since applying VGT many of the sites have been impacted by tropical storms and hurricanes. Nearly all withstood the high rainfall and remained intact, compared to those sites not protected by VGT.

VGT for Disaster Mitigation

Extreme weather conditions appear to be more common in recent years. Those extreme conditions that involve large quantities of water, such as hurricanes, result in flooding and collapse of infrastructure, land and mudslides, and sediment inundation. In nearly every case where VGT has been used to repair damage and prevent further damage the results have been successful.

"In the last days of October 1998 Hurricane Mitch, the most intense storm in the Atlantic Basin in the past 200 years and the most destructive hurricane in the history of the western hemisphere (1), battered the Caribbean coast and parts of Honduras, Nicaragua, El Salvador, and Guatemala. From October 27, 1998, to November 1, 1998, it dumped from 300 to 1900 mm of rain on large areas of the four countries. The storm produced sustained wind speeds of 290+ kilometers hr^{-1} and rainfall intensities of more than 100 mm hr^{-1}. The main destruction came as a result of intense rainfall"[4] . Those structures protected by vetiver including 200km of highway cut and fill remained undamaged and intact. Another case, from Madagascar, involved the stabilization of a railroad that was frequently destroyed by cyclone damage. VGT technology carefully applied resulted in proofing the railroad from future cyclone damage[5].

In 2005 Vietnam received the sharp end of the worst typhoons in the past 60 years. Sea walls were destroyed and much farmland was lost. It was interesting to learn that much of the reinforced armored outer walls of the dykes were destroyed, whereas where the inner walls were protected with VGT no damage occurred from over topping[6].

High rainfall events often trigger landslides that cause much social damage and death. VGT has been used effectively in Central America and Asia to rehabilitate landslide impacted areas and prevent further occurrence.

VGT an Interface with Water

One of the great strengths of vetiver grass is its interface with water. Not only does it grow in standing water, and survives full submergence for months, but it also has the ability to absorb the power and shock of water, thereby protecting the adjacent soil and or slope. Thus VGT can be used for stabilizing river banks, canal and drainage banks, sea dykes, reservoir draw down areas, earth spillways and other structures interfacing with moving water. Vetiver is particularly good at reinforcing the interface between soil and concrete/stone. So often this reinforcement does not exist, resulting in washout of structures such as bridges, concrete lined canals etc. Often one finds that rock filled wire gabbions are destroyed by sudden floodwater events. In Madagascar and Australia low level river crossings that submerge at flood times (Irish crossing) have been very successfully reinforced with vetiver to prevent washout. Where VGT is used to reinforce the gabbions no such damage occurs. In South Africa vetiver has been used successfully to stabilize and reinforce the banks of the tailrace embankments below hydro-electric power stations.

Vetiver grass because of it stem density, stiffness and deep roots is able to withstand substantial water velocity flows without lodging or uprooting. It is an ideal plant to prevent “piping” in embankments, levees and even small bunds in rice paddy fields from erosion scouring and structure failure.

VGT for Improved Water Quality and Remediation of Polluted Sites

Agricultural, industrial and urban enterprise biproducts have caused serious deterioration of water quality that not only affect domestic water supplies but also water used for irrigation and fisheries. There are two major types of pollution, sediment from erosion and urban and industrial waste products. Sediment from eroding lands can be prevented from entering the natural water systems by introducing strict preventative measures such as on farm erosion control, control of sediment flows from construction sites, stream and river side buffer zones and so on. VGT has a positive role for remediation of these problems. In most cases sediment source is site specific and can easily be identified. Reduced sediment flows will result in cleaner rivers, improved fisheries, and in the coastal areas better a environment for marine life and coral.

Agricultural, industrial and urban pollution is all of point source nature and can be easily identified, and in most cases is treatable. VGT has an important role to play in such remediation and prevention. Some outstanding research carried out in Australia by Paul Truong and his colleagues[7] and Xia Hanping of China has shown the effectiveness of VGT in the containment and removal of pollutants from urban landfills[89]. Landfill sites have been physically stabilized with VGT and leachates from the sites that normally enter the nearby drainage systems have been reduced to the minimum and most cases reach the levels proscribed by local environmental legislation.

The reduction of polluting contents of tertiary effluent from sewage treatment plants, particularly the high levels of phosphates, nitrates and BODs is of great importance and can be remedied using VGT methods. A good example of this is in Eke Shire of Queensland where constructed vetiver wetlands have reduced the sewage effluent levels to regulative requirements.[10] In this instance dissolved oxygen increased from 0.2 mg/l to 9 mg/l; 5day BOD was reduced from 130-300 mg/l to 7-11 mg/l; suspended solids were reduced from 200-500 mg/l to11-16 mg/l; total nitrogen reduced from 30-80 mg/l to 4-5.7 mg/l and total phosphorous from 10-20 mg/l to 1.4 –3.3 mg/l. On a much smaller scale VGT can be applied to domestic cess pools to clean up seepage and reduce smell and disease from such effluent. In such cases may be only a dozen vetiver plants planted by the outlet will clean up the effluent seepage. VGT could also be used to reduce grey-water from households from entering urban open drains.

Just as Hengchaovanich proscribed the strength of vetiver roots, Australian researchers have set out the technical parameters for VGT in relation to water quality improvement under the MEDLI formula[11]. MEDLI (Model for Effluent Irrigation by Land Irrigation) is used throughout Australia to design and test the sustainability of effluent irrigation schemes. MEDLI models the partitioning of water, nutrients and salt from the waste stream as it passes through pond treatment, is irrigated onto land growing crops or pastures, and percolates to groundwater. This model allows planners and designers to accurately design and predict results using VGT.

VGT can also be floated and grown on rafts to reduce the pollutants present in small village ponds and livestock effluent ponds. This has the potential benefit of the reduction of toxic materials and providing a cleaner environment for fish.

VGT experimental work is ongoing in China to clean up effluent from oil refineries[12]. Also some years ago in the 1980s VGT was used in Mozambique for the rehabilitation of salinity damage in the adjacent areas to oil well heads.[13]

Most of these applications could probably find a place in Kuwait since they are independent of rainfall, and certainly deserve investigation.

VGT has been successfully used for mine tailing rehabilitation[14] in Australia, China, Indonesia, South Africa and Venezuela. Vetiver grass is extremely tolerant to toxic substances and highly acidic (pH3) soils, and can thus survive under such conditions. Vetiver grass, besides stabilizing the site and containing effluent outflows also acts as a pioneer plant that enables other species to eventually establish.

VGT has an important role to play in reducing the excess nitrates, phosphates and pesticides entering both ground water and surface water supplies. Vetiver placed along and across farm drains, grown as buffers along streams and ephemeral water courses, and as infield contour hedgerows will remove these polluting excess substances. Interesting work in Australia has quantified vetiver's impact[15].

VGT - Agricultural Uses

Apart from on farm soil and water conservation VGT can be used for a number of important agricultural applications including amongst others[16]: forage, mulching, pest control, nutrient recycling, soil organic matter improvement, and wind-break.

Forage. Vetiver grass will under the right management and conditions produce very large quantities of good quality forage, especially if irrigated (constructed wetland included). Vetiver grown hydroponically on floating pontoons will produce as much as 150 tons of dry matter per ha. equivalent. Irrigated with brackish water that is unfit for normal agricultural use it will yield as much as 70 tons per ha[17]. If the crop is managed correctly (frequent harvesting) it will provide forage with high protein levels and can be fed to goats, sheep, camels and cattle. In China[18] digestibility of the nutrient contents of Vetiver grass (*Vetiveria zizanioides*) in the Dongshan goat was measured using the typical method of total-faeces-collection. The results showed that digestibility of gross energy, dry matter, crude protein, ether extract, crude fiber, calcium, phosphorous and nitrogen free extract in Vetiver grass hay were 29.65%, 46.09%, 23.15%, 28.79%, 46.44%, 61.00%, 66.60% and 36.25% respectively. 1 kg dry matter of Vetiver grass hay could provide 1.47 Mcal digestible energy, 13.4 g digestible crude protein and 4.17 g ether extract, indicating that Vetiver grass is a promising feed resource for goats.

In a middle east country such as Kuwait it is probably that vetiver could be grown as a forage under a mechanized and irrigated management practices. In the US (Texas) Gueric Boucard has developed machinery that will plant and harvest vetiver both for its root (aromatic oil) and leaf. Harvested leaves could be easily dried as hay and the baled for storage.

Mulch. Vetiver grass makes excellent mulch, and because it is resistant to pest damage it will last much longer than other mulches. Where evaporation rates are extremely high, as in Kuwait, vetiver mulch could be a useful bi-product from some other application. There are numerous anecdotal references to vetiver's application as a mulch, and although little or no research has been carried out, the grass undoubtedly makes an excellent mulch.

Crop protection. There has been much anecdotal evidence to show that vetiver impacts on insects. A study in recorded 102 insect species that occurred on vetiver plants during two seasons of vetiver production in China. Among these were distinguished 13 species as leaf eaters, four as sucking insects and 19 as herbivores on spikes, stems and roots of plants. Many of these species could be identified as general herbivores (such as grass hoppers). Sixty four percent of the insect species observed on vetiver was identified as visitors or natural enemies of other insects. These observations showed that insect biodiversity in vetiver could actually be high. An interesting observation was that population densities of many of the herbivorous insects on vetiver was low and that they did not do any apparent damage to plants[19]. More recent work in South Africa[20], now being duplicated in Vietnam, demonstrated conclusively that vetiver grass is the preferred host to stem borer - *Chilo* sp. Although the insect does no apparent damage to vetiver the fact that the insect is attracted to vetiver results in a significant reduction in the incidence of stem borer in adjacent maize (and possibly rice) crops. In addition the vetiver grass provided a natural habitat for predator wasps that fed on aphids of agricultural crops.

Soil Improvement. Experiments in China have confirmed the use of vetiver to improve soil quality. For example experiments indicated that Vetiver planted in a citrus orchard on red earth sloped land could help increase citrus yields due to improvement of the soil physical features and chemical composition. It was also noted that conditions for citrus flowering and fruiting were enhanced. For example, the increase in pH and OM meant an increase in soil nutrient availability and an improvement in ability of the citrus root system to assimilate them[21]. At the Jiangxi Provincial Institute of Red Earth conducted a 3-year stationary experiment in which cut Vetiver chips were applied to the soil as manure to improve fertility. In this experiment, 4.5 t and 2.25 t of dry Vetiver leaves and stems were applied on two farmland sites. Results showed that soil total porosity, organic C, total N, total P2O5 as well as available N and available P2O5 on treated farmland increased while soil specific weight decreased. This resulted in production of 2790 kg/ha and 2280 kg/ha of experimental corn seed, which was an increase of 34.8% and 10.1%, respectively, when compared with 2070 kg/ha yield from a control.

Wind breaks. In Fujian Province of China vetiver hedge windbreaks were planted to protect a Jojoba (pronounced hohoba) oil crop. The 0.44 ha garden of sandy soil, comprised of mainly shifting sands (90%), had an annual mean wind velocity of 8.4 m/s with a prevailing northerly wind. In total the hedges were over 800 m long and arranged at 6-8 m intervals. This was parallel to the Jojoba lines and perpendicular to the prevailing wind direction. These hedges filled out the same year the Vetiver was planted and after 1 year had long, thick leaves and stems. By the end of the second year, these lush hedges which were over 2 m high, had already become powerful natural windbreaks arresting the shifting sands and protecting the Jojoba garden. The result was a high yield of oil. Measurements on the sheltered (leeward) side of the hedges showed that wind speed was greatly diminished by the hedges. The closer the measurement was to the hedges the greater the decrease in wind speed. For example, 5 m from the hedge, the wind speed decreased 58.8% while 2 m away from the hedge the wind speed decreased 79.4%[22].

Other uses of VGT

Vetiver grass is used for many other applications that include: the extraction of the aromatic oil from its roots for the perfume industry; thatching; medicinal, handicrafts (basket making etc.) vetiver other uses, and building materials. Perhaps some of the most innovative uses have been developed in Thailand. A good overall view of other uses of vetiver was presented at the Third International Vetiver Conference in 2003[23]. Other future areas that might make vetiver an interesting technology is for energy production and the reduction of greenhouse CO2.

Conclusion

The Vetiver System has a wide range of applications that are effective if correctly applied. The applications have been mostly researched and are proven. Vetiver grass is available in most tropical and semi tropical countries as well as in some semi arid and Mediterranean locations. At a time when the world as a whole is becoming more aware of the problems it faces and the need for natural, biological mitigating measures, vetiver grass provides a realistic solution.

The Vetiver System and Vetiver Grass Technology is documented in over 10,000 pages on the Vetiver Network website at http://www.vetiver.org. It is all downloadable at no cost.

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[1] Greenfield John C. 1987. Vetiver Grass – A Hedge Against Erosion. 1st Edition .

[2] Proceedings of the 2nd International Vetiver Conference 2000, Thailand. Proceedings of the 3rd International Vetiver Conference 2003 Guangzhou, China.

[3] Hengchaovanich Diti. 2000 Slope Stability Enhancement And Erosion Mitigation By Vetiver Grass In Engineering Applications.

[4] Smyle James. 2000. Disaster Mitigation and Vulnerability Reduction: Perspectives On The Prospects For VGT. Paper presented at the Second International Vetiver Conference Thailand, January 2000

[5] Hengchaovanich Diti, and Schoonmaker Freudenberger Karen. (2003). Vetiver .Victorious: The Systematic Use of Vetiver to Save Madagascar's FCE Railway. . Paper presented at the Third International Vetiver , Guangzhou, China.

[6] Truong Paul. 2005. Personal correspondence.

[7] Truong Paul. 2003 Vetiver System for Water Quality Improvement. Proceedings of the 3rd International Vetiver Conference , Guangzhou, China

[8] Xia HP, Liu SZ, and Ao HX. 2002. Study on purification and uptake of vetiver grass to garbage leachate./ Proceedings of the Second International Conference on Vetiver. Office of the Royal Development Projects Board, Bangkok. 393-403

[9] Percy I, and Truong P. 2003. Landfill leachate disposal with irrigated vetiver grass. Third International Conference on Vetiver and Exhibition, Guangzhou, China

[10] Ash Ralph. Truong Paul. 2004 The Use Of Vetiver Grass For Sewerage Treatment *(Paper for Sewage Management QEPA Conference, Cairns, Australia, April 5-7 2004)*

[11] Viertz Alison, Truong, Paul, Gardner Ted, Smeal Cameron. 2003. Modeling Monto Vetiver Growth and Nutrient Uptake for Effluent Irrigation Schemes. Proceedings of the 3rd International Vetiver Conference, Guangzhou, China

[12] Xia Hanping, Ke H.H, Deng Z.P, and Tang P. 2003. Effectiveness of Constructed Wetlands for Oil-Refined Wastewater Purification. Proceedings of the 3rd International Vetiver Conference, Guangzhou, China

[13] Tantum Anthony. 1989. Personal communication.

[14] Truong Paul. 1999. Vetiver Grass Technology For Mine Rehabilitation

[15] Truong Paul, Mason Frank, Waters David, Moody Phil. 2000 Application of the Vetiver System in Off-Site Pollution Control *(Presentation at the Second International Vetiver Conference, Thailand, Jan 2000)* Trapping Agrochemicals and Nutrients from Sugarcane and Cotton crops

[16] Liyu Xu, Shengluan Lu, and Truong Paul. 2003 Vetiver System for Agriculture Development. Proceedings of the 3rd International Vetiver Conference, Guangzhou, China

[17] Boucard Gueric. 2005. Personal communication – Production of vetiver in the Dominican Republic.

[18]Pingxiang Liu, ,Chuntian Zheng, Yincai Lin, Fuhe Luo1, Xiaoliang Lu, and Deqian Yu. Study on Digestibility of Nutrient Content of Vetiver Grass. Proceedings of the 3rd International Vetiver Conference, Guangzhou, China.

[19] Chen Shangwen, 1999. Insects on Vetiver Hedges in China. A report to the vetiver Network.

[20] Van den Berg, J, Midega, C, Wadhams, LJ , Khan, ZR . 2003. Using Vetiver grass to manage maize and rice insect pests. Proceedings of the 3rd International Vetiver Conference, Guangzhou, China

[21] Hu JY, Xie HX, and Zhou CW. 1997. Research on vetiver for red soil development. Agroforestry Today 5(3)

[22] Zhang J. 1996. Planting and utilization of vetiver on coastal dune land. Water and Soil Conservation of Fujian Province, 96(1)

[23]Chomchalow, Narong, and Chapman, Keith and Keith Chapman. 2003 Other Uses and

Utilization of Vetiver. Proceedings of the 3rd International Vetiver Conference, Guangzhou, China.