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Vetiver: An Eco-Friendly Aromatic Grass for Green Technology

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ARTICLE ID: 52

Introduction

Nature is an important and integral part of mankind. It is one of the greatest blessings for human life, nowadays humans failed to recognize it as one. It is surrounded by water we drink, the air we breathe, the sun we soak in, the food we eat, shelter for human and more. Survival of mankind without nature is impossible and humans need to understand that. But with technology advancements, people are not paying attention to nature. Instead of that polluting the nature with different ways, deforestation increasing day by day which leads to soil erosion, ultimately climatic variation happens with increase in global warming. The need to conserve and balance the natural assets it is essential to flourish our duty to conserve natural resources by the implementation of 'green technology', so life can forever be nourished on earth.

Green Technology

It is a technology which is environmentally friendly, developed and used in such a way so that it doesn't disturb our environment and conserves natural resources and also known as environmental technology and clean technology.

Why is green technology important?

- Green Technology is a system that uses innovative methods to create environmentally friendly products and sustainable development of environment for future generation.
- It uses renewable natural resources that never depletes.
- Innovative technology for eco-system effectively changes waste pattern and production in a way that it won't harm the planet.
- Reduce contaminants and harmful processes by various technologies.

Introduction of Vetiver

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Vetriver (*Vetiveria zizanioides*) is a densely tufted grass commonly known as Khus-Khus belong to family Poaceae with the clumps arising from an aromatic rhizome up to 1.5 to 2m tall native to India.

Roots are massive, deep, fast- growing, 3 - 4 m deep in 12 months of planting. Tolerant to drought, allow excellent infiltration of soil moisture, enhancing deep drainage. It has very fine roots with average diameter 1-3 mm, acts as an effective bio-filter, trapping fine, course sediment and even rocks in runoff water.

Uses of Vetiver

Essential oil and its derived products:

The use of vetiver root for essential oil extraction to produce perfume and other fragrant materials such as deodorants, cosmetics, potpourri, lotions, aromatic soap, aromatic wax, aromatic kaolin, flavoring of soft drink, syrup, ice cream etc.

Medicinal properties and uses

Vetiver roots and leaves have been used in therapeutic treatments. Essential oil attributes medicinal properties like anti-inflammatory, antiseptic, aphrodisiac, healing effect, sedative etc. Used for treating nervous tension, muscular spasm, menstrual cramps, premenstrual syndrome, restlessness, rheumatism, acne, arthritis, oily skin, sores etc

Aromatherapy: Using vetiver for aromatherapy treatment strengthens the central nervous system and can overcome depression, insomnia, anxiety, stress, tension and nervousness.

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Handicraft: Handicraft products made from vetiver leaves and roots includes:

- Handy accessories such as bags, hats, belts and brooches.
- Containers such as baskets, pots, boxes, utility bowls.
- Decorating materials such as clocks, picture frames, lamps, dolls, animal figure, flower
- Home appliances such as chairs, stools, room partitions, tables.


Wall hanging


Vetiver mat


Bathing scrubber


Vetiver hat


Incense sticks


Soap bar


Garland


Vetiver basket

Input for construction related activities

- **Roof thatch:** Vetiver clumps and leaves for roof thatching.
- **Vetiver hut:** Dried roots of vetriver have been used since ancient times for making make shift huts and cabins as they provide cooling effects during the summer.
- **Cement replacement material:** Vetiver ashes have been experimentally used as low-cost, environmental-friendly, considered the possibility of using it as a pozzolanic material.

Other uses:

- **Landscaping:** Vetiver is a beautiful ornamental plant for gardens, decks etc. The bush of the vetiver plant is so large that it hides unsightly structures.
- **Decorative hedge:** vetriver is used as a decorative head on the roundabout. It looks good and seems to serve a good purpose.

Major production of vetiver in the world:

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- Major countries like tropical Asia, Africa, Australia, Haiti, Indonesia, Guatemala, India, China and Brazil. Worldwide production is estimated to about 250 tons per annum.
- In India, vetiver scene growing wild throughout Punjab, Uttar Pradesh and Assam cultivated as crop in states of Rajasthan, Uttar Pradesh, Kerala, Karnataka, Madhya Pradesh and Andhra Pradesh. India is major oil producer, 20 to 25 tons of essential oil.

Vetiver Grass System (VGS)

VGS is a bio engineering tool has a vital role in many on and off farm land and water related challenges. Practice of growing vetiver in headgerows for environmental protection through bio-engineering and phytoremediation.VGS was 1st developed by World Bank for soil and water conservation in India in the mid-1980.

Why vetiver grass suitable for green technology?

Vetiver has unique morphological, physiological and ecological characteristics which favor to adopt for Vetiver Grass Technology (VGT) as follows

Morphological characteristics:

- Vetiver has massive, finely fibrous root system, reaching 3-4 m in the first year, this deep root system makes vetiver plant extremely drought tolerant and difficult to dislodge by strong current.
- Root comprises with high tensile strength.
- It has stiff and erect stems, which can stand up to relatively deep-water flow.
- Vetiver hedges can stand up to deep-water flow, reduces flow velocity, traps and filter sediments effectively.
- Both xerophyte and hydrophyte.
- New shoots develop from the underground crown making vetiver resistant to fire, frosts, traffic and heavy grazing pressure.
- Trees and shrubs inherently have several drawbacks in that they are too slow to establish to become effective and the danger of being uprooted, in cases of heavy storms, typhoons or cyclones and does possess several tree-like features.

Physiological characteristics:

- Tolerance to climate variation and extreme temperature varies from -22 C to 60 °C.
- Thrives well under hydroponic conditions.

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- Highly tolerant to wide range of soil pH 3.0 to 11.5.
- Highly tolerant to growing medium high in acidity, alkalinity, salinity, sodicity and magnesium.
- High level of tolerance to herbicides and pesticides.
- Remove heavy metals: As, Cd, Cr, Ni, Pb, Hg, Se and Zn in the soil and water.
- Highly efficient in absorbing dissolved N, P, Hg, Cd and Pb in polluted water.
- Ability to re-grow very quickly after being affected by drought, frosts, salinity and adverse conditions after the weather improves or soil ameliorants added.

Vetiver Grass System for Green Technology

Vetiver has proven that, it has potential applications of Vetiver Grass Technology in the field of environmental protection of terrestrial, aquatic, aerial, natural disaster and agriculture environment.

Vetiver grass technology in terrestrial environment:

Soil erosion, soil and water conservation:

Vetiver acts as vegetative barrier to control erosion on and off farmland.

Root:

- Roots are dense, deep and penetrating into the soil can reach vertical depths of 3+ meters, binding and reinforcing soil shear strength by up to 45%.
- The roots are extremely fine and strong with a tensile strength of 75 MPa, which is equivalent to approximately $1/6^{th}$ of mild steel reinforcement.
- When planted in hedgerow format, due to its clonal nature, the roots of the plants grow and interlock, creating vast underground, dense and strong root wall systems, which serve to bind, stabilize and increase the tensile strength of the soil.
- Protecting against erosion, instability and flood disasters.

Stem

- The strong, thick and stiff stems create above ground hedges, which protect the topsoil by dissipating wind and water energy, slowing down water flow, trapping sediment and controlling water runoff.
- These hedges act to protect the topsoil, ensuring that it remains in place and overtime, create natural barriers to flow by trapping soil and sediments.

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To prove this, Vetiver was planted almost horizontally. The combination of vetiver extensive roots and its positive geotropism effect create a stable protective cover on soil surface below the plant when it is planted on extreme slopes.

Stabilization of slopes and infrastructures:

Vetiver roots per unit area are found stronger and deeper than tree roots is an ideal tool for erosion control of unconsolidated soil and the stabilization of steep slopes such as road and railways batters, dam wall, river, canal banks and landslips. As strong or stronger than those of many hardwood species, vetiver roots have very high tensile strength that has been proven positive for root reinforcement in steep slopes. These roots have a mean tested tensile strength of about 75 megapasal (MPa), which is equivalent to one sixth of mild steel reinforcement and a shear strength increment of 39% at a depth of 0.5 m, hence the best suitable for stabilization.

Embankment of river and canals

Vetiver grass provides a two-way support to eroding slopes are the deep interlocking fibrous root system penetrates up to depths of 3m providing good anchorage, thus binding the soil and preventing its movement by increasing the soil shear strength and aiding slope stabilization.

The massive root system of vetiver can halt 60-70% run off and trap 90 - 98% sediments. The stiff and strong roots help plant to stand steadily in water with 0.6 -0.8m deep and 3.5 m/s velocity of water flow. Significantly reduced erosion and stabilized the banks, with proper plant spacing important for optimum results and the vetiver implants therein have also enhanced the soil fertility for other crops.

Mine rehabilitation

Onsite and offsite pollution control from mining wastes is major breakthrough in the application of VGT for environmental protection. Research conducted over the last six years has clearly established the extremely high levels of tolerance of vetiver grass to Al, Mn, As,

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Cd, Cr, Ni, Cu, Pb, Hg, Se and Zn in the sites of mined soils. Although vetiver is a hyper-accumulator it can be used to remove some heavy metals from the contaminated sites and disposed safely elsewere, thus gradually reducing the contaminant levels.

VGT was highly successful in the rehabilitation of old quarries and mines in Australia, gold mine in Queensland, used to rehabilitation bentonite mine waste, bauxite and copper mines in Northern Australia, rehabilitate a large copper mine in China, tin mine in Philippines and coal and gold mine in Indonesia

Phytoremediation

The process of removal of contaminants from soil or water by efficient use of green plants.

"The efficient use of green plants and their microorganisms to reduce environmental contaminants in a growth matrix (soil or water) without the need to excavate the contaminant material and dispose of it elsewhere".

Phytoremediation- From vetiver roots

- **Phyto-filtration:** In this process, Vetiver grasses with the help of their roots absorb, concentrate and precipitate contaminants especially heavy metal and radioactive elements from the aqueous medium.
- **Phyto- stabilization:** Vetiver grass immobilizes contaminants in the soil and ground water through absorption and accumulation by roots, adsorption onto roots or precipitation onto root zone.
- **Phyto-stimulation:** also called rhizo-degradation, refers to the breakdown of contaminants in the rhizosphere (soil surrounding the roots of plants) through microbial activity that is enhanced by the presence of roots.

Phytoremediation- From vetiver shoots

1. **Phyto-extraction**: The uptake of contaminants by plant roots and movement of these contaminants from roots to the above part of plants by absorbing, concentrating and precipitating the contaminants.
2. **Phyto-degradation/ phyto-transformation**: Breakdown of contaminants into simpler molecules through the metabolic processes of plants.
3. **Phyto -volatilization**: Plants taking up contaminants from soil, transforming them into volatile forms and transpiring them into atmosphere.

Vetiver grass technology in aquatic environment:

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1. Phyto remediation for polluted water:

Polluted water is water contaminated with harmful substances resulting from agriculture and industrial processes such substances include heavy metals like Pb, Hg, Cu, Cd, Cr, As, Ni, agrochemical residues and other harmful compounds.

- Vetiver is the best choice and have the ability to uptake heavy metals and accumulated in roots and shoot.
- It acts as hyper accumulator plants can take up toxic metal ions up to very high concentration, multiple mechanisms are involved storage in the vacuole appears to be a major one of them.
- Vetiver grass roots are able to solubilize and take up micronutrients from polluted water, even from nearly insoluble precipitates.
- Also evolved highly specific mechanisms to translocate and store micronutrients, which are involved in the uptake, translocation and storage of toxic elements.

2. Purification of eutrophicated water:

Eutrophication is the process by which entire water body becomes enriched with minerals and nutrients.

As soluble N and particularly P are usually considered to be key elements for water eutrophication which normally leads to blue green algal growth in inland waterways and lakes, the removal of these elements by vegetation is a most cost effective and environmentally friendly method of controlling algal growth. VGT can be used very effectively to control algal growth in water infested with blue-green algae. This can be achieved by planting vetiver on the edges of the streams or in the shallow parts of the lakes where usually high concentrations of soluble N and P occurred. Alternatively, vetiver can be grown hydroponically on floating platforms which could be moved to the worst affected parts of the lake are pond. The advantages of this innovative floating platform method are that vetiver tops can be harvested easily for stock feed or mulch and vetiver roots can also be removed for essential oil production.

3. Effluents disposal:

Effluents are the liquid waste flowing from farm, factory home and other source into the water body like river, lake etc which are toxic to aquatic environment. With the potential use of vetiver for removing very high quantity of N and P, vetiver planting can be used to

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remove N, P and other nutrients in effluent from sewage, abattoirs, feedlots, piggeries and other intensive livestock industries.

Vetiver grass technology in aerial environment

Carbon sequestration:

Carbon sequestration is the process of capturing and storing atmospheric carbon dioxide. It is one method of reducing the amount of carbon dioxide in the atmosphere with the goal of reducing global climate change. Two areas describing Carbon sequestration:

- Sequestration of carbon (from the air)
- Carbon capture and storage (from atmosphere via the vegetation into the soil)
- Vetiver holds prominence as one of the world's best carbon-sequestering plants. It has advantage with high potential for biomass production in combination sequestrates carbon from both atmosphere and also from soil.
- 4 vetiver plants would sequester the same amount of atmospheric carbon as one fast-growing poplar tree (*Populus sp*)

Air pollution:

When dry, the finely ground mine tailings material is easily blown away by windstorms. As gold tailings are often contaminated with heavy metals, wind erosion control is a very important factor in stopping the contamination of the surrounding environment. Vetiver can offer a long-term solution when planting in long rows at appropriate spacing to reduce wind velocity and at the same time provide a less hostile environment (ex: shading and moisture conservation) for local native species to establish voluntary later. Vetiver growth after the first year was 1.5 mm tall and has survived several windstorms which flattened several sections of the wind barrier in the last 12 months.

Vetiver grass in agriculture

- **Vetiver as botanicals:** Traditional utilization of vetiver as botanical pesticides in various countries. These are:
    i. **Insecticides:** Vetiver extracts are highly effective against termites control, ingestion of wood treated with vetiver oil causes the progressive death of the protozoa living inside the termite gut, ultimately results in a progressive decline of its colony through starvation, as these termites rely on the protozoa for the digestion of their wooden food and repellents for mosquitos.

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ii. **Fungicides:** Fungal attacks on the vetiver mulched plants have virtually disappeared and there seem to be little, if any pest action around the host plants. Thus vetiver mulch seems to have natural funcicide to stop the growth of the fungi which attack the crop plants.

iii. **Agaricides:** 10% vetiver oil of different vetiver ecotypes was variably able to control cow ticks at both the larval and adult stages. Furthermore, extract of dry root was able to control adult stage of ticks better than larvel stage.

iv. **Nematicides:** Vetiver essential oil was found to possess anti-nematicidal property, lethal against Root- knot nematode.

- **Mulching:** Vetiver leaves are excellent materials for mulching; they are durable and long lasting. Vetiver mulch can be applied to vegetable plots, at the base of fruit trees and field-crop plots.
- **Compost:** Vetiver leaves and clumps are completely decomposed to become soft, disintegrated and dark brown to black in colour. Vetiver composet contains major nutrients from the decomposition process, i.e, N, P, K, Ca and Mg with a pH of 7.0. In addition, vetiver compost also provides humic acid that enhances soil fertility.
- **Mushroom medium:** Vetiver leaves contain chemical compounds such as cellulose, hemi- cellulose, lignin and crude protein as well as various minerals in which certain mushrooms can feed on. Oyster, shitake and straw mushrooms are among those that can be produced using small pieces of vetivet as a medium.
- **Animal fodder:** Vetiver leaves can be ground to feed fish and livestock, have relatively higher structural carbohydrates as compared to native grass and rice straw, it also had optimal levels of crude protein considered to be enough to maximize intake and digestion of the vetiver forage. It was concluded that vetiver may be used as ruminant feed if it is mixed with other good quality feed and forages.

Vetiver grass technology in natural disaster

Landslide:

Typical sediment landslide control measures are hard engineering solutions such as gabions, rock fall netting and geotextiles. The root system increases soil shear strength via apparent cohesion and therefore the probability of the occurrence of a landslide is reduced.

Floods:

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Vetiver hedges will protect the banks of rivers and streams under flood conditions. Deep roots prevent it from being washed away while its thick top growth reduces flow velocity and its erosive power.

Conclusion

Vetiver is an important aromatic grass; its essential oil has high value with many medicinal uses. It has unique morphological, physiological and ecological characteristics which favors to adopt for Vetiver Grass Technology (VGT) has been playing role in soil and water conservation technique, infrastructures stabilization, pollution control, waste water treatment, mitigation and rehabilitation, carbon sequestration, sediment control, prevention of storm damage and natural disaster like landslides flirts and many other environmental protection applications through bio engineering and phyto remediation.

In agricultural lands reduce soil loss by 80 to 90% water run of by 50 to 70% crop yields can increase by as much as 40%. Vetriver can make a city more greener using as decorative headache dual purpose in beautifying the landscape and environmental protection of urban area. VGT was highly successful in the rehabilitation of volt queries and mines in Australia gold mine in Queensland used to rehabilitate Ben tonight mine waste bauxite and copper mines in Northern Australia rehabilitate a large copper mine in China tin mind in Philippines and coal and cold mine in Indonesia. These are enough reasons to conclude that whatever is new generation crop of green technology it places vital role interest real aquatic environment and also solve the disaster problems whether can use across the globe with mitigation sum of the negative impacts of climate change there for whatever will become the main technology for environmental protection in the future.