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Vetiver (*Chrysopogon zizanioides*): A Solution for Soil and Water Restoration in India

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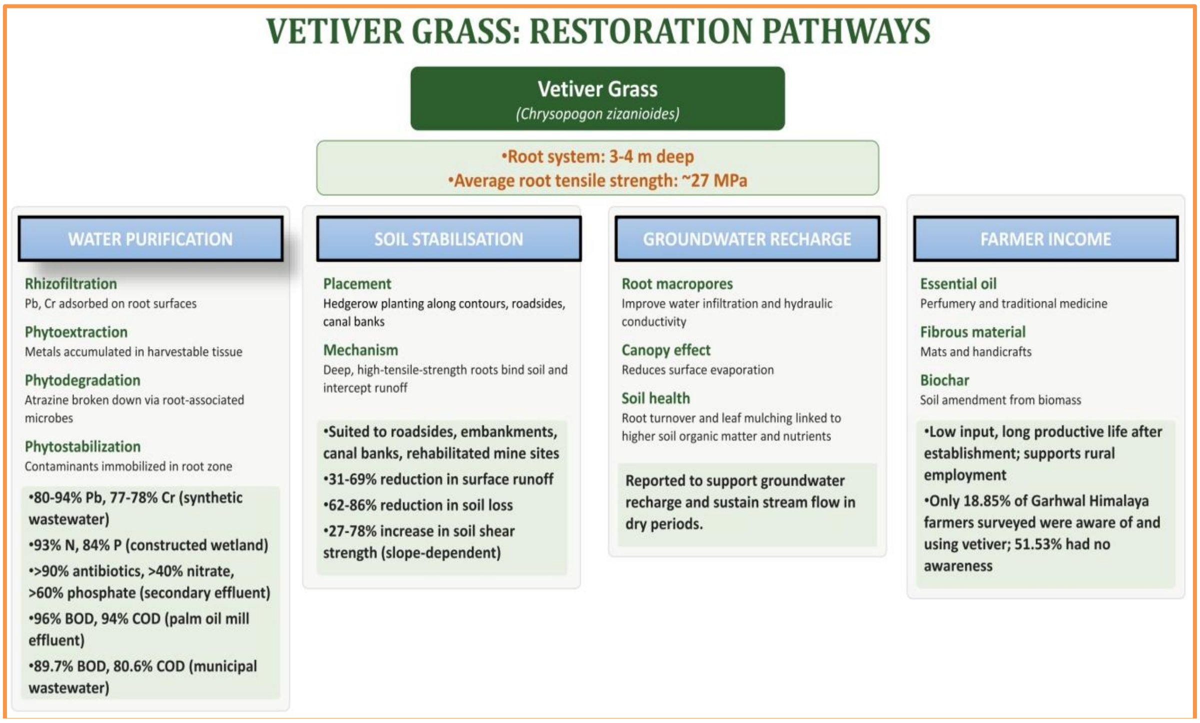
Vetiver is a perennial grass locally known as khus in India. It can thrive at depths of 3–4 m in the soil and contributes to soil stabilization and pollutant filtration from wastewater. It is propagated from cuttings and requires relatively little chemical input or fertilizer, making it a low-cost option for restoring degraded soil and water resources (Dorafshan et al. 2023; Gnansounou et al. 2017). Soil erosion is a significant environmental issue in India. River water is polluted by agricultural and industrial runoff, contributing to declining groundwater levels. Conventional treatment practices require expensive infrastructure and heavy chemical inputs. Vetiver, by contrast, grows readily in saline areas and drought-affected soils with minimal management. Its deep roots stabilize soil, improve water infiltration and remove pollutants, making it an effective low-cost alternative for soil and water restoration in India (Dorafshan et al. 2023; Gnansounou et al. 2017).

How Does Vetiver Clean Water?

Vetiver removes contaminants through four mechanisms. Rhizofiltration adsorbs heavy metals such as lead and chromium onto root surfaces. Phytoextraction accumulates metals in harvestable plant tissue. Phytodegradation relies on root-associated microbes to break down organic pollutants. Phytostabilization immobilizes contaminants in the root zone and limits leaching into groundwater (Dorafshan et al. 2023; Otunola et al. 2023b; Zhang et al. 2023; Das and Pandey 2025; Mohamed et al. 2025). Reported removal efficiencies vary with the type of effluent and experimental design. In a batch study using a floating platform to treat synthetic wastewater, vetiver removed 80–94% of lead and 77–78% of chromium (Singh et al. 2015). In a plug-flow constructed wetland trial treating secondary wastewater effluent, vetiver removed 93% of nitrogen and 84% of phosphorus (Panja et al. 2021). In a separate batch trial on secondary wastewater effluent, vetiver removed more than 90% of spiked antibiotics along with over 40% of nitrate, over 60% of phosphate and over 50% of total organic carbon (Panja et al. 2020). In a floating vetiver system treating palm oil mill secondary effluent, biochemical and chemical oxygen demand fell by 96% and 94%, respectively, over a four-week trial (Darajeh et al. 2016). A controlled trial using real municipal wastewater recorded removal efficiencies of up to 89.7% for BOD and 80.6% for COD at high planting density (Tesfa and Terefe 2025). Vetiver also takes up atrazine from submerged soil and can partially degrade it into less toxic metabolites, although the enhancement over unplanted soil is modest — one incubation study found 69.7% atrazine dissipation in vetiver-planted soil after 30 days, compared with 60.3% in unplanted soil (Zhang et al. 2023). Its capacity to remove heavy metals increases when combined with clay-mineral amendments such as attapulgite or bentonite (Otunola et al. 2023a, 2023b).



Soil Stabilization and Erosion Control

Vetiver roots typically reach a depth of 3 to 4 m (Dorafshan et al. 2023). The tensile strength of individual roots averages approximately 27 MPa and decreases as root diameter increases (Badhon et al. 2021). In plantings on steep slopes, vetiver increased soil shear strength by 27% to 78% relative to unplanted soil, depending on slope angle (Haghighi and Sharifi 2026). Field and flume studies of vetiver hedgerows on sloping land reported reductions in surface runoff of approximately 31% to 69% and reductions in soil loss of approximately 62% to 86% compared with unplanted plots (Donjadee and Tingsanchali 2013). These properties make vetiver effective for stabilizing roadsides, embankments, canal banks and rehabilitated mine sites.

Groundwater Recharge and Soil Health

The deep root network of vetiver improves water infiltration and hydraulic conductivity by creating channels in the soil, while its canopy reduces surface evaporation. Together, these effects contribute to groundwater recharge and help regulate stream flow during dry periods (Gnansounou et al. 2017). Field observations link vetiver plantings to increases in soil organic matter and available nutrients through root turnover and leaf mulching.

Economic Importance

Vetiver is propagated from cuttings and requires minimal management and chemical inputs. Once established, it remains productive for multiple years (Dorafshan et al. 2023). Its roots are used to produce essential oil for the perfumery industry and traditional medicine, and its fibers are used in handicrafts and mat-making after distillation; its biomass can also be converted into biochar for soil amendment. When cultivated at large scale, vetiver generates revenue and supports rural employment (Gnansounou et al. 2017).

Practical Applications of Vetiver

- **Propagation:** Vetiver is propagated by cuttings. This keeps the plant genetically uniform and prevents invasive spread (Gnansounou et al. 2017; Dorafshan et al. 2023).
- **Placement:** Vetiver is planted as contour hedgerows on slopes and along roadsides, embankments, canal banks and reclaimed mine sites (Donjadee and Tingsanchali 2013).
- **Inputs:** Vetiver tolerates poor, saline and drought-prone soils. It needs little fertilizer or irrigation after establishment (Dorafshan et al. 2023).

Table 1. Summary of Vetiver Documented Benefits

Benefit	Reported Outcomes	Citation
Water purification	80 to 94% Pb and 77 to 78% Cr removal from synthetic industrial wastewater. 93% N and 84% P removal from secondary wastewater effluent (plug-flow constructed wetland). 96% BOD and 94% COD reduction from palm oil mill effluent.	Singh et al. 2015; Panja et al. 2021; Darajeh et al. 2016
Organic pollutant degradation	Uptake and partial degradation of atrazine from submerged soil (modest enhancement over unplanted soil). Improved heavy-metal remediation when combined with clay minerals.	Zhang et al. 2023; Otunola et al. 2023a, 2023b
Erosion control	Reduces surface runoff by roughly 31 to 69%. Reduces soil loss by roughly 62 to 86%. Increases soil shear strength by 27 to 78% depending on slope.	Donjadee and Tingsanchali 2013; Haghighi and Sharifi 2026
Root mechanics	Roots reach 3 to 4 m depth. Average root tensile strength is about 27 MPa.	Dorafshan et al. 2023; Badhon et al. 2021
Water recharge	Improves infiltration and hydraulic conductivity. Sustains stream flow in the dry season.	Gnansounou et al. 2017
Farmer adoption (India)	In a 260-respondent survey in the Garhwal Himalaya, only 18.85% of farmers were both aware of and using vetiver, and 51.53% had no awareness of it. The main barriers were lack of technical support (58.85%), limited awareness (51.54%) and restricted access to planting material (45%).	Pandey et al. 2025
Farmer income	Essential oils, handicrafts and biochar. Low input. Long productive life.	Dorafshan et al. 2023; Gnansounou et al. 2017

Conclusion

Vetiver offers a low-cost biological solution to India's land and water problems. It removes pollutants from wastewater, controls erosion on degraded slopes and adds to farmers' income. Its tolerance for saline, drought-prone and nutrient-poor soils makes it well suited to arid and semi-arid regions where wetland-based treatment is not practical. Scaling up this potential in India still faces a real awareness gap: a survey in the Garhwal Himalaya found that fewer than one in five respondents were both aware of and using vetiver, and more than half had never heard of it. The leading barriers were limited technical support and restricted access to planting material. Putting vetiver's proven restoration potential to use in India will depend on extension services, demonstration plots and farmer training as much as on the plant's own agronomic and remediation properties.

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