VETIVER GRASS TECHNOLOGY FOR REHABILITATION OF MINING WASTES AND TAILINGS

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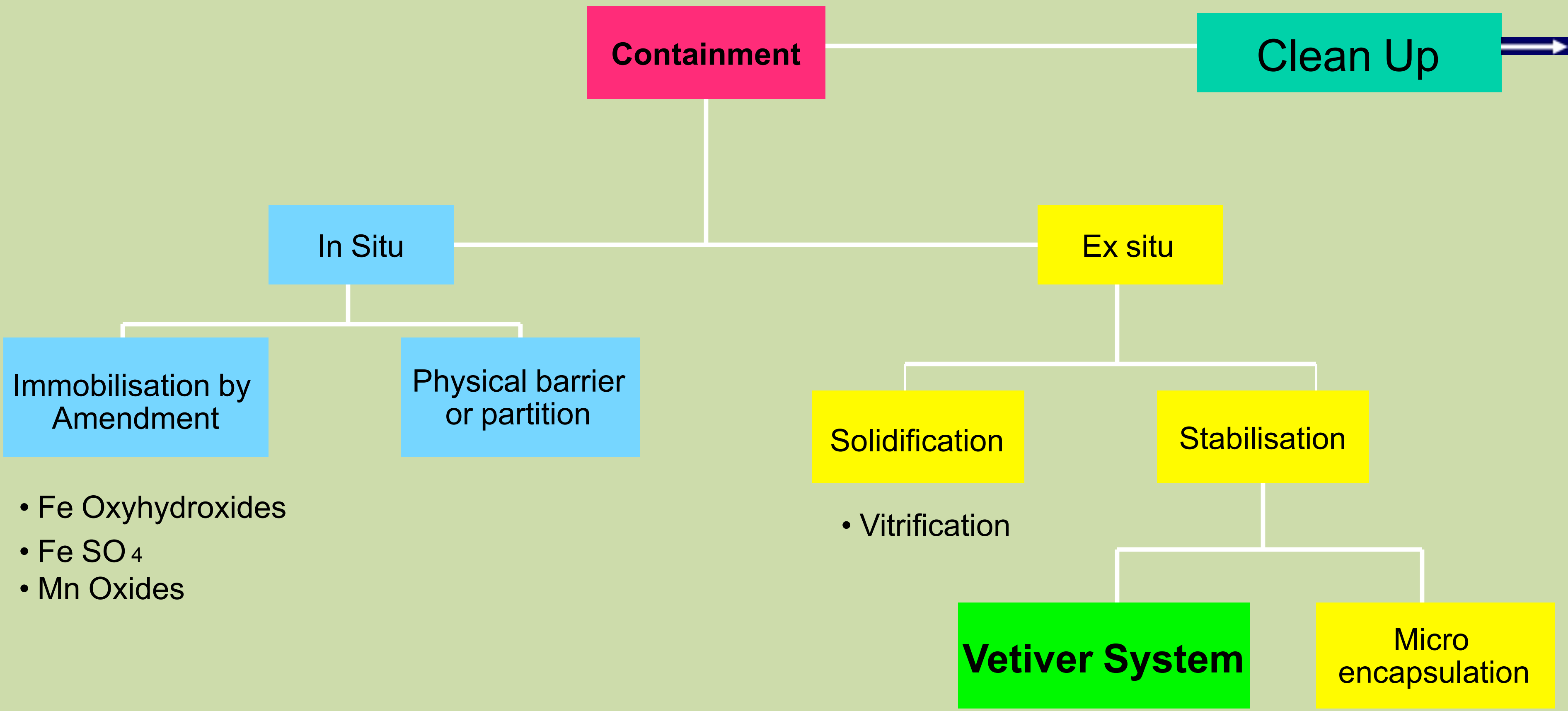
TREATMENT OF CONTAMINATED SITES



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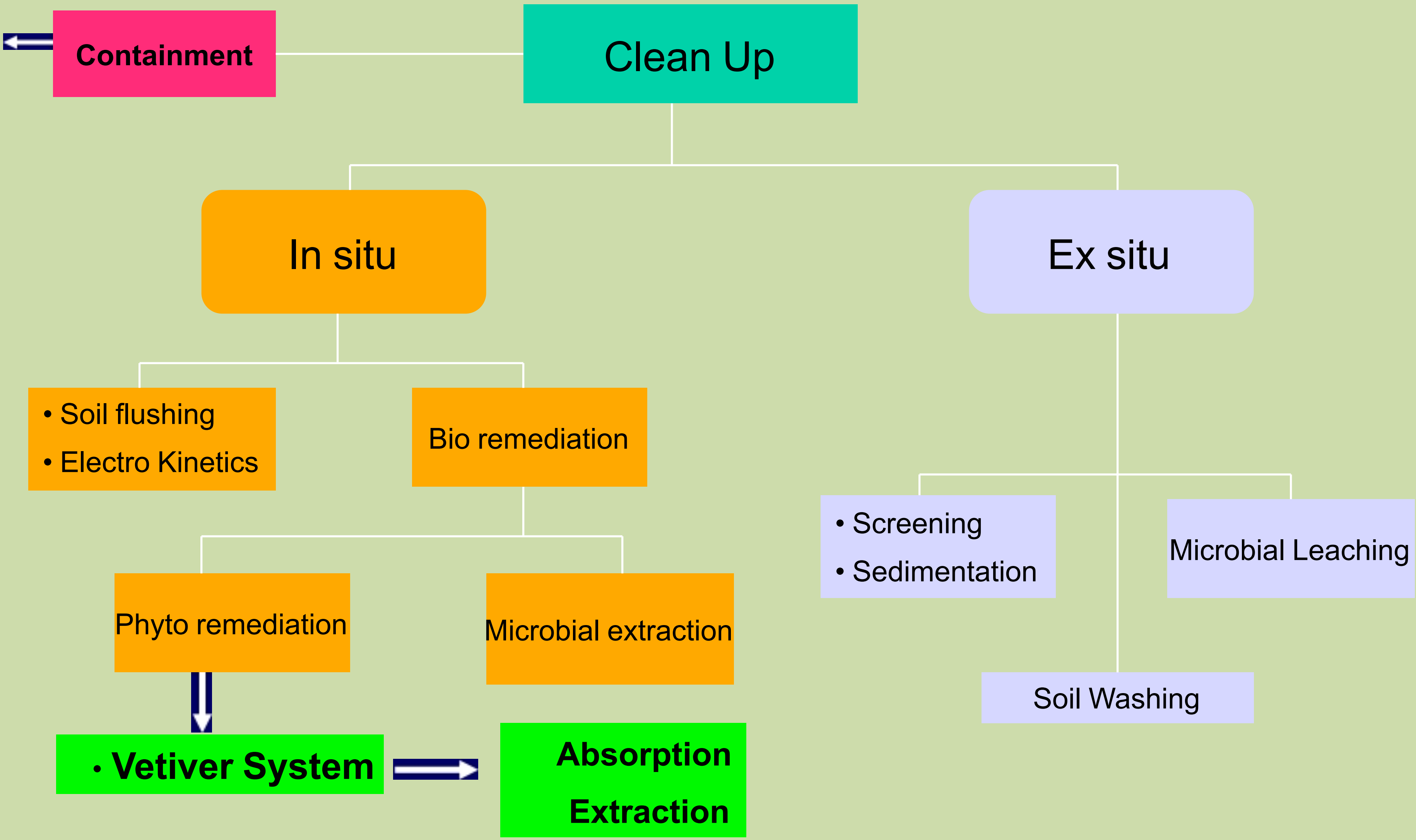


Application of VST in Mining Area

- VST could be used as an integrated technique for environmental management of mining activities.
- Firstly, solid mining wastes such as tailings and waste rocks could be stabilized by vetiver to control or reduce air and water erosion, then reduce the release of heavy metals to surroundings.
- Secondly, wastewater including acid mine drainage (AMD) could be purified by phytofiltration
- Thirdly, the surrounding lands contaminated by heavy metals could be further cleaned up by phytoextraction.
- A progressive worldwide increase in metalliferous mining in recent years opens up a vast range of prospects for IVT application.

Special Characteristics of Vetiver Grass

The following characteristics make vetiver grass highly effective for mining wastes and tailings:

- **A deep, penetrating and extensive root system that binds the soil, and reinforces the soil structure which requires extraordinary force to dislodge.**
- **Erect and stiff stems forming a dense hedge which is very effective in retarding water flow and reducing the erosive power of high velocity overland flows.**
- **Vetiver is tolerant to highly adverse conditions such as saline, sodic and acidic soil conditions.**
- **Vetiver is highly tolerant to elevated levels of heavy metals in mine tailings**
- **Vetiver is tolerant to fire, frost, drought, water logging and inundation**

Stiff and erect stems:

Erect stems up

to 1.8m tall and over 2m with flower head

Forming a thick hedge when planted in row which can spread and slow down runoff water

Special Morphological Features

Even at this young age the stiff **stem** is strong enough to trap large size gravel

Strong current flattened the native grass but not vetiver on this waterway

DEEP, EXTENSIVE AND PENETRATING ROOT SYSTEM

China: One year old with 3.3m deep root system

Vietnam: Agriculture & Forestry University, Saigon

Special Morphological Features

Strong root reinforcement holding up this wall of soil against water erosion

Solid wall reinforced by vetiver roots

Submergence and drought tolerance

Tests conducted in China found that when completely submerged, vetiver survived for 54 days.

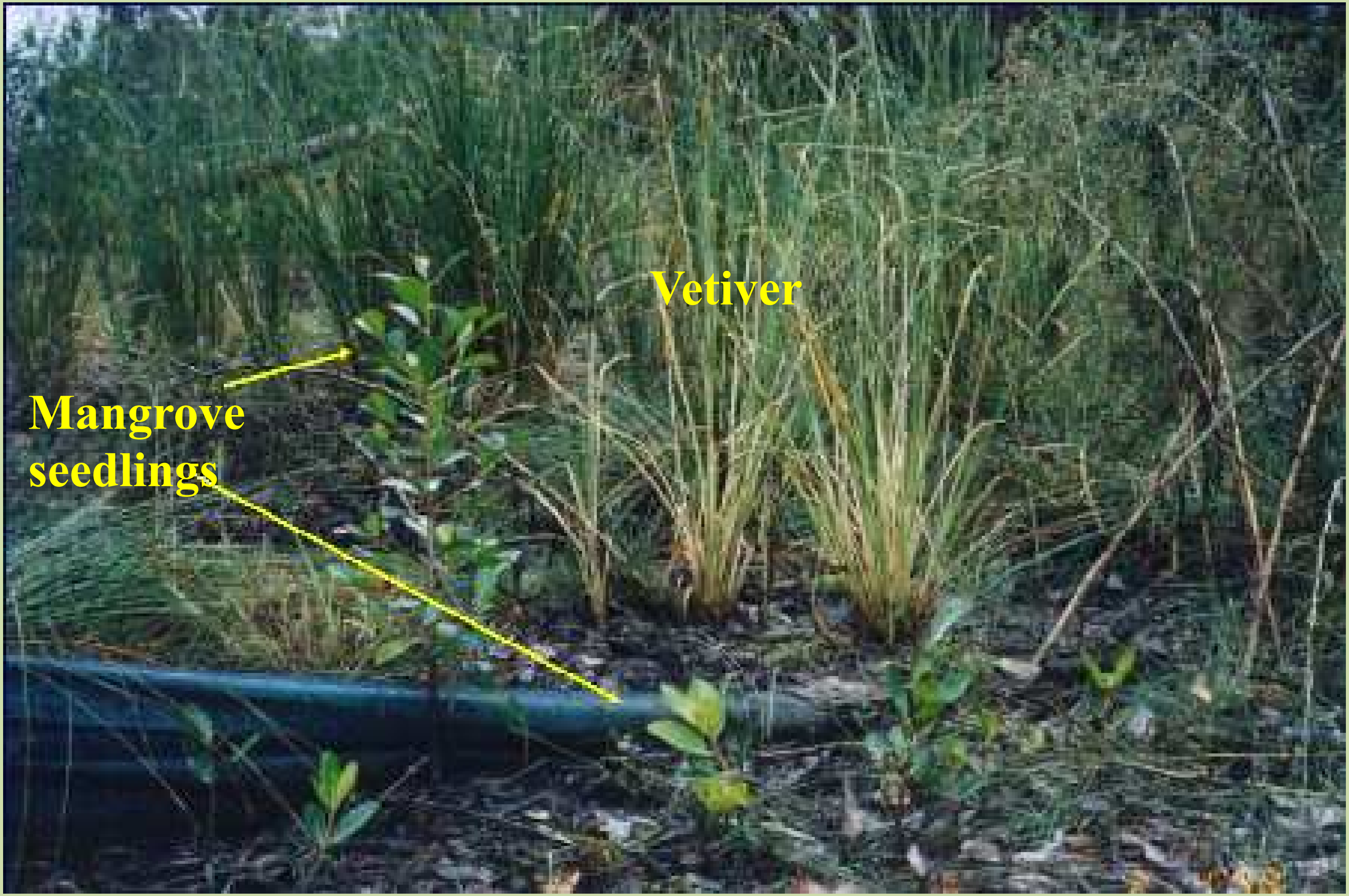
Vetiver remained green but all native grasses were brown off under semi arid conditions in western Queensland .

Tolerance to high soil and water salinity

Saline threshold level is at EC e =8 dsm -1 , 50% growth reduction at 17.5 dsm -1 . Salt level of sea water is about 45-50 dsm -1 and vetiver can survive at 47.5 dsm -1 under dry land salinity conditions

Physiological Features

One year after planting, vetiver growing among mangrove seedlings



Salt tolerance level of Vetiver grass as compared with some crop and pasture species grown in Australia.

Plant Species	Soil EC_{se} (dSm^{-1})	
	Saline Threshold	50% Yield Reduction
BermudaGrass*(Cynodondactylon)*	6.9	14.7
RhodesGrass(C.V.Pioneer)*(Chloris guyana)*	7.0	22.5
TallWheatGrass*(Thynopyronelongatum)*	7.5	19.4
Cotton*(Gossypiumhirsutum)*	7.7	17.3
Barley*(Hordeumvulgare)*	8.0	18.0
Vetiver*(Vetiveriazizanioides)*	8.0	18.0

Tolerance to high soil acidity

Vetiver thrives at soil pH=3.8 and Al saturation percentage of 68%and 87% under field conditions

pH	2.0	2.2	3.8	4.4	4.8	5.5	7.3	7.6
Al%	90	90	68	36	11	2	trace	trace

Highly erodible acid sulfate soil (pH 3.0) in coastal Australia

One year after planting

Threshold levels of heavy metals to vetiver growth as compared with other species

Heavy Metals	Threshold levels in soil (mgKg -1)		Threshold levels in plant (mgKg -1)	
	Vetiver	Other plants	Vetiver	Other plants
Arsenic	100-250	2.0	21-72	1-10
Cadmium	20-60	1.5	45-48	5-20
Copper	50-10	Not available	13-15	15
Chromium	200-600	Not available	5-18	0.02-0.20
Lead	>1 500	Not available	>78	Not available
Mercury	>6	Not available	>0.12	Not available
Nickel	100	7-10	347	10-30
Selenium	>74	2-14	>11	Not available
Zinc	>750	Not available	880	Not available

CASE STUDY 1: Fresh coal mine overburden

Highly erodible alkaline and sodic overburden of open cut coal mine in central Queensland

Vetiver planted on contour line to conserve soil moisture and stabilising loose surface materials

Eighteen months after planting

Nine years after planting, note the return of native trees

CASE STUDY 2: Old coal mine overburden

CASE STUDY 3: Coal mine tailings

The tailings was saline, highly sodic, high levels of soluble S, Mg.Ca, Cu, Zn and Fe but extremely low in N and P.

Five salt tolerant species were used: vetiver, marine couch (*Sporobolus virginicus*), common reed grass (*Phragmites australis*), cumbungi (*Typha domingensis,*) and *Sarcocornia spp.*

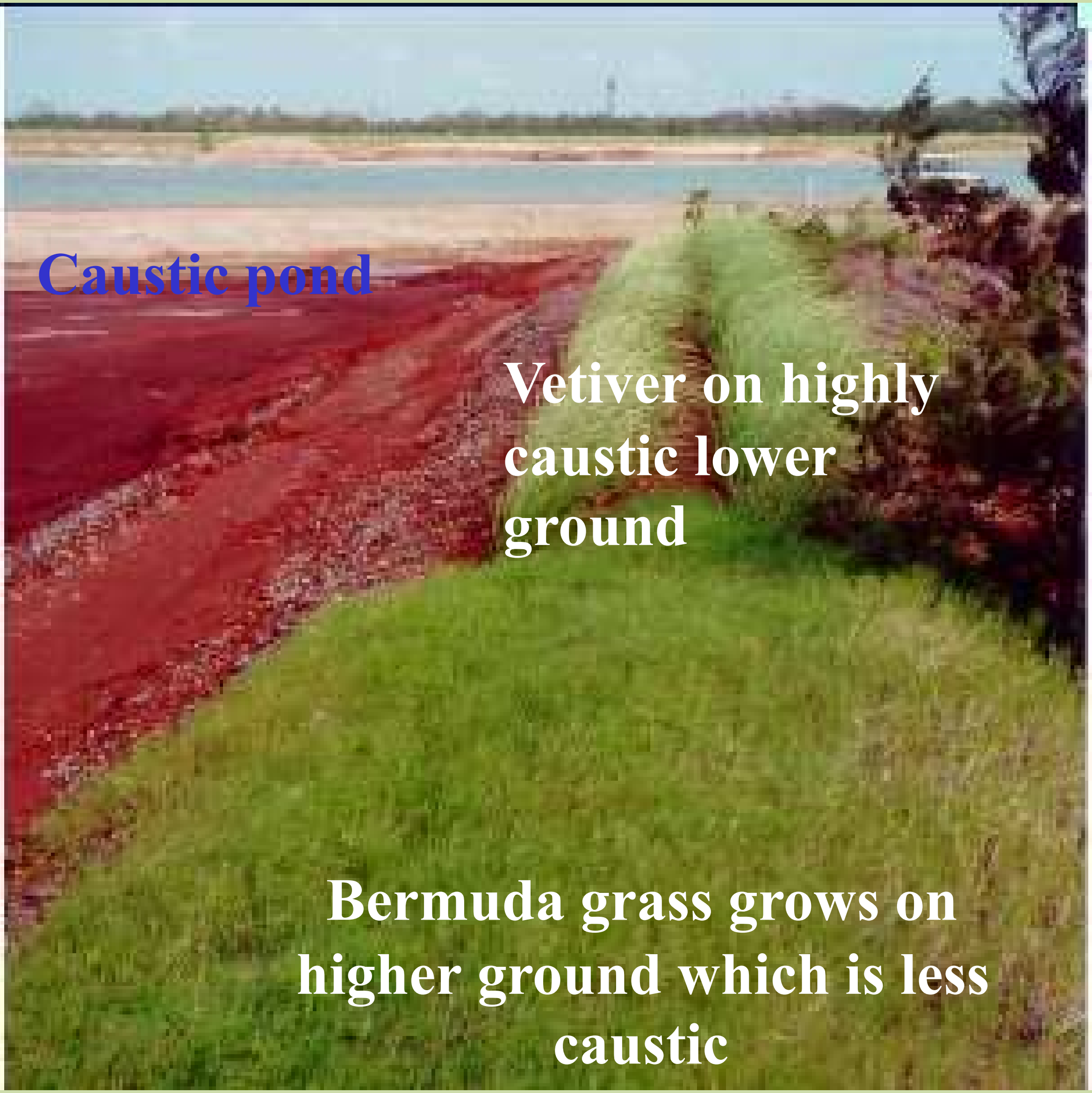
Complete mortality was recorded after 210 days for all species except vetiver and marine couch. Vetiver's survival was significantly increased by mulching but fertiliser application by itself had no effect.

CASE STUDY 4: Bauxite Redmud tailings

Old Redmud

Three week after planting with only N and P fertilizers

Fresh Residue Sands: Alcan Alumina processing at Gove, Australia



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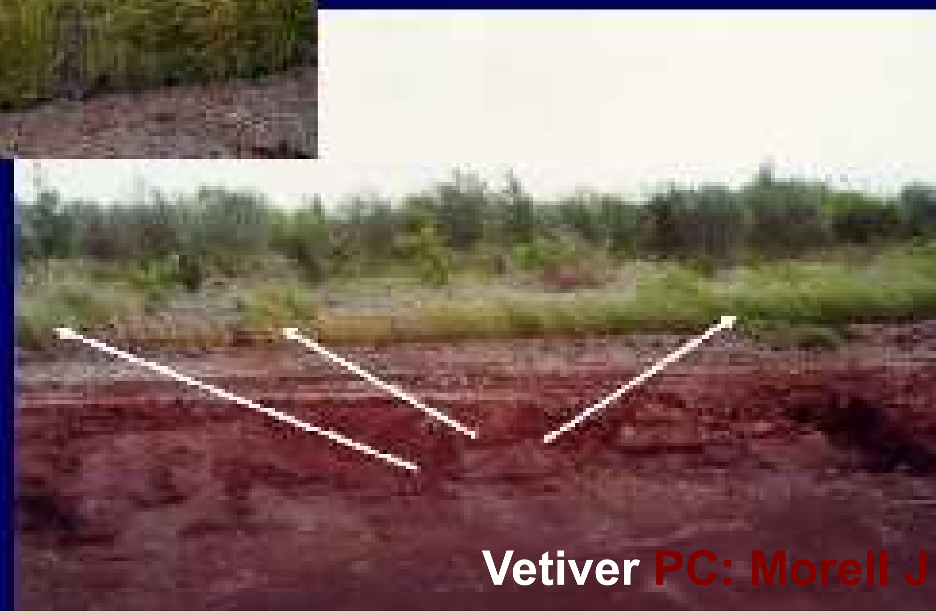
Another by product of Alumina processing is residue sand, which is almost as caustic as red mud

Old Residue Sands : Alcan Alumina processing at Gove, Australia

New planting on highly caustic old residue sand

Vetiver grew well on residue sand except in some extremely caustic area



CASE STUDY 5: Bentonite mine waste dump

This Bentonite mine tailings dump is barren with an extremely erodible surface which has low water infiltration and high runoff rates.

Fourteen months after planting, note the growth of other species

Chemical analyses of the Bentonite tailings

Analyses	Overburden	Bentonite tailings
pH	5.4	5.4
EC (mS/cm)	0.18	0.14
Cl (mg/kg)	135.0	47.4
NO3-N (mg/kg)	1.9	0.7
P (mg/kg)	2.0	5.0
SO4-S (mg/kg)	66.0	101.0
Ca (meq/100g)	0.19	0.93
Mg (meq/100g)	4.75	6.44
Na (meq/100g)	2.7	7.19
K (meq/100g)	0.16	0.43
Organic Matter (%)	0.45	0.35
ECEC (meq/100g)	8	15
Exchangeable Sodium %	**35**	**48**

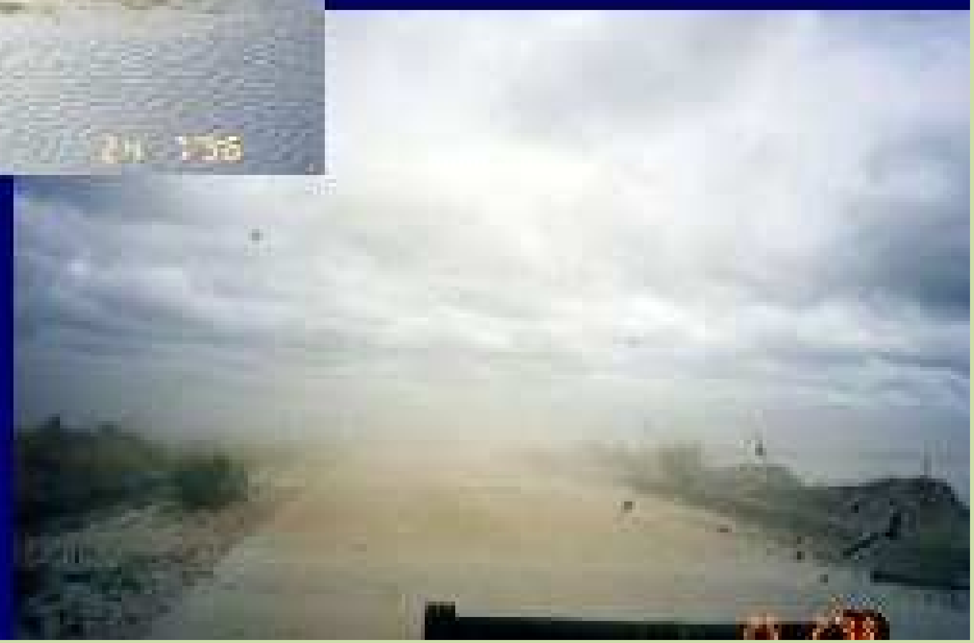
CASE STUDY 6: Old gold tailings dump

Kidston mine old gold tailings : An extremely acidic (pH 2.7, sulfate 8 500mg/kg) gold mine tailings in north Queensland

Good establishment and growth with lime and fertiliser application on this site

CASE STUDY 7: Fresh gold tailings dump

Kidston mine large fresh tailings pond, typical of a big gold mine



Strong wind causes dust storm, which is is highly contaminated with heavy metals such as Arsenic, Copper etc

Conventional measure is to plant a surface cover crop and to build fences to control wind erosion promoting crop establishment

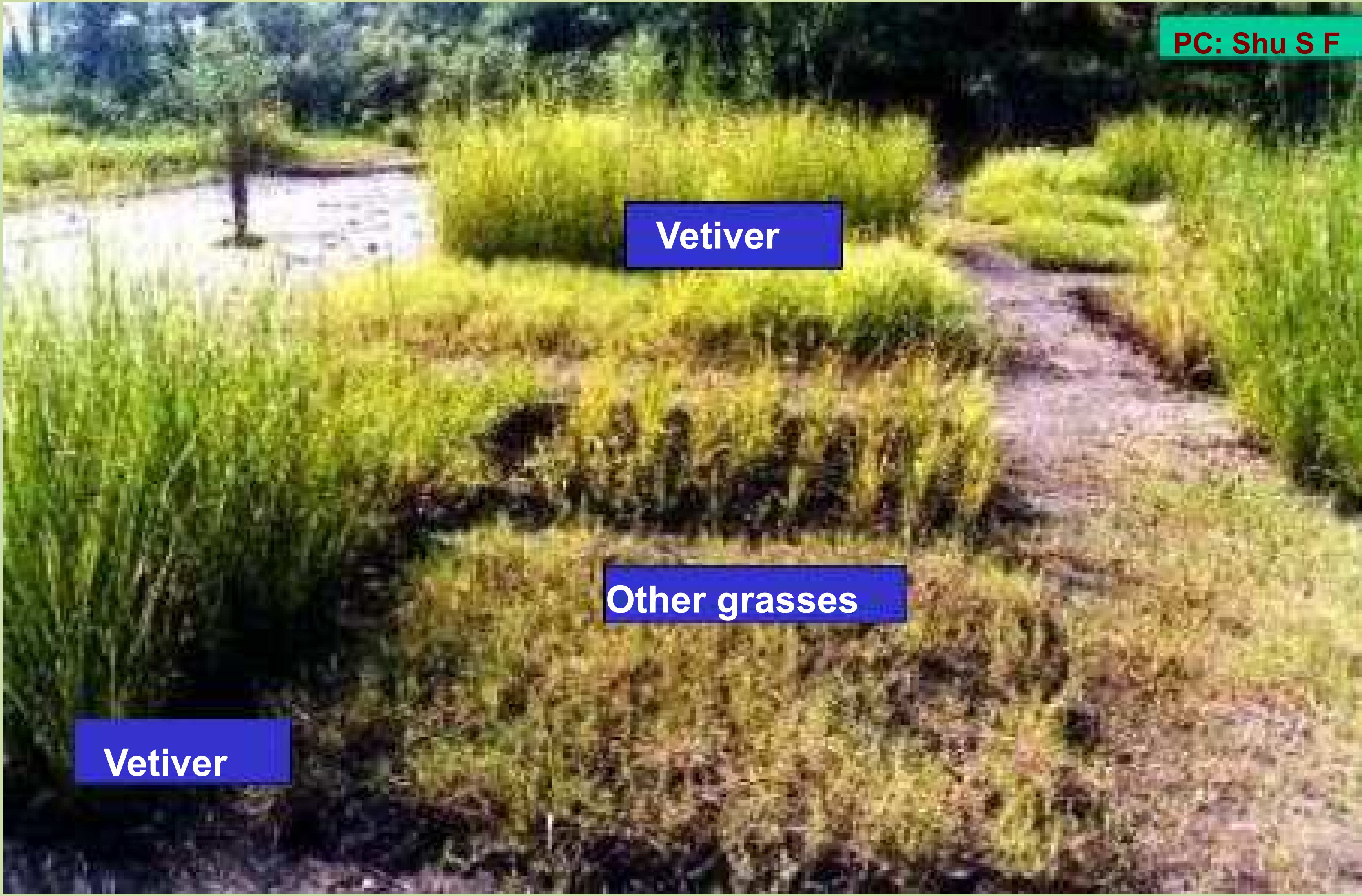
Despite its very Solid construction, these rigid and expensive fences are also vulnerable to high wind velocity

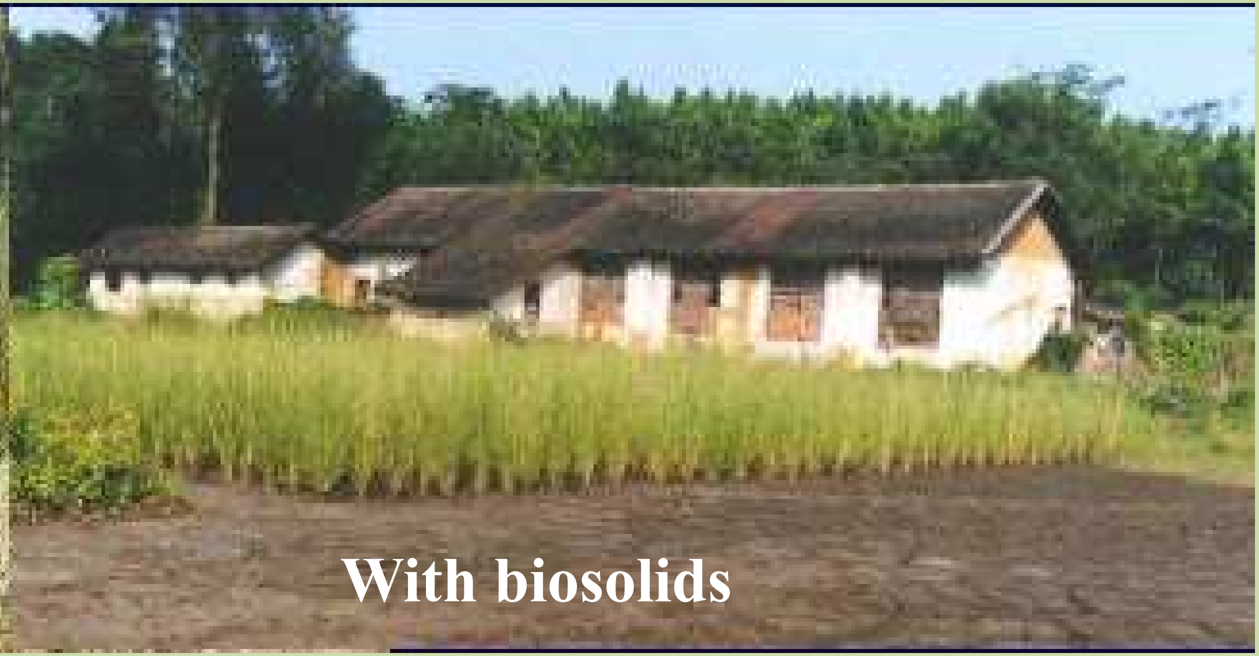
The flexible Vetiver hedges provided a low cost and permanent wind barrier unaffected by strong winds, providing excellent protection for crop establishment (2 years after planting)

Ten years after planting, no fertilizers and occasional grazing

Ten years after planting, no fertilizers and heavy grazing

CASE STUDY 8: Pb – Zn tailings rehabilitation in China





With biosolids

Research: Vetiver had the highest tolerance and accumulated the lowest concentrations of heavy metals in shoot.

Application: The land around the smelting factory was severely contaminated by heavy metals. Many efforts were failed but Vetiver was well established after 5-months

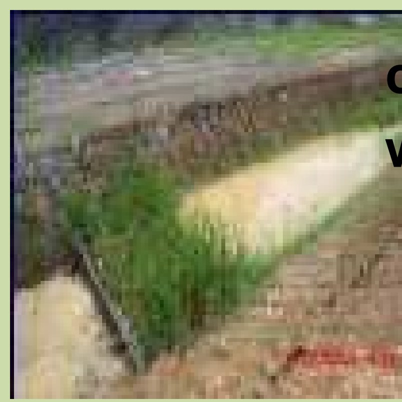
CASE STUDY 9: Coal mines in South Kalimantan, Indonesia



PC: D Booth





VST was successfully used for:

***Rehabilitation of mine tailings slopes**

***Stabilizations banks of channels of waste water disposal ditches.**

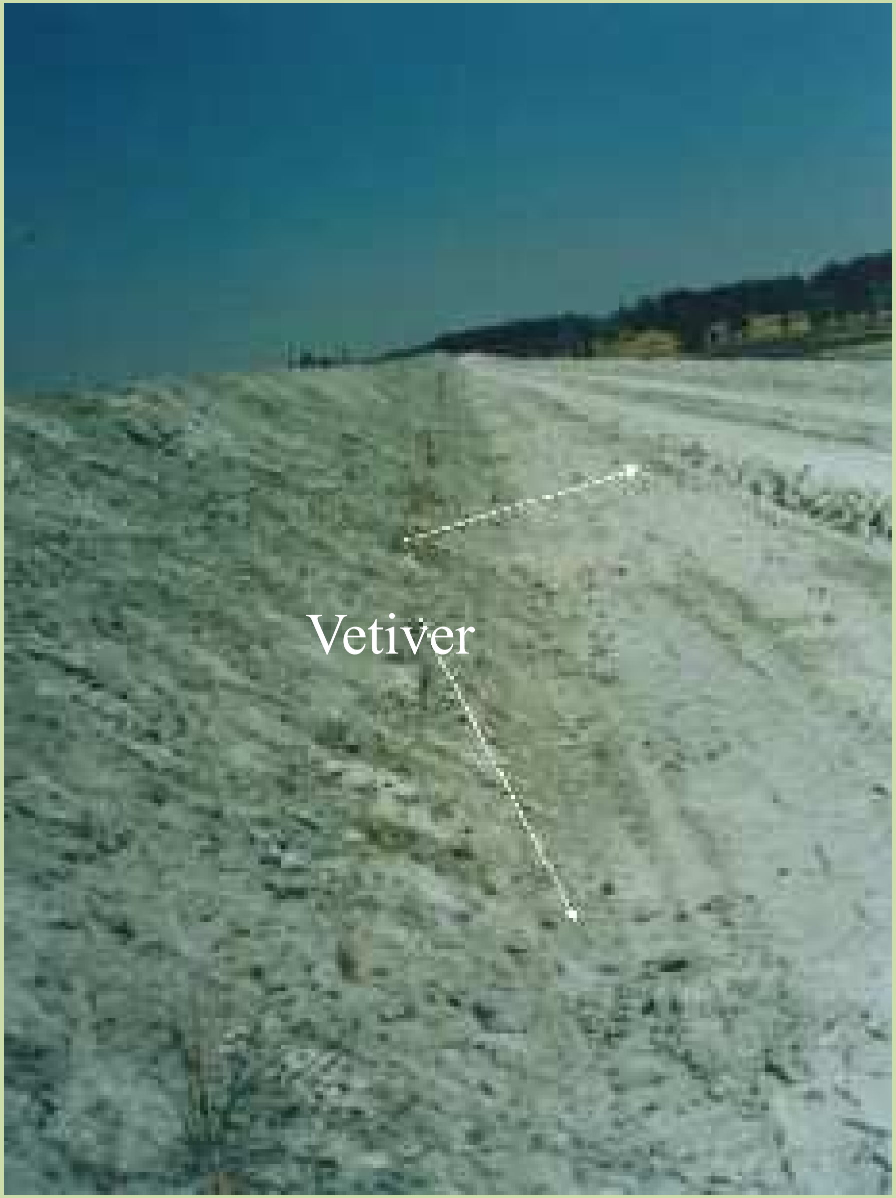
CASE STUDY 10: Gold mines in North Sulawesi, Indonesia

PC: D Booth

VST application at PT Meares Soputan Mining, Toka Tindung gold mine site

CASE STUDY 11: Iron ore mine in Weat Bengal, India

CASE STUDY 12: Gold mine tailings dam in South Africa



Same tailings dam wall, 3 year later

The Rio Tinto- Simandou, Guinea

Anglo America Ashanti Gold Mine in Guinea, West Africa.

Vetiver grass slips planted in contour furrows and hydromulched at Anglo Ashanti Gold, Ghana

Ambatovy Project, Moramanga to Tamatave, Madagascar

- Length of rows: 220 km
- Area rehabilitated: 550ha
- Rehabilitation period: 3 years
- Vetiver plants & fascines sourced from local communities

Xstrata Chromium Mine, Rustenburg, South Africa

Vetiver planted in rows 1 meter apart at intervals of 250mm. Areas between rows of Vetiver scarified and hydroseeded with native grass species

Vetiver turned brown due to winter frost, will regrow in spring

CASE STUDY 13: Open cut Bauxite Mining at Los Pijiguaos, Venezuela (pH 4-5; Rainfall 2 400-2 900mm/y)


Fill slope


Cut slope


Drainage channel


Dam wall

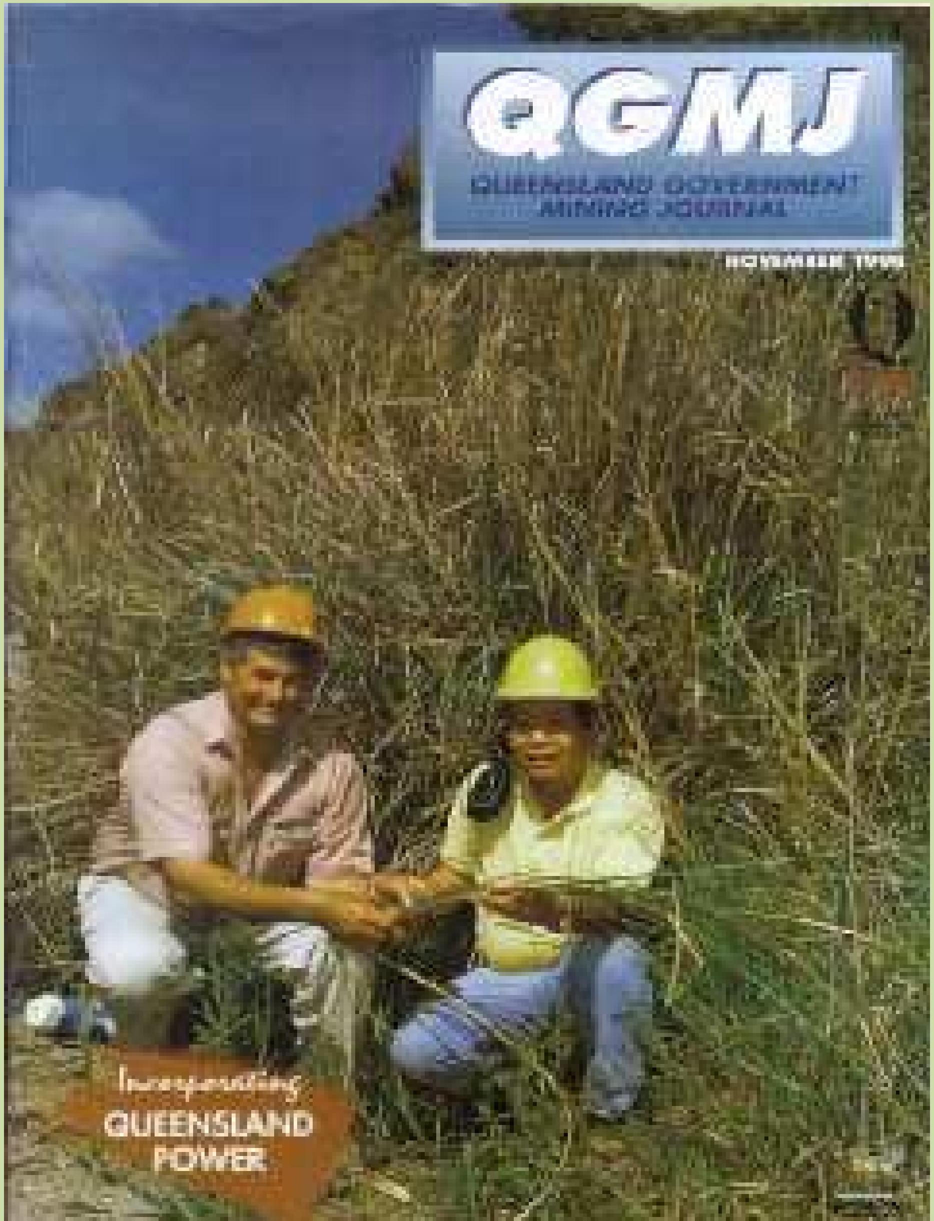
SUMMARY

The Advantages of Using the Vetiver System for Mine Rehabilitation

1. Containment: Erosion and sediment control of waste rock dump and infrastructure

2. Clean Up: Control/reducing the contaminated materials from spreading to the environment by phytoremediation

3. VST is natural: no secondary by-products are produced and can be grazed by livestock.



Queensland Government Mining Journal

Queensland is one of the largest mining states of Australia, its Department of Mineral and Energy recommended VST for mine and quarry rehabilitation in the state.