Vetiver System for Industrial Wastewater Disposal and Mining Waste Rehabilitation in Australia.

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Introduction

GELITA

• GELITA factory produces gelatine from cattle hides at Beaudesert in Queensland, Australia.

• This factory is situated on a property of 170 hectares, generates approximately 1.3 ML a day of wastewater, which is characteristically high in nitrogen and total dissolved salts.

TEYS Bros

•TEYS Bros operates a cattle abattoir in Beenleigh, Queensland, which processes 210 000 cattle per year for both domestic consumption and export.

• This factory is situated on a property of 65 hectares, generates approximately 1.5 ML a day of wastewater, which is characteristically high in nitrogen and phosphorus.

Current Practices

GELITA

- The GELITA factory extracts gelatine from cattle hide using chemical processes involving strong acids, lime and hydroxides.
- The effluent from the processing plant is highly saline (average 600mS/m), alkaline and high in N (300 mg/L) and low in P (2 mg/L).
- The effluent is disposed off by irrigating over 121 hectares of Kikuyu and Rhodes grasses pasture.

TEYS Bros

- Teys Bros abattoir produces 550 ML of effluent a year, which is high in N (170mg/L and P (31mg/L).
- This effluent is irrigated over 42.3ha of land by either spray or surface irrigation onto Kikuyu pasture.

A typical effluent storage pond at GELITA, Beaudesert

Rhodes grass pasture at GELITA, Beaudesert

Traveling irrigation system at GELITA, Beaudesert

Kikuyu grass pasture at TEYS Bros. Beenleigh

Constraints

The Queensland government has applied strict regulations regarding the disposal of this wastewater. In order to meet these regulatory requirements and to fulfil expectations of the Ecologically Sustainable Development, both companies have undertaken a comprehensive research program to develop optimal disposal methodologies.

GELITA

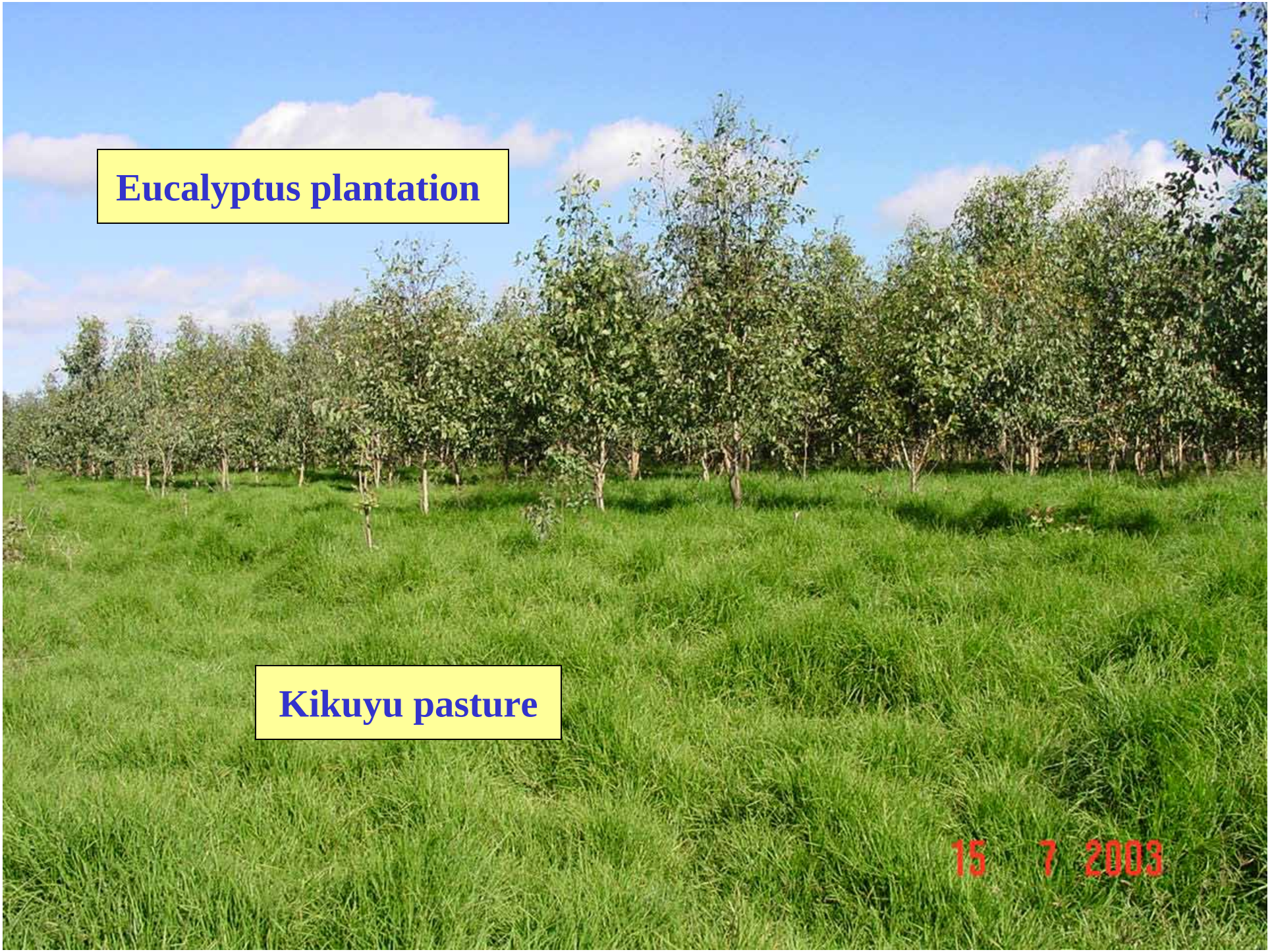
Due to extreme climatic variations over the seven years of operation the planting of pasture and annual crops has not provided a viable operational methodology.

TEYS Bros

- **Under the current practice, out of the total effluent output of 550ML/year, only 204ML/year could be disposed off sustainably. This would leave a surplus effluent volume of 346ML/year to be treated by other means.**

Options and Solutions

- Alternative solutions such as chemical treatment plant and transportation to sewage treatment plant were considered but both of which are impractical and most importantly very costly to build and to operate.
- Tree planting was one of the earlier options considered, it has been trialed for several years but has not provided an effective solution to the problems faced by the company.
- Application of the Vetiver System for wastewater treatment is a new and innovative phytoremedial technology and VS was identified as having the potential to meet all the criteria.
- The vetiver option using MEDLI as a model offers a practicable and cost effective solution.


Eucalyptus plantation
Kikuyu pasture
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The MEDLI Computer model

- Under Queensland law, the treatment of industrial wastewater is administered by the EPA, which has adopted a computer model - MEDLI (Model for Effluent Disposal using Land Irrigation), as a basic tool for industrial wastewater management.
- MEDLI is a Windows based computer model for designing and analysing effluent disposal systems, which use land irrigation, for a wide range of industries such as piggeries, feedlots, abattoirs, sewage treatment plants, and food processing factories.
- However, to date MEDLI has only been calibrated for temperate and subtropical pasture species, not vetiver
- Therefore vetiver has to be calibrated before it can be used in MEDLI, and accepted by EPA.

Calibration of Vetiver for the MEDLI model

- The calibration program was conducted over a period of 2 years to account for both summer and winter growth
- Experimentations were carried out in glasshouse and field trials.

Vetiver growth increased with N application up to 6t/ha/year, higher rates did not affect yield

Vetiver growth increased with P application up to 250/ha/year, higher rates did not affect yield

Recovery rates of N and P by vetiver grass.

Treatment	%Recovery by Shoot	%Recovery by Root	% Recovered in Soil	Total
N2 (t/ha)	76.3	20.4	0.3	97
N4 (t/ha)	72.1	23.1	0.1	95
N6 (t/ha)	67.3	21.2	0.4	89
N8 (t/ha)	56.1	30.0	0.4	87
N10 (t/ha)	46.7	17.0	0.1	64
P250 (kg/ha)	30.5	23.3	46.3	100
P500 (kg/ha)	20.5	14.6	48.7	84
P1000 (kg/ha)	16.5	14.2	40.8	72

Field trial site at GELITA, Beaudesert

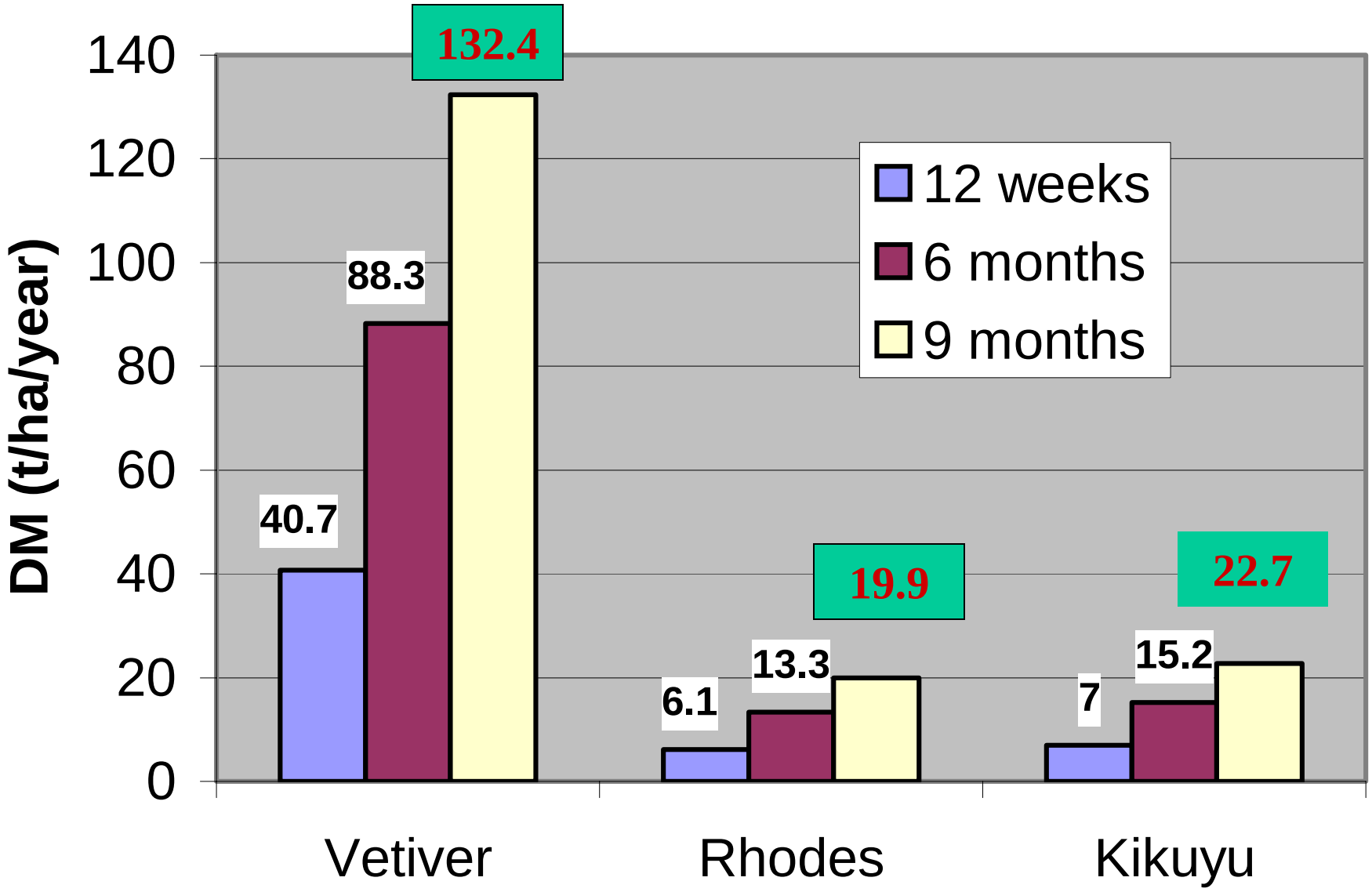
Monitoring weekly Radiation Efficiency Index

Monitoring weekly Leaf Area Index

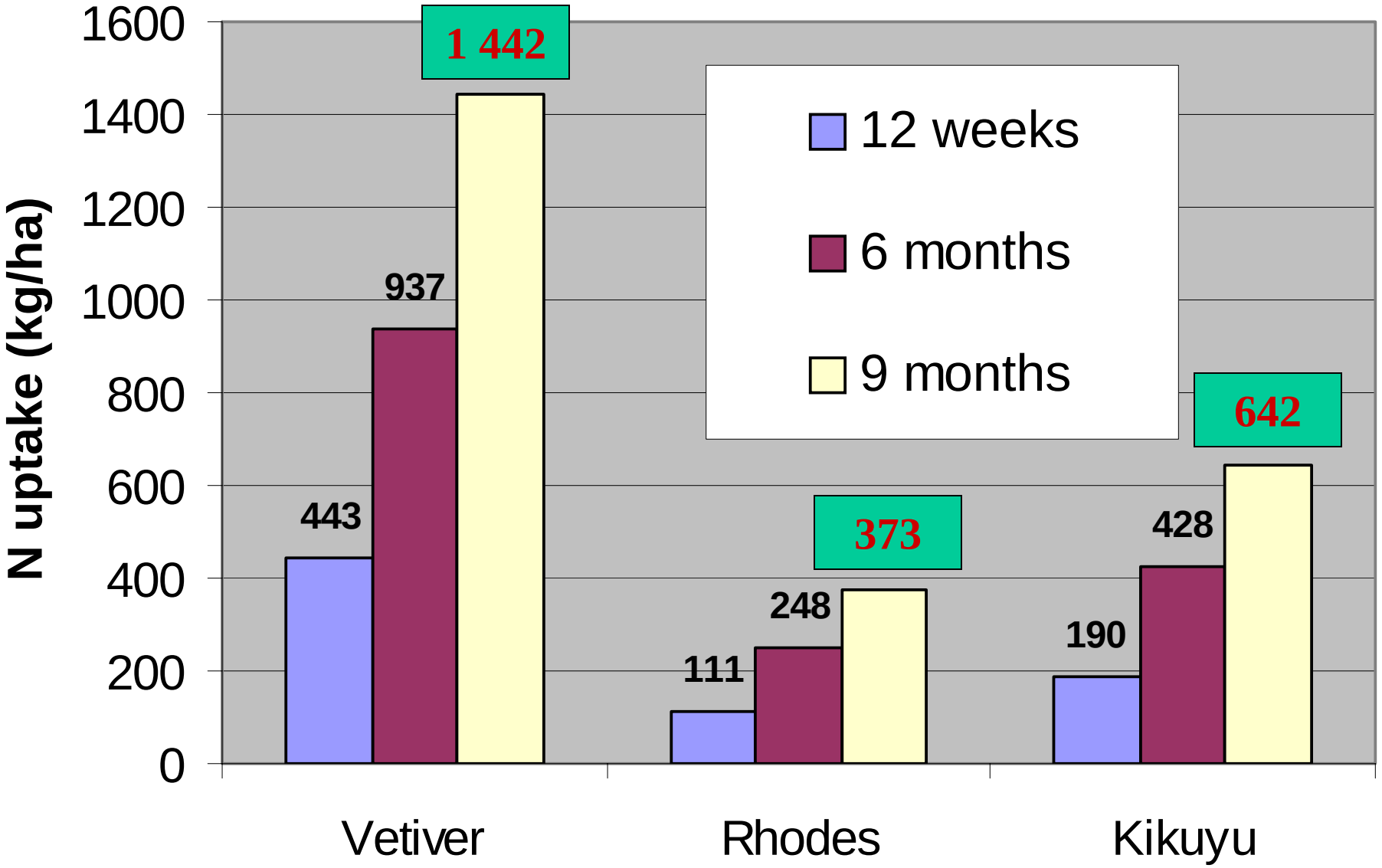
Excellent growth, up to 2m in 18 months at Gelita, Beaudesert

Excellent growth, over 2m in 12 months at Teys Bros. Beenleigh

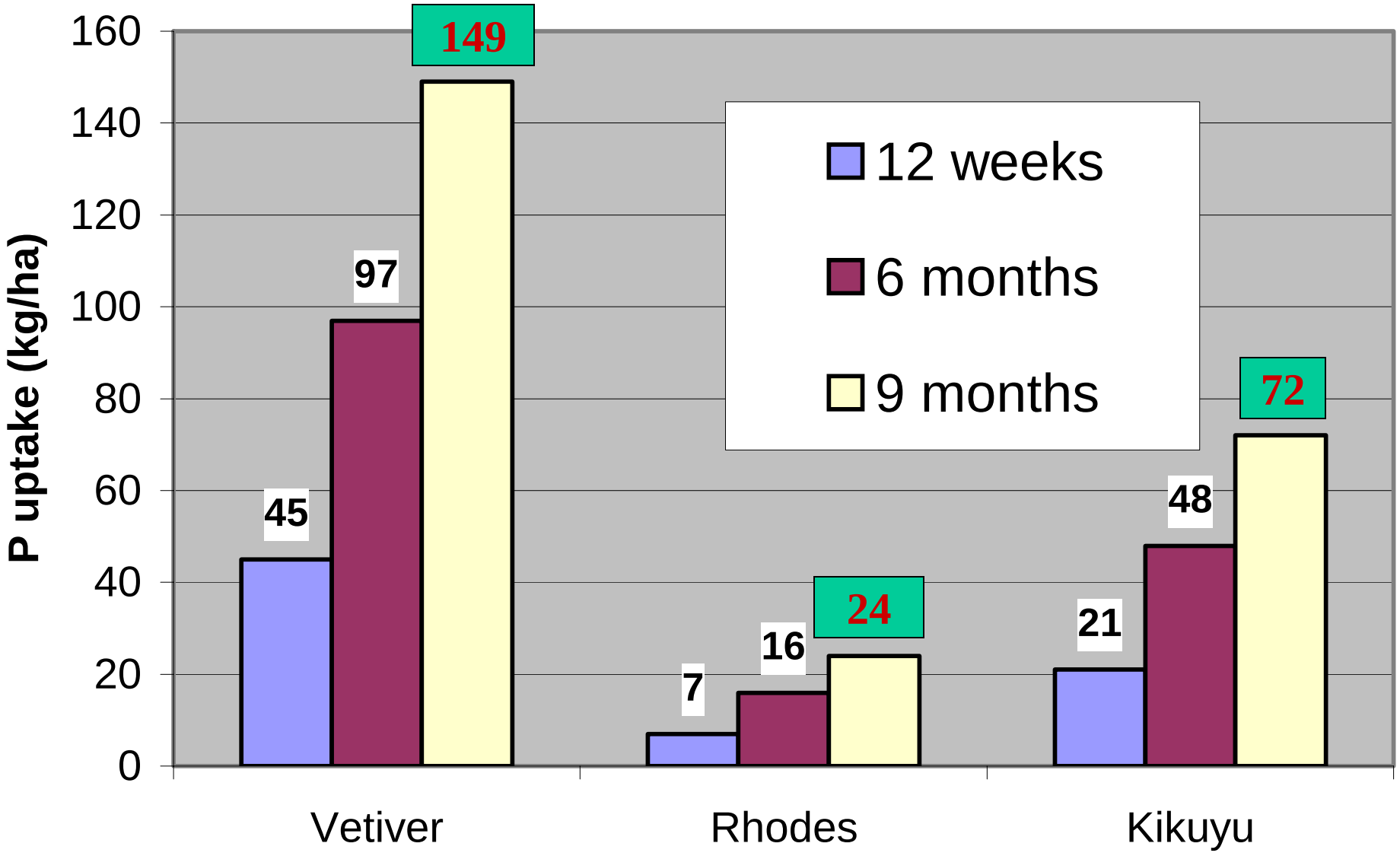
Comparative yield between vetiver, Rhodes grass and Kikuyu grass



Comparative N uptake between vetiver, Rhodes grass and Kikuyu grass



Comparative P uptake between vetiver, Rhodes grass and Kikuyu grass



Results of seepage monitoring

Effectiveness of vetiver planting on quality of effluent seepage

Analytes	Nutrient levels		
	Inlet	Mean levels in monitoring bores	
		20m down slope from inlet	50m down slope from inlet
pH	8.0	6.5	6.3
EC (uS/cm)	2200	1500	1600
Total Kjel. N (mg/L)	170	11.0	10.0
Total N (mg/L)	170	17.5	10.6
Total P (mg/L)	32	3.4	1.5

Results of MEDLI Simulation

GELITA
ASIA PACIFIC AFRICA

Land area required for irrigation and N disposal

Plants	Land needed for irrigation (ha)	Land needed for N disposal (ha)
Vetiver	80	70
Kikuyu	114	83
Rhodes	130	130

Results of MEDLI Simulation

Effluent Volume for Sustainable Disposal

Plants	Effluent volume for irrigation (ML/day)	Effluent volume for irrigation (ML/year)
Vetiver	1.24	452
Kikuyu	0.8	292
Improvement of vetiver over Kikuyu grass		55%

Mining Waste Rehabilitatio

- Coal mine
- Gold mine
- Bentonite mine
- Alumina refinery
- Lead and Zinc

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

Coal Mine: Highly acidic, 30 year old coal mine overburden

Australian Minesite examples

One year after planting

Gold Mine: Highly acidic gold mine tailings

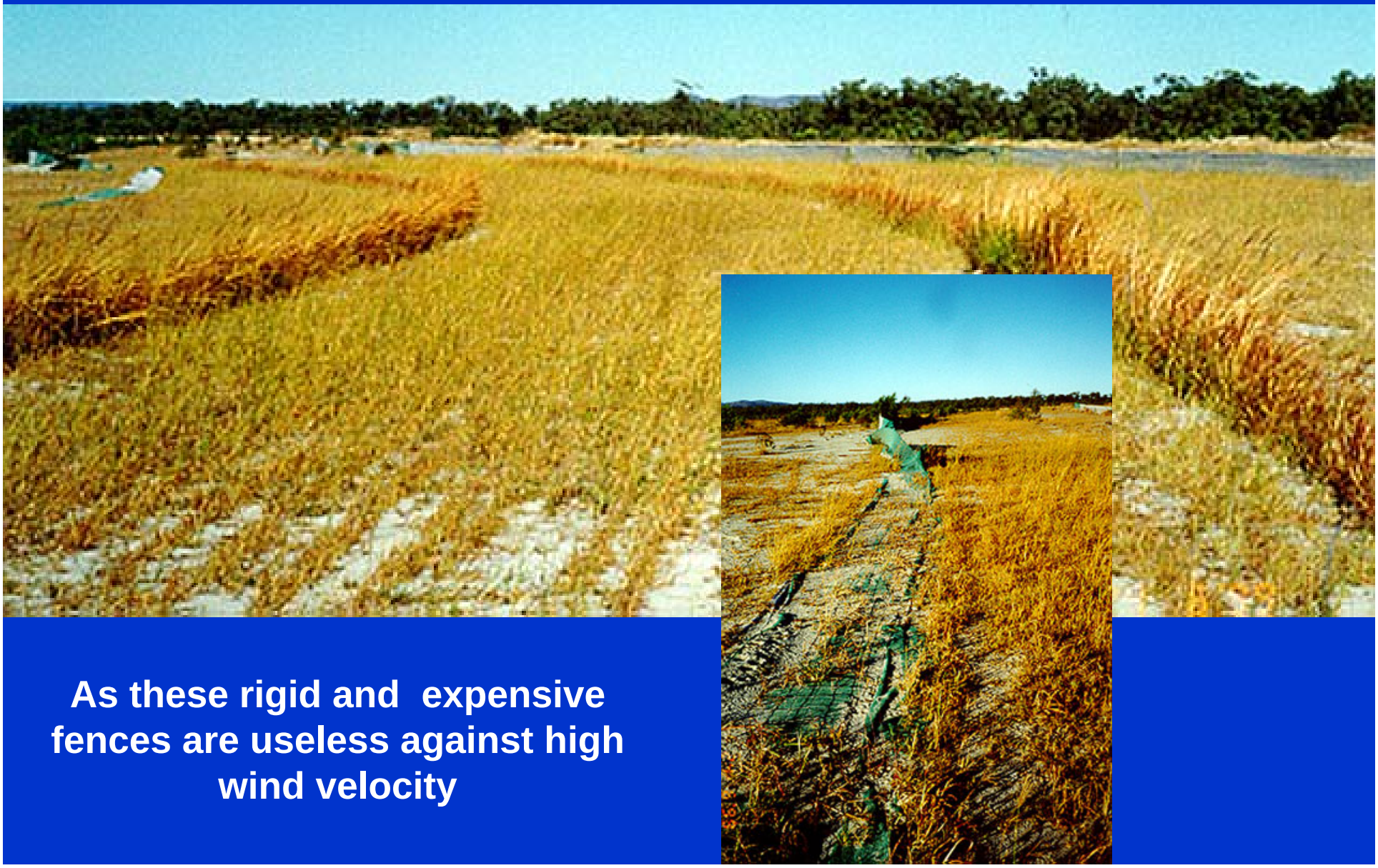
Australian Minesite examples

Good establishment and growth with lime and fertiliser application

Dust storm on a fresh gold tailings dam

Vetiver planting promotes establishment of perennial grass by reducing wind velocity at ground level

Australian Minesite examples

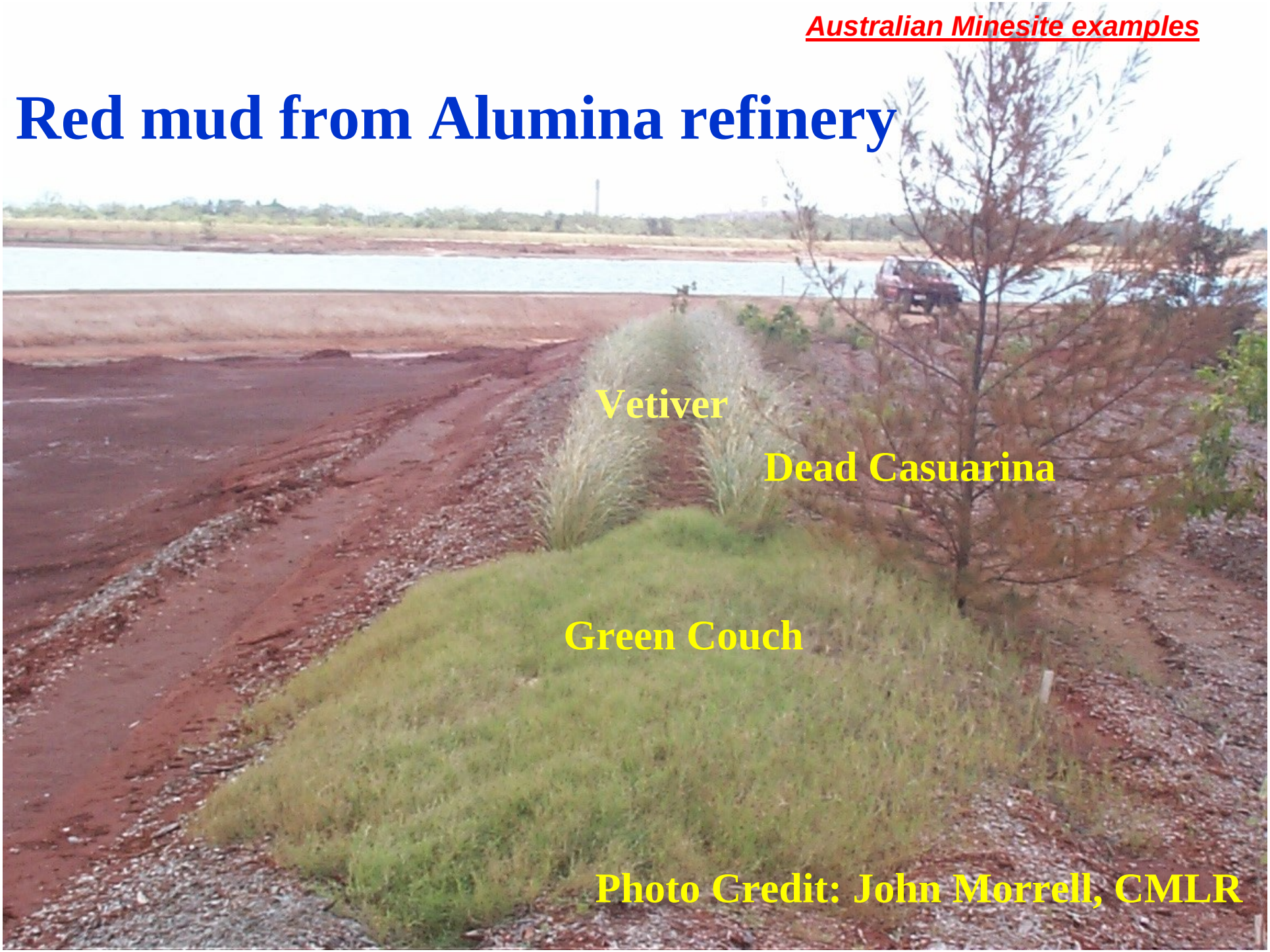


As these rigid and expensive fences are useless against high wind velocity

Bentonite tailings **The tailings surface is barren and extremely vulnerable to wind and water erosion**

Fourteen months after planting, note the growth of other species

Red mud from Alumina refinery



China P & Zn Mine: Excellent growth on tailings of a Pb and Zn mine with landfill compost and fertilisers

China: Vetiver had the best growth on tailings of a Pb and Zn mine (with N,P and K fertilisers)

***South Africa*: A gold slime dam (pH 3.2) in the Free State Province**

***South Africa*:**
Three month old vetiver on a gold slime dam (pH 3.2) in the Free State Province

***South Africa*: Three years after planting this slime dam near Durban was well stabilised by vetiver**


Thank You
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