VETIVER SYSTEM TECHNOLOGY FOR PREVENTION AND TREATMENT OF POLLUTED WATER AND CONTAMINATED LAND

Paul Truong
TVNI Technical Director
Director for Asia and Oceania,
Brisbane, Australia
p.truong@veticon.com.au
paultruong@vetiver.org
www.vetiver.org

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INTRODUCTION

- **The Vetiver System (VS) is was first developed by the World Bank for soil and water conservation and now being used in over 100 countries for various applications.**

- **R&D conducted in several countries showed that vetiver grass is tolerant to the most adverse conditions: high in acidity, alkalinity, salinity and sodicity; heavy metal toxicities and also capable of take up large amount of nutrients in soil and water.**

- **Due to the above features VS has been used successfully for soil and water conservation in agricultural lands, infrastructure and environmental protection in Australia, Africa, Asia, North and South America and southern Europe**.

SPECIAL FEATURES OF VETIVER GRASS SUITABLE FOR WASTEWATER DISPOSAL AND TREATMENT

UNIQUE ATTRIBUTES

Stiff and erect stems up to 2m tall and over 2.5m with flower head. It flowers but setting no seeds.

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

UNIQUE ATTRIBUTES

DEEP, EXTENSIVE AND PENETRATING ROOT SYSTEM

China: One year old with 3.3m deep root system

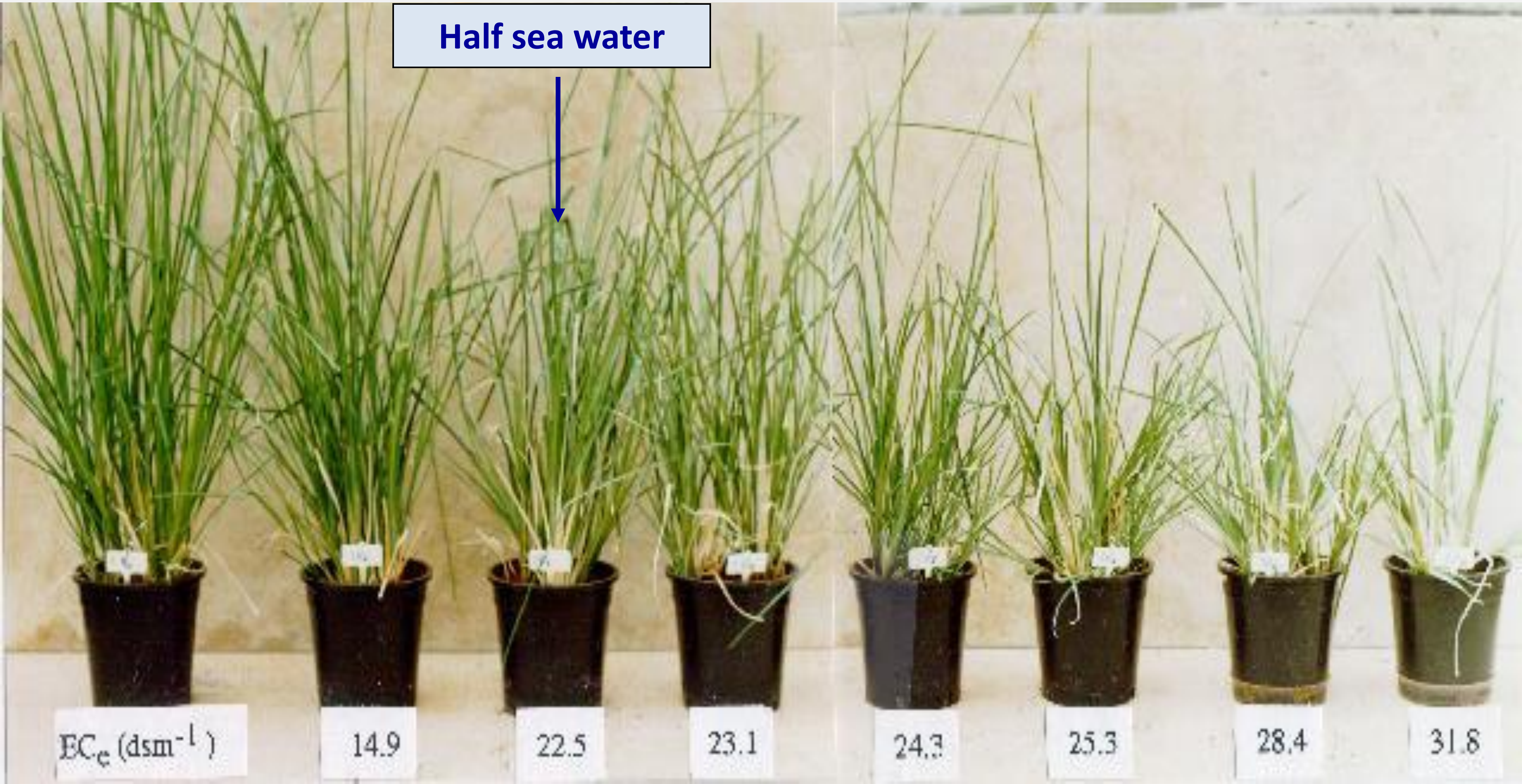
Vietnam: Agriculture & Forestry University, Saigon

Growing vigorously in water in Australia and China. Vetiver can survive more than 50 days when completely submerged.

Extremely drought tolerant in central Australia, note all native grasses were brown off

HIGHLY SALT TOLERANT

Saline threshold level is at EC_e=8 dsm^{-1}, and vetiver can survive at 47.5 dsm^{-1} under dryland salinity conditions



VARIOUS SOIL TYPES

Heavy cracking clay in Australia

Coastal dune in Vietnam

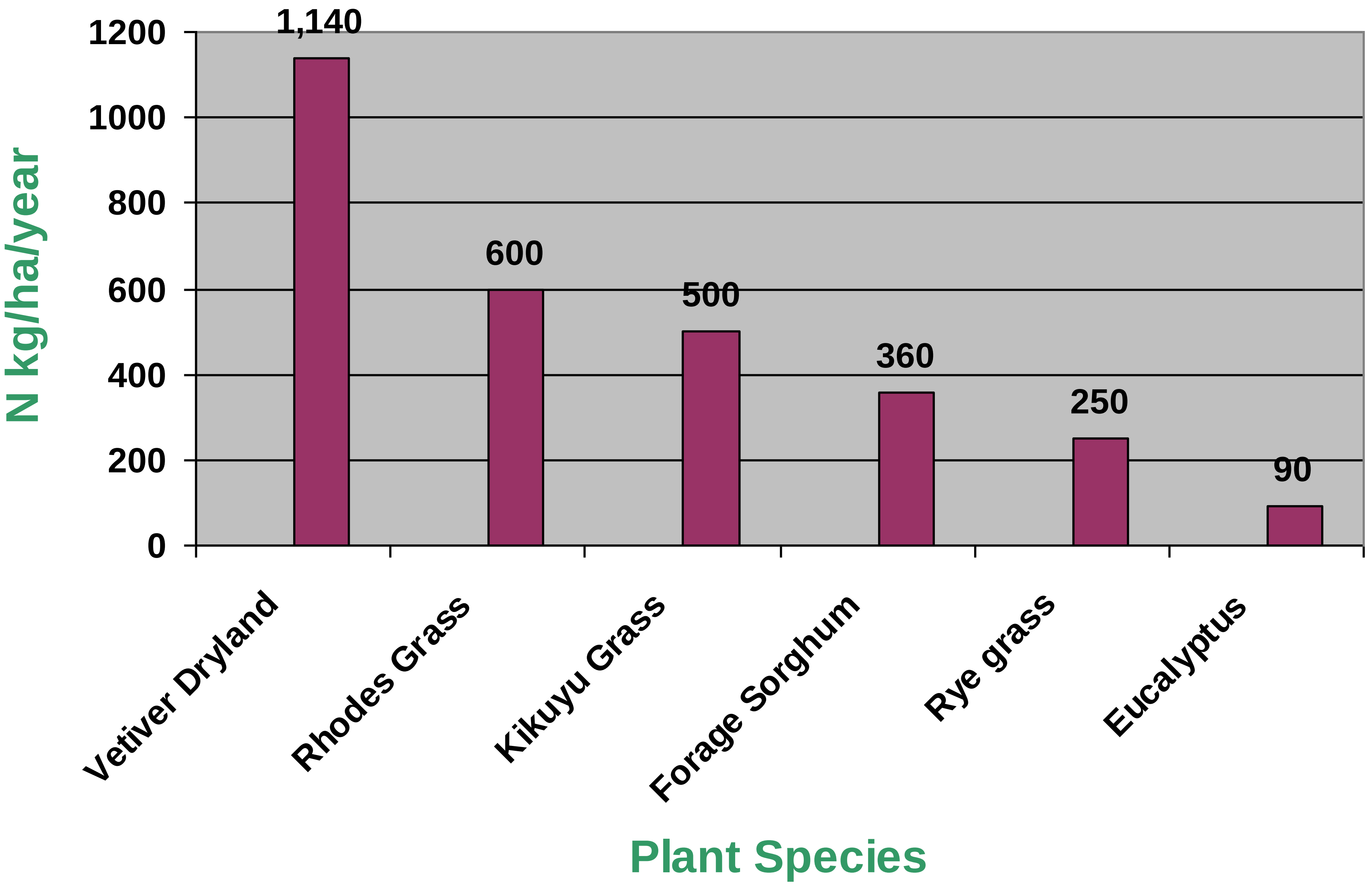
HIGH N AND P REMOVAL: **With high capacity of removing N and P in polluted water, vetiver cleaned up blue green algae in 4 days**

Sewage effluent infested with Blue-Green algae due to high Nitrate (100mg/L) and high Phosphate (10mg/L)

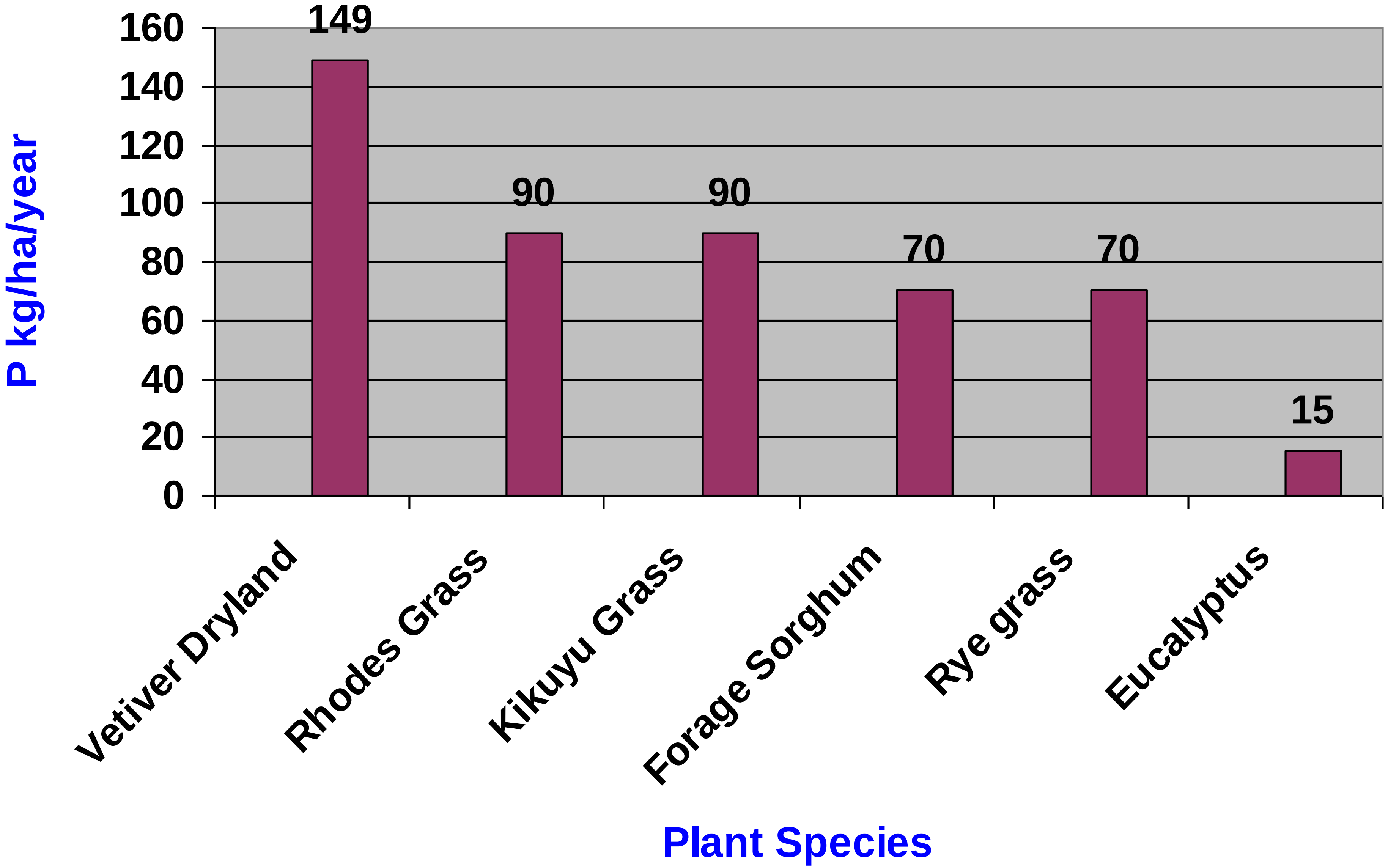
Same effluent after 4 days after treating with vetiver, reducing N level to 6mg/L (94%) and P to 1mg/L (90%)

UNIQUE ATTRIBUTES

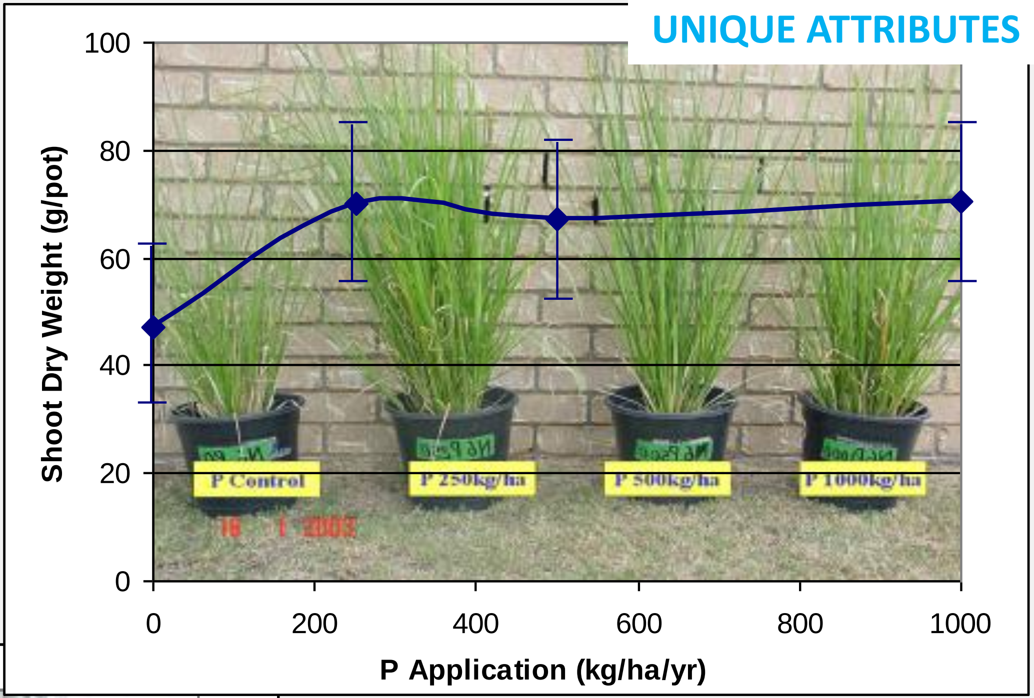
NITROGEN UPTAKE

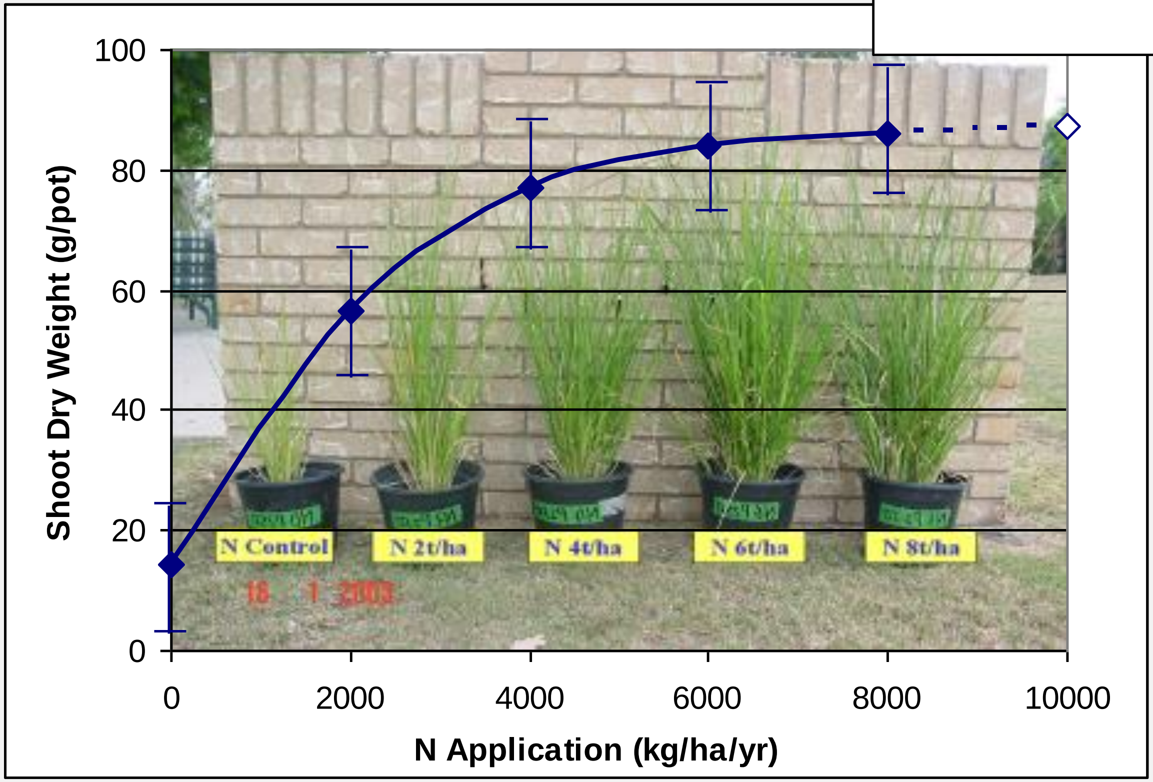


PHOSPHORUS UPTAKE

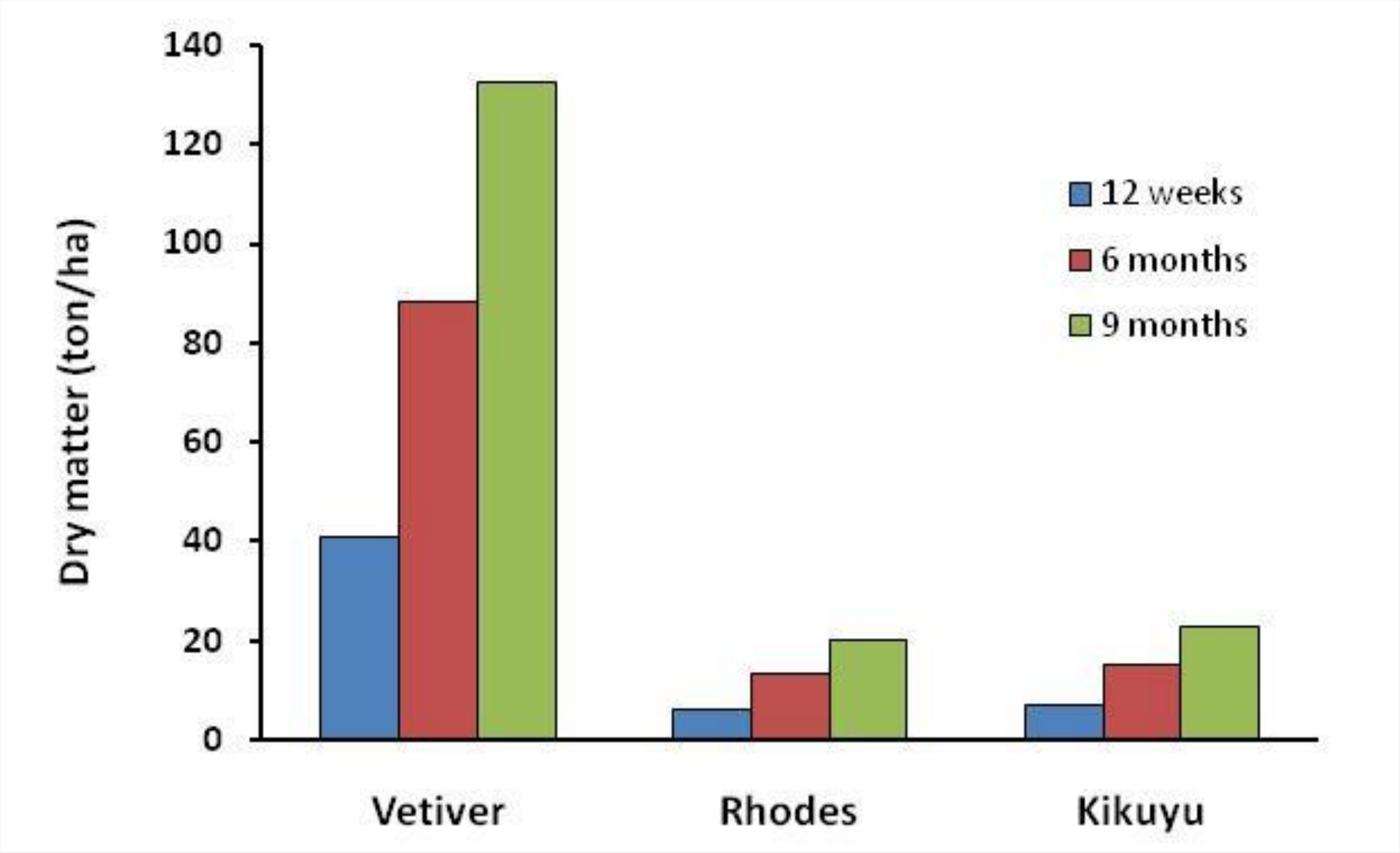


Tolerance to extremely high levels of nutrients





Potential dry matter yield of three grasses over time.

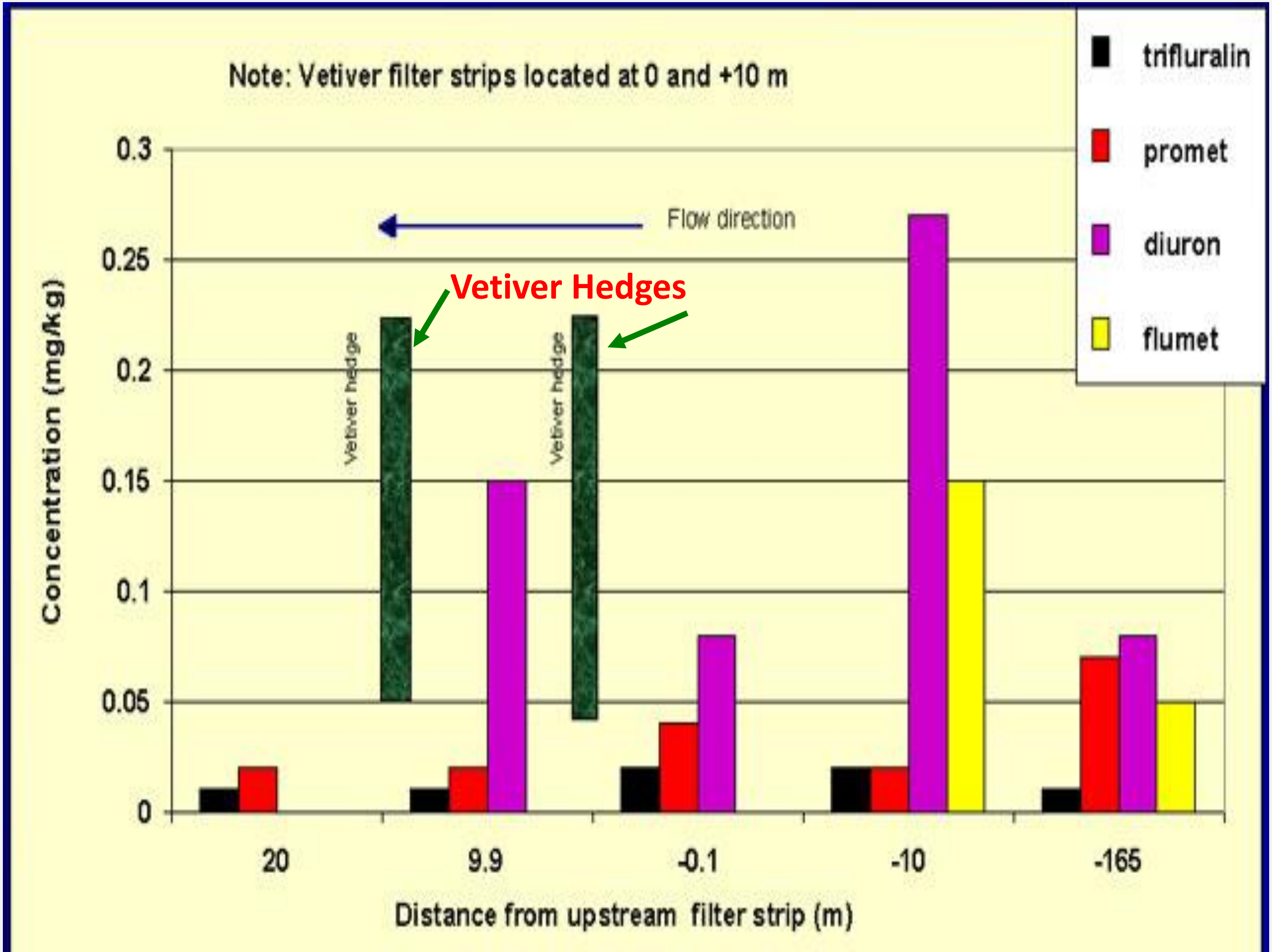


BIO-FILTER: For sediment control in waterways in cotton farms

UNIQUE ATTRIBUTES

Trapping coarse and fine sediment in cotton farms in Australia

Trapping herbicides on cotton farms in Australia



VETIVER SYSTEM TECHNOLOGY

FOR PREVENTION AND TREATMENT

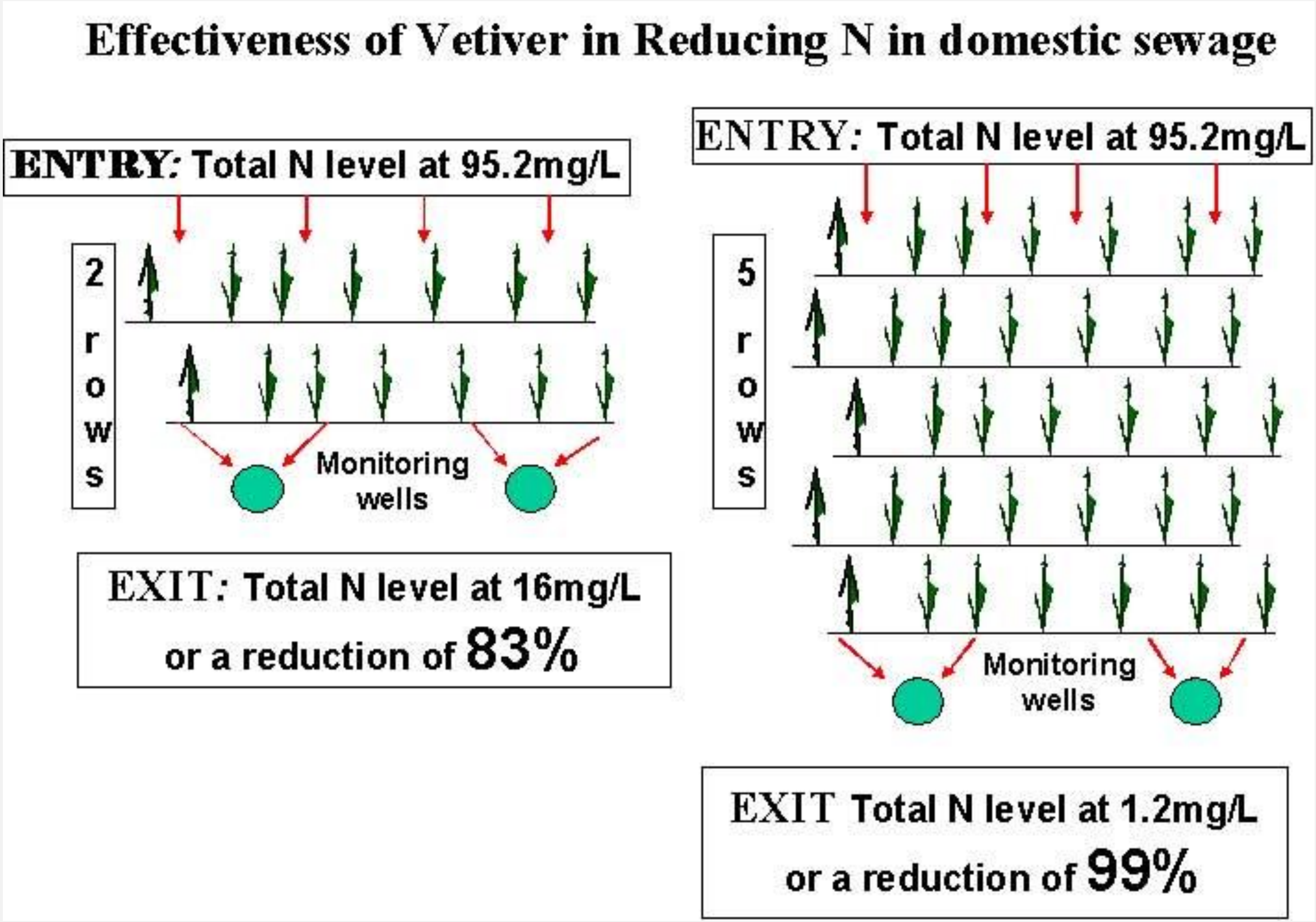
OF CONTAMINATED WATER

CASE STUDY 1: Disposal of domestic sewage effluent

Vetiver planting to absorb effluent discharge from a toilet block in a park in Brisbane.

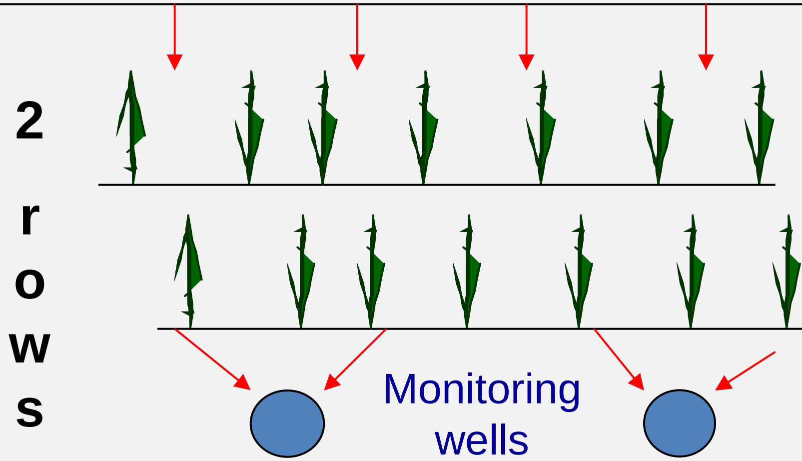
Six months after planting this stand of 100 plants absorbs all the discharge from the toilet block

High capacity for N absorption in domestic sewage in Australia



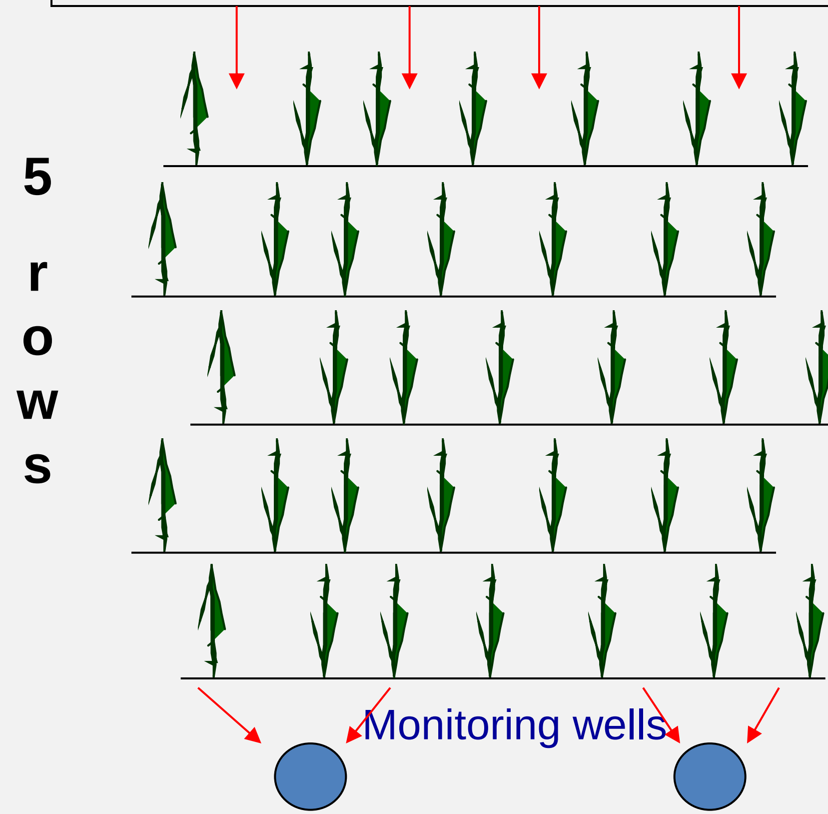
High capacity for P absorption in domestic sewage in Australia

***Entry*: Total P level at 1.3mg/L**

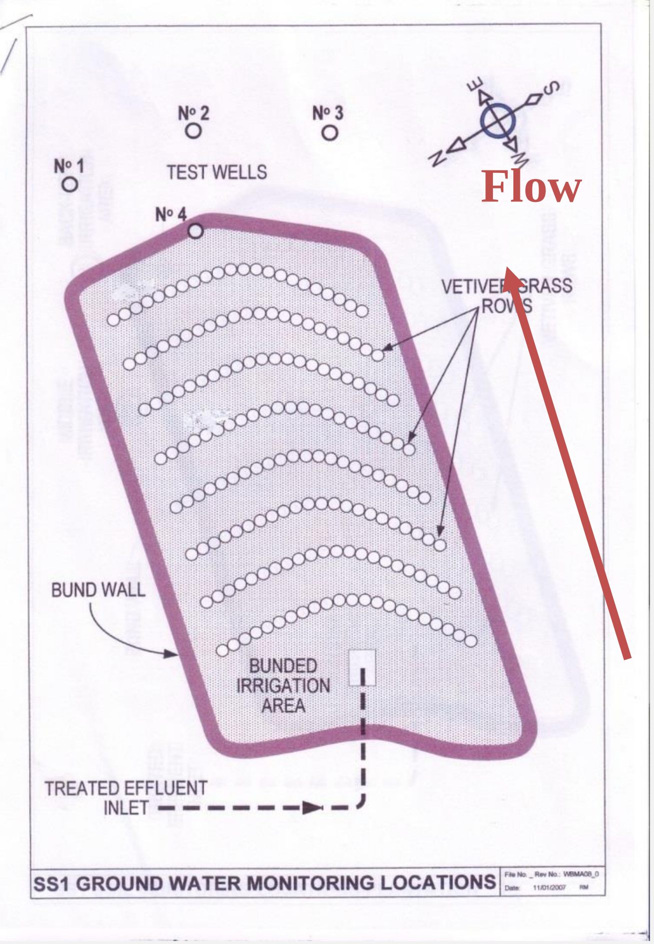


***Exit*: Total P level at 0.24mg/L**
or a reduction of 82%

***Entry*: Total P level at 1.3mg/L**



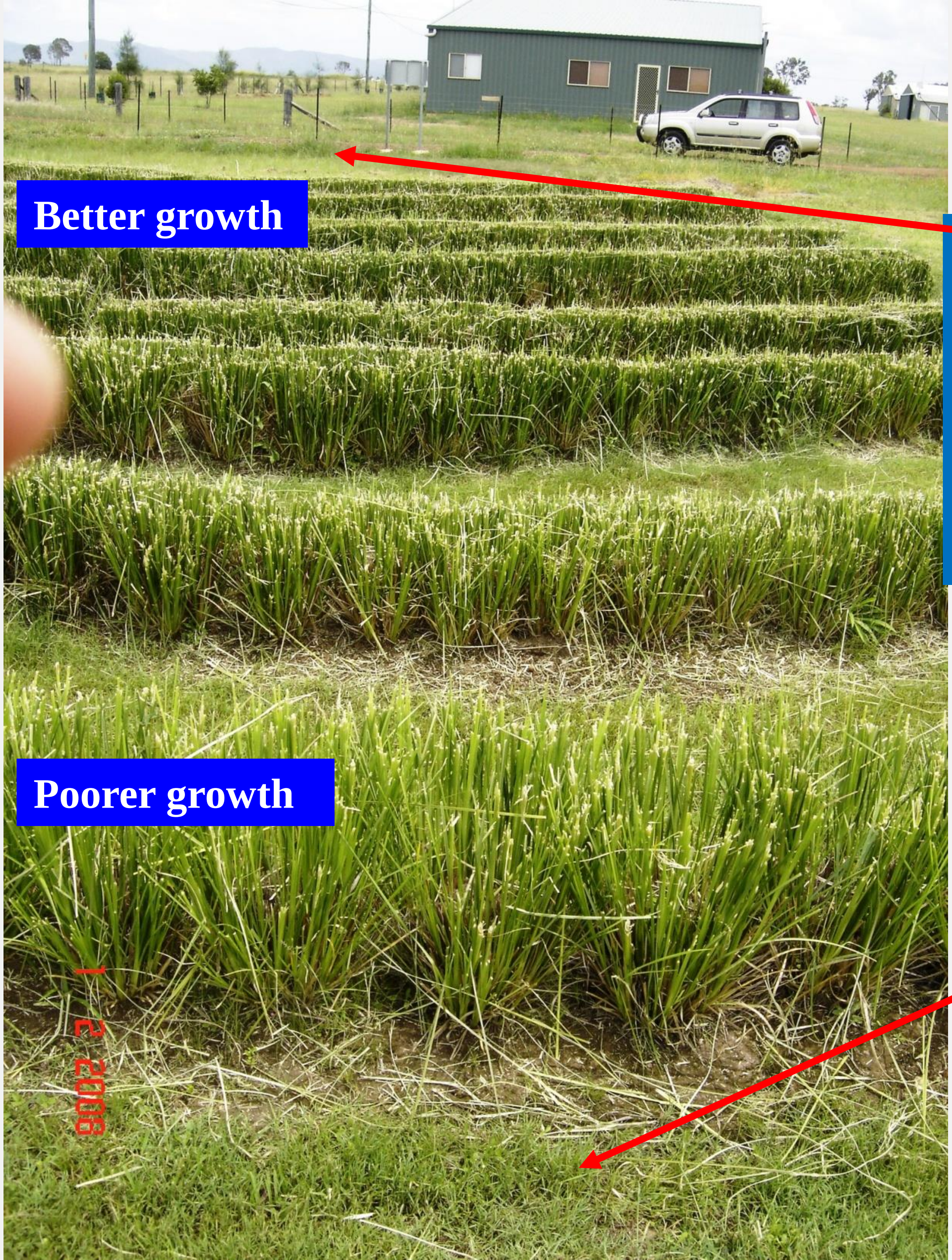
***Exit:* Total P level at 0.20mg/L**
or a reduction of 85%



CASE STUDY 2: Disposal of sewage effluent a small community

- 8 rows of 10m long vetiver
- Row spacing 1m
- Plant spacing 20cm
- Total plants 400
- Land area 100 sqm

RESULTS



IN FLOW

Average daily flow: 1 670L

Average total N: 68mg/L

Average total P: 10.6mg/L

Average Faecal Coliform:>8 000

OUT FLOW

Average daily flow: Almost Nil*

Average total N: 0.13mg/L

Average total P: 0.152mg/L

Average Faecal Coliform:<10

*** Only flow after heavy rain**

CASE STUDY 3: Disposal of municipal domestic sewage effluent by hydroponic and Ephemeral Wetland treatment

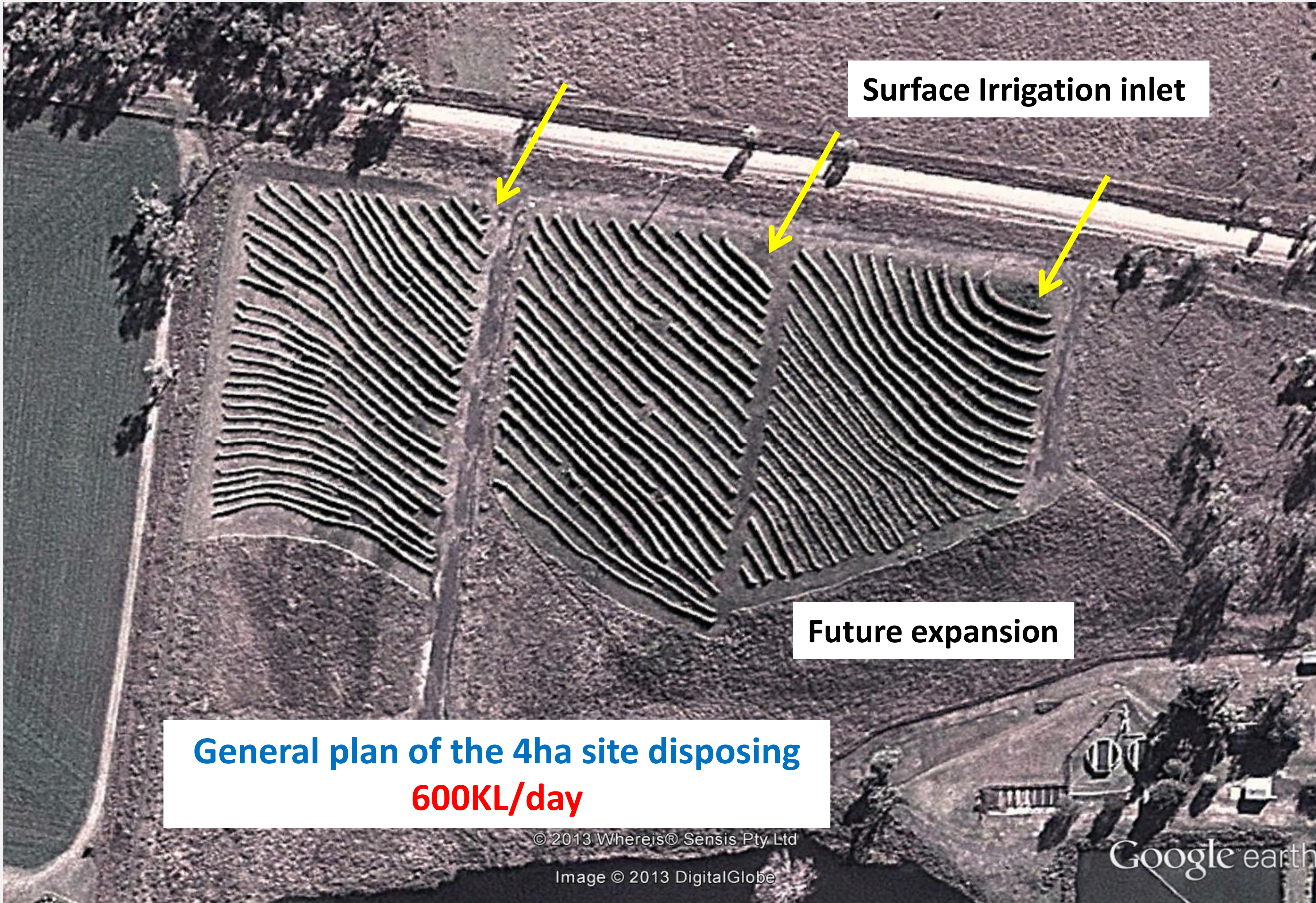
Phase 1: Hydroponic treatment in storage ponds

Phase 2: Ephemeral Wetland treatment of municipal sewage effluent

Effluent quality before and after the vetiver treatment

Tests * (license requirements)	Effluent Input	Effluent Output
PH (6.5 to 8.5)8*	7.3 to 8.0	7.6 to 9.2
Dissolved Oxygen (2.0 minimum) *	0 to 2 mg/l	8.1 to 9.2 mg/l
5 Day BOD (20 - 40 mg/l max) *	130 to 300 mg/l	7 to 11 mg/l
Suspended Solids (30 - 60 mg/l max) *	200 to 500 mg/l	11 to 16 mg/l
Total Nitrogen (6.0 mg/l max) *	30 to 80 mg/l	4.1 to 5.7 mg/l
Total Phosphorous (3.0 mg/l max) *	10 to 20 mg/l	1.4 to 3.3 mg/l

CASE STUDY 4: Disposal of municipal domestic sewage effluent by land irrigation in Australia



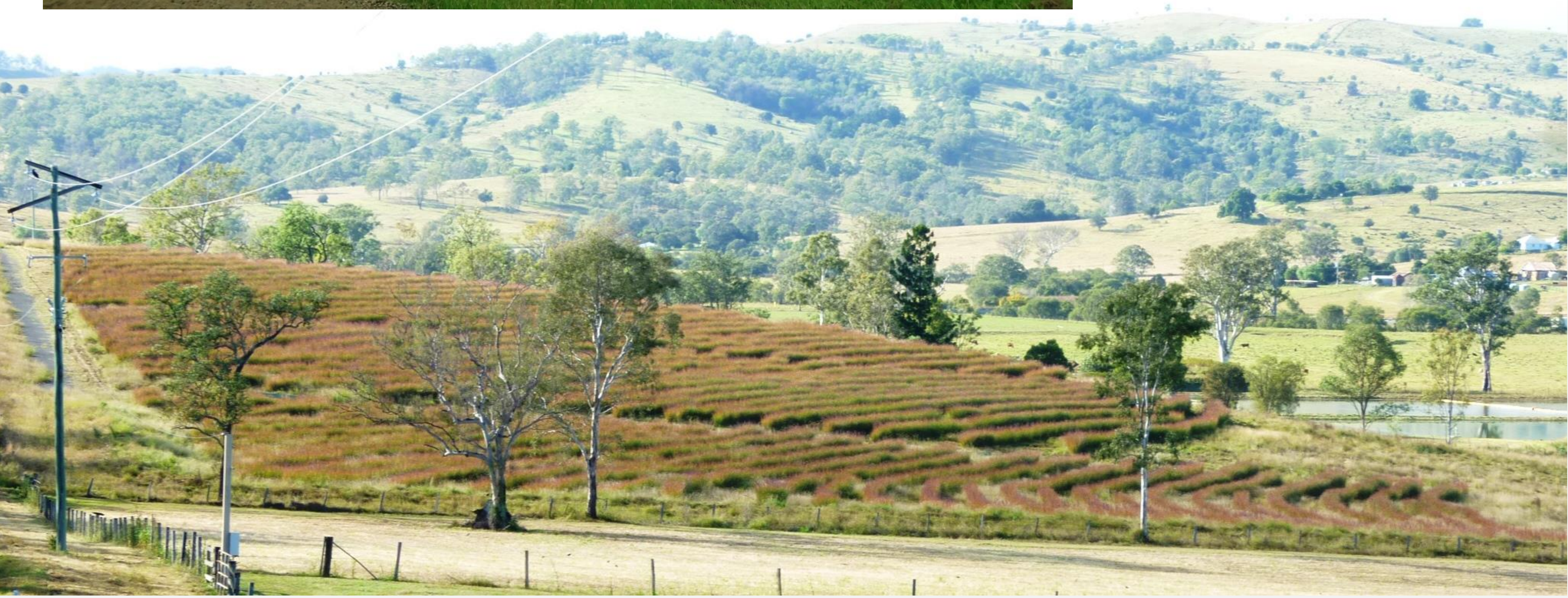
Six month old

12 month old

Six month old

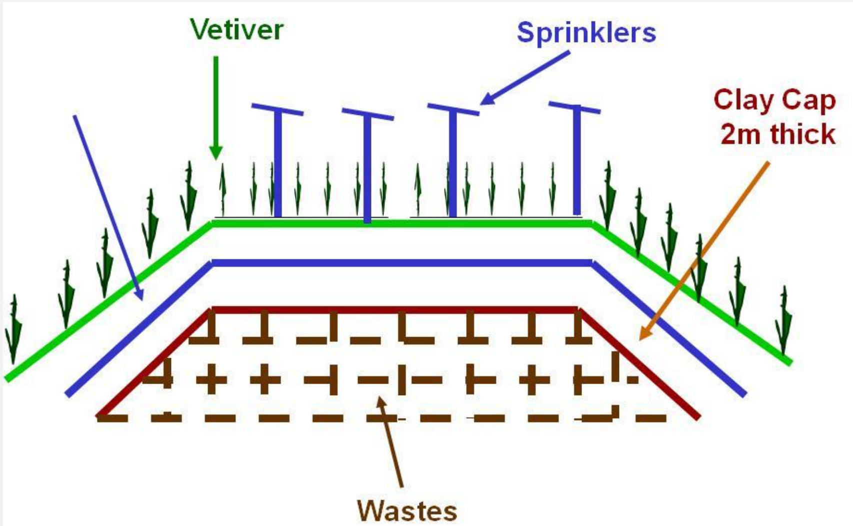
This planting has totally disposed 500-600KL/day

12 month old



CASE STUDY 5: Disposal of municipal landfill leachate in Australia

Spray irrigation on landfill mound: the diagrammatic cross section of the mound (top left), vetiver irrigated every day with leachate after planting (top right), two (bottom left) and twelve (bottom right) months after planting.



Vetiver growth was over 3m in the second summer

Growing in highly saline and polluted leachate pool

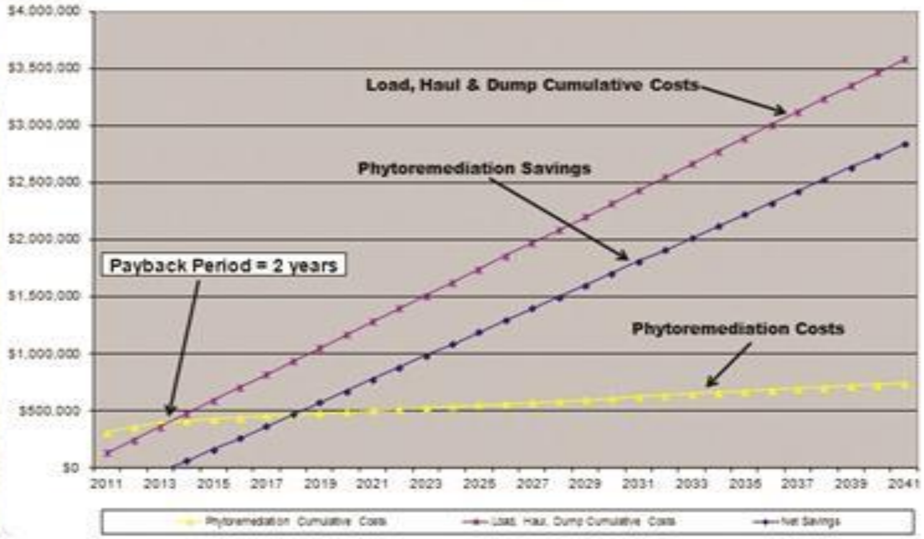
Fresh leachate pool

Twelve months after planting, the 3.5ha site disposing 4 ML/month

CASE STUDY 6: Disposal of industrial landfill leachate in Mexico

Early stage of vetiver establishment at Leon (left) and Poza Rica (right).

CASE STUDY 7: Disposal of industrial landfill leachate in USA



CASE STUDY 8: Disposal of industrial wastewater in Australia

Food processing factory effluent disposal by land irrigation. The 22.5 ha site disposing 48ML/month

CASE STUDY 9: Disposal of industrial wastewater in Australia

Wastewater from a beef abattoir in Australia

Effectiveness of vetiver planting on quality of effluent seepage

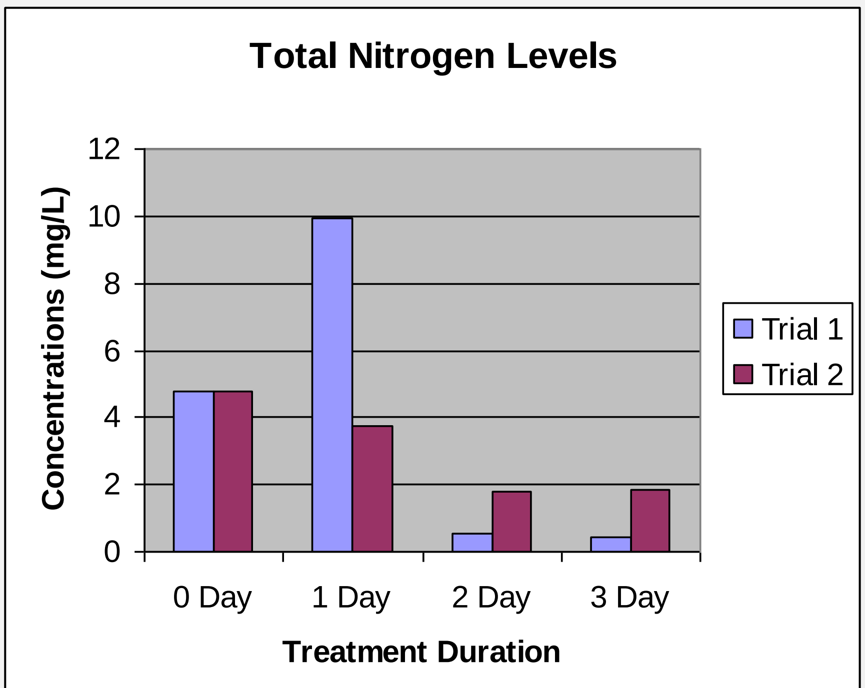
Analytes	Nutrient levels		
	Inlet	Mean levels in monitoring bores	
		20m down slope from inlet	50m down slope from inlet
pH	8.0	6.5	6.3
EC (uS/cm)	2200	1500	1600
Total Kjel. N (mg/L)	170	11.0	10.0
Total N (mg/L)	170	17.5	10.6
Total P (mg/L)	32	3.4	1.5

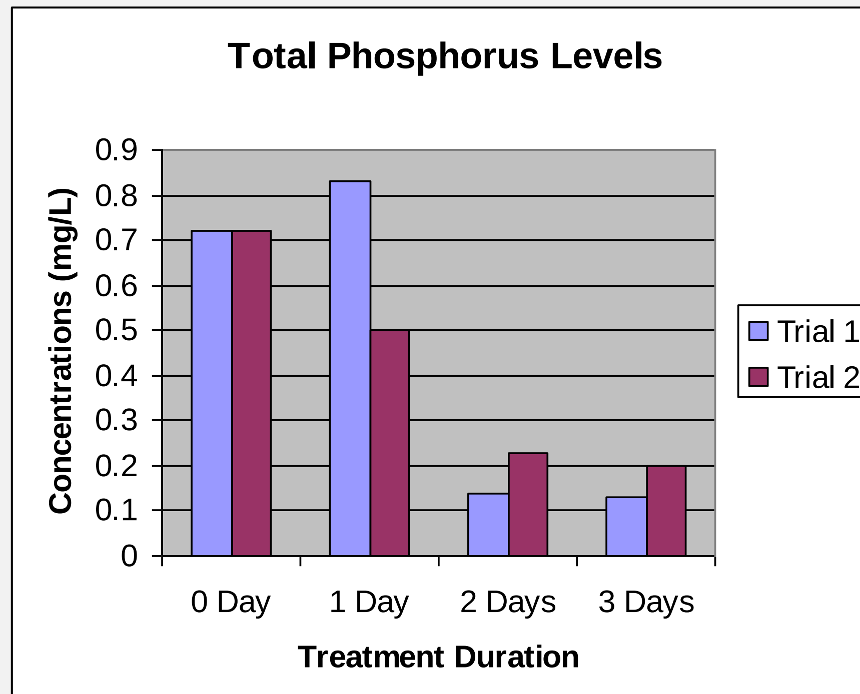
CASE STUDY 10: Disposal of industrial wastewater in Vietnam

A seafood processing factory the Mekong Delta

CONCLUSION

These results show that the factory should retain the 50KL effluent output for 48 hours in the vetiver field before discharging into the nearby creek.





VETIVER SYSTEM TECHNOLOGY

FOR PHYTO REMEDIATION OF

CONTAMINATED LAND

Threshold levels of heavy metals to vetiver growth based on single element experiment

UNIQUE ATTRIBUTES

Heavy metals	Threshold to growth of most vascular plants (mg kg^{-1})		Threshold to vetiver growth (mg kg^{-1})	Vetiver survival under the highest levels of metals reported in the literature (mg kg^{-1} soil)
	Hydroponic level	Soil level	Soil level	
Arsenic	0.02-7.5	2.0	100-250	959
Boron				180
Cadmium	0.2-9.0	1.5	20-60	60
Copper	0.5-8.0	NA	50-100	2600
Chromium	0.5-10.8	NA	200-600	2290
Lead	NA	NA	>1500	10750
Mercury	NA	NA	>6	17
Nickel	0.5-2.0	7-10	100	100
Selenium	NA	2-14	>74	> 74
Zinc	NA	NA	>750	6400

The highest concentrations of heavy metals accumulated in the roots and shoots of vetiver reported in the literature

Heavy metals		Soil condition			Hydroponic condition	
		Roots (mg kg^{-1})	Shoots (mg kg^{-1})		Roots (mg kg^{-1})	Shoots (mg kg^{-1})
Lead		4940	359		≥ 10,000	≥ 3350
Zinc		2666	642		>10,000	>10,000
Chromium		1750	18			
Copper		953	65		900	700
Arsenic		268	11.2			
Boron		28	17			
Cadmium		~ 25	~ 44		2232	93

CASE STUDY 11: Ammonia and nitrate contaminated site at Bajool, Australia

This site was contaminated with extremely high levels of Ammonia and Nitrate as a result of explosive manufacturing.

Land surface area: 7 300m2
Soil depth: 2.5m to 3.0m
Contaminate soil volume: 20 000m3
Soil Ammonia level, ranging from 20 -1 220mg/kg, averaging 620mg/kg
Soil total N level, ranging from 31-5 380mg/kg, averaging 2 700mg/kg
Water Ammonia level, ranging from 235-1 150mg/L, with one sample at 12 500mg/L
Water total N level, ranging from 118 – 7 590mg/L, with one sample at 18 300mg/L


8 months after planting

Hydroponic treatment of pig farm effluent

Thank You