VETIVER SYSTEM FOR PREVENTION AND TREATMENT OF CONTAMINATED LAND AND WATER

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INTRODUCTION

- The Vetiver System (VS) is based on the use of vetiver grass *(Vetiveria zizanioides L.)* for a wide range of applications. VS 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 treating domestic and industrial wastewater in Australia, Africa, Asia and southern Europe.

VETIVER GRASS

SPECIAL MORPHOLOGICAL CHARACTERISTICS

- Stiff and erect stems
- Deep and extensive root system
- It has no above or underground stems

SPECIAL PHYSIOLOGICAL CHARACTERISTICS

- Tolerant to drought, water logging, acidic, alkaline, sodic and saline conditions
- Tolerant to highly polluted environment such as heavy metal and nutrient contamination
- Tolerant high level of herbicides and pesticide in the soil
- Growing on all soil types: heavy clay to sand dune

SPECIAL GENETIC CHARACTERISTICS

- It is sterile, it flowers but sets no seeds
- Therefore it is non invasive and no weed potential
- It can be eliminated easily by Glyphosate spray or uprooting

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

DEEP, EXTENSIVE AND PENETRATING ROOT SYSTEM

China: One year old with 3.3m deep root system

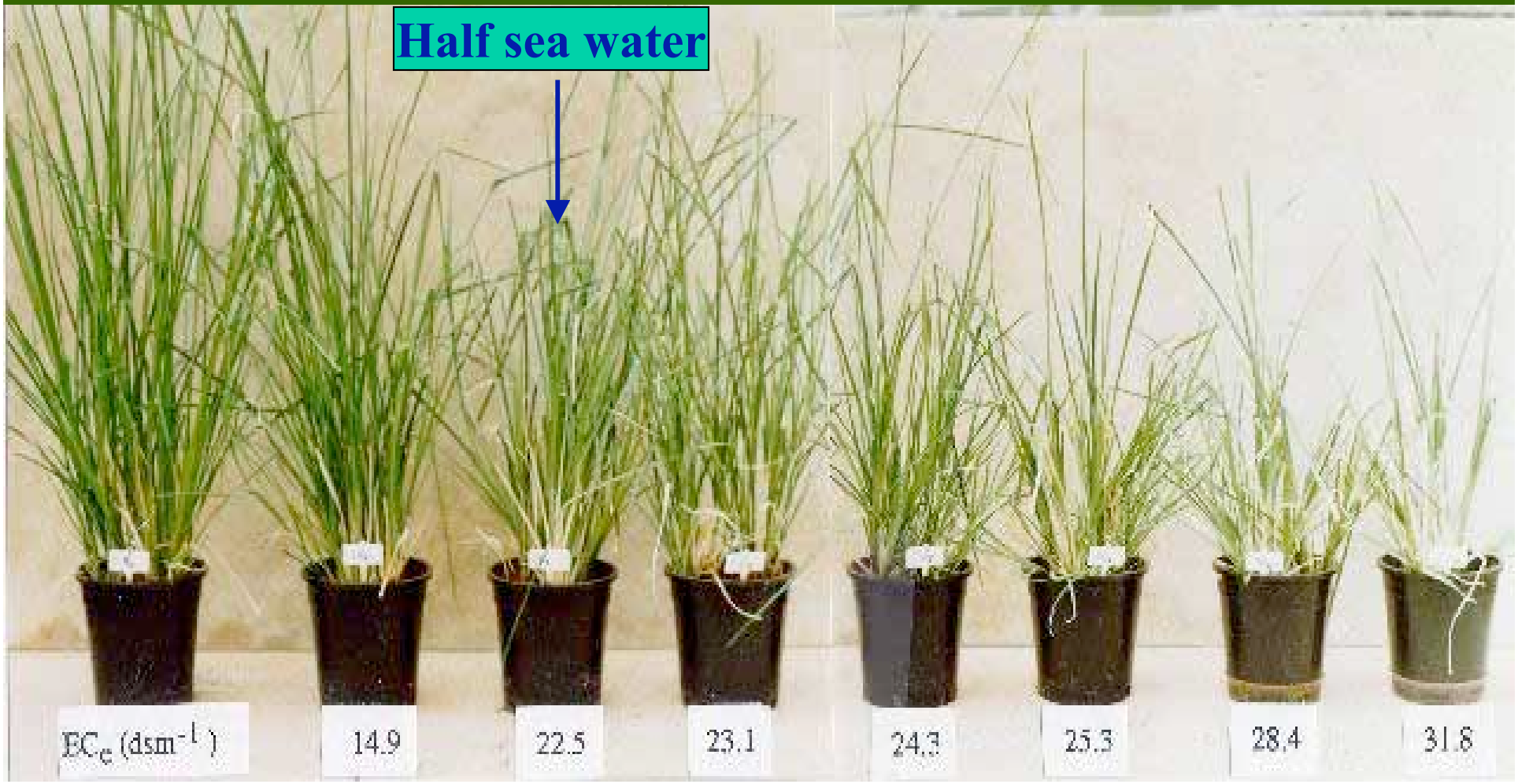
Australia: One year old, 1.3m and root bound

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



Vetiver growing among mangrove seedlings in Australia

VARIOUS SOIL TYPES

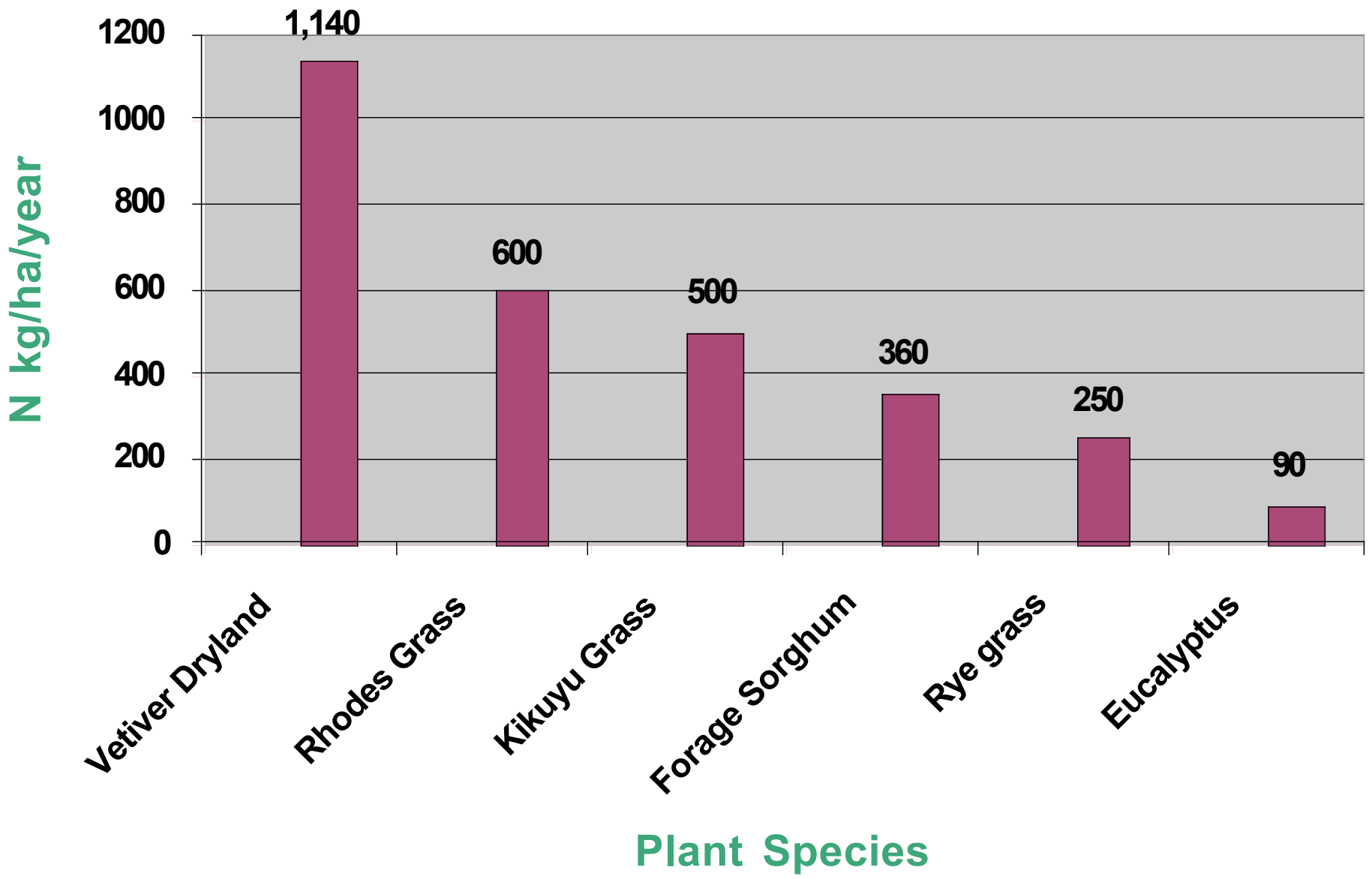
Heavy cracking clay in Australia

Coastal dune in Vietnam

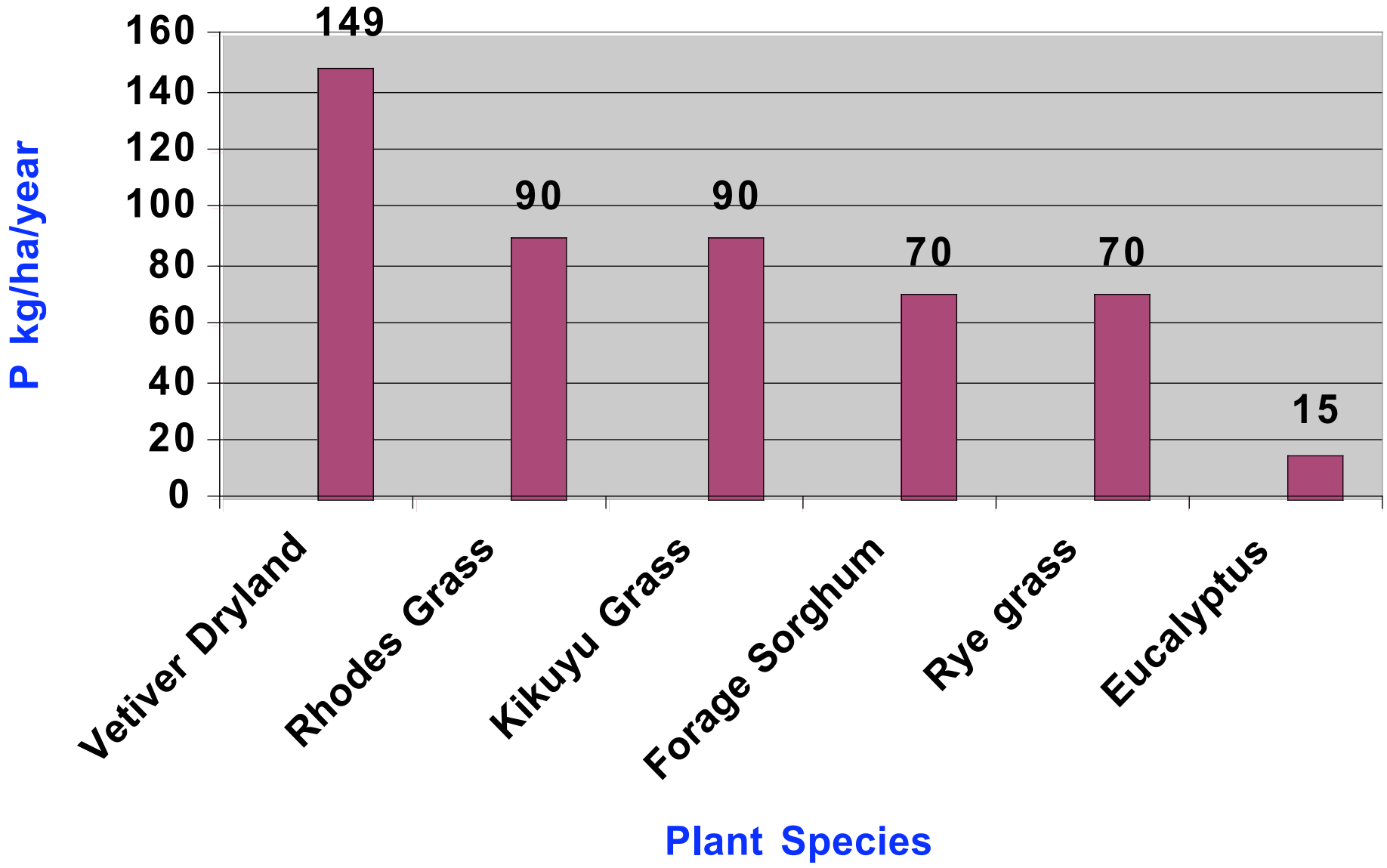
SPECIAL CHARACTERISTICS SUITABLE FOR WASTEWATER TREATMENT

- **Very high capacity for N and P uptake under Dry land, Wetland or Hydroponics conditions**
- **Very fast growth with very high water consumption under wet conditions**
- **Biomass up to 132t/ha**
- **Tolerant high levels of herbicides and pesticides**
- **Highly tolerant to heavy metal toxicities**

NITROGEN UPTAKE



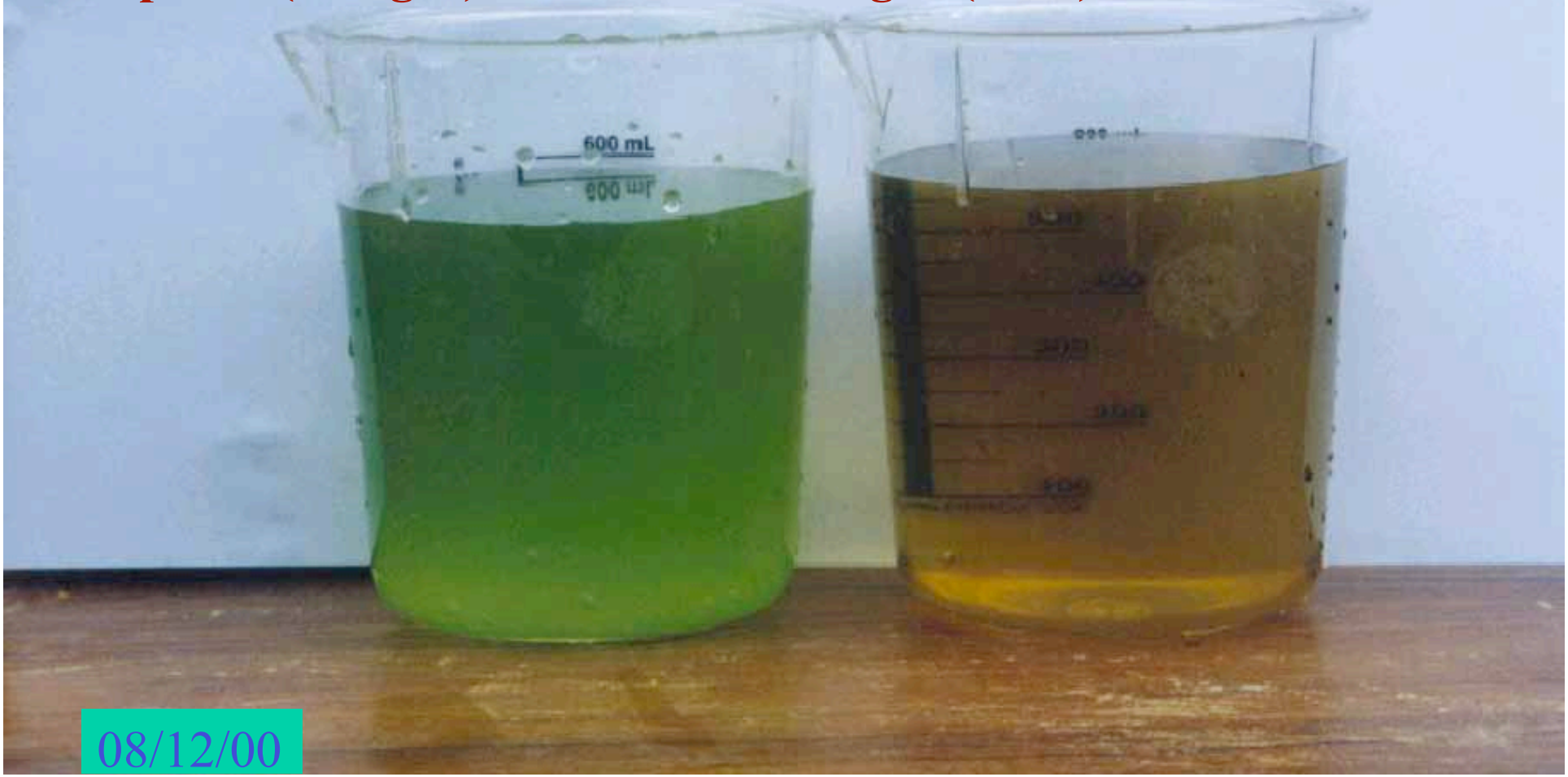
PHOSPHORUS UPTAKE



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%)



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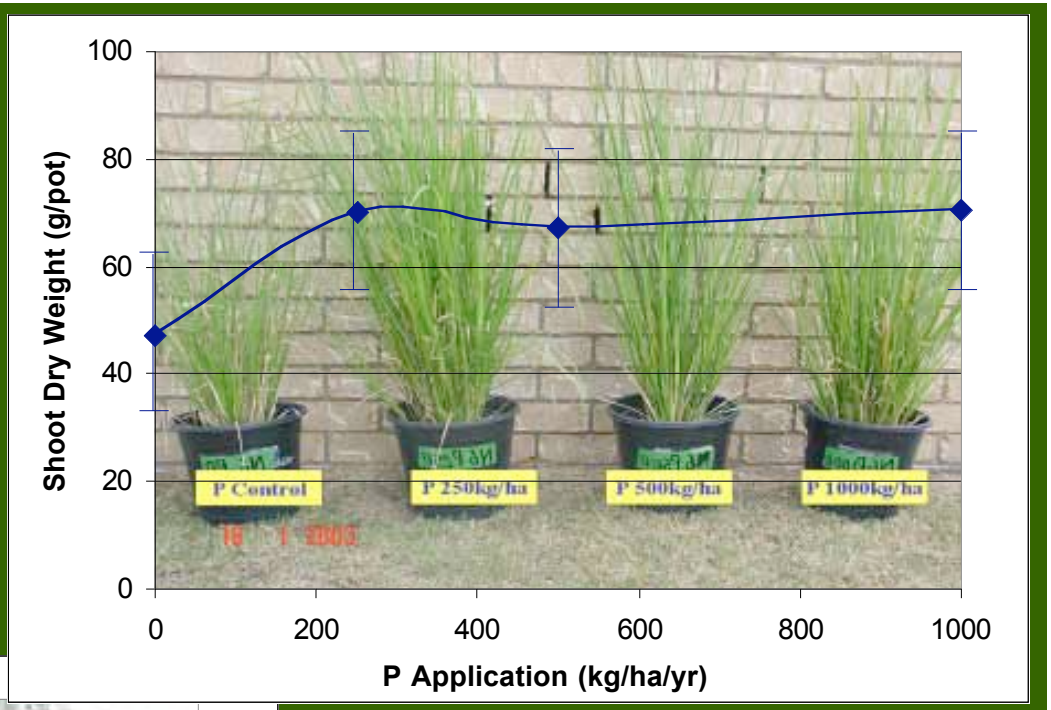
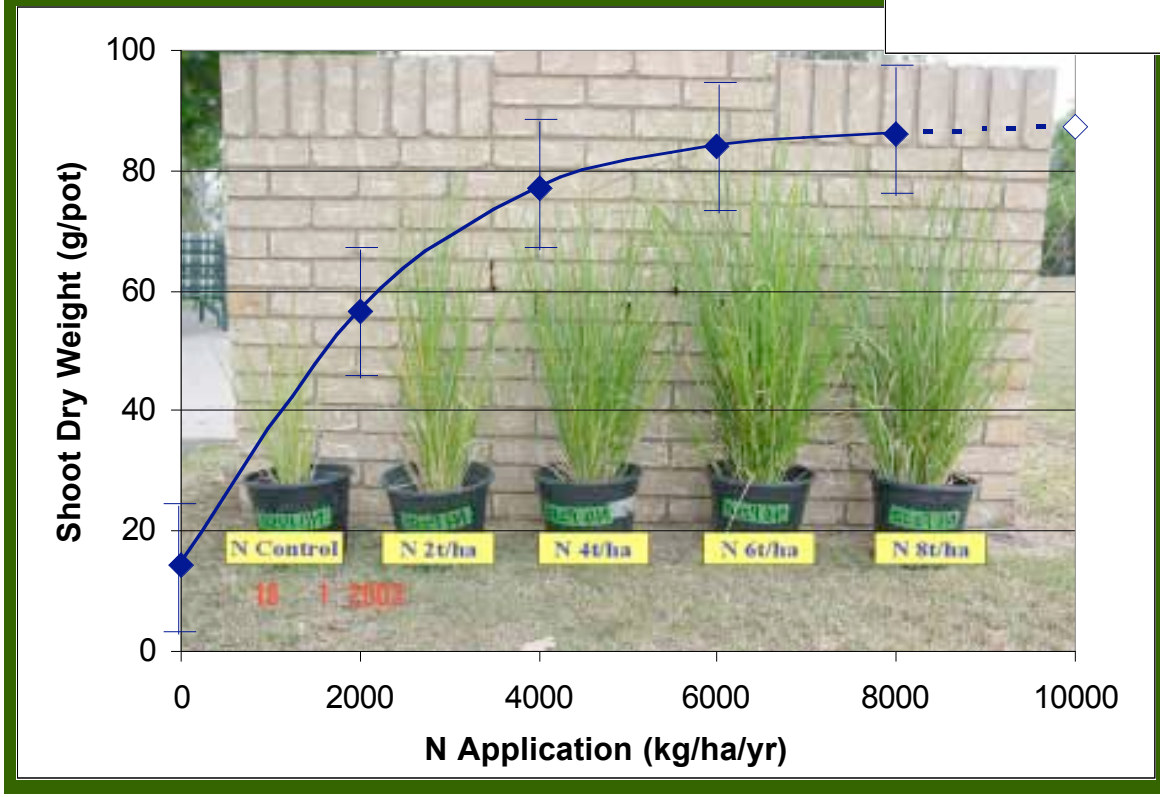
Tolerance to extremely high levels of nutrients





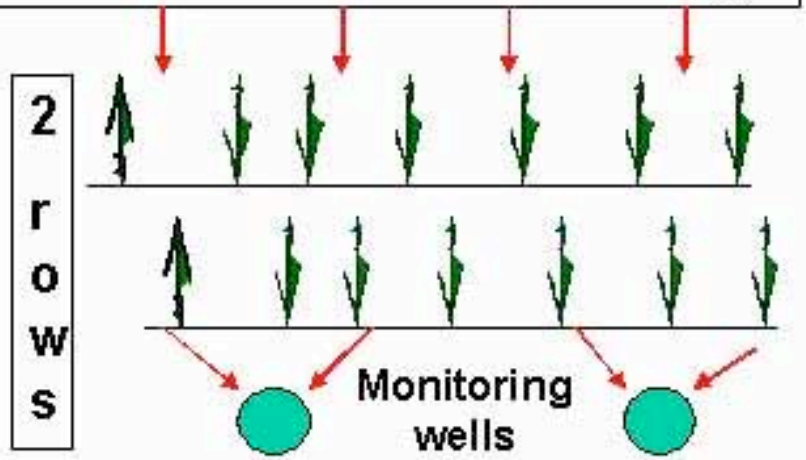
APPLICATIONS OF VETIVER SYSTEM FOR WASTEWATER TREATMENT

- **Domestic Effluent**
- **Industrial Effluent**
- **Landfill Leachate**

High capacity for N absorption in domestic sewage in Australia

Effectiveness of Vetiver in Reducing N in domestic sewage

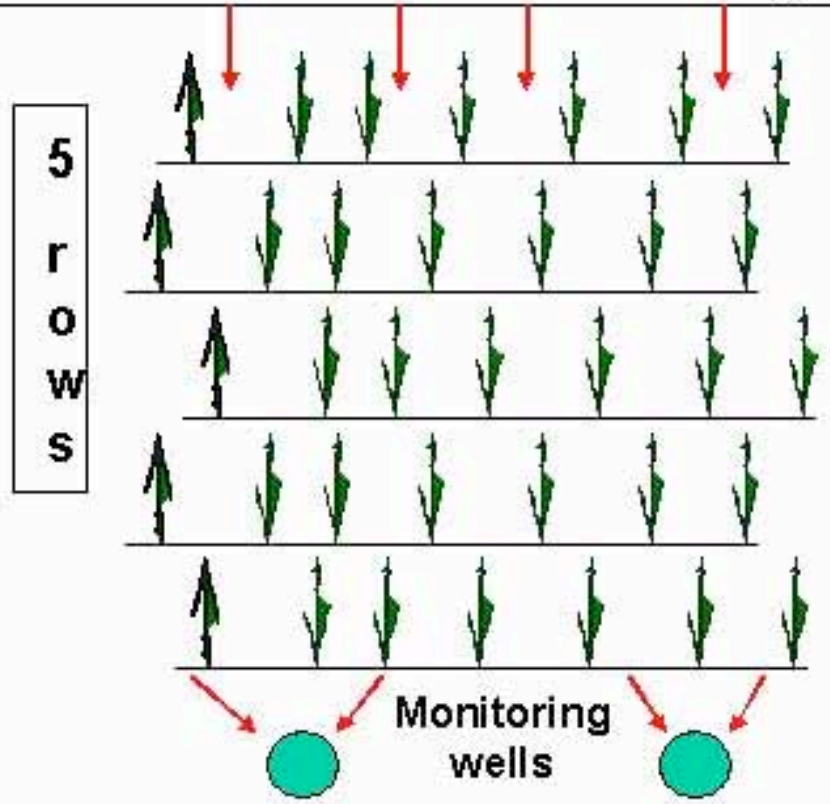
ENTRY: Total N level at 95.2mg/L



EXIT: Total N level at 16mg/L

or a reduction of 83%

ENTRY: Total N level at 95.2mg/L



EXIT Total N level at 1.2mg/L

or a reduction of 99%

Industrial Effluent 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

Hydroponic treatment of municipal sewage effluent in Australia

Hydroponic treatment of pig farm effluent

China

Vietnam

Vetiver roots thrive in high N and P sewage effluent and polluted water

Wetland treatment of municipal sewage effluent in Australia

Two months after planting

Ten months after planting

TEST RESULTS OF SEWERAGE EFFLUENT

(License Requirements in Brackets)

Tests	Plant Influent	2002/03 Results (9 month old)	2003/04 Results (18 month old)
PH (6.5 to 8.5)	7.3 to 8.0	9.0 to 10.0	7.6 to 9.2
D. Oxygen (2.0 minimum)	0 to 2 mg/L	12.5 to 20 mg/L	8.1 to 9.2 mg/L
5 Day BOD (20 - 40 mg/l max)	130 to 300 mg/L	29 to 70 mg/L	7 to 11 mg/L
Suspended Solids (30 - 60 mg/l max)	200 to 500 mg/L	45 to 140 mg/l	11 to 16 mg/l
Total Nitrogen (6.0 mg/l max)	30 to 80 mg/L	13 to 20 mg/L	4.1 to 5.7 mg/L
Total Phosphorous (3.0 mg/l max)	10 to 20 mg/L	4.6 to 8.8 mg/L	1.4 to 3.3 mg/L

Landfill leachate disposal in Australia

Vetiver growth was over 3m in the second summer

Growing in highly saline and polluted leachate pool

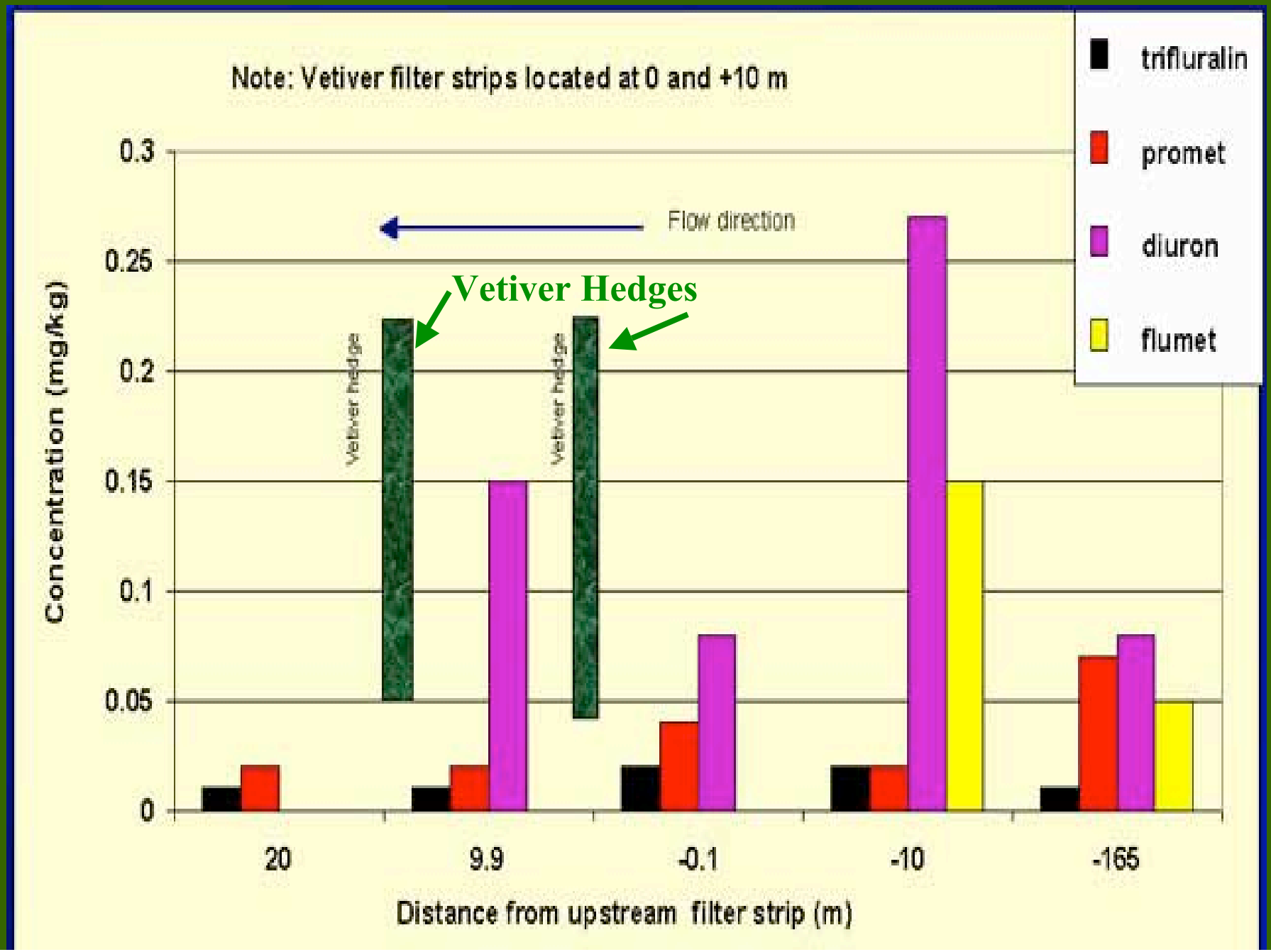
Vetiver strip uses in Australia for water quality improvement

Vetiver strip trapped sediment

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

Trapping coarse and fine sediment in cotton farms in Queensland

Trapping herbicides on cotton farms in central Queensland

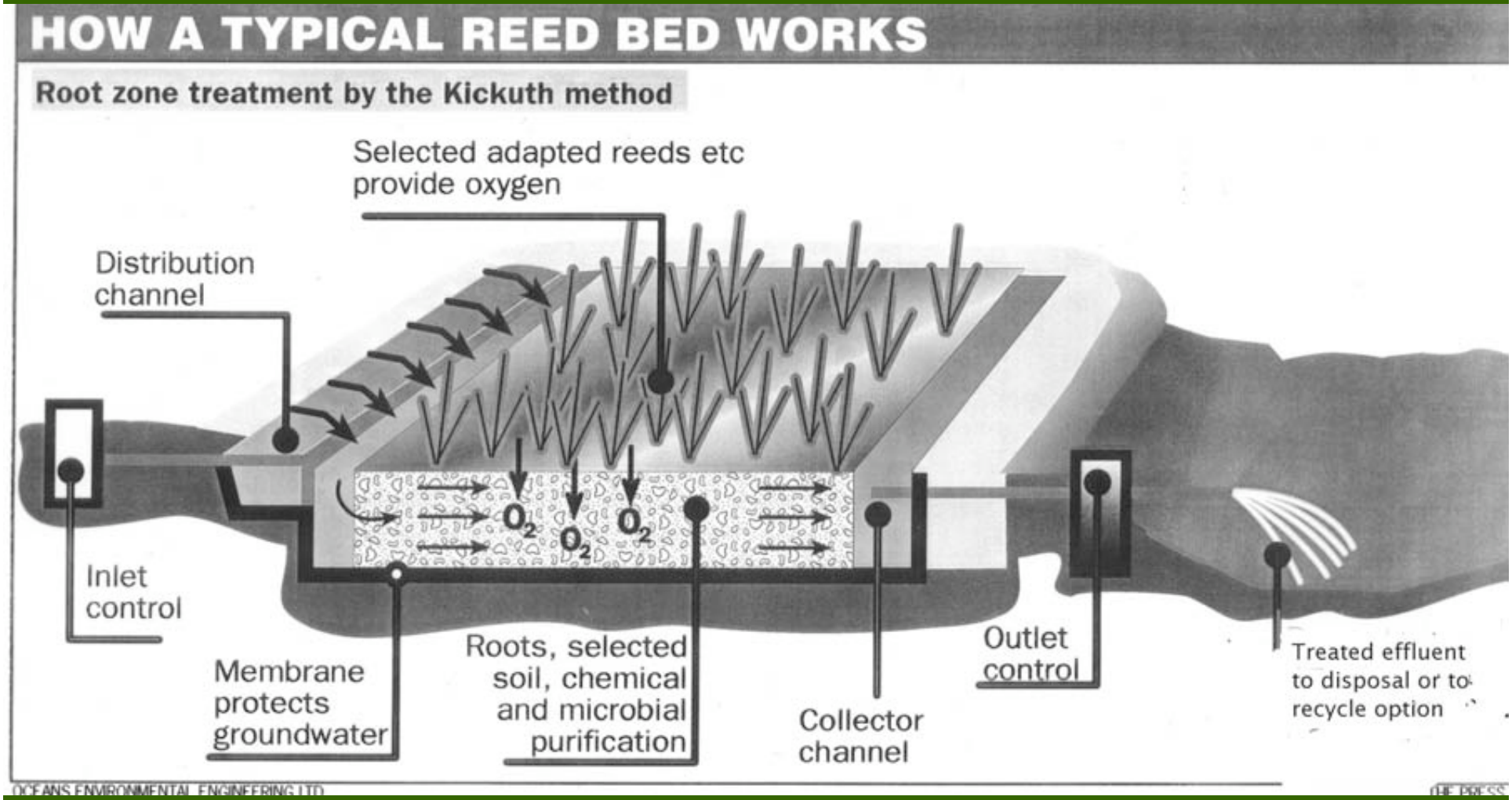


SOME ADVANCED APPLICATIONS OF VETIVER SYSTEM FOR WASTEWATER TREATMENT

- **Industrial Effluent**
- **Domestic Effluent**

Large scale industrial effluent recycling plant

Soil Based Reed Beds (SBRB)

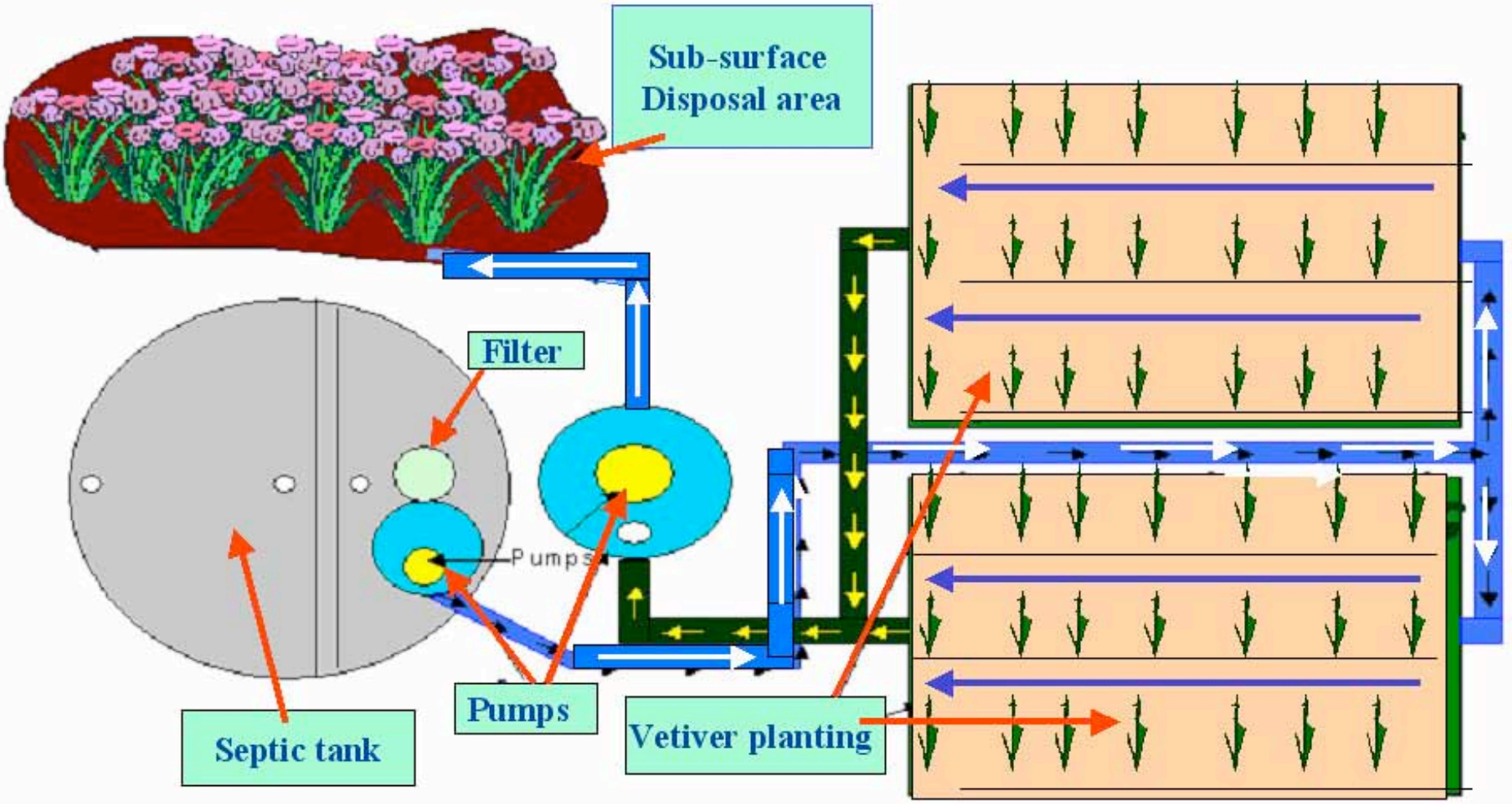


Soil Based Reed Beds research at Gelita APA, Australia

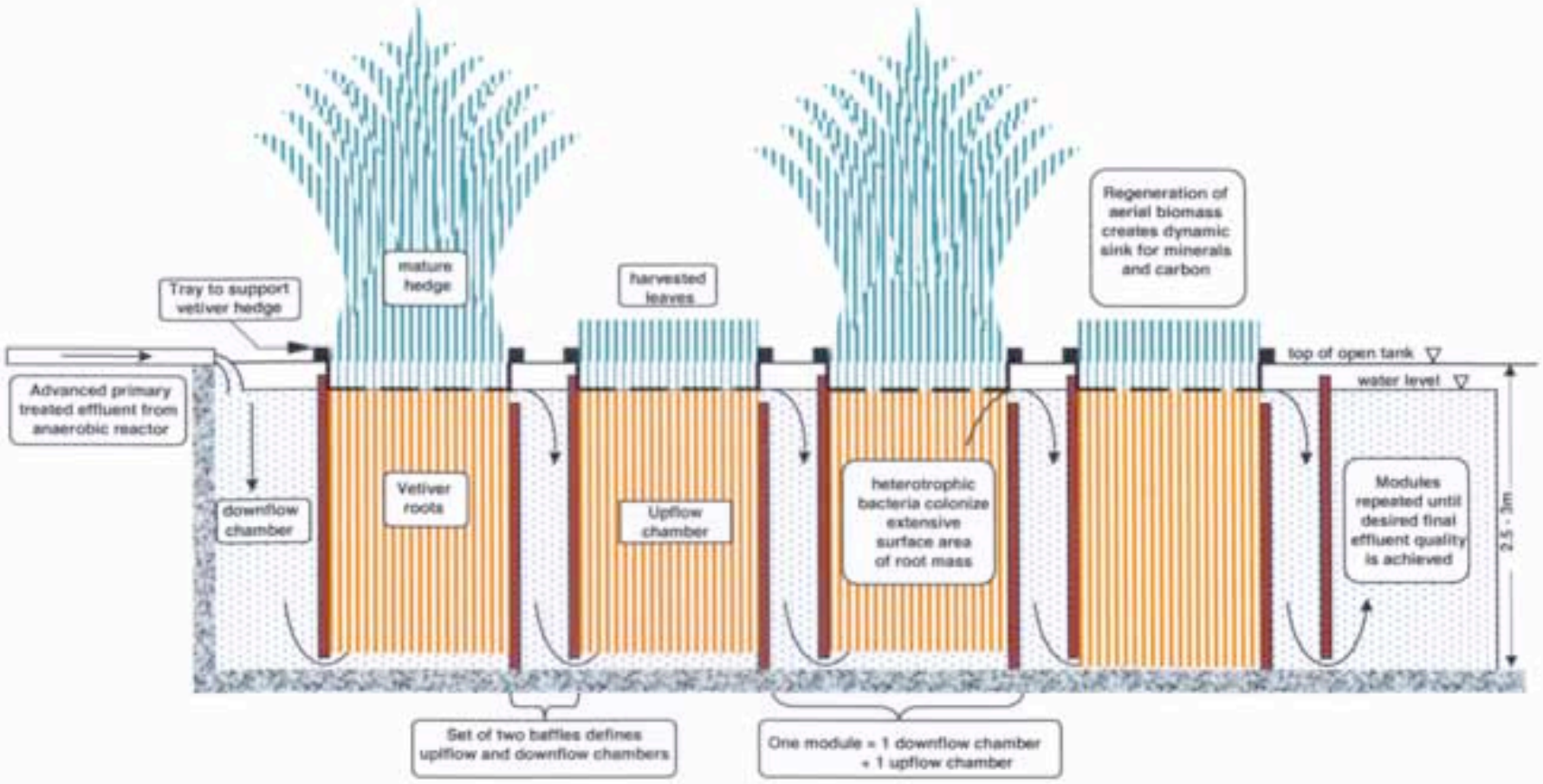
Soil Based Reed Beds research at Gelita APA, Australia

Domestic effluent recycling plant

Diagrammatic layout of a domestic disposal system



Schematic drawing of proposed vetiver hydroponics module to polish household effluent



Modified from Tim Journey's model (ADIC/VOCA)

MINE REHABILITATION AND PHYTOREMEDIATION

- **Vetiver has a very high level of tolerance to adverse conditions**
- **Highly Tolerant to High Acidity, Aluminium and Manganese Toxicities**
- **Tolerance to High Soil Salinity and Sodicity**
- **Highly Tolerant to Heavy Metals**

Highly tolerant to acid sulfate soil conditions with pH = 3.0

One year after planting

HIGHLY TOLERANT TO HEAVY METALS

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

This coal mine waste rock dump remains bare after 50 years

One year after planting

This Bentonite waste site is barren with an extremely erodible surface which has low water infiltration and high runoff rates.

With Exchangeable Sodium between 35 % and 48 %

The surface was ripped to 30cm depth for planting

Fourteen months after planting, note the growth of other species

Old gold tailings: Eighteen months after planting to control erosion, brown color due to winter frost

New gold tailings: The dust is highly contaminated with heavy metals such as Arsenic, Copper etc

Vetiver hedges provided a low cost and permanent wind barrier unaffected by strong winds, provided excellent protection for crop establishment

Permanent wind barrier unaffected by strong winds

Bauxite mine: Mine rehabilitation in Venezuela

12. - APPENDICE (Photografies)

photo 24

photo 25

photo 26

photo 27

Copper mine: Mine rehabilitation in Chile

A team of 4 people:

- Tractor driver
- Two planters
- One supplier

Can plant 2400 slips/hour

Thank You