VETIVER SYSTEM FOR THE PREVENTION AND TREATMENT OF CONTAMINATED WATER AND LAND

Paul Truong

Director, The Vetiver Network International,

***Veticon Consulting,* Brisbane, Australia.**

<truong@uqconnect.net>

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.

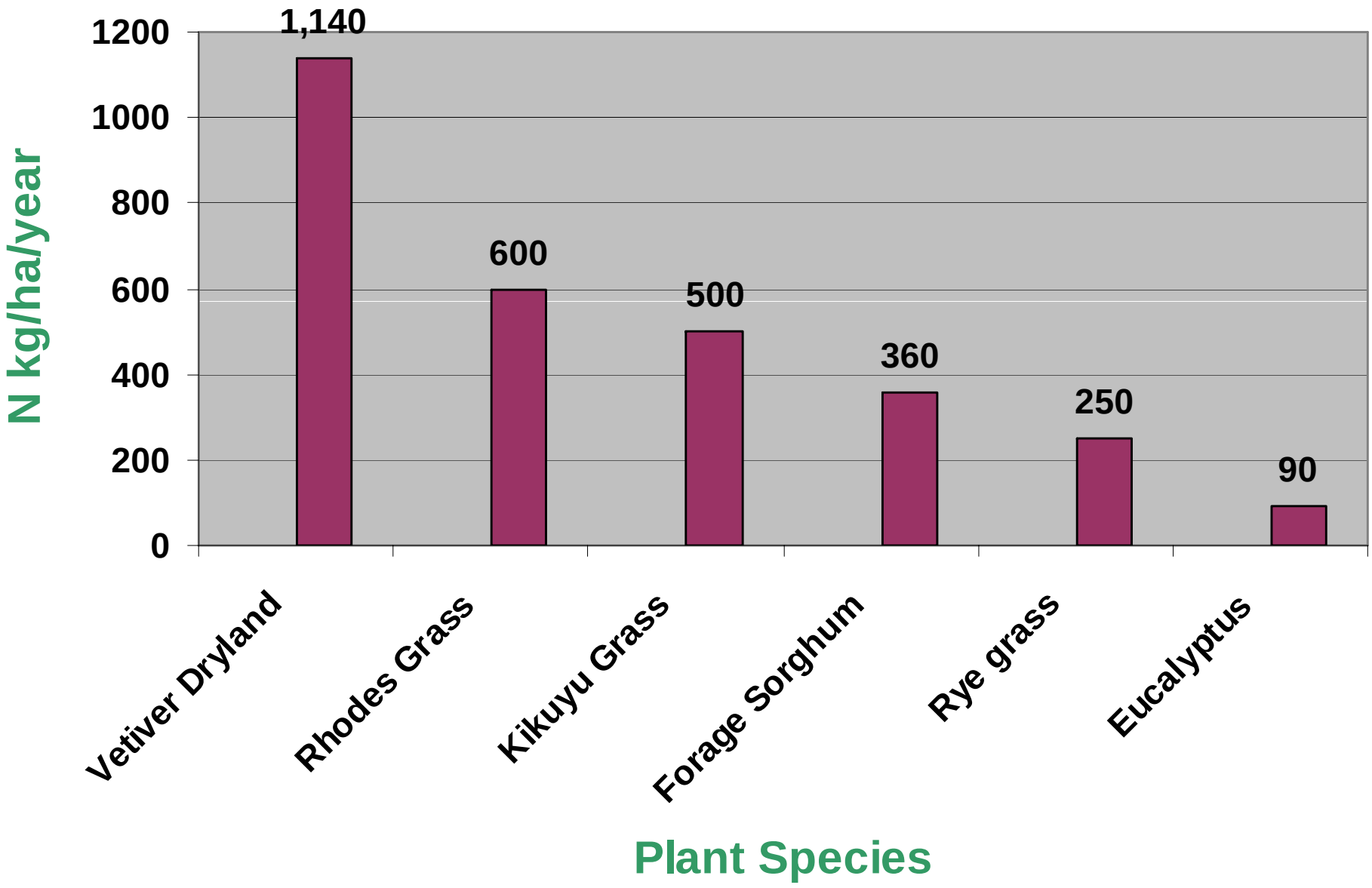
- R&D conducted in several countries showed that vetiver grass is tolerant to the most adverse conditions: high in acidity, alkalinity, salinity and sodicity; heavy metal toxicities and also capable of take up large amount of nutrients in soil and water.

- 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, Latin America and southern Europe.

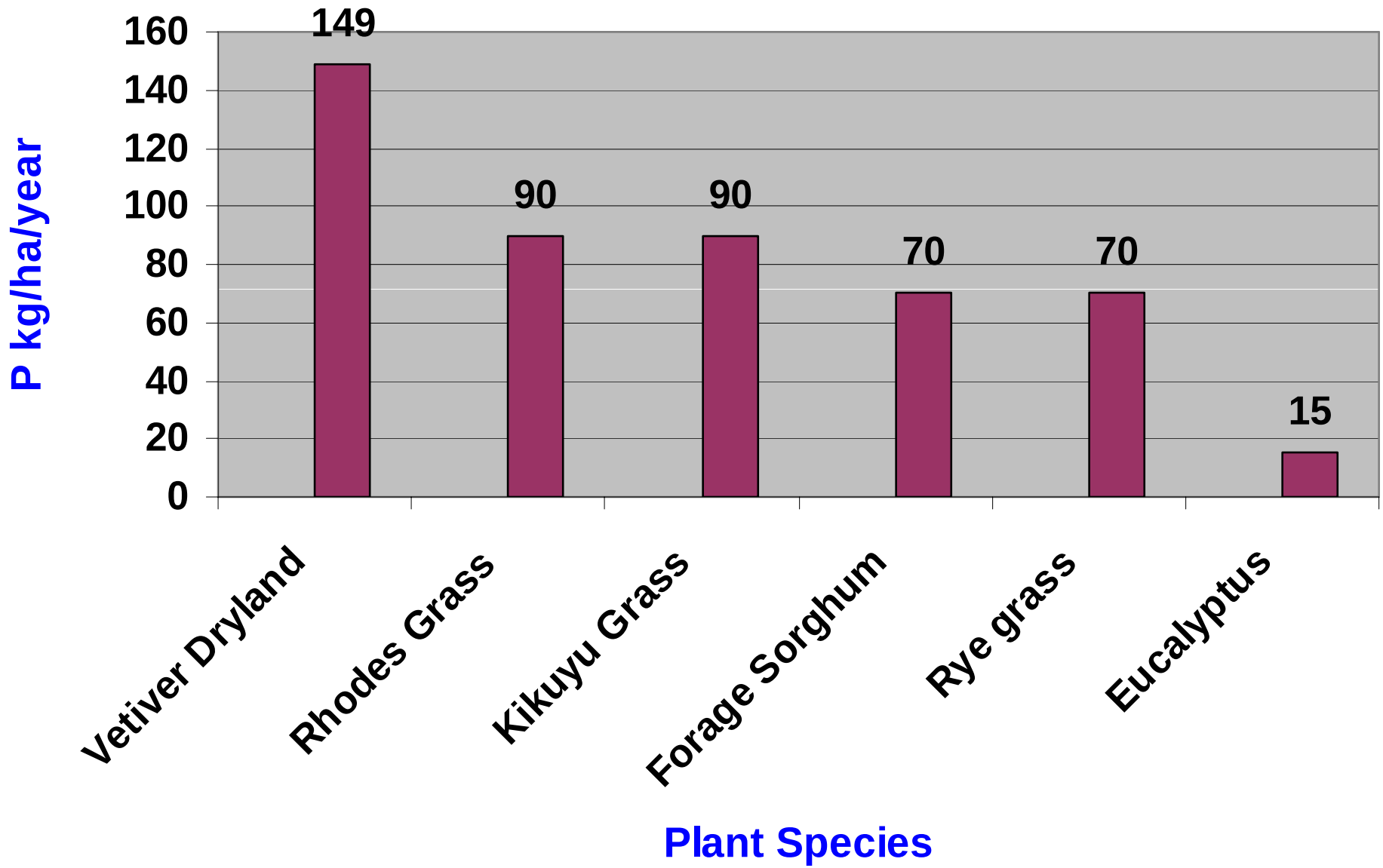
SPECIAL CHARACTERISTICS SUITABLE FOR WASTEWATER TREATMENT

- **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



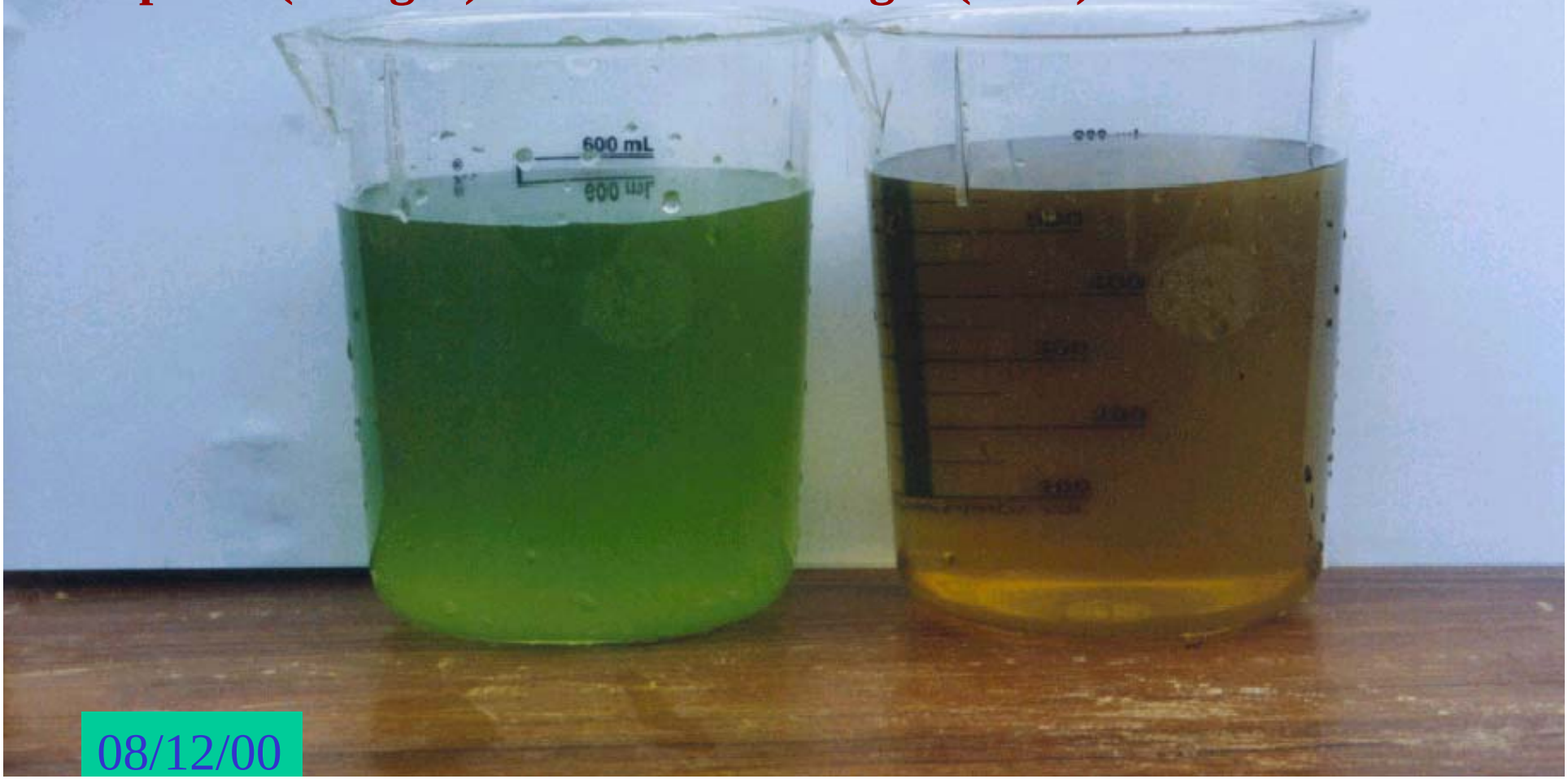
PHOSPHORUS UPTAKE



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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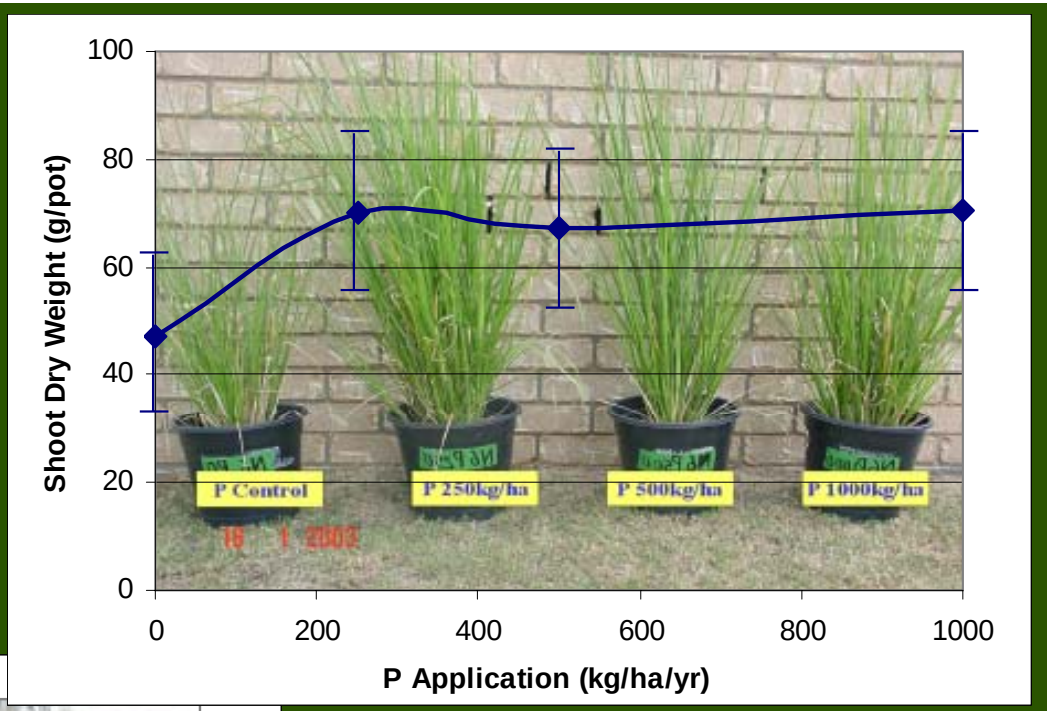
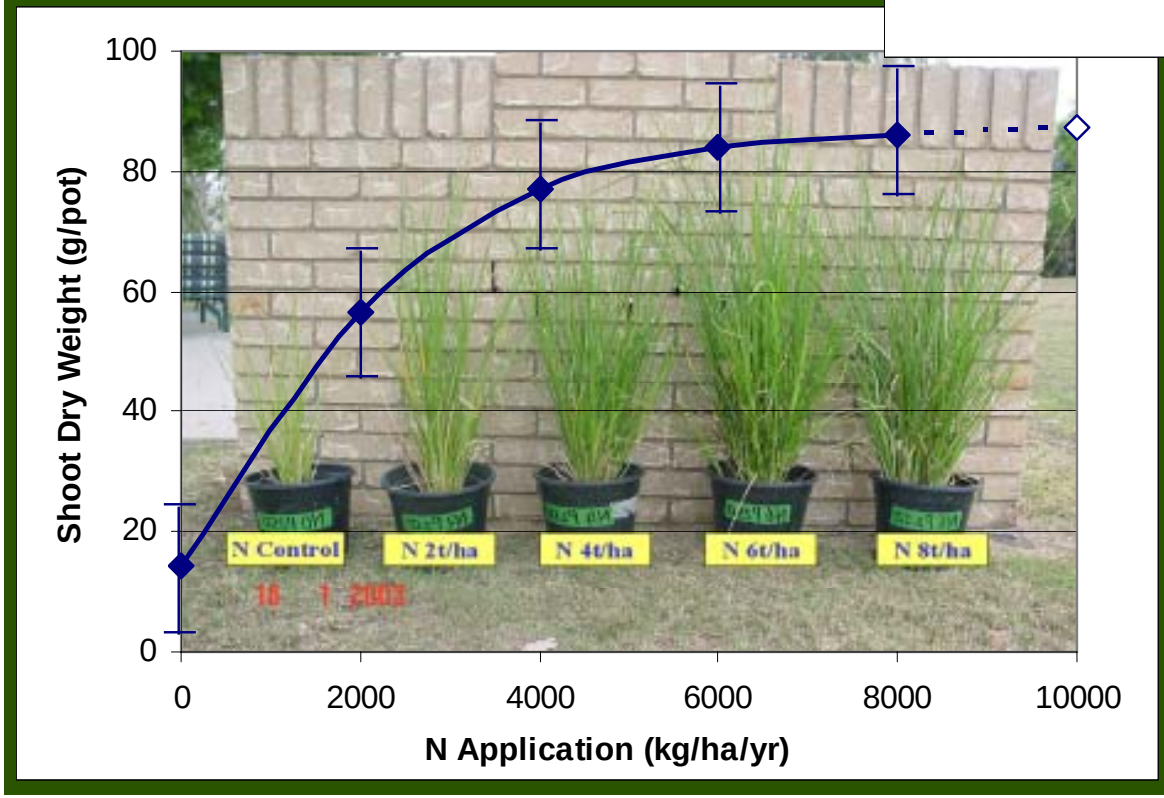
Tolerance to extremely high levels of nutrients



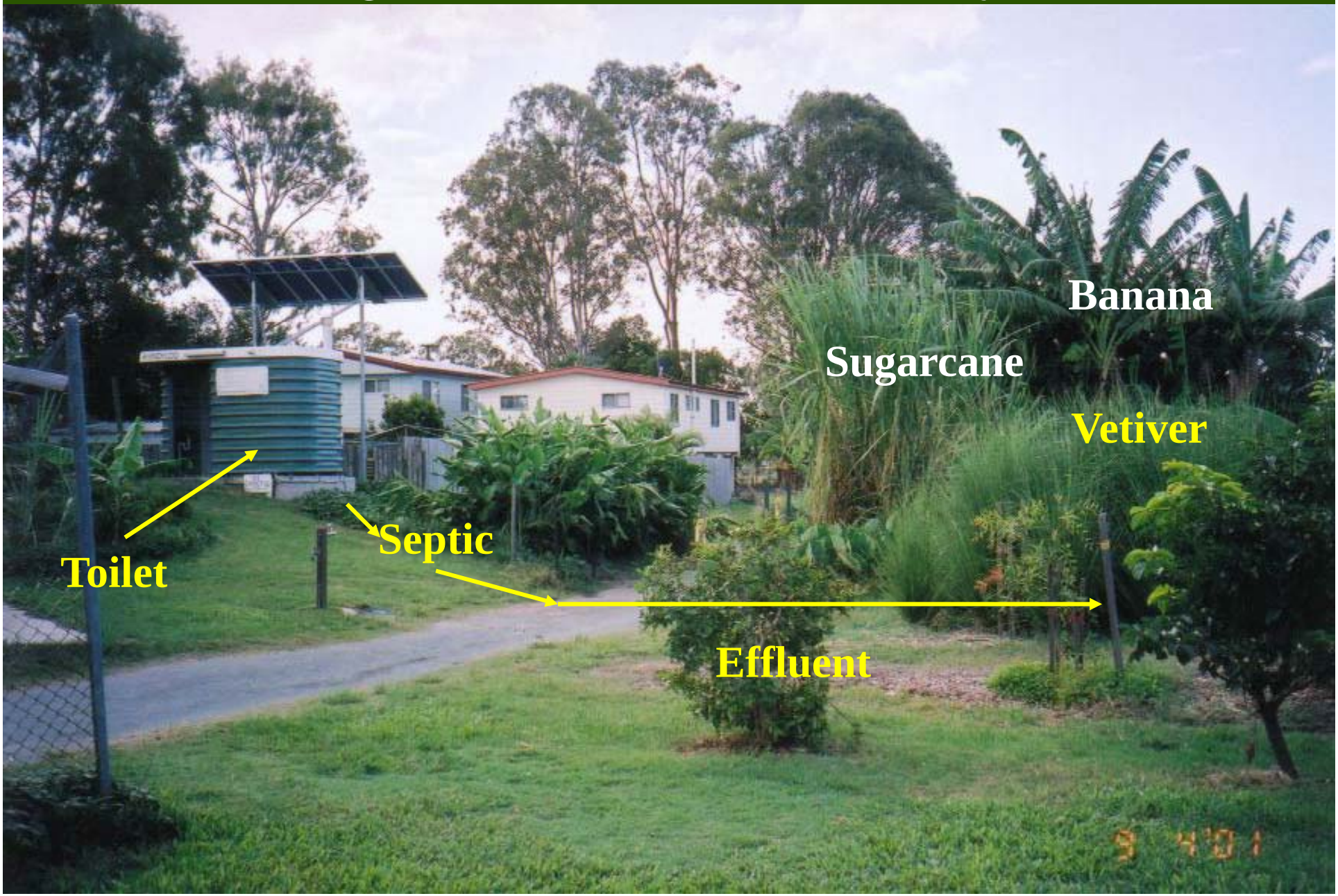


APPLICATION OF VETIVER SYSTEM FOR

EFFLUENT TREATMENT

- ***Domestic effluent***
- ***Municipal sewage effluent***

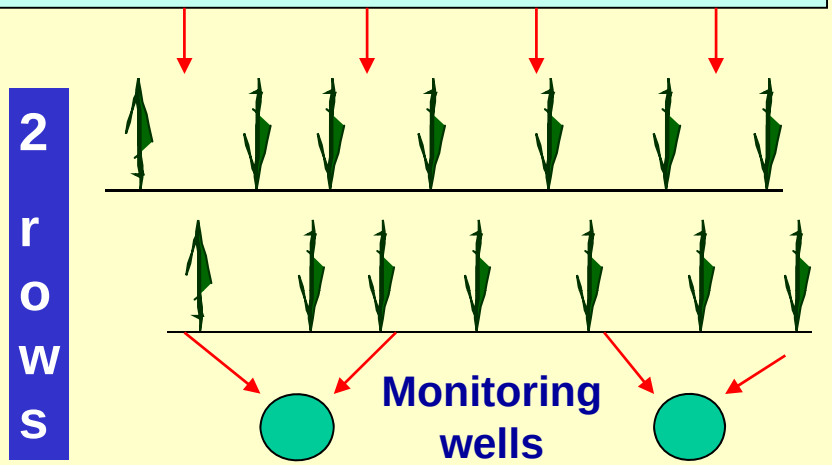
***Domestic effluent* : Vetiver was the most effective plant in absorbing effluent discharge from a toilet block on a Community Center**



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

Effectiveness of vetiver in reducing N level in domestic blackwater

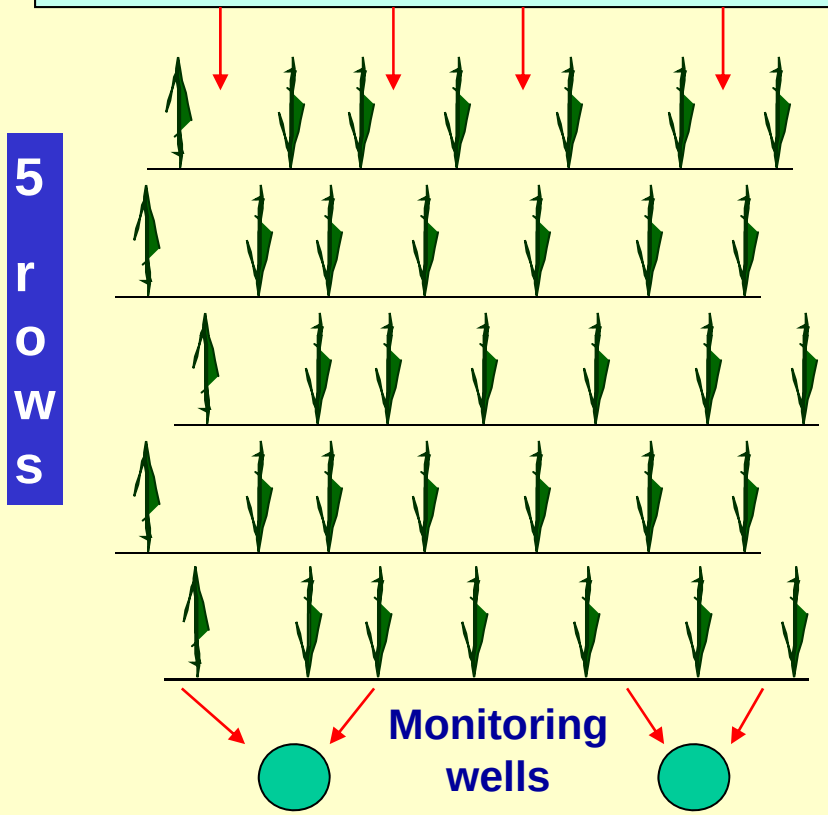
Entry: **Total N level at 95.2mg/L**



Exit: **Total N level at 16mg/L**

or a reduction of 83%

Entry: **Total N level at 95.2mg/L**

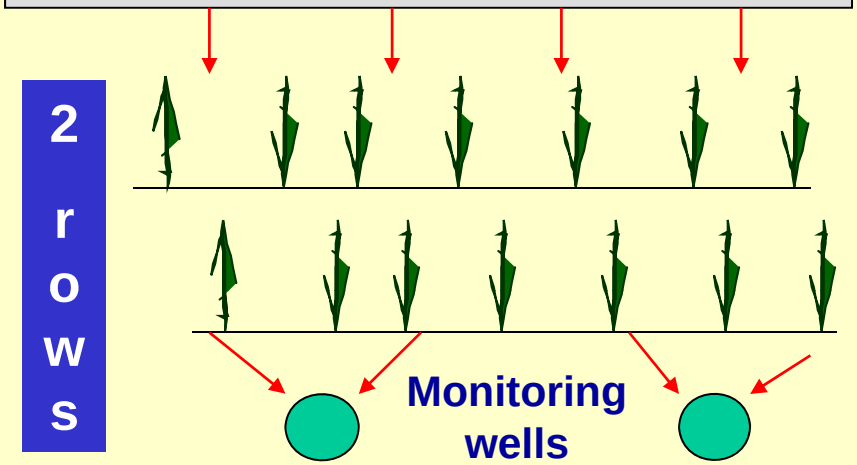


Exit: **Total N level at 1.2mg/L**

or a reduction of 99%

High capacity for P absorption in domestic sewage in Australia

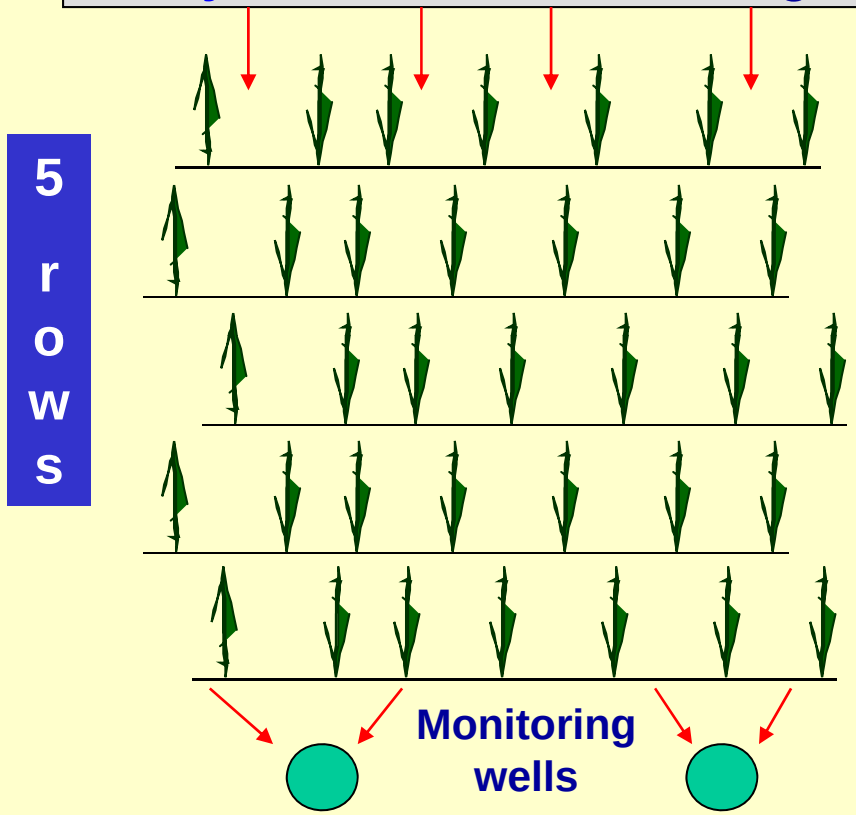
Entry: **Total P level at 1.3mg/L**



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%

Treatment Strategy

Treatment in two phases:

- Pre treating effluent in storage pond with vetiver pontoons and pond edges
- Ephemeral Wetlands to treat the main body of effluent to ANZECC recommended level of 10mg/L for N and 1mg/L for P.

Municipal Effluent Treatment in Australia

First step:
Hydroponics treatment of effluent in ponds

Second step: Ephemeral Wetland treatment of municipal sewage effluent in Australia

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

PC: Vant Hoff

Domestic Sewage Disposal

Aceh, Indonesia

American Red Cross built 2 000 units and will built another 1500 in 2 009

Sewage Disposal

High School, Aceh, Indonesia

Sewage Disposal

Oberoi Resort
Bali, Indonesia

PC: Vant Hoff

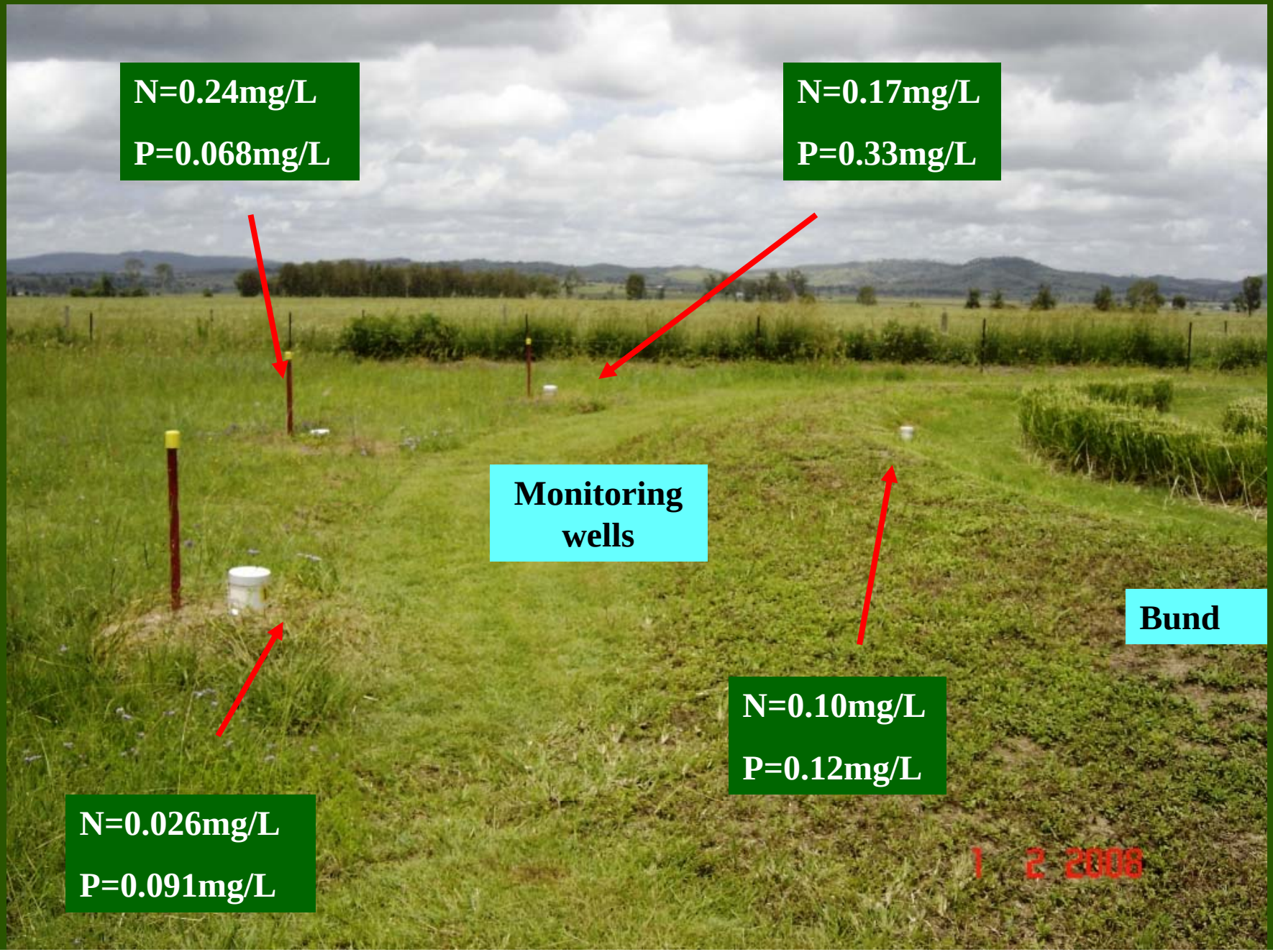
Hydroponics treatment of intensive animal farm effluent

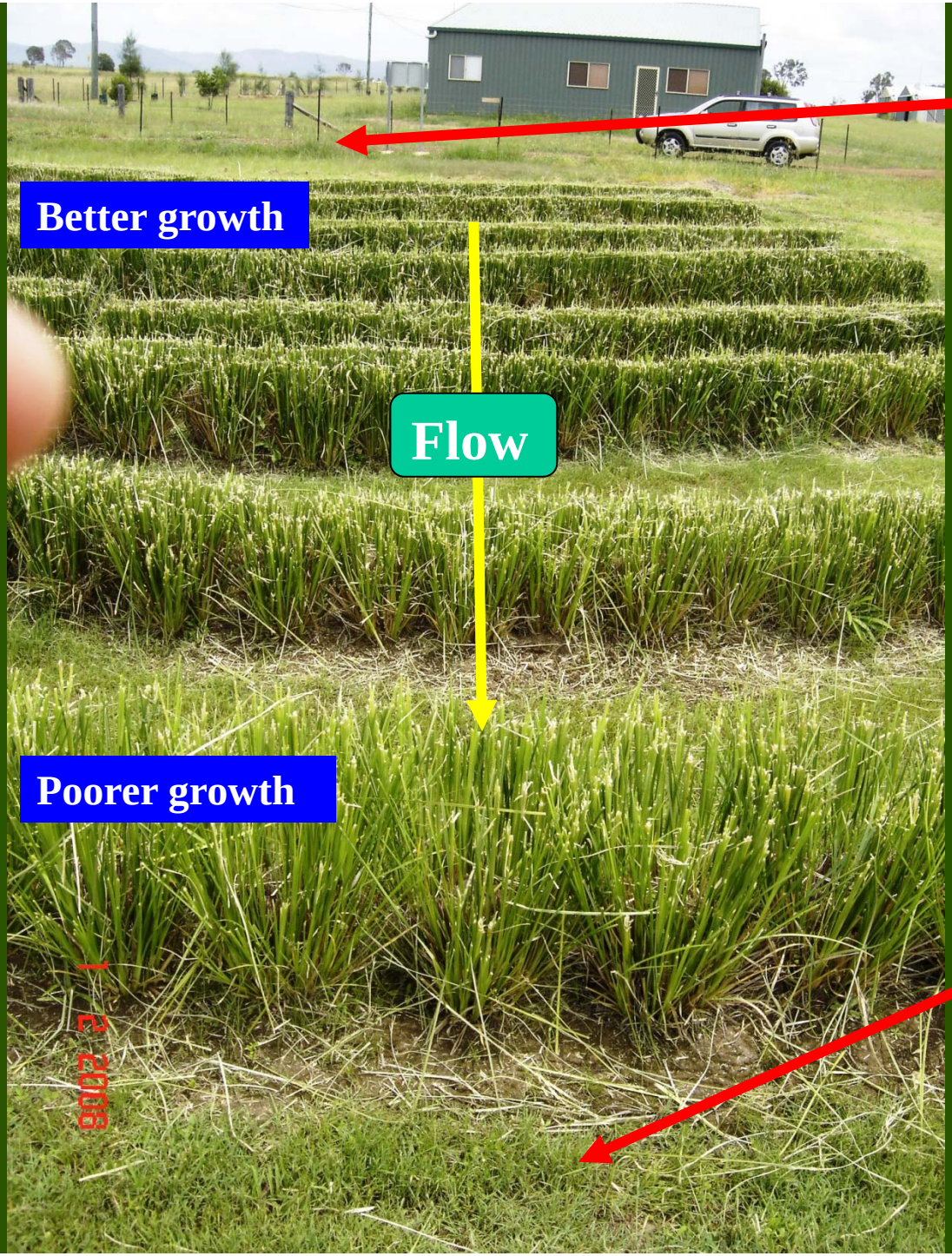
APPLICATION OF THE VETIVER SYSTEM FOR SEWAGE EFFLUENT TREATMENT

Vetiver was planted to dispose sewage effluent from a small recreational airfield in Queensland, Australia

Third year:
Excellent growth, exceeding 2m.

Monitoring wells and nutrient levels (May 2008)





IN FLOW

Average daily flow: 1 670L

Average total N: 68mg/L

Average total P: 10.6mg/L

Average Faecal Coliform:>8 000

SUMMARY

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

APPLICATION OF THE VETIVER SYSTEM FOR LANDFILL LEACHATE TREATMENT

Leachate Seepage Control

Landfill Leachate Seepage Control

Leachate after rain on the side slope of an 30 year old landfill

This leachate runoff is highly contaminated with Chromium, Cadmium, Copper, Lead and Zinc. It will eventually run into a nearby creek

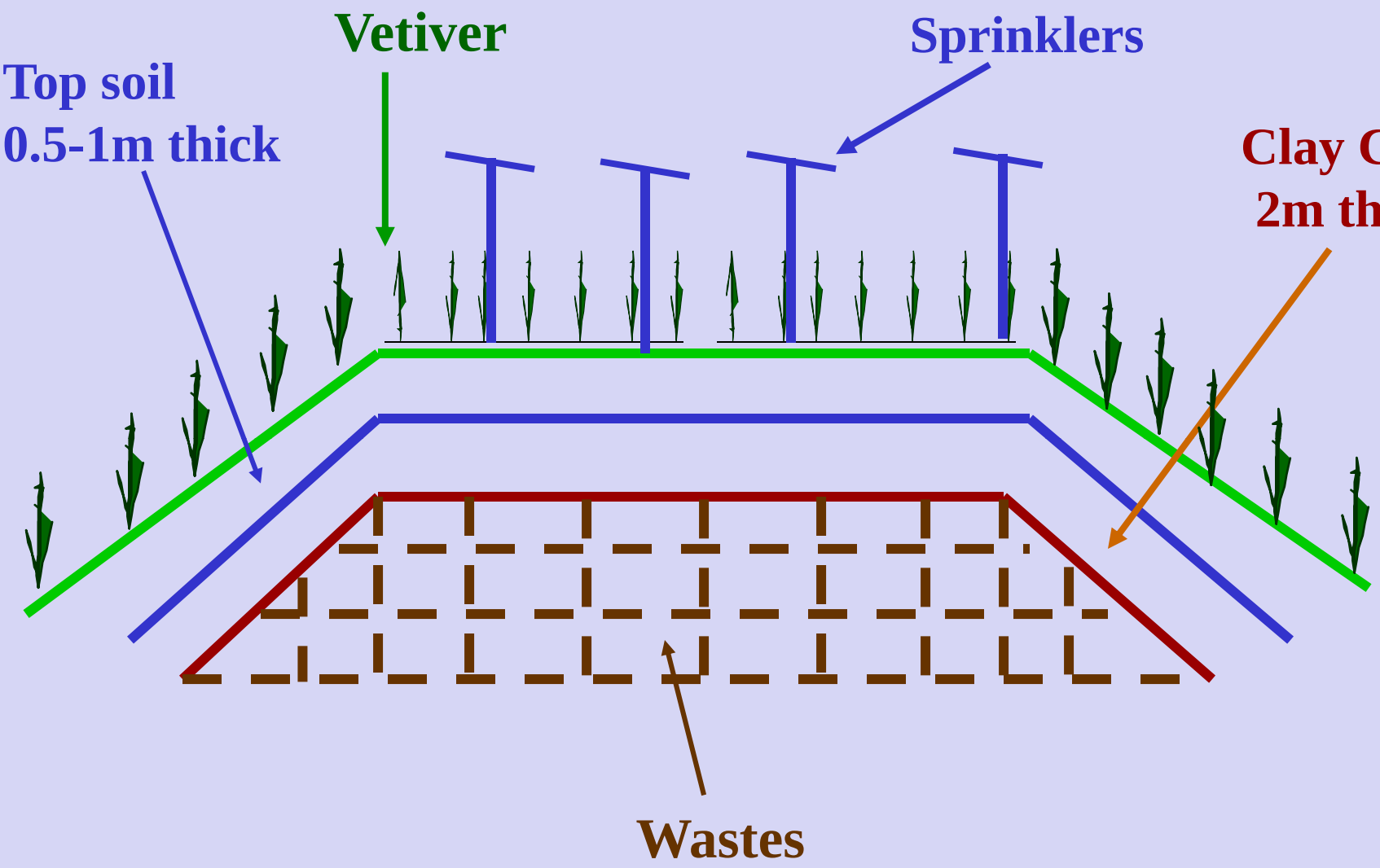
Landfill Leachate Seepage

Twelve months after planting, excellent growth, unaffected by heavy metals contamination in the leachate.

Within a year vetiver has completely stopped the leachate seepage

APPLICATION OF THE VETIVER SYSTEM FOR LANDFILL LEACHATE TREATMENT

Leachate disposal



Diagrammatic cross section of the mound at Stotts Creek Landfill, Muwillumbah

Landfill Leachate Disposal

Irrigated with leachate after planting each day

Three months after planting: good growth and establishment

Vetiver growth was over 3m in the second summer

Growing in highly saline and polluted leachate pool

Landfill Leachate Disposal

Ten months after planting

Fifteen months after planting and full flower in autumn

Phytoremediation Contaminated Land:

This Explosive factory, Australia is highly contaminated with Nitrate and NH3:

- **Soil total N up to 5 400mg/kg**
- **Soil total NH3 up to 1 220mg/kg**
- **Water total N up to 18 300mg/kg**
- **Water total NH3 up to 12 300mg/kg**

Contaminated Lands

Two months after planting

One year after planting

Mining Waste Rehabilitation

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

Mining Waste Rehabilitation

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

Heavy Metals	Threshold levels in soil plant ($mgKg^{-1}$)		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

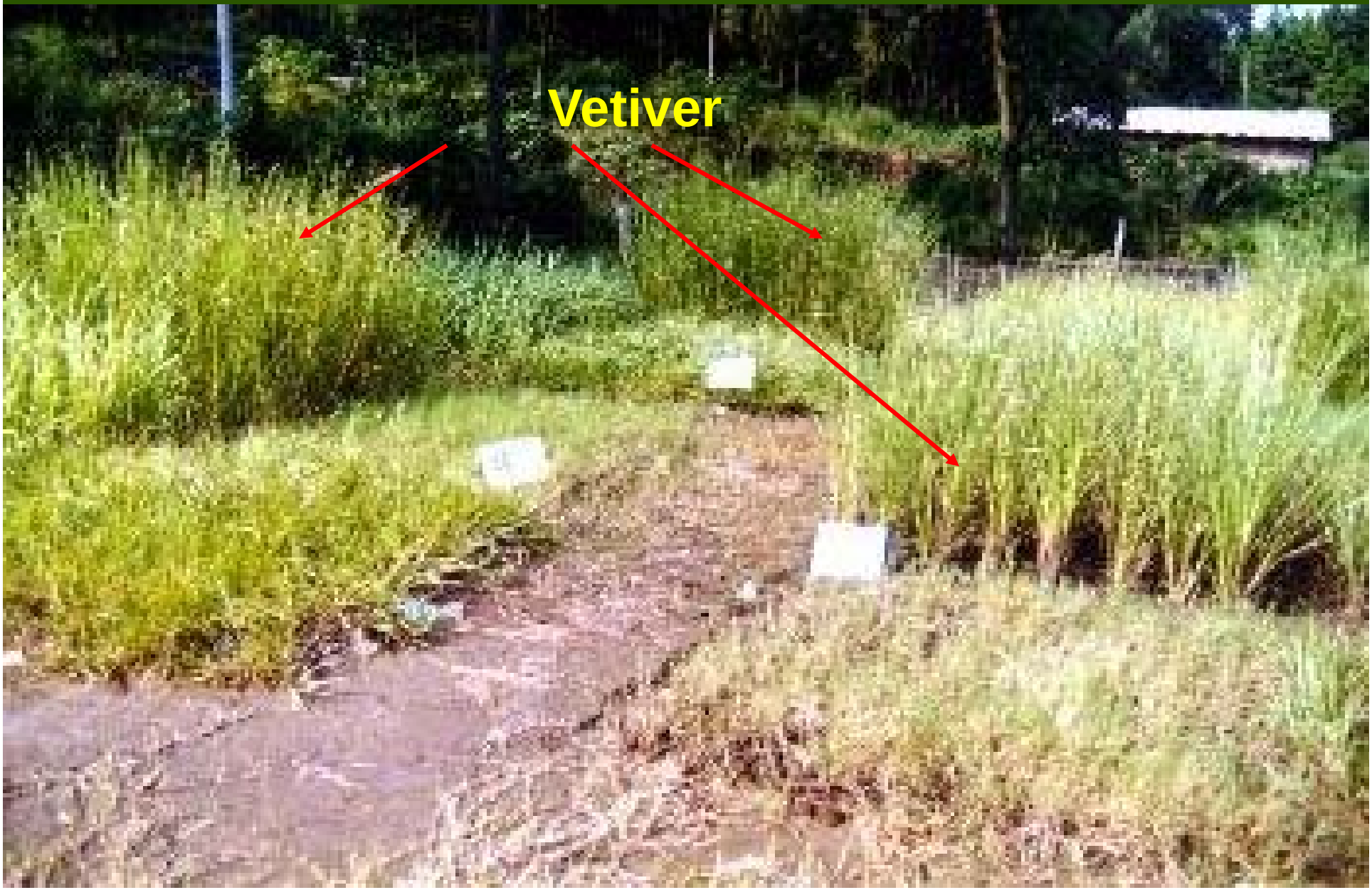
As these rigid and expensive fences are useless against high wind velocity

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

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)

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