Water, Water Conservation, Wastewater, & Climate Change and Melting Glaciers

World Water Day at
at
GNA University, Phagwara
(March 22, 2017)

M.P. Singh

Earthizenz Eco-Friendly Systems

B. Tech.(Civil); M.I.E. (Mech.)

Email:earthizenz@gmail.com

Environment: Climate Change

- Over the years the world has experienced a phenomenon called Global Warming.
- This has been attributed to Green House Gas Emission
- A few GHGs have been identified and their Global Warming Potential have been assigned a value.

- NEW DELHI: India formally joined the Paris Climate Change Agreement by submitting its **instrument of ratification+** at UN headquarters in New York on Sunday October 2, 2016 - the birth anniversary of Mahatma Gandhi.

  The instrument of ratification was deposited by India's permanent representative to the UN, Syed Akbaruddin.

Why so much noise about Carbon?

- All Green House Gas emissions are measured in terms of Tonnes of Carbon Dioxide Equivalent tCO_2e.
- The reverse of emission is **Carbon Sequestration**.
- Meaning Carbon being taken back into the earth
- In 2005 Clean Development Mechanism was implemented through the UNFCC* under the Kyoto Protocol. Countries like USA and Australia did not participate.

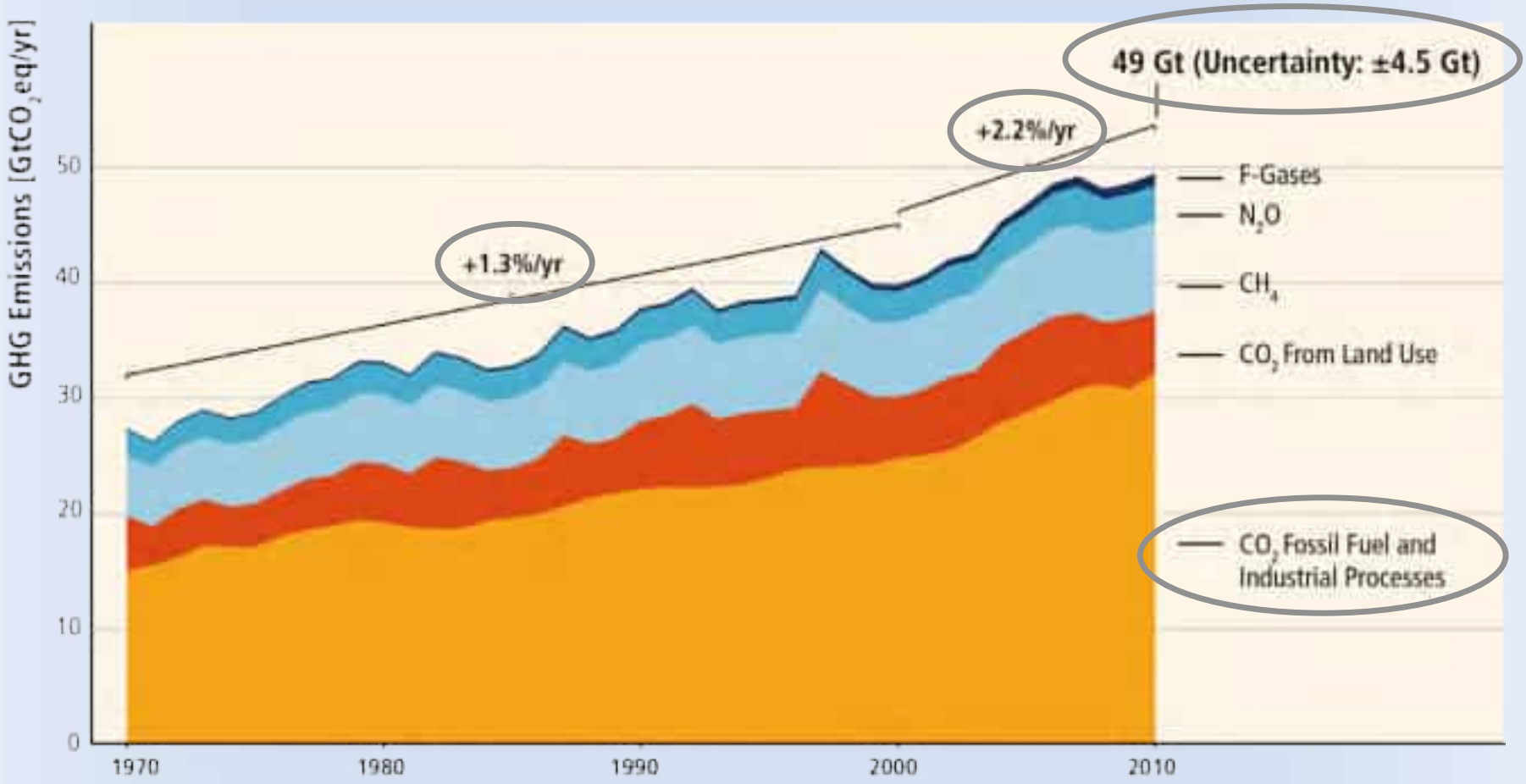
*United Nations Framework Convention on Climate Change.

IPCC Reports

- Starting 1988, when the First Assessment Report of IPCC* was released, there have been four more.
- The fifth one coming in 2014.
- Initially Emission Reduction was considered enough to neutralize Climate Change.
- Now we are talking of *Mitigation, Adaptation, Risk Assessment and Climate Change Proofing*

*Intergovernmental Panel on Climate Change

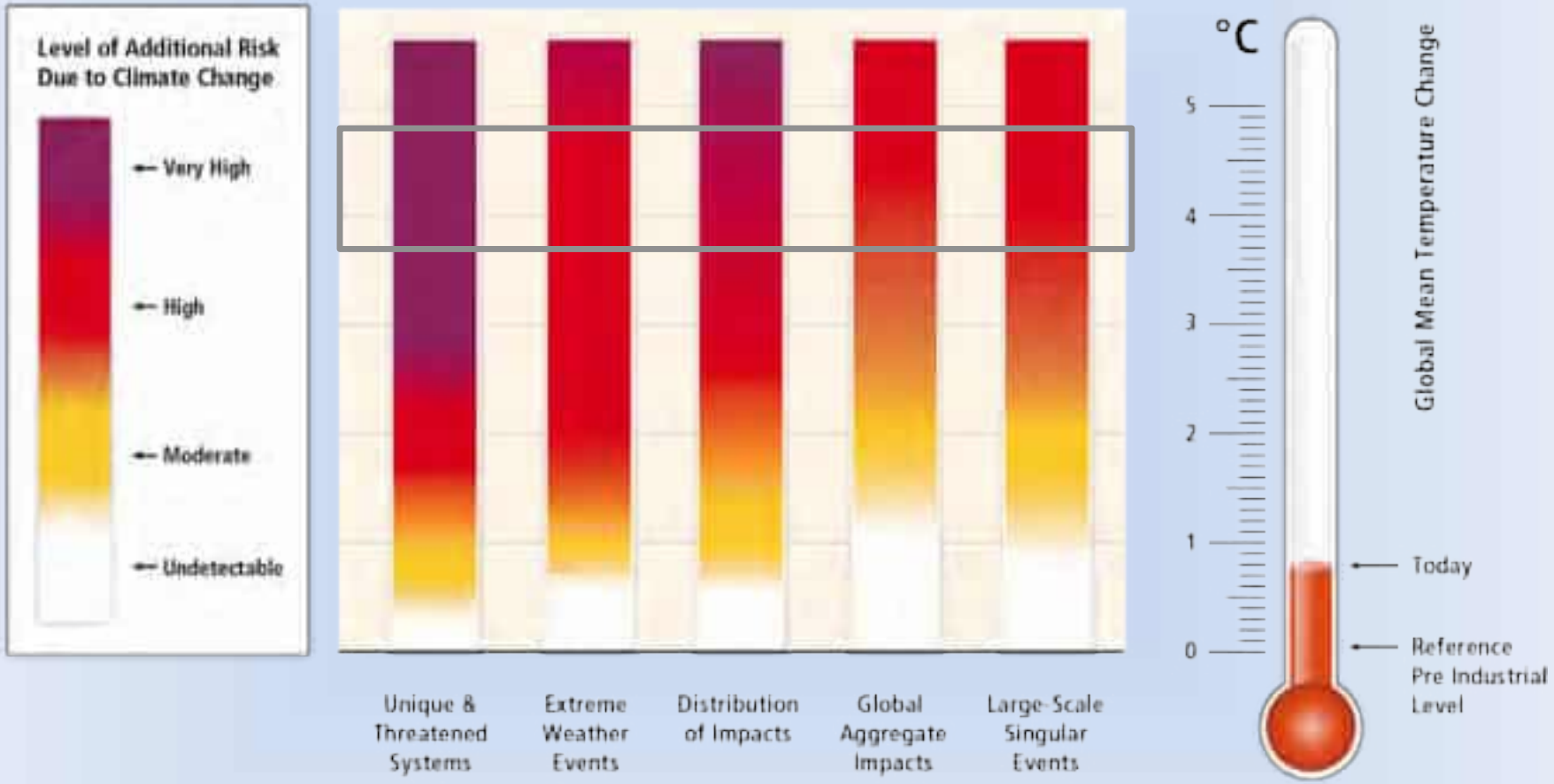
GHG emissions growth between 2000 and 2010 has been larger than in the previous three decades.



Based on Figure SPM.1

Courtesy IPCC AR5

Without additional mitigation, global mean surface temperature is projected to increase by 3.7 to 4.8°C over the 21st century.



Based on WGII AR5 Figure 19.4

Courtesy IPCC AR5

World Water day Themes over the Years: 1993 to 2016

- 1993: “Water for Cities”.
- 1994: “Caring for our Water Resources is Everybody’s Business”.
- 1995: “Women and Water”.
- 1996 was “Water for Thirsty Cities”.
- 1997 was “The World’s Water: Is there enough”.
- 1998 was “Groundwater – The Invisible Resource”.
- 1999 was “Everyone Lives Downstream”.
- 2000 was “Water for the 21st century”.
- 2001 was “Water for Health”.
- 2002 was “Water for Development”.
- 2003 was “Water for Future”.
- 2004 was “Water and Disasters”.
- 2005 was “Water for Life 2005–2015”.
- 2006 was “Water and Culture”.
- 2007 was “Coping with Water Scarcity”.
- 2008 was “Sanitation”.
- 2009 was “Trans Waters”.
- 2010 was “Clean Water for a Healthy World”.

World Water day Themes over the Years: 1993 to 2016 contd

- 2011 was “Water for cities: responding to the urban challenge”.
- 2012 was “Water and Food Security”.
- 2013 was “Water Cooperation”.
- 2014 was “Water and Energy”.
- 2015 was “Water and Sustainable Development”.
- 2016 was “Water and Jobs”.
- **2017 is “Wastewater”.**
- **2018 would be “Nature-based Solutions for Water”.**

- **These themes were decided much in advance. At that stage it was not imagined that Climate change would have such a devastating effect.**

Climate Change & the Melting Himalayas

Climate Change is wreacking havoc in the himalayas and glaciers are in retreat across the range. This and many other climate change effects are threatening the lives othe people and biodiversity of the region.

Climate Change & the Melting Himalayas

A significant climate change impact on the Himalayas is the formation of a large number of glacial lakes. Due to an increase in the rate at which ice and snow melt; the accumulation of water in these lakes has been increasing rapidly.
If the rubble dams holding back the waters were to break, a tsunami of water, mud, ice and rubble will sweep down the valleys.
Such events can have devastating consequences to infrastructure - such as washing away roads and bridges, severely damaging dams and hydropower stations - and communities living downstream by washing away fields, livestock, houses and people.

Presentation Purpose

- To introduce a system that would not only mitigate Climate Change effects, but would take care of, and adapt to the climate change an also plug the risk of future disasters.
- The following slides will tell us how The Vetiver System is one such system, that would, on the one hand speed up the ongoing projects, and prevent future tragedies due to landslides, coastal Tides and other calamities, on the other. In doing so, it would conserve the soil & water within the ground.
- Civil engineering interventions are not only expensive, but have other negativities wrt CDM projects.
- The Vetiver System is largely a bio-engineering intervention.
- We have the fullest support of the The Vetiver Network International.
- Most of the technical examples in this presentation are from the techinical experiences in India and in over fifty countries in the world.
- Vetiver is an Indian Plant and it is a particular sterile and non-invasive South Indian Variety,***(Vetiveria Zizanioides)*** that is being used all over the world.

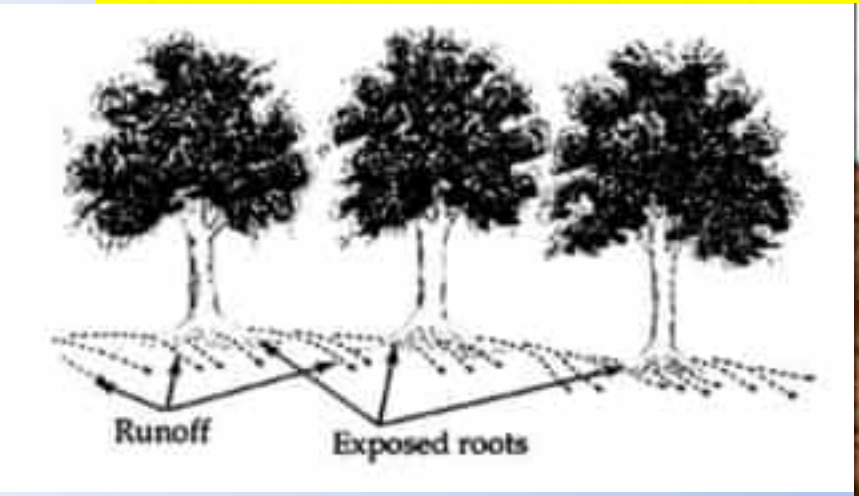
Previous Background

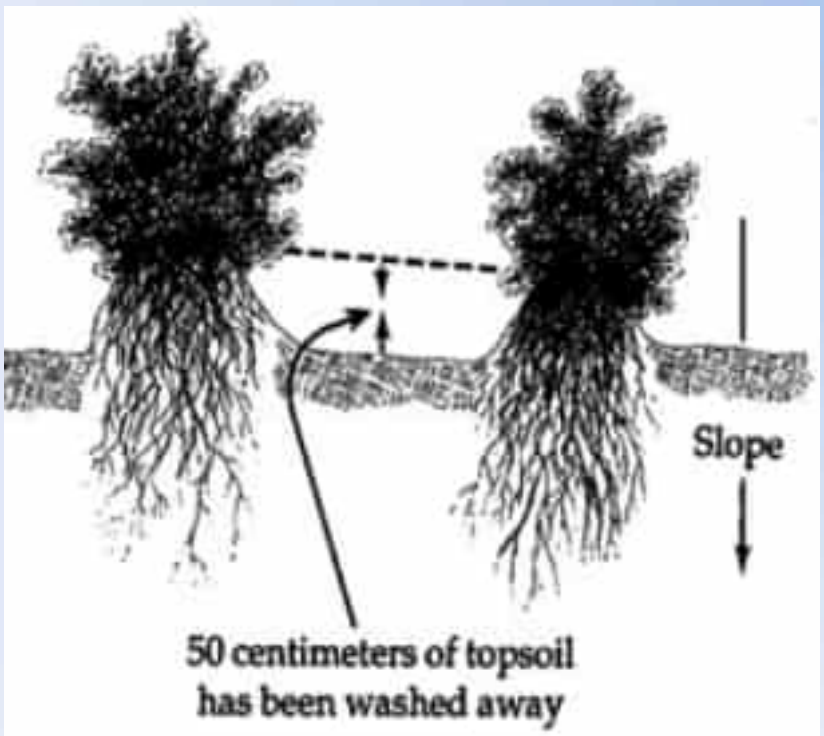
- Richard Grimshaw and John Greenfield re-introduced the Vetiver grass to its mother country, India, as part of an effort initiated by The World Bank here in India, in the 1980s.
- Today, the rest of the world is way ahead of us in understanding our own plant.
- The entire world uses the Vetiver System, we have just about begun.
- In the last 8-10 years we have started believing in our own past and have adopted this system.
- Most of the technical examples in this presentation are from a manual authored by John Greenfield, but is backed up by experience all over the world, including India
- I have , over the last 12 years pooled in a little experience of my own, in certain works, where Dick Grimshaw, Paul Truong and other colleagues from TVNI have helped with their respective experiences.

SHEET EROSION

- Under normal conditions, sheet erosion is not recognized and therefore is seldom treated.
- However, triggered by torrential rainfall, sheet erosion accounts for the loss of thousands of lives through mud slides and landslides, and the loss of billions of tons of soil every year.
- This runoff further strips unprotected areas of their valuable topsoil.
- Major Erosion problems, including landslides, destruction of infrastructure, uprooting o plants and trees follow after this

Results of sheet erosion





THE VETIVER SYSTEM

The Vetiver System Can

- Stop Soil Erosion
- Slow down Water runoff
- In so doing, recharges water into the ground
- Stop fertile Top Soil from running off
- Hasten the Growth of trees & vegetation
- Hence, initiate the process of Reforestation and revegitation
- Protect Infrastructure like roads, dams, aquaducts, bridges
- Protect canal channel and river slopes
- Repair rain cuts, gullies and canyons
- Over a period, enables the terrain to survive long spells of drought
- After doing all this , its Carbon Sequestering capabilities are much more and more permanent than most other species, giving speed & impetus to the AR CDM Projects.

THE VETIVER SYSTEM

The Plant

(Vetiveria Zizanioides)

THE ROOT

Excavated root.
Average tensile root strength 75 Mpa

Longitudinal section through hedge profile
This type of root mass will improve soil shear strength by up to 39%
Can go upto 3 meters deep

DIAMETERS &TENSILE STRENGTHS OF SOME ROOTS OF GRASSES

Grass	Mean diameter of roots (mm)	Mean tensile strength (MPa)
Late Juncellus	0.38±0.43	24.50±4.2
Dallis grass	0.92±0.28	19.74±3.00
White Clover	0.91±0.11	24.64±3.36
vetiver	***0.66±0.32***	***85.10±31.2***
Common Centipede grass	0.66±0.05	27.30±1.74
Bahia grass	0.73±0.07	19.23±3.59
Manila grass	0.77±0.67	17.55±2.85
Bermuda grass	0.99±0.17	13.45±2.18

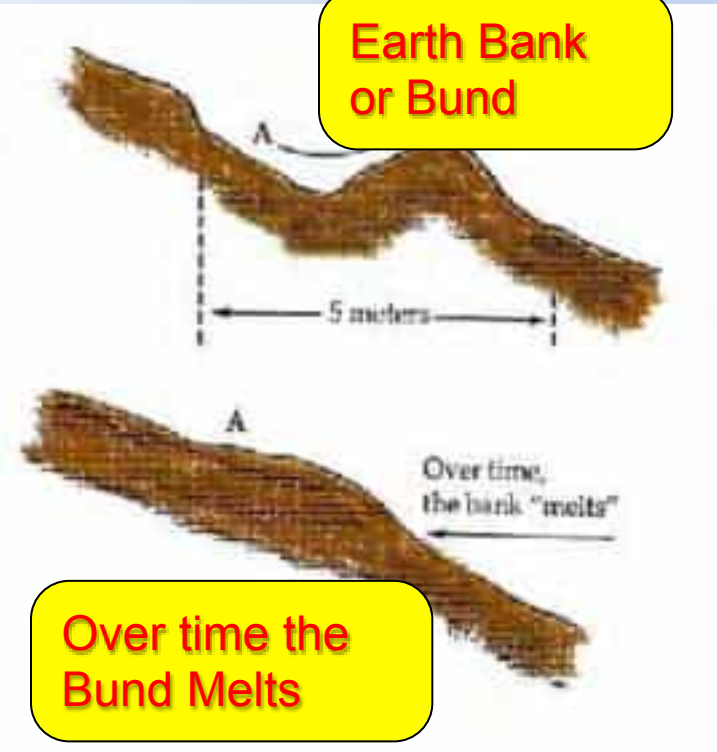
Hengchaovanich and Nilaweera (1996)

The Vetiver Grass Special Characteristics

- Grows under extreme and wide range of conditions
- Is native to India (South Indian Genotypes used globally)
- Long Living Perennial Grass
- Air temperatures: -15 º C to >55º C
- Soil pH from <3 to >10
- Annual Rainfall <300 mm to > 5,000 mm
- Tolerant to all heavy metals
- Saline tolerant (salinity threshold ECse = 8 dSm-1)
- Tolerant to long and total submergence in water (3months)
- Fire tolerant
- Resistant to most pests and diseases
- Powerful (75 Mpa root strength) and deep root system
- Non competitive and non invasive. According to the PIER level of invasiveness criteria, non fertile vetiver cultivars are rated – 8.
- An acceptable level for plant importation by the most strict countries is +1

Vetiver System Technology

The technology comprises a hedgerow of vetiver grass planted on the contour

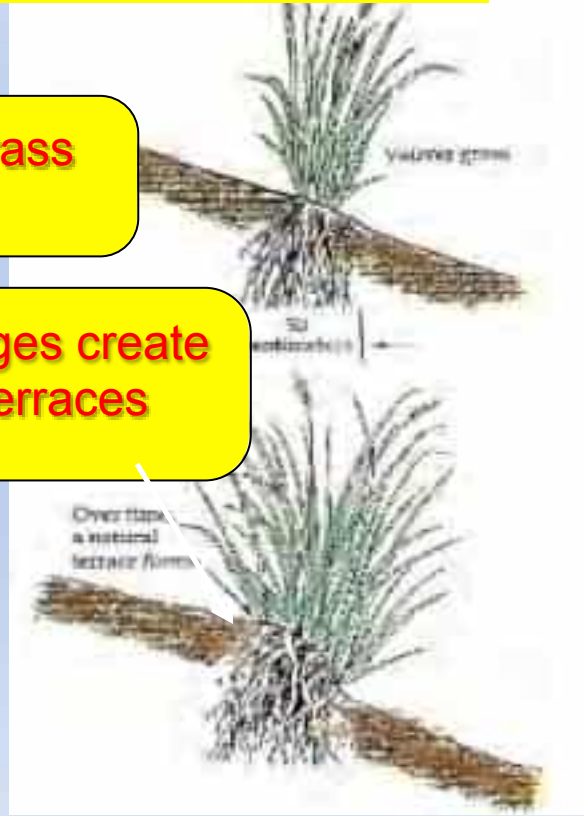


Earth Bank or Bund

Over time the Bund Melts

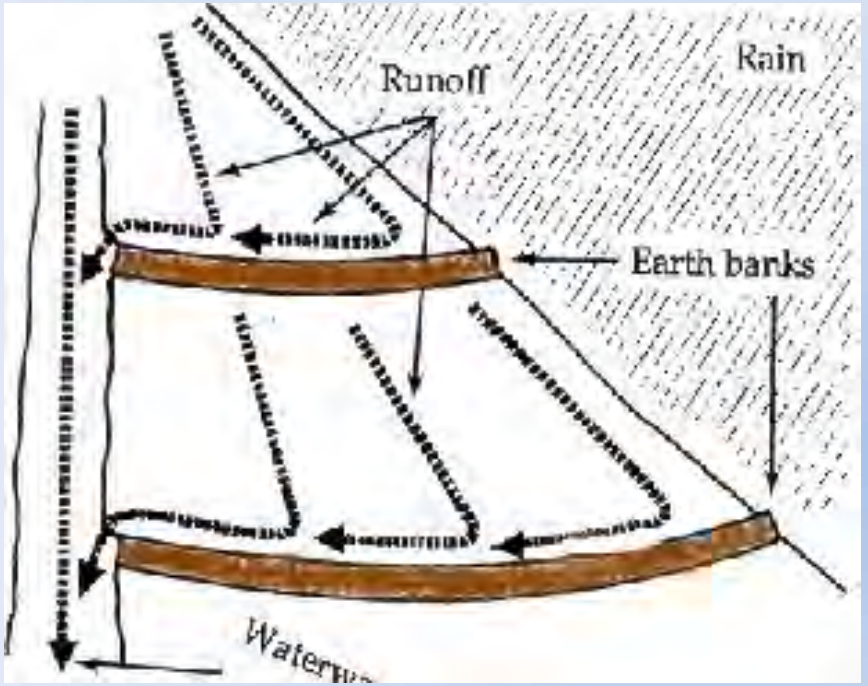
Vetiver grass

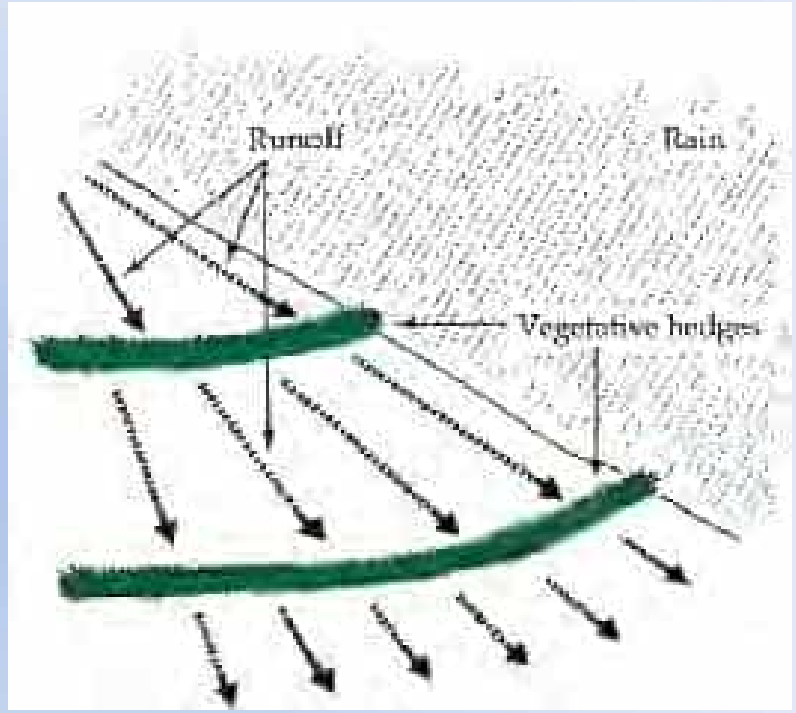
Vetiver Hedges create bunds and terraces over time.



Note that the width of a hedgerow is just 30cm, whereas space required for an earthen bund is in meters

VS Technology Contd…





Banks divert the entire water

Vetiver hedges slow the runoff to increase infiltration,
and some water remains behind and slowly percolates *(Greenfield 1989)*

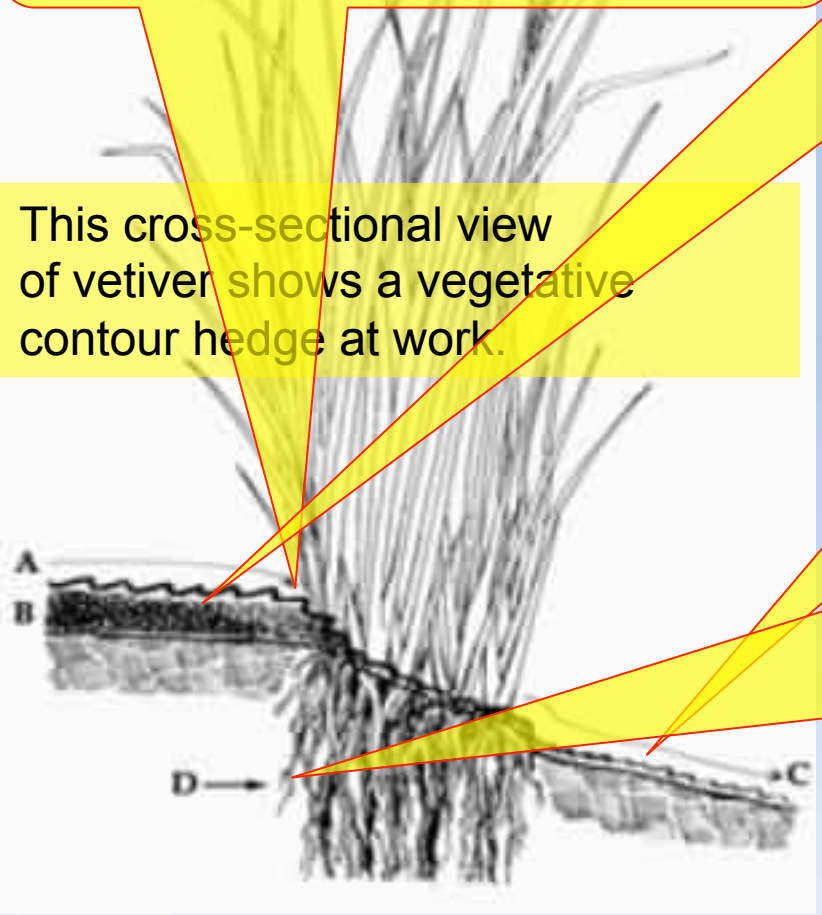
VS Technology Contd…

The leaves and stems of the vetiver plant slow the silt-loaded runoff at A

Reduced Velocity causes it to deposit the silt behind the plant at B

while the water continues down the slope at C at a much slower pace.

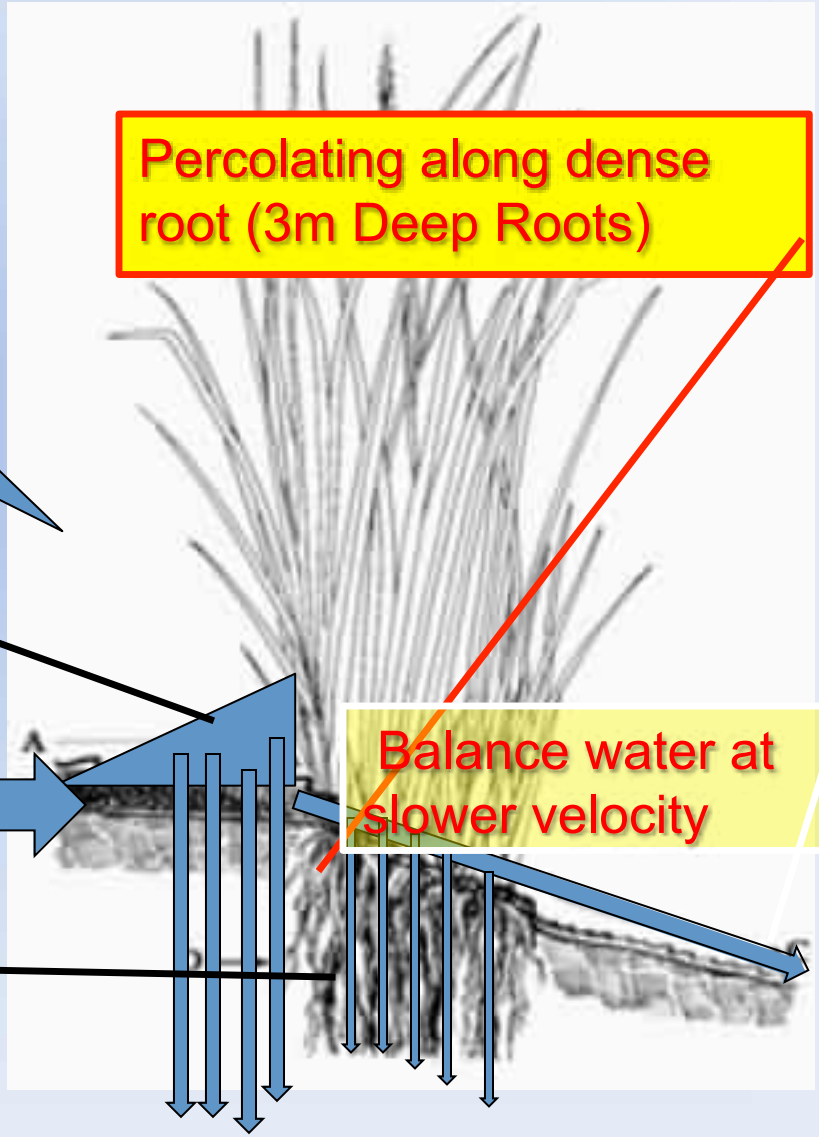
This cross-sectional view of vetiver shows a vegetative contour hedge at work.



The Plant's spongy root system, pictured at D, binds the soil beneath the plant to a *depth of up to 3 meters*.
forming a dense underground curtain that follows the contour of the land, the roots prevent rilling, gullying, and tunneling.

VS Technology : Water conservation

Water Conservation and natural water harvesting, without physical intervention



Back water retained

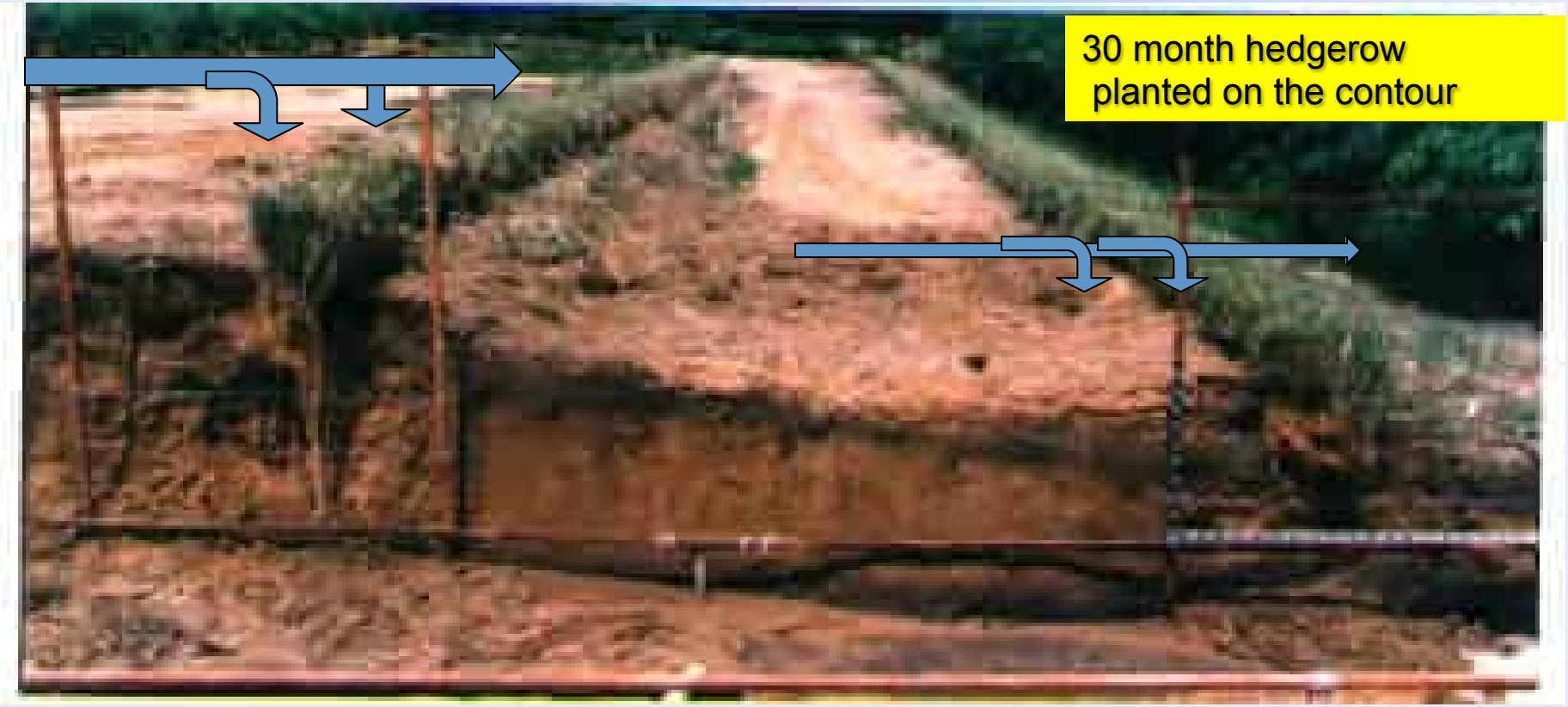
Run off water

Percolating water, recharging the ground

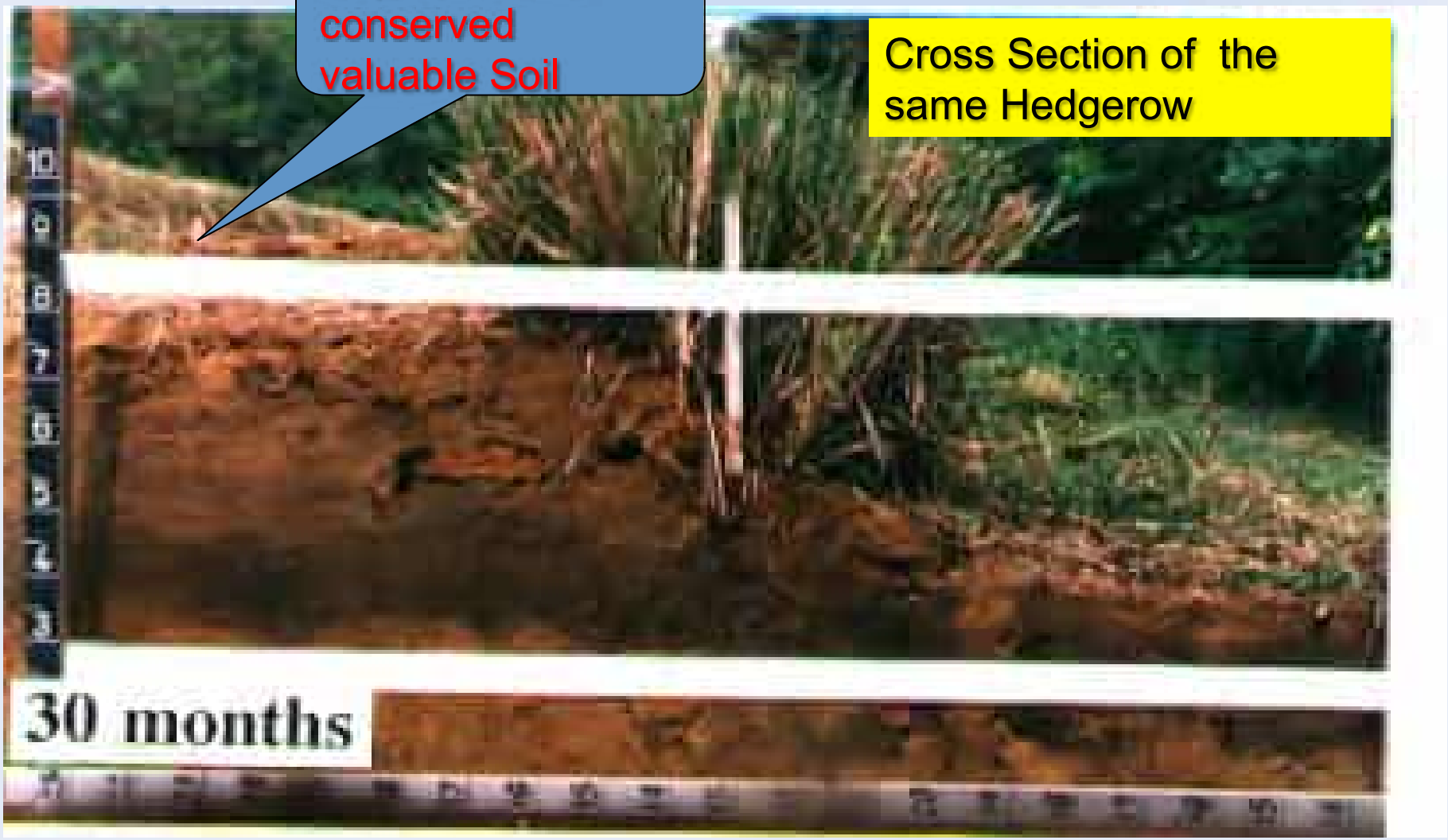
VS Technology Contd…

Four things happen

1. Velocity of water reduces
2. Soil is deposited on the upstream side as the down arrow shows.
3. Some water stays back as backwater to percolate down along the vertical roots of the VS Hedgerow, as the down arrows show.
4. Balance water, with reduced velocity flows through



THE VETIVER GRASS TECHNOLOGY CONTD…



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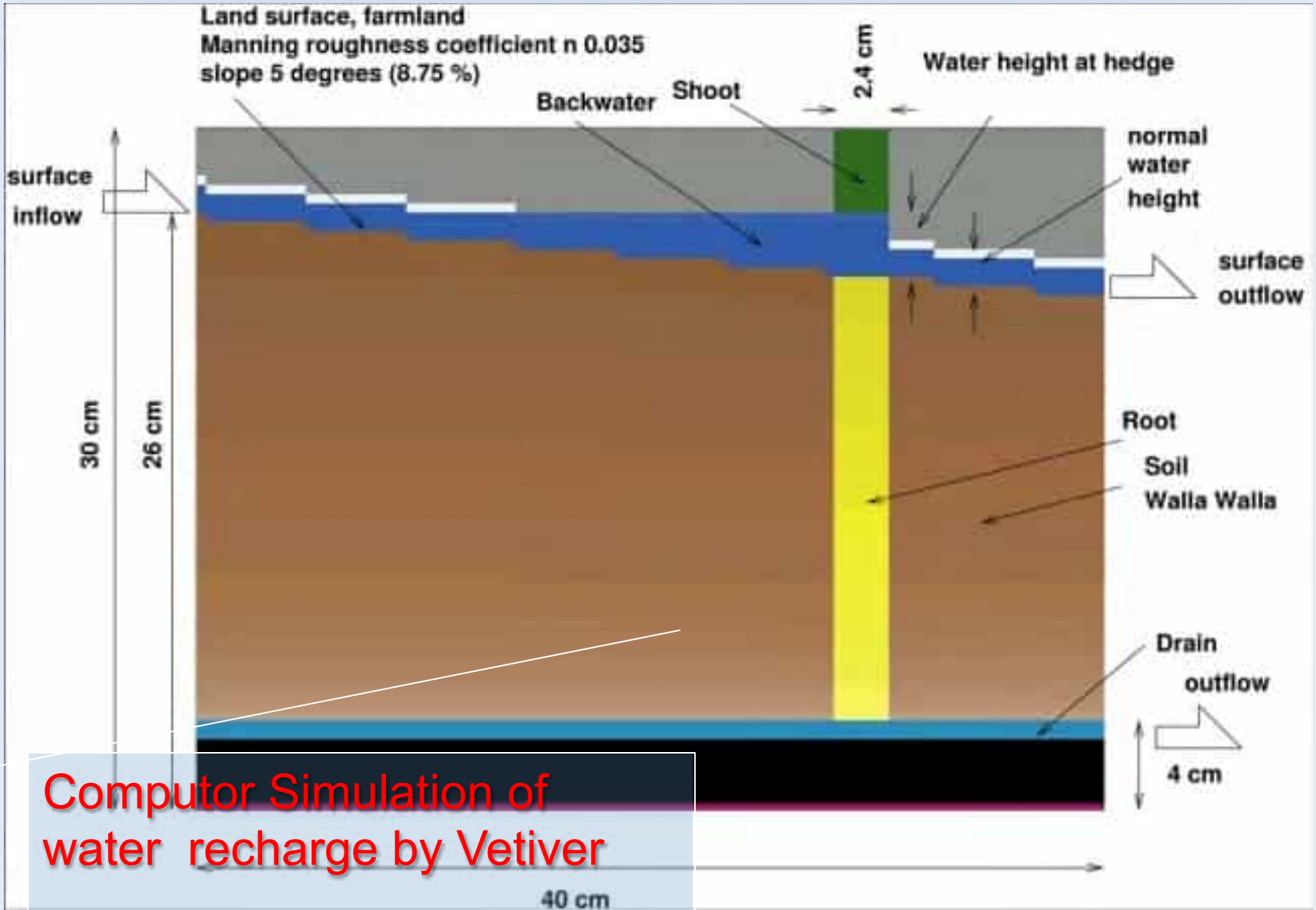
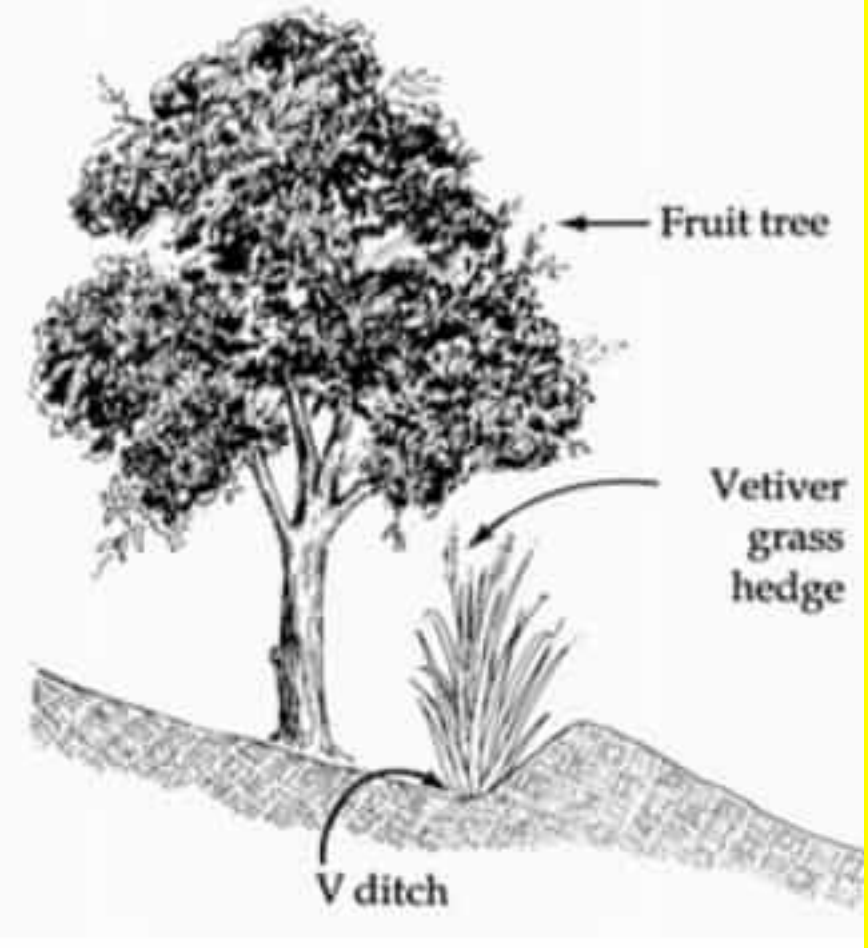
Whole paper can be viewed at:
https://drive.google.com/file/d/0B3E8MMCy36wZNmMxYzZkZWItZGM4YS00MzM0LWE3MDQtOTBiZmE2Yjc4NmFl/edit?usp=sharing



Computor Simulation of water recharge by Vetiver

Vetiver System: tree growth promotor

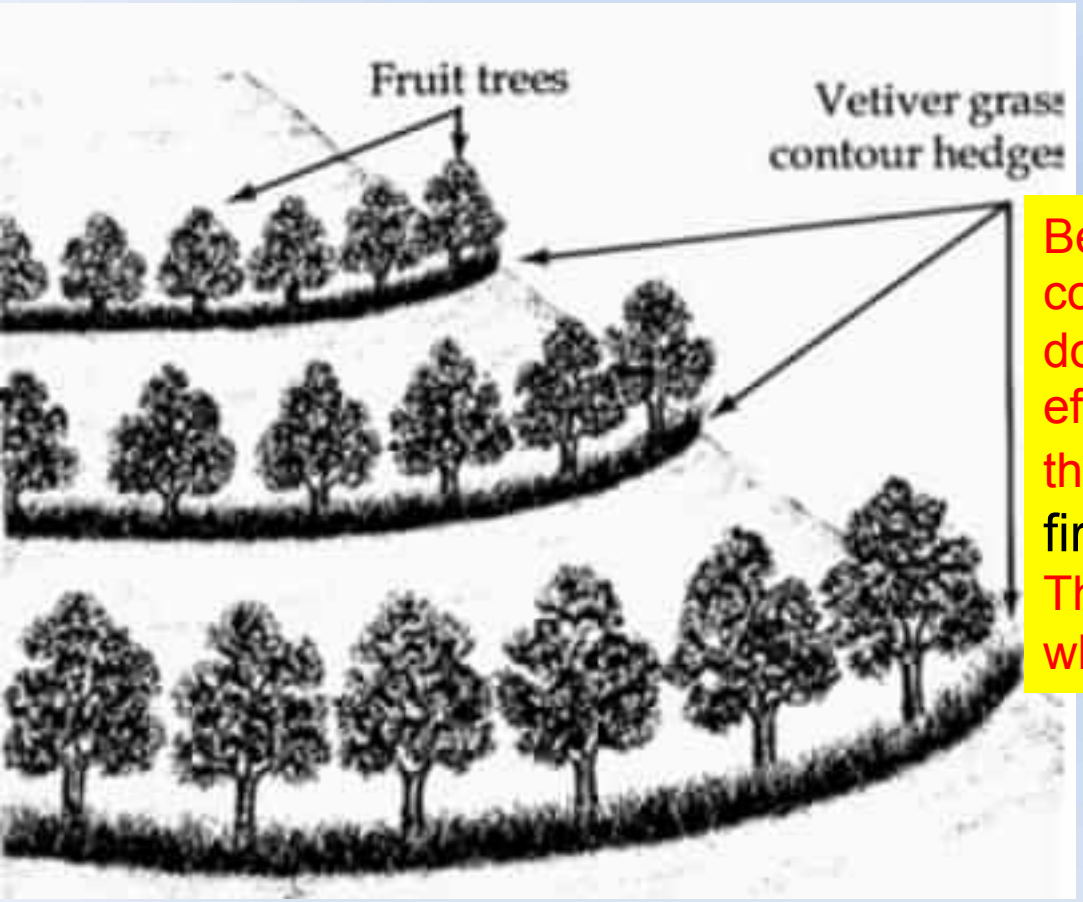


• Under this arrangement of planting, the runoff between one row of trees and the next one down the slope. Collects in the vetiver-lined ditches.

•Thanks to the effects of such water harvesting, the rows of trees do not have to be planted as close together as the trees within a row. Initially, the V ditch will provide a measure of runoff control, thereby increasing the soil's moisture content,

•Vetiver hedges stabilize tree crops. and both the vetiver and the planted trees will benefit.

Vetiver System: tree growth promotor



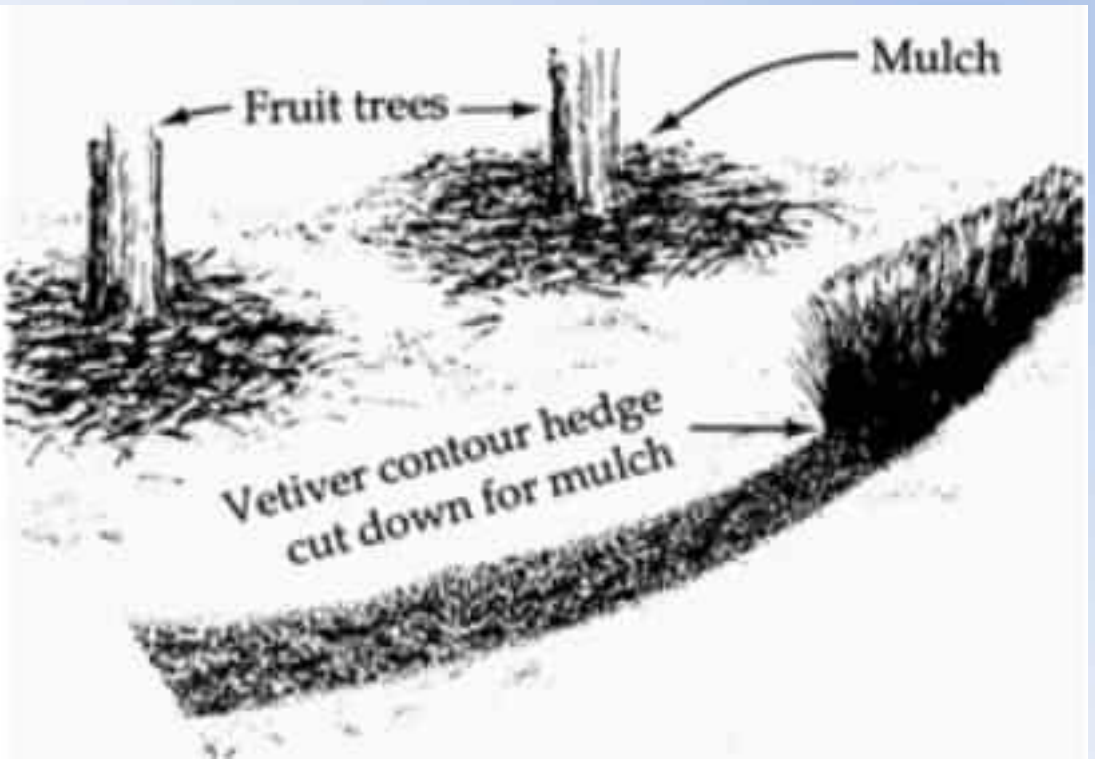
Because the collection of runoff in the contour ditches has the effect of doubling or tripling the amount of effective rainfall, fruit trees planted by this method need no irrigation in the first three years of establishment. The vetiver grass lines stabilize the whole system.

Vetiver System: mulch for the trees

After the vetiver hedges are properly established, the farmer can cut down the vetiver grass to ground level when the dry season sets in and use its leaves as mulch at the base of the fruit trees to help retain stored moisture.

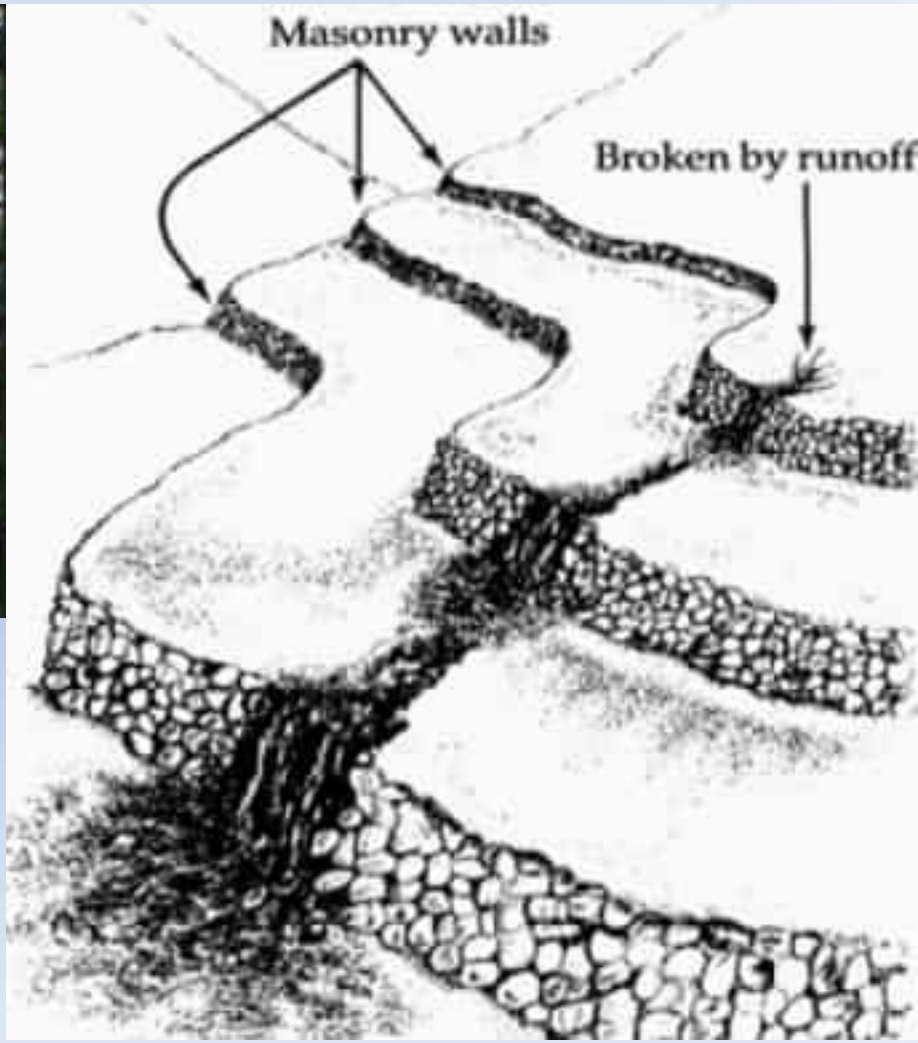
The advantage of using vetiver for this purpose is that its leaves harbor few insects and last well as a mulch. Vetiver hedges also protect the young plants in the hot summer months by providing some indirect shade;

in the colder winter months the hedges act as windbreaks.



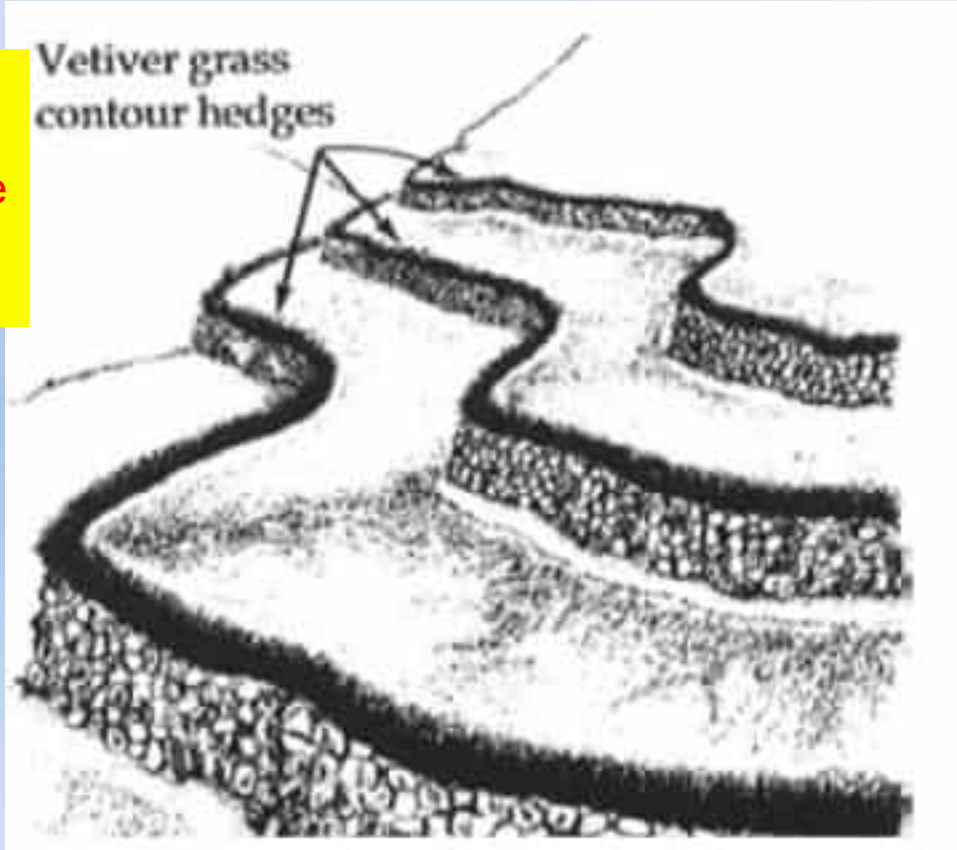
Vetiver System: failure of civil structures

In the highlands terraces are frequently washed out by concentrated flows of run-off water.



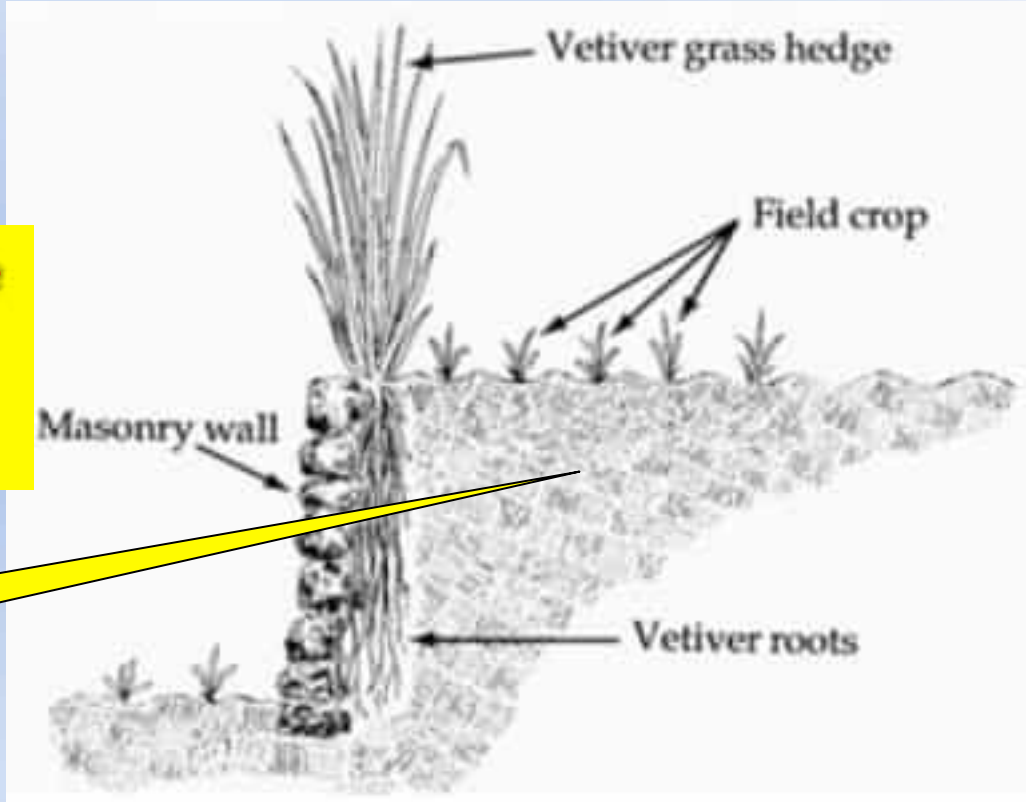
Vetiver System: Guarding civil structures

Vetiver grass, planted on the extreme edge of each terrace, stabilizes the terraces without interfering with the essential drainage between the stones.



Vetiver System: Guarding civil structures

The vetiver root system stabilizes the entire rock face of the vulnerable masonry risers.

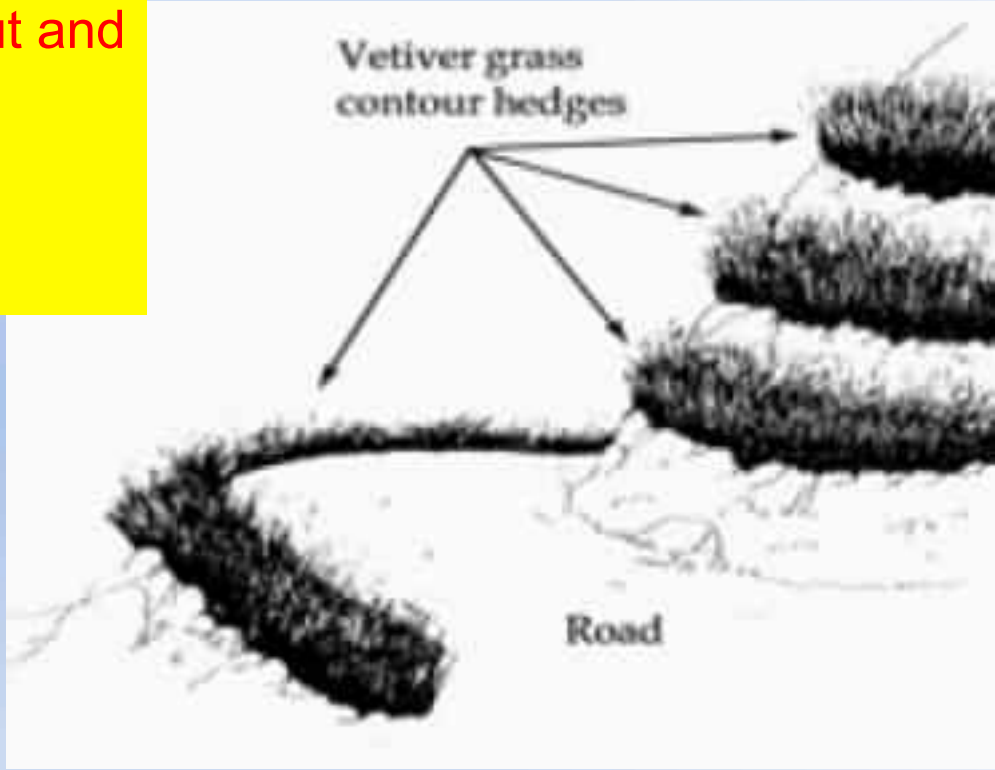


Water recharge into the hill. More effective and enduring. Lasts the whole year

Vetiver System: Protecting Roads & Road Batters

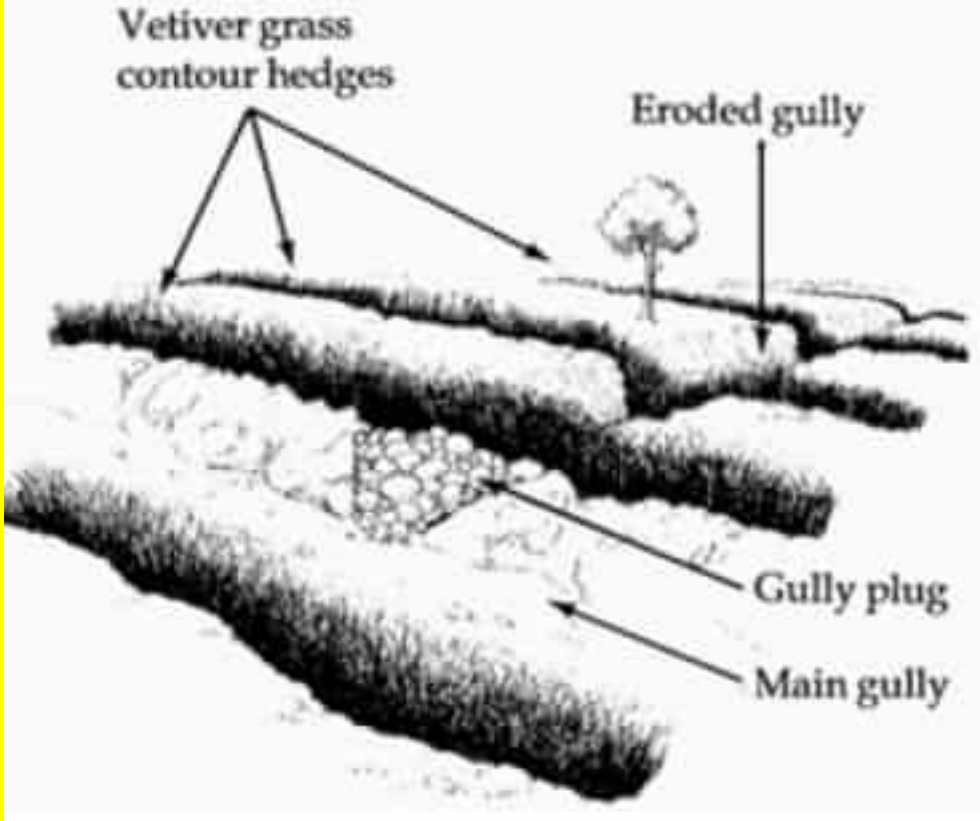
Vetiver grass is also used to protect cut and fill batters

The grass has exhibited a remarkable ability to grow in practically any soil.



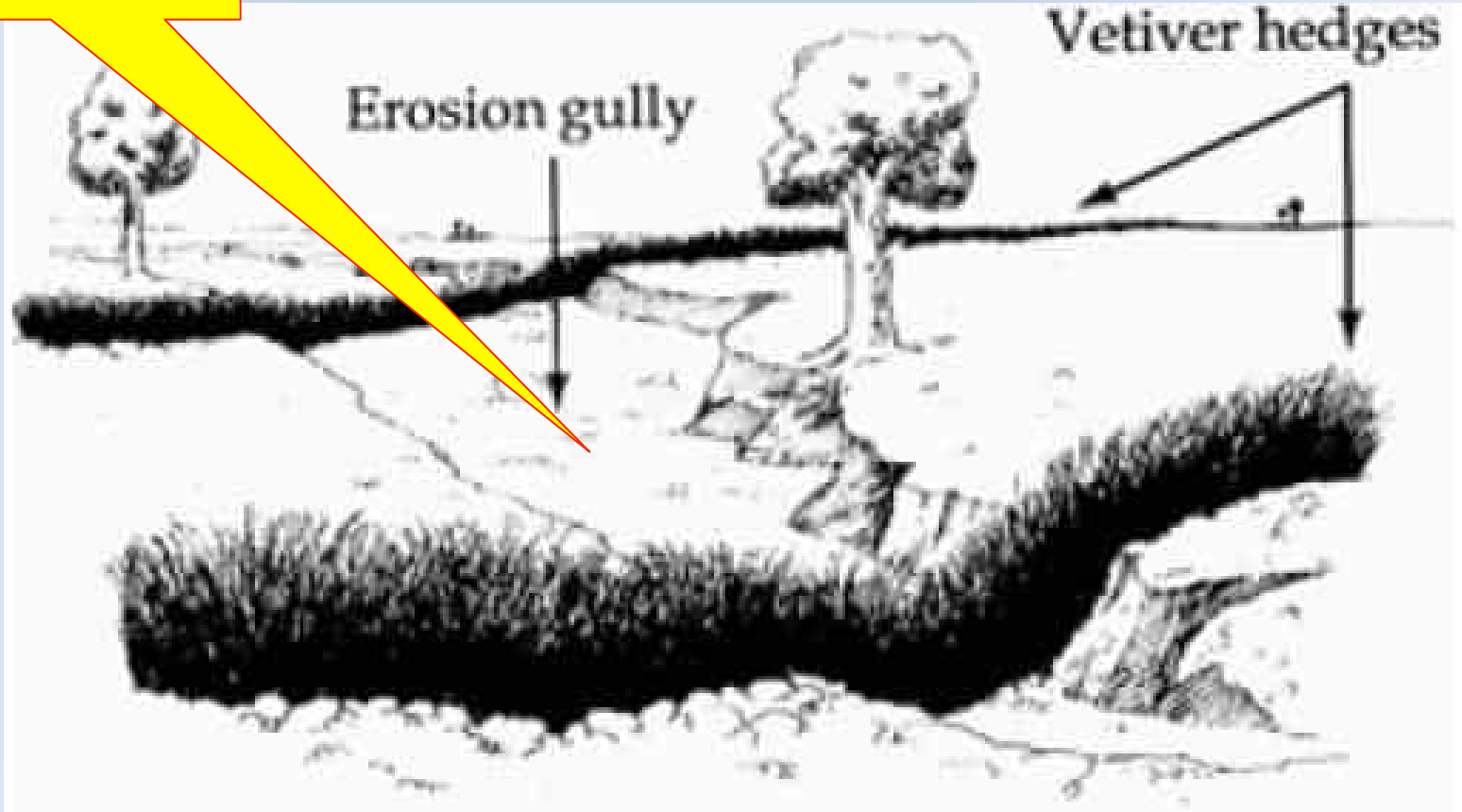
Vetiver hedges can stabilize multi-gullied wasteland areas

The use of vetiver grass in wasteland development has proven effective as the initial stabilizing plant.
When planted as contour hedges across wasteland areas - the first stage in stabilization - *C. zizanioides* reaps the benefits of surplus runoff and harvests organic matter as it filters the runoff water through its hedges.
The improved micro-environment of improved soil moisture allows for the natural generation of native species between the vetiver hedgerows.
As an example, the use of vetiver grass is in most instances an excellent alternative to an engineered structure as a measure to control complex multi-gullied land areas.
The addition of a masonry plug at the end of the system allows silt to build up and gives the grass a basis of establishment.

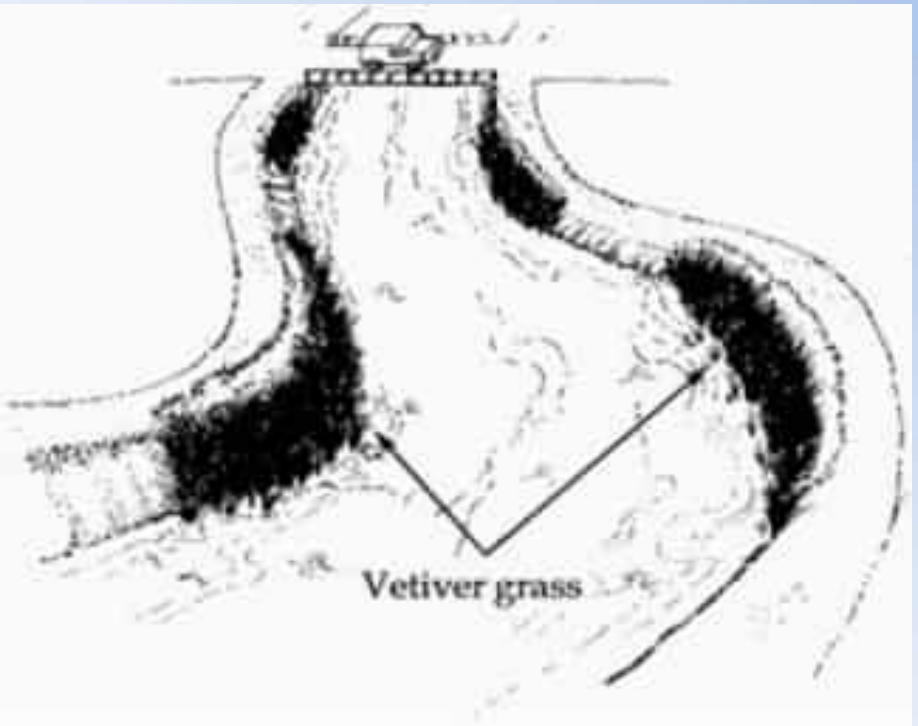


Vetiver System to stabilize gullies

This will ultimately be filled with silt



Vetiver System: Infrastructure Protection



Vetiver to harness the Brahmaputra

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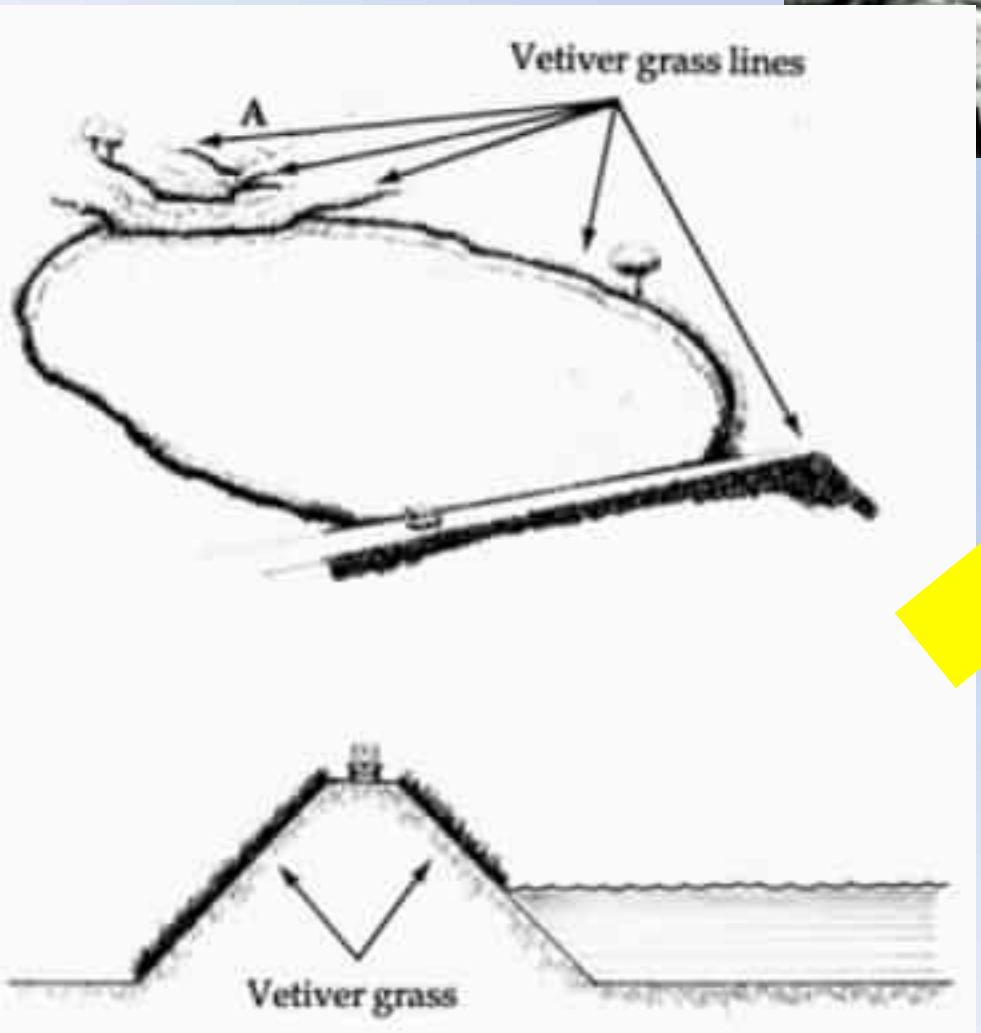
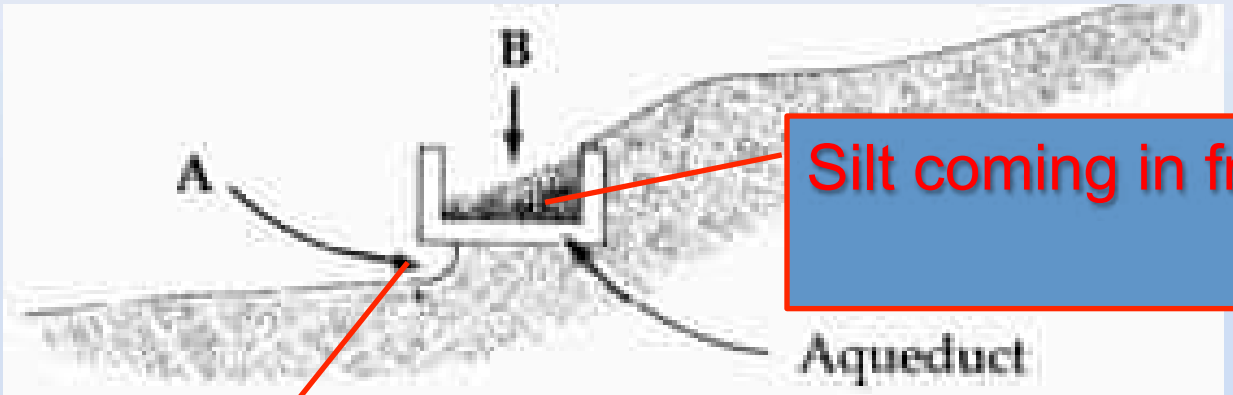
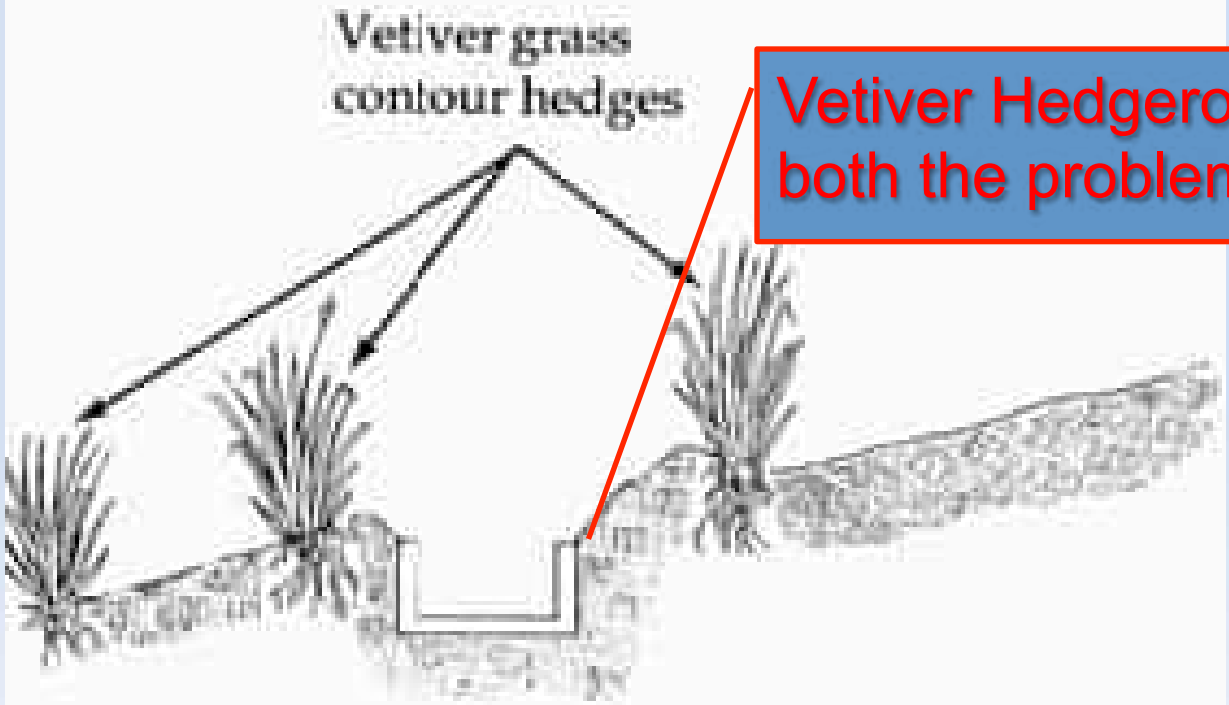


Protection of Bunds and Dams



Silt coming in from point B

Erosion under the Aqueduct



Vetiver Hedgerows solve both the problems

Accidents have stopped happening in the Konkan Raiways ever since, several Kilometers of Vetiver Hedgerows were planted, resulting in strengthening of the Ghats. The RDSO adopted the Vetiver System in 2007-8

Carbon Sequestriation

1 Megagram= 1 tonne

Table 1. C- sequestration by different species (normalized to 12 month crop cycle)

Tree/Crop/Cropping System	C- sequestration (megagrams ha^{-1} $year^{-1}$)
Albizzia lebbek[1]	1.04
Tectonia grandis[1]	1.33
Artocarpus integrifolia[1]	1.21
Shorea robusta[1]	0.87
Poplar[2]	8
Eucalyptus[2]	6
Teak[2]	2
Vetiveria zizanioides	15.24
Lemongrass	5.38
Palmarosa	6.14
Vetch(V)-maize(M)-oat(O)-soybean(S)-wheat(W)-soybean(S)[3]	7.26
O-M-W-S[3]	8.56
V-M-W-S[3]	7.58
Ryegrass(R)-M-R-S[3]	8.44
Alfalfa(A)-M[3]	7.52
Rice-rice[4]	1.54-2.48(residues)
Maize-rice[4]	2.1-3.51(residues)

[1]Jana *et al.*,(2009); [2]Kaul *et al.*,(2010); [3] Santos *et al.*,(2011); [4]Witt *et al.*,(2000)

C-sequestration is the highest

Carbon Sequestration

Trees/crops/cropping systems	C- sequestration (Mg ha $^{-1}$ year $^{-1}$)	Ref.
V-M-O-S-W-S O-M-W-S V-M-W-S R-M-R-S A-M	0.12 0.16 0.28 0.32 0.44	Santos et al.,2011
Rice-maize Maize-rice	0.92-1.37 -0.11-0.23	Witt et al.,2000
Rice-wheat Maize-wheat	0.13-0.31 0.03-0.14	Kukal et al.,2009
Eucalyptus Poplar Teak	1.11 3.88 0.70	Kaul et al.,2010
Vetiver lemongrass	5.54 3.08	

Source: . A Strategy for Sustainable Carbon Sequestration using Vetiver *(Vetiveria zizanioides (L.)): A Quantitative* Assessment over India

A Project Document under the CSIR Network Project, Integrated Analysis for Impact, Mitigation and Sustainability (IAIMS), July 2011

Carbon Sequestration

Table 6: Estimates of sequestration CO_2 (carbon) Emission through vetiver

C-sequestered by Vetiver			
Vetiver System	C-sequestered(Tg $year^{-1}$) in India (10 m ha of degraded soils)	% of emissions (2009)	
		India	World
Biomass	150	34.6	1.8
Soil	50	11.5	0.6
Total	200	46.1	2.4

As a broad estimate, utilization of about 10 m ha of degraded soil in India could potentially sequester up to 46% of total carbon emission by India (in 2009). While the sequestration in practice is naturally likely to be much less, it is still expected to be significant.

Vetiver Leaves as Fodder

Cattle love soft leaves, which can be cut and and mixed with their feed. The photo is only meant to show that cattle do enjoy it. But young vetiver plants should be guarded and cattle should not be allowed for the first few months.

Nutritonal Value of Vetiver as Fodder

Analytes	Units	Vetiver grass	Vetiver grass	Vetiver grass	Rhodes	Kikuyu
		Young	*Mature*	*Old*	*Mature*	*Mature*
Energy (Ruminant)	kCal/kg	522	706	969	563	391
Digestibility	%	51	50	-	44	47
Protein	%	13.1	7.93	6.66	9.89	17.9
Fat	%	3.05	1.30	1.40	1.11	2.56
Calcium	%	0.33	0.24	0.31	0.35	0.33
Magnesium	%	0.19	0.13	0.16	0.13	0.19
Sodium	%	0.12	0.16	0.14	0.16	0.11
Potassium	%	1.51	1.36	1.48	1.61	2.84
Phosphorus	%	0.12	0.06	0.10	0.11	0.43
Iron	mg/kg	186	99	81.40	110	109
Copper	mg/kg	16.5	4.0	10.90	7.23	4.51
Manganese	mg/kg	637	532	348	326	52.4
Zinc	mg/kg	26.5	17.5	27.80	40.3	34.1

A 2007 Google Earth image of farmland in Fiji that John Greenfield planted with vetiver hedgerows in the 1950s'. The hedgerows are still there (red arrows) after 57 years.

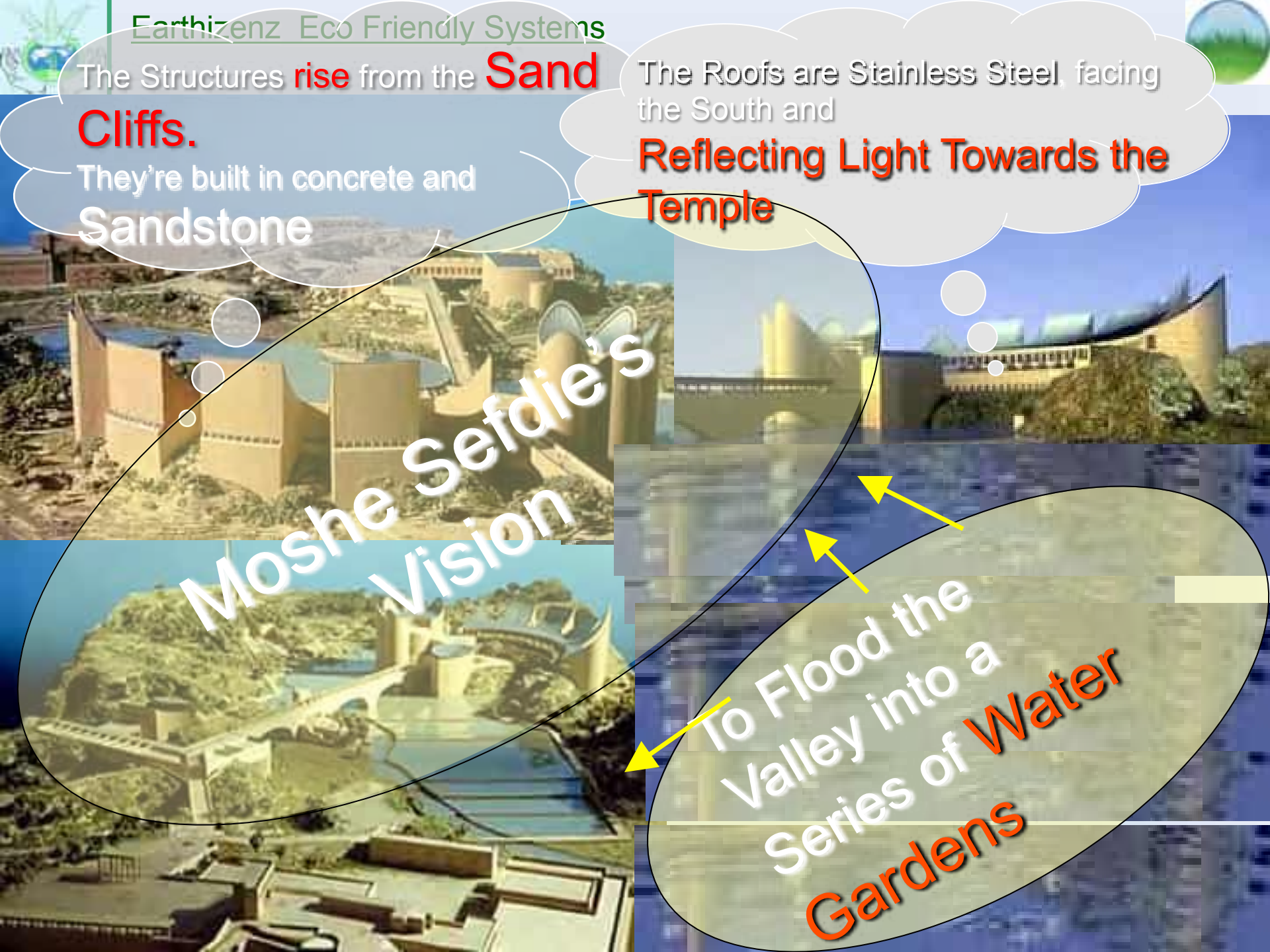
Applications of VS in the Kandi Area in Punjab to prove the claims, through Practical Intervention

The Structures rise from the Sand Cliffs.

They're built in concrete and Sandstone

The Roofs are Stainless Steel facing the South and

Reflecting Light Towards the Temple



Moshe Sefdie's Vision

To Flood the Valley into a Series of Water Gardens

Applications of VS used at Anandpur Sahib

- Revegitation and Possible Reforestation
- Prevention of Soil Erosion and its migration

- Steep Filled up Slope Stabilization (Road Batter)
- Infrastructure Protection

- Silt Control in water body
  (Planting in the Catchment Area)

Vetiver application for Revegitation & Reforestation at Anandpur Sahib, Punjab (Hillock Slopes)

Before
&
After


BEFORE
This hill has soil saver on it
This Swale receives silt
Road Batter
Freshly planted vetiver hedgerow
02 07 2009 14 46


AFTER
The hill with the soil saver
The swale is protected
Road Batter
07 10 2010 11:22


BEFORE
02 07 2009 14 40


AFTER
07.10.2010 11:24


BEFORE
Notice the bare hill. Various methods have been tried for several years
02 07 2009 14:41


Local Species have already started coming.
AFTER
07 10 2010 11 24


BEFORE
02 07 2009 15 27


Local Species have already started coming. Soon they will take over and the HERO would perish
AFTER
07 10 2010 11 57

Vetiver application for

Infrastructure Protection

Before
&
After

This was the look of the Location 'A' in July 2009, foundation was exposed

Location 'B'

Location 'A' after laying soil filled bags

A process used in Congo was implemented with some variations:

(1) Hessian bags have been used, not plastic

(2) On Dr. Paul Truong's advice, soil has been filled & not sand, as in Congo

Location 'B' in 2010

Location 'A' 2010, Vetiver planted

No water in water body


Vetiver has handed it back to Nature, 2012
Location A 2012
The image in the clear Water Body

Vetiver application for

Prevention of Soil Erosion & its

Migration

Before
&
After

SOIL ERODED FROM THE CLIFFS SPREADS ON THE ROADS

ZERO SOIL MIGRATION DESPITE RECORD RAIN

Vetiver application for Steep Filled up Slope Stabilisation (Road Batter) Before & After


BEFORE
The rains did this. Maybe the road drainage system collapsed


Total Washout


The earth has given way from under the geo-textile
The Geo-textile needs to be removed and the earth refilled, remoulded and compacted


The Vetiver that we grew on top has survived


Vetiver rows on top of road batter have survived heavy rains, have multiplied and have taken root speedily and well
03 10 2009 13 23


AFTER


AFTER
Vetiver has retained moisture within the slope enabling other vegetation to grow.
07 10 2010 11:25

Vetiver application for Silt Control in water body

(Planting in the Catchment Area and handling gullies and rain cuts)

Silt Before
and
Silt After


This is a hillock of Debris
Location ‘V’
Rain Cuts & Gullies
Huge source of silt


The same hillock of Debris.
Now lush Green
No question of silt

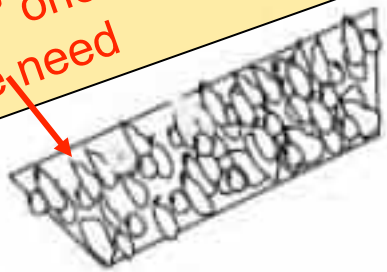

Location ‘V’
(Behind Drop off)
Water Body
Gully/ Rain Cut
Area Z
29.04.2010 13:06

Average 5 rows running across reshaped slopes.

Total rows per raincut (average) =5+5=10

Total length of rows/raincut = 10X25=250m

Trapezoidal "porous wall" one or two as per site need



Total length/ raincut in addition to the rows running across hill= 250+50= 300mtrs

Vetiver rows running across hill, already accounted for

Assume 5 additional rows at the bottom of the cannel, total lenfth=5X10=50m/ raincut


Courtesy: Paul Truong
Note that the vertical interval is only one sand bag thick.
2009

SILT IN OCT 2009


Polythene liner is Visible
SILT IN 2010
Catchment Area Protected with Vetiver
07 10 2010 14 25


SILT In 2010
Polythene liner is Visible
07 10 2010 13 06


SILT IN 2010
First Cell:
Zero Silt
07.10.2010 12:14

Our Intervention: Clumps of Vetver strategically Planted in the rain to Prevent Silt Carried by the same rain to the Water Body.

The Silt was reduced by 99% at the end of the same monsoon as planting

Conclusion

- Vetiver System is the only System that can bring a totally wasted land back to life.
- Lands like vacated mine fields and other degraded lands
- After bringing the land back to life, it allows other local species to take over.
- Vetiver roots have gone deep inside and have enriched the hill with moisture. It has brought below ground carbon stocks.
- Vetiver will ultimately be overtaken by the local species.
- **The below ground carbon stock will stay there for ever.**

Tackling Multiple Ecosystems

Sundarbans is a confluence of Ecosystems

1. The on-land & River Ecosystem
2. The Estuarial Ecosystem
3. The River Ecosystem
4. The Ocean Ecosystem

Vetiver is a plant that can survive all these and create an atmosphere for other flora and fauna to exist in harmony

The Bangladesh side of Sundar Ban

1. There has been a Scientific study done in Bangladesh on the suitability of Vetiver as a plant that can be used as a cheaper and more effective bio-engineering tool.
2. Tests have been carried out on the ability of Vetiver not only to survive on Saline soil, but also to gradually reduce the salinity of the soil enabling other plants, trees and vegetation to survive.
3. I have taken their consent to share their experiments and experience.

Vetiver growth in saline zone of Bangladesh

(a) Kaliganj area (EC=1.57 ds/m)

(b) Bashkhali (EC= 12.37 ds/m, strongly saline zone)

Growth of Vetiver Grass in Saline Soil


After Plantation


5 months after Plantation


Root mass 5 months later


Close view of Root mass

plantation

Sample No.	EC before plantation (ds/m)	EC after plantation (ds/m)
Salinity-1	4.8	0.32-0.34
Salinity-2	10.0	0.26-0.28
Salinity-3	12.5	0.24-0.32

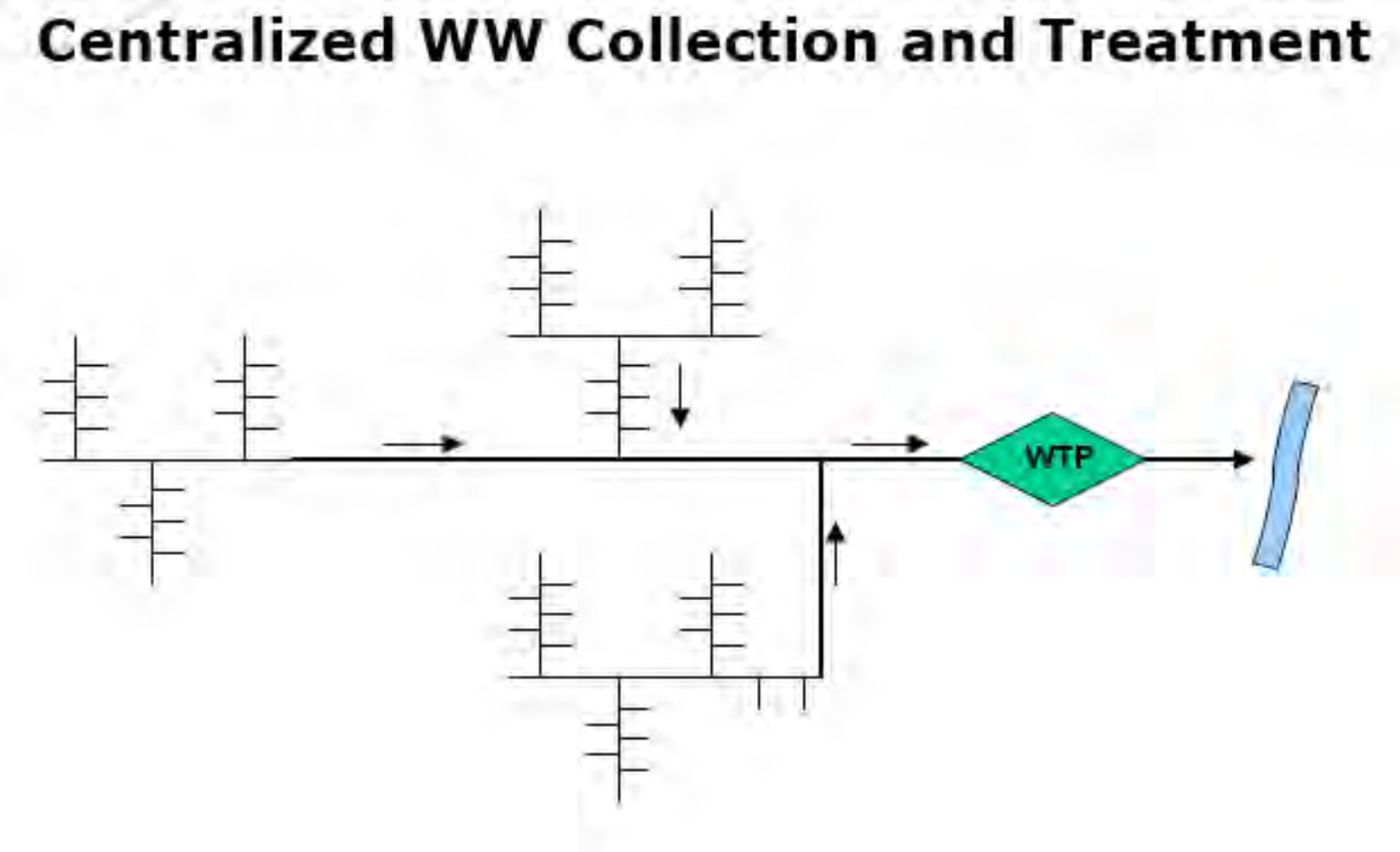
Conclusion

1. It is found that local vetiver (V*etiveria zizanoides)* grass grows on Saline Soils.
2. Due to salinity, vegetation and plants don't grow in the saline zones.
3. Vetiver grass is effective in protecting the slope of dykes in the saline zone. It takes 2-3 months to grow vetiver grass.
4. Vetiver grass contributes to the stability of slope.
5. It was found that soil salinity EC reduced from 4.8 ds/m to 0.33 ds/m, 10.0 ds/m to 0.27 ds/m and 12.5 ds/m to 0.28 ds/m in 5 weeks of vetiver plantation.
6. It means that vetiver grass is effective in removing salinity of soils in 5 weeks after plantation.
7. The growth in extreme salinity is low but still the Vetiver grows and is breaking up the salt, thus continuously lowering salinity levels

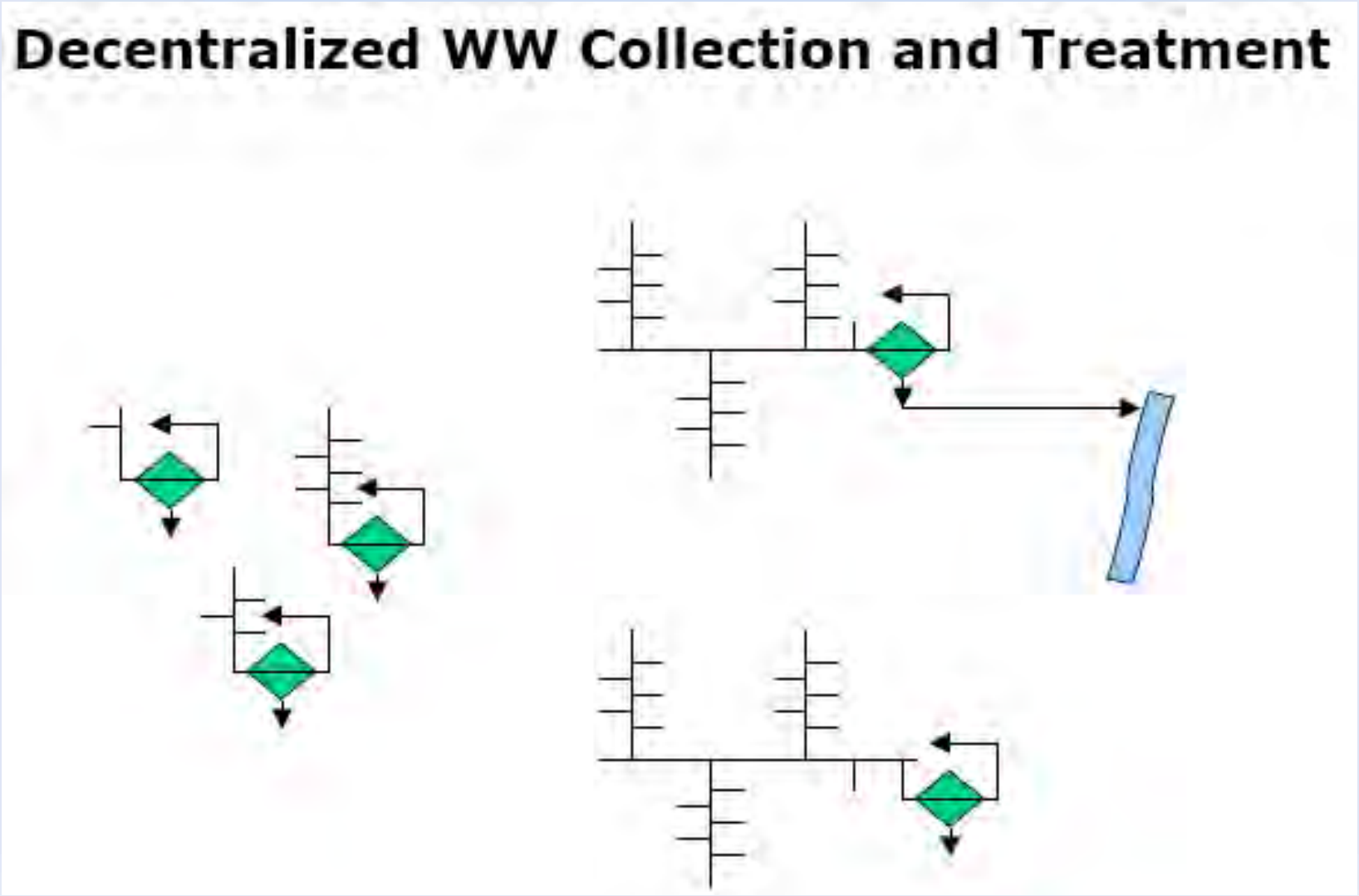
Vetiver grass plantation is a sustainable and cost effective solution for dyke protection in the saline zones. Hence it is suitable for the coastal and estuarial area like the Sundarbans.

Following slides are about Decentralized Wastewater management

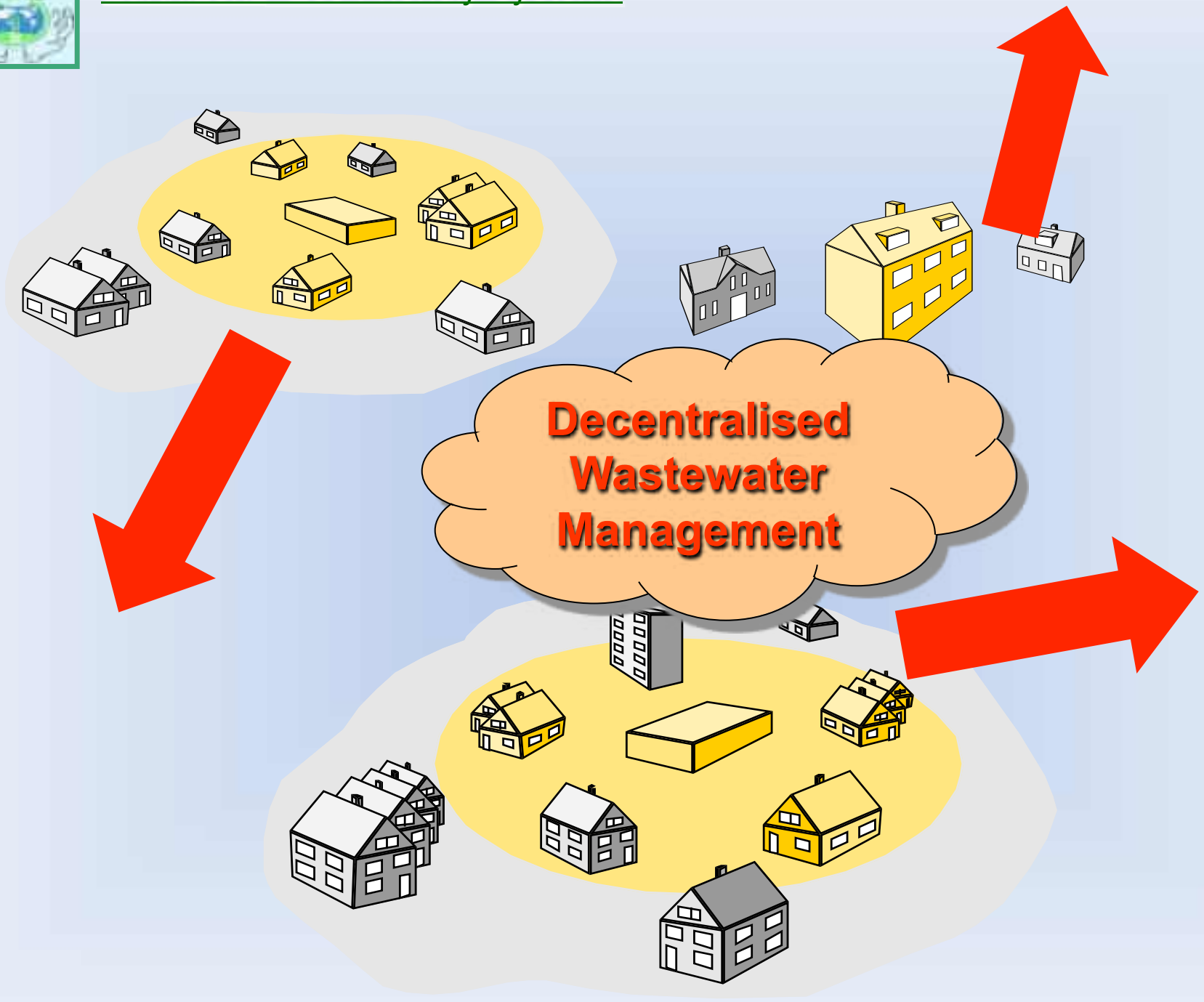
Centralized WW Treatment is OUT



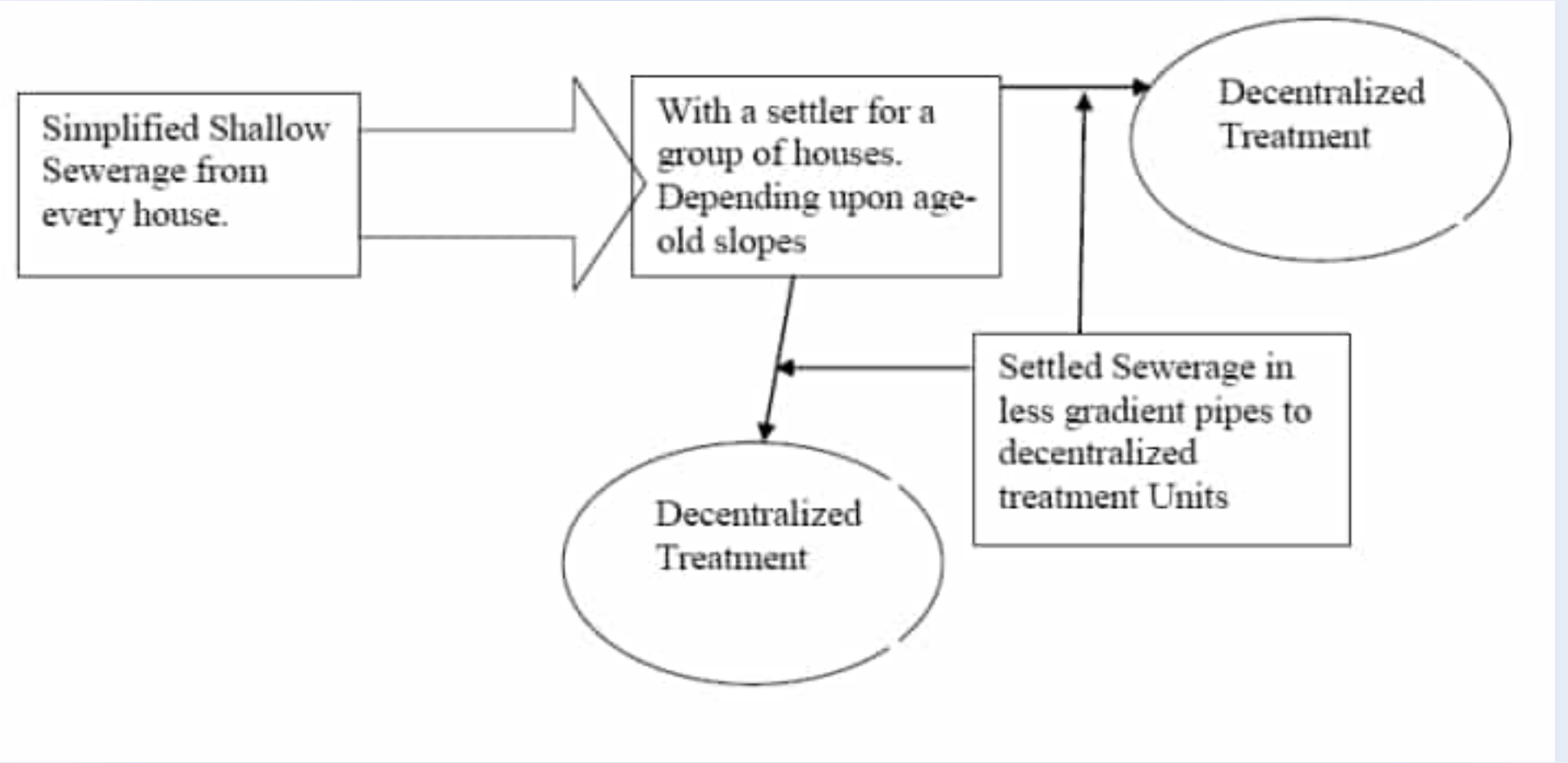
Current System (Under Discussion)



Earthizenz Eco Friendly Systems



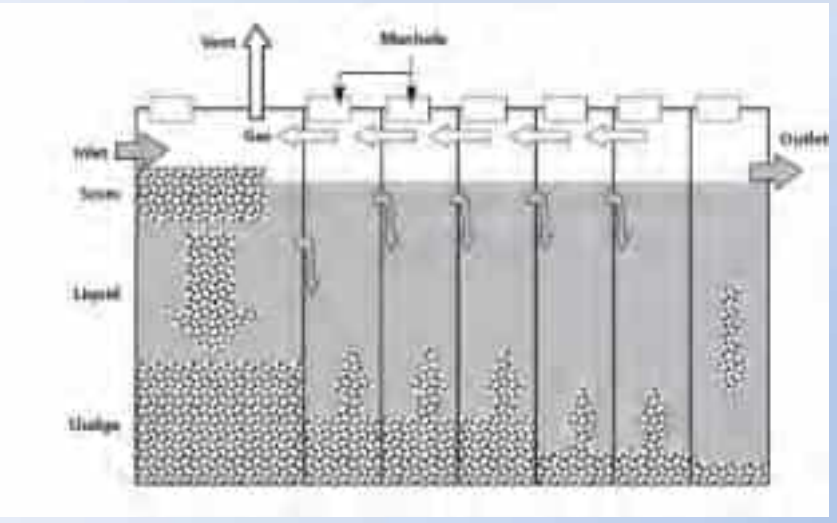
Hybrid Settled & Gravity Sewrage System

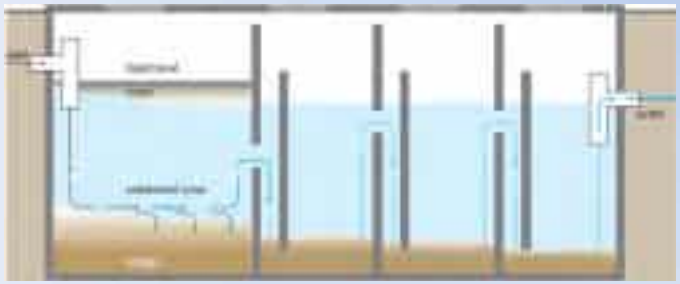


The DEWATS SYSTEM

- ✓ Decentralised Wastewater Treatment Systems (DEWATS)
- ✓ DEWATS is based on different natural treatment techniques
- ✓ put together in different combinations according to need.
- ✓ Pre-treatment and sedimentation in settlement tank or in septic tank
- ✓ Secondary anaerobic treatment in baffled reactors, 75% removal of BOD/COD
- ✓ Aerobic/ anaerobic treatment in reed bed system.
- ✓ Vetiver grass forms part of the Collage of plants
- ✓ The treated water from the reed bed system is stored in a polishing pond for the aerobic process. Vetiver Floats naturally aerate the pond
- ✓ Vetiver Hedgerows are grown on the slopes of the pond.

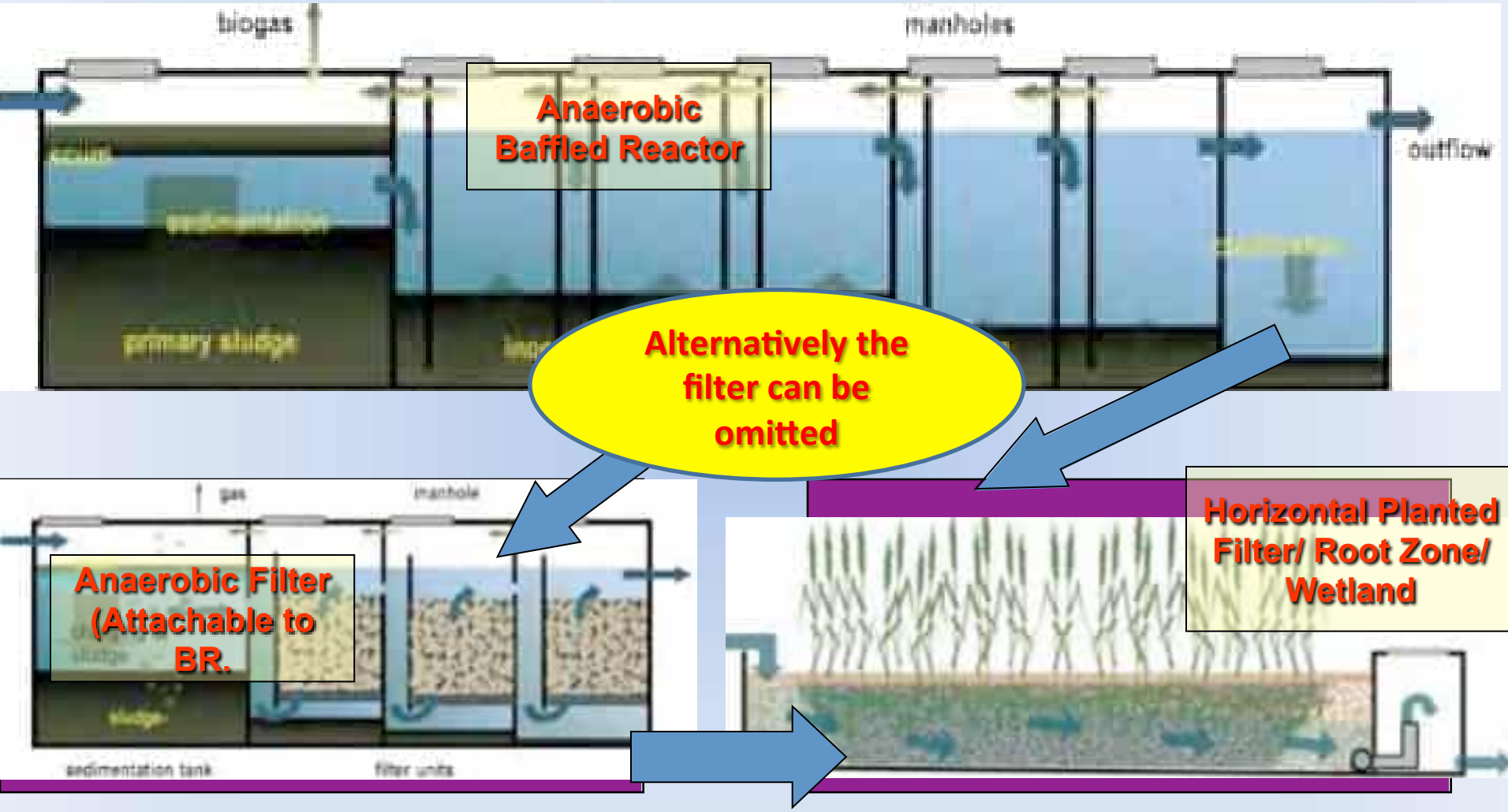
Secondary Treatment





- **Baffled reactor** is used for this phase.
- Several tanks (upflow chambers) are built in a series to digest degradable Matter.
- Baffles guide WW between the chambers **from top to bottom and up again**.
- During the process the fresh influent is mixed and inoculated for digestion with the **active blanket** deposit of suspended particles and **microorganisms** occurring naturally at the bottom of each chamber in such conditions.
- Because of the physical separation of Chambers, various microorganisms are present at different stages, allowing high treatment efficiency

Secondary& Tertiary Treatment



Combined into One Unit

The Settling tank, Baffled upflow reactor and Anaerobic Filter can be plugged together,

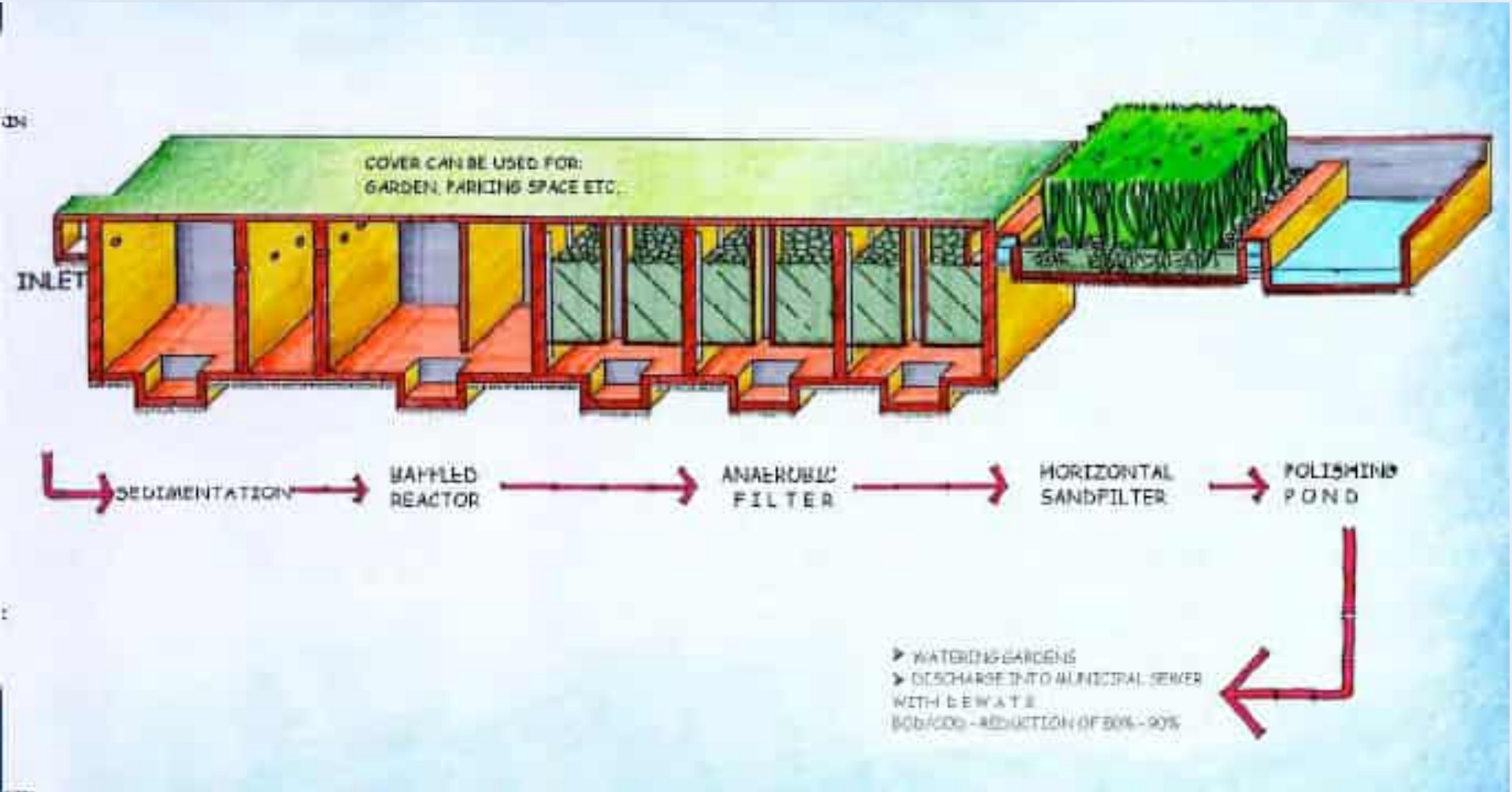
The whole system is underground and has a total Hydraulic Residence time of 8 t0 14 hrs. like the UASB reactor

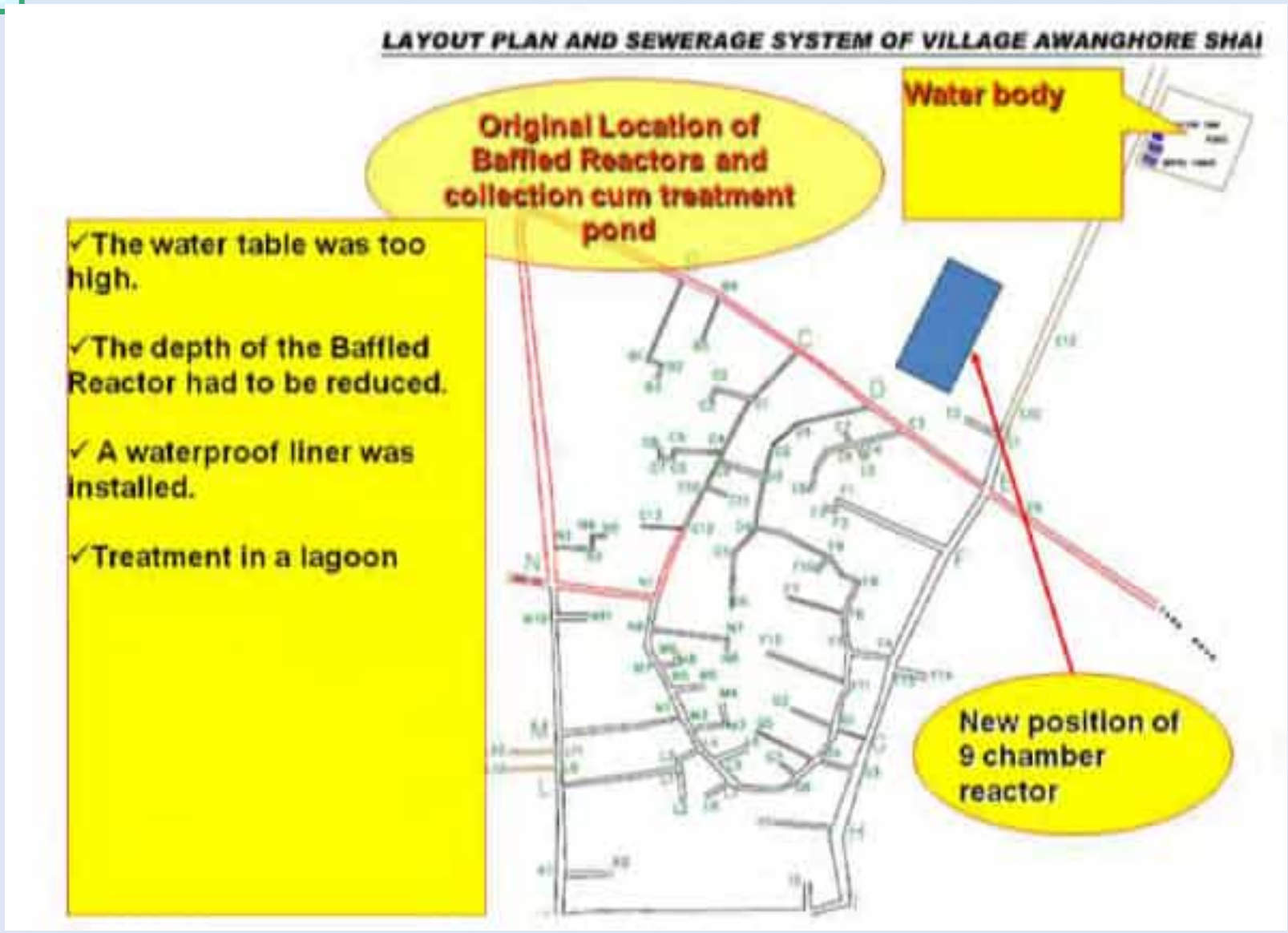
The whole System can fit in any place and is always underground

Small surfaces become available for treatment (sidewalks, private yards, parking lots, alleys, parks, etc.)

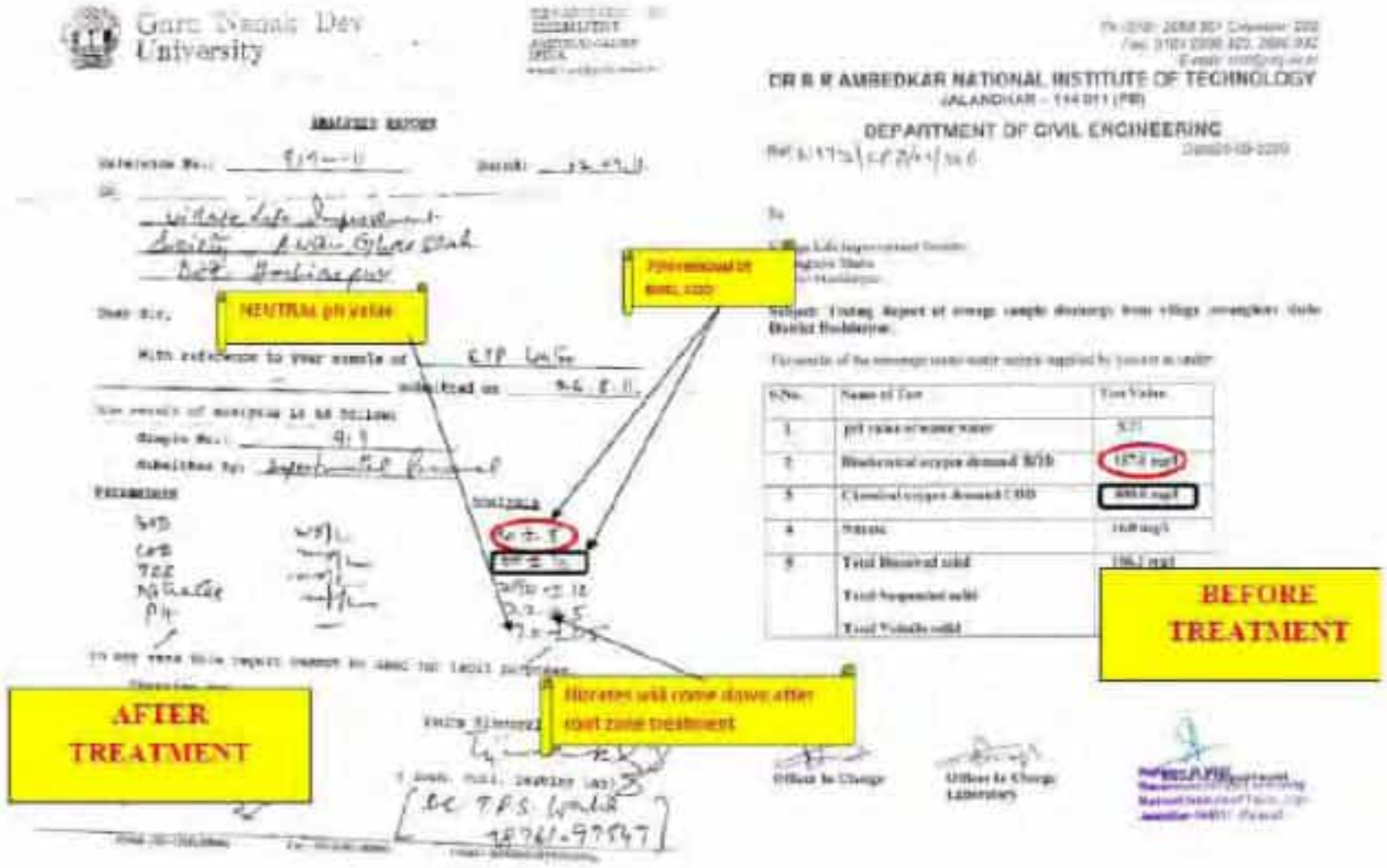
In a Street

The right combination and dimension of Modules is important.




LAYOUT PLAN AND SEWERAGE SYSTEM OF VILLAGE AWANGHORE SHAI
Original Location of Baffled Reactors and collection cum treatment pond
Water body
✓The water table was too high.
✓The depth of the Baffled Reactor had to be reduced.
✓ A waterproof liner was installed.
✓Treatment in a lagoon
New position of 9 chamber reactor

Before and After Reports of Awam Ghore Shah



Baffled Reactor and Lagoon

This is the additional depth we had to go to due to , change of position discussed above. At the original place, entry would have been at least 1.5 meters higher.

Treatment of this lagoon is still pending for want of funds. The BOD levels are very near acceptable levels. Sunlight is doing the rest of the treatment in the meantime.

Street before intervention

Street after intervention

Notice the inflow level, compared to centralized treatment at Awan Ghore Shah. This is tremendous cost Saving

Baffled Reactor under Construction

Baffled Reactor Complete

Pilot Project in Village Mokhra, Distt. Rohtak

We are doing a Pilot Project, using the afore mentioned technology at Mokhra. The facts of the area are:

- The village has a population of about 25000.
- The Ground water table is at 6 feet BGL.
- Discharging grey water into 6 **deep** ponds, located in the village, through multiple channels.
- The MD University and the National Ground Water Board concur on the fact that the water is unfit for human consumption.
- The GWQI & SPI indices are: 453.4543 & 2.728279 Respectively
- GWQI > 100 means Unfit, SPI between 0.5-3 means Polluted.
- The village has the usual onsite sanitation.
- Water supply is 70 per caput per day, pumped from the canal. Timing is variable, dependent on the power supply. Work is already underway

Vetiver Planted filter at a hospital

Vetiver Planted filter at a hospital


These are three points where three treatment facilities are discharging wastewater of 400 houses. The white line depicts the bifurcation to facilitate the making of the polishing pond

Using treated water and Vetiver to mimprove useless land

Totally Useless Land at Banthra (UP) turned into a beautiful Forest with Vetiver (1950-1970)

Following slides are about in-house Wastewater Treatment and Recycling


Water is made to go to the bottom of every chamber. The sludge at the bottom gets activated.
Air pipes running across partitions
28 11 2008 15 57


These tees ensure that the lightweight fatty stuff remains in the chamber and does not travel to the next chamber
28 11 2008 15:58


Final exit point of effluent. Goes to the boundary wall and through and under it.
Final Air Vent
28 11 2008 15:58


Whole clumps brought from the nursery and planted in the gravel.
Entry point of effluent. Passes through large stone and a very course wire netting and trickles into the bio filter bed


Root zone treatment given here. This bed will be broadened after the house is passed by the urban authority
Treated water re-enters the house into an under ground storage tank. A solar pump will pump this water to an over head tank for usage in gardening and also feeding a fountain for final aeration and


The original channel was a straight gravel bed with about 2% slope, no cells
Another channel with no slopes, but four cells provided. Water rises in each cell upto about 8” and goes to the next cell
24 02 2009 10:14


27.04.2009 11:06

Constructed Wetland now


Water collected in an underground water tank and pumped up in an overhead tank as per need.
27.04.2009 16:27

The planted filter now

Primary/ Secondary Wastewater treatment now

The Treatment is in the drive way