Constructed Wetland For Treatment of Wastewater

Easy Technology Yet to be Promoted !

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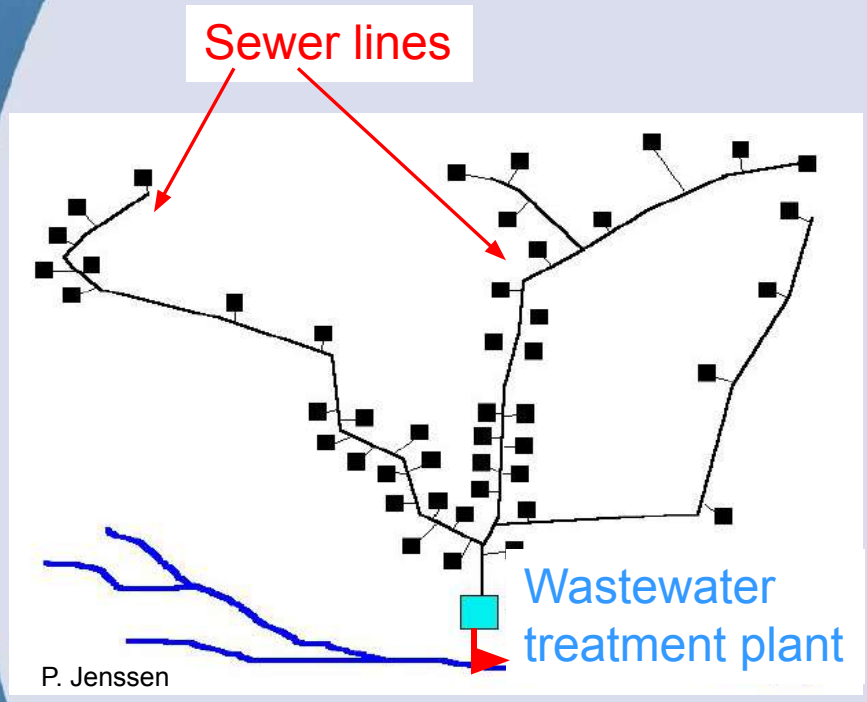
Conventional Waterborne Sanitation: Investment Cost for Collection



Source: adapted from (6)

- High Investment for Collection i.e **70 - 90 %**
- Treatment **10 - 30 %**

(Otis 1996, Mork et al.2000)

In the US:

- 37% of all new developments are serviced by onsite or decentralised systems
- over 50% of onsite/cluster systems are in cities and their suburbs

(USEPA 2000)

Decentralized Wastewater Treatment is the Current Needs as many of the growing cities in the world still does not have Sewer System

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Level of treatment

1. **Preliminary**
   - Removal of large contaminants, such as solid waste and grit to avoid operation and maintenance problems
2. **Primary**
   - Removal of suspended solids and organic matter
3. **Secondary**
   - Removal of biodegradable organic matter
4. **Tertiary**
   - Removal of specific pollutants such as nutrients

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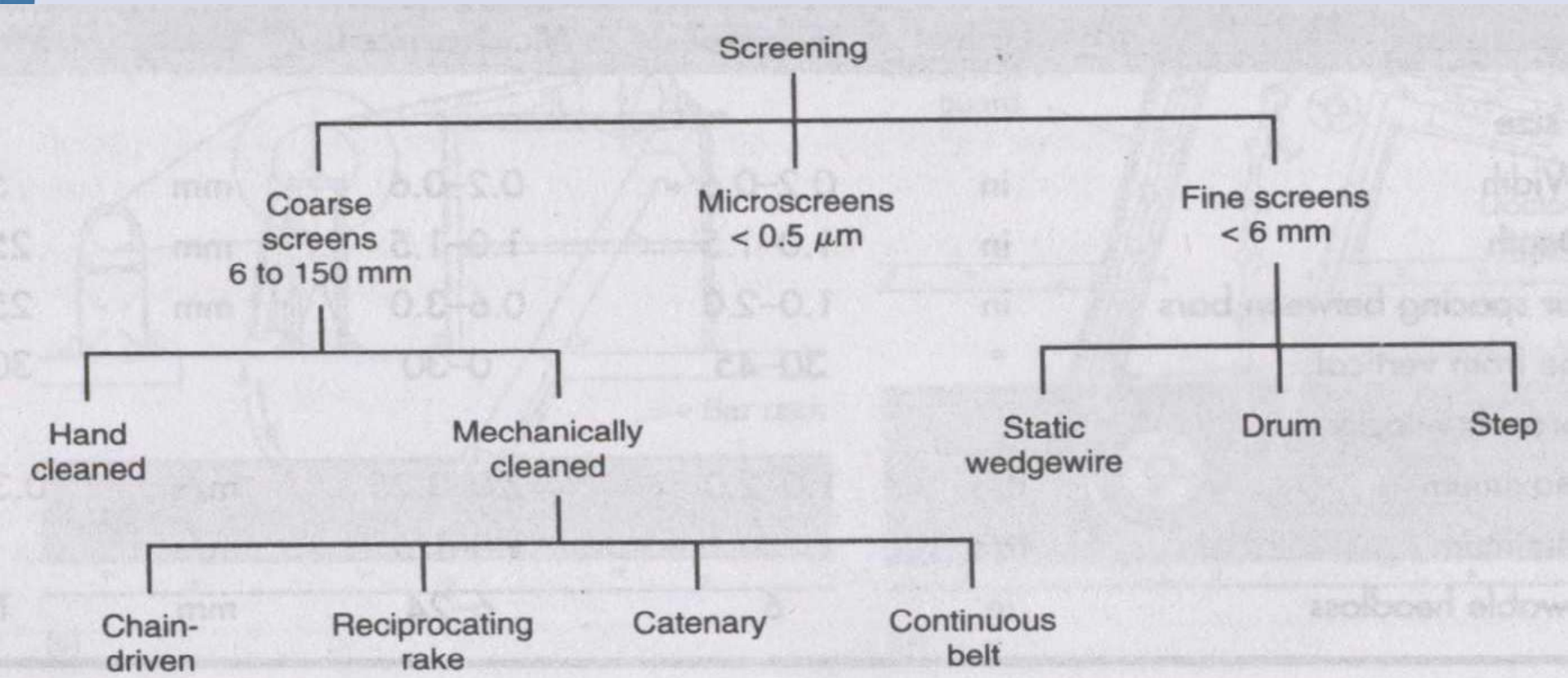
Preliminary Treatment

- Screening
  - Coarse – manual or mechanical
  - Fine
- Grit Removal



Teku

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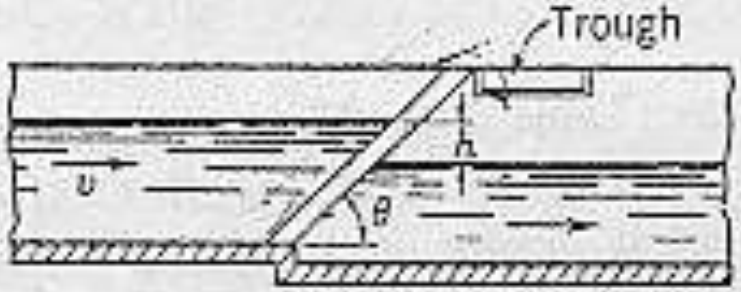
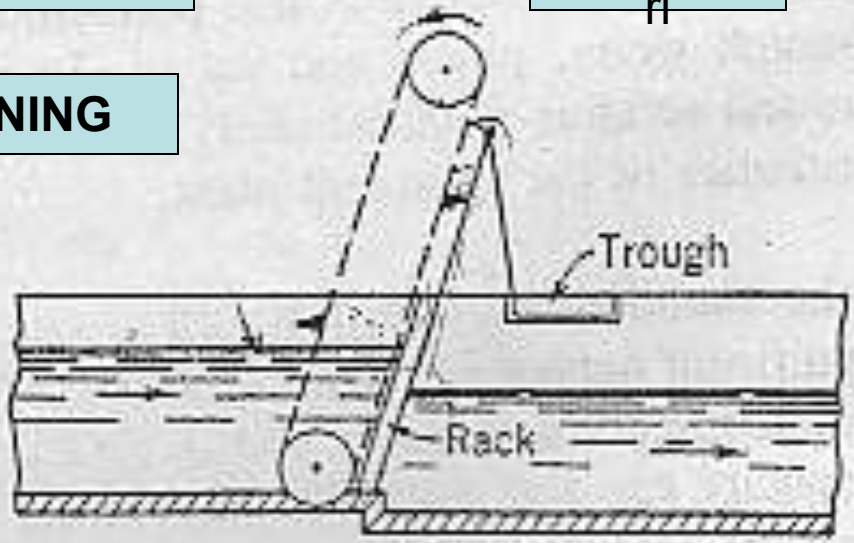
SCREENING



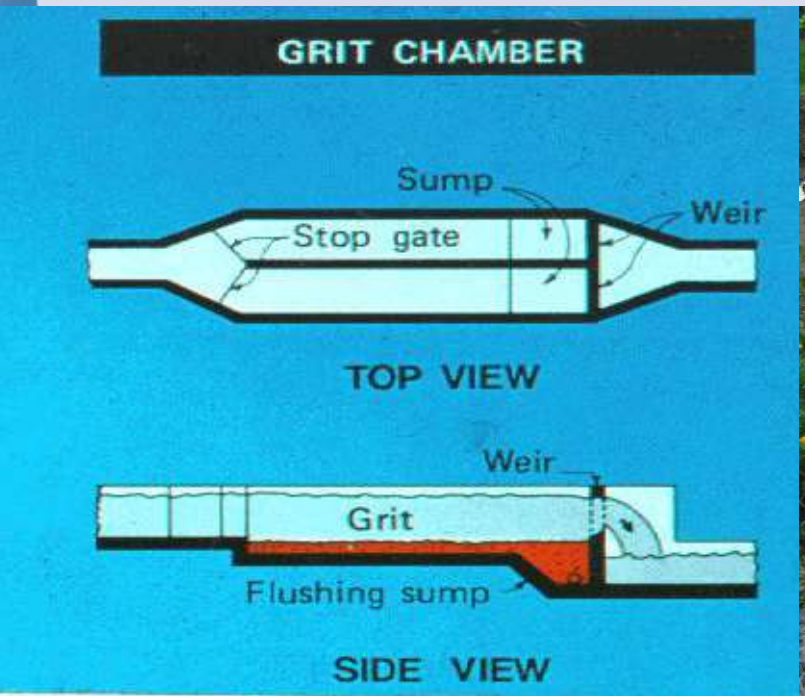
Manual Screen



Mechanical Screen

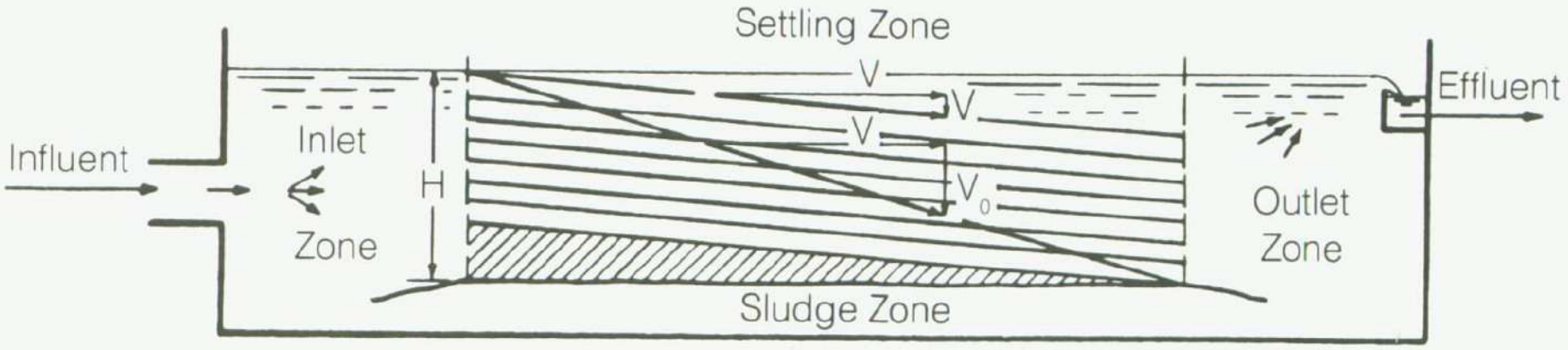
Grit Chamber

- Normally after coarse screen & before sedimentation
- Removes inert solids to avoid wear & tear of mechanical equipment, clogging of pipes and accumulation of heavy inert materials in sludge



Primary Treatment - Sedimentation

- Reduces suspended solids and BOD
- Equalizes wastewater flow and quality
- Settlement by gravity under quiescent condition
- Four zones: inlet, settling, outlet, sludge
- Different types
  - Radial Flow (Circular tank)
  - Horizontal Flow (Rectangular tank)
  - Upward flow



Primary Treatment

- Floatation
  - Removes very small and light particles that settle very slowly
  - Air bubbles are introduced which attach to particles and rise to the surface. This is skimmed.
- Equalization
- pH Neutralization

Secondary (Biological) Treatment

- Best for high BOD content (biodegradable)
- Aerobic or Anaerobic
- Suspended Growth
  - Microorganisms remain in liquid suspension
  - Activated Sludge; Oxidation Ditch
- Attached Growth
  - Microorganisms are attached to a media
  - Trickling Filters, Rotating biological contactors
- Natural Systems
  - Lagoons
  - Constructed Wetlands

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WETLANDS

- Transitional areas between land and water
- Presence of surface or near-surface water at least periodically
- Comparatively shallow and slow moving water in which dense stands of water tolerant plants are grown
- Slow flows provides prolonged contact times between the water and surfaces within the wetland
- Interaction between microorganisms and organic/inorganic materials that break down or transform a wide variety of pollutants

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CONSTRUCTED WETLANDS

- **A Biological wastewater treatment system designed to mimic process found in natural wetland ecosystems.**

- **They are based on soil and plants rather than concrete and metal, they can potentially treat wastewater with low costs and low maintenance.**

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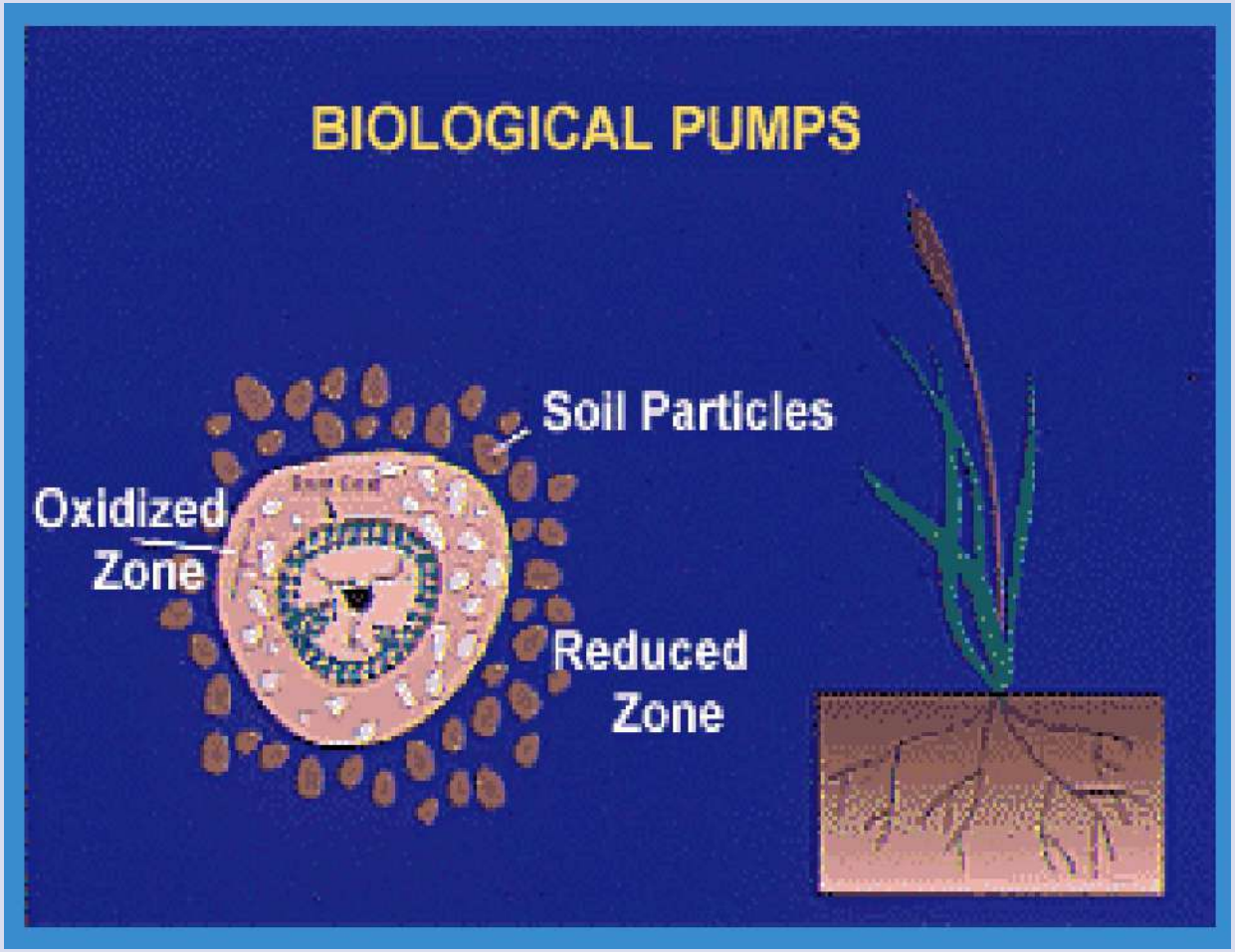
BIOLOGICAL PUMPS
Soil Particles
Oxidized Zone
Reduced Zone

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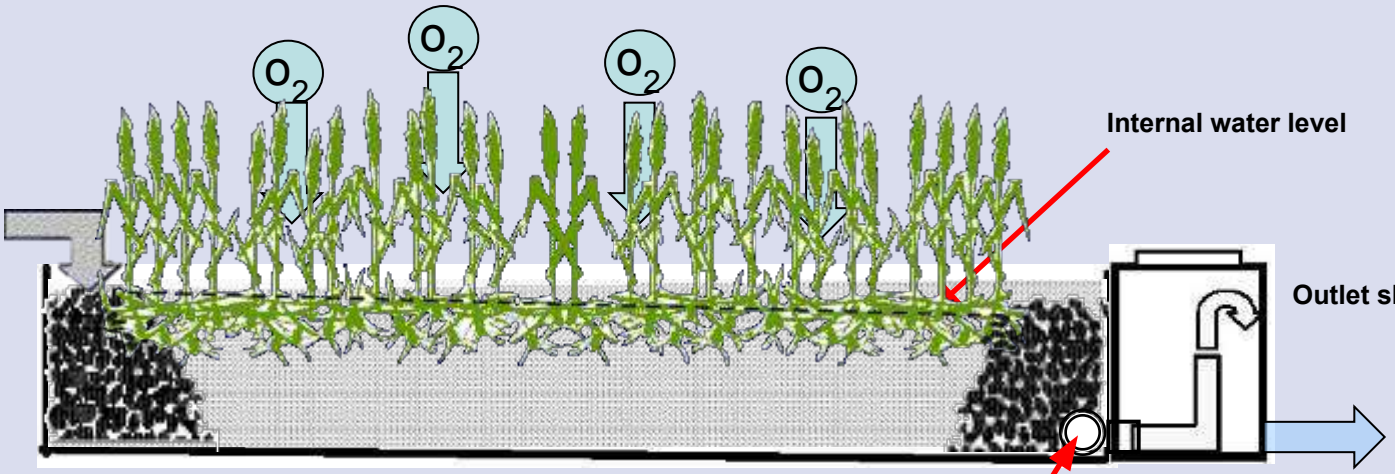
Typical working process

Influent

Inlet

Continuous oxygen supply to upper layer



Effluent

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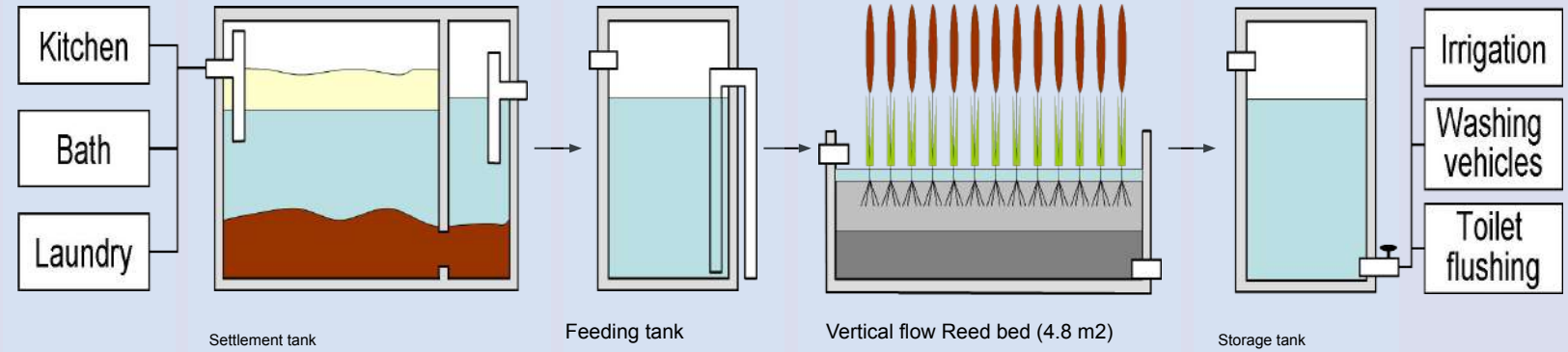
Greywater recycling through CW



V: 250 l

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Pollutant Removal Mechanism in Constructed Wetlands

Wastewater Constituents	Removal Mechanism
Suspended Solids	Sedimentation Filtration
Soluble organics	Aerobic microbial degradation Anaerobic microbial degradation
Nitrogen	Ammonification followed by microbial nitrification Denitrification Plant uptake Matrix adsorption Ammonia volatilization (mostly in SF system)
Phosphorous	Matrix sorption Plant uptake
Metals	Adsorption and cation exchange Precipitation Plant uptake Microbial Oxidation /reduction
Pathogens	Sedimentation Filtration Natural die – off Predation UV irradiation (SF system) Excretion of antibiotics from roots of macrophytes

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Types of Constructed Wetlands

- .Free Water Surface Flow System (FWS)
- . Sub-Surface Flow System (SSF)
  - . Horizontal sub-surface flow (HF)
  - . Vertical sub-surface flow (VF)
- . Hybrid System (combination of 1 and 2)

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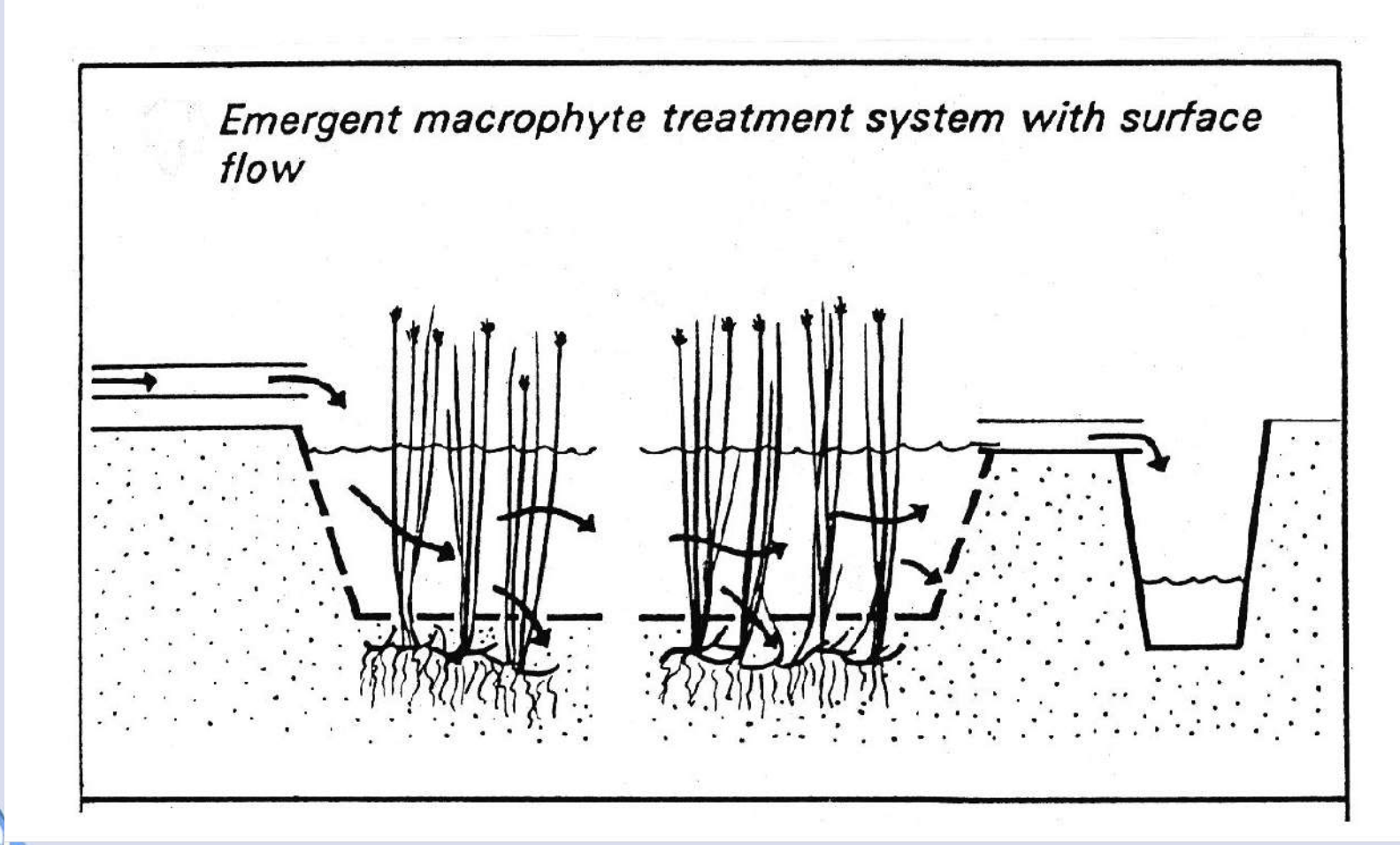
Free Water Surface Flow System (FWS)



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Wastewater Treatment System

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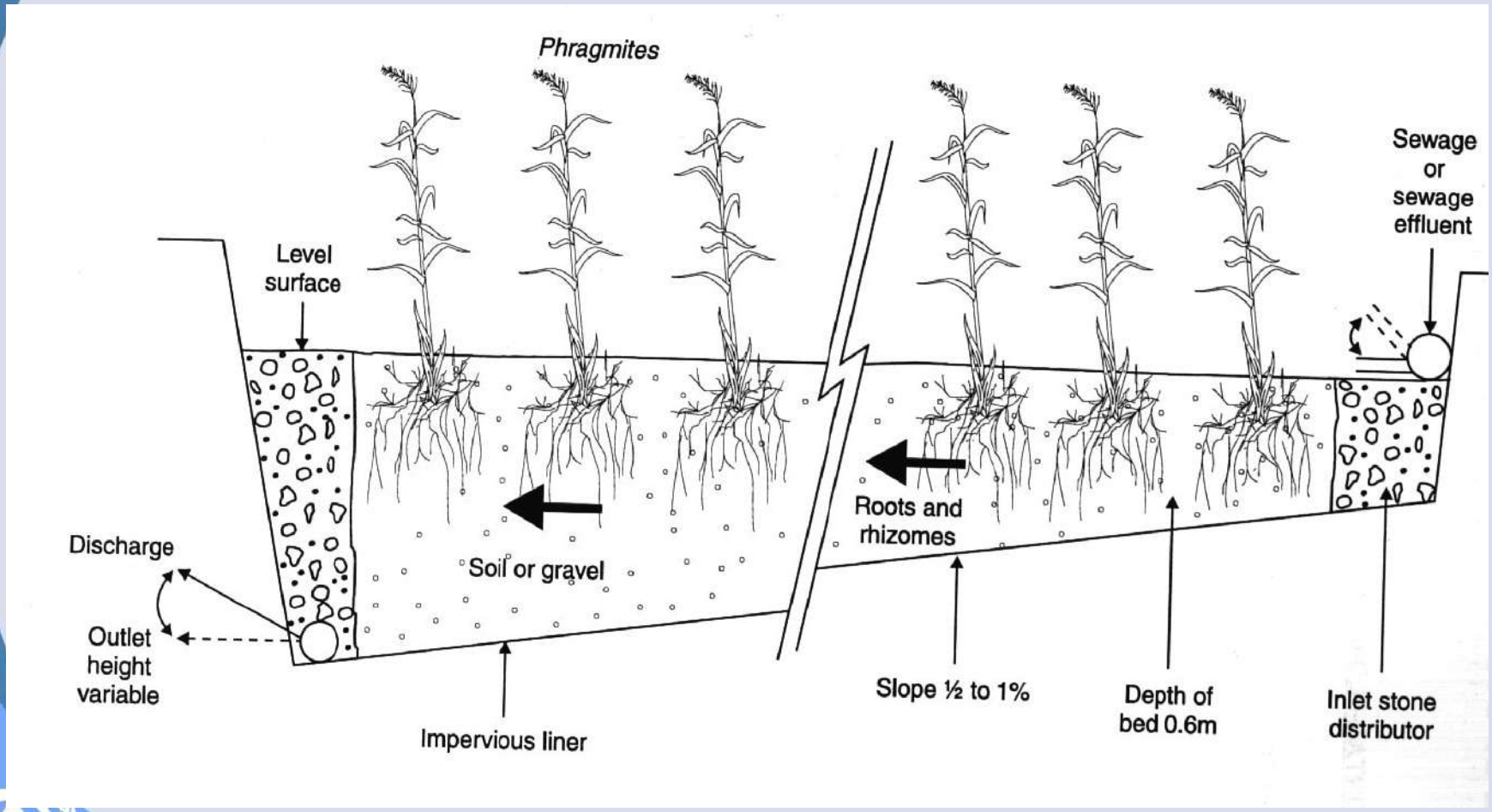
Sub-Surface Flow System



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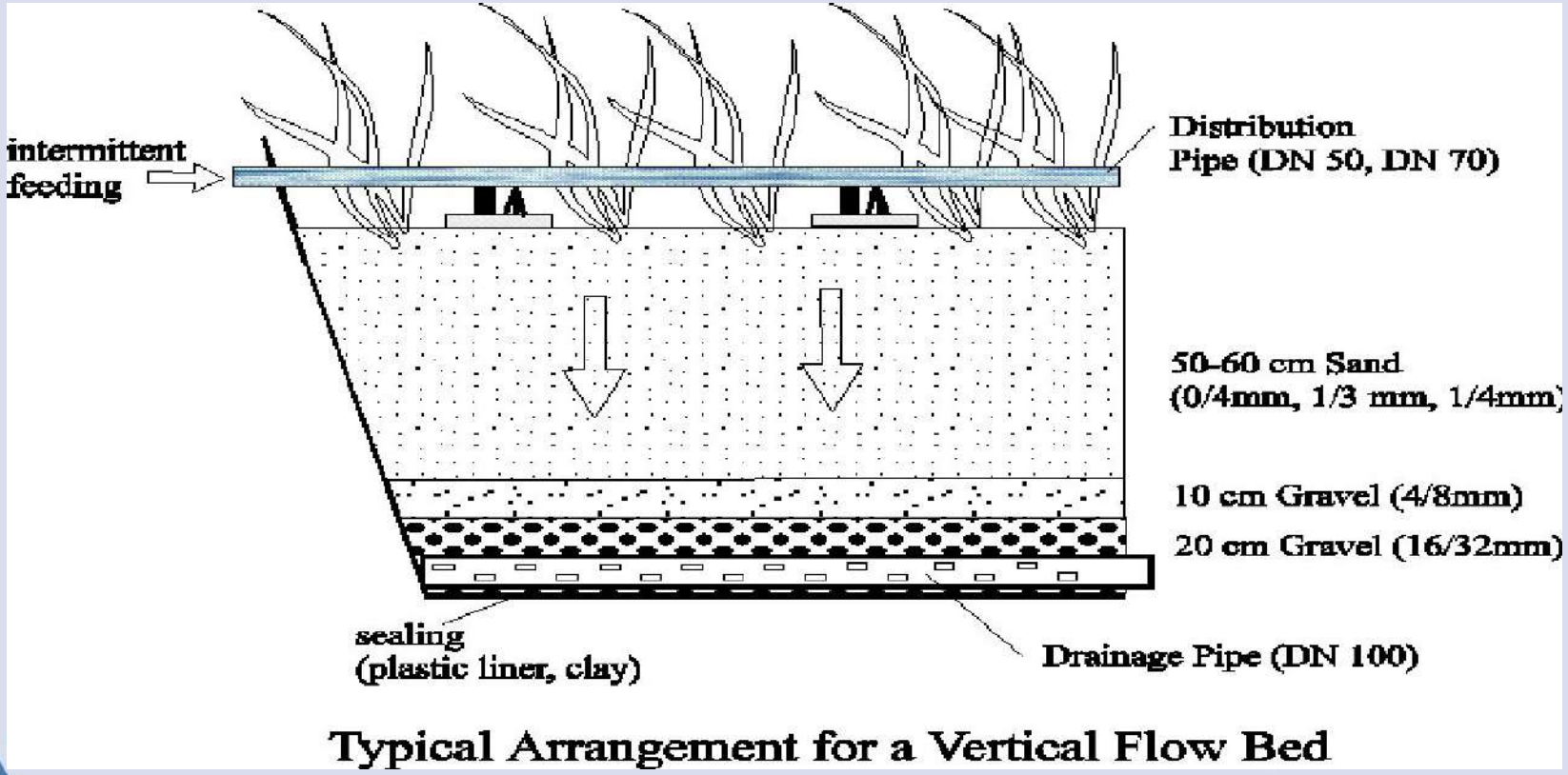
Constructed wetlands with Vertical Sub-Surface Flow (VF)



Typical Arrangement for a Vertical Flow Bed

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Longitudinal Section

Figure 5

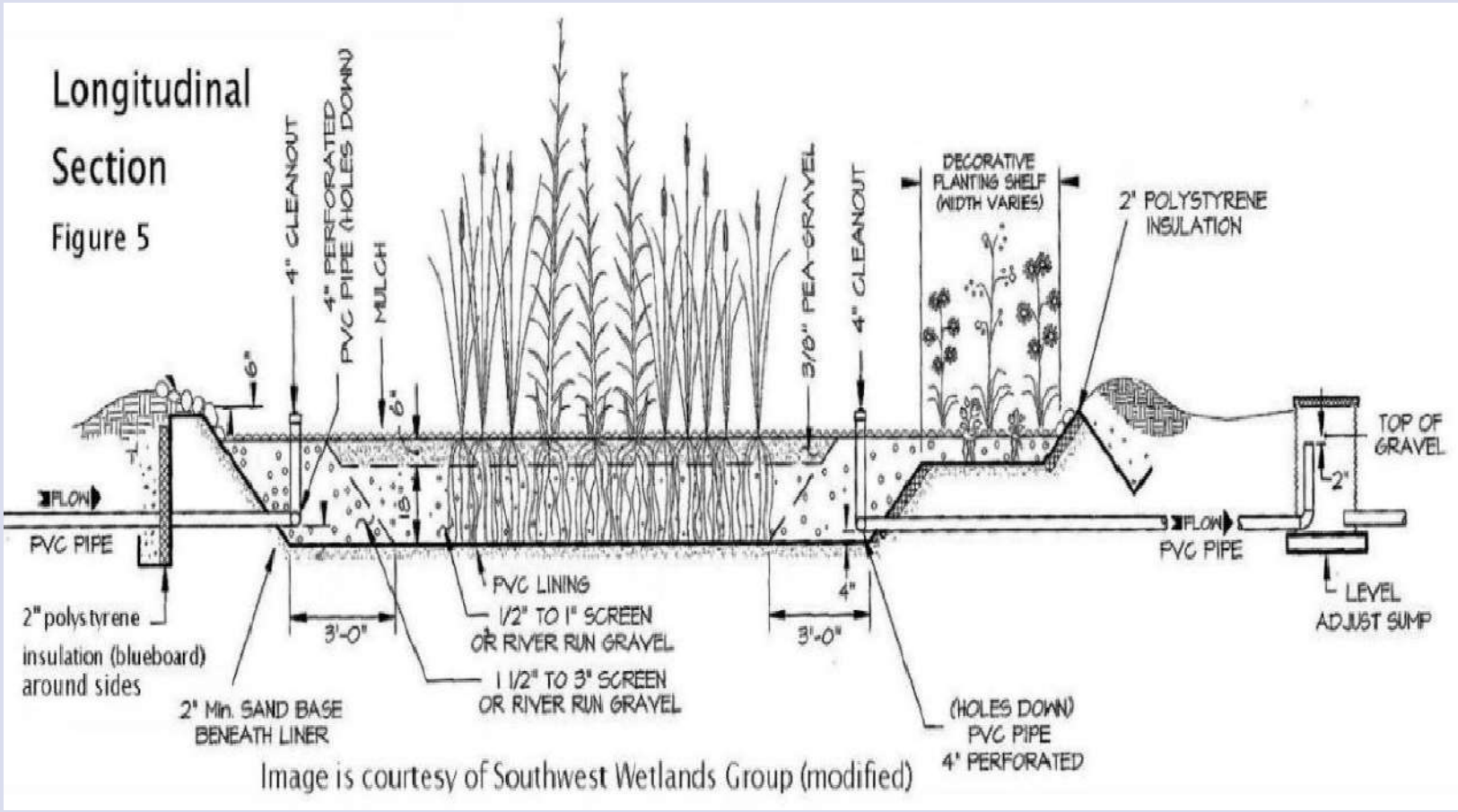

Image is courtesy of Southwest Wetlands Group (modified)

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Constructed Wetland could be one of the Options

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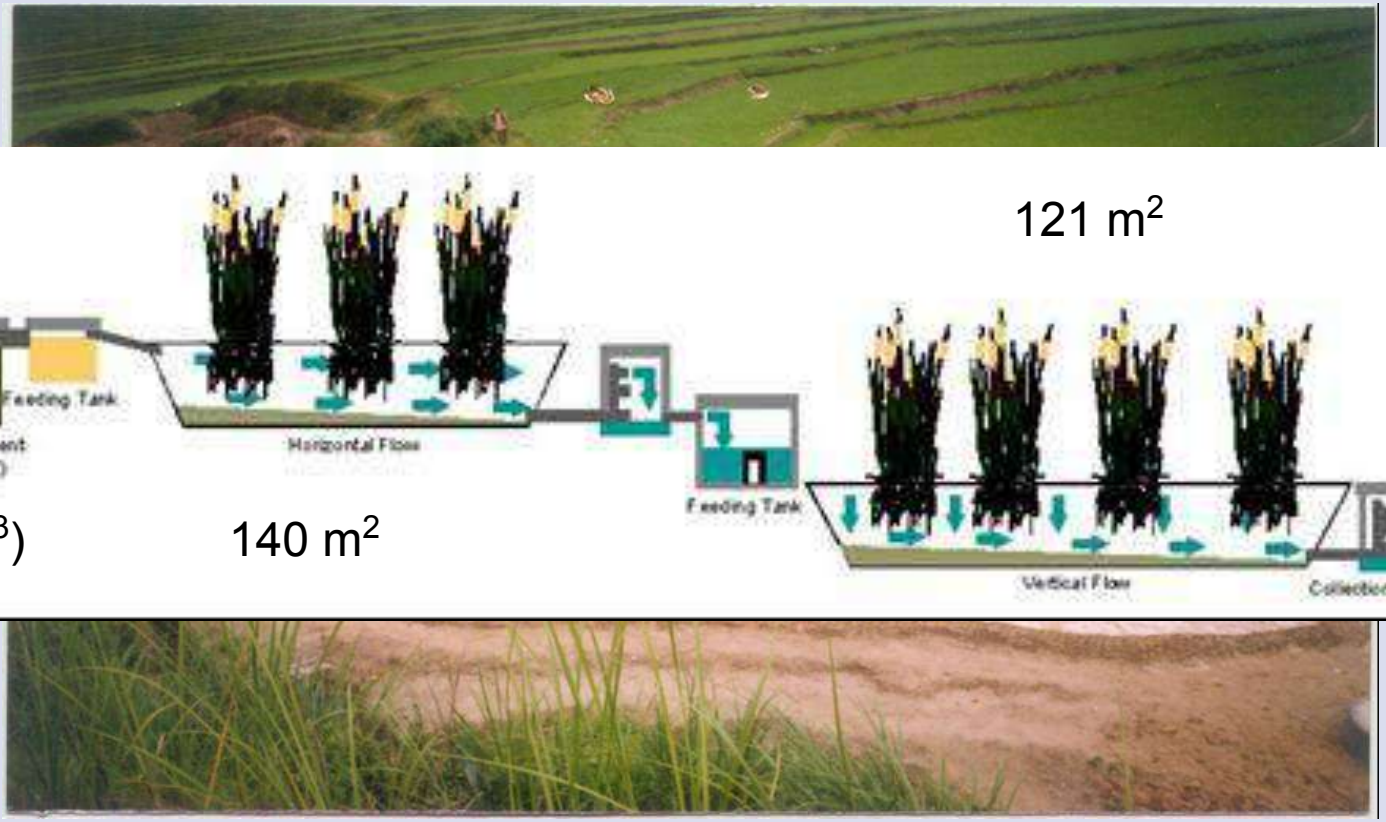
Constructed Wetland for Treatment of Hospital Wastewater in 1997



(16.5 m^3)

140 m^2

121 m^2

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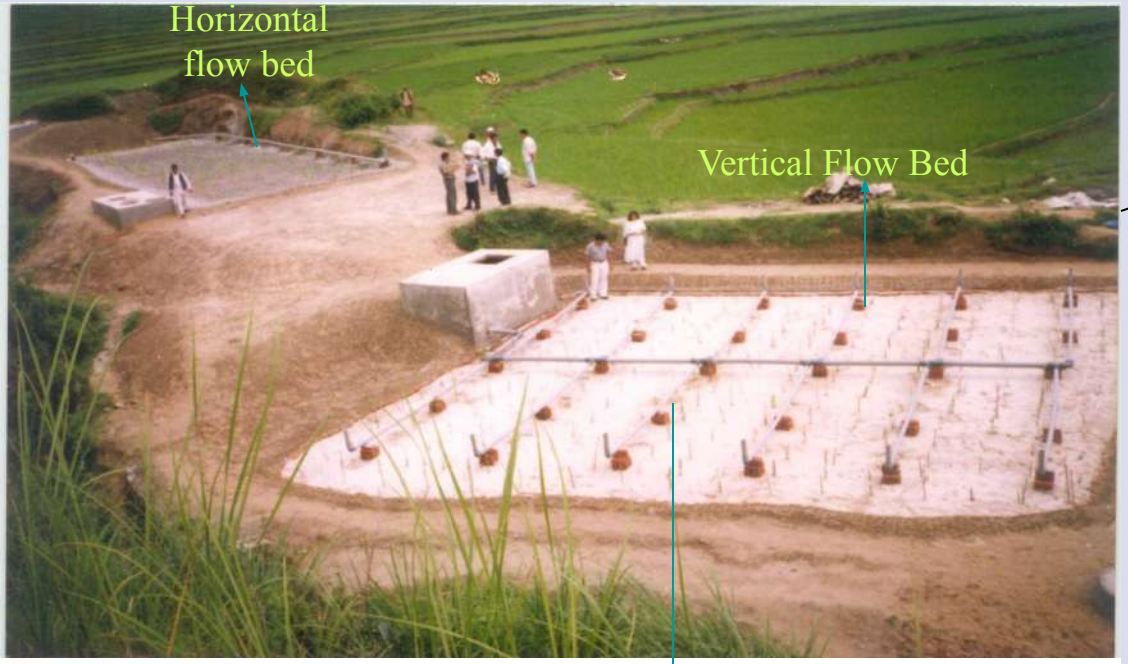
First CW in Nepal at Dhulikhel Hospital



Reed Bed Treatment system just after completion

Before treatment

After Treatment

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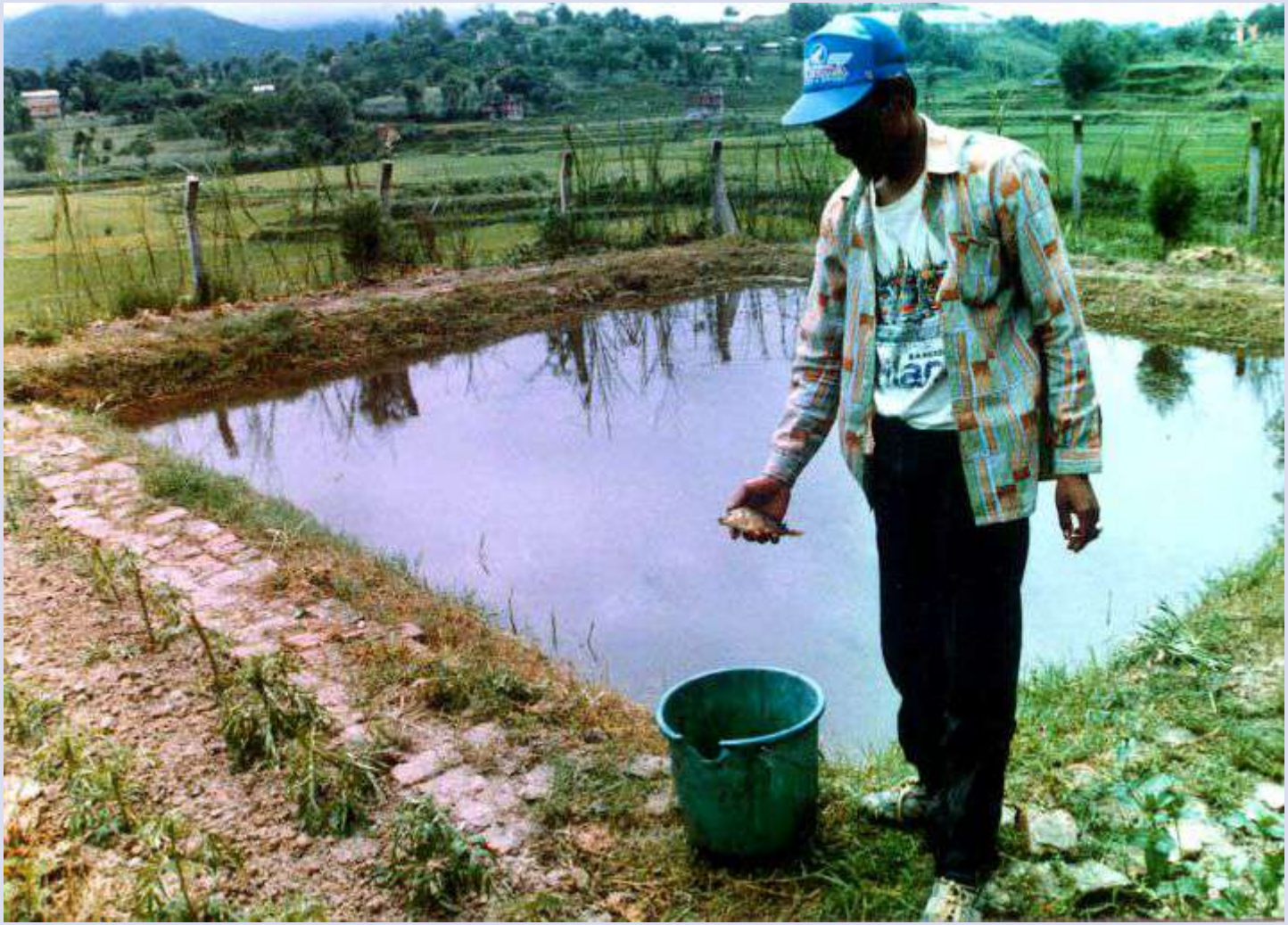

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TREATED WASTEWATER

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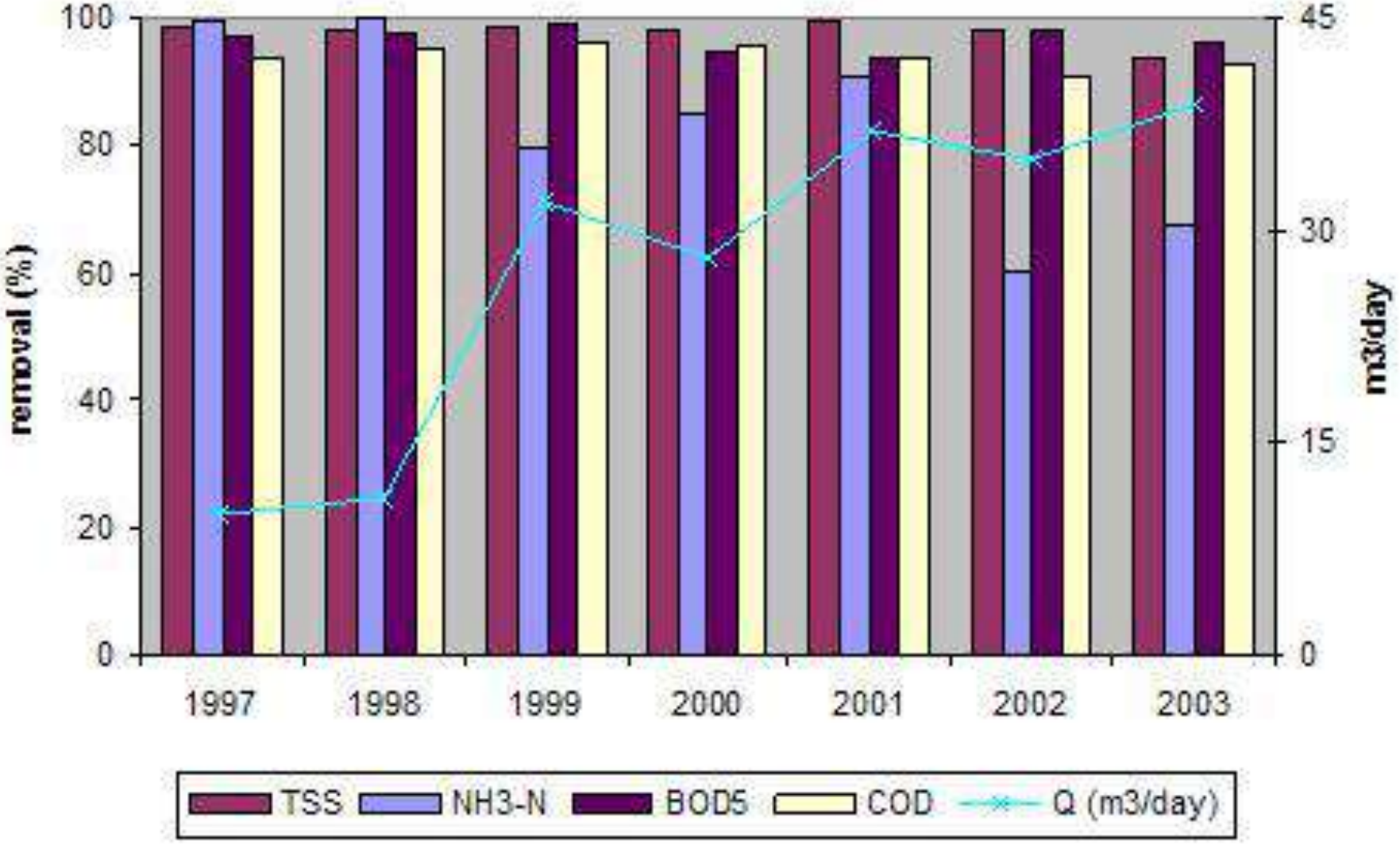
Pollution removal rate of Dulikhel Hospital CW (1997-2003)
removal (%)
m3/day
100
80
60
40
20
0
45
30
15
0
1997
1998
1999
2000
2001
2002
2003
TSS
NH3-N
BOD5
COD
Q (m3/day)

Year	TQ In m3	E. Coli. Inlet col/ml	E. Coli. Outlet col/ml	E.coli Removal %
1997 (Average of four months)	10	123667	20	99.9838
1998 (Average of three months)	11	3743333	19	99.9995
1999 (Average of three months)	32	540000000	239	99.99996
2000 (Average of three months)	28	270000	509	99.8117

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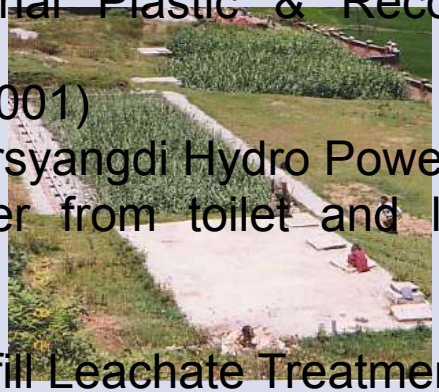
1. Dhulikhel Hospital (1997)
2. Septage Treatment Plant, KMC (1998)
3. Gray Water Recycling, Private House (1998)
4. Malpi International School (2002)
5. Sushma Koirala Memorial Plastic & Reconstructive Surgery Hospital (2000)
6. Kathmandu University (2001)
7. Staff Quarter, Middle Marsyangdi Hydro Power Station (2002)
8. Recycling of Wastewater from toilet and laboratory, ENPHO (2002)
9. Kapan Monastery (2003)
10. Faecal Sludge and Landfill Leachate Treatment Plant (2002)
11. Gray Water Recycling, Private House (2003)
12. Shuvatara School (2004)
13. Bagmati Area Sewerage Construction/Rehabilitation Project, BASP (under construction)
14. Community Scale Madhyapur Thimi Municipality Wastewater Treatment Plant (2005)
15. Poly Clinic, Ilam (under design)
16. Manohara Land pooling Area (under design study)

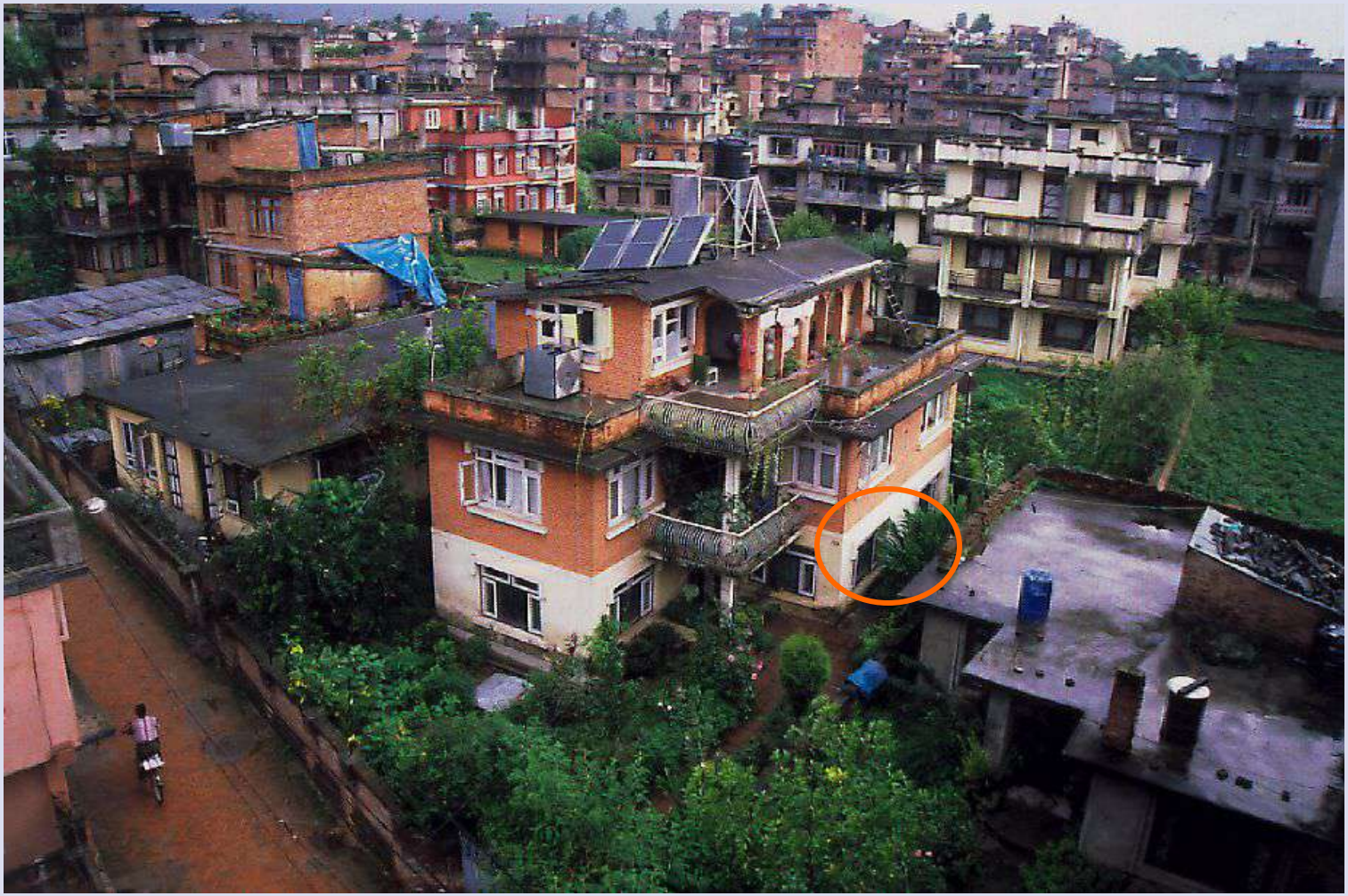









WASTEWATER RECYCLING, 1998



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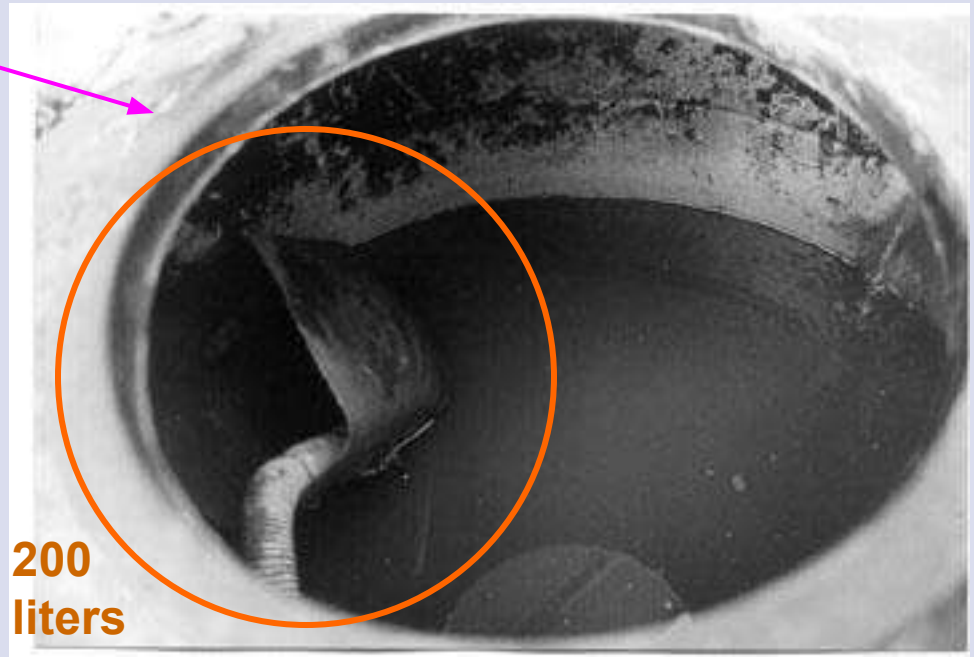

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Quality of Gray water Before and After

	Influent range	Effluent range
BOD mg/l	100 to 400	0 to 12
COD mg/l	177 to 687	7 to 72
TSS mg/l	52 to 188	1 to 6
NH4-N mg/l	4 to 26	0 to 2
PO4-P mg/l	1to 5	1 to 4
Total Coliform col/100 ml	$91x10^7$	<1000

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CW for Kathmandu University

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1,500
1,180 m2
1,645 m2

Wastewater Treatment Plant at Gumba

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Rainwater Harvesting and waste water treatment at a housing colony for squatter communities

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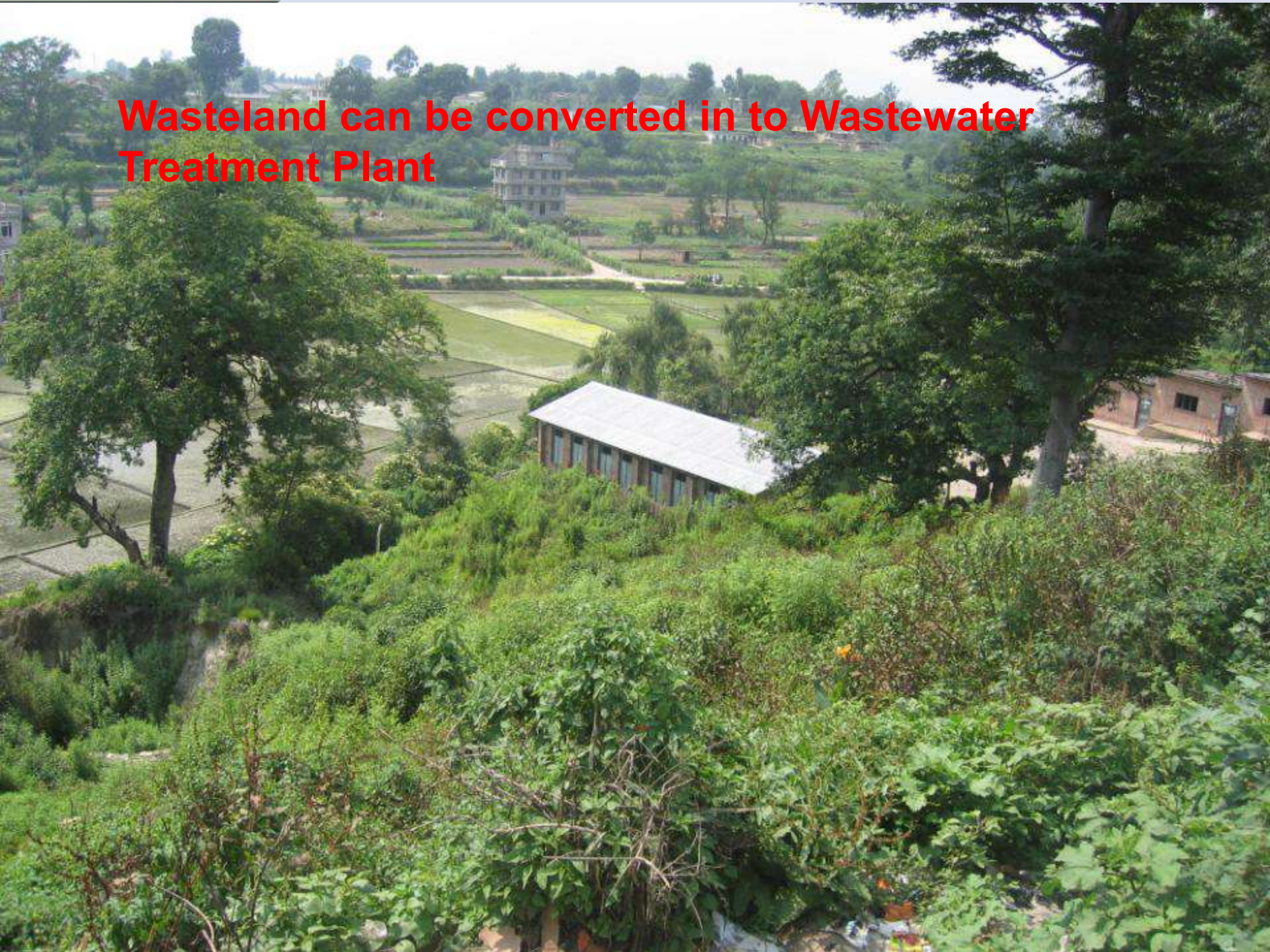
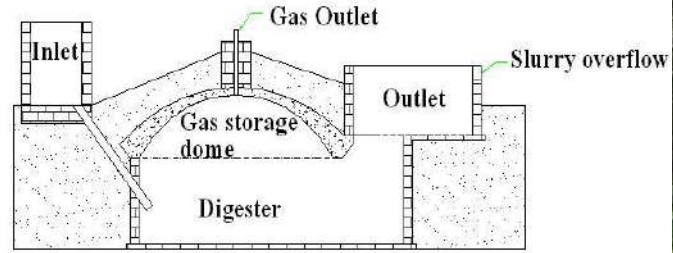

Wasteland can be converted in to Wastewater Treatment Plant

VF Constructed Wetland

HF Constructed Wetland

ABR

SDB



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Community managed WWTP in Dhulikhel

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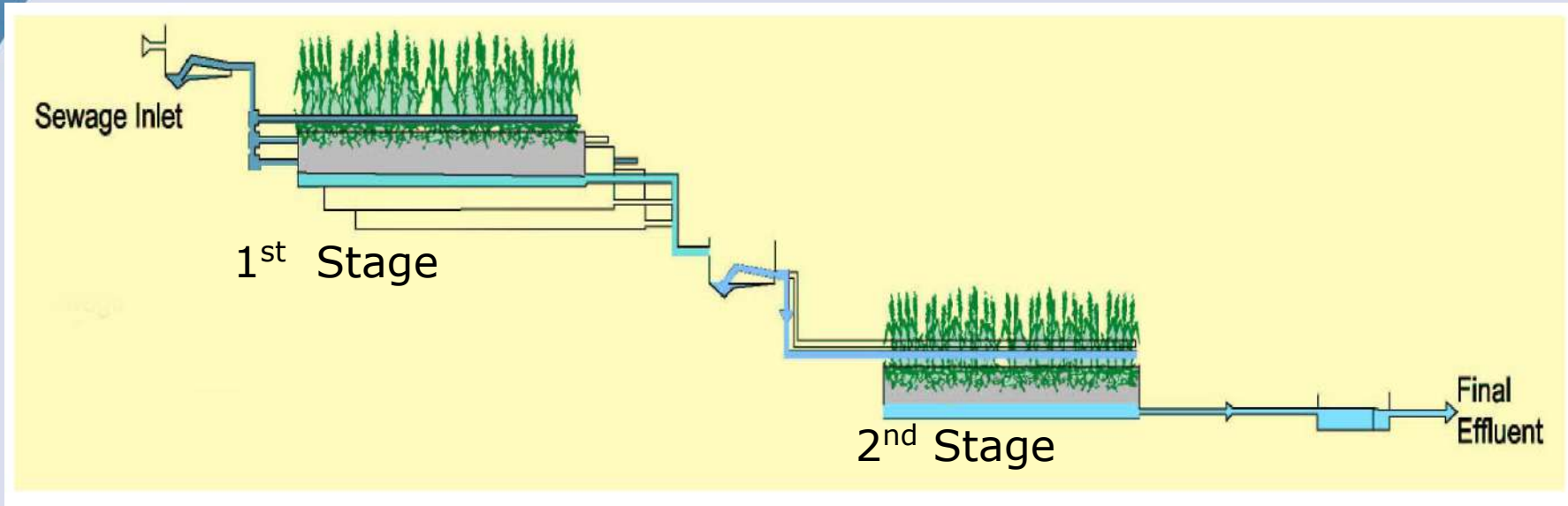
New Concept without Settlement Tank Practice in France



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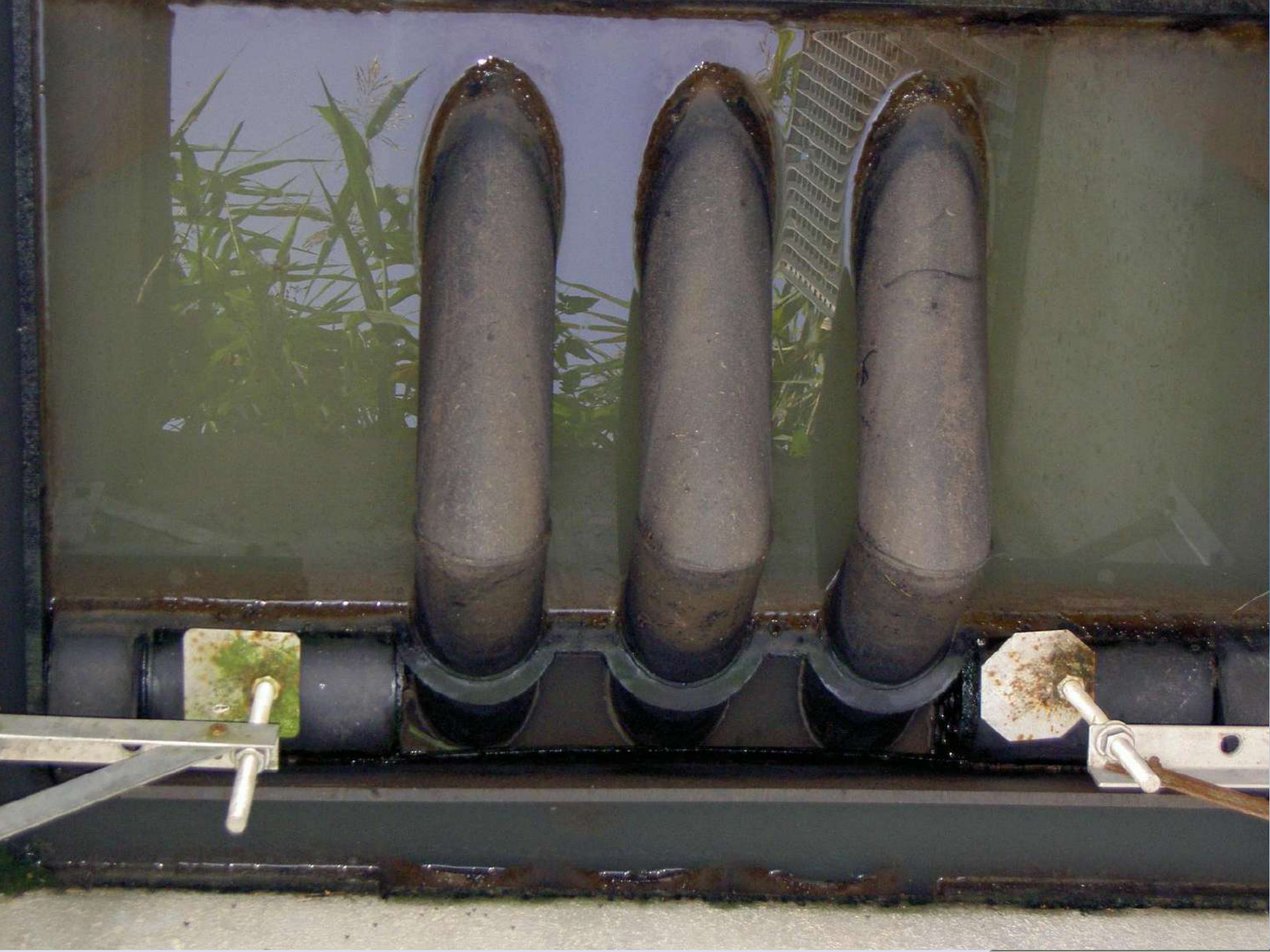


2003/ 5/27

GK Fishermans Village
Bayawan City, Philippines Oriental Negros
2,800 sq.m.

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Absolut Chemicals Alcohol Distillery
Lian, Batangas, Phillipines
300 sq.m.

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Large Scale Replication

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Estimation of Area

- 0.75 m^2 of surface area should be enough to treat wastewater generated by a person per day.
- For treatment of 1 m^3 of wastewater about 7 to 10 m^2 of area is required.
- Size of the wetland can be determined by effluent discharge quality criteria and purpose of treated water for further use.

HF system

- Surface Area

$$A_h = \frac{Q_d (\ln C_i - \ln C_e)}{K_{BOD}}$$

A_h = Surface area of bed (m^2)

Q_d = average daily flow rate of sewage (m^3/d)

C_i = influent BOD_5 concentration (mg/l)

C_e = effluent BOD_5 concentration (mg/l)

K_{BOD} = rate constant (m/d)

0.083 m/d (Schierup *et al.,* 1990)

0.1 m/d (Cooper *et al.* 1996)

0.19 m/d (Dhulikhel Hospital)

O & M Issues

- LOW maintenance system, people often think as NO maintenance system.
- Cost Recovery and regular O&M
- Some major O & M in CW
  - Care less in sludge removal from primary treatment
  - Cleaning of distribution pipes
  - Flushing system particularly intermittent feeding
  - Care Taker

Issues on CW

- Wastewater treatment is still not a priority for city in developing world
- CW though simple technology but still not yet aware
- Limited professional consultants and not interested in cost reduction
- Research findings of Academics and Scientists are not yet transformed into full scale system

Issues…….

- Primary treatment for large scale CW has yet to be improved in terms of cost and design
- Filling materials are not easy to access in all places leads to increase in cost
- Not easy to access land because of cost and NIMBY SYNDROM
- Communities involvement inadequate
- Recycling of greywater is not culturally acceptable

O & M issues……..

- CW is a LOW maintenance system, but people often think it as NO maintenance system.

- Some major O & M
  - Care less in sludge removal from primary treatment
  - Cleaning of distribution pipes
  - Flushing system particularly intermittent feeding
  - Care Taker

Clogging of Bed due to selection of inappropriate media

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Accumulation Sludge in Settling Tank and clogging of bed

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Cost

- Capital cost Major cost is filter media

Excavation/compaction	10.7 %
Gravel	42.6 %
Liner	15.8 %
Plants	10.9 %
Plumbing	6.1 %
Control structures	5.7 %
Other	8.2 %
Total	100 %

Based on cost for SSF – 4,600 m^2, 0.6 m deep in USA

CW	Year	Cost per m^2
Dhulikhel Hospital	1997	2,700
Malpi School	2000	3,300
ENPHO	2002	2,700
Kapan Monastery	2003	5,000
Sunga WWTP	2005	7,300

Average cost = 5,000 m^2

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