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Combined constructed wetlands and stabilization ponds - a key ecotechnology for treating Africa’s wastewater

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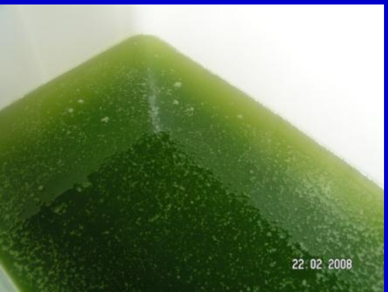


Outline of presentation

- Background
- Natural wastewater treatment systems (NWTS)
- Africa’s peculiar resource potential and technology selection
- Treatment efficiency of NWTS
- Waste Stabilization Ponds (WSPs) and Constructed wetlands (CWs) compared
- Benefits of combined WSPs and CWs
- Examples from tropical Asia
- Preliminary results
- Conclusion

MDG 7: Environmental sustainability

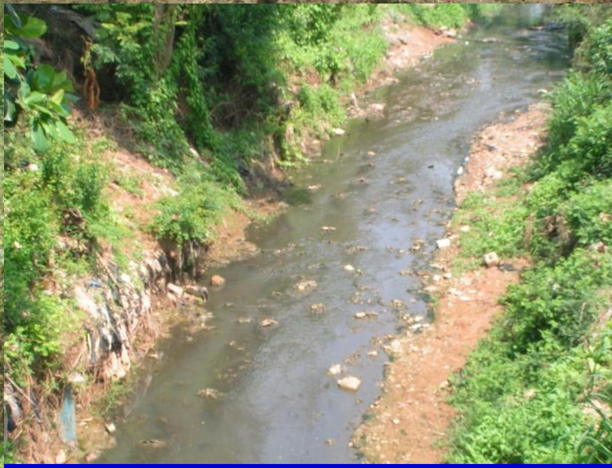
- Programs
- Reverse loss
- Access safe water



Reuse of wastewater

- Eating contaminated vegetables
- 20 million urban dwellers in West Africa reuse diluted wastewater or partially treated wastewater



Ecotechnologies: What are they?

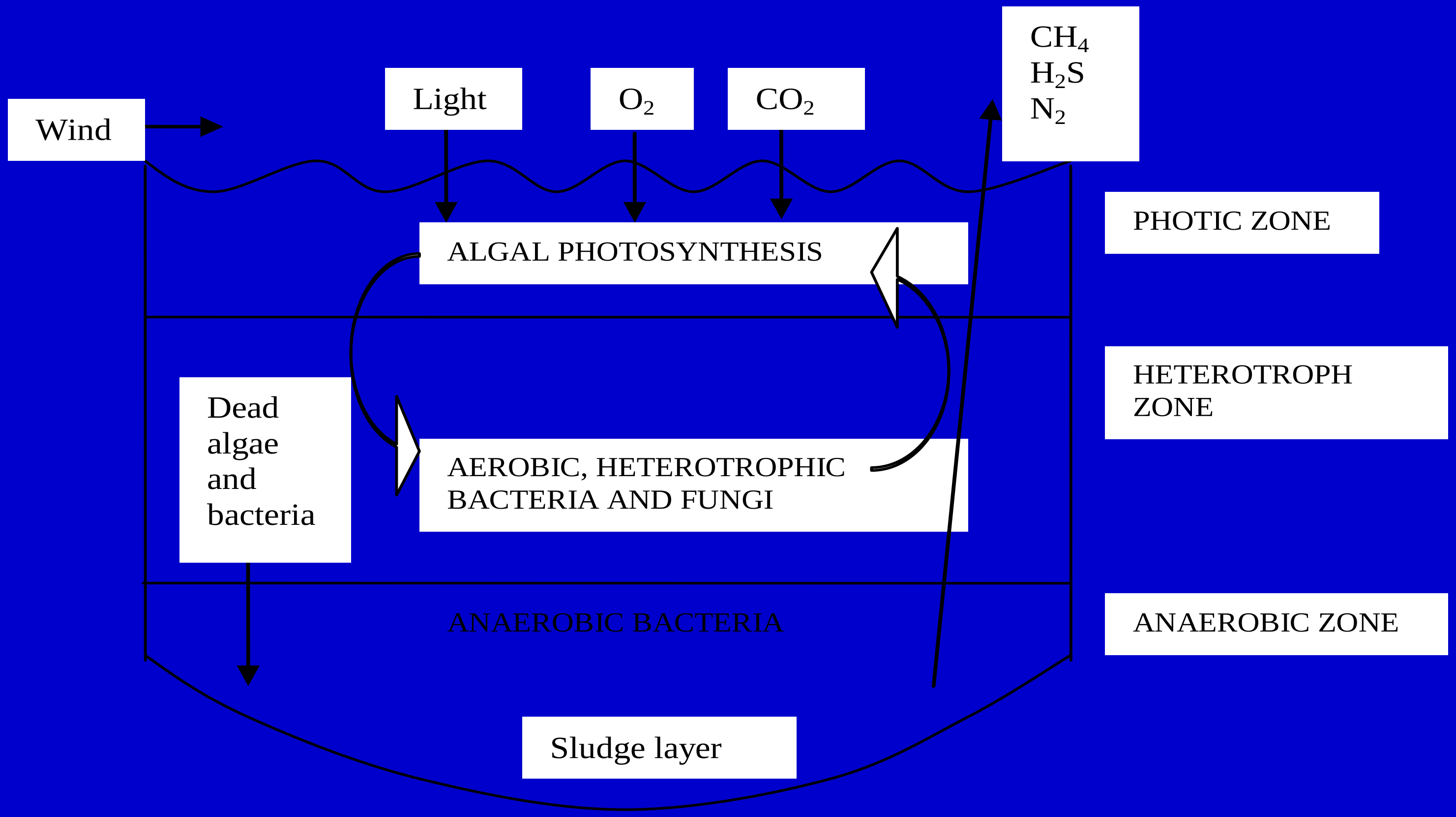
- Self-adjusting
- Little or no human intervention
- Beneficial outcomes for both humans and the environment



Natural wastewater treatment systems (NWTS)

- Artificial systems
- Aerobic processes
- Anaerobic processes
- Facultative conditions

NWTS processes



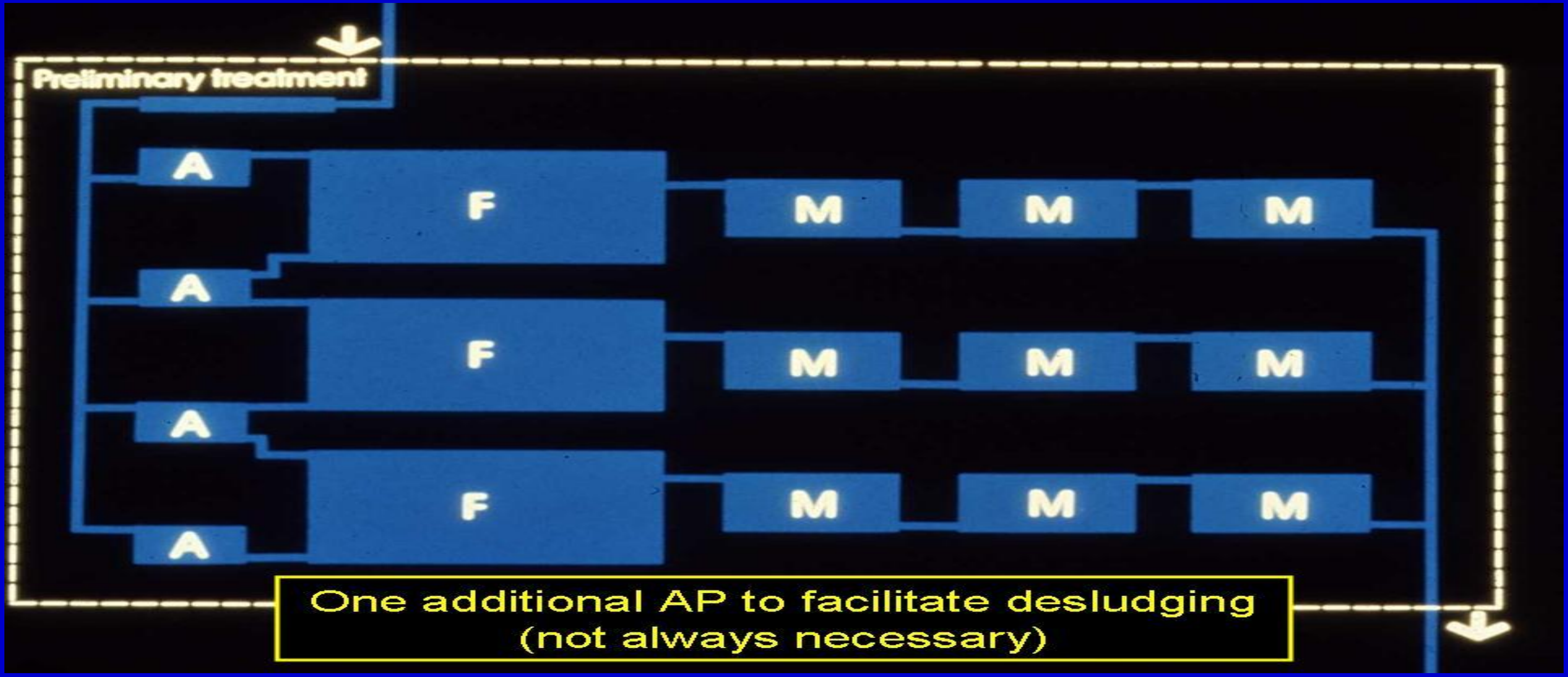
Processes in a facultative pond

Source: Bitton (2005)

Examples of NWTS

Example 1

- Waste Stabilization Ponds (WSPs)



Courtesy: D.D. Mara

Examples of NWTS

Example 2

- Natural wetland

Example 3: Constructed Wetlands

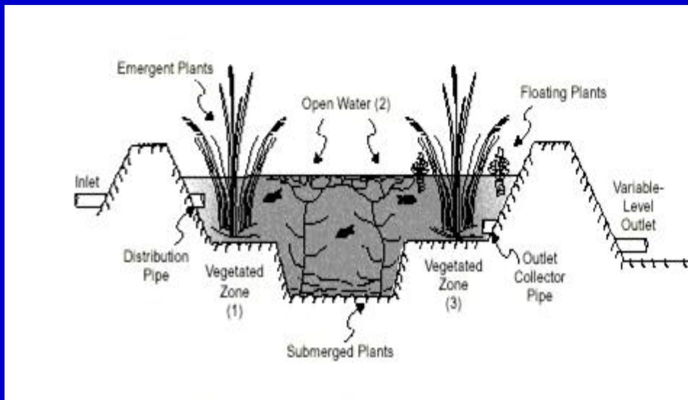
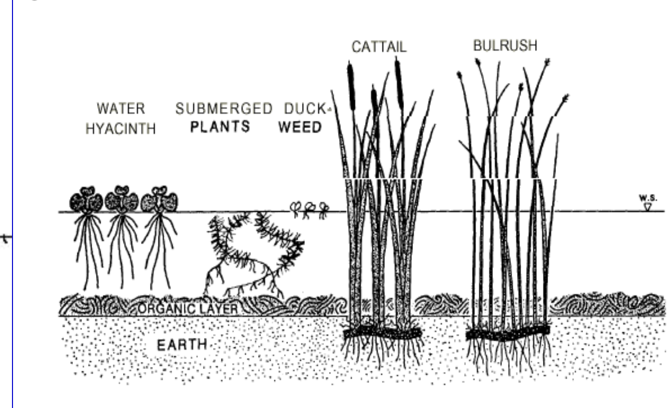
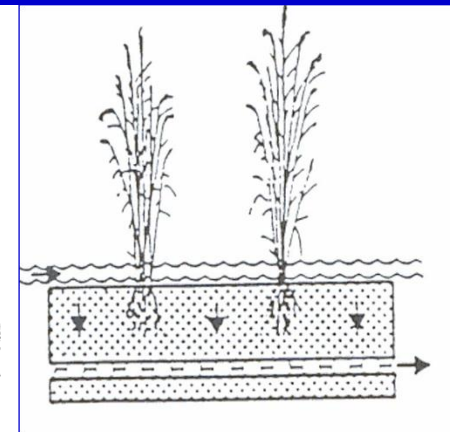
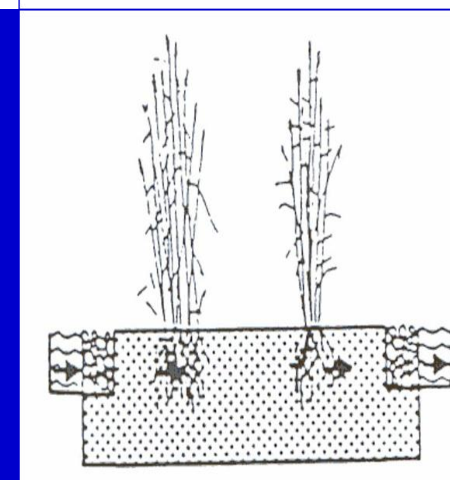


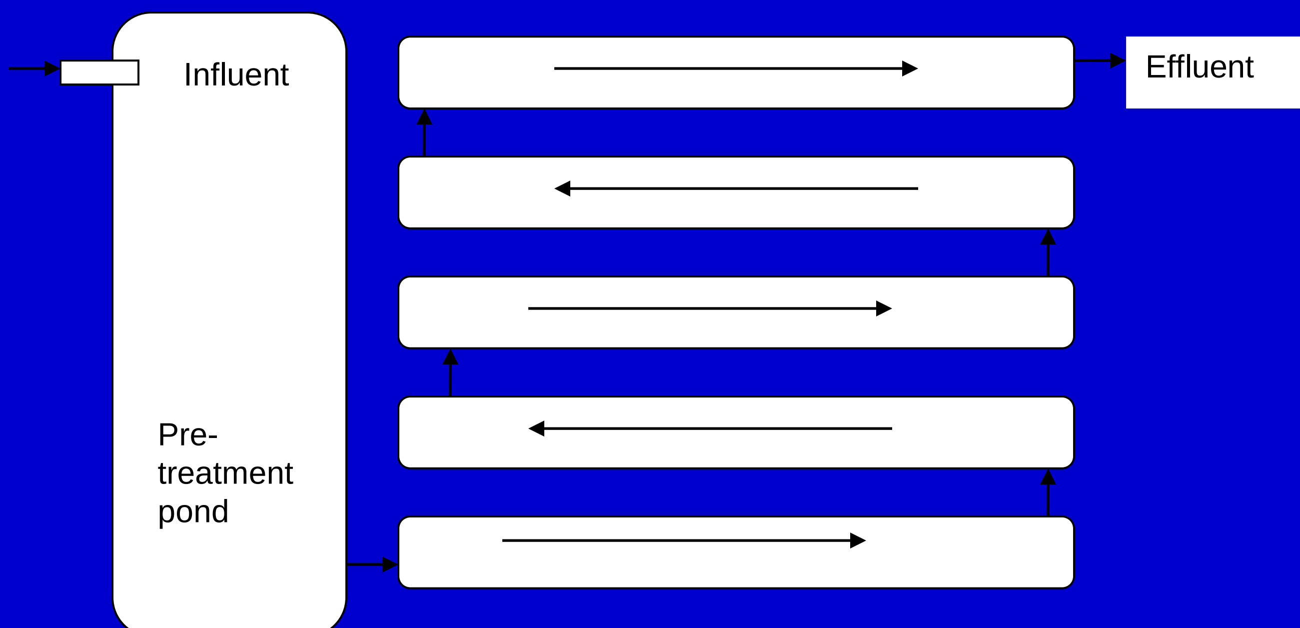
Figure 2-4. Profile of a three-zone FWS constructed wetland cell

Figure I-I. Common aquatic plants.







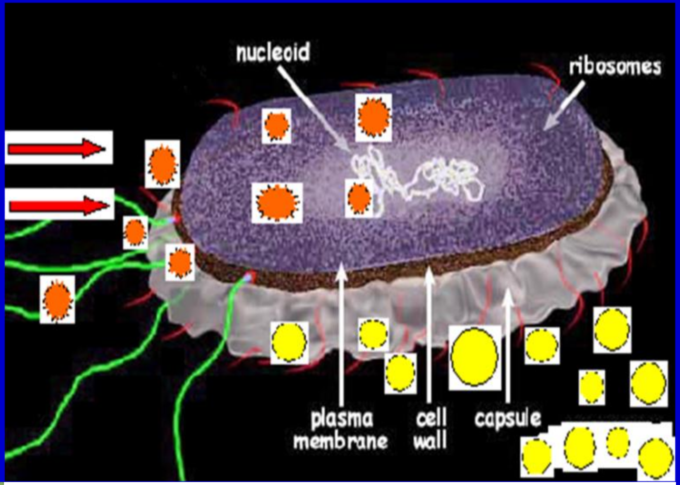


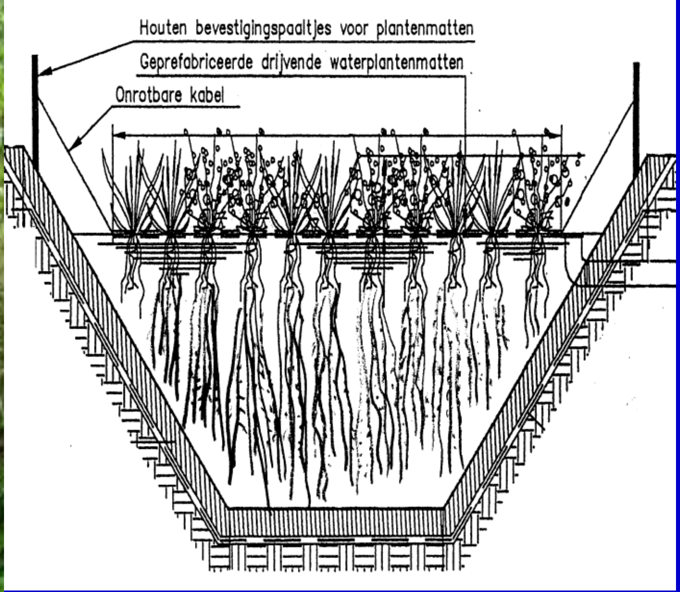
Criteria for technology selection

- Robustness
- Waste generation
- Re-use benefits
- Extent of chemical use and degree of environmental nuisance
- Energy source and other costs

Africa's resource potential in relation to ecotechnology use

- Sunshine
- Diversity
- Labour and land





Treatment efficiency of NWTS

Treatment technology	Log removal		
	Bacteria	H. eggs	P. cysts
Activated sludge	0-2	0-2	0-1
Trickling filter	0-2	0-2	0-1
Aerated lagoon	1-2	1-3	0-1
WSPs	1-6	1-3	1-4
Surface flow CW	1-4	-	1-2
Sub-surface flow CW	1-4	-	1-3

WSPs and CWs compared (Merits and demerits)

Characteristics	WSPs	CW (SF/SSF)
Land requirement	•Mosquito breeding problems •Cheaper even with high land cost	•Cost effective when land is cheap •Require 60% more land space to produce $25 mgL^{-1}$ BOD •$150 mg SSL^{-1}$
Faecal coliform Removal efficiency	Disinfection more efficient in MP than in CW MP (1 log) SF-CW (0.47)	• Removal poor when influent concentration is high

WSPs and CWs compared
(Merits and demerits- Continued)

Characteristics	WSPs	CW (SF/SSF)
BOD removal efficiency	• Effluent high in BOD and Suspended solids due to algal presence	• When loading is low removal is good
Nutrient removal efficiency	•Relatively poor, better when macrophytes are present	• Good when loading is low
Treatment cost (same water quality)	•On the basis of land area requirement, performance, capital, Operating and maintenance costs, WSPs are to be preferred to SSF CW	

Benefits of combined WSPs and CWs

- Robustness
- High purification rates
- Nutrient removal
- Mosquito breeding
- Aesthetic value
- Erosion
- Economic benefits




Example 1:Bangladesh

- Duckweed operated WSP generated enough duckweed used in feeding fish daily
- Annual fish yield: 12 – 16 tons ha^{-1}
- Profit : US$ 2000.00 per year
- Rice production : US$ 1000.00-1400.00 ha yr^{-1}

Source: Gijzen et al., 2004

Example 2: China

- Performance of an integrated duckweed wastewater WSP with fish pond.
- Faecal coliform removal:99.97% (10^4cfu/100mL)
- BOD removal: 86%, TSS: 85%
- NH_3-N: 55%, Total phosphorus: 52%
- Plant treated 100,000m^3d^{-1}
- 2,030 tonnes of fish produced annually
- Harvest of duckweed, reed and fish pays for O&M costs.

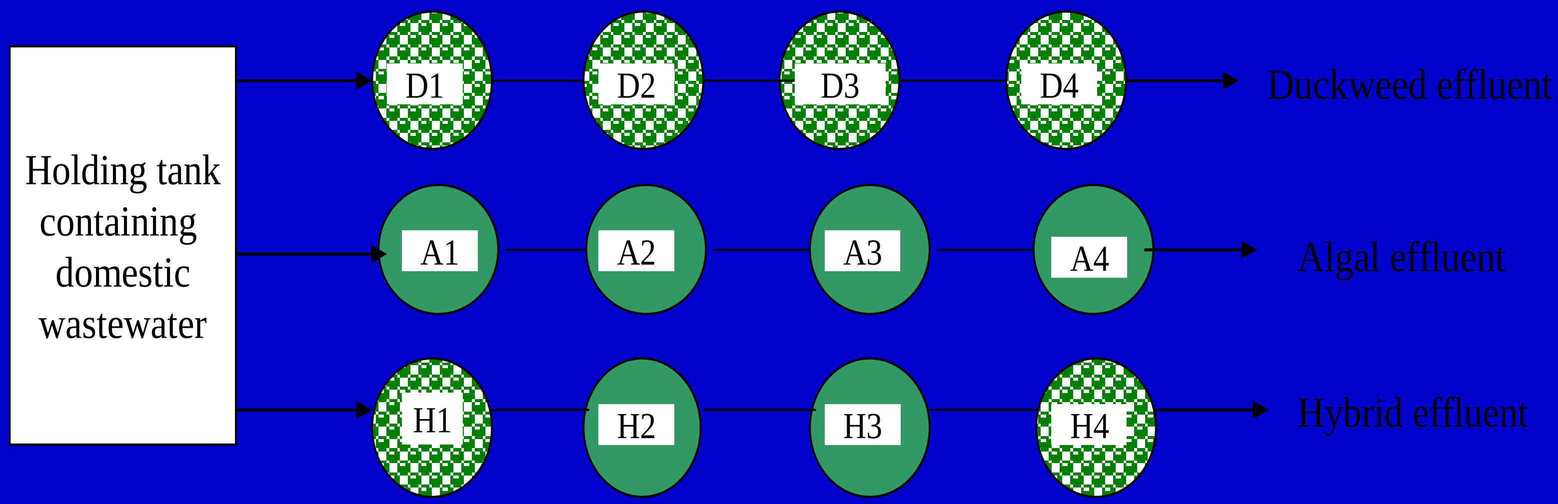
Source: Wang et al., 2005

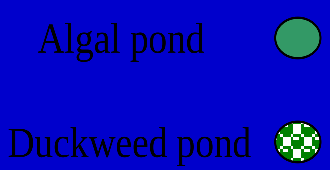
Example 3: Malaysia

- Putrajaya wetlands comprised 24 wetland cells(200ha)
- Removes agricultural pollutants before entry into adjoining lake.
- Removal by 6 cells were as follows:
- TN: 82%, NO_3-N: 71%, PO_4: 84%
- Wetland created a pleasant landscape for eco-tourism and wild life

Source: Shutes, 2001; Sim et al., 2008

Preliminary results: Ghana





Flow rate = 6.9litres/day

Total Retention time = 20days

Diameter = 0.38m

Depth = 0.3m

Results: Percentage removal by pond systems

	Duckweed ponds	Algal ponds	Hybrid ponds
BOD (mg/L)	92% (13.5)	73% (45.5)	89% (18.5)
NH_3-N (mg/L)	84% (11.6)	86% (19.0)	91% (6.6)
Total P (mg/L)	69% (1.7)	49% (2.8)	63% (1.9)
F. Coliform (log removal)	3.7(4.2×10^3)*	4.7(3.6×10^2)*	4.3(9.1×10^2)*
Chl-a conc (µg/L)	39	383	76

* FC concentration in cfu/100mL

Feed potential of duckweed in Ghana

- Duckweed production rate:135g$m^{-2}d^{-1}$ (Accra)
- Duckweed production rate:79.8g$m^{-2}d^{-1}$(Kumasi)
- Duckweed production rate: 821.8g$m^{-2}d^{-1}$ (Egypt)
- Feed conversion ratio of duckweed: 1 (sometimes quoted as 2)
- Potential for fishery

Conclusion

- The use of combined WSPs and CWs in a integrated system of wastewater treatment is an efficient and cost effective means of converting wastewater into an economic good.
- Challenges however exist in adapting this technology in sub-Saharan Africa.
- Challenges/ research opportunities include
- Prevention of clogging
- Identifying and adapting local plants that are efficient

Conclusion (cont'd)

- Optimizing duckweed production rate
- Identifying suitable local fish species and fish feed formulations

Thank you