

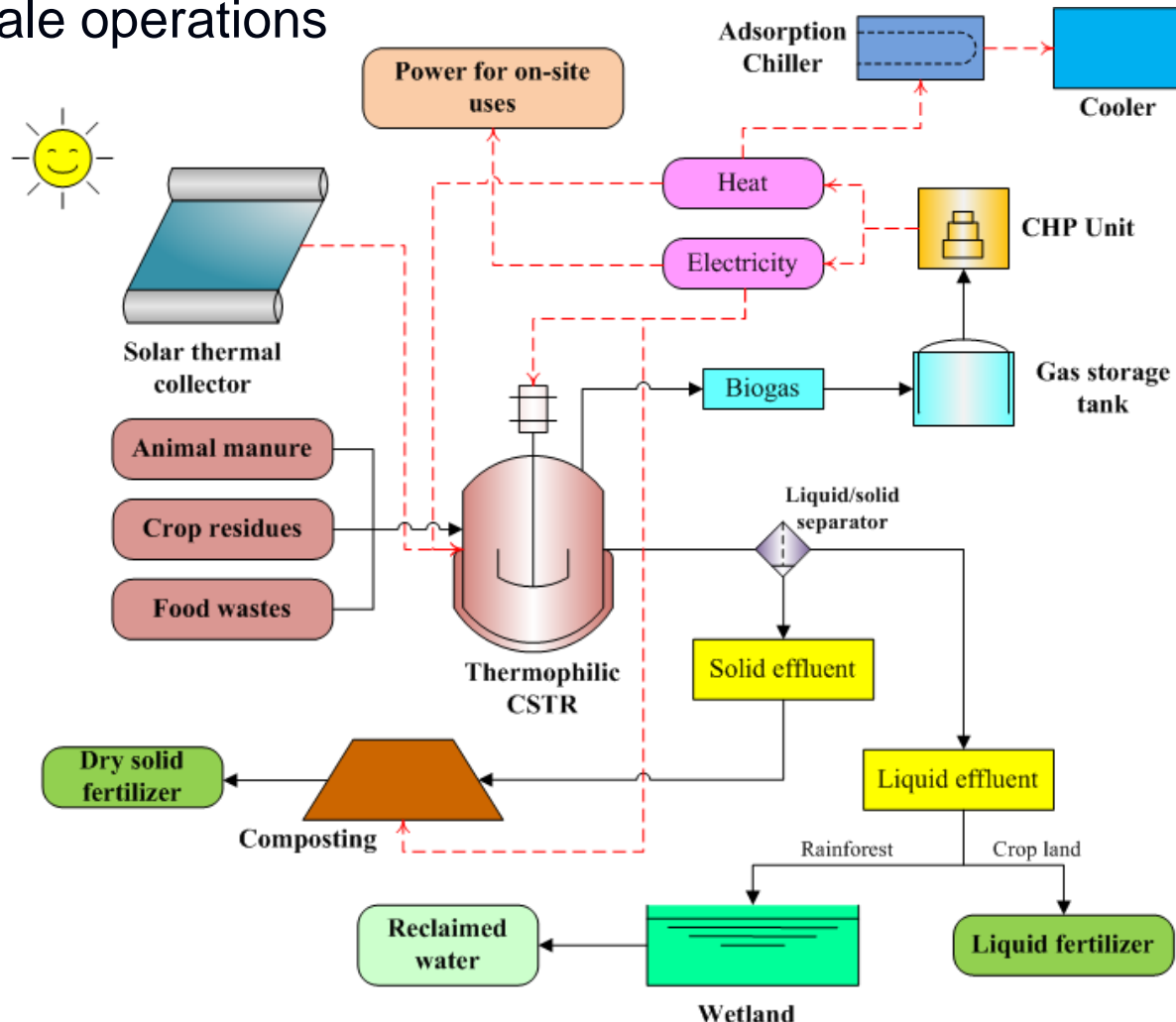
Wetland treatment of organic wastes

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A Solar-Biopower Concept

Integrating wastes utilization with solar and biological technologies will create a novel self-sustainable clean energy generations system for small-medium scale operations



Anaerobic Digestion and Constructed Wetlands for animal wastes treatment

Anaerobic digestion

Sustainability (+)

- Digestion effective generates energy while pretreating wastewaters

Sustainability (-)

- Effluent from digestion is high in oxygen-demanding wastes and nutrients
- Direct land application of digestate can pollute waters, contaminate foods, and saturate soils with nutrients, pathogens, and antibiotics

Constructed wetlands

Sustainability (+)

- Effectively treat nutrients, pathogens, and antibiotics
- Can be used for anaerobic digestate and runoff
- Relatively inexpensive to install and maintain

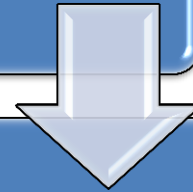
Sustainability (-)

- Still cost-prohibitive with no return on investment for small to medium operations



Outline

Overview of treatment wetlands



Potential challenges



Floating treatment wetlands



Treatment wetlands for animal wastes

Typical design

	Average reduction
BOD	65%
TSS	53%
NH4-N	48%
TN	42%
TP	42%

Typical designs aim for moderate treatment with land application of wastewater.

Data from EPA 2001.

Maximum treatment design

- Increased wetland size and innovative design increase treatment efficiency
 - > 90% removal
 - Year-round attainment of surface discharge requirements
- Treatment of:
 - Pathogens
 - Pharmaceuticals

Benefits and barriers to wetlands

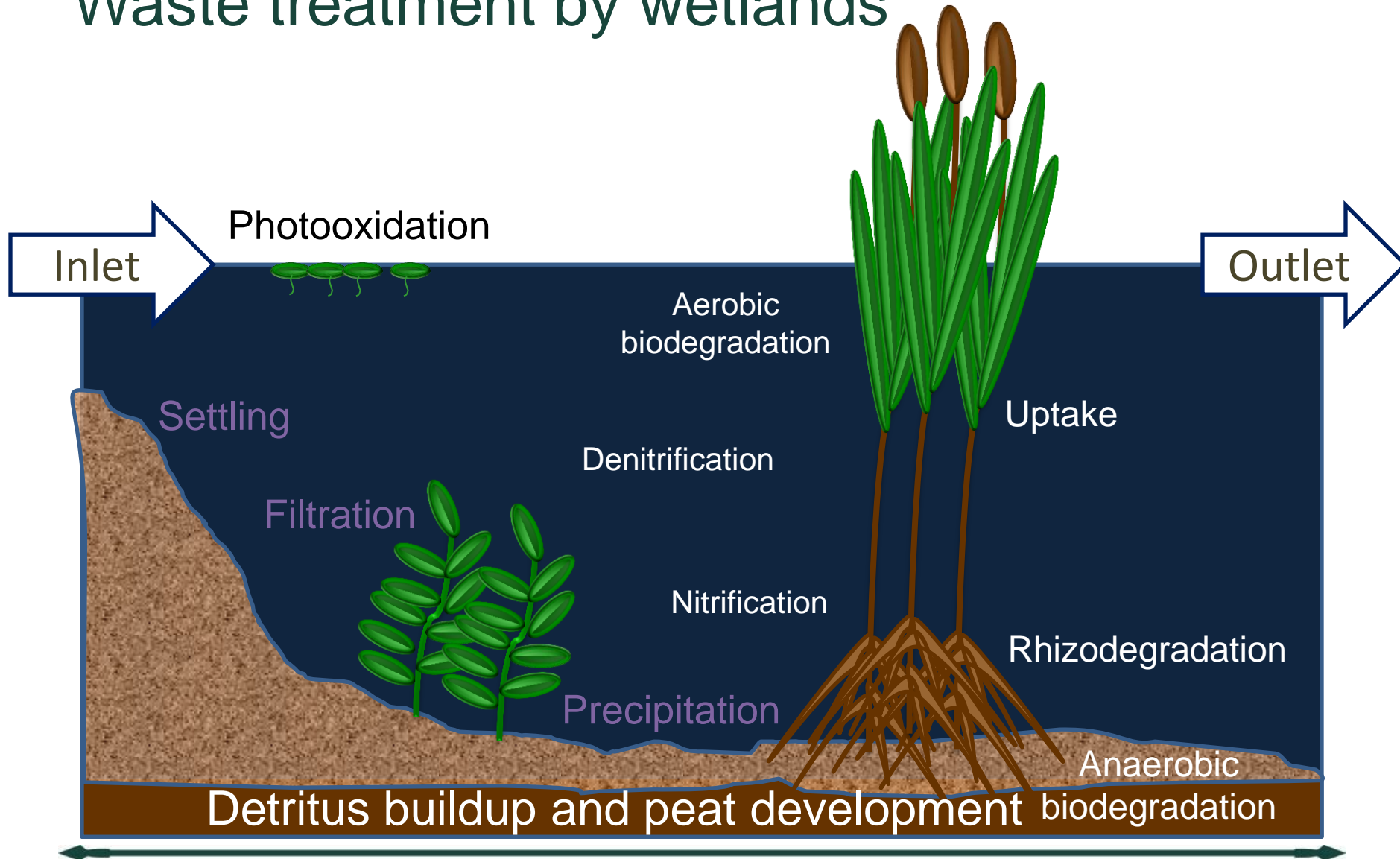
Benefits

- Are effective
- Are low-cost with low-maintenance
- Are driven by renewable energy
- Provide habitat and other ecosystem services
- Are aesthetically pleasing

Barriers

- Require large areas
- Cost money
 - \$54.5K/ha (surface flow)
 - \$215K/ha (subsurface flow)

Waste treatment by wetlands

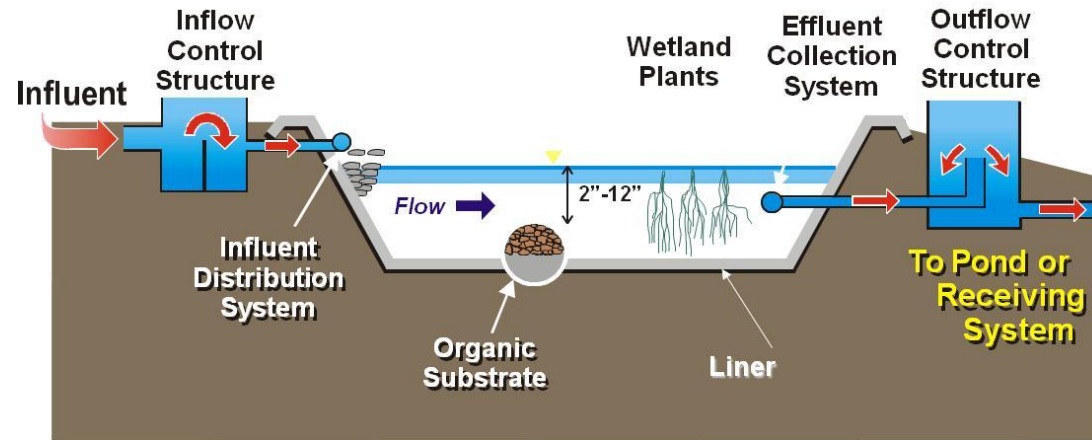


Overview of treatment wetlands

Traditional Types of Systems

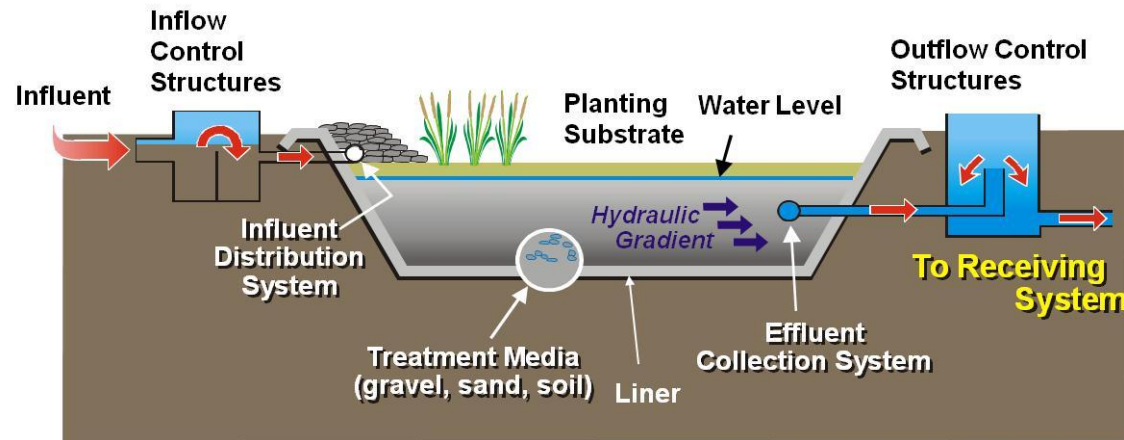
- Surface Flow (SF)

- Macrophyte ponds
- Emergent systems



- Subsurface Flow (SSF)

- Vertical flow
- Horizontal flow



General modeling approach for wetlands

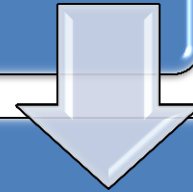
- Removal characterized by
 - Overall efficiency
 - Area-dependent removal rate

$$\frac{d(AhC)}{dt} = Q_i C_i - Q_o C_o - IAC - kA(C - C_b)$$

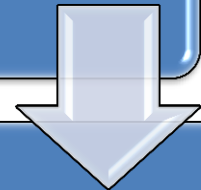
Depends on initial concentrations, temperature, season, plant biomass,...

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Floating treatment wetlands



Challenges to wetland adoption for this project

- Clogging of wetlands with fines or organic matter
 - Subsurface systems may need cleaned after 10 years (for U.S. wastewater systems)
 - Clogging may occur more frequently in Latin America
- Odor and mosquitoes
 - Can be a problem for poorly-maintained systems
 - Good plant coverage can reduce

Observations from EARTH



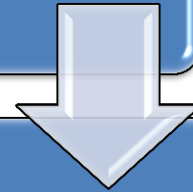
Potential challenges

Observations from EARTH

- After a few years, wetland systems were (probably) not properly functioning
 - Accumulation of plant biomass likely reduced hydraulic residence time
 - Decay of dead plants reintroduced organic carbon and nutrients
- Harvest of plants likely would have:
 - Increased treatment of digestate by the wetland
 - Provided additional biomass for energy production

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Floating wetlands

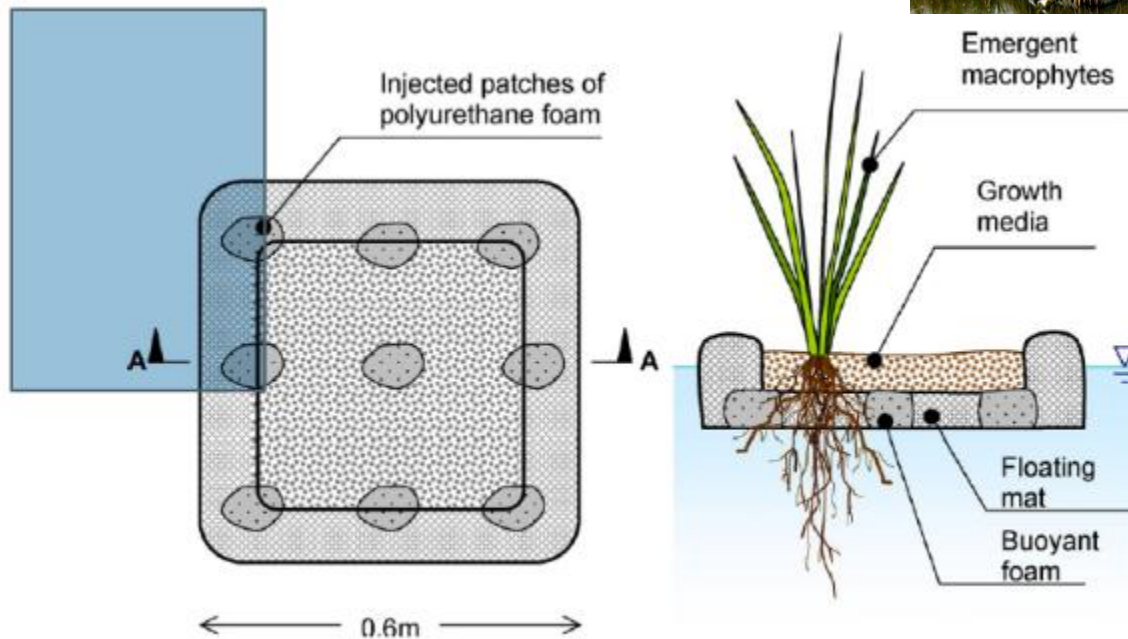


Fig. 1. Plan-view (right) and cross-section (left) of an experimental floating treatment wetland. Only a single plant is shown for clarity.

Tanner and Headley 2011

Floating wetlands: Benefits for this project

- Can achieve similar reductions as surface flow wetlands (Xian et al. 2010)
 - Total N by 84% ($C_o = 13 - 20$ mg/L)
 - Total P by 90.4% ($C_o = 1.5 - 2.3$ mg/L)
 - COD by 83.4% ($C_o = 200 - 300$ mg/L)
 - Sulfonamides by 91.8% - 99.5%
- Can handle large fluctuations in water depth
- Easier to harvest plant biomass regularly

Research plans

- Test floating wetlands at tub-scale to:
 - Determine optimal dilution of digestate
 - Quantify removal coefficients for design of full-scale system
- Characterize site-specific information:
 - Anaerobic digestate properties
 - Effluent criteria (based on end use)
- Test floating wetlands at full-scale to:
 - Quantify nutrient and organic carbon removal
 - Quantify biomass production and estimate optimal harvest schedule



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