An Integrated System for Wastewater Scrubbing and Bioenergy Production

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Introduction

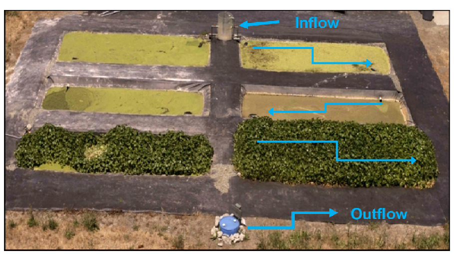
Municipal Wastewater Effluent (MWE), contains levels of nutrients that can support dense growth of aquatic vegetation. If discharged, this growth can clog natural waterways, outcompete native plants and create a safe haven for mosquitoes. Moreover, the eventual death of this vegetation leads to oxygen depletion and resultant fish kills.

Constructed wetlands can be used to lower levels of residual contaminants and nutrients in water, while biogasification of vegetation harvested from the wetlands can generate useable energy and thereby enhance their cost effectiveness.

Currently, the most technically feasible procedure for extracting usable energy from the biomass is anaerobic digestion, which produces methane-rich biogas that can offset fossil fuel consumption. Deployment of this type of integrated nutrient removal/bioenergy system would recycle carbon and nitrogen, support local food production, and reduce the demand for fossil fuels.

Materials and methods

Two gravity-flow 37 m^2 Channelized Aquatic Scrubbers (CAS) were constructed at the City of Santa Rosa Laguna Treatment Plant, each composed of three channels ranging in depth from 15 to 50 cm and stocked with native floating aquatic plants and algae common in the Laguna de Santa Rosa.

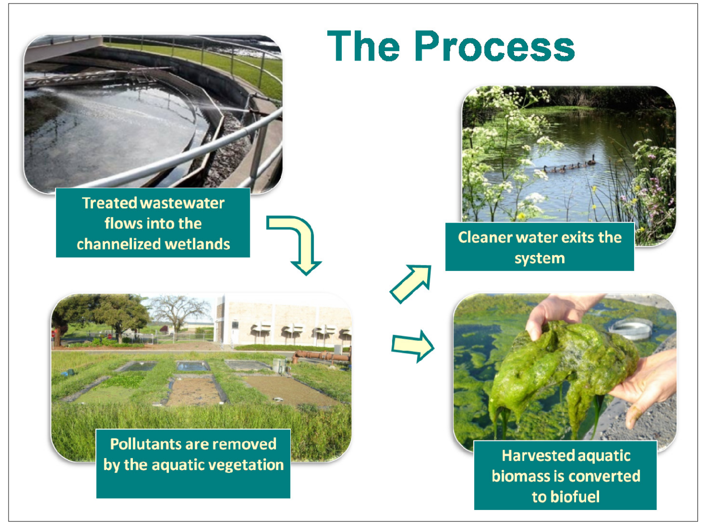


Channelized Aquatic Scrubbers (CAS)

Aquatic Vegetation, includes algae (*Oedogonium* and *Hydrodictyon*) and plants (*Hydrocotyle*, *Lemna*, *Azolla*)

Anaerobic digestion

Biomass mixtures are anaerobically digested at 35°C and gas production monitored by water displacement.



Results

- Initial operation of the CAS on tertiary-treated MWE inflow demonstrated an ability to maintain N-nitrate levels below the regulatory limit of 10 mg ml^{-1} (Fig. 1)
- The CAS removed 1.0 ± 0.5 g N m^{-2} d^{-1} (mean ± SD) over a 12-month period (Fig. 2); nitrate removal efficiency is independent of vegetation type
- N assimilated by harvested biomass accounted for 31.0 ± 7.4% (mean ± SD) of this nitrate removal
- Net productivity of the CAS averaged from 1.3 to 13.7 g dry weight m^{-2} d^{-1}
- Bioassays demonstrated that the CAS substantially decreased levels of estrogen-mimicking compounds in the water (unpublished results)
- Anaerobic digestion of harvested biomass at 35 °C in the laboratory yielded 145 ± 22 ml biogas g^{-1} dry weight (mean ± SE); co-digesting with a mix of wine lees and hydraulically flushed dairy manure solids enhances biogas production on a per weight basis

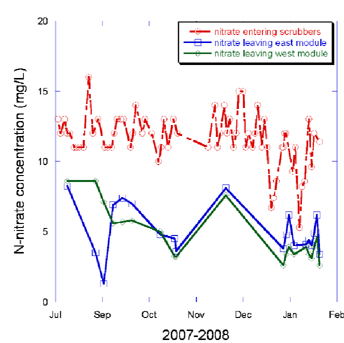


Figure 1: nitrate removal by CAS fed with tertiary-treated MWE

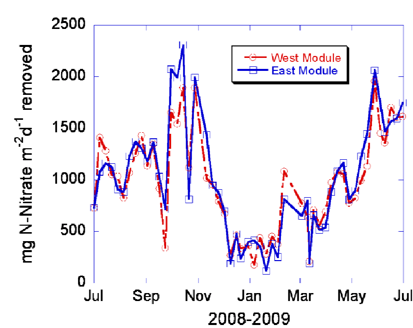


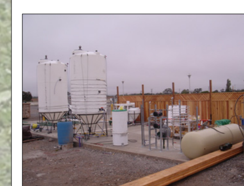
Figure 2: nitrate removal efficiency by CAS fed with secondary-treated MWE

Conclusions and Future Prospects

- The CAS displayed a high efficiency of nitrate removal relative to similar systems in California
- Denitrification plays the dominant role in removing nitrate
- Harvested biomass is a good feedstock for anaerobic digestion
- The CAS could potentially be applied for removing endocrine-disrupting compounds from water
- We are currently assessing the impact of harvest frequency on the efficiency of nitrate and phosphate removal

Project Expansion

Two 5.7 m^3 digesters, recently built on the treatment plant grounds, will be fed with varying proportions of CAS-harvested vegetation, *Ludwigia* from the Laguna, and agricultural wastes. The digested material will be utilized as a soil amendment for an on-site garden.



Digester system under construction

CAS (bottom) and garden (center)

Acknowledgements

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