Algal Turf Scrubbers – A Biomimicry

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WTWG
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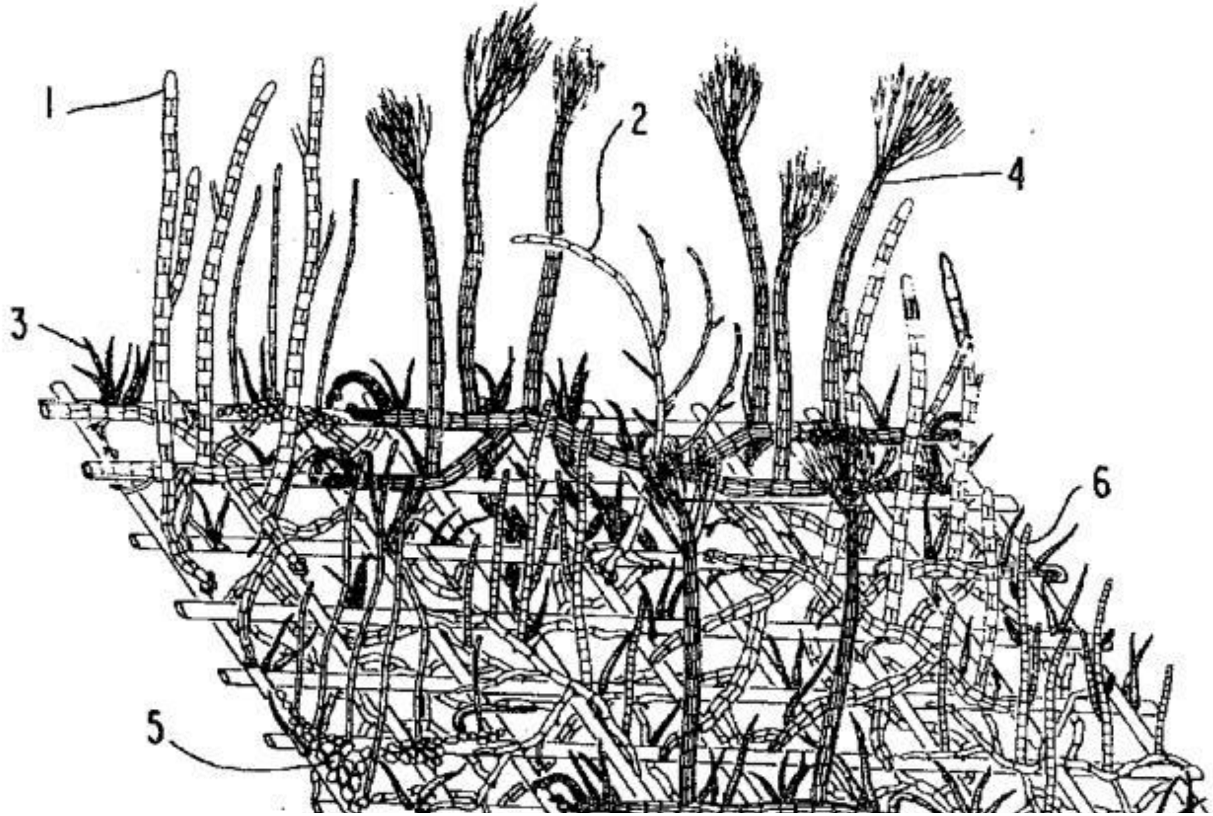
What is an Algal Turf Scrubber?

A screen that acts as a culture unit for native algae to attach and grow onto, removing nitrogen and phosphorus from a flowing water source, and where the algae can be continuously harvested and processed from the treatment unit for use in various products.

Have been in development since 1970's

Increases DO of the effluent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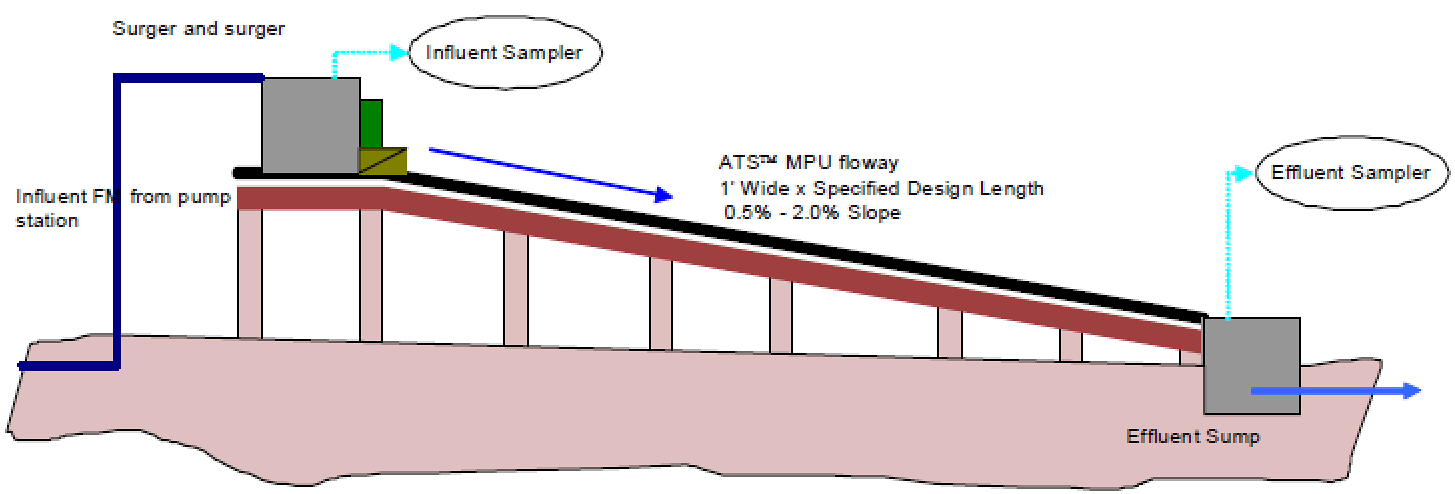

Surger and surger
Influent Sampler
Influent FM from pump station
ATS™ MPU floway
1' Wide x Specified Design Length
0.5% - 2.0% Slope
Effluent Sampler
Effluent Sump

NYC, Rockaway Water Pollution Control Plant

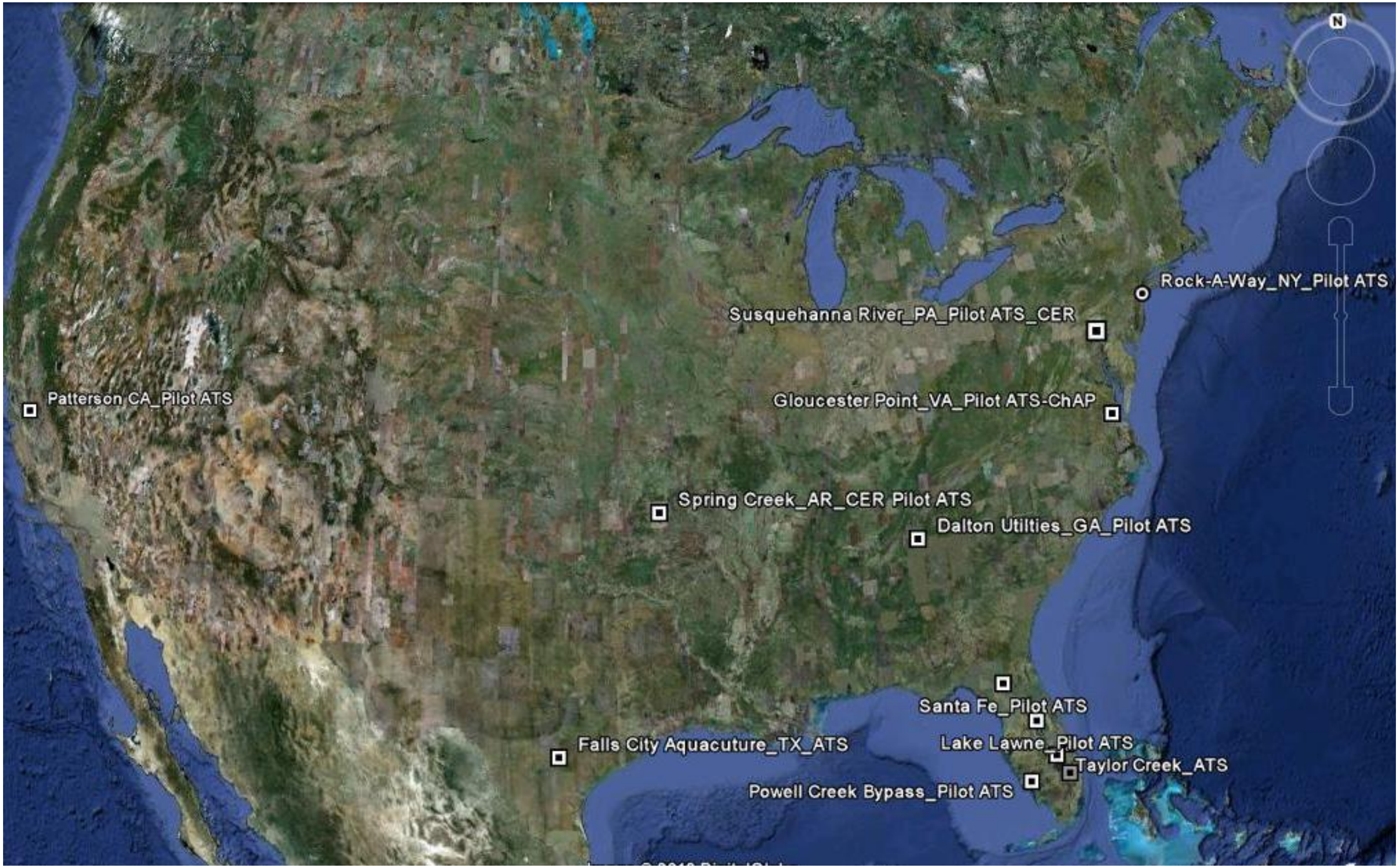
System Inflow Design

Harvesting Techniques

Small Scale – by hand

Large Scale – centralized facility

ATS Pilot and Full Scale Locations



Design and Definition Considerations

- Temporal Shift/Growing Season – number of months algae can grow
- Flow rate and Passive vs Active flow
- Productivity/Growth Rate g/m2/d
  - Shape recommendation to maximize length
- Nutrient content
- Percent slope
- Use of algal biomass – use vs disposal

Full Life Cycle Reductions?

Potential Algal Biomass Products:

- Cosmetic and Pharmaceutical
- Biofuel Production
- Omega 3s
- Compost/Organic Fertilizer
- Livestock Feed

Other Variables to Consider

- Sampling for Removal
- Scale/Footprint – number of acres necessary for loads to be reduced
- Siting – flowing waters
- Lifecycle Cost – start-up, operations and maintenance, algal biomass production and transport

Quantifiable Reductions

1) Nutrient removal rate= biomass production rate x nutrient content of biomass

expressed as grams nutrient/m2/day

Typical biomass production rates for ATS in the Chesapeake Bay region range from 10-35 grams dry weight/m2/day and typical nutrient contents are 3-5% nitrogen and 0.3-0.5% phosphorus

2) Influent vs effluent changes

Table 2a. Biomass production of the Aluminum ATS at 2% slope. Data are grams dry weight/m2/day. Numbers in parentheses are the months included in the seasons.

Season	vacuum harvest	greenwater	slough	total
Summer 2008 (6-8)	14.2	2.4	1.4	18.0
Fall 2008 (9-11)	6.2	4.2	0.5	10.9
Winter 2008-2009 (12-3)	---	---	---	---
Spring 2009 (4-5)	4.0	8.6	0.7	13.3
Summer 2009 (6-7)	11.6	4.6	1.4	17.6
Fall 2009* (8-10)	6.6	6.3	0.7	13.6
Growing Season Averages (fall 08-summer 09)	7.3 (52%)	5.8 (42%)	0.9 (6%)	14.0

* at 0.5% slope

The productivity of the ATS raceways at Muddy Run in southeastern Pennsylvania was high, compared to natural ecosystems, but algal growth was limited by low temperatures in the winter months.

Nutrient uptake scale up here would be:
749 pounds N/acre/year

90 pounds P/acre/year

Productivity at VIMS, mouth of York River

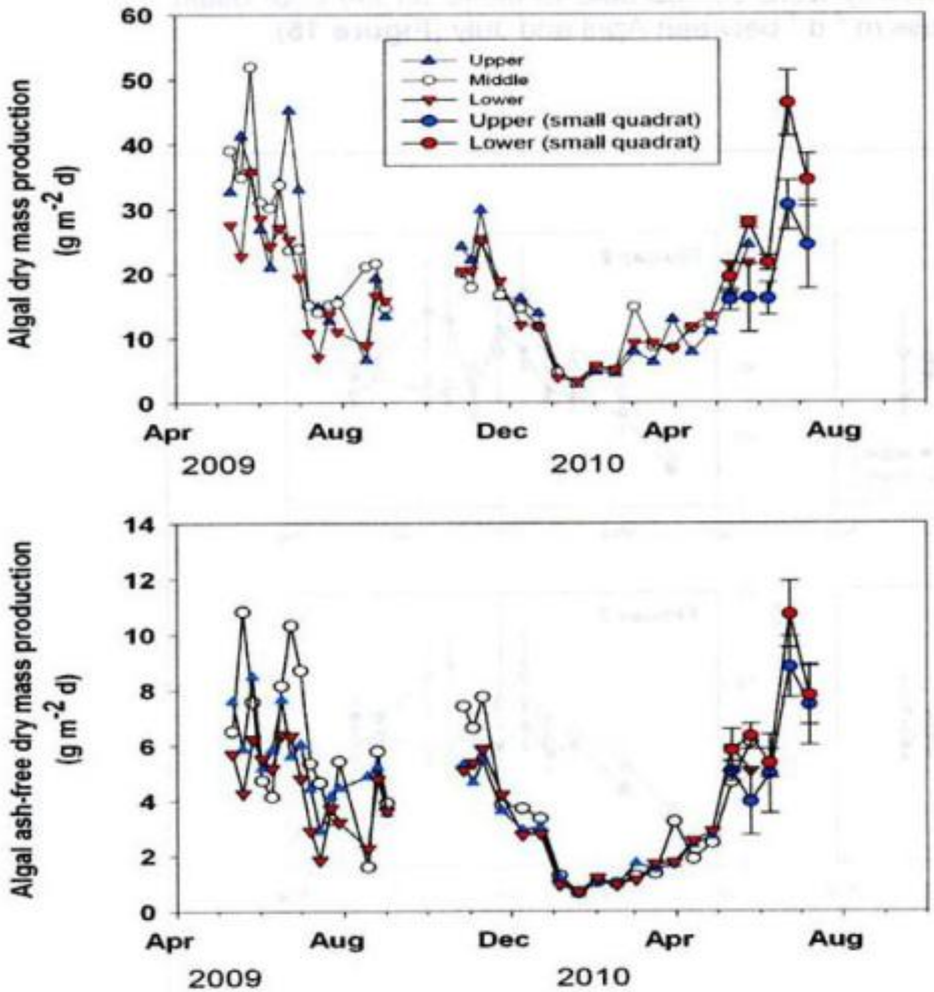


Figure 14. Seasonal variation in biomass production rates of the attached algal community on the VIMS boat basin floway from May 2009 to July 2010. Prior to May 2010, a single sample of 1 m^2 was taken weekly from each of the top, middle, and bottom of the floway during warmer months, and every two weeks during winter. After May 2010, three replicates samples of 0.0625 m2 were collected from each of the top and bottom of the floway.

Nutrient uptake scale up here would be:

846 pounds N/acre/year

130 pounds P/acre/year

Table ___. Comparison of some algal turf scrubber™ studies from the Chesapeake Bay region. All of these studies were from outdoor raceways that were operated for at least one annual cycle.

System location	water treated	growing season (months)	flow rate (L/minute/meter)	productivity (g DW/m2/day)	nutrient content (% N)	(% P)
Lancaster, PA[1]	Susquehanna River	8	173	12.9	2.5	0.3
Beltsville, MD[2]	dairy manure	9	93	~10	5.9	0.8
Bridgetown, MD[3]	ag drainage ditch	9	35 (day) 14 (night)	<5	2.0	0.3
Gloucester, VA[4]	York River	12	100	~20	1.3	0.2
Reedville, VA[5]	Great Wicomico River	12	125	15.4 (2D screen) 39.6-47.7 (3D screen)	2.5	0.2

[1] Kangas et al. 2009 (Lewis Report), [2] Mulbry et al. 2008, [3] Kangas and Mulbry 2012, [4] Canuel and Duffy 2011 (Statoil Report), [5] Adey et al. 2012

Table ___. Nitrogen uptake calculations for an ATS in the Chesapeake Bay region.

Lower boundary estimate: productivity of 10 g DW/m2/day; growing season of 8 months; nitrogen content of 1 % of biomass

(10 g DW/m2/day)(240 days/year)(0.01 N) (4047 m2/acre)(1 kg/1000 g)(2.2 pounds/1 kg) = **214 pounds N/acre/year**

Upper boundary estimate: productivity of 30 g DW/m2/day; growing season of 12 months; nitrogen content of 3 % of biomass

(40 g DW/m2/day)(365 days/year)(0.03 N)(4047 m2/acre)(1 kg/1000 g)(2.2 pounds/1 kg) = **3900 pounds N/acre/year**

Table ___. Phosphorus uptake calculations for an ATS in the Chesapeake Bay region.

Lower boundary estimate: productivity of 10 g DW/m2/day; growing season of 8 months; phosphorus content of 0.2 % of biomass

(10 g DW/m2/day)(240 days/year)(0.002 P)(4047 m2/acre)(1 kg/1000 g)(2.2 pounds/1 kg) = **43 pounds P/acre/year**

Upper boundary estimate: productivity of 30 g DW/m2/day; growing season of 12 months; phosphorus content of 0.3 % of biomass

(40 g DW/m2/day)(365 days/year)(0.003 P)(4047 m2/acre)(1 kg/1000 g)(2.2 pounds/1 kg) = **390 pounds P/acre/year**

Using median values total removal rates for **1,000 acres** of ATS in the Chesapeake Bay region would be:

2,058,000 lbs/N/yr
216,000 lbs/P/yr

Potential Expert Panel Members

- Patrick Kangas, UMD College Park
- Walter Adey, National Museum of Natural History, Smithsonian Institution, DC
- Emmett Duffy, Agricultural Research Service,Beltsville, MD
- Elizabeth Canuel, Virginia Institute of Marine Science, Gloucester, VA
- Peter May, Biohabitats, Baltimore, MD
- Jay Diedzic, Blackrock Algae, Baltimore, MD
- John McLaughlin, NYC DEP
- Russell Hill, UMCES@IMET, Baltimore, MD
- Dr. Feng Chen, UMCES@IMET, Baltimore, MD
- HY-TEK Bio representative, Baltimore, MD
- Hydromentia representative

Timeline

- Early 2013 start ~ June 2013 finish