CONTROLLED ALGAE GROWTH FOR WATER QUALITY IMPROVEMENT ON THE MARYLAND EASTERN SHORE

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INTRODUCTION

Agricultural runoff has been implicated as an important source of nutrients that contributes to the cultural eutrophication of the Chesapeake Bay. The purpose of this research was to examine the performance of the algal turf scrubber ™(ATS) technology for nutrient removal from a drainage ditch that receives runoff from corn and soybean fields. A special focus of the research was to test solar power as an energy source for operating the pumps that bring water to the ATS.

Algae are grown attached to a screen in a shallow trough over which water is pumped in the ATS. The algae are harvested periodically which results in a net removal of nutrients that were taken up during algal growth.

SITE DESCRIPTION

The experimental ATS was 6 meters wide and 50 meters long with a 2% slope. Water was contained with an EPDM pond liner and algae were grown attached to a nylon mesh screen that was placed on the pond liner. Water was pumped onto the ATS from an agricultural drainage ditch (Long Marsh) and it flowed by gravity to the bottom of the system where it collected in a sump, used for sedimentation of particulate material, and drained back into the ditch.

The ATS system was located adjacent to Mason Branch on the Collier Farm in Caroline County, Maryland approximately 1 km downstream from the bridge for Maryland State Route313.

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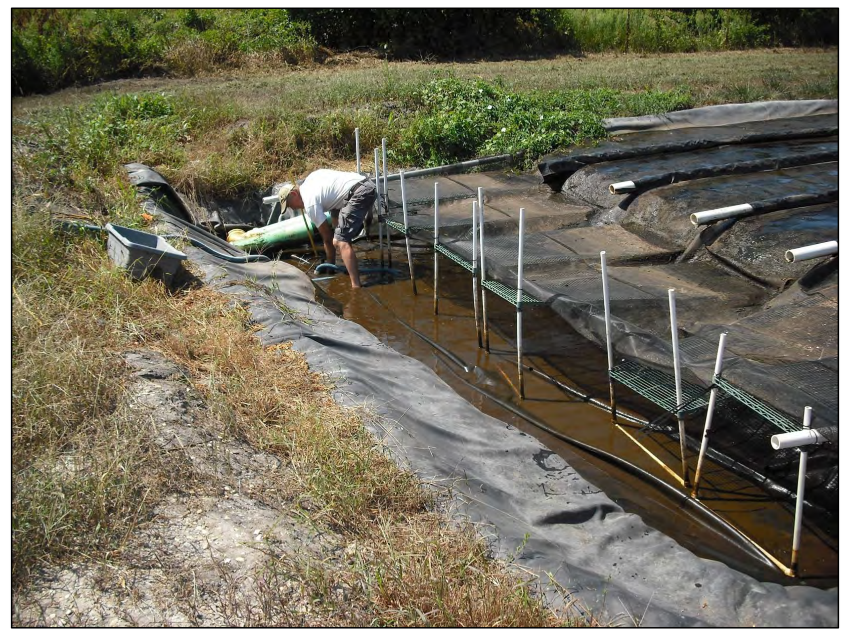
USE OF SOLAR POWER

One of the intentions of the research was to test photovoltaic panels as a power source for pumping water to the ATS. Two solar systems were tested, each connected to a 12-volt Grunfos well pump. The first system, installed in June 2010, was designed for daylight power only and it consisted of twelve 80-watt panels. The second system, installed in May 2011, was designed for 24 hour power and it consisted of ten 200-watt panels connected to eight 230 amp/hour 12V deep cycle batteries.

BIOMASS PRODUCTION AND NUTRIENT UPTAKE

Nutrient removal in the algal production system (grams nutrient/m2/day) was calculated by multiplying biomass production in the harvest (grams dry weight/m2/day) by the nutrient content of the biomass (% nutrient).

During the 2011 growing season algal biomass production rates ranged from less than 1 to 10 grams dry weight/m2/day and the nutrient content of the biomass ranged from 1.3 to 1.5 % nitrogen and from 0.2 to 0.3 % phosphorus. Nutrient removal rates fluctuated considerably but averaged 125 mg N/m2/day and 25 mg P/m2/day at the highest flow rates. Extrapolated nutrient removal rates are 230 – 350 pounds N and 40 pounds P per acre per year over a 7 month growing season.



ECONOMIC INSIGHTS

Capital and operating costs of the ATS are listed in Tables 1 and 2. These values are extrapolated from the construction and operation of the experimental ATS on the Collier Farm and from information on other ATS projects. Energy input to run the pumps dominated the economic assessment: with solar power, it is the capital cost of the photovoltaic panels, while for grid-based power, it is the operating cost of electricity.

Table 1. Capital cost comparisons. Data are in US dollars $acre^{-1}$.

Component	grid power	solar power
Site preparation: grading, compaction	5,000	5,000
Site preparation: labor	10,100	10,100
Water pump	3,800	*
Solar power system	-----	200,000
Land cost	2,000	2,000
Liner and installation	15,400	15,400
Surge boxes and plumbing	4,000	4,000
ATS Screen	3,200	3,200
Subtotal	47,400	240,000
Engineering and contingencies (15% of subtotal costs)	7,100	36,000
Total	50,700	276,000

*included in solar power system cost

Table 2. Operating cost comparisons. Comparisons are based on a 270 day growing season. A 10 year capital depreciation period is assumed for the solar power option. Data are US dollars $acre^{-1}$ $year^{-1}$.

Cost component	grid power	solar power
Capital charge	5,070	24,000
Labor & overheads	540	540
Power for water pump	14,800	0
Total annual costs	20,400	24,540

SUMMARY AND CONCLUSIONS

ATS raceways were operated remotely on the Maryland Eastern Shore using solar power water pumping during the 2010 and 2011 growing seasons.

Algal biomass productivity and nutrient removal rates were lower than has been found in most other studies from the Chesapeake Bay region. Rates were likely limited by characteristics of the solar-powered water flow rates and by low nutrient concentrations within the agricultural drainage ditch.

Annual operating costs were estimated to be on the order of $20,000/acre for either conventional grid-based power or solar power from photovoltaic panels.

Costs of nutrient removal were high at greater than $40/pound for N and $230/pound for P due to high water pumping costs and relatively low rates of algal growth and algal nutrient content.

The ATS technology is probably best employed at nutrient “hot spots” (sites with high nutrient concentrations) within the Chesapeake Bay watershed where algal growth rates can be maximized.