ALGAL TURF SCRUBBER® SYSTEMS FOR POLLUTION CONTROL

HydroMentia
WATER TREATMENT TECHNOLOGIES

HOW THE ALGAL TURF SCRUBBER® SYSTEM WORKS

ATS™ SURGER AND DISTRIBUTION

ATS™ surger and distribution systems provides flow at linear hydraulic loading rates of 10 to20 gal lf $^{-1}$ min^{-1}

The ATS™ consists of a suitably sloped substrate, typically plastic geomembrane, overlain with an attachment grid, upon which pollutant-laden waters are discharged and an algal turf is cultured.

Wave surge motion is incorporated into the headwaters of the ATS™ to enhance the exchange of metabolites between algal cells and the water medium. Pulsed flow is provided via a self-siphoning surger.

The algal turf consists of dense mats of small anatomically simple algae less than several centimeters in height.

As water travels down the ATS™, pollutants are recovered through both biological and physical processes.

Carbon dioxide, nitrogen, phosphorus and other elements necessary for metabolic growth are rapidly removed from the water column through biological uptake. Removal of these compounds results in water quality changes within the ATS™, including elevation of pH concentrations.

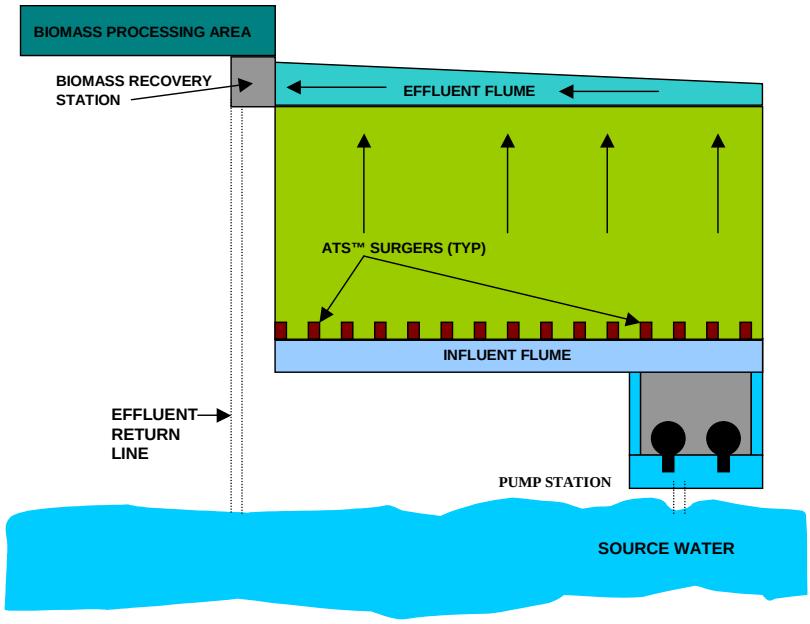
Employing a patented precipitation process, ATS™ systems offer the benefit of low-cost chemical precipitation of pollutants.

Through control of operating parameters such as flow rates, micro and macro nutrients concentrations and biomass recovery rates, pollutants such as phosphorus are precipitated onto the algal cell walls, then recovered along with harvested biomass, thereby further enhancing phosphorus treatment capacity and reducing system treatment costs.

Physical removal also occurs on the ATS™ through particulate trapping or filtration within the web of algal filaments.

Critical to performance of the ATS™ system, cultured algal biomass is routinely harvested. Routine recovery serves to optimize pollutant recovery, avoid succession to macroalgae and macrophytes and eliminate long-term liabilities associated with on-site storage of pollutants typical of conventional treatment wetland systems.

SIMPLE CONSTRUCTION



BENEFITS OF THE ALGAL TURF SCRUBBER® SYSTEM

LOW TREATMENT COSTS

REDUCED LAND REQUIREMENTS

PROVEN PERFORMANCE

REDUCED LONG-TERM LIABILTIIES

MARKETABLE END PRODUCTS

HydroMentia's Algal Turf Scrubber® (ATS™) technology was developed by Dr. Walter Adey, Director of Marine Laboratories at the Smithsonian Institution. Dr. Adey developed the ATS™ while researching low nutrient ecological systems at the Smithsonian.

Optimized for nutrient uptake and pollutant precipitation, the ATS™ can reduce nitrogen and phosphorus concentrations and loads while requiring 90% to 99% less land than comparable treatment wetland systems.

Due to its small footprint and simple and cost-effective construction, the ATS™ offers a lower-cost alternative for nutrient pollution control than either treatment wetlands or chemical treatment.

In addition to recovery of excess nitrogen and phosphorus, ATS™ systems offer treatment for a wide variety of toxic compounds including metals and chlorinated compounds.

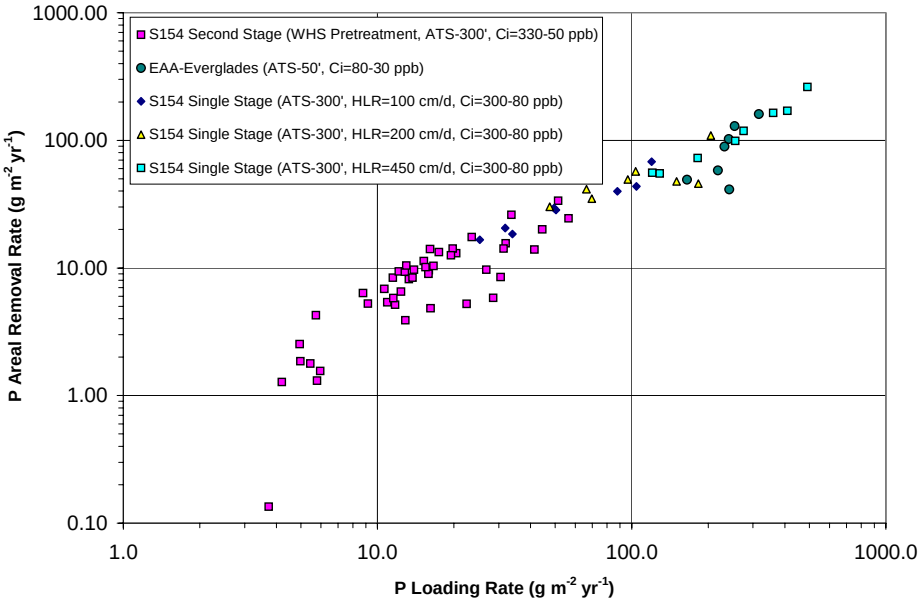
HydroMentia's proprietary biomass management techniques allow cost-effective and efficient recovery and management of the algal biomass. Recovered biomass can be readily processed into high quality compost, organic fertilizer or livestock feed, and in the future biofuel.

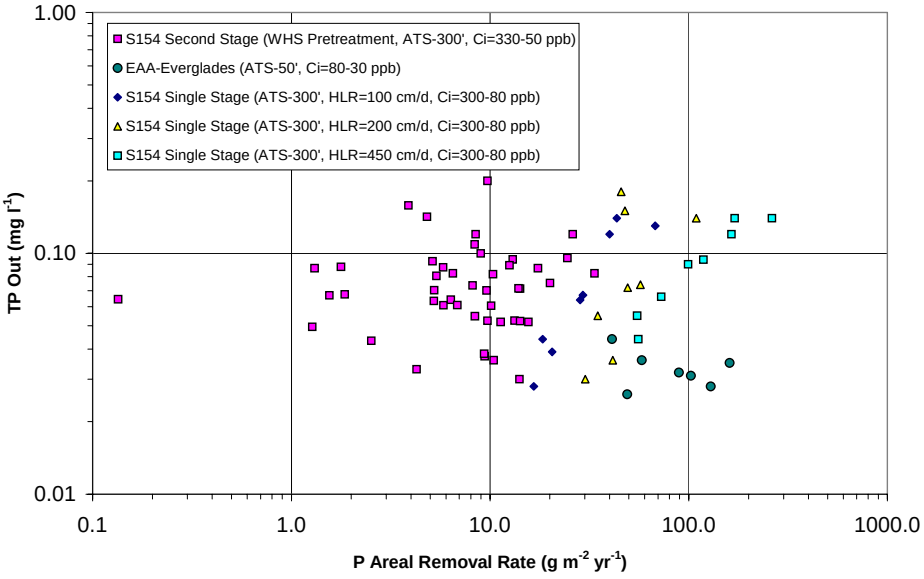
Through recovery and management of the biomass, the ATS™ eliminates potential long-term liabilities commonly associated with systems that store captured pollutants.

With over two decades of research and commercial application, the ATS™ offers proven and sustainable treatment performance.

A 2.5 acre ATS™ can provide nutrient control for over 10 million gallons per day.

ALGAL TURF SCRUBBER® PHOSPHORUS CONTROL





FLEXIBLE DESIGN

The Algal Turf Scrubber® can be designed and constructed to meet a wide range of phosphorus control objectives.

ATS™ units have been applied to surface water runoff, agricultural and municipal effluents with total phosphorus concentrations ranging from 80 to 8000 parts per billion (ppb).

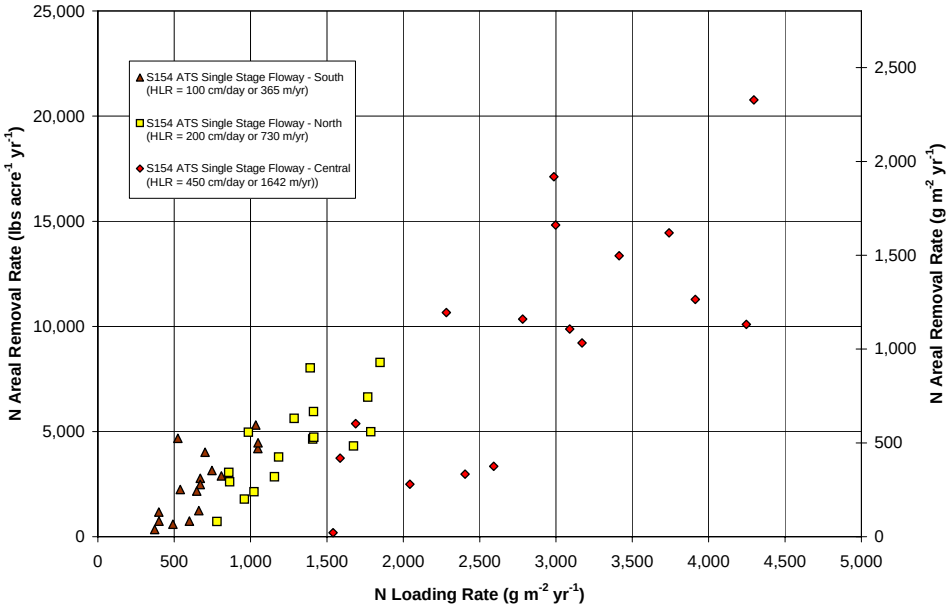
Whether your treatment objective is reducing total phosphorus loads or achieving a specific outflow phosphorus concentration, the ATS™ system can be optimized to meet your needs.

Capable of consistently and reliably reducing phosphorus concentrations to below the most stringent TMDL objectives, the ATS™ is the ideal surface water treatment technology.

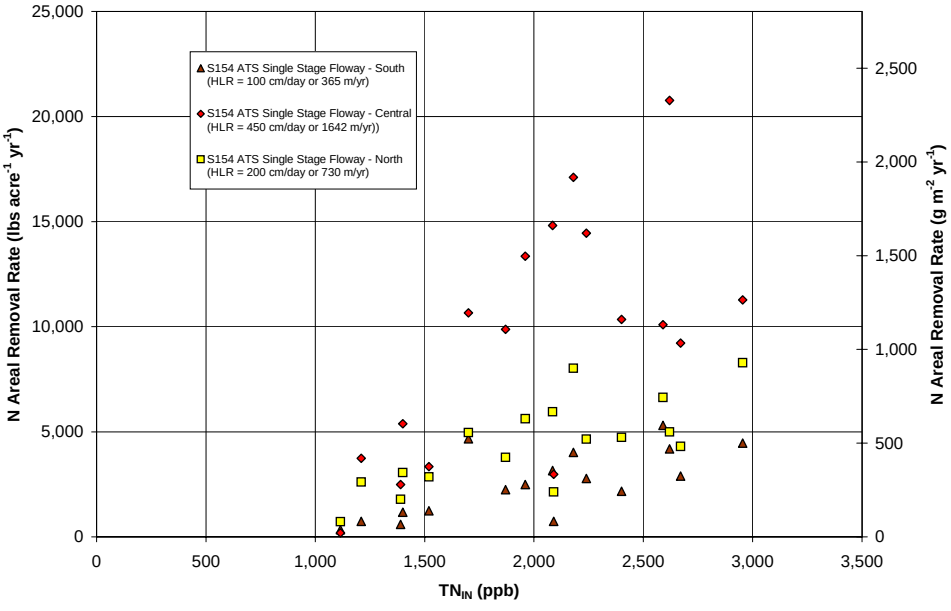
DESIGN ADVANCEMENTS

Recent advancements have resulted in significant increases in areal removal rates even at relatively low inflow phosphorus concentrations. Capable of recovering phosphorus at rates greater than 1,000 lbs/acre-ATS™/yr, these advancements allow for significant reductions in the treatment facility footprint. The net results are both lower capital and operating costs for the ATS™.

ALGAL TURF SCRUBBER® NITROGEN CONTROL



Total Nitrogen Inflow Concentrations Range from 1.1 to 2.7 mg/l



Total Nitrogen Inflow Concentrations Range from 1.1 to 2.7 mg/l

LOAD VERSUS CONCENTRATION

As with phosphorus, the Algal Turf Scrubber® can be designed and constructed to meet a wide range of nitrogen control objectives.

ATS™ units have been applied to surface water runoff, agricultural and municipal effluents with total nitrogen concentrations ranging from 1 to 18 parts per million (ppm).

Whether your treatment objective is to reduce your AWT effluent to allow discharges to local source waters or load reduction to meet the new TMDL requirements, the ATS™ system can be optimized to meet your needs.

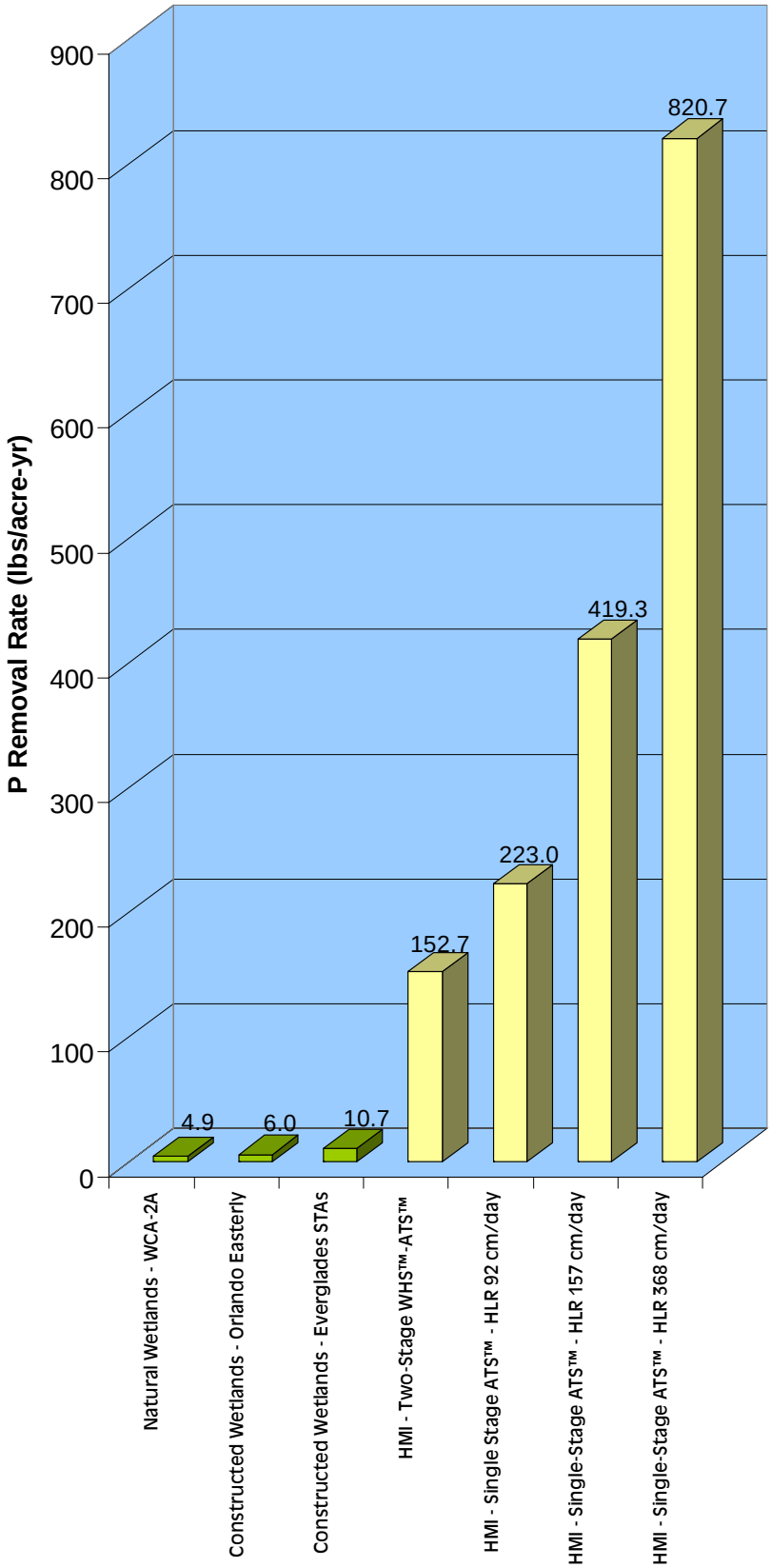
LOW-LEVEL TREATMENT

ATS™ systems are capable of providing consistent, cost-effective nitrogen reduction, even with the lower nitrogen concentrations often present in surface water runoff.

Designed to operate at high Linear Hydraulic Loading Rates (LHLR), high nitrogen areal removal rates can be achieved for a wide range of point and nonpoint source applications, including lake restoration projects.

The result is that the ATS™ offers the lowest cost treatment technology for nitrogen control.

TREATMENT FACILITY LAND REQUIREMENTS



Comparative phosphorus areal removal rates for ATS™ and treatment wetland systems

POLLUTANT AREAL REMOVAL RATES

Biological treatment systems including treatment wetlands and Managed Aquatic Plant Systems (MAPS) have been repeatedly shown to offer the lowest cost alternatives for nonpoint source pollution control. However, with these systems, land requirements become a critical selection factor, both in terms of overall costs and land availability. For many of today's applications, sufficient land simply is not available for construction of a treatment wetland system.

It is here that ATS™ system benefits provide a distinct advantage over treatment wetland systems. Operated at significantly higher hydraulic loading rates, ATS™ systems offer equivalent treatment performance while requiring a fraction of the land area.

COST-EFFECTIVE POLLUTANT RECOVERY

Recent advancement have demonstrated the versatility of the ATS™ system. Operational data have shown that increases in hydraulic loading rates of over 400%, have resulted in minimal loss in percent removal of priority pollutants.

Dependent on project specific objectives, HydroMentia's engineers can design an ATS™ system to optimize pollutant removal while achieving designated outflow pollutant concentrations.

COMPARATIVE TREATMENT COSTS

LOW COST POLLUTANT CONTROL

Pollutant control strategies for point and nonpoint source pollution include a wide variety of approaches including on-site best management practices, chemical treatment, filtration and biological treatment. Selection of the best approach is often determined based on treatment costs.

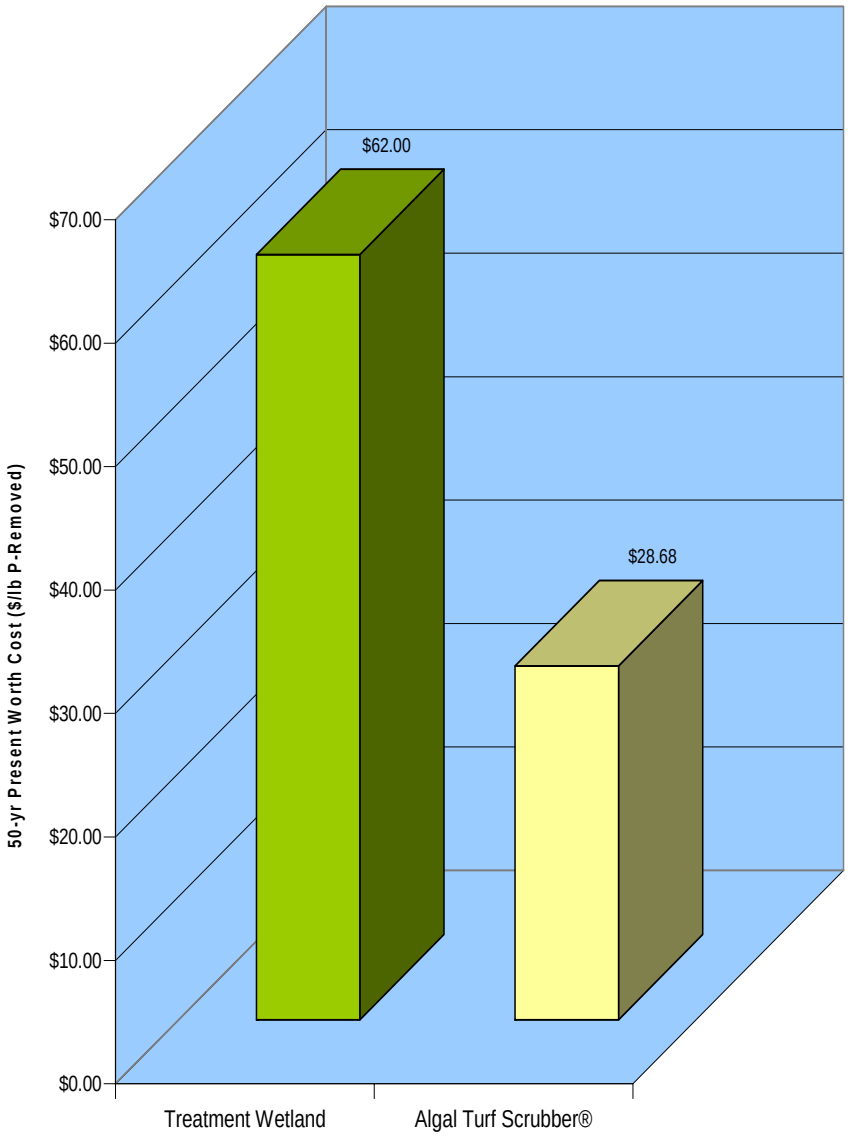
Treatment costs are reduced through numerous benefits of the Algal Turf Scrubber®, including:

- Small footprint
- Reduced design costs
- Fast construction
- Simplified operation
- Marketable by-products

Assessing phosphorus and nitrogen control options using a 50-yr present worth cost shows the clear cost savings that can be achieved when using the ATS™ system. With both lower initial capital costs and long-term present worth costs, the ATS™ technology saves money, both short and long-term.

BY-PRODUCT VALUES

Not included in referenced costs are the potential revenues generated by the sale of the high quality organic fertilizer/ compost product produced from the ATS™ operation. Bulk sales of high-quality organic fertilizers can exceed $50/ton. A typical ATS™ operation produces 50 to 100 tons of organic fertilizer per ton of phosphorus recovered. In the future, biofuel production may offer even greater revenue generation potential.



[1] HydroMentia. April 2005. Single Stage Algal Turf Scrubber Present Worth Cost & By-Product Market Analysis. (TP_{IN}=200 ppb, TP_{OUT}=146ppb, 27.0% Removal, 56,000 AF/yr, Pumping Costs Included)
[2] USACE, SFWMD, HDR. October 2003. Lake Okeechobee Watershed Project Draft PIR, Water Quality Treatment Ranking (TP_{IN}=261 ppb, TP_{OUT}=100 ppb, 61.6% Removal, 97,500 AF/yr)

BIOMASS MANAGEMENT AND PROCESSING

End products made from the harvested algae include compost (above), livestock feed and biofuel (below).

EFFICIENT BIOMASS RECOVERY

To reduce operating costs, HydroMentia developed a proprietary technique for recovering algal biomass in which process water conveys severed biomass to a central harvesting station.

A four-wheel all terrain vehicle or tractor with attached implement is used to sever algal biomass from the growing matrix. The severed material is then conveyed via process water to a receiving flume, where it is recovered by an automatic rake at a centralized harvesting station.

These design efficiencies allow a single operator to recover biomass from approximately one acre of ATS™ in less than one hour. With algal biomass recovery scheduled once every 7 to 14 days, minimal labor is required to maintain the ATS™ at optimal performance.

COST- EFFECTIVE PROCESSING

Recovered material is conveyed to a bunker or transport trailer, where it is available for further processing.

High in nutrient content, algal biomass can be processed into a high-grade organic fertilizer/compost, livestock feed or biofuel.

Organic fertilizer produced within ATS™ systems are suitable for a broad range of fertilizer markets. As a livestock feed, processed algae is typically 20 to 30% crude protein, offering a protein-rich high quality feed ingredient for the massive U.S. agricultural market

Currently in development are systems for processing the conversion of algal biomass to energy products, including biodiesel and ethanol.

ALGAL TURF SCRUBBER® APPLICATIONS

BROAD RANGE OF APPLICATIONS

ATS™ offers cost savings for a broad range of water treatment applications.

STORMWATER RUNOFF

Nonpoint source applications that involve nutrient pollutants are especially well-suited for the ATS™ with the system's capacity to treat large volumes of water contaminated with relatively low concentrations of pollutants. ATS™ systems can be designed to meet the most stringent of TMDL objectives.

WASTE WATER TREATMENT

ATS™ offers an exciting opportunity for advanced treatment of domestic wastewaters. Since water is a limited resource throughout the country, secondary or tertiary treated wastewater can be polished with an ATS™ unit, making the water clean enough to be discharged to local surface waters. This eliminates the need for disposal via deep well injection and spray irrigation.

AGRICULTURAL

ATS™ serves as an agricultural solution to an agricultural problem—nutrient discharges. As the lowest-cost alternatives for nutrient recovery, ATS™ systems are well suited for agricultural applications.

30 MGD Aquaculture Facility located in Okeechobee, Florida

INDUSTRIAL APPLICATIONS

Due to the rapid rate of algae production and recovery within the ATS™ unit, trace metals present in source waters may be incorporated into recovered biomass. Many of these trace metals serve as necessary and valuable micronutrients for algal growth. Recovered from the treatment system and processed as an organic fertilizer/compost, these trace elements become a beneficial resource.

Applied to industrial wastes, a high-production, high-pH scrubber unit can effectively recover, through algal uptake and precipitation, a wide variety of organic and inorganic compounds.

LAKE RESTORATION

Serving as an "artificial kidney," ATS™ units can be designed to recover incoming pollutant loads to meet TMDL mandates while reducing nutrient pollutants stored within lake sediments.

The net result is a reduction of in-lake nutrient concentrations, improved water clarity, and enhanced littoral zone communities and fisheries.

GEOGRAPHIC OPPORTUNITIES

Short start-up periods allow the ATS™ to operate on a seasonal basis for reduced operational costs, or for application in northern climates.

ATS™ APPLICATIONS

Stormwater Treatment
- Phosphorus
- Nitrogen

Tertiary Treatment
- Nutrients

Agricultural
- CAFO
- Runoff

Industrial
- Nutrients
- Metals

Lake Restoration

ALGAL TURF SCRUBBER® SYSTEMS FOR POLLUTION CONTROL

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