

RESEARCH RESULTS – FLOATING ISLANDS



A. Montana Research

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Nitrate Removal

Nitrate removal is done by anaerobic bacteria; they require a dissolved carbon source in the water², as well as alkaline conditions, in order to operate. Tests have shown that natural occurring bacteria are as effective as commercially available stems.³

¹ This documents presents a condensed, vulgarized version of the original document presented by Mr. Stewart

² If the DOC (dissolved organic carbon) in the water body is too low, you may add molasses

³ Commercial microbe formula used: Marine and Fresh Water Bio Denitrator by Dolphin Pharmaceuticals

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A one layer matrix (bacteria without plants) is just as inefficient as no matrix. However, there is a 50% nitrate removal improvement when a four-layer matrix is used: 3017mg/day/sqft. This shows that nitrate removal need an extensive anoxic zone with a developed bio-film on the provided surfaces to do the work effectively.

We achieved a nitrate removal rate of about $1500 \text{ mg} \cdot \text{day}^{-1} \cdot \text{ft}^{-2}$ using bacteria without plants. We have confirmed that the nitrate removal rate requires anoxic conditions plus a carbon food source.

The removal rates for *Typha latifolia* and *Carex urticulata* (without a dissolved carbon source = without microbes) was 41.8mg/day/sqft for *typha latifolia*; naturally occurring algae showed a removal rate of 34.2mg/day/sqft. The addition of carbon increased the nutrient removal rate of the plants significantly. The most effective plant species is *Carex nebrascensis* with 55.9mg/day/sqft.

Ammonia removal

We achieved an ammonia removal rate of about $200 \text{ mg} \cdot \text{day}^{-1} \cdot \text{ft}^{-2}$ using bacteria without plants. This is approximately 2.7 times the removal rate measured in a conventional wetland at a swine production facility. We have confirmed that the removal rate for ammonia is highly dependent upon the availability of oxygen and alkalinity, and have tested methods for supplying oxygen and alkalinity to the systems.

Plants that tolerate high ammonia levels (livestock effluents, 150mg ammonia/L) are: *Veronica Americana/American Speedwell*, *Carex hystericina/Porcupine sedge*, *Carex nebrascensis/Nebraska Sedge*, *Scirpus acutus/Hardstem Bulrush*. Under low oxygen conditions the removal rate was 103mg/day/sqft.

The highest ammonia removal rate occurred in tests of high temperature (38°C during one week): 338mg/day/sqft. The nitrate produced by ammonia removal was removed as well during this test.

Low temperature test (water temperature between 16°C and 6 °C) show that ammonia removal takes place at 228mg/day/sqft; when the water temperature sinks to between 6°C and 3°C ammonia removal stops. Nitrate concentration rises when ammonia is sequestered; at low temperatures the removal of nitrates is lower.

Phosphate removal

A four-layer matrix (bacteria without plants) removed phosphate twice as much as a one-layer matrix:

Four-layer matrix: 55.1mg/day/ft²

One-layer matrix: 26.6mg/day/ft²

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No-matrix: 9.5mg/day/ft²

We achieved a phosphate removal rate of about 70 mg/day/ft² using bacteria without plants. This is approximately 1.3 times the removal rate measured for hydroponically grown aquatic plants in an Australian study.

The removal rates for *Typha latifolia* and *Carex urticulata* (without a dissolved carbon source = without microbes) was 7.0mg/day/ft²; compared to 15.6mg/day/ft² for algae. The addition of carbon increased the nutrient removal rate of the plants significantly.

Carex nebrascensis and *Carex hystericina* show removal rates of 11.8mg/day/ft². *Scripus acutus* is the most effective phosphate remover.

Phosphate removal is not efficient in low water temperatures (between 16°C and 6 °C).

Suspended particles/Turbidity

We have investigated the effects of floating islands for improving water quality by removing suspended soil particles in tank-scale experiments. Initial tank-scale results indicate that the islands improve water clarity significantly until they reach a particle-saturation level.

Tests of turbidity showed that floating island remove suspended soil particles from the water.⁴

Water clearing effects are still working at low water temperatures (water temperature between 16°C- 6 °C).

Nutrient removal by floating islands

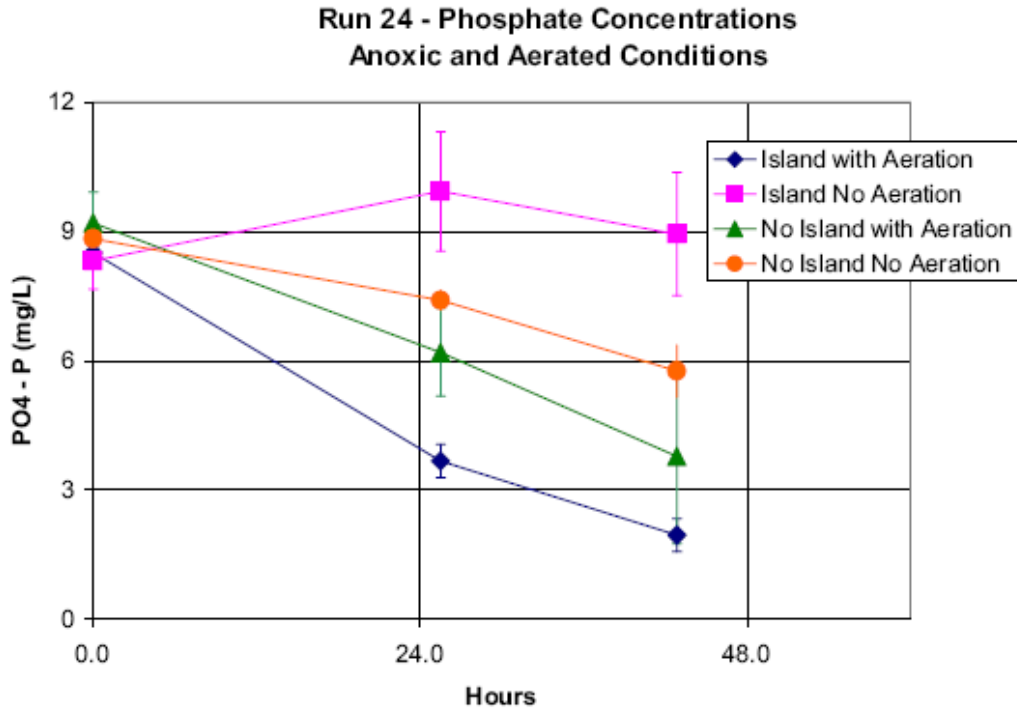
The removal rate for nitrate was 332mg/day/ft² and for phosphate 29mg/day/ft² for planted islands⁵; the equivalent results for islands without plants were 52mg/day/ft² for nitrate and 30mg/day/ft² for phosphate.

Nitrate removal levels rise to 10,600mg/day/ft² and phosphate removal levels to 140mg/day/ft² when the island are mature.

⁴ Test1: increase of visibility from 14cm to 120cm in 26 days; test 2: increase of visibility from 5cm to 52cm in 41 days.

⁵ Plants used in this experiment were: *typha latifolia*, *salix geyeriana* and *populus balsamifera*

Floating islands work with reduced efficiency during low temperature conditions.



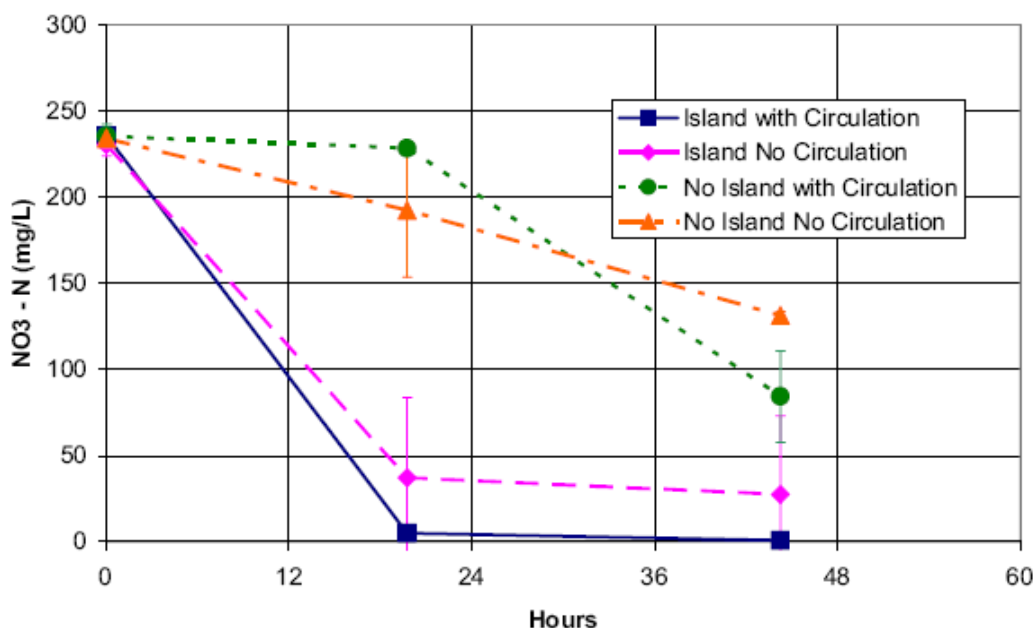
The highest phosphate removal rate is achieved by islands with aeration, followed by aeration without islands. The least effective is islands without aeration. This demonstrates clearly the importance of oxygen for phosphate removal.

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Run 23 - Nitrate Removal



The highest nitrate removal rate is achieved by islands with circulation, followed by islands without circulation; the least effective is the absence of an island. This demonstrates the importance of the supply of a sufficient anoxic surface for nitrate removal.

Water circulation is an important factor for nutrient removal during freezing conditions. It can be achieved with a 45W solar panel and a 1100gph submersible pump.

B. NIWA Research

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Actual research to date (limited by the availability of islands) has found that, after 10 weeks, plants placed bare-rooted directly onto the matrix grow slower but show more root development than their counterparts planted into pockets.

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C. Michigan Research



A report commissioned by an independent party (in Michigan, USA) demonstrates the reduction of organic lake bottom sediments after the installation of a properly designed aeration system.

By Gregory Bator, Twin Lakes Property Owners' Association⁶

East Twin covers about 900 acres of surface area with 9300 perimeter feet of shoreline.

The lake contains roughly 192 million gallons of water.

East Twin is relatively a shallow lake. Depths range four to eight feet, with some areas no deeper than about 26 feet. The lake bottom is primarily a hard sandy surface. During a period of low water levels, the high sediment level at the western end of our lake became more prominent. The sediment occupied as much as 6 of the eight feet of depth in many

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locations. These levels were unacceptable to boaters, water enthusiasts, and fishing aficionados.

Our problem area is located at the western end of our lake. This area consists of 160 acres of surface area. We knew that the sediment levels in our lake created low oxygen levels in the muck. When low oxygen levels are present the water's condition is anaerobic. This is undesirable. When aerobic conditions exist, tiny aerobic organisms can exist to naturally eat up or decompose the sediment at faster rates. This was desired.

Initially, most people believe that the air introduced into the lake supplies the requisite oxygen to create aerobic activity. This belief is not correct. The aeration units pump air into the membranes that create columns of bubbles that circulate the lake's water from bottom to top. When water is exposed to the atmosphere it is oxygenated from a process called diffusion. The chief operative characteristic of our aeration units is actually water circulation. The aeration units operate only during ice-free periods.

The operating units are housed in protected metal cabinets and contain two 1/3 hp compressors. The units are quiet and trouble-free. In total, the units are connected to 12,000 feet of self-weighted bottom line tubing that remains at the lake's bottom. The tubing is connected to 24 diffuser units that each creates four columns of tiny bubbles at the water's surface. The 24 diffuser units are situated in specifically designed locations. The diffuser system circulates over 200 million gallons of water daily. This water circulation allows the biologic oxygen demand (BOD) to reach levels necessary for aerobic activity to occur in the lake. BOD is widely used in environmental engineering practice to determine the amount of oxygen water requires for the sediment breakdown process. Before the aeration program began, the heavy sediment areas were anaerobic.

We entered this program with eyes wide open and spirits prepared for long-term results only. We hoped to reduce our sediment levels by 6 inches per year.

We appear to be exceeding our conservative projections. Testing results are demonstrating continual drops in the undesired sediment levels. After two and a half years of operation, tests are revealing approximately two feet less of sediment in our lake. These tests are conducted 4 times per year in the same locations. Data retrieved from the tests demonstrates reduced sediment levels. These are encouraging results.

Anecdotal reports of lake users have been positive. Increased wildlife has been identified, perhaps attracted by the sediment particles being pushed to the surface.

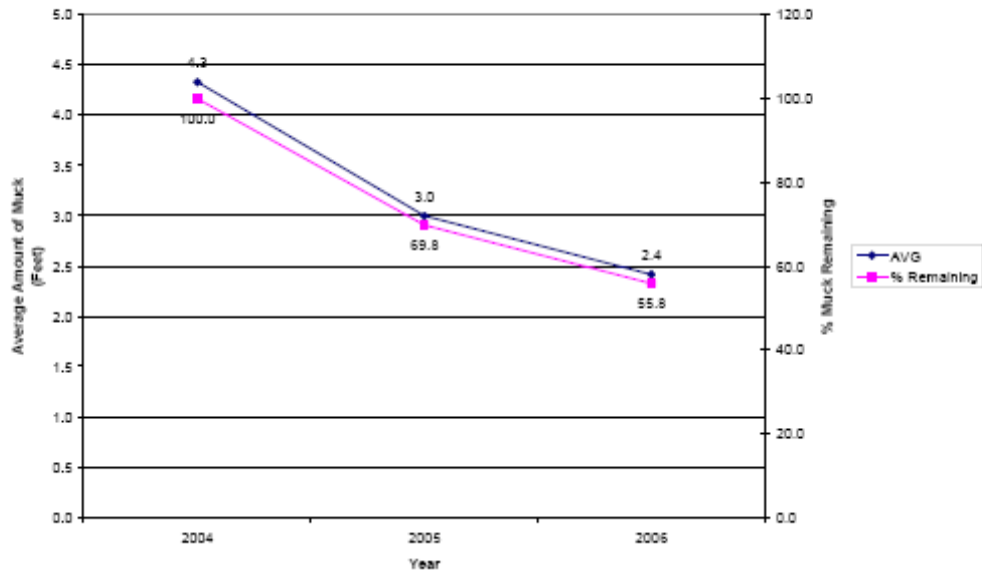
Improved water clarity has also been noted with some west end lake users now being able to see their sandy bottom.

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Rate of Muck Reduction
Based on Yearly Averages (Sites 1-6)



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Appendix - Plant selection for floating islands⁷:

Acorus calamus
Alisma plantago-aquatica
Amorpha fruticosa
Asclepias incarnata
Beckmannia syzigachne
Calamagrostis
Caltha palustris
Carex aquatilis

Carex hystericina
Carex nebrascensis
Carex stricta
Carex utriculata
Ceratophyllum demersum
Cicuta virosa
Decodon verticillatus
Deschampsia caespitosa
Dulichium arundinaceum
Eleocharis acicularis
Eleocharis equisetoides
Eleocharis obtusa
Eleocharis palustris
Eleocharis quadrangulata
Eupatorium maculatum
Hibiscus militaris
Hydrocotyle umbellata
Iris fulva
Iris pseudacorus
Iris versicolor
Iris virginica
Juncus balticus
Justicia americana
Leersia oryzoides
Lobelia cardinalis
Lythrum salicaria
Mentha aquatica
Onoclea sensibilis
Osmunda regalis

⁷ List with additions by: Robert Mohlenbrock , USDA, NRCS, 1997 - Northeastern Wetlands Flora @ PLANTS Database

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Osmunda cinnamomea
Peltandra virginica

Picea Engelmannii
Phalaris arundinacea
Phragmites communis
Phragmites australis

Poa Pratensis
Polygonum hydropiperoides
Polygonum pensylvanicum

Polygonum punctatum
Pontederia cordata

Populus balsamifera
Rudbeckia laciniata
Rumex verticillatus
Sagittaria graminea
Sagittaria latifolia
Sagittaria rigida
Salix aurita

Salix geeyeriana
Saururus cernuus
Schoenoplectus acutus
Schoenoplectus maritimus
Schoenoplectus pungens
Schoenoplectus tabernaemontani

Scirpus acutus
Scirpus validus
Sium suave
Sparganium americanum
Sparganium eurycarpum
Spartina cynosuroides
Spartina pectinata
Symplocarpus foetidus
Thelypteris palustris
Typha angustifolia
Typha latifolia
Veronica americana
Woodwardia areolata
Zizania aquatica

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