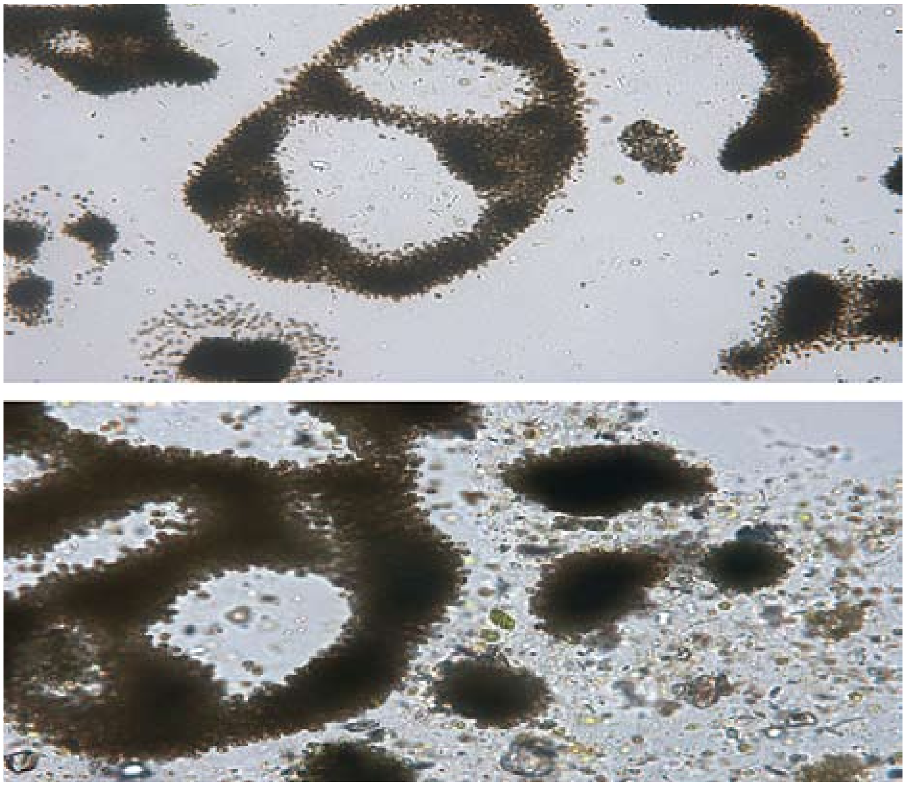
Clay Flocculation Counters Microcystin Pollution In China Study

Dr. Song Biyu
College of Resources
and Environmental Science
Wuhan University
Wuhan, Hubei Province, China
songbiyu@gmail.com

Dr. Yang Yi
Dr. James S. Diana
Michigan Sea Grant
School of Natural Resources
and Environment
University of Michigan
Ann Arbor, Michigan, USA



These enlarged microscopic photos of *Microcystis aeruginosa* from the experimental fish pond shows the algae before treatment (top) and after treatment with chitosan-modified clay for 100 minutes.

Summary:
Since typical water treatment processes are ineffective at removing toxic microcystins, techniques for eliminating microcystin-producing algae in water bodies have been developed. The most promising microcystin control in aquaculture is flocculation and sedimentation of harmful algal blooms with clay. In a study with tilapia in a eutrophic fish pond, the authors found that polymeric aluminum chloride-modified clay had a faster and slightly stronger effect in removing *M. aeruginosa* than a more environmentally friendly chitosan-modified clay.

Microcystins are the most commonly found and poisonous algal toxins produced by several harmful cyanobacterial species. Microcystins are usually associated with freshwater environments, and can be accumulated by aquatic animals such as mussels, snails, zooplankton, shrimp, frogs and fish through ingestion of drinking water and foods with bioaccumulated toxicity.

Microcystins are monocyclic heptapeptides including several variants. As a family of potent liver toxins, they can cause hepatotoxicosis, gastroenteritis and allergic reactions, and are potentially hazardous in ecosystems and to human health.

Microcystins are associated with *Microcystis, Anabaena, Oscillatoria, Nostoc, Hapalosiphon* and *Anabaenopsis* algal species. *M. aeruginosa* is the primary microcystin-producing species. It often forms blooms in eutrophic freshwater ecosystems, representing a threat to aquatic organisms and human beings.

Microcystin Control

Since their molecular structure has cyclic and double bonds, microcystins have considerable physiochemical stability. Existing water treatment processes such as coagulation, sedimentation, filtration and chlorination are ineffective at removing the toxins. Therefore, techniques for eliminating the microcystin-producing algae in water bodies have been developed instead of direct microcystin removal during water treatment.

The most promising control strategy with respect to maximum effectiveness and minimal costs and environmental impacts is flocculation and sedimentation of harmful algal blooms with clay.

Over the past 25 years, clays have been investigated in several countries as a means of removing harmful algae from the water column.

China Study

In China, many freshwater bodies have been contaminated by organic compounds, and more than two-thirds are eutrophic. As a result, toxic cyanobacteria blooms occur frequently, and algal toxins, especially microcystins, are a serious concern. Developing safe and efficient techniques to control *M. aeruginosa* has become a top priority in China today.

The authors recently performed a study to investigate microcystin concentrations in Nile tilapia muscle tissue and surrounding pond water from a typical eutrophic fish pond in Hubei province, China (Table 1). Furthermore, it aimed to develop removal methods for eliminating the dominant microcystin-producing species, *M. aeruginosa*.

Table 1. Concentrations and distributions of microcystins in pond water samples and Nile tilapia muscles from a eutrophic fish pond in China.

Sample Date	Cyanobacteria (%)	Dominant Cyanobacteria	Microcystin (%)	Microcystin Concentration (ng/g) in Fish Muscle
July	36.59	*Microcystis*	0.134 ± 0.041	0.84 ± 0.84 (0.10-2.21)
August	27.13	*Microcystis, Coelosphaerium species*	0.052 ± 0.017	0.68 ± 0.49 (0.33-1.49)

Two types of clay were used to remove both laboratory-cultured and field-collected *M. aeruginosa*: chitosan- and polymeric aluminum chloride (PAC)-modified clay (kaolin).

Clay Treatment

Results showed that both clays removed cultured *M. aeruginosa* effectively. After treatment with clay, the algae settled to the pond bottom, and cell vitality decreased noticeably. The sedimented *M. aeruginosa* cells died within a month of flocculation with chitosan-modified clay. Maximum electron transport rates (ETRmax), a measure of photosynthetic activity, decreased by 76% after one month.

For algae treated with PAC-modified clay, algal cells became yellowish and decayed in a week. ETRmax declined 79% after one week. Of the two treatments, PAC-modified clay had a faster and slightly stronger effect. Table 2 shows optimal dosages of both clay treatments.

Chitosan-modified clay is more environmentally friendly because it does not contain aluminum chloride and is biodegradable. It can effectively remove field-reared *M. aeruginosa*. After chitosan-modified clay treatment, chlorophyll-α decreased 98.6%.

Table 2. Optimal doses of coagulants for maximum algal removal at different concentrations of *M. aeruginosa* in a laboratory.

Algal Concentration (mg/L Chlorophyll-a)	Optimal Dose Chitosan-Modified Clay (ml)	Optimal Dose PAC-Modified Clay (ml)
0.19	0.5	2.0
0.27	0.8	–
0.38	2.0	–
0.43	–	4.0
0.64	5.0	–
0.72	–	8.0
1.10	–	14.0

Editor's Note: Co-author Yang Yi passed away on July 31, 2009. Yang Yi was an accomplished scholar, an excellent researcher and an innovator in applying simple aquaculture techniques to gain efficiency for small-scale farmers. He was on faculty at the Asian Institute of Technology in Bangkok and later at Shanghai Ocean University. He was also president of the Asian Fisheries Society from 2007 until 2009.