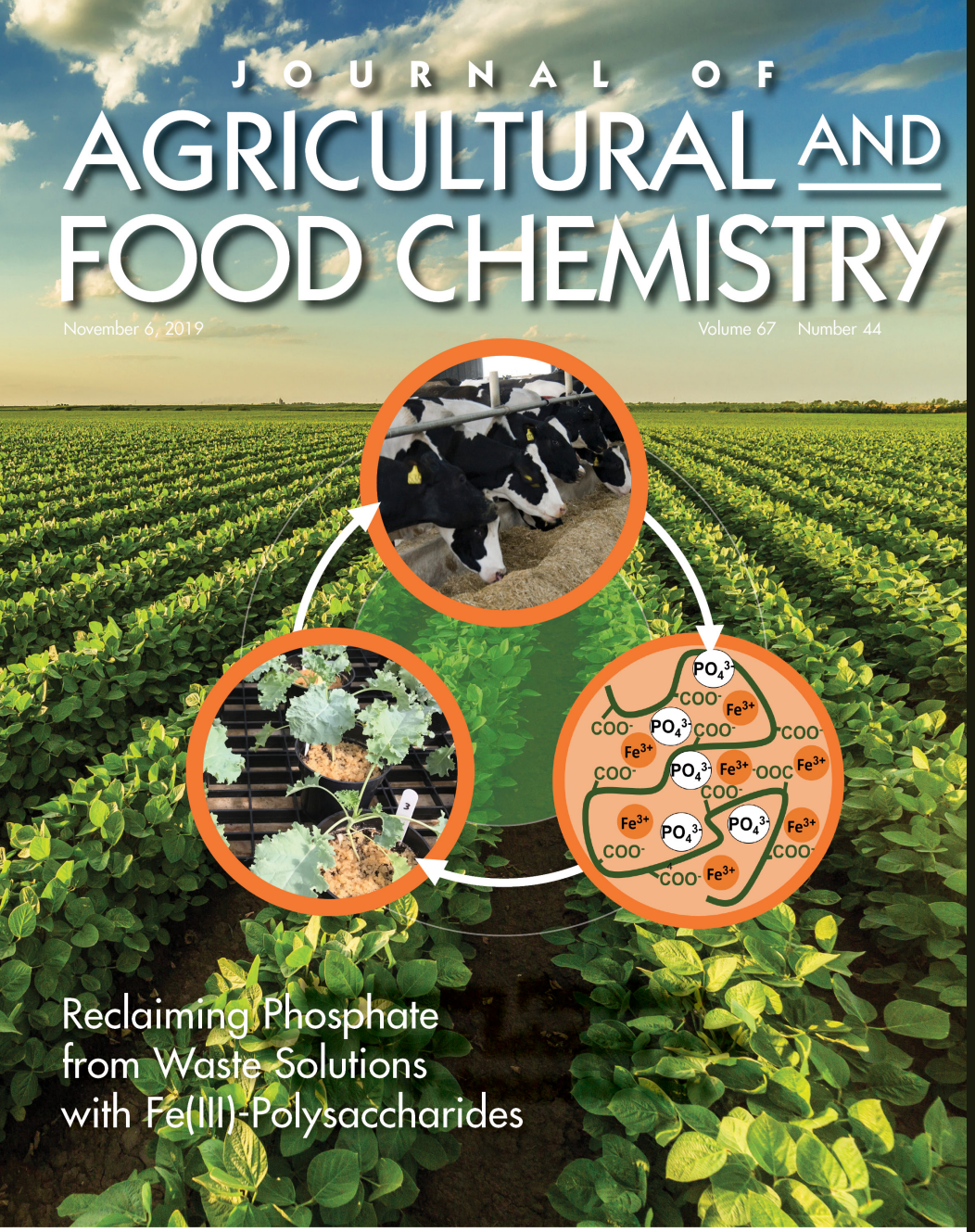


MAXIMIZING THE BENEFIT, MINIMIZING THE HARM OF CAFO MANURE USED AS FERTILIZER

Goals

- Develop a process for converting the dilute manure from intense animal agriculture into a slow-release fertilizer
- To reduce the loss of phosphorus and nitrogen from the use of manure on fields to grow crops
- To make it much cheaper to transport manure to the locations where it will have more value and benefit
- To make more money from manure while contributing to a reduction in HABs

Manure: An Environmentally Sustainable Fertilizer

- Manure contains nutrients that promote crop growth
- Using it as fertilizer recycles nutrients in the animal's feed
- Phosphorus supply is limited and declining
- Need to find good ways to recycle phosphorus
- HOWEVER ...

The Problem

Large volumes of manure are produced with high water content: 95-98% water.

1,000 dairy cows can produce 4,800,000 gallons of manure per year

Manure contains nutrients that can be used as fertilizer

BUT, the value is low relative to cost of transportation

- *Often too expensive to transport more than a few miles*

Application of more nutrients than crops absorb allows nutrients to be washed into waterways by precipitation

Nutrients in waterways promote the growth of harmful algae

The Solution

Separate the nutrients from the water

Reduces weight by 20-40X – can transport 20-40X further at same cost

Bind nutrients in a matrix that slowly releases them over the growing season

Nutrients are available when crops need them most

Less can be washed into waterways by precipitation

This makes the product more valuable than the untreated manure

If product value exceeds cost of production, production can generate a profit

Profit can provide a financial incentive for reducing the risk of environmental harm from manure use

Phase 1

Identify treatment processes in lab tests that work best with the types of dairy manure, soils, and crops that are common in the state of Ohio

Key goal: treatment gross cost lower than $0.03/gallon, net cost lower than $0.01/gallon

Test at the pilot-scale to confirm that the process optimized in the lab works in real fields

Laboratory work to test & optimize the best methods for treating manure

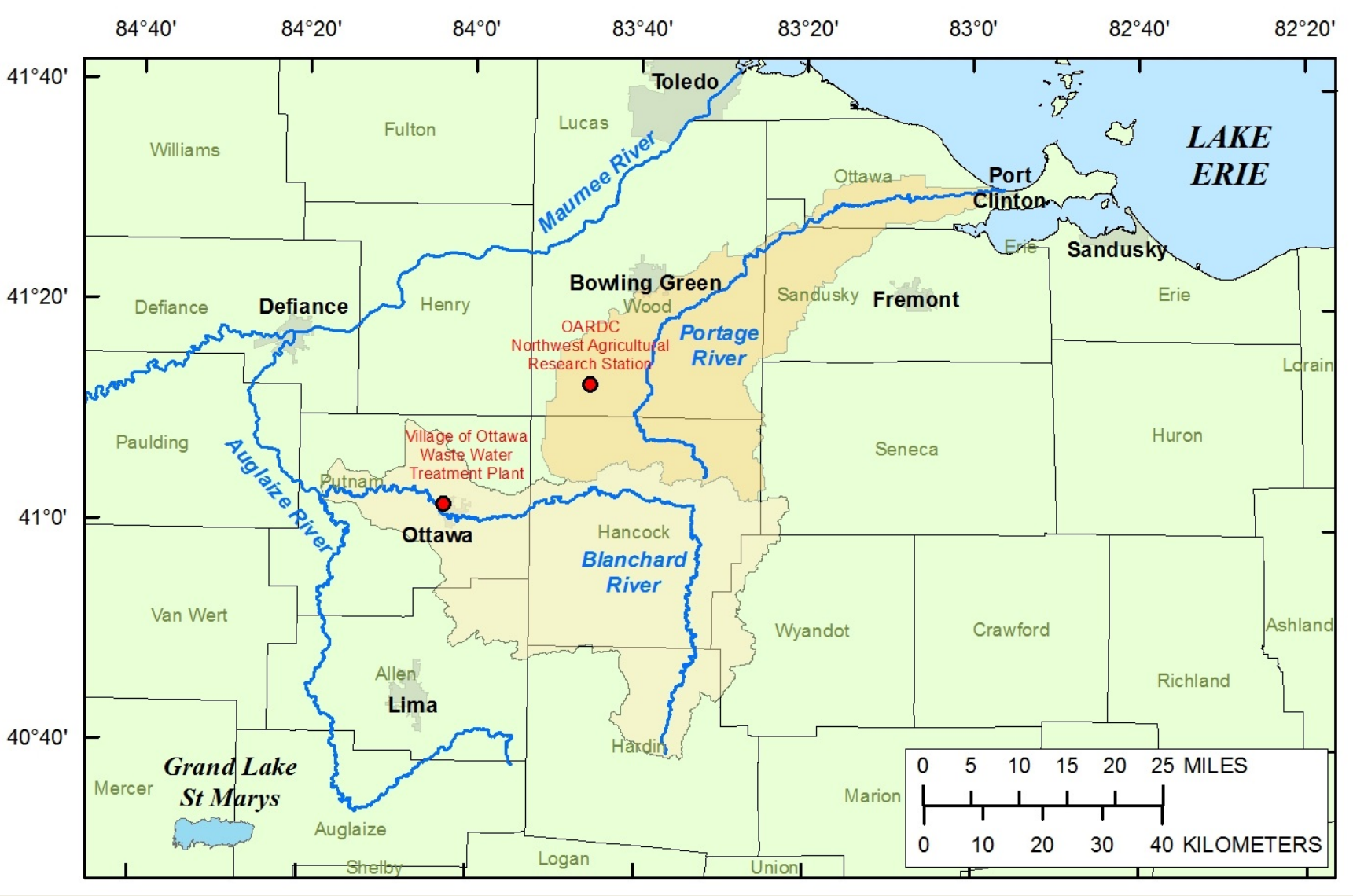
Hundreds of lab tests conducted to identify best materials and process

Found two cationic polymers to be effective that work best with the addition of ferric chloride to enhance coagulation

Soil columns used to determine nutrient release rates

Materials and treatment method selected that gave best results in the lab

Pilot-Scale Study Location



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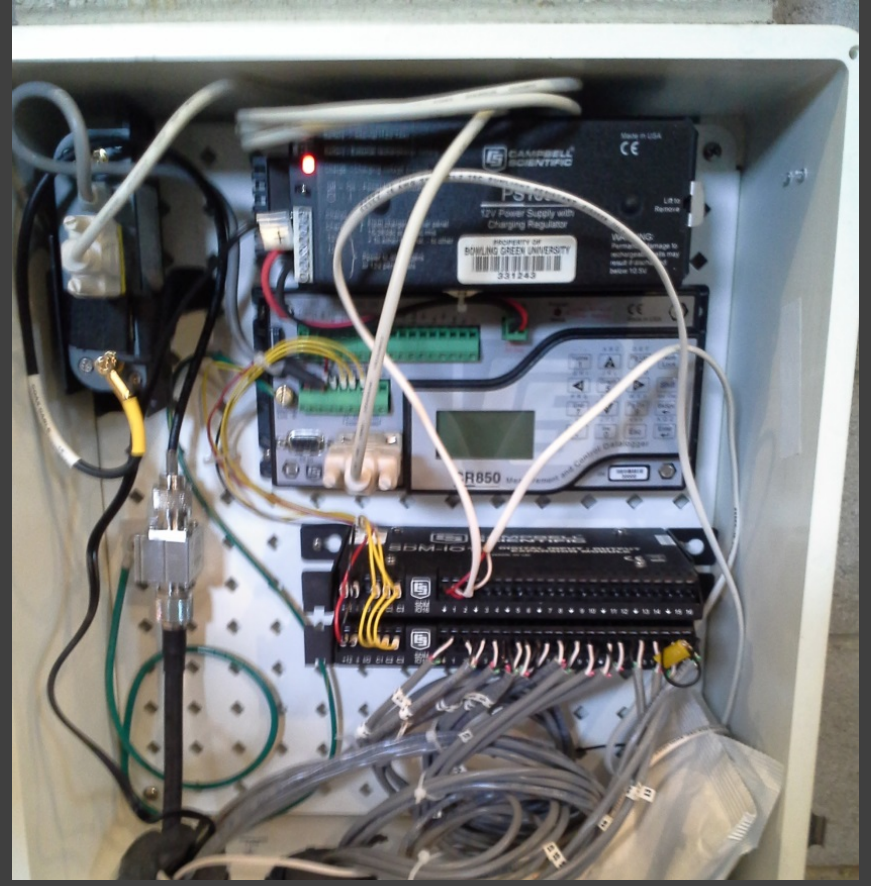
Pilot-Scale Test Facility

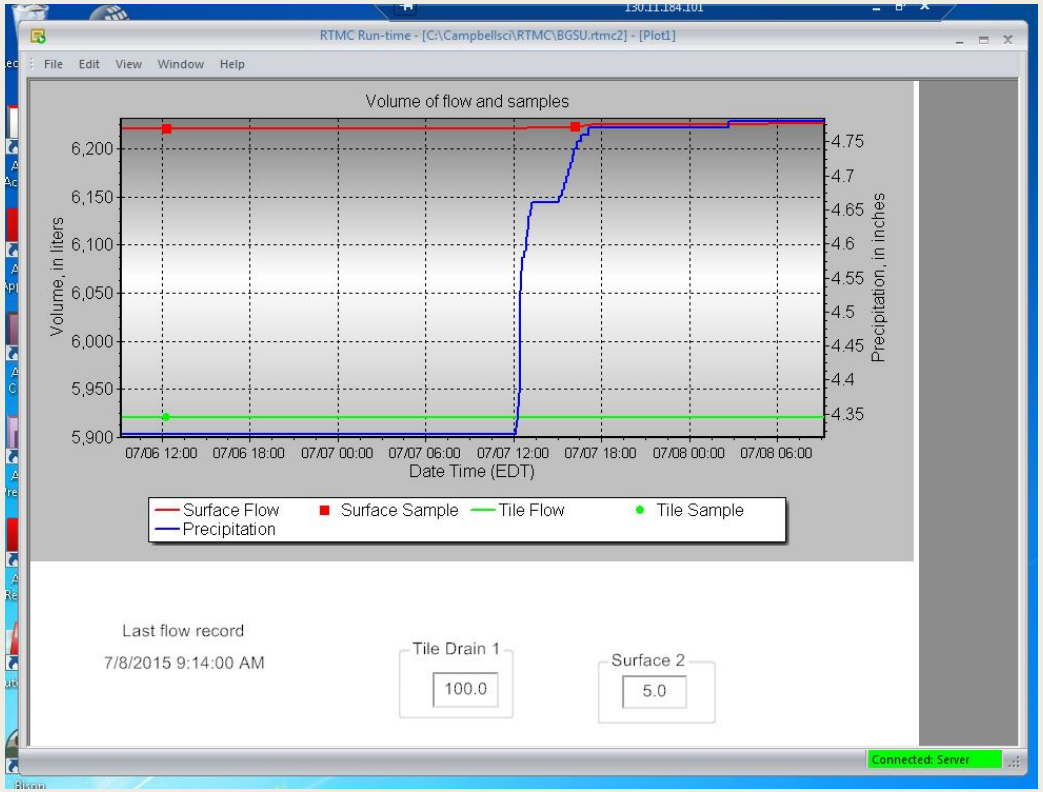
- Eight test plots where surface and subsurface (tile) runoff is transported to a central sheltered location

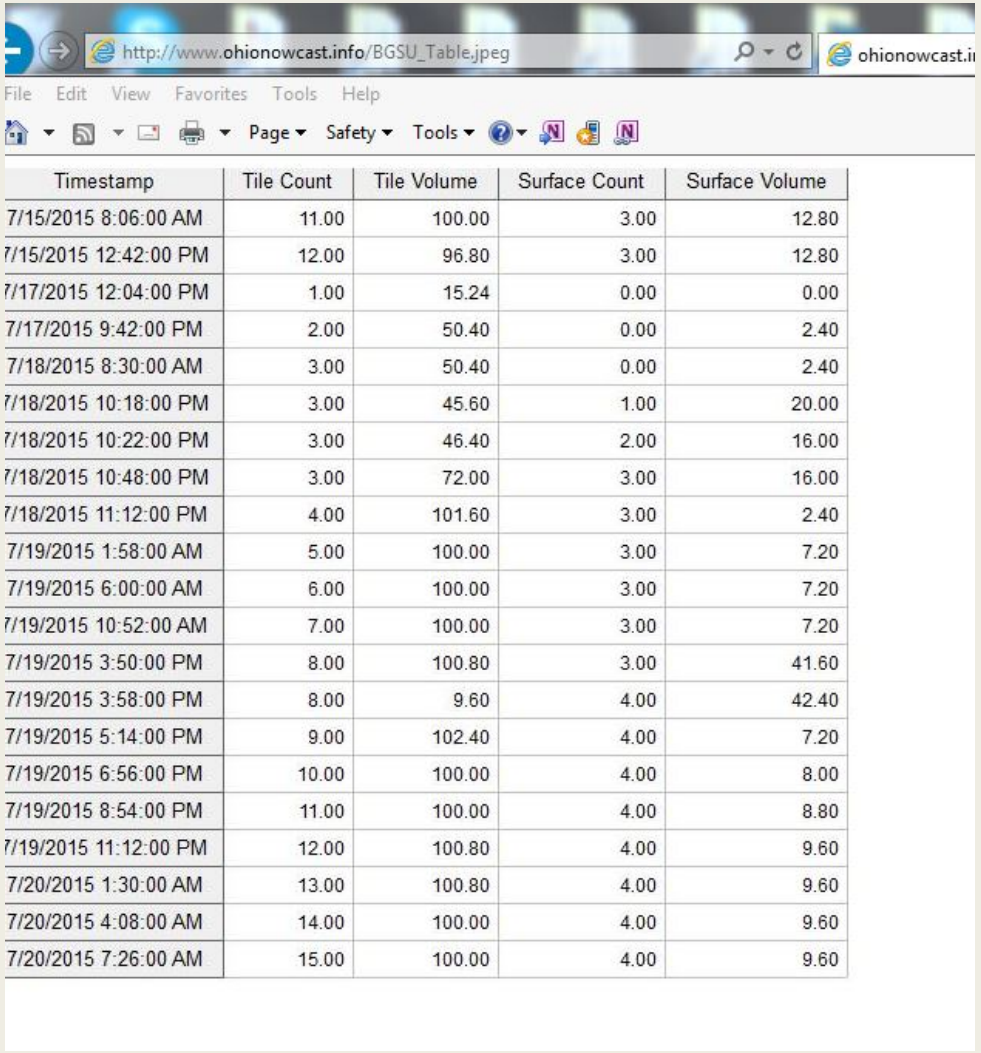
1. *Test equipment installed to measure variable flow*
2. *Collect and analyze runoff samples*
3. *Establish baseline conditions of the test plots*



INSIDE: AUTOMATED SAMPLERS, TIPPING BUCKETS, MODEM COMMUNICATIONS

Flow rate, volume, and sample reports





Timestamp	Tile Count	Tile Volume	Surface Count	Surface Volume
7/15/2015 8:06:00 AM	11.00	100.00	3.00	12.80
7/15/2015 12:42:00 PM	12.00	96.80	3.00	12.80
7/17/2015 12:04:00 PM	1.00	15.24	0.00	0.00
7/17/2015 9:42:00 PM	2.00	50.40	0.00	2.40
7/18/2015 8:30:00 AM	3.00	50.40	0.00	2.40
7/18/2015 10:18:00 PM	3.00	45.60	1.00	20.00
7/18/2015 10:22:00 PM	3.00	46.40	2.00	16.00
7/18/2015 10:48:00 PM	3.00	72.00	3.00	16.00
7/18/2015 11:12:00 PM	4.00	101.60	3.00	2.40
7/19/2015 1:58:00 AM	5.00	100.00	3.00	7.20
7/19/2015 6:00:00 AM	6.00	100.00	3.00	7.20
7/19/2015 10:52:00 AM	7.00	100.00	3.00	7.20
7/19/2015 3:50:00 PM	8.00	100.80	3.00	41.60
7/19/2015 3:58:00 PM	8.00	9.60	4.00	42.40
7/19/2015 5:14:00 PM	9.00	102.40	4.00	7.20
7/19/2015 6:56:00 PM	10.00	100.00	4.00	8.00
7/19/2015 8:54:00 PM	11.00	100.00	4.00	8.80
7/19/2015 11:12:00 PM	12.00	100.80	4.00	9.60
7/20/2015 1:30:00 AM	13.00	100.80	4.00	9.60
7/20/2015 4:08:00 AM	14.00	100.00	4.00	9.60
7/20/2015 7:26:00 AM	15.00	100.00	4.00	9.60

The Pilot-Scale Tests

Manure	Manure treated at Village of Ottawa WWTP
Compare	Compare the nutrient migration in soil of treated manure to that of raw manure
Monitor	Monitor surface and tile nutrient concentrations and flow
Determine and compare	Determine and compare nutrient runoff amounts and crop yields

Project Team

Bowling Green State University

- *Laboratory studies*
- *Collect and process field samples*
- Analysis of samples for dissolved and total nutrients
- Polymer production, analysis, and testing

USGS Ohio-Kentucky-Indiana Water Science Center

- *Equipment installation, testing, programing, and maintenance*
- *Assist with quality control of chemical analysis*

OSU OARDC Northwest Agricultural Research Station

- *Construct and maintain field plots and assist with access*
- *Services for land application of dairy manure and planting of row crops*

Village of Ottawa, Ohio (Phase 2)

- *Large-scale manure treatment and transport*

PART OF THE PROJECT TEAM

Findings

Higher loads (amounts) were found for combined loads (surface and tile) in raw relative to treated plots for dissolved reactive phosphorus ($p<0.05$)

Statistically significant differences were also found for flow-weighted mean concentrations

Suggests that dissolved reactive phosphorus was likely retained in the soil and hydrological transport was reduced for the plots amended with the treated manure as compared to raw manure

Crop yields were virtually the same on plots fertilized with raw and treated manure indicating the treated manure was as effective as raw as a fertilizer

This coagulant/polymer treatment shows potential in helping to reduce dissolved phosphorus in flow from agricultural fields with applied manure

Alginate & Pectin Polymers

The polymers found in the first phase technology do not capture ammonia

We have found that alginate & pectin polymers capture ammonia as well as phosphate

Combined with iron or aluminum salts these materials are light sensitive

These materials are considered to be safe for use in food

Alginate obtained from seaweed/kelp (macroalgae)

Pectin from fruit and fruit peel

But the purified, refined materials are too expensive ($0.68/gallon)

Next Steps

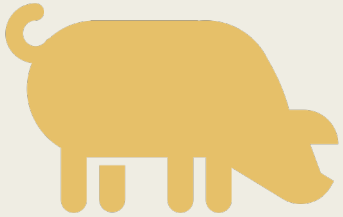
Test crude preparations and extracts of seaweed for effectiveness in manure treatment

- *macrocystis (sea kelp), a monospecific genus of large brown algae;*
- *ectocarpus, such as ectocarpus siliculosus, a filamentous brown algae; and*
- *Sargassum, another type of brown algae but in the order Fucales, found in temperate and tropical oceans throughout the world that has become a huge problem in some areas of the Caribbean*

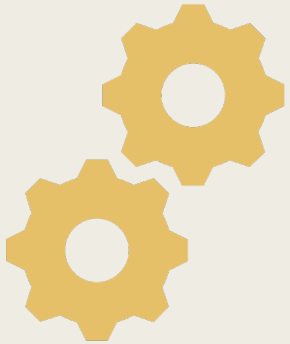
Also testing polysaccharides such as oxidized starch that are inexpensive but have properties that suggest they would be effective

- *Carboxylate groups that bind metals such as iron, aluminum, and calcium*

Next Steps



Develop plans for a simple, automated farm-scale system that can use this process for treating manure



Minimize cost and optimize effectiveness to that this technology can be used throughout the region and beyond

Benefits

- Lowered risk of adverse environmental impact of the use of a valuable agricultural material in an environmentally sustainable way
- More economical use of animal manure in locations where it can provide the most benefit
- Help to mitigate threats to our waters caused by HABs

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