Lethbridge College

Using Aerobic Bioreactors to Improve Nutrient Management in Agriculture and Aquaculture

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For

Getting the Most from Nutrient Management Workshop

February 23, 2017,

Lethbridge, Alberta

How we can address the challenges facing agriculture in 21 century, such as environmental pollution by agricultural waste and limited reserves of nutrient source?

We need to continue looking for new ideas, “out-of-box” solutions. In future, we may need to completely change our agricultural paradigm, the way we produce food today.





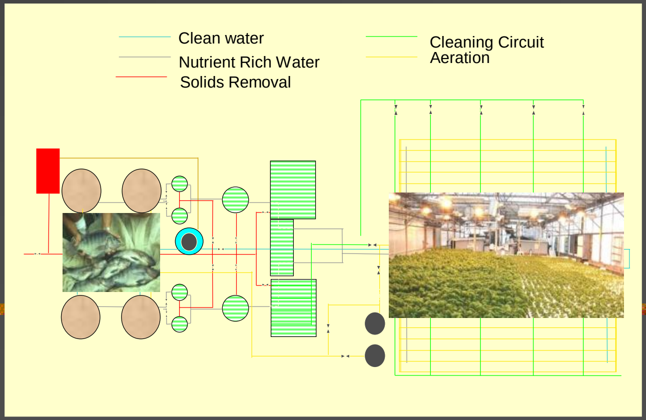
The solution may already exist today, but we are not fully aware of it.

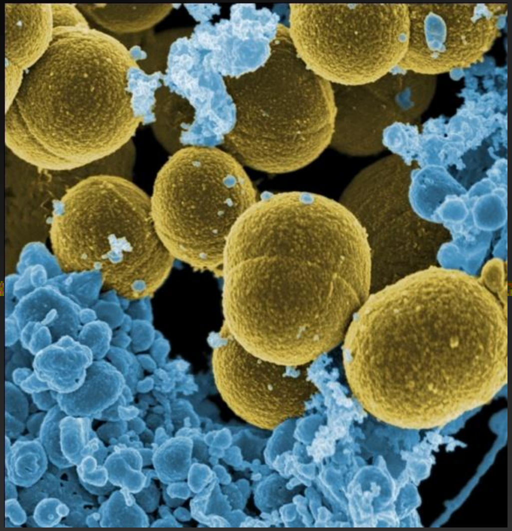
Example: Integrated Production Systems, where the byproduct of one component, such as livestock farm, becomes the feedstock of another component, can be the answer

The example of Integrated Food Production System is aquaponics

What is “aquaponics”?

Aqua**culture** + **Hydro*****ponics*** = ***Aquaponics***



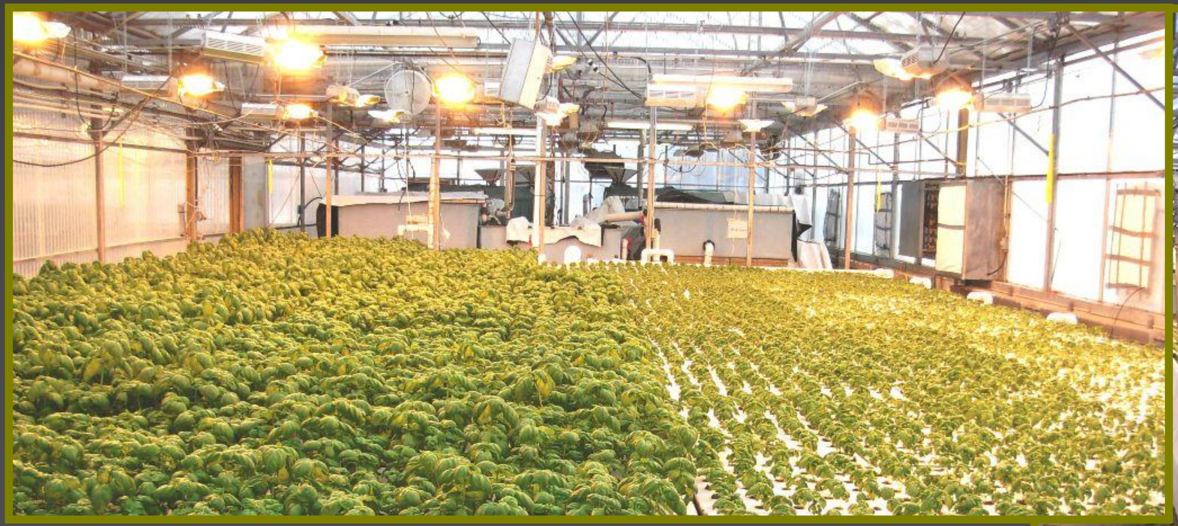


The Basic Process:

Fish provide source of nutrients, microorganisms convert organic waste into soluble nutrients available for plants, plants utilize soluble salts regenerating water for fish production

Parameters of the pilot-scale system in Brooks, Alberta

- Total volume – 73 m^3
- Plant area – 84 m^2
- Flow rate – 700 L min^{-1}
- Fish production capacity – 3.7 tons $year^{-1}$
- Basil crop production – 3.5 tons $year^{-1}$



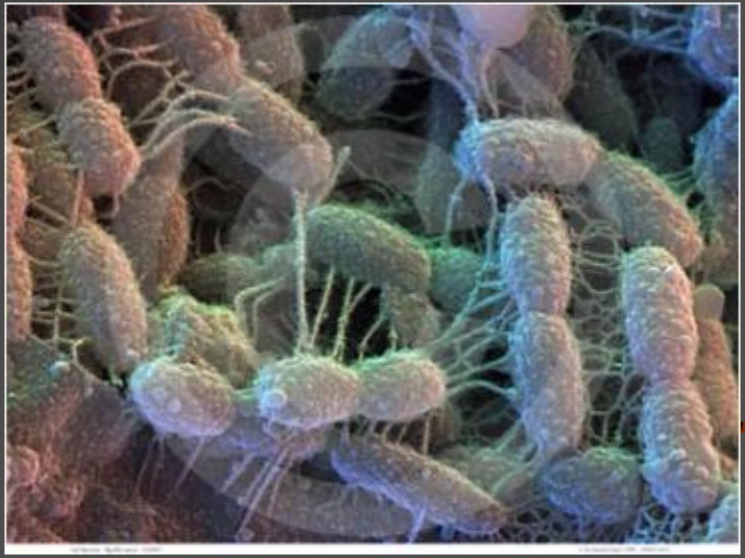

Brooks aquaponics facility became the first zero-waste farm in history

Aerobic bioreactors will be an essential component of Integrated Food Production System

Why do we need Aerobic Bioreactor?

- Aerobic bio-digestion is a breakdown of organic material into minerals available for plants and CO_2 in the presence of oxygen
- Another term for this process is “mineralization” or “ammonification”
- This process occurs in specially designed aerobic bioreactors

- Heterotrophic organisms such as bacteria and fungi play very important role in the process of decomposition and nutrient recycling in nature making nutrients available for any other living organisms on earth



- We utilize the same process for more efficient food production to make agriculture more sustainable

Factors affecting efficiency of Aerobic Bioreactor

- Available Dissolved Oxygen
- Continuous Agitation
- Temperature
- pH
- Dry solids content
- C:N ratio

Recommended parameters for fermenting mixture

- Available Dissolved Oxygen – not less than 2 ppm
- Temperature – 30-40^{o}C
- pH 5.0-6.5
- Dry solids content – 1-5%
- C:N ratio – 5-35

Role of C:N ratio

- C:N ratio is critical for the efficient mineralization process
- Excess of nitrogen is released when C:N ratio drops below 25:1
- Immobilization of nitrogen by bacteria occurs if C:N ratio is higher than 25:1
- The process should be carried out with gradual decrease of C:N ratio
- The challenge is that the mineralization is inhibited by the excess of nitrogen

Typical C:N ratios in some organic feedstocks

Cattle manure	- 10-30
Pig manure	- 10-20
Chicken manure	- 5-15
Alfalfa meal	- 15
Fish manure	- 2.5-5.5
Blood meal	- 3

What is advantage of aerobic biodigestion compared to the conventional manure management methods?

Comparison of different methods of manure management

	Fresh Manure	Composting	Aerobic bioreactor
Loss of nutrients	Significant	Up to 50% loss	Zero loss
Time of processing	N/A	Up to 1 year	2-3 weeks
Food safety – risk of cross-contamination	Very high	High	Minimal
Transportability and delivery	Very expensive	Expensive	Inexpensive (fertigation)
Odor	High	Low	Odorless
Cost of equipment	Inexpensive	Relatively expensive	Relatively expensive
Labor	Labor-intensive	Labor-intensive	Labor-unintensive
Application	Expensive	Expensive	Inexpensive
Availability of nutrients during 1st year	40-50%	20-30%	100%
Risk of environmental contamination	High	Relatively high	Low

Development of aerobic bioreactor technology for treatment of aquaculture waste

Aerobic Bioreactor at CDC South pilot aquaponics, Brooks

Aerobic Bioreactor in Red Hat Coop pre-commercial aquaponics facility


grodan

Cucumbers in Red Hat Coop

Effect of aquaponics water on basil production. Commercial trials at Red Hat Co-operative Ltd , April 18, 2013

iPhone

4-week old aquaponic plants

6-week old hydroponic plants

MDM Aquafarms, Alberta

Aerobic Bioreactor

Northern Bioponics, BC

Aerobic Bioreactor

Development of aerobic bioreactor technology at Crop Diversification Centre North

Chicken manure was used as a feedstock for bioreactor instead of fish manure


Bioreactor ~1200 liters
- agitated and oxygenated
Probiotic Reservoir ~5000 liters
- oxygenated and water-cycled
- feed tank for substrate culture

Aerobic Bioreactor at CDC North


Poultry Manure 1000 L Bioreactor
the addition of ~ pure oxygen makes this an **odorless** process!

- Nutrient-rich solution containing soluble organic and mineral components is produced as a result of aerobic biodigestion of poultry manure

Only mineral component of poultry manure is left after the process including sand and oyster shells

Typical composition of liquid aerobic digestate generated from chicken manure

	Butch 1	Butch 2	Butch 3	Butch 4	Butch 5
Nitrate and Nitrite	2,140	3,060	1,560	2,180	1,660
Ortho -P dissolved	108	335	288	118	212
Potassium	2,130	3,190	2,270	2,280	2,180
Calcium	300	627	368	263	320
Magnesium	200	212	122	184	139
Sulfur	150	232	88	171	117
Boron	1.02	1.60	0.56	1.17	0.69
Iron	0.58	1.40	2.39	3.35	0.16
Manganese	4.84	4.27	2.52	3.59	1.68

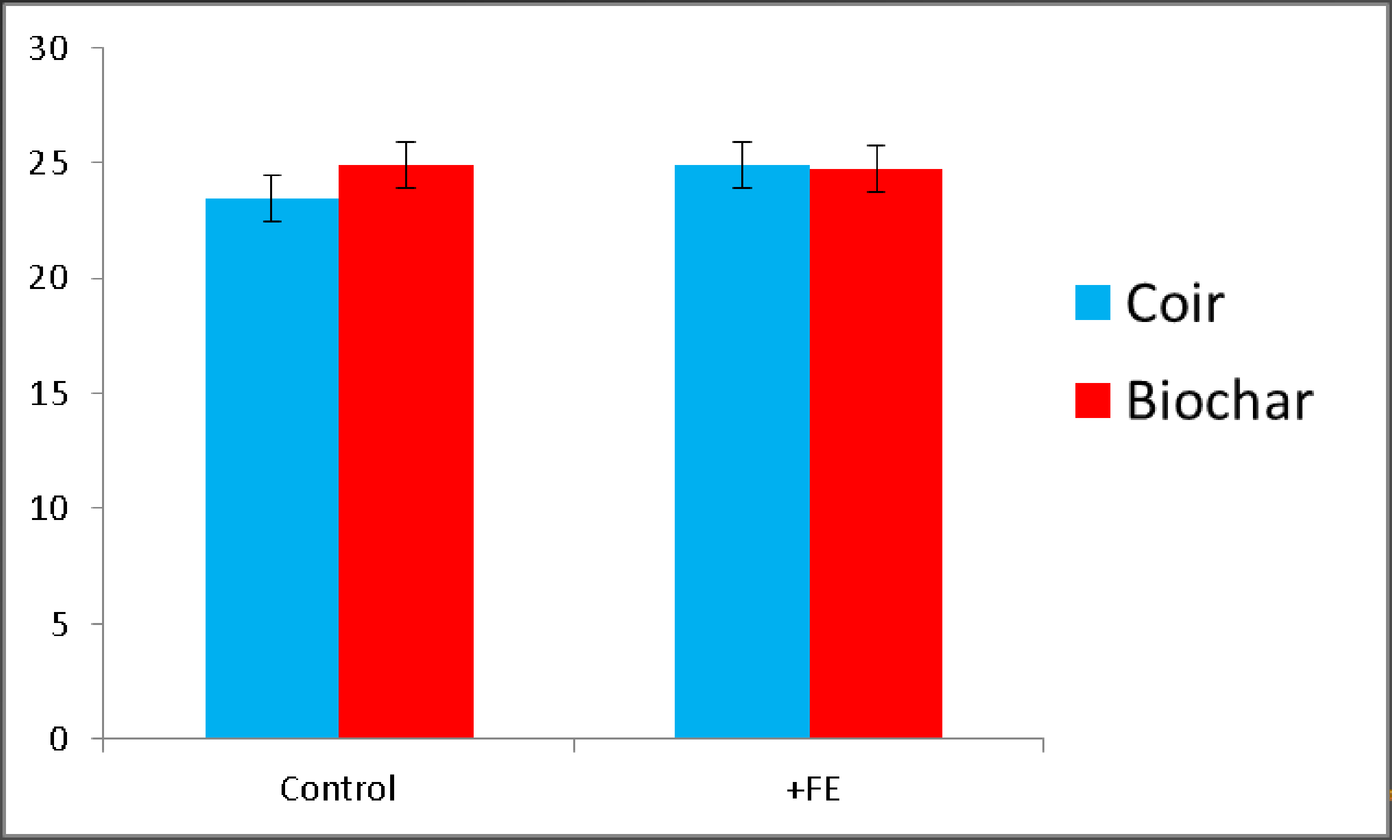
Tomato trial at CDC North started in December 2013

Biochar was repeatedly used for the 4th year. Fresh coconut coir was used as a control

Tomato plants 2 weeks after transplanting

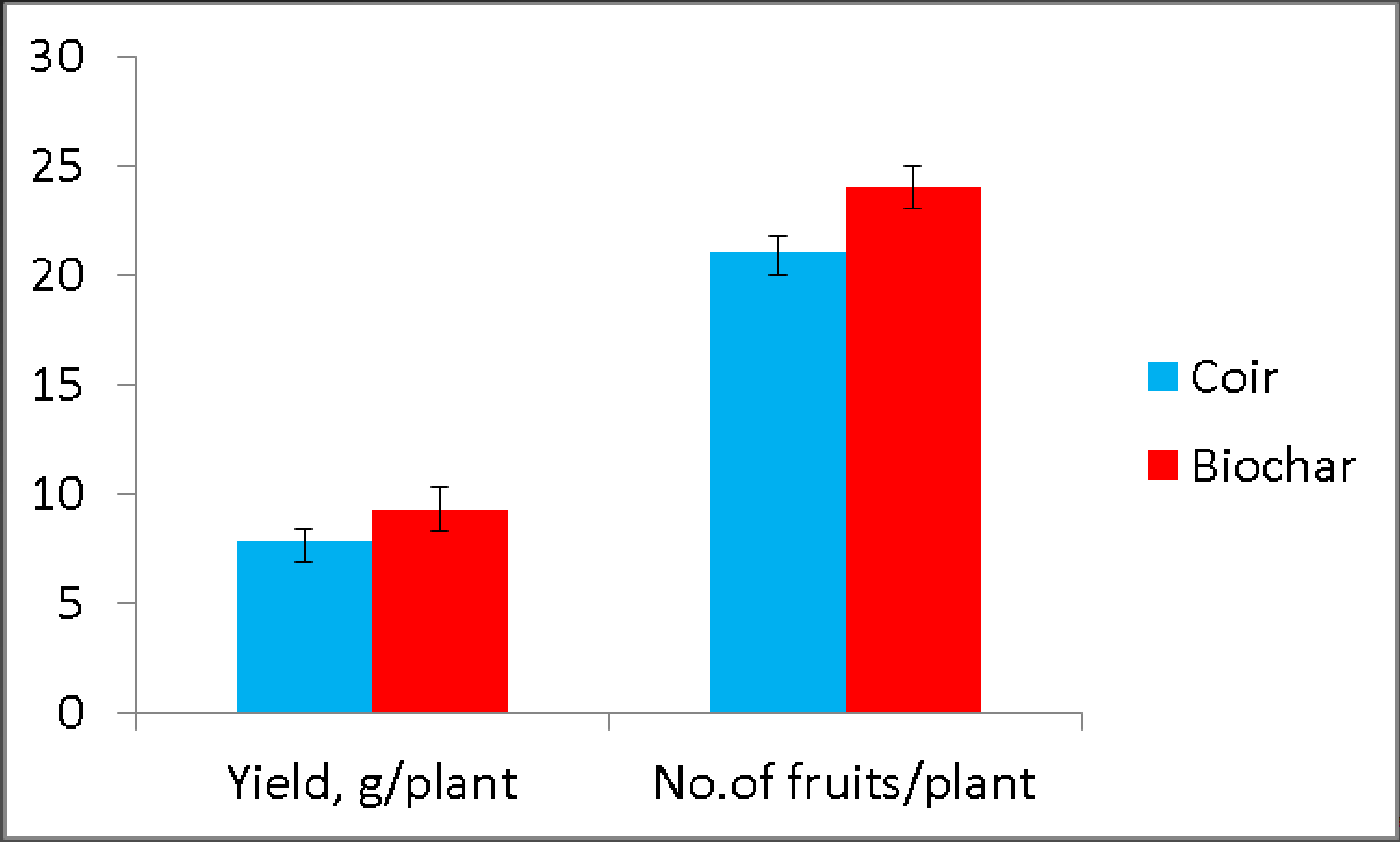
Tomato plants 8 weeks after transplanting

Yield of tomato, cv. Torero, grown on poultry manure digestate, kg/plant



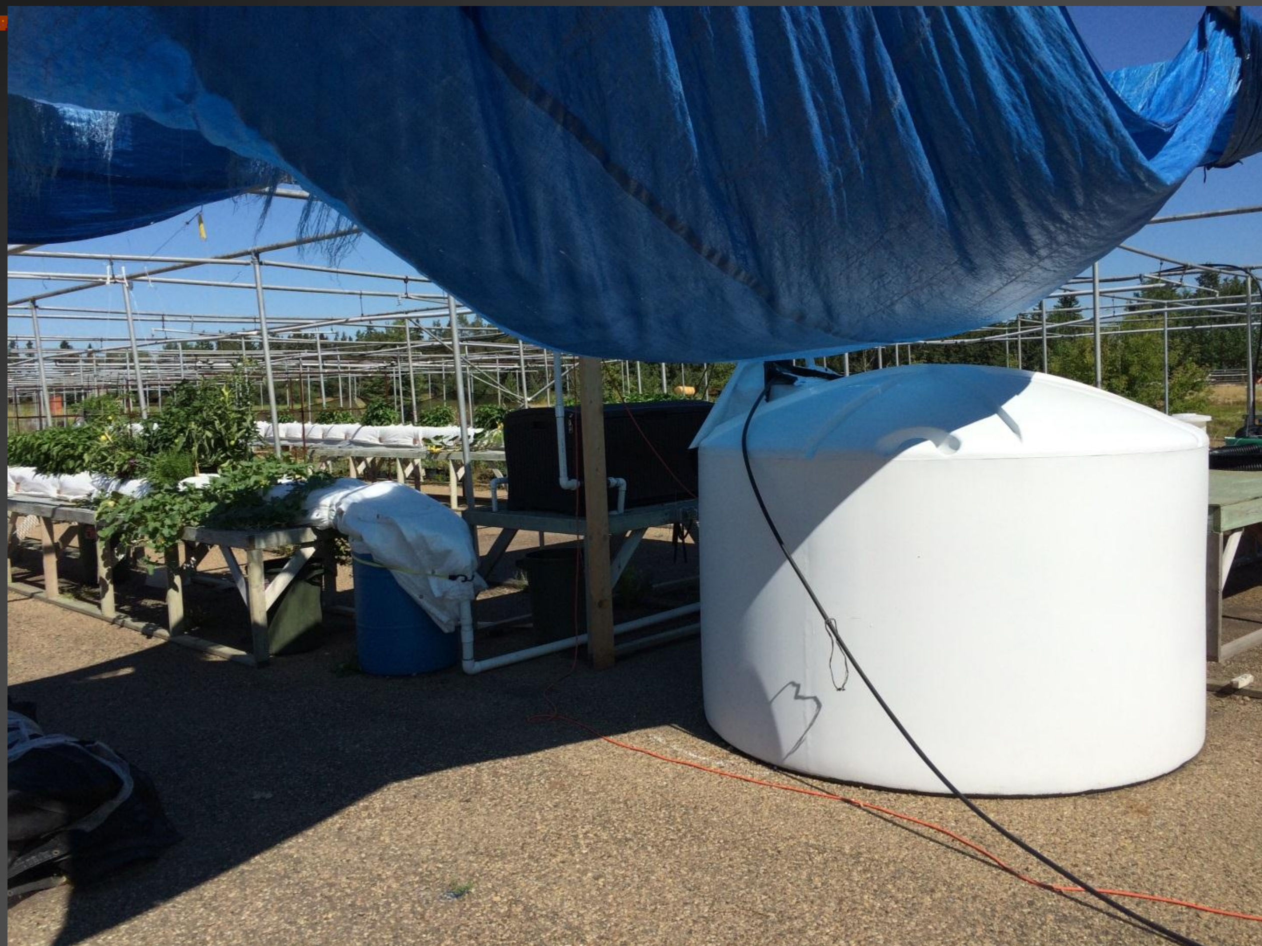
Cucumbers grown on poultry digestate

Yield of long English cucumber, cv Kasja, grown on poultry manure digestate



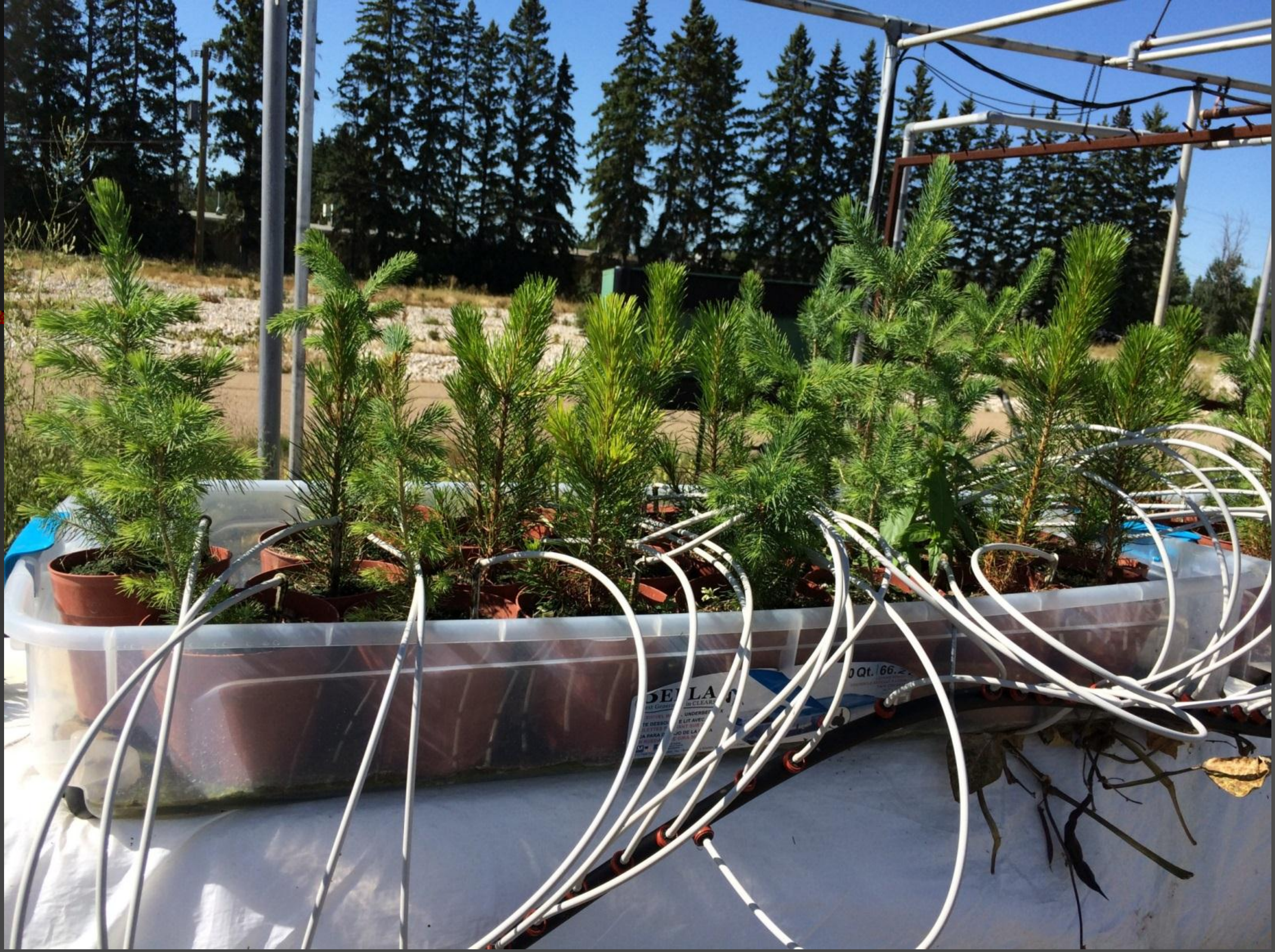
Pepper trial with poultry manure digestate started in mid-July, 2014

Mildly spicy cultivar Anaheim was used in the trial



- Organically-rich solutions were trialed to grow tree seedlings in summer 2014.

- White spruce, *Picea glauca*, lodgepole pine, *Pinus contorta* var. *latifolia*, aspen, Populus tremuloides, and hybrid poplar were among tree species tested in the experiments.

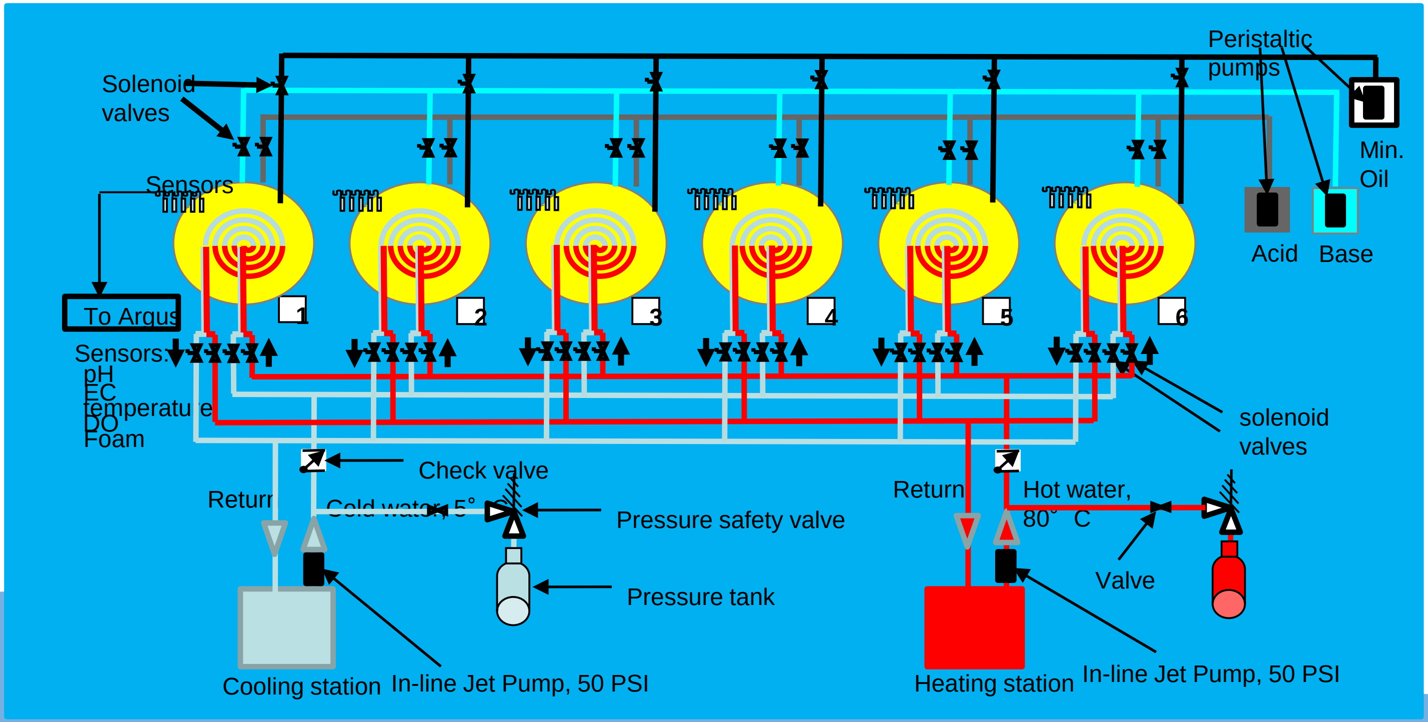


Seedlings of lodgepole pine and white spruce grown on biologically active aerobic digestate. The seedlings were transferred in mid-July and doubled in height after two months.

Development of aerobic bioreactor facility at Lethbridge College

Objective 1. Creating a Stable Nutrient Rich Plant Solution from Various Fishes Effluents and Solid Wastes

Specially designed computer control system will be able to automatically maintain chosen parameters and collect data every second

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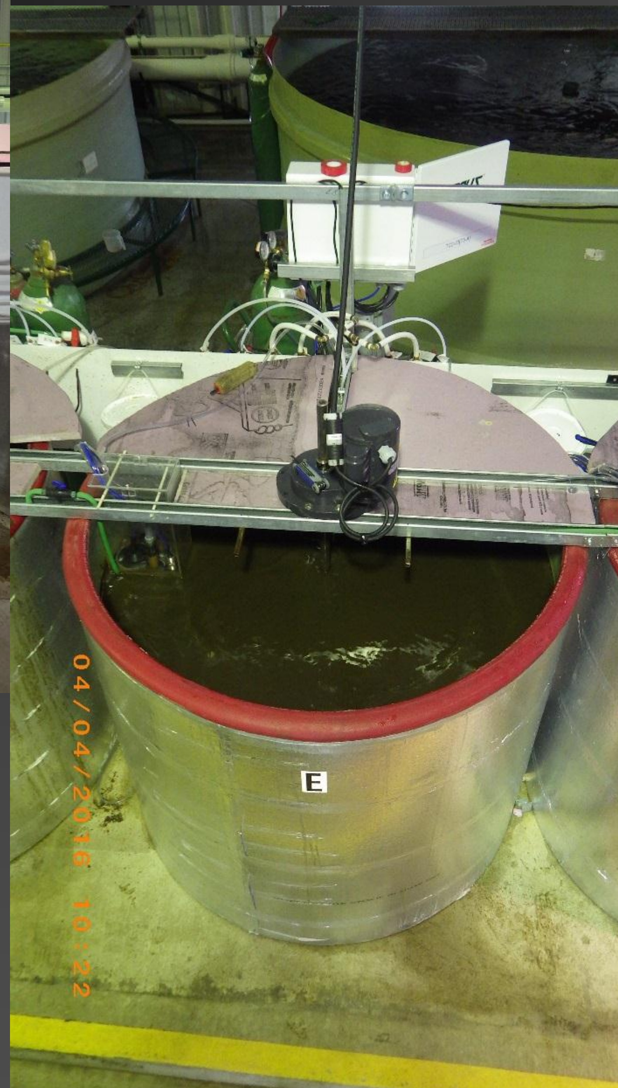
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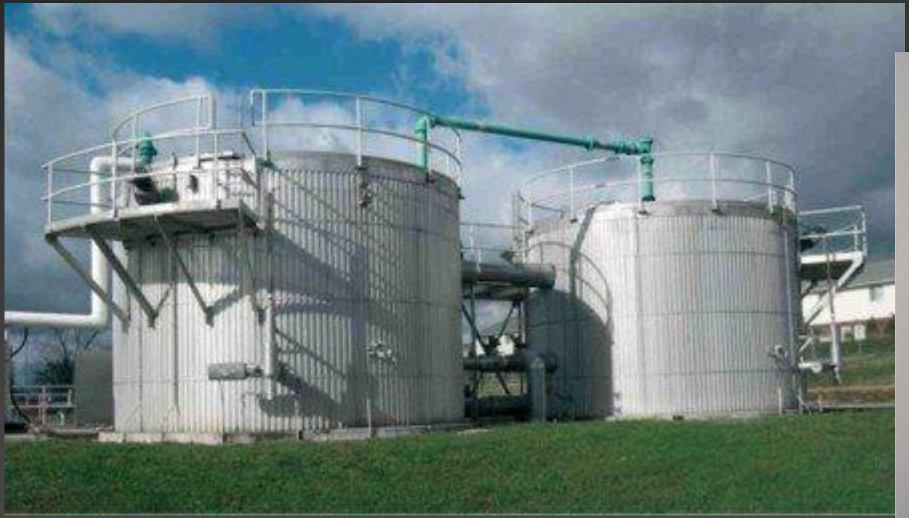
How close the technology to commercialization in large scale?

Manure storage tanks can be retrofitted into aerobic bioreactors

http://www.cstindustries.com/products/manure-slurry-storage-tanks-manufacturer/

INDUSTRIAL SCALE AEROBIC BIOREACTORS CAN BE PURCHASED



AEROBIC THERMOPHILIC STABILIZATION (ATS)

- http://www.asio.cz/en/aerobic-thermophilic-stabilization-ats

Soluble fertilizers can be delivered through Fertigation stations

Conclusions

- Aerobic bioreactors can be a more efficient alternative to the existing methods of manure management in agriculture
- The technology is safer as it decreases the chances for cross-contamination
- Fertigation provides more efficient delivery of nutrients than application of solid organic fertilizers
- No pollution, as the nutrients are delivered in more controllable way
- Application of soluble fertilizers, which are more accessible for plants, through fertigation improves Nutrient Use Efficiency

Thank you