Nutrient Recovery and Anaerobic Digestion

NW Bioenergy Research Symposium

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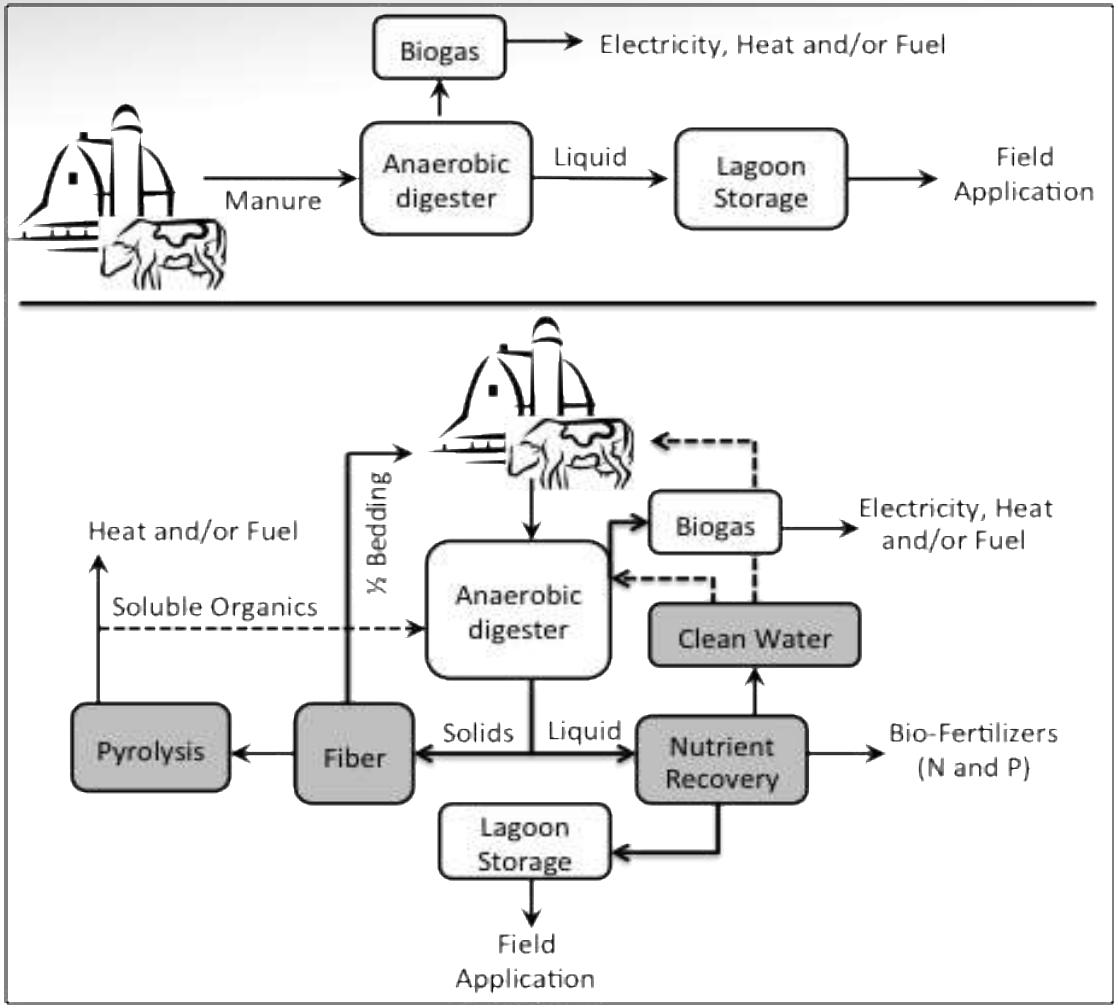
Anaerobic Digestion as a System

WSU views anaerobic digestion as much more than a stand alone waste management tool. A larger vision is to integrate numerous other emerging technologies into a system approach. These include:

- Nutrient Recovery
- Fiber Products
- Pyrolysis
- Clean Water



The Nutrient Problem

Anaerobic digestion (AD) mitigates numerous air, water and climate environmental concerns while producing renewable energy **however** little advantage is gained for CAFO or industry producers concerned with their overall nutrient loading to fields.

Total Ammonia: 2-7 g N/L
Total Phosphorus: 0.5-1.5 g P/L

Food Scraps

(1) Raw Food Scraps; (2) Screened; (3) Macerated

3,250 ft^3 CH_4
0.035 KW

Digester

effluent

17 pounds N
2 pounds P
12 pounds K

1 million tons annually holds within its mass 8,500 tons N, 1,000 tons P and 6,000 tons K.

If Washington State were to recovery and harness its annual 1 million tons of food scraps from the landfill waste stream, this would amount to an annual production of 35 MW electrical power and 75,000 and 50,000 tons ammonium sulfate and solids products, respectively

Co-Digestion

Dairy Manure Only

112 tons Nitrogen
17 tons Phosphorus
112 tons Potassium

D

22 M ft^3
CH_4
239 KW

S

10,000 yd^3 fiber

15 tons ammonia loss to air

L

~ 3:1:5 NPK dry

75 tons Nitrogen
13 tons Phosphorus
108 tons Potassium

102%	
65%	
13%	
	132%
	132%
0%	
80%	
	136%
	85%
	14%

Dairy Manure + 20% Substrate

226 tons Nitrogen
28 tons Phosphorus
127 tons Potassium

D

51 M ft^3
CH_4
554 KW

S

10,000 yd^3 fiber

27 tons ammonia loss to air

L

~ 3:1:3 NPK dry

177 tons Nitrogen
24 tons Phosphorus
123 tons Potassium

*Frear et al, 2011, Clean – Soil, Air, Water 2011, 39 (7), 697–704--#s based on 1,000 cows manure

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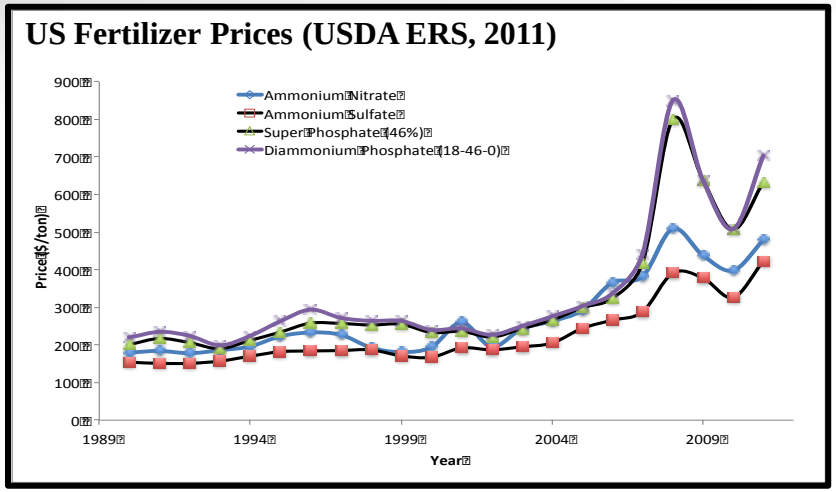
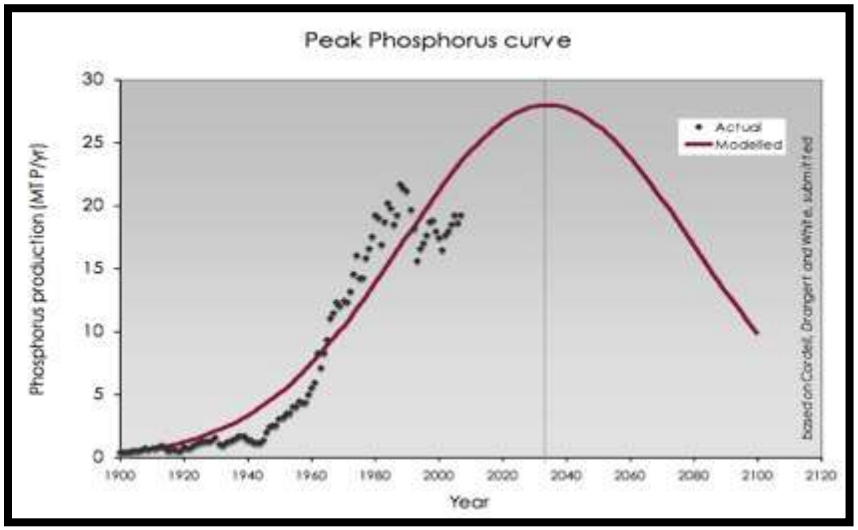
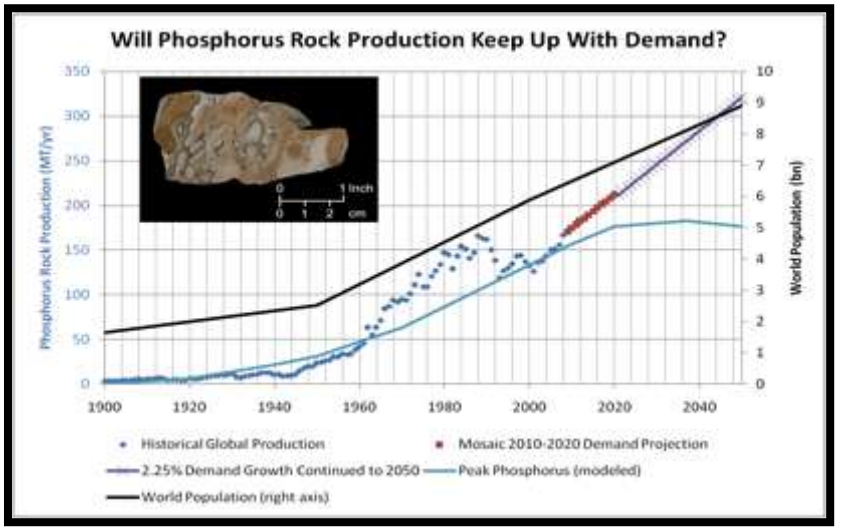
Fertilizer Threats

Serious environmental threats from fertilizer application

- Excess nitrate in drinking water
- Eutrophication of waterways
- Salting of cropland
- Nitrous oxide and GHG emissions
- Ammonia and PM 2.5
- Dead zones







The Solution

Insert a nutrient recovery process on the back end of the digester to recover N and P nutrients from the effluent. **Research question is what system is most economical, and produces highest yield?**

Nutrient Recovery Unit

No Ammonia Inhibition

Saleable Bio-fertilizers

Reduced Nutrient Loading

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Recovery of Nutrients and Bio-fertilizers

Numerous technologies exist in the municipal sector, some of which are being actively engineered for farm applications, such as that being developed by WSU. Essentially, dilute, soluble forms of nutrients are concentrated and partitioned from the main body of effluent

Dairy Manure AD: Fiber, P-rich fine solids, ammonia sulfate solution

Partitioning and Agronomic Use of Nutrients

Concentration of nutrients from the effluent through active nutrient recovery systems allows for greater flexibility in producing fertilizer applications suited to particular crops, while also potentially reducing hauling/fueling and ammonia release losses. Most importantly, excess nutrients impacting crops, soil, and waterways/human health can be more effectively exported.

Left: Single pass of manure and ammonium sulfate;
Right: Single pass manure only—same amount of nitrogen

Nutrient Recovery

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226 tons Nitrogen
28 tons Phosphorus
127 tons Potassium

D

51 M ft^3
CH_4
554 KW

S

10,000 yd^3 fiber

27 tons
ammonia loss
to air

L

177 tons Nitrogen
24 tons Phosphorus
123 tons Potassium

~ 3:1:3 NPK dry

Reduction from no NR

54%
71%
7%

226 tons Nitrogen
28 tons Phosphorus
127 tons Potassium

D

51 M ft^3 CH_4
534 KW

S

10,000 yd^3 fiber

A

1,200 tons AS
product

SS

980 tons secondary
solids

Settling

2,100 tons
tertiary solids

L

8 tons
ammonia

82 tons Nitrogen
7 tons Phosphorus
114 tons Potassium

~ 5:1:9 NPK dry

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Full Scale NR System -1

- Project Site： Wenning Poultry Fort Recovery, Ohio
- Capacity: 150,000 gallon/day
- Power Generation: 3 MW
- Products:
  - ✓ 2,500 gallon/day $(NH_4)_2SO_4$ solution
  - ✓ 5,000 gallon (wet)/day P-solid
  - ✓ 145,000 gallon/day low-nutrient effluent

Aeration Reactor

Blower

Ammonia Absorption

H_2SO_4 and AS Loading

Commercial Scale NR System -2

- Project site: Vander Haak Dairy, WA
- Capacity: 40,000 gallon/day
- Power Generation: 0.7MW
- Products：
  - ✓ 150 gallon/day $(NH_4)_2SO_4$ solution
  - ✓ 4,000 gallon wet/day P-solid
  - ✓ 36,000 gallon/day low-nutrient effluent

Aeration reactor

Blower

Ammonia Absorption Tower

Ammonium Sulfate Tank

Industry Needs

In order to further the commercialization of nutrient recovery and partitioning technologies, the following considerations must be addressed:

- Development of manure markets, pricing structures, supply/demand/storage, and product consistency
- Research supporting environmental, climate and agronomic benefits of bio-fertilizers—both direct and indirect wither alone or in banded combinations
- Development of viable and mature business models from on-going demonstrations sites and continued improvements in design/operations
- Development of environmental services protocols and programs federally, regionally, and locally
- Systems approach to both engineering and business models

Any questions?

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