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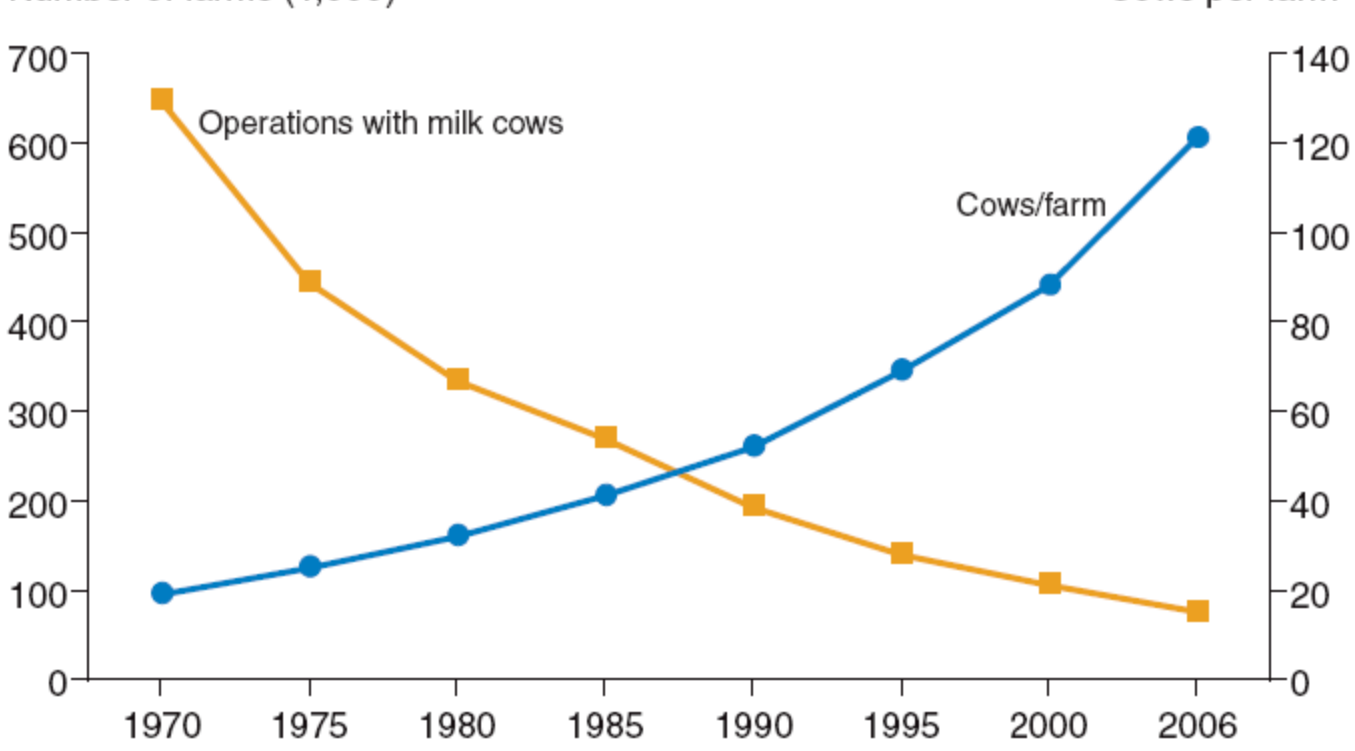
Intersection of Water Quality and Renewable Energy

Midwest Manure Summit

February 16, 2011

Figure 1

The number of dairy farms is declining, while average size is growing



Source: USDA, NASS.

One of the effects of the diminishing distance between rural areas and cities like Richmond, Va., is greater concern for water and air quality. Photo courtesy of Agricultural Research Service, USDA.

The Problem

Land Application of Livestock Manure

- Land application of manure is the traditional method of management
  - ➢ Increasing herd density coupled with land base constraints have created logistical and transport challenges
  - ➢ Negative public perception
  - ➢ Environmental concerns
    - ❖ Nutrient concentration
    - ❖ Pathogens and viruses
    - ❖ Air quality impacts

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Regulatory Impacts

- There are two primary federal initiatives that will impact agriculture and the methods employed for manure handling over the next 1-5 years
  1. Total maximum daily loads (TMDL), regulated under the jurisdiction of the Clean Water Act
  2. Ammonia emissions, regulated under the Clean Air Act (PM2.5)

Total Maximum Daily Loading

- TMDL regulations are evolving
  - Pathogens and nutrients are ranked #1 and #4 in terms of causes of impairment
- Florida finalized new water quality standards with specific nitrogen and phosphorus limits
  - New standards are to be implemented in early 2013 and will likely impact CAFO operations
- The EPA intends to propose new rules for the Chesapeake Watershed (six states plus District of Columbia) in 2012 with implementation in 2013
  - The rulemaking will consider expanding the universe of CAFOs and require more stringent permit standards to control nutrients

Ammonia Emissions

- National Air Emission Monitoring Study (NAEMS)
  - publication scheduled for July 2011.
  - Best estimates for operations impacted range between 1000 and 2000 animal units
- Ammonia is the primary contaminant that will trigger Best Available Control Technology (BACT)

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In the News

- "All it took was an early thaw for drinking water to become unsafe. There are 41,000 dairy cows in Brown County and they produce more than 260 million gallons of manure each year. But Environmentalist and some lawmakers say real change will occur only when Congress passes laws giving the E.P.A. broad powers to regulate farms."
  - ***The New York Times, September 18, 2009.***

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Manure Contaminated Wells

- Wisconsin has experienced almost 200 confirmed releases of animal waste since 2002.
- Forty-eight manure spills are listed on the Bureau of Remediation and Redevelopments tracking system as having a potential impact on groundwater

Source: WI Environmental Assessment for a General WPDES Permit for Large CAFOs

The Future of Animal Agriculture

- The future of US animal agriculture is largely dependent on effective integrated manure management systems (IMMS) that address:
  - Recovery/re-use of bedding material
  - Nutrient management
  - Energy creation
  - Water quality including pathogen and virus management
  - Creation of value-added co-products
- IMMS must be:
  - Affordable to farmers
  - Environmentally sound
  - Acceptable to society

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Manure Treatment Systems Compared to Traditional Storage/Land Application

- Typical number quoted for land application is $0.01/gallon.
- Treatment to produce clean water will never compete with land application.
- However, integrating renewable energy with water quality can provide farmers with an economically viable alternative.

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Wastewater Treatment and Integrated Systems

Integration of Ultrafiltration (UF) and Reverse Osmosis (RO) from Past Wastewater Applications

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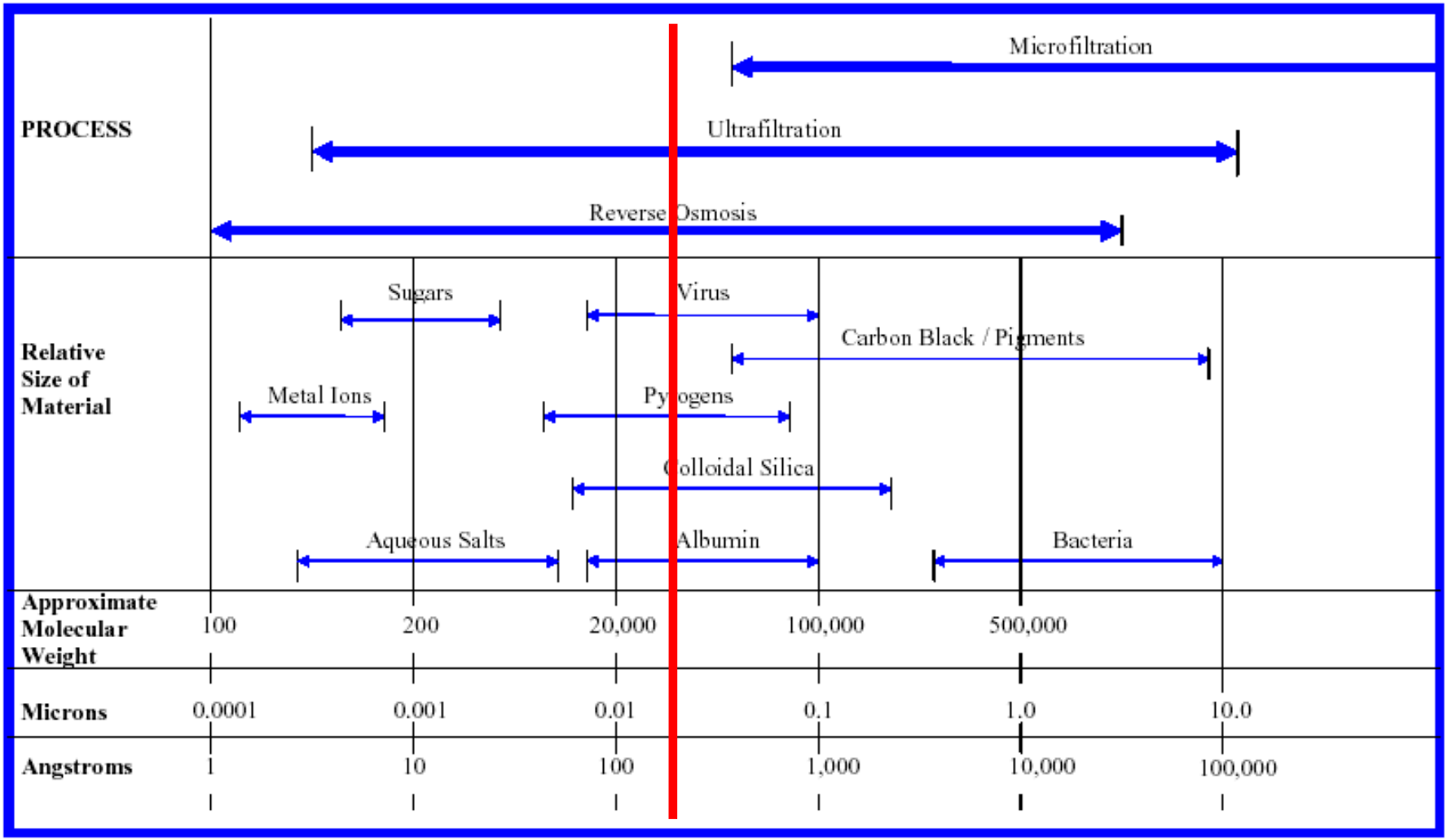
What are membranes?

- Essentially they are very “tight” filters and can be broken into three approximate categories based on pore size (or molecular weight cutoff)
  - Microfiltration
  - Ultrafiltration
  - Reverse osmosis

PARTICLE SIZE vs TREATMENT PROCESS



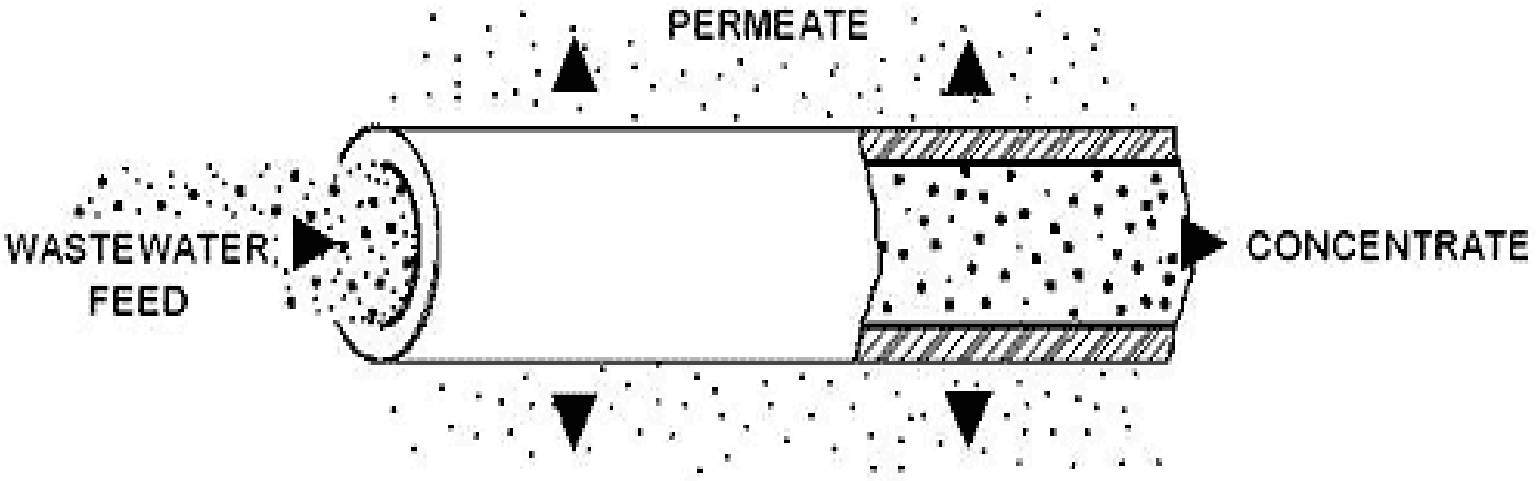
History of membranes

- Membranes have been used successfully since the 1950s for reverse osmosis
- Membranes were primarily used only in clean water applications until the early 1990s
- Prior to the early 1990s, membranes were considered unreliable and too expensive for wastewater applications
- Today, membranes cost significantly less than 20 years ago and are considered highly reliable

Membrane-Based Water Treatment System

- Ultrafiltration and reverse osmosis are cross-flow separation processes.
- The liquid stream to be treated flows tangentially along the membrane surface and produces two streams:
  - The liquid passing through the membrane is known as permeate
  - The other stream is the concentrate

Tubular UF Membrane



- Produces a permeate stream that contains soluble constituents minus solids
- Permeate is suitable for further treatment via reverse osmosis
- Concentrate contains majority of phosphorus and organic nitrogen

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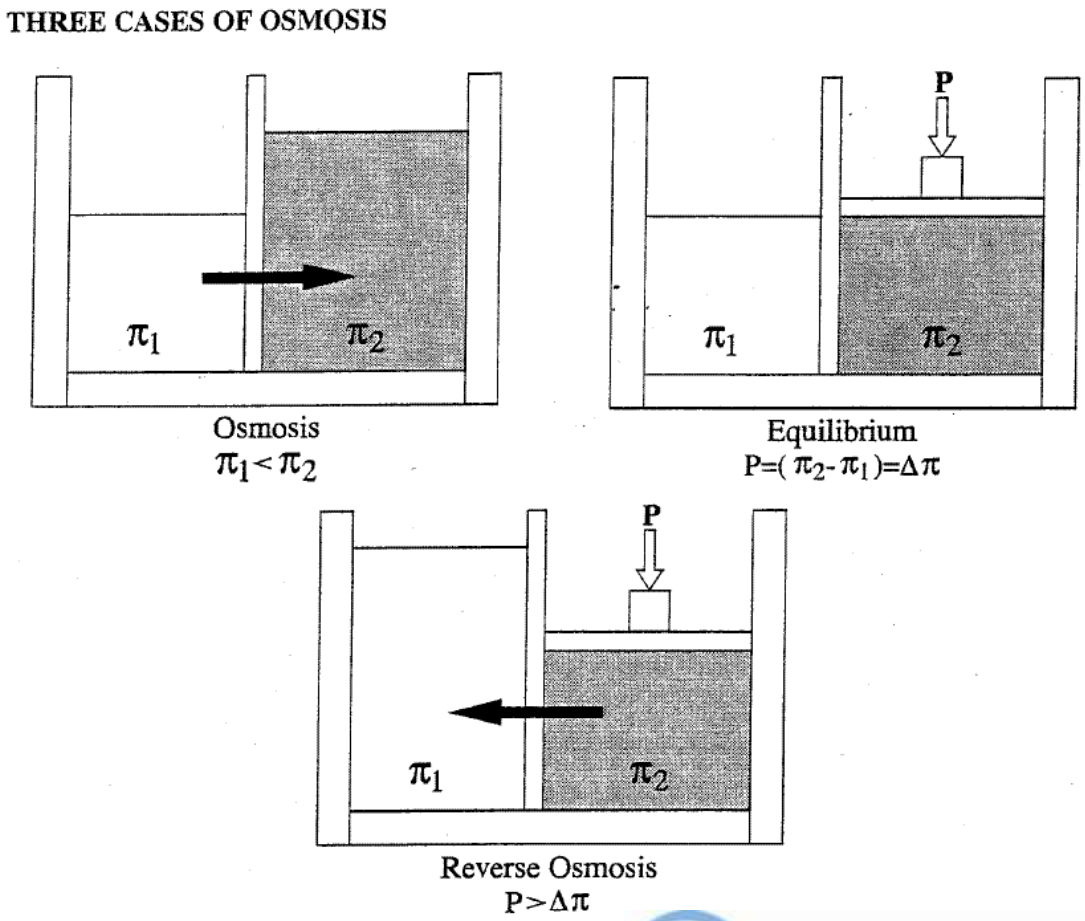
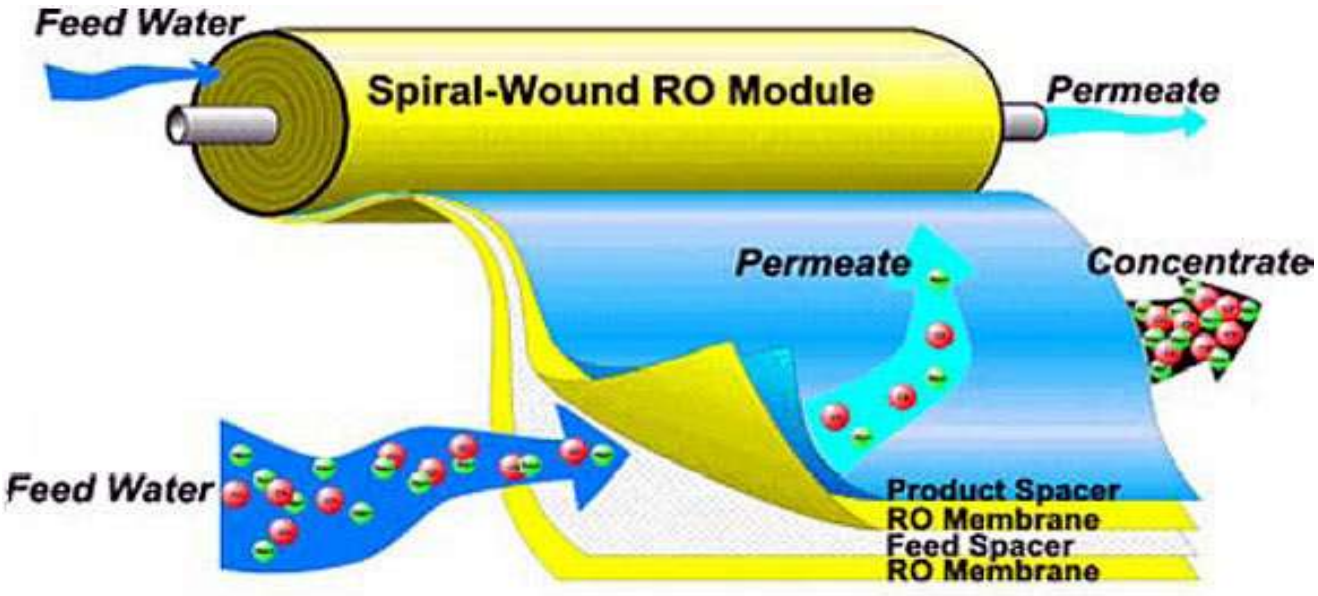
Osmosis and Reverse Osmosis



RO Membrane



- Permeate is suitable for cow drinking, land irrigation or direct discharge
- Concentrate contains ammonium nitrogen

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Ultrafiltration and Reverse Osmosis Evaluation Study conducted at Vir-Clar Dairy in 2009

Reverse Osmosis System

Ultrafiltration System

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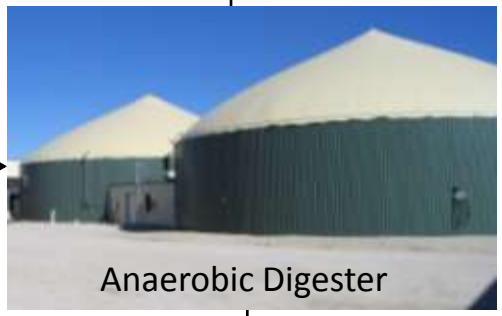
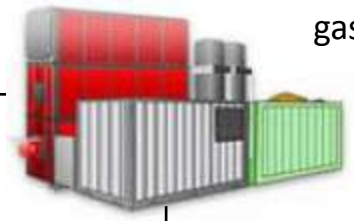
Standard Digester Configuration



Digested manure for land application maintains same environmental challenges as before digestion

Integrated Renewable Energy and Membrane-based Wastewater Treatment System

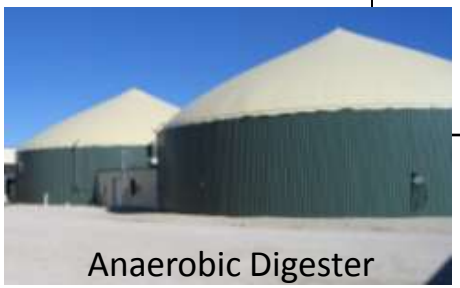


Manure solids as feedstock to gasification system

Saleable biochar product

OR → Land apply as soil amendment or saleable compost

OR



Irrespective of energy production pathway, water quality provides basis for sustainable management of nutrients, BOD, air quality concerns associated with ammonia and pathogens

Integrate with digester to create high rate AnMBR System

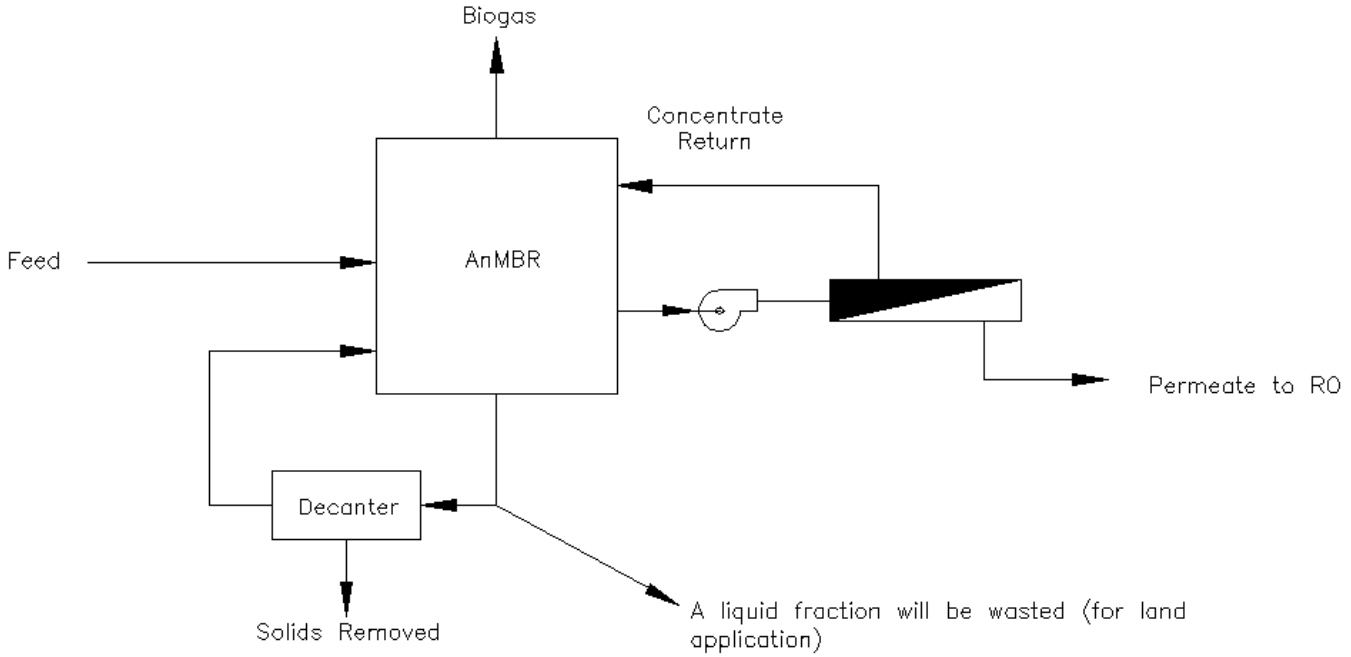
Supernatant from solid liquid separation to water treatment

Clean Water for cow drinking, irrigation or discharge

Concentrated nutrients for land application

AnMBR – Anaerobic Membrane Bioreactor

- Couples a traditional anaerobic digester (such as a complete mix system) with an ultrafiltration system
- Separation of hydraulic retention time from solids retention time
- High quality effluent (pathogen free)



AnMBR Pilot Work
Ongoing at a Car-Min-Vu Dairy
(Webberville, MI)

View of membrane modules

View of 100 Gallon Reactors

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Removal of Viruses and Indicators by Anaerobic Membrane Bioreactor Treating Animal Waste

Kelvin Wong, Irene Xagoraraki,* James Wallace, William Bickert, Sangeetha Srinivasan, and Joan B. Rose Michigan State University

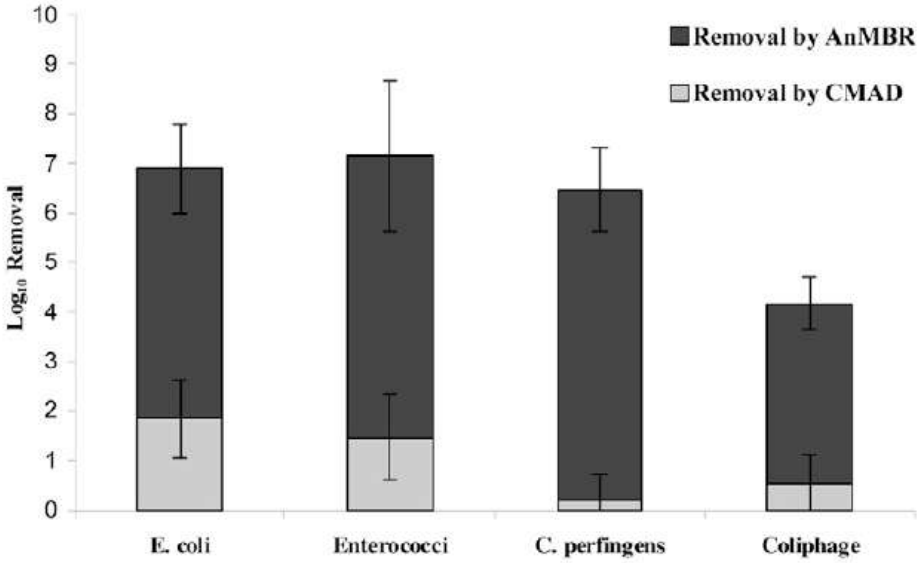
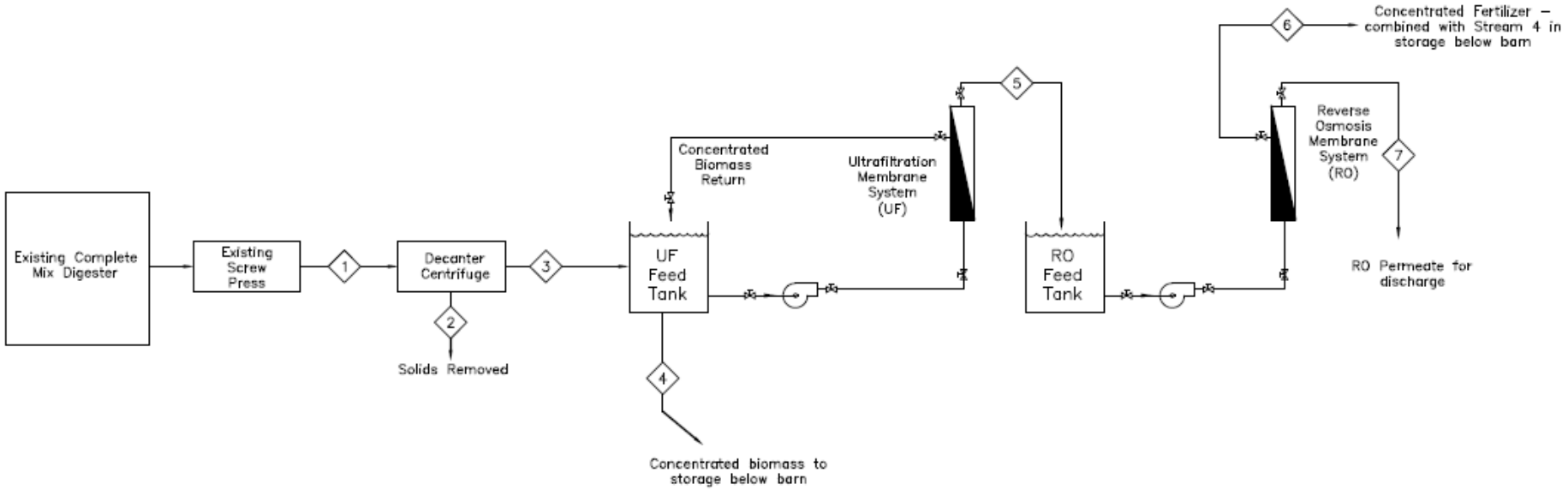


Fig. 2. Log_{10} removal of indicators by the combined CMAD/AnMBR system. Sampling was done from June to August. AnMBR, anaerobic membrane bioreactor; CMAD, complete mix anaerobic digester.

Nutrient Mass Balance



Mass Balance	1	2	3	4	5	6	7
Total lb/day	321,445	12,858	308,587	51,431	257,156	115,720	141,436
BOD5	1,589	64	1,525	1,268	257	256	1.4
TSS	6,429	3,857	2,572	2,572	-	-	-
Total N	368	174	694	181	513	512	1.1
Total P	299	135	164	162	3	3	-

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Process Evolution

- As a stand-alone process, manure treatment is more expensive than traditional land application.
- However, integrating renewable energy with membrane-based wastewater treatment has the potential to shift the manure management paradigm and create an economically and environmentally sustainable condition.

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THANK YOU