MANURE PHOSPHORUS MANAGEMENT: PROCESSING TECHNOLOGIES AND EFFICIENCY

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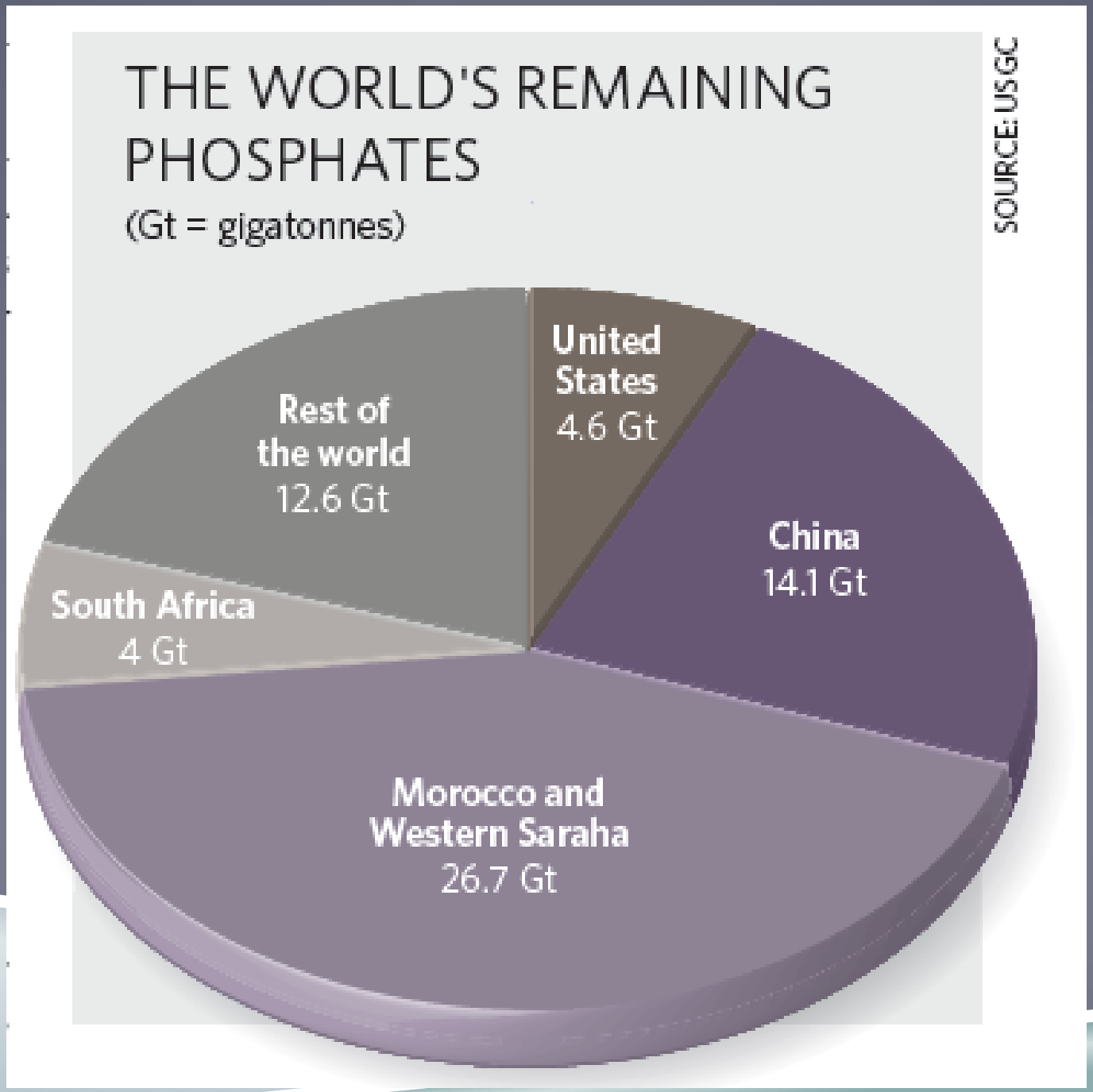
Becky Larson
Assistant Professor and Extension Specialist
Department of Biological Systems Engineering

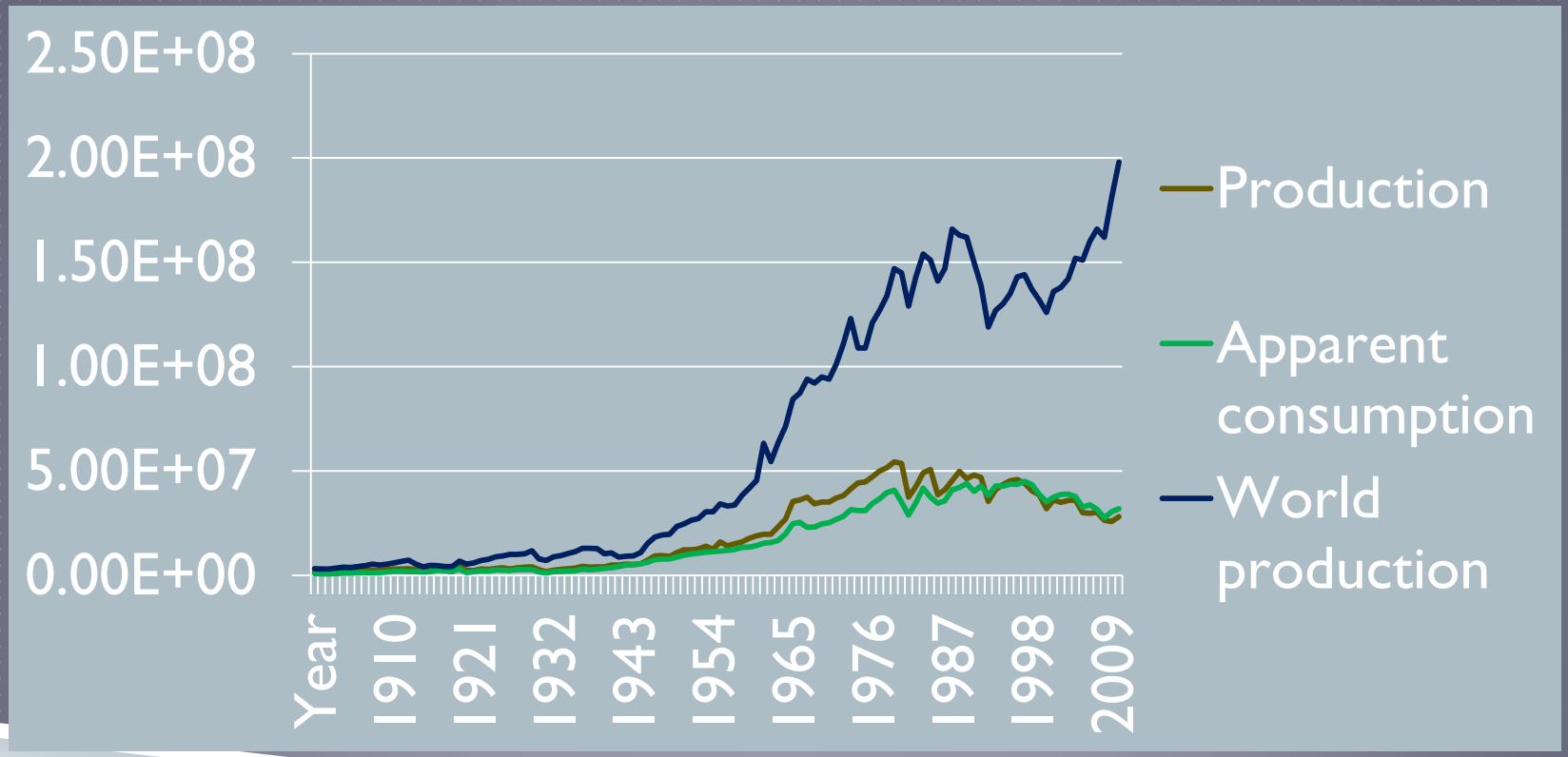
UNIVERSITY OF WISCONSIN-MADISON
COLLEGE OF
AGRICULTURAL & LIFE SCIENCES

UW Extension
University of Wisconsin–Extension

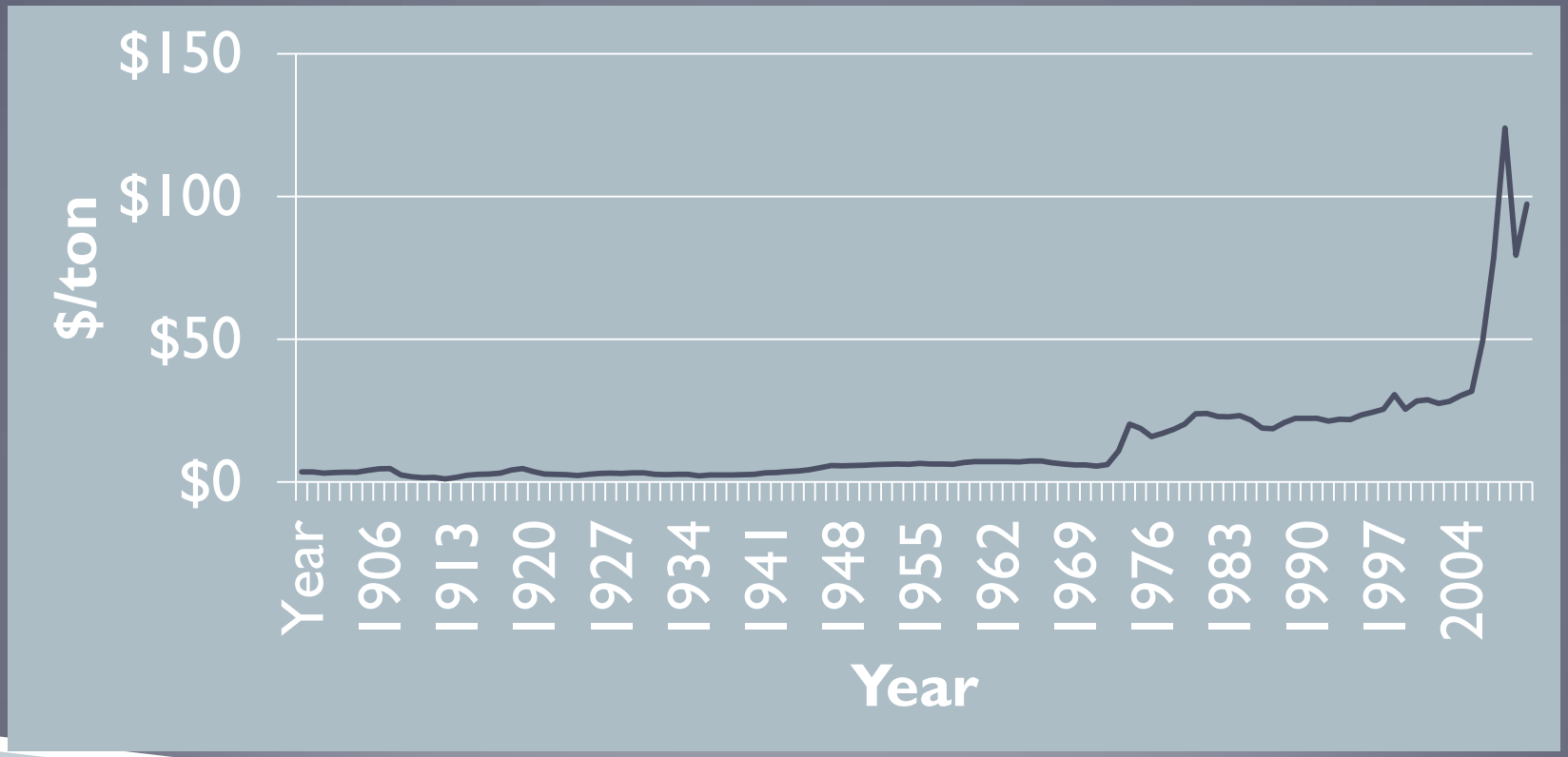
Gilbert, 2009. Nature.


THE WORLD'S REMAINING PHOSPHATES
(Gt = gigatonnes)
SOURCE: USGC
United States
4.6 Gt
China
14.1 Gt
Morocco and Western Saraha
26.7 Gt
South Africa
4 Gt
Rest of the world
12.6 Gt

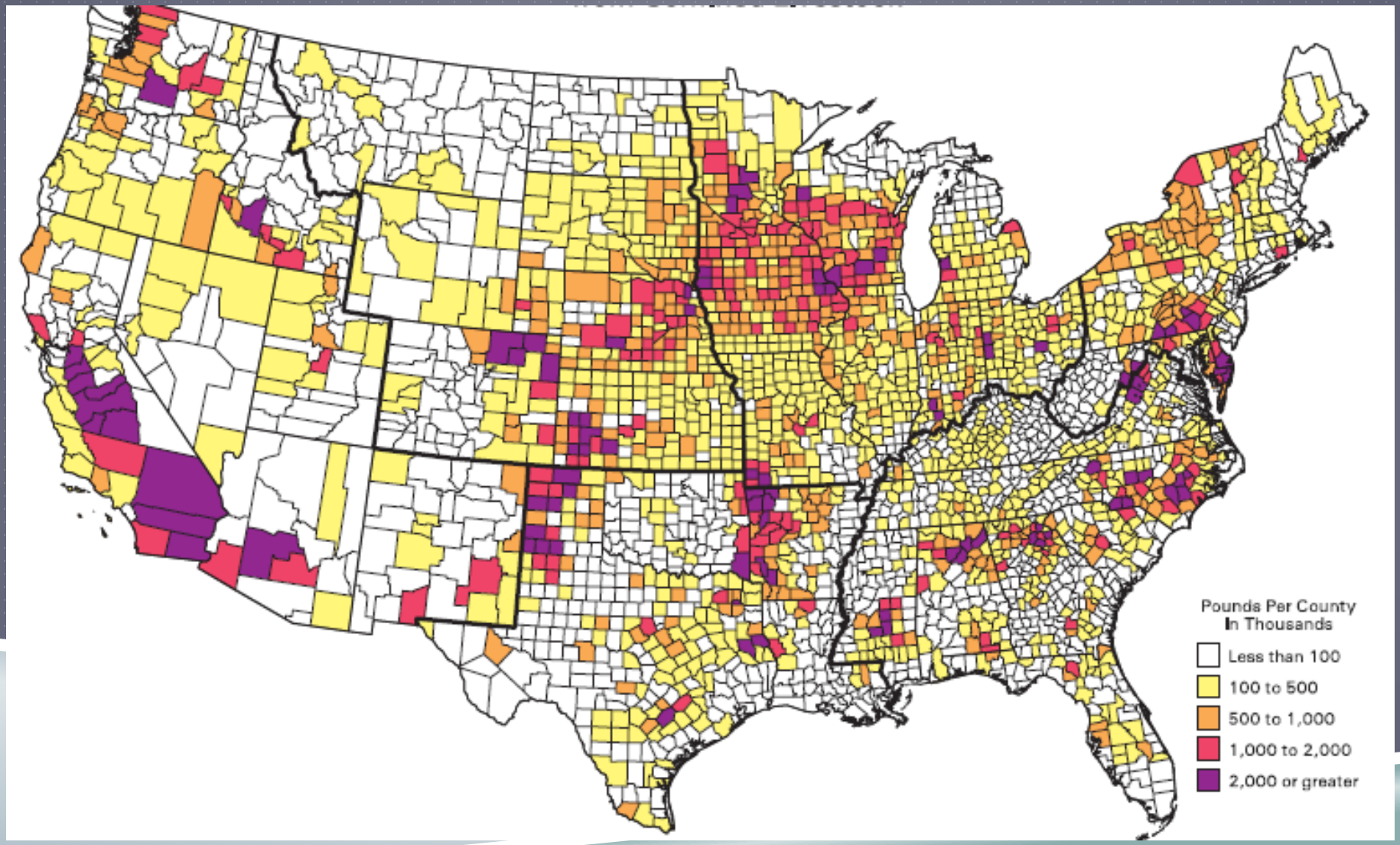
PHOSPHORUS PRODUCTION



PRICE OF PHOSPHORUS



ESTIMATED MANURE PHOSPHORUS PRODUCTION FROM CONFINED LIVESTOCK



WHY MANURE?

- 95% of phosphate rock mined in the US was used to make fertilizers and animal supplements
- Debate on reserves and estimated supply
- Increasing demand as population grows
- Significant amount is more difficult to extract than current sources
- US to see significant drop in production in 25 years
- Recovery and recycling have great potential
- Initial interest in wastewater treatment plant recovery
- 5 times more phosphorus in livestock waste than human waste
- Livestock population greater than 10 times the human population

WISCONSIN MANURE

- 1.26 million dairy cows (NASS 2010)
- Over 8 billion gallons of manure annually
- ~7 pounds P_2O_5 per1,000 gallons of manure
- Many agricultural sources with potential for environmental impact
- Need for solutions which make economic sense
- Potential benefits to agricultural operations, environment, economics, and the public

P SUSTAINABILITY

- Reuse = limit purchase of P
- Reduce losses to environment
- Meet regulatory requirements

PHOSPHORUS REMOVAL MECHANISMS

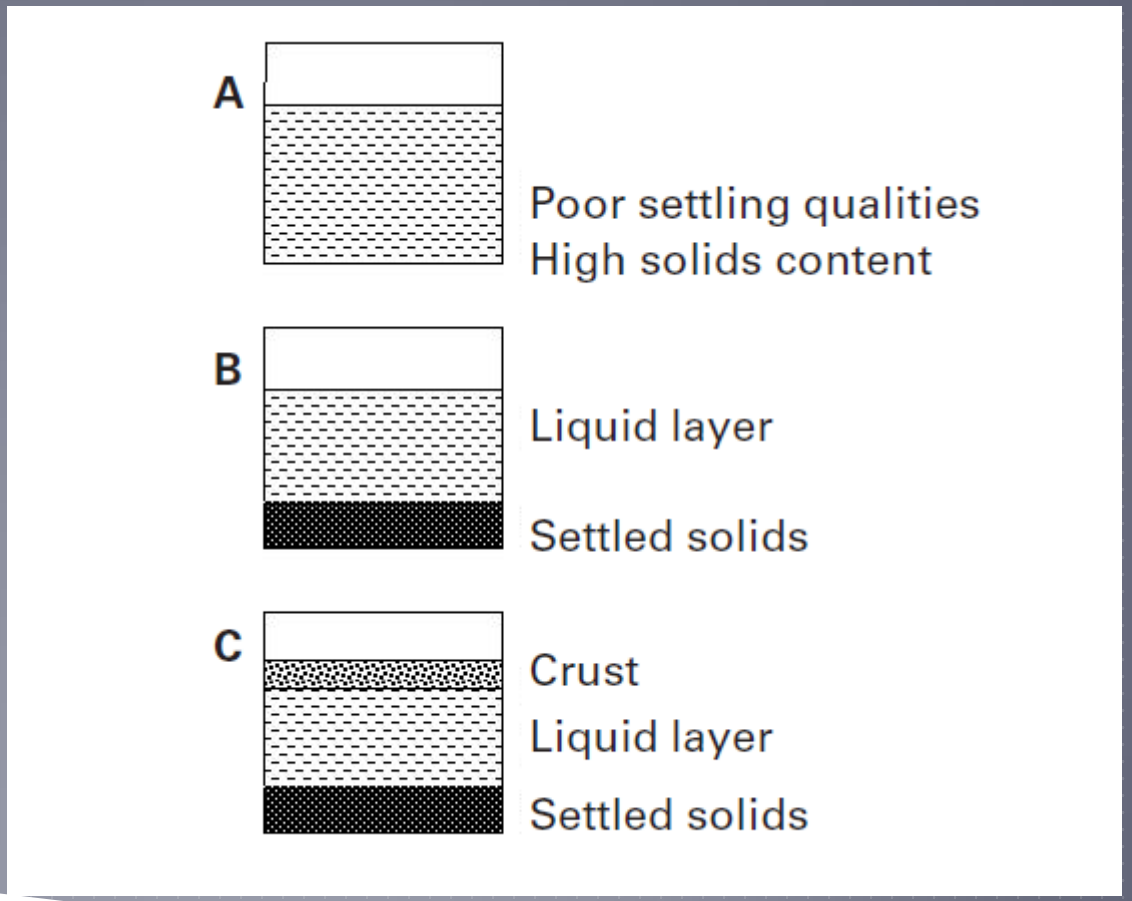
- Phosphorus does not disappear
- Chemical removal
  - Aluminum sulfate, aluminum chloride
  - Ferric chloride, ferric sulfate
  - Lime
- Physical
  - Separation
- Biological

SOLID LIQUID SEPARATION

- Can produce multiple products of various strengths of phosphorus
- Must examine entire manure handling system to see benefits
- Numerous technologies
  - Screw press
  - Centrifuge
  - Settling basins
- Varying cost and complexity

SOLIDS SETTLING & PHOSPHORUS

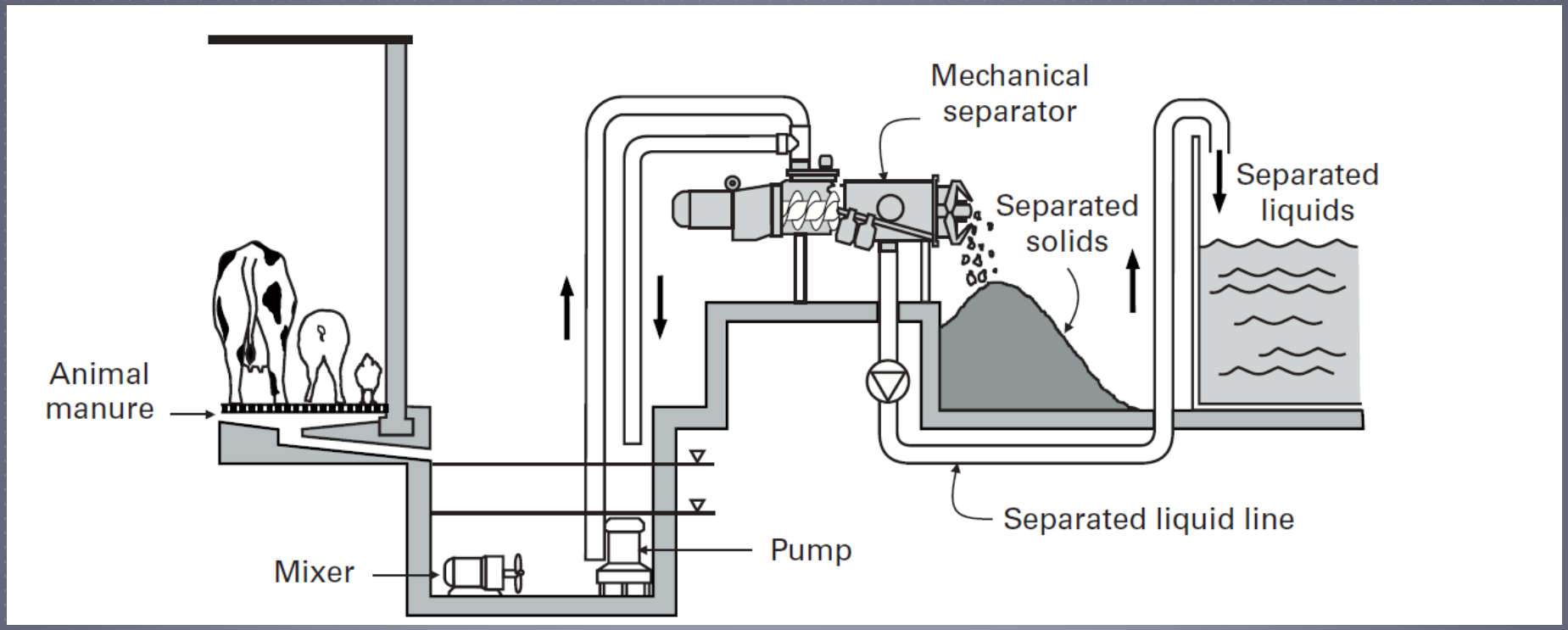
- Dependent upon influent solids concentration
- Dependent upon particle size (smaller particles are more difficult to separate)



SETTLING BASINS/STORAGE

- Removal of approximately 28% TP in settling basins with no addition (initial TS of ~4%)

SOLID LIQUID SEPARATION



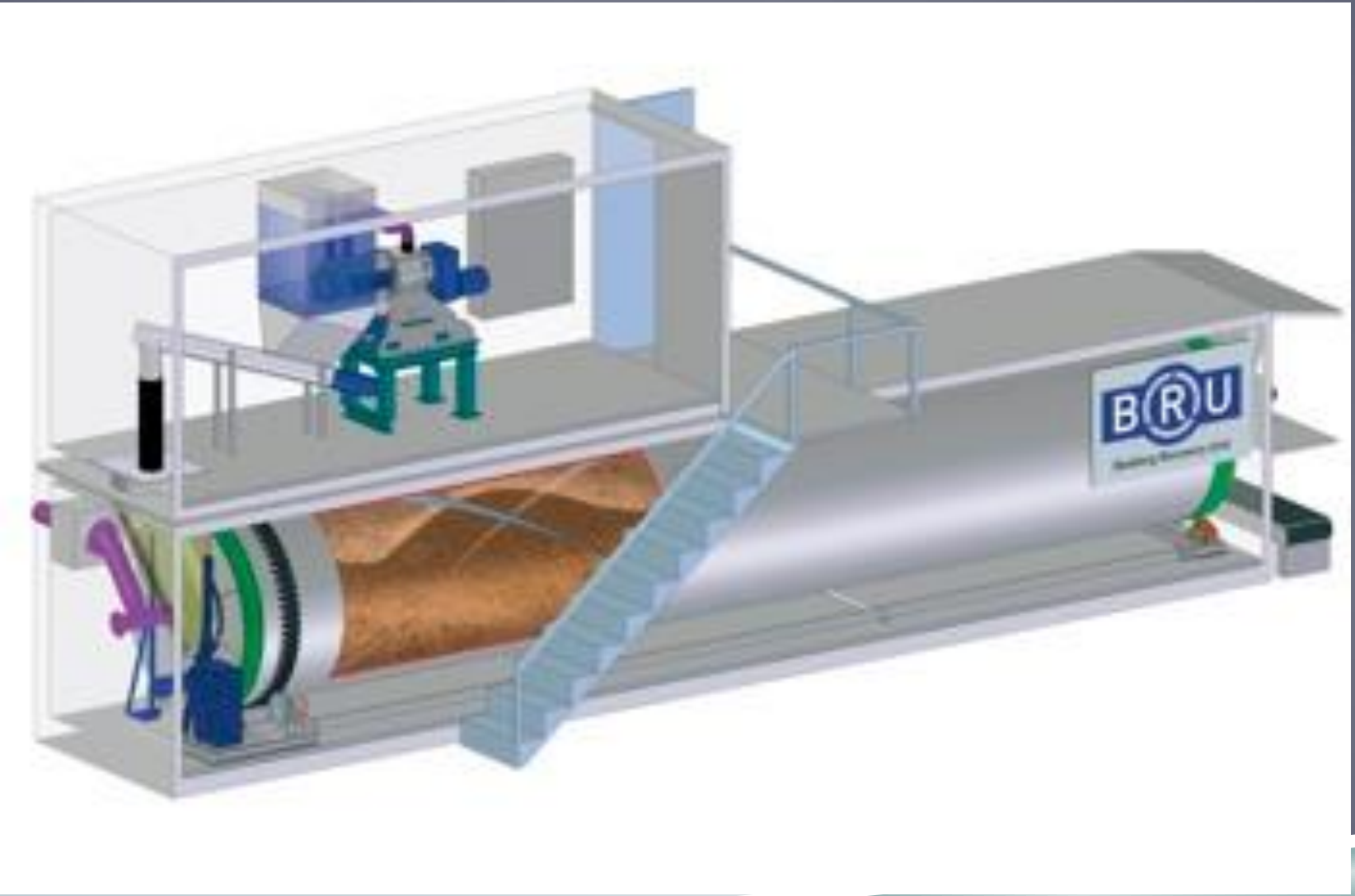
Midwest Plan Service, 2001

SEPARATOR - SCREW PRESS

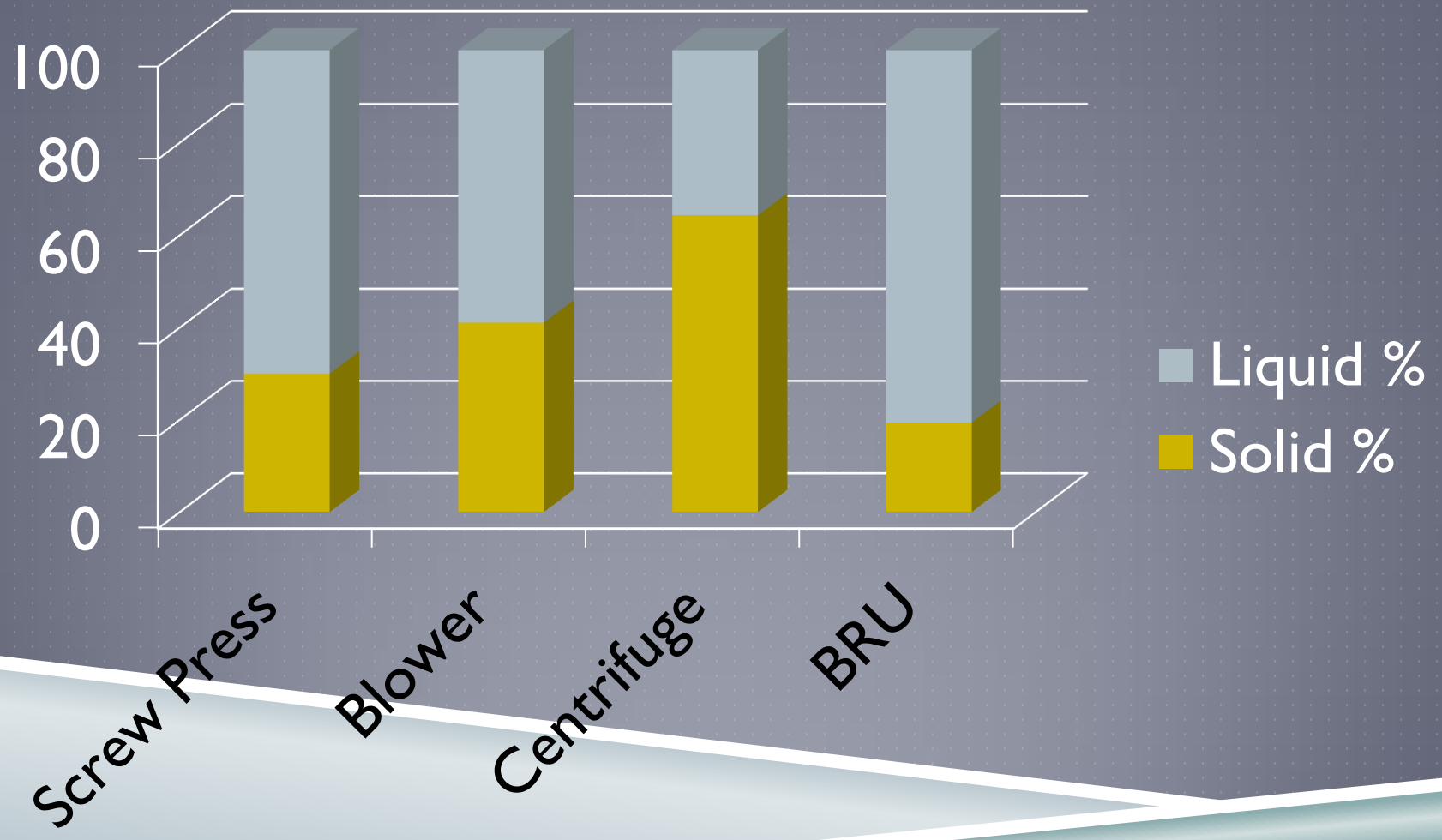
SEPARATOR - CENTRIFUGE

Centrifuge - Dane County Digester; Clear Horizons

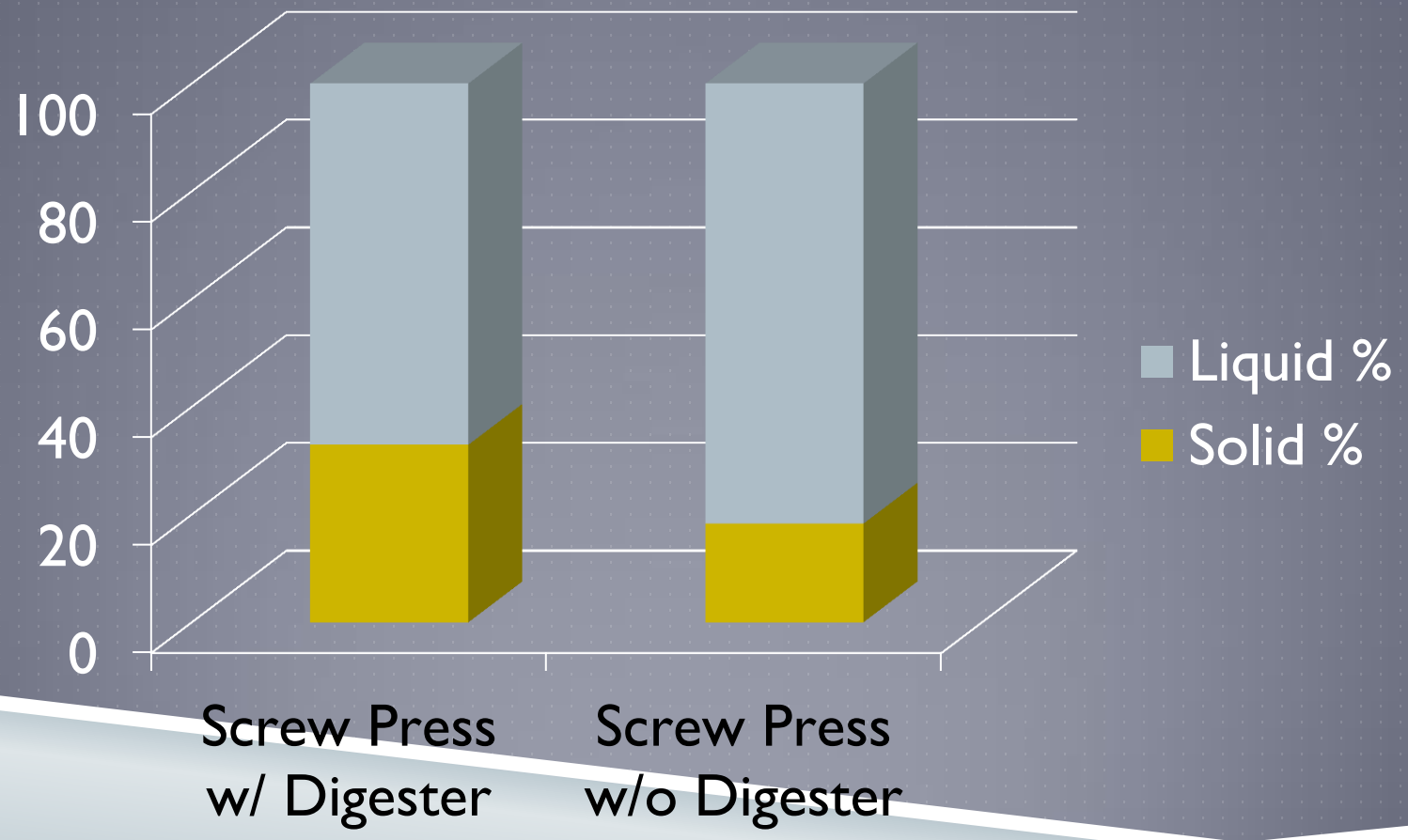
SEPARATOR - BEDDING RECOVERY UNIT



PHOSPHORUS


100
80
60
40
20
0
Screw Press
Blower
Centrifuge
BRU
Liquid %
Solid %

PHOSPHORUS


100
80
60
40
20
0
Screw Press w/ Digester
Screw Press w/o Digester
Liquid %
Solid %

N-P-K

Concentration	N (g/kg)	P_2O_5 (g/kg)	K_2O (g/kg)
Manure	50	18	41
Liquid	101	27	75
Solid	15	14	8

Ratio	N	P_2O_5	K_2O
Manure	3	1	2
Liquid	4	1	3
Solid	2	2	1

SCREENS

	TSS		VSS		TKN		TP	
Screen size[b] (mm)	Amount retained (g/L)	Fraction of TSS (%)	Amount retained (g/L)	Fraction of VSS (%)	Amount retained (mg/L)	Fraction of TKN (%)	Amount retained (mg/L)	Fraction of TP (%)
3.360	0.74	6.4	0.38	6.7	43.13	7.6	10.57	6.8
2.000	2.76	23.9	0.94	16.6	43.85	7.7	8.16	5.7
1.588	3.24	28.1	1.78	31.4	33.04	5.8	8.86	6.0
1.000	3.78	32.8	1.60	28.3	66.11	11.6	16.66	11.4
0.794	3.18	27.6	2.18	38.5	66.12	11.6	16.67	12.1
0.590	3.98	34.5	2.48	43.8	77.93	13.7	16.96	12.3
0.500	3.92	34.0	1.54	27.2	59.81	10.5	15.16	11.0
0.297	4.22	36.6	1.90	33.6	60.68	10.6	15.43	11.1
0.250	4.82	41.8	2.14	37.8	78.26	13.7	23.26	16.7

SCREENS WITH POLYMERS

Polymer rate (mg/L)	Removal efficiency [a] (%)							
	TSS		VSS		TKN		TP	
	PAM							
0	64.9	(0.090)	64.3	(4.44)	18.9	(0.021)	19.6	(2.68)
60	71.6	(0.232)	73.8	(2.06)	37.1	(0.436)	34.4	(1.03)
120	75.9	(0.671)	74.2	(0.823)	35.8	(2.60)	33.8	(5.05)
180	82.8	(0.246)	79.8	(2.03)	48.1	(3.56)	44.4	(5.31)
240	86.8	(1.47)	83.5	(2.63)	55.9	(5.65)	52.0	(8.64)
300	90.0	(1.15)	87.6	(1.75)	63.9	(3.36)	58.9	(4.73)
360	92.7	(0.285)	92.4	(0.835)	65.0	(4.69)	57.8	(5.93)
420	94.9	(0.575)	92.9	(1.67)	74.0	(8.76)	66.4	(9.43)
480	95.0	(0.614)	93.0	(0.208)	73.1	(3.56)	64.9	(2.73)

DISSOLVED AIR FLOTATION

R. Sheffield

- Air is dissolved in the waste water stream and injected at bottom of unit
- Fine solids are carried or "floated" to surface
- Chemical addition of polymers and flocculent is needed for optimum efficiency

CHEMICAL PRECIPITATION

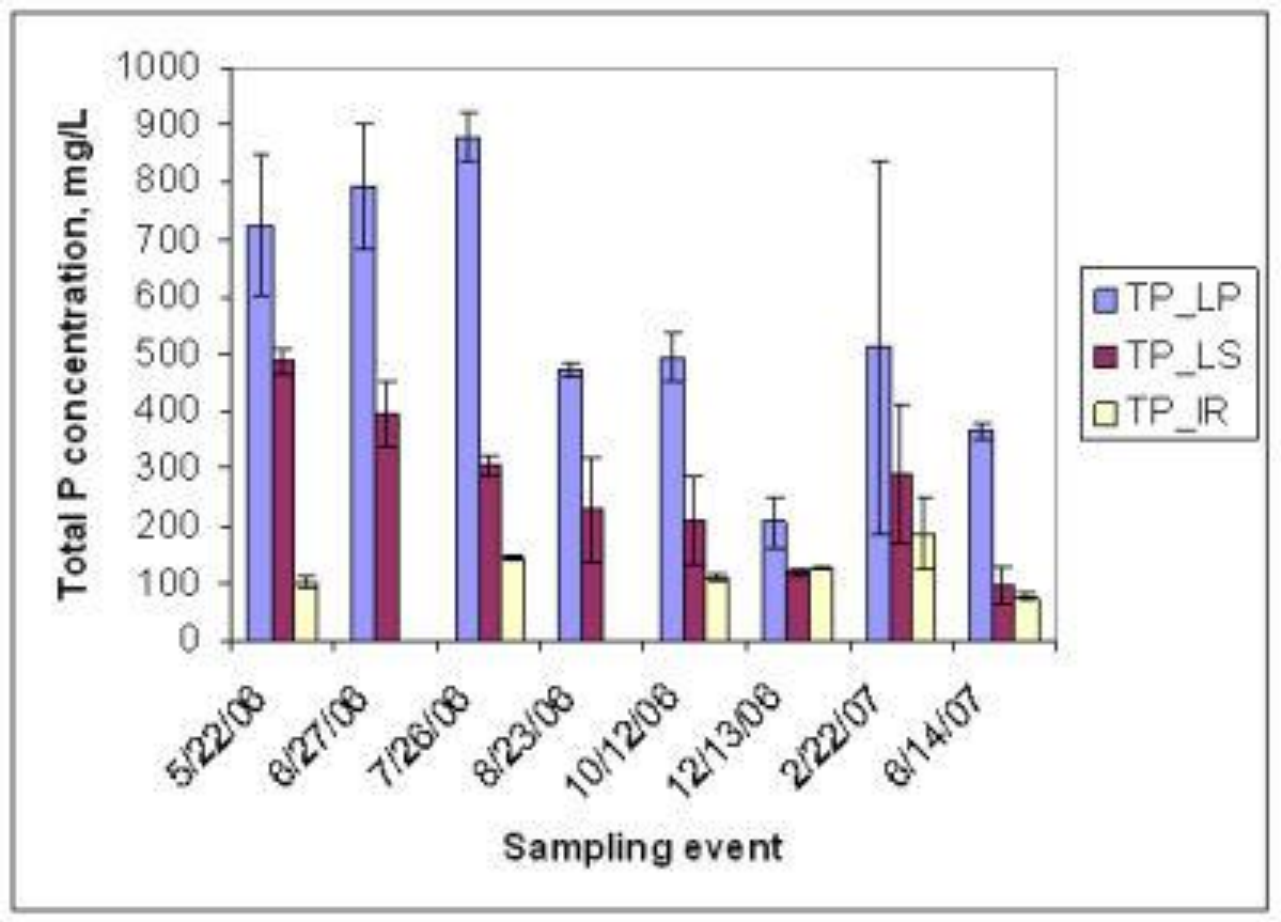
- More effective for dissolved phosphorus
- Requires regular additions, large doses for manure
- Can be costly
- Can pose issues in soils
- Typically require polymer additions for application
- Significant amount of sludge production

CHEMICAL & POLYMER P SEPARATION

- Significant additions of chemical and polymer
- 80-90% TP removal
- Dairy manure at 0.87% & 1.5% TS
- Chemical additions alone cost $0.01

BIOLOGICAL ADDITION

- Phosphorus uptake by microorganisms
- L4DB® microbial treatment used for study in Texas
- Found some decreases in TP but not dissolved reactive phosphorus
- Reduction of ~50%

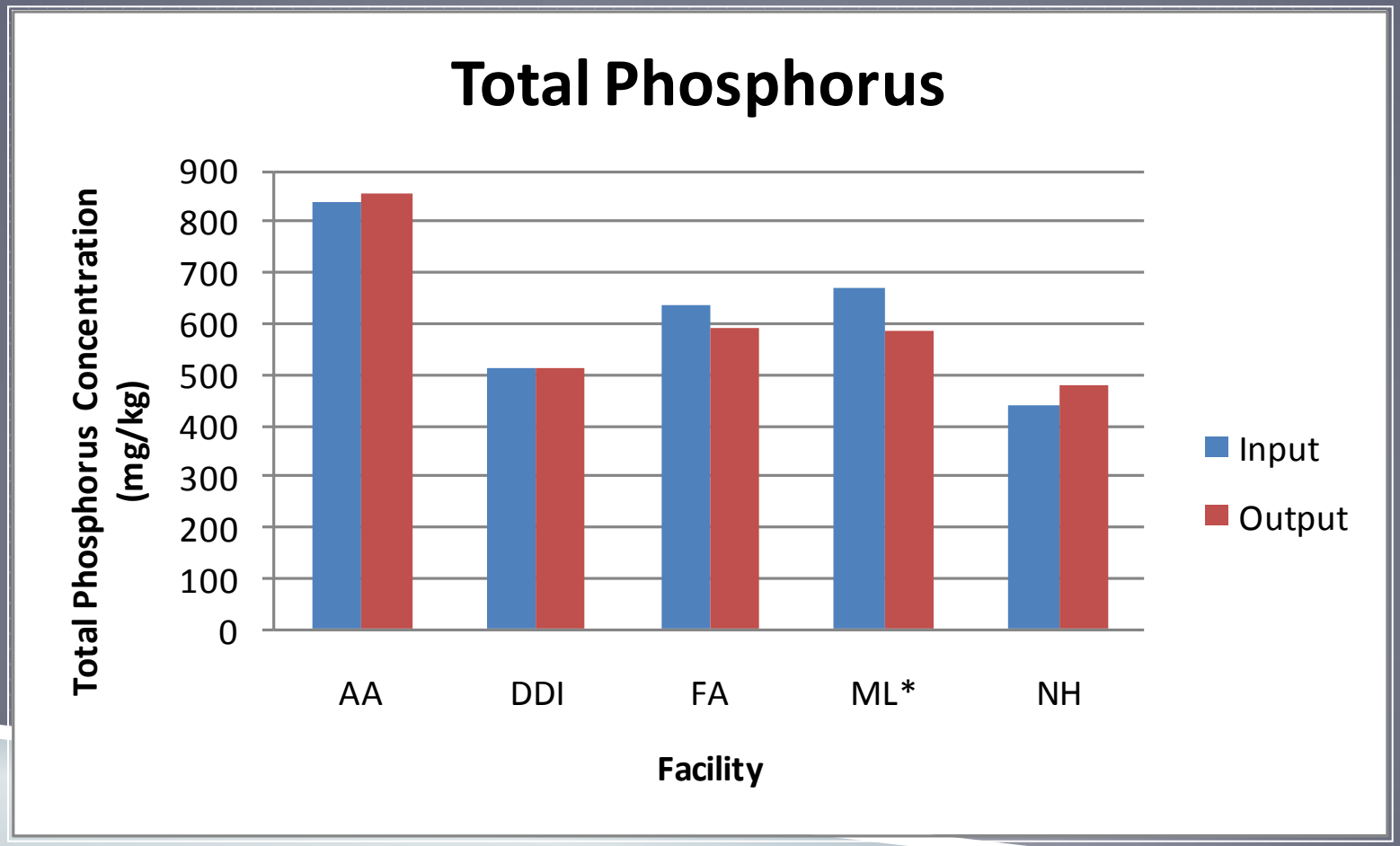


S. Rahman & S. Mukhtar, Texas A&M University

ANAEROBIC DIGESTION

- No phosphorus removal!

NUTRIENTS & ANAEROBIC DIGESTION



Wright, et al. 2004. Preliminary Comparison of Five Anaerobic Digestion Systems on Dairy Farms in New York State

COMPOSTING

- Volume reductions = increase in P concentration
- Reduction in soluble P

EFFICIENCY COMPARISON

Technology	Initial TS (%)	TP Removal (%)
Settling Basin	~4	28
Screw Press	variable	15-24
Centrifuge	variable	60
Dewatering using Geotextiles	0.71	46
Inclined Plane		53
Screens	0.4-3.2	<17
Screens with Polymers	0.4-3.2	34-65
Chemical Precip	0.87-1.5	80-90

SOLIDS SEPARATION – SYSTEM PERFORMANCE

- Key issues
  - Separator efficiency
    - Solids capture rate rates range from less than 5% to higher than 70%
    - Can be increased significantly with the use of polymer

WHY IS THIS IMPORTANT? – Determines the amount of solids that will be recovered

  - Solids content of recovered solids
    - Studies range from approximately 12% to 40% or higher

WHY IS THIS IMPORTANT? – Characteristics of solids are critical to value-added opportunities

Source: Katers, John. 2008. Value-added Opportunities for Separated Manure Solids presentation.

SOLIDS SEPARATION – SYSTEM PERFORMANCE (CONT.)

- Screens
  - Perform better with low solids manures
    - Avoids clogging of screens
    - Less moisture will be found in the solids
    - Balancing act between screen size and separator efficiency
- Presses
  - Higher separator efficiency and solids content
    - Little data available on performance
    - Often used following screens

Source: Katers, John. 2008. Value-added Opportunities for Separated Manure Solids presentation.

WHAT IS THE "RIGHT" SEPARATION SYSTEM

- Depends on the objectives of the facility
  - Capture as many solids as possible – high separator efficiency
  - High solids content product – separation efficiency may be lower and more solids will end up in the lagoons
- Cost can be a factor
  - The most expensive separator may not be best to meet the objectives
  - The least expensive separator may not be best to meet the objectives

Source: Katers, John. 2008. Value-added Opportunities for Separated Manure Solids presentation.

COSTS

- Separation systems are highly variable on cost to implement
- Really it all comes down to end use!
- If you are land applying, the cost of these systems has to primarily be from savings in application
  - How far away are your fields that are not P limited?
- When markets begin to develop for solids this may change
- Possible to sell solids as bedding, compost, etc.

CONCLUSIONS

- Efficiency of phosphorus sequestration is highly dependent upon initial concentration and solids removal
- No P disappears, it always ends up somewhere but where is it that you want it to be?
- Must integrate the system through land application
- Pay attention to the costs associated with your system
- Make sure you are aware of removal data that a potential company may give you, even that done at a non-biased source THESE SYSTEMS ARE EXTREMELY VARIABLE

MANAGE YOUR SYSTEM!

- If you are not experiencing the removal you may want you need to examine where the issues may exist
- Companies commonly try to get your system to operate with little maintenance issues not necessarily removal performance

FUTURE…

- Developing some tools to evaluate your system
- What is up ahead?

THANK YOU!

Becky Larson
ralarson2@wisc.edu
(608) 890-3171