Maximizing Nutrient Retention from Manure Storages

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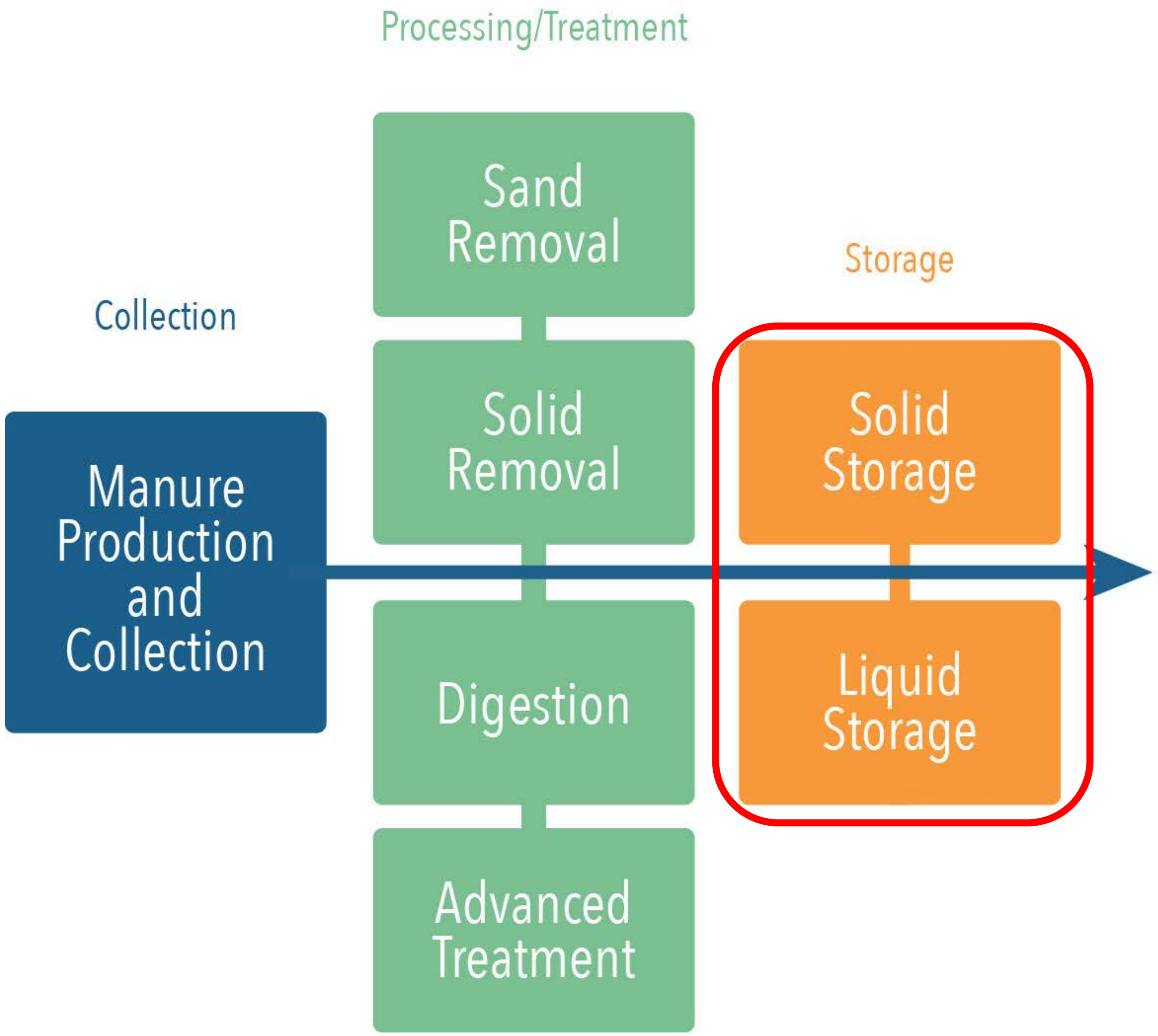
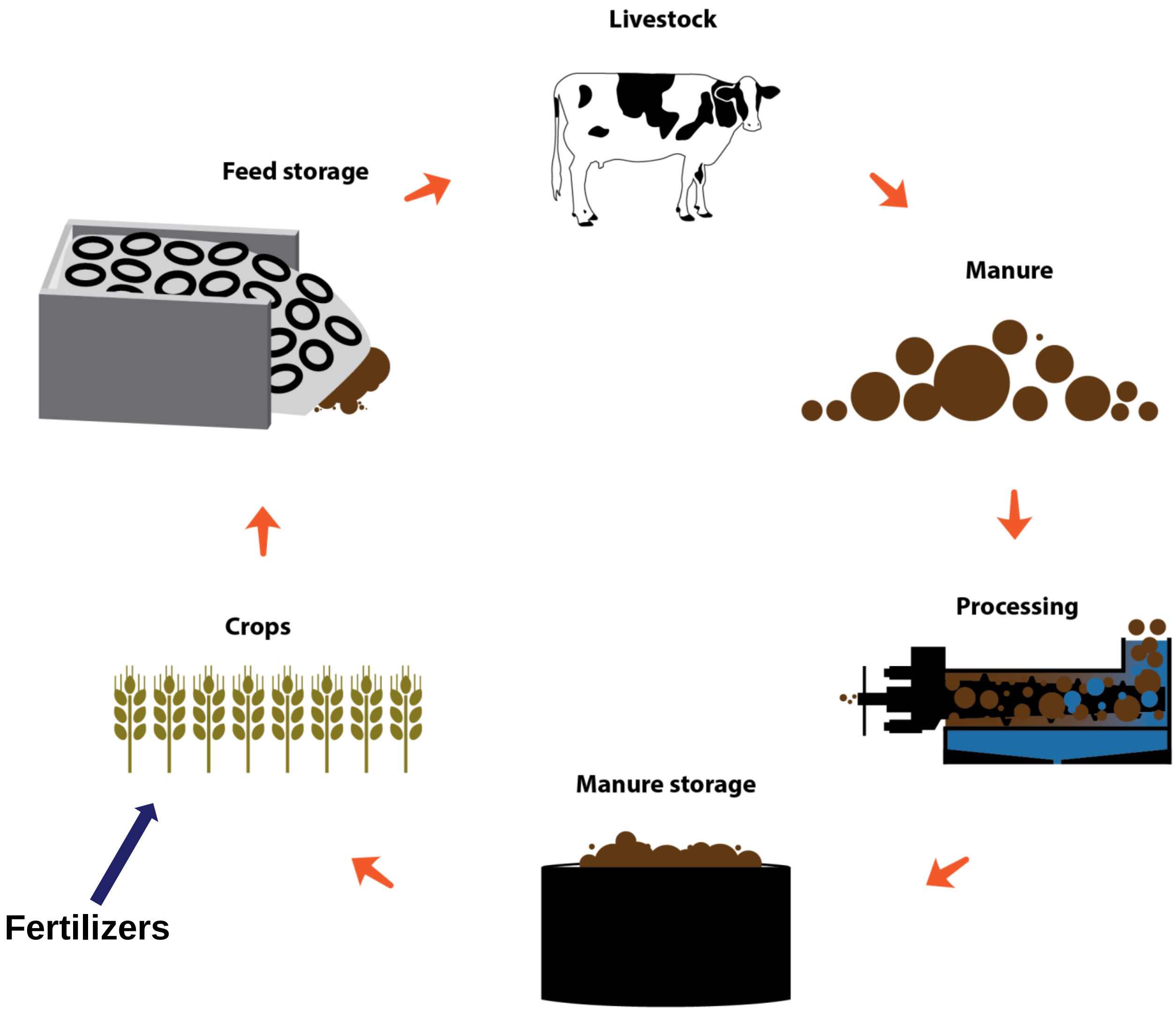
Manure Storage

Manure Systems



Sustainability and Manure Cycling



Storage Impacts

- Nitrogen losses
- Stratification
  - Settling of solids and nutrients
  - Increased solids and phosphorus in settled material

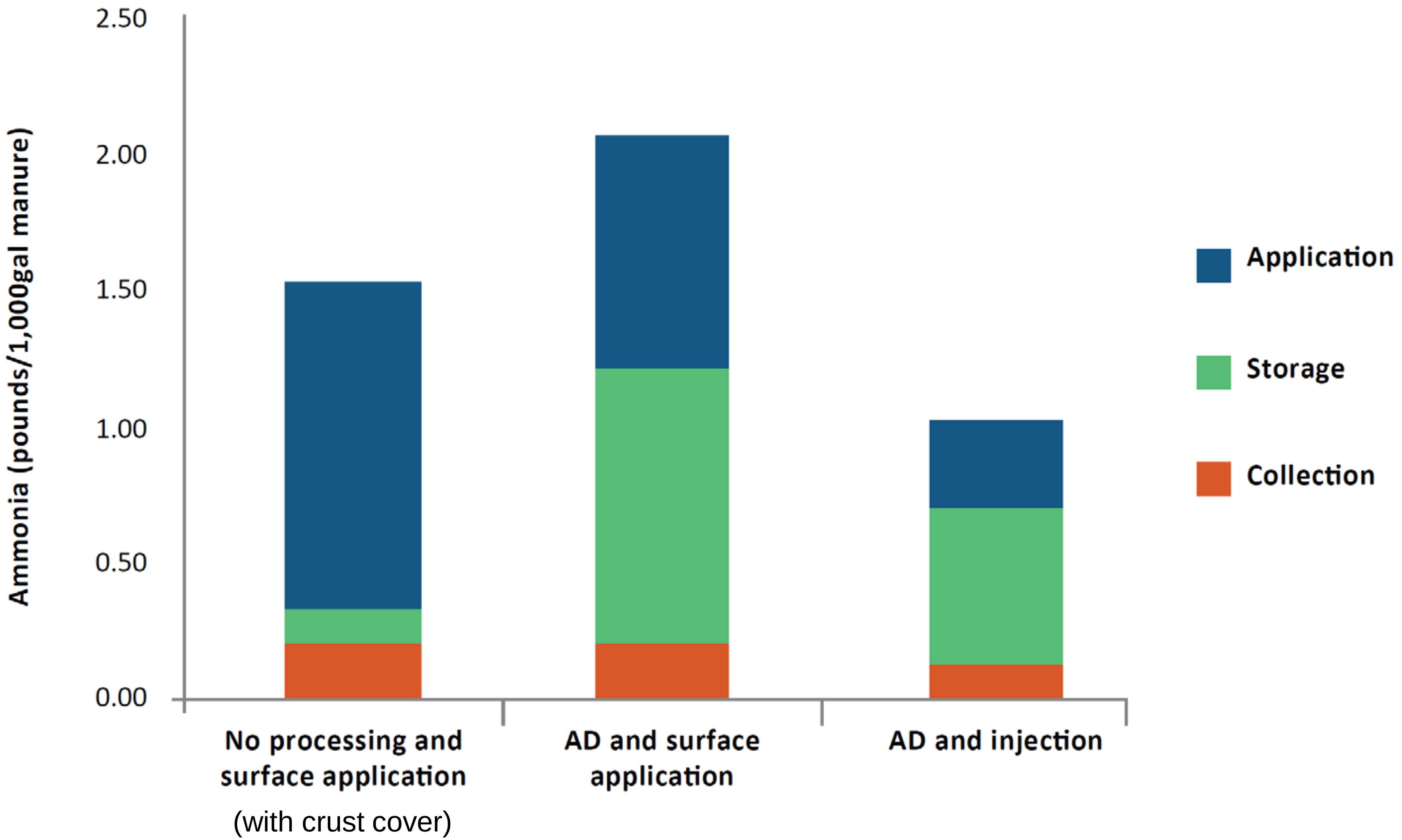
Selection of storage facility

Nitrogen Retention in Different Manure-Handling Systems

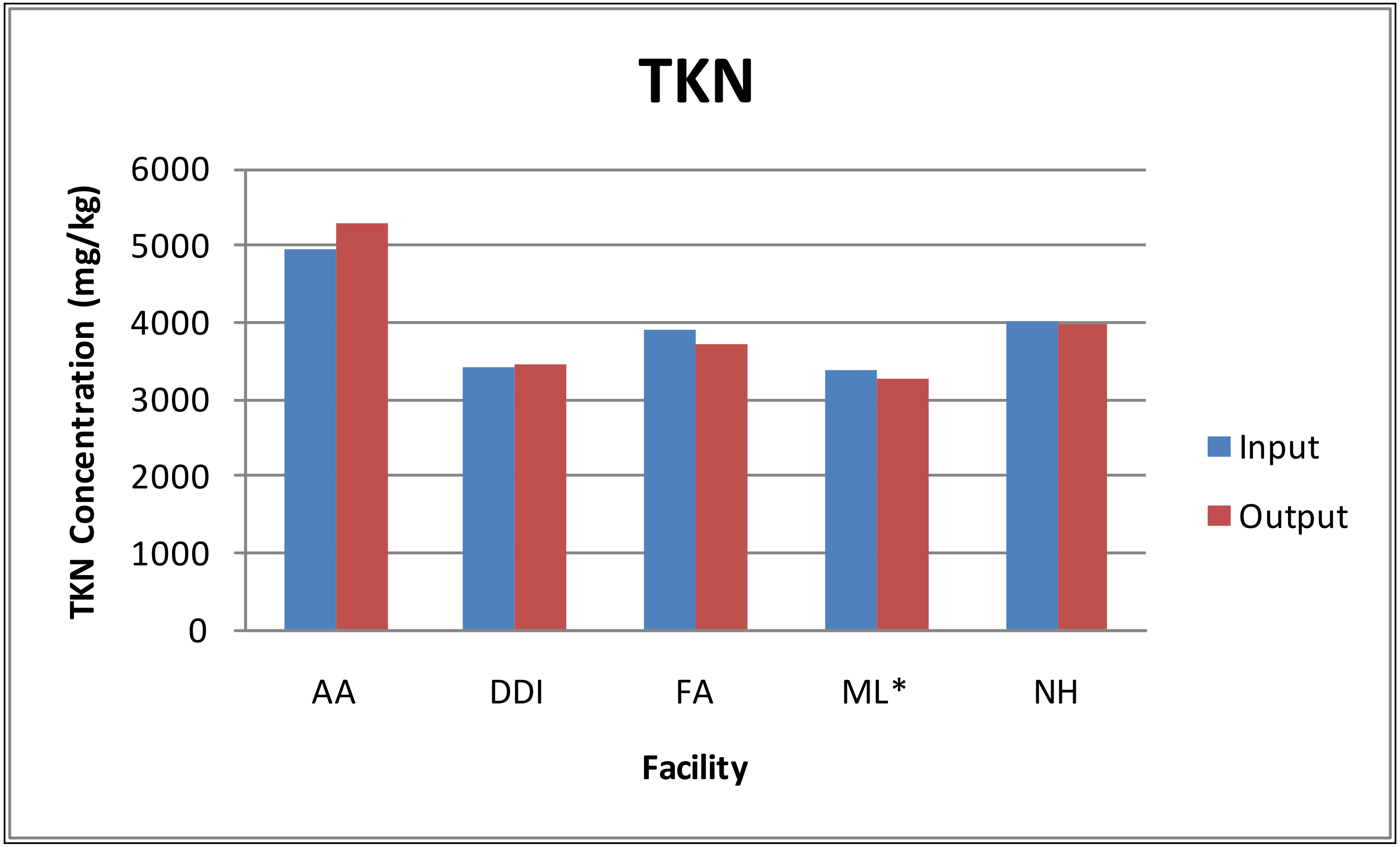
System	Nitrogen Lost, %	Nitrogen Retained, %
Daily scrape and haul	20-35	65-80
Manure pack	20-40	60-80
Open lot	40-55	45-60
Deep pit (poultry)	25-50	50-75
Litter	25-50	50-75
Under floor pit	15-30	70-85
Aboveground tank	10-30	70-90
Holding pond	20-40	60-80
Anaerobic lagoon	70-85	15-30

Adapted from: Livestock Waste Facilities Handbook, MWPS

Ammonia Emissions Losses

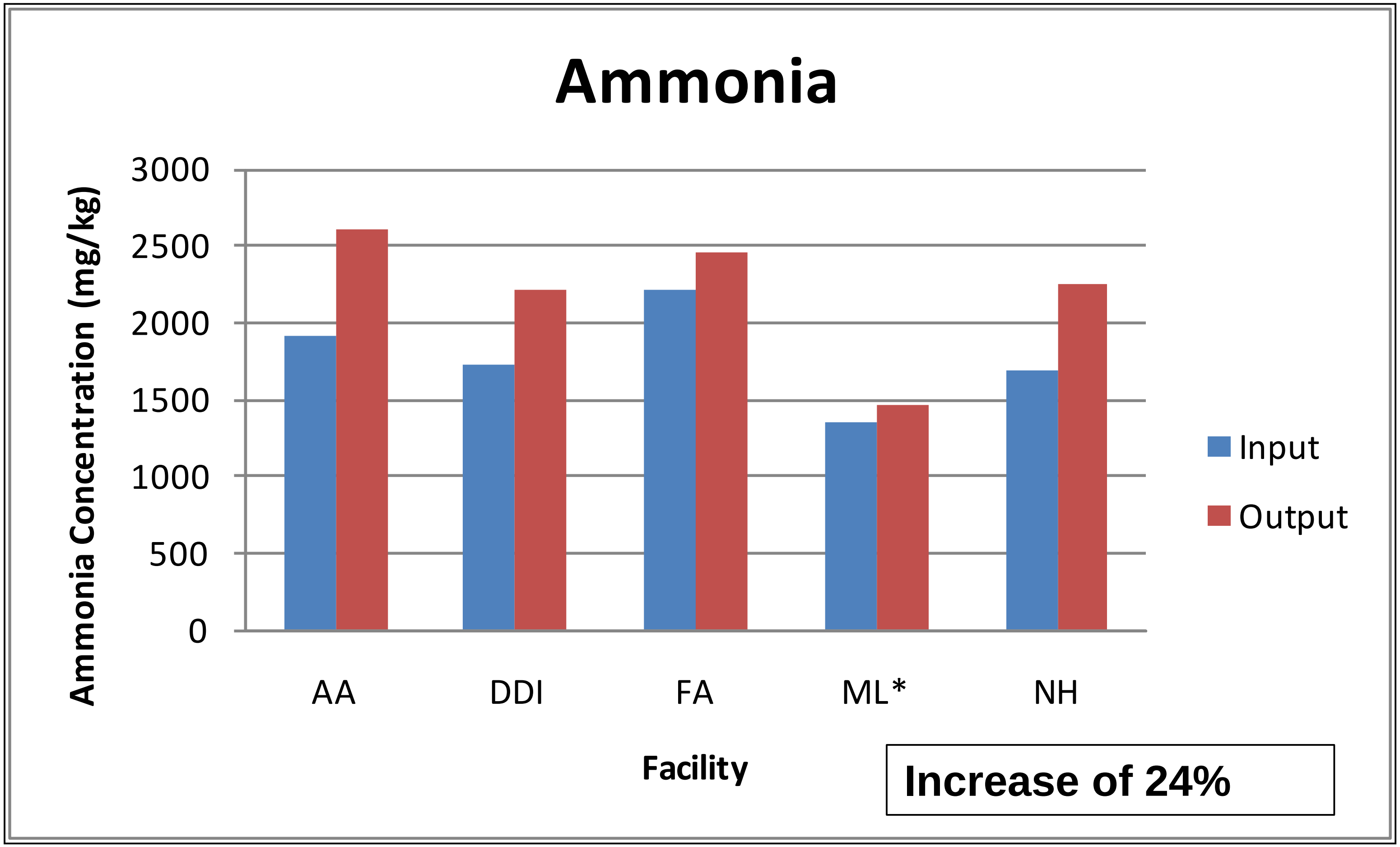


Nutrients & Anaerobic Digestion



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

Nutrients & Anaerobic Digestion



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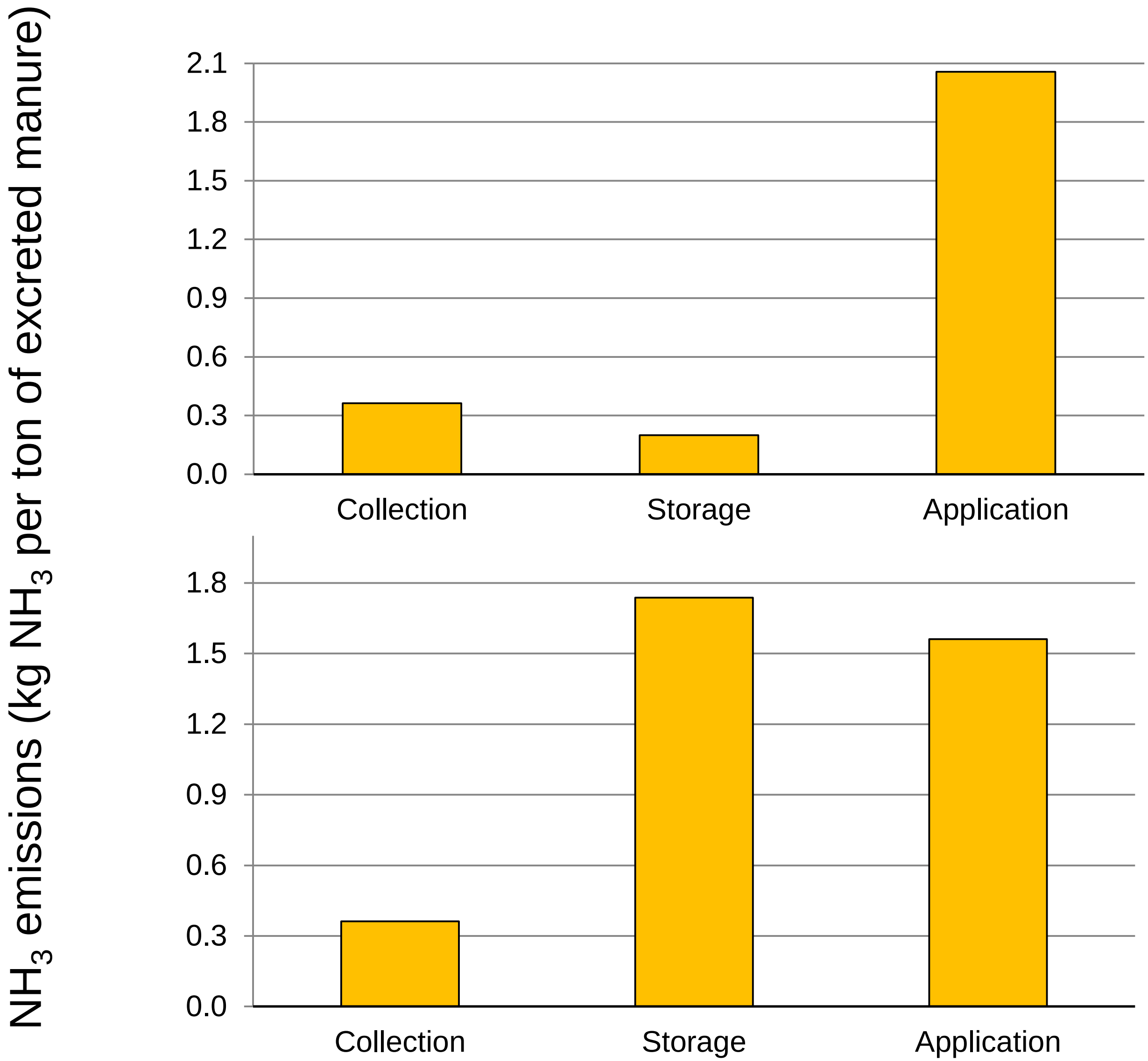
Ammonia Emissions

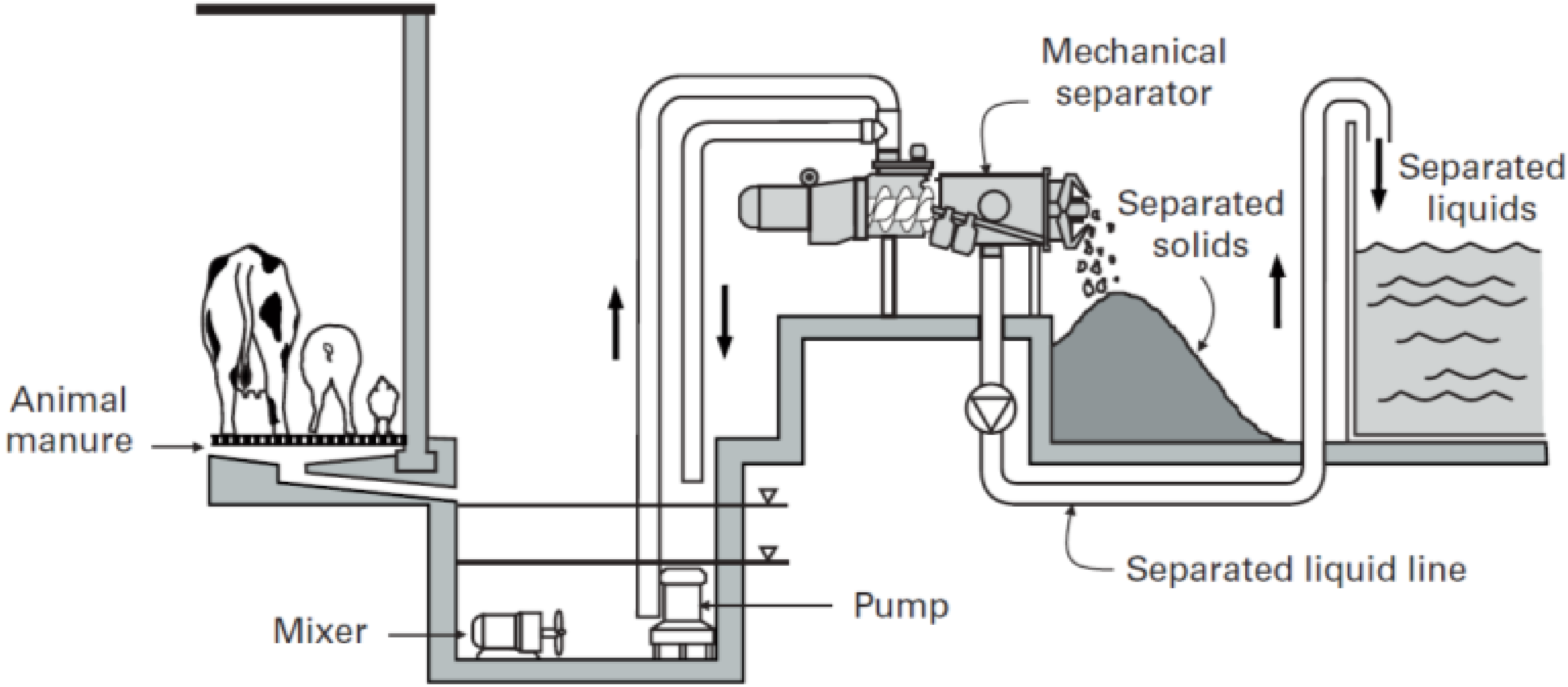


Base case (no digestion)

Anaerobic digestion

Aguirre-Villegas, H. A., Larson, R. and Reinemann, D. J. (2014), From waste-to-worth: energy, emissions, and nutrient implications of manure processing pathways. Biofuels, Bioprod. Bioref., 8: 770–793. doi:10.1002/bbb.1496

Separation Systems



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

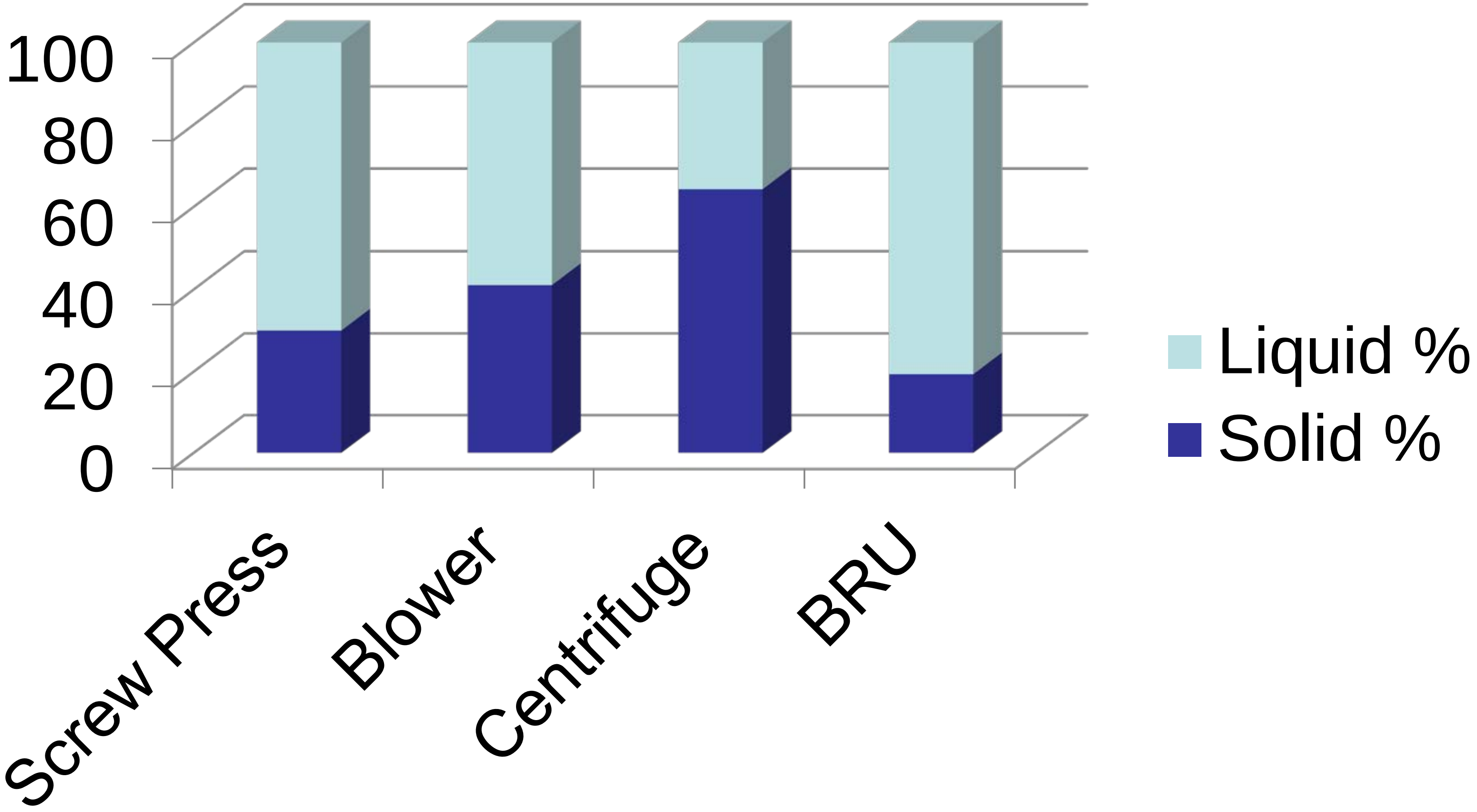
Ratio	N	P_2O_5	K_2O
Manure	3	1	2
Liquid	4	1	3
Solid	2	2	1

Mass Separator Efficiency

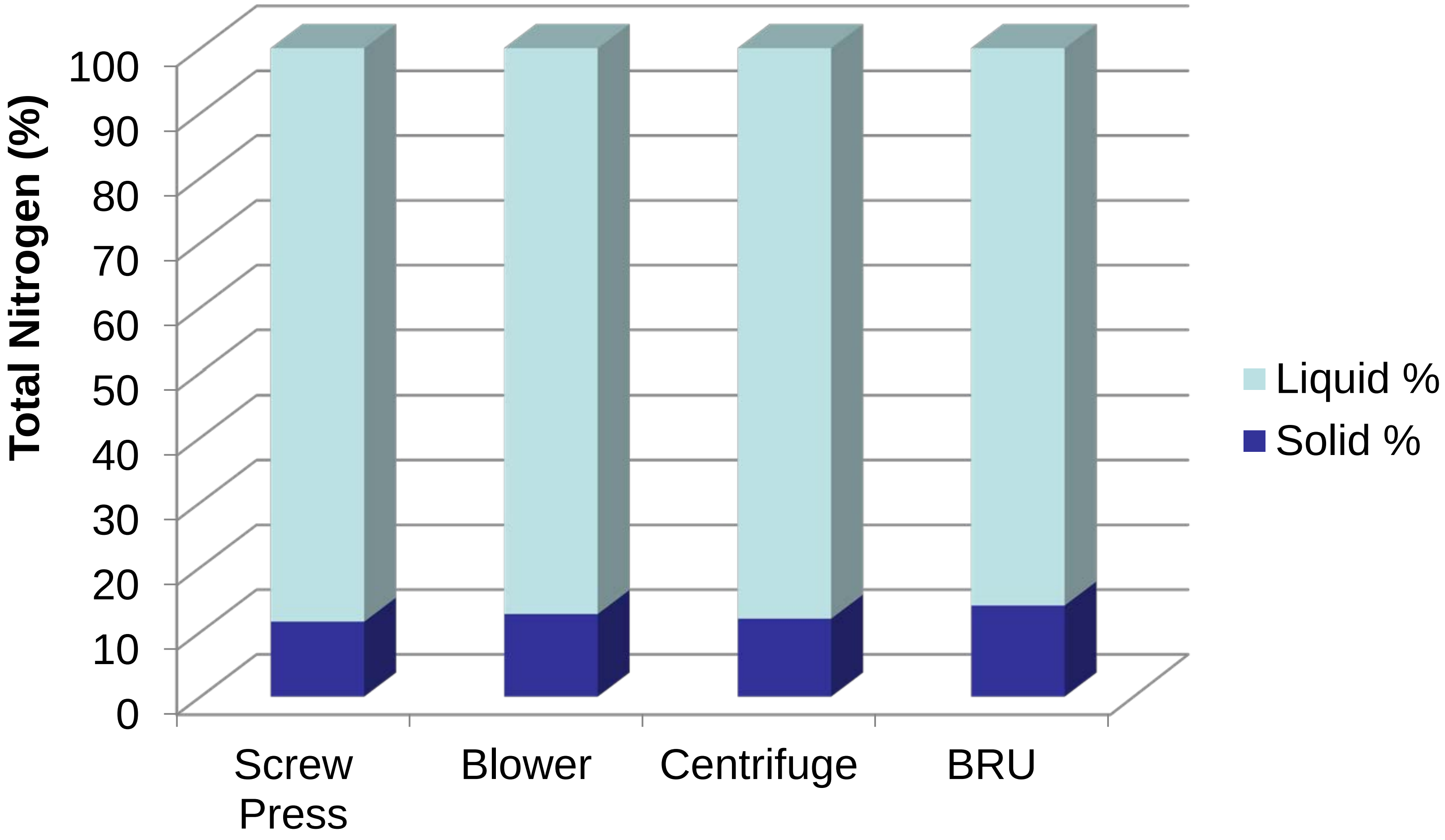
Component	Mass separation efficiency (%)[1]
Total solids	45
Total nitrogen	18
Organic nitrogen	20
Inorganic nitrogen	15
Total phosphorous	21

[1]From Chastain (2013) based on (Gooch, Inglis, and Czymmek 2005; Chastain, Vanotti, and Wingfield 2001)

Phosphorus by Separator Type



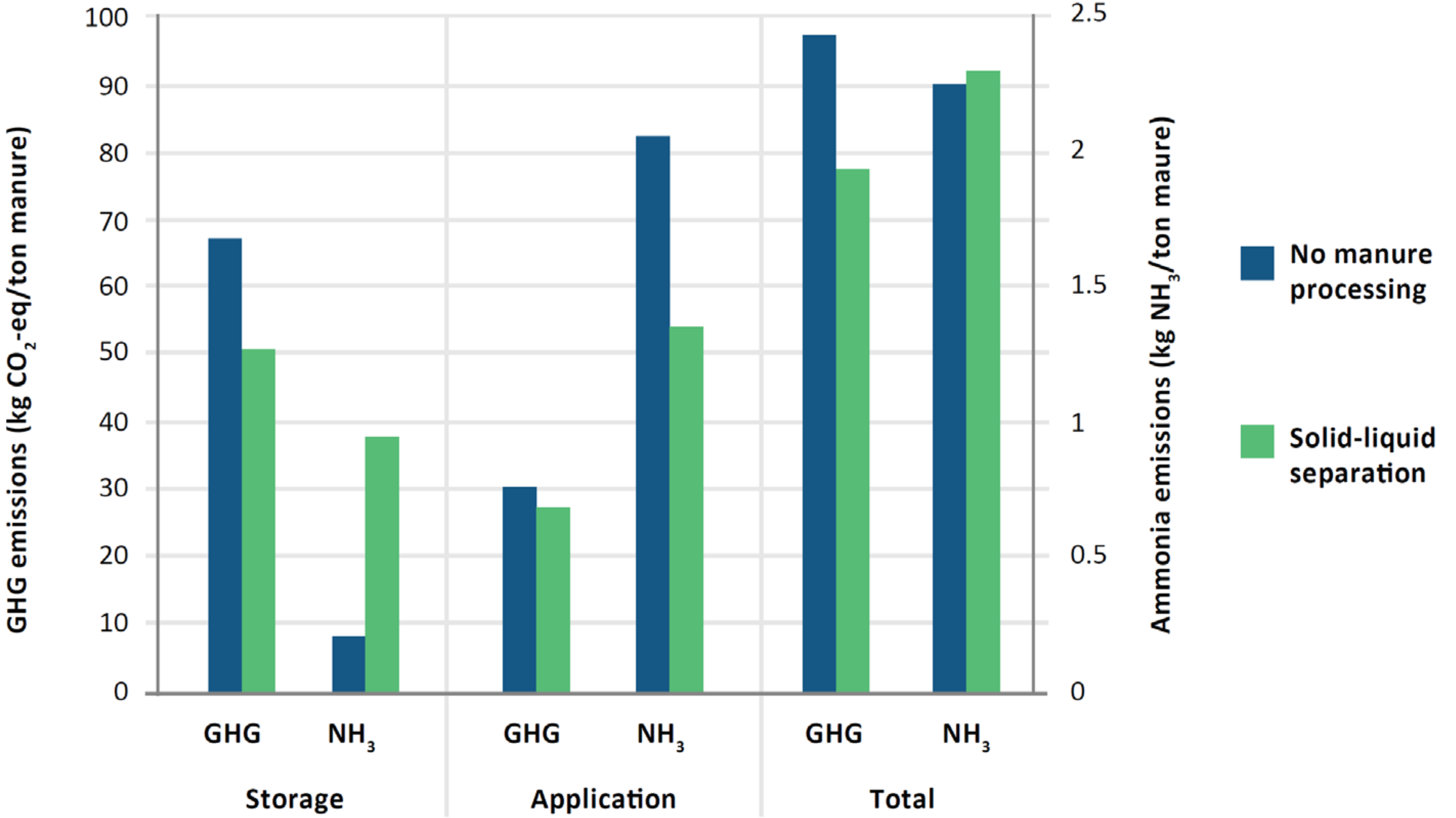
Total Nitrogen by Separator Type



Screens

Screen size[b] (mm)	TSS		VSS		TKN		TP	
	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

Ammonia Emissions with Separation



Aguirre-Villegas, H.A., R.A. Larson, and D. Reinemann. 2014. From Waste-To-Worth: Energy, Emissions, and Nutrient Implications of Manure Processing Pathways. *Biofuels, Bioproducts & Biorefining*, 8:770-793.

Separation and Emissions Reductions

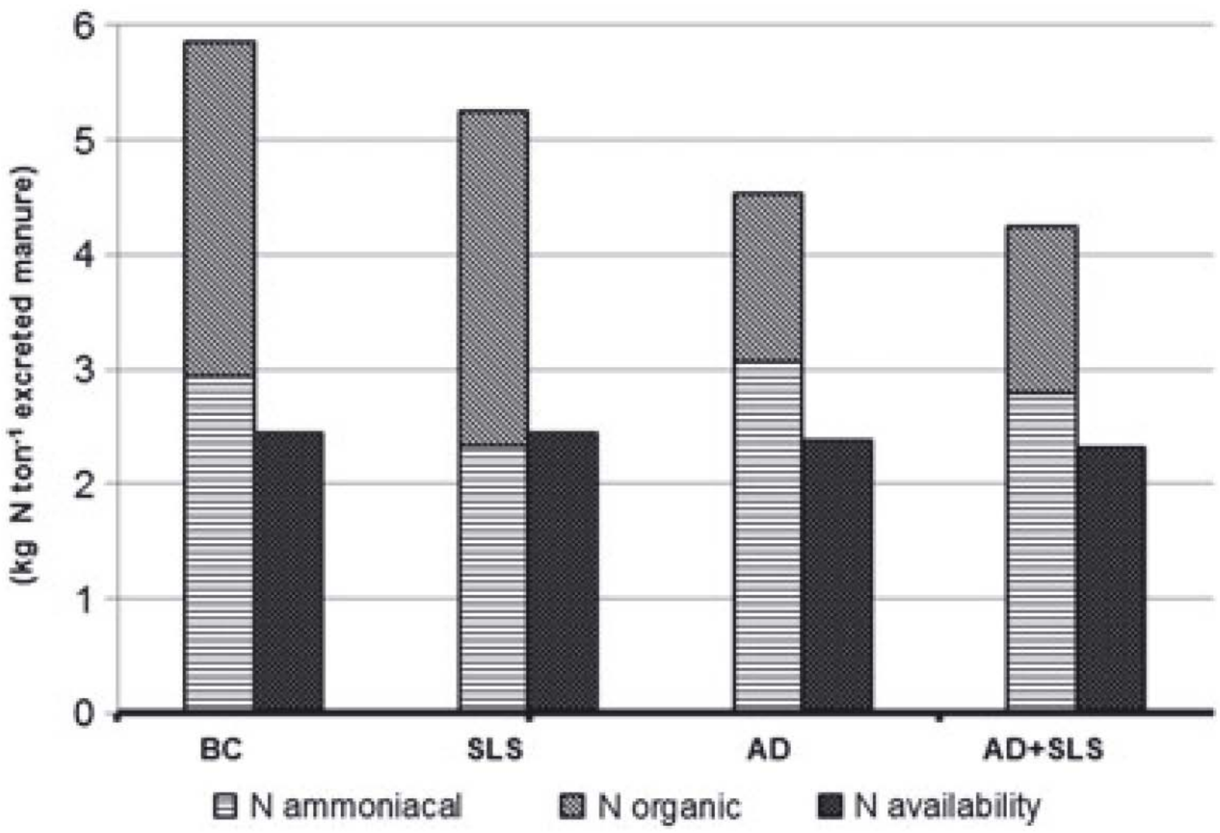


Figure 7. Organic N, ammoniacal, and N availability after land application for each pathway.

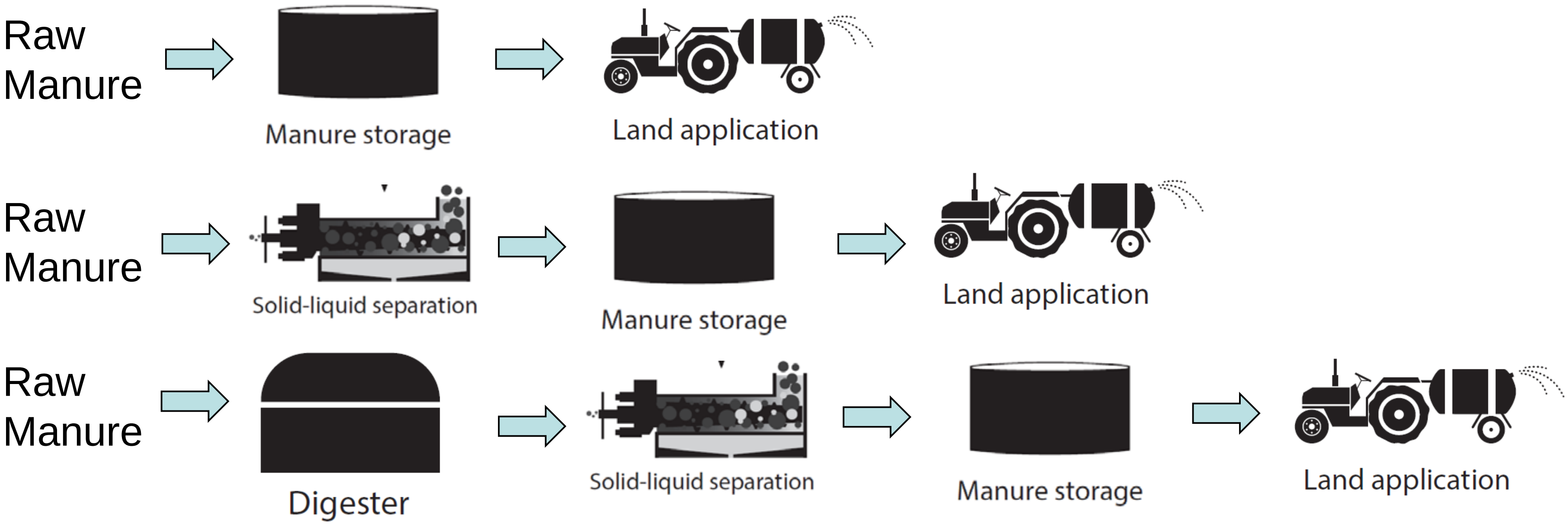
Aguirre-Villegas, H.A., R.A. Larson, and D. Reinemann. 2014. From Waste-To-Worth: Energy, Emissions, and Nutrient Implications of Manure Processing Pathways. *Biofuels, Bioproducts & Biorefining*, 8:770-793.

Field Validation of Ammonia Emissions

6 months storage

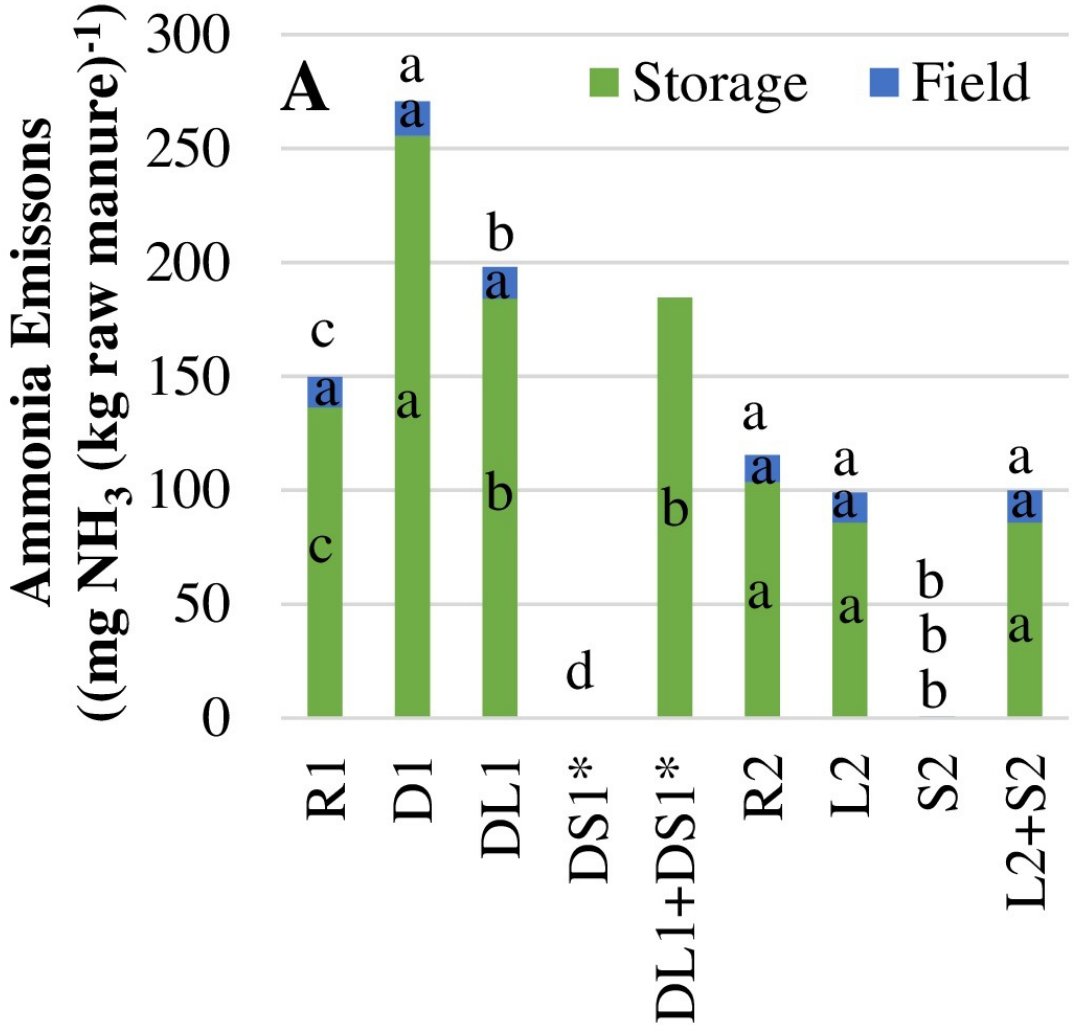
4.5 months field

Treatments



Raw Manure
Manure storage
Land application
Raw Manure
Solid-liquid separation
Manure storage
Land application
Raw Manure
Digester
Solid-liquid separation
Manure storage
Land application

Ammonia Emissions



M.A. Holly, R.A. Larson, J.M. Powell, M.D. Ruark, H. Aguirre-Villegas, Greenhouse gas and ammonia emissions from digested and separated dairy manure during storage and after land application, Agriculture, Ecosystems & Environment, Volume 239, 15 February 2017, Pages 410-419, ISSN 0167-8809, http://doi.org/10.1016/j.agee.2017.02.007

Manure Storage Covers

Impermeable covers

- Reduce all forms of emissions and odors
- Can be expensive and difficult to manage

Manure Storage Covers

- Permeable covers (natural crust, biomass covers)
  - Straw covers 15 cm and 30 cm straw covers reduce NH_3 emissions by 28% and 90% (VanderZaag et al. 2009)
  - Chopped straw increases emissions of CH_4 (Berg et al., 2006; Guarino et al., 2006)
  - Straw covers increase emissions of carbon dioxide (CO_2) and nitrous oxide (N_2O) due to aerobic conditions at the surface and the increased organic material (VanderZaag et al., 2009)
  - Limited life span (straw 3 months – Guarino et al. 2006)
  - Other natural permeable covers: chopped corn stalks, saw dust, rice hulls, ground corn cobs, and grass clippings also reduce NH_3 emissions (Vanderzaag et al., 2008) similar issues to straw

Thermally Treated Biomass Storage Covers

Intensity of Thermal Treatment

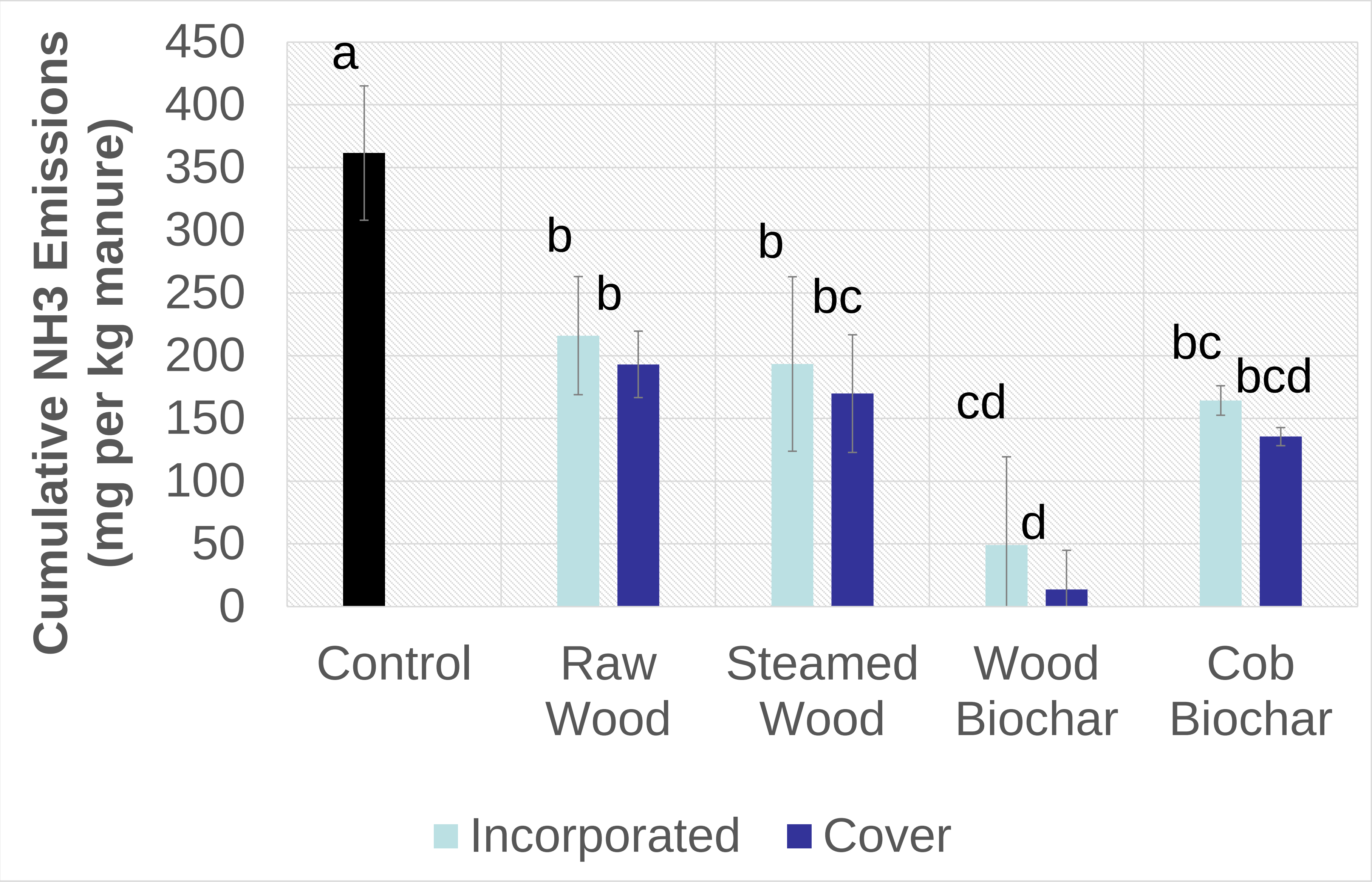
Cover Treatments

Biomass Treatment	Manure Incorporation	Suspended as a Cover
Raw Wood	Incorporated Raw Wood	Raw Wood Cover
Wood Biochar	Incorporated Wood Biochar	Wood Biochar Cover
Steam Treated Wood	Incorporated Steamed Wood	Steamed Wood Cover
Corn Cob Biochar	Incorporated Cob Biochar	Cob Biochar Cover

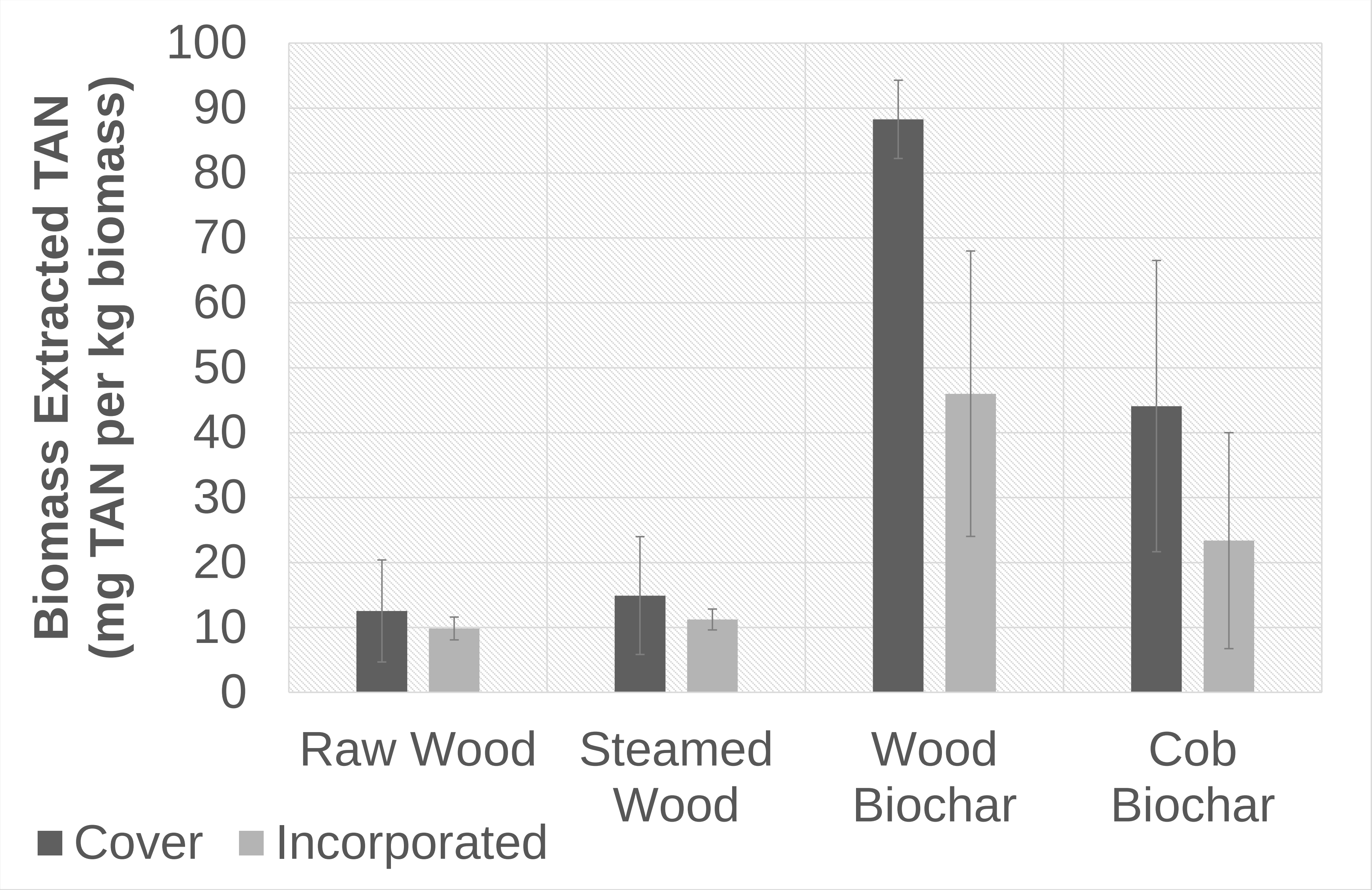
Biomass Covers

Raw wood 70% white birch 30% maple (left), steamed wood, wood biochar, and corncob biochar (right)

Covered Storage Ammonia Emissions



Biomass Nitrogen Uptake



Ammonia Emissions & Sorption

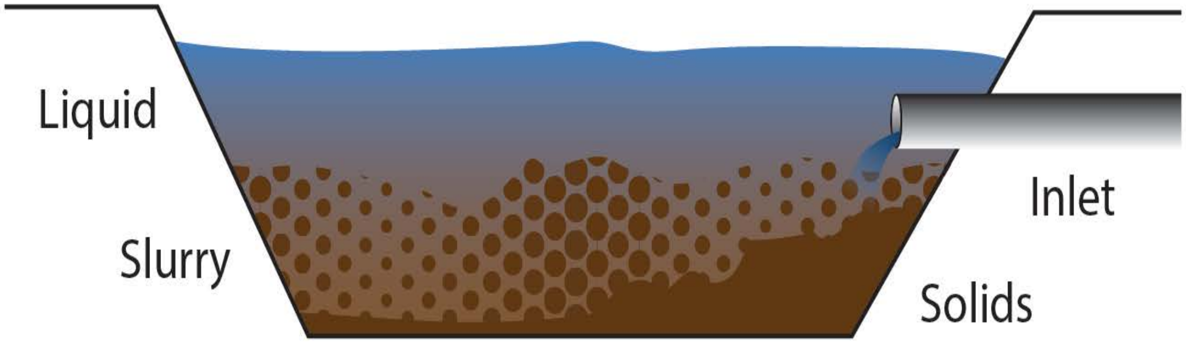
	Total NH_3 Emissions (mg)	NH_3 mitigated (mg)	Sorption of NH_3 (mg)
Control	5462		
Raw Wood	3047	2414	16
Steamed Wood	2561	2900	18
Wood Biochar	221	5241	71
Cob Biochar	2257	3205	18

Manure Agitation

Manure variation

Caused by:

- Animal type
- Diet
- Bedding material
- Additional by-products
- Storage
- Processing



Manure Inconsistencies

- Can cause inconsistencies in application (over and under application in manure)
  - environmental consequences
  - crop yield losses
- Consistency in manure can reduce application inconsistencies
- Agitation and sampling frequency are key aspects to reducing these inconsistencies
- Further steps down the line are not effective if the values for application are incorrect

Agitation/mixing practices

- Key to obtaining uniformity in manure applications
- Can limit variability significantly
  - Dou et al. 2001
  - 6-8% variability without agitation
  - 20-30% variability with no agitation
  - 5 samples required with agitation
  - 40+ samples required without agitation
- How much agitation is enough agitation?
- Can be used in liquid and solid systems

Data Variation

Parameter	Min	Max	Avg
Ammonia	4%	10%	6%
TS	7%	21%	16%
TKN	8%	15%	9%
TP	5%	12%	8%

Thank you!

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