Recommendations from the BMP Expert Panel for Manure Treatment Technologies

For Agriculture Workgroup

Thursday, April 21, 2016

Doug Hamilton, Oklahoma State, Panel Chair

Jeremy Hanson, Virginia Tech, Panel Coordinator

Virginia Tech 1872 Invent the Future

Chesapeake Bay Program
Science. Restoration. Partnership.

Overview

- Background
  - The panel and its charge
  - Manure in the model 101
- The panel's recommendations
  - Manure treatment as part of a larger system
  - (Abridged) walkthrough of the technologies: Thermochemical, Composting, etc.
  - Future research and management needs
  - Level 3 transfer efficiencies
- BMP verification
- Timeline for review/approval of the report
- Discussion

Background: The panel and its charge

Table B.1 – Membership of the Manure Treatment Technologies BMP Expert Panel	
Panelist	**Affiliation**
Keri Cantrell	KBC Consulting (formerly with USDA-ARS)
John Chastain	Clemson University
Doug Hamilton (Chair)	Oklahoma State University
Andrea Ludwig	University of Tennessee
Robert Meinen	Penn State University
Jactone Ogejo	Virginia Tech
Jeff Porter	USDA-NRCS, Eastern National Technology Support Center
Panel support:	
Jeremy Hanson (Coord.)	Virginia Tech/CBPO
Brian Benham	Virginia Tech (Cooperative Agreement Project Director)
Chris Brosch	Delaware Dept. of Agriculture (WTWG rep)
Mark Dubin	University of Maryland/CBP (AgWG Coord.)
Ashley Toy	EPA Region 3 (Regulatory Support)
David Wood	CRC/CBP (CBP modeling team rep)

Background: The panel and its charge (cont'd)

AgWG convened a subgroup in 2014

- Ad hoc subgroup for manure treatment technologies suggested six categories (see Appendix C) for panel review:
  - Thermochemical (combustion, gasification, pyrolysis, torrefaction)
  - Composting
  - Anaerobic digestion
  - Solid-Liquid Separation
  - Chemical-Wet
  - Chemical-Dry

Expert panel convened later that year

- As it progressed, the expert panel further refined the categories based on available data and applicability in the region:
  - Thermochemical (combustion, gasification, pyrolysis)
  - Composting
  - Anaerobic digestion
  - Mechanical solid-liquid separation
  - Settling
  - Wet chemical treatment
- **Recommendations for Phase 6 Watershed Model only**

The CBP partnership modeling tools in one slide…

Planning tools: CAST, MAST, VAST, BayFAST

BMP reporting platform: NEIEN

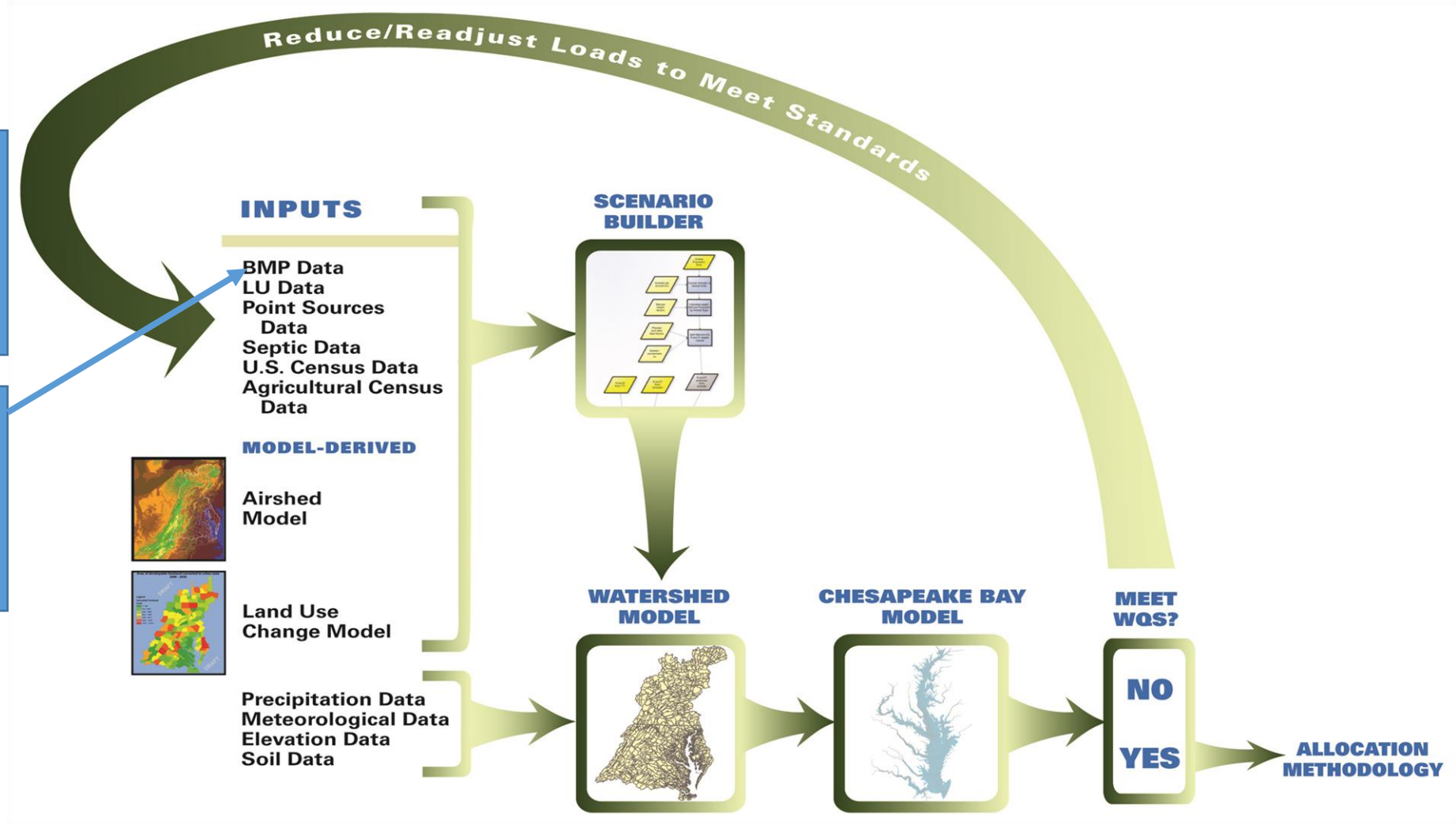


Figure B.1 - Chesapeake Bay Program partnership modeling suite (Phase 5.3.2)

Manure in the modeling tools 101

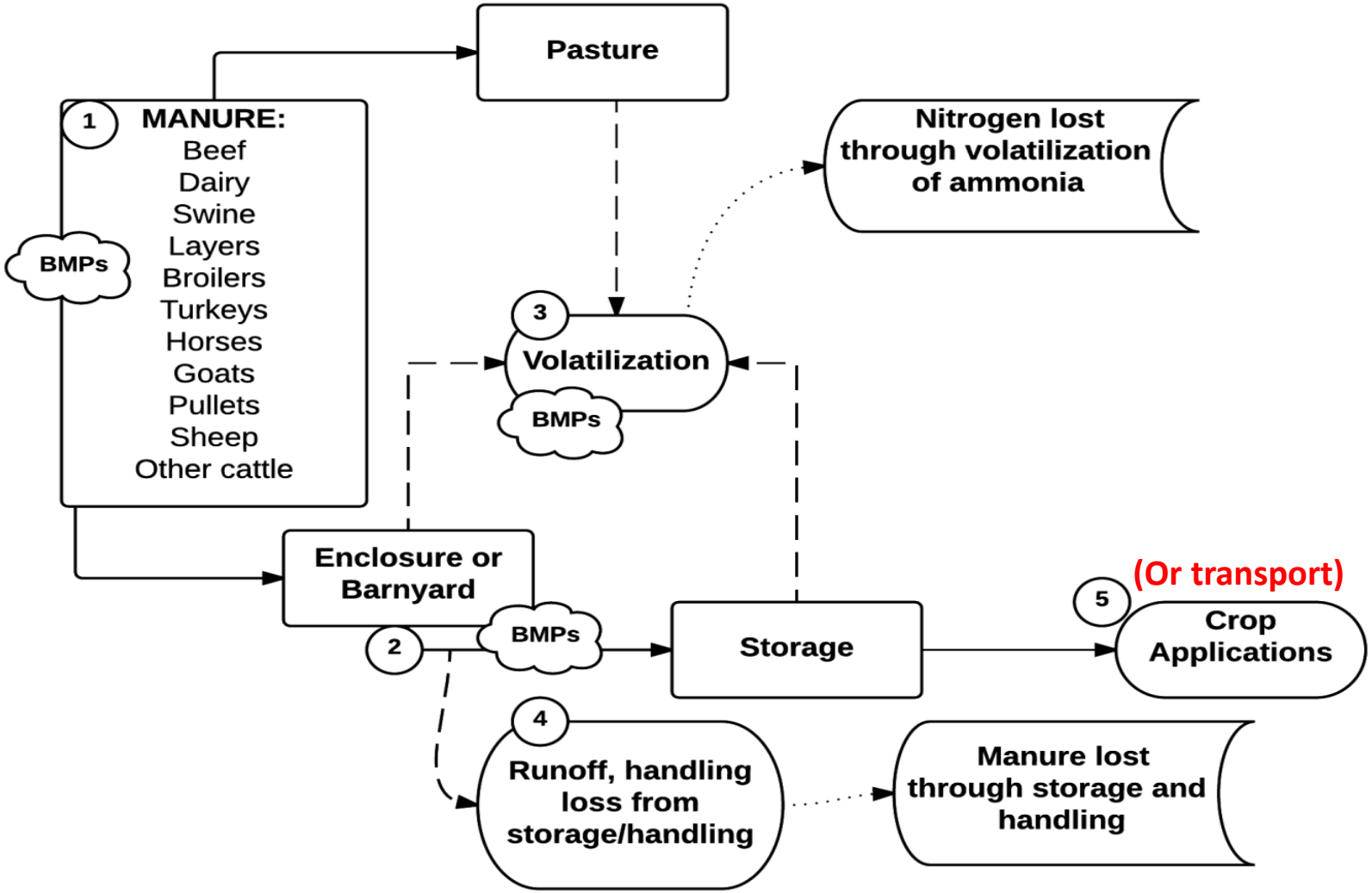


Figure B.2 – Conceptual diagram of manure nutrients in the Phase 5.3.2 Watershed Model

The panel’s recommendations

Some key ideas to understand before we dive into their findings…

Three Levels of Recommendations

- Default
- Defined
- Data-driven

The Effect of Treatment Technologies

- Only “Removal” of nutrients from manure stream is by Nitrogen Volatilization.
- Nitrogen and Phosphorus Separation facilitate the Transport BMP.

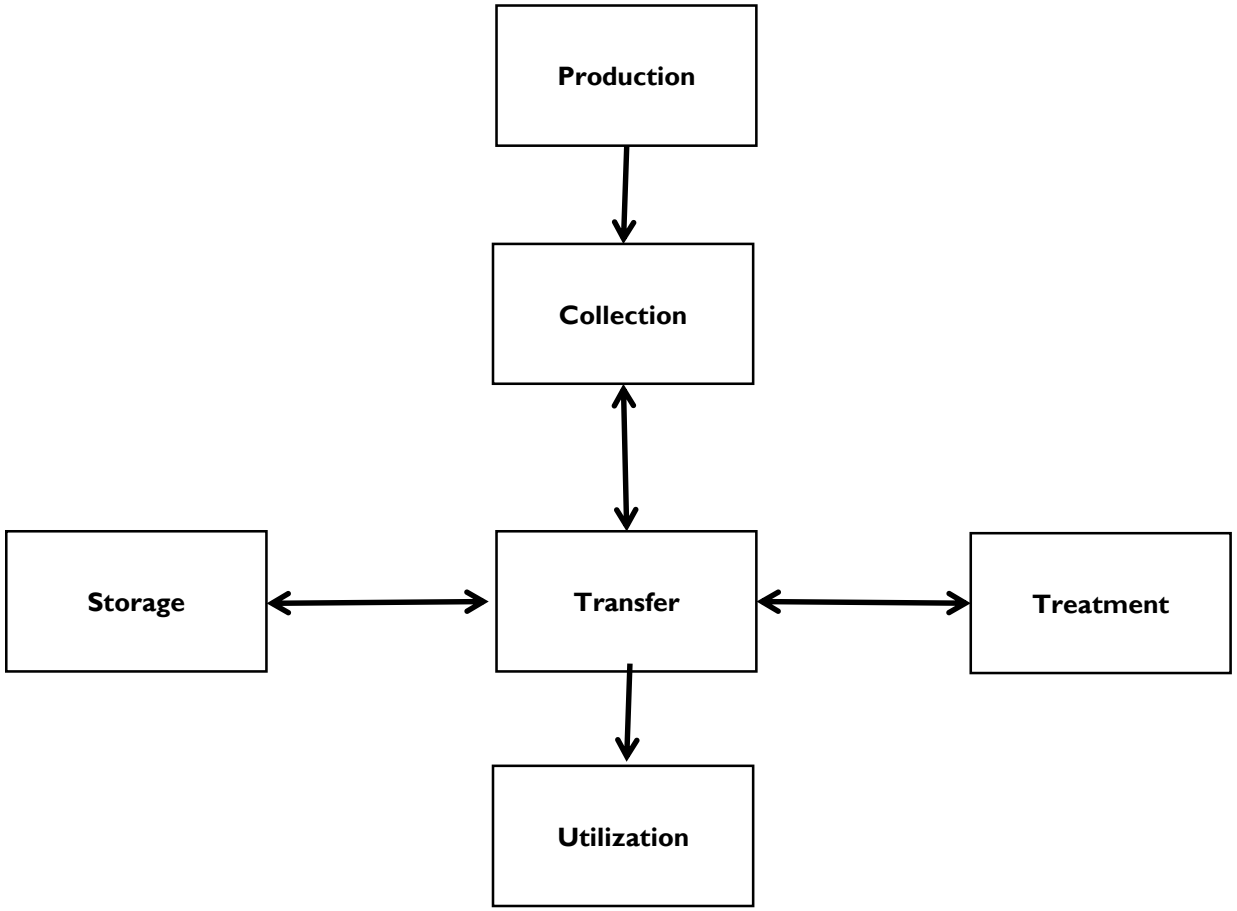


Figure TT.1. Schematic Representation of Manure Handling Systems (from Figure 9-2 in USDA NRCS, 1992).

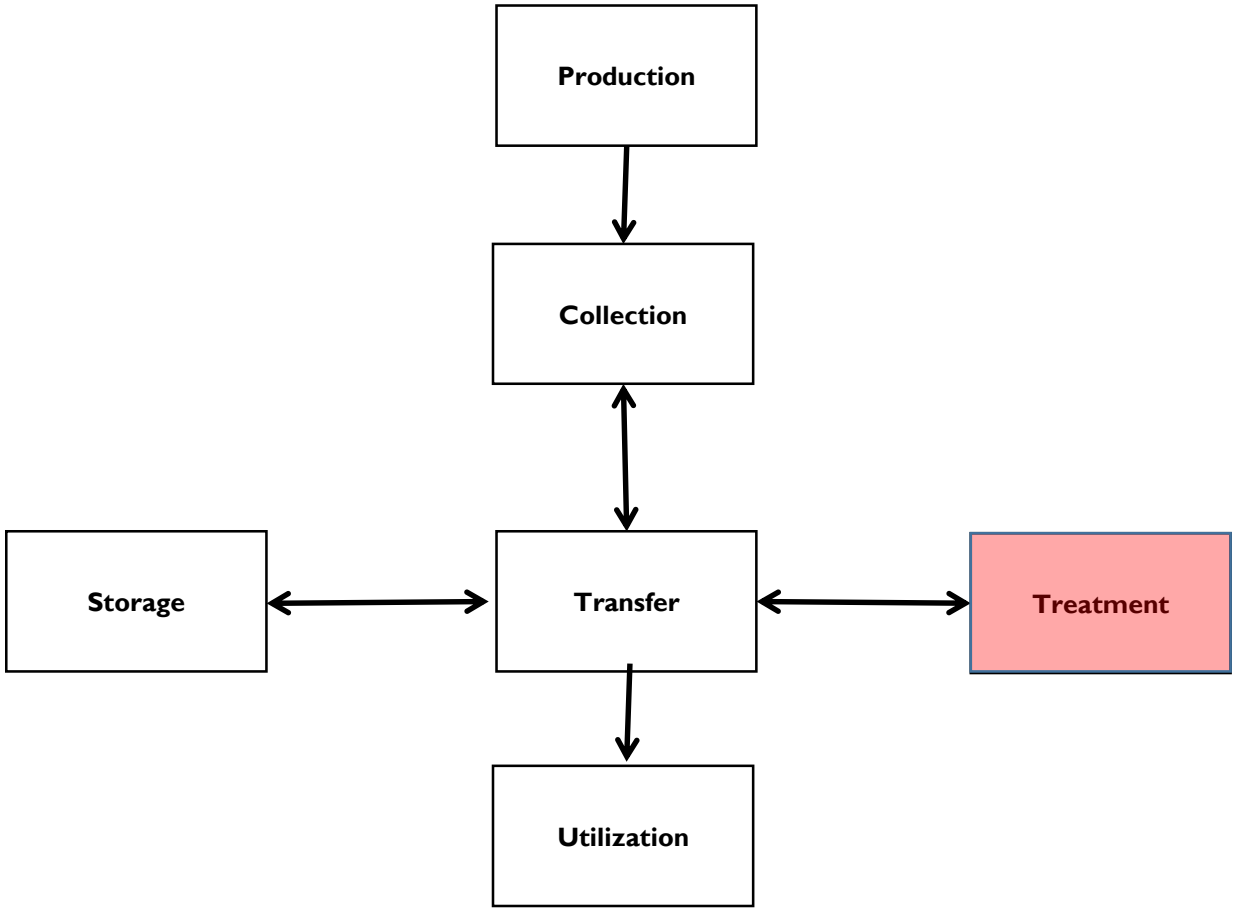
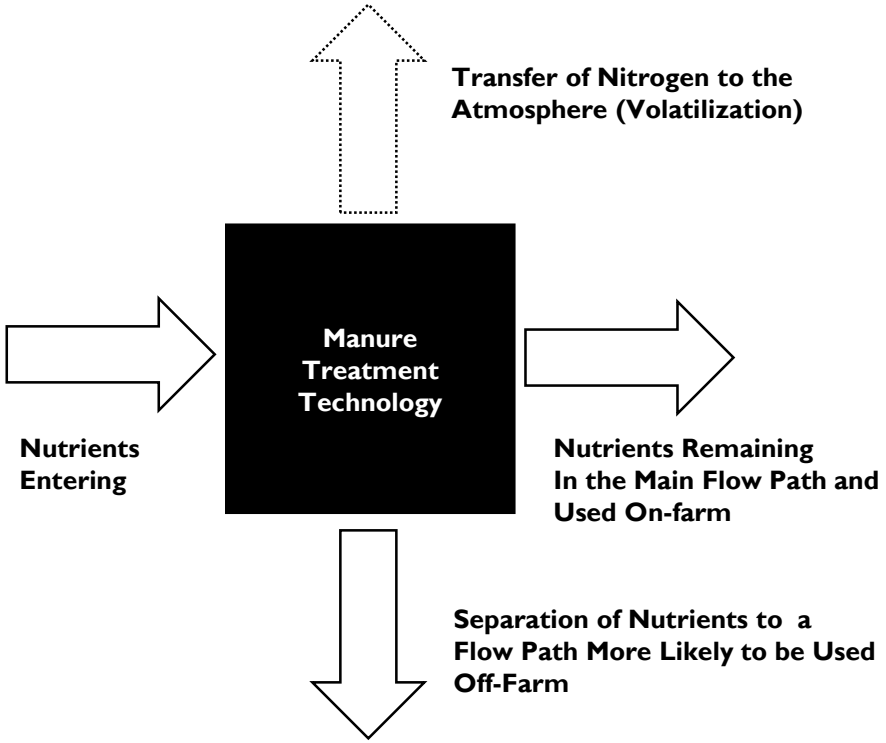
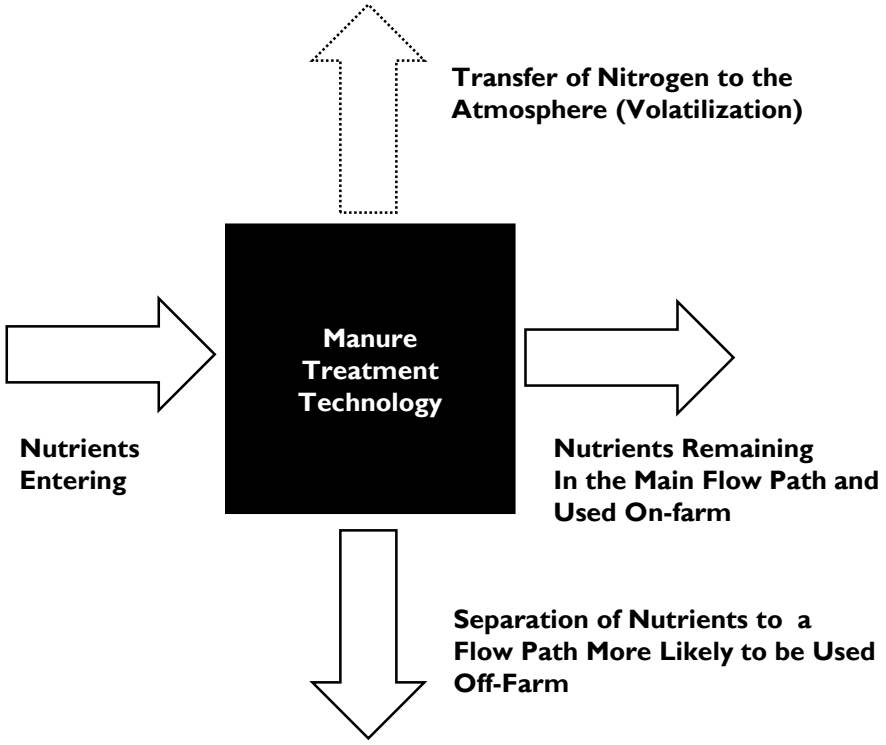


Figure TT.1. Schematic Representation of Manure Handling Systems (from Figure 9-2 in USDA NRCS, 1992).

Manure Treatment Schematic

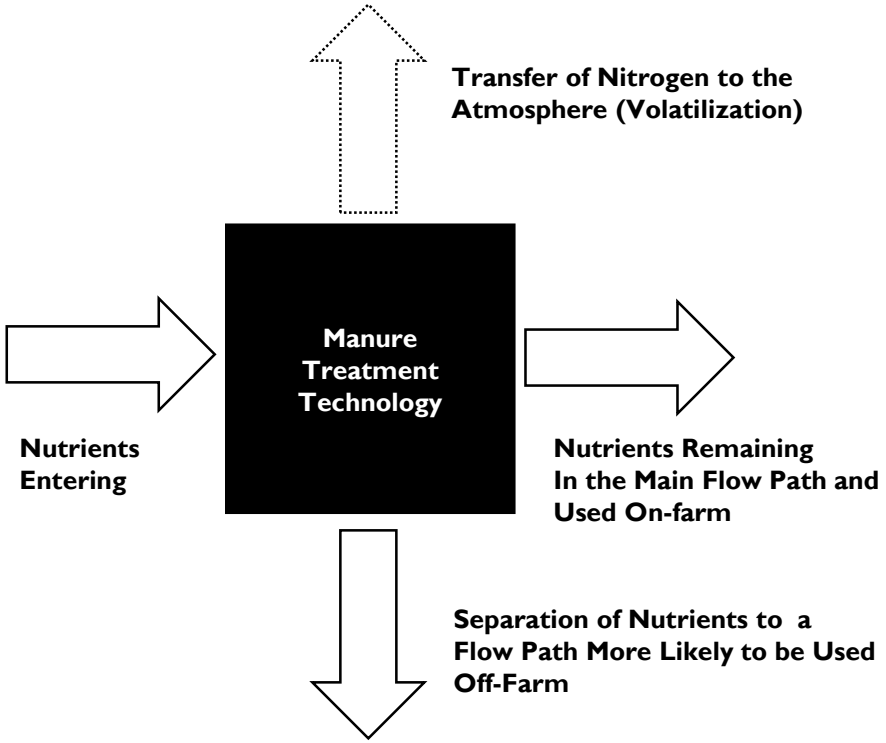


Transfer Efficiency



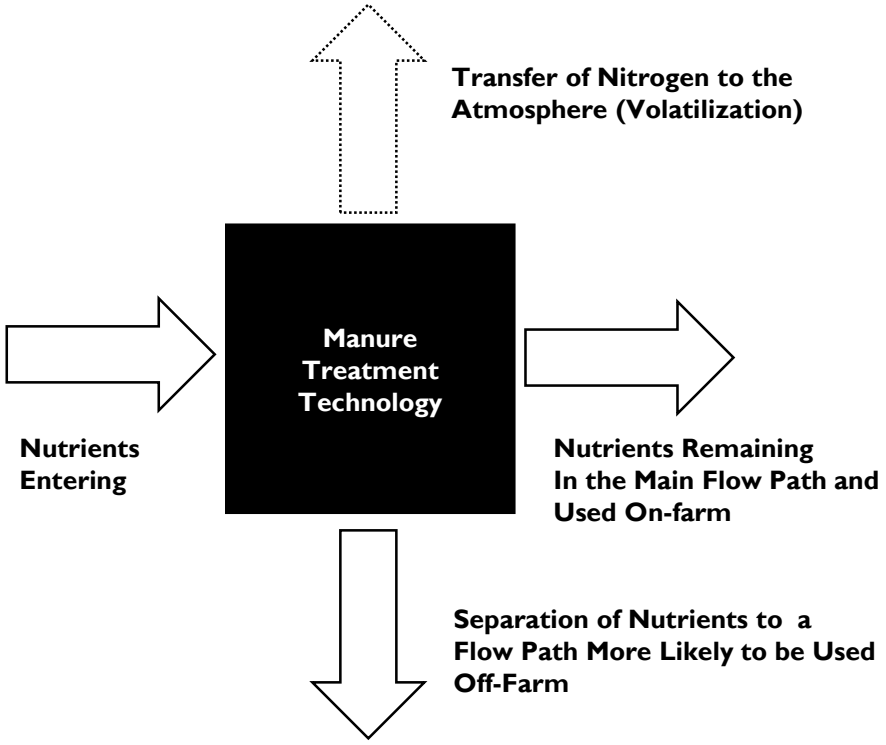
$$\frac{\text{Mass of Nutrient Leaving in Any Flow Path}}{\text{Mass of Nutrient Entering}} \times 100$$

Nitrogen Volatilization Efficiency (NVE)



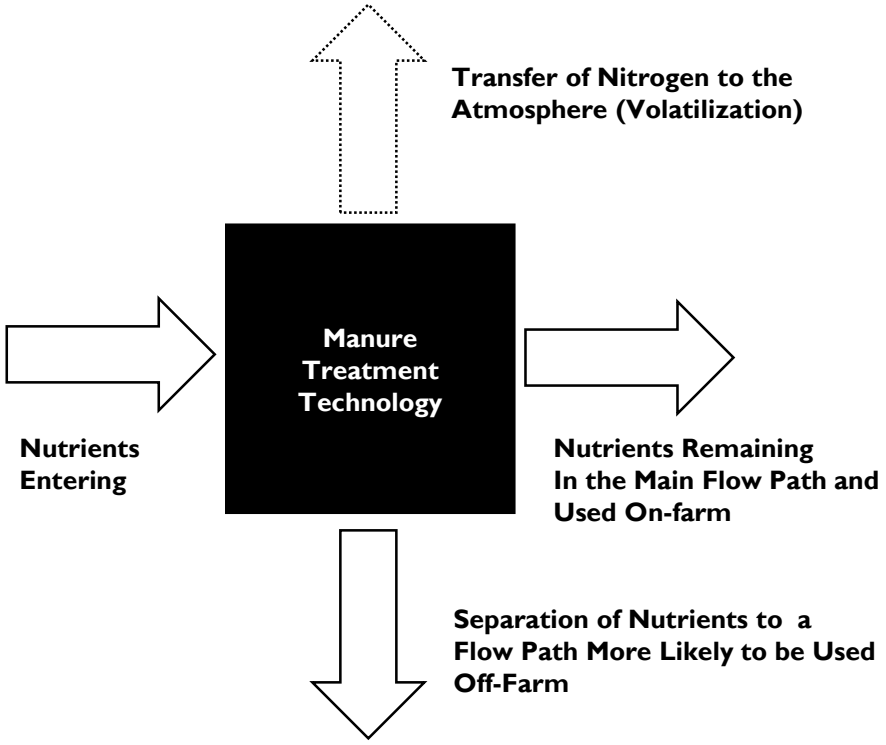
$$\frac{\text{Mass of TN Transferred to Atmosphere}}{\text{Mass of TN Entering}} \times 100$$

Nitrogen Separation Efficiency (NSE)



$$\frac{\text{Mass of TN Separated from Main Flow}}{\text{Mass of TN Entering}} \times 100$$

Phosphorus Separation Efficiency (PSE)



$$\frac{\text{Mass of TP Separated from Main Flow}}{\text{Mass of TP Entering}} \times 100$$

How NVE, NSE and PSE fit in

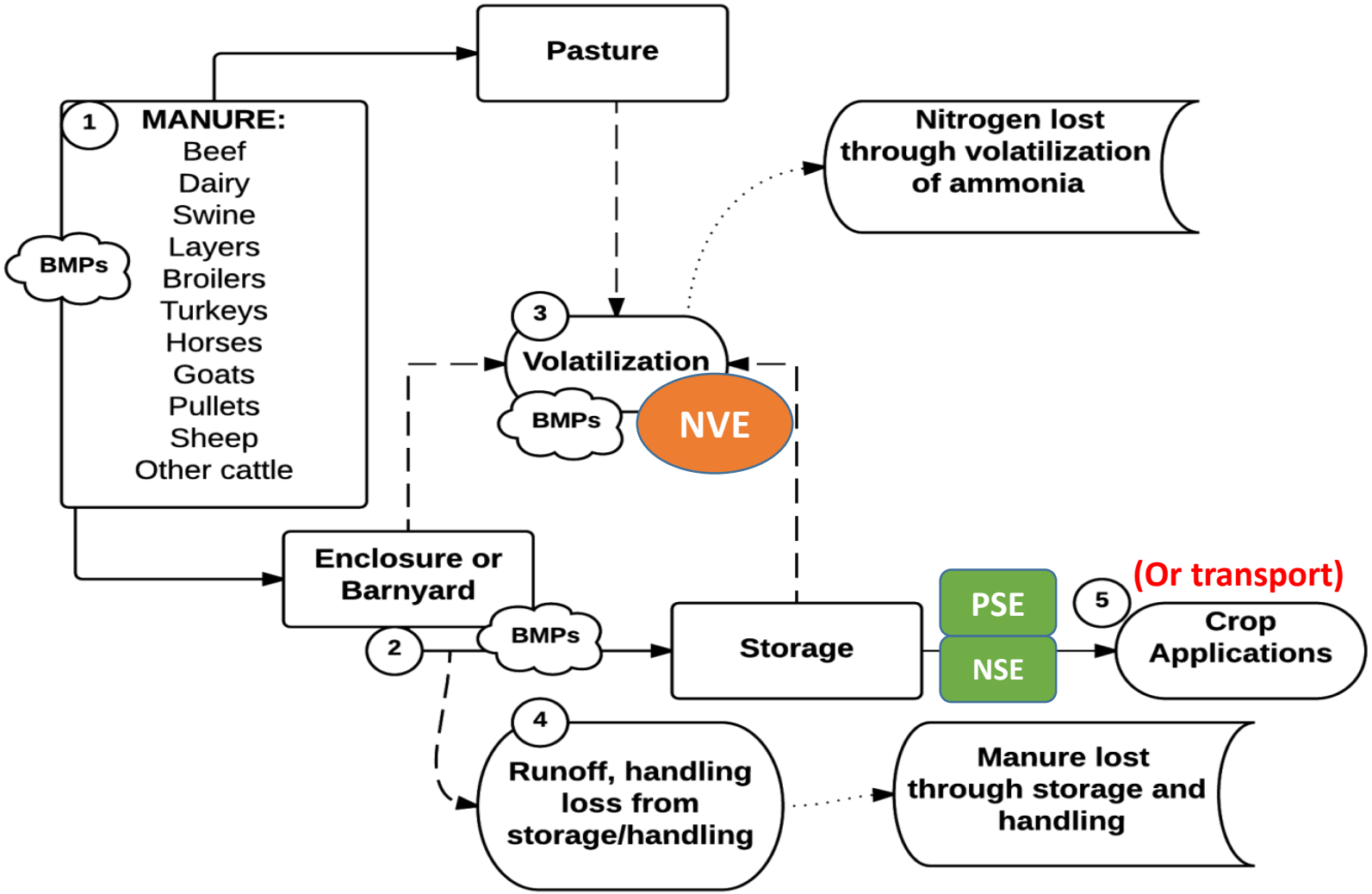


Figure B.2 (modified) – Conceptual diagram of manure nutrients in the Phase 5.3.2 Watershed Model

Three levels of Recommendations

1. **Default (Level 1)** is used when only technology and manure type is known.
2. **Defined (Level 2)** is used when the manure type and pertinent operating conditions of the technology are known.
3. **Data-driven (Level 3)** is used when monitoring data for a given farm is available.

Six Broad Definitions of Technologies

1. **Thermochemical Processing**
2. **Composting**
3. **Anaerobic Digestion**
4. **Settling**
5. **Mechanical Solid-Liquid Separation**
6. **Wet Chemical Treatment**

USDA-NRCS

Gasification

1,400 – 2,700 °F
Limited O_2
Syngas
Ash or Char

USDA-NRCS

Combustion

1,500 – 3,000 °F
Excess O_2
Direct Heat
Ash

USDA-NRCS

Pyrolysis

575 – 1,475 °F
No O_2

Thermochemical Conversion

Thermochemical Conversion

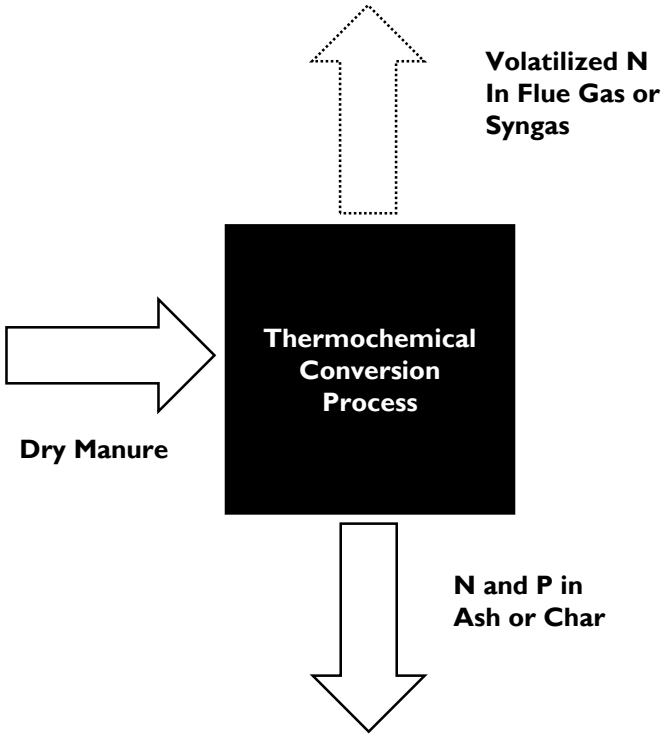
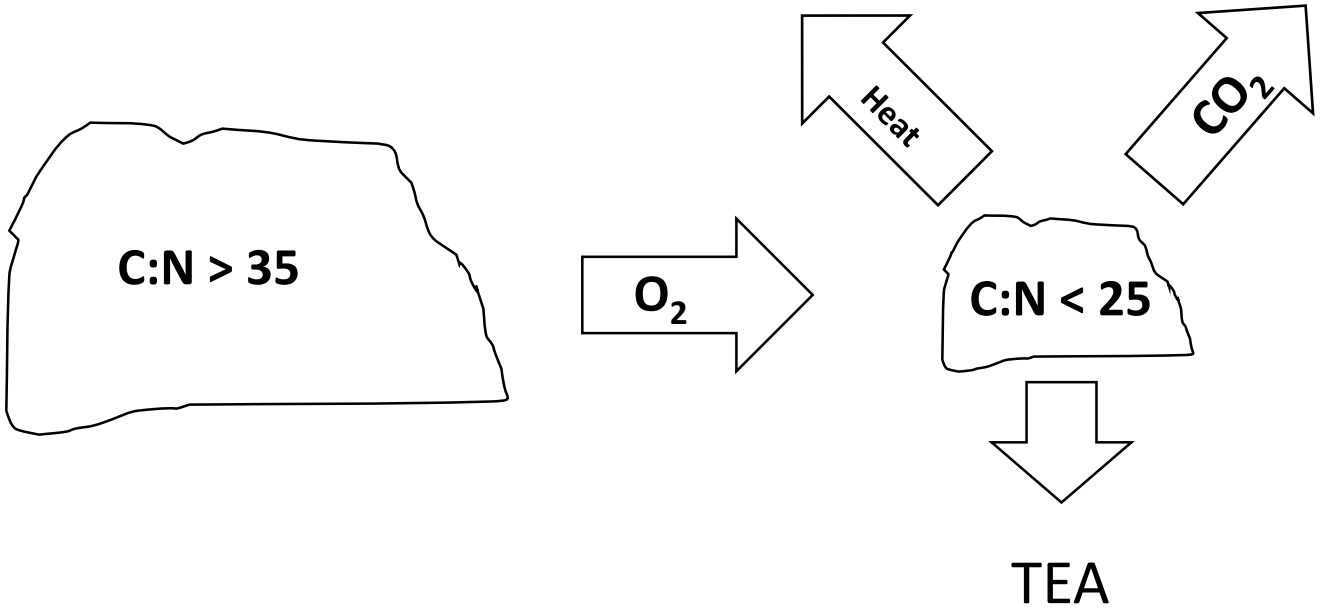


Table TCC.1. Default Transfer Efficiencies for Thermochemical Conversion Processes

Thermochemical Conversion Process	Transfer Efficiency (%)		
	NVE	NSE	PSE
Combustion	85	15	100
Gasification	85	15	100
Pyrolysis	25	75	100

Table TCC5: Defined Transfer Efficiencies of Thermochemical Conversion Processes based on Process Factors

Thermochemical Conversion Process	Operating Temperature (°F)	Transfer Efficiency (%)		
		NVE	NSE	PSE
Combustion	1,500 – 3,000	95	5	100
Gasification	1,500 – 2,700	85	15	100
Gasification	<1,500	25	75	100
Fast Pyrolysis RT ~ Seconds	750 – 1,100	75	25	100
Slow Pyrolysis RT ~ Hours or Days	575 – 1,475	25	75	100



Composting

Composting

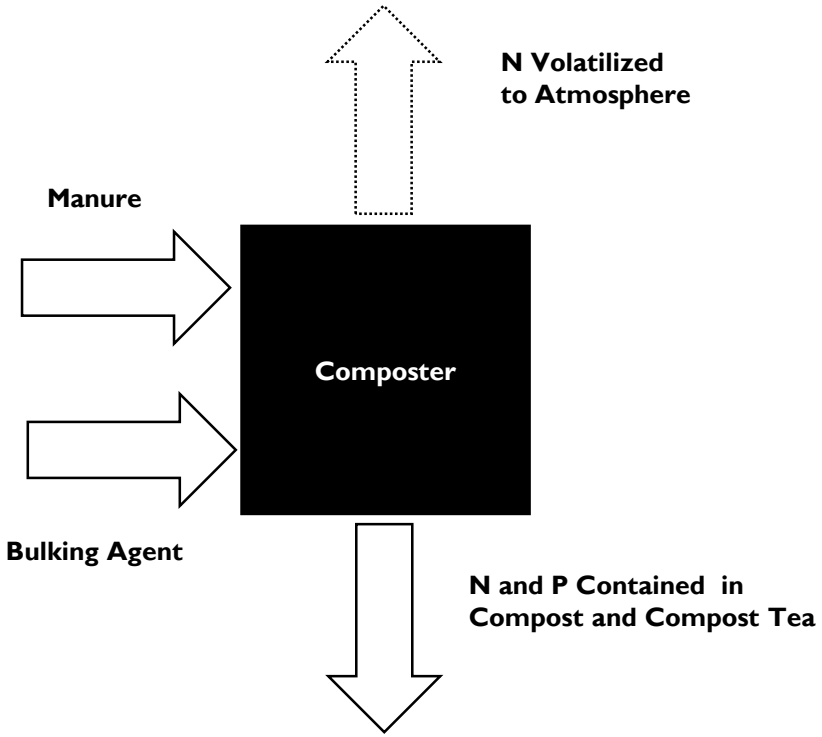

N Volatilized
to Atmosphere
Manure
Composter
Bulking Agent
N and P Contained in
Compost and Compost Tea

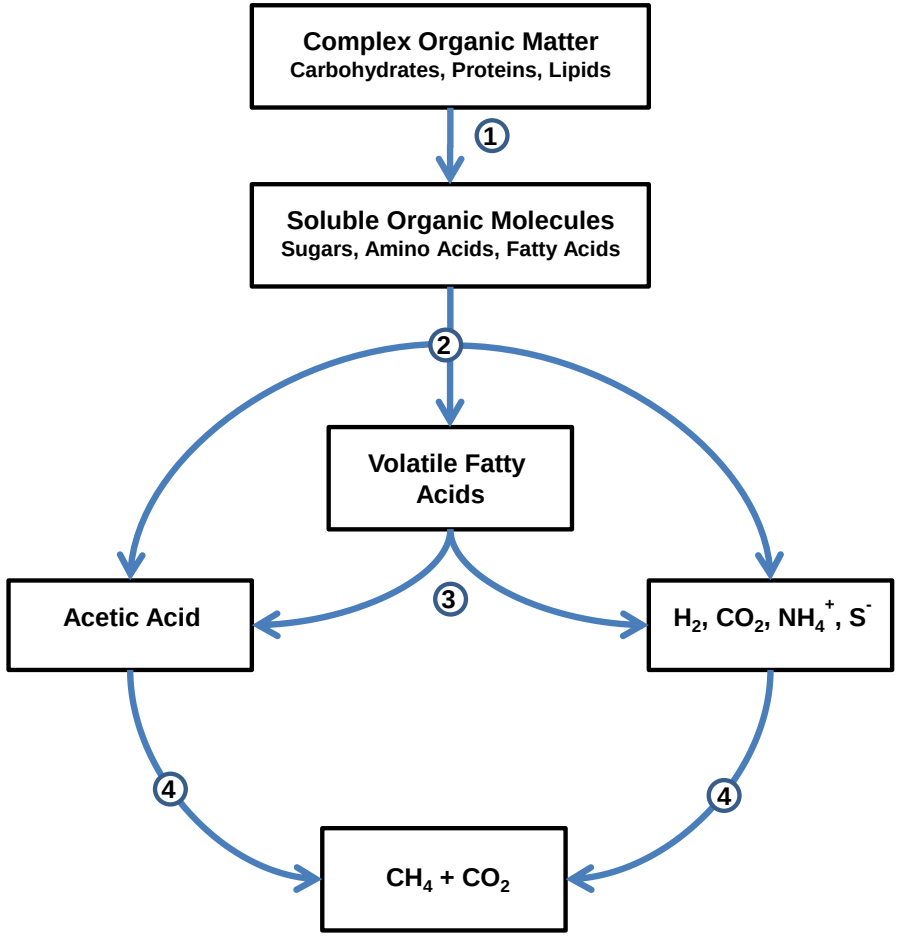
Table C1. Default Transfer Efficiencies for Composting Systems

Type of Composting System	Transfer Efficiency (%)		
	NVE	NSE	PSE
Turned Pile and Windrow	25	75	100
Static Pile and Windrow	26	74	100
In-Vessel and Rotating Bin	10	80	100
Forced Aeration	25	75	100

Table C8. Defined Transfer Efficiencies based on Composting System and C:N of Bulking Agent

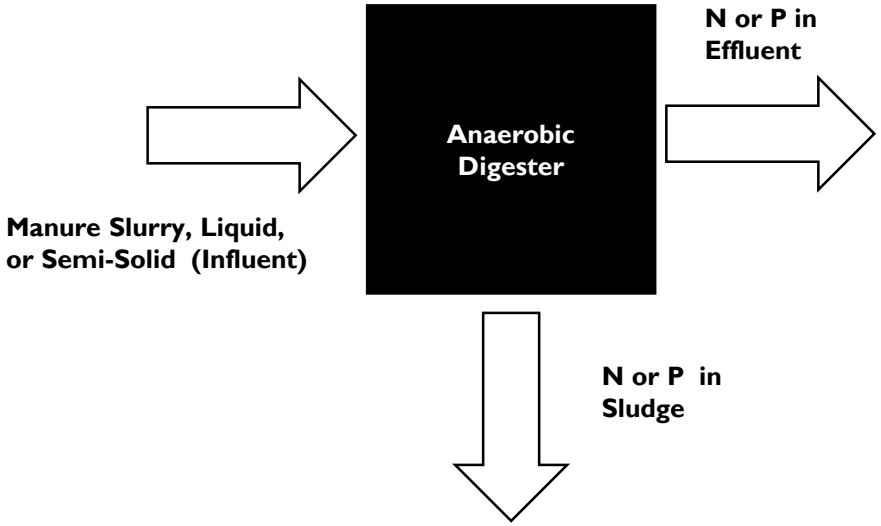
Type of Composting System	C:N of Bulking Agent <100			C:N of Bulking Agent >100		
	Transfer Efficiency (%)			Transfer Efficiency (%)		
	NVE	NSE	PSE	NVE	NSE	PSE
Turned Pile and Windrow	32	68	100	28	72	100
Static Pile and Windrow	33	67	100	29	71	100
In-Vessel and Rotating Bin	13	87	100	11	89	100
Forced Aeration	32	68	100	28	72	100

Anaerobic digestion



1 Hydrolysis
2 Acidosis
3 Acetogenesis
4 Methanogenesis

Anaerobic Digestion



Default Efficiencies for Anaerobic Digesters

NVE = NSE = PSE = 0

Settling

nrcs.usda.gov

Settling Basin

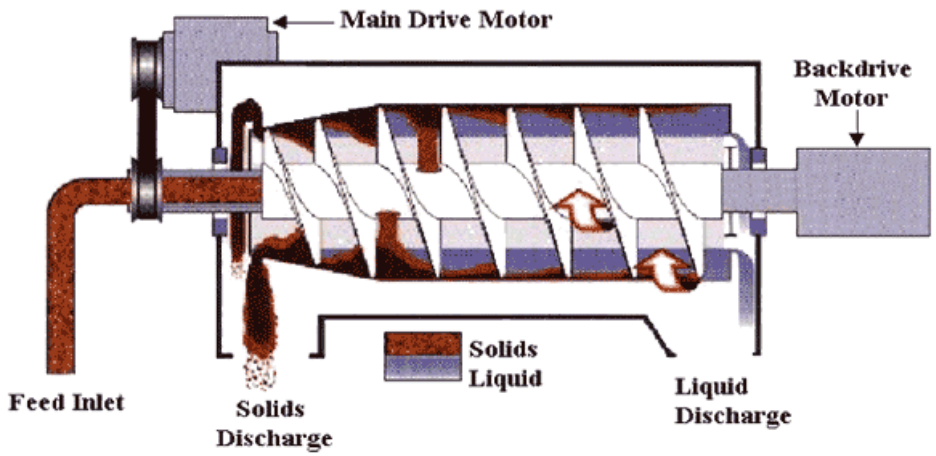
Umich.edu

Clarifier

OCES

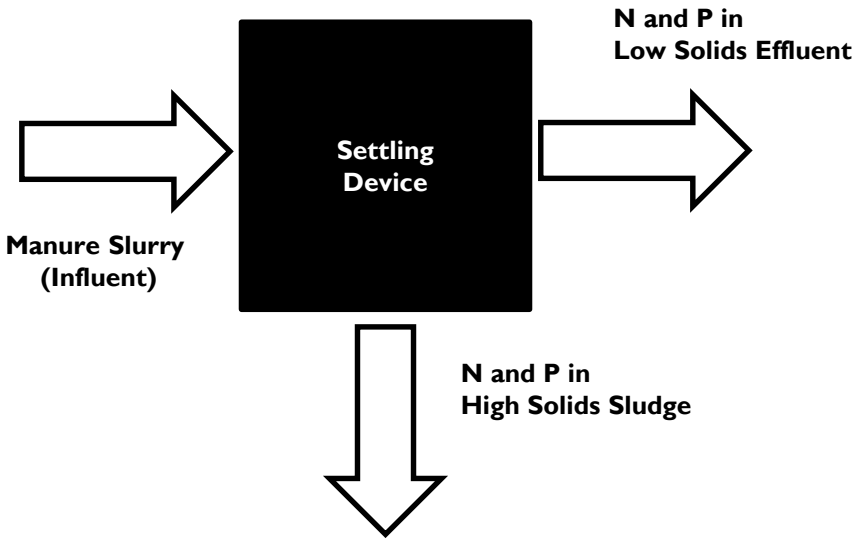
Devices that use Particle Size

Hutch-hayes.com



Devices that use Centrifugal Force

Mechanical Solid-Liquid Separation


Settling
Device
N and P in
Low Solids Effluent
Manure Slurry
(Influent)
N and P in
High Solids Sludge

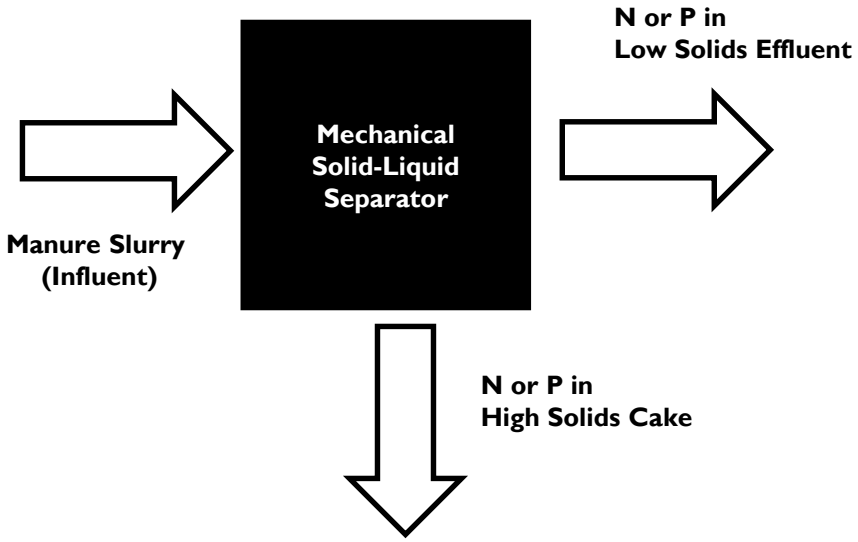

Mechanical
Solid-Liquid
Separator
N or P in
Low Solids Effluent
Manure Slurry
(Influent)
N or P in
High Solids Cake

Table STTL1. Default Transfer Efficiencies of Gravity Settling based on Type of Influent

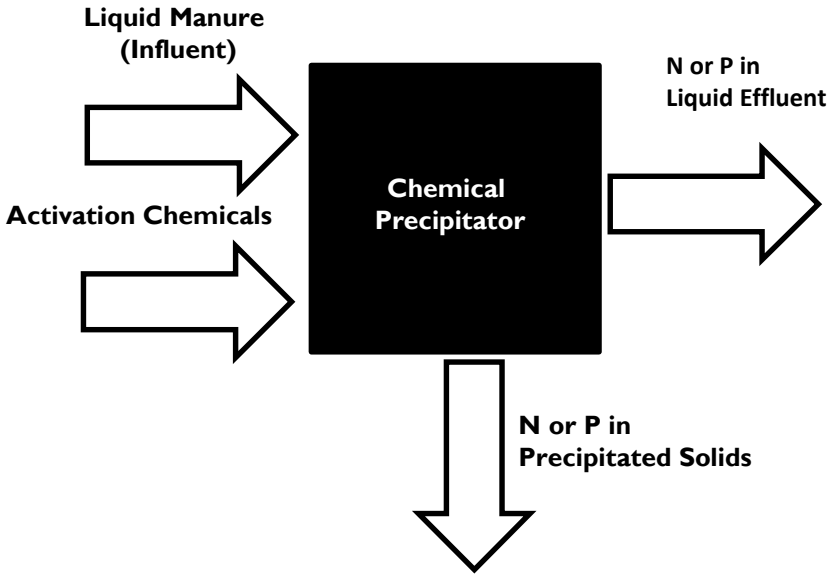
Type of Influent	Transfer Efficiency (%)		
	NVE	NSE	PSE
Milking Center Wash Water	0	20	47
Flushed Dairy Manure	0	25	45
Flushed Swine Manure	0	20	50

Table MSLS.1. Default Transfer Efficiencies for Mechanical Solid-Liquid Separators given Types of Separator and Manure

Type of Separator	Transfer Efficiency (%)				
	NVE	NSE		PSE	
	All Types of Manure	Dairy Manure	Swine Manure	Dairy Manure	Swine Manure
Stationary Screen	0	13	3	11	2
Rotating Screen	0	0	5	0	3
Screw Press	0	8	5	6	8
Belt Press	0	10	10	15	18
Brushed Screen Roller Press	0	13	6	15	6
Centrifuge	0	20	10	45	50

Wet Chemical Treatment

Wet Chemical Treatment



Because Wet Chemical Treatment depends on Dosing of Activation Chemicals

1. Default Level = Default Level for Settling and Mechanical Solid-Liquid Separation.

2. Recommend using Data Driven Levels.

Data Driven (Level 3) Transfer Efficiencies

Data Driven (Level 3) transfer efficiencies

- Applicable to a treatment system that utilizes one or more manure treatment technologies described in the report. Technologies may be proprietary or non-proprietary and may be used in any sequence to produce one or more end products for subsequent transport or land application.
- Unique transfer efficiencies determined using monitoring data; the calculated transfer efficiency will vary annually from system to system.
- Transport or land applications of any end products from these systems should be reported under separate BMPs (e.g. Manure Transport).
- Manure treatment systems that lack adequate annual performance data to support a Data Driven Transfer Efficiency (i.e., Level 3) should be reported using the appropriate Level 1 or Level 2 Transfer Efficiency for that system's primary manure treatment technology.
- See Table DD.1, page 115 of report

Future Research Needs

1. **Liquid Aerobic Systems**
2. **Other Defined Technologies**
3. **Update with Farm-Scale Data**

BMP verification

- MTT BMPs subject to the same expectations set forth in the partnership's BMP Verification Framework
  - http://www.chesapeakebay.net/about/programs/bmpverification
- Follow the AgWG's existing BMP verification guidance
  - http://www.chesapeakebay.net/about/programs/bmp/verification_guidance
- Manure treatment technologies have elements of both "Visual Assessment, Multi-Year" and "Non-Visual Assessment" BMP categories, as defined by the AgWG. Jurisdictions can follow the guidance for either of these categories for Level 1, 2 and 3 MTT BMPs.

BMP verification (continued)

- MTT BMPs are reported/credited annually, and closely related to Manure Transport. Transport is a Non-Visual Assessment BMP, so jurisdictions can utilize protocols/procedures outlined by the AgWG to spot check and verify their records of how much manure is treated, where it is transported, etc.
- The treatment systems themselves have physical components (e.g., a compost facility, a gasifier, etc.) which can be verified using the AgWG's guidance for Visual Assessment-Multi-Year BMPs.
- Systems reported using Level 3 transfer efficiencies will likely be associated with programs that provide more rigorous verification (regulatory, permit, trading). These programs will have detailed and specific requirements for data collection and reporting to provide the mass of volatilized nitrogen.

Reporting treatment BMPs for Phase 6 Watershed Model

Not covered in this presentation. See Appendix A and the April 14th webinar recording for details. The WTWG will discuss/review Appendix A in depth.

Table A.1. Manure Treatment BMPs eligible for crediting in the Phase 6.0 Watershed Model

Practice Number	Practice Category	Technology Specifications*
MTT1	Thermochemical	Slow Pyrolysis
MTT2	Thermochemical	Fast Pyrolysis**
MTT3	Thermochemical	Gasification-Low Heat
MTT4	Thermochemical	Gasification-High Heat**
MTT5	Thermochemical	Combustion
MTT6	Thermochemical	Combustion-High Heat**
MTT7	Composting	In-Vessel and Rotating Bin- Standard
MTT8	Composting	In-Vessel and Rotating Bin- C:N>100**
MTT9	Composting	In-Vessel and Rotating Bin- C:N<100**
MTT10	Composting	Forced Aeration- Standard
MTT11	Composting	Forced Aeration- C:N>100**
MTT12	Composting	Forced Aeration- C:N<100**
MTT13	Composting	Turned Pile and Windrow- Standard
MTT14	Composting	Turned Pile and Windrow- C:N>100**
MTT15	Composting	Turned Pile and Windrow- C:N<100**
MTT16	Composting	Static Pile and Windrow- Standard
MTT17	Composting	Static Pile and Windrow- C:N>100**
MTT18	Composting	Static Pile and Windrow- C:N<100**
MTT19	Directly Monitored	

* Definitions for specific thermochemical and composting technologies can be found in the report in Sections 4 and 5, respectively.

**Information about process factors, as described in Section 4, pages 29 - 32, and Section 5, pages 43-47, is needed to report these BMPs

Table A.2. Pollutant Reductions Associated with Manure Treatment Practices			
Practice #	TN Removal (%)	TP Removal (%)	TSS Removal (%)
MTT1*	25	0	0
MTT2	75	0	0
MTT3	25	0	0
MTT4	85	0	0
MTT5	85	0	0
MTT6	95	0	0
MTT7*	10	0	0
MTT8	11	0	0
MTT9	13	0	0
MTT10	25	0	0
MTT11	28	0	0
MTT12	32	0	0
MTT13	25	0	0
MTT14	28	0	0
MTT15	32	0	0
MTT16	26	0	0
MTT17	29	0	0
MTT18	33	0	0
MTT19	Monitored	0	0
*MTT1 represents the default practice Thermochemical treatment systems, and MTT7 represents the default for composting treatment systems.			

Timeline for review/approval of report

- **Thurs. March 31:** Report released for review/comment
- **Thurs. April 14**: Webinar
- **Wed. April 20**: Briefing for Trading and Offsets Workgroup
- **Thurs. April 21**: Presentation to AgWG. Abridged version of webinar presentation, no approval or decision will be requested until after comment period closes and response to comments is available.
- **Wed. May 3**: Initial 30-day comment period closes. Comments on the report should be submitted to Jeremy Hanson (jchanson@vt.edu) by close of business.
- **Thurs. May 19**: Present/discuss response to comments to AgWG; earliest potential date to seek AgWG approval of report.
  - Note: Any necessary adjustments to the schedule for workgroup approval as a result of major substantive comments will be made in coordination with leadership of the AgWG and WTWG.
- **Thurs. June 2**: Earliest potential date to seek WTWG approval
- **Mon. June 13** or **Mon. June 27**: Earliest potential dates to seek WQGIT approval

Questions?

THANK YOU

Comments on report are request by close of business on Wednesday, May 3. Comments should be submitted to Jeremy Hanson (jchanson@vt.edu).

Contact Jeremy with questions.

The April 14th webinar recording is available on the calendar entry:

http://www.chesapeakebay.net/calendar/event/23875/