Selection Guidance for Manure Management Technologies

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INTRODUCTION

Manure is an inevitable by-product of livestock production. Traditionally, manure has been land applied for the nutrient value in crop production and improved soil quality. With livestock operations getting larger and, in many cases, concentrating in certain areas of the country, it is becoming more difficult to balance manure applications to plant uptake needs. In many places, this imbalance has led to over application of nutrients with increased potential for surface water, ground water and air quality impairments.

The purpose of this poster is to provide an overview of several manure management technologies, outlining strengths and limitations for each process.

TECHNOLOGY SELECTION PROCESS

Several variables need to be evaluated before a decision is made on the selection of manure management technologies. Some of the major items of consideration include:

- Landowner Goals and Objectives
- Resource Concerns
- Regulatory Requirements
- Operational Size and Type
- Available/Required Application Area
- Marketable Product
- **$$**

TECHNOLOGY PROCESSES

- Biological
  - ✓ Anaerobic Digestion
  - ✓ Composting
  - ✓ Nitrification/Denitrification
- Chemical
  - ✓ Chemical Enhancement
  - ✓ Manure Amendments
  - ✓ Thermo-Chemical
    - Incineration
    - Gasification
    - Pyrolysis
- Physical
  - ✓ Solid/Liquid Separation
  - ✓ Pelletizing
- Other
  - ✓ Feed Management
  - ✓ Early Slaughter
  - ✓ Manure Transfer/Brokering
  - ✓ Agronomic
    - Land Application
    - Cover Crops
    - Crop Rotations

WHAT CAN BE DONE?

- Encourage landowners to install conservation practices to avoid water and air quality issues
- Encourage the use of innovative technologies that will reduce excess manure volume and nutrients and provide value added products
- Encourage the use of cover crops and rotational cropping systems to uptake nutrients at a rate more closely related to those from applied animal manures
- Encourage the use of local manure to provide nutrients for locally grown crops, and, when possible, discourage the importation of externally produced feed products
- Where excess manure can no longer be locally land applied, encourage options that make feasible the transport of nutrients to regions where needed
- Ensure that landowners understand the benefits and limitations of the various manure management technologies

CONCLUSIONS

- There are several options for addressing manure distribution and application management issues
- Each livestock operation will need to be evaluated separately, because there is no single alternative which will address all manure management issues
- Option selections are dependent on a number of factors such as: objectives, land availability, nutrient loads, and available markets
- Several alternatives may need to be combined to meet the desired outcome
- Water and air quality concerns also need to be addressed when dealing with manure management issues
- Most options require significant financial investment

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Physical Processes

Solid/Liquid Separation

Benefits

1. Partition solids, liquids and nutrients
2. Separated solids more economical to transport
3. Alternative uses for solids (i.e. bedding, fuel)
4. Multiple waste streams provide flexibility in farm operations

Limitations

1. Expense of mechanical separation processes
2. Multiple waste streams need to be addressed

Pelletizing

Benefits

1. Biofibers and nutrients densified for long term storage
2. Reduced transportation costs

Limitations

1. Maintaining pellet integrity may be an issue
2. Proper moisture is necessary to maintain pellet integrity
3. Potential odor

Chemical Processes

Thermo-Chemical Processes
Incineration, Gasification, Pyrolysis

Benefits

1. Energy source for various applications
2. Reduced manure volume
3. Phosphorus and potassium retained
4. Pathogens destroyed

Limitations

1. Nitrogen lost with most processes
2. High initial cost
3. May require labor expertise

See handout for specific thermo-chemical process benefits and limitations.

Chemical Enhancement

Benefits

1. Enhanced separation of suspended and dissolved solids from liquid waste stream
2. Improved partitioning of nutrients, especially phosphorus

Limitations

1. Chemical reaction can vary from day-to-day
2. Testing is required to determine proper chemical and application rates
3. Chemical costs

Biological Processes

Anaerobic Digestion

Benefits

1. Reduced odor
2. Biogas used for energy applications
3. Reduces effects of greenhouse gases
4. Significant reduction in pathogens
5. Nutrients remain after digestion process

Limitations

1. No nutrient reduction
2. No volume reduction
3. Large construction footprint
4. High Initial cost
5. May require labor expertise

Composting

Benefits

1. Reduced manure volume
2. Stable product
3. Phosphorus and potassium retained
4. Efficient means of dead animal disposal

Limitations

1. Significant amounts of NH_3, CO_2 and NO_x can be lost to the atmosphere
2. Processing may take months for final product
3. Markets can become quickly saturated

Other Processes

Land Application

Benefits

1. Valuable nutrients are recycled
2. Improved soil quality
3. Incorporation/injection can significantly reduce air emissions and odors
4. Can be locally applied if suitable land is available

Limitations

1. Potential movement with surface water
2. Without proper testing and analysis, soils can become nutrient saturated
3. High potential for ammonia loss to the atmosphere
4. Potential for odor

Feed Management

Benefits

1. Reduced manure nutrient content
2. Manure volume may be reduced
3. Reduced methane production
4. Reduced animal production costs

Limitations

1. Integrator and not the producer has control of poultry and some swine feed rations
2. Additives or ration changes could increase feed costs

Common and Emerging Manure Technologies

Practice	Application	Positives	Negatives	Comments
Biological Treatment Technologies				
Anaerobic Digestion [proven technology]	Biological treatment of animal manure and other biomass in the absence of oxygen [wet or liquid manure (dairy, swine), but dry manure (beef, poultry) if hydrated first]	a) Reduced odor b) Reduces the effects of greenhouse gases (methane, CO_2 , H_2O, and small amounts of N_2, CO, H_2,O_2 and H_2S) c) Syngas used for energy production (biogas) d) Pathogens significantly reduced e) End products: liquid and solids can be used as fertilizer f) Potential income from carbon credits	a) No nutrient reduction b) No reduction of manure volume c) Large construction footprint required for practice d) High cost e) Solid/liquid separation needed to reduce maintenance costs and cost of pumping (<25 % solids) f) Effluent product-may need more treatment	a) Nutrients are retained through the digestion process b) A portion of the N & P is converted to more plant available forms c) Through the digestion process the manure tends to become more liquid in nature d) Anaerobic digestion is a relatively slow process (i.e., several wks) e) Reduced air emissions issues f) Many successful applications when operation and maintenance are done by dedicated staff, or by a third party
Aerobic Digestion [proven technology]	Biological treatment of animal manure and other biomass in the presence of oxygen [most commonly liquid (effluent)]	a) Reduced methane and NO_X b) Pathogens significantly reduced c) Reduced odor d) Phosphorus and Potassium can be recovered and used as fertilizer e) Effluent product –cleaner than w/ anaerobic process	a) High operating cost because of electricity demand for aerator b) Significant loss of nitrogen to the atmosphere	a) Available technology makes it possible to nearly eliminate air emissions issues b) Does a better job removing suspended solids resulting in generally cleaner water output than with anaerobic digestion
Aerobic Digestion "Composting" [proven technology]	Processing of animal manure or other organic by-products into biologically stable organic matter [solid animal manure]	a) Reduced manure volume/weight b) Stable product c) Phosphorus and potassium retained d) Pathogens significantly reduced e) Can be used as a soil amendment f) Depending on the nutrient content may qualify as an organic fertilizer g) Efficient means of dead animal disposal h)Soil quality benefits	a) Significant amounts of NH_3, CO_2, methane, and NO_X can be lost to the atmosphere. (Properly aerated compost will have minimal NOx emissions) b) b) Processing may take 3 to 6 months or more for a finished product c) c) Salts within the manure are concentrated d) Markets can become quickly saturated	a) Markets would need to be developed for efficient sale of composted materials b) Markets may become saturated in areas of high animal production density c) Many on-farm attempts are hindered by the workload involved with turning the pile of compost several times during the composting process, and by lack of marketing expertise d) Use of rotary drum composters can reduce the composting period
Anaerobic + Aerobic Digestion [proven technology]	Anaerobic digestion followed by aerobic digestion	a) Reduced methane/NO_X b) Pathogens significantly reduced c) Reduced odor	a) High combined expense to maintain both systems b) Large construction foot print c) Significant loss of nitrogen to the atmosphere	a) Combined process is more efficient at removing solids and pathogens from slurry manures resulting in cleaner water exiting the system,
Thermo-Chemical Technologies (used in various combinations)				
Incineration [emerging manure technology]	Thermal conversion of animal manure and other biomass in an oxygen rich environment [Well suited for dry or dried manures}	a) Reduced manure volume b) Heat energy production c) Phosphorus and potassium retained in ash has fertilizer value d) Pathogens destroyed	a) Potential air emission issues - air scrubbing may be necessary b) Nitrogen lost through air emissions (NO_X) c) Sand and other inorganics may affect performance d) High initial cost	a) For wet or liquid manures solid/liquid separation methods may be required b) A commercial poultry litter incineration plant is in operation in MN; others are proposed in NC, GA, MS, AR, and MD. A single plant would burn almost all of the poultry litter produced on the MD eastern shore. c) A prototype dairy manure incineration system is in operation in WI (Elimanure)
Gasification [emerging manure technology]	Thermal conversion of animal manure and other biomass in an oxygen starved environment [Well suited for dry or dried manures}	a) Reduced manure volume b) Syngas used for energy production (biogas) c) Phosphorus and potassium retained in char has fertilizer value d) Reduces the effects of greenhouse gases (methane, CO_2 H_2O, and small amounts of other gases) e) Smaller construction footprint than anaerobic digestion f) Pathogens destroyed	a) Nitrogen lost through air emissions (N_2) b) Sand and other inorganics may affect performance c) Syngas may need further processing before being used for power production d) High initial cost	a) For wet or liquid manures solid/liquid separation methods may be required b) Gasification technology is old, but applications using manure are limited c) Gasification projects utilizing manure have been, or are being, tested through the FPPC and CIG grants d) Privately funded prototype for poultry –HTI of MI e) Minimal air emissions issues
Pyrolysis [emerging manure technology]	Thermal conversion of animal manure and other biomass under anaerobic conditions [Well suited for dry or dried manures}	a) Reduced manure volume b) Syngas used for energy production (biogas) alternatives c) Bio-oil has various uses including energy production d) Phosphorus and potassium retained in char has fertilizer value e) Reduces the effects of greenhouse gases (methane, CO_2 H_2O, and small amounts of other gases) f) Smaller construction footprint than anaerobic digestion g) Pathogens destroyed	a) Some nitrogen lost through air emissions (N_2) b) Bio-oil may not be stable c) Production rates between feed sources can vary greatly d) Uses for bio-oil may be limited without additional processing e) High initial cost	a) For wet or liquid manures solid/liquid separation methods may be required b) Pyrolysis technology is old, but applications using manure are limited c) Products include: biogas, bio-oil, and bio-char d) A FPPC poultry litter pyrolysis project is currently underway in the Ches. Bay Watershed (VA) e) Minimal air emissions issues

Other Associated Technologies

Practice	Application	Positives	Negatives	Comments
Chemical Treatment Technologies				
Chemical Enhancement	Application of metal salts and/or polymers to manure to improve solid/liquid separation	a) Enhanced separation of suspended and dissolved solids from the liquid waste stream b) Improved partitioning of nutrients, especially Phosphorus	a) Chemical reaction can vary day-to-day b) Testing needed to determine proper chemical and application rate c) Chemicals expensive	a) Chemical enhancement in conjunction with solid/liquid separation can remove 90% or more of total phosphorus from the liquid waste stream. b) Large number of chemicals and polymers are available
Manure Amendments	Application of amendments during manure production or storage to address a resource concern	a) Generally easy to use b) Can select amendment for specific need c) Effectively reduces ammonia emissions d) Can be used as a phosphorus binder e) Can be used to enhance solid/liquid separation	a) Difficult to determine product effectiveness b) Generally only a "stop-gap" solution c) Amendments can be expensive	a) For poultry, research shows that certain amendments increased productivity and lowered ammonia emissions. b) Manure amendments have been shown to phosphorus in runoff and to lower leaching potential
Other Technologies Associated with the Use and Management of Animal Manure/Byproducts				
Granulating or Pelletizing	Volume reduction through pressure and heat of animal manure and other biomass	a) Biofibers and nutrients densified for longer term storage b) Reduced transportation costs	a) Maintaining pellet integrity may be an issue b) Proper moisture is necessary to maintain pellet quality	a) Pellets can be developed as transportable energy source or as a fertilizer source b) Easily handled, reduced volume fertilizer product for transport and marketing c) Current Perdue Agrirecycle plant in DE ships about 60K tons of litter product from the eastern shore
Feed management and early slaughter	a) Feed additives that reduce the nutrient content of the manure b) Feed efficiency may reduce the amount of manure and methane generated c) Older ruminant animals produce more methane	a) Reduced manure nutrient content b) Manure volume may be reduced c) Reduced methane production d) Reduced animal production costs	a) Integrator and not the producer has absolute control of poultry and sometimes swine diets b) Additives or ration changes could increase feed costs	a) The widespread addition of Phytase to broiler diets has decreased manure phosphorus levels by 20 percent or more in the last decade b) A focus on feed management, coupled with price increases for phosphate has decreased an excess amount of phosphorus in dairy rations.
Agronomic Practices Associated with the Land Application of Manure	Appropriate application of manure to agricultural land to grow crops	a) Valuable nutrients are recycled b) Improved soil quality factors c) Pathogens can be reduced if applied properly d) Incorporation/injection can significantly reduce air emissions and odors e) Locally applied if suitable land is available	a) Potential movement with surface water b) High potential for ammonia and NO_X loss to atmosphere c) Odor d) Cannot be applied to nutrient saturated fields	a) Nutrient Management planning tools are available to help producers apply nutrients in accordance with EPA and USDA requirements (e.g., NRCS-590 NMP, CNMP and EPA-NMP) b) Numerous conservation practice standards (bmp) are available to provide guidance for installation of science based technologies that minimize environmental degradation or help to improve a degraded condition. Practices are available for the Land treatment area and for the animal production area c) Research by ARS and the Land Grant universities has shown that conservation practices that keep manure nutrients from entering waterways, also keeps manure pathogens from entering waterways
Manure transfer/brokering	Transporting manure from regions where it's not needed to regions where it can be safely utilized as a plant nutrient source	a) Generates income for the producer b) Manure not applied to nutrient saturated fields c) Nutrients are recycled d) Soil quality benefits e) Less dependence on commercial fertilizers	a) Need a broker and viable market b) Income may be marginal after brokerage and transportation costs are deducted.	a) Many States subsidize the intra- and inter- State transfer manure to other locations b) Many individual farm operations enter into contracts for transfer of manure to off-site farms/ facilities c) Manure brokering is very competitive business throughout the Delmarva Peninsula, and with the poultry industry in WV
Solid/Liquid Separation	Processes used to partition the waste streams of animal manures and other materials [Wet and liquid manure systems]	a) Processes partition solids, liquids and nutrients in the waste stream b) Separated solids are lighter and more economical to transport c) Separated solids may be used for animal bedding or as a fuel source d) Multiple waste streams can provide additional flexibility in farm operations e) Makes separated solid/liquids easier to handle f) Separation of solids from liquids can reduces odors	a) Mechanical separation process can be quite expensive b) Multiple waste streams need to be addressed-separate transference, storage, and treatment considerations	a) Various separation methods are available including both mechanical and non-mechanical processes b) Separation efficiencies vary by process and manure type c) Separation of solids and/or nutrients can be enhanced by chemical means (polymers)