

Practice	Application	Positives	Negatives	Comments
<b>Biological Treatment Technologies</b>				
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 <sub>2</sub> , H <sub>2</sub> O, and small amounts of N <sub>2</sub> , CO, H <sub>2</sub> O <sub>2</sub> and H <sub>2</sub> S) 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 <sub>x</sub> 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 <sub>3</sub> , CO <sub>2</sub> , methane, and NO <sub>x</sub> can be lost to the atmosphere. (Properly aerated compost will have minimal NO <sub>x</sub> emissions.) b) Processing may take 3 to 6 months or more for a finished product 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 <sub>x</sub> b) Pathogens significantly reduced c) Reduced odor	a) High combined expense to maintain both systems b) Large construction footprint 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,
<b>Thermo-Chemical Technologies (used in various combinations)</b>				
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 <sub>x</sub> ) 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 <sub>2</sub> , H <sub>2</sub> O, and small amounts of other gases) e) Smaller construction footprint than anaerobic digestion f) Pathogens destroyed	a) Nitrogen lost through air emissions (N <sub>2</sub> ) 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 f) Technology is being used for mortality management (cost shared in NC)
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 <sub>2</sub> , H <sub>2</sub> O, and small amounts of other gases) f) Smaller construction footprint than anaerobic digestion g) Pathogens destroyed	a) Some nitrogen lost through air emissions (N <sub>2</sub> ) 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 Chesapeake Bay Watershed (VA) e) Minimal air emissions issues

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<b>Chemical Treatment Technologies</b>				
Chemical Enhancement	Addition of metal salts and/or polymers to manure to improve solid/liquid separation	<ul style="list-style-type: none"> <li>a) Enhanced separation of both suspended and dissolved solids from the liquid waste stream</li> <li>b) Improved partitioning of nutrients, especially phosphorus</li> </ul>	<ul style="list-style-type: none"> <li>a) Chemical performance can vary from day to day</li> <li>b) Testing is necessary to determine proper chemical and application rate</li> <li>c) Chemicals can be quite expensive</li> </ul>	<ul style="list-style-type: none"> <li>a) Chemical enhancement in conjunction with solid/liquid separation can remove 90% or more of total phosphorus from the liquid waste stream</li> <li>b) There are a large number of polymers and chemicals that can be used</li> </ul>
Manure Amendments	Application of amendments during manure production or storage to address a resource concern	<ul style="list-style-type: none"> <li>a) Generally easy to use</li> <li>b) Amendment can be selected to meet a specific need</li> <li>c) Effective in reducing ammonia emissions</li> <li>d) Can be used as a phosphorus binder</li> <li>e) Can also be used to enhance solid/liquid separation</li> </ul>	<ul style="list-style-type: none"> <li>a) Difficult to determine product effectiveness</li> <li>b) Generally only serves as "stop gap" solution to a problem</li> <li>c) Product may be expensive</li> </ul>	<ul style="list-style-type: none"> <li>a) For poultry research has shown that use of certain amendments have led to increased productivity and lower energy use as a result of lower ammonia emissions</li> <li>b) Manure amendments have been shown to reduce phosphorus in runoff and lower the leaching potential</li> </ul>
<b>Physical Treatment Technologies</b>				
Granulating or Pelletizing	Volume reduction through pressure and heat of animal manure and other biomass	<ul style="list-style-type: none"> <li>a) Biofibers and nutrients densified for longer term storage</li> <li>b) Reduced transportation costs</li> </ul>	<ul style="list-style-type: none"> <li>a) Maintaining pellet integrity may be an issue</li> <li>b) Proper moisture is necessary to maintain pellet quality</li> </ul>	<ul style="list-style-type: none"> <li>a) Pellets can be developed as transportable energy source or as a fertilizer source</li> <li>b) Easily handled, reduced volume fertilizer product for transport and marketing</li> <li>c) Current Perdue Agri-recycle plant in DE ships about 60K tons of litter product from the eastern shore</li> </ul>
Solid/Liquid Separation	Processes used to partition the waste streams of animal manures and other materials  [Well suited for wet and liquid manure systems]	<ul style="list-style-type: none"> <li>a) Processes partition solids, liquids and nutrients in the waste stream</li> <li>b) Separated solids are lighter and more economical to transport</li> <li>c) Separated solids may be used for animal bedding or as a fuel source</li> <li>d) Multiple waste streams can provide additional flexibility in farm operations</li> <li>e) Makes separated solid/liquids easier to handle</li> <li>f) Separation of solids from liquids can reduce odors</li> </ul>	<ul style="list-style-type: none"> <li>a) Mechanical separation process can be quite expensive</li> <li>b) Multiple waste streams need to be addressed-separate transference, storage, and treatment considerations</li> </ul>	<ul style="list-style-type: none"> <li>a) Various separation methods are available including both mechanical and non-mechanical processes</li> <li>b) Separation efficiencies vary by process and manure type</li> <li>c) Separation of solids and/or nutrients can be enhanced by chemical means (polymers)</li> </ul>
<b>Other Technologies Associated with the Use and Management of Animal Manure/Byproducts</b>				
Feed management and early slaughter	<ul style="list-style-type: none"> <li>a) Feed additives that reduce the nutrient content of the manure</li> <li>b) Feed efficiency may reduce the amount of manure and methane generated</li> <li>c) Older ruminant animals produce more methane</li> </ul>	<ul style="list-style-type: none"> <li>a) Reduced manure nutrient content</li> <li>b) Manure volume may be reduced</li> <li>c) Reduced methane production</li> <li>d) Reduced animal production costs</li> </ul>	<ul style="list-style-type: none"> <li>a) Integrator and not the producer has absolute control of poultry and sometimes swine diets</li> <li>b) Additives or ration changes could increase feed costs</li> </ul>	<ul style="list-style-type: none"> <li>a) The widespread addition of Phytase to broiler diets has decreased manure phosphorus levels by 20 percent or more in the last decade</li> <li>b) A focus on feed management, coupled with price increases for phosphate has decreased an excess amount of phosphorus in dairy rations.</li> </ul>
Agronomic Practices Associated with the Land Application of Manure	Appropriate application of manure to agricultural land to grow crops	<ul style="list-style-type: none"> <li>a) Valuable nutrients are recycled</li> <li>b) Improved soil quality factors</li> <li>c) Pathogens can be reduced if applied properly</li> <li>d) Incorporation/injection can significantly reduce air emissions and odors</li> <li>e) Locally applied if suitable land is available</li> </ul>	<ul style="list-style-type: none"> <li>a) Potential movement with surface water</li> <li>b) High potential for ammonia and NO<sub>x</sub> loss to atmosphere</li> <li>c) Odor</li> <li>d) Cannot be applied to nutrient saturated fields</li> </ul>	<ul style="list-style-type: none"> <li>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)</li> <li>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</li> <li>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</li> </ul>
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	<ul style="list-style-type: none"> <li>a) Generates income for the producer</li> <li>b) Manure not applied to nutrient saturated fields</li> <li>c) Nutrients are recycled</li> <li>d) Soil quality benefits</li> <li>e) Less dependence on commercial fertilizers</li> </ul>	<ul style="list-style-type: none"> <li>a) Need a broker and viable market</li> <li>b) Income may be marginal after brokerage and transportation costs are deducted.</li> </ul>	<ul style="list-style-type: none"> <li>a) Many States subsidize the intra- and inter- State transfer manure to other locations</li> <li>b) Many individual farm operations enter into contracts for transfer of manure to off-site farms/ facilities</li> <li>c) Manure brokering is very competitive business throughout the Delmarva Peninsula, and with the poultry industry in WV</li> </ul>