Utilization of Nutrients from Animal Manure: Legislation and Technology Solutions

Ariel A. Szögi* and Matias B. Vanotti

U.S. Dept. of Agriculture, Agricultural Research Service. Coastal Plains Soil, Water, and Plant Research Center. 2611 W. Lucas Street, Florence, SC 29501, USA

* **Corresponding author** (szogi@florence.ars.usda.gov)

Livestock and poultry manures are a traditional source of organic nutrients in agriculture. Under proper management, animal manure is a valuable source of plant nutrients that can reduce or eliminate the use of commercial fertilizer and also provides organic carbon that enhances soil physical properties. However, excess nutrient application to soil is a major environmental issue in U.S. and Canada (Ludwick and Johnston 2002), Europe (Brouwer et al. 1999) and other parts of the world with intensive confined animal production such as Brazil (Oliveira 1993). In general, there are major concerns regarding the generation of large amounts of manure by concentration of confined animal production units within relatively small geographic areas and the potential to impair ground and surface water quality due to soil leaching or runoff of land applied nutrients. In the U.S., land application of manure may be difficult and costly to implement due to current trends indicating that animal operations are declining in number and growing in size (USDA-ERS 2000). For confined animal operations in the U.S., 60% of available nitrogen (N) and 70% of available phosphorus (P) were in excess of the amount of manure N and P that could be assimilated on the farms that produced them (**Table 1**). In addition, about 20% of the farm-level excess N and 23% of the farm-level excess P exceeded the land assimilative capacity at the county level (Kellogg et al. 2000). Therefore, substantial amounts of manure N and P need to be moved at least off the farms and that some need to be transported longer distances beyond county limits to solve distribution problems of these nutrients.

A new rule revised and clarified U.S. Environmental Protection Agency's (USEPA) administration of Clean Water Act regulations pertaining to animal operations (U.S. EPA 2003).

Table 1: Manure nutrient production on confined livestock operations in the U.S., 1997 (Source: Gollehon et al. 2001)

	Thousand tons of nutrients	
	N	P_2O_5
Available	1226	664
Farm-level excess	734	462

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This rule will limit manure application rates on crop and pasture land for those concentrated animal feeding operations (CAFOs) falling under the regulation. Under the Clean Water Act, CAFOs require a national Pollutant Discharge Elimination System (NPDES) permit to operate. As part of the NPDES, the rule requires all CAFOs to develop and implement a nutrient management plan for applying animal manure and commercial fertilizer to cropland. The nutrient management plan is N or P based depending on the phosphorus content of the soil. In addition, U.S. Department of Agriculture (USDA) is promoting the use of comprehensive nutrient management plans (CNMPs) as a management practice for all CAFOs to reduce the potential environmental threat of manure to soil, water and air quality as well a human and animal health. Still, state regulatory agencies will have a central role in implementing the new rule and sustaining voluntary efforts of other agencies. These measures that apply to about 15,500 livestock operations across the country will promote the need for either an increase in the amount of farm land for manure application, or a large increase in the amount of manure moved beyond the farm operation (Ribaudo et al. 2003).

In order to comply with new U.S. federal and state regulations for manure application, a new generation of technologies is currently under development. Tools used for development of CNMPs are currently being tested and improved. Site specific technologies and soil P index are being implemented at the state level to maximize agronomic utilization of nutrients and environmental benefit (Henry et al. 2003). However, environmentally-safe alternatives to land application of manure should be part of CNMPs in those areas where nutrient land application largely exceeds the soil assimilation capacity and/or would cause significant environmental risks. Thereby, more efficient and cost-effective methods are needed for manure handling and utilization.

Some of the alternative technologies to manure spreading that are currently under research or full-scale demonstration in the U.S. are shown in **Fig. 1** (Vanotti and Hunt 2001). Aside from diet manipulation that reduces the excretion of certain nutri-

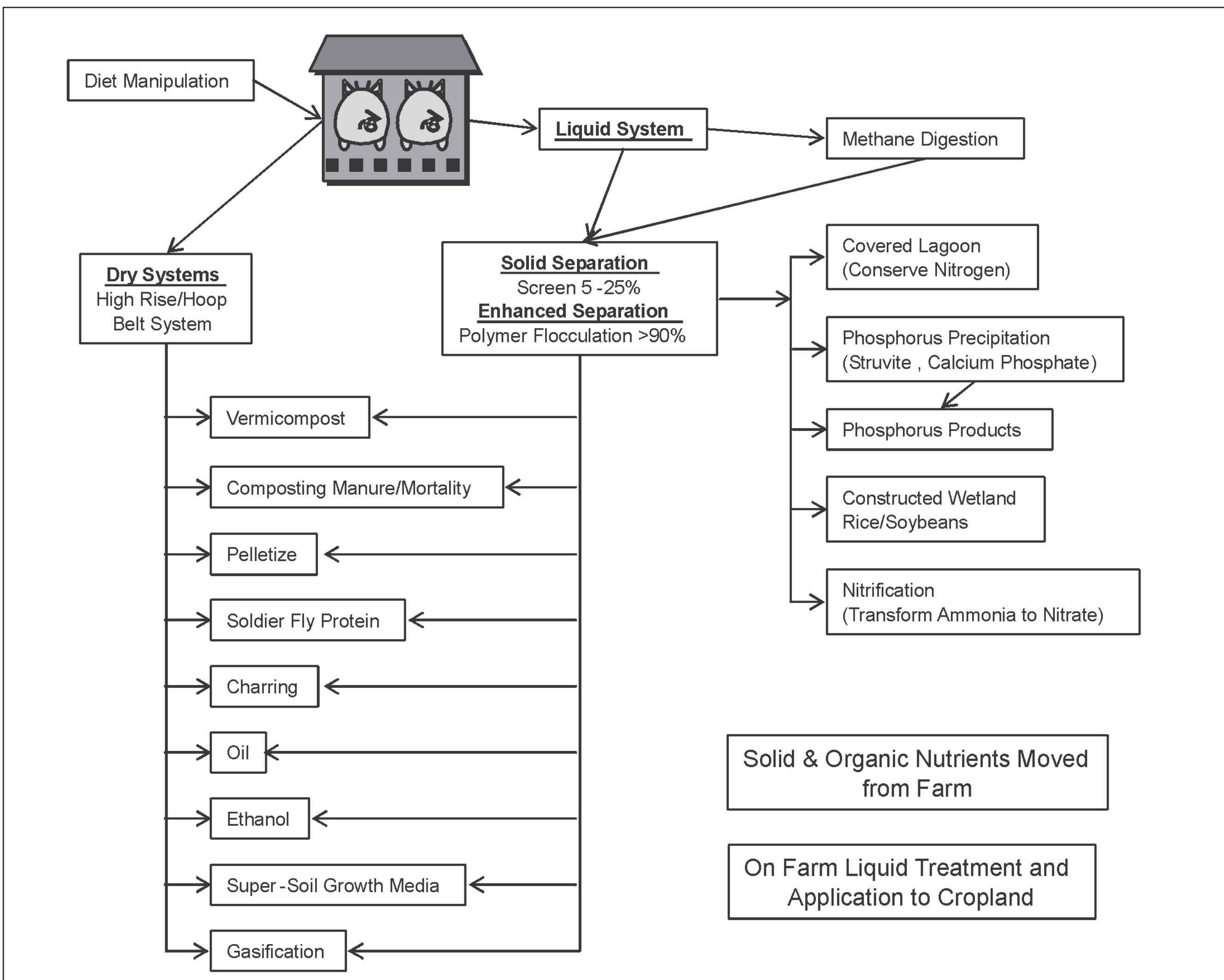

Fig. 1: Alternative technologies to manure

ents (e.g., phosphorus), Fig. 1 shows two other approaches to manure management. One approach is the utilization of dry systems such as the high rise or hoop structures where fresh manure is mixed with a bulking agent or a conveyor belts under a slatted floor is used to separate urine and solids so that the manure is directly handled as a solid. A second approach is to improve or retrofit existing liquid systems so that organic nutrients are separated from fresh manure and transported and treated with a variety of technologies to generate value-added products such as peat substitutes, fertilizers, soil amendments, energy, and proteins. The remaining liquid needs to be treated on farm using a variety of biological, physical or chemical processes to achieve specific nutrient reduction and management goals. Hopefully, some of these new technologies will solve one of the major problems in sustainability of confined animal production which is the imbalance between N and P in the manure (Cochran et al. 2000, USEPA 2003). Nutrients in manure are not present in the same proportion needed by crops. For example, a typical N:P ratio (4:1) in swine manure is generally lower than the mean N:P ratio (8:1) taken up by major crops and pastures (USDA 2001). Thus, when manure is applied based on a crop's nitrogen requirement, there is a P buildup in soil and increased potential for P losses through runoff and subsequent eutrophication of surface waters (Heathwaite et al. 2000, Sharpley et al. 2000). For liquid systems, past research efforts on soluble P removal from livestock wastewater in the U.S. and Europe using biological and chemical treatments were frustrating due to the large chemical demand or limited value of byproducts (Westerman and Bicudo 1998, Greaves et al. 1999). However, most recently a wastewater treatment process was developed for removal of nitrogen and phosphorus from livestock wastewater by consecutive solid/liquid separation, biological N treatment and P removal (Vanotti et al. 2001). Phosphorus is removed after biological N treatment by increasing the pH of wastewater by adding controlled amounts of hydrated lime to precipitate soluble P (Vanotti et al. 2003a,b, Szogi et al. 2003). The treated effluent has a specified N:P ratio that is useful as a balanced liquid fertilizer or a low P fertilizer for remediation of contaminated soils. The precipitated phosphorus is recovered as a concentrated P fertilizer product. This technology has the potential to solve current problems with excessive accumulation of N and P in soils receiving liquid manures and produces a valuable P fertilizer material that can be transported to P deficient croplands.

New regulations and current trends of animal production concentration will promote the need of environmentally-safe technologies for handling of excess manure nutrients. Affordable technologies for N and P recovery from manures will be needed in the near future to enable CAFOs to implement required CNMPs when land is limiting for manure application. The inclusion of P recovery technologies in CNMPs will help to maintain sustainability of confined animal production while conserving P, a finite resource.

References

Brouwer F, Hellegers, Hoogeveen M, Luesink H (1999): Managing nitrogen pollution from intensive livestock production in the EU. Rapport 2.99.04 Agricultural Economics Research Institute (LEI). The Hague, 129 p.

Cochran K, Rudek J, Whittle D (2000): Dollars and Sense: An economic analysis of alternative hog waste management technologies. Environmental Defense, Washington, D.C. 20009

Gollehon N, Caswell M, Ribaudo M, Kellog R, Lander C, Letson (2001): Confined animal production and manure nutrients. Resource Economics Division, Economic research Service, U.S. Department of Agriculture. Agriculture Information Bulletin No. 711, 34 p.

Greaves J, Hobbs P, Chadwick D, Haygarth P (1999): Prospects for the recovery of phosphorus from animal manures: a review. Env Tech 20, 697–708

Heathwaite L, Sharpley A, Gburek W (2000): A conceptual approach for integrating phosphorus and nitrogen management at watershed scales. J Environ Qual 29, 158–166

Henry ST, Kloot RW, Evans M, Hardee G (2003): Comprehensive nutrient management plans and the tools used to develop them in South Carolina. In Proc 9th International Symposium Agricultural and Food Processing Wastes, ASAE 418–421

Kellog, RL, Lander CH, Moffitt DC, Gollehon N (2000): Manure nutrients relative to the capacity of cropland and pastureland to assimilate nutrients: Spatial and temporal trends for the United States. NRCS and ERS GSA Publ. No. nps00-0579. Washington, D.C.

Ludwick AE, Johnston AM (2002): Organic nutrients. In Plant Nutrient Use in North American Agriculture. PPI/PPIC/FAR Technical Bulletin 2002-1. Potash & Phosphate Institute, Norcross, GA. 33–44

Oliveira PAV de (1993): Manual de manejo e utilizaçao dos dejetos de suinos. Documentos, 27. EMBRAPA-CNPSA, 188 p

Ribaudo MO, Gollehon NR, Agapof J (2003): Land application of manure by animal feeding operations: Is more land needed? J Soil Water Conserv. 58, 30–38

Sharpley A, Foy B, Withers P (2000): Practical and innovative measures for the control of agricultural phosphorus losses to water: An overview. J Environ Qual 29, 1–9

Szögi AA, Vanotti MB, Hunt PG (2003): Extraction of phosphorus in swine lagoons. In Proc 9th International Symposium Agricultural and Food Processing Wastes, ASAE 596–602

USEPA (2003): National pollutant discharge elimination system permit regulation and effluent limitation guidelines and standards for concentrated animal feeding operations (CAFOs). Federal Register 68, 7176–7274

USDA-ERS (2000): Confined animal production poses manure management problems. Agricultural Outlook, September 2000, 12–18

USDA (2001): Comprehensive Nutrient Management Planning Technical Guidance. USDA Natural Resources Conservation Service, Dec. 1, 2000. Washington, D.C.

Vanotti MB, Szögi AA, Hunt PG (2001): Wastewater treatment system. Patent Application Serial No. 09/903,620. U.S. Patent & Trademark Office, Washington, D.C.

Vanotti MB, Szögi AA, Hunt PG (2003a): Extraction of soluble phosphorus from wastewater. Trans. ASAE. (In press)

Vanotti MB, Hunt PG, Szögi AA, Ellison A Q (2003b): Extraction of soluble phosphorus in a swine waste treatment system without lagoon. In Proc. 9th International Symposium Agricultural and Food Processing Wastes, ASAE. 603–611

Westerman PW, Bicudo JR (2000): Tangential flow separation and chemical enhancement to recover swine manure solids, nutrients and metals. Bioresour Technol 73, 1–11