MANAGEMENT PRACTICES FOR SWINE MANURE IN THE CANADIAN PRAIRIES REGION

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Abstract

The three Prairie Provinces (Alberta, Manitoba, and Saskatchewan) dominate Canada’s agricultural landscape with more than 80% of the country’s farmland and 50% of the total number of farms. Recent years have seen a significant growth of the swine industry in all three provinces. One of the consequences of this expansion has been the need to effectively manage increased quantities of manure in a sustainable fashion. If not properly managed, swine manure can become an important source of pollution, especially as it relates to its impacts on surface water, ground water, and agricultural soils. Typical swine manure management systems in the Prairie region encompasses manure collection, storage and handling, and land application. The design and selection of optimal management sub-systems depend on strategic criteria that must include environmental, agronomic, socio-economical, and technical considerations. In this article, issues related to manure management have been reviewed. Typical manure management sub-systems and components for the Prairie Provinces with a particular emphasis on Saskatchewan are presented. Best management practices suggested by governing bodies are also reviewed.

Keywords: Manure management; Environmental regulations; Systems approach
INTRODUCTION

The three Prairie Provinces (Alberta, Manitoba, and Saskatchewan) dominate Canada’s agricultural landscape with more than 80% of the country’s farmland and 50% of the total number of farms. Pork production in the prairies is considered a promising option due to expansive areas of relatively inexpensive cultivated land, much of which is semi-arid, affordable feed grains and low populations; all of which contributes to lower costs of production (Bolton, 1999). The dynamic growth of the livestock industry in the Prairie Provinces is bringing wealth and jobs, but at the same time it is also raising concerns over management practices regarding environment and agronomic issues. Environmental sustainability is a key element for the future with regard to the continued growth of the hog industry in the Prairies and across Canada (PSC, 2005).

According to Statistics Canada, in the fourth quarter of 2005, Prairie Provinces had a 43% contribution to the National hog population of about 14.5 million heads (SAF, 2006). During the same period, Manitoba farmers have reported the highest number of hog population of 2.9 million among the Prairie Provinces. Manitoba and Alberta are respectively Canada’s third and fourth largest pig-producing provinces, after Québec and Ontario, with about 34 percent of national production (MAFRI, 2005; Alberta Pork, 2006). The three provincial governments realize the potential growth of the pork industry and have launched a Tri-Provincial Committee for Livestock development and Manure Management. Prairie livestock operations generally use manure as a source of nutrients for crop production; consequently manure should be considered a manageable, valuable fertilizer resource (PAMI, 1997). In 2001, a total of 11,659 Canadian hog farms have produced 12.12 million tonnes of manure (Agricultural Census, 2001). According to the Agricultural Census (1996), two of the five major clusters where manure production was concentrated at the highest level of over 2,000 kilograms of manure per hectare, fall in the Prairies (central and southern Alberta and southern Manitoba). As a rule of thumb, a single sow in a farrow-to-finish operation will produce enough manure to fertilize approximately 1 ha annually (SAF, 2003).

Using 2006 fertilizer prices, it has been found that the economic values of the nutrients contained in the swine manure produced in the Prairie Provinces in 2005 were approximately $34, $33 and $14 millions for nitrogen, phosphorous, and potassium respectively. The bulk of this nutrient value can be harnessed if manure is managed in a planned and efficient way. An intensive livestock operation is defined as the confining of one animal unit to less than 370 square metres (SAF, 2005). Manure management is the use of animal manures in a way that is appropriate to the capabilities and goals of the farm while enhancing soil and water quality, crop nutrition, and farm profits (Nowak et al., 1998). A manure management plan (MMP) specifies how manure generated at a livestock facility is going to be used during the upcoming cropping year(s) in ways that maximize the numerous benefits of applying manure to cropland, meet all rules and regulations, and protect surface and ground water quality (MPCA, 2005). Without proper management, manure can degrade surface water, ground water, and soils. Environmental policy aims at improving the management of agricultural systems such that environmental harm is minimized.

A ‘systems-engineering approach’ should be considered to identify and assess the relative importance of the criteria that need to be considered in the design, evaluation, and selection processes of alternate manure management systems (Lagué, 2002). If manure is substituted directly for commercial fertilizer inputs and is used to enhance soil tilth, soil structure, and biological activity, then further decisions must be made on how to store, transport and apply the manure to the soil (Hanna et al., 2005). These decisions will impact equipment and labour requirements; the nutrients added to the soil; potential odour release and possible environmental contamination. Localized pressures on water quality may increase in the Prairie Provinces, where intensive livestock production is expanding. It is important to ensure that facilities are properly sited and that provisions for appropriate manure disposal are in place (AAFC, 2001).

Universities and research centers across the Prairies are getting involved in environmental studies related to livestock industries. For example, the University of Saskatchewan and Prairie Swine Centre Inc. are conducting environmental studies with an objective to develop new information on operating systems and management procedures, which would ensure the long-term environmental sustainability of pork production (PSC, 2005). By establishing a fact-based source of information many concerns related to air quality, odour emissions, and nutrient management can be alleviated. The recommendations of the Expert
Committee on Manure Management (ECMM) also focused on the need to develop and maintain a national technical performance database of the many manure management technologies available to farmers, which will require development of assessment protocols (CARC, 2004). With respect to storage and land application of manure, more scientific information about the comparative impacts of different technologies on GHG emissions and on odour emissions and ammonia losses is needed before it becomes possible to identify technological options that have significant positive impacts on all of these important issues (Laguë, 2004). In this article, issues related to manure management have been reviewed. Typical manure management sub-systems and components for the Prairie Provinces with a particular emphasis on Saskatchewan are presented. Best management practices suggested by governing bodies are also reviewed.

MANAGEMENT STRATEGIES AND RELATED ISSUES

Management strategies can be considered through an appropriate decision-making process aimed at the identification and adoption of a particular manure management system. A complex set of factors including environmental regulations, economic constraints, agronomic conditions, social and health issues contributes to this process. Major strategic issues related to swine manure management in Canada were identified as dealing with odours, ammonia emission, soil suitability for manure utilization, and phosphorus issues (AAFC, 1998). Specifically, the regional concerns for the Prairies were storage of liquid manure, hog production facilities established over shallow water tables, and land suitability to receive liquid manure, in relation to soil types and nature of the vegetation. ‘A Strategy for Sustainable Manure Management in Saskatchewan’, prepared by SAF, identified challenges in seven strategic areas including manure storage, manure application and use, manure odours, manure handling and transportation systems, manure treatment, environmental planning, communications and extension (SAF, 2000). The ECMM recommended six major issues that should be considered by Canadian Federal and Provincial Agricultural Departments for scientific manure management (CARC, 2004). The issues included air quality, pathogens and pharmaceutical residues, nutrient management, manure handling and treatment, water quality, and public health.

Provincial Acts, Regulations and By-Laws

Each of the western Canadian Prairie Province governments has legislation that applies to manure management. Manure management requirements for all livestock operations in Alberta are included under the Agricultural Operation Practices Act (AOPA). AOPA requires that manure management records be kept for at least five years by a confined feeding operation and for a person who transfers control of manure to another person, receives or removes 300 tonnes or more of manure per year, applies 300 tonnes or more of manure per year (Seiferling, 2002). The Natural Resources Conservation Board (NRCB) is responsible to monitor and to enforce requirements for confined feeding operations (CFOs) under the Agricultural Operations and Practices Act (AOPA) as well as to ensure that agricultural operations follow standards for manure management (NRCB, 2003). If an operator applies more than 300 tonnes of manure annually, he must not apply manure to soil before having the soil tested. The new regulations under AOPA have been in effect since January 1, 2005.

In Manitoba, livestock operations are regulated by a number of provincial acts and regulations and local municipal by-laws that could affect the establishment, expansion, and/or management of their facilities. The Manitoba Livestock Manure Management Initiative Inc. is a livestock industry-driven approach to address manure odour and management concerns. Land use considerations are dealt with The Municipal Act and manure management is regulated by The Environment Act, while odour and other nuisance issues are addressed by The Farm Practices Protection Act as well as municipal by-laws.

Saskatchewan’s legislation for livestock operation is regulated by the ‘Agricultural Operations Act (AOA) 1995’. Saskatchewan is one of the few jurisdictions in North America in which a single department, Saskatchewan Agriculture and Food and Rural Revitalization (SAFRR), serves as the lead agency for both regulatory control and promotion of expanded livestock production (Campbell, 2005). The Department approves plans for manure storage and manure utilization under the authority of the AOA. Complaints
received regarding nuisance issues are sent to the Agricultural Operations Review Board (AORB) that operates within the jurisdiction of The Agricultural Operations Act. The SAFRR is responsible for ensuring that intensive livestock operations protect water sources on or near their operations. Legislation for the intensive livestock industry has been in place since 1971, and requires that operators develop and implement plans that protect water resources, including access to an adequate land base for agronomic use of manure (SAF, 2003).

Management issues

Swine manure management strategies and regulations are based on several issues which have been outlined by different organizations and regulatory bodies. A study was conducted in Saskatchewan to evaluate the relative importance of 37 criteria grouped in five categories (agronomic, economic, environment, social health & safety, and technical) for a systematic approach to the design, evaluation, and selection of manure management systems (Laguë, 2002). The environment category was identified as the most important series of criteria, which was followed by social & health considerations and safety criteria.

Environmental issues

Livestock manure must be properly applied to the soil in order to minimize potential environmental damage and to maximize benefits to soil. Air, water, and soil qualities are directly related to environment. Air quality regarding manure management concerns mainly odour and greenhouse gas emissions. Odour is reduced by enhancing the breakdown of volatile fatty acids (VFA’s), which are very closely associated with the production of odour (PAMI, 1997). Treating manure aerobically before spreading can reduce odour by 50 to 80 per cent. Manure odours from livestock buildings, which pose site-specific concerns, can be reduced in different ways. To control odours, farmers can install windbreaks, filters on exhaust fans, and other devices.

Environmental water quality problems resulting from swine manure use on land have been related to excess manure generation relative to land available for application and to inadequate manure storage and handling facilities (Hatfield et al., 1998). The accumulation and potential escape of manure nutrients to ground or surface water as well as emissions to the atmosphere are significant environmental concerns associated with over-applications of manure. Swine manure holds several components that can pollute water. These include oxygen-demanding materials (organic matter), plant nutrients, and infectious agents. Due to the relative scarcity of surface water, groundwater is an important resource in the Prairies. A large percentage of rural residents on the Canadian Prairies rely on wells for domestic water supplies (Atlas of Saskatchewan 1999). Many groundwater sources in the Prairies have high electrical conductivities. Although current guidelines for irrigation waters assume that SAR values above 5 mmol/L may create a soil sodicity problem, an actual medium-sized Saskatchewan hog-farm produces effluent with SAR values ranging from 19 to 28 mmol/L (Weiterman et al., 2000). Though the problem is not inevitable, but early attention to a possible problem is preferred to correcting an existing one.

There is a sufficient land base on the Prairies to handle all the manure that is produced. Soil quality is concerned about nutrient imbalance in the soil due to nitrate leaching. On the Prairies, soils are considered deficient in N and P, and, there is a need for nitrogen and phosphorus to sustain crop production (AAFC, 1998). In calcareous Prairie soils, soluble inorganic phosphates react quickly with calcium and magnesium to become immobile. The calcareous nature of these soils restricts inorganic P mobility. Only 40–50% of the P in manure is mineralized during the first year following application. Inadequate manure management poses a risk of pollution to surface waters from phosphate runoff on sloping land or from leaching of organic phosphate into shallow aquifers.

Agronomic issues

Sustainable Nutrient Management is a widely focused area of whole farm manure management. Besides season, crop type and history, and soil nutrient conditions, decision on a manure application rate according to agronomic recommendations depends on the type of manure to be applied. In case of liquid manure, a higher proportion of the nutrient is immediately available in inorganic forms as compared to
solid manure in which much of the nutrient is contained in organic forms, which are only slowly rendered available in the soil via microbial decomposition. It has been observed that 50% to 90% of the nitrogen applied as liquid swine manure is available for crop use in the year of application, while in the case of solid cattle penning manure with straw bedding, only 10% of the nitrogen was available (Schoenau, 2005). Therefore, application rates of liquid swine manure in the order of a few thousand gallons per acre or cattle manure applications of a few tons per acre are required in comparison to a few pounds of commercial fertilizer.

Managing animal wastes as liquid manure contributed to the rapid expansion of the hog industry in Canada, and this is likely to continue in the Prairie Provinces. Liquid manure used to be spread at large application rates, and uniformity of application was a problem. Applying manure when the soil is cold will minimize soil microbial action on the manure and minimize the transportation of organic and ammonium nitrogen to nitrate-nitrogen, thereby reducing potential loss of manure nitrogen to leaching and to the production of nitrous oxide (CPC, 2006). If possible application timing should correspond to periods of rapid uptake of nutrients by developing crops or to times of minimal soil microbial activity. Manure application operations may compact the soil when the soil’s water content is at or near field capacity. Manure application to wet soils should be avoided to prevent soil compaction (NRCS, 1996).

On most Prairie agricultural soils, applying hog manure to meet the crop nutrients for N can be safely accomplished without P overload. Prairie soils have a high pH and sorption capacity that immobilizes the P to the soil (SSCA, 2005). It is generally agreed in Saskatchewan that 50% of the total manure nitrogen applied is available to the crop in the year of application; 25% of the original total nitrogen applied is available in the second year and 5% of the original total nitrogen applied is available in the third year (SAF, 2000). Research in Saskatchewan found that from 10% to 50% of the total P in liquid swine manure could be present as soluble inorganic phosphate, which is considered to be immediately available to plants (SAFRR-AAFRR-MAF, 2005). However, because inorganic P in manure is not routinely measured, the availability of P in manure in the year of application is estimated to be 50% of the total P measured in manure. Based on a review work on manure management practices in Saskatchewan, the most important element having a high priority for future work has to do with the concern in Southwestern Saskatchewan about possible soil sodicity problems from manure applications in areas where water for human and animal use is drawn from wells.

Traditional application rates are based on N needs for the crops. It was long thought that P is quite immobile in soils and for that reason, soil loading rates have been considered relatively unimportant to the environment. Manure generally features a lower N:P ratio than most crops require. This means that P is not limiting in manured soils and therefore will tend to accumulate (Smith et al., 1998). There is now some evidence that suggests that soil P status can affect the release of P to the soil solution. In a study correlating the P concentration in water collected from drains under cropped land to standard soil test measurements of P status of the overlying fields, there was an observed increased release of soluble P at high loading rates. Measures have been suggested to manage P in manure (AAFC, 1998) in different phases including feeding systems, agronomic monitoring, manure application, and water management systems.

**Engineering or Technical issues**

For provinces where farm buildings are exempt from building codes (which is generally the case in the Prairie Provinces), substantial compliance with prescribed standards for design and construction is required. In Alberta and Manitoba, detailed standards and regulations are provided for manure storages and some components need not have professional engineers involvement. Both Manitoba and Saskatchewan require that professional engineers assume responsibility for manure storage design and regulations apply only to manure storages outside the barn, or deep pit in-barn storage (Darby and Robson, 2005). A fully slatted floor with deep pit and long term storage generates most ammonia gas (CPC, 2006). Buildings with partially slatted floor and manure pit produce 20% less ammonia emissions. Greater emission reductions were achieved when manure was collected under the slatted floor in flushing water
where the manure falls into the liquid and the solids are submerged. If this mixture was regularly pumped out and replaced by new flushing liquid (as in a pit recharge), the reduction was 60% (Hendriks, 1999). Though building codes are exempted for the Prairies, Plan M-3003 (Canada Plan Service) can be referred for general recommendations for slotted floor materials and spacing, and Plan M-3702 for making cast-in-place concrete slotted floors for pigs (West and Turnbull, 2005).

Injecting the manure into the soil constitutes an important step toward reducing gaseous losses of ammonia and odour. Surface spread and incorporated manure require increased rates to match the yield response of the manure (SSCA, 2005). Injection has the advantage of leaving more crop residue on the soil surface residue thereby reducing both the risk of soil erosion and the loss of nutrients due to water run-off or evaporation. It was observed that during liquid manure application, chisel points basically left the manure in vertical bands within the field; sweeps distributed the manure more uniformly in horizontal bands beneath the soil surface, and covering discs mound soil up around the manure as it is discharged from the tank (Hanna et al., 2005).

**Best Management Practices**

Best management practices (BMPs) refer to operating techniques and methodologies for reducing and/or preventing pollution before it occurs and are based on scientific principles and real-world experience. Most technologies and practices work best in very specific situations and should be thoroughly researched before being implemented. One of the important themes of BMPs for managing manure is the concept of a systems approach, which considers the entire system, from animal to field, through planning and implementation (AAC, 2005). The Departments of Agriculture across the Prairie Provinces have accepted following five principles as the basis for sustainable manure management (SAFRR-AAFRR-MAF, 2005).

1. Sound manure management requires annual planning and proper record keeping.
2. Manure application rates will depend on the type of manure and nutrient availability, and should be calculated using results from annual soil and manure analysis to meet crop nutrient requirements.
3. Manure application should account for the season, weather conditions, and site-specific conditions relating to soil, topography, and water.
4. Manure application equipment should be calibrated to ensure consistent and appropriate delivery rates of manure.
5. Manure should be managed in a way that maximized crop nutrient utilization and minimizes negative impacts to soil, water, and air resources.

The above mentioned principles demonstrate a lot of emphasis on land application of manure. The Prairie Province's committee on livestock development and management has suggested BMPs for minimizing the risk of nutrient and pathogen loss to surface and ground water. The Committee has also prepared guidelines related to manure application and use, including nutrient management planning, soil conservation, and surface and ground water protection planning. (SAFRR-AAFRR-MAF, 2005). Details of the procedural management can be found in 'Manure and the Protection of Water, Soil and Air' (SAAFRR-AAFRR-MAF, 2005). Recently, the Canadian Pork Council (2006) has published an environmental management guidebook entitled ‘Practices and Technologies Aimed at Reducing Environmental Impacts from Hog Production: Scientific and Economic Evaluation’.

Saskatchewan Agriculture and Food also suggested minimum separation distances for applying manure to agricultural fields. These distances vary according to the mode of application (e.g. surface or subsurface) and social and environment factors. By incorporating manure rapidly into the soil, farmers minimize odours and nutrient loss due to evaporation. Manure application timing should be selected to achieve the best balance between nutrient use efficiency, access to fields and the likelihood of conflicting events (SAF, 2005). Provincial (Saskatchewan) regulations do not specifically prevent winter spreading; however, it is not a recommended practice. Stubble fields are preferred as they are less subject to soil erosion, and there is greater infiltration of the snowmelt.
MANURE MANAGEMENT PRACTICES IN THE PRAIRIES

There are regional differences in the methods used for managing swine manure, which are primarily driven by the climate and by the size of livestock operations. Solid, semi-solid, and liquid manure systems are used in the Prairies region. Farm size, the prevailing agronomic conditions, and environmental regulations influence the methods employed to manage manure. Laguë et al. (2000) demonstrated an example of a complete manure management system comprising of four major components including in-barn management, storage systems, land application techniques and end-use or soil-crop system. Thus there could be various alternatives of a manure management system combining different options from a particular component. Goss et al. (1994) cited a detailed list as engineering alternatives in a manure handling system. CETAC-WEST (1999) developed a classification system for hog manure management technologies. Such a system will appeal to a wide range of potential users of an inventory. Common management subsystems that are in practice across the Prairies are reported in Table 1.

Manure Collection

Methods of manure collection depend on the manure management systems - solid, semi-solid or liquid. In the Prairies, for liquid manure management, manure is collected using flush system from solid floor and using gutter cleaner and deep-pit system from slatted floor. Use of separator in a slurry or semi-solid manure management system depends on the size of the farm. There are not much examples of such a system with separator in the Prairies. In case of solid manure systems, such as feedlots and some deep-bedded barns are in practice across the Prairies. Hoop structures for deep bedded swine solid manure system is getting popular.

Manure Storage

The present focus on hog production in the Prairies has brought liquid manure storage issues to the forefront (SAF, 2000). Focused activities are in the areas of site selection, site characterization, design, construction, and monitoring of earthen manure storages. Related research activities include monitoring liner integrity over the long term, quantifying potential nutrient movement, and decommissioning of storages. In Western Canada, earthen manure basins (EMB) are very popular for storing liquid manure. Prairie hog farms generally use lined and unlined, covered and uncovered EMBs or concrete tanks for the storage of liquid manure. Approximately 90% of hog producers in Canada’s Prairie Provinces store manure in liquid form (Koroluk et al. 2000). Unlined lagoon structures, and tanks below the slatted floors are the two most common storage methods. Storage covering is given due importance towards reducing GHG and odour emissions and several research studies are underway across the Prairie provinces with different covering means including straw cover, NAP (negative air pressure) cover, and geotextile cover on earthen manure basins (Cicek et al., 2003; Laguë et al., 2004; Agnew et al., 2005; Zhang et al., 2005; Laguë et al., 2006).
When managing solid manure, most Prairie farmers pile up manure into heaps without putting a roof over it. Other methods of managing solid manure include open pile with a roof; open pad without containment, open pad with containment, and covered storage pad. However, piling up and manure packing are commonly used method for storing solid manure (AAFC, 1999; Koroluk et al. 2000). Manure storage systems represent the top environmental investment in hog industry in Canada. Producers in the western provinces put about half of their environmental investment into manure storage systems (Grimard, 2004).

**Manure treatment**

In order to comprehensively address odour and pathogen issues, manure must be processed in some fashion, regardless of whether it is in liquid or solid form (Bowman, 2003). Aerobic treatment is useful in treating liquid manure for odour reduction, chemical oxygen demand (COD) and biochemical oxygen demand (BOD) reduction, and pathogen control (PAMI, 1997). A research update (No. 730) describes some of the aerobic and anaerobic treatment process practiced in the Prairies (PAMI, 1997). There are regional differences in the adoption of manure treatment practices. Alberta, Saskatchewan, and Manitoba farms treated stored manure to the greatest extent, 72.2%, 67.1% and 64.7% respectively (Beaulieu, 2004). The highest proportion of farms that dried manure was reported in each of the Prairie Provinces. Biodigesters, integrated into hog farm operations, help reduce greenhouse gas emissions and odors. A Biodigester Pilot Plant is in developing stage at the Prairie Agricultural Machinery Institute, Humboldt, Saskatchewan (Anno., 2005 b). It is one of Canada’s first biodigester pilot plants, which will allow industry to analyze a variety of organic materials in biodigesting environments for methane gas production.

Clear-Green Environmental of Saskatchewan is now in operation for delivering biogas to SaskPower's microturbines to produce electricity. Located at the Cudworth Pork Investors Group hog facility, the plant produces biogas using a digester process, which relies on bacteria to break down the manure in a large enclosed tank. The biogas is being drawn off and piped into four microturbines that are capable of generating enough electricity for about 30 - 40 homes. DGH Engineering Ltd. started a digester system in Teulon, Manitoba in February 2004 with a plan to produce both heat and energy for the hog finishing operation. In Alberta, BIOGEM Power Systems Inc. produces power and heat from a multiple manure source digester in Iron Creek.

**Manure Application**

There is a very high seasonal variation in land application of manure in field. In the Prairie Provinces, a larger proportion of manure application takes place in the fall because spring is often too busy a time to apply manure while crop growth reduces opportunities to apply manure during the summer (Beaulieu, 2004). Moreover, manure storage facilities need to be emptied before the prairie winter. Winter application is avoided to minimize the risk of run-off water contamination from frozen ground. According to FEMS (Farm Environmental Management Survey), nationally, most hog manure was applied during the fall (36%) and spring (30.2%) months (Beaulieu, 2004). In the spring, the share of farms applying manure in the
Prairie Provinces ranged between 26.8% and 41.9%. Nationally, a majority (65.9%) of hog harms in Canada, including 60.7% of Saskatchewan livestock farms, applied manure to the land in fall. FEMS (2004) also reported that 43.9% of hog farms (contributing 27.7% of the manure) in Canada and about 50% farms in Saskatchewan either left manure on the soil surface or incorporated it more than a week after its application to the land. Manitoba had the highest share of injected manure or manure incorporated the same day of its application (20.8% of manure, 18.1% of farms).

Prairie farms have been applying manure in four different ways: solid spreading, irrigation system, liquid surface spreading, and liquid injection. However, there has been a drastic change in the method of application between 1996 and 2000. During this period, there has been a 11% decline in the use of solid spreaders in Saskatchewan compared to increases of 7.5% in Manitoba and Alberta (Census of Agriculture, 2001). However, there has been an appreciable increase in the application of manure using liquid injector in all the provinces (Table 2). According to the Farm Inputs Management Survey (FIMS), for the Prairies, hog operations were the highest users of liquid manure facilities, accounting for half of the farms reporting liquid manure storage (AAFC, 1995). Prairies reported the lowest percentage of farms (28%) with the ability to store liquid manure for 251 days or more with largest percentage (59%) having the ability to store liquid manure for less than 101 days. Solid hog manure storage accounted for 39% in the Prairies.

Manure from deep pits and a pull-plug pit typically is surface applied and may be incorporated by disk ing or plowing. Although producers need to determine rates for their particular situation, in the Black Soil Zone, for example, annual application rates of about 100 pounds of nitrogen per acre per year, which is the equivalent of 3,000 to 4,000 gallons of injected liquid hog manure, would be a sustainable application rate (Schoeneau, 2005).

Over the last decade, subsurface manure injection has become very popular in Saskatchewan and other provinces of the country. When manure is injected into the soil, using either high disturbance sweep type openers or low disturbance coulter, crop response and nutrient recovery are both much better which is an advantage both agronomically and environmentally (Schoenau, 2002). In field research trials in Saskatchewan, large increases in biomass yield have been observed from the low disturbance injection of liquid swine effluent into forage grass stands such as crested wheat and brome grass (Schoenau et al., 2005). A precision solid and semi-solid manure applicator is being developed by PAMI in collaboration with the University of Saskatchewan. This land applicator will be capable of accurate distribution that will help increase the economic value of manure as a resource while lowering the environmental risk and negative social impacts of manure application (Agnew et al., 2004). The prototype is capable of precision broadcast application as well as precision banded application and is being developed to inject solid manure underneath the soil surface (Landry, 2005).
Other strategic practices

In Saskatchewan, manure management plans are now encouraged for farms that are above a threshold number of livestock units. One such initiative is environmental farm planning (EFP). According to Agriculture Policy Framework, an EFP is a voluntary, confidential, producer-driven planning exercise that uses specifically designed resource materials and technical assistance to develop a farm plan that identifies on-farm environmental risks and establishes a priority sequence of action items for addressing those risks (APF, 2005). The Canada-Saskatchewan Farm Stewardship Program (CSFSP, 2004) has been designed to help Saskatchewan producers address on-farm environmental risk with the objective is to accelerate the adoption of beneficial management practices (BMPs) on farms. To be eligible to apply for federal funding through the CSFSP one needs to complete an environmental farm plan (EFP). Saskatchewan's EFP program is being delivered by the Provincial Council of Agriculture Development and Diversification Boards for Saskatchewan Inc. (PCAB).

Expenditures for shelterbelts, windbreaks, buffer strips, and fences for waterway protection are particularly high - about one third of the total - in the western provinces (Grimard, 2004). Some finishing units across the prairies have gone to bio-tech shelters which are low cost housing units (coverall hoop structures) where groups of feeder pigs are finished (Bolton 1999). This type of unit has become popular with small and expanding producers and they use a solid manure system. Regarding external measures for controlling odour, Manitoba had the highest percentage (36.9%) of farms using some method of odour control (Beaulieu, 2004). Wind barriers were used to the greatest extent in the Prairie Provinces. The use of wind barriers in the Prairie Provinces may be encouraged through the availability of the Prairie Farm Rehabilitation Administration (PFRA) Shelterbelt Program. Manitoba had the highest proportion of farms using wind barriers to control odours (28.1% of farms).

CONCLUSIONS

The expansion of the swine industry will continue to be a major component of Prairie Provinces economic development. Major management issues related to swine manure have been identified as environmental and agronomic concerns. Air, water and, soil qualities pose concern in environmental regulations, which are coupled with the nutrient balance and manure application. It was observed that proper nutrient management is not only required for higher crop yield and agronomical reasons, it is also essential for protecting the environment by controlling air pollution (odour), water contamination, and soil degradation. Thus, appropriate systems engineering approaches are needed for sustainable manure management. This has been reflected on the ongoing researches in universities and industries across the region.

Localized pressure along with the Provincial government's environmental regulations is in effect for proper manure management. Provincial Acts and the recommendations of the Regulatory bodies mainly focused on the environmental aspect of manure management, which was followed by the nutrient management.
Management strategies for best management practices (BMPs) are in place following the recommendations of Environmental Council of Manure Management (ECMM), a regulatory body of Canadian Federal and Provincial Agricultural Departments, Departments of Agriculture across the Prairie Provinces (Tri-Provincial regulations), and other Provincial Acts and Regulations.

Liquid manure management is the most common among the alternative systems that are used across the region. Earthen manure basins (EMB) are very common for storing liquid manure; covers on them are getting popular. Manure storage systems represent the top environmental investment in hog industry. A majority of Prairie livestock farms (67.1%) adopted some kind of manure treatment in 2001. There is seasonal variation in manure application; more than 50% of Prairie livestock farms applied manure to the land in fall. Liquid manure injection is very common and low disturbance injectors are getting much attention in research as well as in farms. To avoid adverse effects of over application, application rates need to be controlled using agronomic data and precise calibration of the applicator. Composting, generally confused with the piling of manure under roofed or unroofed structure, needs to be scientifically practiced for better quality and high returns. Though not yet extensively practiced, non-conventional management of manure for producing bio-gas and electricity is getting focused across the Prairies in experimental and demonstration levels.

References


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Table 1. Swine Manure management systems practiced in the Prairies.

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<td>Floor/gravity</td>
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<td>Slatted (Liquid system)</td>
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<td></td>
<td>Scrapings</td>
<td>Scrappers</td>
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<tr>
<td></td>
<td></td>
<td>Gutter cleaner</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Front-end loader</td>
</tr>
<tr>
<td>Transport to Storage from barn</td>
<td>Stacker (solid)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Front-end loader (solid)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pumping (liquid and semi-solid)</td>
<td></td>
</tr>
<tr>
<td>Storage</td>
<td>Liquid and slurry:</td>
<td></td>
</tr>
<tr>
<td>Long term</td>
<td>Covered and Uncovered Basin</td>
<td>Earthen basin</td>
</tr>
<tr>
<td>Short term</td>
<td>Straw cover</td>
<td>Concrete</td>
</tr>
<tr>
<td></td>
<td>NAP cover</td>
<td>Steel</td>
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<tr>
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<td>Geotextile cover</td>
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<td></td>
<td>Deep pit storage</td>
<td></td>
</tr>
<tr>
<td>Solid stack</td>
<td>Roofed</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Unroofed</td>
<td></td>
</tr>
<tr>
<td>Treatment/processing</td>
<td>Aerobic</td>
<td>Sedimentation</td>
</tr>
<tr>
<td></td>
<td>Anaerobic</td>
<td>Screening</td>
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<tr>
<td></td>
<td></td>
<td>Filtering</td>
</tr>
<tr>
<td>Transport to application area</td>
<td>Liquid and sluries</td>
<td>Pump and pipe line</td>
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<td></td>
<td></td>
<td>Pump and dragged hose</td>
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<tr>
<td></td>
<td></td>
<td>Tanker with injector</td>
</tr>
<tr>
<td>Solid</td>
<td>Spreader trolley</td>
<td></td>
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<td></td>
<td>Truck</td>
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<tr>
<td>Application/spreading</td>
<td>Liquid and sluries</td>
<td>Tank wagon with surface spreader</td>
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<td>Irrigation systems (sprinkler)</td>
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<td></td>
<td>Drag hose injector</td>
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<tr>
<td>Solid</td>
<td>Box spreader (broadcast)</td>
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<td></td>
<td>Open tank spreader (broadcast)</td>
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<tr>
<td></td>
<td>Dump truck</td>
<td></td>
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<tr>
<td></td>
<td>Earth move or wagon</td>
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</tr>
<tr>
<td></td>
<td>Solid injector (auger) (under trial)</td>
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Table 2. Percent change in manure application methods during 1996 to 2001 in the Prairies

<table>
<thead>
<tr>
<th>Manure application using:</th>
<th>CANADA</th>
<th>SASKATCHEWAN</th>
<th>MANITOBA</th>
<th>ALBERTA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solid spreader</td>
<td>-2.8</td>
<td>-11.2</td>
<td>7.9</td>
<td>7.5</td>
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<td>Irrigation system</td>
<td>-27.8</td>
<td>-12.0</td>
<td>-59.3</td>
<td>-55.1</td>
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<tr>
<td>Liquid spreader (surface)</td>
<td>24.0</td>
<td>-27.5</td>
<td>-19.9</td>
<td>11.4</td>
</tr>
<tr>
<td>Liquid spreader (injected)</td>
<td>145.2</td>
<td>177.6</td>
<td>448.9</td>
<td>37.4</td>
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</tbody>
</table>