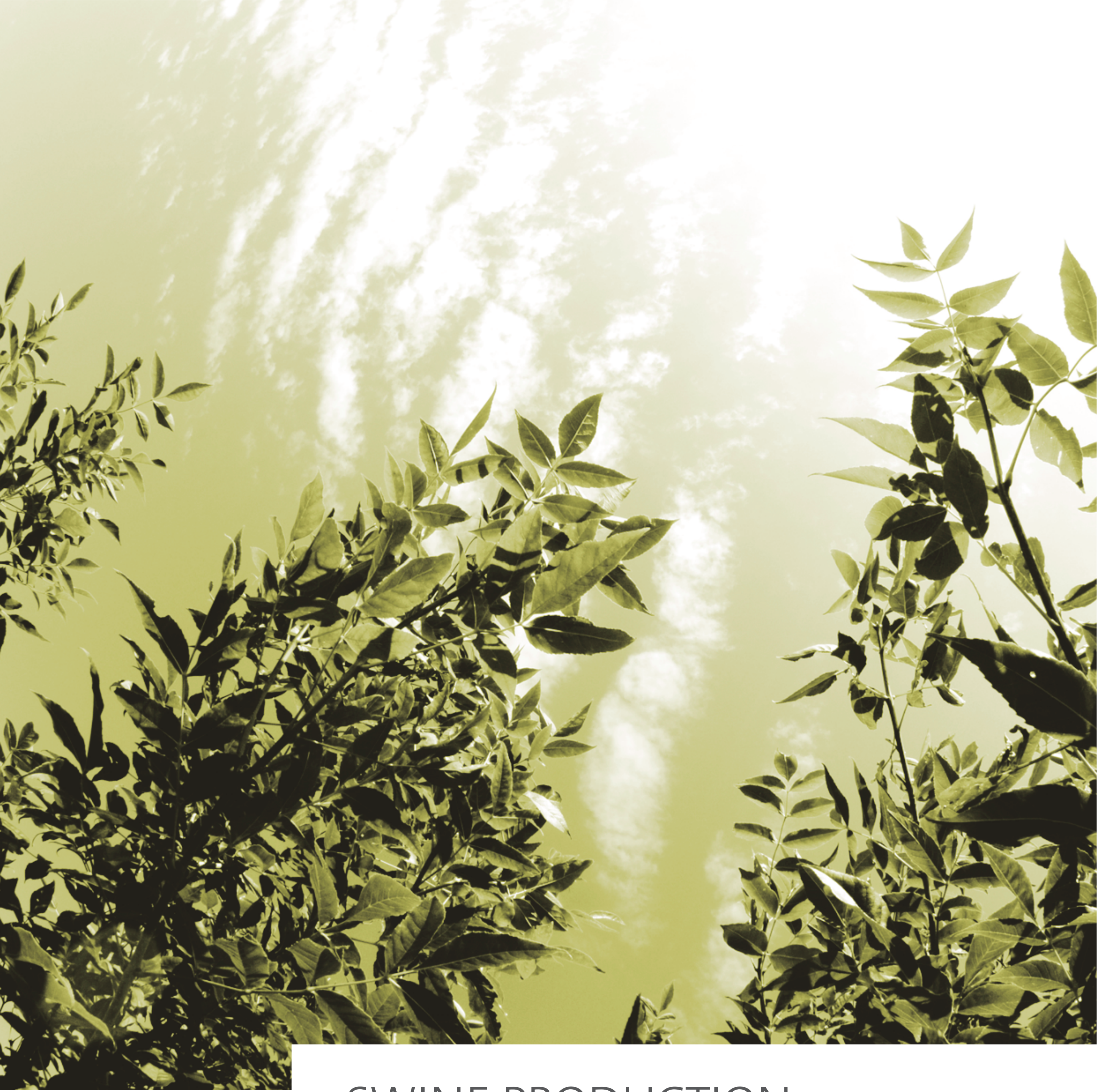

SWINE PRODUCTION AND GREENHOUSE GASES

Fédération des producteurs de porcs du Québec

INDEX

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SECTION

1 SWINE PRODUCTION AND GREENHOUSE GASES

Introduction

The greenhouse effect is a natural phenomenon essential for maintaining the integrity of the biosphere. It is the result of the presence of greenhouse gases (GHG) that capture solar energy in the atmosphere. The main greenhouse gases are: carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). Methane and nitrous oxide are respectively 21 and 310 times more powerful than carbon dioxide (CO_2) in keeping heat inside the atmosphere.

The intensified use of fossil fuels, deforestation or other modifications in land use, and industrial processes, among other things, have increased the atmospheric concentration of these gases. This phenomenon, confirmed by scientists, may accentuate the "natural greenhouse effect" which in turn, could not only induce warming but also disturb the energy flow between air, water and land.

The most recent Canadian inventory of GHG estimated total greenhouse gas emissions at 721 million tons (Mt) of carbon dioxide equivalents (CO_2 eq) in 2006 (Environment Canada, 2006). According to the same inventory, GHG emissions associated with agriculture totalled 62 Mt of CO_2 eq, which represents about 8.6% of total Canadian emissions.

In 2006, the agricultural sector in Québec generated 7.5% of total greenhouse gas emissions, that is, 6.36 Mt of carbon dioxide equivalents (MDDEP, 2008), while emissions generated by swine production, due, among other things, to the spreading of pig manure as fertilizer, amounted to about 15% of total farm emissions, which represents less than 1% of total GHG emissions in Québec (Leblanc and Lease 2008). Despite the fact that the swine sector is not an important source of GHG emissions, an association is sometimes made between these emissions and odours, which is why the swine industry considers it necessary to promote good farming practices as a means of reducing these emissions.

The processes giving rise to GHG emissions in the farming sector are, first of all, the enteric fermentation of livestock (dairy and beef cattle, sheep and goats) produced through feed digestion. This is followed by manure management, spreading of fertilizers and other field production practices (agricultural soil management). The emissions from enteric fermentation of livestock and manure management represented 58% of total GHG emissions in the Québec farm sector in 2006. As for the emissions associated with agricultural soil management, they are composed of direct and indirect nitrous oxide (N_2O) emissions. Direct N_2O emissions are generated by the application of synthetic nitrogen fertilizers, and manure and slurry (liquid manure) on cultivated fields, by the decomposition of crop residues and soil tillage operations. Indirect N_2O emissions result from the volatilization and leaching of mineral fertilizers, manure and slurry, and the nitrogen contained in plant residues. These sources represented about 42% of Québec's total GHG emissions from the agricultural sector in 2006.

DISTRIBUTION OF AGRICULTURAL SOURCES FOR GREENHOUSE GASES IN QUÉBEC, IN 2006, IS PRESENTED IN FIGURE 1.

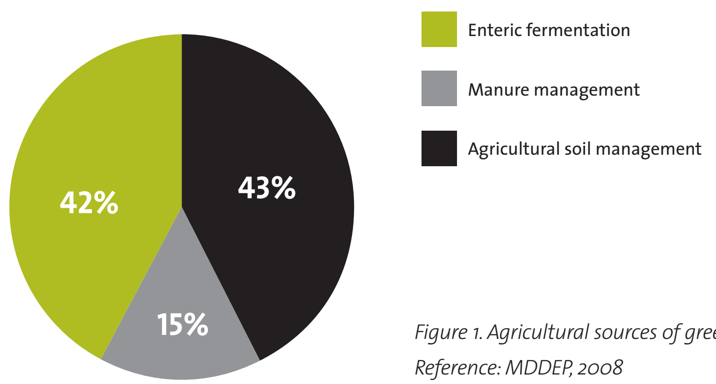


Figure 1. Agricultural sources of greenhouse gases in Québec, in 2006
Reference: MDDEP, 2008

Emissions of greenhouse gases produced by the agricultural sector

The main GHG generated by the agricultural sector are carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O).

The major sources of methane emissions on the farm include:

- enteric fermentation coming mostly from ruminants (cattle, sheep, goats)
- slurry (liquid manure) storage tanks and pits.

The principal agricultural sources of nitrous oxide emissions involve, on the one hand, nitrogen management (the spreading of manure and mineral fertilizers) aimed at field crops and, on the other hand, the drainage conditions of agricultural soils. Indeed, nitrous oxide is produced during two biological transformations of mineral nitrogen: nitrification, which converts ammonium (NH_4+) nitrogen into nitrate (NO_3-), and denitrification, which reduces nitrate to molecular nitrogen (N_2). Denitrification produces about 10% more N_2O than nitrification, per unit of transformed nitrogen and constitutes between 80 and 95% of the total nitrous oxide emissions.

In agriculture, most of the carbon dioxide emissions come from:

- the combustion of fossil fuels for heating farm buildings, the operation of farm machinery, etc., and
- intensive cropping systems which favour the rapid decay of organic matter.

Moreover, storage of solid manure in piles also generates nitrous oxide emissions.

Greenhouse gas emissions produced by swine farms

The emissions of greenhouse gases produced in swine operations have three distinct sources: animal housing, manure storage tanks and pits and the application of liquid manure (slurry) on cultivated land.

In this context, the direct sources of GHG include methane, nitrous oxide and carbon dioxide. Methane is produced and emitted from swine barns and slurry tanks. Nitrous oxide is emitted from the nitrogen contained in manure during application on cultivated soils. And finally carbon dioxide is emitted by fossil fuels like propane, heating oil, diesel or natural gas which are used for heating farm buildings, producing on-farm electricity (e.g. with a generator) or for operating farm machinery (e.g. field or farm operations).

Indirect sources of GHG are those not necessarily produced through a process directly related to swine production. Electricity produced outside the farm, for instance by Hydro-Québec, is an example of indirect emission sources. On the farm, electricity is used for lighting, heating (e.g. heating mats in sow barns or nurseries), operating electric motors (for pumping water, cooling, or feed preparation and distribution) and ventilation systems. Its use represents an indirect source of GHG emissions.

On the other hand, ammonia (NH_3) emissions due to nitrogen volatilization from swine barns, slurry (liquid manure) tanks (during mixing) or slurry spreading in the fields are not direct GHG emissions sources, since ammonia is not a greenhouse gas. However, emissions of ammonia diffused in the environment constitute an indirect source of greenhouse gas emissions, following their deposition on cultivated fields and further nitrification and denitrification through biological transformation.

Measures to reduce or avoid greenhouse gases on the swine farm

In general, the implementation of certain "best environmental practices" can reduce total GHG emissions in the swine production sector through:

- best practices regarding feed management in animal buildings and pig slurry spreading techniques;
- planting shelter belts or hedgerows (carbon sequestration by trees); and,
- replacing conventional energy with renewable energies (e.g. recovery of methane produced during anaerobic digestion of pig slurry).

Module 1: Animal housing management

HERD HEALTH

Buying genetically superior stock and implementing practices that mitigate animal stress and improve the health status of the herd all directly enhance feed efficiency, thereby decreasing the amount of feed per kilogram of weight gain and consequently nitrogen loss and GHG emissions in the environment.

Selecting genetically superior animals

The genetic selection of animals with high feed efficiency improves zootechnical performance and reduces the amount of nutrients excreted into manure. Indeed, a 0.1% improvement in feed efficiency results in a 3.3% decrease in nutrient loss (Canadian Pork Council 2007).

Mitigating stress in animal housing

Stress modifies the way pigs assimilate nutrients. Animals exposed to stressful conditions, including heat, overcrowding, or limited access to feed and water, suffer competition, decreased growth performance and increased feed conversion (units of feed consumed per unit of weight gain). Hence, depending on the growth stage of the pigs, feed consumption may increase on the average from 35 to 90 grams (g) per day, per degree between 14 and 22°Celsius (ITP 2000).

Husbandry conditions that respect animal welfare eliminate harmful stress and maximize zootechnical and environmental performance. Hyun et al. (1998) report a 10 to 20% decrease in growth performance with a concomitant increase in the feed conversion rate from 5% to 15% on pig farms which are overcrowded in the summer and where the feed and water distribution systems generate competition.

Improving the health status of the herd

The zootechnical performance of sick animals is considerably diminished. The pigs eat less and use the nutrients to fight pathogens rather than to grow.

The presence of certain diseases on the farm diminishes feed conversion by 2 to 15% (English, Baxter Fowler and Smith 1988). This drop in performance results in a 5 to 25% increase in nitrogen loss to the environment, depending on the disease and its severity (FPPQ, Août 2005. Réduire les odeurs par la régie alimentaire. Fiche technique no 9).

FEED MANAGEMENT

Feed or nutrients given in excess of the nutritive needs of the pig, as well as meal unconsumed by the herd, increase production costs and the loss of nitrogen, phosphorus and other nutrients. Several feeding practices can become part of herd management in order to diminish nitrogen excretion, thus reducing greenhouse gas emissions.

Reducing the crude protein content of the diet

Crude proteins are made up of essential and non-essential amino acids used to synthesize body proteins, such as those found in the muscles. In other words, the crude protein content of the diet should satisfy the pig's needs for essential amino acids, especially as the animal excretes the nitrogen that exceeds its needs (for growth and maintenance). In the last few years, reducing the crude protein content in feed, by incorporating synthetic amino acids (e.g. lysine, methionine, threonine or tryptophan) has proved to be an excellent strategy to reduce nitrogen excretion in pig slurry. Thus, the practice of replacing 2% of the crude protein in feed with synthetic amino acids reduces nitrogen excretion by 15 to 20%, according to Pomar (1997), and reduces feeding costs by $0.60 to $1.40 per pig (FPPQ. Août 2005. Réduire les odeurs par la régie alimentaire. Fiche technique no 9).

Adding phytase enzyme to the diet

Only 14 to 50% of the phosphorus found in feed ingredients of plant origin is available compared with that from a mineral source, like monocalcic phosphorus. The rest is not available since it is bound inside the plant in the form of phytates. The complex structure of phytates also retains other minerals and a certain amount of amino acids.

When adding phytase – an enzyme that can degrade phytates - to the diet, one increases the digestibility of phosphorus, other minerals and proteins, thereby reducing the excretion of nitrogen in manure by about 2% (FPPQ. Septembre 2002. Fermes en surplus: analyse des solutions. Fiche technique no 1). Adding phytase to the diet could increase the cost of feed, however, most of the time this cost increase is offset by the savings made by reducing the mineral supplementation of phosphorus and calcium in the diet.

Implementing phase feeding

Pigs have nutritional needs that vary throughout their growth. Consequently, the protein content of feed must change according to their growth stage in order to avoid protein over-consumption. This feeding strategy, combined with a crude protein-reduced formulation, can significantly decrease nitrogen loss in pig manure. That is why, depending on husbandry conditions, producers use from 3 to 5 different feed formulations during the pigs' finishing phase, which reduces nitrogen excretion by 10 to 20% (Pomar, 1997) and feeding costs by $0.90 to $1.75 per pig (FPPQ. Août 2005. Réduire les odeurs par la régie alimentaire. Fiche technique no. 9).

In the same way, preparing separate feed formulations for pregnant and lactating sows can reduce excretion of nitrogen, phosphorous and other minerals by about 20% (Canadian Pork Council 2007).

Installing wet-feed hoppers and water-saving drinking bowls

A feed distribution system comprised of wet-feed hoppers and water-saving drinking bowls allows better feed efficiency in that it reduces the amount of meal needed to reach the desired weight gain. A wet-feed hopper (or wet feeder) combines, in the same device, at-will distribution of water and meal. The dry-feed hopper (or dry feeder), on the other hand, distributes only dry meal. Water distribution, in this case, is provided through a separate water-saving drinking bowl, installed beside the dry feeder.

Since feed distribution on the ground is the main cause of feed waste, the use of a well adjusted hopper in the finishing barn allows for about 5.5% feed waste reduction (FPPQ. Septembre 2002. Trémies-abreuvoirs et bols économiseurs. Fiche technique no 4). Thus, the optimal use of feed hoppers reduces nitrogen excretion by 8 to 10% and feeding costs by \$1.80 to \$4.00 per pig (FPPQ. Août 2005. Réduire les odeurs par la régie alimentaire. Fiche technique no 9).

Controlling the granulometry of feed ingredients and favouring pelleted feed instead of meal

Granulometry refers to the particle size of raw materials composing the meal. The reduction of the particle size increases the contact surface available for the action of the animal's digestive enzymes, which improves the availability of the nutrients and their assimilation by the pig. A particle size of 600 microns decreases nitrogen excretion by 5 to 10%, according to several researchers (Giesemann et al. 1990, Hancock 1996, Healy et al. 1994 and Wonkra et al. 1995), and also decreases feeding costs by \$0.90 to \$4.00 per pig (FPPQ. Août 2005. Réduire les odeurs par la régie alimentaire. Fiche technique no 9).

Pelleted meal has many advantages: better digestibility - due to the fine size of the particles composing each pellet and the heat treatment involved in their preparation - , greater daily feed consumption, and less feed waste in the form of dust or unconsumed deposits inside the mangers or on the floor. Pelleting reduces nitrogen excretion by 3% to 10%, and feeding costs by \$0.25 to \$2.00 per pig, depending on the equipment available (FPPQ. Août 2005. Réduire les odeurs par la régie alimentaire. Fiche technique no 9).

NUTRIENT EXCRETION MODEL

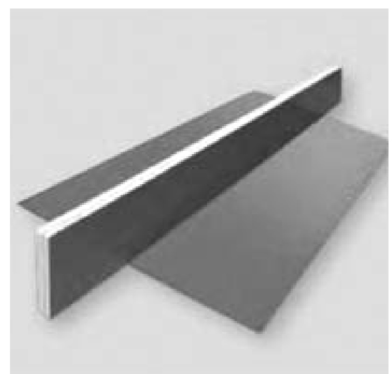
In swine production, the nutrient excretion model is a convenient way to visualize the relationship between herd performance and nitrogen and phosphorus loading of manure, to confirm the results of the on-farm animal feces characterization required by the *Règlement sur les exploitations agricoles* (Québec 2002) and finally, to evaluate various improvements in husbandry techniques with regards to environment and farm profitability (Roch and Maltais 2006).

ENERGY EFFICIENCY

In addition to fossil fuels for heating, swine buildings use electricity for ventilation, for feed preparation and distribution, for lighting and to provide warmth for piglets. Furthermore, slurry management on the pig farm also uses fossil fuels for pumping into tank-wagons, transporting and spreading onto fields. Most of these activities generate carbon dioxide (CO_2).

Many best management practices and the use of efficient equipment can improve energy efficiency on the pig farm, and thereby reduce operating costs and GHG emissions.

Best management practices enable producers to improve their farm energy efficiency and can be readily adopted through simple behaviour changes, with no additional investment. It is the most economical way to improve energy efficiency on the farm. For example, cleaning the heating system or fan shutters, grids, blades or paddles, as well as more efficient light management are easily applied as best practices on the farm (CRAAQ. 2008. Audit énergétique sommaire en production porcine).



By the same token, investing in new energy-efficient technologies is another option for swine producers. For instance, installing heating mats, solar wall, high-efficiency fans, and equipment designed to reduce the volume of animal feces are all interesting on-farm energy-saving systems and are supported by rebate programs (e.g. Hydro-Québec) or other financial aids (e.g. Prime-Vert Program). For example, the installation of wet-feed hoppers or water-saving drinking bowls diminishes pig slurry volumes by about 25%, which results in a proportional decrease of the fossil fuel consumption required for their transport and spread (CRAAQ, 2008. Audit énergétique sommaire en production porcine).

Through more efficient energy consumption, farms become more competitive and, at the same time, reduce their net greenhouse gas emissions.

Module 2: Manure handling and storage management

ANIMAL HOUSING MANAGEMENT

Inside animal buildings greenhouse gases are essentially methane, produced by animal enteric fermentation and by the slurry stored underneath the slatted floors. Thus, frequent scraping and removal of animal manure off the floor and shortening the amount of time it is stored in barn gutters all contribute to reduce methane emissions. Indeed, slurry manure kept inside buildings tends to stay warmer than that stored outside, and will consequently emit more methane.

Nitrous oxide emissions inside buildings, on the other hand, are considered to be nonexistent.

MANAGEMENT OF SLURRY MANURE STORAGE

Slurry manure contains carbonaceous compounds, particularly non-utilized feed and non-digestible matter from the meal, such as barley hull. The tank where this slurry is stored constitutes an anaerobic (oxygen-free) environment. Under these conditions, methanogenic bacteria convert these carbonaceous compounds into methane. It is worth noting that methane emissions from the slurry tank are more intense in the summer because of the greater biological activity of bacteria at this time.

Farm practices which decrease methane production from slurry tanks aim at reducing, both the amount of fermentable matter (volatile solids) excreted in the slurry, and the intensity of this fermentation. Volatile solids are comprised of the undigested organic part of the meal excreted into the slurry and potentially avaible for conversion into methane.

It is possible to decrease the amount of volatile solids that maintain fermentation inside slurry tanks by modifying husbandry practices and implementing new feeding models and strategies. Indeed, the amount of volatile solids excreted into the slurry will vary according to the type of ingredients used in the meal preparation and herd performance. Thus, by adjusting the meal formulation (ingredient type and quantity), excretion of volatile solids per unit of feed can be reduced together with their accumulation inside the slurry tank (Canadian Pork Council 2007b). Slurry separation with a centrifuge decanter or a selective solid-liquid manure isolation system underneath the slatted floor can also significantly reduce the accumulation of these solids inside the slurry tank.

As for fermentation intensity, it can be lessened by shortening the slurry storage time, that is, with more frequent spreading of slurry in the fields, based in soil conditions and crop needs.

Installation of a roof or cover on top of the slurry tank has several agronomic and environmental advantages: among others, the reduction of odours, and consequently separation distances between neighbours, as well as the increase of tank storage capacity and nutrient concentration inside the slurry. Thus, installing a cover on top of the slurry tank will reduce the slurry volumes to be transported and spread by 15 to 30% (FPPQ. June 2007. Les couvertures sur les fosses à lisier. Fiche technique no 4), which will also diminish fossil fuel consumption. In addition, tank covers can retain gases emitted from the slurry, such as methane, hydrogen sulfide and ammonia.

A floating straw mat is a low-cost option for controlling gas emissions, such as ammonia and odours, from slurry tanks. However, this type of cover does not allow methane recovery.

Otherwise, setting up weatherproof covers, coupled with appropriate technologies for gas recovery, represents an even more efficient option for reducing GHG emissions from the slurry tank.

Some producers have indicated an interest in pig slurry composting. This technique requires a large amount of dry substrate (forestry wastes, poultry manure, etc.), an amount almost equivalent to slurry on a per mass basis, in order to obtain the optimal moisture content for the process. Nevertheless, this technique leads to important nitrogen losses during the first phases of composting, not only in its molecular form but also as ammonium nitrogen and nitrogen oxide, in particular N_2O, notably if the mix is not homogeneous.

ANAEROBIC DIGESTION PROCESSES

Biomethanization of pig slurry consists of the microbial digestion in an oxygen-free environment of the organic matter contained in slurry, manure or other organic excretion. This reaction produces a biogas, composed mainly of methane (60%), carbon dioxide (40%) and a negligible amount of other gases. Once produced, this biogas can be burned directly in a boiler system where the hot water is used for heating buildings or, in some cases, directly in a small gas-powered electric generator (CRAAQ. 2008. La biométhanisation à la ferme).

These anaerobic digestion systems will allow reduction of GHG emissions by:

- recovering methane produced inside bioreactors;
- generating heat and other forms of energy on the farm with the biogas, which accordingly reduces the need for fossil fuels;
- better management of the nitrogen inside the liquid fraction (greater fertilizing efficiency) resulting from the digestion treatment, thus decreasing nitrous oxide emissions from agricultural soils.

Module 3: Management of slurry field application

On swine farms, nitrous oxide emissions basically arise from all of the handling and management operations of nitrogen-containing fertilizers (synthetic fertilizers and slurry manure), as well as from the soil drainage conditions (Bonnes pratiques agroenvironnementales. 2e édition. 2005).

Soil nitrate management, more specifically, can be optimized by synchronizing the nitrate availability and supply with the plants' nutrient needs, by:

- analyzing the nitrogen content of slurry and keeping slurry application and/or shipping records;
- optimizing fertilizer supply (soil analysis, crop needs, application dosage, previous crops);
- applying slurry at the right time;
- varying spreading time of slurry in the field; and,
- avoiding application of slurry when soils are water-saturated.

Nitrous oxide emissions during field application of slurry can be decreased by an appropriate slurry sampling protocol (CRAAQ, 2008. Protocole de caractérisation des lisiers de porc) and more precise and efficient spreading methods, measures which avoid supplying nitrogen in excess of crop needs. Also, by fractioning the spread of slurry over two or three applications, the supply of nitrogen corresponds better to the needs of the growing crop, which helps to reduce nitrate accumulation in the soil accordingly.

Moreover, applying slurry during the growing season optimizes nitrogen use by plants, which helps to reduce nitrogen loss through denitrification. Indeed, the bulk of nitrous oxide emissions takes place in early spring or late fall, when heavy rains or melting snow saturate the soil with water. Since a water-saturated soil is prone to anaerobic conditions, it also favours soil nitrate denitrification by anaerobic microorganisms, which first transform nitrates into molecular nitrogen (N_2), then into nitrous oxide (N_2O). For this reason, it is important to check soil water saturation conditions before spreading slurry in order to minimize nitrogen loss through denitrification.

Furthermore, it is possible to mitigate the risk of developing anaerobic conditions in the soil by avoiding excess water saturation through optimal landscaping (surface drainage) and subsoil drainage. As well, performing a diagnostic of soil drainage conditions could help identify field areas at risk, and allow appropriate corrective measures (Conseil des productions végétales du Québec inc. 2000).

Incorporating slurry in cultivated soil as well as using trailing-hose spreaders to apply slurry on grassland improves nitrogen efficiency by reducing ammonia losses through volatilization, decreases odours at spreading, and reduces the risks of runoff to surface waters. Although ammonia is not a GHG, it can convert into nitrous oxide after deposition onto agricultural soils, thus becoming an indirect GHG emissions source. That is why it is important to control nitrogen loss through volatilization.

Module 4: Social acceptability

Planting a shelterbelt or hedgerow, that is, a living plant barrier comprising one or many rows of carefully selected trees and shrubs according to their ability to reduce odours, reduces heating cost as well as dust and noise, in and around buildings. This strategy also improves on-farm biodiversity, makes the farm more attractive and greatly increases the social acceptability of swine production. Indeed, shelterbelts remove carbon dioxide from the atmosphere and store it in their biomass (carbon sequestration). Actual costs have been estimated at $1,000/100m. (FPPQ. September 2002. Écrans boisés. Fiche technique no 6).

SECTION

2 IDENTIFICATION OF BEST PRACTICES ON THE SWINE FARM (DIAGNOSTIC)

This section proposes to review the "best practices" that can be applied on swine farm in order to reduce or avoid greenhouse gas emissions, through the above modules "Animal housing management", "Manure handling and storage management", "Management of slurry field application" and "Social acceptability".

Among the best practices presented in Table 1, check [✔] those that you have already implemented on your farm, those that will be implemented during the upcoming year (priority 1), those that will be implemented in the next few years (priority 2) and finally those that will be implemented in the long-term (priority 3), after a thorough analysis of your situation.

This first evaluation constitutes your first best practices qualitative diagnosis for reducing or avoiding GHG emissions on your swine farm.

Afterwards, it will be possible to draw up a GHG reduction or avoidance plan, for those swine producers willing to further their overall efforts.

TABLE 1. IDENTIFICATION OF BEST PRACTICES AIMED AT REDUCING OR AVOIDING GHG EMISSIONS ON THE SWINE FARM, PER PRIORITY

BEST PRACTICE		PRIORITY			
		Actually on farm	1	2	3
Module 1: Animal housing management					
Herd health					
Selecting genetically superior animals					
Mitigating stress in animal buildings and improving the health status of the herd					
Feed management					
Reducing the crude protein content of the diet by 2%					
Adding phytase enzyme to the diet					
Implementing phase feeding					
Installing wet-feed hoppers and water-saving drinking bowls					
Controlling the granulometry of feed ingredients and favouring pelleted feed					
Using the nutrient excretion model					
Energy efficiency					
Performing an energy audit on your swine farm					
Module 2: Manure handling and storage management					
Animal housing management					
Evacuating slurry manure frequently					
Managing slurry manure storage					
Reducing the amount of volatile solids accumulating inside the slurry tank					
Implementing mechanical slurry treatment (solid/liquid slurry separation)					
Capturing slurry storage structures (slurry tanks, etc.)					
Capturing biogas produced inside slurry storage structures					
Anaerobic digestion processes					
Implementing biomethanization technology on the farm					
Module 3: Management of slurry field application					
Annual analysis of slurry following an established protocol and recording slurry application and/or shipping					
If responsible for soil and crop management	Optimize supply of all nitrogen-containing fertilizers				
	Vary timing of slurry application				
	Identify field zones with excess water and diagnose soil-drainage conditions				
Incorporating slurry in cultivated soil or use trailing-hose spreaders to apply slurry onto grassland					
Module 4: Social acceptability					
Planting a shelterbelt (hedgerow)					

SECTION

3 GREENHOUSE GAS REDUCTION OR AVOIDANCE PLAN ON SWINE FARM

This section will help you to draw up the greenhouse gas reduction or avoidance plan on your swine farm, subsequent to your preliminary diagnosis (section 2) and according to the incidence of the chosen best practices on nitrogen excretion, odours, husbandry conditions and profitability.

For each best practice appearing in Table 2, confirm [√] the actions you want to take in the short term (priority 1), in the next few years (priority 2) or, after thorough analysis, in the long term (priority 3), in the column titled "GHG emissions reduction or avoidance plan". The best practices listed in this table are innovative yet known practices, that will enable you, on the one hand, to reduce the total amount of volatile solids and nitrogen excreted on the farm and, on the other hand, to improve the energy efficiency as well as the social acceptability of your farm.

This part constitutes the greenhouse gas emissions reduction or avoidance plan that best suits your swine farm, according to your own management strategy and timetable.

TABLE 2. GREENHOUSE GAS EMISSIONS REDUCTION OR AVOIDANCE PLAN ON THE SWINE FARM

BEST PRACTICE	INCIDENCE OF BEST PRACTICE ON NITROGEN EXCRETION, GHG AND ODOUR EMISSIONS, HERD PERFORMANCE AND PRODUCTION COSTS			GHG EMISSIONS REDUCTION OR AVOIDANCE PLAN. Check [√] actions to be taken		
	Impact on nitrogen excretion, GHG emissions and odours	**Impact on the improvement of herd performance**	**Economic impact**	**In the short term**	**In the next few years**	**After analysis**
Selecting genetically superior animals	Nitrogen excretion reduction by 3.5 to 7.8%	Improvement of weight gain (kg/day) from 0.708 to 0.824 Improvement of feed conversion rate from 3.12 to 2.64	Nil			
	FPPQ. Août 2005. Réduire les odeurs par la régie alimentaire. Fiche no 9					
Mitigating stress in animal housing and improving the health status of the herd	Depending on the disease and its severity, increase of nitrogen excretion by 5 to 25%	Certain diseases decrease feed conversion from 2 to 15%	Varies according to actions taken			
	FPPQ. Août 2005. Réduire les odeurs par la régie alimentaire. Fiche no 9					
Reducing the crude protein content of the diet by 2%	Reduction of nitrogen excretion by 15 to 20% Reduction of odours in buildings: less than 20%	Increased weight gain from 2 to 4% Improvement of feed conversion by 2 to 4%	Reduction of feeding costs by $0.60 to $1.40/pig			
	FPPQ. Août 2005. Réduire les odeurs par la régie alimentaire. Fiche no 9 **FPPQ. Juin 2005. Réduction des odeurs du bâtiment au champ. Fiche no 8.**					
Adding phytase enzyme to the diet	Reduction of nitrogen excretion by 2%	Adding phytase generally improves availability of amino acids and energy of the grain	Increase in feeding costs is offset by savings made by decreasing phosphorous and calcium supplements			
	FPPQ. Septembre 2002. Régie alimentaire pour réduire les rejets d'azote et de phosphore. Fiche no 2					
Implementing phase feeding	Reduction of nitrogen excretion by 10 to 18%	Improvement of weight gain from 1.5 to 4% Improvement of feed conversion rate by 1.5 to 3%	Reduction of feeding costs by $0.90 to $1.75/pig			
	FPPQ. Août 2005. Réduire les odeurs par la régie alimentaire. Fiche no 9					

TABLE 2. GREENHOUSE GAS EMISSIONS REDUCTION OR AVOIDANCE PLAN ON THE SWINE FARM (CONTINUED)

BEST PRACTICE	INCIDENCE OF BEST PRACTICE ON NITROGEN EXCRETION, GHG AND ODOUR EMISSIONS, HERD PERFORMANCE AND PRODUCTION COSTS			GHG EMISSIONS REDUCTION OR AVOIDANCE PLAN Check [√] actions to be taken		
	Impact on nitrogen excretion, GHG emissions and odours	**Impact on the improvement of herd performance**	**Economic impact**	**In the short term**	**In the next few years**	**After analysis**
Installing wet-feed hoppers and water-saving drinking bowls	Nitrogen excretion reduction by 8 to 10%	Improvement of weight gain by 5 to 10% Improvement of feed conversion by 4 to 7%	Reduction of feeding costs by $1.80 to 4$/pig			
FPPQ. Août 2005. Réduire les odeurs par la régie alimentaire. Fiche no 9						
Controlling the granulometry of the feed and favouring pelleted feed	A particle size of 600 microns reduces nitrogen excretion by 5 to 10%	Pelleted meal increases daily meal consumption and decreases feed waste	Reduction of feeding costs, depending on strategy chosen			
FPPQ. Août 2005. Réduire les odeurs par la régie alimentaire. Fiche no 9						
Using the nutrient excretion model	Reduction of nitrogen and phosphorus excretion (varies with action taken)	Improvement of weight gain Improvement of feed conversion	The feed balance sheet enables testing different scenarios for improving husbandry practices			
FPPQ. Janvier 2007. Le bilan alimentaire. Outil d'évaluation des charges d'azote et de phosphore. Fiche no 2A.						
Performing an energy audit on your swine farm	Reduction of GHG emissions through decreased use of fossil fuels	Improvement of husbandry conditions (localized heating for piglets; building heating and ventilation)	Savings in energy-guzzling sectors of the swine farm			
CRAAQ. 2008. Audit énergétique sommaire en production porcine.						

TABLE 2. GREENHOUSE GAS EMISSIONS REDUCTION OR AVOIDANCE PLAN ON THE SWINE FARM (CONTINUED)

BEST PRACTICE	INCIDENCE OF BEST PRACTICE ON NITROGEN EXCRETION, GHG AND ODOUR EMISSIONS, HERD PERFORMANCE AND PRODUCTION COSTS			GHG EMISSIONS REDUCTION OR AVOIDANCE PLAN. Check [√] actions to be taken		
	Impact on nitrogen excretion, GHG emissions and odours	**Impact on improvement of herd performance**	**Economic impact**	**In the short-term**	**In the next few years**	**After analysis**
Evacuating slurry manure frequently	Reduction of methane and odour production inside buildings: less than 25%	Improvement of husbandry conditions	Negligible			
	FPPQ. Juin 2005. Réduction des odeurs du bâtiment au champ. Fiche no 8.					
Reducing the amount of volatile solids accumulating inside the slurry tank	Reduction of methane (CH4) production in slurry storage tanks	To be checked with your nutritionist	To be checked with your nutritionist			
	Canadian Pork Council. Méthode pour calculer les GES en production porcine. 2007.					
Implementing mechanical slurry treatment (solid/liquid slurry separation)	Under the slatted floor: CH4 reduction by 20% inside buildings and 80% in storage Centrifuge: CH4 reduction by 50% in storage	N/A	Solid/liquid separation: Centrifuge decanter: $18/pig produced or $354/sow Under slatted floor: $10/pig produced or $197/sow			
	Pelletier et al. 2005. Réduction des émissions de GES : faisabilité de l'implantation d'une chaîne de gestion des lisiers au Québec. IRDA et BPR. 94 pages.					
Covering slurry storage structures	• Reduction of annual ammonium nitrogen losses by 10 to 20% • Reduction of odour emissions (varies with cover type)	N/A	Gross cost varies from $0.25/pig produced (strawmat) to $2.80/pig produced (floating cover) for a slurry tank 30m in diameter			
	FPPQ. Juin 2007. Les couvertures sur les fosses à lisier. Fiche no 4.					

GREENHOUSE GAS EMISSIONS REDUCTION OR AVOIDANCE PLAN ON THE SWINE FARM (CONTINUED)

BEST PRACTICE	INCIDENCE OF BEST PRACTICE ON NITROGEN EXCRETION GHG AND ODOUR EMISSIONS, HERD PERFORMANCE AND PRODUCTION COSTS			GHG EMISSIONS REDUCTION OR AVOIDANCE PLAN. Check [√] actions to be taken		
	Impact on nitrogen excretion, GHG emissions and odours	**Impact on improvement of herd performance**	**Economic impact**	**In the terme short-term**	**In the next few years**	**After analysis**
Recovering biogas produced inside slurry storage structures (e.g. floating cover)	• 100% reduction of ammonium nitrogen • Odour reduction by 80% • Substitution of fossil fuels	N/A	Floating cover: \$110/m² or \$2.80/pig produced Possibility of installing a methane collection system (cost not included)			
	FPPQ. Juin 2007. Les couvertures sur les fosses à lisier. Fiche no 4.					
Implementing biomethanization technology on the farm	90% reduction potential of GHG emissions on the farm Reduction of odour emissions	Improvement of husbandry and health of the herd	\$350,000 for 5,000 pigs produced/year Profitability threshold = \$0.13/kWh to \$0.22/kWh Co-digestion potential (revenues) Methane production			
	CRAAQ. 2008. La biométhanisation à la ferme. CRAAQ.					
Annual analysis of slurry and record of slurry application and/or shipping	Reduction of N_2O emissions from soil	N/A	Negligible			
	CRAAQ. 2008. Protocole de caractérisation du lisier de porc.					
Optimizing supply of all nitrogen-containing fertilizers	Reduction of N_2O emissions from soil	N/A	Negligible			
	MAPAQ. Février 2005. Bonnes pratiques agroenvironnementales pour votre entreprise agricole. 2e édition.					

TABLE 2. GREENHOUSE GAS EMISSIONS REDUCTION OR AVOIDANCE PLAN ON THE SWINE FARM (CONTINUED)

BEST PRACTICE	INCIDENCE OF BEST PRACTICE ON NITROGEN EXCRETION, GHG AND ODOUR EMISSIONS, HERD PERFORMANCE AND PRODUCTION COSTS			GHG EMISSIONS REDUCTION OR AVOIDANCE PLAN. Check [✔] actions to be taken		
	Impact on nitrogen excretion, GHG emissions and odours	**Impact on improvement of herd performance**	**Economic impact**	**In the short term**	**In the next few years**	**After analysis**
Varying timing of slurry application	Reduction of N_2O emissions from soil	N/A	Negligible			
MAPAQ. Février 2005. Bonnes pratiques agroenvironnementales pour votre entreprise agricole. 2nd edition.						
Identifying field zones with excess water and diagnose soil-drainage conditions	Reduction of N_2O emissions from soil	N/A	Negligible			
Conseil des productions végétales du Québec inc. 2000. Guide des pratiques de conservation en grandes cultures. Module 7.						
Incorporating slurry in cultivated soil or use trailing-hose to apply slurry onto grassland	50% to 95% reduction in ammonium nitrogen loss through volatilization	N/A	Additional cost at spreading of $0.71/m^3			
FPPQ. Mars 2005. Rampes d'épandage. Fiche no 5.						
Planting a shelterbelt (hedgerow)	Carbon sequestration by trees Possible fossil fuel reduction for heating Reduction of odour emissions	N/A	$1,000/100m linear (3 rows)			
FPPQ. Septembre 2002. Écrans boisés. Fiche no 6.						

SECTION

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