HOG FARM EMISSIONS: a review of evidence for cancer risk to humans

According to some reports, pork is the most produced and consumed meat worldwide – 103,000 metric tons were produced and consumed in 2010, compared with poultry at 78,000 metric tons[6]. The way pigs are farmed has changed over time. In 1986, there were 4,700 hog farms in Quebec, with an average herd size of 620.[1] In 2011, there were 1,953 farms, with an average herd size of 2,000,[1] totalling just over 4 million hogs, the most in any province.[2]

While large scale hog farming* may be a benefit to Quebec's agricultural economy, it does not come without impacts to residents of nearby communities. A recent review conducted by the National Collaborating Centre for Environmental Health (NCCEH)[3] found peer-reviewed studies reporting a range of health issues in communities near hog farms, including:

- Mood-related issues such as higher tension, depression, anger, fatigue and confusion compared to people living in areas without hog farms.
- Higher rates of respiratory symptoms indicating toxic or inflammatory effects in people living with 2km of a 4,000 hog operation.
- Increased occurrences of headaches, runny nose, sore throat, coughing, diarrhea and burning eyes in people living within 2 km of a 6,000 hog operation.
- Reduced function of the immune system that helps protect against microorganisms and allergens in people living with 2.4 km of at least one hog operation.
- Higher levels of respiratory, sinus and nausea problems in people living near industrial hog farms.
- Five percent higher rates of wheezing in teens with asthma at schools within 3 miles of a large hog farm, and 24 percent higher rates at schools with detectable farm odor indoors twice a month or more.

The health impacts listed above may be serious for some people, but have not been directly linked to an increased risk of cancer. The purpose of this short review is to identify any known or suspected carcinogens produced by large scale hog farming, if they can be found in air, food or drinking water and therefore put community members at risk, and any measured levels reported.

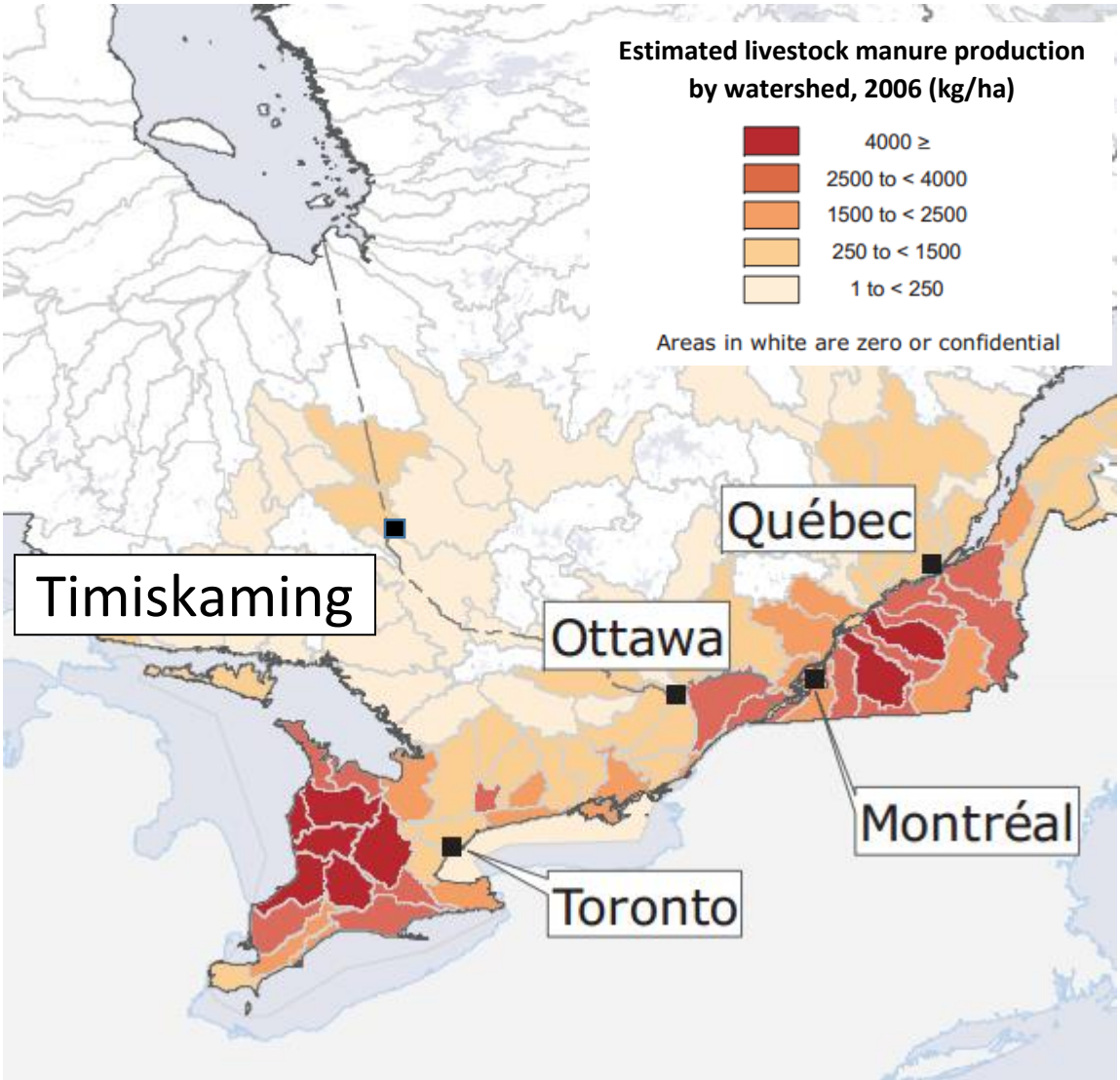
* We use the term 'hog farm' in this review , although 'pig farm' and 'swine operation' are also frequently used.

SSRL Spatial Sciences Research Lab · CAREX Canada · PROPEL Centre for Population Health Impact · FNEHIN · Canadian Partnership Against Cancer · Partenariat canadien contre le cancer · CIHR IRSC

Virtually all of the negative impacts of hog farming are related to animal wastes. Estimates show that a hog produces between 1 and 4 kg of waste every day, depending on its age and size.[4] This amounts to anywhere between 2 and 8 tonnes of manure (including urine) daily on a farm with 2,000 hogs. Liquid manure is first stored near the hog barns, either in a holding tank or in an open lagoon, and is eventually sprayed as fertilizer on nearby fields.

In eastern Canada, the most concentrated livestock areas are in southern Ontario and along the St. Lawrence River in Quebec (Figure 1). Notably, Timiskaming First Nation is situated near the only significant livestock zone outside of these main areas. New hog farms are currently proposed in this area in the province of Quebec, which will increase the production of manure in the future.

Figure 1. Livestock Manure Production by Watershed – Eastern Canada, 2006[4]



Outdoor Air

A wide range of gases are emitted from liquid manure while it is stored and especially when it is later sprayed on nearby fields. Some are concerning because they contribute to global warming (methane and carbon dioxide) or can cause short-term health issues for farm workers such as eye or skin irritation and nausea at high concentrations (ammonia, hydrogen sulfide).[3] In addition, more than 500 volatile organic compounds (VOCs) have been measured in hog manure;[5] most of these are associated with bad smells, and very few are thought to be linked to increasing cancer risk.

One of the more commonly found VOCs is acetaldehyde (Table 1), a possible carcinogen according to the International Agency for Research on Cancer.[6] We used acetaldehyde levels reported by two studies of hog farm emissions in North Carolina to estimate lifetime excess cancer risk associated with this exposure. The estimate indicates how many additional cases of cancer would be expected in a population of one million people who are exposed to acetaldehyde at the reported levels continuously for 70 years. The estimate ranges between 0.5 per million (using the lowest seasonal average level) and 16.7 per million (using the highest level measure over a 5-minute period). Health Canada considers lifetime excess cancer risks of between 1 and 10 per million as negligible, being unlikely to occur given the assumptions used in the calculation. It is also reasonable to expect that acetaldehyde levels decrease quickly with distance from the barns and manure storage areas.

In comparison, lifetime excess cancer risk due to acetaldehyde levels measured at non-farm locations (Table 1) are lower, ranging from 0.06 to 0.4 per million, based on annual average levels in 2010 from the National Air Pollution Surveillance (NAPS) monitoring network. So, while levels of acetaldehyde are higher close to hog barns than in non-farm locations, the lifetime excess cancer risk is negligible.

Table 1. Measured levels of acetaldehyde at hog farms and in non-farm locations

Location	Measured level	Lifetime excess cancer risk
Five hog farms in North Carolina, various locations on each farm[7]	5 minute average = 15.5 μg/m^3	2.8 to 3.6 per million
	5 minute maximum = 72 μg/m^3	12.9 to 16.7 per million
Eight hog barns on one farm in North Carolina, at ventilation fans[5]	Lowest seasonal average = 2.6 μg/m^3	0.5 to 0.6 per million
	Highest seasonal average = 13.0 μg/m^3	2.3 to 3.0 per million
Eleven non-farm locations across Canada in 2010[8]	Mean annual average of 0.34 μg/m^3	0.06 to 0.08 per million
	Maximum annual average of 1.8 μg/m^3	0.3 to 0.4 per million

While measured levels of acetaldehyde in close proximity to hog barns are not of concern with respect to increasing cancer risk, there are very few studies of impacts to communities near hog farms. The NCCEH review[3] mentioned above found no community health studies in Canada, and only eight from the US and two from Germany. None of these studies used actual air quality measurements, but simply compared the health of residents in communities near hog farms to residents of communities without hog farms nearby.

Drinking Water and Food

In addition to dangerous bacteria, pig manure may contain elevated levels of nitrate, nitrite, and heavy metals such as arsenic and lead, due to natural digestion processes, feed additives, mineral supplements and even some veterinary medications.[9] [10] [11] These potentially harmful substances can enter lakes, streams and groundwater if manure holding tanks or lagoons fail, or in runoff from agricultural fields sprayed with manure. They may also be present in soils fertilized with manure.

Nitrate and nitrite occur naturally as part of the nitrogen cycle, when microorganisms in plants, soil and water combine nitrogen and oxygen from the air. However, human activities are the most common sources, including agriculture, wastewater treatment, industrial processes, and even motor vehicle exhaust. [12] Salts containing nitrate or nitrite are also used to cure and preserve meat and fish. The major concern with long-term exposure to nitrate and nitrite is the body's ability to convert them to N-nitroso compounds, some of which are associated with an increased risk of cancer.

Nitrate, rather than nitrite, is more commonly found in water and levels are usually naturally higher in surface waters than in groundwater. Recent measurements show that on average, drinking water quality guidelines for these substances are met, but maximum levels have been recorded well above the guideline in some areas of Quebec (Table 2). Specific comparisons of drinking water near agricultural activities also show elevated levels of nitrate and nitrite, and data from North America and Europe show that nitrate and nitrite levels in water have been increasing over time, making them a priority for monitoring.[12]

Table 2. Summary of nitrate and nitrite guidelines and measured levels in drinking water[12]

Canadian Drinking Water Guidelines		Measured levels (mg/L) Ontario (2000 – 2009)		Quebec (2000 – 2009)		130 sites in Canada (2009 – 2010)	
Substance	Maximum Acceptable (mg/L)	Avg. (mg/L)	Max. (mg/L)	Avg. (mg/L)	Max. (mg/L)	Avg. (mg/L)	Max. (mg/L)
Nitrate	45	0.35	19	3.7	**93**	3.6	20.8
Nitrite	3	--	--	--	--	0.05	0.3

Nitrates can be taken up by plants, and levels in leafy vegetables are naturally much higher than those found in other foods or water. Because vegetables also tend to have higher levels of vitamin C and other antioxidants, which prevent the conversion of nitrate to N-nitroso compounds in the body, there is little concern about this source of exposure.[13]

A comprehensive study of trace metals in manure and soil due to farming operations in Manitoba was published in 2012.[14] The authors measured over 50 trace elements, including arsenic and lead which are associated with increased cancer risks, from 124 manure samples from poultry, hog, dairy and beef farms as well as in the feeds used on the farms. Their findings showed that dry manures contained 3 to 5 times the level of trace metals compared to feeds, indicating that animal digestion concentrated metals in waste. They also measured the same trace elements in 10 heavily manured fields and 10 nearby un-manured fields. There was no evidence that arsenic or lead were accumulating in soils through fertilizing with manure. This suggests that plants grown on fields fertilized with hog manure (or other kinds of manure) are not at risk of taking up higher levels of arsenic or lead.

We want to move forward in improving environmental quality: the air we breathe, the land we walk on, the water we drink, the food we eat; that's who we are as a people. If our earth is health, we are healthy.[15]

There is often substantial local opposition to developing or expanding hog farms, as there are a number of known potential health impacts on nearby residents. It is unlikely that these effects include an increased risk of cancer. However, the number of published studies looking at health impacts is small, and there are very few actual measured data useful for monitoring changes in air quality, drinking water quality and food safety related to hog farms and community impacts.

If a new hog farm is being permitted, or an expansion to an existing hog farm is being allowed, local governments should:

- Require baseline monitoring studies of air quality (including VOCs and fine particulates) in residential areas within 5km, taking into consideration the predominant wind directions. This may require a wind direction and speed monitoring station at the farm location, recording hourly data at the least.
- Require baseline monitoring studies of any local streams, lakes and wells, to establish levels of nitrate, nitrite, ammonia, metals, fecal coliform and commonly used veterinary drugs.
- Conduct drinking water quality sampling (including e.coli, nitrate , nitrite and arsenic), at drinking water treatment facilities and at private water intakes and wells that may be at risk of contamination with manure in the event of a holding tank/waste lagoon failure or runoff from agricultural fields.
- Require regular sampling after development to rapidly identify any changes occurring and develop appropriate mitigation strategies to protect human health.

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