Manure as a Public Health Issue: What Accountability and Directions for Livestock Agriculture?

A Special Report
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The contamination of the municipal water supply in Walkerton, Ontario with *E. coli* and the resulting human tragedy shocked the public. While we may never know the source of the contamination, an anxious public is looking for answers and livestock agriculture is a leading suspect. In particular, "factory farms" are coming under increased scrutiny. What is livestock's record of safety and accountability with respect to manure runoff and water contamination, and what can be done to ensure that livestock operations are both safe and efficient? Little hard evidence exists on these topics- this paper raises questions and discusses the following issues:

- What are the sources of water contamination in rural areas, and how significant is livestock agriculture's contribution to the problem?
- Are "factory farms" responsible for water quality problems?
- What steps must be taken to ensure that livestock agriculture does not degrade water quality and remains competitive?

Commercial livestock facilities in Canada have received increased public scrutiny recently. For example, Maclean's cover story for June 12th, 2000[1] asserts that "there are dangerous consequences of factory farming that are being felt across the country". The concerns relate to perceived environmental and public health problems related to manure. But what is the evidence supporting them, and how do they relate to increasing farm sizes and agri-food competitiveness?

Water Quality Issues Related in Livestock Agriculture

There are four primary environmental issues related to livestock agriculture

- bacterial contamination of surface water and groundwater
- nitrate leaching
- phosphorous runoff
- unpleasant odours

Bacterial contamination of groundwater is a threat to drinking water obtained from rural wells. In particular, contamination by *E. coli* 0157 (commonly known as *hamburger disease*, the bacteria responsible for the deaths in Walkerton) and some coliform bacteria can pose serious health risks. Bacterial pathogens can also contaminate surface water, resulting in fish kills, beach closures, and accelerated eutrophication of lakes and streams. Nitrate leaching problems occur as nitrate contained in manure seeps through topsoil and into the groundwater which is tapped by household

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[1] Nikiforuk, Andrew. "When Water Kills", *Maclean's* 113 (24) 18-21. June 12, 2000

wells. Manure and wash water from livestock facilities also contain phosphorous which is a threat to surface water and aquatic ecosystems, but less of a direct threat to human health. Phosphorous encourages the growth of aquatic plants that remove oxygen and warm the water temperature, speeding up eutrophication. Finally, manure from livestock operations can cause unpleasant odours for nearby households.

What is the significance of these issues for public health? The few rural well surveys conducted over the last 25 years suggest reason for concern. The table below summarizes the results from the most recent well surveys conducted for provinces in Canada over the last 25 years. The

	Time Period	**Percentage of Wells Contaminated With Bacteria**	**Percentage of Wells Exceeding Recommended Nitrate Level**
Alberta	1994	68.0	3.0
Ontario	1991-92	34.0	14.0
Quebec	1975-78	27.0	1.5
New Brunswick	1985-86	29.0	20.2
Nova Scotia	1989	7.0	not measured

Source: Adapted from Goss *et al*[2]

study results vary according to the period in which they were conducted and by province. However, with the possible exception of Nova Scotia, the level of bacterial contamination of rural wells in all provinces appears alarmingly high. There seems to be a predominance of well contamination with bacteria rather than with nitrates. This effect has been intensifying over time. For example, a 1992 survey of rural well water in Ontario, compared with a similar survey conducted in 1955, showed the following:

	1955	**1992**
Number of Wells Tested	484	1290
Percentage Exceeding Ontario Nitrate Standards	13.8	14.0
Percentage Containing Fecal Coliforms	15.0	25.0

Source: OMAFRA

The table shows that between 1955 and 1992 the incidence of nitrates in well water remained

[2] Goss, M.J., D.A.J. Barry, and D.L. Rudolph. “Contamination of Ontario farmstead domestic wells and its association with agriculture: 1. Results from drinking water wells”, *Journal of Contaminant Hydrology* 32 267-293. 1998.

relatively steady. However, the number of wells containing fecal coliform bacteria increased sharply. This is particularly significant given that a greater proportion of the wells surveyed in 1955 were dug rather than bored, and therefore had a greater potential for contamination. Thus, as underscored by the tragedy in Walkerton, bacterial contamination is a significant issue in rural well water and public health, and it appears to be a growing concern.

Sources of Bacterial Contamination

What are the sources of bacterial contamination of surface and groundwater? In the wake of Walkerton, the media has touted livestock farming as the leading source. Indeed, manure from livestock do contribute to water quality problems - in some cases significantly. For example, a study of drinking water quality in Southern Ontario conducted in 1997[3] found that 20% of wells surveyed contained bacteria originating from animal manure. Another Ontario study[4] found that on farms where manure was applied, there were significantly higher levels of bacteria and nitrates than on farms that did not apply manure or nitrogen fertilizer.

However, there are other sources of contamination. These include effluent from sewage treatment facilities, surface runoff from urban areas, and emissions from inadequate household septic systems. The evidence on the proportions of water contamination due to manure and these other sources is very sparse. However, a study of surface water quality in an intensive livestock region in Southwestern Ontario[5] showed that the majority of bacterial loadings in 3 reservoirs were due to sources other than manure. In particular, faulty household septic systems were found to be the leading cause of bacterial contamination in two of the reservoirs.

Thus, while the reality is that manure from livestock is a contributor to water contamination and that farmers must accept responsibility for it, there are other sources of contamination, some of which may be more significant. The safety and effectiveness of household septic systems in particular should receive attention as part rural water quality maintenance.

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[3] Conboy, M.J. and M.J. Goss. “Contamination of Rural Drinking Wells by Fecal Origin Bacteria- Survey Findings”, *Water Quality Research Journal of Canada* 34(2) 281-303. 1999.

[4] Goss, M.J., D.A.J. Barry, and D.L. Rudolph. “Contamination of Ontario farmstead domestic wells and its association with agriculture: 2. Results from mulilevel monitoring well installations”, *Journal of Contaminant Hydrology* 32 295-311. 1998.

[5] Anonymous. “The Clean Up Rural Beaches Plan”, *Talk of the Thames*- Summer, 1989. London, Ontario: Upper Thames River Conservation Authority.

Structure of Livestock Agriculture's Impact on Bacterial Contamination

The popular press and some politicians have also asserted that it is "factory farms" that are responsible for rural water quality problems. At first blush, this seems entirely plausible. The amount of manure excreted by a farm animal does not vary significantly whether it is part of a small number that are housed together or a very large number. So large farms produce more manure. That we are observing acute water quality problems now must thus be a consequence of the rapid expansion in livestock numbers and in the size of farms.

However, the evidence to back up this assertion is lacking. Indeed, there are compelling reasons to believe the opposite may be true:

- At larger farm sizes it becomes more viable to install technology that better controls manure emissions
- Large livestock facilities are generally newer. Older (smaller) livestock farms tend to have less up to date manure handling facilities.
- Newer (larger) livestock facilities must provide approved nutrient management plans in order to obtain building permits[6]. Older (smaller) facilities have no requirement to provide nutrient management plans.

The implicit assumption behind the environmental argument against large livestock farms is that since they have more livestock and produce more manure, they constitute a greater problem. In fact, it can be very difficult for small farms to adopt the same environmentally-friendly manure storage and handling technology that is feasible on larger operations. This is primarily because there are economic and technical constraints on smaller producers to adopt some of the more efficient environmental protection technologies. For example, equipment is available that separates liquid and solid manure to give "grey" water that can be reused. Livestock facilities can be equipped with manure composters and digesters similar to urban sewage treatment facilities that limit the potential for spills from manure storage. Umbilical injection application systems have been developed that inject manure directly into the ground, limiting surface runoff and odour, while conserving greater levels of nitrogen in the manure. These technologies tend to favour larger farms because of their high fixed costs.

Another aspect (related to farm size) is the age of farm buildings and facilities. Older livestock farms frequently have substandard manure storage and application facilities that were not designed with many of today's water contamination and odour issues in mind, so, relative to newer facilities, there is good reason to believe older facilities are more prone to produce odour and emission problems. For example, when farmsteads were established they were commonly situated close to watercourses so the farm could make use of surface water. Today, the surface water is no longer an important operational aspect of the farm, and barnyards, septic systems, and

[6] A nutrient management plan is one that explicitly puts together the amount of nutrient from the manure that is produced on a farm with an amount of land, taking into account the characteristics of the land that will absorb the manure nutrients.

milkhouse drains may have been erected that unintentionally contaminate the watercourse. These issues were not of concern when the original farmstead was planned years ago.

New facilities, which are typically constructed at relatively large sizes, face regulatory review that older facilities do not. In many municipalities, in order for a building permit to be issued for new barns and livestock facilities, a nutrient management plan must be submitted and approved to demonstrate that there is sufficient land for manure application on an agronomically sustainable basis. The enforcement of nutrient management plans is informal at best, however it provides a formal review of the land base available for manure application and manure storage at the time the facilities are approved for construction. In contrast, older facilities are not required to file nutrient management plans to demonstrate that they apply manure on an agronomically sustainable basis, and no formal review is made of their manure storage facilities. Thus, in many cases, "factory farms" have passed an environmental review that older (smaller) farms need not comply with.

There is little empirical evidence available to reflect on the environmental impact of small vs. large livestock operations. However, the little evidence of differences in manure storage and application between large and small farms provides weak support for the notion that large farms handle manure more safely. A survey of Minnesota swine farms[7] found that larger operations more commonly complied with recommended manure management practices than small farms. The survey found that larger farms were more likely to handle manure in liquid form, analytically test manure nutrients, calibrate application equipment, inject rather than broadcast manure, and keep records of manure applications, and were less likely to apply manure in summer or winter. However, the study also found that larger farms owned fewer acres of land per animal unit upon which manure could be applied. Thus, while the evidence supporting large farms as more environmentally friendly is weak, it provides a contrast to the allegations of "factory farm" opponents.

The foregoing suggests that large livestock farms may not bear primary responsibility for rural water quality problems. Indeed, the large farms may be in a better position to handle and treat manure in a more environmentally responsible manner than small farms, and must pass environmental regulatory checks that small farms do not need to. This is important because research has shown, and industry trends confirm, that there are size economies in many livestock enterprises. If the large livestock farms are targeted as the culprits for water contamination (as some suggest) it will penalize our most efficient farms. If it can be shown that the large farms are responsible for a greater level of contamination, then this may be justified. However, if it is the cumulative effect of smaller farms with less up to date manure storage and application technology

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[7] Schmitt, M.A.; Schmidt, D.R.; Jacobson, L.D. "A manure management survey of Minnesota swine producers: effect of farm size on manure application", *Applied Engineering in Agriculture* 12 (5) 595-599. St. Joseph, MI: American Society of Agricultural Engineers, Sept 1996.

that are primarily responsible, then we will be sacrificing our most efficient and competitive farms and failing to solve the water quality problem. In this case, the issue that arises is the social cost of protecting small "family" farms.

Resolving Water Quality Concerns

What must be done to protect rural water quality? What must occur first is a recognition and acceptance by the agricultural community that there are legitimate public health concerns, and that livestock farms may be part of the problem. There will be some in agriculture who will assume a defensive posture and insist that the disaster in Walkerton was merely an isolated case of negligence. However, the empirical evidence from well water surveys carried out across Canada indicate that rural water quality is a genuine concern, and manure pollution is a contributing factor.

At the same time, livestock ought not to be treated as the sole source of bacterial contamination, since non-farm sources of bacterial contamination are likely significant. But what changes should occur in livestock? Concerns related to water quality have motivated some municipalities to enact changes to zoning regulations. For example, the township of West Perth in Perth County, Ontario has proposed to limit the size of livestock operations to 600 animal units, require 30% of the land required for manure application to be owned, and prohibit transportation of manure greater than 8 km. This type of regulation will appeal to those who feel something tangible must be done to reduce the source of manure. But if there is no reason to believe that large farms produce more pollution than small farms, then discriminating against the large operations will not solve the problem. In fact, penalizing the larger, more efficient farms will harm local economies dependent on livestock, reduce the tax base that can be used to fund water quality improvements, and eliminate potential sources of employment for rural communities.
What is clear is that better methods of storing, treating, and applying manure must be adopted and come into wider use if manure pollution problems are to be solved. Some of these technologies are known to municipal decision makers, but regulations have not focussed directly on the technology. Much of the reason is that there is some uncertainty as to how well the technology will work, and municipalities do not feel that they should assume this risk. Take manure injection technology as an example. It is widely anticipated that by injecting directly into the soil, there will be benefits in terms of reduced surface runoff of manure and reduced manure odour problems relative to the typical broadcast application. But what will the magnitude of the benefits be? This is uncertain.

The public policy response will hinge on whether to introduce incentives that facilitate environmental improvements or to directly regulate livestock agriculture- the old question of the carrot or the stick. Because the information as to how best mitigate manure pollution is dispersed among livestock farmers, policies that encourage use of this information to innovate cleaner manure systems are more likely to bring better, longer-term results. Direct regulation assumes that the regulator has as much knowledge as farmers do, and does not give the same incentives for innovation and ongoing improvements. However, policies that foster innovation put in place an evolutionary process with uncertain improvements; the effects of regulation are more tangible and relatively certain.

One approach to resolving this issue is through *contingent contracts*. Contingent contracts are used when multiple parties have an interest in an uncertain outcome, but have differing beliefs as to what that specific outcome will be. Rewards are made contingent on performance, with provisions made for failure. Thus, the optimistic party has every incentive to perform, while the less optimistic party is reassured knowing that the worst case is addressed in the provisions for failure. For example, suppose a machine is being manufactured for a special use and that it is urgently needed, but the actual timing of delivery is crucial because the customer must coordinate logistics before the machine can be used. The manufacturer quotes a delivery date that the customer believes is too optimistic. However, rather than argue about who is right, the parties set up a contingent contract. If the manufacturer actually delivers on the quoted date, a premium will be awarded; however, if the machine is delivered late, the manufacturer agrees to absorb a portion of the logistics cost the customer incurred in anticipation of the scheduled delivery. Using this type of contingent contract, the manufacturer can do no better than to try and deliver the machine on schedule, and the customer has some assurance its costs will be covered if the machine arrives late.

In this case, farmers and the rest of the rural community have a common desire to minimize and reduce water contamination from livestock. Livestock producers have an incentive to innovate and apply existing technology to solve the problem rather than regulation on size or animal units. The rest of the community is less concerned with the specific approach, but needs assurance that there will be reductions in manure pollution. A third player in this situation is manure equipment manufacturers who believe they have a solution to the problem confronting both the farmer and the community. The rewards are such that all parties gain if the technology is successful at reducing water pollution. A contingent contract structure can be put in place so that farmer and equipment manufacturer can do no better than to adopt better technology and innovate cleaner technologies, while the community has some assurance that environmental improvements will be made.

For example, suppose a farmer wished to erect a large livestock facility using an environmentally beneficial manure storage and application system. The local municipality could propose that the producer and the manure equipment manufacturer each put up a performance bond with the community providing additional support in terms of technical assistance and tacit financial assistance (e.g. tax incentives to help establish new technology). Annual monitoring would take place, and the producer and the manufacturer would be returned a certain amount each year that the facility remains in compliance. In the event of non-compliance the farmer and the equipment manufacturer would lose a certain portion of the bond subject to a pre-specified schedule. These deductions from the performance bond would be used by the municipality to help clean up the damage, and the penalty would provide an incentive for the farmer to fix the problem. The design of this program would be complex with respect to determining the appropriate bond/premium schedule contributed by the parties, and it would need to be reviewed and revised as the effect of the new manure technology is developed. But it gives the incentive for the farmer to reduce emissions without sacrificing the size economies of the facility.

If similar technology were adopted across farms, the performance bonds could be combined in a pool. Monitoring costs would be in addition to the costs of monitoring nutrient management plan compliance, but these are likely to fall as new and better measurement equipment becomes available. There is also the potential for public reporting or "snitch lines" to lower monitoring costs. However, the incentives could be structured to help farmers succeed in limiting emissions rather than punishing them for non-compliance.

This scheme might also help municipalities with another potential problem with manure emissions. What happens if there is a catastrophic manure spill, and as a result the farmer declares bankruptcy, leaving the municipality or watershed authority no recourse on the farm assets as a means of funding the cleanup? In this case, the performance bond scheme presents municipalities with a source of funds to deal with cleanup after a large spill. It is the municipality's insurance against a manure catastrophe. In this sense, it might make sense for multiple municipalities to join together in setting up the performance bond scheme to take advantage of risk pooling the same way private insurance companies do. It also provides livestock agriculture with a means of taking responsibility for environmental damage. Another advantage of enlarging the pool to include multiple municipalities is to eliminate the potential for a "patchwork" of performance bond schemes. Regions are better served by competing in livestock on the basis of true comparative advantage rather than comparative manure regulations.

The bond-contingent contract scheme should be successful in encouraging innovation in manure management. However, it may also be useful to have additional, more general regulatory measures. In particular, this would serve to assure the rest of the community of maximum manure pollutant levels entering the water system. Ideally, regulation would address the actual levels of manure pollution that occur, so that the maximum level of emissions is capped at a certain level. This would target the actual problem and avoid the distortionary effects of regulating a proxy for manure emissions such as animal units. Regulating actual emissions avoids discrimination based on size, design of manure facilities, or age of facilities. This type of regulation challenges monitoring capability, but technology will improve monitoring in the future. Provisionally, it may make sense to group farms (perhaps in rural blocks) and monitor on that scale. Then, if emission problems arise, the source of pollution can be tracked to a group of farms, and then the individual farm.

Summary and Conclusions

Rural water quality is a public health concern in Canada, and the evidence suggests that livestock manure is contributing to the problem. A public policy response is warranted, but it must be done responsibly. Hysteria and mindless comments such as some that have been published or quoted in the press are not responsible. Research needs to be done to discover who really is responsible for rural water contamination, and public policy should address the primary sources:

- If household septic systems are an important source of water contamination, then we need to put the emphasis on the right things and re-regulate septics.
- If "factory" farms are genuinely a primary cause, then environmental farm plans need to be

more restrictive, better monitored and enforced. More thought and action needs to go into enforcing nutrient management plans to ensure that large livestock facilities actually store and apply manure the way they say they will.

- If older "family" farms are a significant source, then we need to develop the right regulatory procedure for them. Alternatively, the cost of maintaining small farms should be determined and evaluated, including the environmental externalities associated with them.

Farmers must accept responsibility for water contamination rather than assuming a defensive posture, and farms should be held accountable for their environmental performance:

- environmental farm plans need to be obeyed, and there needs to be a process for enforcing them with penalties if they are not abided by.
- research into alternative methods of manure application and storage should continue, and farmers should be encouraged to adopt manure technology that is cleaner and maximizes the fertilizer and organic matter value of manure.

New institutions are needed to encourage innovation in manure storage, handling, and application, and new regulations to back them up are required:

- Regulatory instruments are required that target actual manure emission levels rather than proxy measures like farm size or animal units. Alternatively, public perception will direct policy toward the largest and most visible livestock farms. If larger farms are actually more environmentally friendly, as we suggest they may be, then a policy targeting "factory farms" will harm our most efficient farms, and hence local economies and employment, without producing significant water quality benefits.
- Innovative mechanisms to encourage manure stewardship and liability protection will help livestock agriculture take responsibility for its environmental effects. Environmental bond schemes that encourage cooperation between farmers, municipalities, and manure equipment manufacturers will facilitate this. Operated on a broad scale, this type of system can act as an insurance policy the rest of the community takes out on its economic base in livestock agriculture.

The tragedy in Walkerton is both a wake-up call and an opportunity for livestock agriculture. It must get its house in order by determining the contribution it makes to water quality problems and the structure of that contribution. By responding pro-actively, it is an opportunity to both reduce water contamination, maintain nutrient values from manure, and retain efficient farms.