Biosolids Application and the Precautionary Principle:

Comparison with Current Agricultural Practices

Marc Hébert, Agr., M. Sc., Service des matières résiduelles, Ministère du Développement durable, de l'Environnement et des Parcs

(Marc.Hebert@mddep.gouv.qc.ca)

In recent years, certain rural municipalities in Québec have banned the application of municipal biosolids on municipal land, a decision they often justify by citing the precautionary principle. However, case law in 2011 established that such bans do not fall under municipal jurisdiction. But, the question remains, what is the result of applying the precautionary principle to land application of biosolids?

Precautionary Principle

The Québec *Sustainable Development Act* defines the precautionary principle as follows: "When there are threats of serious or irreversible damage, lack of full scientific certainty must not be used as a reason for postponing the adoption of effective measures to prevent environmental degradation."

A well-known example of the precautionary principle comes from the area of climate change. Scientists have observed changes in the world's climate, and people fear a future acceleration of such changes could have a "serious and irreversible" impact on the environment and human health. Although full scientific certainty of this outcome has not been established, many governments consider greenhouse gases (GHGs) to be the main cause of climate change, and the precautionary principle states that we must not wait for "full scientific certainty" before acting.

Québec has therefore adopted "effective measures" in both its Climate Change Action Plan and its Residual Materials Management Policy, which includes initiatives to promote the recycling of urban organic waste, including the use of treated sludges (biosolids) that are generally believed to be carbon

neutral (SYLVIS 2009). According to researcher Claude Villeneuve (2011), if all of Québec's municipal biosolids were recycled as fertilizer, urban emissions would plummet by some 500,000 tons CO_2 equivalent a year. The policy also calls for a ban on the landfilling or incineration of sludge and other putrescible organic matter by 2020. To reach this goal, the government hopes to step up recycling of organic materials by applying them on soils with or without prior composting or anaerobic digestion (biomethanization).

The land application of biosolids is therefore in line with the precautionary principle as it applies to climate change, which is a global issue. But, considering the risks associated with contaminants such as pathogens, nutrients, metals, and pharmaceutical products that could be found in biosolids, what does this mean at the local level for areas of rural Québec near sites where such fertilizers are used? To gain a better understanding of these risks, we will compare biosolids land application with other practices currently used on farms.

Salmonella, *E. coli*, etc.

In Québec, farmers apply manure and slurries to some 50% of cultivated farm areas, notably to fertilize crops intended for human consumption. Depending on the type of manure, certain pathogens can be found that can affect humans, including Salmonella,and *E. coli* O_{157}:H_7, as well as certain antibiotic-resistant bacteria, like *C. difficile*. Aside from regulatory standards on the storage and application of manure, which are aimed mainly at protecting water, some additional good practices have been suggested to minimize the risks of contaminated fruit, vegetables, and other plant products (CRAAQ 2010). These best practices consist notably of treating manure and slurries, although only 2% of these materials are currently treated through composting or other methods.

Municipal wastewater sludge must be partially (> 90%) or almost completely (> 99.9%) disinfected and treated before it can be applied (MDDEP 2008). We are referring to municipal biosolids here, not sludges. For the application of biosolids, the same basic regulatory standards apply as for all types of manure, but additional restrictions are also in place requiring authorizations and inspections. It is prohibited to apply

municipal biosolids on land used to cultivate fruits and vegetables unless the biosolids have been certified compliant by the Bureau de normalisation du Québec (BNQ), which requires the most stringent disinfection criteria (e.g., granulated biosolids in the City of Laval). The minimum required distances between areas where biosolids are applied and groundwater collection facilities (100 m) are also much larger than for manure and slurries (30 m).

It follows that the microbial risk of biosolids application is lower overall than that of farm manure. No documented health incidents tied to municipal biosolids have been reported in Québec, France, or even the United States. However, in the 2000s, some ten people died in Ontario and the United States from water or vegetables contaminated by cattle manure containing the *E. coli* O_{157}:H_7 bacteria, and hundreds of others suffered serious and chronic effects of the bacteria. In the last ten years, governments in Québec and the rest of Canada have implemented additional drinking water treatment and quality control measures to minimize these health risks.

Nutrients

Phosphorous is essential to life. However, it can also act as a “contaminant” and has polluted a number of lakes and rivers in Québec, notably as a result of its use in crop fertilization. The phosphorous applied to farmlands comes mainly from manure (63%) and inorganic fertilizers (35%), but can also be found in a variety of fertilizing residual materials (FRM) (2%), including municipal biosolids. On farms, these various sources of phosphorous are subject to the same regulatory standards governing application. Fortunately, such measures appear to have worked, as the water quality of rivers in agricultural watersheds has improved.

Nitrogen can also contaminate groundwater with nitrates. However, less than 3% of wells in Québec have nitrate levels that exceed water quality standards, and these cases seem essentially linked to overuse of manure and inorganic fertilizers, especially on sandy soils. In terms of nutrients, the application of biosolids does not present a risk higher than farming practices currently in use.

Figure 1 Biosolids have been used on farms in Saguenay since 1991. Photo: Guy Gagnon

Metals

The amount of “heavy metals” and other inorganic trace elements (ITE) in municipal sludge has dropped sharply in the last 25 years due to the implementation of multiple restrictions on the manufacture of consumer goods, including the ban of lead paint and measures to reduce wastewater contamination at the source (e.g., to foster recovery of dental amalgams or pretreatment of industrial wastewaters). Today, for example, Saguenay biosolids contain no more lead or cadmium than is found naturally in the soil of farming areas. The cadmium, mercury, and lead content of Saguenay soil remains minimal and is very safe—even after 12 seasons of biosolid applications (Perron and Hébert, 2008). As for micronutrients useful to plants and animals, such as copper, cobalt, nickel, molybdenum, selenium, zinc, and even arsenic, municipal biosolids generally contain levels similar to those found in farm manures (Perron and Hébert, 2007). We have not seen any impact on the ITE content of milk from 14 dairy farms where biosolids were applied for an average of 11 years (Hébert *et al.* 2011). This is especially notable in the case of molybdenum, which had raised some concern in the United States (Harrison and McBride, 2009).

With biosolids, the risk of introducing ITEs is low or similar to that of current farming practices, such as the application of farm manures. To avoid enriching the soil with excessive amounts of copper and other ITEs when applying certain types of farm manure, good practices have been suggested that actually draw on the approach developed for biosolids (CRAAQ, 2010).

The Soil Association (2010), the U.K.'s main organic farming organization, recently recommended that the European Union allows the application of municipal biosolids in organic farming, because the sludges have changed. At international symposia on sludges, there is increasingly less talk about ITEs.

Dioxins and Other Persistent Organic Contaminants

There is also less talk about dioxins and furans just as with PCBs, PAHs, and DDT, which can no longer be sold, but may persist in the environment. However, the content of these substances in biosolids is now very low in Canada (Hydromantis, 2010). PBDEs (brominated flame retardants), which can still be found in a number of household products, have been a topic of concern recently, notably with regard to cattle production (Harrison and McBride, 2009). However, for the Québec dairy farms most exposed to biosolids, only minute traces of PBDE have been found in cow's milk (a few parts per trillion [ng/L]), or 300 times less than levels found in human breast milk (Hébert *et al*., 2011). The higher PBDE content of breast milk (a few parts per billion) stems mainly from the inhalation of household dust. The Canadian government's gradual ban on the use of potentially harmful PBDEs should ultimately reduce the amount of PBDEs contained in household dust and biosolids in the long run.

Emerging Substances of Concern

In recent years, there has been growing concern among scientists and the general public about "emerging substances of concern" (ESC). ESCs include a wide variety of common household molecules such as antibiotics, antibacterial products (triclosan, triclocarban), detergents and their degradation byproducts (nonylphenols, ethoxylates), hormones, medications, and perfumes and other personal care products. However, a recent Canadian study demonstrated that biosolids contain very low levels of such substances, generally in parts per billion (Hydromantis 2010). For instance, in tests conducted on

Saguenay biosolids, 37 of the 57 pharmaceutical products targeted in analyses were not detected, including ibuprofen (Advil™) and acetaminophen (Tylenol™), which are used heavily, as well as 4 types of penicillin, which are commonly-prescribed antibiotics.

Higher levels of ESCs—if concentrations of only about a few parts per million can be deemed high—such as bactericides triclocarban and triclosan, have been detected in Canadian biosolids. However, these molecules were found in Saguenay biosolids in concentrations 10,000 times lower than those found in commercial products like toothpaste and antibacterial soap. Carbamazepine, a drug prescribed for nervous disorders, is among those that take the longest to degrade. Nonetheless, it was present at a concentration of only eight parts per billion on a wet basis, which, by extrapolation, would be the equivalent of less than one pill spread out over one hectare of soil (10,000 m^2) every year, whereas a single patient might take one or more such pills every day, 365 days a year.

Table 1: Contents of Certain Compounds in Pharmaceutical and Personal Care Products, as well as Saguenay Biosolids, in Nanograms per Gram on a Wet Basis

Compound	**Commercial products**	**Concentration – Commercial products (ng/g)**	**Concentration – Saguenay biosolids (ng/g)**
Triclocarban	Body soaps	3 000 000	250
Triclosan	Toothpaste, antiperspirant	3 000 000 (max)	197
Miconazole	Antifungal cream	20 000 000	71
Carbamazepine	Anticonvulsant and mood-stabilizing drug	200 000 000 (estimate)	8

Although municipal biosolids may contain a very wide range of pharmaceutical products, the minute levels of these substances appear insufficient to pose an additional risk to human health, when compared to direct exposure to these compounds in daily life. The amount of antibiotics and other drugs in biosolids

may also be lower than that of farm manures, because such products are often administered to entire herds of livestock. Fortunately, after application, most of these residual organic contaminants—particularly natural and synthetic hormones—quickly biodegrade in the soil, which acts as a biofilter (CRAAQ 2010).

Unknown Contaminants and Interactions

To take into account emerging substances of note that are not routinely tested, as well as the possible interaction between various chemical contaminants, McCarthy *et al.* (2011) conducted bioassays on Ontario biosolids. They found no levels of toxicity in earthworms (*Lumbricus terestris*), whether acute, subacute, chronic, or reproductive. Nor was any toxicity found in collembola, small arthropods essential to the cycling of organic matter in soil. Coors *et al.* (2011) even observed that the application of biosolids in Ottawa had a positive impact ("negative" toxicity) on enchytraeid (small, whitish segmented worms) and detritivorous nematode (organisms equally important for soils) populations. Conversely, after tilling, these researchers observed a pronounced decline in enchytraeid populations. Farmers have long known the impact a single plowing can have on populations of large earthworms, which often attracts droves of seagulls to the freshly tilled furrows!

When making these comparisons with routine farming practices, it is important to keep in mind that every year, pesticides are applied to about 50% of cultivated land in Québec to ensure sufficient crop yield and quality. Pesticides are toxic by definition and are thus subject to specific federal and provincial regulations aimed at minimizing the risks of their use.

Another Look at the Precautionary Principle

Land farming of municipal biosolids does pose certain risks, which is why the practice is regulated by norms and control measures. However, based on the current legal framework, these risks are very low and generally less than those associated with other current agricultural practices. In addition to offering farmers alternatives to imported inorganic fertilizers derived from non-renewable sources, enabling the application of municipal biosolids would also help in the fight against climate change by reducing the amounts of organic matter relegated to waste disposal sites. Rational and systematic application of the

precautionary principle tends to *support* the use of biosolids and other FRMs, but it also justifies the ultimate ban on landfilling or incinerating these substances. This is the approach advocated by Québec Residual Materials Management Policy.

As with many other fields, the main risks stem from illegal practices. Fortunately, such cases remain limited. In 2010 less than 3% of FRM land application sites received statutory or regulatory violation notices, and only 1% of farms received complaints from citizens about odors. In this regard, it is important to note that, aside from the framework set out by MDDEP, municipalities have the legal jurisdiction to mitigate biosolids odor problems by prohibiting biosolids application for 12 days a year, as is done with manures.

References

Coors, A. *et al.* (2011). *Bioassays of a Biosolids Land Application Site in Ontario Using Structural and Functional Endpoints of Soil Organisms*. www.nebiosolids.org/uploads/pdf/Bioassay%20Page/CoorsBioassayPrsentatnCondensed-May11.pdf .

CRAAQ. (2010). *Guide de référence en fertilisation*, 2nd edition, 473 p., www.craaq.qc.ca/Publications?p=32&l=fr&IdDoc=2193 .

Harrison, E.Z. and M. McBride. (2009). *The Case for Caution: Health and Environmental Impacts of Application of Sewage Sludges to Agricultural Land*, 28 p., http://cwmi.css.cornell.edu/case.pdf .

Hébert, M., D. Lemyre-Charest, S. DeGrosbois *et al.* (2011, forthcoming). “Épandage agricole des biosolides municipaux : contenu en métaux et en PBDE du lait de vache,” *Vertigo*, (http://vertigo.revues.org/).

Hydromantis. (2010). *Emerging Substances of Concern in Biosolids: Concentrations and Effects of Treatment Processes – Field sampling program*, 255 p., www.ccme.ca/assets/pdf/pn_1445_biosolids_esoc_final_e.pdf .

MDDEP. (2008). *Guidelines for the Beneficial Use of Fertilizing Residuals*, Ministère du Développement Durable, de l'Environnement et des Parcs, 166 p., http://www.mddep.gouv.qc.ca/matieres/mat_res-en/fertilisantes/critere/index.htm

McCarthy, L. (2011). *Bioassays of Biosolids Land Application in Ontario,* www.nebiosolids.org/uploads/pdf/Bioassay%20Page/McCarthy-BiosolidsLandApOntario-May11.pdf .

Perron, V. and M. Hébert. (2007). "Caractérisation des boues d'épuration municipales – Partie II : éléments traces métalliques," *VECTEUR environnement*, Vol. 40, No. 5, pp. 42–46. http://www.mddep.gouv.qc.ca/matieres/articles/caract_boues2.pdf

Perron, V. and M. Hébert. (2008). "Valorisation agricole de biosolides municipaux à Ville de Saguenay – impact à moyen terme sur le contenu en métaux des sols récupérateurs," *Agrosolutions*, February 2008, Vol. 19, No. 1, 10 p., www.irda.qc.ca/pages/Agrosolutions_vol19_no1_Perron.pdf .

Soil Association. (2010). *Resource Depletion*, www.soilassociation.org/Default.aspx?TabId=1259 .

SYLVIS. (2009). *The Biosolids Emissions Assessment Model (BEAM): A Method for Determining Greenhouse Gas Emissions from Canadian Biosolids Management Practices*, 200 p., http://www.ccme.ca/assets/pdf/beam_final_report_1432.pdf .

Villeneuve, C. (2011). *Gestion des biosolides municipaux : quelle est la meilleure option pour le climat?*, 6th Canadian Biosolids and Residuals Conference, RÉSEAU environnement, Québec City, September 25–27, 2011.