APPENDIX A

PUBLIC HEALTH AND RISK PERSPECTIVES

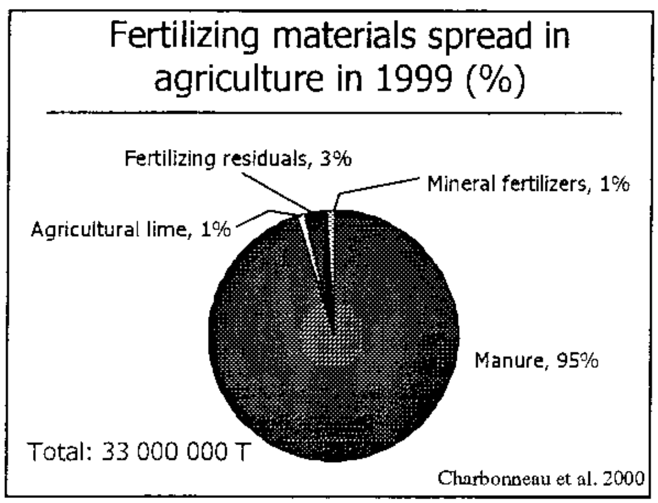
Appendix A

Public Health and Risk Perspectives Related to Biosolids Recycling

Introduction

The management of biosolids should be viewed from the point of view of sustainability. In a sustainable society, there should be no net accumulation of any kind of waste, and for wastewater treatment to be part of a sustainable system, biosolids should be put to beneficial use or be reintegrated by natural means, otherwise they will contribute to more pollution and to a waste of resources.

Biosolids in the context of this project are the by-products of wastewater treatment. Other organic materials chiefly animal excrement or manure are also part of a sustainable system. In fact, manure constitutes by far the largest component. Data from the Province of Quebec are shown on the following figure. (from Groen: 2003)



This proportion is similar in Ontario and elsewhere (e.g. Kûlling et al: 2001).

A major consideration in achieving a sustainable biosolids management program is ensuring that the organic product has no negative impacts on health and sanitation. There have been recent 'scares' in the media about food safety and concerns about transmission of pathogens to humans, even though biosolids have been recycled to agricultural land in Ontario for decades with no scientifically substantiated negative effects.

Potential Spreading of Disease

Disease carrying organisms can be present in wastewater, and disease can be spread by means of air, water or soil. Infection can only come about, however, by direct ingestion, inhalation or contact with open skin or mucous membranes.

Biosolids treatment and recycling practice is geared to avoiding all of these.

Municipal wastewater and untreated sludge contains a myriad of organisms, including: pathogenic bacteria like salmonella, shigella, escherichia coli, and others; viruses like polio virus, hepatitis A virus, rotavirus, coronavirus, and others; protozoa like giardia; and worms like ascaris. In terms of relative numbers, pathogens in biosolids represent a very small fraction of the total number of bacteria in soil (see below).

Type of Bacteria in Soil	**Population Ratio**
Indigenous	10,000,00
Indicator	10,000
Pathogen	1

(Burnham, 2002)

Biosolids are treated within the sewage treatment plants to reduce pathogen levels using mesopholic anaerobic digestion. A recent study in Winnipeg (Wakelin et al: 2003) showed that faecal coliforms were reduced from 138 million per gram in the raw wastewater to 2 million in dewatered biosolids. Typical concentrations in Kingston biosolids are about 1.1 million/gram. Thus processes within the plant reduce pathogen numbers applied to soil significantly when compared to untreated material like manure.

Pathogens are adapted to thrive in warm-blooded organisms and for the most part do poorly once out of that environment. The following table shows life expectancy of some pathogens in typical soil.

Organism	Survival Time in Soil (Days)
Coliforms	38
Streptococci	35-63
Fecal streptococci	26-77
Salmonella spp.	15-280
Salmonella typhi	1-120
Tubercle bacilli	>180
Leptospira	15-43
Entamoeba histolytica (cysts)	6-8
Enteroviruses	8
Ascaris ova	7 years
Hookworm larvae	42

(from Wakelin et al: 2003)

Survival is affected by such factors as type, structure and chemical composition of the soil, temperature, and sunlight (Harris et al: 1997). Soil is an effective filter for these organisms by both physically obstructing movement and by absorbing viruses to soil particles (Apedaile: 2001).

Current Ontario land application guidelines as well as draft Regulation under the Nutrient Management Act are structured to minimize any risk of contamination, either through ground and surface waters or through ingestion by humans or livestock by regulating:

- distance of application from wells and watercourses
- specifying slope of land and ground cover
- time interval before use of land for pasturing and prohibiting certain crops and limiting interval before harvest of others
- regulating number of allowable pathogens in biosolids applied

The issues of biosolids safety is not clear-cut and there are some risks that must be managed sensibly. Nevertheless, there is a large body of research in the field of potential health issues, and current information provides a satisfactory basis for biosolids land application according to Ontario guidelines. A summary of evidence follows: (Weber and Sidwha: 2002)

- Farmers value sewage biosolids for their fertilizer and soil conditioning properties.
- Sewage biosolids are an effective source of nitrogen and phosphorus for crop production.

- Phosphorus buildup in soils receiving multiple applications of sewage biosolids has not exceeded the maximum permissible value.
- There is no documented evidence for disease transfer due to biosolids land application.
- Heavy metal degradation of soils receiving multiple applications of sewage biosolids has not occurred.
- Organic contaminants in sewage biosolids degrade rapidly in soil or are so insoluble that there is no impact on the foodchain.
- Buildup of dioxins and furans in soils receiving multiple applications of sewage biosolids has not occurred.
- There is public acceptance of land application done in conformance with the guidelines when odours are minimized and Ministry of Environment oversight is evident.

The risk of infectious disease to rural residents where biosolids recycling takes place is very small. For example, a study looking at human and animal health on 47 farms receiving biosolids and 46 farms not receiving them in Ohio concluded that the risks of respiratory or digestive illness as well as general symptoms, were not significantly different between the two sample groups (Apedaile: 2001). Other long-term studies on sewage treatment plant workers have shown that this group was no more likely to be sick than workers at water plants, light and gas companies, or highway departments (Kuchenrither et a: 2002). Opponents of biosolids recycling point to a number of lawsuits that have been brought claiming harm and even death as a result of land application (Reilly 2001). However, what they fail to report is that none of these suits has ever been successful in the courts.

Concerns have also been raised about the possibility of spreading pathogens by airborne droplets (aerosols). In general, dewatered biosolids are applied by flipping the solids into the air to spread them evenly over the soil (as is done with manure spreaders also). Thus there is obviously a potential for pathogens to be released through this process. However this risk is very low since setback distances are regulated, prohibiting application less than 300 m from any residence. Research shows that dilution of organisms would be enormous at this distance (one billion to one at a distance of 50 m) (Wakelin et al: 2003), hence risk would be minute.

Similarly low risks were postulated by researchers in Quebec (Forcier: 2002).

Metals

Heavy metals, when present in significant concentrations in soil, can lead to uptake by plant matter with consequent bioaccumulation in living organisms including humans. Because of this potential, heavy metals in sludge are highly regulated in Ontario and values in Kingston biosolids are well below allowable limits.

Table A.1 Compost Product Standards and Guidelines

Element	West Plant*	Ravensview*	Ontario Biosolids Guidelines	USEPA 503.13 Rule	Canadian Fertilizer Standards	Compost CCME AA/A	Compost CCME B
Arsenic (As)	1.86	6.6	170	75	75	13	75
Cadmium (Cd)	1.4	1.15	34	85	20	3	20
Chromium (Cr)	32.29	152.4	2800	N/A	N/A	210	1060
Cobalt (Co)	2.09	5.1	340	N/A	150	34	150
Copper (Cu)	457.14	539.2	1700	4300	N/A	100	757
Lead (Pb)	27.66	61.19	1100	840	500	150	500
Mercury (Hg)	1.49	2.11	11	57	5	0.8	5
Molybdenum (Mo)	9.91	10.9	94	75	20	5	20
Nickel (Ni)	12.23	21.1	420	420	180	62	180
Potassium (K)	776.73	989.6	N/A	N/A	N/A	N/A	N/A
Selenium (Se)	2.35	2.62	34	100	14	2	14
Zinc (Zn)	442.74	452.6	4200	7500	1850	500	1850

There have been many studies that show that application rates below those currently permitted are protective of crop yield and quality, and of the environment (Webber and Sidwha: 2002).

An interesting study in Switzerland reported for example that heavy metal input to agricultural land from biosolids was 12% of the total, whereas 38% came from manures, 25% from air particle deposition and 14% from inorganic fertilizers (Fed. Research: 2001). The historical trend, by virtue of rigorous control of metal inputs using control at source, has been for metals in sewage to go down in most jurisdictions including Kingston. Thus the risks of heavy metal contamination are minute.

Organic Chemicals

Wastewaters in highly industrialized and “advanced” societies frequently contain complex organic materials, many of which have been identified from time to time as potential carcinogens, e.g. persistent chemicals like dioxins and furans. However, health risks are low. There are also synthetic biocides, organochloride pesticides, antibiotics and endocrine disrupters to be concerned with. In the case of dioxins and furans for example, it has been calculated that for limits applicable in Quebec, one individual in 737 million would suffer a health risk after 100 years of land application in the province. Clearly these risks are extremely low. (Van Coillie and Laquere: 2003)

Natural and synthetic hormones are introduced into biosolids through widespread use of birth control pills, hormone replacement therapy and other artifacts of the "modern lifestyle". Other sources include modern animal husbandry practices, e.g. swine, cattle). The persistence of such materials in soil after land application is being studied.

Recent research concludes that "these chemicals are rapidly removed from aerated soils under temperate growing conditions, and application methods which minimize preferential flow or runoff or animal or human wastes should protect adjacent water from contamination with these chemicals." (Lorenzeu, et al: 2003)

Extensive past and on-going research into the fate of existing and the constantly growing list of new organic compounds indicates that, in general, some, like tensides used in cleaning materials and certain pesticides, are readily biodegradable or volatilize into the environment. However, it is note-worthy that a large portion of these complex and refractory hydrocarbon compounds reach the soil not through biosolids application but by aerial deposition , since they have their source in combustion processes. (Federal Research: 2001) In Switzerland, for example, the contribution of polycyclic aromatic hydrocarbons in municipal biosolids to agricultural lands is between 420 and 600 kg/yr whereas airborne sources contribute 8000 kg/yr, and 139,000 kg/yr of volatile PAC come from treated railway ties. Research has also shown that accumulation of harmful organic materials in plants after land application of biosolids is, with few exceptions, very small. As a result of increase scientific knowledge and resulting legislation, a downward concentration of these organic materials in biosolids has been noted (ibid). However, this same policy paper makes the point that "a significant load reduction on the food chain of harmful organic substances …… cannot really be achieved by cessation of biosolids and manure recycling." (Ibid, P.19). Clearly the first line of defense in this case is reduction of these materials at source.

Summary

The ultimate management of anthropogenic organic materials such as sewage sludge and their safe reintegration into a sustainable ecosystem as treated biosolids continues to be a challenge. However, as good stewards of the earth which we occupy essentially as temporary "visitors", we owe it to future occupants to leave a "light footprint" by returning to the earth what we use, in as benign a manner as possible with minimum energy consumption. Biosolids recycling on land represents such a process. Nevertheless, continued research to substantiate and refine the appropriateness of existing regulations is clearly advisable. Indeed, there is much important work going on today in Canada on such as aspects as: development of analytical methods for pharmaceuticals and personal care products in biosolids, best management practices to manage preferential flow through soils, optimization of anaerobic digestion to improve pathogen destruction, survey of dioxins, furans, DL-PCBs and BFR, odour impacts, and many others (for example Payne: 2003, Bright et al: 2003, Hebert et al: 2003). This will ensure that biosolids recycling will continue to be safe, rational and science-based.

References

Apedaile, E, "A Perspective on Biosolids Management" Cdn. Jl. Of Infect. Dis., 12,4, 2001.

Bright, D., M. Van Ham and M. Ronayne "Organic Contaminant Source Identification and Control in Wastewater Treatment Plant Influent – Case Studies on Dioxin/Furan Inputs in Biosolids Based on More Than a Decade of Canadian and U.S. data" , presented at 2nd Cdn. Organic Residuals Recycling Conference, Penticton BC, April 2003

Federal Research Institute for Agrarian Ecology and Agriculture "Risk Analysis of Waste Fertilizer Use in Agriculture, Part 1 – General Assessment" Report for the Swiss Federal Dept of Agriculture, 2001 (in German).

Forcier, F. "Biosolids and Bioaerosols: The Current Situation", report for Quebec Ministry of Environment, Sept. 2002.

Groen, E., "Classifying and Managing the Odour of Fertilizing Residuals in Quebec," presented at WEAO Specialty Seminar, Issues and Research in Land Application of Biosolids, Toronto: March 2003.

Harris, T., J. Johns, Merriman and J. Merricks "Viral Contamination", in Groundwater Pollution Primer' Virginia Technical University, 1997.

Hébert, M., E. Groeneveld and V. Rioux "Independent quality control of fertilizing residuals by Environment Quebec", presented at 2nd Cdn. Organic Residuals Recycling Conference, Penticton BC, April 2003.

Killing, D., & F. Stadelmann & U. Herter, "Sewage Sludge – Fertilizer or Waste", presented at UKWIR Conference, Brussels, Nov. 2001.

Kuchenrither, R, S. Sharvelie and J. Silverstein, "Risk Exposure: Are treated wastewater and biosolids hazardous to your health", Water Env. & Tech, 14,5: 37,2002.

Reilly, M "The Case Against Land Application of Sewage Sludge Pathogens", Cdn. Jl. Of Infectious Diseases, 12, 4.2001).

Payne, M., "Current Biosolids Research in Ontario", presented at WEAO Specialty Seminar, Land Application of Biosolids, Toronto: March 2003.

Van Coillie, R and M. Laquerre "Critères de Qualité et Risques du Cadmium et des Dioxines et Furannes Chlorés des Matières Residuelles Fertilisantes au Québec", Vecteur Environnement, 36, 1:22, 2003.

Wakelin, S, G. Racz, J. Oleszkiewicz, N. Szoke and P. Barsalou, "Estimating the Potential for Disease in Nearby Residents as a Result of the City of Winnipeg Biosolids Land Application Program (WinGRO)", presented at 2nd Cdn. Organic Residuals Recycling Conference, April 2003.

Webber, M, and P. Sidwha "A Summary of Ontario Sewage Biosolids Land Application Research" presented at WEAO Specialty Seminar, Land Application of Biosolids, Toronto: March 2003.

APPENDIX B

US EPA CLASS A AND B PROCESS DESCRIPTION

APPENDIX B – US EPA Class A, B & EQ Classifications

The US EPA *Standards for the Use or Disposal of Sludge* (40 CFR 503) include two approaches for controlling pathogens that may be present in raw sludge: Class A in which disinfection processes reduce pathogen levels in biosolids to “below detectable levels” and Class B in which disinfection processes “significantly reduce” pathogen levels in biosolids. Risks relating to land applying Class B biosolids are further controlled by access and crop harvesting restrictions. The purpose of these restrictions is to ensure that the pathogen levels in biosolids are reduced to levels considered safe for the biosolids to be land applied or surface disposed.

Class B Requirements

Class B biosolids may contain some pathogens and therefore, land application include site restrictions that prevent crop harvesting, animal grazing, and public access for a certain period of time until environmental conditions have further reduced pathogens. Class B pathogen requirements may be met using one of three alternatives as follows:

1. **Alternative 1: The monitoring of indicator organisms** – test for fecal coliform density as an indicator for all pathogens. The geometric mean should be less than 2 million MPNs per gram per total solids as the time of use or disposal.

2. **Alternative 2: Biosolids treated in a Process to Significantly Reduce Pathogens (PSRP)** – Biosolids must be treated in one of the following processes:

    - **Aerobic digestion** – mean cell residence time between 40 days at 20°C and 60 days at 15 °C

    - **Air drying**– dried on sand beds or paved or unpaved basins for a minimum of 3 months; where for a minimum 2 of 3 months ambient average daily temperature must be above 0°C

    - **Anaerobic digestion**– mean cell residence time between 15 days at 35°C to 55°C and 60 days at 20°C

    - **Composting**– using either the within-vessel, static aerated pile, or windrow composting methods, the temperature of the biosolids is raised to 40°C or higher and maintained for 5 days; for 4 hours during the 5 day period the temperature in the compost pile exceeds 55°C.

- **Lime stabilization -** lime is added to raise the pH of the biosolids to 12 after 2 hours of contact.

3. **Alternative 3: Biosolids treated in a process equivalent to a PSRP** – process determined to be equivalent to a PSRP by permitting authority either on site-specific basis or national basis.

Class A Requirements

Pathogen and indicator organism limits for Class A biosolids are as follows:

- Less than one plaque forming unit (PFU) of enteric viruses per 4 g total sludge;
- Less than one viable helminth ovum per 4 g of total sludge; and,
- Less than 3 most probable number (MPN) of *Salmonella spp.* per 4 g total sludge or less than 1000 MPN of fecal coliforms per gram of total sludge.

Six basic alternatives were provided in the EPA document

4. **Alternative 1: Thermally treated biosolids** – fluid and thermal treatment systems that could maintain an increased temperature for a prescribed period so all sludge particles are treated

5. **Alternative 2: Biosolids treated in a high pH – high temperature process** – alkaline treatment that must raise the sludge's pH above 12 for at least 72 hours and concurrently raise its temperature above 52 ^{o}C for at least 12 hours. Then the sludge must be air dried to at least 50% total solids. This alternative is based on the N-Viro International Corp. alkaline treatment system and may involve lower temperatures than those required under Alternatives 1 or 5.

6. **Alternative 3: Biosolids treated in other treatment processes** – comprehensive monitoring of input and product quality. Provides monitoring to demonstrate that a treatment process adequately reduces enteric virus and viable helminth ova concentrations.

7. **Alternative 4: Biosolids treated in unknown processes** – comprehensive monitoring of product quality. Provides monitoring of finished product for pathogens when the process' operating parameters are unknown.

8. **Alternative 5: Biosolids treated in a listed "Process to Further Reduce Pathogens" (PFRP)** – to allow use of PFRPs originally established under 40 CFR 257; includes: composting, heat drying, heat treatment, thermophilic aerobic digestion, beta ray irradiation, gamma ray irradiation,

and pasteurization. Control parameters must be monitored and documented but no testing for the presence of enteric viruses and helminth ova is required.

9. **Alternative 6: Biosolids treated in Process equivalent to a PFRP.** This allows demonstration of PFRP equivalency on site-specific or national basis to include documentation of process performance and operating parameters. Such processes that have been submitted for approval include: modified lime stabilization; solar drying; anaerobic digestion and long-term storage; vermi-composting, and various configurations of thermophilic anaerobic digestion. Some have already been given some site-specific equivalency.

Requirements for Class A testing are more stringent than Class B. Whereas generators may use the geometric mean of seven discrete samples to meet fecal coliform tests in Class B, all Class A samples must meet Class A criteria.