EXECUTIVE SUMMARY

Introduction

Biosolids are a product of sewage treatment that consists of a combination of physical, chemical and biological processes. The pathogen content of biosolids is significantly reduced during the digestion process. The solids remaining after the digestion process are further dewatered to produce biosolids cake. Further heating and processing can be used to produce pellets. Biosolids cake or pellets may then be landfilled, incinerated or land applied. The spreading of biosolids on land has become a common biosolids management practice by municipalities in Ontario and across North America. Their nutrient value and organic matter content make them potential useful fertilizers and soil amendments. Although biosolids are a potentially valuable resource, considerable public concern remains over their potential use.

Jacques Whitford Limited (Jacques Whitford) was contracted by Toronto Public Health (TPH) to conduct a review study of biosolids pellets (pellets), produced by the City of Toronto, at the Ashbridges Bay Treatment Plant (ABTP). The study findings will be used to assist in developing appropriate management practices for pellet use within the City of Toronto and to provide practical and scientifically defensible information to address public concerns related to pellets. The assessment took into consideration the regulatory framework for land application of biosolids in Ontario.

This study assessed the potential risks to people, pets (cats and dogs), birds and other wildlife, associated with the use of pellets in the City of Toronto. Qualitative evaluations were also undertaken for risks to plants and soil organisms, biological entities and emerging issues. Potential exposure to metals and organic chemicals in pellets were quantitatively evaluated for three types of use:

- use of pellets on City-owned recreational areas such as parks and golf courses;
- home use of pellets on lawns and gardens by City of Toronto residents; and
- use of pellets as part of a landfill topdressing mixture applied by the City of Toronto. Topdressing is a material applied on top of soil, without mixing.

Study Objectives

The overall objectives of the study were to:

- Improve knowledge and understanding about biosolids pellets and related issues;
- Provide information to assist in developing appropriate management practices for pellet use in the City of Toronto; and,
- Provide practical and scientifically defensible information to address public concerns related to pellets.

Study Background

Following a literature review of government documents, scientific literature and grey literature, very little information specific to pellets was found.

The Ashbridges Bay Treatment Plant (ABTP) is the largest of four wastewater treatment plants serving the City of Toronto. In 1998, the City of Toronto decided to pursue a policy of 100% beneficial use of biosolids at ABTP and installed a pelletizer. The pelletization plant was constructed at the ABTP in 2002 to convert 50% of the plant's biosolids into dry pellets, leaving 50% as dewatered cake. Both forms of biosolids could then be applied to land. The pelletizer plant that was installed was a Seghers HARDpelletizer which produces pellets through a process of coating a nucleus of dry biosolids with wet biosolids. The pellets are exposed to high temperatures and controlled dryer times. Pellets that are approximately 3 mm in diameter, 97% solid (with the remaining 3% as water), and with greatly reduced pathogen content can be achieved when the pelletizer is functioning optimally and meets all expected standards. Currently, the pelletizer is out of service following a fire in August 2003, but a portion of the dewatered cake continues to be land applied while the majority is shipped to a landfill in Michigan. The City of Toronto produced 4,416 dry tonnes of pellets in 2002 and plans to repair the pelletizer plant.

Regulatory Context

Land application of biosolids cake on agricultural land is regulated in Ontario through Regulation 347 of the Environmental Protection Act, the Nutrient Management Act and the Ontario Ministry of Environment's (MOE) *Guidelines for the Utilization of Biosolids and Other Wastes on Agricultural Land*. The Guidelines specify general rules for application of biosolids regarding issues such as separation distances from surface water, wells and residences, application rates and quality standards for eleven inorganic elements. In addition, a Certificate of Approval containing site-specific terms and conditions for land application must be obtained for each application site. Soil testing is often required.

Regulations in Canada and the United States permit the use of biosolids products (i.e., saleable items) outside of agriculture. Biosolids products sold as fertilizers or soil supplements are regulated by the Federal Fertilizers Act, which specifies standards for labelling, registration and product quality. The Act has no monitoring requirement regarding product use. Biosolids that are not sold but given away are regulated by the same Provincial regulations as the cake.

Levels of Chemicals in Biosolids

Quantitative exposure assessment was conducted only for entities of potential concern (EoPC) for which the City had adequate information on their levels in the biosolids, volatility and persistence in the environment. The Works and Emergency Services department of the City of Toronto collects and analyzes samples of biosolids cake for eleven regulated inorganic elements, nutrients and total solids every two weeks. Sample results are available for the past 14 years, from April 1989. Pellets were also analyzed for a similar set of parameters as biosolids cake. In addition to the biweekly monitoring, the City of Toronto performs annual plant performance evaluations and includes hourly sampling over a 22-hour period. During this sampling period, an extensive list of parameters is tested including polychlorinated biphenyls (PCBs), polychlorinated dibenzo-p-dioxins and polychlorinated dibenzofurans (dioxins and furans).

Table I presents the chemical EoPCs that were evaluated in the study. Of the eleven inorganic elements that were selected, five (copper, cobalt, molybdenum, nickel and zinc) are considered essential micronutrients for plant growth.

The biosolids cake dataset from 1996 to 2003 was considered more representative of current biosolids quality and was therefore used in the analysis. The cake dataset was preferred because it was more complete than the pellet data set and pelletization did not generally appear to alter chemical concentrations significantly (Refer to Appendix F for statistical justification).

Table I: Selected Chemicals (Entities of Potential Concern) for Quantitative Evaluation

Inorganics		Trace Organics
Arsenic[a] (As) Cadmium[b] (Cd) Cobalt (Co) Chromium III[c] (Cr III) Copper (Cu) Mercury (Hg)	Molybdenum (Mo) Nickel[b] (Ni) Lead (Pb) Selenium (Se) Zinc (Zn)	PCBs[a] Dioxins[a] (PCDDs) Furans[a] (PCDFs)

Notes:

a. Substances evaluated as cancer-causing when ingested and inhaled
b. Substances evaluated as cancer-causing when inhaled
c. Since the specific species of chromium were not measured, Chromium III was evaluated as representative of total chromium instead of Chromium VI. This is considered appropriate because it is unlikely that Chromium VI is the dominant species and therefore selecting Chromium VI to be representative of total chromium would grossly overestimate risk.

Levels of Chemicals in Pellet-amended Soil

The biosolids analytical data were used to estimate the potential future concentrations of chemicals in the soil as a result of biosolids application for each chemical EoPC. The pellets were assumed to be incorporated into garden soils to a depth of 15 cm and restricted to the top 5 cm when applied on sod (lawns). The pellets were assumed to be mixed into topdressing applied over final landfill cover to facilitate seeding.

A number of assumptions were adopted in the estimation of amended soil and landfill topdressing EoPC concentrations. First, it was taken into consideration that some people might use more than the recommended amount, therefore twice the maximum application rate was assumed. Second, pellets were assumed to be applied for twenty-five years. Although assumptions such as using twice the recommended application rate for 25 years continuously may be overly conservative, this conservatism may counter the lack of assessment of longer term use. Also not considered in the evaluation are other removal mechanisms including leaching from soils, removal via uptake by plants, removal in surface runoff from rain or other precipitation, or other removal mechanisms that will occur over this period of time.

As well, the levels of chemicals in the pellets were assumed not to be just the average of the biosolids samples collected from 1996 to 2003, but the 95% upper confidence limit of the mean - which is considered an upper estimate of the average pellet concentration and will tend to overestimate concentrations over time. The resulting chemical levels calculated for pellet-amended soil, for dust and vapour arising from this soil, and for garden produce grown on this soil are considered to be the reasonably conservative concentrations (i.e., an upper estimate of concentrations) for the evaluation of long term pellet application. These values are presented in Table II.

Human Health Risk from Chemical Exposure

The risk to people from exposure to chemicals present in pellets was assessed for the most sensitive or representative receptors under each of the three types of pellet use. These receptors (summarized in Table III) included the following four exposure scenarios:

- City Parks Workers applying pellets on City-owned recreational areas such as parks and golf courses;
- City Landfill Workers applying topdressing to landfills, over the final cover to facilitate seeding;
- Recreational Users using City parks or golf courses where pellets were used;
- Home Users using pellets on their lawns or gardens and eating fruits and vegetables from their gardens;

For non-cancer risk, toddlers were selected to be protective of other age groups for the recreational and residential scenario. Toddlers are commonly selected as the most sensitive receptor due to their low body weight, higher ingestion rate and hand-to-mouth activity.

Cancer risk was evaluated for exposure over a lifetime. An additional composite (lifetime) receptor was therefore considered in the assessment. Under the Recreational Use Scenario, the composite receptor was assumed to go to City-owned recreational areas that use pellets throughout their lifetime. Under the Home Use Scenario, the composite receptor was assumed to live in a household that uses pellets on lawns and gardens through their 75 year lifetime. Differences in lifestyle and biological factors at different stages of life were incorporated in the assessment of lifetime exposures.

Table II: Estimated Upper Bound[c] Chemical Levels in Pellet-amended Soil, Dust and Vapour, and Garden Produce

EoPC	Pellets (mg/kg)	Amended Soil[a] (mg/kg)		Landfill Top Dressing (mg/kg)	Garden Produce (mg/kg, wet weight)			Dust In Air (mg/m^3)		Vapours (mg/m^3)
		5 cm Depth	15 cm Depth		Fruit	Vegetables		From 5 cm Soil	From 15 cm Soil	From 5 cm Soil
						Root	Above Ground			
Inorganics										
As	8.1	4.1	3.0	0.32	0.0034	0.0034	0.033	3.1E-07	2.2E-07	NA [b]
Cd	5.1	1.3	0.65	0.20	0.018	0.018	0.092	1.0E-07	4.9E-08	NA [b]
Co	3.3	8.4	7.9	0.13	0.011	0.011	0.030	6.4E-07	6.0E-07	NA [b]
Cr	160	58	37	6.2	0.031	0.031	0.052	4.4E-06	2.8E-06	NA [b]
Cu	1200	260	110	45	5.1	5.1	2.3	2.0E-05	8.2E-06	NA [b]
Hg	1.7	1.1	0.92	0.067	0.035	0.035	0.066	8.7E-08	7.0E-08	NA [b]
Mo	13	2.8	1.1	0.50	0.013	0.013	0.053	2.1E-07	8.4E-08	NA [b]
Ni	39	23	18	1.5	0.20	0.20	0.18	1.7E-06	1.3E-06	NA [b]
Pb	93	54	41	3.6	0.071	0.071	0.40	4.1E-06	3.1E-06	NA [b]
Se	3.1	1.1	0.69	0.12	0.0033	0.0033	0.064	8.5E-08	5.3E-08	NA [b]
Zn	900	260	140	35	23	23	14	2.0E-05	1.0E-05	NA [a]
Trace Organics										
PCBs [d]	1.7E-04	0.011	0.011	6.5E-06	2.0E-05	2.0E-05	2.0E-05	8.0E-10	8.0E-10	1.3E-09
PCDD/Fs	1.5E-05	4.7E-06	2.7E-06	5.8E-07	2.9E-09	2.9E-09	2.9E-09	3.6E-13	2.1E-13	8.5E-14

Note:

a. Chemical levels after 25 years of annual pellet application at double the recommended application rate (i.e. 5.4 tonnes per hectare per year).
b. Inorganic compounds do not volatilize and therefore have not been considered for vapour inhalation.
c. The upper bound concentration is based on the 95% confidence limit on the mean of measured concentrations in biosolids.
d. Given the limited available data, the mean concentrations for trace organics were selected for this assessment.

Table III: Selected Receptors

Scenario	Health Effect	
	Non-Carcinogen	**Carcinogen**
City Workers	Adult City Parks Worker exposed to pellets for 30 years in City-owned recreational areas (parks, golf courses, gardens).	Adult City Parks Worker exposed to pellets in City-owned recreational areas (parks, golf courses, gardens) for 30 years.
	Adult City Landfill Worker exposed to amended landfill top dressing for 30 years	Adult City Landfill Worker exposed to amended landfill top dressing for 30 years
Recreational Use (parks, golf courses)	Toddler exposed to pellets and amended soil for 4.5 years (between the ages of 7 months to 5 years)	Composite receptor that represents a lifetime of visiting the park for 75 years (from birth to 75 years old)
	Adult golfer exposed to amended soil for 30 years	Adult golfer exposed to amended soil for 30 years
Home use (garden, lawn)	Toddler exposed to pellets, amended soil and impacted garden produce for 4.5 years (between the ages of 7 months to 5 years)	A composite receptor that represents a lifetime of exposure for 75 years (from birth to 75 years old)
	Adult resident exposed to pellets, amended soil, impacted garden produce and exposure while applying pellets for 55 years (from 20 to 75 years of age)	

The receptors are exposed to pellets directly or to amended soil under various situations. The exposure pathways are presented in Figure I. The calculation for the ingestion pathway considered incidental ingestion of soil. Under the Home Use Scenario, the calculation also included exposure from ingestion of vegetables and fruits grown in home gardens. Since it could take days before pellets spread on lawns get incorporated into the soil under arid conditions, the calculation took into account the scenario that toddlers wandering on lawns may put pellets into their mouths that they find on the soil surface.

In general, where information gaps existed, conservative assumptions were made to assure that risks were not underestimated. For example, conservative assumptions include assuming amended soil concentrations based on twice the recommended application rate of pellets, assuming direct ingestion of pellets, and assuming continuous exposure to pellet amended soil over a lifetime.

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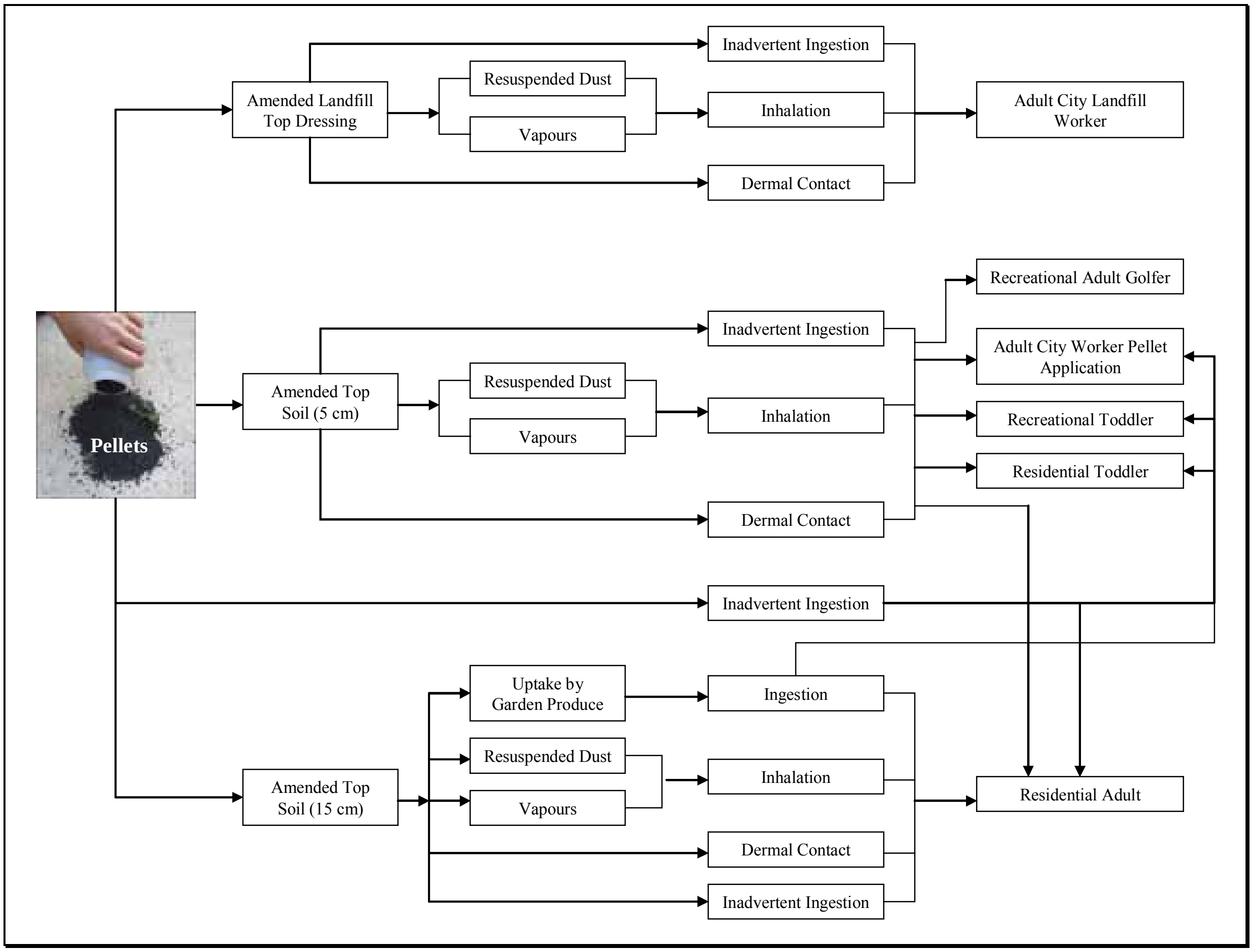
Figure I: Exposure Pathways and Receptors



Risk from a given contaminant increases with the potency of the contaminant and with the dose to which people are exposed. The potencies of the EoPCs for inhalation and oral routes of exposure were adopted from published values by regulatory agencies such as Health Canada, United States Environmental Protection Agency (US EPA) and the Ontario Ministry of the Environment (MOE) after a review of their scientific basis. Potencies for dermal exposure were available for very few chemical substances. The common practice is to evaluate dermal exposure using oral potencies after correcting for differences in absorption for the two different routes of exposure. This practice implicitly assumes that health effects are related only to the total uptake of the chemical into the body and not dependent on the route of exposure.

For non-cancer effects, hazard quotients are calculated as the ratio of the estimated exposure levels and selected toxicity reference values, below which health effects are not expected. According to MOE guidance, a hazard quotient for each exposure pathway less than 0.2 is considered protective of health. The hazard quotients for the inhalation pathway and the combined oral and dermal exposure pathways from exposure after 25 years of pellet application were below 0.2 for all the chemicals evaluated under all exposure scenarios being considered.

Cancer risks were calculated as a product of estimated exposure levels and selected toxicity reference values. Exposure ratios (ERs) were estimated as the ratio of the cancer risk estimate and the exposure limit. The exposure limit corresponds to a cancer risk of one in one hundred thousand deemed acceptable by Health Canada or a cancer risk of one in one million deemed acceptable by the MOE. In general, exposure ratios of one or less are below the level of regulatory concern. Exposure ratios greater than one do not necessarily imply an elevated level of risk because of the uncertainties inherent in the risk assessment. With the exception of arsenic, for all carcinogenic chemical entities of potential concern, there was no increased lifetime cancer risk found above either benchmark of acceptable risk (one in one hundred thousand for Health Canada and one in one million for the MOE).

In the case of arsenic, the exposure ratio for the composite (lifetime) receptor resulting from ingestion/dermal exposure after 25 years of pellet use in the home environment was within the acceptable range (i.e. between one in one million and one in one hundred thousand cancer risk). The exposure based on incremental risk (excluding background) indicates an acceptable level of risk as defined by the MOE. The lifetime cancer risk was estimated to be five in one million. Many fertilizers contain traces of arsenic; the levels of arsenic in the biosolid pellets are below allowable limits for fertilizers and soil quality guidelines. The estimated risk was within the range of uncertainty generally associated with risk assessments; the many assumptions used in the calculations tend to overestimate the risk, meaning the actual risk may be overstated. For example, assuming twice the recommended pellet application rate in calculating amended soil concentrations may overestimate risk.

Human Health Risk from Exposure to Biological Agents

There are well-developed guidelines for conducting chemical risk assessments and guidance on acceptability of risk for both human and ecological receptors; however, there are no well-defined guidelines for assessing risk from environmental exposure to biological agents and no clear definition for acceptability. The science of assessing such risks is under development at the present time. Therefore, the study focussed on the effectiveness of the pelletization process to destroy biological agents of potential concern and the likelihood of biological agents to be present in biosolids.

Although not entirely relevant to Ontario, the US EPA classifies biosolids based on their qualities. The information available on the pelletization process and the limited analytical results on pathogen content suggest that the pellets produced at the ABTP pelletizer might be of similar quality to that required for Class A biosolids as defined by the US EPA. Confirmatory testing would be required to verify this. Class A biosolids that fall under the US EPA's jurisdiction can be distributed and used without site restriction if they also meet the US EPA chemical pollutant concentration limits.

Limitations of Biological Agents Literature Review

The literature data suggest a minimum process time of 60 to 90 minutes at a temperature of 80ºC in order to achieve the destruction of most pathogens.

The pelletizer manufacturer asserts that the process meets the requirements of the US EPA for Class A biosolids. The available information seems to support this assertion; however, some biological entities in the biosolids pellets may not be deactivated by the pelletization process. Exposure to such entities increases with frequency and duration of handling, as well as quantities used, and would be greater for workers than for residents. Because of the increased contact time for workers routinely handling large quantities of pellets, and thus increased exposure via inhalation, accidental ingestion, and dermal pathways, some degree of care to minimize potential exposures to trace biological entities during handling would be reasonable.

Although the pelletization process appears to provide the conditions for effective destruction of micro-organisms, additional monitoring would be needed to confirm this capability. This can be done by routine monitoring for selected bacteria and phages.

This study of biological agents addressed types of pathogenic organisms shed in faeces that may be present in sewage. This included vegetative bacteria and enveloped viruses, bacterial spores, human enteric viruses, protozoan parasites and helminths.

Ecological Risk

Ecological risk assessment (ERA) is a process that evaluates the likelihood that adverse environmental effects may occur, or are occurring, because of exposure to one or more stressors. Chemicals present in pellet-amended soil are the stressors considered in the present study.

The assessment was carried out for a set of ecological (non-human) receptors deemed representative of species in the Toronto area that are important to the human population. The selection of potential ecological receptors (also known as valued ecological components or VECs) was based on a review of the intended and likely uses of pellets on private and public property in the City of Toronto or on landfills, and of the biota typically found in the Toronto area. Only soil and soil-based exposures were assessed in the selection. Table IV summarizes the valued ecological components selected for this assessment.

Table IV: Summary of Valued Ecological Components Selected

Receptor Type	Selected VEC[a]
Plants and soil invertebrates	Screening assessment only
Domestic pet – Carnivore	House cat
Domestic pet - Omnivore	Dog
Mammal - Herbivore	Meadow vole
Mammal – Carnivore	Masked shrew
Mammal – Omnivore	Raccoon
Mammal – Carnivore	Red fox
Fowl – Carnivore	American Robin
Fowl – Carnivore	Red-tailed hawk

Note:
a. VEC = valued ecological component

The scenarios selected for evaluation were the Home or Recreational Use Scenario and the Landfill Use Scenario.

Ecological risk assessment for wildlife and pets was not conducted for scenario use of pellets on gardens. Pellets applied to gardens are incorporated into greater depth than on lawns. Also because of the limited land area reserved for home gardens, the gardens would not form a large or continuous habitat for wildlife and pets.

The Landfill Use Scenario was not considered for the evaluation of toxicity to plants and soil organisms because the chemical levels are much lower than the other scenarios that are more conservative.

Plant Toxicity

A preliminary qualitative assessment was conducted to evaluate the potential for impact on plant life and soil organisms. A screening assessment is considered appropriate in light of the intended use of pellets as a nutrient-containing soil supplement. The levels that could accumulate in soil (summarized in Table II) after years of pellet use were compared to the Ecotoxicity values developed by MOE and Canadian Council of the Ministers of the Environment (CCME) for the protection of plants and invertebrates.

For most of the chemicals, the soil levels after 25 years of pellet use were less than the relevant MOE and CCME ecotoxicity criteria (Refer to Table 7-1). The estimated concentrations of copper, selenium and zinc in soils amended with pellets down to 5 cm depth after 25 years of application at twice the recommended application rate were found to be greater than either one or both of the guideline criteria (Table V). The soil levels were well below the MOE ecotoxicity criteria for both selenium and zinc. The slight exceedance of the CCME ecotoxicity criteria, particularly for selenium, is unlikely to be a concern. The exceedance of both criteria for copper may have different implication. The copper soil level was expected to exceed the CCME ecotoxicity criteria after 10 years of pellet application on lawns although it still would meet the MOE ecotoxicity criteria.

Table V: Ecotoxicity of Soil Based on Plants or Invertebrates for Selected Metals

Soil Concentration	Cu	Se	Zn
MOE ecotoxicity Criteria[a]			
(mg/kg)	225	10	600
CCME ecotoxicity Criteria [b]			
(mg/kg)	63	1	200
Pellets Amended Soil Concentration Assuming 5 cm depth (Lawns) [c]			
1 year (mg/kg)	39	0.51	82
10 year (mg/kg)	**120**	0.73	150
25 years (mg/kg)	**260**	**1.1**	**260**
Pellet Amended Soil Concentration Assuming 15 cm depth (Gardens) [c]			
1 year (mg/kg)	33	0.49	77
10 year (mg/kg)	61	0.56	99
25 years (mg/kg)	**110**	0.69	140

Notes:

a. MOE Rationale for the Development and Application of Generic Soil, Groundwater and Sediment Criteria for the Use at Contaminated Sites in Ontario, May 1996, Table B, coarse texture, residential; parkland land use – ecological based criteria

b. CCME, Canadian Soil Quality Guidelines for the Protection of Environmental and Human Health, 1999, rev. 2002, residential/parkland land use, soil quality guideline for protection of environmental health.

c. Based on an assumed application rate of 5.4 dry tonnes/ha.

d. Values in **BOLD** are greater than one or both criteria.

The species that determine the criteria value may not be normally found in the urban park and home environments. Furthermore, the criteria are developed for regular soil and not pellet-amended soil. It has been reported that most metals are organically bound or in less bioavailable forms for plant uptake in heat dried or composted biosolids.

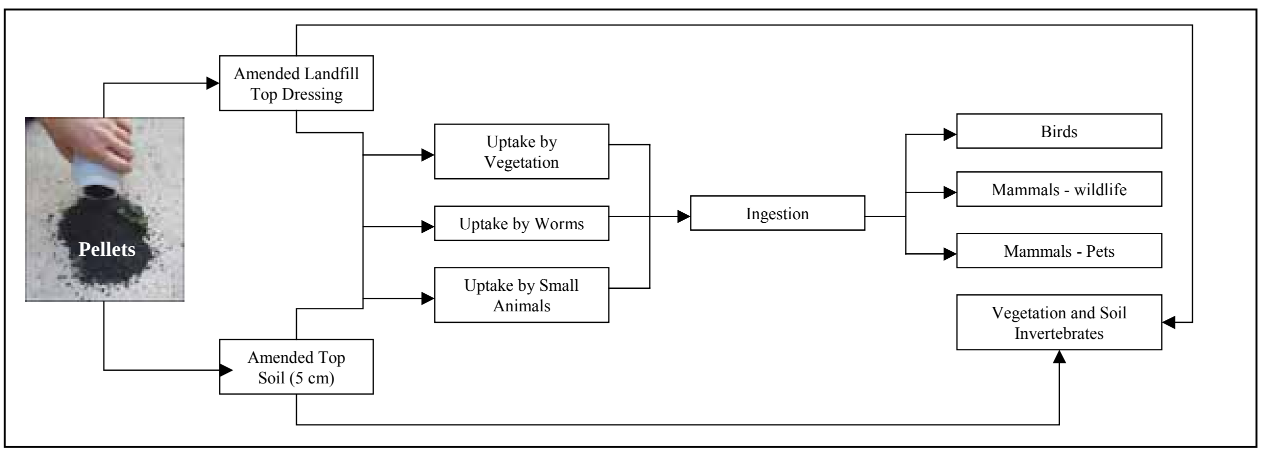
Although these long-term chemical levels are greater than the ecotoxicity criteria, firm conclusions regarding toxicity cannot be reached based on the preliminary evaluation. A more comprehensive analysis would be required using toxicity values based on plants most commonly found in parks and gardens in the Toronto area, in order to make firm conclusions on plant or soil organism toxicity. Possible lower plant uptake of copper from pellets could also be considered.

Wildlife and Pets

A preliminary quantitative ecological assessment was conducted for wildlife and pets, using an assessment framework similar to that used for human health. Wildlife valued ecological components selected for assessment represent species at different strata of the food chain. Receptors include animals that feed on vegetation only (vole), animals that feed on invertebrates (masked shrew), animals that primarily feed on other smaller animals (red fox), animals that feed on both smaller animals and vegetation (racoon), birds that eat invertebrates only (American Robin), and birds of prey (red-tailed hawk).

Evaluation of the exposure and risk to the chemical entities of potential concern involves an analysis of the exposure routes, which expose a receptor species to the source. For surface soils and terrestrial receptors, including mammals and birds, exposure to the entities of potential concern resulting from pellet use may occur through the exposure routes as depicted in Figure II.

Figure II: Ecological Exposure Pathways and Receptors



The ingestion pathway is most important for wildlife and pet receptors. This assessment considered ingestion of plants or prey species that have accumulated chemicals from the soil as well as ingestion of soil as a result of feeding or grooming.

Different assessment endpoints were selected for pets than for wildlife, reflecting the importance to people of pets as individuals.

- Wildlife Assessment Endpoint: Populations of birds or mammals that may be reduced as a result of increased mortality or decreased reproduction because of the presence of constituents of concern in soils.
- Pet Assessment Endpoint: Individual pets that may have increased risk of health effects because of the presence of constituents of concern in soils.

Risks were characterized by calculating ecological hazard quotients. An ecological hazard quotient is the ratio of estimated exposure level to a reference exposure level. For wildlife, the reference exposure level was based on the Lowest Observed Adverse Effect Levels or the No Observable Adverse Effect Levels in relation to survival or reproduction. For domestic dogs and cats, the No Observable Adverse Effect Level was used to respect the special relationship between humans and pets. A hazard quotient less than one indicates that no effects to wildlife at a population level or pets at an individual level are expected. A hazard quotient greater than one does not necessarily imply an adverse effect; rather it indicates that the risk of an effect cannot be ruled out based on the analysis performed. Taking into consideration the uncertainty associated with ecological assessment, marginal exceedances are not necessarily a cause for concern.

For the home lawn and City parkland scenarios, all hazard quotients calculated are less than one, except for exposure of American robins to chromium III, exposure of domestic dogs and house cats to arsenic, and exposure of house cats to dioxins and furans. The exceedance is marginal and is within the range of uncertainty of the assessment. This finding indicates that all the other receptors evaluated are not expected to be at risk for the selected assessment endpoints.

For the landfill scenario, all hazard quotients are less than one indicating that no risk to receptors evaluated is expected for the selected assessment endpoints.

In the home use scenario, a hazard quotient was estimated for the exposure of dogs and house cats to arsenic and the exposure of house cats to dioxins and furans. The hazard quotient is estimated as equal to the benchmark and indicates no expected risks to these receptors.

A hazard quotient of 3 was estimated for exposure of robins to chromium III, indicating that risk to robins cannot be ruled out based on the analysis performed, should pellets be widely used across their home range. If the robin is considered to migrate out of the Toronto area for approximately half of each year, unless pellets are applied to more than 60% of the robin population's home range, the hazard quotient can be considered to be less than one and hence no effects to robins would be expected. Additionally, bioavailability of chromium III in soil would be expected to be less than the 100% assumed in the assessment. Either of these factors alone would be sufficient to reduce the hazard quotient for robins to below one, indicating that no effect to robins should be expected.

Emerging Issues

Some concerns related to biosolids recycling have come to light in the recent years. Some of these have arisen because of the detection of additional toxic chemicals in sewage or biosolids. Others are due to new evidence indicating potential adverse effects for certain substances that could be present in sewage. Lack of adequate knowledge, such as the effect of low level exposure to endocrine disruptors, also creates concern. Odour, a long-standing issue, may affect public acceptance of pellet use because of the lack of prediction of potential impact.

This study briefly examined some of these issues, including:

- Odour;
- Polybrominated diphenyl ethers;
- Phthalates;
- Alkylphenol ethoxylates;
- Endocrine disruptors;
- Linear Alkylbenzene Sulphonates;
- Pharamaceuticals; and
- Radionuclides.

Odour detection is very subjective. Although biosolids pellets would be at the low end of a subjective measurement scale of odour unpleasantness, individual tolerance and sensitivity to odours will dictate public acceptance.

The characterization of chemicals identified is not well developed for biosolids and pellets. In some cases, the analytical methods to reliably measure these chemicals are still under development. For this reason, these chemicals are not included in the routine biosolids monitoring program. To reduce the risk from exposure to these chemicals from beneficial use of biosolids, Toronto restricts the discharge of many of these chemicals, including radionuclides, into the sewer system under its sewer use by-law. Besides setting strict discharge limits for many known endocrine disruptors including phthalates, nonylphenol and ethoxylates, the by-law also requires institutions and industries that discharge these chemicals to submit pollution prevention plans to the City. Health Canada, which is responsible for regulating pharmaceuticals, is considering development of a cradle to grave approach to dealing with pharmaceuticals.