Pergamon

Waste Management, Vol. 16, Nos 5/6, pp. 351–359, 1996

0956-053X/96 $15.00 + 0.00

PII: S0956-053X(96)00098-0

AN OVERVIEW OF MUNICIPAL SOLID WASTE MANAGEMENT IN CANADA

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INTRODUCTION

The management of municipal solid waste in most countries has become a complicated task, due mainly to the combined pressures of dwindling landfill space and the public's desire to conserve resources. Despite the apparent availability of landfill space in Canada, the waste management situation for major municipalities in Canada does not differ from that in other industrialised nations. Canada is the world's second largest country in terms of land mass (13 million square kilometres), yet it only has a population of about 29 million people (1995). Most of the population is concentrated in a narrow band along the southern border of the country. Major urban areas are found along the St. Lawrence River, the north shores of the lower Great Lakes (Erie and Ontario) and in the lower mainland area of British Columbia. The purpose of this paper is to provide an overview of the waste management situation in Canada. It will describe the differences in waste regulations between regions and provide an overview of waste related statistics, including the chemical and physical composition of the waste.

Waste Regulation

In Canada, the day-to-day management of municipal solid waste (MSW), i.e. collection and disposal, is the responsibility of local government. Local governments in each of the 10 provinces and two territories adhere to regulations on siting, licensing and monitoring waste disposal facilities. Although the federal government does maintain some regulatory authority over MSW management at federally-owned facilities and deals with matters of inter-provincial and international transport, it does not act as a centralised regulatory authority. Consequently, in the past regulations have varied from province to province based on regional and political differences.

Recognising the need for unified national action on some environmental and resource related issues, the Canadian Council of Ministers of the Environment (CCME) was established in the 1980s. The council has a broad mandate to develop guidelines and standards for specific environmental issues. Committees consisting of representatives from both levels of government develop uniform policies that can be drafted into provincial legislation.

With respect to MSW management issues, CCME has developed guidelines for MSW incinerators (1988)[1]; set waste diversion targets (1990a); and developed a National Packaging Protocol. The incineration guidelines were implemented by both British Columbia and Ontario shortly after their adoption and still form the basis for control strategies for this technology. The national objective of 50% diversion of waste from landfill by the year 2000 was based upon the hierarchical approach of reduction, reuse, recycling and recovery (CCME, 1990a).[2] This was followed by the implementation of the National Packaging Protocol, which set a target of 50% reduction in packaging sent for disposal by the year 2000, using the approach of source reduction and reuse to achieve at least half of the diversion and recycling for the remainder (CCME, 1990b).[3] The aim of the initiatives is to drastically reduce the reliance on landfill, which ultimately accepts the overwhelming majority (about 74% excluding construction and demolition (C&D) waste) of the currently disposed MSW.

QUANTITIES AND CHARACTERISTICS OF THE WASTE GENERATED

Quantity

In 1992 it was estimated that it cost Canadians about $3 billion to manage the approximately 33.76 million

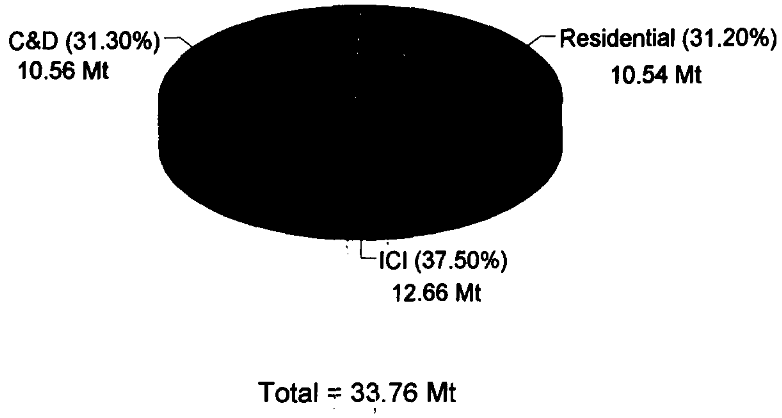

FIGURE 1. Waste quantities by sector, 1992.

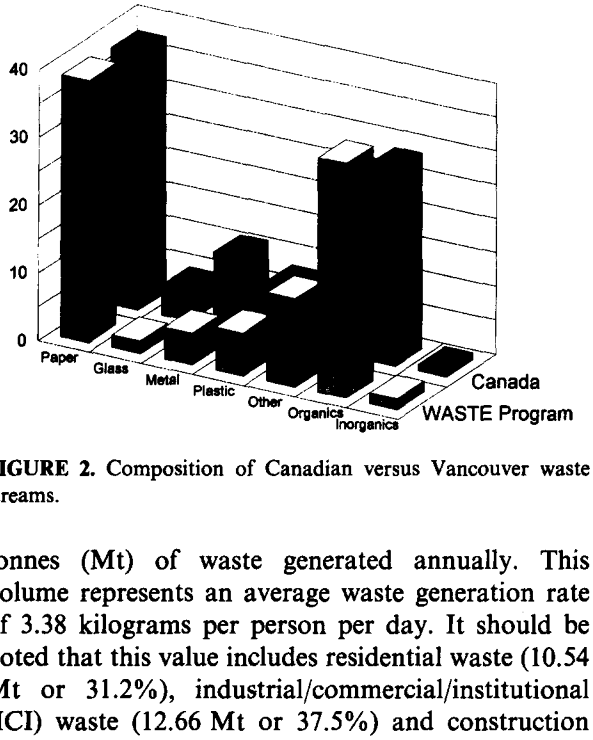

FIGURE 2. Composition of Canadian versus Vancouver waste streams.

tonnes (Mt) of waste generated annually. This volume represents an average waste generation rate of 3.38 kilograms per person per day. It should be noted that this value includes residential waste (10.54 Mt or 31.2%), industrial/commercial/institutional (ICI) waste (12.66 Mt or 37.5%) and construction and demolition (C&D) waste (10.56 Mt or 31.3%) (see Fig. 1). Based on just residential and ICI waste, the per capita generation rate was 2.3 kg per day. While this appears to represent an annual increase of approximately 7% in the residential and ICI generation rates between 1988 and 1992, the 1988 Environment Canada statistics were compiled using different accounting methods than the values for 1992 (Waste Program, 1993).[7]

Current estimates are that the residential and ICI waste streams consist of approximately 8.26 Mt of paper, 6.28 Mt of organics, 2.38 Mt of metal, 1.76 Mt of plastic, 0.97 Mt of glass, 0.2 Mt of inorganics and 2.05 Mt of other waste. Figure 2 outlines the national composition of the MSW stream (residential and ICI) as percentages, along with a comparison with the data gleaned from the WASTE Program study conducted in 1991 (Waste Program, 1993).

Waste Characterisation

Estimates of the quantity and mix of MSW are based upon collection statistics, production data and discard rate estimates. While these provide a relatively accurate picture of the waste stream, little information is available on the chemical nature of this material. Some estimates have been developed from material flow calculations but results from a Canadian study in 1991 suggest such estimates may be misleading.

Environment Canada, the US Environmental Protection Agency (EPA) and the International Lead and Zinc Research Organization sponsored the WASTE Program study in 1991. The initial study, at the Vancouver Energy-from-Waste (EFW) facility, was the first in a series of projects to identify the sources and fate of trace metals in MSW management systems. The main objective was to generate data on the trace metal composition of the various fractions of the waste (Fig. 3). Since the methodology used was based on direct sampling techniques, the assessment included a detailed analysis of all major portions of the waste stream including the putrescible (degradable) fraction. These data indicate that some of the putrescible organic fractions can contribute a significant portion of the various trace elements in the waste stream, probably as a result of a combination of natural background levels and anthropogenic activities. This finding suggests that targeting specific waste materials for diversion may not be an effective strategy to reduce potential exposures to trace metals.

MANAGEMENT ALTERNATIVES

As noted previously, approximately 74% of all MSW in Canada is currently disposed of in landfills. The CCME initiatives were aimed at reducing both the volume of waste and the dependency on this option.

Quantities Diverted from Landfill

Following the recommendations of CCME, progress has been made in diverting waste from landfills. In

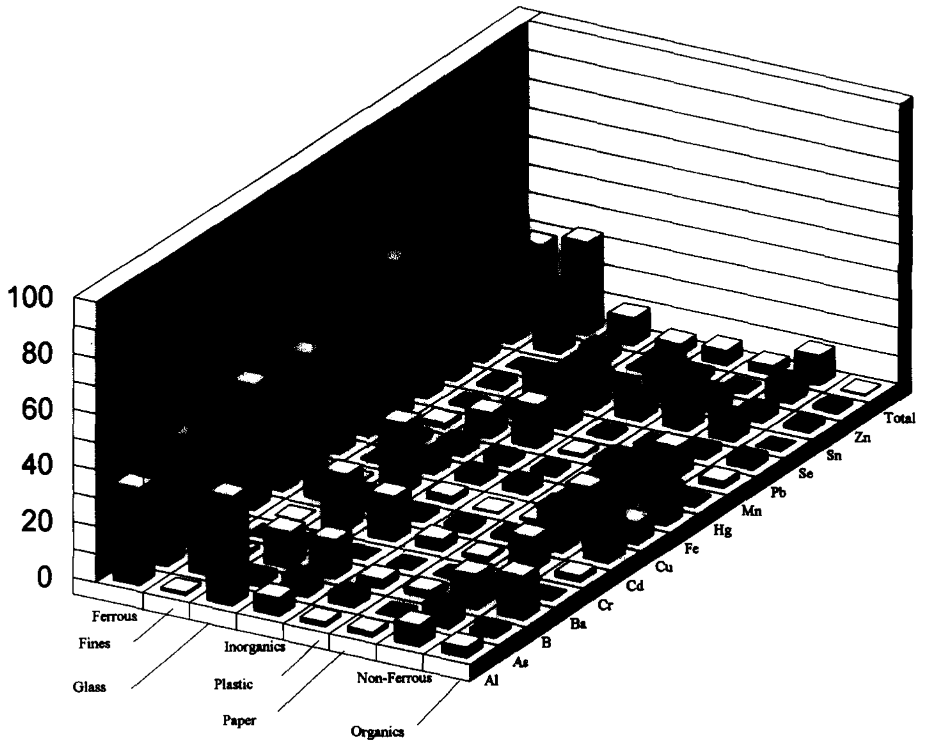

FIGURE 3. Trace metal composition of various fractions of the MSW stream.

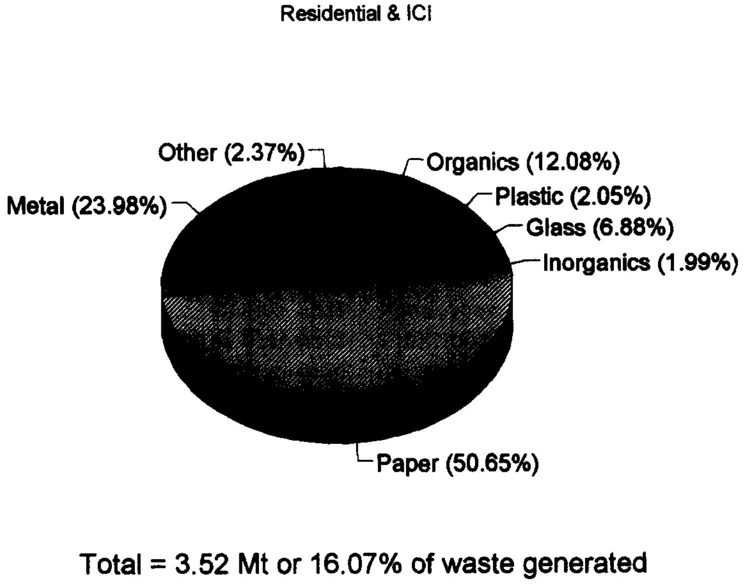

FIGURE 4. Waste diversion stream 1992.

1992, it was estimated that about 31% of the total waste stream (including C&D waste) was diverted from landfill by recycling, although much of this was due to the reuse of asphalt and concrete and the recycling of auto scrap. Based on the residential and ICI waste streams only, between 15 and 19% was diverted for recycling, about 2% was composted and about 5% was incinerated (Environment Canada, 1995). The diverted stream is estimated to have consisted of 1.73 Mt of paper, 0.925 Mt of metal, 0.413 Mt of organics, 0.235 Mt of glass, 0.07 Mt of plastic, 0.068 Mt of inorganics and 0.081 Mt of other waste. Figure 4 provides an illustrative outline of the composition of the diverted stream.

Recycling

Approximately 4.4 million tons of MSW (residential, ICI and C&D) were recycled in 1992. The recycled material is estimated to have consisted of 1.78 Mt of paper, 1.01 Mt of metal (excluding auto hulks),

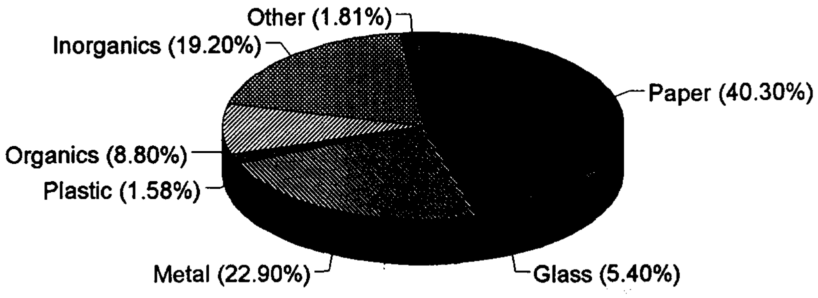

FIGURE 5. Recycled stream 1992.

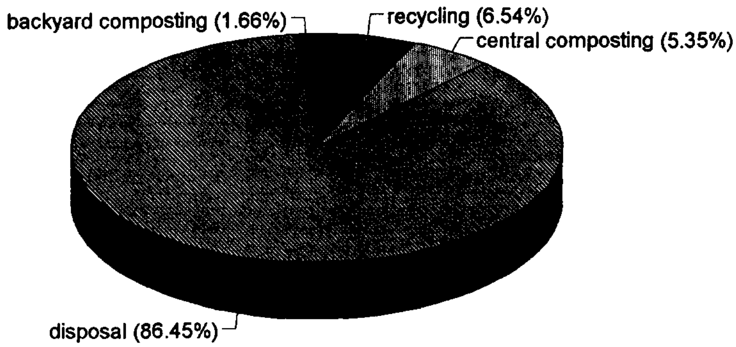

FIGURE 6. Organics stream 1992.

0.85 Mt of inorganics (excluding asphalt and concrete), 0.39 Mt of organics, 0.24 Mt of glass, 0.07 Mt of plastics and 0.08 Mt of other wastes (Fig. 5). These values translate into approximately 0.44 kg/person/day of MSW diverted through recycling options. While recycling is becoming an important management option, one of the largest concerns is that much of the energy consumed by recycling processes is used collecting the material (typically over 80%). In response to this, major new initiatives are being considered to improve the energy efficiency of waste collection and recycling.

Composting

Composting has the capability of permanently removing a substantial portion of material from the waste stream. Approximately 5.89 million tons of organic residential and ICI waste was produced in Canada in 1992, while only an estimated 385,000 tons (6.56%) were diverted to some type of recycling process and approximately 413,000 tons (7.01%) were diverted to compost. Of the amount diverted to compost, 315,000 tons were diverted through central composting facilities and another 98,000 tons were separated for backyard composting (Fig. 6).

Incineration

The presence of appropriate landfill sites close to major urban centres has limited the development of incineration facilities in Canada. In large metropolitan centres with sprawling residential suburbs, increased difficulties in siting landfills has led to the consideration of incineration. Some of these communities have closed older facilities built in the 1950s and have yet to open new ones. In Ontario the lack of new facilities is due in no small part to local opposition to projects and a moratorium introduced in 1991 by the provincial government.

The reasons cited for the ban were that incineration: (1) threatened human health and the environment; (2) created large quantities of ash; (3) was incompatible with the 3 Rs (reduce, reuse, recycle); (4) was the most expensive management option; and (5) was inconsistent with Ontario's pollution prevention strategy (David, 1995).[4]

In June of 1995 a new provincial government was elected in Ontario. August 1995 saw the fulfilment of that government's campaign promise to lift the ban on incineration. The draft legislation was accompanied by new operating rules—Guideline A-7—"Combustion and Air Pollution Control Requirements for New Municipal Waste Incinerators" and both were posted

TABLE 1
Comparison of New (1995) Ontario Guidelines with US EPA Regulations (1995) and EC Standards (1991) for MSW Incinerators

Parameter	Units	CCME 1988	Ontario guidelines December 1995		US EPA final rules			European Union	
			Standard	Method	New plants October 1995	Existing plants October 1995	Methods	Size > 72 tpd	Comments
Carbon monoxide	ppmdv	50					CEMS	78	CEMS
Modular					35	35	4 h avg.		1 hour avg.
Mass burn WW or RW					70	70	unless		
Mass burn rotary refractory					70	70	noted		
Fluidised bed					70	70			
Pulverised coal/RDF mixed fuel					105	105			
RDF stoker (24 h)					105	140			
Mass burn rotary waterwall (24 h)					105	140			
PCDD/F	ng/Rm3								
Total							Method 23		
All facilities					9		average 3		
> 225 tpd						21	tests		
> 225 tpd with ESP						42			
> 35 tpd and < 225 tpd						88			
TEQ	ng/Rm3								
All facilities		0.5	0.14	Method 23	0.14–0.21		Calculated		
> 225 tpd				avg. of		0.28–0.49	ITEQ		
> 225 tpd with ESP				3 tests		0.56–0.91			
> 35 tpd and < 225 tpd						1.26–1.96			
Particulate matter	mg/Rm3						Method 5	27	
All		20	17	Method 29	17				
> 225 tpd				avg. of 3 tests		19	avg. of 3 tests		
> 35 tpd and < 225 tpd						49			
Opacity	%	10			10	10	Method 9		
Cadmium	mg/Rm3	POI	0.014	Method 29	0.014		Method 29	0.14	Including Hg
> 225 tpd				avg. of		0.028	avg. 3 tests		
> 35 tpd and < 225 tpd				3 tests		0.07			
Lead	mg/Rm3	POI	0.142	Method 29	0.14		Method 29	4.552	Including Cr, Cu
> 225 tpd				avg. of		0.343	avg. 3 tests		& Mn
> 35 tpd and < 225 tpd				3 tests		1.12			
Mercury	mg/Rm3	POI	0.057	Method 29	0.056		Method 29	0.14	Including Cd
> 225 tpd				avg. of		0.056	avg. 3 tests		
> 35 tpd and < 225 tpd				3 tests		0.056			
% removal					85	85			

Table 1—*contd*

Parameter	Units	CCME 1988	Ontario guidelines December 1995		US EPA final rules			European Union	
			Standard	Method	New plants October 1995	Existing plants October 1995	Methods	Size > 72 tpd	Comments
Acid gases	ppmdv								
Sulfur dioxide			21		21		CEMS	103	Periodic
> 225 tpd						22			
> 35 tpd and < 225 tpd						56			
% removal	%				80				
> 225 tpd						75			
> 35 tpd and < 225 tpd						50			
Hydrogen chloride	ppmdv	30	18		18		Method 26	30	CEMS
> 225 tpd						22	avg. 3 tests		7 day avg.
> 35 tpd and < 225 tpd						175			
% removal	%				95				
> 225 tpd						95			
> 35 tpd and < 225 tpd						50			
Nitrogen oxides	ppmdv		110			see below	CEMS		
> 225 tpd					105	exempt	24 hour		
> 35 and < 225 tpd					exempt		arithmetic		
Large plants existing						168	average of		
Fluidised bed						exempt	CEM data		
Refractory wall units						175			
RDF stokers						140			
Mass burn waterfall						175			
Mass burn rotary						140			
Other									

for public comment. Numerous responses to this initiative were received by the agency and a revised version of the guideline was issued in late December 1995.

While great similarities exist between the new guideline and those in force before the ban, the most important aspect of the guideline is the use of performance-based limits on air emissions. These will force all new facilities to use the most advanced combustion and air pollution control (APC) technologies available today. The limits, outlined in Table 1, will require the application of acid gas control scrubbers, NO_x reduction, fabric filters and powdered activated carbon addition to control emissions. The latter is required to meet the stringent mercury and PCDD/F limits outlined in the table. For comparison purposes, the CCME guideline values from 1988, the EC standards and the latest US EPA standards are compared in the table. All values are reported at 25°C, 1 atmosphere under dry conditions and 11% O_2.

While the lifting of the incinerator ban provides another waste management option for Ontario communities, the uncertainty of the approvals climate in the province will impede development for the foreseeable future. Even with the draft guidelines in place in July, bids received in December to dispose of the residual waste in metropolitan Toronto, approximately 1.7 Mt annually, did not include a local incineration alternative.

Canadian Incinerator Statistics

In 1992 approximately 1.2 million tons or 5.48% of the MSW (residential, ICI, C&D–no autohulks or asphalt/cement) produced were sent for combustion. Almost 1.1 Mt (92%) were incinerated at the 10 EFW facilities with the remaining 111,000 tons (8%) in the seven non-EFW facilities. Figure 7 outlines the breakdown of waste incinerated at EFW and non-EFW facilities.

With regards to energy production at the incinerator facilities, hourly production of approximately 2173.4 kilotons of steam was produced at seven EFW facilities and about 14.1 Mwatts of electricity was produced at the 3 remaining EFW facilities.

The technology employed in these facilities was

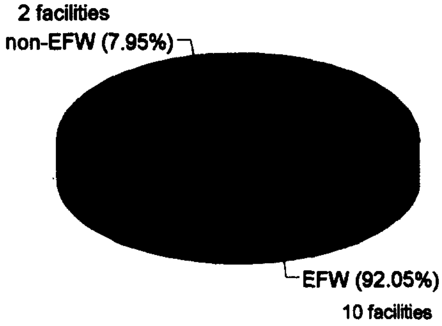

FIGURE 7. EFW versus non-EFW facilities.

distributed between five mass burn facilities burning 64% of the waste incinerated, nine two-stage facilities burning 25% of the waste incinerated and one semi-suspension facility burning the remaining 11% of the waste incinerated (Fig. 8). Seven of the facilities had fabric filter air pollution control systems, one facility with an electrostatic precipitator system and the seven smaller facilities had no APC system in place.

Table 2 summarises current MSW incinerator facilities in Canada, including startup date, capacity, type of facility and air pollution control technologies, along with the mass of MSW combusted from 1992 to 1994.

Landfilling

Landfilling is by far the most common waste management option used by municipalities in Canada. Estimates put the total number of landfills in Canada at around 10,000 (Government of Canada, 1991).[6] However another study (Environment Canada, 1995)[5] identified 113 large Canadian landfills, indicating that the majority of landfills are small, typically rural facilities.

Approximately 17.52 million tons of (residential and ICI) MSW were landfilled in 1992. It is estimated to have consisted of approximately 6.1 Mt of paper, 5.5 Mt of organics, 1.6 Mt of plastics, 1.4 Mt of metal, 0.68 Mt of glass, 0.47 Mt of inorganics and 1.8 Mt of other waste. Figure 9 illustrates the materials being disposed of in landfill. These values translate into approximately 1.76 kg/person/day of MSW which ends up in a landfill.

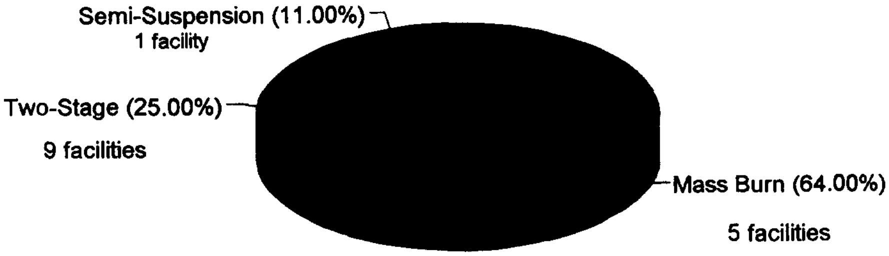

FIGURE 8. Incinerator types.

TABLE 2
Summary of Current MSW Incineration Facilities in Canada (Over 15 tpd Rated Capacity)

Name and location	Start	Rated capacity tons/day		Incinerator type	APC type	Energy recovery	Energy type	Total rated capacity (1995)		1992 Combusted (tons/year)		1993 Combusted (tons/year)		1994 Combusted (tons/year)	
								No energy recovery	Energy recovery	No energy recovery	Energy recovery	No energy recovery	Energy recovery	No energy recovery	Energy recovery
Harbour Grace, Newfoundland	1982	2 × 16	32	Pit burner with forced overfire air	None	No		11,680		5800		5800		5800	
Labrador City, Newfoundland	1981	1 ×16	16	Two-stage with forced air	None	No		5840		2900		2900		2900	
Cape Breton county, Nova Scotia	1987	2 × 72	144	Small mass burn units	ESP, DLI and FF (1994)	Yes	Electric		52,560		35,000		35,000		35,000
PEI EFW Facility, Prince Edward Island	1983	3 × 33	99	Two-stage modular consumat units	None	Yes	Steam		36,135		30,000		30,000		30,000
Quebec Urban Community EFW Facility, Quebec	1974	4 × 230	920	Mass burn (upgraded in 86–89)	ESP, SH, DLI and FF, AC	Yes	Steam		335,000		260,000		260,000		260,000
Levis incinerator, Quebec	1976	1 × 80	80	Mas burn	Cooling tower followed by ESP	No		29,200		27,700		27,700		27,700	
MRC des Isles de la Madeleine, Quebec	1995	1 × 31	31	Two-stage with rotary kiln	SH, DLI, FF	No		11,388		Not built		Not built		Under construction	
Victoria Hospital EFW Facility, Ontario	1987	3 × 91	273	Two-stage modular Petro-Sun units	SH followed by DLI and FF	Yes	Steam		99,645		30,000		30,000		30,000
SWARU Incinerator Facility, Ontario	1971	2 × 250	500	Semi-suspension combustion	FF (no DLI, bags precoated with lime)	Yes	Electric		182,500		98,700		98,700		98,700
General Motors Canada EFW Facility, Ontario	1987	1 × 90	90	Combination two-stage and rotary kiln	FF	Yes	Steam		32,850		7200		7200		7200
Peel Resource Recovery Inc., Ontario	1992	4 × 91	364	Two-stage modular Consumat units	SH, DLI followed by FF	Yes	Electric		132,860		133,000		133,000		133,000
Wainwright Regional Incinerator Authority, Alberta	1995	1 × 27	27	Multi-stage pulse hearth	DLI with FF	Yes	Steam		9855		Not built		Under construction		Under construction
Burnaby EFW Facility, British Columbia	1987	3 × 240	720	Mass burn	SH, DLI and FF, AC	Yes	Steam		262,800		235,000		235,000		235,000
Cowichan Valley, British Columbia	1978	3 × 15	45	Two-stage modular unit	None	No		16,425		11,700		11,700		10,800	
Tumbler Ridge, British Columbia	1983	1 × 15	15	Two-stage modular unit	None	No		5475		2000		2000		2000	
Ladysmith, British Columbia	1978	1 × 15	15	Two-stage modular unit	None	No		5475		4100		2100		4100	
Lake Cowichan, British Columbia	1983	1 × 15	15	Two-stage modular unit	None	No		547		3100		3100		3100	
Montreal (closed 1993), Quebec	1974	4 × 270	1080	Mass burn	ESP	Yes	Steam		0		335,000		193,800		0
3M Canada (closed 1993), Ontario	1987	1 × 63	63	Rotary kiln two-stage	DS, FF	Yes			0		8000		5000		0

Note: ESP-Electrostatic Precipitator, DLI-Dry Lime Injection, FF-Fabric Filter, AC-Activated Carbon, SH-Spray Humidifier, DS-Dry Scrubber.

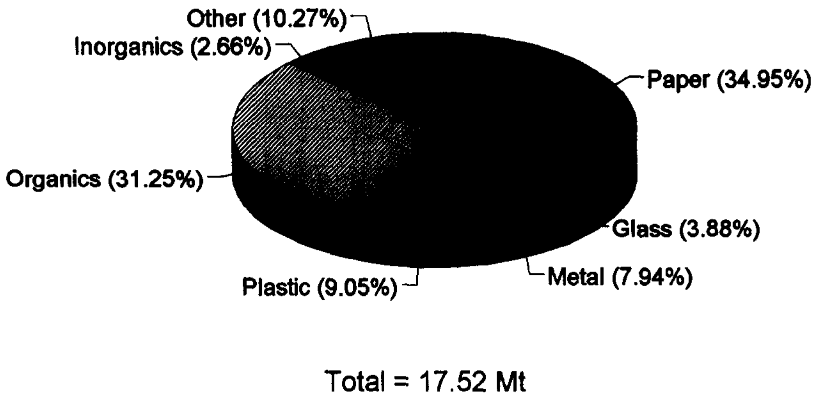

FIGURE 9. Composition of MSW landfilled in 1992.

Landfill Gas

Landfills produce landfill gas (typically methane, carbon dioxide, nitrogen and oxygen) from the anaerobic decomposition of organic matter. There were approximately one million tons of methane emitted from Canadian landfills in 1990. Of that amount it is estimated that 20% was captured and combusted. Emissions are predicted to rise to approximately 1.3 million tons by 2020. The technical feasible level of emission recovery from landfill is about 63% of total emissions (Hickling, 1994).[8] In Canada, at least 24 landfill sites will have either gas control or utilisation systems in place by 1995.

CONCLUSIONS

In 1992 Canadians produced an average of 2.2 kilograms per person per day of MSW. Approximately 83.9% of all residential and ICI waste generated in Canada is landfilled. Of the 16.1% diverted, approximately 1.88% was composted and the remaining 14.22% was incinerated or recycled.

Canadians continue to examine alternatives for waste management. However, the size of the country and the relative amount of available space suggests that a large portion of the country will rely on landfill for the foreseeable future. Waste material in a landfill can be considered as a future energy resource. Landfill gas recovery and waste mined from the landfill are opportunities for energy conservation. Waste which is mined can be recovered (incinerated), reused or recycled.

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