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Waste management

The management of household waste has become one of the most important environmental issues of the latter part of this century, both in industrialized and developing nations. Following the Second World War, with the reduction of the life cycle of consumer goods and the unrestrained use of natural resources by industrialized nations, there was an increase in the harvesting of the world's resources, to produce more and more consumer items. Waste reduction, reuse, recycling and recovery are obviously approaches that will help slow down the depletion of natural resources, while simultaneously contributing to a reduction in landfilling and incineration, two waste management methods currently popular in industrialized societies.

Canadian perspective

Canada is one of the world's major producers of municipal solid waste, producing over 1,000 kg of waste per capita each year (including commercial and construction waste). The typical garbage bag in a municipal household in Canada contains by weight 25 to 40% paper and cardboard, 20 to 35% of putrescible organic matter or green waste, about 10% of glass, about 8% of plastic and 5 to 12% of metals.

In Canada, in 1992, 78% of this waste was disposed of by landfill and 5% by incineration. The remaining 17% were recycled or composted, representing a significant improvement compared to the 6% value registered in 1988. This improvement is due in part to the implementation of initiatives proposed by the Canadian Council of Ministers of the Environment (CCME), whose objective was a 50% reduction in total waste production before the end of the century. In addition to urging recovery at the municipal level, these initiatives also targeted packaging. In fact, waste from packaging was reduced by 25% between 1988 and 1993. It should be mentioned also that the annual costs for waste disposal, including pick-up and transportation, are estimated at over $3 billion (data for 1995). This does not include the environmental and social costs (negative externalities) associated with this loss of resources.

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Quebec perspective

The type and quantity of waste produced in Quebec are similar to that of other regions. According to data from Recyc-Québec, the industrial and commercial sectors recycle about 35% of their waste, but in the household sector, the percentage is only 17%. Over 95%

of unrecovered waste is eliminated in 553 landfill sites. The rest is eliminated in the three incinerators that are still in operation. Despite the existence of the Regulation Respecting Solid Waste (implemented in 1978), many landfill sites still do not comply with standards, and there are still dump sites that are completely illegal. Since the implementation in 1995 of an Act Respecting the Establishment and Enlargement of Certain Waste Elimination Sites, all disposal projects must be submitted to the

environmental impact assessment and review process. It should be mentioned also that the report of the Panel on Waste Management in Quebec, tabled in 1997, redefined waste management, especially by promoting the 4 R's. However, the Department of the Environment and Wildlife has yet to make the recommendations of this report official government policy.

Environmental assessment of waste management projects

The environmental impacts of waste management depend on the type and quantity of the waste to be processed, on the site and on the disposal methods. The environmental assessment must also cover the environmental parameters of the site and weather conditions, and must address the worst-case scenario where pollutants are released into the environment and can affect a community. Public health is generally the major issue in environmental assessments targeting waste management projects.

Finally, waste recovery, reuse, recycling and composting projects are not included in the environmental impact assessment process. Selective collection projects are also excluded. The only projects dealing with some type of waste recovery that have been evaluated in Quebec are cogeneration initiatives, or the enhancement of waste for energy production, such as forest or cellulosic waste, hazardous organic waste, tires and used oil. These usually involve incineration processes used by power plants and cement factories to produce energy.

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Landfilling

As mentioned above, landfilling is the most common method of waste management in Quebec and is used for 95% of total wastes produced. The 1978 regulation requires that sanitary landfilling be practiced in a manner that ensures the abatement of water and air pollution. Despite this regulation, there are still many landfill sites where various materials are disposed without taking into consideration the environmental impacts; they are operated without any monitoring. The purpose of sanitary landfilling is simple: confine garbage to a designated area. Disposal can be made by piling, by dumping into a trench (a hole is dug and then it is filled with successive layers of waste and inert and granular material such as soil) or by elimination in a quarry (an abandoned quarry is filled with waste; most of the waste from the City of Montreal is stored in the old Miron quarry, which ceased operations at the beginning of the 70s). It should be noted that all the sites used for disposal of dry material are former quarries.

Water pollution

Leachate, also called percolate, is the liquid produced by the biodegradation of waste and by the seepage of the water through waste. This water becomes loaded with microorganisms as well as organic and inorganic substances. It is difficult to determine beforehand what the leachate will contain because its composition depends on many factors such as the type of waste, the quantity of water, the type of landfilling operation, the thickness of the layer of waste, etc. Tests on percolated water from a landfill site in Quebec revealed a biochemical oxygen

demand of 3,600 mg/L, suspended particulates with a concentration of 150 mg/L and a total coliform count varying between 1,800 and 2 million parts per deciliter (100 mL).

Local hydrogeological conditions and confinement or sealing methods are therefore major determining factors with respect to risks for the environment and for health. Surface and ground water may have been polluted and can become a hazard for the people using it. Landfill sites using the piling method and located near a stream or river represent a significant risk for water quality. There are also some streams whose coloration reveals some type of pollution. As for underground water, potential impacts can be assessed only if the properties of the water table and the geological properties of the soil have been fully determined.

Leachate has to be recovered and processed to prevent water contamination. For any new landfill site, it is therefore necessary to ensure that there is no leakage, and the leachate has to be pumped to a water treatment plant. It should be mentioned here that existing regulations only provide that the leachate meet certain chemical and microbiological requirements before being released into the environment (Q-2, r.14, a.30). At present, there is no requirement to assess the overall ecotoxicological effects of leachate, despite the fact that certified tests are currently available.

Air pollution

Biogas is a source of air pollution originating in sanitary landfill sites (open-air waste burning is usually prohibited, although it is tolerated in northern regions). Biogas, a byproduct from a landfill site, is created by the anaerobic decomposition of organic matter by various microorganisms. This decomposition produces various organic volatile substances. Typical biogas contains between 45 to 60% of methane (CH_4) and between 35 and 50% of CO_2, the remaining substances being nitrogen, various gases, and also sulphur and volatile organic compounds (VOC) that are generally quite smelly. Biogas can also be explosive because of the presence of methane. In fact, pressure created by biogas inside the accumulated waste material forces the gas to the surface through preferred flow channels. If an airtight cover is placed over a landfill site, or if such a site is compacted, the gas may be directed horizontally toward closed structures such as basements. In high concentrations, biogas can be asphyxiating.

The California Air Resource Board and EPA have analyzed the properties of biogases at several landfill sites. Their studies reveal that in addition to the risk of asphyxia or explosion when methane is present, VOCs constitute a significant health risk. It should be pointed out that cancer-causing compounds such as benzene and polyvinyl chloride can also be present. Studies conducted on dispersion characteristics reveal in some instances cancer risk levels exceeding the acceptable limit (1×10^5), especially in disposal sites for hazardous waste.

In Quebec, there are no regulations targeting biogas emissions, and these are only superficially mentioned in the regulations respecting hazardous material that were implemented in December 1997. However, in 1996, the government authorized the enlargement of the Lachenaie sanitary landfill on the condition that all biogases be captured and treated.

Sector: Waste Activity: Sanitary Landfilling

STRESSOR/ EXPOSURE	Type of Stressor	Environmental Impact	Area of Influence	Control Measures	Standards or Recommendations
Technological disaster	- fire	- dust-laden smoke/deposits	- plume dispersion	- covering	- prohibit fires
	- explosion	- destruction	- site and perimeter	- biogas management, site leakage prevention	- daily covering when not stipulated in any law
Gaseous or air emissions	- biogas - methane (CH_4)	- greenhouse effect	- world-wide	For all these pollutants: promotion of use for energy production	- gas detection for CH_4.
	- carbon dioxide (CO_2)	- greenhouse effect	- world-wide		- none
	- VOC	- pollution by ground-level ozone	- local and regional		- none
Liquid emissions or discharge into water	- leachate BOD, COD	for all these pollutants: disturbance of marine life, pollution of surface and underground waters	from local to several kilometres	- solid waste: migration/seep-age <300m/5 years -hazardous waste: various membranes depending on speed of migration	capture and treatment of leachates to comply with emission standards
	- various hydro-carbons				
	- heavy metals				
	- various micro-organisms				
Solid emissions or discharge into the soil	- airborne waste	- appearance	- air/ground perimeter	litter fence, daily covering, reduction in waste handling operations	3 m high and 20 m from the landfill site - Aspergillus <10,000 ufc - extermination
	- mold	- unhealthy conditions	- community		
	- vermin	- unhealthy conditions	- community		
Nuisances	- noise	- unhealthy conditions	vicinity and community	- buffer zone	10 m (width of buffer zone); covering with 20 cm of soil
	- odour	- unhealthy conditions		- buffer zone and daily covering	
Indirect impacts or other exposure	devaluation and price downgrading	economic	community	monetary and social compensation, communications	impact assessment (Q-2, Section IV.1)

STRESSOR/ EXPOSURE	Effect on health	Population at risk	Probability of occurrence	Environment/ biological indicator (monitoring)	Information/ references
Technological disaster	- nose-throat irritation, asphyxia, skin burning	vicinity and workers	- high	- fire and injury reports	http://www.cfe.cornell.edu/wmi/ USEPA (1988) Q-2, r. 14 to 59
	- traumas, deaths		- 31 cases in the USA between 1967 and 1987	- morbidity/mortality gas detection	
Gaseous or air emissions	- asphyxia, injuries	vicinity and workers (especially in enclosed areas)	- occasional (vicinity), high (workers)	- gas detection (<1.25% per vol.)	CCME (1989) Comité de santé environnementale (1993) California Air Resource Board
	climate changes for CH_4 and CO_2			- atmospheric CO_2	
	- cancer		- very low	- benzene and dichloroethane levels, and total VOCs	
Liquid emissions or discharge into water	unhealthy conditions, acute or chronic poisoning; cancer-causing effects, possibility of teratogens or mutagens	people swimming or consuming contaminated water; vulnerable people are mostly children	acute poisoning: rare chronic poisoning: few reported cases	monitoring of various pollutants in leaching water and also in natural water receiving the discharges	- World Bank (1991) - American J. of Preventive Medicine 7(6): 352-362 (1991) - Q-2, r. 14 a. 29-30, order 1310-97, a.3
Solid emissions or discharge into the soil	- quality of life, hygiene	For all these pollutants: vicinity and community	- very high	- complaints	Lavoie and Marchand (1997) Q-2, r. 14, a. 35 Q-2, r. 14, a. 42
	- infections, allergies		- high	- Aspergillus <10,000 ufc	
	- spreading of various diseases		- very low to low	- epidemics, inspections	
Nuisances	- sleep quality	vicinity and community	- very high	- L_{eq} 8 hrs per night, 45 dB(A)	Létourneau, M., Le bruit communautaire, MEF, 39 p. - Gingras, B. (1997), BISE 7(5) 1-3
	- stress		- very high	- complaints/ perception	
Indirect impacts or other exposure	assessment/ roperty taxes individual and collective stress	vicinity and community	occasional to very high	monitoring property assessments, perception studies	- Impacts psychosociaux inhérents à l'exploitation d'un LES, DSP, PRSSS Estrie, Oct. 94 - Archives of Environmental Health 50(2): 95-102

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Incineration

Generally, airborne emissions from waste incineration are quite visible, and reaction from the public is often swift, even if less than 5% of waste produced in Quebec is incinerated. Carbon dioxide and water are the main products resulting from waste incineration. The other substances, produced mostly by the incineration of inorganic compounds, are transformed into ashes that are then buried.

The combustion fumes include gases, particles and flyash, which is made up of small, easily airborne particles which penetrate deeply into the respiratory tract. The particles and flyash can be inert matter, such as silica, but may also include various metals that have become vaporized. Carcinogenic metals, especially cadmium and chromium, generally represent greater risks (slightly under 1×10^5, which is less than one case of cancer for 100,000 persons exposed). Considerable amounts of mercury and lead are also released and these heavy metals are toxic.

Some substances that have not been completely incinerated can concentrate on particles and these substances can also be found in gaseous form in the smoke. Other gases that can be identified in incinerator fumes are volatile organic compounds (VOC), polychlorinated biphenyls (BPC), polycyclic aromatic hydrocarbons (PAH), and especially dioxins and furans. The literature suggests that in general, there is no significant increase in the risk of cancer when the incinerators are operated to standards. It is estimated that the extra absorption of dioxins and furans, in the worst-case scenario as found in the vicinity of the Carrières incinerator in Montreal, represents only 5% of the input provided by “background noise”, which is predominantly from food sources.

Incinerator smoke also contains many other gases such as sulphur dioxide and chlorinated compounds. At normal levels, these substances are not considered likely to produce harmful effects as such on the environment and health. However, they do represent an addition to other pollutants that cause climatic changes and destroy the ozone layer, and these substances are also a cause of acid rain and urban smog.

The solid waste resulting from incineration is made up of heavy grill ashes (that cannot become airborne), and these form most of the solid waste from incineration (95%). In general, they are non-toxic, and are usually disposed of at landfill sites. However, these ashes contain various substances that can be a concern and they require careful management, as in the case of hazardous waste. In some countries, they are used in road building and also for backfilling.

Sector: Waste Activity: Incineration

STRESSOR/ EXPOSURE	Type of Stressor	Environmental Impact	Area of Influence	Control Measures	Standards or Recommendations
Technological disaster	- fires and explosions	air pollution from smoke, destruction	air and water, locally and regionally	technical controls, emergency measures, confinement	Department of the Environment, CSST, Emergency preparedness, municipalities
Gaseous or air emissions	- carbon dioxide (CO_2)	- greenhouse effect	- world-wide	- none	-Rio (1992) and Kyoto (1997) commitments
	- carbon monoxide (CO)	- negligible	- local	- combustion control	- 13 ppm (8 hrs) Q-2 Reg. Qual. Atmosph.
	- nitrogen dioxide (NO_2)	- acid rain, ground level ozone	- local to continental	- none	- 0.2 ppm (1hr) and 0.1 ppm (24 hrs), Q-2 Reg. Qual. Atmosph.
	- sulphur dioxide (SO_2)	- acid rain, smog	- local to continental	- gas cleaning	- 0.5 ppm (1hr) and 0.1 ppm (24 hrs), Q-2 Reg. Qual. Atmosph.
	- hydrogen chloride (HCL)	- acidification of the environment	- local to regional	- gas cleaning	- none
	- doxins, furans, PAH, benzene	- bioaccumula-tion in living organisms	- local to world-wide	- combustion temperature	- 0.5 mg/m^3 (TCDD) CCME, 99.99% destruction (EPA)
	- VOCs	- creation of ground-level ozone	- local to regional	- combustion performance	- ???
	- heavy metals (Pb, Hg, As, Cr, Cd)	- water and soil contamination	- mostly local	- flue gas cleansing	- none
Liquid emissions or discharge into water	- leaching water from ash disposal	- surface and ground water pollution	- local and regional	- prevention of leakage from disposal site	- incineration waste regulated by R4, a.6
Solid emissions or discharge into the soil	- fly ash and disposal of ash from racks	- pollution, mostly caused by more toxic flyash	-site and perimeter	- prevent fugitive emissions (dampen, contain)	- none
Nuisances	- noise	negligible impacts on the natural environment	- local	for all these nuisances: buffer zones, etc.	- L_{eq} 45dB (nighttime)
	- appearance		- local		- none
	- odours		- local and regional		- municipal regulations
Indirect impacts or other exposure	- not in my backyard syndrome	degradation of the human environment	- local to regional	- education, public input	- environmental assessment process

STRESSOR/ EXPOSURE	Effect on health	Population at risk	Probability of occurrence	Environment/ biological indicator (monitoring)	Information/ references
Technological disaster	- traumas, injuries, deaths;	- workers, vicinity and community	- rare	- morbidity and mortality reports, fire department reports	
Gaseous or air emissions	- climatic change (injuries, deaths)	- world-wide	- high	- geoclimatic data and weather phenomena	Carrier *et al* (1991) Laflamme *et al* (1996 Minott (1989) Travis (1989) EPA (1983, 1989) Environment Canada (1991) CCME (1989)
	- [carboxyhemo globinemia (cHB)	- workers	- very rare	- level of blood cHB	
	- irritation of respiratory tract	- vicinity	- rare	- atmospheric NO_2 level	
	- respiratory problems (asthma, bronchitis, etc.)	- mostly vicinity	- rare	- epidemiology of respiratory ailments	
	- respiratory irritations	- vicinity	- very rare	- epidemiology of respiratory ailments	
	- potential cancerogenic, mutagenic and teratogenic effects	- workers, residents under dispersion plume	- 0.3 to 21 cases per 10^8 persons exposed	- few indicators with the required sensitivities	
	- none at expected levels	- N.A.	- N.A.	- air emission tonnage	
	- certain cancers (lung, leukemia) and neurotoxicity	- workers and vicinity (children) under the plume	- rare or insignificant	- air content determination, epidemiological studies	
Liquid emissions or discharge into water	- neurotoxicity, possibility of some cancers	- users of drinking water	- very rare	- surface and ground water quality	
Solid emissions or discharge into the soil	- possible neurotoxicity due to lead	- especially children in vicinity	- rare	- lead detected in the soil	
Nuisances	- sleep disturbance, stress	- vicinity	- occasional	- noise levels L_{eq} (8 hrs), 45 dB, nighttime	DEW (1993) Le bruit communautaire, 39 p. Gingras, B. (1997), BISE, 7(5) 1-3
	- quality of life	- vicinity	- occasional	- perception studies “focus group”	
	- environmental allergy	- vicinity	- occasional	- perception studies, assessment of odors	

STRESSOR/ EXPOSURE	Effect on health	Population at risk	Probability of occurrence	Environment/ biological indicator (monitoring)	Information/ references
Indirect impacts or other exposure	individual and collective stress, conflicts, economic losses	community	occasional	“focus group”, property assessment	http://atsdr1.cdc.gov.8080/atsdrhome.html

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