Ontario Agricultural Waste Study:

Environmental Impacts of Open-Burning Agricultural Plastics

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Final Report

July, 2011

Executive Summary

In their daily activities, farmers use a variety of plastics, including baler twine, silage wrap, grain bags and pesticide containers. A comprehensive program operated by CleanFARMS exists nationally to manage waste pesticide containers, but no similar program exists for other farm plastics, and these materials present a serious disposal issue to farmers across Canada.

On-farm burial and burning of waste plastics remains a common practice, resulting in both air pollution and resource conservation concerns.

Open burning of agricultural plastics can lead to the release of many air pollutants and hazardous byproducts, including heavy metals, dioxins and furans. On-site burning of household garbage (such as burning barrels) has been identified as the largest source of dioxin emissions in Ontario. Dioxins and furans are a health concern even in very small quantities, being associated with endocrine disruption, heart disease, cognitive and motor disabilities, as well as being a known human carcinogen. Exposure to pollutants can occur through direct inhalation or ingestion of contaminated plants or animals.

The burning of plastic agricultural plastics is of particular concern to the Great Lakes Basin Watershed - home to 95 percent of the surface water in North America along with 21 percent of the world's surface freshwater - where dioxins and furans pose a serious threat to aquatic species, wildlife, soil fertility, and humans. Dioxins and furans are also considered a Tier 1 pollutant by the Canada-Ontario Agreement Respecting Great Lakes Basin Ecosystem, whereby all sources of Tier 1 pollutants are to be eliminated.

Recycling the agricultural plastics that are used annually in either Alberta or Ontario would represent a net greenhouse gas savings of more than 20,000 tonnes of CO_2 equivalent, or the same impact as removing more than 4000 vehicles from the road for a year.

There is a strong national need to develop a comprehensive stewardship program for waste agricultural plastics to address the lack of adequate management systems for these waste products, and the potential environmental impacts associated with improper disposal.

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Background

In their daily activities, farmers use a variety of plastics, including baler twine, silage wrap, grain bags and pesticide containers. Use of agricultural plastics is increasing, as applications such as large plastic grain bags for on-field storage are becoming ubiquitous. A comprehensive program operated by CleanFARMS exists nationally to manage waste pesticide containers, and farmers have easy access to this program to dispose of their used pesticide containers. However, no similar program exists for other farm plastics, and these materials present a serious disposal issue to farmers across Canada.

The types of plastics commonly utilized by the agricultural industry are outlined in Appendix A. Once these materials become waste, farmers generally have four options for end-of-life management:

1. On-farm open burning
2. On-farm burial
3. Transport to a municipal landfill site for burial
4. Transport to a public or private location for recycling

In almost all cases, the recycling of plastics results in a net reduction of a host of harmful emissions and also reduces the consumption of non-renewable resources. This generally means that recycling results in the largest net environmental benefits for most agricultural plastic products.

However, access to recycling facilities for agricultural plastics is limited in most locations. In addition, disposal of these materials at municipal landfill sites is restricted in some areas. Therefore, while most farmers make efforts to be good environmental stewards, open burning of waste plastics on farms remains a common practice. This presents both air pollution and resource conservation concerns.

In November 2010, a survey was conducted by Black Sheep Strategy on behalf of CleanFARMS to investigate the disposal options Ontario farmers were using for the plastic agricultural waste they generate.

During the survey, farmers reported they burned over half of their empty seed bags on-site, along with almost half of the used twine and net wrap. Plastic wrap, empty feed bags, and silage wrap were reported as being burned on-site in about one quarter of cases, while a large portion of the remainder is sent to landfill. Farmers also indicated their willingness to recycle material, with 16% indicating they take plastic wrap to a collection site and 14% take wrap to town recycling. (Black Sheep Strategy, 2011) It is likely that the somewhat dubious practice of burning agricultural plastics is underreported in surveys such as this one, as respondents will attempt to provide “correct” answers in cases where they may feel their behaviour may not be socially acceptable. Some other references have suggested that up to 80% of some agricultural films, for example, are burned on-site (Environmental Health Strategies, 2005).

This survey is supported by anecdotal information from the western provinces that suggests that open burning of agricultural plastics is very common, as well as U.S. references that suggest approximately half the agricultural plastics in that country are burned (Environmental Health Strategies, 2005).

Of the Ontario farmers surveyed, 20% of them stated that they “strongly disagree” with the statement “I am uncomfortable burning or putting certain products in my own or other landfills, but don’t see any alternative” while 27% “strongly agreed”. These statistics show that over one quarter of the farmers feel that burning or burying their plastic agricultural waste is not the best option, but also feel they have no other choice. The 20% that disagreed with the statement are representative of the population of farmers that are not aware of the potential risks of burning plastic agricultural waste.

Surveys show that a significant amount of agricultural plastic waste is burned on farms.

Potential Human Health Impacts

Agricultural plastics burn easily but incompletely in an open burning scenario. Incomplete combustion can lead to the release of carbon monoxide as well as many other air pollutants. In addition, hazardous byproducts can be present in the residual ash and in airborne emissions in the form of heavy metals, dioxins and furans. For additional information on incomplete combustion of plastics during low temperature burning, see Appendix B.

Probably the emissions of greatest concern during open burning of agricultural plastics are dioxins and furans, which are particularly formed in instances of low combustion temperatures, such as those associated with open burning.

It is natural to assume that dioxins and furan emissions are mostly produced by large industrial facilities. However, the United States Environmental Protection Agency estimates that 19 percent of dioxins and furans released in 1995 were generated by residential burning of household garbage (C2P2, 2010). At the same time, the burning of household garbage in burning barrels has been identified as the largest source of dioxin emissions in Ontario (Great Lakes Binational Toxics Strategy, 2007). Open burning of agricultural plastics is one of the contributors to these emissions.

Dioxins and furans are a health concern even in very small quantities, being associated with endocrine disruption, heart disease, cognitive and motor disabilities, as well as being a known human carcinogen. Humans can be exposed to dioxins through plants, or through meat, as they concentrate in animal fat (C2P2, 2010). This suggests that the burning of agricultural plastics, and associated dioxin generation, is particularly troubling, as the practice occurs on or near active agricultural land. Further, if the majority of dioxin intake to humans comes from food sources, dioxin emissions from the burning of agricultural plastics has the potential to impact a wide population when they land on feed crops and are concentrated in the bodies of farm animals.

Emissions of other air pollutants associated with open burning of garbage include volatile organics (such as benzene), fine particulate matter (PM10) and poly aromatic hydrocarbons (PAH)(such as benzo(a)pyrene), and heavy metals. For many of these other pollutants, the principal pathway into humans is directly from inhalation of smoke from burning garbage (C2P2, 2010). This suggests the predominant risk associated with these emissions from the burning of agricultural plastics is borne by the famer and local community.

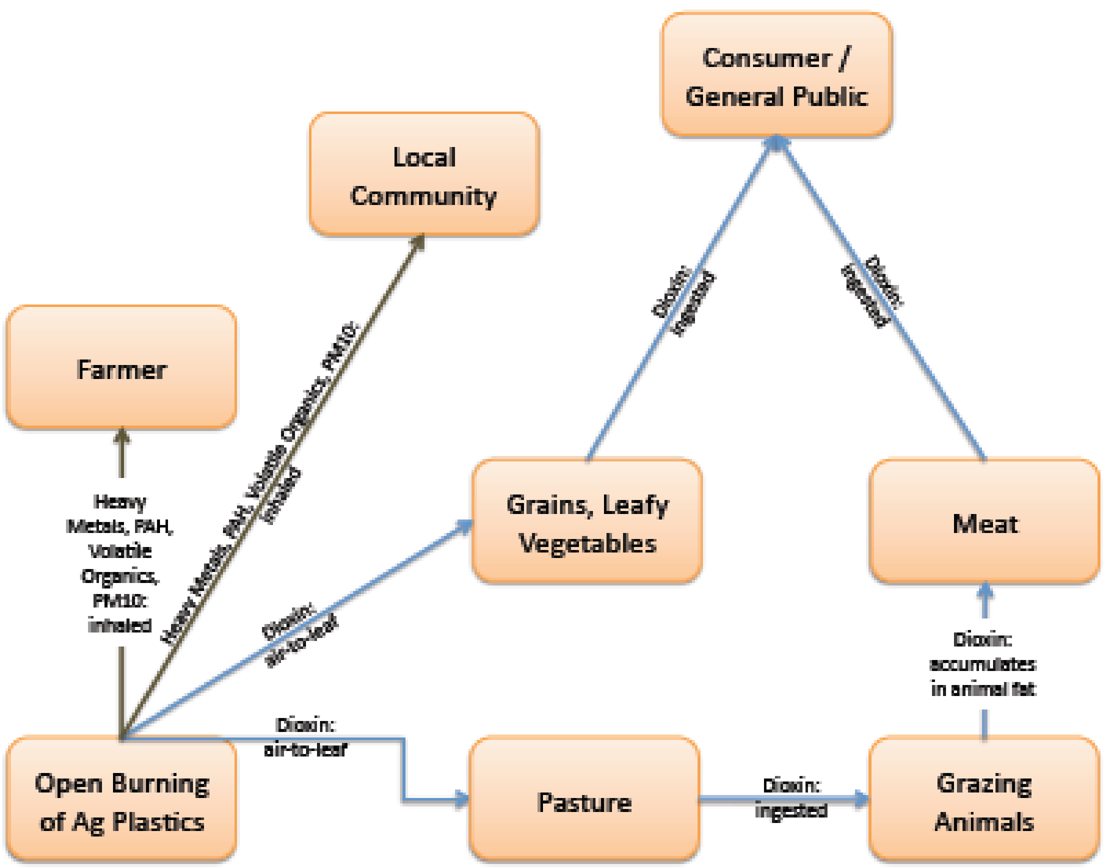

Figure 1: Pathways of Exposure to Pollutants from Burning Ag Plastics

Burning 10,000 pounds of agricultural plastic has the potential to contaminate 75,000 kg of soil from exposure to dioxins, based on Canadian Soil Quality Guidelines (Levitan and Barros, 2003 and Environment Canada, 2010). In Alberta alone, it is estimated that more than 20 million pounds of agricultural plastics are sold annually, and that the predominant method of waste management is open burning (RCA, 2009). If half of this plastic is handled through on-site burning, it has the potential to contaminate 75 million kg of soil, or approximately 7500 truckloads.

Based on this research, as well as the 2007 National Pollutant Release Inventory, burning of 20 million pounds of agricultural plastics could release the equivalent of 6% of Alberta's total inventory of dioxins and furans. The burning of agricultural plastics in Ontario has been estimated to generate 0.8 g TEQ (toxic equivalents) per year of dioxins and furans, representing less than 2% of Ontario's total inventory (Environmental Health Strategies, 2005). Although these numbers seem small, as releases would be concentrated on agricultural land, this may still present human health concerns.

The burning of plastic agricultural plastics is of particular concern to the Great Lakes Basin Watershed. The Great lakes drainage basin is 580,430 km^2 and is home to 95 percent of the surface water in North America along with 21 percent of the world's surface freshwater (Environment Canada, 2005). The dioxins and furans that are released during the incomplete combustion of plastic products pose a serious threat to aquatic species, wildlife, soil fertility, and humans (Krantzberg et al, 2006).

According to the United States Environmental Protection Agency (USEPA) and Environment Canada, dioxins and furans are two of the most critical contaminants in the Great Lakes and identified as Lakewide Management Plan (LaMP) critical pollutants. Both dioxins and furans are carcinogenic and likely play a role in endocrine disruption. These contaminants have been found in Lake Huron fish and wildlife and are also seen in low levels of fish, wildlife, and humans living in or near Lake Ontario. Also, dioxins and furans have been linked to the degradation of Lake Ontario bald eagle, mink, and otter populations. These species are losing fitness and reproductive health due to the levels of dioxins and furans in the area, which exceed human health standards. Additionally, dioxins and furans have been detected in Lake Ontario tributaries and are routinely found in higher levels in the Niagara River. (Human Health and the Great Lakes, 2003)

Dioxins and furans are also considered a Tier 1 pollutant by the Canada-Ontario Agreement Respecting Great Lakes Basin Ecosystem. Being a Tier 1 pollutant suggests the pollutant is a persistent bioaccumulative toxic substance. It is through the "Harmful Pollutants" annex that Canada and Ontario have agreed it is important to eliminate all sources of Tier 1 pollutants. Consequently, this would require all burning of plastic agricultural waste to be suspended.

Another group of pollutants of concern that are emitted from the burning of plastic agricultural waste are polycyclic aromatic hydrocarbons (PAHs). PAHs are considered a Tier 2 pollutant under the Canada-Ontario Agreement, meaning they have the potential for causing widespread impacts or have already had adverse impacts on the Great Lakes environment. The “Harmful Pollutants” annex calls for a significant reduction in Tier 2 substances.

> ***On-site burning of household garbage has been identified as the largest source of dioxin emissions in Ontario. According to the USEPA and Environment Canada, dioxins and furans are two of the most critical contaminants in the Great Lakes.***

Environmental Impacts / Resource Conservation

Disposal of agricultural plastics through either burning or landfilling represents a significant loss of resources, as this material is essentially wasted. Within the Alberta context, recycling the 20 million pounds (~9 000 tonnes) of agricultural plastics that are used annually would represent a net greenhouse gas savings of more than 20,000 tonnes of CO_2 equivalent (ICF, 2005). This equates to removing more than 4000 vehicles from the road for a year, or the amount of carbon sequestered by almost half a million tree seedlings for 10 years.

At the same time, Ontario estimates vary widely, from 4000 tonnes (Black Sheep Strategy, 2010) to 20,000 (Environmental Health Strategies, 2005) tonnes of ag plastics generated annually. Using a mid-range value would result in similar environmental benefits to those outlined for Alberta.

4000 passenger vehicles for one year

Carbon sequestered by 500,000 tree seedlings over 10 years

Greenhouse Gas Benefits Associated with Recycling Agricultural Plastics in Alberta or Ontario

Conclusions

Based on the current disposal practices used for agricultural plastics, and the potential pollution and resource conservation impacts associated with improper disposal practices such as burning, there is a strong national need to develop a comprehensive stewardship program for waste agricultural plastics to address the lack of adequate management systems for these waste products. Required elements of a program include the infrastructure required to collect, process, transport and recycle materials, as well the social marketing, incentive and regulatory supports to drive the required behaviour change.

Appendix A: Types of Agricultural Plastics

Resin Type	Common Uses	Agricultural Uses
1 **PET** **Polyethylene Terephthalate**	The most commonly recycled plastics material, PET is primarily used for soft drink bottles.	Rare
2 **HDPE** **High Density Polyethylene**	HDPE is used in bottles; margarine tubs; and grocery bags. It represents over 50% of the plastic bottle market.	Nursery pots, pesticide and oil containers
3 **V** **Polyvinyl Chloride**	PVC (or vinyl) is used to manufacture products ranging from heavy walled pressure pipes to crystal-clear food packaging.	Water pipes, hoses
4 **LDPE** **Low Density Polyethylene** **Linear Low Density Polyethylene (LLDPE)**	The largest end-use of LDPE is film for bags, such as bread bags, trash bags.	Greenhouse film, mulch film, silage bags Stretch wrap for silage
5 **PP** **Polypropylene**	PP is used in products ranging from yarns and fabrics to food packaging.	Nursery pots, rows and trays, shade cloth, row covers, weed barrier Twine
6 **PS** **Polystyrene**	PS is used in some yogurt cups, egg cartons, meat trays, and disposable utensils. It is also used to make videocassettes and televisions.	Flats, pots, growing mixes
7 **OTHER**	Various other plastics resin types and multi-layered material form this group.	

Source: Ontario Ag, Food and Rural Affairs, 2002

Types of agricultural plastics that have been successfully recycled include (Ontario Ag, Food and Rural Affairs, 2002):

- Plastic Stretch Wrap: A white, tacky linear low-density polyethylene (LLDPE) plastic film wrapped around hay bales to keep them air and moisture tight. Most commonly, bales are triple-wrapped and the plastic is 1 mil in thickness and between 18" and 24" in width.

- <u>Silage Bags</u> ("Ag Bags"): Long tubes of low-density polyethylene (LDPE) plastic used to store hay and corn silage. Typically, they are 8'-9' wide and 100'-200' long, 9 mil or thinner in thickness, formed of a bonded white and black layer.
- <u>Cover Sheets for Bunker Silos</u>: Black LDPE plastic film that is used in large sheets typically 20'-40' wide, 100'-150' long, and 8-10 mil in thickness, which is used to wrap hay or corn silage in cement bunker silos.
- <u>Greenhouse plastics:</u> Typically LDPE film, used in 50' wide sheets or 25' wide tubes, up to 300' long and 4-6 mil in thickness.
- Commercial Pesticide containers under 23 litres in volume: (not to be confused with domestic pesticides) Typically high density polyethylene (HDPE). The most common size is 10 litres, although various formulations are available in small sizes (500ml) up to 20 litre pails.
- Commercial Pesticide containers over 23 litres in volume: Typically HDPE (although of a different density and melting rate than HDPE than under 23 litres). Sizes vary from small 50 litres in volume up to 1000 litres in volume. Containers are both single use as well as multiple use.
- Fertilizer Containers (liquid) under 23 litres in volume: Same as for commercial pesticide containers.
- Fertilizer Containers (liquid) over 23 litres in volume: Same as for commercial pesticide containers.

Appendix B: Emission Factors and Health Impacts Associated with Open Burning of Agricultural Plastics

Emissions from Low Temperature Burning of Plastics

At temperatures below 750°C, significant pyrolytic degradation of polyethylene (PE) occurs, however, complete combustion of PE would not occur (Wrobel and Reinhardt, 2003). This may provide some insight into the expected emissions from burning PE in an open burning situation. It was speculated that for burning of silviculture piles covered by polyethylene, immediately after pile ignition, especially considering the low thermal conductivity of plastics, the combustion temperature would not be intense enough to heat the PE to a temperature high enough to initiate combustion. Because PE melts and thermally degrades at relatively low temperatures (105 and 180°C), pyrolysates would be formed and emitted before the temperature can rise high enough to ensure more complete combustion. At temperatures below 755°C, as much as 18 to 41 percent of the mass of PE is lost and volatilized prior to particle ignition. (Wrobel and Reinhardt, 2003)

In the context of open burning, PE pyrolysis chemistry would likely be of far greater importance than combustion chemistry. In the case of silviculture piles, the temperature of the pile surface would rise from ambient to about 1000°C over roughly one to five minutes. Thus, the PE is likely to undergo thermal degradation and melt during the early stage of combustion, when the pile temperature is between 250 and 600°C. These temperatures are not high enough to allow PE combustion. The emissions from this early phase of the pile burn would contain a high percentage of aliphatic hydrocarbons and radicals, as well as a low percentage of aromatic and polycyclic aromatic hydrocarbons (PAHs). As the biomass pyrolysis and oxidation rates accelerate, the temperature of the pile will increase high enough to make PE combustion an important process, but by this time most, if not all of the PE would have already been pyrolyzed and lost to the atmosphere. (Wrobel and Reinhardt, 2003)

To get a sense of the potential impact of open burning of agricultural plastics, research done by Cornell University suggests that recycling 10,000 pounds (~4500 kg) of agricultural film (and subsequently avoiding that same amount of open burning) would reduce dioxin emissions by 0.3 mg toxic equivalents (TEQ). At the same time, the Canadian Soil Quality Guidelines (CSoQG) for dioxins and furans is 4 nanograms of dioxin and furan TEQs per kilogram of soil (Environment Canada, 2010). Equating the Cornell research with soil quality guidelines implies that burning 10,000 pounds of agricultural plastic has the potential to contaminate 75,000 kg of soil from exposure to dioxins.

Emissions Released/ Tonne of Plastic Burned

	Product	Mass ratio (mg/kg)	Units	Emissions/ Tonne	Units	Source	Conflicting Sources
VOCs	Benzene	0.0478	mg/kg plastic	47.8	mg	USEPA 1992 and Reinhardt 2003	
VOCs	Toluene	0.0046	mg/kg plastic	4.6	mg	USEPA 1992 and Reinhardt 2003	6mg/kg (Lemieux 2004)
VOCs	Ethyl Benzene	0.0012	mg/kg plastic	1.2	mg	Reinhardt 2003	
VOCs	Xylene	0	mg/kg plastic	0	mg	Lemieux 2004	
VOCs	Styrene	40	mg/kg plastic	40	g	Lemieux 2004	
	PAHs	935.95	ug/kg plastic	935.95	mg	USEPA 1992	
	Dioxins and Furans			0.067	TEQ	Cornell University	
	1-Hexene	0.0043	mg/kg plastic	4.3	mg	Reinhardt 2003	
	Carbon Monoxide	175000	mg/kg plastic	175	kg	Reinhardt 2003	
	Particulates (PM_{10})	19000	mg/kg plastic	19	g		

Total Canadian dioxin/furan emissions = 200 g TEQ/year (CCME, 2001). Canada-Wide Standard for Dioxins and Furans

Dioxin/ Furan releases reported for Alberta ~ 10 g TEQ/year (Env Canada, 2010) http://ec.gc.ca/pdb/websol/emissions/ap/ap_result_e.cfm?year=2007&substance=df&location=AB&sector=&submit=Search 2007 Dioxins and Furans (D/F) Emissions for Alberta. 2007 National Pollutant Release Inventory

20 million pounds of ag plastic / 10,000 pounds * 0.3 mg TEQ = 600 mg TEQ = 0.6 g TEQ = 6% of total Alberta releases

Benzopyrene: 9.65 ug/kg * 9,000,000 kg (20,000,000 lbs) / 1,000,000 = 87 g = 0.016% of Alberta sources (excluding natural sources)

Benzo (k) fluouranthene: 2.51 ug/kg = 23 g = 0.007% of Alberta sources (excluding natural sources)

Benzo (b) fluouranthene: 9.25 ug/kg = 83 g = 0.011% of Alberta sources (excluding natural sources)

Benzo(A)pyrene: 7.53 ug/kg = 68 g = 0.013% of Alberta sources (excluding natural sources)

Indenopyrene: 10.7 ug/kg = 96 g = 0.04% of Alberta sources (excluding natural sources)

The following tables show emission factors for burning plastic film obtained during tests performed by the US Environmental Protection Agency.

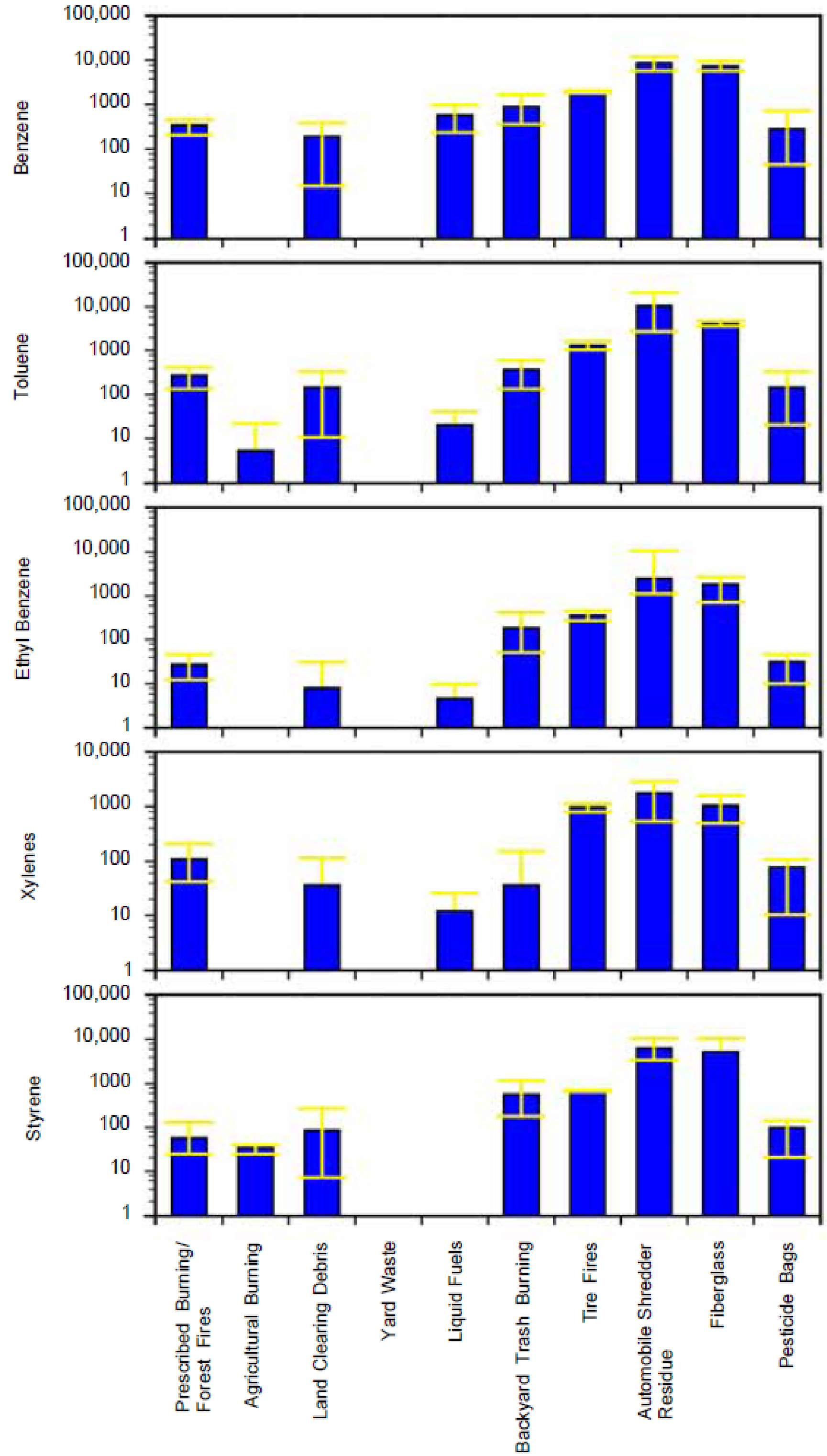

Figure 1. VOCs from Open Burning Sources (mg/kg burned material)

Source: Lemieux, 2004

Emission Factors for Organic Compounds From Burning Plastic Film[a]

Emission Factor Rating: C

Pollutant	Units	Condition of plastic			
		Unused Plastic		Used Plastic	
		Pile[b]	Forced air[c]	Pile[b]	Forced air[c]
Benzene	(mg/kg plastic)	0.0478	0.0288	0.0123	0.0244
	(lb/1000 tons plastic)	0.0955	0.0575	0.0247	0.0488
Toluene	(mg/kg plastic)	0.0046	0.0081	0.0033	0.0124
	(lb/1000 tons plastic)	0.0092	0.0161	0.0066	0.0248
Ethyl benzene	(mg/kg plastic)	0.0006	0.0029	0.0012	0.0056
	(lb/1000 tons plastic)	0.0011	0.0058	0.0025	0.0111
1-Hexene	(mg/kg plastic)	0.0010	0.0148	0.0043	0.0220
	(lb/1000 tons plastic)	0.0020	0.0296	0.0086	0.0440

[a]Reference 22

[b]Emission factors are for plastic gathered in a pile and burned.

[c]Emission factors are for plastic burned in a pile with a forced air current.

(Source: USEPA, 1992)

Note: These two sources appear to disagree by several orders of magnitude.

Polycyclic Aromatic Hydrocarbon Emission Factors from Open Burning of Agricultural Plastic Film[a]

Emission Factor Rating: C

Pollutant	Units	Condition of Plastic			
		Unused plastic		Used plastic	
		Pile[b]	Forced air[c]	Pile[b]	Forced Air[c,d]
Anthracene	(ug/kg plastic film)	7.14	0.66	1.32	0.40
	(lb/1000 tons plastic film)	0.0143	0.0013	0.0026	0.0008
Benzo(A)pyrene	(ug/kg plastic film)	41.76	1.45	7.53	0.00
	(lb/1000 tons plastic film)	0.0835	0.0029	0.0151	0.0000
Benzo(B)fluoranthene	(ug/kg plastic film)	34.63	1.59	9.25	0.93
	(lb/1000 tons plastic film)	0.0693	0.0032	0.0185	0.0019
Benzo(e)pyrene	(ug/kg plastic film)	32.38	1.45	9.65	0.00
	(lb/1000 tons plastic film)	0.0648	0.0029	0.0193	0.0000
Benzo(G,H,I)perylene	(ug/kg plastic film)	49.43	2.11	14.93	0.00
	(lb/1000 tons plastic film)	0.0989	0.0042	0.0299	0.0000
Benzo(K)fluoranthene	(ug/kg plastic film)	13.74	0.66	2.51	0.00
	(lb/1000 tons plastic film)	0.0275	0.0013	0.0050	0.0000
Benz(A)anthracene	(ug/kg plastic film)	52.73	2.91	14.41	1.19
	(lb/1000 tons plastic film)	0.1055	0.0058	0.0288	0.0024
Chrysene	(ug/kg plastic film)	54.98	3.70	17.18	1.19
	(lb/1000 tons plastic film)	0.1100	0.0074	0.0344	0.0024
Fluoranthene	(ug/kg plastic film)	313.08	53.39	107.05	39.12
	(lb/1000 tons plastic film)	0.6262	0.1068	0.2141	0.0782
Indeno(1,2,3-CD)pyrene	(ug/kg plastic film)	40.04	2.78	10.70	0.00
	(lb/1000 tons plastic film)	0.0801	0.0056	0.0214	0.0000
Phenanthrene	(ug/kg plastic film)	60.40	12.56	24.05	8.72
	(lb/1000 tons plastic film)	0.1208	0.0251	0.0481	0.0174
Pyrene	(ug/kg plastic film)	203.26	18.24	58.81	5.95
	(lb/1000 tons plastic film)	0.4065	0.0365	0.1176	0.0119
Retene	(ug/kg plastic film)	32.38	2.91	18.77	3.04
	(lb/1000 tons plastic film)	0.0648	0.0058	0.0375	0.0061

[a]Reference 22.

[b]Emission factors are for plastic gathered in a pile and burned.

[c]Emission factors are for plastic burned in a pile with a forced air current.

[d]0.00 values indicate pollutant was not found.

(Source: USEPA, 1992)

1-Hexene (Alpha-Olefin C6)

Alpha olefin is an olefin featured by the position of double bond (reactive unsaturation) at the two end carbons in carbon chains. Alpha olefins and their derivatives are used as comonomers in the production of polyethene. High density polyethene (HDPE) and linear low density polyethene (LLDPE) use approximately 2–4% and 8–10% of comonomers. (chemicalland21, 2010)

Specific health impacts of 1-Hexene were not identified.

Benzene

Benzene is a chemical that is often used in manufacturing. In its most common form, benzene is a liquid that is clear, slightly sweet smelling, and highly combustible. Benzene is frequently used in manufacturing rubber, paint, plastics, resins, drugs, pesticides, synthetics, and other products. It is also present in gasoline and tobacco smoke.

A known carcinogen, benzene can be harmful to those exposed to it over an extended period of time. It evaporates quickly in air and is partially soluble in water. Benzene exposure is most dangerous when it occurs over a long period of time or when the concentration of benzene to which a person is exposed is very high. Contact with low to moderate levels of benzene for a short time can cause headaches, vomiting, disorientation, shakiness, elevated heart rate, and loss of consciousness. Very high levels of exposure can be fatal. People who work with benzene or who are exposed to it over a long period of time are at the highest risk for developing benzene-related illnesses, which range from anemia to cancer. (Benzene FYI, 2010)

Carbon Monoxide

Carbon monoxide is an odorless, colorless and toxic gas. Because it is impossible to see, taste or smell the toxic fumes, CO can kill you before you are aware it is in your home. At lower levels of exposure, CO causes mild effects that are often mistaken for the flu. These symptoms include headaches, dizziness, disorientation, nausea and fatigue. The effects of CO exposure can vary greatly from person to person depending on age, overall health and the concentration and length of exposure. (USEPA, 2010)

CO interferes with the blood’s ability to carry oxygen to the brain, heart and other tissues. Depending on the amount inhaled, CO can slow reflexes and cause fatigue, headache, confusion, nausea, and dizziness and in large amounts can cause death by suffocation. (RDOS, 2006)

Dioxins

The composition of domestic waste and combustion conditions determine the extent of dioxin formation. Because these determinants vary over broad ranges, there are no universally applicable emission factors for dioxin releases to air, land or residues for open burning of domestic waste (Costner, 2006). However, there is generally enough chlorine in the waste stream, even from natural materials such as salt and wood, to generate dioxins when garbage is burned. The smoldering, high particulate combustion of open burning offers ideal conditions for dioxin formation. (Great Lakes Binational Toxics Strategy, 2004)

Dioxins are one of the emissions of greatest concern even in very small quantities, and are associated with disruption of multiple endocrine pathways, increased risk for ischemic heart disease, cognitive and motor disabilities, and endometriosis. They are also listed as a "known human carcinogen" in the 10th edition of the National Toxicology Program's Report on Carcinogens (2002). Emerging research in animals and humans suggests that exposure to dioxins early in life may increase risk of breast cancer. (Levitan and Barros, 2003)

Ethylbenzene

Ethylbenzene is a colorless liquid found in a number of products including gasoline and paints. It is naturally found in coal tar and petroleum and is also found in manufactured products such as inks, pesticides, and paints. Ethylbenzene is used primarily to make another chemical, styrene. Other uses include as a solvent, in fuels, and to make other chemicals.

Breathing very high levels of ethylbenzene can cause dizziness and throat and eye irritation. Breathing lower levels has resulted in hearing effects and kidney damage in animals. Exposure to high levels of ethylbenzene in air for short periods can cause eye and throat irritation. Exposure to higher levels can result in dizziness. Irreversible damage to the inner ear and hearing has been observed in animals exposed to relatively low concentrations of ethylbenzene for several days to weeks. Exposure to relatively low concentrations of ethylbenzene in air for several months to years causes kidney damage in animals. The International Agency for Research on Cancer (IARC) has determined that ethylbenzene is a possible human carcinogen. (patientsville, 2010)

Particulates

Particulate emissions from open burning have been associated with many health effects, including increased risk of stroke (Levitan and Barros, 2003). Increased levels of small particulate are responsible for a marked increase in Emergency Room visits, hospitalizations, and days lost from school and work. Small particle pollution from the combustion of organic materials is an extremely serious health threat - it poses much more of a danger to human health than present levels of other common air pollutants such as ozone, sulfur dioxides and carbon monoxide. connected exposure to increased levels of fine particulates with a significant rise in the number of premature deaths from respiratory and heart disease. (RDOS, 2006)

Polycyclic Aromatic Hydrocarbons (PAHs): (Anthracene , Benzo(A)pyrene, Benzo(B)fluoranthene, Benzo(e)pyrene, Benzo(G.H.I)perylene, Benzo(K)fluoranthene, Benz(A)anthracene, Chrysene, Fluoranthene, Indeno(1.2.3-CD)pyrene, Phenanthrene, Pyrene, Retene)

PAHs are a group of chemicals that are formed during the incomplete burning of coal, oil, gas, wood, garbage, or other organic substances, such as tobacco and charbroiled meat. There are more than 100 different PAHs. PAHs generally occur as complex mixtures (for example, as part of combustion products such as soot), not as single compounds. A few PAHs are used in medicines and to make dyes, plastics, and pesticides. Others are contained in asphalt used in road construction. They can also be found in substances such as crude oil, coal, coal tar pitch, creosote, and roofing tar. They are found throughout the environment in the air, water, and soil. They can occur in the air, either attached to dust particles or as solids in soil or sediment.

PAHs can be harmful to human health under some circumstances. Several of the PAHs, including benz[a]anthracene, benzo[a]pyrene, benzo[b]fluoranthene, benzo[j]fluoranthene, benzo[k]fluoranthene, chrysene, dibenz[a,h]anthracene, and indeno[1,2,3-c,d]pyrene, have caused tumors in laboratory animals when they breathed these substances in the air, when they ate them, or when they had long periods of skin contact with them. Studies of people show that individuals exposed by breathing or skin contact for long periods to mixtures that contain PAHs and other compounds can also develop cancer. Animal studies also show reproductive and immune system issues. (ATSDR, 2010)

Sulfur Dioxide

Health effects are irritation of the upper respiratory tract, eye irritation and shortness of breath. (RDOS, 2006)

Toluene

Toluene is a clear, colorless liquid with a distinctive smell. Toluene occurs naturally in crude oil and is also produced in the process of making gasoline and other fuels from crude oil and making coke from coal. Toluene is used in making paints, paint thinners, fingernail polish, lacquers, adhesives, and rubber and in some printing and leather tanning processes. (patientsville, 2010)

Toluene produces reversible effects on the liver, kidneys, and nervous system; the nervous system appears to be most sensitive to its effects. The physiologic effects of toluene depend on the concentration and length of exposure. Toluene's anesthetic action can result in rapid central nervous system depression and narcosis at high concentrations. Volatilization after ingestion and hypoxia after aspiration can contribute to CNS toxicity, and aromatic impurities in commercial toluene-containing products can have added neurotoxic effects. (ATSDR, 2010)

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