

EPB 433- Health and Environmental Effects of Burning Waste Plastics



Issue:

Consumption of plastics has steadily increased over the years due their flexibility, affordability and durability as compared to other materials with similar use. Approximately 20,000 tonnes of waste residential plastic and another 3,500 tonnes of waste agricultural plastic comprising primarily of discarded grain storage bags are generated annually in Saskatchewan. While stewardship recycling programs exists for some of the residential waste plastics, the Ministry of Environment is working with industry partners and stakeholders to establish a waste agricultural plastic recycling program especially for the discarded grain storage bags. A large fraction of waste plastics still ends up in the landfills and/or is burned unlawfully in the open by the users.

Being readily combustible, these plastics when burned under open and uncontrolled fire conditions at low temperatures generate black plumes of smoke and toxic volatilization products, which become incorporated into the ambient environment, resulting in human and environmental exposure. In addition, large amount of greenhouse gases such as methane and carbon oxides and particulate matter are emitted into the atmosphere. When garbage or refuse is burned under open-fire low temperature conditions, the waste plastics that they contain contribute to smoke generation and infuse toxic decomposition products of plastics into the smoke which can potentially cause significant health and environmental concerns.

“The burning of plastic grain bags releases chemicals into the air that we all breathe, causing serious lung damage and contributing to other long-term health problems. For people with lung diseases such as asthma and Chronic Obstructive Pulmonary Disease, even a single exposure to this type of smoke can worsen their disease. This can result in hospitalization, increased use of expensive medications and absences from school or work.”

.... Dr. Brian Graham, President & CEO, Lung Association of Saskatchewan

Background Information:

Plastics are non-biodegradable. Principle types of plastics found in the waste are poly(ethylene) **PE** used in trash bags, grain storage bags and shopping bags; poly(vinyl chloride) **PVC** used in bottles, packaging and containers; poly(ethylene terephthalate) **PETE** used predominantly in beverage bottles and similar containers; poly(styrene) **PS** a light spongy material used in meat, eggs and miscellaneous product trays and hot beverage cups; and poly(propylene) **PP** used in yogurt containers, straws, margarine tubs and special bags. Most of these plastics are discarded after single use and become garbage.

The manufacturing of plastics involve various chemical processes and utilizes variety of chemical compounds and additives including phenols, amines and esters, antioxidants, UV and light stability improvers, antistatic agents and heat stabilizers that impart the finished product specific characteristics for its intended use.

The finished product that is the plastic itself is environmentally quite stable. However, the additives, their chemical reaction and degradation products incorporated into the polymeric material have the potential to be released into the environment and cause significant health and environmental concerns¹.

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Pollutants generated from burning of Plastics & related health effects:

The byproducts of plastic combustion are airborne particulate emission (soot) and solid residue ash (black carbonaceous colour). Several studies have demonstrated that soot and solid residue ash possess a high potential of causing significant health and environmental concerns. The soot when generated is accompanied with volatile organic compounds (VOCs), semi-VOCs, smoke (particulate matter), particulate bound heavy metals, polycyclic aromatic hydrocarbons (PAHs), polychlorinated dibenzofurans (PCDFs) and dioxinsⁱⁱ and has the ability to travel thousands of kilometers, depending on prevailing atmospheric conditions, before it can drop back on earth and enter into the food chain. Further, the composition of byproducts of plastic combustion as to their type and concentration depends on the combustion temperature and the flame residence time.

The toxicity of combustion products generated from burning of plastics has been evaluated by various researchers under experimental conditions. Significant amount of pollutants of environmental and health concern including carcinogens such as PAHs, nitro-PAHs and dioxins have been identified in the airborne particulate emissions. Further, these particulates have been found to be highly mutagenicⁱⁱⁱ. PAHs in the range of 8-340 ppm have been observed in the soot which is significant enough to cause cancerⁱⁱ. Researchers have also found high concentration of persistent free radicals (unstable and highly reactive molecules) both in the soot and the solid residual ash which are considered to be very important in the creation of adverse health effects especially to human lungs^v.

A study of the combustion of PE (both low (LDPE) and high density (HDPE) polyethylene) at different operating conditions detected more than 230 VOCs and semi-VOCs especially olefins, paraffin, aldehydes and light hydrocarbonsⁱⁱ. Amongst VOCs, benzene is a known carcinogen and has been observed to be released in significant quantity during plastic combustion. Some of the toxic semi-VOCs including benzo(a)pyrene and 1,3,5 trimethylbenzene have also been observed in significant quantities in the emissions from plastic combustion^{iv}.

Heavy metals including lead, cadmium, chromium and copper have been measured in the smoke and the solid residue ashⁱⁱ. DEHP is one of the compounds among the plasticizers used in plastic manufacturing that has been described by USEPA as a probable human carcinogen, a potential endocrine disruptor and is believed to be harmful by inhalation, generating possible health risks and irreversible effects^v. This compound is also released during the combustion of plastic. Most of the pollutants discussed have the potential to cause health and environmental effect as discussed in the table below.

Potential pollutant generated from burning of Plastics	Health Effects	Environmental Effects
Carbon Monoxide	Causes dizziness, headaches and slowed reflexes. Affects mental function, visual acuity and alertness	Oxidized to carbon dioxide (which is a greenhouse gas) in the atmosphere
Dioxins and Furans	May cause cancer; causes growth defects; affects DNA; affects immune and reproductive systems	Increased toxic loading on environment; leads to contaminated water/land, affects animal health
Polynuclear Aromatic Hydrocarbons (PAHs)	Cancer causing agent in most animal species including mammals, fish and birds	Increased toxic loading on environment, leads to contaminated water/land, affects animal health
Volatile Organic Compounds (VOCs)	Directly toxic including problems ranging from cancer risks to nervous disorders. Causes respiratory irritation/illness, chronic lung disease	Contributes to low level ozone (smog), causes vegetative damage. Leads to contaminated water/land, affects animal health
Particulate Matter (PM)	Irritation of respiratory tract, aggravated asthma, contributes to chronic obstructive pulmonary disease	Increased toxic loading on the environment; leads to contaminated water/land and affects animal health
Aldehydes	This is a animal carcinogen. Causes eye and respiratory illness and headaches	Increased toxic loading on environment, leads to contaminated water/land, affects animal health

With the above discussion, it is worth emphasizing that open uncontrolled burning is by no means an environmentally sound option to dispose of waste plastics including waste agricultural plastics such as discarded grain storage bags. Other environmentally sound options must be explored for their safe disposal and/or recycling.

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- ⁱ Wang, Z., Richter, H., Howard, J. B., Jordan, J., Carlson, J. and Levensis, Y. A. (2004). "Laboratory investigation of the products of the incomplete combustion of waste plastics and techniques for their minimization. *American Chemical Society, Ind. Eng. Chem. Res.*, 43, 2873-2886.
- ⁱⁱ Valavanidis, A., Iliopoulos, N, Gotsis, G. and Fiotakis, K. (2008). "Persistent free radicals, heavy metals and PAHs generated in particulate soot emissions and residual ash from controlled combustion of common type of plastics". *Journal of Hazardous Materials*, 156, 277-284.
- ⁱⁱⁱ Lee, H., Wang, L. and Shin, J. F. (1995). "Mutagenicity of particulates from the laboratory combustion of plastics". *Mutat. Res.*, 346, 135-144.
- ^{iv} Font, R., Aracil, I., Fullana, A. and Conesa, J. A. (2004). "Semivolatile and volatile compounds in combustion of polyethylene". *Chemosphere*, 57, 615-627.
- ^v Simoneit, B. R., Medeiros, P. M. and Didyk, B. M. (2005). "Combustion products of plastics as indicator for refuse burning in the atmosphere". *Environmental Science & Technology*. 39, 6961-6970