DIOXIN POLLUTION PREVENTION AND PVC PLASTIC IN MUNICIPAL SOLID WASTE: PRECAUTIONARY STATE POLICY

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Introduction

The disposal of municipal solid waste (MSW) generates polychlorinated dibenzo-p-dioxins and polychlorinated dibenzofurans (referred to together as "dioxin") through open burning, waste incineration and landfill fires[1,2]. Backyard burning of household trash is a significant source of dioxin[3]. In the U.S., about 100 municipal waste combustors incinerate about 20% of MSW after recycling[4], compared to 70% in Maine. Dioxin air emissions from MSW incineration have declined due to facility closures, operating improvements and added pollution controls[5]. Dioxin air emissions remain significant and incinerator ash adds very large amounts of dioxin to the land[6].

40% to 70% of the chlorine input to MSW incinerators is from polyvinyl chloride (PVC), a widely used plastic[7]. Yet PVC accounts for only 0.6% of the total mass of MSW[4]. Several variables affect dioxin formation during incineration including chlorine precursors, metal catalysts, oxygen content, combustion temperature, residence time, quenching conditions and pollution controls[5]. Many studies have correlated chlorine input and dioxin formation during combustion[8,9,10,11,12,13]. A PVC industry-funded study found no correlation between chlorine input and dioxin air emissions in MSW combustors[14]. Others have also discounted the importance of chlorine input to dioxin formation[15]. These negative findings have been criticized for flawed analysis[16]. The relationship between chlorine input and dioxin formation in waste incineration remains complex and uncertain.

The precautionary principle holds that if an activity raises threats of harm to human health or the environment, then preventive actions should be taken even if some cause and effect relationships are not fully established scientifically[17]. While risk assessment justifies a halt to open burning, a precautionary approach supports dioxin pollution prevention by reducing the incineration of PVC.

Materials and Methods

In 1997, the Maine Department of Conservation surveyed 545 town fire wardens and state forest fire rangers about backyard trash burning. The Maine Department of Environmental Protection (DEP) used these survey results, EPA emission factors for burn barrels[3] and air dispersion modeling (ISCST3) to characterize exposure, risk and mass emissions of dioxin. In 1999, a medical waste disposal crisis spurred the Maine Hospital Association and Maine DEP to develop a plan for in-state management of biomedical waste and reductions in waste volume and toxicity[18]. In 2000, the Maine DEP began drafting a plan for the statewide collection of household hazardous waste[19] and in 2001 the Maine Legislature began policymaking on PVC to address dioxin issues.

Results and Discussion

The 1997 backyard burning survey identified 8,510 permitted burn barrels in Maine or about one barrel for every 144 people. An inverse relationship was found between population (by county or

by town) and the number of burn barrels per 1,000 residents, showing that backyard incineration is a rural phenomenon. When surveyed, local fire wardens offered three broad categories of opinion as to why rural people burned their trash in backyard barrels: economic incentives (e.g. avoiding pay-as-you-throw disposal fees), cultural habits and the inconvenience of proper disposal[2].

Environmental releases of dioxin in air emissions and ash from backyard burn barrels in Maine in 1997 are reported in Tables 1 and 2, based on 21 tons per day of waste burned in barrels[2]. Burn barrels were found to be a significant source of dioxin air emissions (7 - 23 grams TEQ/year). The high dioxin content of burn barrel ash also raises environmental health concerns. Air dispersion modeling showed that fifteen minutes of open burning resulted in dioxin impacts two times the health based guideline for subchronic (24-hour) exposure at a downwind distance of 500 meters[2].

The 2000 Maine dioxin inventory (Table 3) revises the estimate of dioxin air emissions from burn barrels to 4.1 grams TEQ (26% of air emissions). This exceeds the 2.0 grams TEQ dioxin air emissions from Maine's four municipal waste combustors, which burn about 600,000 tons of MSW each year[20]. Dioxin releases to land from disposal of MSW incinerator ash account for 34.1 grams TEQ or 60% of all dioxin released to air, water and land, far more than from any source. Table 3 also shows that PVC plastic is the major chlorine donor for dioxin sources that account for 79% of quantified dioxin releases to air, water and land. PVC is also the major chlorine donor for dioxin releases from car and building fires, open burning at construction sites and landfill fires. About 75% of PVC is used for building and construction[21]. PVC mixed with wood recovered from construction and demolition debris may form dioxin when burned at biomass power plants.

In 2001, Maine's 39 hospitals pledged to steadily reduce the use and disposal of PVC plastic so as to prevent dioxin formation from both medical and solid waste incineration. Disposable PVC medical products such as IV bags, tubing and gloves account for 10% -15% of medical waste[22]. Table 4 lists the steps being taken by to reduce PVC use. Maine hospitals have made modest progress in reducing PVC (Table 5), reflecting the complexity of the task and the need to move the market[23]. The Southern Maine Medical Center has already switched to PVC-free IV bags.

In 2001, the State identified PVC as a problem waste that should be included in a statewide household hazardous waste collection program[19]. Legislation was proposed (LD 1543) to define PVC plastic as a dioxin-forming product, fund an education program to discourage open burning of MSW and encourage the diversion of PVC waste away from incineration. The bill was strongly opposed by the chemical industry and was substantially amended before being signed into law to:
1. Ban all open burning of MSW in Maine (except for clean wood waste)
2. Fund a one-time educational program to discourage open burning and promote PVC alternatives
3. Establish a state policy to reduce the total release of dioxin to the environment with the goal of its continued minimization and, where feasible, ultimate elimination
4. Require a study by the State Planning Office (SPO) to assess the feasibility of diverting PVC in MSW away from incineration, which concluded in 2003 that: "the majority … supported identifying polyvinyl chloride plastics as a material of concern in the state's efforts to reduce the formation of dioxins and their release into the environment" and "there was substantial support for efforts that would result in the diversion of polyvinyl chloride plastic away from incineration"[24].

Further actions are needed to prevent dioxin releases to air, water and land from MSW disposal.

Given the factors that motivate rural Americans to use backyard burn barrels, statutory bans on open burning are unlikely to be effective alone. The highly successful anti-tobacco industry public health campaign to reduce smoking could serve as a model. An industry-funded but publicly-controlled public education campaign against open burning should target the chemical industry as responsible for dioxin-forming products such as PVC in the waste stream. Like household hazardous waste, PVC should be separately collection and diverted away from incineration. Expanded labeling of PVC products would facilitate education, identification and waste segregation. Disposable PVC packaging, e.g. consumer bottles and 'blister packs', should be phased out. We should exercise precaution by working to eliminate PVC plastic from MSW.

Table 1: Estimated Dioxin Releases to Air from Backyard Burn Barrels in Maine

Pollutants	Scenario	Emission Rate EPA Study[3] (mass emitted per kg waste)	Estimated Daily Emissions per Household (g/day)	Estimated Total Annual Emissions (g/year)
Dioxins TEQ	Worst-Case	0.005 mg/kg	0.000007	23
	Average	0.002 mg/kg	0.000006	7
Calculations based on: Maine waste production = 1.2 kg/capita/day; average household size = 2.5 people; number of burn barrels in Maine = 8,510; Maine average recycling rate = 25%; combustion rate = 68.1% (worse-case scenario) or 57.9% (average scenario) of original mass burned. Tables 1 & 2 adapted from Maine Department of Environmental Protection[2].				

Table 2: Estimated Dioxin Releases to Land (as Ash) from Backyard Burn Barrels in Maine

Scenario	Dioxin Concentration in Ash (EPA Study[3]) ng/kg (ppt) TEQ	Ash Produced (kg/year)	Total Dioxin Releases to Land as Ash (grams/year)
Worst-Case	2,586	3,732,039	10
Average	1,611	2,942,300	5

Table 3. Maine Dioxin Inventory 2000: Dioxin Releases to Land, Air and Water

Dioxin Source	Dioxin Release to:	Total Dioxin (grams TEQ)	Is PVC a Major Chlorine Donor?
Municipal Solid Waste Incinerator Ash	Land	34.1	YES
Backyard Burn Barrels	Air	4.0	YES
Residential Fuel Burning (wood & oil)	Air	3.4	
Commercial / Industrial Fuel Burning	Air	3.1	
Backyard Burn Barrel Ash	Land	2.9 [a]	YES
Pulp & Paper Mills – Kraft Bleach Discharge	Water	2.3	
Municipal Solid Waste Incinerators	Air	2.0	YES
Medical Waste Incinerators	Air	1.7	YES
Utility Boilers (biomass/wood and oil-fired)	Air	1.1	some [b]
Pulp & Paper Mills - Sludge & Ash	Land	1.0	
Non Point Sources, including On Road Vehicles	Air / Water	0.6	
Sewage Sludge	Land	0.2	
Miscellaneous Industrial Sources	Air	0.1	
Biomass/Wood-Fired Power Plant Ash	Land	< 0.1	some [b]
Automobile & Building Fires	Air / Land	nd	YES
Industrial Sludge & Kiln Dust	Land	nd	
Landfill Fires	Air / Land	nd	YES
Open Burning (construction sites, etc.)	Air / Land	nd	YES
TOTAL		> 56.6	
Adapted from Maine DEP[6]. nd = no data; a = extrapolated from 1997 study; b = from PVC-contaminated scrap wood			

Table 4: Hospital PVC Reduction Steps[18]

1. Establish a written PVC reduction policy
2. Assess current use of PVC products.
3. Reduce PVC use in disposable products
4. Replace PVC use in durable products
5. Ask GPOs to evaluate of PVC alternatives
6. Renegotiate GPO contracts on PVC prod.
7. Report annually on progress achieved
GPO = Group purchasing organization

Table 5: Maine Hospitals' Progress – Jan 2003[22]

Activity Completed	% Completed (# of hospitals)
PVC Reduction	
Product inventory	21 % (8)
Patient safety review *	10 % (4)
Minimize incineration	8 % (3)
Product phase-out	not yet quantified
* based on patient exposure to toxic PVC additive DEHP	

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