disposal practices. or public notification and participation. The Hazardous Waste Treatment Council. an industry group. estimates that approxixnately 50 billion pounds of hazardous wastes are burned in RCRA-exempt facilities each year. a quantity which '*dwarfs" the amount burned in fully regulated incinerators.

Evaluating RCRA's recycle/re-use loophole more than five years ago, a Congressional committee issued the following warning:

> Such exemption. particularly for cement kilns...could well be inconsistent- with the RCRA mandate to regulate hazardous wastes as necessary to protect human health and the environment. The committee does not consider cement kilns burning hazardous wastes for energy...to be distinguishable from a commercial hazardous waste incinerator in its potential impact on human health and the environment. [U.S. House of Representatives, 98-198. 39- 194.1

COSTS AND BENEFITS OF BURNING OF HAZARDOUS WASTES IN KILNS

In the U.S.. manufacturers of cement and aggregate have been burning hazardous wastes in their kilns for more than a decade. A single large kiln which substitutes hazardous waste for 50 percent of its traditional fuel may burn up to 475 million pounds of hazardous waste per year; an average-size cement kiln will burn approximately 80 million pounds of hazardous waste per year.' (Kleppinger, 1989)

Burning hazardous wastes increases cement/agreggate kilns' profits. Because they are exempted from all federal. regulations covering other U.S. hazardous waste disposal facilities. cement and aggregate manufacturers can offer waste generators cut-rate, no-liability waste disposal. Most are paid for burning the wastes and they save additional money by substituting hazardous waste for the fuels they would normally purchase. Kilns typically substitute waste for 25 to 50 percent of their fuel needs. (Beers 1989: Kleppinger 19891 although some facilities may use as much as 100% "waste-fuel."

The economic disadvantages of burning hazardous waste are borne entirely by the general public, especially communities near waste-burning facilities, as a study commissioned by the State of New York pointed out:

> A waste fuels project clearly has the potential to impact on residents living in the vicinity of the facility. The host community must bear the risks associated with the transport, storage and incineration of hazardous wastes. [Beers 1987)

For communities located near waste-burning cement/aggregate kilns. costs can be staggering. For example, at one California cement kiln. consultants

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' Kleppinger's calculations assume kilns substitute waste for 50% of their fuel needs at 3,000 Btu/ton of clinker produced.

calculated the "population excess cancer burden" to be 42 per 1,000, when only eight of the carcinogenic constituents in the wastes were considered and a very narrow model of human exposure to toxic releases was employed. [Meredith/Bali 19881

For a 70-year exposure for a community of 10,000 people this "excess cancer burden" translates into $56 million in cancer-related health care costs alone. based on an average cost of $134,000 per cancer case, which includes treatment, care and income loss. [New York Legislature 19871 No data are available to calculate the incidence and costs of birth defects. immune system depression and associated diseases. behavioral and nervous system effects, pulmonary, reproductive. digestive, and renal system effects. or effects upon non-human species that are known to accompany exposure to the emissions of waste-burning facilities.

SOURCES AND CHARACTERISTICS OF HAZARDOUS WASTES BURNED IN CEMENT/AGGREGATE KILNS

With the exception of the law governing the disposal of wastes containing certain levels of PCBs, there are no federal laws restricting the types of hazardous wastes that can be burned in unregulated cement/aggregate kilns or in regulated hazardous waste incinerators.

Most kilns burn "blended fuel." a mixture of miscellaneous hazardous wastes from a variety of sources. which they purchase from hazardous waste brokers. Even so-called blended hazardous waste fuels include significant quantities of solid rubber, glass, metal. plastics, cloth, and rocks. [Systech Corporation) The presence of solids decreases combustion efficiency and increases the quantities of unburned and partially burned wastes discharged) to the environment.

Some studies indicate that the hazardous wastes most commonly burned in kilns come from the following sources, although some kilns have been reported to be burning wastes of all types from virtually all classes of generators:

* Paint, ink. and coatings manufacturers' wastes [Mournighan 19851
* Spent halogenated and non-halogenated solvents generated by a wide variety of manufacturing processes, including metalworking, degreasing, painting and printing:
* Still bottoms from solvent recovery;
* Petroleum industry wastes;
* A number of used and off-specification organic chemicals: and
* Waste oils. consisting primarily of engine crankcase oils. but also including transmission fluids, hydraulic and compressor fluids and coolants. [Beers 1987]

Heavy Metals
Wastes from many of these sources -- particularly waste oils, inks, paints, solvents from electronics manufacturing, etc. -- are known to contain metals. Table 1 presents metals and their concentrations in typical wastes burned in cement/aggregate kilns.

Metals are not destroyed by burning. All metals introduced to a kiln are eventually dispersed in the environment. A study conducted for the State of New York concluded:

> "[B]ecause metals are not destroyed in the incineration process, wastes containing significant quantities of metallic constituents . . . are not good candidates for incineration in cement and lightweight aggregate kilns." [Beers 1987]

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TABLE 1

Metals and Their Concentrations in Hazardous Wastes
Burned in Cement/Aggregate Kilns

	Concentration, parts per million (ppm)	
Metal	"Typical" Waste	California Kiln
Arsenic	< 10	
Barium		< 3,000
Chromium	< 1.500	< 1.000
Lead	< 2.000	< 4,000
Manganese	< 500	
Mercury	< 10	
Titanium	< 6,000	< 2.500
Zinc	< 1.000	< 3.000
Total	<11,020	<13,500

Sources: Murphy and Mix. "Risks Associated With Waste-Fuel Use in Cement Kilns," in Environmental Progress III: 1 (Feb/ 1984). p. 65. The authors present metals concentrations in "typical" kiln waste-fuel.Meredith/Boli & Associates, Inc. "Health Risk Assessment (Screening Level Procedure) for the Waste-Derived Fuel Research Bum Program.'* California Portland Cement. Mohave. California, 19 May 1966.29 July 1988 (Revised)

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Organic Chemical Wastes

Other than metals. the remaining 98.65% percent of waste burned in kilns consists of organic chemicals. These carbon-based chemicals. commonly called hydrocarbons. include acetone, benzene, toluene. xylene, etc. They also include the halocarbons -- hydrocarbons which contain one or more of the halogens (chlorine, bromine, fluorine and iodine), such as tetrachloroethylene, freons, trichloroethylene, etc.

Table 2 presents a partial list of organic chemical wastes known to be burned in cement/aggregate kilns. Burning these chemicals releases some portion of the unburned chemicals in addition to new chemicals formed during combustion. products of incomplete combustion (PICs).

When chlorine-containing wastes are burned. the resulting PICs often include the polychlorinated dioxins and furans [USEPA Region 3. 19861. Once formed. these notoriously toxic chemicals are distributed to the air. fly ash. and other residues. which, in the case of cement/aggregate kilns, may be incorporated in the cement and aggregate products.

Besides the dioxins and furans, burning halocarbons in hazardous waste incinerators has been shown to form and release a variety of other highly toxic halocarbons. Combustion of non-halogenated hydrocarbons is known to produce a variety of toxic hydrocarbons. many of which are known or suspected carcinogens. (For details, see Chapter 2).

Studies have also shown that burning hazardous wastes in cement and aggregate kilns increased emissions of airborne particulates by 66 percent. Burning wastes containing halocarbons increased emissions of airborne particulates by 203 percent. [Mournighan and Branscome 19871 Further, wastes containing both halocarbons and metals caused a substantial increase in metals' emissions. [Mournighan and Branscome 1987, Murphy and Mix 1984]

Burning halocarbons in cement kilns also increases the likelihood of upsets. since the presence of chlorine encourages the accumulation and subsequent release of solids in the kiln. Combustion upsets increase emissions of unburned wastes and products of incomplete combustion. [Murphy and Mix 1984]

TABLE 2

Synthetic Chemicals Identified in
Hazardous Wastes Burned in Cement/Aggregate Kilns

Non-Halogenated Hydrocarbons	Halocarbons
2-Nitropropane (b)	Chlorobenzene (b)
Acetone (a)	Chloroform (b)
Benzene (b)	Methylene chloride (b)
Butanol (a)	Polychlorinated biphenyls (PCBs) (b)
Cellosolves (a)	Tetrachloroethylene (a)
Cresols (b)	1.1.1 -Trichloroethane (a)
Ethanol (a)	Trichlotoethylene (a)
Heptane (a)	Trichlorofluoromethane (CFC- 11) (b)
Hexane (a)	
His01 10 (a)	
Isobutanol (a)	
Isopropanol (a)	
Methyl ethyl ketone (a)	
Methyl isobutyl ketone (a)	
Mineral spirits (a)	
n-Butylacetate (a)	
n-Propyl acetate (a)	
Toluene (a)	
Xylene (a)	

(a) Source -- Murphy and Mix, "Risks Associated With Waste-Fuel Use in Cement Kilns." in Environmental Progress III:1 (Feb/1984). p. 65.(b) Source -- Meredith/Boli & Associates. Inc. "Health Risk Assessment (Screening Level Procedure) for the Waste-Derived Fuel Research Bum Program." California Portland Cement. Mohave. California. 19 May 1988.29 July 1988 (Revised)

II. TOXIC RELEASES FROM WASTE-BURNING CEMENT/AGGREGATE KILNS

"No technology for managing hazardous wastes can be risk-free. Cement and lightweight aggregate kilns are no exception to this rule." [Beers 1987)

Waste-burning cement and aggregate kilns are point-sources of unburned hazardous wastes, heavy metals and products of incomplete combustion (PICs) -- chemicals that are formed during combustion processes. These substances are distributed to the environment in the following forms:

* **Stack** emissions -- unburned wastes. metals and products of incomplete combustion (PICs), which are present both as gases and as components of fine particles that escape pollution control devices:
* Fugitive emissions -- volatile chemicals that escape during waste transfer and storage:
* Ply Ash -- fine particles that are carried up the stack. a portion of which are captured by pollution control devices and a portion which escape into the air:
* Effluents from pollution control devices such as wet scrubbers:
* Spills. those incurred on-site and those occurring during off-site transport:
* Cement and/or aggregate products that are sold or distributed.

UNBURNED WASTES

Unburned wastes are released into the environment in stack gases (both as vapors and deposited on fine particles), as fugitive chemicals (during waste transport and storage), in accidental spffls, as constituents of captured fly ash, in effluents from pollution control devices (such as wet scrubbers). and as constituents of the solid residues that are incorporated into cement and aggregate products. The quantities of unburned hazardous wastes that are released into the environment via these routes varies with combustion conditions in the kilns. According to EPA. variations in combustion conditions in hazardous waste incinerators may result in unusually large emissions of unburned wastes (see Chapter 4, Upset Conditions).

Stack Emissions of Unburned Hazardous Wastes

Destruction and removal efficiency (DRE), a measure of the ability of a combustion process to dispose of hazardous waste. is calculated by comparing the quantity of a specific chemical in the waste with the quantity of that same chemical found **in the** stack gases. downstream from any pollution control devices. A **DRE** of 99.99 percent does not mean that 99.99 percent of that particular chemical was actually destroyed: it means that 0.01 percent of that chemical was identified in stack gases after passage through the combustion zone and any pollution capture devices.

An EPA review of test burns in eight cement kilns found **DREs** for a variety of specific chemicals ranging from 91.043 to 99.9999 percent, with an average. DRE of 99.53 percent. [Mournighan and Branscome 19871 In comparison, a proposal by California Portland Cement to burn hazardous wastes in one of their kilns stated. **"[D]estruction/removal** efficiencies **(DREs)** of **99%** to 99.99% (or better) will be obtained depending on the **specific** constituent." **[Meredith/Boli 1988]**

Based on **DREs** of 99 to 99.99 percent. the 41 cement/aggregate kilns that are currently burning 3 billion pounds per year of hazardous waste are also releasing unburned hazardous 'waste into the air at a rate ranging from 300.000 to 30 million pounds per year. The 99.53% average DRE found in **kilns** studied by EPA would result in over 14 million pounds per year of fugitive emissions **from** cement/aggregate kilns in the U.S.

The air emissions of unburned wastes can be expected to include any of the hazardous chemicals present in the waste. such as those listed in Table 2. Since **DREs** are based entirely on analyses of stack gases. they do not reflect the deposition of unburned wastes on captured or released fly ash or in the solid residues that are incorporated into cement and aggregate products. In studies of hazardous waste incinerators, components of unburned wastes have been detected in both fly ash and bottom ash. however no data are available to identify their presence and quantities in the particulate emissions and residues from waste-burning cement/aggregate kilns.

Fugitive Emissions of Unburned Hazardous Wastes

Fugitive emissions -- waste chemicals accidentally released during transport. storage, and processing -- pose significant threats to public health and the environment. Even at fully-regulated hazardous waste incinerators. EPA's Science Advisory Board cautioned:

> **"[F]ugitive** emissions and accidental spills may release as much or more toxic material to the environment than the direct emissions from incomplete waste incineration." **[USEPA** 19851

At a **Systech/Lafarge** cement kiln burning hazardous waste. fugitive emissions were reported to total 20,074 pounds per year. The 27 chemicals -- including 12 carcinogens -- identified as fugitive emissions at this facility are listed below In Table 3. Actual totals may be **significantly** greater than the quantities reported by Systech.

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TABLE 3

FUGITIVE EMISSIONS FROM
SYSTECH/LAFARGE CEMENT KILN FREDONIA, KANSAS

Hydrocarbons	Halocarbons
Acetone	• Chlorobenzene
• Benzene	Ethylene chloride
n-Butanol	* Methylene chloride
t-Butanol	* Tetrachloroethylene
Cellosolve (2-ethyoxyethanol)	1,1,1-Trichloroethane
• Diethyl phthalate	* 1,1,2-Trichloroethane
• Dimethyl phthalate	* Trichloroethylene
Ethyl benzene	Freon 113
Ethylene glycol	
Methanol	
Methyl ethyl ketone	
Methyl isobutyl ketone	
Methyl methacrylate	
Naphthalene	
Phenol.	
• Styrene	
* Toluene	
Vinyl acetate	
• Xylene	

TOTAL FUGITIVE EMISSIONS: 20,074 POUNDS PER YEAR.

• Known or suspected carcinogen or mutagen

Source: USEPA, Sara Title 3 TRI Form R for Systech Corp., Fredonia, KS. 6/28/88 in "A.. Alert," Air Water Earth. P.O. Box 311712. New Braunfels, Texas 78131, 1988

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