Burning Hazardous Wastes in Cement Kilns

Cement kilns in some industrialized countries have begun augmenting or even fully replacing conventional fuels with industrial hazardous waste. However, the FAO recommend against burning chlorinated pesticides in cement kilns in some cases. FAO also warn that disposal of hazardous materials, such as obsolete pesticides, by burning in cement kilns is *"often not applicable in a safe and/or cost-effective manner,"* going on to note as follows:[1]

> *"Many of the older types of cement kilns are not suitable. Only a few of the cement kilns in developing countries meet the technical requirements that, in principle, would make them suitable for incineration of certain groups of pesticides. Expert advice is needed to assess whether kilns can be used and special equipment is required to inject the pesticides into the kiln. Such equipment is expensive and should only be installed and used under expert supervision."*

Performance of Cement Kilns Burning Hazardous Waste

According to the United States Environment Protection Agency (USEPA), the *"conditions inherent in the cement kiln mimic conditions of hazardous waste incineration".*[2] As such, some of the general limitations of hazardous waste incinerators may be equally applicable to cement kilns that burn hazardous wastes. For example, a review of test burns in eight cement kilns found Destruction and Removal Efficiencies (DREs) for a variety of specific chemicals to range from 91.043 to 99.9999 percent, with an average DRE of 99.53 percent.[3] However, as only stack emissions of undestroyed chemicals are considered in determining DREs – the quantities of undestroyed chemicals deposited in Cement Kiln Dust (CKD), clinker and other residues are not taken into consideration – the actual destruction efficiencies were undoubtedly lower.

Impacts of Burning Hazardous Waste in Cement Kilns

The impacts of hazardous waste burning cement kilns can be compared to those of cement kilns that burn conventional fuels, as follows:

- Dioxins are emitted from cement kiln stacks, whether the kiln is fired with conventional fuels or with hazardous waste. However, according to USEPA, cement kilns that burn hazardous waste emit dioxins in their stack gases at rates more than 80 times higher than those of cement kilns that burn conventional fuels.

- Similarly, dioxins are found in CKD from cement kilns that burn conventional fuels as well as those burning hazardous waste. USEPA recently reported that CKD from cement kilns burning hazardous waste carries dioxins at concentrations about 100 times higher than CKD from kilns burning only conventional fuels.[4]

- Cement kilns that burn hazardous waste produce more CKD, as documented by the U.S. Environmental Protection Agency:[5]

  > *"Finally, the Agency also found that the burning of hazardous waste is correlated with the volume of dust that is actually disposed. Kilns that burn hazardous waste remove from the kiln system an average of 75 to 104 percent more dust per ton of clinker than kilns that do not burn hazardous waste."*

- From 15 to 90 percent of CKD has a diameter below 10 microns (μm), which is within the respirable range for humans.[6] As these fine particles are carried to the stack, the portion that is not captured by pollution control devices is released directly to the air. Some fraction of the captured CKD also escapes during transfer and disposal. One cement kiln burning 90 tons of hazardous waste per day was found to produce CKD at the rate of 200 tons per day.[7]

- The smaller CKD particles are those most likely to escape capture by pollution control devices or to be resuspended or washed from CKD stored in piles or pits. These particles are also the most likely to lodge deeply in the lungs. Airborne particles smaller than 2 μm have been linked to high rates of pneumonia, pleurisy, bronchitis, and asthma.[8] The American Lung Association drew attention to the issue of CKD as follows:[9]

  "Particulate matter is a health concern because inhaling even relatively low airborne concentrations of dust can cause or aggravate lung diseases such as asthma or emphysema, and is associated with premature death. … Since CKD collected in air pollution control devices typically has a small particle size, poorly managed cement kiln dust handling, transport and disposal has been shown to cause severe fugitive dust and air pollution problems."

- Dioxins have also been found in the clinker from both hazardous and non-hazardous waste facilities.[10]

- Emissions of airborne particulates increased by 66 percent when hazardous wastes were burned in cement and aggregate kilns and by 203 percent when the hazardous wastes also contained chlorine sources.[11]

- When hazardous wastes containing both chlorinated chemicals and metals were burned, metals emissions from cement kilns increased.[12, 13]

- Burning chlorinated chemicals in cement kilns increases the likelihood of upsets, since the presence of additional chlorine encourages the formation of "rings" in the kilns. When the rings detach or break, the sudden release of solids in the kilns can result in upsets which are accompanied by increased emissions of unburned wastes and products of incomplete combustion, or even more severe consequences:[14]

  "In a very severe upset, the flame at the firing end of the kiln can be extinguished. Upsets are not uncommon. The kiln we studied averaged three upsets a month …."

- Fugitive emissions are substances that volatilize or, if adsorbed to particulates, such as CKD, blow or wash into the surrounding environment during waste transfer and storage. At one cement kiln burning hazardous waste, fugitive emissions were reported to be 20,074 pounds per year.[15]

- Spills, both on-site and off-site, are also a concern at cement plants where hazardous materials are burned. A report commissioned by the New York State Legislature on waste-burning in cement kilns assessed the likelihood of repeated spills: [16]

  "[I]t is virtually impossible to completely prevent small spills of hazardous waste during unloading and pumping of waste fuels. These spills may be caused by equipment failures, maintenance operations, or operator error."

Table 1. Dioxin releases from cement kilns [17, 18]

Country	Emission Factors	Reported Concentration Range
To Air (µg I-TEQ/tonne clinker produced, except Sweden)		**To Air** (ng I-TEQ/m^3)
UK	0.02 to 1.08	0.01 to 0.35
USA	0.27 (Not burning hazardous wastes) 1.04 (burning haz waste and EF <450F) 28.58 (burning haz waste and EF >450F)	0.00029 to 144.08
Canada	-	0.005 to 0.548
Germany	0.0005 to 0.1384	0.000015 to 0.096 (NB. high value of 0.24 ng I-TEQ/m^3 ignored)
Netherlands	-	0.045 to 19.5
EU	0.05 to 5.0	
Sweden	0.03 to 0.56 µg NTEQ/tonne	0.005 to 0.1 ng NTEQ/m^3
Cement Kiln Dust (ng I-TEQ/kg CKD)		
UK	0.001 to 30	
USA	0.03 (Not burning hazardous waste) 35 (burning hazardous waste)	

Table 1 lists reported values for both the estimated emission factors (ie. air emissions of PCDD/Fs per tonne of clinker produced) and the reported concentrations of PCDD/Fs emitted by cement kilns. Also included are values for PCDD/Fs reported in cement kiln dust.

According to the USEPA, the average emission factor for kilns burning hazardous waste is about 90 times greater than that for kilns not burning hazardous waste.[17] A comparison of PCDD/F concentrations in cement kiln dust samples from cement kilns burning and not burning hazardous waste shows a similar relationship (i.e., the cement kiln dust from kilns burning hazardous waste had about 100 times higher PCDD/F TEQ concentration than dust from kilns not burning hazardous waste).

The USEPA also reported the emission factors based on the inlet temperature of the air pollution control devices used at kilns burning hazardous wastes. For those with an inlet temperature greater than 450 F the emission factor was 28.58 ng/kg clinker produced, compared to those with an inlet temperature of less than 450F of 1.04 ng/kg clinker.

The mean PCDD/F concentrations in net CKD generated by the kilns burning hazardous waste are higher (35 ng I-TEQ_{DF} /kg) than in net CKD generated by the facilities not burning hazardous waste (3.0E-02 ng I-TEQ_{DF} /kg).

The recent EU Dioxin inventory did not differentiate emissions from cement kilns burning hazardous wastes and those that do not. However, the comment was made that,[18] *"… there is still substantial uncertainty concerning dioxin emissions. The reason for this is the incineration of different kinds of waste in particular cement plants which might contribute considerably to the national dioxin emission balance or to the local immission situation. Measurements may be recommended at some plants incinerating waste, in particular hazardous waste with chlorinated compounds."*

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