Experiences from other international processes; Basel and Stockholm convention

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Launching of Cement Industry Sector Partnership under the UNEP Global Mercury Partnership.
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UN chemicals and waste conventions

Chemicals contribute to many advantages to today's world; however their use can also pose risks to human health and the environment. To reduce this harmful global impact, three conventions have been established that regulate chemicals and hazardous waste at global level; the Basel, Rotterdam and Stockholm convention.

Origin of the UN chemicals and waste conventions

- Movements of hazardous wastes from industrialised to industrialising countries for 'treatment' or 'disposal'.
- Hazardous waste disposal costs in industrialised countries were high, regulations becoming stricter.
- Disposal costs in developing economies were low, few regulations, low standards.
- No legal framework to control 'dumping'.
- Lack of awareness and lack of technical knowledge.

Rotterdam Convention

Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade currently regulates information about the export/import of 43 hazardous chemicals listed in the Convention's Annex III, 32 of which are pesticides (including 4 severely hazardous pesticide formulations) and 11 of which are industrial chemicals.

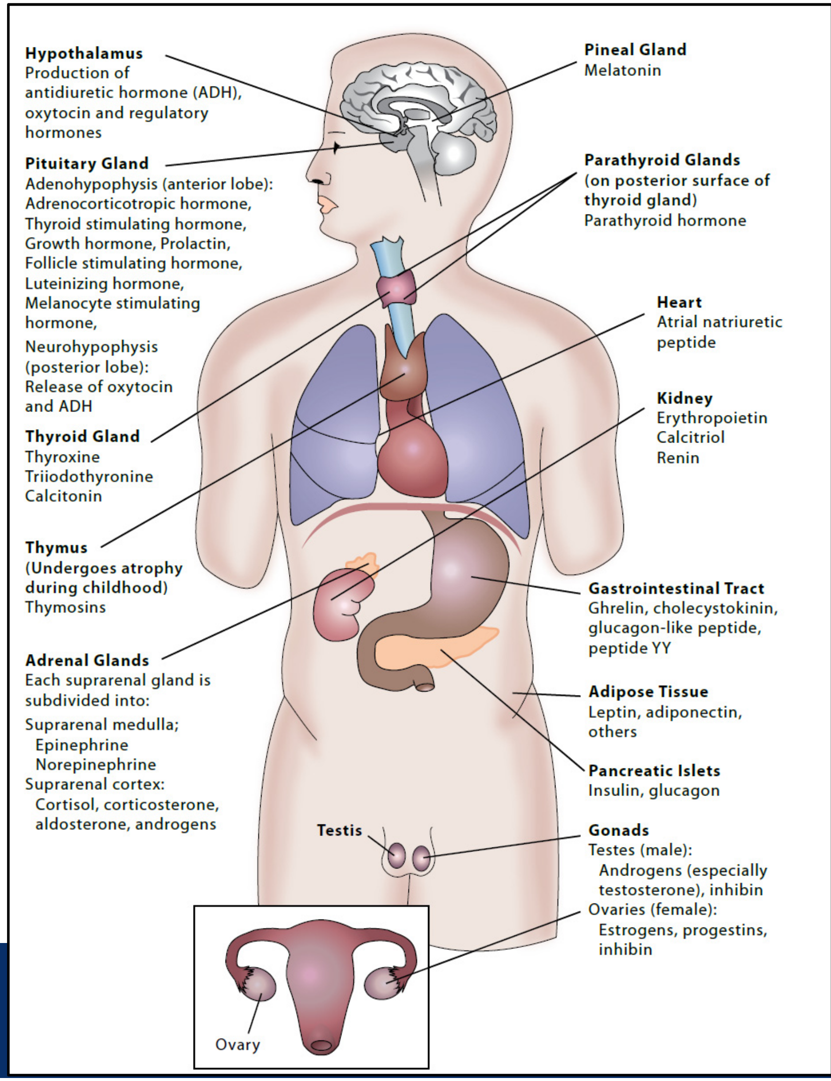
The Convention was adopted in 1998 and entered into force in 2004. It currently has 152 Parties.

Stockholm Convention

The Stockholm Convention on Persistent Organic Pollutants currently regulates 22 toxic substances that are persistent, travel long distances, bio-accumulate in organisms and are toxic.

The Convention was adopted in 2001 and entered into force in 2004. It currently has 179 Parties.

Endocrine disrupting chemicals have probably worse impacts than earlier anticipated….



Objectives of the Stockholm Convention on Persistent Organic Pollutants (POPs)

"elimination or restriction of production and use of all intentionally produced POPs, disposal of stockpiles and wastes, and the continuing minimization and, where feasible, ultimate elimination of releases of unintentionally produced POPs such as dioxins and furans"

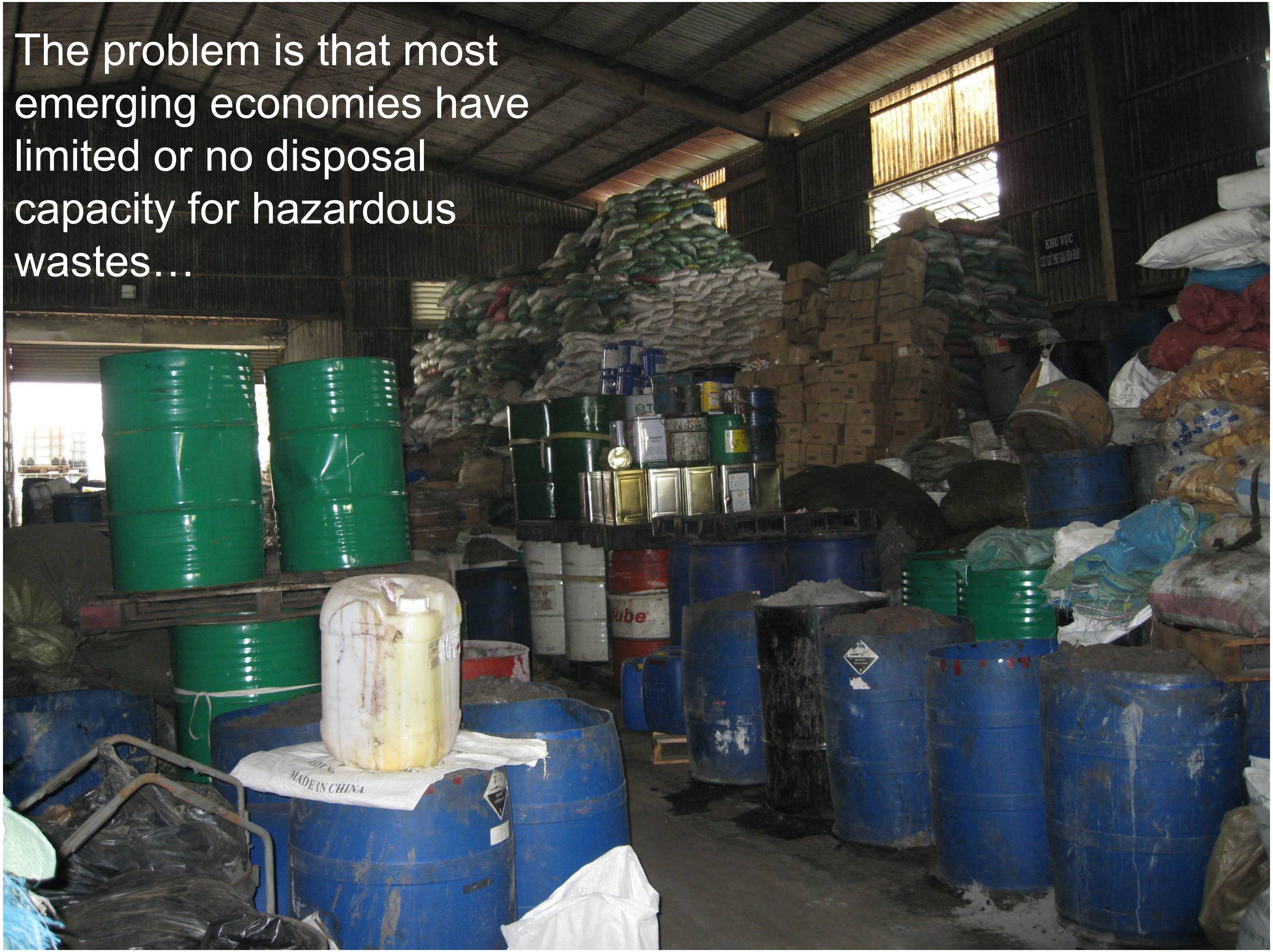
Basel Convention

Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal regulates the export/import of hazardous waste and waste containing hazardous chemicals.

The Convention was adopted in 1989 and entered into force in 1992. It currently has 180 Parties.

Objectives of the Basel Convention

- To protect human health and the environment against adverse effects of hazardous wastes.
- Reduction of transboundary movements of hazardous wastes.
- Minimisation of generation - quantity and degree of hazard.
- Promotion of local solutions and environmentally sound management of hazardous wastes.


The problem is that most emerging economies have limited or no disposal capacity for hazardous wastes…
MADE IN CHINA

Mozambique 1997-2001

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Danes burn fingers on cement kiln project

Controversy is growing over a Danish funded project to convert a cement kiln in Mozambique for the incineration of obsolete pesticides. Danish aid agency DANIDA is investing DKK 42 million (US$ 6 million) in upgrading the cement kiln, collecting 540 tonnes of obsolete pesticides from 69 locations and managing the disposal operation.

Disposal of obsolete pesticides in developing countries has usually relied on repackaging the chemicals and transport for incineration in dedicated toxic waste facilities in Europe. In this case DANIDA believed that it is helping to solve Mozambique's obsolete pesticides problem while making the cement kiln more economically viable. Therein lies the root of criticisms targeted against the project.

South African Based Environmental Justice Networking Forum (EJNF) alleges that the contractor hired to collect the pesticides in Mozambique and deliver them to the cement kiln has tried to import waste from other countries for incineration in Africa. This raises concerns that the Mozambique facility will be seen as a regional resource and will attract toxic waste from elsewhere.

Incinerator operators charge for the destruction of toxic waste, and in cement kilns the waste can often augment or replace regular fuel which needs to be purchased. However, emission controls are less sophisticated on cement kilns than on dedicated toxic waste incinerators and there is a risk that seriously hazardous pollutants such as dioxins will be emitted.

Advocates of cement kilns claim that the higher incineration temperatures (up to 2000°C in cement kilns; around 1200°C in dedicated incinerators), longer residence times of the waste at those temperatures and the emission controls which are in place prevent the formation and emission of dioxins or other pollutants. Norway for example, uses cement kilns to incinerate all its toxic waste and claims to meet the most stringent emission standards. Others are less convinced.

Greenpeace and the Basel Action Network in support of EJNF claim that DANIDA has "refused to conduct a true comparison of all available

"Perceptions" about cement kilns treating hazardous wastes treatment ten years ago – two examples

1. A cement kiln project was stopped in Mozambique in 2001 due to a combination of fear, active opposition, inferior preparation, lack of communication, improper technical knowledge and the absence of internationally accepted guidance documents.

2. The Stockholm Convention mention cement kilns firing hazardous was to be an "industry source having the potential for comparatively high formation and release of dioxins to the environment".

We wanted to explore the feasibility of using local cement kilns for treatment of organic hazardous chemicals – especially in emerging economies were other treatment options were absent.

Policy principles vs. waste treatment in cement kilns

Co-processing in cement kilns shall primarily be about recovery of energy and recycling of materials in wastes, i.e. substitution of fossil fuel and virgin raw materials.

However, in lack of available treatment options and urgent needs, a feasible cement kiln can be used for treatment of organic hazardous constituents provided that this is done under strict Government control and guidance.

US EPA Toxic Substances Control Act (TSCA) PCB Incineration Criteria

"…more complex organic halogens such as PCB requires 1200°C and 2 seconds residence time "

A DRE of 99.9999% is required by TSCA for the incineration of PCB's

EU Directive 2000/76/EC on Incineration of Waste regulates Co-incineration of Hazardous Waste in Cement Kilns

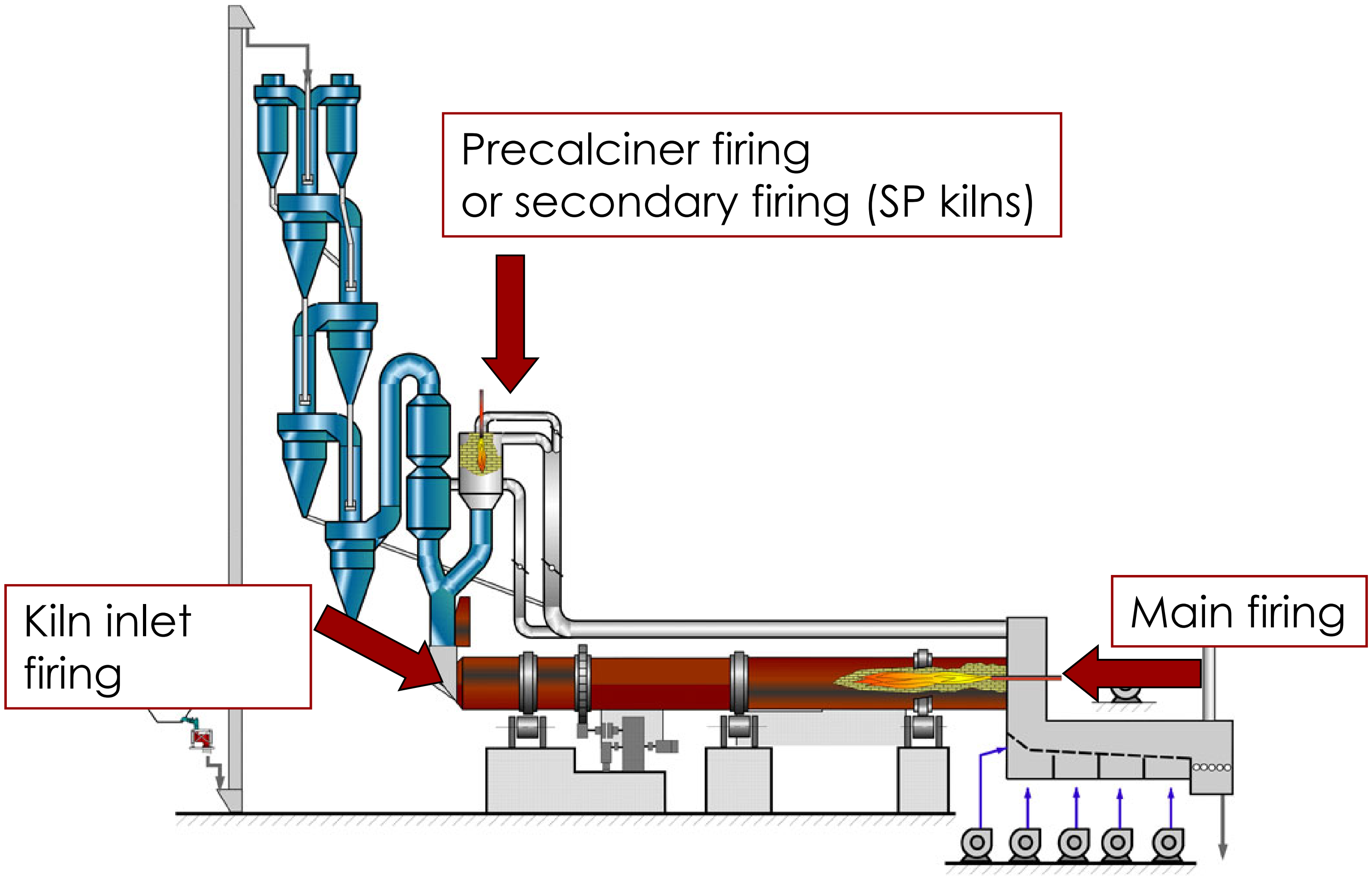
"...if more than 1 % of halogenated organic substances, expressed as chlorine, are incinerated, the temperature has to be raised to minimum 1100°C during at least two seconds".

Environmental aspects

Co- processing of wastes should only be performed if the cement kiln operates according to the best available techniques and best environmental practice.

If certain provisions for waste quality and waste feeding are met, co-processing of waste will not change the emissions from a cement kiln stack significantly.

Fuel feed point in cement kiln systems



Co-processing practice

Alternative fuels have to undergo a rigorous acceptance and inspection procedure before being used. It is necessary to avoid/limit mercury inputs into the kiln system.

Emission monitoring is obligatory in order to demonstrate compliance with existing laws, regulations and agreements.

Waste acceptance

Operators need to ensure that only wastes originating from trustworthy parties will be accepted, considering the integrity of all participants throughout the supply chain.

The traceability of the wastes needs to be ensured prior to reception by the facility, with deliveries of unsuitable wastes refused.

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Operational aspects

Materials transport, handling and storage must be effectively monitored, and full compliance with existing regulatory requirements must be assured.

This includes analysis and reporting of parameters such as the heating value, the content of water, heavy metals, ash, sulphur and chlorine. Also retained samples should be stored for a certain period of time.

Process optimization

Characterize the parameters that correspond to good operation and use these as a basis to improve other operational performance.

Having characterized good kiln operating parameters, establish reference data by adding controlled doses of waste, and assess what are the changes and required controls and practices to control emissions.

Stable fuel feeding is important

Manage the kiln process to achieve and maintain stable operating conditions, i.e. by optimizing process control (including implementing computer-based automatic control systems) and using modern, gravimetric solid fuel feed systems.

Best available techniques

Minimize fuel energy use by employing preheating and pre-calcination to the extent possible considering the existing kiln system configuration; and use of modern clinker coolers, enabling maximum heat recovery from the exhaust gas.

Stable operating conditions is crucial

Monitoring and stabilisation of critical process parameters, i.e. homogenous raw mix and fuel feed, regular dosage and excess oxygen, stable kiln operation and monitoring of CO.

Ensure rapid cooling of exhaust gases to a temperature lower than 200 °C.

Supply of wastes

Consistent long-term supply of a given waste or alternative fuel (e.g. a supply of a month or more) is required in order to maintain stable conditions during operation.

Substances entering the kiln should be carefully selected and controlled; specifications should be set based on product/process or emission considerations and monitored.

Pre-treatment of heterogeneous wastes

Pre-treatment of waste, including hazardous waste, for the purpose of providing a more homogeneous feed and thus more stable combustion conditions may, depending on the nature of the waste-derived fuel, involve drying, shredding, mixing or grinding.

Halogenated wastes

The feeding of raw mix containing waste with organic compounds that could act as precursor should be avoided.

Halogenated waste should preferably be fed through the main burner.

Waste-derived fuel should never be used during start-up and shutdown.

Waste feeding

In general, organic waste should be fed through either the main burner or the secondary burner for pre-heater/pre-calciner kilns.

For the secondary burner it should be ensured that the combustion zone temperature is maintained > 850 °C for a sufficient residence time (>3 s).

Combustion and process stability can be ensured by:

Consistency in fuel characteristics (both alternative and fossil).

Consistency in fuel supply rate or frequency of introduction of batch-charged materials.

Keeping adequate excess oxygen to achieve good combustion.

Keeping CO concentrations of in exhaust gases stable .

The following should be fulfilled in a test burn:

The destruction and removal efficiency for hazardous compounds should be at least 99.99%. Chlorinated aromatic compounds should be chosen as a test compound if available because they are generally difficult to destroy.

For POPs, a DRE/DE of ≥99.9999% should be demonstrated.

Normal performance

The cement kiln should meet an emissions limit for PCDD/PCDFs of 0.1 ng TEQ/Nm^3 both under baseline and co-processing conditions and needs to be in compliance with national emission limit values.

Scope of safety audits

- Material control (product quality & health/safety).
- Auditing of waste generators/collectors.
- Occupational health and safety.
- Design safety (installation design & equipment).

Cement manufacturing is a sensitive process

All materials (in the form of AFRs) introduced into a cement production process should ideally resemble the homogeneity, particle size distribution, heat and water content and chemical composition as normal fine coal and raw meal used in cement manufacturing.

As waste materials often are heterogeneous, pre-treatment and pre-processing are often necessary.

Cement manufacturers are vulnerable

Co-processing is still controversial among some stakeholders and one accident may under worst case conditions undermine co-processing acceptance in the entire industry, i.e. all players have the responsibility to minimize risks and strive towards excellence and best practice to protect the reputation.

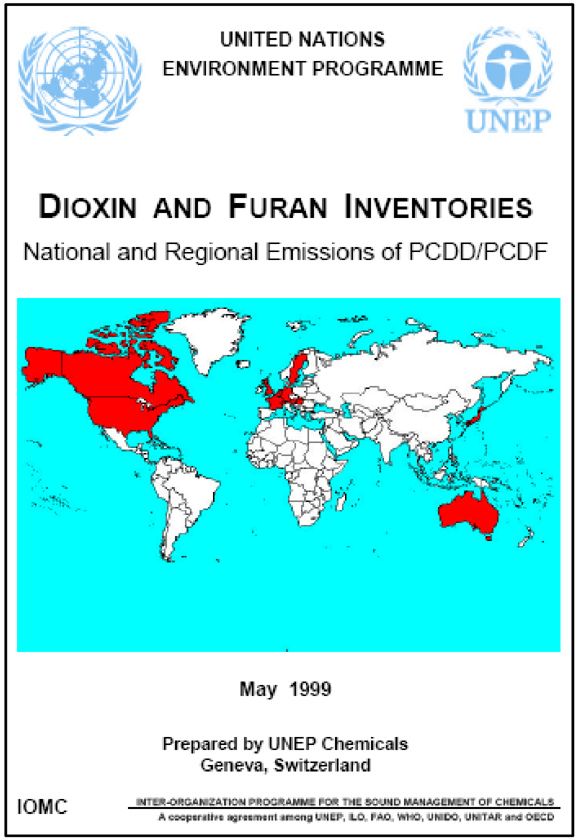
"Investigations" were initiated

1. A systematic and comprehensive investigation of the feasibility of using cement kilns in developing countries for destruction of POPs and other hazardous wastes – thorough documentation.
2. A project with WBCSD CSI to gather and evaluate formation, release and control of U-POPs from the cement industry.
3. Preparation and testing of best-practice Guidelines on environmentally sound co-processing and treatment of hazardous wastes in cement kilns.

Outdated Emission Factors?

The global dioxin emission inventory for 1996 applies an emission factor for hazardous waste burning cement kilns of 2,600 µg TEQ/t and 200 µg TEQ/t for non-hazardous waste burning cement kilns……

…. implying an exit gas concentration of >1800 ng TEQ/Nm^3 and 87 ng TEQ/Nm^3 for hazardous waste burning and non-hazardous waste burning cement kilns respectively.


UNITED NATIONS
ENVIRONMENT PROGRAMME
UNEP

DIOXIN AND FURAN INVENTORIES

National and Regional Emissions of PCDD/PCDF

May 1999

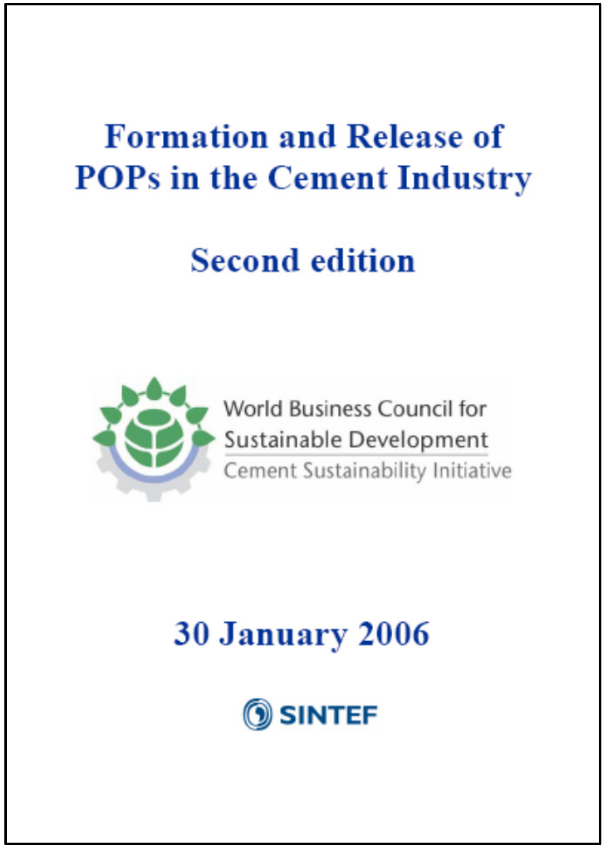
Prepared by UNEP Chemicals
Geneva, Switzerland

IOMC
INTER-ORGANIZATION PROGRAMME FOR THE SOUND MANAGEMENT OF CHEMICALS
A cooperative agreement among UNEP, ILO, FAO, WHO, UNIDO, UNITAR and OECD

http://www.pops.int/documents/meetings/bat_bep/2nd_session/egb2_followup/

More than 2200 PCDD/PCDF measurements, many PCB and some HCB measurements were compiled from cement companies around the world.

The data showed that most modern cement kilns can meet an emission level of 0.1 ng TEQ/Nm^3, or an average flue gas concentration of 0.021 ng I-TEQ/m^3, also when co-processing wastes and treating hazardous wastes.


Formation and Release of POPs in the Cement Industry

Second edition

World Business Council for Sustainable Development
Cement Sustainability Initiative

30 January 2006

SINTEF

From 1420 kg to 77 grams……

Using the Emission factors cement made by Brzuzy and Hites (1996) of 4160 µg TEQ/ton would imply that the cement industry released 1420 kg PCDD/PCDF per year, or 60% of estimated total global emissions….

Assuming a global cement production of approximately 2 billion tons and using the emission factors of the UNEP Toolkit, 0.05 µg TEQ/ton, would imply a cement industry contribution of 100 g/y.

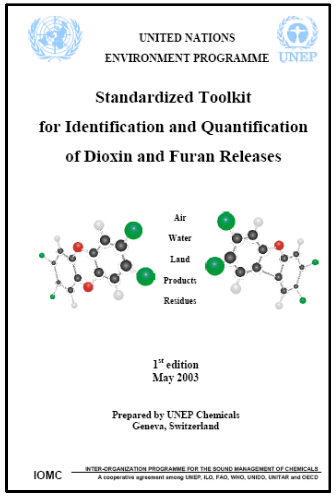
Using the average flue gas concentration of 0.021 ng I-TEQ/m^3 from the 500 latest measurements, and assuming a global clinker production of 1.6 billion t/y and an exhaust-gas volume of 2300 Nm^3/ton clinker, implies that the contribution from the global cement industry would constitute 77 grams per year.

Findings confirmed by the UNEP “Standardized Toolkit", 2005

“In the USA, earlier tests indicated that higher emissions were found for some wet kilns where hazardous wastes were fired"

"More detailed investigation suggested that – provided combustion is good - the main controlling factor is the temperature of the dust collection device in the gas cleaning system”

“The plants equipped with low temperature electrostatic precipitators appear to have well controlled emissions with or without waste fuels“


UNITED NATIONS
ENVIRONMENT PROGRAMME
UNEP

Standardized Toolkit
for Identification and Quantification
of Dioxin and Furan Releases

Air
Water
Land
Products
Residues

1st edition
May 2003

Prepared by UNEP Chemicals
Geneva, Switzerland

IOMC INTER-ORGANIZATION PROGRAMME FOR THE SOUND MANAGEMENT OF CHEMICALS
A cooperative agreement among UNEP, ILO, FAO, WHO, UNIDO, UNITAR and OECD

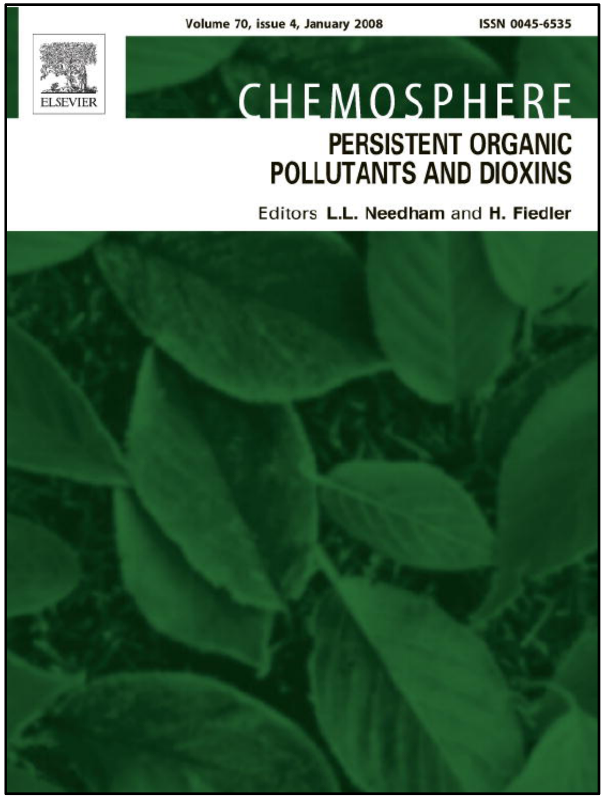
UNEP Toolkit emission factors for cement production, 2005

PCDD/PCDF Toolkit 2005 109

Table 41: Emission factors for cement production

Classification	Emission Factors – µg TEQ/t of Cement				
	Air	Water	Land	Product	Residue
1. Shaft kilns	5.0	ND	ND	ND	ND
2. Old wet kilns, ESP temperature >300 °C	5.0	ND	ND	ND	NA
3. Rotary kilns, ESP/FF temperature 200-300 °C	0.6	ND	NA	ND	NA
4. Wet kilns, ESP/FF temperature <200 °C Dry kilns preheater/precalciner, T<200 °C	0.05	ND	NA	ND	NA

No differentiation on firing hazardous wastes; only on technology and the temperature in the APCD!



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Review

Formation, release and control of dioxins in cement kilns

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Abstract

Co-processing of hazardous wastes in cement kilns have for decades been thought to cause increased emissions of PCDD/PCDFs – a perception that has been evaluated in this study. Hundreds of PCDD/PCDF measurements conducted by the cement industry and others in the last few years, on emissions and solid materials, as well as recent test burns with hazardous wastes in developing countries do not support this perception. Newer data has been compared with older literature data and shows in particular that many emission factors have to be reconsidered. Early emission factors for cement kilns co-processing hazardous waste, which are still used in inventories, are shown to be too high compared with actual measurements. Less than 10 years ago it was believed that the cement industry was the main contributor of PCDD/PCDFs to air; data collected in this study indicates however that the industry contributes with less than 1% of total emissions to air.

The Stockholm Convention on POPs presently ratified by 144 parties, classifies cement kilns co-processing hazardous waste as a source category having the potential for comparatively high formation and release of PCDD/PCDFs. This classification is based on early investigations from the 1980s and 1990s where kilns co-processing hazardous waste had higher emissions compared to those that did not burn hazardous waste. However, the testing of these kilns was often done under worst case scenario conditions known to favour PCDD/PCDF formation.

More than 2000 PCDD/PCDF cement kiln measurements have been evaluated in this study, representing most production technologies and waste feeding scenarios. They generally indicate that most modern cement kilns co-processing waste today can meet an emission level of 0.1 ng I-TEQ/m^3, when well managed and operated. In these cases, proper and responsible use of waste including organic hazardous waste to replace parts of the fossil fuel does not seem to increase formation of PCDD/PCDFs.

Modern preheater/precalciner kilns generally seems to have lower emissions than older wet-process cement kilns. It seems that the main factors stimulating formation of PCDD/PCDFs is the availability of organics in the raw material and the temperature of the air pollution control device. Feeding of materials containing elevated concentrations of organics as part of raw-material-mix should therefore be avoided and the exhaust gases should be cooled down quickly in long wet and long dry cement kilns without preheating.

PCDD/PCDFs could be detected in all types of solid samples analysed: raw meal, pellets and slurry; alternative raw materials as sand, chalk and different ashes; cement kiln dust, clinker and cement. The concentrations are however generally low, similar to soil and sediment.

Keywords: Stockholm convention; POPs; Hazardous waste co-processing; Cement kilns

REVISED DRAFT
GUIDELINES ON BEST AVAILABLE TECHNIQUES AND
PROVISIONAL GUIDANCE ON BEST ENVIRONMENTAL PRACTICES
RELEVANT TO ARTICLE 5 AND ANNEX C OF
THE STOCKHOLM CONVENTION ON
PERSISTENT ORGANIC POLLUTANTS

GENEVA, SWITZERLAND DECEMBER 2006

BASEL CONVENTION

Cement Kiln Co-Processing (High Temperature Treatment)

Name of Process:
Cement Kiln Co-Processing
(High Temperature Treatment)
Applicable Pesticides and related POPs wastes:
Cement kilns are in principle capable of treating wastes consisting of, or contaminated with, any POP.

Cement kilns can be designed and adapted to accept wastes in any concentration or physical form (Chadbourne, 1997)

Status:
Portland cement was invented in the late 18'th century and is manufactured in huge high temperature kilns (Roy, 1985). The cement industry is today widely distributed throughout the world and produced in 2006 approximately 2.2 billion tons of cement (Karstensen, 2006); i.e. many thousands of kilns are in daily operation in most countries of the world.

Cement kiln co-processing of hazardous wastes provides high temperatures, long residence time, surplus oxygen, good mixing conditions and an alkaline environment, as well as efficient recovery of any energy and raw material substitutes in the hazardous waste.

Co-processing of hazardous wastes in cement kilns has been practiced for more than 30 years and is acknowledged to be feasible for sound hazardous waste treatment in both EU and US regulation, as well as in numerous other countries (Council Directive, 2000; Federal Register, 1999). The US Environmental Protection Agency (EPA) has done numerous studies on the influence of co-processing hazardous wastes in cement kilns. Cement kiln operators in the US began recovering energy from organic waste materials, including hazardous chlorinated compounds, as early as 1974. That practice became commonplace by 1987 and since 1991 US cement kilns have used roughly 1,000,000 tons per year of hazardous waste as fuel. Some of these kilns are permitted to replace up to 100% of their conventional fuels with waste-derived fuels (Branscome et al., 1985; Garg, 1990; Gorman et al., 1986; Cement Kiln Recycling Coalition Comments CKRC, 2002).

Testing of cement kiln emissions and cement products for the presence of organic chemicals during the burning of hazardous materials has been undertaken since the 1970s, when the practice of co-processing hazardous wastes in cement kilns was first considered. Lauber (1982), Ahling (1979) and Benestad (1989) describe some of these early tests on US, Swedish and Norwegian kilns, which confirmed the ability of cement kilns to destroy the organic component of a waste feed in an environmentally sound manner. Numerous tests around the world have demonstrated that there is essentially no difference in the emissions or the product quality when hazardous waste materials are used to replace parts of the fuels and ingredients needed to produce cement clinker, provided that this is done properly and responsible (Karstensen, 1994; Chadborne, 1997; Karstensen, 2001; Karstensen et al., 2006; GTZ-HOLCIM, 2006, Ka...

Technology description:
Portland cement is made by heating a mixture of limestone, silica, alumina and iron m... 1450°C. In this process, partial fusion occurs and nodules of so-called cement clinker... mixed with a few percent of gypsum and ground into a fine meal – cement (Duda, 19... is essential to maintain kiln charge material temperatures of approximately 1450°C an... Also, the clinker needs to be burned under oxidising conditions (IPPC, 2007).

Fuel and wastes fed through the main burner of a cement kiln will be decomposed un... flame burning zone at temperatures up to 2,000°C and a retention time up to 8 secon... secondary burner, kiln inlet or precalciner will be burnt at temperatures up to 1,200°C... either electro static precipitator (ESP's) or bag house fabric filters, or both, for particul... control devices are not used at cement kilns (except for SO_2 in some instances) since... and provide acid gas control. In preheater kilns, the finely ground alkaline raw mater... it is fed counter-currently to the exit gas from the kiln (Environment Agency, 2001).

Studies on PCDD/PCDF emissions have come to the conclusion that co-processing of h... influence the emissions (Branscome et al, 1985; Lauber, 1987; Garg, 1990). In a stud... Council for Sustainable Development data from more approximately 2200 PCDD/F mea... performed under normal and worst case operating conditions, and with the co-process... wastes fed to both the main burner and to the precalciner shows that most cement kil... ng TEQ/Nm3 (Karstensen, 2008a).

UNEP

BASEL CONVENTION
TECHNICAL GUIDELINES

Technical Guidelines for the Environmentally Sound Management of Wastes Consisting of, Containing or Contaminated with Polychlorinated Biphenyls (PCBs), Polychlorinated Terphenyls (PCTs) or Polybrominated Biphenyls (PBBs)

BASEL CONVENTION

DEDICATED TO MAKING A DIFFERENCE

Cement Sustainability Initiative (CSI)

Guidelines for the Selection and Use of Fuels and Raw Materials in the Cement Manufacturing Process

Fuels and raw materials

DRAFT
December 2005

Version 1.0

World Business Council for Sustainable Development

Holcim gtz

Guidelines on Co-processing Waste Materials in Cement Production
The GTZ-Holcim Public Private Partnership

GUIDELINES ON BEST AVAILABLE TECHNIQUES AND PROVISIONAL GUIDANCE ON BEST ENVIRONMENTAL PRACTICES

relevant to Article 5 and Annex C of the Stockholm Convention on Persistent Organic Pollutants

Cement kilns firing hazardous waste

UNEP

Stockholm Convention

UNEP

BASEL CONVENTION

TECHNICAL GUIDELINES

Technical guidelines on the environmentally sound co-processing of hazardous wastes in cement kilns

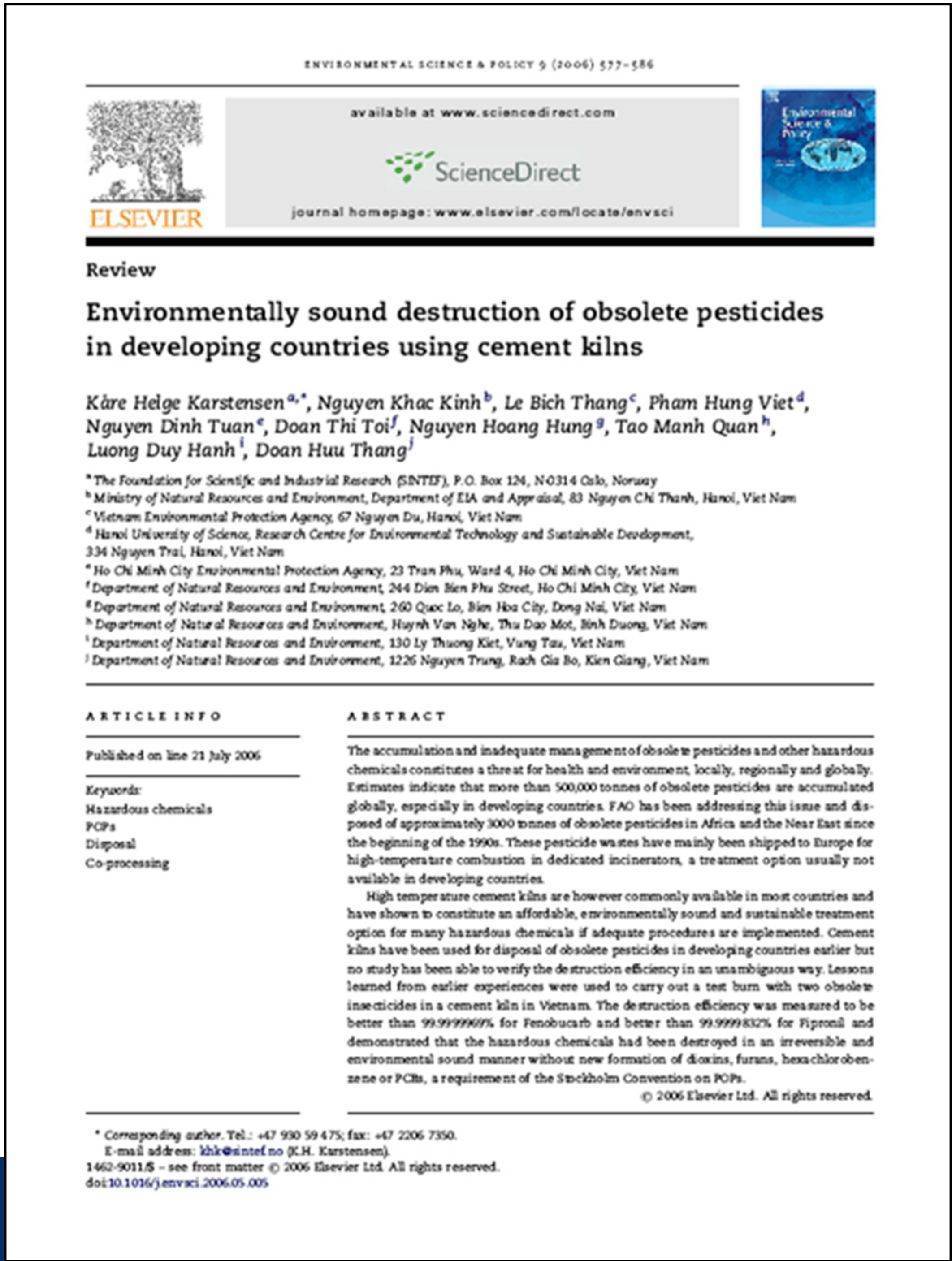
BASEL CONVENTION

Results of the "investigations"

1. Recent test burns have revealed several benefits of using cement kilns compared to other treatment techniques, e.g. superior destruction performance, low and controlled emissions of POPs, large treatment capacity, availability, affordability, local job creation and sustainability – provided responsible operation.

2. The data gathering of POPs from the cement industry showed that the contribution from the industry was significantly less than anticipated and showed that most modern cement kilns can meet an emission level of 0.1 ng TEQ/Nm^3, also when co-processing wastes and treating hazardous wastes.

3. Guidelines for co-processing of wastes in cement kilns are today widely adopted – and continuously amended.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ELSEVIER

Review

Environmentally sound destruction of obsolete pesticides in developing countries using cement kilns

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ABSTRACT

The accumulation and inadequate management of obsolete pesticides and other hazardous chemicals constitutes a threat for health and environment, locally, regionally and globally. Estimates indicate that more than 500,000 tonnes of obsolete pesticides are accumulated globally, especially in developing countries. FAO has been addressing this issue and disposed of approximately 3000 tonnes of obsolete pesticides in Africa and the Near East since the beginning of the 1990s. These pesticide wastes have mainly been shipped to Europe for high-temperature combustion in dedicated incinerators, a treatment option usually not available in developing countries.

High temperature cement kilns are however commonly available in most countries and have shown to constitute an affordable, environmentally sound and sustainable treatment option for many hazardous chemicals if adequate procedures are implemented. Cement kilns have been used for disposal of obsolete pesticides in developing countries earlier but no study has been able to verify the destruction efficiency in an unambiguous way. Lessons learned from earlier experiences were used to carry out a test burn with two obsolete insecticides in a cement kiln in Vietnam. The destruction efficiency was measured to be better than 99.9999969% for Fenobucarb and better than 99.999832% for Fipronil and demonstrated that the hazardous chemicals had been destroyed in an irreversible and environmental sound manner without new formation of dioxins, furans, hexachlorobenzene or PCBs, a requirement of the Stockholm Convention on POPs.

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Emission of dioxins/furans and other U-POPs from test burns of non-POP pesticides in a hazardous waste incinerator

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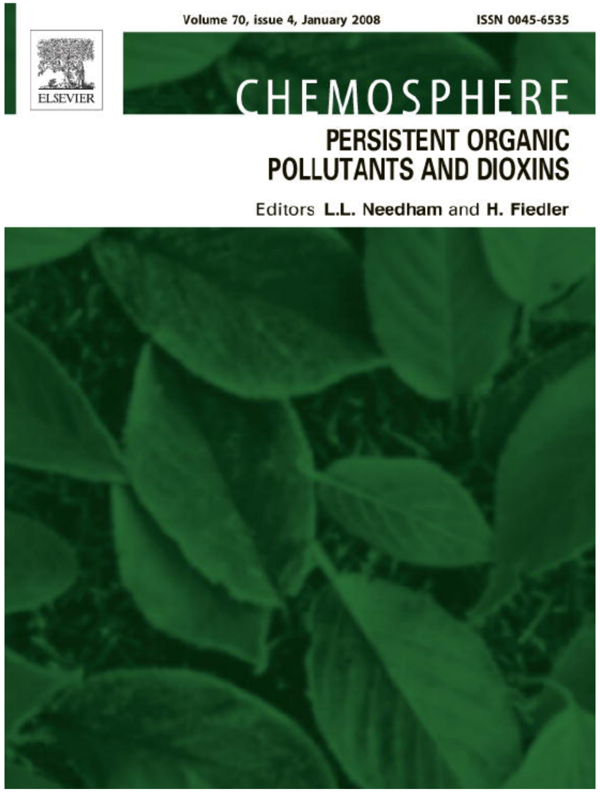
Emission
PCDD/PCDFs
Dioxin-like PCBs
Chlorinated benzenes

ABSTRACT

This paper presents the results of test burns for obsolete pesticides (OPs) of the permethrin group in a high temperature incinerator (HTI) in Southeast Asia. Three test burn runs were conducted, a baseline run when no OP was fed to the incinerator, and two test runs with different mixtures of OP compounds (formula 1 and 2, refer to Table 1 for detail) containing chlorine in the feeding wastes. The unintentional formed persistent organic pollutants (U-POPs) including 17 dioxins/furans, 12 dioxin-like PCBs and 12 chlorobenzenes (CBs) were monitored in all input materials and all discharges (flue gas, scrubbing liquid and solid residues). The results show relatively high levels of the U-POPs in the flue gas emission with total dioxins/furans of 4.4, 3.4, and 8.4 ng I-TEQ/m^3 in the baseline, test run 1 and test run 2, respectively, which are above international acceptable emission levels. The PCB levels in flue gas were, respectively, 0.01, 0.3 and 0.4 ng I-TEQ/m^3. The baseline thus had similar U-POPs levels with the OP test runs.

In stack emission, approximately 90% of the U-POPs and 100% of CBs were present in gas phase. The emission factors, mass of pollutants per metric ton (tonne) of input waste, of U-POPs associated with fly ash (from bag house) were the highest, followed by flue gas and bottom ash while those associated with scrubbing liquid were relatively low. Among the waste input material only the black toner power contained U-POPs, but at low levels. The profiles of the dioxins/furans and PCBs in the toner waste were significantly different from that in the discharges. Despite the overall good destruction and removal efficiency of permethrin (better than 90%) the high emission of U-POPs and CBs from the test burn is of another more serious concern. To our best knowledge the findings of this study are the first of this kind for the Southeast Asia. The findings emphasize that if not properly conducted a standard destruction technology of a non-POP chemical can lead to a release of a range of more dangerous U-POPs into the environment.



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Test burn with PCB–oil in a local cement kiln in Sri Lanka

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A B S T R A C T

The production and use of polychlorinated biphenyls (PCBs) have ceased and most developed countries have disposed off their stocks long time ago. PCBs can however still be found in the environment and one important source is accumulated stocks in developing countries. Sound treatment of PCB is costly and most developing countries do not have dedicated hazardous waste incinerators or non-combustion technologies available for domestic disposal and can usually not afford export.

High temperature cement kilns have been used to treat organic hazardous wastes in developed countries for decades and shown to constitute a sound option if well managed and controlled. In contrast to dedicated hazardous waste incinerators and other treatment techniques, cement kilns are already in place in virtually every country and may constitute a treatment option. The objective of this study was therefore to carry out the first test burn with PCB–oil in a developing country cement kiln and to assess its feasibility and destruction performance.

The 3 d test burn demonstrated that the Sri Lankan cement kiln was able to destroy PCB in an irreversible and environmental sound manner without causing any new formation of PCDD/PCDF or HCB. The destruction and removal efficiency (DRE) was better than 99.9999% at the highest PCB feeding rate.

Cement manufacturers can contribute

Cement manufacturers can contribute to a successful implementation of the Basel and the Stockholm Convention by solving hazardous waste problems in feasible local kilns; by substitution of fossil fuels and virgin raw materials with wastes and biomass, and thereby reduce their carbon footprint; by minimizing risks and strive towards excellence and best practice; by reducing their over-all emissions proactively.

Successful co-processing

by Jean-Pierre Degré, Cementis, Switzerland & Kåre Helge Karstensen, Sintef, Norway

Co-processing of wastes and other low-grade resources in cement kilns offers a partial solution to sustainability issues ranging from resource scarcity via greenhouse gas emission reduction to waste generation. However, co-processing requires a professional approach from the industries involved as well as regulation and monitoring by the authorities to successfully lower the need for fossil fuels and virgin raw materials, and reduce CO_2 emissions. In this article, Cementis and Sintef present best practices that constitute a benchmark for cement plants co-processing AFRs and treating hazardous wastes.

Co-processing requires a professional approach from the industries involved and regulation and monitoring by the authorities to successfully reduce the need for fossil fuels and virgin raw materials and reduce CO_2 emissions

The development of a proper hazardous waste and low-grade resources management infrastructure is not only required to protect human health and the environment but it is also necessary to sustain further development of their economies. Many countries do not have a proper hazardous waste management infrastructure in place.

Often the generating industries and/or collectivities have limited options available to treat their wastes in a cost-effective and environmentally-sound manner. For example, liquid organic hazardous wastes, including oily wastes, are frequently used in small furnaces and boilers without any control or traceability.

Human and industrial activity leads to increased levels of waste generation, long before proper treatment means are available. Sometimes, temporary solutions are implemented, such as on-site storage or short-term landfilling. Countries are, therefore, faced not only with the management of current waste production, but also with the management of stockpiles of stored wastes.

On the other hand, with concrete being a basic construction and development element, increasingly large cement plants are built, requiring huge amounts of energy and minerals resources.

If professionally managed and perfectly controlled, the cement industry can offer a complete service, which is a viable, economical, local and environmentally sound option for treating many hazardous and non-hazardous industrial and municipal wastes. As compared to other treatment processes, co-processing in cement kilns requires no major investments as proper infrastructure is already in place. Moreover, it creates no liquid or solid residues. Therefore, cement kiln co-processing can be extremely attractive under proper guidance, regulation and control everywhere, including in emerging economies. However, the practice needs to be anchored in a national policy.

In October 2011, the UN COP 10 endorsed the proposal by the Secretariat of the Basel Convention for "Technical guidelines on the environmentally sound co-processing of hazardous wastes in cement kilns" (www.basel.int).

The cement industry

In 2010, worldwide cement production was over 3bnt, with China responsible for at least 60 per cent of this figure. Estimates put world cement consumption at over 3.5-4bnt by 2020 with the corresponding increases in energy, raw materials and pollutant mass emissions.

As shown in Figure 1, the most important ways to minimise the environmental and CO_2 impacts of the cement sector are:

- maximise the efficiency of the manufacturing process and associated equipment to use fuels and materials as efficiently as possible. With the development of Best Available Techniques (BAT) technologies, this savings potential will remain marginal in the future
- reduce the amount of traditional natural resources and fossil fuel used in the process by increasing the use of low-grade resources and wastes

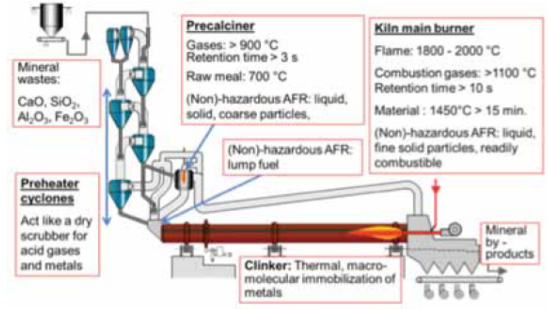


Figure 2: fuel feed points in the cement pyroprocessing system

Assessment of possible impacts

When a cement plant operator and the pre-processing facility have received information about the waste, they must:

- assess the potential impact of transporting, unloading, storing and using the material on the health and safety of employees, contractors, and the community. Ensure that equipment or management practices required to address these impacts are in place
- assess what personal protective equipment will be required for employees to safely handle the waste on site
- determine the compatibility of wastes as reactive or non-compatible wastes must not be mixed
- assess the effect the waste may have on the process operation. Chlorine, fluorine, sulphur and alkali content in wastes may build up in the kiln system, leading to accumulation, clogging, and unstable operation. Excess in chlorine or alkali may produce cement kiln dust or bypass dust (and may require installation of a bypass), which must be removed, recycled or disposed of responsibly. The heat value is the key parameter for the energy provided to the process. Wastes with high water content may reduce the productivity and efficiency of the kiln system. The ash content affects the chemical composition of the cement and may require an adjustment of the composition of the raw materials mix
- guage the potential impact on process stability and quality of the final product
- judge the effect the waste may have on plant emissions and whether new equipment or procedures are needed to ensure that there is no negative impact on the environment
- determine what materials analysis data the waste supplier will be required to provide with each delivery, and whether each load needs to be tested prior to off-loading at the site.

Commonly-restricted wastes

The following wastes are not acceptable for direct co-processing activities:

- electronic waste and entire batteries – very high levels of heavy metals
- infectious and biologically-active medical waste – those wastes must be managed in 'closed boxes' so there is a total lack of traceability if directly injected in a kiln
- mineral acids and corrosives – no added-value for the clinker process
- explosives
- asbestos – must be destroyed in a full melting process. The clinker production is only partially a melting process
- radioactive waste
- unsorted municipal waste – lack of traceability. MSW sorting is mandatory.

Wastes pre- and co-processing

The use of wastes must not detract from smooth and continuous cement kiln operation, product quality, or the site's normal environmental performance, implying that wastes used in cement kilns must be homogenous and have a stable chemical composition and heat content, and a pre-specified size distribution. Pre-processing and preparation with the objective of providing a more homogeneous feed and more stable combustion conditions may, therefore, be necessary.

Techniques used for waste pre-processing and mixing are wide ranging, and may include:

- mixing and homogenising of liquid wastes to meet input requirements, eg viscosity, composition and/or heat content
- shredding, crushing, and shearing of packaged wastes and bulky combustible wastes, eg tyres
- mixing of wastes in a bunker using a grab or other machine (eg sprelling machines for sewage sludge)
- production of refuse-derived fuel (RDF), usually produced from source separated waste and/or other non-hazardous waste.

Alternative resources and fuel feed points

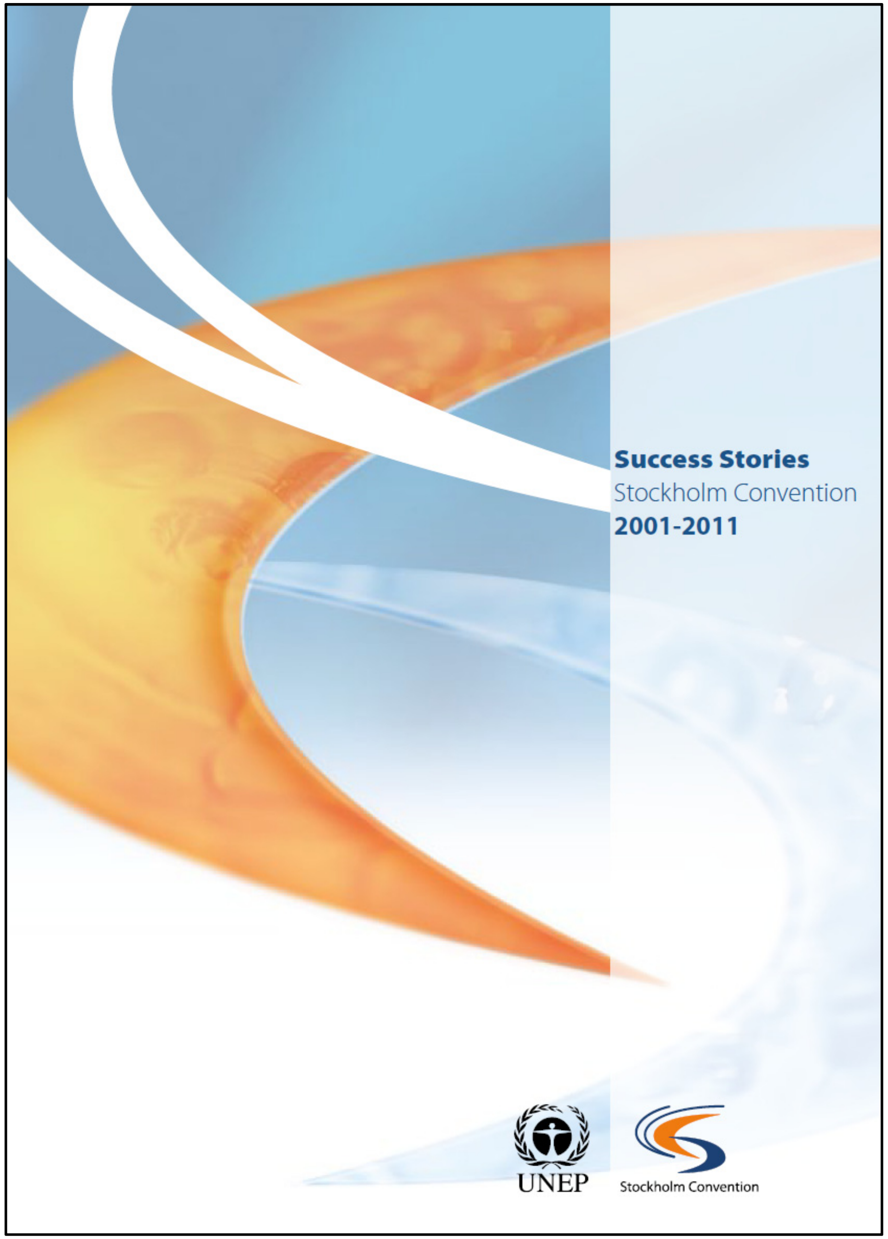
Fuel can be fed into the pyroprocessing system via the following points (see also Figure 2):

- main burner at the rotary kiln outlet end
- feed chute at the transition chamber at the rotary kiln inlet end (for lump fuel)
- fuel burners to the riser duct
- precalciner burners to the precalciner
- feed chute to the precalciner (for lump fuel)
- mid-kiln valve to long wet and dry kilns (for lump fuel).

> *The use of wastes must not detract from smooth and continuous cement kiln operation, product quality, or the site's normal environmental performance, implying that wastes used in cement kilns must be homogenous and have a stable chemical composition and heat content, and a pre-specified size distribution.*

Hazardous wastes co-processing

Hazardous wastes should be introduced in the high-temperature combustion zone of the kiln system, ie the main burner, the precalciner burner, the secondary firing at the preheater, or the mid-kiln (for long dry and wet kilns). Persistent organic pollutants (POPs) and highly-chlorinated organic compounds should be introduced at the main burner to ensure complete combustion due to the high combustion temperature and long retention time.



DESTRUCTION OF POPS IN DEVELOPING COUNTRIES BY USING LOCAL CEMENT KILNS

By Dr. Kåre Helge Karstensen, Chief Scientist, Foundation for Industrial and Scientific Research, Norway

Introduction

Environmentally sound disposal of POPs is costly and complicated, and export may not be affordable to many developing countries. In contrast to incinerators and other treatment techniques, cement kilns already exist in virtually every country and resorting to them may be feasible and cost-efficient for the treatment of POPs wastes and other types of wastes. For almost thirty years, the only treatment option in Norway for organic hazardous wastes and POPs has been high temperature cement kilns. The Foundation for Industrial and Scientific Research (SINTEF) has been instrumental in this development and the Norwegian Government wants to share and disseminate this knowledge within developing countries.

Co-processing of alternative resources and treatment of hazardous wastes in cement kilns should be restricted to BAT/BEP kilns. Emerging markets have the highest demand for construction and subsequently the highest ratio of modern newly built cement kilns, e.g. BAT/BEP kilns. In addition, China and India produce nearly two billion tons of cement (two-thirds of the world production), emitting approximately two billion tons of CO2. Waste treatment in cement kilns implies complete recovery of energy and valuable raw material components in the wastes, i.e. reducing the need for non-renewable fossil fuel and virgin raw materials and thereby contributing to overall reduced CO2 and other greenhouse gas emissions, compared to land filling, building a new incinerator or exporting.

Problem statement

A cement kiln has many inherent features which makes it ideal for hazardous waste treatment: high temperatures, long residence time, surplus oxygen during and after combustion, good turbulence and mixing conditions, thermal inertia, dry scrubbing of the exit gas by alkaline raw material (neutralises acid gases like hydrogen chloride), fixation of the traces of heavy metals in the clinker structure, no production of by-products such as slag, ashes or liquid residues and complete recovery of energy and raw material components in the waste.

It is however of outmost importance to apply best practice and lessons learned when implementing such practices and SINTEF, the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH and Holcim, one of the world's leading suppliers of cement and aggregates, developed best practice guidelines for co-processing of wastes in cement kilns during the period 2003-2006.

HAZARDOUS CHEMICALS MANAGEMENT: A STRATEGIC COOPERATION BETWEEN SINTEF AND AIT

By Dr. Kåre Helge Karstensen, Chief Scientist, Foundation for Industrial and Scientific Research, Norway

Introduction

The Global Environment Outlook of 2008 addresses increased waste generation as one of the biggest environmental challenges in Asia. Indeed, most Asian countries have weak knowledge and awareness about this issue, dispersed institutional responsibility and capacity, inadequate legislative and regulatory frameworks, and weak enforcement procedures when it comes to waste management.

Problem statement

As a result, Asian countries face some of the largest challenges regarding POPs management. For example, China has the world's biggest emissions of dioxins, while the southern and central parts of Vietnam have the highest dioxin-contaminated areas in the world. The spreading of semi-volatile chemicals such as POPs is further enhanced by global warming: rising temperatures will also make target organisms more vulnerable and worsen the negative impacts. Currently, according to the National Population and Family Planning Commission (NPFPC) of China, every 30 seconds a baby is born with physical defects due to chemical waste pollution. Professor Pan Jianping at the Women and Child Health Research Office in Xi'an Jiaotong University has warned that the increasing rate of birth defects among Chinese infants would soon become a social problem, which "will influence economic development and the quality of life".

How the issue was addressed

The School of Environment, Resources and Development of the Asian Institute of Technology (AIT) gives comprehensive courses in the field of Environmental Engineering and Environment. The Foundation for Industrial and Scientific Research (SINTEF) is one of Scandinavia's largest independent research institutions and has wide experience in solving practical hazardous waste related problems in several Asian countries.

Both AIT and SINTEF possess unique competences and experience with "immediately" available and affordable technologies which can significantly reduce the burden of hazardous chemicals in Asia, e.g. clean-up of contaminated soil by a combination of bio- and phytoremediation, or by using existing industrial facilities, e.g. cement kilns.

AIT for example has shown that phytoremediation, which exploits the ability of some plant species to remove, extract and/or mineralize contaminants and xenobiotics, can successfully remove and/or detoxify several contaminants in the soil. Local and fast-growing plant species with deep fibrous roots, such as grasses, are particularly useful.

As for waste treatment in cement kilns, this allows for the complete recovery of energy and valuable raw material components in the wastes, thereby reducing the need for non-renewable fossil fuel and virgin raw materials and contributing to overall reduced CO_2 and other greenhouse gas emissions compared to land filling, building a new incinerator or exporting the waste for treatment in another country.

A course on the "State-of-the-art of hazardous chemicals management" was developed jointly between AIT and SINTEF and has been given regularly since 2007. It provides updated and comprehensive training on hazardous chemicals management ranging throughout the whole life-cycle (from the generation of hazardous chemicals and their impact to the operation and performance verification of treatment facilities via the policy aspects). Practical examples are provided from Asian countries.

Implementation

The on-going cooperation between AIT and SINTEF on hazardous chemicals management started in October 2006. As part of this strategic cooperation, regular courses, regional seminars and technical cooperation activities were carried out in South-East Asia.

AIT courses

One of the normal course assignments for the students has been to elaborate how to avoid or minimise dioxin emissions from waste treatment plants and industry in practice. Field trips have been mandatory for the students and entailed visits to contaminated areas, hazardous waste incinerators, cement kilns co-processing wastes, etc.

A complete course description can be found on AIT's webpage: http://www.serd.ait.ac.th/karstensen

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Field trip to storage site for transformers containing PCBs in Thailand

© Kåre Karstensen

Field trip to hazardous waste incinerator in Bangkok, Thailand

A Cement Industry Partnership with UNEP on Mercury

Accountable for 10% of anthropogenic mercury emissions, a partnership with UNEP represents an unique opportunity for the cement industry to address a serious threat to health and environment.

A successful cooperation will require dedication, transparency, willingness to conduct testing, document and share information, and to address possible challenges in a responsible and proactive manner.

A successful partnership will contribute to improve the industry's reputation and to reduce its ecological footprint.

Co-processing alternative fuels and raw materials and treatment of organic hazardous wastes in cement kilns

- Cement kilns are in operation in "all" countries;
- Facilities and infrastructure are already in place;
- Recovers energy & recycle materials; conserves non-renewable resources;
- Inherent features, e.g. time & temperatures, are excellent for organic hazardous waste destruction;
- Usually no residues to dispose of compared to 30% in DI;
- Emissions will normally be unaffected if properly operated;
- Reduces disposal costs and CO_2 emissions compared to landfilling and incineration;
- New cement kilns in DCs are always BAT.

Summary of recommendations and best practice for co-processing

- An approved EIA and all necessary national/local licenses.
- Compliance with all relevant national and local regulations.
- Compliance with the Basel and the Stockholm Convention.
- An approved location, technical infrastructure and processing equipment.
- Reliable and adequate power and water supply.

Summary of recommendations and best practice for co-processing

- Adequate air pollution control devices and continuous emission monitoring ensuring compliance with regulation and permits - needs to be verified through regular baseline monitoring and reporting.

- Rapid exit gas conditioning/cooling and low temperatures (<200^0C) in the air pollution control device to prevent U-POP formation.

- Clear management and organizational structure with unambiguous responsibilities, reporting lines and feedback mechanism.

Summary of recommendations and best practice for co-processing

- An error reporting system for employees.
- Qualified and skilled employees to manage wastes and health, safety and environmental issues.
- Adequate emergency and safety equipment and procedures, and regular training.
- Authorized and licensed collection, transport and handling of wastes.
- Safe and sound receiving, storage, preparation and feeding of wastes.

Summary of recommendations and best practice for co-processing

- Adequate laboratory facilities and equipment for waste acceptance and feeding control.
- Demonstration of wastes destruction performance through test burns.
- Adequate record keeping of wastes and emissions.
- Adequate product quality control routines.

Summary of recommendations and best practice for co-processing

- An environmental management and continuous improvement system certified according to ISO 14001, EMAS or similar.
- Regular independent audits on all aspects of co-processing and independent emission monitoring and reporting.
- Regular stakeholder dialogues with local community and authorities, and for responding to comments and complaints.
- Open disclosure of performance reports on a regular basis.