Incinerator performance: effects of changes in waste input and furnace operation on air emissions and residues

Waste incineration can be considered a robust technology for energy recovery from mixed waste. Modern incinerators are generally able to maintain relatively stable performance, but changes in waste input and furnace operation may affect emissions. This study investigated how inorganic air emissions and residue composition at a full-scale incinerator were affected by known additions of specific waste materials to the normal municipal solid waste (MSW) input. Six individual experiments were carried out (% ww of total waste input): NaCl (0.5%), shoes (1.6%), automobile shredder waste (14%), batteries (0.5%), poly(vinyl chloride) (5.5%) and chromate-cupper-arsenate impregnated wood (11%). Materials were selected based on chemical composition and potential for being included or excluded from the waste mix. Critical elements in the waste materials were identified based on comparison with six experiments including ‘as-large-as-possible’ changes in furnace operation (oxygen levels, air supply and burnout level) only using normal MSW as input. The experiments showed that effects from the added waste materials were significant in relation to: air emissions (in particular As, Cd, Cr, Hg, Sb), element transfer coefficients, and residue composition (As, Cd, Cl, Cr, Cu, Hg, Mo, Ni, Pb, S, Sb, Zn). Changes in furnace operation could not be directly linked to changes in emissions and residues. The results outlined important elements in waste which should be addressed in relation to waste incinerator performance. Likely ranges of element transfer coefficients were provided as the basis for sensitivity analysis of life-cycle assessment (LCA) results involving waste incinerator technologies.
Chemical composition of material fractions in Danish household waste

The chemical composition of Danish household waste was determined by two approaches: a direct method where the chemical composition (61 substances) of 48 material fractions was determined after hand sorting of about 20 tonnes of waste collected from 2200 households; and an indirect method where batches of 80-1200 tonnes of unsorted household waste was incinerated and the content of the waste determined from the content of the outputs from the incinerator. The indirect method is believed to better represent the small but highly contaminated material fractions (e.g., batteries) than the direct method, because of the larger quantities included and the more homogenous material to sample from.

Differences between the direct and the direct methods led to corrections in the of heavy metal concentration of a few fractions. The majority of the energy content of the waste originates from organic waste like paper, cardboard anti organic fractions. The single fraction contributing most to the total energy content is the non-recyclable plastic fraction, contributing 21% of the energy content and 60% of the chlorine content, although this fraction comprises less than 7% by weight. Heavy metals originate mainly from inert fractions, primarily batteries.

Combustion Aerosols from municipal Waste Incineration – Effects of Feedstock Composition and Boiler Operation,

General information
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Organisations: CHEC Research Centre, Department of Chemical and Biochemical Engineering, Department of Environmental Engineering, Residual Resource Engineering, Technical University of Denmark
Publication date: 2009

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Source: orbit
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Research output: Chapter in Book/Report/Conference proceeding → Article in proceedings – Annual report year: 2009 → Research → peer-review
Environmental assessment of waste incineration in a life-cycle-perspective (EASEWASTE)

A model for life-cycle assessment of waste incinerators is described and applied to a case study for illustrative purposes. As life-cycle thinking becomes more integrated into waste management, quantitative tools for assessing waste management technologies are needed. The presented model is a module in the life-cycle assessment model EASEWASTE. The module accounts for all uses of materials and energy and credits the incinerator for electricity and heat recovered. The energy recovered is defined by the user as a percentage of the energy produced, calculated on the lower heating value of the wet waste incinerated. Emissions are either process-specific (related to the amount of waste incinerated) or input-specific (related to the composition of the waste incinerated), while mass transfer to solid outputs are governed by transfer coefficients specified by the user. The waste input is defined by 48 material fractions and their chemical composition. The model was used to quantify the environmental performance of the incineration plant in Aarhus, Denmark before and after its upgrading in terms of improved flue gas cleaning and energy recovery. It demonstrated its usefulness in identifying the various processes and substances that contributed to environmental loadings as well as to environmental savings. The model was instrumental in demonstrating the importance of the energy recovery system not only for electricity but also heat from the incinerator.
Scopus rating (2008): SJR 0.537 SNIP 0.966
Web of Science (2008): Indexed yes
Original language: English
DOIs:
10.1177/0734242X08088583
Source: orbit
Source ID: 211743
Research output: Contribution to journal › Journal article – Annual report year: 2008 › Research › peer-review

**Miljøvurdering af affaldsforbrænding og alterniver**

**General information**
Publication status: Published
Organisations: Residual Resource Engineering, Department of Environmental Engineering
Contributors: Møller, J., Fruergaard, T., Riber, C., Astrup, T., Christensen, T. H.
Publication date: 2008

**Publication information**
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ENV2008-098.pdf
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Research output: Book/Report › Report – Annual report year: 2008 › Research

**Partitioning of Trace Elements in a WtE boiler; The Influence of Different Waste Types**

**General information**
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Organisations: CHEC Research Centre, Department of Chemical and Biochemical Engineering, Residual Resource Engineering, Department of Environmental Engineering, Technical University of Denmark
Publication date: 2008

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Publisher: Environmental Expert
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Research output: Chapter in Book/Report/Conference proceeding › Article in proceedings – Annual report year: 2008 › Research › peer-review

**Evaluation of waste specific environmental impacts from incineration**

**General information**
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Organisations: Department of Environmental Engineering
Contributors: Riber, C.
Number of pages: 35
Publication date: Dec 2007

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Publisher: DTU Environment
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Electronic versions:
MR2007_170.pdf
Source: orbit
Source ID: 206853
Combustion aerosols from municipal waste incineration - Effect of fuel feedstock and plant operation

Combustion aerosols were measured in a 22MW (thermal energy) municipal waste incinerator. Different types of waste fractions were added to a base-load waste and the effect on aerosol formation was measured. The waste fractions applied were: PVC plastic, pressure-impregnated wood, shoes, salt (NaCl), batteries, and automotive shredder waste. Also, runs with different changes in the operational conditions of the incinerator were made. Mass-based particle size distributions were measured using a cascade impactor and the number-based size distributions were measured using a Scanning Mobility Particle Sizer. The plant is equipped with flue gas cleaning and the penetration through this was determined. The particle morphology was investigated by Transmission Electron Microscopy (TEM) and chemical analysis of the aerosol particles was made by Energy Dispersive X-ray Spectroscopy (EDS). The mass-based particle size distribution was bimodal with a fine mode peak around 0.4 mm and a coarse mode peak around 100 µm. The addition of NaCl, shredder waste, and impregnated wood increased the mass concentration of fine particles (aerodynamic diameter below 2.5 µm). In general, the mass concentration was stable and close to the reference PM2.5-value of 252 +/- 21mg/m³ (std. T, P). The total number concentration deviated during runs and between runs spanning from 43.10^6 to 87.10^6#/cm³ (std. T, P). The aerosols formed were mixtures of dense and aggregated particles in all tests. The fine particles are mainly composed by alkali salts, zinc, and lead. The heavy metals Cu, Cd, Hg, and Pb are significantly enriched in the fine particles.
Experience with the use of LCA-modelling (EASEWASTE) in waste management

General information
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Web of Science (2007): Indexed yes
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DOIs: 10.1177/0734242X07079184
Source: orbit
Source ID: 201341
Research output: Contribution to journal › Journal article – Annual report year: 2007 › Research › peer-review

Indirect Determination of Chemical Composition and Fuel Characteristics of Solid Waste: Methodology and Application
Determination of chemical composition of solid waste can be performed directly or indirectly by analysis of combustion products. The indirect methodology instrumented by a full scale incinerator is the only method that can conclude on elements in trace concentrations. These elements are of great interest in evaluating waste management options by for example LCA modeling.
A methodology description of indirect determination of chemical composition and fuel properties of waste is provided and validated by examples.
Indirect analysis of different waste types shows that the chemical composition is significantly dependent on waste type. And the analysis concludes that the transfer of substances in the incinerator is a function of waste chemical content, incinerator technology and waste physical properties. The importance of correct representation of rare items in the waste with high concentrations of toxic elements is shown exemplified by Hg. The average concentration is evaluated to be affected by three occurrences; background, rare items and very rare items (1/800 tonnes), that are all important to the Hg average concentration.

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Organisations: Department of Environmental Engineering
Contributors: Riber, C., Christensen, T. H.
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Keywords: Indirect analysis, Waste characterization, Waste incineration, Household waste, Fuel properties of waste

Life-cycle assessment of waste incinerators - the significance of increasing air pollution control on the environmental impact

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Organisations: Department of Environmental Engineering
Contributors: Damgaard, A., Riber, C., Hulgaard, T., Christensen, T. H.
Publication date: 2007

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Method for fractional solid-waste sampling and chemical analysis

Chemical characterization of solid waste is a demanding task due to the heterogeneity of the waste. This article describes how 45 material fractions hand-sorted from Danish household waste were subsampled and prepared for chemical analysis of 61 substances. All material fractions were subject to repeated particle-size reduction, mixing, and mass reduction until a sufficiently small but representative sample was obtained for digestion prior to chemical analysis. The waste-fraction samples were digested according to their properties for maximum recognition of all the studied substances. By combining four subsampling methods and five digestion methods, paying attention to the heterogeneity and the material characteristics of the waste fractions, it was possible to determine 61 substances with low detection limits, reasonable variance, and high accuracy. For most of the substances of environmental concern, the waste-sample concentrations were above the detection limit (e.g. Cd > 0.001 mg kg\(^{-1}\), Cr > 0.01 mg kg\(^{-1}\), Hg > 0.002 mg kg\(^{-1}\), Pb > 0.005 mg kg\(^{-1}\)). The variance was in the range of 5-100%, depending on material fraction and substance as documented by repeated sampling of two highly different material fractions ('Vegetable food' and 'Shoes, leather, etc.'). Statistical analysis showed for the 'Vegetable food' that the variance could not be attributed to a single step in the procedure, whereas in the case of 'Shoes, leather, etc.', the first coarse shredding was the main source of variance (20-85% of the overall variation). Only by increasing the sample size significantly can this variance be reduced. The accuracy and short-term reproducibility of the chemical characterization were good, as determined by the analysis of several relevant certified reference materials. Typically, six to eight different certified reference materials representing a range of concentrations levels and matrix characteristics were included. Based on the documentation provided, the methods introduced were considered satisfactory for characterization of the chemical composition of waste-material fractions. ©PY 2007 Taylor & Francis.
Second generation methodology for chemical characterization of solid waste fractions

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Contributors: Riber, C., Astrup, T., Christensen, T. H.
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Experiences on the use of LCA-modeling (EASEWASTE) in waste management

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Volume: CD-ROM
Place of publication: Copenhagen
Publisher: The International Solid Waste Association
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Måling af tungmetaller i dansk dagrenovation og småt brændbart

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Organisations: Department of Environmental Engineering
Contributors: Riber, C., Christensen, T. H.
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Characterization of solid waste by direct and indirect analysis

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Organisations: Department of Environmental Engineering
Contributors: Riber, C., Christensen, T. H.
Publication date: 2005

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Volume: Proceedings. CD-ROM
Place of publication: Cagliari, Italy
Publisher: CISA, Environmental Sanitary Engineering Centre
Editors: Cossu, R., Stegmann, R.
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Source ID: 183538
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Heavy metal content of combustible municipal solid waste in Denmark

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