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SHORT-TERM AND LONG-TERM DIOXIN SAMPLING AND ANALYSIS AT A MSW INCINERATOR IN TAIWAN

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Introduction

With a population of 22.3 million Taiwan has one of the highest population densities (616 persons per km²) in the world [1]. Taiwan's Environmental Protection Administration (ROCEPA) has adopted "incineration first, landfilling second" as Taiwan's municipal waste management policy in 1991. Of the 32 planned MSW incinerators 19 are already operating [2]. With increasing number of incinerators, public concern about dioxin concentrations in the environment is rising. Thus ROCEPA stipulated an emission limit for large-scale incinerators (>10 t/hr) of 0.1 ng I-TEQ/Nm³ PCDD/PCDF on par with emission control in advanced countries[3].
In order to evaluate continuous monitoring of PCDD/F a project was set up comprising

- Demonstration of a dioxin continuous emission monitoring system (CEMS) at a MSW incineration plant
- Completion of suitability test for a dioxin CEMS
- Formulation of a technical specification for dioxin CEMS as basis for future regulations

Taipei City operates its three waste-to-energy plants in Neihu, Mucha and Peitou since 1991, 1995 and 1999 respectively. Peitou plant was selected for demonstrating dioxin CEMS and completion of suitability test. Peitou plant has four incineration lines with a total design capacity of 1,800 tons/day [4]. The stoker-type plant is equipped with economizer, semi-dry scrubber, and bag filter [5].
After public tendering, the dioxin long-term sampling system AMESA® was chosen as CEMS. Following laboratory testing in Germany one standard AMESA® equipment was installed at Peitou incineration plant. As an extra feature the control cabinet was equipped with an air conditioning system due to the hot and humid climate in Taiwan. Furthermore the remote control software AMLEIT was set up for online checking. The function of this CEMS and its options are explained in detail elsewhere [6,7,8].

Methods and Materials

To reach the requirements of the 17th ordinance (17. BImSchV) to the German Federal Immission Control Law, long-term sampling systems have to be tested according to the guidelines for the qualification testing of systems for continuous monitoring of emissions of specific substances [9]. In 1996/1997 a certification test was carried out and in 1998 the German Government announced AMESA® as capable for long-term monitoring of PCDD/PCDF emissions that underlie the regulations of the 17. BImSchV [10, 11].
Accordingly the test performed in Taiwan focused on critical items due to differences between European and Taiwanese regulations and situation. Taiwan's regulations for sampling and analysis follow mainly US EPA method 23 and not European EN 1948 [12, 13]. Taiwan's garbage has average water content of 55.5% - varying with season - which is mainly due to the high proportion of kitchen waste and the subtropical climate. Low heat value averages 5,740 kJ/kg [14].
Parallel to AMESA® one manual sampling equipment (Environmental Supply Company C-5000 Source Sampling System) was used for reference during short-term sampling (4 to 6 hrs). For

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quality control 7 out of total 30 pairs were taken with a second, identical manual sampling equipment (i.e., 7 sets of 3 simultaneous samples). National Institute of Environmental Analysis (NIEA) of ROCEPA analyzed 80 samples according to NIEA A808.70B and GfA Gesellschaft für Arbeitsplatz- und Umweltanalytik mbH analyzed 7 samples according to USEPA method 23.
In order to proof the validity of data, outlier determination was performed adopting a method previously applied by US EPA to paired samples by Method 5 and CEMS of dust measurements[15].
"Relative Standard Deviation (RSD)" is a factor of uncertainty and defined as

$$RSD = \frac{SD}{M} \times 100\% \qquad SD = \sqrt{\frac{n\sum y^2 - (\sum y)^2}{n^2}}$$

Where SD = Standard Deviation
n = Number of samples
y = Difference in concentration results between AMESA® and manual method, and
M = Mean value.

Results and Discussion
Adopting an RSD of 35% for this outlier test resulted in 7 pairs being invalid. The linear regression of the remaining pairs revealed y = 1.6062 x - 0.0186 and an R-value of 0.9012.
For evaluating possible reasons causing the outlier samples all data were carefully checked covering the whole process from sampling to analysis including operation conditions. According to the recovery rates of each standard solutions and isokinetic suction rate, the quality of both AMESA® and manual sampling procedures and analysis procedures in both labs were acceptable and did not show irregularities. Detailed investigation and additional analyses of washing solutions and condensate were performed revealing an average loss of 25.9% (relative to emission limit value). The loss in the condensate was 0.04%. Thus the loss mainly originates from the probe of AMESA® and was attributed to extraordinary, yet unknown dust properties.
After compensation of the probe loss, the slope rate of original linear regression equation was revised from 1.6020 to 1.249. Other coefficients and intercepts do not change.
Besides the probe loss, AMESA® met all other requirements of the suitability test. For Peitou plant it is suggested to clean the probe by solvents after each sampling and to analyze the solvent together with the sample until the reason for the probe loss and a resolution are found. To simplify the cleaning procedure probes with changeable inner tubes are available that reduce the work of dismantling and cleaning to a few minutes.
The first period of short-term sampling (4 - 6 hours per sample) was performed after start-up of the incinerator. Each sample was taken on consecutive days revealing high PCCD/F concentrations at the first day and gradually falling concentrations the following days (Figure 1). This pattern is known as memory effect and lasted several days after startup.
The relationship between operation conditions and total PCDD/F concentrations were evaluated. Parameters included furnace loading, furnace temperature, limestone injection amount, activated carbon injection amount, flue gas flow rate, concentration of HCl, SOx, NOx and CO in flue gas among others. The best, still vague correlation was found to be particulate matter with y = 0.024 x – 0.0166 (R^2 = 0.3898) and y = 0.0565 x – 0.0865 (R^2 = 0.303) for AMESA and manual short-term samples, respectively.
The congener distribution shows a general dominance of PCDF over PCDD with an average of 2.1 (Figure 2) varying from 0.8 to 6.9. The ranking within PCDF in each group as well as among different groups is stable showing PeCDF>HxCDF>TCDF>HpCDF>OCDF. PCDD distributions are more variable, both within and among group comparison with a tentative ranking HxCDD>PeCDD>TCDD>HpCDD>OCDD.

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References

1. Census Bureau, Directorate-General of Budget, Accounting & Statistics (DGBAS), Executive Yuan, Taiwan, R.O.C. (2003) 2000 Population and Housing Census, http://www.dgbas.gov.tw/census~n/six/lue5/census_p&h&E.htm
2. ROCEPA (2002) Administrator Hau: Policy of One Incinerator for Each City and County to Stay, Environmental Policy Monthly Vol. V, Issue 12, http://www.epa.gov.tw/english/EPM/
3. ROCEPA (2001) New Dioxin Standards Set for Small and Medium Incinerators, Environmental Policy Monthly Vol. III, Issue 10, http://www.epa.gov.tw/english/EPM/
4. ROCEPA (2003) Implementation of the Construction Project of Waste to Energy Plants in Taiwan, http://www.epa.gov.tw/english/OFFICES/plant.htm
5. Bureau of Environmental Protection, Taipei City Government (2003) Peitou Incinerator, http://www.ptrip.gov.tw/english%20site/index.htm
6. W. Funcke, H. Linnemann, Ch. Phillipp (1993) Long-term-Sampling Method for Polychlorinated Dibenzofurans (PCDF´s) and Dibenzo (p) dioxins (PCDD´s) in Flue Gas of Combustion Facilities, Chemosphere, 26, 2097-2101
7. E. Becker, J. Reinmann, W. Rentschler, J. Mayer (2000) Continuous Monitoring of the Dioxin-/Furan-Emissions of all Waste Incinerators in Belgium, Organhalogen compounds, Vol. 49S, 21 -23
8. Jürgen Reinmann, Werner Rentschler, Ernst Becker (2001) New Results and Features of the Continuous Dioxin-/Furan Monitoring System AMESA, Organohalogen Compounds, Vol. 50, 99-102
9. German Federal Ministry of the Environment, Conservation, and Nuclear Safety (1998) Uniform Federal Practice for Emission Monitoring, – Federal Ministry for the Environment circular dated June 8, 1998 – IG I 3 – 51 134/3 –
10. Wilbring P, Gerchel B (1997) TÜV Rheinland Sicherheit und Umweltschutz GmbH, Cologne, report 936/805017B
11. Gemeinsames Ministerialblatt, Bundesministerium des Innern (1998) 49. Jahrgang, Bonn, 13. Januar, 1998, ISSN 0939-4729
12. NIEA A807.70C (Sampling of PCDD/Fs from duct emission, 排放管道中戴奥辛及夫喃採樣方法
13. NIEA A808.70B (Analysis of PCDD/Fs from duct emission, 排放管道中戴奥辛及夫喃檢驗方法
14. ROCEPA (2002) Percentage of Recyclables in Taiwan Garbage Remains High, Environmental Policy Monthly Vol. V, Issue 9, http://www.epa.gov.tw/english/EPM/
15. Energy and Environmental Research Corporation, Morrisville (1996) Site-specific Quality Assurance Test Plan: Particulate Matter CEMS Demonstration, DuPont Inc. Experimental Station On-Site Incinerator, Wilmington, DE, Volume 1

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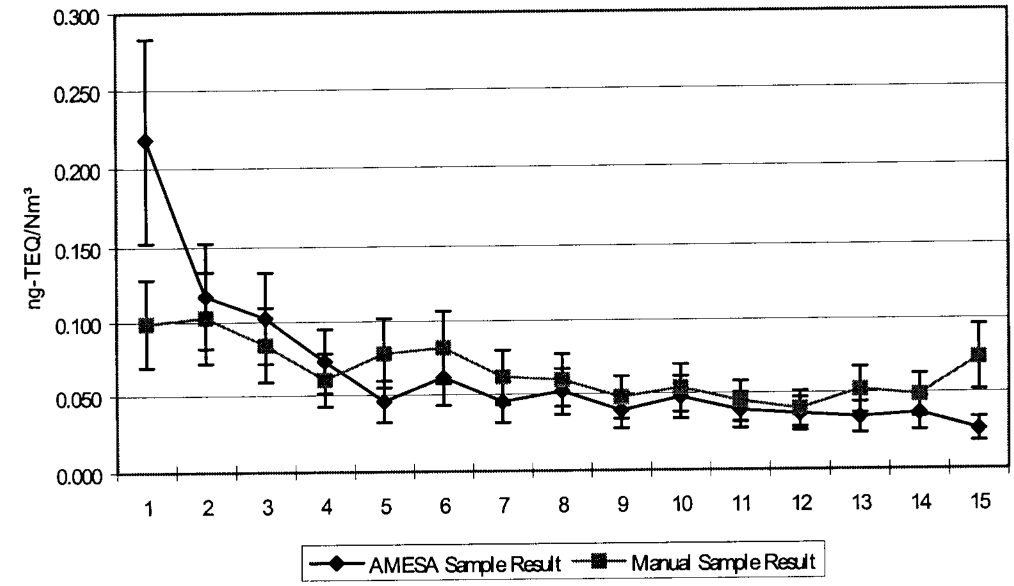

Figure 1: Memory effect after startup during first days of short-term sampling (1 sample per day) with bars indicating RSD of 35%. Results of AMESA® as shown are not compensated for probe loss. Onsite documentation for day 1 suggests that the result of manual sampling might be too low.

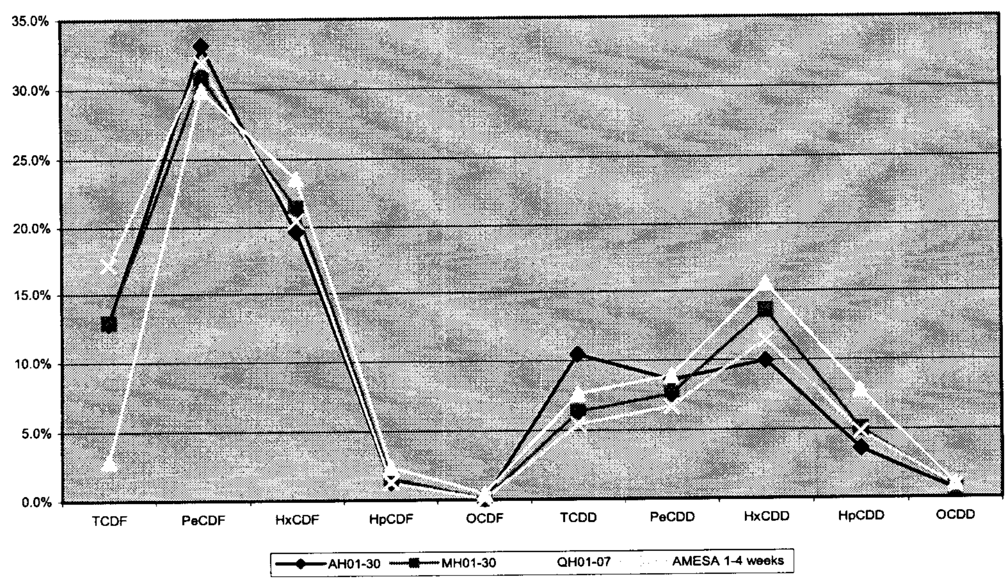

Figure 2: Congener distribution of short-term samples (AH01-30: AMESA®, MH01-30: manual, QH01-07: manual QC) and long-term samples (AMESA®). Shown are the relative distributions for mean values based on ng I-TEQ/Nm³.