INTEGRATED ASSESSMENT OF PCDD/F EMISSIONS TO AIR FROM OPEN BURN SITES IN THE PHILIPPINES

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Introduction

The Philippines Study on Dioxin and Furan Emissions (Funded under the Canada Persistent Organic Pollutants Fund through Canadian International Development Agency (CIDA) on behalf of the Government of Canada) was conceived to better understand open burning processes in the Philippines, their contributions PCDD/PCDF emissions and associated health risks. The first and second inventory of dioxin and furan emissions in the Philippines indicated that open burning was the highest contributor to PCDD/F emissions, accounting for 45% of total emissions. These data were based on using the UNEP Dioxin Toolkit emission factors, rather than on site-specific experimental data and due to a lack of local information, did not account for emission from trash burning or garbage disposal site burning. This project sought to help better understand the uncertainties through a series of consultant studies undertaken by Hatfield Consultants (Canada), International Technology Management Corporation (Philippines) and RMSI (India). The study presented here utilized the data produced from these consultant investigations to quantify the dioxin emissions at the municipal and national level in order to better understand the contribution of open burning to dioxin emissions in the Philippines.

Materials and methods

Simulated burning tests: Hatfield Consultants Partnership was retained by the World Bank to assess PCDD/F exposure pathways and calculate emission factors associated with waste burning. The approach consisted of air sampling of two types of uncontrolled open burning sources: (i) spontaneous seasonal combustion of waste at a case-study dumpsite (Calajunan Dumpsite, Iloilo, Philippines) and (ii) representative backyard burns. Dumpsite waste (20 kg) was collected and burned in a number of controlled burn trials to simulate combustion emissions that could be expected from spontaneous fires at the dumpsite. The composition of municipal waste in the Calajunan dumpsite is reported to be: 32.9% kitchen waste, 21% paper, 15% plastic, 13% yard waste, 6.8% other inorganics and under less than 5% each for textiles, rubber/leather, metal, glass, special, and other organics (Iloilo City 2003). A total of 52 samples were collected, consisting of 16 air, 13 soil, four ash, seven sediment, and 12 tissue samples. In total, 11 simulated burn samples were collected at the Calajunan dumpsite, while three backyard burn samples were collected in neighboring barangays. Air sampling was based on high volume samplers (15 L/min ; 0.9 m3/hr), E-samplers for particulates, and a TSI Dust Trak aerosol monitor to record real-time PM2.5 concentrations in air.

Survey data: The International Technology Management Corporation (hereafter 'INTEM', Makati City, Philippines) was retained to identify, characterize and quantify the sources of dioxin and furan emissions from waste management in ten (10) municipalities. This project employed survey methodology to collect information on the city/municipality, its burning practices (solid waste- backyard and dumpsite, agricultural waste, upland forests, agricultural slash and burn and others) and activities associated with those burning practices. Additional information was collected on the methods, frequency, seasonality, geographic extent, engaged population and type of materials burned.

Scaling of burning tests and survey data to country-wide emissions: Estimation of the emissions from the different waste sources employed the experimental emission factors from simulated burns on site for backyard burning and landfill burns, and applied these factors to the burned waste survey data from ten municipalities and cities. Other emission factors, mainly derived from the dioxin toolkit, were employed to estimate total emissions from agricultural residue burning and charcoal production from coconut shell burning. To enable extrapolation of the highly resolved city data to country-wide open burn emissions, crop production data were used as obtained from the Philippine Bureau of Agricultural Statistics. The emission estimates were compared against

those from the original emissions inventory, and corrections implemented. It should be noted that the original inventory did not have local experimental data, nor emissions from dumpsites and backyard thrash burning.

Results and discussion:

Survey results: Ten cities and municipalities were surveyed to collect and review available information on the demographics of the city/municipality, its burning practices (solid waste- backyard and dumpsite, agricultural waste, upland forests, agricultural slash and burn and others) and activities associated with those burning practices.

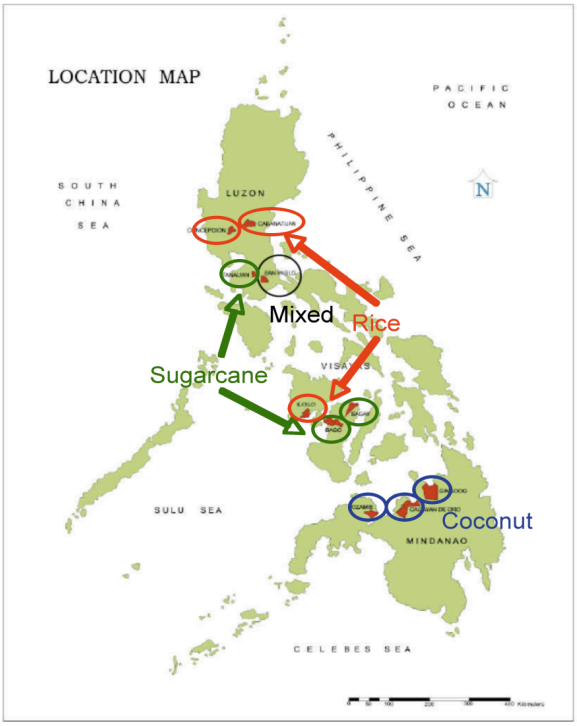

Figure 1. Location of ten cities surveyed.

The key-findings for the cities of Iloilo, Cabanatuan, Bago, Concepcion, Gingook, Ozamis, Sagay, San Pablo, Tanauan, and Cagayan de Oro, which capture different agricultural production centers (Figure 1), are:

- Of rural households, 25-70% burn their waste; in urban households this ranges from 2-58%.
- The household waste burned is dominated by yard waste, plastic and paper, with lower contributions of wood, styrofoam and Tetrapack.
- The self-reported amount of household waste burned (per day) ranges from 0.5-7.2 kg for urban and 0.5-4.9 kg for rural households
- Non-household waste burned includes agricultural residue, open dump sites, and kaingin.

Simulated burn emission factors: Based on measured data, emission factors for simulated dumpsite burns (barrel) range from 19-1178 ng/kg (n=2), those for simulated backyard burns range from 84-2,541 ng/kg (mean of 934 ng/kg; n = 3), the backyard burn was 7,215 ng/kg.

It should be noted that the waste composition between the burns was different (Table 1). The presence of Styrofoam appears to reflect higher EFs, and the presence of plastic has no impact on the emissions. The presence of metal products (not specified) in the backyard burn results in the highest EF, possibly due to the presence of catalysts such as copper and aluminum, which promote the formation of PCDD/F.

Table 1. Estimated Waste Composition Between Simulated Burns

	Sim. Dumpsite - barrel		***Sim. Backyard***			***Backyard***
Grass/wood/leaves	20%	15%	50%	50%	60%	15%
Food waste	-	5%	-	5%	10%	-
Glass	10%	10%	-	-	-	10%
Household trash	15%	-	20%	10%	10%	20%
Metal products	-	-	-	-	-	10%
Paper products	25%	20%	10%	15%	15%	20%
Plastic	25%	20%	20%	15%	5%	20%
Styrofoam	5%	10%	-	5%	-	5%
EF, ng/kg	***19***	***1,178***	***176***	***2,541***	***84***	***7,215***

The simulated value of 2,541 ng/kg was chosen to reflect emissions from backyard burning. This is much higher than the UNEP Toolkit EF of 300 ng TEQ/kg, but falls within the range of EFs reported from experimental studies (e.g. EU values range from 75-3,230 ng TEQ/kg). The dumpsite EF was 1,178 ng/kg, based on in situ measurements. Otherwise, Toolkit EFs were used for agricultural burns (30 ng/kg), kaingin (5 ng/kg), charcoal (3 ng/kg), and copra (0.007 ng/kg).

Emissions Estimates in Surveyed Municipalities: The TEQ emissions increased 7.5-fold when using the measured instead of the Toolkit emissions factors, ranging from 5 g TEQ/a for Iloilo to 60 g TEQ/a for CDO. There is wide variation among the cities depending on the amount of household waste generated and burned which, as mentioned earlier, depends to a large extent on the fraction of rural barangays included in the survey. Figure 2 shows the separate emissions resulting from each burn activity, based on total mass burned, rather than area-specific activity coefficients, because area was not available for all burn scenarios. It is clear that emissions are dominated by backyard burns when the measured emission factors are used. Using these factors for dumpsite burns, the contribution to emissions at most is 10-15%.

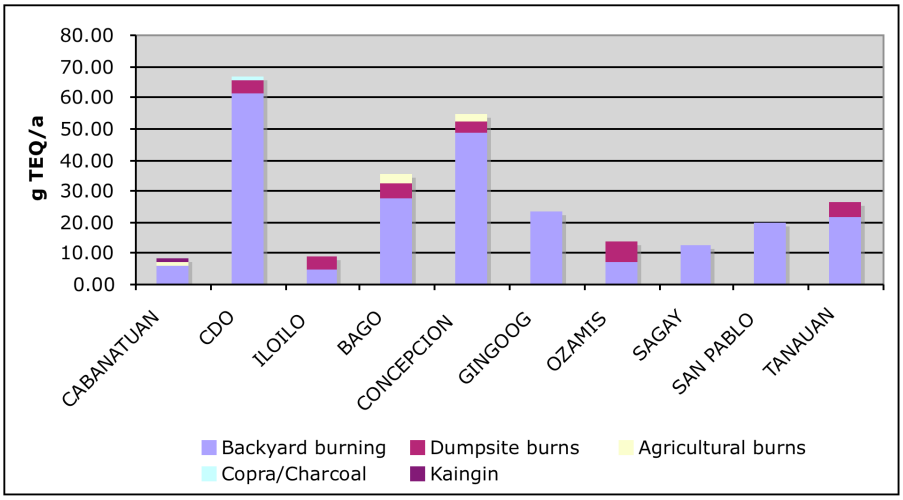

Figure 2. Waste-specific dioxin emissions based on measured and Toolkit emission factors

National Emissions Estimates from Open Burning: To scale all emissions sources to country-wide total emissions (Figure 2), assumptions were made based on the survey and national statistics data. Since the majority of agricultural burning is associated with rice and sugar cane, corn and coconut/copra drying, we calculated an area-specific activity coefficient (tons burned per hectare and per year), derived from the Intem survey data. Using the total planted crop area reported by the Agricultural Statistics Bureau for 2000 and 2007 (latest data available), the AC for each crop and using the Toolkit emission factors, the annual emissions amount to 512.7 gTEQ/a for rice, 59.7 g TEQ/a for sugarcane, and 802.5 gTEQ/a for all four crops considered. Satellite imagery analysis was used to estimate the impact of kaingin on dioxin emissions. By taking into account the total area percent of thermal anomalies in the forest (e.g. 1% in 2000), and the number of thermal anomalies detected per year (e.g. 1,248 in 2008), the average area per fire can be established (e.g. 0.84 ha/fire). When the degraded forest area, and the biomass weight per unit area are known, the total emissions were calculated to be less than 1 g TEQ in 2008.

For open dumpsites, the Intem data indicate that 3,745 tons of waste burn per year and that 60% of the dumpsites burn. DENR statistics indicate that in 2009 fourth quarter (latest data) there were 838 dumpsites, resulting in a total contribution of 2,218 g TEQ/a (2009). Intem's survey indicated that dumpsites may only burn for three months out of the year and that mainly the top 0.2 m. of the dumpsite is affected. These data need better resolution in the future. Based on the Philippines census data, 12 M. tons of waste is produced per year. The 2000 census further indicates that nation-wide 46% of households burn their waste; this number went down to an average of 31% by 2009. Using average burned waste of 722 kg/household per year and the experimental emission factor, 5,870 g TEQ/a was produced in 2000 vs. 3,868 g TEQ/a in 2010.

The results in Figure 3 indicate that open burning processes contribute 97% to the total national inventory, and that thus the 2004 Inventory significantly underestimated emissions. It should be noted that at the time of the

last inventory, the only open burn processes that were considered related to agricultural residue burns (mainly palay, sugarcane, corn, copra, and kaingin). As indicated in the figure, these sources account for about 9% of the inventory. The main contributions are derived from dumpsite and backyard burn emissions, representing 24% and 64%, respectively.

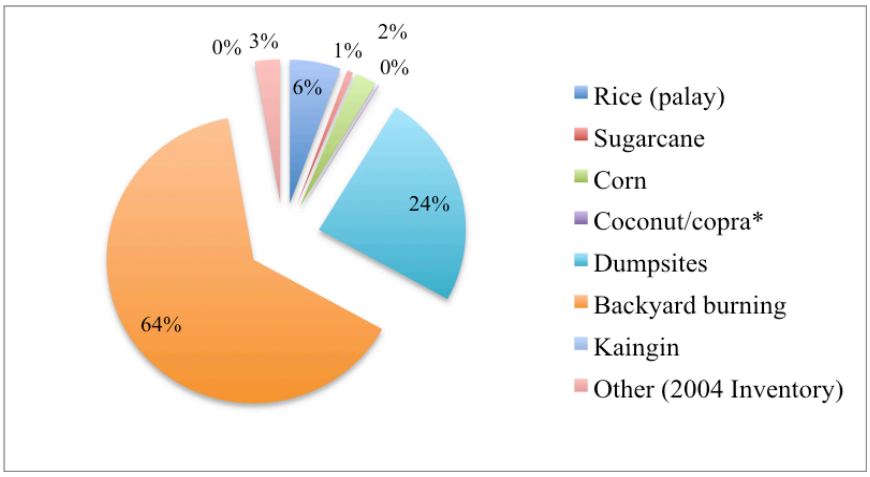

Figure 3. Emissions from open burn processes and other sources (2004) to air

The integration of the disparate datasets resulted in the best-informed and most highly resolved study of open burn emissions in the Philippines, and improved upon earlier emissions estimates. This work demonstrated the value of field studies and behavioral 'ground-truthing' to improve accuracy of emission factor estimates and to more fully quantify sources. As the Government of the Philippines is planning on undertaking a thorough study of emissions estimates and a new inventory, it is anticipated that this work will provide information that will be useful in designing and implementing this work.

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