DESIGN AND OPERATION OF THE MEXICAN DIOXIN AIR MONITORING NETWORK (MDAMN)

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Introduction

Polychlorinated dibenzo-p-dioxins and –furans (D/Fs) are persistent organic pollutants (POPs), which constitute an environmental risk due to their persistence and effects on human health. These compounds are often emitted during combustion, frequently initiated by human activities which include different industrial processes, waste incineration and agricultural burnings. After emission, D/Fs can be transported very large distances on a continental level[1], deposited on plants, and finally bioaccumulated through the food chain into animal and human tissues[2,3,4]. In humans, D/Fs have been classified as possible carcinogens[5], and have the potential for adverse effects on the male reproductive system[6] and an enhanced incidence of diabetes in humans[7].

Due to their impact on the environment and human health, D/Fs have been included in the Stockholm Convention, with the objective to reduce or eliminate releases deriving from the use of intentional and unintentional POPs, as well as stockpiles and wastes[8]. Since 1999, the working group on D/Fs of the Commission for Environmental Cooperation/Program of Sound Management of Chemicals has been working on a regional plan to reduce the risk in North America from these compounds. Information about D/Fs in ambient air is a key tool for monitoring and evaluating the effectiveness of the design and implementation of both policy and plans towards reduction and elimination of the risk of these compounds.

The present work describes the criteria based design of the Mexican Dioxins Air Monitoring Network (MDAMN) whose main objective is to generate the baseline information of these compounds in background ambient air for both the National Implementation Plan of the Stockholm Convention as well as the Regional Initiative. This work would complement the information generated by the corresponding networks - EPA National Dioxin Air Monitoring Network (NDAMN) in the USA and National Air Pollution Surveillance Network (NAPN) in Canada. Further objectives of the network are the evaluation of risk for humans and ecosystems due to the presence of D/Fs, and the analysis of long range transport of these pollutants. The present work also describes some details of the start of operation of the MDAMN in Spring 2008.

Materials and Methods

The selection of the sites for the MDAMN was carried out applying criteria such as a minimum distance to emission sources, potential impact on human health and ecosystems, as well as, pollutant transport on a local and regional level.

For the emission sources, the sources have been considered that are included in the emission inventories prepared by the USEPA and Environment Canada[9,10]. The potential impact on human health is differentiated into impacts via inhalation of D/Fs in ambient air, as indicated by the population density in each candidate region[11], and impacts via ingestion, as indicated by the production of cattle, pork, chicken and fish in each candidate region[12]. The potential impact on ecosystems was evaluated by the presence of vulnerable or fragile ecosystems, the presence of endemic species and the uniqueness of the composition of flora and fauna. The transport on a local and regional level was evaluated by surface winds and synoptic winds, using data from surface meteorological stations, and results from the MM5 and NOAA Hysplit models.

In order to guarantee the high standards of quality assurance and quality control during the operation of the network, a Standard Operation Procedure (SOP) and Quality Assurance Project Plan (QAPP) were developed, in collaboration between USEPA and the Mexican Institute of Ecology using procedures and methods developed by the U.S. National Dioxin Air Monitoring Network[0] At each monitoring site, a principal investigator from a local research institution is in charge of operating according to the SOP and QAPP, and provide information related to the validation of the obtained data, coordinated by the Mexican Institute of Ecology.

Results and Discussion

The final design of the network consists of 8 sites, which will serve to determine background levels in the Mexican Republic, and one site as an urban reference, located in southeastern Mexico City (see Figure 1 and Table 1). Different regions and ecosystems of Mexico were selected in order to be representative of the country.

Distance to emission sources

Most of the selected sites comply strictly with the criterion of a minimum distance to specified potential sources of D/Fs. The exceptions are Mexico City and Chiapas. The first site is located in a low-income residential zone in southeastern Mexico City; the latter is situated in a region where forest fires (accidental and induced) as well as the intentional burning of agricultural waste are common. Emissions in the Chiapas area are considered characteristic for the whole Mesoamerican region; and, therefore, the inclusion of this site is important for the national representativeness of the network.

Potential impact on human health and ecosystems

Sites with high expected impact on human health are represented by the Mexico City site. Although inhalation of D/Fs (the predominant exposure pathway in Mexico City) constitutes only a minor risk in comparison to ingestion, the high population density increases the total risk of cancer for this population in particular. Further sites with high expected impact on human health due to ingestion are the sites located in Veracruz, Jalisco, Sinaloa, and Baja California, due to its high productivity of cattle, pork, chicken and fish. Sites with high expected impacts on ecosystems include the sites in Baja California, Sinaloa, Veracruz, Yucatán and Chiapas, which are ecological reserves or national parks with a recognized uniqueness of its flora and fauna.

Long range transport of D/Fs

The analysis with the MM5 model showed the general atmospheric circulation pattern in Mexico. Meanwhile during the dry season (October to March) the predominant flow is from northwest; during the rainy season (April to September) the predominant flow is from the east. The analysis with the NOAA Hysplit model showed that all selected sites receive impact from a continental origin, i.e., North America and Mesoamerica (see Figure 2). This kind of analysis also will help with the interpretation of data, once the network has been operated and a significant set of data has been obtained. Note that, in particular, the sites at Baja California and Veracruz are of high interest for analyzing long range transport, due to their high altitude at the top of mountains.

Operation of the MDAMN

The network started its operation in March 2008. At all of the above mentioned sites, samples will be taken four times per year, using high volume samplers (Tisch, PS-1 model) with quartz fiber filters (QFF) and polyurethane foam (PUF) cartridges. For each sample, an approximate volume of 8,400 m^3 of air will be sampled during 580 hours of operation.

QFF and PUF samples will be analyzed for dioxins, furans and coplanar PCBs in the laboratories of USEPA. The results will serve to determine the baseline of these pollutants in ambient air, and evaluate the effectiveness of the measures implemented to reduce emissions of non intentional POPs and ambient concentrations.

This project constitutes an unprecedented effort between the North American countries to implement in Mexico the first dioxin monitoring network of its type, with a criteria based design and with the participation of many renowned Mexican research institutions. The applied methodology for the definition of this network can be the fundament of similar monitoring efforts of POPs in Mexico and other developing countries.

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References

1. Commoner, B., Woods Bartlett, P., Eisl, H., Couchot, K. North American Commission for Environmental Cooperation, 2000.
2. Su, S.H., Pearlman, L.C., Rothrock, J.A., Iannuzzi, T.J., and Finley, B.L. *Environmental Management* 2002; 29 (2): 234.
3. Fung, C.N., Zheng, G.J., Connell, D.W., Zhang, X., Wong, H.L., Giesy, J.P., Fang, Z. and Lam, P.K.S. *Marine Pollution Bulletin* 2005; 50 (10): 1036.
4. Welsch-Pausch, K. and McLachlan, M. S. *Environmental Pollution* 1998; 102 (1): 129.
5. World Health Organization 2000.
6. Dhooge, W., Van Larebeke, N., Koppen, G., Nelen, V., Schoeters, G., Vlietinck, R., Kaufman, J.-M., and Comhaire, F. *Environmental Health Perspectives* 2006; 114 (11): 1670.
7. Remillard, R.B.J. and Bunce, N.J. *Environmental Health Perspectives* 2002; 110 (9): 853.
8. United Nations Environment Programme 2001.
9. Environment Canada 2001.
10. USEPA 1998.
11. Mexican National Institute of Statistics 2000.
12. Mexican Ministry for Agriculture 2006.
13. Cleverly, D., Ferrario, J., Byrne, C., Riggs, K., Joseph ,D., Hartford, P. *Environmental Science & Technology* 2007; 41 (5): 1537.

Table 1: List of sites of the Mexican Dioxin Air Monitoring Network.

#	Site	State	Altitude (amsl)	Coordinates	Ecosystem type
1	San Pedro Mártir	Baja California	2,830 m	31° 02.650' N 115° 27.817' W	Pristine mountain pine forest, national park.
2	La Campana	Chihuahua	1,550 m	29° 15.840' N 106° 21.454' W	Semi-arid grassland.
3	Nuestra Señora	Sinaloa	590 m	24° 24.090' N 106° 36.591' W	Tropical dry forest, ecological reserve.
4	Vaquerías	Jalisco	2,100 m	21° 46.919' N 101° 36.616' W	Semi-arid grassland.
5	Coquimatlán	Colima	360 m	19° 12.815' N 103° 48.188' W	Tropical dry forest
6	Mexico City	Mexico, D.F.	2,240 m	19º 21.543' N 99º 04.430' W	Urban
7	Cofre de Perote	Veracruz	4,231 m	19° 29.657' N 97° 08.855'W	Pristine mountain fir forest, national park
8	Celestún	Yucatán	3 m	20° 51.556' N 90° 23.559' W	Mangrove and Coastal Lagoon, biosphere reserve.
9	Montes Azules	Chiapas	160 m	16° 06.750' N 90° 56.451' W	Tropical rain forest, ecological reserve.

Figure 1: Map of the Mexican Dioxin Air Monitoring Network.

Figure 2: Example for synoptic map of the MM5 model at 500 mbar (left panel). Example of a NOAA Hysplit model result for the Celestún site (right panel).