A COMPARISON OF PCDD/F FINGERPRINTS IN AMBIENT URBAN AIR OF BIG CITIES: A CONTINENTAL AND ECONOMIC EFFECT?

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Scope of the project. As part of a research project evaluating the chemical fingerprints of PCDD/F in the ambient air in the cities of the world with more than 5 Million inhabitants, we compared congeners and homologues PCDD/F profiles in ambient air samples from twelve different cities: London, UK; Beijing, Hong Kong, and Guangzhou, China; New Delhi, India; Sao Paulo, Brazil; Los Angeles, USA; Bogotà (Colombia); Tokio (Japan); Ho Chi Minh (Vietnam); Mexico City; and Seul (South Korea). Finally, we compared the percentage of total PCDF and total PCDD/F concentration of each city versus its GPD per capita in order to check any relationship between these quantities.

Methods, limitations, and data sources. For each city, we evaluated publically available data sets both for the PCDD/F and GDP data. Data have not been validated or analyzed with reference to the type of sampling protocol or seasonality. In cities with more than one sampling station or sampling period, their average has been calculated and used in this study. Station to station and seasonal variability will be analyzed using multivariate analyses in the next phase of this research. The congener profiles are based on the percentage of each of the 17 2,3,7,8-substituted congeners divided by the sum of those congeners. The homologue profiles show the percentage of each of the 10 homologues divided by the sum of all Cl_4 – Cl_8 PCDD/Fs.

Results and discussion. The congener profile for Los Angeles, London and Tokio (Figure 1) shows a dominance of 1,2,3,4,6,7,8-HpCDD and OCDD with a relatively low percentage of OCDF compared to the other cities. New Dehli is distinguished by a relatively low percentage of 2,3,4,6,7,8-HxCDF. Beijing has a relatively low concentration of 1,2,3,4,6,7,8-HpCDD and the three Chinese cities present a similar fingerprint Sao Paulo and Bogotà show a dominance of OCDD and a similar fingerprint. Seul's fingerprint is dominated by 2,3,4,7,8-PCDF while Ho Chi Minh shows the most different fingerprint as there isn't a clear domination of any congener.

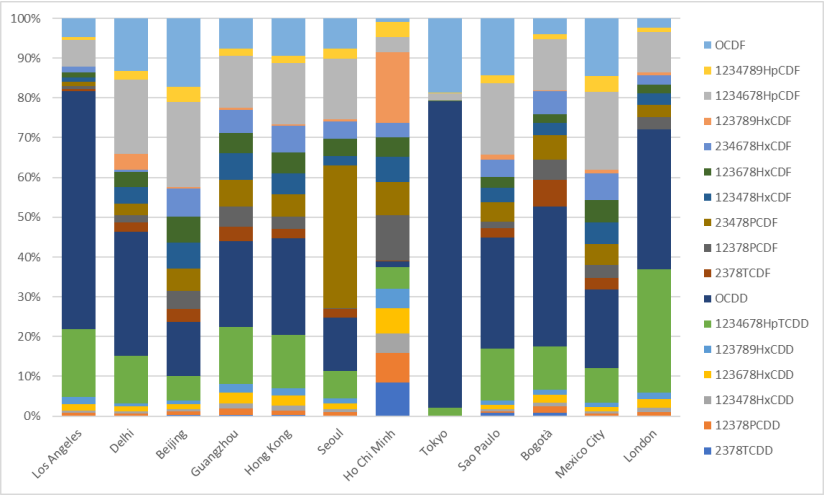

Figure 1: PCDD/F congener percentage distribution in the twelve cities studied

The homologue profiles show four groupings (Figure 2). First, New Dehli, Bogotà and Sao Paolo have similar profiles with the most prominent homologues being, OCDD, HpCDF, and OCDF, with HpCDD and HxCDF in about equal proportions. Second, Guangzhou and Hong Kong have similar profiles with the decreasing order of

importance being OCDD, HxCDF, HpCDF, HxCDD, and OCDF. Third, Beijing and Mexico City was dominated by the higher chlorinated furans with the decreasing order of importance being HpCDF, HxCDF, OCDF, OCDD, and PeCDF. Fourth, London and Los Angeles were dominated by the higher chlorinated dioxins with the decreasing order of importance being OCDD, HpCDD, HpCDF, and HxCDF. Seul was dominated by PeCDF, followed by the higher chlorinated furans and by OCDD. Tokio was dominated largely by OCDD with very small percentages of other homologues. Ho Chi Minh was dominated by the higher chlorinated furans.

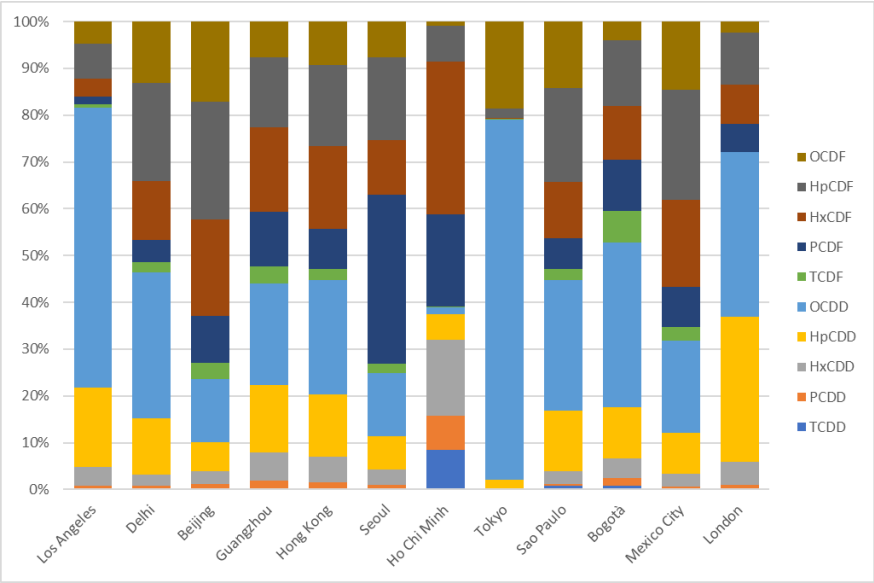

Figure 2: PCDD/F homologue percentage distribution in ambient air.

The percentage of total dioxins (CDDs) and total furans (CDFs) shows a simplified fingerprint (Figure 3). In six cities—New Delhi, Guangzhou, Hong Kong, Ho Chi Minh, Bogotà and Sao Paulo—the percentage of CDFs is between 45% and 55%. Beijing and Seul profile is predominantly (more than 75%) CDFs. Mexico City profile is dominated by CDFs (about 70%). Los Angeles, Tokio and London profiles are dominated, in contrast to all the other considered cities, by CDDs (London > 70%; Los Angeles and Tokio > 80%).

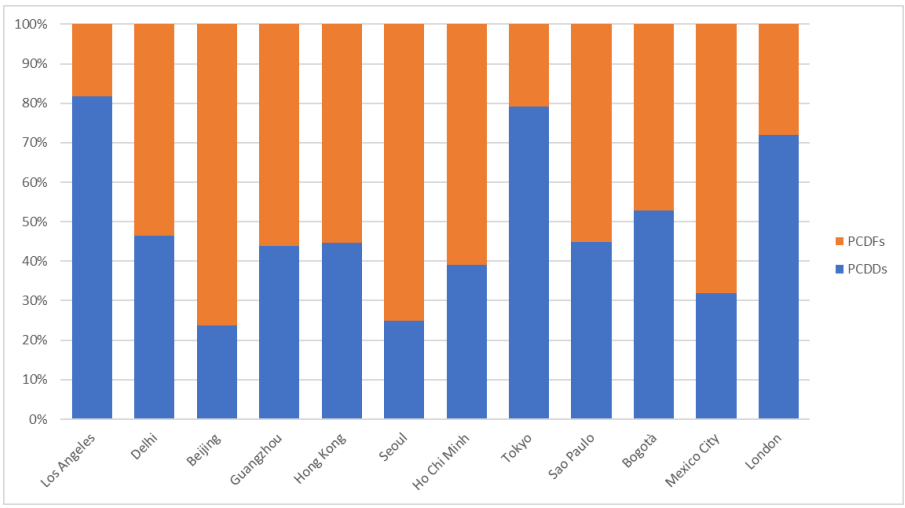

Figure 3: Total PCDD/PCDF ratio in the twelve studied cities.

The relationships between the percentage of total dioxins (CDDs) and total furans (CDFs) with the GDP per capita for each city shows an interesting trend (Figure 4). The three cities with higher GDP per capita – Los Angeles, Tokio and London – shows a simplified profile with low percentage of CDFs (about 20-30%). In the cities with lower GDP per capita – Delhi, Beijing, Guangzhou, Ho Chi Minh, Sao Paulo, Bogotà and Mexico City – the percentage of CDFs is higher than 50%. Hong Kong and Seul, with a GDP per capita between 40 and 50 k USD per capita, show a percentage of CDFs, respectively, of 55% and 75%.

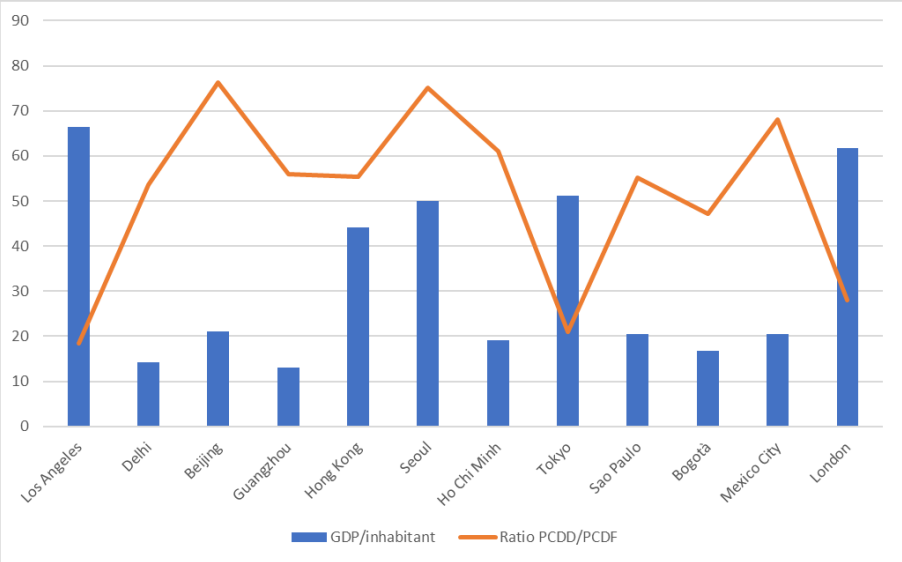

Figure 4. Relationship between percentage of CDFs versus GDP per capita (in k USD).

In conclusion the simplified profiles of CDDs and CDFs in the large cities studied in this project indicates that it should be determined by the economy of the city (to a higher GDP per capita corresponds higher percentage of CDDs) with, probably, a continental effect. In-fact cities like Seul and Hong Kong with higher GDP as compared to the other continental Asian cities studied, present a simplified fingerprint dominated by CDFs. This working hypothesis will be further studied adding to our database further cities spread on different continents with different GDP.

References

Cortés J., ,Cobo M, González C.M., Gómez C.D., Abalos M., Aristizábal B.H. (2016). Environmental variation of PCDD/Fs and dl-PCBs in two tropical Andean Colombian cities using passive samplers. Science of the Total Environment 568 (2016) 614–623.

de Assuncao J. V., Pesquero R. C., Bruns R. E., Carvalho R.F. L. (2005). Dioxins and furans in the atmosphere of Sao Paulo City, Brazil. Chemosphere 58(10): 1391–8.

Deng W. (2013). Atmospheric PCDD/Fs in Southeastern China. Journal of Environmental Science and Engineering B 2 (2013) 319–331.

Hammond D. (2010). Ambient Air Monitoring Results of Polychlorinated Dibenzo-p-dioxins, Polychlorinated Dibenzofurans, Polychlorinated Biphenyls, and Polybrominated Diphenylethers at Urban Areas in California from 2002 to 2006. Proceedings of Air & Waste Management Association, Symposium on Air Quality Measurement Methods and Technology, November 2-4, 2010, Los Angeles, California. Extended abstract n. 26.

Katsoyannis A., Gioia R., Sweetman A. J, and Jones K. C. (2010). Continuous Monitoring of PCDD/Fs in the UK Atmosphere: 1991–2008. Environ. Sci. Technol. 2010, 44, 5735–5740

Kumar B., Singh S. K., Lal R. B., Kumar S., Sharma C. S. (2012). Congener specific distribution of polychlorinated dibenzo-p-dioxins and dibenzo-p-furans in ambient air particulates (<PM10) in Delhi, India. Journal of Xenobiotics 2012; volume 2-7, 35–40.

Ogura I., Masunaga S., Nakanishi J. (2001). Atmospheric Deposition of Polychlorinated Dibenzo-*p*-Dioxins, Polychlorinated Dibenzofurans, and Dioxin-Like Polychlorinated Biphenyls in the Kanto Region, Japan. Chemosphere, Volume 44, Issue 6, September 2001, Pages 1473-1487

Rahman Md. M., Shon Z.H., Ma C.I., Brown R.J.C., Pandey S.K., Park C.G., Bae I.S., Sohn J.R., Yoon H.O., Kim K.H. (2014). Partitioning of dioxins (PCDDs/Fs) in ambient air at urban residential locations. Int. J. Environ. Sci. Technol., DOI 10.1007/s13762-013-0389-7.

Tuan H.N., To T.H., Ngo T.T., Nguyem H.M., Kai H.C. (2017). Atmospheric PCDD/F concentration and source apportionment in typical rural, Agent Orange hotspots, and industrial areas in Vietnam. Chemosphere 182 (2017) 647-655.

Wöhrnschimmel H., Yao Y. (2014). Assessing Comparability of Atmospheric PCDD, PCDF and Coplanar PCB Data from North American Ambient Air Monitoring Networks. Commission foe Environmental cooperation, Montreal, Canada. Project Report, 256 pp.

Zhou Z., Zhao B., Qi L., Xu P., Ren Y., Li N., Zheng S., Zhao H., Fan S., Zhang T., Liu A., Huang Y., Shen L. (2014). Distribution of Polychlorinated Dibenzo-p-dioxins and Dibenzofurans in the Atmosphere of Beijing, China. Aerosol and Air Quality Research, 14: 1269–1278.