Honeybees and citizen scientists: two communities collaboratively expanding the use of honey for Pb biomonitoring in urban centres

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Honey from *Apis mellifera* (Western honeybee) can act as a biomonitor by elucidating regional-scale pollutant distribution. Geospatial investigation of trace element (TE) compositions of honey, bees, and other bee products is a well-established approach for environmental metal monitoring currently undergoing an expansion in two new directions. First, recent studies now include analysis of lead (Pb) isotopic compositions to aid in Pb source apportionment[1,2] and second, focus has shifted to applications of this approach to urban centres. This change is driven by dramatic alterations in human and environmental interactions since the Industrial Revolution and rapid population growth in cities[3].

We developed a framework for use of honey, bee pollen, and bee tissue analysis in Vancouver, British Columbia, and are now applying it to a range of urban centres. For comparison, we present TE and Pb isotopic analyses of honey from three very different settings: Kaua'i (Hawai'i), New York City, and Paris. In all locations, we observe systematic variations of TE and Pb isotopic compositions of the honey related to local land use, pedology, and lithology. These Pb isotope observations contribute to our ever-growing dataset of honey samples from around the world. This project would not have been possible without collaborators and hobby beekeepers worldwide and their willingness to share honey to support scientific inquiry. This study demonstrates the value of a citizen-science approach to environmental monitoring in our changing world.

[1] Smith et al. (2019) *Nat. Sustain* **2** 223-232
[2] Zhou et al. (2018) *Env. Sci. & Tech.* **52** 991-1001
[3] United Nations, Dept. of Econ. And Soc. Affairs, Population Division (2019) *World Population Prospects 2019: Highlights* ST/ESA/SER.A/423.