URBAN MONITORING

# Bees as biomarkers

Bee keeping is on the rise in cities. Beehive products can be used to trace the source and transport of metal contaminants by studying one of our favourite food stuffs — honey.

Mark Patrick Taylor

Urban gardening is rapidly rising in popularity[1], driven by a growing interest in food quality, source and freshness. Scandals involving the origin[2], composition[3] and contamination[4] of supermarket foods have increased consumer awareness regarding the need to have access to clean and safe food from reliable producers. This awareness is coupled with a paradoxical shift in global societies: an increasing call for greater sustainability alongside a rapid urbanization of populations. Overlying these fundamental changes to human ecology is a deeper understanding of and concern about environmental contamination[5], particularly that associated with urban air quality. To address these concerns, biomarkers can be used to track metal contamination from source to their locations as they are deposited in the environment.

A study by Smith[6] and co-authors in this issue of *Nature Sustainability* examined honey produced in Vancouver by European honey bees (*Apis Mellifera*) as a potential biomarker for anthropogenic contamination. Female worker honey bees are highly mobile in their local environment and forage over ~7 km$^2$, which makes them a suitable candidate as a sentinel species. Since the first relevant study in the early 1960s[7], several research teams have examined bees, wax and honey as potential biomarkers for environmental trace metal contamination. These studies have returned mixed results, with most only comparing concentrations in bees or their honey to those found in corresponding soil samples.

Recent research, including the analysis by Smith and colleagues, compares concentrations in bees or their honey to those found in corresponding dust[8] and air[9] samples or their proxies, identifying a significant relationship between these variables (Fig. 1). Chemical analyses of beehive products have been compared to proxies, such as lichens[10] and pine tree leaves[11], which have been studied widely as atmospheric indicators[12] of contamination. Some of these studies have confirmed that bees and their products can provide reliable and consistent information about local air and dust contaminants.

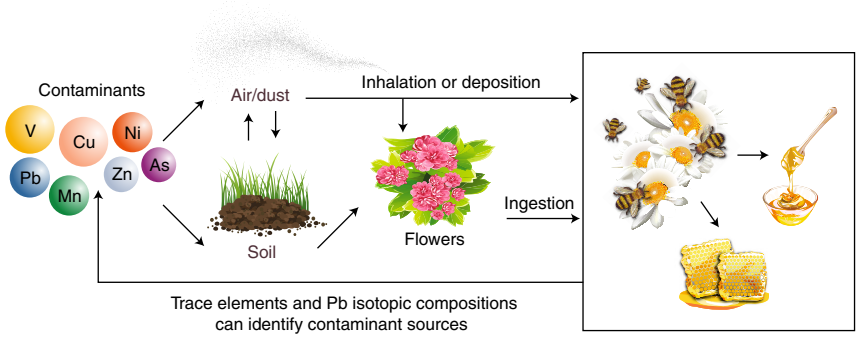


**Fig. 1 | Honey bee exposures to trace element contaminants.** Environmental sources of metal and metalloid contaminants held in air, dust and soils can be accumulated on and in honey bees, which then transfer these to their beehive products (wax and honey). Adapted from ref. [8], ACS.

The Smith et al. study of Vancouver honey offers some important new advances in understanding the utility of using honey bees and their products as biomarkers[6]. Data were collected over a four-year period. The extensive spatial design of the study includes samples from multiple hives from locations characterized by different land use types, ranging from the city port and downtown area (the city centre) to residential neighbourhoods of differing densities, agricultural land and island reference sites across the greater Vancouver region.

The detailed multi-element and lead (Pb) isotopic composition analyses produced remarkably coherent data, complemented by Pb isotope data on tree rings from the same environment[6]. Elemental concentrations did not show significant temporal variations, concentrations were specific to sample locations, and the Pb isotopic compositions of honey were associated with land use types and current or historic air pollution sources. Considering Pb's known toxicity and presence as an urban contaminant, it is remarkable that prior to this study, no North American studies had examined the ubiquitous European honey bee or its products for their Pb isotopic compositions to fingerprint contamination sources. This new research addressed this gap and found that honey from downtown hives, near the Port of Vancouver, had elevated trace element concentrations compared to suburban and rural sources.

There are several compelling reasons that this new research is not only interesting from a scientific perspective but also relevant to the wider public. Pollination is critical to the long-term food security and survival of humanity. European honey bees and other animals provide an essential role in crop pollination. Understanding how human-related environmental contamination can inadvertently affect bees and their products can help us better manage and counteract unintended consequences. A case in point is the liberal use of agricultural pesticides containing neonicotinoids and their role in declining wild and European honey bee populations[13].

The twin demands for locally produced clean food and greater sustainability have shifted consumer habits and increased awareness that city-sourced food may come with 'added extras'. Indeed, the most common question posed by the commercial urban beekeepers who participated in a Sydney-based study on European honey bees[8] was: "Is the honey clean?" The trace element data in this new study reflect past and current activities across Vancouver's industrial and agricultural areas, with Pb being a key contaminant of concern because of its persistence and toxicity, particularly in young children. The sampled honeys

had trace element concentrations that were consistent with global honey values[14]. It is important to note that, although Pb concentrations in honey samples were sufficient for source apportionment analysis, they were too low to pose a significant risk to public health. Even at the highest levels tested in the study, the authors calculated that an adult would have to consume more than 600g of honey to exceed US Food and Drug Administration provisional tolerable Pb daily intake levels.

Along with tracking potential contaminant sources, this project also contributes to the Vancouver community initiative 'Hives for Humanity', which provided the honey for analysis. This bona fide partnership helps to demonstrate the wider societal value of research by bridging science and community interests and advancing consumer knowledge of urban produce and its relationship to the environment. Community engagement in scientific endeavours is an increasingly important aspect for researchers due to funding constraints and the need to address societal problems. The study's collaborative approach and measurement of honey's geochemistry provides a template that can be applied in other global cities where citizens seek to understand how industrial activities affect the food they produce and consume. ❐

Mark Patrick Taylor
*Department of Environmental Sciences, Faculty of Science and Engineering, Macquarie University, Sydney, Australia.*
*e-mail:* mark.taylor@mq.edu.au

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