



HONEYBEES AS BIOMONITORS - VARIABILITY IN THE OCCURRENCE OF HEAVY METALS, A SYSTEMATIC REVIEW



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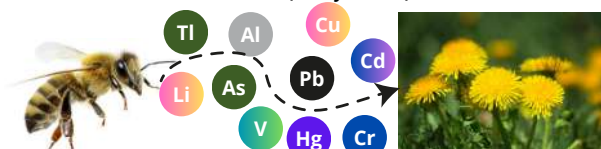
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BACKGROUND AND OBJECTIVE

Honey bees (*Apis mellifera*) have been widely used as biomonitors due to their ability to accumulate environmental pollutants from air, soil and water within their foraging range.

This systematic review examines their role in detecting **heavy metal (HM) contamination** by quantifying and comparing HM levels reported in the **scientific literature (1996–2024)** across different environments: **urban, rural, and forest** (used as a control).

Pollutants (heavy metals)



METHODS

- Databases searched:** PubMed, Scopus, and others
- Search terms:** (bees OR pollinators OR honey bees) AND (biomonitor OR bioindicator) AND (contamination OR pollution) AND (heavy metals OR minerals)
- Studies included:** 18 peer-reviewed articles (1996–2024)
- Statistical parameters calculated:** Mean (parts per billion, ppb), median (ppb), minimum, maximum, standard deviation (SD), and coefficient of variation (CV%).
- Data categorization:** Results were grouped into three environmental areas — urban, rural, and forest (used as a control).

RESULTS

Heavy metal	Mean (ppb)	SD	CV%
Cr (Chromium)	0.140	±0.103	73.88
Al (Aluminum)	7.170	±3.5	48.80
Li (Lithium)	0.020	±0.0	—
V (Vanadium)	0.050	± 0.058	116
As (Arsenic)	0.536	± 0.307	57.30
Cd (Cadmium)	0.265	±0.296	112
Tl (Thallium)	0.317	±0.026	8.29
Cu (Copper)	7.950	±7.36	92.50
Hg (Mercury)	590	±0.0	—
Pb (Lead)	1.130	±0.495	43.80

Table 1. Concentrations of heavy metals in honey bees.
Values are expressed as mean ± standard deviation (ppb). CV%: coefficient of variation. The symbol “—” indicates that the CV was not calculated due to lack of variability (SD = 0).

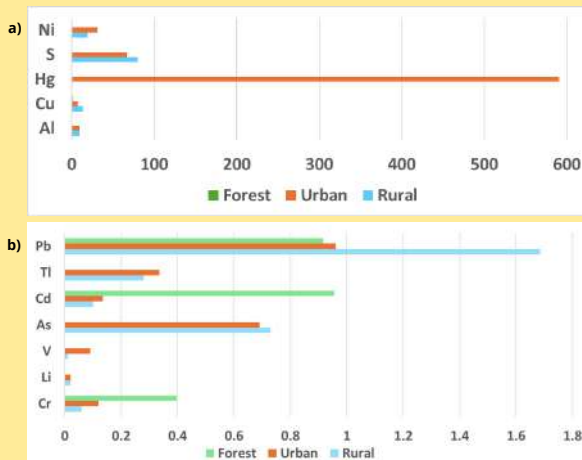


Figure 1a,b. Median concentration (ppb) of principal heavy metals present in honeybees around the world.

Only one study reported concentrations of Cr, Cd, Cu, Pb, and Zn in forest areas.

In general, heavy metal concentrations were lower in rural areas than in urban areas.



CONCLUSIONS AND RECOMMENDATIONS

- Honey bees are **effective biomonitors** of heavy metal pollution, with levels increasing from forest to rural and urban areas.
- To improve monitoring, **standardized sampling and broader global datasets** are needed.
- Beekeepers** can play a vital role in environmental surveillance by supporting local monitoring and long-term data collection. Pollutants can harm bee health, reduce honey quality, and potentially impact human health.

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Background/Purpose, To collect data on environmental pollutants potentially harmful to human health (e.g. heavy metals, HM) over time, honey bees have been used as biomonitors due to their ability to accumulate air, soil and water pollutants within a specific radius during foraging trips.

Problem description, The aim of this study was to perform a systematic review that has determined and quantified ($\mu\text{g/g}$) the levels of heavy metals, Cr, Al, Li, V, As, Cd, Tl, Hg and Pb in honeybees samples, in different regions (Forest as a control, Urban and Rural areas).

Methodology, this systematic literature review summarizes the previous application of *Apis mellifera* bees in the monitoring of HM ($\mu\text{g/g}$) as contaminants in articles published during the period 1996-2024. Eighteen studies were included. For the literature search we examined databases, as PubMed, Scopus, etc, and used the following keywords: (bees OR pollinators or Honey bees) AND (biomonitor OR bioindicator) AND (contamination OR pollution) AND (Heavy metals OR minerals). The maximum, minimum, mean, standard deviation and coefficient of variation (CV%) of the results obtained were determined, as well as the study site Forest as a control, Urban and Rural areas.

Results, The concentration ($\mu\text{g/g}$) of Cr in general was 0.140 ± 0.103 , CV 73.88%; Al (7.17 ± 3.5 ; CV 48.8%), Li (0.020 ± 0.0), V (0.050 ± 0.058 ; CV 116%), As (0.536 ± 0.307 ; 57.3%), Cd (0.265 ± 0.296 ; CV 112%), Tl (0.317 ± 0.026 ; 8.29%), Cu (7.95 ± 7.36 ; 92.5 %), Hg (590 ± 0.0), and Pb (1.13 ± 0.495 , CV 43.8%). Only one study shows concentrations of Cr, Cd, Cu, Pb and Zn in forest areas, with respect to rural areas there is a lower concentration of heavy metals with respect to urban areas.

Conclusion, honeybees represent an avenue for continuous monitoring and provide quantitative information on specific HMs. The analysis revealed that the presence of HM in honeys present in forest areas is lowest, followed by rural and highest in urban areas. Further studies should be carried out to obtain a more solid database for more reliable results.