Table S1. Honey Sampling Sites and Proximity to Pollution Sources.

Sampling Site (SP)	Coordinates	Altitude (m)	Extraction Method	No. of Beehives	Local Vegetation	Distances to Pollution Sources (km) (Zone I / Zone II / Zone III)
SP1 - Trâmpoiele	46°08′39″N, 23°09′43″E	564	Fumigation using amadou (tinder fungus) and corn cobs; stainless steel centrifuge.	55	Pastures and hayfields	6.5 / 1.5 / 4.8
SP2 - Izvorul Ampoiului	46°08′35″N, 23°10′36″E	482	Fumigation using amadou (tinder fungus) and corn cobs; stainless steel centrifuge.	60	Pastures and hayfields	5.4 / 2.2 / 4.7
SP3 - Feneș	46°06′01″N, 23°17′56″E	357	Fumigation using amadou (tinder fungus) and corn cobs; stainless steel centrifuge.	47	Hayfields, farmland, mixed forests	5.2 / 11.8 / 13.7
SP4 - Vâltori	46°08′34″N, 23°12′48″E	502	Fumigation using amadou (tinder fungus) and corn cobs; stainless steel centrifuge.	100	Pastures, hayfields, and forest patches	3.6 / 4.8 / 7.3
SP5 - Valea Mică	46°04′45″N, 23°16′42″E	400	Fumigation using amadou (tinder fungus) and corn cobs; stainless steel centrifuge.	60	Not specified	5.3 / 11.3 / 12.7
SP6 - Presaca Ampoiului	46°06′16″N, 23°19′24″E	373	Fumigation using amadou (tinder fungus) and corn cobs; stainless steel centrifuge.	55	Not specified	7.3 / 13.6 / 15.4
SP7 - Budeni	46°11′35″N, 23°06′19″E	692	Fumigation using amadou (tinder fungus) and corn cobs; stainless steel centrifuge.	45	Not specified	13.3 / 7.8 / 8.1

Table S2. Advanced Thermochemical Protocol and Operational Specifications of the TopWave Microwave-Assisted Digestion System for High-Precision Trace Metal Recovery.

Parameter	Value
Microwave Power	Up to 1500 W
Digestion Temperature Profile	4-step gradient: 145°C, 170°C, 190°C, 100°C
Ramp Time	10–15 min (each step)
Hold Time	10 min (at final temp)
Maximum Temperature	190°C
Maximum Pressure	>60 bar
Vessel Material	TFM-PTFE (Polytetrafluoroethylene)
Vessel Volume	100 mL
Number of Vessels	24
Cooling Time	10–15 min (active cooling)
Acid Volume (HNO_3)	0.5 mL (analytical grade, 65%)
Sample Mass	1 g

The digestion procedure was optimized to ensure complete decomposition of the organic matrix in honey, enabling accurate and reproducible trace metal quantification using atomic absorption spectrometry (FAAS/GFAAS). The stepwise temperature profile (145 °C → 170 °C → 190 °C → 100 °C) was specifically chosen to enhance the oxidative breakdown of carbohydrates, proteins, and bioactive compounds without inducing analyte loss or volatilization—particularly critical for thermally sensitive elements like Cd and Pb. The use of concentrated nitric acid (HNO_3, 65%) provided an efficient oxidizing environment for the mineralization of the organic matter, while TFM-PTFE digestion vessels ensured chemical inertness and pressure resistance during high-temperature, high-pressure conditions. Cleaning protocols using 10% HNO_3 and ultrapure water minimized contamination risk, in line with QA/QC standards. The digestion system's pressure control and homogenous microwave energy distribution helped achieve consistent digestion efficiency across all replicates, confirmed by the high recovery rates (91.2–113.1%) and low RSD values (<5%) reported in the analytical validation.

Table S3. Calibration Parameters and Analytical Performance for Pb, Cd, Zn, and Cu Determination in Honey Using FAAS and GFAAS

Metal	Calibration Range (μg/L)	R^2 Value	LOD (μg/kg)	LOQ (μg/kg)	RSD (%)	Recovery (%)	Method / Instrument
Pb	2.5–50	0.9994	0.7	2.1	4.8	94.3–106.7	GFAAS
Cd	2.5–50	0.9991	0.3	0.9	3.5	91.2–110.4	GFAAS
Zn	2.5–50	0.9988	1.2	3.5	5.1	95.6–104.2	FAAS
Cu	2.5–50	0.9990	1.0	3.0	4.2	92.7–107.3	FAAS

Table S4. Analytical Performance Parameters for Heavy Metals in Honey (FAAS/GFAAS)

Element	LoD (μg/L)	LoQ (μg/L)	Precision (RSD%)	Accuracy (Recovery %)
Pb	0.8	2.7	<5%	90–113%
Cd	0.8	2.7	<5%	90–113%
Zn	2.0	6.5	2–5%	85–110%
Cu	2.0	6.5	2–5%	85–110%

Table S5. Validation Results Using Certified Reference Material (CRM) for Heavy Metal Determination in Honey

Element	Certified Value (mg/kg)	Measured Value (mg/kg)	Recovery (%)	RSD (%)	Compli-ance	CRM Name
Pb	0.150 ± 0.015	0.143 ± 0.006	95.3	4.2	Yes	BCR-151 (Honey)
Cd	0.050 ± 0.005	0.046 ± 0.003	92.0	3.8	Yes	BCR-151 (Honey)
Zn	3.50 ± 0.20	3.41 ± 0.12	97.4	3.5	Yes	BCR-151 (Honey)
Cu	0.90 ± 0.07	0.94 ± 0.05	104.4	4.1	Yes	BCR-151 (Honey)

Note: BCR-151 (Honey) was used as the Certified Reference Material (CRM) provided by the European Commission Institute for Reference Materials and Measurements. Recovery percentages were calculated as (Measured / Certified) × 100. RSD was based on triplicate analyses. All values are within the acceptable uncertainty range, confirming the reliability of the FAAS/GFAAS method for trace metal analysis in honey matrices.