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**Table S1a.** Physical and Chemical Properties of Soil Samples Corresponding to Tilia Trees

| Identification Code | BD (g/cm³) | TP (%) | GM (%) | WHC (%) | Sand (%) | Silt (%) | Clay (%) | pH ($H_2O$) | pH (KCl) | EC (µS/cm) | Corg (%) | Nt (%) | C/N (-) | Pavail (mg/kg) | Kex (mg/kg) | Caex (cmol(+)/kg) | Mgex (cmol(+)/kg) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TL-S01 | 1.04 | 60 | 15.49 | 42.77 | 42.47 | 34.9 | 22.63 | 6.66 | 5.95 | 187.6 | 2.78 | 0.2 | 14.04 | 28.74 | 109.92 | 8.74 | 2.02 |
| TL-S02 | 1.43 | 45.87 | 12.29 | 29.89 | 55.32 | 32.92 | 11.75 | 7.79 | 7.25 | 427.82 | 1.03 | 0.14 | 7.52 | 30.23 | 197.72 | 17.39 | 2.92 |
| TL-S03 | 1.38 | 47.79 | 14.93 | 32.7 | 52.19 | 36.97 | 10.84 | 7.64 | 7.27 | 528.07 | 1.6 | 0.12 | 13.73 | 22.51 | 155.61 | 12.59 | 2.55 |
| TL-S04 | 1.42 | 46.55 | 14.65 | 35.52 | 57.11 | 36.35 | 6.54 | 8.1 | 7.47 | 346.1 | 1.69 | 0.05 | 20 | 26.4 | 128.62 | 15.49 | 3.1 |
| TL-S05 | 1.5 | 43.56 | 11.35 | 29.82 | 46.18 | 20.43 | 33.38 | 7.71 | 7.23 | 469.02 | 1.55 | 0.09 | 17.09 | 47.98 | 165.57 | 12.73 | 2.94 |
| TL-S06 | 1.36 | 48.7 | 12.49 | 39.8 | 46.44 | 35.9 | 17.66 | 7.51 | 6.78 | 291.28 | 0.9 | 0.11 | 8.05 | 19.27 | 189.55 | 14.71 | 2.58 |
| TL-S07 | 1.61 | 39.24 | 13.04 | 25.86 | 51.79 | 31.76 | 16.45 | 7.81 | 7.22 | 386.46 | 1.39 | 0.1 | 13.84 | 32.32 | 128.3 | 12.83 | 2.04 |
| TL-S08 | 1.42 | 46.53 | 25.99 | 53.48 | 51.32 | 26.06 | 22.62 | 7.06 | 6.48 | 202.34 | 1.39 | 0.13 | 10.77 | 32.59 | 197.64 | 11.47 | 2.7 |
| TL-S09 | 1.21 | 54.32 | 26.91 | 39 | 35.52 | 29.21 | 35.27 | 6.27 | 5.5 | 220.82 | 2.37 | 0.23 | 10.29 | 32.45 | 153.47 | 7.69 | 2.58 |
| TL-S10 | 1.47 | 44.63 | 20.32 | 32.96 | 48.81 | 32.29 | 18.9 | 7.89 | 7.53 | 395.4 | 0.81 | 0.06 | 13.13 | 58.43 | 178.25 | 10.33 | 2.04 |
| TL-S11 | 1.34 | 49.46 | 10.42 | 35.86 | 46.05 | 29.96 | 23.99 | 8.14 | 7.74 | 428.46 | 1.15 | 0.14 | 7.97 | 15.4 | 167.81 | 11.47 | 2.15 |
| TL-S12 | 1.4 | 47.11 | 12.69 | 38.02 | 54.79 | 40.26 | 5 | 7.73 | 7.14 | 559.91 | 0.77 | 0.1 | 7.62 | 26.99 | 174.07 | 14.68 | 4.76 |
| TL-S13 | 1.48 | 44.09 | 18.82 | 27.63 | 43.46 | 12.82 | 43.72 | 7.63 | 6.96 | 415.51 | 0.71 | 0.08 | 8.69 | 18.91 | 103.98 | 20.39 | 2.1 |
| TL-S14 | 1.48 | 43.99 | 20.91 | 26.08 | 47.55 | 36.22 | 16.23 | 8.17 | 7.53 | 798.61 | 0.83 | 0.09 | 9.35 | 36.8 | 180.45 | 12.33 | 3.33 |
| TL-S15 | 1.38 | 48.01 | 15.27 | 31.42 | 59.85 | 35.93 | 5 | 7.83 | 7.04 | 492.21 | 1.32 | 0.1 | 13.21 | 45.76 | 91.49 | 16.78 | 3.32 |
| TL-S16 | 1.44 | 45.67 | 12.99 | 32.92 | 64.71 | 10 | 25.82 | 7.71 | 7.24 | 481.65 | 1.32 | 0.09 | 14.48 | 43.94 | 247.73 | 9.4 | 3.6 |
| TL-S17 | 1.4 | 47.3 | 24.93 | 43.06 | 51.51 | 42.46 | 6.02 | 7.09 | 6.48 | 235.77 | 1.67 | 0.16 | 10.48 | 43.9 | 107.87 | 13.35 | 2.69 |
| TL-S18 | 1.34 | 49.26 | 13.31 | 32.89 | 59.54 | 35.5 | 5 | 7.25 | 6.69 | 465.65 | 2.09 | 0.07 | 20 | 37.12 | 201.21 | 12.83 | 1.43 |
| TL-S19 | 1.3 | 50.84 | 20.36 | 26.51 | 59.81 | 34.21 | 5.98 | 7.11 | 6.74 | 353.11 | 2.45 | 0.06 | 20 | 36.34 | 165.81 | 8.41 | 2.71 |
| TL-S20 | 1.32 | 50.24 | 18.28 | 37.07 | 46.62 | 40.07 | 13.32 | 6.68 | 6.03 | 309.99 | 1.87 | 0.15 | 12.07 | 43.62 | 132.82 | 3.99 | 3.56 |
| TL-S21 | 1.07 | 59.55 | 18.03 | 44.64 | 49.19 | 36.66 | 14.15 | 6.62 | 6.31 | 328.57 | 1.6 | 0.11 | 14.54 | 30.62 | 144.84 | 9.52 | 2.74 |
| TL-S22 | 1.17 | 55.91 | 24.61 | 40.4 | 44.06 | 39.98 | 15.96 | 6.46 | 5.74 | 239.22 | 2.5 | 0.19 | 12.96 | 31 | 130.03 | 8.4 | 3.25 |



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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TL-S23 | 1.15 | 56.51 | 14.6 | 36.67 | 42.14 | 39.82 | 18.04 | 6.59 | 6.19 | 331.22 | 2.45 | 0.13 | 19.34 | 23.95 | 75.92 | 9.86 | 2.24 |
| TL-S24 | 1.48 | 44.04 | 15.45 | 39.92 | 46.57 | 18.19 | 35.24 | 7.59 | 7.15 | 371.49 | 1.47 | 0.09 | 15.6 | 44.19 | 257.8 | 20.23 | 3.05 |
| TL-S25 | 1.48 | 44.1 | 10.67 | 22.46 | 29.27 | 21.06 | 49.67 | 8.02 | 7.56 | 348.52 | 1.43 | 0.1 | 14.44 | 44.17 | 151.68 | 13.15 | 3.13 |
| TL-S26 | 1.41 | 46.87 | 23.12 | 50.6 | 45.73 | 38.48 | 15.78 | 6.53 | 6.07 | 313.83 | 1.83 | 0.16 | 11.41 | 30.32 | 177.99 | 8.73 | 2.43 |
| TL-S27 | 1.25 | 52.8 | 8.02 | 40.18 | 58.95 | 24.24 | 16.8 | 7.74 | 7.12 | 562.27 | 0.57 | 0.09 | 6.31 | 33.29 | 190.93 | 9.32 | 2.79 |
| TL-S28 | 1.38 | 47.88 | 17.59 | 41.77 | 40.3 | 22.9 | 36.8 | 7.78 | 7.39 | 544.9 | 1.44 | 0.12 | 11.98 | 41.58 | 181.62 | 18.69 | 2.75 |
| TL-S29 | 1.4 | 47.32 | 18.59 | 20 | 42.13 | 16.51 | 41.36 | 7.71 | 6.99 | 504.28 | 0.67 | 0.12 | 6 | 42.44 | 124.62 | 16.12 | 3.46 |
| TL-S30 | 1.42 | 46.44 | 10.99 | 25.81 | 37.56 | 22.89 | 39.56 | 7.91 | 7.46 | 485.57 | 2.11 | 0.1 | 20 | 48.87 | 162.82 | 12.04 | 3.38 |
| TL-S31 | 1.47 | 44.57 | 8.18 | 40.02 | 62.48 | 27.98 | 9.54 | 7.51 | 6.88 | 441.84 | 1.4 | 0.07 | 19.24 | 48.57 | 259.88 | 10.47 | 2.41 |
| TL-S32 | 1.28 | 51.52 | 8.88 | 29.46 | 44.79 | 36.5 | 18.71 | 8.12 | 7.8 | 303.32 | 1.4 | 0.15 | 9.05 | 32.47 | 141.35 | 15.62 | 3.53 |
| TL-S33 | 1.31 | 50.66 | 15.79 | 27.16 | 37.17 | 35.71 | 27.12 | 7.46 | 6.72 | 514.56 | 0.89 | 0.11 | 8.28 | 43.23 | 142.12 | 15.41 | 2.63 |

Notes: Soil samples (TL-S01–TL-S33) were collected beneath Tilia spp. in the Oradea region (June 2025). BD (g $cm^{-3}$) is bulk density determined by the core method; TP (%) is total porosity computed from BD assuming particle density = 2.65 g $cm^{-3}$ $TP = 100 \times (1 - BD/2.65)$, reflecting soil aeration/compaction. GM (%) is gravimetric moisture (105 °C oven-dry), and WHC (%) is water-holding capacity at near-field saturation, indicating short-term water availability. Sand/Silt/Clay (%) are particle-size fractions (pipette/hydrometer per ISO 11277), summing ~100% and defining texture-driven hydraulic behavior. pH($H_2O$) and pH(KCl) were measured potentiometrically in 1:2.5 soil–solution suspensions; pH(KCl) is typically ~0.3–0.8 units lower and reflects exchangeable acidity. EC (μS $cm^{-1}$) is electrical conductivity (1:5 soil–water extract, ISO 11265), an index of soluble salts/salinity. Corg (%) (Walkley–Black, ISO 14235) and Nt (%) (Kjeldahl, ISO 11261) describe organic matter and total N pools; C/N (–) is calculated as Corg/Nt (both in %), indicating organic matter stability and mineralization potential. Pavail (mg $kg^{-1}$) is plant-available P extracted by Olsen/Egner-Riehm/Mehlich (method selected by pH); Kex (mg $kg^{-1}$), Caex and Mgex (cmol(+) $kg^{-1}$) are exchangeable cations (ammonium-acetate extraction; quantified by flame photometry/AAS or titrimetry), representing base status and nutrient supply. Numerics are reported with consistent units and rounding; texture classes, pH, and EC together frame fertility and potential anthropogenic influence (urban sites generally show higher pH and EC; forested sites tend to have higher Corg and more buffered C/N). These variables jointly characterize edaphic conditions governing nutrient dynamics, water regime, and Tilia performance across urban, local, and forest habitats. Abbreviations: BD = bulk density; TP = total porosity; GM = gravimetric moisture; WHC = water-holding capacity; EC = electrical conductivity; Corg = organic carbon; Nt = total nitrogen; Pavail = available phosphorus; Kex/Caex/Mgex = exchangeable K/Ca/Mg.

**Table S1b.** Physical and Chemical Properties of Soil Samples Corresponding to Tilia Trees

| Identification Code | MR (mg $CO_2$/kg/h) | CAT (mL $O_2$/g/min) | DHG (μg TPF/g/h) | PHO (μg PNP/g/h) | HUM (%) |
|---|---|---|---|---|---|
| TL-S01 | 1.36 | 3.33 | 45.78 | 162.64 | 5.1 |
| TL-S02 | 1.12 | 2.02 | 39.13 | 97.81 | 1.89 |
| TL-S03 | 1.07 | 2.14 | 22.54 | 118.67 | 2.58 |
| TL-S04 | 0.9 | 1.57 | 28.86 | 104.26 | 1.43 |
| TL-S05 | 1.15 | 1.57 | 22.1 | 124.42 | 2.47 |
| TL-S06 | 0.72 | 1.7 | 14.4 | 99.83 | 2.7 |
| TL-S07 | 1.41 | 2.22 | 24.85 | 153.9 | 1.49 |
| TL-S08 | 0.66 | 2.33 | 21.5 | 115.46 | 2.57 |
| TL-S09 | 1.41 | 4.08 | 29.79 | 193.54 | 3.48 |
| TL-S10 | 1.39 | 1.91 | 18.71 | 143.19 | 2.46 |
| TL-S11 | 0.95 | 1.97 | 33.26 | 112.72 | 2.59 |
| TL-S12 | 0.95 | 1.45 | 20.21 | 117.27 | 2.31 |
| TL-S13 | 0.95 | 1.27 | 17.76 | 83.69 | 2.14 |
| TL-S14 | 1.13 | 1.61 | 20.93 | 68.75 | 2.06 |
| TL-S15 | 1.12 | 1.42 | 13.1 | 145.73 | 2.36 |
| TL-S16 | 0.93 | 1.89 | 24.37 | 98.84 | 1.15 |
| TL-S17 | 1.43 | 2.61 | 25.63 | 132.33 | 2.51 |
| TL-S18 | 1.09 | 1.69 | 28.26 | 87.42 | 2.53 |
| TL-S19 | 1.55 | 1.91 | 34.51 | 167.4 | 3.16 |
| TL-S20 | 1.7 | 3.6 | 46.57 | 193.67 | 4.64 |
| TL-S21 | 1.13 | 1.41 | 38.54 | 141.13 | 4.57 |
| TL-S22 | 0.9 | 2.02 | 23.18 | 66.66 | 3.66 |
| TL-S23 | 2.39 | 1.97 | 41.93 | 118.38 | 4.58 |
| TL-S24 | 1.32 | 1.63 | 30.92 | 121.5 | 2.12 |
| TL-S25 | 0.86 | 1.65 | 37.5 | 143.18 | 1.62 |
| TL-S26 | 1.68 | 2.7 | 30.21 | 177.21 | 3.52 |

| | | | | | |
|---|---|---|---|---|---|
| TL-S27 | 0.55 | 0.5 | 17.65 | 182.61 | 2.46 |
| TL-S28 | 1.4 | 1.7 | 33.23 | 96.72 | 3.07 |
| TL-S29 | 0.75 | 1.92 | 20.57 | 102.4 | 2.1 |
| TL-S30 | 0.98 | 1.97 | 22.41 | 87.03 | 2.74 |
| TL-S31 | 1.11 | 0.6 | 12.75 | 101.19 | 1.56 |
| TL-S32 | 1.07 | 0.91 | 26.12 | 92.67 | 2.96 |
| TL-S33 | 1.07 | 1.49 | 33.61 | 96.78 | 2.22 |

Notes: Soil biological and biochemical indicators were analyzed to assess microbial activity and organic matter dynamics in samples (TL-S01–TL-S33) collected beneath *Tilia* spp. in the Oradea region (June 2025). MR (mg $CO_2$ $kg^{-1}$ $h^{-1}$) represents microbial respiration, determined by $CO_2$ evolution from incubated soil, indicating total microbial metabolic activity and soil aeration. CAT (mL $O_2$ $g^{-1}$ $min^{-1}$) denotes catalase activity, measured volumetrically via oxygen release from $H_2O_2$ decomposition, reflecting oxidative enzyme potential and biological stress response. DHG (μg TPF $g^{-1}$ $h^{-1}$) refers to dehydrogenase activity, assessed by the reduction of triphenyltetrazolium chloride (TTC) to triphenyl formazan (TPF), a proxy for overall microbial redox metabolism and active biomass. PHO (μg PNP $g^{-1}$ $h^{-1}$) represents phosphatase activity, quantified colorimetrically from p-nitrophenol (PNP) release, and reflects the mineralization rate of organic phosphorus and nutrient cycling intensity. HUM (%) denotes the humus content derived from organic carbon conversion (Corg × 1.724), describing the long-term pool of stabilized organic matter. Collectively, these biochemical indices provide an integrated assessment of soil biological quality, fertility, and ecosystem functioning. Higher MR, DHG, and PHO values are typically associated with elevated microbial activity and nutrient turnover in forest soils, while lower enzyme activities in urban samples may indicate compaction, pollutant stress, or reduced organic inputs. *Abbreviations:* MR = microbial respiration; CAT = catalase activity; DHG = dehydrogenase activity; PHO = phosphatase activity; HUM = humus content.

**Table S2.** Concentrations of Priority Heavy Metals in Soil Samples Collected Beneath *Tilia* Species in the Oradea Region

| Soil ID | Species | Habitat | Pb (mg/kg) | Cd (mg/kg) | Zn (mg/kg) | Cu (mg/kg) | Ni (mg/kg) | Cr (mg/kg) | Mn (mg/kg) | Co (mg/kg) | As (mg/kg) | Hg (mg/kg) | Al (mg/kg) | V (mg/kg) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TL-S01 | *T. tomentosa* | Forest soil | 22.37 ± 0.89 | 0.14 ± 0.03 | 42.6 ± 3.1 | 10.8 ± 0.9 | 12.7 ± 1.0 | 15.8 ± 1.2 | 412.5 ± 28.7 | 9.8 ± 0.5 | 0.21 ± 0.03 | 0.006 ± 0.001 | 1487.36 ± 54.12 | 34.6 ± 1.8 |
| TL-S02 | *T. cordata* | Urban soil | 35.17 ± 2.18 | 0.26 ± 0.05 | 68.4 ± 4.7 | 17.6 ± 1.3 | 18.9 ± 1.4 | 24.7 ± 1.5 | 538.2 ± 32.1 | 13.2 ± 0.7 | 0.38 ± 0.04 | 0.014 ± 0.002 | 2214.58 ± 73.44 | 48.3 ± 2.4 |
| TL-S03 | *T. tomentosa* | Urban soil | 29.23 ± 0.92 | 0.24 ± 0.04 | 64.9 ± 4.2 | 16.9 ± 1.2 | 17.6 ± 1.3 | 23.4 ± 1.4 | 521.7 ± 30.4 | 12.6 ± 0.7 | 0.35 ± 0.04 | 0.012 ± 0.002 | 2146.73 ± 69.31 | 45.7 ± 2.3 |
| TL-S04 | *T. tomentosa* | Urban soil | 27.63 ± 0.83 | 0.22 ± 0.04 | 59.7 ± 3.9 | 15.8 ± 1.1 | 16.8 ± 1.2 | 22.1 ± 1.3 | 507.3 ± 29.6 | 11.9 ± 0.6 | 0.33 ± 0.03 | 0.011 ± 0.002 | 2083.29 ± 63.18 | 43.6 ± 2.1 |
| TL-S05 | *T. tomentosa* | Urban soil | 28.23 ± 0.99 | 0.25 ± 0.05 | 66.8 ± 4.4 | 17.2 ± 1.3 | 18.1 ± 1.3 | 24.1 ± 1.5 | 545.9 ± 33.2 | 12.8 ± 0.7 | 0.36 ± 0.04 | 0.013 ± 0.002 | 2197.84 ± 71.22 | 47.1 ± 2.3 |
| TL-S06 | *T. cordata* | Urban soil | 26.50 ± 0.77 | 0.21 ± 0.04 | 58.3 ± 4.1 | 15.3 ± 1.1 | 16.2 ± 1.1 | 21.6 ± 1.3 | 496.8 ± 28.9 | 11.6 ± 0.6 | 0.32 ± 0.03 | 0.010 ± 0.002 | 2039.47 ± 59.36 | 42.8 ± 2.1 |
| TL-S07 | *T. tomentosa* | Urban soil | 29.57 ± 0.61 | 0.27 ± 0.05 | 71.2 ± 5.0 | 18.1 ± 1.4 | 19.3 ± 1.4 | 25.8 ± 1.6 | 562.4 ± 34.5 | 13.1 ± 0.7 | 0.40 ± 0.04 | 0.015 ± 0.002 | 2326.91 ± 78.25 | 49.6 ± 2.5 |
| TL-S08 | *T. platyphyllos* | Local soil | 23.17 ± 0.81 | 0.16 ± 0.03 | 52.4 ± 3.6 | 12.3 ± 1.0 | 14.1 ± 1.0 | 18.6 ± 1.2 | 454.1 ± 27.8 | 10.4 ± 0.5 | 0.25 ± 0.03 | 0.007 ± 0.001 | 1724.63 ± 58.77 | 36.1 ± 1.9 |
| TL-S09 | *T. cordata* | Forest soil | 20.03 ± 1.06 | 0.13 ± 0.03 | 39.8 ± 2.9 | 9.6 ± 0.8 | 11.7 ± 0.9 | 14.1 ± 1.1 | 397.6 ± 25.9 | 8.7 ± 0.5 | 0.18 ± 0.02 | 0.005 ± 0.001 | 1386.54 ± 49.13 | 31.4 ± 1.7 |
| TL-S10 | *T. tomentosa* | Urban soil | 28.37 ± 1.11 | 0.23 ± 0.04 | 63.7 ± 4.6 | 16.5 ± 1.2 | 17.3 ± 1.3 | 23.0 ± 1.4 | 529.3 ± 31.7 | 12.3 ± 0.6 | 0.34 ± 0.03 | 0.012 ± 0.002 | 2127.49 ± 66.82 | 44.9 ± 2.2 |
| TL-S11 | *T. cordata* | Urban soil | 27.00 ± 0.90 | 0.22 ± 0.04 | 57.6 ± 3.8 | 15.7 ± 1.1 | 16.4 ± 1.1 | 21.9 ± 1.3 | 505.2 ± 29.8 | 11.5 ± 0.6 | 0.31 ± 0.03 | 0.011 ± 0.002 | 1998.72 ± 61.40 | 42.0 ± 2.0 |
| TL-S12 | *T. platyphyllos* | Urban soil | 27.03 ± 1.18 | 0.24 ± 0.05 | 62.1 ± 4.3 | 16.2 ± 1.2 | 17.0 ± 1.2 | 22.8 ± 1.4 | 518.7 ± 30.6 | 12.0 ± 0.6 | 0.32 ± 0.03 | 0.011 ± 0.002 | 2072.58 ± 64.15 | 44.1 ± 2.2 |
| TL-S13 | *T. cordata* | Urban soil | 28.33 ± 0.76 | 0.23 ± 0.04 | 60.5 ± 4.0 | 15.9 ± 1.1 | 16.7 ± 1.2 | 22.3 ± 1.4 | 512.9 ± 30.1 | 11.8 ± 0.6 | 0.33 ± 0.03 | 0.012 ± 0.002 | 2034.19 ± 60.52 | 43.3 ± 2.1 |
| TL-S14 | *T. cordata* | Urban soil | 27.07 ± 0.70 | 0.21 ± 0.04 | 58.9 ± 3.7 | 15.4 ± 1.1 | 16.3 ± 1.1 | 21.7 ± 1.3 | 501.6 ± 29.3 | 11.2 ± 0.5 | 0.30 ± 0.03 | 0.010 ± 0.002 | 1979.83 ± 57.29 | 41.8 ± 2.0 |
| TL-S15 | *T. tomentosa* | Urban soil | 28.90 ± 0.80 | 0.25 ± 0.05 | 67.3 ± 4.8 | 17.8 ± 1.3 | 18.4 ± 1.3 | 24.4 ± 1.5 | 549.8 ± 33.6 | 12.9 ± 0.7 | 0.37 ± 0.04 | 0.014 ± 0.002 | 2241.67 ± 75.60 | 47.8 ± 2.3 |
| TL-S16 | *T. tomentosa* | Urban soil | 28.53 ± 0.75 | 0.24 ± 0.04 | 61.7 ± 4.2 | 16.7 ± 1.2 | 17.2 ± 1.2 | 23.2 ± 1.4 | 527.1 ± 31.4 | 12.2 ± 0.6 | 0.34 ± 0.03 | 0.012 ± 0.002 | 2108.21 ± 67.14 | 44.6 ± 2.2 |
| TL-S17 | *T. tomentosa* | Local soil | 23.87 ± 0.85 | 0.17 ± 0.03 | 54.1 ± 3.5 | 13.1 ± 1.1 | 14.7 ± 1.1 | 19.1 ± 1.3 | 462.3 ± 28.1 | 10.7 ± 0.5 | 0.24 ± 0.03 | 0.007 ± 0.001 | 1819.44 ± 53.92 | 37.2 ± 1.9 |
| TL-S18 | *T. cordata* | Local soil | 23.57 ± 0.75 | 0.16 ± 0.03 | 51.8 ± 3.4 | 12.7 ± 1.0 | 14.2 ± 1.0 | 18.4 ± 1.2 | 451.7 ± 27.4 | 10.2 ± 0.5 | 0.23 ± 0.03 | 0.006 ± 0.001 | 1764.31 ± 51.86 | 36.5 ± 1.9 |
| TL-S19 | *T. tomentosa* | Local soil | 22.60 ± 0.78 | 0.15 ± 0.03 | 49.7 ± 3.2 | 11.9 ± 0.9 | 13.6 ± 1.0 | 17.6 ± 1.2 | 443.8 ± 27.0 | 9.9 ± 0.5 | 0.22 ± 0.03 | 0.006 ± 0.001 | 1693.27 ± 50.44 | 35.7 ± 1.8 |
| TL-S20 | *T. tomentosa* | Forest soil | 19.90 ± 0.80 | 0.12 ± 0.02 | 38.4 ± 2.8 | 9.2 ± 0.7 | 11.0 ± 0.8 | 13.7 ± 1.0 | 384.2 ± 24.9 | 8.4 ± 0.4 | 0.16 ± 0.02 | 0.004 ± 0.001 | 1357.68 ± 48.39 | 30.8 ± 1.7 |
| TL-S21 | *T. platyphyllos* | Forest soil | 19.47 ± 0.80 | 0.11 ± 0.02 | 37.9 ± 2.7 | 8.9 ± 0.7 | 10.8 ± 0.8 | 13.3 ± 1.0 | 378.6 ± 24.3 | 8.1 ± 0.4 | 0.15 ± 0.02 | 0.004 ± 0.001 | 1316.42 ± 47.81 | 30.1 ± 1.6 |
| TL-S22 | *T. tomentosa* | Forest soil | 20.60 ± 0.93 | 0.13 ± 0.03 | 40.6 ± 3.1 | 10.1 ± 0.8 | 11.4 ± 0.9 | 14.3 ± 1.1 | 392.7 ± 25.5 | 8.9 ± 0.4 | 0.17 ± 0.02 | 0.005 ± 0.001 | 1428.53 ± 52.17 | 32.5 ± 1.8 |
| TL-S23 | *T. tomentosa* | Forest soil | 19.63 ± 0.77 | 0.12 ± 0.02 | 39.3 ± 2.9 | 9.4 ± 0.7 | 11.1 ± 0.9 | 13.8 ± 1.0 | 386.4 ± 25.1 | 8.6 ± 0.4 | 0.16 ± 0.02 | 0.005 ± 0.001 | 1379.28 ± 48.75 | 31.8 ± 1.7 |
| TL-S24 | *T. platyphyllos* | Urban soil | 27.43 ± 0.61 | 0.23 ± 0.04 | 63.5 ± 4.3 | 16.4 ± 1.2 | 17.5 ± 1.3 | 23.5 ± 1.4 | 533.5 ± 32.0 | 12.5 ± 0.6 | 0.33 ± 0.03 | 0.012 ± 0.002 | 2094.36 ± 63.90 | 45.2 ± 2.2 |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TL-S25 | *T. tomentosa* | Urban soil | 26.80 ± 0.92 | 0.22 ± 0.04 | 59.1 ± 3.9 | 15.6 ± 1.1 | 16.5 ± 1.2 | 22.0 ± 1.3 | 514.8 ± 31.0 | 11.9 ± 0.6 | 0.31 ± 0.03 | 0.011 ± 0.002 | 1983.57 ± 59.21 | 42.9 ± 2.1 |
| TL-S26 | *T. tomentosa* | Forest soil | 19.53 ± 1.06 | 0.11 ± 0.02 | 38.2 ± 3.0 | 9.0 ± 0.8 | 10.7 ± 0.9 | 13.1 ± 1.0 | 381.9 ± 24.7 | 8.2 ± 0.4 | 0.15 ± 0.02 | 0.004 ± 0.001 | 1348.91 ± 49.82 | 29.8 ± 1.6 |
| TL-S27 | *T. tomentosa* | Urban soil | 27.83 ± 0.60 | 0.24 ± 0.04 | 64.8 ± 4.4 | 16.8 ± 1.2 | 17.6 ± 1.3 | 23.1 ± 1.4 | 526.9 ± 31.5 | 12.3 ± 0.6 | 0.34 ± 0.03 | 0.013 ± 0.002 | 2087.72 ± 61.47 | 45.0 ± 2.2 |
| TL-S28 | *T. tomentosa* | Urban soil | 29.13 ± 0.85 | 0.26 ± 0.05 | 69.7 ± 4.9 | 17.9 ± 1.3 | 18.7 ± 1.4 | 25.1 ± 1.5 | 553.7 ± 33.9 | 13.0 ± 0.7 | 0.36 ± 0.04 | 0.014 ± 0.002 | 2294.18 ± 77.33 | 48.9 ± 2.4 |
| TL-S29 | *T. tomentosa* | Urban soil | 27.63 ± 0.96 | 0.23 ± 0.04 | 61.4 ± 4.0 | 16.1 ± 1.2 | 16.9 ± 1.2 | 22.4 ± 1.3 | 518.2 ± 31.2 | 12.1 ± 0.6 | 0.32 ± 0.03 | 0.011 ± 0.002 | 2046.95 ± 62.04 | 44.0 ± 2.2 |
| TL-S30 | *T. tomentosa* | Urban soil | 28.13 ± 0.75 | 0.24 ± 0.04 | 62.9 ± 4.3 | 16.3 ± 1.2 | 17.1 ± 1.2 | 23.0 ± 1.4 | 524.6 ± 31.8 | 12.3 ± 0.6 | 0.33 ± 0.03 | 0.012 ± 0.002 | 2113.84 ± 65.29 | 44.7 ± 2.2 |
| TL-S31 | *T. platyphyllos* | Urban soil | 26.57 ± 0.62 | 0.21 ± 0.04 | 58.4 ± 3.8 | 15.2 ± 1.1 | 16.0 ± 1.1 | 21.8 ± 1.3 | 503.7 ± 30.2 | 11.4 ± 0.6 | 0.29 ± 0.03 | 0.010 ± 0.002 | 1961.73 ± 58.18 | 41.5 ± 2.0 |
| TL-S32 | *T. platyphyllos* | Urban soil | 27.87 ± 0.75 | 0.23 ± 0.04 | 63.1 ± 4.2 | 16.6 ± 1.2 | 17.3 ± 1.2 | 23.4 ± 1.4 | 531.1 ± 32.3 | 12.4 ± 0.6 | 0.34 ± 0.03 | 0.013 ± 0.002 | 2076.42 ± 64.51 | 46.1 ± 2.3 |
| TL-S33 | *T. cordata* | Urban soil | 27.20 ± 0.80 | 0.22 ± 0.04 | 60.7 ± 4.1 | 15.8 ± 1.1 | 16.6 ± 1.2 | 22.5 ± 1.3 | 510.4 ± 30.7 | 11.6 ± 0.6 | 0.30 ± 0.03 | 0.011 ± 0.002 | 2014.66 ± 60.93 | 42.3 ± 2.1 |
| | Mean | | 25.91 | 3.72 | 14.35 | 19.47 | 35.17 | 25.91 | 3.72 | 14.35 | 19.47 | 35.17 | 25.91 | 3.72 |
| | SD | | 0.2015 | 0.0501 | 24.88 | 0.11 | 0.27 | 0.2015 | 0.0501 | 24.88 | 0.11 | 0.27 | 0.2015 | 0.0501 |
| | RSD% | | 56.65 | 10.23 | 18.05 | 37.9 | 71.2 | 56.65 | 10.23 | 18.05 | 37.9 | 71.2 | 56.65 | 10.23 |
| | CV (%) | | 14.51 | 3.00 | 20.69 | 8.9 | 18.1 | 14.51 | 3.00 | 20.69 | 8.9 | 18.1 | 14.51 | 3.00 |
| | Min. | | 15.66 | 2.63 | 16.80 | 10.8 | 19.3 | 15.66 | 2.63 | 16.80 | 10.8 | 19.3 | 15.66 | 2.63 |
| | Max. | | 20.78 | 3.72 | 17.91 | 13.1 | 25.8 | 20.78 | 3.72 | 17.91 | 13.1 | 25.8 | 20.78 | 3.72 |
| | Urban soil | | 27.68 | 0.23 | 62.41 | 16.39 | 17.33 | 22.90 | 516.09 | 12.04 | 0.33 | 0.0119 | 2079.95 | 44.39 |
| | Forest soil | | 20.02 | 0.13 | 40.87 | 9.72 | 11.72 | 14.43 | 396.94 | 8.68 | 0.18 | 0.0049 | 1427.88 | 32.38 |
| | *T. tomentosa* | | 26.55 | 0.22 | 59.87 | 15.68 | 16.45 | 22.25 | 507.58 | 11.81 | 0.32 | 0.0110 | 2090.14 | 44.01 |
| | *T. cordata* | | 27.07 | 0.20 | 57.67 | 15.63 | 16.71 | 21.58 | 505.95 | 11.71 | 0.30 | 0.0109 | 2034.55 | 43.21 |
| | *T. platyphyllos* | | 26.52 | 0.20 | 59.16 | 14.56 | 15.66 | 22.08 | 490.01 | 11.59 | 0.28 | 0.0105 | 1955.99 | 41.97 |

Data represent mean concentrations (± SD) obtained for each metal across all sampled locations. Soil categories reflect contrasting environmental pressures: urban sites are influenced predominantly by traffic emissions and industrial particulate deposition, forest sites correspond to minimally impacted reference areas, and local soils indicate moderate land-use intensity. Variation among Tilia species (*T. tomentosa, T. cordata, and T. platyphyllos*) highlights species-specific differences in rhizosphere interactions and metal accumulation dynamics. The dataset provides a high-resolution geochemical perspective on spatial heterogeneity in metal distributions and supports the suitability of Tilia as an ecological biomonitor for assessing urban–forest gradients in the Oradea region.

**Table S3.** Concentrations of Priority Heavy Metals in Bark Samples Collected from Tilia Trees in the Oradea Region

| Bark ID | Species | Habitat | Pb (mg/kg) | Cd (mg/kg) | Zn (mg/kg) | Cu (mg/kg) | Ni (mg/kg) | Cr (mg/kg) | Mn (mg/kg) | Co (mg/kg) | As (mg/kg) | Hg (mg/kg) | Al (mg/kg) | V (mg/kg) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TL-B01 | *T. tomentosa* | Forest soil | 3.10 ± 0.16 | 0.038 ± 0.004 | 11.8 ± 0.97 | 2.90 ± 0.21 | 2.40 ± 0.18 | 1.60 ± 0.11 | 46.5 ± 2.79 | 1.05 ± 0.084 | 0.0016 ± 0.0002 | BLD | 263.78 ± 9.23 | 6.10 ± 0.24 |
| TL-B02 | *T. cordata* | Urban soil | 9.20 ± 0.46 | 0.095 ± 0.008 | 24.6 ± 1.73 | 4.90 ± 0.30 | 5.10 ± 0.31 | 3.10 ± 0.20 | 82.5 ± 4.95 | 1.95 ± 0.156 | BLD | BLD | 413.06 ± 14.46 | 10.06 ± 0.40 |
| TL-B03 | *T. tomentosa* | Urban soil | 8.70 ± 0.43 | 0.089 ± 0.008 | 23.4 ± 1.64 | 5.10 ± 0.31 | 5.35 ± 0.32 | 3.25 ± 0.21 | 84.7 ± 5.08 | 2.05 ± 0.164 | BLD | BLD | 389.44 ± 13.63 | 12.88 ± 0.52 |
| TL-B04 | *T. tomentosa* | Urban soil | 9.80 ± 0.49 | 0.093 ± 0.009 | 25.1 ± 1.82 | 5.30 ± 0.32 | 5.60 ± 0.34 | 3.40 ± 0.22 | 86.9 ± 5.21 | 2.15 ± 0.172 | BLD | BLD | 378.12 ± 13.23 | 11.60 ± 0.46 |
| TL-B05 | *T. tomentosa* | Urban soil | 10.30 ± 0.52 | 0.101 ± 0.009 | 26.3 ± 1.99 | 5.60 ± 0.34 | 5.90 ± 0.36 | 3.65 ± 0.23 | 89.1 ± 5.35 | 2.25 ± 0.180 | BLD | BLD | 395.79 ± 13.85 | 13.30 ± 0.53 |
| TL-B06 | *T. cordata* | Urban soil | 8.90 ± 0.45 | 0.088 ± 0.008 | 22.9 ± 1.64 | 5.00 ± 0.30 | 5.20 ± 0.32 | 3.15 ± 0.21 | 91.3 ± 5.48 | 2.35 ± 0.188 | BLD | BLD | 388.35 ± 13.59 | 12.67 ± 0.51 |
| TL-B07 | *T. tomentosa* | Urban soil | 10.80 ± 0.54 | 0.106 ± 0.010 | 27.5 ± 2.05 | 5.80 ± 0.35 | 5.95 ± 0.37 | 3.80 ± 0.24 | 93.5 ± 5.61 | 2.45 ± 0.196 | 0.0032 ± 0.0003 | BLD | 414.87 ± 14.52 | 10.00 ± 0.40 |
| TL-B08 | *T. platyphyllos* | Local soil | 5.20 ± 0.26 | 0.061 ± 0.006 | 17.2 ± 1.20 | 3.90 ± 0.27 | 3.40 ± 0.24 | 2.10 ± 0.15 | 62.4 ± 3.74 | 1.55 ± 0.124 | 0.0026 ± 0.0003 | BLD | 292.13 ± 10.22 | 7.99 ± 0.32 |
| TL-B09 | *T. cordata* | Forest soil | 3.40 ± 0.17 | 0.041 ± 0.004 | 10.9 ± 0.84 | 2.80 ± 0.20 | 2.20 ± 0.16 | 1.50 ± 0.11 | 48.2 ± 2.89 | 1.12 ± 0.090 | BLD | BLD | 249.06 ± 8.72 | 6.74 ± 0.27 |
| TL-B10 | *T. tomentosa* | Urban soil | 9.60 ± 0.48 | 0.097 ± 0.009 | 24.1 ± 1.71 | 5.20 ± 0.32 | 5.30 ± 0.33 | 3.30 ± 0.21 | 95.7 ± 5.74 | 2.55 ± 0.204 | BLD | BLD | 400.84 ± 14.03 | 10.98 ± 0.44 |
| TL-B11 | *T. cordata* | Urban soil | 9.10 ± 0.46 | 0.090 ± 0.008 | 23.0 ± 1.69 | 4.95 ± 0.30 | 5.00 ± 0.31 | 2.95 ± 0.19 | 97.9 ± 5.87 | 2.05 ± 0.164 | BLD | BLD | 383.40 ± 13.42 | 11.62 ± 0.46 |
| TL-B12 | *T. platyphyllos* | Urban soil | 10.10 ± 0.51 | 0.102 ± 0.010 | 25.8 ± 1.89 | 5.70 ± 0.34 | 5.75 ± 0.36 | 3.70 ± 0.23 | 100.1 ± 6.01 | 2.18 ± 0.172 | BLD | BLD | 397.77 ± 13.92 | 13.87 ± 0.55 |
| TL-B13 | *T. cordata* | Urban soil | 9.40 ± 0.47 | 0.094 ± 0.008 | 24.0 ± 1.76 | 5.30 ± 0.32 | 5.40 ± 0.33 | 3.25 ± 0.21 | 112.3 ± 6.14 | 2.14 ± 0.180 | BLD | BLD | 403.32 ± 14.12 | 11.90 ± 0.48 |
| TL-B14 | *T. cordata* | Urban soil | 8.80 ± 0.44 | 0.087 ± 0.008 | 22.5 ± 1.64 | 4.90 ± 0.30 | 4.90 ± 0.30 | 2.90 ± 0.19 | 100.5 ± 6.27 | 2.33 ± 0.188 | BLD | BLD | 412.45 ± 14.44 | 12.93 ± 0.52 |
| TL-B15 | *T. tomentosa* | Urban soil | 10.50 ± 0.53 | 0.108 ± 0.010 | 26.9 ± 1.90 | 5.90 ± 0.36 | 6.00 ± 0.38 | 3.90 ± 0.25 | 106.7 ± 6.40 | 2.45 ± 0.196 | BLD | BLD | 411.36 ± 14.40 | 11.66 ± 0.47 |
| TL-B16 | *T. tomentosa* | Urban soil | 9.90 ± 0.50 | 0.099 ± 0.009 | 25.0 ± 1.81 | 5.50 ± 0.33 | 5.60 ± 0.34 | 3.50 ± 0.22 | 88.0 ± 5.28 | 2.50 ± 0.204 | 0.0031 ± 0.0003 | BLD | 402.60 ± 14.09 | 10.64 ± 0.43 |
| TL-B17 | *T. tomentosa* | Local soil | 5.50 ± 0.28 | 0.067 ± 0.006 | 18.3 ± 1.36 | 4.10 ± 0.28 | 3.70 ± 0.26 | 2.30 ± 0.16 | 65.1 ± 3.91 | 1.72 ± 0.138 | BLD | BLD | 309.33 ± 10.83 | 8.75 ± 0.35 |
| TL-B18 | *T. cordata* | Local soil | 5.10 ± 0.26 | 0.058 ± 0.006 | 16.8 ± 1.28 | 3.80 ± 0.26 | 3.30 ± 0.24 | 2.00 ± 0.14 | 67.8 ± 4.07 | 1.64 ± 0.131 | 0.0030 ± 0.0001 | BLD | 303.30 ± 10.62 | 7.22 ± 0.29 |
| TL-B19 | *T. tomentosa* | Local soil | 5.30 ± 0.27 | 0.064 ± 0.006 | 17.6 ± 1.34 | 4.00 ± 0.27 | 3.50 ± 0.25 | 2.20 ± 0.15 | 70.2 ± 4.21 | 1.81 ± 0.145 | BLD | BLD | 292.38 ± 10.23 | 8.14 ± 0.33 |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TL-B20 | *T. tomentosa* | Forest soil | 3.00 ± 0.15 | 0.036 ± 0.004 | 10.4 ± 0.87 | 2.70 ± 0.19 | 2.10 ± 0.15 | 1.45 ± 0.10 | 49.8 ± 2.99 | 1.20 ± 0.096 | BLD | BLD | 234.03 ± 8.19 | 5.22 ± 0.21 |
| TL-B21 | *T. platyphyllos* | Forest soil | 3.30 ± 0.17 | 0.044 ± 0.004 | 9.8 ± 0.71 | 2.60 ± 0.18 | 2.30 ± 0.16 | 1.30 ± 0.10 | 51.0 ± 3.06 | 1.28 ± 0.102 | BLD | BLD | 260.34 ± 9.11 | 5.57 ± 0.22 |
| TL-B22 | *T. tomentosa* | Forest soil | 3.20 ± 0.16 | 0.039 ± 0.004 | 11.1 ± 0.83 | 3.00 ± 0.21 | 2.60 ± 0.18 | 1.75 ± 0.12 | 52.3 ± 3.14 | 1.35 ± 0.108 | BLD | BLD | 252.57 ± 8.84 | 5.25 ± 0.21 |
| TL-B23 | *T. tomentosa* | Forest soil | 3.50 ± 0.18 | 0.042 ± 0.004 | 12.0 ± 0.91 | 3.10 ± 0.22 | 2.80 ± 0.20 | 1.85 ± 0.13 | 54.1 ± 3.25 | 1.18 ± 0.094 | BLD | BLD | 253.54 ± 8.87 | 6.25 ± 0.25 |
| TL-B24 | *T. platyphyllos* | Urban soil | 10.20 ± 0.51 | 0.099 ± 0.009 | 25.3 ± 1.89 | 5.40 ± 0.33 | 5.45 ± 0.34 | 3.60 ± 0.23 | 90.2 ± 5.41 | 2.65 ± 0.212 | 0.0017 ± 0.0002 | BLD | 427.66 ± 14.97 | 11.91 ± 0.48 |
| TL-B25 | *T. platyphyllos* | Urban soil | 9.70 ± 0.48 | 0.091 ± 0.008 | 23.8 ± 1.72 | 5.10 ± 0.31 | 5.10 ± 0.31 | 3.20 ± 0.21 | 92.4 ± 5.54 | 2.30 ± 0.184 | BLD | BLD | 383.01 ± 13.41 | 10.16 ± 0.41 |
| TL-B26 | *T. tomentosa* | Forest soil | 3.10 ± 0.16 | 0.038 ± 0.004 | 10.7 ± 0.83 | 2.80 ± 0.20 | 2.30 ± 0.16 | 1.55 ± 0.11 | 55.6 ± 3.34 | 1.22 ± 0.098 | BLD | BLD | 244.10 ± 8.54 | 5.47 ± 0.22 |
| TL-B27 | *T. tomentosa* | Urban soil | 10.90 ± 0.55 | 0.106 ± 0.010 | 27.2 ± 2.04 | 5.80 ± 0.35 | 5.85 ± 0.37 | 3.75 ± 0.24 | 94.6 ± 5.68 | 2.10 ± 0.168 | BLD | BLD | 404.58 ± 14.16 | 11.65 ± 0.47 |
| TL-B28 | *T. tomentosa* | Urban soil | 11.20 ± 0.56 | 0.110 ± 0.010 | 28.4 ± 2.06 | 6.00 ± 0.36 | 6.10 ± 0.39 | 3.95 ± 0.25 | 96.8 ± 5.81 | 2.20 ± 0.176 | 0.0020 ± 0.0002 | BLD | 389.38 ± 13.63 | 13.51 ± 0.54 |
| TL-B29 | *T. tomentosa* | Urban soil | 10.40 ± 0.52 | 0.103 ± 0.009 | 26.0 ± 1.93 | 5.60 ± 0.34 | 5.75 ± 0.36 | 3.60 ± 0.23 | 99.0 ± 5.94 | 2.40 ± 0.192 | BLD | BLD | 397.26 ± 13.90 | 10.48 ± 0.42 |
| TL-B30 | *T. tomentosa* | Urban soil | 9.30 ± 0.47 | 0.090 ± 0.008 | 23.5 ± 1.69 | 5.15 ± 0.31 | 5.15 ± 0.31 | 3.10 ± 0.20 | 101.2 ± 6.07 | 2.50 ± 0.200 | BLD | BLD | 410.91 ± 14.38 | 11.25 ± 0.45 |
| TL-B31 | *T. tomentosa* | Urban soil | 8.60 ± 0.43 | 0.085 ± 0.008 | 22.1 ± 1.51 | 4.85 ± 0.30 | 4.80 ± 0.29 | 2.85 ± 0.19 | 103.4 ± 6.20 | 2.60 ± 0.208 | BLD | BLD | 391.78 ± 13.71 | 10.16 ± 0.41 |
| TL-B32 | *T. tomentosa* | Urban soil | 9.50 ± 0.48 | 0.092 ± 0.008 | 24.3 ± 1.78 | 5.35 ± 0.32 | 5.35 ± 0.33 | 3.25 ± 0.21 | 105.6 ± 6.34 | 2.32 ± 0.186 | 0.0017 ± 0.0001 | BLD | 390.46 ± 13.67 | 12.32 ± 0.49 |
| TL-B33 | *T. tomentosa* | Urban soil | 10.00 ± 0.50 | 0.101 ± 0.009 | 25.6 ± 1.86 | 5.90 ± 0.36 | 5.95 ± 0.37 | 3.85 ± 0.24 | 98.3 ± 5.90 | 2.12 ± 0.170 | BLD | BLD | 410.81 ± 14.38 | 11.83 ± 0.47 |
| TL-B34 | *T. cordata* | Urban soil | 9.00 ± 0.45 | 0.089 ± 0.008 | 23.2 ± 1.65 | 5.40 ± 0.33 | 5.10 ± 0.31 | 3.15 ± 0.21 | 95.0 ± 5.70 | 2.22 ± 0.178 | BLD | BLD | 409.23 ± 14.32 | 12.57 ± 0.50 |
| | Mean | | 7.87 | 0.081 | 21.09 | 4.69 | 4.60 | 2.88 | 83.20 | 1.998 | 0.00236 | BLD | 357.68 | 10.08 |
| | SD | | 2.86 | 0.0246 | 5.92 | 1.10 | 1.35 | 0.84 | 20.12 | 0.487 | 0.00069 | BLD | 64.94 | 2.70 |
| | RSD% | | 36.34 | 30.48 | 28.06 | 23.49 | 29.40 | 29.07 | 24.17 | 24.36 | 29.28 | BLD | 18.15 | 26.80 |
| | CV (%) | | 36.34 | 30.48 | 28.06 | 23.49 | 29.40 | 29.07 | 24.17 | 24.36 | 29.28 | BLD | 18.15 | 26.80 |
| | Min. | | 3.00 | 0.036 | 9.8 | 2.6 | 2.1 | 1.3 | 46.5 | 1.05 | 0.0016 | BLD | 234.03 | 5.22 |
| | Max. | | 11.2 | 0.110 | 28.4 | 6.0 | 6.1 | 3.95 | 112.3 | 2.65 | 0.0032 | BLD | 427.66 | 13.87 |
| | Urban soil | | 9.72 | 0.096 | 24.74 | 5.37 | 5.52 | 3.37 | 94.01 | 2.29 | 0.0012 | 0.0001 | 401.52 | 11.43 |
| | Forest soil | | 3.25 | 0.040 | 11.19 | 2.88 | 2.28 | 1.57 | 51.33 | 1.18 | 0.0002 | 0.0000 | 253.07 | 5.86 |
| | *T. tomentosa* | | 8.37 | 0.083 | 22.40 | 4.90 | 4.85 | 3.04 | 85.73 | 2.12 | 0.0012 | 0.0002 | 372.61 | 10.94 |
| | *T. cordata* | | 7.38 | 0.080 | 21.17 | 4.50 | 4.53 | 2.86 | 86.86 | 2.06 | 0.0001 | 0.0000 | 363.77 | 10.74 |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *T. platyphyllos* | 7.38 | 0.078 | 21.53 | 4.47 | 4.57 | 2.77 | 82.25 | 2.17 | 0.0014 | 0.0000 | 356.58 | 10.03 |

Data represent mean concentrations (± standard deviation, SD) of heavy metals measured in bark samples collected from *Tilia* species across all sampled locations in the Oradea region. "BLD" indicates values below the analytical detection limit. Habitat categories reflect differences in environmental exposure: urban soils are influenced primarily by vehicular traffic emissions and industrial particulate deposition; forest soils represent low-impact background reference areas; and local soils correspond to moderately impacted zones with mixed land-use activity. Variation among species (*T. tomentosa*, *T. cordata*, and *T. platyphyllos*) highlights species-specific differences in bark sorption capacity and metal accumulation behavior, supporting the suitability of *Tilia* spp. as biomonitors of atmospheric metal pollution along the urban–forest gradient in Oradea.

**Table S4**. Concentrations of Selected Heavy Metals in *Tilia* Leaf Samples from Different Habitats in the Oradea Region

| Bark ID | Species | Habitat | Pb (mg/kg) | Cd (mg/kg) | Zn (mg/kg) | Cu (mg/kg) | Ni (mg/kg) | Cr (mg/kg) | Mn (mg/kg) | Co (mg/kg) | As (mg/kg) | Hg (mg/kg) | Al (mg/kg) | V (mg/kg) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TL-L01 | *T. tomentosa* | Forest soil | 0.16 ± 0.03 | BLD | 8.7 ± 1.2 | 0.6 ± 0.08 | 0.07 ± 0.01 | BLD | 4.8 ± 0.6 | BLD | BLD | BLD | BLD | BLD |
| TL-L02 | *T. cordata* | Urban soil | 0.32 ± 0.05 | BLD | 19.6 ± 2.3 | 2.4 ± 0.30 | 0.32 ± 0.04 | 0.014 ± 0.002 | 12.6 ± 1.7 | 0.028 ± 0.004 | BLD | BLD | 14.8 ± 1.9 | 0.006 ± 0.001 |
| TL-L03 | *T. tomentosa* | Urban soil | 0.30 ± 0.05 | BLD | 18.9 ± 2.2 | 2.1 ± 0.28 | 0.29 ± 0.04 | 0.012 ± 0.002 | 11.9 ± 1.5 | 0.022 ± 0.003 | BLD | BLD | 12.6 ± 1.7 | 0.005 ± 0.001 |
| TL-L04 | *T. tomentosa* | Urban soil | 0.28 ± 0.05 | BLD | 20.3 ± 2.4 | 2.6 ± 0.32 | 0.34 ± 0.04 | 0.016 ± 0.003 | 13.1 ± 1.8 | 0.031 ± 0.004 | BLD | BLD | 15.9 ± 2.1 | 0.007 ± 0.001 |
| TL-L05 | *T. tomentosa* | Urban soil | 0.31 ± 0.05 | BLD | 21.0 ± 2.5 | 2.9 ± 0.35 | 0.37 ± 0.05 | 0.018 ± 0.003 | 14.2 ± 1.9 | 0.035 ± 0.005 | BLD | BLD | 18.4 ± 2.4 | 0.008 ± 0.001 |
| TL-L06 | *T. cordata* | Urban soil | 0.33 ± 0.06 | BLD | 19.2 ± 2.3 | 2.2 ± 0.27 | 0.30 ± 0.04 | BLD | 11.4 ± 1.5 | BLD | BLD | BLD | 11.7 ± 1.6 | BLD |
| TL-L07 | *T. tomentosa* | Urban soil | 0.34 ± 0.06 | BLD | 22.1 ± 2.6 | 3.1 ± 0.38 | 0.39 ± 0.05 | 0.020 ± 0.003 | 14.6 ± 1.9 | 0.040 ± 0.005 | BLD | BLD | 19.6 ± 2.5 | 0.009 ± 0.002 |
| TL-L08 | *T. platyphyllos* | Local soil | 0.22 ± 0.04 | BLD | 13.5 ± 1.8 | 1.3 ± 0.16 | 0.16 ± 0.02 | BLD | 8.6 ± 1.1 | BLD | BLD | BLD | 8.4 ± 1.1 | BLD |
| TL-L09 | *T. cordata* | Forest soil | 0.15 ± 0.03 | BLD | 7.9 ± 1.1 | 0.5 ± 0.07 | 0.06 ± 0.01 | BLD | 4.1 ± 0.5 | BLD | BLD | BLD | BLD | BLD |
| TL-L10 | *T. tomentosa* | Urban soil | 0.29 ± 0.05 | BLD | 18.7 ± 2.2 | 2.0 ± 0.26 | 0.28 ± 0.04 | 0.011 ± 0.002 | 10.8 ± 1.4 | 0.018 ± 0.003 | BLD | BLD | 10.9 ± 1.5 | 0.004 ± 0.001 |
| TL-L11 | *T. cordata* | Urban soil | 0.27 ± 0.05 | BLD | 17.5 ± 2.1 | 1.8 ± 0.24 | 0.25 ± 0.03 | BLD | 10.1 ± 1.3 | BLD | BLD | BLD | 9.6 ± 1.4 | BLD |
| TL-L12 | *T. platyphyllos* | Urban soil | 0.31 ± 0.05 | BLD | 21.8 ± 2.6 | 3.0 ± 0.36 | 0.38 ± 0.05 | 0.017 ± 0.003 | 13.8 ± 1.8 | 0.033 ± 0.004 | BLD | BLD | 17.8 ± 2.3 | 0.007 ± 0.001 |
| TL-L13 | *T. cordata* | Urban soil | 0.33 ± 0.06 | BLD | 20.6 ± 2.4 | 2.5 ± 0.30 | 0.33 ± 0.04 | BLD | 12.4 ± 1.6 | BLD | BLD | BLD | 11.5 ± 1.6 | BLD |
| TL-L14 | *T. cordata* | Urban soil | 0.28 ± 0.05 | BLD | 19.9 ± 2.3 | 2.1 ± 0.27 | 0.29 ± 0.04 | BLD | 11.3 ± 1.5 | BLD | BLD | BLD | 10.2 ± 1.4 | BLD |
| TL-L15 | *T. tomentosa* | Urban soil | 0.35 ± 0.06 | BLD | 22.8 ± 2.7 | 3.2 ± 0.40 | 0.40 ± 0.05 | 0.021 ± 0.003 | 14.9 ± 2.0 | 0.041 ± 0.005 | BLD | BLD | 20.1 ± 2.7 | 0.010 ± 0.002 |
| TL-L16 | *T. tomentosa* | Urban soil | 0.30 ± 0.05 | BLD | 18.3 ± 2.2 | 1.9 ± 0.25 | 0.26 ± 0.03 | BLD | 10.5 ± 1.4 | BLD | BLD | BLD | 9.8 ± 1.3 | BLD |
| TL-L17 | *T. tomentosa* | Local soil | 0.23 ± 0.04 | BLD | 14.4 ± 1.9 | 1.4 ± 0.17 | 0.18 ± 0.02 | BLD | 8.1 ± 1.0 | BLD | BLD | BLD | 7.1 ± 1.0 | BLD |
| TL-L18 | *T. cordata* | Local soil | 0.21 ± 0.04 | BLD | 12.8 ± 1.8 | 1.1 ± 0.14 | 0.14 ± 0.02 | BLD | 7.6 ± 0.9 | BLD | BLD | BLD | 6.4 ± 0.9 | BLD |
| TL-L19 | *T. tomentosa* | Local soil | 0.24 ± 0.04 | BLD | 15.1 ± 2.0 | 1.5 ± 0.18 | 0.19 ± 0.02 | BLD | 8.4 ± 1.1 | BLD | BLD | BLD | 7.9 ± 1.1 | BLD |
| TL-L20 | *T. tomentosa* | Forest soil | 0.14 ± 0.02 | BLD | 8.4 ± 1.2 | 0.7 ± 0.08 | 0.08 ± 0.01 | BLD | 4.4 ± 0.6 | BLD | BLD | BLD | BLD | BLD |
| TL-L21 | *T. platyphyllos* | Forest soil | 0.17 ± 0.03 | BLD | 10.6 ± 1.5 | 0.8 ± 0.09 | 0.10 ± 0.01 | BLD | 5.3 ± 0.7 | BLD | BLD | BLD | BLD | BLD |
| TL-L22 | *T. tomentosa* | Forest soil | 0.18 ± 0.03 | BLD | 11.2 ± 1.5 | 0.9 ± 0.10 | 0.11 ± 0.01 | BLD | 5.9 ± 0.8 | BLD | BLD | BLD | BLD | BLD |
| TL-L23 | *T. tomentosa* | Forest soil | 0.16 ± 0.03 | BLD | 9.5 ± 1.3 | 0.6 ± 0.07 | 0.09 ± 0.01 | BLD | BLD | BLD | BLD | BLD | BLD | BLD |
| TL-L24 | *T. platyphyllos* | Urban soil | 0.29 ± 0.05 | BLD | 21.3 ± 2.6 | 2.8 ± 0.34 | 0.36 ± 0.04 | 0.015 ± 0.002 | 13.3 ± 1.8 | 0.029 ± 0.004 | BLD | BLD | 16.7 ± 2.2 | 0.006 ± 0.001 |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TL-L25 | *T. platyphyllos* | Urban soil | 0.32 ± 0.05 | BLD | 18.9 ± 2.2 | 2.3 ± 0.28 | 0.31 ± 0.04 | BLD | 11.8 ± 1.5 | BLD | BLD | BLD | 12.3 ± 1.7 | 0.005 ± 0.001 |
| TL-L26 | *T. tomentosa* | Forest soil | 0.15 ± 0.03 | BLD | 9.1 ± 1.3 | 0.5 ± 0.06 | 0.07 ± 0.01 | BLD | BLD | BLD | BLD | BLD | BLD | BLD |
| TL-L27 | *T. tomentosa* | Urban soil | 0.34 ± 0.06 | BLD | 22.0 ± 2.6 | 2.9 ± 0.36 | 0.37 ± 0.05 | 0.018 ± 0.003 | 13.9 ± 1.9 | 0.038 ± 0.005 | BLD | BLD | 18.9 ± 2.5 | 0.007 ± 0.001 |
| TL-L28 | *T. tomentosa* | Urban soil | 0.30 ± 0.05 | BLD | 23.4 ± 2.8 | 3.1 ± 0.39 | 0.41 ± 0.05 | 0.022 ± 0.004 | 14.7 ± 2.0 | 0.044 ± 0.006 | BLD | BLD | 21.5 ± 2.8 | 0.009 ± 0.002 |
| TL-L29 | *T. tomentosa* | Urban soil | 0.33 ± 0.06 | BLD | 20.8 ± 2.5 | 2.4 ± 0.30 | 0.34 ± 0.04 | 0.013 ± 0.002 | 12.9 ± 1.7 | 0.030 ± 0.004 | BLD | BLD | 15.6 ± 2.1 | 0.006 ± 0.001 |
| TL-L30 | *T. tomentosa* | Urban soil | 0.31 ± 0.05 | BLD | 19.4 ± 2.3 | 2.1 ± 0.26 | 0.30 ± 0.04 | BLD | 11.6 ± 1.5 | BLD | BLD | BLD | 10.7 ± 1.4 | BLD |
| TL-L31 | *T. tomentosa* | Urban soil | 0.29 ± 0.05 | BLD | 18.0 ± 2.2 | 1.7 ± 0.22 | 0.24 ± 0.03 | BLD | 10.2 ± 1.3 | BLD | BLD | BLD | 9.2 ± 1.2 | BLD |
| TL-L32 | *T. tomentosa* | Urban soil | 0.27 ± 0.04 | BLD | 21.5 ± 2.6 | 2.6 ± 0.33 | 0.35 ± 0.04 | BLD | 13.5 ± 1.8 | BLD | BLD | BLD | 17.1 ± 2.2 | BLD |
| TL-L33 | *T. tomentosa* | Urban soil | 0.35 ± 0.06 | BLD | 22.6 ± 2.7 | 3.0 ± 0.38 | 0.39 ± 0.05 | 0.019 ± 0.003 | 14.3 ± 1.9 | 0.039 ± 0.005 | BLD | BLD | 20.4 ± 2.7 | 0.008 ± 0.001 |
| TL-L34 | *T. cordata* | Urban soil | 0.32 ± 0.05 | BLD | 20.4 ± 2.4 | 2.3 ± 0.28 | 0.33 ± 0.04 | BLD | 12.1 ± 1.6 | BLD | BLD | BLD | 12.9 ± 1.7 | BLD |
| | Mean | | 0.2688 | 0.0000 | 17.3588 | 1.9676 | 0.2603 | 0.0064 | 10.2088 | 0.0126 | 0.0000 | 0.0000 | 10.8235 | 0.0029 |
| | SD | | 0.0666 | 0.0000 | 4.8562 | 0.8605 | 0.1134 | 0.0085 | 4.0812 | 0.0169 | 0.0000 | 0.0000 | 6.8816 | 0.0036 |
| | RSD% | | 24.77 | 0.00 | 27.98 | 43.73 | 43.57 | 133.16 | 39.98 | 134.09 | 0.00 | 0.00 | 63.58 | 127.15 |
| | CV (%) | | 24.77 | 0.00 | 27.98 | 43.73 | 43.57 | 133.16 | 39.98 | 134.09 | 0.00 | 0.00 | 63.58 | 127.15 |
| | Min. | | 0.1400 | 0.0000 | 7.9000 | 0.5000 | 0.0600 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | Max. | | 0.3500 | 0.0000 | 23.4000 | 3.2000 | 0.4100 | 0.0220 | 14.9000 | 0.0440 | 0.0000 | 0.0000 | 21.5000 | 0.0100 |
| | Urban soil | | 0.3091 | 0.0000 | 19.8152 | 2.3830 | 0.3124 | 0.0101 | 12.1296 | 0.0182 | 0.0000 | 0.0000 | 14.7043 | 0.0042 |
| | Forest soil | | 0.1588 | 0.0000 | 9.6000 | 0.6571 | 0.0836 | 0.0000 | 3.9875 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | *T. tomentosa* | | 0.2676 | 0.0000 | 17.4381 | 1.9905 | 0.2629 | 0.0081 | 10.1286 | 0.0161 | 0.0000 | 0.0000 | 11.2238 | 0.0035 |
| | *T. cordata* | | 0.2762 | 0.0000 | 17.2375 | 1.8625 | 0.2525 | 0.0018 | 10.2000 | 0.0035 | 0.0000 | 0.0000 | 9.6375 | 0.0008 |
| | *T. platyphyllos* | | 0.2620 | 0.0000 | 17.2200 | 2.0400 | 0.2620 | 0.0064 | 10.5600 | 0.0124 | 0.0000 | 0.0000 | 11.0400 | 0.0036 |

Data represent mean concentrations (± standard deviation, SD) of heavy metals measured in leaf samples collected from *Tilia* species across urban and forest habitats in the Oradea region. "BLD" indicates values below the analytical detection limit. Habitat categories reflect contrasting environmental exposure conditions: urban sites are influenced predominantly by vehicular traffic emissions, industrial particulate deposition, and resuspension of road dust, whereas forest sites correspond to low-impact background reference areas minimally affected by anthropogenic inputs. Elemental variation between habitats demonstrates clear enrichment in urban environments, where leaves accumulated significantly higher concentrations of Pb, Zn, Cu, Ni, Mn, Al, and V compared to forest sites, confirming the substantial contribution of atmospheric deposition sources in densely trafficked locations. In contrast, forest samples exhibit trace to minimal values for most metals, reflecting natural baseline geochemical conditions. Variation among Tilia species indicates measurable differences in foliar sorption behavior and metal retention efficiency, highlighting the influence of species-specific leaf surface microstructure and physiological characteristics. These results support

the suitability of Tilia spp. leaves as sensitive passive biomonitors for assessing airborne metal contamination and for tracking the spatial distribution of atmospheric pollution across the urban–forest gradient in the Oradea region.

**Table S5**. Concentrations of Selected Heavy Metals in *Tilia* Flower Samples from Different Habitats in the Oradea Region

| Bark ID | Species | Habitat | Pb (mg/kg) | Cd (mg/kg) | Zn (mg/kg) | Cu (mg/kg) | Ni (mg/kg) | Cr (mg/kg) | Mn (mg/kg) | Co (mg/kg) | As (mg/kg) | Hg (mg/kg) | Al (mg/kg) | V (mg/kg) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TL-F01 | *T. tomentosa* | Forest | 0.16 ± 0.03 | BLD | 28.4 ± 4.1 | 11.8 ± 1.9 | BLD | BLD | 112.4 ± 11.3 | BLD | BLD | BLD | 42.5 ± 8.2 | BLD |
| TL-F02 | *T. cordata* | Urban | 0.32 ± 0.05 | BLD | 74.2 ± 6.5 | 26.7 ± 2.8 | 0.88 ± 0.12 | BLD | 241.8 ± 21.6 | BLD | BLD | BLD | 182.4 ± 21.6 | 0.09 ± 0.02 |
| TL-F03 | *T. tomentosa* | Urban | 0.30 ± 0.05 | BLD | 78.5 ± 7.1 | 27.4 ± 2.9 | 0.93 ± 0.13 | 0.21 ± 0.04 | 254.3 ± 22.5 | 0.05 ± 0.01 | BLD | BLD | 194.8 ± 22.5 | 0.11 ± 0.02 |
| TL-F04 | *T. tomentosa* | Urban | 0.28 ± 0.04 | BLD | 82.6 ± 7.8 | 29.6 ± 3.1 | 1.02 ± 0.14 | 0.24 ± 0.04 | 268.7 ± 24.0 | 0.06 ± 0.01 | BLD | BLD | 205.6 ± 23.3 | 0.13 ± 0.02 |
| TL-F05 | *T. tomentosa* | Urban | 0.31 ± 0.05 | BLD | 85.3 ± 8.0 | 30.1 ± 3.2 | 0.97 ± 0.13 | BLD | 276.1 ± 24.6 | BLD | BLD | BLD | 218.3 ± 24.0 | BLD |
| TL-F06 | *T. cordata* | Urban | BLD | BLD | 89.1 ± 8.6 | 32.5 ± 3.4 | 1.05 ± 0.15 | 0.27 ± 0.05 | 288.9 ± 25.3 | 0.07 ± 0.01 | BLD | BLD | 232.6 ± 25.5 | 0.15 ± 0.03 |
| TL-F07 | *T. tomentosa* | Urban | 0.34 ± 0.06 | BLD | 92.4 ± 9.0 | 33.8 ± 3.5 | 1.12 ± 0.16 | 0.30 ± 0.05 | 302.4 ± 26.5 | 0.08 ± 0.01 | BLD | BLD | 248.1 ± 26.2 | 0.18 ± 0.03 |
| TL-F08 | *T. platyphyllos* | Local | 0.22 ± 0.04 | BLD | 52.6 ± 5.4 | 18.7 ± 2.2 | BLD | BLD | 178.6 ± 16.4 | BLD | BLD | BLD | 96.4 ± 12.8 | BLD |
| TL-F09 | *T. cordata* | Forest | 0.15 ± 0.03 | BLD | 25.9 ± 3.8 | 10.6 ± 1.7 | BLD | BLD | 96.5 ± 10.8 | BLD | BLD | BLD | 38.2 ± 7.5 | BLD |
| TL-F10 | *T. tomentosa* | Urban | BLD | BLD | 81.3 ± 7.6 | 28.3 ± 3.0 | 0.95 ± 0.13 | 0.22 ± 0.04 | 265.3 ± 23.8 | BLD | BLD | BLD | 199.3 ± 23.1 | 0.10 ± 0.02 |
| TL-F11 | *T. cordata* | Urban | 0.27 ± 0.05 | BLD | 76.8 ± 6.9 | 27.1 ± 2.9 | 0.90 ± 0.12 | BLD | 251.9 ± 22.9 | BLD | BLD | BLD | 187.4 ± 21.6 | BLD |
| TL-F12 | *T. platyphyllos* | Urban | 0.31 ± 0.05 | BLD | 88.5 ± 8.5 | 31.4 ± 3.3 | 1.03 ± 0.14 | BLD | 280.4 ± 25.0 | 0.06 ± 0.01 | BLD | BLD | 215.8 ± 23.9 | 0.12 ± 0.02 |
| TL-F13 | *T. cordata* | Urban | 0.33 ± 0.06 | BLD | 91.2 ± 8.8 | 33.1 ± 3.4 | 1.08 ± 0.15 | 0.26 ± 0.05 | 297.2 ± 26.0 | 0.07 ± 0.01 | BLD | BLD | 229.6 ± 25.1 | 0.14 ± 0.03 |
| TL-F14 | *T. cordata* | Urban | 0.28 ± 0.05 | BLD | 83.7 ± 7.9 | 29.9 ± 3.2 | 0.99 ± 0.13 | BLD | 269.6 ± 24.0 | BLD | BLD | BLD | 206.7 ± 23.3 | BLD |
| TL-F15 | *T. tomentosa* | Urban | BLD | BLD | 97.5 ± 9.4 | 35.2 ± 3.7 | 1.18 ± 0.17 | 0.34 ± 0.06 | 318.1 ± 27.4 | 0.09 ± 0.01 | BLD | BLD | 261.4 ± 27.0 | 0.20 ± 0.03 |
| TL-F16 | *T. tomentosa* | Urban | BLD | BLD | 86.4 ± 8.2 | 30.4 ± 3.2 | 1.01 ± 0.14 | 0.28 ± 0.05 | 276.9 ± 24.6 | BLD | BLD | BLD | 217.0 ± 24.0 | 0.14 ± 0.03 |
| TL-F17 | *T. tomentosa* | Local | BLD | BLD | 55.7 ± 5.7 | 19.6 ± 2.3 | BLD | BLD | 185.9 ± 16.9 | BLD | BLD | BLD | 104.3 ± 13.6 | BLD |
| TL-F18 | *T. cordata* | Local | BLD | BLD | 51.2 ± 5.3 | 17.4 ± 2.1 | BLD | BLD | 172.8 ± 15.5 | BLD | BLD | BLD | 92.7 ± 12.1 | BLD |
| TL-F19 | *T. tomentosa* | Local | 0.24 ± 0.04 | BLD | 57.9 ± 6.0 | 20.1 ± 2.3 | BLD | BLD | 192.4 ± 17.8 | BLD | BLD | BLD | 113.8 ± 14.4 | BLD |
| TL-F20 | *T. tomentosa* | Forest | 0.14 ± 0.02 | BLD | 29.1 ± 4.2 | 12.3 ± 1.9 | BLD | BLD | 108.9 ± 11.8 | BLD | BLD | BLD | 45.1 ± 8.5 | BLD |
| TL-F21 | *T. platyphyllos* | Forest | 0.17 ± 0.03 | BLD | 33.8 ± 4.6 | 13.5 ± 2.0 | BLD | BLD | 121.4 ± 12.3 | BLD | BLD | BLD | 53.6 ± 9.2 | BLD |
| TL-F22 | *T. tomentosa* | Forest | 0.18 ± 0.03 | BLD | 31.4 ± 4.4 | 14.2 ± 2.1 | BLD | BLD | 139.6 ± 13.5 | BLD | BLD | BLD | 61.4 ± 9.8 | BLD |
| TL-F23 | *T. tomentosa* | Forest | BLD | BLD | 28.7 ± 4.1 | 12.9 ± 2.0 | BLD | BLD | 118.2 ± 11.7 | BLD | BLD | BLD | 49.2 ± 8.7 | BLD |
| TL-F24 | *T. platyphyllos* | Urban | 0.29 ± 0.05 | BLD | 84.7 ± 8.0 | 30.8 ± 3.3 | 1.00 ± 0.14 | BLD | 272.6 ± 24.2 | BLD | BLD | BLD | 211.6 ± 23.6 | BLD |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TL-F25 | *T. platyphyllos* | Urban | BLD | BLD | 90.5 ± 8.7 | 32.9 ± 3.6 | 1.09 ± 0.15 | 0.25 ± 0.05 | 298.1 ± 26.1 | 0.05 ± 0.01 | BLD | BLD | 239.8 ± 25.8 | 0.12 ± 0.02 |
| TL-F26 | *T. tomentosa* | Urban | 0.15 ± 0.03 | BLD | 79.2 ± 7.1 | 26.2 ± 2.8 | 0.86 ± 0.12 | BLD | 246.2 ± 22.1 | BLD | BLD | BLD | 174.5 ± 20.2 | BLD |
| TL-F27 | *T. tomentosa* | Urban | 0.34 ± 0.06 | BLD | 95.3 ± 9.2 | 34.1 ± 3.6 | 1.15 ± 0.16 | 0.32 ± 0.06 | 311.9 ± 27.0 | 0.08 ± 0.01 | BLD | BLD | 255.1 ± 26.8 | 0.17 ± 0.03 |
| TL-F28 | *T. tomentosa* | Urban | BLD | BLD | 87.6 ± 8.3 | 30.7 ± 3.3 | 1.02 ± 0.14 | 0.24 ± 0.04 | 279.5 ± 24.8 | BLD | BLD | BLD | 220.4 ± 24.3 | 0.13 ± 0.02 |
| TL-F29 | *T. tomentosa* | Urban | BLD | BLD | 93.9 ± 9.0 | 33.5 ± 3.6 | 1.10 ± 0.15 | BLD | 301.1 ± 26.3 | BLD | BLD | BLD | 242.6 ± 25.8 | BLD |
| TL-F30 | *T. tomentosa* | Urban | BLD | BLD | 85.8 ± 8.1 | 31.2 ± 3.4 | 1.04 ± 0.14 | 0.21 ± 0.04 | 286.8 ± 25.2 | BLD | BLD | BLD | 233.2 ± 25.1 | 0.11 ± 0.02 |
| TL-F31 | *T. tomentosa* | Urban | 0.29 ± 0.05 | BLD | 81.4 ± 7.7 | 28.9 ± 3.1 | 0.97 ± 0.13 | BLD | 263.7 ± 23.7 | BLD | BLD | BLD | 209.6 ± 23.5 | BLD |
| TL-F32 | *T. tomentosa* | Urban | 0.27 ± 0.04 | BLD | 78.1 ± 7.1 | 27.6 ± 2.9 | 0.92 ± 0.13 | 0.19 ± 0.04 | 249.0 ± 22.6 | BLD | BLD | BLD | 195.7 ± 22.7 | BLD |
| TL-F33 | *T. tomentosa* | Urban | 0.35 ± 0.06 | BLD | 98.6 ± 9.5 | 36.5 ± 3.8 | 1.20 ± 0.17 | 0.35 ± 0.06 | 322.3 ± 27.8 | 0.10 ± 0.01 | BLD | BLD | 268.3 ± 27.6 | 0.21 ± 0.03 |
| TL-F34 | *T. cordata* | Urban | BLD | BLD | 88.9 ± 8.4 | 32.1 ± 3.5 | 1.06 ± 0.15 | 0.27 ± 0.05 | 291.2 ± 25.5 | 0.07 ± 0.01 | BLD | BLD | 243.5 ± 25.9 | 0.15 ± 0.03 |
| | Mean | | 0.167 | 0.000 | 72.53 | 26.21 | 0.721 | 0.116 | 239.43 | 0.0229 | 0.000 | 0.000 | 176.19 | 0.066 |
| | SD | | 0.137 | 0.000 | 23.38 | 7.85 | 0.479 | 0.136 | 68.83 | 0.0348 | 0.000 | 0.000 | 74.43 | 0.075 |
| | RSD% | | 82.1% | 0.0% | 32.2% | 29.97% | 66.37% | 117.4% | 28.75% | 151.6% | 0.0% | 0.0% | 42.24% | 113.3% |
| | CV (%) | | 82.1% | 0.0% | 32.2% | 29.97% | 66.37% | 117.4% | 28.75% | 151.6% | 0.0% | 0.0% | 42.24% | 113.3% |
| | Min. | | 0.000 | 0.000 | 25.90 | 10.60 | 0.000 | 0.000 | 96.50 | 0.000 | 0.000 | 0.000 | 38.20 | 0.000 |
| | Max. | | 0.350 | 0.000 | 98.60 | 36.50 | 1.200 | 0.350 | 322.30 | 0.100 | 0.000 | 0.000 | 268.30 | 0.210 |
| | Urban soil | | 0.185 | 86.31 | 30.83 | 1.022 | 0.165 | 279.75 | 0.033 | 220.55 | 0.094 | 0.185 | 86.31 | 30.83 |
| | Forest soil | | 0.133 | 29.55 | 12.55 | 0.000 | 0.000 | 116.17 | 0.000 | 48.33 | 0.000 | 0.133 | 29.55 | 12.55 |
| | *T. tomentosa* | | 0.160 | 73.10 | 26.40 | 0.735 | 0.138 | 241.89 | 0.022 | 179.06 | 0.070 | 0.160 | 73.10 | 26.40 |
| | *T. cordata* | | 0.169 | 72.63 | 26.18 | 0.745 | 0.100 | 238.74 | 0.026 | 176.64 | 0.066 | 0.169 | 72.63 | 26.18 |
| | *T. platyphyllos* | | 0.198 | 70.02 | 25.46 | 0.624 | 0.050 | 230.22 | 0.022 | 163.44 | 0.048 | 0.198 | 70.02 | 25.46 |

Data represent mean concentrations (± standard deviation, SD) of heavy metals measured in flower samples collected from *Tilia* species across urban and forest habitats in the Oradea region. The abbreviation "BLD" indicates values below the analytical detection limit. Habitat categories reflect contrasting environmental exposure conditions: urban sites are influenced predominantly by vehicular traffic emissions, industrial particulate deposition, and resuspension of road dust, whereas forest sites correspond to low-impact background reference areas minimally affected by anthropogenic inputs. Elemental variation between habitats demonstrates clear enrichment in urban environments, where flowers accumulated significantly higher concentrations of Pb, Zn, Cu, Ni, Mn, Al, and V compared to forest sites, confirming the substantial contribution of atmospheric deposition sources in densely

trafficked locations. In contrast, forest flower samples exhibit trace to minimal values for most metals, reflecting natural baseline geochemical conditions. Variation among *Tilia* species indicates measurable differences in floral sorption behavior and metal retention efficiency, highlighting the influence of species-specific surface morphology, glandular secretions, and physiological characteristics affecting particulate capture and accumulation. These results support the suitability of *Tilia* spp. flowers used for herbal tea as sensitive passive biomonitors for assessing airborne metal contamination, and emphasize the importance of evaluating harvest location to ensure pharmacological quality and consumer safety when floral material is collected from polluted urban area

**Table S6.** Concentrations of Heavy Metals in Tilia Flower Infusions Prepared Under Different Brewing Conditions (μg/L)

| Sample Code | Water Type | Temp (°C) | Time (min) | Species (Tilia) | Pb (μg/L) | Cd (μg/L) | Zn (μg/L) | Cu (μg/L) | Ni (μg/L) | Cr (μg/L) | Mn (μg/L) | Co (μg/L) | As (μg/L) | Hg (μg/L) | Al (μg/L) | V (μg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| INF-T1 | Ultra-pure | 70 | 5 | *T. tomentosa* | LOD | 0.006 ± 0.001 | LOD | 0.6 ± 0.05 | LOD | LOD | 4.8 ± 0.4 | LOD | LOD | LOD | LOD | 0.06 ± 0.01 |
| INF-T2 | | 80 | 7 | | LOD | LOD | 3.2 ± 0.3 | LOD | LOD | 0.08 ± 0.01 | LOD | 0.03 ± 0.01 | LOD | LOD | 3.5 ± 0.3 | LOD |
| INF-T3 | | 85 | 10 | | LOD | LOD | LOD | LOD | LOD | 0.12 ± 0.01 | 6.5 ± 0.5 | LOD | LOD | LOD | 4.2 ± 0.3 | 0.10 ± 0.01 |
| INF-T4 | | 90 | 12 | | LOD | 0.007 ± 0.001 | 4.5 ± 0.4 | 0.8 ± 0.06 | 0.25 ± 0.03 | LOD | 10.2 ± 0.8 | 0.05 ± 0.01 | LOD | LOD | 5.1 ± 0.4 | 0.14 ± 0.01 |
| INF-T5 | | 95 | 15 | | 0.12 ± 0.014 | 0.010 ± 0.002 | 6.8 ± 0.6 | 1.1 ± 0.08 | 0.32 ± 0.04 | 0.21 ± 0.02 | 14.8 ± 1.1 | 0.07 ± 0.01 | LOD | LOD | 6.0 ± 0.5 | 0.19 ± 0.02 |
| INF-T6 | Tap water | 70 | 5 | | LOD | LOD | 5.1 ± 0.5 | LOD | LOD | 0.15 ± 0.02 | LOD | 0.04 ± 0.01 | LOD | LOD | 4.8 ± 0.4 | 0.11 ± 0.01 |
| INF-T7 | | 80 | 7 | | LOD | 0.006 ± 0.001 | LOD | 0.7 ± 0.06 | 0.22 ± 0.03 | LOD | 9.6 ± 0.7 | 0.06 ± 0.01 | LOD | LOD | 5.6 ± 0.4 | LOD |
| INF-T8 | | 85 | 10 | | 0.10 ± 0.012 | LOD | 7.4 ± 0.6 | 1.3 ± 0.09 | 0.36 ± 0.04 | 0.24 ± 0.02 | 16.5 ± 1.3 | LOD | LOD | LOD | 7.2 ± 0.6 | 0.22 ± 0.02 |
| INF-T9 | | 90 | 12 | | 0.16 ± 0.015 | 0.011 ± 0.002 | 9.2 ± 0.8 | 1.6 ± 0.10 | 0.48 ± 0.05 | 0.38 ± 0.03 | 21.9 ± 1.7 | 0.11 ± 0.01 | LOD | LOD | 8.5 ± 0.7 | 0.34 ± 0.03 |
| INF-T10 | | 95 | 15 | | 0.23 ± 0.021 | 0.015 ± 0.003 | 11.5 ± 1.0 | 2.0 ± 0.14 | 0.62 ± 0.06 | 0.52 ± 0.04 | 28.4 ± 2.1 | 0.16 ± 0.02 | LOD | LOD | 9.8 ± 0.8 | 0.41 ± 0.03 |
| INF-C1 | Ultra-pure | 70 | 5 | *T. cordata* | LOD | LOD | LOD | LOD | LOD | LOD | LOD | LOD | LOD | LOD | 2.8 ± 0.2 | LOD |
| INF-C2 | | 80 | 7 | | LOD | 0.006 ± 0.001 | 4.1 ± 0.4 | LOD | 0.24 ± 0.03 | 0.10 ± 0.01 | 5.5 ± 0.5 | LOD | LOD | LOD | LOD | 0.07 ± 0.01 |
| INF-C3 | | 85 | 10 | | LOD | LOD | 5.6 ± 0.5 | 0.9 ± 0.07 | LOD | 0.18 ± 0.02 | 11.8 ± 0.9 | 0.05 ± 0.01 | LOD | LOD | 4.9 ± 0.4 | 0.15 ± 0.01 |
| INF-C4 | | 90 | 12 | | 0.14 ± 0.016 | 0.009 ± 0.002 | 8.3 ± 0.7 | 1.4 ± 0.10 | 0.38 ± 0.04 | 0.29 ± 0.03 | 18.3 ± 1.4 | 0.09 ± 0.01 | LOD | LOD | 6.3 ± 0.5 | 0.23 ± 0.02 |
| INF-C5 | | 95 | 15 | | 0.18 ± 0.020 | 0.013 ± 0.002 | 10.9 ± 1.0 | 1.9 ± 0.13 | 0.55 ± 0.05 | 0.41 ± 0.03 | 24.6 ± 1.9 | 0.14 ± 0.02 | LOD | LOD | 8.0 ± 0.6 | 0.36 ± 0.03 |
| INF-C6 | Tap water | 70 | 5 | | LOD | LOD | LOD | LOD | 0.22 ± 0.03 | 0.22 ± 0.02 | LOD | LOD | LOD | LOD | 5.1 ± 0.4 | 0.10 ± 0.01 |
| INF-C7 | | 80 | 7 | | LOD | LOD | 5.2 ± 0.4 | 0.8 ± 0.06 | LOD | LOD | 13.2 ± 1.0 | 0.07 ± 0.01 | LOD | LOD | 6.7 ± 0.5 | LOD |
| INF-C8 | | 85 | 10 | | 0.13 ± 0.015 | 0.010 ± 0.002 | 7.9 ± 0.6 | 1.2 ± 0.09 | 0.41 ± 0.05 | 0.34 ± 0.03 | 20.7 ± 1.6 | 0.11 ± 0.01 | LOD | LOD | 8.4 ± 0.7 | 0.28 ± 0.02 |
| INF-C9 | | 90 | 12 | | 0.21 ± 0.021 | 0.014 ± 0.002 | 9.8 ± 0.9 | 1.7 ± 0.11 | 0.60 ± 0.06 | 0.50 ± 0.04 | 26.9 ± 2.0 | 0.18 ± 0.02 | LOD | LOD | 9.7 ± 0.8 | 0.39 ± 0.03 |
| INF-C10 | | 95 | 15 | | 0.31 ± 0.029 | LOD | 13.4 ± 1.2 | 2.4 ± 0.15 | 0.78 ± 0.07 | 0.67 ± 0.05 | 33.1 ± 2.4 | 0.24 ± 0.02 | LOD | LOD | 11.2 ± 0.9 | 0.46 ± 0.03 |
| INF-P1 | Ultra-pure | 70 | 5 | *T.* | LOD | LOD | 3.8 ± 0.3 | LOD | LOD | 0.09 ± 0.01 | LOD | LOD | LOD | LOD | LOD | 0.06 ± 0.01 |
| INF-P2 | | 80 | 7 | | LOD | LOD | LOD | 0.6 ± 0.05 | LOD | 0.14 ± 0.02 | 7.4 ± 0.6 | LOD | LOD | LOD | 3.9 ± 0.3 | 0.09 ± 0.01 |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| INF-P3 | | 85 | 10 | LOD | 0.006 ± 0.001 | 6.1 ± 0.5 | 0.9 ± 0.07 | 0.28 ± 0.03 | LOD | 12.9 ± 1.0 | 0.04 ± 0.01 | LOD | LOD | 5.0 ± 0.4 | LOD |
| INF-P4 | | 90 | 12 | 0.13 ± 0.015 | 0.008 ± 0.001 | 7.3 ± 0.6 | 1.3 ± 0.09 | LOD | 0.26 ± 0.02 | 19.8 ± 1.5 | 0.08 ± 0.01 | LOD | LOD | 6.2 ± 0.5 | 0.20 ± 0.02 |
| INF-P5 | | 95 | 15 | 0.16 ± 0.018 | 0.011 ± 0.002 | 9.5 ± 0.8 | 1.7 ± 0.11 | 0.42 ± 0.05 | 0.37 ± 0.03 | 23.7 ± 1.8 | 0.13 ± 0.02 | LOD | LOD | 7.6 ± 0.6 | 0.32 ± 0.03 |
| INF-P6 | Tap water | 70 | 5 | LOD | LOD | LOD | 0.7 ± 0.06 | 0.25 ± 0.03 | LOD | 10.5 ± 0.8 | 0.05 ± 0.01 | LOD | LOD | 5.3 ± 0.4 | 0.12 ± 0.01 |
| INF-P7 | | 80 | 7 | LOD | 0.007 ± 0.001 | 5.8 ± 0.5 | LOD | 0.34 ± 0.04 | 0.21 ± 0.02 | LOD | 0.06 ± 0.01 | LOD | LOD | 6.5 ± 0.5 | 0.16 ± 0.01 |
| INF-P8 | | 85 | 10 | 0.11 ± 0.013 | LOD | 8.4 ± 0.7 | 1.4 ± 0.10 | LOD | 0.33 ± 0.03 | 18.6 ± 1.4 | 0.10 ± 0.01 | LOD | LOD | 7.9 ± 0.6 | 0.27 ± 0.02 |
| INF-P9 | | 90 | 12 | 0.18 ± 0.017 | 0.012 ± 0.002 | 10.7 ± 0.9 | 1.9 ± 0.12 | 0.50 ± 0.05 | 0.46 ± 0.04 | 25.8 ± 2.0 | 0.15 ± 0.02 | LOD | LOD | 9.1 ± 0.7 | 0.38 ± 0.03 |
| INF-P10 | | 95 | 15 | 0.27 ± 0.023 | 0.016 ± 0.003 | 12.9 ± 1.1 | 2.3 ± 0.15 | 0.70 ± 0.06 | 0.60 ± 0.05 | 31.4 ± 2.3 | 0.20 ± 0.02 | LOD | LOD | 10.5 ± 0.8 | 0.44 ± 0.03 |
| Mean | | | | 0.17 | 0.0098 | 7.71 | 1.33 | 0.42 | 0.30 | 17.37 | 0.10 | 0.000 | 0.000 | 6.66 | 0.226 |
| SD | | | | 0.07 | 0.00334 | 2.92 | 0.55 | 0.17 | 0.17 | 8.37 | 0.06 | 0.000 | 0.000 | 2.22 | 0.130 |
| RSD% | | | | 35.8 | 34.0 | 37.8 % | 41.6 % | 40.7 % | 56.3 % | 48.2 % | 57.4 % | 0.000 | 0.000 | 33.3 | 57.4 |
| CV (%) | | | | 35.8 | 34.0 | 37.8 % | 41.6 % | 40.7 % | 56.3 % | 48.2 % | 57.4 % | 0.000 | 0.000 | 33.3 | 57.4 |
| Min. | | | | 0.10 | 0.006 | 3.20 | 0.60 | 0.22 | 0.08 | 4.8 | 0.03 | 0.000 | 0.000 | 2.8 | 0.06 |
| Max. | | | | 0.31 | 0.016 | 13.40 | 2.40 | 0.78 | 0.67 | 33.1 | 0.24 | 0.000 | 0.000 | 11.2 | 0.46 |
| *T. tomentosa* | | | | 0.15 | 0.0092 | 6.52 | 1.08 | 0.36 | 0.24 | 15.21 | 0.077 | 0.000 | 0.000 | 6.08 | 0.196 |
| *T. cordata* | | | | 0.21 | 0.0104 | 8.27 | 1.42 | 0.50 | 0.34 | 19.26 | 0.125 | 0.000 | 0.000 | 7.01 | 0.255 |
| *T. platyphyllos* | | | | 0.18 | 0.0100 | 7.63 | 1.29 | 0.41 | 0.31 | 18.76 | 0.101 | 0.000 | 0.000 | 6.89 | 0.227 |
| Ultra-pure | | | | 0.13 | 0.0084 | 6.41 | 1.09 | 0.33 | 0.21 | 10.35 | 0.07 | 0.000 | 0.000 | 5.29 | 0.164 |
| Tap water | | | | 0.21 | 0.0114 | 8.52 | 1.33 | 0.48 | 0.36 | 22.68 | 0.123 | 0.000 | 0.000 | 7.75 | 0.283 |

**Table S7.** Transfer Efficiency (%) in *Tilia tomentosa* Infusions Prepared Under Different Brewing Conditions

| Sample | Water | Temp | Time | Pb | Cd | Zn | Cu | Ni | Cr | Mn | Co | As | Hg | Al | V |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| INF-T1 | Ultra | 70 | 5 | 0.00 | 0.05 | 0.00 | 0.59 | 0.00 | 0.00 | 0.52 | 0.00 | 0 | 0 | 0.00 | 1.18 |
| INF-T2 | Ultra | 80 | 7 | 0.00 | 0.00 | 0.87 | 0.00 | 0.00 | 0.19 | 0.00 | 0.09 | 0 | 0 | 0.50 | 0.00 |
| INF-T3 | Ultra | 85 | 10 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.27 | 0.70 | 0.00 | 0 | 0 | 0.60 | 1.97 |
| INF-T4 | Ultra | 90 | 12 | 0.00 | 0.05 | 1.22 | 0.79 | 7.91 | 0.00 | 1.10 | 0.15 | 0 | 0 | 0.73 | 2.76 |
| INF-T5 | Ultra | 95 | 15 | 18.80 | 0.08 | 1.84 | 1.09 | 10.12 | 0.47 | 1.60 | 0.21 | 0 | 0 | 0.86 | 3.75 |
| INF-T6 | Tap | 70 | 5 | 0.00 | 0.00 | 1.38 | 0.00 | 0.00 | 0.36 | 0.00 | 0.13 | 0 | 0 | 0.69 | 2.16 |
| INF-T7 | Tap | 80 | 7 | 0.00 | 0.05 | 0.00 | 0.65 | 6.78 | 0.00 | 1.08 | 0.19 | 0 | 0 | 0.81 | 0.00 |
| INF-T8 | Tap | 85 | 10 | 15.66 | 0.00 | 2.00 | 1.21 | 11.09 | 0.58 | 1.86 | 0.00 | 0 | 0 | 1.05 | 4.32 |
| INF-T9 | Tap | 90 | 12 | 25.09 | 0.08 | 2.48 | 1.49 | 14.81 | 0.91 | 2.47 | 0.23 | 0 | 0 | 1.24 | 6.69 |
| INF-T10 | Tap | 95 | 15 | 36.12 | 0.10 | 3.11 | 1.87 | 19.14 | 1.25 | 3.20 | 0.34 | 0 | 0 | 1.43 | 8.06 |

**Table S8**. Transfer Efficiency (%) in *Tilia cordata* Infusions Prepared Under Different Brewing Conditions

| Sample | Water | Temp | Time | Pb | Cd | Zn | Cu | Ni | Cr | Mn | Co | As | Hg | Al | V |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| INF-C1 | Ultra | 70 | 5 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0 | 0 | 1.06 | 0.00 |
| INF-C2 | Ultra | 80 | 7 | 0.00 | 0.02 | 1.52 | 0.00 | 13.25 | 0.24 | 0.65 | 0.00 | 0 | 0 | 0.00 | 0.06 |
| INF-C3 | Ultra | 85 | 10 | 0.00 | 0.00 | 2.08 | 0.96 | 0.00 | 0.42 | 1.40 | 0.21 | 0 | 0 | 0.74 | 0.32 |
| INF-C4 | Ultra | 90 | 12 | 20.69 | 0.03 | 3.09 | 1.48 | 19.75 | 0.68 | 2.18 | 0.39 | 0 | 0 | 0.95 | 0.49 |
| INF-C5 | Ultra | 95 | 15 | 26.69 | 0.04 | 4.04 | 2.01 | 28.61 | 0.97 | 2.93 | 0.61 | 0 | 0 | 1.21 | 0.77 |
| INF-C6 | Tap | 70 | 5 | 0.00 | 0.00 | 0.00 | 0.00 | 12.50 | 0.82 | 0.00 | 0.00 | 0 | 0 | 0.77 | 0.84 |
| INF-C7 | Tap | 80 | 7 | 0.00 | 0.00 | 1.92 | 0.86 | 0.00 | 0.00 | 1.71 | 0.30 | 0 | 0 | 1.01 | 0.00 |
| INF-C8 | Tap | 85 | 10 | 19.25 | 0.03 | 2.91 | 1.29 | 28.91 | 0.98 | 2.68 | 0.47 | 0 | 0 | 1.26 | 2.36 |
| INF-C9 | Tap | 90 | 12 | 31.06 | 0.04 | 3.62 | 1.83 | 42.30 | 1.45 | 3.48 | 0.78 | 0 | 0 | 1.46 | 3.29 |
| INF-C10 | Tap | 95 | 15 | 45.80 | 0.00 | 4.96 | 2.59 | 55.01 | 1.94 | 4.29 | 1.04 | 0 | 0 | 1.68 | 3.89 |

**Table S9.** Transfer Efficiency (%) in *Tilia platyphyllos* Infusions Prepared Under Different Brewing Conditions

| Sample | Water | Temp | Time | Pb | Cd | Zn | Cu | Ni | Cr | Mn | Co | As | Hg | Al | V |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| INF-P1 | Ultra | 70 | 5 | 0.00 | 0.00 | 1.52 | 0.00 | 0.00 | 0.24 | 0.00 | 0.00 | 0 | 0 | 0.00 | 0.35 |
| INF-P2 | Ultra | 80 | 7 | 0.00 | 0.00 | 0.00 | 0.70 | 0.00 | 0.37 | 0.85 | 0.00 | 0 | 0 | 0.59 | 0.52 |
| INF-P3 | Ultra | 85 | 10 | 0.00 | 0.01 | 2.44 | 0.94 | 13.25 | 0.00 | 1.47 | 0.11 | 0 | 0 | 0.76 | 0.00 |
| INF-P4 | Ultra | 90 | 12 | 20.54 | 0.02 | 2.93 | 1.35 | 0.00 | 0.83 | 2.25 | 0.22 | 0 | 0 | 0.94 | 1.19 |
| INF-P5 | Ultra | 95 | 15 | 25.12 | 0.02 | 3.82 | 1.76 | 19.71 | 1.19 | 2.69 | 0.36 | 0 | 0 | 1.16 | 1.90 |
| INF-P6 | Tap | 70 | 5 | 0.00 | 0.00 | 0.00 | 0.73 | 11.82 | 0.00 | 2.75 | 0.15 | 0 | 0 | 0.90 | 0.52 |
| INF-P7 | Tap | 80 | 7 | 0.00 | 0.02 | 2.30 | 0.00 | 16.09 | 0.68 | 0.00 | 0.19 | 0 | 0 | 1.11 | 0.69 |
| INF-P8 | Tap | 85 | 10 | 13.90 | 0.00 | 3.34 | 1.91 | 0.00 | 1.07 | 4.88 | 0.32 | 0 | 0 | 1.35 | 1.16 |
| INF-P9 | Tap | 90 | 12 | 22.73 | 0.03 | 4.25 | 2.59 | 10.14 | 1.49 | 6.75 | 0.47 | 0 | 0 | 1.56 | 1.63 |
| INF-P10 | Tap | 95 | 15 | 34.12 | 0.03 | 5.12 | 3.13 | 14.22 | 1.94 | 8.21 | 0.63 | 0 | 0 | 1.81 | 1.98 |

**Table S10.** Sampling locations, species identification, and associated biological and soil samples of *Tilia* trees

| Tree ID | Species | Latitude (°N) | Longitude (°E) | Sampling date | Time | Area | Site type | Soil sample ID | Bark | Leaves | Flowers |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | *Tilia cordata* | 47.04409 | 21.91902 | 19.06.2025 | 10:00 | Oradea | Urban | 6 | Yes | Yes | Yes |
| 2 | *Tilia platyphyllos* | 46.92496 | 22.02560 | 28.06.2025 | 12:00 | Mierlău | Locality | 8 | Yes | Yes | Yes |
| 3 | *Tilia cordata* | 46.99047 | 22.02396 | 28.06.2025 | 08:00 | Băile 1 Mai | Forest | 9 | Yes | Yes | Yes |
| 4 | *Tilia tomentosa* | 46.99601 | 22.00010 | 28.06.2025 | 10:00 | Băile 1 Mai | Locality | 17 | Yes | Yes | Yes |
| 5 | *Tilia tomentosa* | 47.06824 | 21.92436 | 26.06.2025 | 09:00 | Oradea | Urban | 29 | Yes | Yes | Yes |
| 6 | *Tilia platyphyllos* | 47.06342 | 21.97818 | 26.06.2025 | 10:00 | Oradea | Urban | 32 | Yes | Yes | Yes |
| 7 | *Tilia tomentosa* | 46.98907 | 22.02400 | 28.06.2025 | 09:00 | Băile 1 Mai | Forest | 20 | Yes | Yes | Yes |
| 8 | *Tilia platyphyllos* | 46.92789 | 21.96047 | 28.06.2025 | 13:00 | Boboștea | Forest | 21 | Yes | Yes | Yes |
| 9 | *Tilia tomentosa* | 46.99886 | 21.97733 | 28.06.2025 | 11:30 | Băile Felix | Forest | 23 | Yes | Yes | Yes |
| 10 | *Tilia tomentosa* | 46.98960 | 22.02401 | 28.06.2025 | 09:15 | Băile 1 Mai | Forest | 1 | Yes | Yes | Yes |
| 11 | *Tilia tomentosa* | 46.92474 | 22.02544 | 28.06.2025 | 12:00 | Mierlău | Locality | 19 | Yes | Yes | Yes |
| 12 | *Tilia tomentosa* | 47.07000 | 22.01672 | 26.06.2025 | 14:00 | Oradea–Podgoria | Forest | 26 | Yes | Yes | Yes |
| 13 | *Tilia tomentosa* | 47.05524 | 21.91768 | 26.06.2025 | 07:30 | Oradea | Urban | 30 | Yes | Yes | Yes |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 14 | *Tilia platyphyllos* | 47.05834 | 21.91790 | 25.06.2025 | 12:00 | Oradea | Urban | 31 | Yes | Yes | Yes |
| 15 | *Tilia tomentosa* | 47.07063 | 21.91079 | 26.06.2025 | 12:00 | Oradea | Urban | 7 | Yes | Yes | Yes |
| 16 | *Tilia tomentosa* | 47.04845 | 21.93011 | 25.06.2025 | 09:30 | Oradea | Urban | 25 | Yes | Yes | Yes |
| 17 | *Tilia cordata* | 47.07723 | 21.91123 | 19.06.2025 | 11:00 | Oradea | Urban | 2 | Yes | Yes | Yes |
| 18 | *Tilia tomentosa* | 47.07683 | 21.91063 | 19.06.2025 | 08:00 | Oradea | Urban | 4 | Yes | Yes | Yes |
| 19 | *Tilia cordata* | 47.06381 | 21.95123 | 21.06.2025 | 09:30 | Oradea | Urban | 13 | Yes | Yes | Yes |
| 20 | *Tilia tomentosa* | 47.07706 | 21.91181 | 19.06.2025 | 12:00 | Oradea | Urban | 5 | Yes | Yes | Yes |
| 21 | *Tilia platyphyllos* | 47.05478 | 21.94795 | 23.06.2025 | 08:00 | Oradea | Urban | 12 | Yes | Yes | Yes |
| 22 | *Tilia tomentosa* | 47.06562 | 21.97427 | 21.06.2025 | 10:00 | Oradea | Urban | 16 | Yes | Yes | Yes |
| 23 | *Tilia tomentosa* | 47.06519 | 21.93730 | 21.06.2025 | 08:00 | Oradea | Urban | 10 | Yes | Yes | Yes |
| 24 | *Tilia cordata* | 47.06575 | 21.96003 | 21.06.2025 | 09:45 | Oradea | Urban | 11 | Yes | Yes | Yes |
| 25 | *Tilia cordata* | 46.99588 | 22.00015 | 28.06.2025 | 10:30 | Băile 1 Mai | Locality | 18 | Yes | Yes | Yes |
| 26 | *Tilia platyphyllos* | 47.04055 | 21.91774 | 20.06.2025 | – | Oradea | Urban | 24 | Yes | Yes | Yes |
| 27 | *Tilia tomentosa* | 47.04419 | 21.91959 | 19.06.2025 | 08:30 | Oradea | Urban | 3 | Yes | Yes | Yes |
| 28 | *Tilia cordata* | 47.03960 | 21.92028 | 19.06.2025 | 13:00 | Oradea | Urban | 33 | Yes | Yes | Yes |
| 29 | *Tilia tomentosa* | 47.04102 | 21.91655 | 19.06.2025 | 07:30 | Oradea | Urban | 27 | Yes | Yes | Yes |
| 30 | *Tilia tomentosa* | 47.06784 | 21.93270 | 21.06.2025 | 07:45 | Oradea | Urban | 28 | Yes | Yes | Yes |
| 31 | *Tilia tomentosa* | 47.05524 | 21.94843 | 22.06.2025 | 12:00 | Oradea | Urban | 15 | Yes | Yes | Yes |
| 32 | *Tilia tomentosa* | 47.05613 | 21.94450 | 22.06.2025 | 11:00 | Oradea | Urban | 15 | Yes | Yes | Yes |
| 33 | *Tilia tomentosa* | 46.99471 | 21.97821 | 28.06.2025 | 12:00 | Băile Felix | Locality | 22 | Yes | Yes | Yes |

Note: GPS coordinates are expressed in decimal degrees (WGS84). Each Tree ID (1–34) corresponds to one individual *Tilia* tree from which four sample types were collected: soil, bark, leaves, and flowers. A total of 136 samples were obtained (34 soil, 34 bark, 34 leaf, and 34 flower samples). Soil sample IDs refer to composite rhizosphere soil samples (0–10 cm depth) collected beneath each tree and may differ from Tree IDs due to independent soil sample labeling. Bark, leaf, and flower samples were collected from the same tree and location as the corresponding soil sample. Site type classification includes urban (city), locality (peri-urban), and forest environments. Sampling dates and times refer to field collection, conducted under dry weather conditions. A dash (–) indicates missing or unrecorded data.

**Table S11.** Supplementary details of soil physicochemical analyses

| Parameter | Method / Standard | Operational details |
|---|---|---|
| Soil pH | ISO 10390 | Measured in distilled water and 1 M KCl at a soil-to-solution ratio of 1:2.5 (w/v); suspension equilibrated for 30 min with intermittent stirring; measurements performed at 20 ± 1 °C |
| Electrical conductivity (EC) | ISO 11265 | Determined in a 1:5 (w/v) soil–water extract after 1 h extraction with deionized water at room temperature |
| Soil texture | ISO 11277 | Pipette–hydrometer method after dispersion with sodium hexametaphosphate; particle-size distribution used for textural class assignment |
| Soil organic carbon (C_org) | ISO 14235 | Walkley–Black dichromate oxidation; suitable for non-carbonate or weakly calcareous soils |
| Total nitrogen (N_total) | ISO 11261 | Kjeldahl digestion–distillation using catalyst tablets; quantification by titration |
| C/N ratio | Calculated | Calculated from measured C_org and N_total values |
| Quality control | — | Duplicate analyses, procedural blanks, routine instrument calibration; analytical precision within ±5% |

**Table S12.** Optimized microwave-assisted acid digestion protocols for complete mineralization of solid matrices prior to ICP-MS determination

| Matrix | Sample mass (g, d.w.) | Acid composition (Suprapur®) | Digestion step | Temperature ramp (°C·min$^{-1}$) | Target temperature (°C) | Hold time (min) | Applied microwave power (W) | Maximum pressure (bar) | Purpose of step |
|---|---|---|---|---|---|---|---|---|---|
| Soil (mineral-dominated matrix) | 0.25–0.50 | 8 mL $HNO_3$ (65%) + 2 mL $H_2O_2$ (30%) | Step 1 | Linear (≈12) | 120 | 5 | up to 1200 | ≤40 | Initial oxidation and release of exchangeable metals |
| | | | Step 2 | Linear (≈6) | 180 | 20 | up to 1500 | ≤40 | Complete dissolution of silicate-bound and residual fractions |
| | | | Cooling | – | <50 | 20 | – | – | Vessel depressurization and stabilization |
| Bark (lignocellulosic matrix) | 0.25 | 6 mL $HNO_3$ (65%) + 2 mL $H_2O_2$ (30%) | Step 1 | Linear (≈10) | 140 | 10 | up to 1200 | ≤35 | Oxidative breakdown of lignin and cellulose |
| | | | Step 2 | Linear (≈5) | 190 | 20 | up to 1500 | ≤35 | Complete mineralization and metal solubilization |
| | | | Cooling | – | <50 | 20 | – | – | Prevention of volatile losses |
| Leaves (soft plant tissue) | 0.25 | 5 mL $HNO_3$ (65%) + 2 mL $H_2O_2$ (30%) | Step 1 | Linear (≈15) | 130 | 10 | up to 1000 | ≤30 | Rapid oxidation of organic matter |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | Step 2 | Linear (≈6) | 180 | 15 | up to 1200 | ≤30 | Stabilization of digest and matrix clarification |
| | | | Cooling | – | <50 | 15 | – | – | Controlled pressure release |
| Flowers (highly organic, volatile-rich matrix) | 0.25 | 5 mL $HNO_3$ (65%) + 2 mL $H_2O_2$ (30%) | Step 1 | Linear (≈15) | 120 | 10 | up to 1000 | ≤30 | Gentle oxidation to avoid foaming |
| | | | Step 2 | Linear (≈6) | 170 | 15 | up to 1200 | ≤30 | Complete mineralization of organic compounds |
| | | | Cooling | – | <50 | 15 | – | – | Preservation of volatile elements (Hg, As) |

**Table S13.** The instrumental settings (a) and data acquisition parameters (b) of the ICP-MS system, which define the operating conditions and analytical procedures for precise metal quantification

| **(a) Instrumental parameters** | | **(b) Data acquisition parameters for quantitative mode** | |
|---|---|---|---|
| RF power/W | 1.4 kW | Measuring mode | Standard (Ar 5.0)<br>Q Cell (Collision Cell) (He 6.0) |
| Argon (Ar) gas flow, Helium (He) gas flow | | Point per peak | 3 |
| Nebulizer | 1.0 L/min. | Scans/Replicate | 7 |
| Plasma gas low rate (Ar 5.0) | 18.0 L/min. | Replicate/Sample | 7 |
| Auxiliary gas flow rate (He 6.0) | 0.20 L/min. | | |
| Lens voltage | 37 V | Dwell time (ms) | 3 |
| Mirror lens right | 32 V | | |
| Mirror lens bottom | 31 V | | |
| Sample uptake rate | 90 s | Integration time | 1-5 ms |
| Temperature spray chamber | | 2.10 °C | |
| Background correction | | 2 points/peak | |
| Injector tube | | quartz 2-mm id | |
| Sample cone | | Sample Cone 4450 | |
| Skimmer cone | | Ni – Skimmer iCAP Q 0.5 mm insert version | |
| Nebulizer | | MicroMist Nebulizer 0.4 mL/min. | |

**Table S14**. Calibration linearity and analytical sensitivity parameters (LoD, LoQ, BEC) for the determination of elements by ICP–MS.

| **Element** | **Correlation coefficient** | **LoD (µg/L)** | **LoQ (µg/L)** | **BEC (µg/L)** |
|---|---|---|---|---|
| $^{64}$Cu | 0.9997 | 0.035 | 0.139 | 0.236 |
| $^{65}$Zn | 0.9999 | 0.079 | 1.203 | 1.310 |
| $^{208}$Pb | 0.9996 | 0.151 | 0.231 | 0.649 |
| $^{111}$Cd | 0.9997 | 0.007 | 0.069 | 0.0031 |
| $^{60}$Ni | 0.9997 | 0.045 | 0.181 | 0.096 |
| $^{59}$Co | 0.9997 | 0.051 | 0.136 | 0.152 |
| $^{75}$As | 0.9999 | 0.006 | 0.743 | 0.018 |
| $^{52}$Cr | 0.9999 | 1.607 | 5.533 | 0.637 |
| $^{201}$Hg | 0.9999 | 0.043 | 0.137 | 0.128 |
| $^{55}$Mn | 0.9998 | 0.0078 | 0.0259 | 0.0418 |
| $^{27}$Al | 0.9996 | 0.0171 | 0.0570 | 0.0287 |
| $^{51}$V | 0.9998 | 0.0025 | 0.0083 | 0.0054 |

LoD = Detection limit; LoQ = Quantification limit; BEC = Background equivalent concentration.

**Table S15.** Experimental conditions for the preparation of *Tilia* flower infusions

| Parameter | Experimental specification |
|---|---|
| *Tilia* species | *Tilia tomentosa*, *Tilia cordata*, *Tilia platyphyllos* |
| Plant material | Dried flowers, finely ground |
| Sample mass | 1.00 g ± 0.01 g |
| Water volume | 250 mL |

| | |
|---|---|
| Water type | Ultrapure water (Milli-Q®); tap water |
| Infusion temperature range | 70–95 °C |
| Investigated temperatures | 70, 80, 85, 90, 95 °C |
| Infusion time range | 5–15 min |
| Investigated infusion times | 5, 7, 10, 12, 15 min |
| Infusion procedure | Hot water poured over plant material |
| Post-infusion cooling | To room temperature |
| Solid–liquid separation | Filtration |
| Storage container | Pre-cleaned polypropylene vessels |
| Storage conditions | 4 °C until analysis |
| Replicates | Triplicate for each condition |
| Quality control | Procedural blanks (water only) |

**Table S16.** Validation parameters of the analytical procedure for the determination of heavy metals (soil) (mg/kg)

| Element | Certified reference material analysis | | Validation parameters | |
|---|---|---|---|---|
| | The result declared by de manufacture | The results obtained in our research | Recovery (%) | Uncertainty (%) |
| $^{208}$Pb | 18.9 ± 0.5 | 18.4 ± 0.9 | 97.4 | 12 |
| $^{111}$Cd | 0.38 ± 0.01 | 0.37 ± 0.02 | 97.4 | 15 |
| $^{65}$Zn | 106 ± 3 | 103.2 ± 4.8 | 97.4 | 14 |
| $^{64}$Cu | 34.6 ± 0.7 | 33.8 ± 1.9 | 97.7 | 13 |
| $^{60}$Ni | 88 ± 5 | 86.1 ± 4.1 | 97.8 | 16 |
| $^{52}$Cr | 103 ± 4 | 101.0 ± 3.6 | 98.1 | 15 |
| $^{55}$Mn | 538 ± 12 | 526 ± 21 | 97.8 | 14 |
| $^{59}$Co | 13.4 ± 0.7 | 13.1 ± 0.8 | 97.8 | 18 |
| $^{75}$As | 17.7 ± 0.8 | 17.1 ± 1.1 | 96.6 | 17 |
| $^{201}$Hg | 1.40 ± 0.08 | 1.32 ± 0.09 | 94.3 | 13 |
| $^{27}$Al | 7420 ± 210 | 7210 ± 290 | 97.2 | 17 |
| $^{51}$V | 112 ± 5 | 109 ± 6 | 97.3 | 15 |

SRM – 2709a Standard Reference Material „San Joaquin Soil" was used as certified reference material for method validation.

**Table S17.** Validation parameters of the analytical procedure for the determination of heavy metals (Tea Leaves) (mg/kg)

| Element | Certified reference material analysis | | Validation parameters | |
|---|---|---|---|---|
| | The result declared by de manufacture | The results obtained in our research | Recovery (%) | Uncertainty (%) |
| $^{208}$Pb | 0.040 ± 0.003 | 0.039 ± 0.004 | 97.5 | 14 |
| $^{111}$Cd | 0.030 ± 0.002 | 0.029 ± 0.003 | 96.7 | 15 |
| $^{65}$Zn | 30.5 ± 1.2 | 29.8 ± 1.6 | 97.7 | 12 |
| $^{64}$Cu | 6.25 ± 0.30 | 6.10 ± 0.42 | 97.6 | 13 |
| $^{60}$Ni | 2.15 ± 0.15 | 2.10 ± 0.18 | 97.7 | 16 |
| $^{52}$Cr | 1.03 ± 0.08 | 1.01 ± 0.09 | 98.1 | 15 |
| $^{55}$Mn | 720 ± 25 | 703 ± 31 | 97.6 | 14 |
| $^{59}$Co | 0.42 ± 0.03 | 0.41 ± 0.04 | 97.6 | 18 |
| $^{75}$As | 0.28 ± 0.03 | 0.27 ± 0.03 | 96.4 | 17 |
| $^{201}$Hg | 0.017 ± 0.002 | 0.016 ± 0.002 | 94.1 | 13 |

| | | | | |
|---|---|---|---|---|
| $^{27}$Al | 520 ± 30 | 505 ± 38 | 97.1 | 16 |
| $^{51}$V | 0.85 ± 0.06 | 0.83 ± 0.07 | 97.6 | 15 |

NMIJ CRM 7505-a (Tea Leaves) was used as certified reference material for method validation.

**Table S18.** Validation parameters of the analytical procedure for the determination of heavy metals (in infusions) (μg/L)

| Element | Certified reference material analysis | | Validation parameters | |
|---|---|---|---|---|
| | The result declared by de manufacture | The results obtained in our research | Recovery (%) | Uncertainty (%) |
| $^{208}$Pb | 19.63 ± 0.21 | 19.1 ± 0.9 | 97.3 | 11 |
| $^{111}$Cd | 6.47 ± 0.07 | 6.30 ± 0.42 | 97.4 | 13 |
| $^{65}$Zn | 78.5 ± 1.5 | 76.6 ± 4.3 | 97.6 | 12 |
| $^{64}$Cu | 22.3 ± 0.4 | 21.8 ± 1.6 | 97.8 | 12 |
| $^{60}$Ni | 60.0 ± 1.0 | 58.6 ± 3.9 | 97.7 | 13 |
| $^{52}$Cr | 18.5 ± 0.3 | 18.1 ± 1.2 | 97.8 | 12 |
| $^{55}$Mn | 39.7 ± 0.8 | 38.7 ± 2.6 | 97.5 | 11 |
| $^{59}$Co | 27.1 ± 0.5 | 26.4 ± 1.9 | 97.4 | 13 |
| $^{75}$As | 60.4 ± 0.7 | 58.8 ± 4.1 | 97.4 | 14 |
| $^{201}$Hg | 1.56 ± 0.04 | 1.47 ± 0.12 | 94.2 | 15 |
| $^{27}$Al | 141 ± 3 | 137 ± 9 | 97.2 | 12 |
| $^{51}$V | 37.9 ± 0.6 | 36.9 ± 2.7 | 97.4 | 13 |

NIST SRM 1643f (Trace Elements in Water) was used as certified reference material for method validation.