

**Short thesis for the degree of Doctor of  
Philosophy (PhD)**

**Effect of Urbanization on Terrestrial  
Ecosystem in Europe (Vienna) and in  
Asia (Pakistan)**

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## 1. INTRODUCTION

Urbanization poses significant threats to the sustainability of natural resources and disrupts ecological systems. As urban areas have expanded from 3-4% of the most productive regions to encompass a substantial portion of the world's population, especially in developing countries, the resultant growth affects biodiversity, ecosystem productivity, and crucial biogeochemical cycles ( Zhang, 2016). This development leads to reduced carbon sink capacity and increased pollution, notably nitrogen dioxide emissions from urban traffic (Nieuwenhuijsen, 2020).

Soil, a vital natural resource for sustaining plant life, faces degradation due to urbanization through contamination from pesticides, heavy metals, and other pollutants. The soil's quality, essential for ecological functions and health, is diminished by agricultural practices and anthropogenic activities, exacerbating environmental issues (Joimel et al., 2017). Effective assessment of soil pollution involves using pollution indices that integrate various soil properties and contamination levels, thereby highlighting the impact of human activities compared to natural processes (Kowalska et al., 2018). In addition to soil degradation, urbanization severely affects air quality due to industrial activities and vehicular emissions, leading to significant health risks as indicated by (World Health Organization., 2016) statistics on air pollution-related deaths.

Plant species differ in their sensitivity to pollution stress. Matyssek et al. (1991) found that tolerance or resistance is achieved by ongoing biochemical,

physiological, and morphological changes, allowing for survival even in extremely polluted environments. Adaptations boost plants tolerance to urban stressors such as drought, high temperatures, radiation, and pathogens. Monitoring air pollution, particularly through the Air Pollution Tolerance Index (APTI), provides insights into plant resilience against pollution which can guide urban landscaping strategies aimed at mitigating pollution effects (Singh & Rao, 1983).

## **2. OBJECTIVES AND HYPOTHESIS OF THE STUDY**

The aims of this study were to assess how urbanization affected the quality of soil and air pollution. Our study objectives are the following:

1. Determine the elements concentration of Vienna's soil and leaves along an urbanization gradient in urban, suburban, and rural areas.
2. Determine the elements concentration of Pakistan soil and leaves along an urbanization gradient in urban, suburban, and rural area
3. Study the sensitivity of trees to air pollution using the Air Pollution Tolerance Index (APTI).

Our hypothesis of the study is the following:

1. We hypothesized that pollutant levels increased dramatically along urbanization gradients (rural, suburban, and urban), and the pollution index is useful indicator of the ecological condition of the soil.
2. We hypothesized that the highest metal and dust concentration of leaves is in the urban area, while the lowest is in the rural area.
3. Our hypothesis is that the Pollution Index (PI) values and the elemental analysis of soil are sufficient indicators to evaluate the pollution in urban environments.
4. The tree species differ in sensitivity to air pollution, and this is reflected by their APTI values.
5. The concentration of metals in soil and Neem tree (*Azadirachta indica*) leaves is higher in urban areas than rural areas.

6. Our hypothesis is that increasing soil elements concentrations do not always result in increased plant absorption.

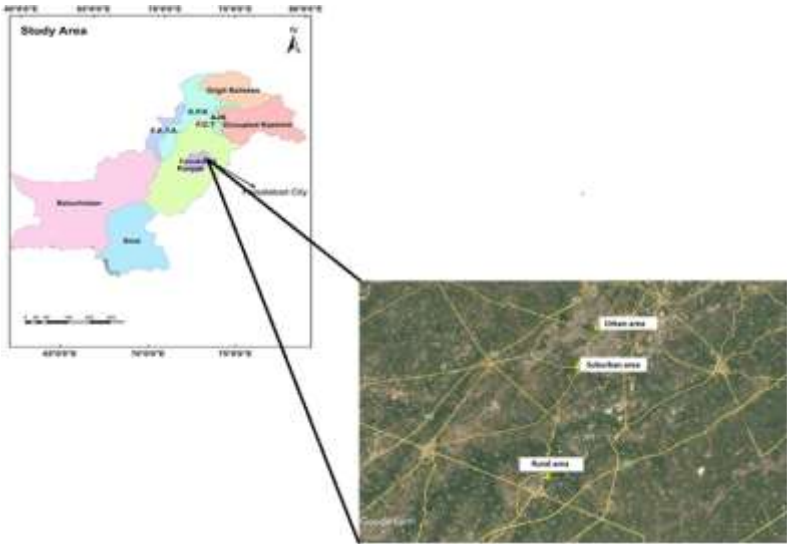
### 3. MATERIALS AND METHODS

#### 3.1. Studied areas

Vienna, Austria and Faisalabad, Pakistan were selected as comparative regions due to their different urban development patterns. The three zones along an urbanization gradient—rural (low), suburban (moderate), and urban (high)—were categorized according to population density, industrial activity, and traffic intensity in order to evaluate the effects of urbanization on soil and plant leaves (Fig. 1 and 2).



**Figure 1.** Sampling sites in Vienna, Austria



**Figure 2.** Sampling sites in Faisalabad, Pakistan

### **Studied Species**

In case of the plant leaves *Acer platanoides* (Norway maple), *Quercus robur* (oak), and *Fraxinus excelsior* (ash) were chosen for Vienna due to their widespread distribution (Fig. 3). *Azadirachta indica* (Neem) was selected for Pakistan because it is one of the most widely planted and naturally occurring tree species (Fig. 4).



**Figure 3.** (A) *Acer platanoides* (Norway maple), (B) *Quercus robur* (Oak) and (C) *Fraxinus excelsior* (Ash)  
(Captured by author)



**Figure 4.** Individual of *Azadirachta indica* (Neem) in Faisalabad city (Captured by author)

### **3.2. Physio-chemical soil parameters analysis**

A soil solution was prepared using 5.0 g of soil samples mixed with 30 ml of distilled water to measure pH and electrical conductivity from Vienna and Pakistan. Measurements were taken using a pH and electrical conductivity meter. Wet content was assessed after drying the samples at 105°C for 24 hours. The Arany-type plasticity index was calculated for vienna soil samples using the formula:

$$PA = 100 * V/M \quad (1)$$

Where V is the volume of deionized water and M is the weight of the soil. Soil texture categories were defined based on PA values. Organic matter content was determined by the loss on ignition method at 550°C using the formula:

$$LOI_{550} = ((DW_{105} - DW_{550}) / DW_{105}) * 100 \quad (2)$$

Calcium carbonate concentration was assessed after incinerating samples at 950°C using the formula:

$$LOI_{950} = ((DW_{550} - DW_{950}) / DW_{105}) * 100 \quad (3)$$

### **3.3. Deposited Dust Amount Analysis**

The leaf area was measured by scanning the leaves to assess dust levels on Vienna leaf samples, utilizing image software (Simon et al., 2014, 2021). The leaves were placed in 500 ml containers with 250 ml deionized water and shaken for ten minutes. The suspension was filtered

through a 150 $\mu$ m sieve and shaken again in 150 ml deionized water, followed by vacuum filtration of the 300 ml suspension through filter paper. The amount of coarse dust (PM<sub>10</sub>) was quantified by weighing the filter papers before and after filtration, employing the gravimeter method (Simon et al., 2014, 2016 , 2021).

### **3.4. Air Pollution Tolerance Index (APTI)**

For the leaf sample from Vienna, ascorbic acid concentration, total chlorophyll, relative water content, and pH were measured to compute APTI values using the formula:

$$\text{APTI} = [A \times (T+P) + R]/10 \quad (4)$$

Ascorbic acid was quantified via redox titration, while chlorophyll extraction involved ethanol and spectrophotometric analysis at specific wavelengths. The relative water content was calculated based on fresh weight, turgid weight, and dry weight. APTI values classify tree species as tolerant (20–24), intermediate (15–19), sensitive ( $\leq 14$ ), or very tolerant ( $>24$ ).

### **3.5. Elemental Analysis of Soil and Plant Leaves**

Elemental analysis of soil and leaf samples from Vienna and Pakistan involved drying the samples and filtering them through a 2 mm sieve. They were homogenized using an electrical homogenizer and dried at 105 °C overnight. For soil, 0.1 g was digested with 0.5 ml of 30% hydrogen peroxide and 4.5 ml of 65% nitric acid, followed

by dilution in 10 ml of 1% nitric acid. Plant tissues (0.2 g) were digested with 5 ml of 65% nitric acid and 1 ml of 30% hydrogen peroxide. Analyses were conducted using ICP-OES with a six-point calibration method. Elements analyzed included Al, B, Ba, Ca, Cd, Co, Cr, Cu, Fe, K, Li, Mg, Mn, Na, Ni, P, Pb, S, Sr, and Zn (Simon et al., 2011, 2014, 2016, 2021). Use of CRM resulted in recoveries within 10% of certified values.

### **3.6. Pollution Index**

In Vienna, urban soil pollution was assessed using the Pollution Index (PI), which compares the concentration of heavy metals in soil ( $C_n$ ) to background concentrations ( $B_n$ ) from geochemical values in literature. This approach is necessary due to the challenge of finding uncontaminated soils in established urban areas. The PI indicates contamination levels: low ( $PI \leq 1$ ), moderate ( $PI \leq 2$ ), high ( $PI \leq 5$ ), and extremely high ( $PI > 5$ ).

### **3.7. Bioaccumulation Factor Analysis (BAF)**

To calculate the Bioaccumulation Factor (BAF) for soil and leaf samples from Pakistan, using the formula

$$BAF = C_{\text{plant}} / C_{\text{soil}} \quad (5)$$

where  $C_{\text{plant}}$  is the metal concentration in leaves and  $C_{\text{soil}}$  is the metal concentration in soil. This calculation was conducted for each sampling area (rural, suburban, and

urban) along the urbanization gradient (Ivanciuc et al., 2006).

### **3.8. Statistical Analysis**

IBM SPSS Statistics 21 and Canoco for Windows 4.5 were employed for statistical analysis. The normal distribution was assessed using the Shapiro–Wilk test and homogeneity of variance was evaluated via Levene's test. Prior to multivariate analysis (PCA and CDA), all variables underwent distribution evaluation and were standardized using  $\ln(x+1)$  transformation. CDA and PCA were utilized to uncover patterns and separations between areas and species. ANOVA was conducted to compare differences among areas and species.

## 4. RESULTS AND DISCUSSION

### 4.1. Soil Pollution of Heavy Metals in Vienna, Austria

#### 4.1.1. Basic physical and chemical parameters of soil

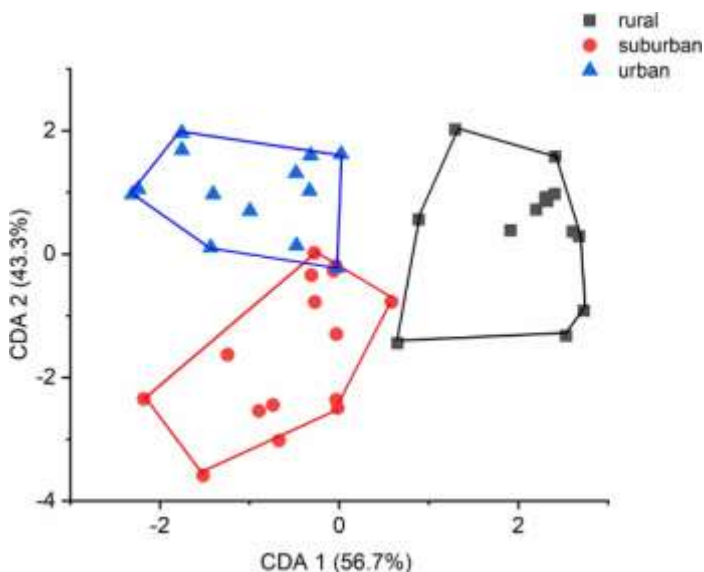
We found a significant difference for all parameters showed notable variations, except for calcium-carbonate content. Suburban areas had higher pH levels and electrical conductivity compared to rural areas. Urban areas had the lowest levels of organic matter and moisture content (Table 1).

**Table 1.** Basic physical and chemical parameters of soil along the urbanization gradient. Notations: different superscripts indicate significant differences ( $p < 0.05$ ).

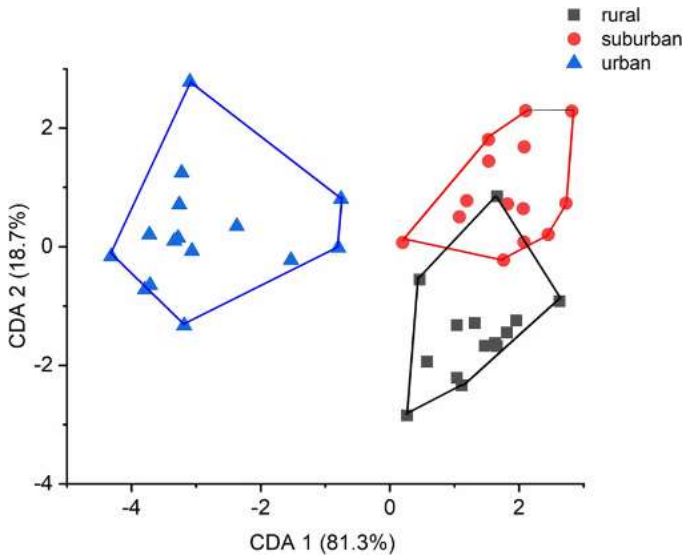
Parameters	Studied areas		
	rural	suburban	urban
pH	$7.1 \pm 0.1^a$	$7.8 \pm 0.1^b$	$7.5 \pm 0.1^{ab}$
Electrical conductivity, $\mu\text{S cm}^{-2}$	$372 \pm 91^a$	$931 \pm 73^b$	$516 \pm 67^b$
Water Content, %	$35 \pm 3^{ab}$	$28 \pm 4^a$	$22 \pm 3^b$
Organic matter, %	$12.7 \pm 0.8^{ab}$	$12.3 \pm 0.5^a$	$10.0 \pm 2.6^b$
Calcium carbonate, %	$6.7 \pm 2.3$	$7.8 \pm 1.3$	$6.0 \pm 1.5$
Arany-type plasticity index	$36 \pm 4$	$43 \pm 4$	$41 \pm 3$
Soil texture	Sandy loam	Clay loam	Loam

### 4.1.2. Elemental Concentrations of Soil

CDA (Canonical discriminant analysis) analysis revealed a clear separation between major and minor elements across suburban, urban, and rural areas, with significant variance contributions from the Discriminant Functions. For major elements, CDA1 contributed 56.7% and CDA2 43.3% to total variance (Fig. 5), while for microelements, the contributions were 81.3% and 18.7%, (Fig. 6) respectively. Similar to our findings Rodríguez-Eugenio et al. (2018) also demonstrated that the content of heavy metals in soils varies depending on the various land uses and other human activities.



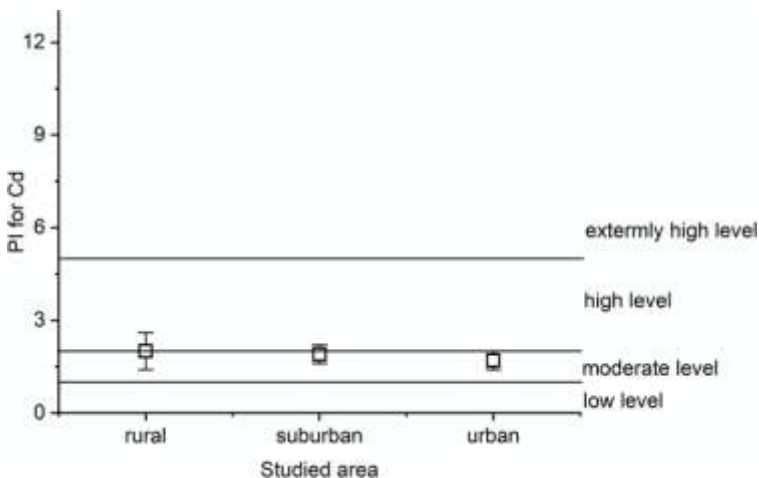
**Figure 5.** CDA scatterplot based on the major element concentration of soil



**Figure 6.** CDA scatterplot based on the minor element concentration of soil

### 4.1.3. Pollution Index

For Cd, the PI value is higher than 1 along the urbanization gradient in all the areas, indicating a moderate level of pollution (Fig. 7). In the case of other elements (Cr, Cu, Ni, Pb, and Zn), low level of pollution was found. Pfleiderer et al. (2012) also found anthropogenic contamination, with higher Cd and Pb concentrations in traffic and industrial areas compared to Vienna parks, indicating a higher level of pollution.

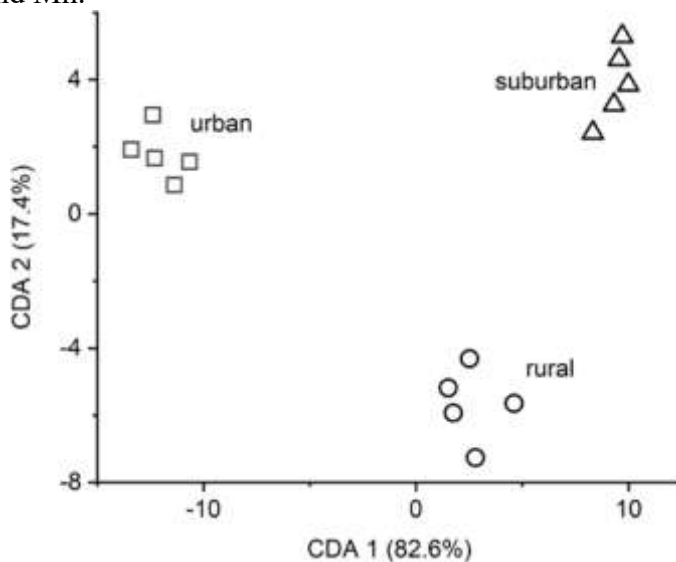


**Figure 7.** Value of pollution index (PI) which indicated a moderate level of pollution for Cd along the urbanization gradient (mean  $\pm$  SE)

## 4.2. Air pollution based on tree species in Vienna

### 4.2.1. Differences along an urbanization gradient

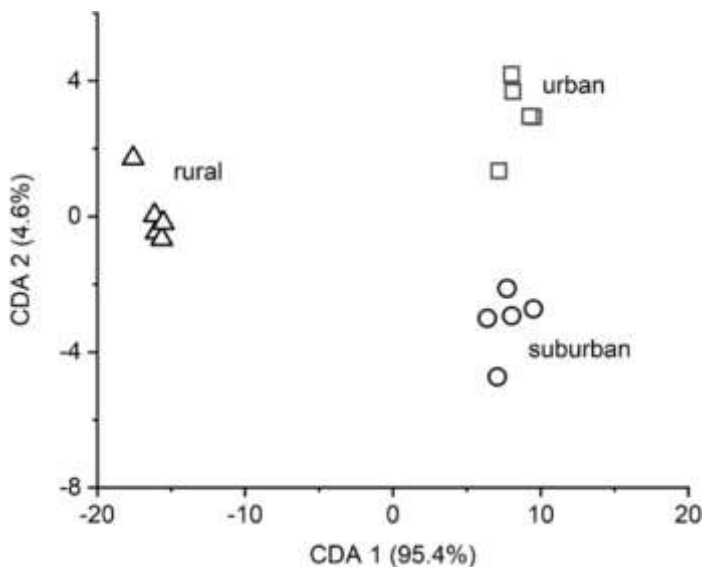
Significant differences in elemental concentrations of *A. platanoides* were observed among urban, suburban, and rural areas using canonical discriminant analysis (Fig. 8). While APTI values did not significantly differ among these areas, they indicate sensitivity to air pollution. The areas showed significant differences in PM10, Al Cr, Fe, and Mn.



**Figure 8.** Discriminant score plots of *A. platanoides* based on APTI parameters and the elemental concentrations of tree leaves

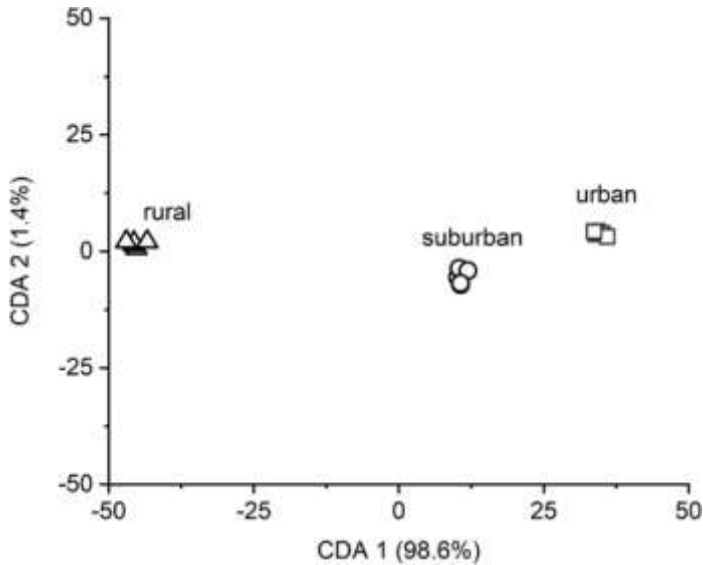
Using CDA with APTI parameters and elemental concentration data of *F. excelsior*, significant differences

were found among different areas (Fig. 9). While no differences were observable in the APTI value, based on the APTI value of *F. excelsior*; it is also a sensitive species. Notable variations were seen in AAC, TChl, Ba, Cr, Cu, Fe, Sr, and Zn concentrations in the leaves.



**Figure 9.** Discriminant score plots of *F. excelsior* based on APTI parameters and the elemental concentrations of tree leaves

Significant differences in elemental concentrations among areas were observed in *Q. robur*, (Fig. 10) and it is a sensitive species. With notable variances in TChl, Al, Cr, Fe, Mn, Ni, and Sr.



**Figure 10.** Discriminant score plots of *Q. robur* based on APTI parameters and the elemental concentrations of tree leaves

#### 4.2.2. Differences among the species

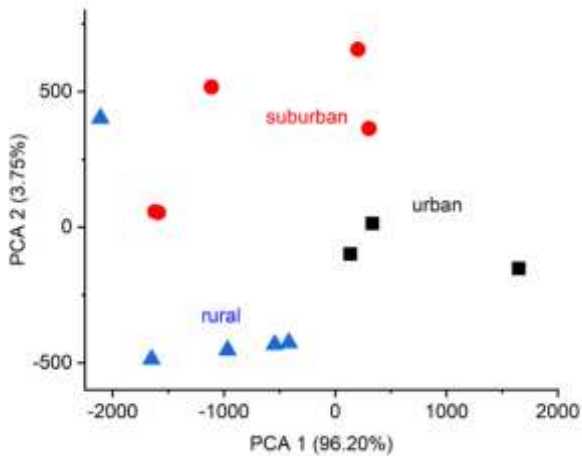
Significant differences were observed among species in various APTI parameters and elemental concentrations across all studied areas. In the urban area, *Acer* leaves exhibited the highest total chlorophyll (TChl) and APTI values, along with elevated concentrations of Al, Fe, and Mn. *Fraxinus* leaves showed the highest relative water content (RWC), Cu, Ni, and Sr. *Quercus* leaves had the highest pH and ascorbic acid concentration (AAC) values, as well as Cr concentration. In the suburban area, *Acer* leaves again ranked highest for RWC, pH, TChl, APTI,

and concentrations of several elements, while *Fraxinus* leaves had the highest Ba, Ni, and Sr. *Quercus* leaves were noted for the highest pH and AAC. In the rural area, *Acer* leaves held the highest values for pH and APTI, and concentrations of various elements, with *Fraxinus* showing the highest RWC and Ba and Sr levels. Jyothi & Jaya, (2010) state that tolerant tree species can function as sinks for air pollution, whereas sensitive tree species can operate as indicators for its decrease. Furthermore, plants with higher APTI values can be utilized to reduce air pollution, whereas plants with lower APTI values can be used to assess air pollution, as determined by Gholami et al. (2016).

### **4.3. Pollution Analysis by soil and plant leaves in Faisalabad**

#### **4.3.1. Physio-Chemical Properties of Soil in Faisalabad**

The principal component analysis (PCA) of soil samples revealed that pH and electrical conductivity were the only significant variables (Fig. 11) Soil pH varied between 6.37 and 7.63, being highest in rural and urban soils, and lowest in suburban soils. Electrical conductivity was greatest in suburban soils and least in rural areas. Soil moisture levels showed no significant variation, with urban soils having the lowest and rural soils the highest moisture content. Organic matter was most abundant in urban areas, whereas calcium carbonate levels were lowest in rural soils and highest in suburban soils.



**Figure 11.** Scatter plot based on principal component analysis (PCA) of physical and chemical parameters of soil

#### 4.3.2. Elemental concentration in Soil

Significant differences in elemental concentrations were found in soil samples, with urban soils exhibiting the highest levels. Concentrations tended to increase along the urbanization gradient, while rural areas showed minor concentrations, except for manganese, which was also present in suburban areas (Table 2).

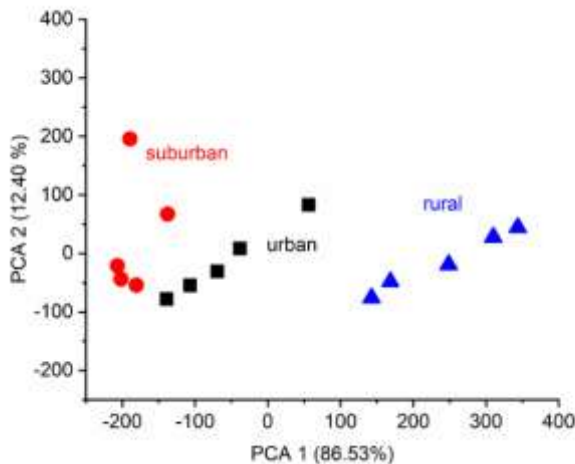
**Table 2.** The concentration of elements (mean  $\pm$  SD, mg kg<sup>-1</sup>) in the soil samples along the urbanization

Elements	Studied area			Results of ANOVA	
	Urban	Suburban	Rural	F	p
<b>Ba</b>	99.6 $\pm$ 3.9	73.7 $\pm$ 5.7	65.3 $\pm$ 4.3	72.340	<0.001
<b>Co</b>	5.3 $\pm$ 0.4	3.9 $\pm$ 0.5	3.8 $\pm$ 0.3	21.717	<0.001
<b>Cr</b>	15.4 $\pm$ 1.5	12.5 $\pm$ 0.6	11.1 $\pm$ 0.8	20.974	<0.001
<b>Cu</b>	19.9 $\pm$ 2.3	14.3 $\pm$ 1.4	9.6 $\pm$ 1.0	47.248	<0.001
<b>Fe</b>	13558.3 $\pm$ 1863.6	10926.6 $\pm$ 958.7	10521.9 $\pm$ 713.8	8.321	0.005
<b>Mn</b>	616.3 $\pm$ 173.8	355.0 $\pm$ 27.3	369.3 $\pm$ 39.3	9.978	0.003
<b>Ni</b>	21.4 $\pm$ 2.6	16.9 $\pm$ 1.6	16.8 $\pm$ 1.3	9.463	0.003
<b>Pb</b>	26.0 $\pm$ 4.0	13.9 $\pm$ 0.6	9.0 $\pm$ 0.8	69.785	<0.001
<b>Sr</b>	22.5 $\pm$ 4.2	21.2 $\pm$ 2.2	13.4 $\pm$ 1.5	14.556	0.001
<b>Zn</b>	111.0 $\pm$ 15.8	100.6 $\pm$ 29.6	52.5 $\pm$ 4.8	12.798	0.001

### 4.3.3. Elemental Concentration in *A. indica* Leaves

The PCA results indicate that sites are distinct based on tree leaf elemental concentration (Fig. 12). Significant differences in metal concentrations were found in all metals except Cd and Cu. Urban areas exhibited elevated pollution levels for Ba, Pb, Co, Ni, Cr, and Cd, whereas urban and suburban areas showed low pollution intensity for Zn, Fe, Mn, and Sr, with rural areas having high pollution levels for Fe and Cu. Which means the presence of high metal concentrations in soil does not always result in increased plant absorption due to the impact of

other soil factors. the leaves of neem tree are indicators of pollution from both human activities and vehicle traffic (Abdullateef et al., 2014).



**Figure 12.** Scatter plot based on principal component analysis (PCA) of elemental concentration of leaves

#### 4.3.4. Bio-Accumulation Factor (BAF)

The statistical analysis indicated that the bio-accumulation factor varies greatly between areas. This indicated that the urbanization gradient has an effect in the uptake of metals by plants, besides this just as with plants, no obvious pattern could be observed. For Co, Cu, Fe, Pb, and Zn the rural area had the highest BAF (Table 3). Indicating that most elements had their highest bio-accumulation factor there.

**Table 3.** The results (mean  $\pm$  SD, mg kg<sup>-1</sup>) of BAF along the urbanization gradient from different areas in Faisalabad.

Elements	Studied area			Results of ANOVA	
	Urban	Suburban	Rural	F	P
<b>Ba</b>	0.22 $\pm$ 0.02	0.16 $\pm$ 0.01	0.12 $\pm$ 0.00	82.828	<0.001
<b>Co</b>	0.10 $\pm$ 0.00	0.07 $\pm$ 0.00	0.11 $\pm$ 0.00	681.266	<0.001
<b>Cr</b>	0.11 $\pm$ 0.00	0.03 $\pm$ 0.00	0.07 $\pm$ 0.01	184.187	<0.001
<b>Cu</b>	0.29 $\pm$ 0.01	0.38 $\pm$ 0.01	0.63 $\pm$ 0.03	349.040	<0.001
<b>Fe</b>	0.05 $\pm$ 0.00	0.05 $\pm$ 0.00	0.09 $\pm$ 0.00	562.426	<0.001
<b>Mn</b>	0.12 $\pm$ 0.00	0.11 $\pm$ 0.00	0.11 $\pm$ 0.00	47.486	<0.001
<b>Ni</b>	0.22 $\pm$ 0.01	0.23 $\pm$ 0.01	0.19 $\pm$ 0.00	38.957	<0.001
<b>Pb</b>	0.21 $\pm$ 0.01	0.27 $\pm$ 0.02	0.31 $\pm$ 0.02	30.802	<0.001
<b>Sr</b>	11.82 $\pm$ 0.46	15.96 $\pm$ 4.12	14.22 $\pm$ 0.61	3.697	<0.001
<b>Zn</b>	0.37 $\pm$ 0.01	0.40 $\pm$ 0.04	0.54 $\pm$ 0.01	61.876	<0.001

## 5. CONCLUSION

Element concentrations in soil samples from Vienna were analyzed to understand urbanization's effect on ecological health, revealing moderate cadmium pollution and low levels of other metals, primarily from traffic emissions. The study established that soil analysis and pollution indices are effective measures of urban pollution. The pollution tolerance of various tree species was assessed, identifying suitable species for urban planning. Tree leaves served as reliable bioindicators, showing higher pollutant levels in urban settings. A comparative study in Faisalabad, Pakistan, noted similar negative impacts of urbanization on soil quality, with Neem trees possibly bio-accumulating heavy metals. Overall, the analysis underscored the complex relationship between soil metal concentrations and plant absorption, emphasizing differing pollution indicators and species responses between the two cities.

## 6. NEW SCIENTIFIC RESULTS

- The study revealed that the pollution index results indicated that the Cd had moderate pollution level ( $1 \leq PI \leq 2$ ), whereas Cr, Cu, Ni, Pb, and Zn remained within the low pollution level throughout the urbanization gradient.
- The traffic emissions may be the major source of the metal pollution in Vienna.
- The elemental analysis of soil and the values of PI are adequate indicators to assess the level of pollution.
- APTI is useful for selecting pollution-tolerant species, which can be used for urban green infrastructure planning.
- Based on APTI values of *A. platanoide*, *F. excelsior* and *Q. robur* were sensitive indicator species of air pollution.
- *Azadirachta indica* (Neem), indicating strong tolerance to air pollution. This species is recommended as an accumulator species, as tolerant plants can survive under polluted conditions and help to reduce it.
- Tree leaves are reliable bioindicators of urban air pollution.
- The presence of high metal concentrations in soil does not always result in increased plant absorption due to the impact of other soil factors.
- The primary cause of the metals in Faisalabad are probably industrial pollutants and the traffic emissions.

- Conducting elemental analysis of plant leaves and soil provides a reliable method for evaluating environmental pollution.

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Registry number: DEENK/53/2026.PL  
Subject: PhD Publication List

Candidate: Dina Biki

Doctoral School: Pál Auhász-Nagy Doctoral School of Biology and Environmental Sciences

MTMT ID: 10104080

### List of publications related to the dissertation

#### Foreign language scientific articles in international journals (3)

1. **Biki, D.**, Gutiérrez Pérez, D. I., Tóthmérész, B., Simon, E.: Pollution Assessment Using Soil and Plant Leaves in Faisalabad, Pakistan.  
*Atmosphere* 16 (5), 1-13, 2025. ISSN: 2075-4433.  
DOI: <http://dx.doi.org/10.3390/atmos16050580>  
IF: 2.3 (2024)
2. **Biki, D.**, Tózsér, D., Sipos, B., Molnár, V. É., Simon, E., Tóthmérész, B.: Complex study of air pollution based on tree species in Vienna.  
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3. **Biki, D.**, Tózsér, D., Sipos, B., Tóthmérész, B., Simon, E.: Heavy Metal Pollution of Soil in Vienna, Austria.  
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### List of other publications

#### Foreign language scientific articles in international journals (5)

4. Anwar, A., Mezbah Uddin, A. H. M., Hasan, S., Parvez, M. S., Sipos, B., **Biki, D.**, Sajtos, Z., Tóthmérész, B., Magurá, T., Simon, E.: Assessment of anthropogenic activities impact based on metals in soil and tree leaves along roadside in Bangladesh.  
*Sci Rep* 15 (1), 1-14, 2025. EISSN: 2045-2322.  
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5. Parvez, M. S., Cakli, H., Hoque, I., Rahman, M. M., Ameer, A., Uddin, A. H. M. M., Hasan, S., **Bibi, D.**, Tóthmérész, B., Magura, T., Simon, E.: Accumulation of Microplastics and Potentially Toxic Elements in Plant Leaves Along an Urbanization Gradient in Bangladesh. *Toxics*. 12 (12), 1-18, 2024. EISSN: 2305-6304.  
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6. Kovács, S., Hamar-Farkas, D., Horváth, K., Gyuricza, C., Rázná, K., Kucka, M., Horváth, L., Neményi, A., Lantos, C., Pusk, J., Sebő, Á., Simon, E., **Bibi, D.**, Mukherjee, S., Török, K., Tilly-Mándy, A., Papp, L., Orfó, L.: Investigation of a Perspective Urban Tree Species, *Ginkgo biloba* L., by Scientific Analysis of Historical Old Specimens. *Planta-Basel*. 13 (11), 1-17, 2024. ISSN: 2229-7747.  
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7. Sipos, B., **Bibi, D.**, Magura, T., Tóthmérész, B., Simon, E.: High phytoremediation and translocation potential of an invasive weed species (*Amaranthus retroflexus*) in Europe in metal-contaminated areas. *Environ. Monit. Assess.* 195 (6), 1-11, 2023. ISSN: 0167-6369.  
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8. Simon, E., Molnár, V. E., Lajos, D., **Bibi, D.**, Tóthmérész, B., Szabó, S.: Usefulness of Tree Species as Urban Health Indicators. *Planta-Basel*. 10 (12), 1-12, 2021. ISSN: 2229-7747.  
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IF: 4.658

Total IF of journals (all publications): 28,658

Total IF of journals (publications related to the dissertation): 9

The Candidate's publication data submitted to the Tudósir have been validated by DEENK on the basis of the Journal Citation Report (Impact Factor) database.

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