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Pollution Assessment Using Soil and Plant Leaves in Faisalabad, Pakistan

Dina Bibi [1], Daniela Isabela Gutiérrez Pérez [1], Béla Tóthmérész [2] and Edina Simon [1,3,*]

[1] Department of Ecology, University of Debrecen, Egyetem Square 1, H-4032 Debrecen, Hungary; bibi.dina@science.unideb.hu (D.B.); dgutierrez99@mailbox.unideb.hu (D.I.G.P.)
[2] HUN-REN-UD Functional and Restoration Ecology Research Group, Egyetem Square 1, H-4032 Debrecen, Hungary; tothmeresz.bela@science.unideb.hu
[3] HUN-REN–UD Anthropocene Ecology Research Group, Egyetem Square 1, H-4032 Debrecen, Hungary
* Correspondence: edina.simon@gmail.com or simon.edina@science.unideb.hu

Abstract: Soil has the ability to serve as a universal sink, meaning it may absorb contaminants from the environment. Additionally, plant leaves can also be used as indicators of environmental contamination. In our study, the bioaccumulation factor (BAF) was used to assess metal accumulation in the soil and leaves of the neem tree (*Azadirachta indica*) in Faisalabad, Pakistan. We analyzed the primary physical and chemical characteristics of the surface layer of soil in urban, suburban, and rural areas along an urbanization gradient. The ICP-OES technique was used to analyze the following elements: Ba, Cd, Co, Cr, Cu, Fe, Mn, Ni, Pb, Sr and Zn. The highest concentration of all elements was found in soil samples from urban areas, with an increasing tendency along with the urbanization gradient. A significant difference was found along the urbanization gradient on the plant leaves except for Cd, Cu, and Zn; a high level of pollution was measured for Ba, Pb, Co, Ni, Cr, and Cd in the urban area. We also calculated the bioaccumulation factor (BAF), but no clear pattern was found. Our findings show that high concentrations in soil do not always turn into higher plant uptake for plants. Our findings suggest that traffic and industrial emissions are likely the main cause of the metals in Faisalabad, because their concentration is higher than their background concentration. Our results also suggest that elemental analysis of soil and plant leaves is an appropriate indicator of environmental contamination.

Keywords: soil; *Azadirachta indica*; heavy metals; urbanization; bioaccumulation factor

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1. Introduction

The greatest challenge facing today's living things on Earth is the degradation of the environment. Pollution can be defined as an adverse alteration in the physical, chemical, and biological properties of the soil and air that affects the survival of humans, other beneficial living things, the development of industrial civilization, the standard of living, and cultural assets [1]. The primary component of pollution, pollutants, can be either naturally occurring or foreign chemicals or energy. When contaminants surpass natural levels, they are referred to as pollutants. Pollution in the air and on the ground is different. The largest amount of environmental contamination is placed on soil since it serves as a "universal sink" [2]. Soil pollution is the term used to describe the buildup of persistently harmful compounds, chemicals, salts, radioactive elements, or disease-causing agents in soils that negatively affect plant growth and animal health [3]. Common air pollutants are nitrogen oxides produced by motor vehicles and industries, sulphur dioxide, carbon monoxide, and chlorofluorocarbons (CFCs). Air pollutants are the discharge of chemicals and particulates into the environment.

Global demand for a lavish lifestyle has significantly increased domestic, agricultural, and industrial activity. As more people move from rural areas and small towns to major cities in search of better living conditions, the population of cities is growing. Due to the burning of fossil fuels, the exhaust from locomotives, the release of harmful industrial effluents and emissions, home activities, and garbage disposal, environmental pollution is one of the world's main eco-conservation problems. In addition, inefficient municipal waste treatment and uncontrolled dumping alter the physical, chemical, and productive characteristics of soil [4]. Pakistan is a growing country where population growth and industrial and economic development are all leading to a rise in urban trash generation. In Pakistan's largest cities, air pollution has grown to be a serious environmental problem. Carbon dioxide, methane, and nitrous oxide emissions from a variety of industrial and vehicle sources increased dramatically between 1990 and 2008 [5]. An estimated 54,888 tons of solid garbage are created in Pakistan each day, and this debris is improperly disposed of and burned, which worsens air pollution [6].

The population of Faisalabad is predicted to nearly double in size over the course of 20 years, from 3.2 million in 2017 to roughly 6.7 million by 2047. Faisalabad is one of the main industrial centers of the nation which is frequently called the "Manchester of Pakistan", with the textile sector ranking among the top sectors in the area. Massive intakes of people from all over the nation in search of employment possibilities have also been facilitated by Faisalabad's development as an industrial center [7]. The city produces over 600 tonnes of municipal solid trash per day. The Municipal Corporation has historically handled garbage management in an inadequate and ineffective way [8]. Textile processing mills, chemicals mills, dying and bleaching units, poultry feeds, paper manufacturing units, foundries, steel units, power looms, ginning and sugar mills, and an ever-growing number of vehicles are contributing to the city's increasing environmental conditions. Furthermore, around half of the garbage produced is removed from the city and the remainder is left on open land, which leads to dangerous infections in the city [9].

More and more people are utilizing trees' leaves for air monitoring purposes. The leaves are frequently used as a gauge for air pollution. Higher plant leaves collect metals from the soil and atmosphere as well as contaminants from wet and dry air deposition [10]. Plants mostly absorb metals from soil. The deposited particles may be suspended, carried away by rainwater into the soil, or held on the plant leaf. Weather, pollutant characteristics, plant surface features, leaf shape, and particle size all have an impact on the retained degree. As was already mentioned, the buildup of metal in plants serves as a record of the location and timing of the contamination. Because of this, higher plant evaluation can offer crucial details on diverse pollution incidents [11].

The aims of our study were to investigate heavy metal concentrations in soil and tree leaves along the urbanization gradient (urban, suburban, rural) in Faisalabad, Pakistan. Our hypotheses are as follows: (i) the concentration of metals in soil and Neem tree (*Azadirachta indica)* leaves is higher in urban areas than rural areas, (ii) the pollutant levels vary dramatically along with the urbanization gradient.

2. Materials and Methods

2.1. Sample Areas

The sampling areas were situated inside and in the surrounds of the city of Faisalabad, Pakistan. Faisalabad is the 3rd largest city in Pakistan, because of its industrial hub. Faisalabad, with a population of over 5 million people, is a highly populated city and a prominent industrial hub in the Punjab region. It is renowned for its strong textile and hosiery industries. Faisalabad is home to about 180 brick kilns, 140 textile dying operations, 120 foundries, and 80 engineering units, among other industries. Faisalabad has hot, humid summers and cold, dry winters with an annual rainfall of 526 mm. The region is classified as semi-arid. The primary source of pollution in Faisalabad city is vehicle emissions, which are produced by many cars, motorcycles, and heavy-duty trucks.

Samples were collected along the urbanization gradient (urban, suburban, rural). The urban area was Jinnah Garden (31°25′ N, 73°5′ E) in the city center, the suburban area was Waris Pura (31°40′ N, 73°08′ E), and the rural area was Samundari Chak (31°03′ N, 72°57′ E) (Figure 1).

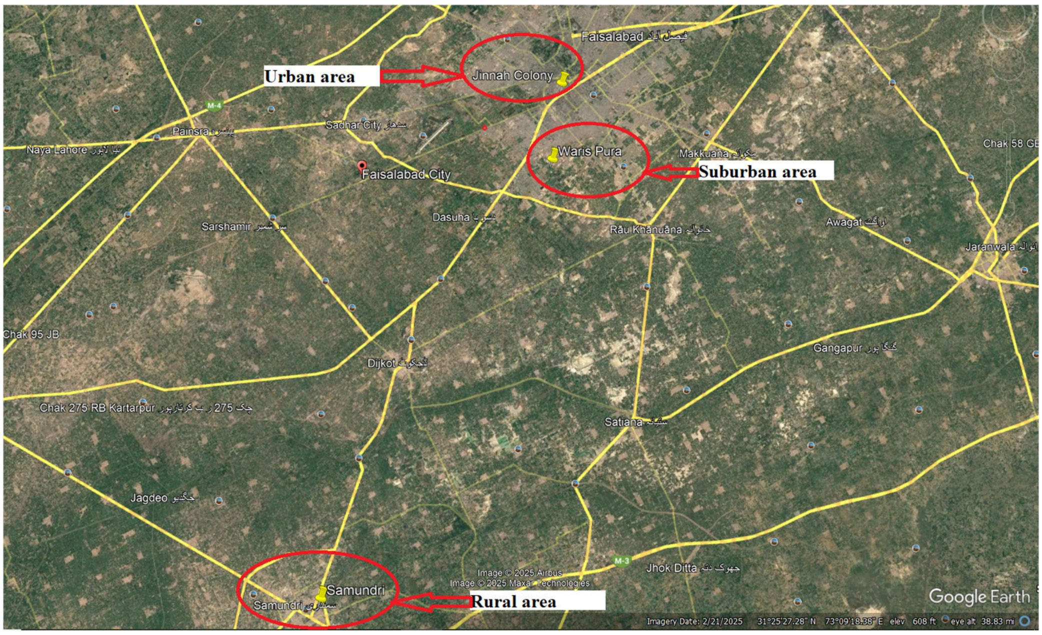

Figure 1. Map of the sampling areas; urban, suburban, and rural along the urbanization gradient around Faisalabad City in Pakistan (created using Google Earth Pro 7.3).

2.2. *Sample Species and Collection*

Soil samples (N = 15) were collected along the urbanization gradient from three different areas; urban, suburban, and rural. At each sampling site, five soil samples were collected from five different places. All samples were obtained from a depth of 0–20 cm with a small hand spade. After that, samples were placed into a polybag and kept at room temperature. In the case of the leaf sample of Neem tree (*Azadirachta indica*) (N = 15), samples were collected along the urbanization gradient. There were 5 individually chosen trees in each sampling site, and 30 leaves were collected from each tree specimen. Samples were stored in paper bags and placed at room temperature. Soil samples were collected from the *Azadirachta indica* individuals, which were also collected from the leaves. Both soil and leaf samples were collected at the same time in December in Faisalabad, Pakistan. This period was characterized by pleasant winter weather with little rainfall, dry temperatures, and light to moderate breezes from the northeast. The wind was generally quiet.

2.3. *Soil Parameter Analysis*

To analyze the main soil parameters, Figure 2 shows the methods. The level of pH and the electrical conductivity, water capacity, organic matter content, and calcium carbonate content of soil was studied.

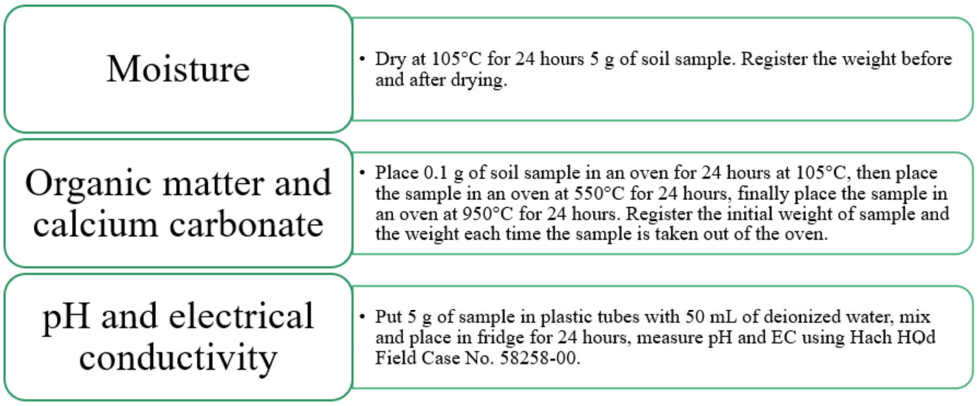

Figure 2. Methods used to analyze the soil main parameters.

2.4. Elemental Analysis of Soil and Leaves

Soil samples were dried, stones, plant root, and residues were removed with plastic tweezers. Samples were sieved in a 2 mm plastic sieve. Then, leaves and soil samples were homogenized with a knife mill (Retsch GM 200 Verder Company, Haan, Germany) and Figure 3 shows the elemental analysis technique that was used.

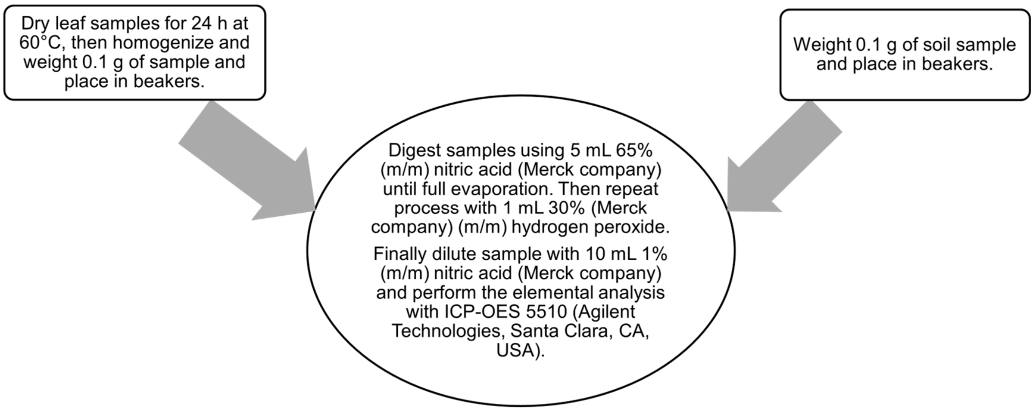

Figure 3. Method for elemental analysis [12].

2.5. Bioaccumulation Factor Analysis (BAF)

For BAF, the following formula was used:

$$BAF = C_{plant}/(C_{soil})$$

where C_{plant} is the concentration of metals in leaves and C_{soil} is the concentration of metals in soil. This calculation was performed for each sampling areas (urban, suburban, rural) along the urbanization gradient.

2.6. Statistical Analysis

In the case of soil, we assessed the separation between the rural, suburban, and urban area based on the physical and chemical parameters using principal component analysis (PCA). The principal component analysis is a multivariate data analysis of elemental concentrations. In the studied case, we analyzed and demonstrated whether the studied areas are different based on the basic physical and chemical parameters and elemental concentrations of soils. The differences among the studied areas along the urbanization gradient based on physical and chemical parameters were assessed using variance analysis (ANOVA). The homogeneity of variance was studied using Levene's test [13]. In the case of the leaves, we used the PCA with the elemental concentration in leaf tissues as an independent variable to separate the study area as dependent variables.

3. Results

3.1. Physico-Chemical Properties of Soil

To study all physico-chemical parameters of soil of the sampling sites, the principal component analysis method (PCA) was used (Figure 4). All measurements showed no significant changes, except for the pH and electrical conductivity. The pH of the soil ranges from 6.37 to 7.63 with a mean value of 7.33. The highest pH level was found in the rural soil and the urban soil, with the lowest pH level in the suburban soil (Figure 5, Table 1). There was a notable difference in electrical conductivity, with the highest level reported in the suburban soil and the lowest level detected in the rural region (Figure 6, Table 1). However, in the soil moisture, a significant difference was not found, and the lowest level of moisture was found in urban soil, and the highest level was found in rural soil (Table 1). For organic matter, a significant difference was not found, and the highest level of organic matter was found in urban areas (Table 1). Regarding the calcium carbonate, there was also no significant difference, its lowest level was in rural soil, and the highest level was in suburban soil (Table 1).

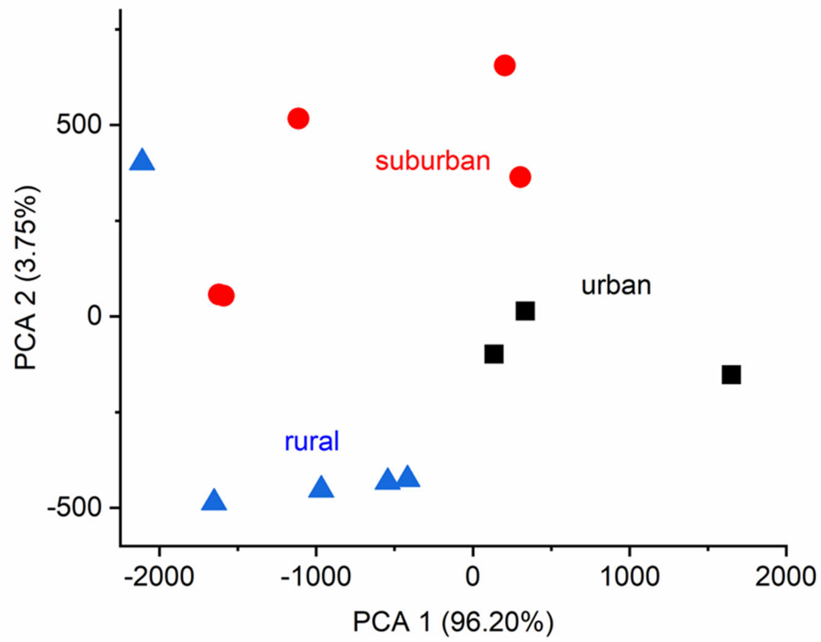

Figure 4. Scatter plot based on principal component analysis (PCA) of physio-chemical properties of soil in Faisalabad, in Pakistan.

Table 1. Physio-chemical properties of soil (mean ± SD, mg kg^{-1}) along the urbanization gradient in Faisalabad, in Pakistran.

Parameters	Studied Areas			Results of ANOVA	
	Urban	Suburban	Rural	F	*p*
pH	6.9 ± 0.2	6.4 ± 0.7	7.3 ± 0.3	4.729	0.031
Electrical conductivity, μS cm^{-2}	276 ± 91	774 ± 240	186 ± 407	6.519	0.012
Moisture content, %	4.0 ± 1.9	4.2 ± 2.3	14 ± 2	1.047	0.381
Organic matter, %	5.8 ± 1.4	4.5 ± 0.5	4.6 ± 0.8	2.955	0.900
Calcium carbonate, %	2.9 ± 0.4	3.4 ± 1.6	2.1 ± 0.6	1.920	0.189

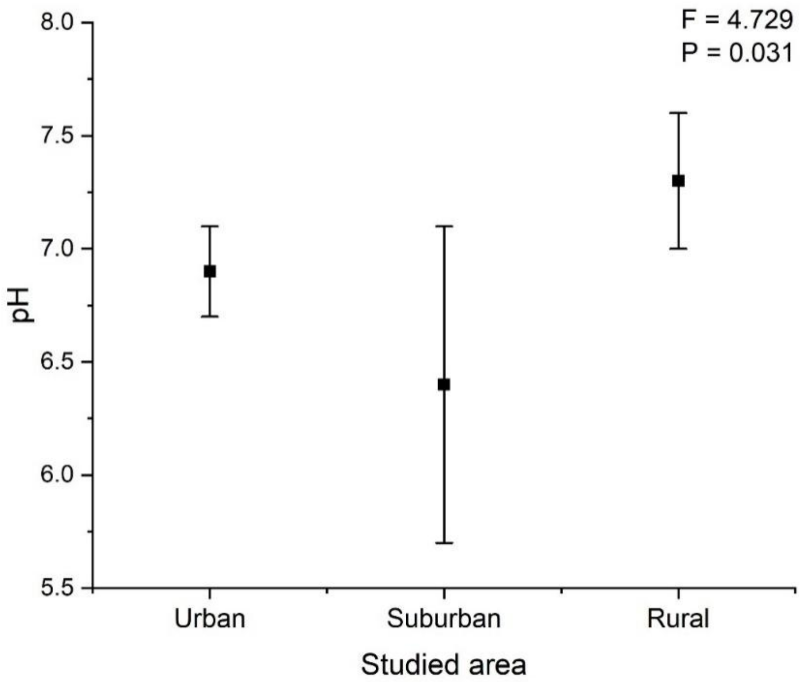

Figure 5. Results of pH among the urbanization gradient, (mean ± SD).

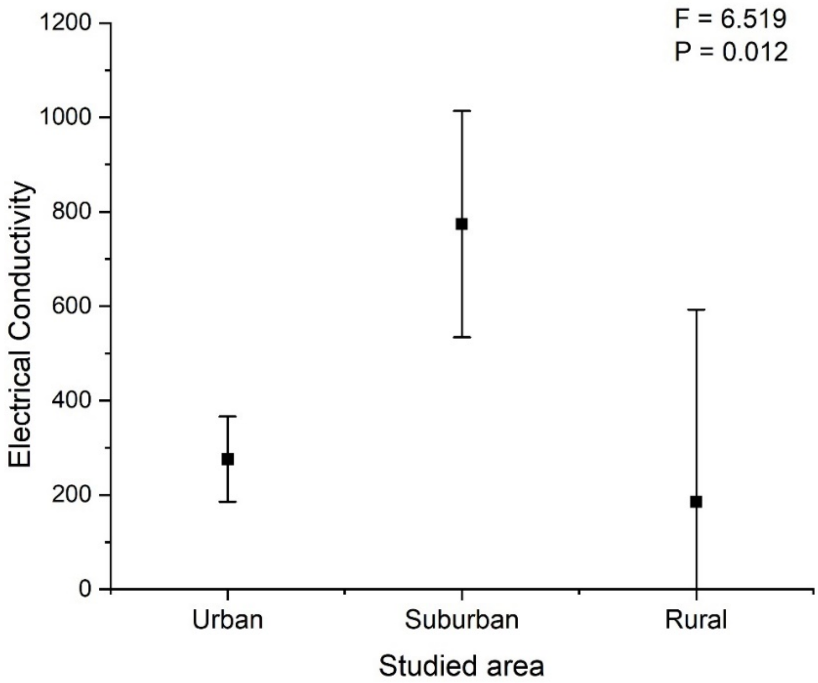

Figure 6. Results of EC among the urbanization gradient, (mean ± SD).

In the case of soil, we found significant differences in all elements, and for each element, the highest concentrations were often detected in urban soil samples, having a propensity to expand in line with the urbanization gradient (Table 2). This means that minor concentration remains in the rural area, except manganese, which is in suburban area (Table 2).

Table 2. Soil concentration of elements (mean ± SD, mg kg^{-1}) along the urbanization.

Elements	Studied Area			Results of ANOVA	
	Urban	Suburban	Rural	F	*p*
Ba	100 ± 4	74 ± 6	65 ± 4	72.340	<0.001
Co	5.3 ± 0.4	3.9 ± 0.5	3.8 ± 0.3	21.717	<0.001
Cr	15 ± 2	13 ± 1	11 ± 1	20.974	<0.001
Cu	20 ± 2	14 ± 1	9.6 ± 1.0	47.248	<0.001
Fe	13,559 ± 1864	10,927 ± 959	10,522 ± 714	8.321	0.005
Mn	616 ± 174	355 ± 27	370 ± 39	9.978	0.003
Ni	21 ± 3	17 ± 2	17 ± 1	9.463	0.003
Pb	26 ± 4	14 ± 1	9.0 ± 0.8	69.785	<0.001
Sr	23 ± 4	21 ± 2	13 ± 2	14.556	0.001
Zn	111 ± 16	101 ± 30	53 ± 5	12.798	0.001

This is quite separate from the results in plant leaves, where concentrations of most metals did not show an apparent pattern along the urbanization gradient. This suggests that a high concentration of a metal in soil does not always transform into a high concentration of that metal in plant leaves.

3.2. Elemental Concentration in A. indica Leaves

The PCA result also shows a separation among studied sites based on the elemental concentration of tree leaves (Figure 7). In the case of plants, we found significant differences in all metals except for Cd and Cu. A higher level of pollution was indicated by Ba, Pb, Co, Ni, Cr, and Cd in urban areas. Zn, Fe, Mn, and Sr indicated a low intensity of pollution in urban and suburban areas; Fe and Cu found high levels of pollution in rural areas (Table 3).

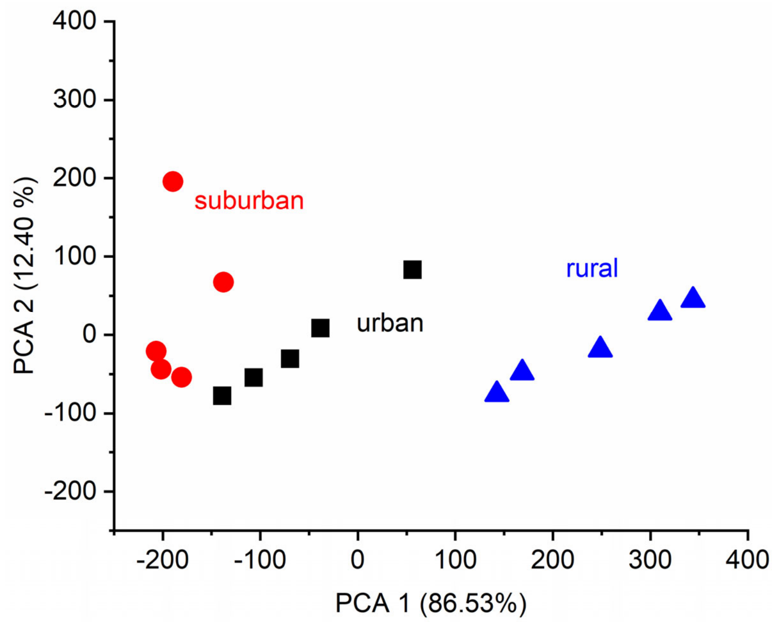

Figure 7. Scatter plot based on principal component analysis (PCA) of elemental concentration of *A. indica* leaves.

This indicates that urbanization increases the concentration in the leaves of the Neem tree for some metals yet a correlation between metal concentration in leaves and urbanization cannot be recognized for all metals, whether it is an increase or decrease along the urbanization gradient (Table 3).

Table 3. Concentration of elements (mean ± SD, mg kg^{-1}) along the urbanization in *A. indica* leaves.

Elements	Studied Area			Results of ANOVA	
	Urban	**Suburban**	**Rural**	**F**	***p***
Ba	21 ± 1	12 ± 1	7.7 ± 0.7	271.098	<0.001
Cd	0.1 ± 0.1	0.1 ± 0. 1	0.1 ± 0.02	2.032	0.174
Co	0.6 ± 0.1	0.3 ± 0.03	0.4 ± 0.03	100.100	<0.001
Cr	1.8 ± 0.2	0.4 ± 0.02	0.8 ± 0.2	130.133	<0.001
Cu	5.9 ± 0.7	5.5 ± 0.4	6.1 ± 0.9	0.944	0.416
Fe	646 ± 89	537 ± 42	938 ± 97	34.121	<0.001
Mn	76 ± 20	38 ± 2	39 ± 4.2	16.419	<0.001
Ni	4.8 ± 0.5	3.8 ± 0.4	3.2 ± 0.3	16.159	<0.001
Pb	5.4 ± 0.6	3.7 ± 0.5	2.8 ± 0.4	32.923	<0.001
Sr	264 ± 41	340 ± 99	191 ± 27	6.826	0.010
Zn	41 ± 7	41 ± 17	28 ± 3	2.550	0.119

3.3. Bio-Accumulation Factor (BAF)

The statistical analysis indicated that the bio-accumulation factor varies greatly between areas except for strontium. This suggest that the urbanization gradient has an effect on the uptake of metals by plants, but as with plants, no obvious pattern was identified. For Co, Cu, Fe, Pb, and Zn, the rural area had the highest BAF, with this being the area where most elements had their highest bio-accumulation factor. This showed that for these metals, the level of urbanization reduces their BAF; this may occur because urbanization alters soil characteristics in ways that make elements less soluble, and therefore, more difficult for plants to absorb. For Ni and Sr, the highest BAF values were found in suburban areas and for Ba, Cr, and Mn in urban areas (Table 4).

Table 4. The results (mean ± SD, mg kg^{-1}) of BAF along the urbanization gradient.

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

4. Discussion

Our results indicate that urban tree leaves and soil can be utilized to efficiently monitor urban air and soil quality. During the study, our focus was on the physico-chemical characteristics of soil in Faisalabad, Pakistan, throughout a gradient of urbanization. We also measured the element concentrations in soil and plant leaves (*Azadirachta indica*). We used the bio-accumulation factor BAF, but no obvious pattern was discovered. Urban soil samples had the greatest concentrations of all components showing an increase in concentration with the level of urbanization. In the case of plants, substantial levels of pollution were found for Ba, Pb, Co, Ni, Cr, and Cd in urban areas. Our research showed that higher concentrations in soil do not necessarily result in higher plant uptake.

For the soil parameters, it was identified that water content decreases towards the urban sites; this could be related to the high compaction of urban soils caused by either construction or transport, a phenomenon that does not happen in rural areas with the same intensity [14]. For organic matter, it was found that urbanization causes an increase with the urban soil having a high content and the suburban and rural having average organic matter content based on the classification provided by [15] where a low OM content is considered around 1%, average content around 2–4%, and high OM content greater than 5%; the high organic matter content in urban soil could be related to the role of soils in the carbon cycle; in urban areas, there are higher carbon emissions so soils tend to sequestrate more carbon, resulting in higher organic carbon content [14]. Another explanation is the high organic matter caused by littering in urban areas like [16], found in a study performed in Ghana. For calcium carbonate, a relation between urbanization and its content in soil could not be identified. As the pH range of 6.0 to 7.5 promotes nutrient availability and it is safe for the majority of plants, it may be claimed that the soils in Faisalabad have ideal pH levels, according to the Food and Agriculture Organization of the United Nations.

As eating vegetables polluted with heavy metals is important for human health, there are several research studies in Pakistan that compare and analyze the quantities of heavy metals in soil and vegetables. Despite this, few studies have compared the concentrations in soil with the plant leaves of trees like the Neem tree (*Azadirachta indica*), despite its importance as people consume the leaves of this tree for medicinal purposes and occasionally even as a vegetables in recipes [17]. Naithani et al. [18] evaluated the presence of lead, cadmium, chromium, nickel, arsenic, and mercury in two primary constituents (*Azadirachta indica*) in Ampucare, a polyherbal product. *Azadirachta indica* leaves were found to accumulate five heavy metals, including As, Fe, Cu, Zn, and Cd, in a large coal-burning area [19].

The scientific review conducted by [20] examined the levels of heavy metal pollution in Pakistani water, soil, and vegetables for Zn, Cu, Fe, Mn, Cd, Cr, Pb, Ni, and As. The findings revealed that the concentration of Cd in the leaves of various vegetable types in Faisalabad ranges from 0.035 to 0.073 mg kg^{-1}, which is lower than the concentrations of cCd found in Neem trees for this study, which range from 0.07 to 0.09 mg kg^{-1}. For Zn, the report found levels between 0.46 and 1.89 mg kg^{-1}, and for Cu, between 0.252 and 0.923 mg kg^{-1} in Faisalabad; this is very low in comparison with the concentrations found for Neem tree that are between 28 and 41 mg kg^{-1} for Zn and 5.46 and 6.08 mg kg^{-1} for Cu. Waseem et al. [20] reported that the soil concentrations of Zn in Pakistan vary from 0.1 to 1193 mg kg^{-1}, and for Cu, from 6 to 412 mg kg^{-1}; this allows us to infer that the Neem tree could be a good bio-accumulator of Zn and Cu. In the case of Cr, it is reported that in the leaves of different vegetables in Faisalabad, its concentration varies between 0.217 and 0.546 mg kg^{-1}, and for lead, between 1.33 and 2.6 mg kg^{-1}. These results are not that different from those of this study.

Vehicles and industries are the two primary sources of Fe distribution in Faisalabad. Zając et al. [21] calculated a 16–267 mg kg^{-1} Fe metal concentration in used oil; vehicles have been found to release Fe through a variety of processes, including brake abrasion and exhaust emissions, especially from diesel engines [22]. The second source of Fe in Faisalabad is a reputable iron industry that produces heavy iron agricultural equipment and supplies it to other regions of Pakistan. Such industrial processes were proposed by Filipiak-Szok et al. [23] as a high level source of Fe dispersion.

Among all heavy metals, cadmium is very hazardous to plants, animals, and humans. Anthropogenic activities are the primary source of cadmium contamination in soil and plants. Cd compounds are more soluble than other heavy metals, making them more likely to accumulate in edible plant components. Soil samples from Pakistan's Islamabad highway have Cd concentrations ranging from 5.8 to 6.1 mg kg^{-1}, with an average of 5.95 mg kg^{-1} [24]. Cd levels in Faisalabad's paddy and straw ranged from 0.116 to 0.370 mg kg^{-1} and 0.315 to 0.370 mg kg^{-1}, respectively [25]. This is important given that it was previously mentioned that cadmium concentration has been found in tree leaves increasing its concentration along the urbanization gradient but in soil it was below the detection limit, allowing us to conclude that neem tree is a good bioindicator and bio-accumulator of cadmium and can be used to significantly lower its concentration in soil.

According to [26], roadside plants play a significant role in reducing environmental pollution. Soil and plant samples from ten places along the Islamabad highway were evaluated for lead levels. Researchers in [27] showed that analyzing the elements present in soil may effectively indicate the extent of pollution in urban environments, as determined by soil sample analysis. Traffic emissions are the most probable main cause of metal pollution in Vienna.

Since textile production is the primary industry in the Faisalabad region and pigments are one of the anthropogenic sources of Mn, it is possible that the pigments used in textile production contain Mn and are contaminating the region's soils. This was previously mentioned in the description of the sampling sites. The production of chemical fertilizers is another industry that may contribute to Mn pollution in the soil. Since Mn is present in fertilizers as $MnSO_4$ the application of these fertilizers to local crops may also be the reason for the elevated levels of manganese in the soil [28]. A study in Faisalabad found higher Mn concentrations in the city's soils, ranging from 354 to 746 mg kg^{-1}, attributed to the presence of industries and traffic. The concentration of Fe was also analyzed, with high concentrations found (6716 to 9119 mg kg^{-1}), but lower than the current concentrations [29].

Regarding the soil analysis, as it was previously mentioned, the evidence shows that the level of urbanization is related with an increase in metal concentration in soils something that has been observed in several studies; for example, [30] had similar results where they found that there is a significant increase for all metals in the urban corn cultivated soil compared to the rural corn cultivated soil. One study performed by [31] concluded that zinc concentration in soils in Beijing increased from natural to urban environments. Another study also performed in Beijing found that the accumulation of heavy metals was higher in the city center than in the outskirts of the city; but unlike the previous one in this study, a significant correlation between population density and the accumulation of metals was found [32].

Heavy metals such as Cd, Pb, Zn, and Cu are commonly present in urban soils at high concentrations [33]. The study conducted by [34] demonstrated that through the processes of sorption, complexation, and precipitation, soil serves as a reservoir for heavy metals. Langner et al. [35] found that human activities and the presence of organic matter over a period of time cause the levels of heavy metals such as Cd, Cu, and Pb to rise in soils in residential areas. These increases in metal concentrations are directly proportional to the age of the urban environment. The research carried out by [36] demonstrated that the content of heavy metals in soil is affected by different forms of land use and human activities.

For the BAF, it is well known that there is an inverse relationship between pH and metal uptake for a great number of metals as indicated by numerous studies. This is because lower pH values increase metal solubility, which makes it easier for plants to absorb metals [37], but besides, this the highest BAF for most metals is found in the rural area which has the highest pH. The authors of [38] demonstrate that after analyzing the soil parameters, it was discovered that calcium carbonate was likely the factor that affected metal uptake the most. Higher calcium carbonate contents cause plants to absorb less metal because in soils rich in this mineral, metals can form compounds like hydrated hydroxides and carbonate minerals. Additionally, metals must be soluble in water in order for plants to absorb them from the soil; this means that water is needed to move the metal from the soil to the root and shoot systems [39]; this could explain why the rural area tends to have the highest BAF for most metals since the lowest content of calcium carbonate and the highest moisture is found in the rural soil.

Lower BAF values (>1) of metals, such as Fe, Cu, Zn, and Cd, were found in the leaves of *A. indica* than in an earlier study where this species was used as a bioindicator for soil pollution of the heavy metals in the coal-burning area of the country [19]. This differs from our results that only show a BAF higher than 1 for strontium.

5. Conclusions

This study assessed the impact of urbanization's effects on the environment of the urban environment in Faisalabad, Pakistan, by examining the concentration of elements in soils and Neem tree leaves (*A. indica*). Urban soil samples showed the highest concentration of all metals, with an increasing trend along the urbanization gradient, evidence that urbanization has a negative effect on the quality of soil. Except for Cd, Cu, and Zn, there were significant variations seen throughout the urbanization gradient based on plant leaves. The bio-accumulation factor (BAF) was determined as well but no clear pattern was found along the urbanization gradient; in addition, it could be identified that Neem tree could be a good bio-accumulator of cadmium and strontium. Our research indicates that the presence of high concentrations in soil does not always result in increased plant absorption due to the impact of other soil factors. Our findings indicated that the primary causes of the metals in Faisalabad are probably industrial pollutants and traffic because Faisalabad, Pakistan's third-largest city, is a major industrial hub with numerous power loom factories and large-scale industrial units. High population density and urban growth have increased vehicular traffic, leading to the hypothesis that industrial emissions and traffic-related pollutants are primary contributors to environmental metal contamination. Moreover, our studies indicate that carrying out elemental analysis on plant leaves and soil is a reliable method for assessing environmental pollution.

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