



RESEARCH PAPER

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Ziziphus spina-christi as a bioindicator of heavy metals (Cu, Cd) in Baghdad, Iraq

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ABSTRACT

Heavy metal pollution is considered one of the major environmental problems associated with urbanization, traffic emissions, and industrial activities. This study evaluated the potential of *Ziziphus spina-christi* as a bioindicator of copper (Cu) and cadmium (Cd) pollution in Baghdad, Iraq. Leaf samples were collected from four urban regions including Al-Qahira, Al-Karrada, Al-Dura, and Al-Kadhimiya, in addition to a control (blank) sample. The collected samples were digested using nitric acid and analyzed using an atomic absorption spectrometer to determine heavy metal concentrations. The results showed clear variation in heavy metal accumulation among the studied regions. Copper concentrations were highest in Al-Qahira and Al-Dura (0.06), followed by Al-Karrada (-0.02), while the lowest concentration was recorded in Al-Kadhimiya (-0.05) compared with the control sample (-0.03). Cadmium concentrations were highest in Al-Kadhimiya (-0.02) and Al-Dura (-0.03), whereas lower concentrations were observed in Al-Qahira (-0.13) and Al-Karrada (-0.14) relative to the blank sample (-0.15). The elevated concentrations recorded in densely populated and traffic-heavy areas indicate the influence of anthropogenic activities on environmental contamination. The findings demonstrate that *Ziziphus spina-christi* effectively accumulates heavy metals within its tissues and can serve as a reliable bioindicator of urban environmental pollution. The plant also shows promising potential for phytoremediation applications due to its tolerance to polluted conditions. Therefore, *Ziziphus spina-christi* may be considered an environmentally friendly and cost-effective tool for monitoring and managing heavy metal pollution in Baghdad, Iraq.

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INTRODUCTION

Environmental pollution caused by heavy metals has become one of the major ecological concerns in rapidly urbanizing cities worldwide. Industrial expansion, population growth, traffic congestion, and uncontrolled waste disposal contribute significantly to the accumulation of toxic metals in soil, air, and water. Among these pollutants, copper (Cu) and cadmium (Cd) are considered particularly hazardous because of their persistence in the environment and their potential harmful effects on plants, animals, and human health. Continuous exposure to heavy metals may lead to serious environmental degradation and ecological imbalance.

In recent years, increasing attention has been directed toward the use of plants in environmental monitoring and remediation. Phytoremediation is regarded as an eco-friendly and cost-effective approach for reducing environmental contamination through the absorption, accumulation, and stabilization of toxic substances by plants (Priya *et al.*, 2023). Certain plant species possess the ability to tolerate and accumulate heavy metals within their tissues, making them suitable indicators of environmental pollution and potential tools for remediation strategies (Elboughdiri, 2020).

Ziziphus spina-christi is a drought-resistant plant widely distributed in arid and semi-arid regions, including Iraq. The species is known for its ability to survive under harsh environmental conditions such as high temperature, water scarcity, salinity, and urban pollution. Due to its adaptability and tolerance, the plant has attracted scientific interest as a possible bioindicator of environmental contamination. Previous studies have shown that *Ziziphus spina-christi* can absorb and accumulate heavy metals from polluted environments, particularly through its leaves and root systems (Al-Naimi *et al.*, 2023).

The accumulation of heavy metals in plant tissues reflects the degree of environmental contamination surrounding the plant, which supports its use as a biological indicator for pollution assessment (Talkhoncheh and Rouzbahani, 2024). In addition, the species has demonstrated considerable tolerance to elevated concentrations of heavy metals without severe

physiological damage, indicating its potential role in phytoremediation applications (Alotaibi *et al.*, 2021).

Baghdad, the capital city of Iraq, experiences increasing environmental pressure due to rapid urbanization, dense traffic movement, industrial activities, and population growth. These factors contribute to the release of heavy metals into the urban environment, creating potential ecological and public health risks. However, limited studies have investigated the use of native plant species as bioindicators of heavy metal pollution in Baghdad. Therefore, the present study aimed to evaluate the potential of *Ziziphus spina-christi* as a bioindicator of copper and cadmium pollution in selected urban regions of Baghdad, Iraq. The study also sought to compare heavy metal concentrations among different areas and assess the suitability of the plant as a potential phytoremediator for monitoring environmental contamination.

MATERIALS AND METHODS

Study area and sample collection

This study was conducted in Baghdad, Iraq, to evaluate the potential of *Ziziphus spina-christi* leaves as bioindicators of heavy metal pollution, particularly copper (Cu) and cadmium (Cd). Leaf samples were collected from four urban regions characterized by high population density and traffic activity: Al-Qahira, Al-Karrada, Al-Dura, and Al-Kadhimiya. A control (blank) sample was also included for comparison. Three replicates were collected from each study area. Healthy mature leaves were manually harvested from *Ziziphus spina-christi* plants and placed in clean polyethylene collection bags to avoid contamination during transportation.

Sample preparation and heavy metal analysis

Collected leaf samples were washed with distilled water to remove dust particles and air pollutants, then air-dried and finely ground prior to chemical analysis. Approximately 50 mg of each powdered sample was transferred into digestion vessels and treated with 5 ml of 65% nitric acid (HNO₃). The mixture was shaken thoroughly and allowed to stand for approximately 20 minutes before microwave digestion.

Microwave digestion was performed using a GINA upper wave analyzer until complete digestion and cessation of

foaming and vapor formation. After cooling to room temperature, the digested samples were carefully handled under vapor filters while wearing appropriate protective equipment. The digested solution was transferred into Falcon tubes and diluted with distilled water to the required volume.

For quality control, blank samples and repeated digestion procedures were performed. Heavy metal concentrations were determined using a CONTRA 700 atomic absorption spectrometer at the General Company for Foodstuff Trading, Iraqi Ministry of Trade. Copper (Cu) and cadmium (Cd) concentrations were measured in triplicate, and the average values were recorded for each sampling area.

Statistical analysis

The obtained data were expressed as mean \pm standard deviation (SD). Statistical analyses were carried out using one-way analysis of variance (ANOVA) followed by Tukey's multiple comparison test to determine significant differences among the studied regions and the control group. Graphical representations were generated using GraphPad Prism version 10 (San Diego, CA, USA). Differences were considered statistically significant at $p < 0.05$.

RESULTS AND DISCUSSION

The concentrations of copper (Cu) and cadmium (Cd) detected in the leaves of *Ziziphus spina-christi* varied among the studied regions of Baghdad, indicating differences in environmental pollution intensity across locations. The obtained values are presented in Table 1, while Figs 1 and 2 illustrate the distribution patterns of Cu and Cd concentrations, respectively.

Table 1. Variation of heavy metal (Cu and Cd) concentrations in *Ziziphus spina-christi* leaves in study regions

Areas	Cu Mean	Cd Mean
Blank	-0.03	-0.15
Alqahira	0.06	-0.13
Al-krada	-0.02	-0.14
Al-Dura	0.06	-0.03
Al-Kadhimiya	-0.05	-0.02

Copper concentration in *Ziziphus spina-christi*

The results showed noticeable variation in copper accumulation among the sampled regions. The highest

Cu concentrations were recorded in Al-Qahira and Al-Dura (0.06), indicating greater exposure to anthropogenic pollution sources in these areas. Al-Karrada showed a relatively lower concentration (-0.02), whereas Al-Kadhimiya recorded the lowest Cu value (-0.05), which was even lower than the blank sample (-0.03). These findings suggest that copper pollution is more pronounced in highly populated and traffic-congested regions such as Al-Qahira and Al-Dura.

Fig. 1 further demonstrates the spatial variation in copper concentration among the study sites. The elevated copper levels observed in Al-Qahira and Al-Dura may be associated with increased vehicle emissions, industrial activities, and urban population density. Similar observations were previously reported by El-Amier and Alghanem (2018), who found increased heavy metal accumulation in plants growing near roadsides and polluted urban environments. In addition, Rafati *et al.* (2019) and Abd EL-Nabi *et al.* (2025) reported that traffic-related activities contribute significantly to copper contamination in urban vegetation.

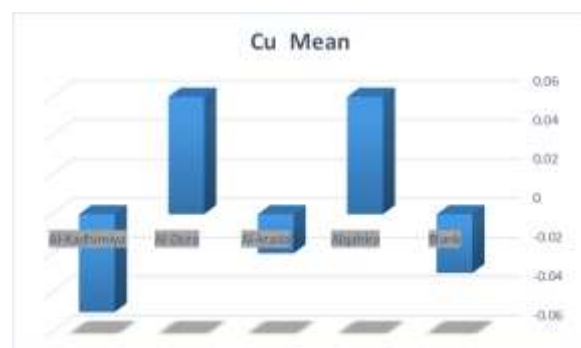


Fig. 1. Copper levels in *Ziziphus spina-christi* between different regions

The comparatively lower Cu concentration observed in Al-Kadhimiya may indicate relatively lower environmental pollution pressure in that area compared to the other studied regions.

Cadmium concentration in *Ziziphus spina-christi*

Cadmium concentrations also differed among the study regions. The highest Cd accumulation was observed in Al-Kadhimiya (-0.02) and Al-Dura (-0.03), while lower concentrations were recorded in Al-Qahira (-0.13) and

Al-Karrada (-0.14). The blank sample showed the lowest concentration (-0.15). These findings indicate that cadmium contamination was more evident in Al-Kadhimiya and Al-Dura compared to the other sampled locations.

Fig. 2 illustrates the distribution of cadmium levels among the study regions. The elevated Cd concentrations in Al-Kadhimiya and Al-Dura may reflect the influence of local pollution sources, including traffic emissions, industrial discharge, and urban activities. Similar findings were reported by El-Radaideh and Al-Taani (2018), who demonstrated that roadside and urban soils often contain elevated cadmium concentrations due to human activities.

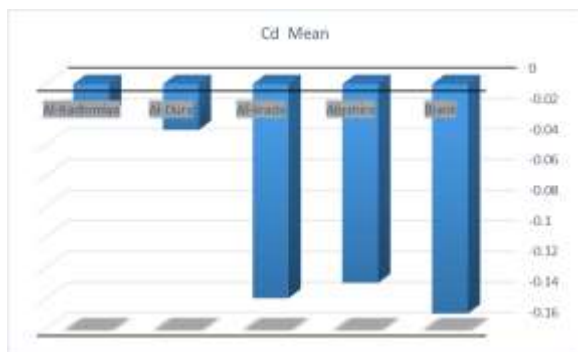


Fig. 2. Cadmium levels in *Ziziphus spina-christi* between different regions

The present findings also support the role of *Ziziphus spina-christi* as an effective bioindicator of environmental pollution. The plant demonstrated the ability to accumulate heavy metals within its tissues, confirming previous studies that highlighted its suitability for phytoremediation and pollution monitoring in urban ecosystems (Al-Naimi *et al.*, 2023; Elezz *et al.*, 2025).

Overall, the observed variation in Cu and Cd concentrations among the different regions reflects differences in environmental pollution intensity within Baghdad. The results suggest that *Ziziphus spina-christi* can serve as a reliable and environmentally friendly indicator species for monitoring heavy metal contamination in urban areas.

CONCLUSION

The present study demonstrated that *Ziziphus spina-christi* has considerable potential as a bioindicator for monitoring heavy metal pollution in urban environments. The concentrations of copper (Cu) and cadmium (Cd) detected in plant leaves varied among the studied regions of Baghdad, reflecting differences in pollution intensity associated with traffic density, population activity, and other anthropogenic sources. Higher copper concentrations were observed in Al-Qahira and Al-Dura, while cadmium accumulation was more pronounced in Al-Kadhimiya and Al-Dura. These findings indicate that urban activities significantly contribute to heavy metal contamination in the surrounding environment. The ability of *Ziziphus spina-christi* to accumulate heavy metals without severe visible damage further supports its suitability for phytoremediation and environmental monitoring purposes.

Overall, the study highlights the ecological importance of *Ziziphus spina-christi* as a cost-effective, environmentally friendly, and sustainable tool for assessing heavy metal pollution in Baghdad, Iraq. The plant may therefore be useful in future environmental monitoring programs and urban pollution management strategies.

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