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Environmental Risk Assessment of Heavy Metals in Dust and Their Impact on Roadside Plants Due to Traffic Activity in Diyala Governorate

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ABSTRACT: The current study aims to evaluate the levels of dust pollution on plants grown on roadsides and resulting from traffic in Diyala Governorate. Four locations were chosen that represent different levels of traffic density and industrial activity: Al-Tabu Street, Khuraisan Street, Buhriz Street, and Hay Al-Muallem Street. Concentrations of heavy metals were measured, including (lead (Pb), cadmium (Cd), copper (Cu), and zinc (Zn), and the results showed the highest concentration of heavy metals was recorded in zinc, which reached 145.9 mg/kg and lead, 61.2 mg/kg. This is attributed to Due to the high traffic density and industrial activities, the lowest concentrations were in Buhriz Street, where the lowest concentration of cadmium was 1.2 mg/kg, while the copper concentration reached 22.1 mg/kg due to the lack of traffic activity. The current study also included measuring the physiological functions of plants, including (Photosynthesis rate, stomatal measurement, and chlorophyll concentrations), as the results showed that dust accumulation has effects on the physiological functions of plants, through a decrease in construction efficiency. Photosynthesis and differences in chlorophyll concentrations. The study also showed the impact of traffic and industrial activities on plant life as a result of dust falling on the surfaces of their leaves, which emphasizes the importance of working to reduce dust pollution levels in urban areas to improve environmental quality.

Keywords: dust pollution, heavy metals, traffic, cultivated plants.

1. INTRODUCTION

Iraq, including Diyala Governorate, witnessed a gradual increase in population numbers, especially in recent times, which led to an increase in industrial and commercial activities for the population. The need for means of transportation for the population also increased, especially in developing countries. With this large increase in traffic resulting from human activities, dust pollution is generated, which is one of the The most prominent environmental challenges faced by urban and peri-urban communities [1], It has negative impacts on the environment and humans, including roadside plants, which are exposed to daily dust deposition due to the emission of fine particles into the air. Dust settles on the surface of their leaves, impairing vital functions such as respiration and photosynthesis, and adversely affecting growth and

productivity in the long term [2], Recent studies have confirmed that the amount of dust deposited on the surfaces of plant leaves may contain various pollutants, including heavy metals and organic and inorganic compounds [3], The particle sizes range from 0.001 to 100 micrometers, which also affects air quality and may increase health risks for humans [4], The heavy metals present in dust particles have harmful effects on plant health. The most significant of these metals include iron, manganese, lead, copper, cadmium, and zinc. Dust is important for monitoring environmental pollution resulting from emissions due to... Traffic and industrial traffic [5], and plants grown on roadsides are affected by high concentrations resulting from dust pollution, which causes clogged stomata, preventing gaseous exchange and absorption of carbon dioxide [CO_2], which is necessary and important for photosynthesis. However, the amount of light that reaches the leaves as a result of dust accumulation in the atmosphere will affect the efficiency of the plant's physiological functions [6], The ability of these plants grown on urban roads to absorb dust particles and retain them on the surfaces of their leaves makes them natural barriers to reducing pollution, as these plants face chronic accumulation of dust on the surfaces of their leaves, which puts them under great environmental pressures, which reduces their efficiency and affects their health and growth in general. The accumulation of fine dust particles may lead to changes in the shape and color of leaves as well as in their chemical composition, thus weakening their ability to perform important functions that act as environmental enhancers [7], In the local context of Diyala Governorate in Iraq, especially in urban and semi-urban areas, the increase in traffic and dust is considered one of the most important sources of air pollution [8], and as a result of the large and continuous increase in the use of vehicles and other human activities, the governorate is witnessing a clear deterioration in air quality, Which increases the accumulation of fine particles at high levels on the leaves of plants grown on roadsides. Dust pollution has a significant impact on plant health, whether on general growth or physiological functions [9], and climatic conditions such as wind and rain play a major role in removing dust. Studying the impact of climatic factors is of great importance to know Pollution levels and their impact on plants [10], The importance of this study is to know the effect of dust pollution on plants grown on roadsides due to the large traffic movement in the governorate. Diyala, by analyzing the amount of dust present on the surface of plant leaves, as well as measuring stomata and determining chlorophyll levels, and working to reduce the level by cultivated plants and improve the quality of the environment.

2- MATERIALS AND METHODS

2-1 Study area.

The study sites were carefully chosen for different areas in Diyala Governorate, depending on traffic movement. The selected sites included dense traffic streets, including Al-Tabu Street and Khuraisan Street, and others with medium and low density, which is Buhriz Street. The study also included another traffic-dense site that is close to sources of industrial pollution. The study sites were chosen. Hay Al-Moallem Street, located near the industrial area.

2.2 Collecting sample

Samples were taken from the dust accumulated on the leaves of plants planted on both sides of the roads using a soft brush for the selected sites, dusting and not damaging the leaves. Soil samples were taken from a depth of 0-10 cm near the cultivated plants for each site. They were transported in special, closed bags to preserve the samples until they

arrived at the laboratory. Then all data were recorded for each sample, including location, date, time of collection, environmental conditions, and traffic level during sample collection [11].

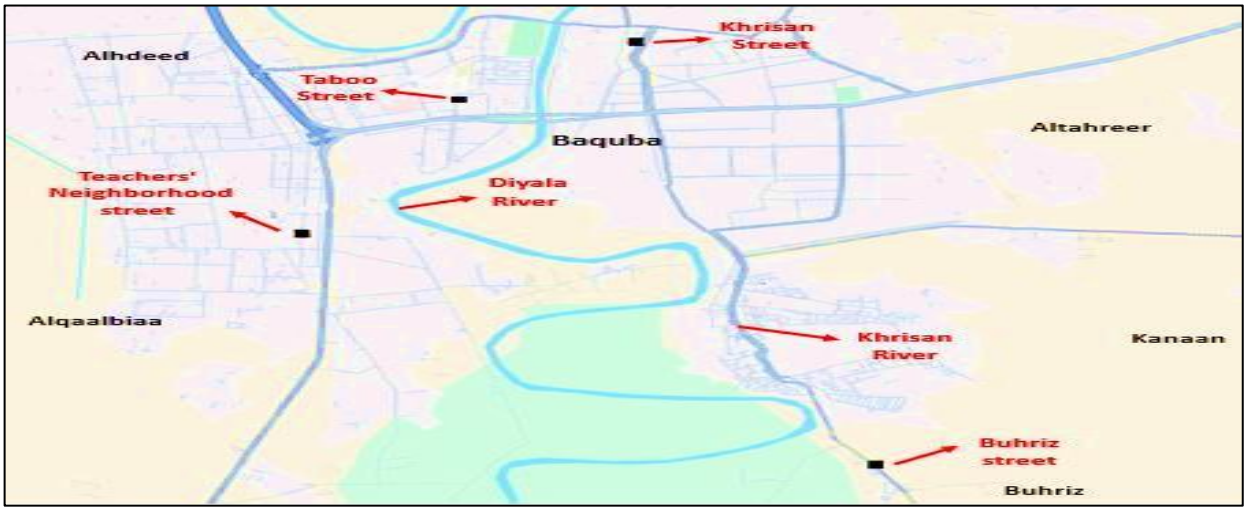

FIGURE 1. – site of the study area

2.3 Chemical analysis.

The samples were dried using a convection oven device known as Hot Air Oven at low to medium temperatures [40-105 °C]. To remove moisture, they were ground using a mechanical grinder to turn the samples into a fine and homogeneous powder. The ground samples were then passed through a sieve with sized holes. Specific [usually 2 mm or less] To ensure uniform particle size, 1g of the ground sample was taken and placed in a heat-resistant glass beaker, then 5ml of concentrated nitric acid was added. [HNO_3] at a concentration of 70%. The sample was heated in a heating device (Hot Plate) at a temperature of 100-150°C in order to dissolve completely. The solution was then cooled and filtered using filter paper to get rid of any undissolved particles. The filtered solution was transferred to a device ICP-OES to analyze heavy metals and determine their concentrations accurately (12).

2.4 Measuring plant physiological functions.

After the collection process, The healthy leaves were placed in the room to measure gas exchange, to measure the rate of photosynthesis using the LI-6400XT device through the difference between the concentration of carbon dioxide before and after the air passed over the leaf, and the stomata were measured based on the amount of water vapor exchange between the leaf and the surrounding air (13), then I use 96% ethanol to analyze the chlorophyll concentration, at specific wavelengths (645 and 663 nm) using a spectrophotometer. Using the following standard equations (14).

$$\text{Chlorophyll a (mg/g)} = 12.7 \times A663 - 2.69 \times A645$$

$$\text{Chlorophyll b (mg/g)} = 22.9 \times A645 - 4.68 \times A663$$

2.5 Statistical analysis.

Statistical analysis was conducted using (SPSS) software to analyze the data to calculate averages and standard deviations. ANOVA tests were conducted to compare concentrations and determine whether there were statistical differences between the different sites.

3. RESULTS

Table 1. -Heavy Metal Concentrations by Locations

Locations	Lead (Pb) (mg/kg)	Cadmium (Cd)(mg/kg)	Copper (Cu) (mg/kg)	Zinc (Zn) (mg/kg)
Tabou Street	50.4	2.1	32.7	128.4
Khurasan Street	45.3	1.9	29.3	112.1
Buhriz Street	30.4	1.2	22.1	88.7
Al-Muallimin Street	61.2	2.7	35.6	145.9

Table (1) shows the concentrations of heavy metals: lead (Pb), cadmium (Cd), copper (Cu), and zinc (Zn), which were measured in dust taken from four sites in Diyala Governorate. The results show that the highest concentrations were recorded in Hay Al-Muallem Street, where the high traffic density and surrounding industrial activity contribute significantly to increasing pollution levels, while Buhriz Street recorded the lowest concentrations as a result of the decrease in traffic in the area.

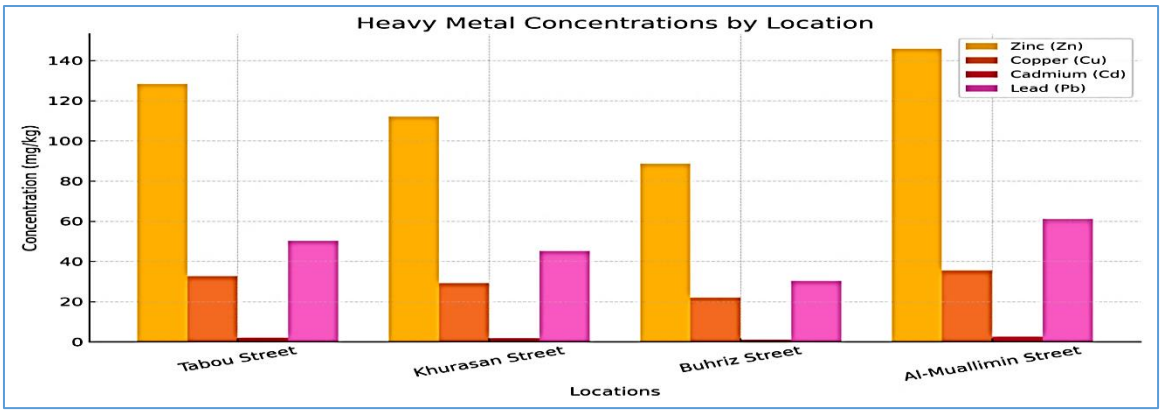

FIGURE 2. - Levels of Heavy Metal Concentrations at the Study Site

Table 2. Calculation of Highest and Lowest Concentration, Averages, Standard Deviations, and p-values for Heavy Metal Concentrations

Concentration	Lowest Concentration (mg/kg)	Highest Concentration (mg/kg)	Mean ± Std (mg/kg)	p-Value
Lead (Pb)	30.4	61.2	46.82 ± 11.08	0.041
Cadmium (Cd)	1.2	2.7	1.97 ± 0.60	0.067
Copper (Cu)	22.1	35.6	30.00 ± 5.28	0.054
Zinc (Zn)	88.7	145.9	118.78 ± 21.08	0.038

Table 2 shows that lead (Pb), the highest concentration was recorded at 61.2 mg/kg and the lowest concentration was 30.4 mg/kg, with a mean ± standard deviation of 46.82 ± 11.08 mg/kg, and a p-value of 0.041, which It indicates that there are statistically significant differences between the different sites. As for cadmium (Cd), the highest concentration was 2.7 mg/kg and the lowest concentration was 1.2 mg/kg, with a mean ± standard deviation of 1.97 ± 0.60 mg/kg, and the p-value was 0.067, which indicates slight differences between sites, as between copper (Cu), the highest concentration is 35.6 mg/kg and the lowest concentration is 22.1 mg/kg, with a mean ± standard deviation of 30.00 ± 5.28 mg/kg and a p-value of 0.054. , which is close to the level of statistical significance, Finally, the results of zinc (Zn) showed the highest concentration among the studied elements, reaching 145.9 mg/kg

as the highest value and 88.7 mg/kg as the lowest value, with a mean ± standard deviation of 118.78 ± 21.08 mg/kg and a p-value of 0.038, which indicates There were statistically significant differences between the sites.

Table 3. Mean Values, Standard Deviations, and p-values for Dust Accumulation

Locations	Mean±Std	P-Value
Tabou Street	96.1 ± 1.5	0.035*
Khurasan Street	84.5 ± 1.6	0.040*
Buhriz Street	65.4 ± 1.1	0.042*
Al-Muallimin Street	102.8 ± 1.4	0.033*

The results of Table (3) showed that the highest mean dust concentration was recorded in Al-Muallimin Street, reaching 102.8 mg/m², reflecting the significant impact of industrial activity and high traffic density in the area. In contrast, the lowest mean dust concentration was recorded in Buhriz Street, with a value of 65.4 mg/m², indicating reduced traffic and human activity in the location. Additionally, the p-value was less than 0.05 for all sites, indicating statistically significant differences between the studied locations

Table 4.-Mean Values, Standard Deviations, and p-values for Plant Physiological Functions

Physiological functions of plants	Mean±Std	P-Value
Chlorophyll A (mg/g)	2.0±0.4	0.032*
Chlorophyll B (mg/g)	0.8±0.2	0.048*
Photosynthesis rate (CO2/M2/S)	9.4±1.8	0.025*
Connecting stomata (mol/m2/s)	0.17±0.03	0.040*

The results of Table (4) showed that the highest mean value for photosynthesis rate was 9.4 ± 1.8 µmol $CO_2/m^2/s$, while the lowest mean value for stomatal conductance was 0.17 ± 0.03 mol/m²/s. Additionally, the p-value for all physiological functions was less than 0.05, indicating statistically significant differences between the studied locations.

4. DISCUSSION

The results obtained in Hay Al-Moallem Street recorded the highest concentration compared to the concentrations of other locations. The reason is the increase in traffic density and significant industrial activities in the area, which include factories, welding workshops, and cable production. These activities can result in copper emissions that reach the surrounding soil and dust., while Buhriz Street obtained the lowest concentrations, due to the small traffic movement in this location. This study is consistent with a study conducted by Wang et al. (2020), where the results of the study indicated an increase in the concentration of lead, which exceeded 70 mg/kg in areas with significant industrial activity, which means that industrial activities may clearly contribute to increasing pollution. (16), as a study conducted by Issa (2015) evaluated copper and zinc contamination in the soil of industrial areas, which showed that areas with low traffic density show low concentrations due to the lack of emission sources from car exhausts (17), and given the spatial distribution of these metals, The current study showed that the highest concentration of zinc (145.9 mg /kg), recorded on Al-Moallem Street Street, and the reason is due to the use of zinc in coatings or other industrial processes. These results are consistent with a study conducted by Solji in Iran (2015), which showed that high levels of zinc in the surrounding soil result from industrial activities (18), as the zinc concentration ranged between 23.02 and 144.17 mg/kg. As for cadmium, there are no significant differences (p = 0.067) between the sites, and this indicates the stability of this element. A study by Chen

and others (2020) concluded that cadmium is characterized by limited sources, as it is associated with natural activities and some limited industrial activities (19), as the dust results showed, as Al-Muallemin Street recorded a dust accumulation rate of (102.8 mg/m²).), a significant increase due to traffic density, and this is consistent with a study by Bada and Oyegbemi (2012), which showed that the increase in dust accumulation on roads increases with the increase in traffic density (20), Another study also showed that there is a relationship between the increase in traffic and the increase in Concentration of heavy metals such as lead and zinc in dust. In contrast, Buhriz Street recorded the lowest accumulation of dust (65.4 mg/m²), and the reason for this is the low traffic density in the area, and this was confirmed by a study conducted by Ahmed and Ishiga (2006) in the city of Dhaka, Bangladesh. , which confirmed that areas with low traffic density contain lower levels of heavy metals and dust, in contrast to areas with low traffic density. The study concluded that the main source of dust accumulation is traffic and human activities in commercial areas (21). The results also showed significant differences in all studied physiological functions ($P<0.05$). The highest photosynthesis rate was 9.4 ± 1.8 μmol $CO_2/m^2/s$, attributed to increased dust and heavy metal concentrations in plants. This aligns with a study conducted by Zhang et al. (2022), which demonstrated a significant impact on photosynthetic efficiency in plants due to increased lead concentrations and its accumulation in plant tissues (22). Another study by Lil Alvarado et al. (2016) indicated that photosynthetic efficiency decreased by up to 44% in some cells due to lead accumulation, which caused cell membrane damage, stomatal closure, and reduced carbon dioxide intake (23).

5. CONCLUSIONS

The current study conducted on plants grown on the sides of roads in Diyala Governorate, Iraq, the subject of the current study, showed that, the concentrations of heavy metals in dust deposited on plant leafe surfaces showed an increase in heavy elements due to traffic and extensive industrial activity, especially in Al-Mu'allimin street, It had higher concentrations of zinc and lead, which had a negative impact on plants grown on the sides of roads. The study also showed that dust accumulation on the surfaces of plant leaves clearly affects plant physiological functions, such as (photosynthesis, chlorophyll concentration, and stomata), which supports or indicates the risk of dust pollution on plants.

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