

## STUDY OF SOME PLANT SPECIES AS PHYTOREMEDIATION OF HEAVY METALS EMISSION FROM OIL REFINERY

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### ABSTRACT

This study was carried out to investigate the phytoremediation potential of six different plant species (*Melia azedarach*, *Punica granatum*, *Cupressus arizonica*, *Platanus orientalis* and *Platanus orientalis*) in the city of Erbil mitigating heavy metal emissions of an oil refinery. The research assesses photosynthetic pigments, heavy metal concentrations (Fe, Cu, Mn, Ni, Zn, As, Pb, Co, Hg and Se) from an oil, and biochemical attributes in leaves, highlighting their responsiveness to contamination. Variations in metal levels between control and polluted sites underscore the refinery's impact, while reduced photosynthetic pigments indicate potential ramifications for plant vigor. The intricate interplay between pollution levels and plant physiology is explored, offering crucial insights for effective environmental management strategies. Metals like Arsenic, Cadmium, Lead, and Mercury, commonly found in food, pose health risks due to human activities. The research underscores the significance of plants as indicators and reducers of pollutants, emphasizing the potential of phytoremediation in addressing environmental challenges. The findings contribute valuable information for developing sustainable approaches to combat pollution, particularly in industrial settings.

**Key words:** Air pollution; Environmental Contamination; Heavy Metals; Photosynthetic Pigments; Phytoremediation



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### INTRODUCTION

Today environmental pollution especially Air pollution and natural change in atmospheric compositions, that the levels of materials exceed their normal ambient (clean air) points, resulting in obvious negative influences on humans, animals, plants, or ingredients v, When plants acts as filters to add anthropogenic activities and causes encounter environmental pollution levels that exceed what is considered physiologically acceptable, it leads to the deactivation of photosynthesis Consequently, any change in the concentration of chlorophyll can have an impact on the

plant's physical, physiological, and biochemical functions. Green plants have traditionally been significant in influencing environmental conditions. Numerous green plants serve as indicators and reducers of pollutants in the environment (Z. Salih & Aziz, 2019). Phytoremediation is a burgeoning technology that aids in purging soil and water bodies of harmful pollutants. It offers an affordable and sustainable means to bolster the economies of developing nations. Moreover, phytoremediation stands as one of the most promising and practical solutions for impoverished farmers, particularly when

managed through community-based approaches (Imadi, Shah, Kazi, Azooz, & Ahmad, 2016). Pollution is characterized as the release of substances into the environment that are detrimental to humans and other living organisms. These pollutants can take the form of harmful solids, liquids, or gases, occurring in concentrations higher than normal, ultimately diminishing the overall quality of our environment (Z. R. Salih, Khudhur, & Muhammad, 2025) (Manisalidis, Stavropoulou, Stavropoulos, & Bezirtzoglou, 2020). Metals like Arsenic (As), Cadmium (Cd), Lead (Pb), and Mercury (Hg) are common chemical constituents found in plants (Z. R. Salih et al., 2025). These metals are detectable in the environment at various levels, and they can be identified as residues in food. Human activities, including the use of pesticides and fertilizers in agriculture, industrial processes, emissions from vehicle exhausts, and improper handling or storage of food, contribute to the presence of these metals in the food chain (Angon et al., 2024). Industries such as battery manufacturing, electronics, leather production, and the oil sector pose serious risks to health and the environment by releasing pollutants like toxic dyes and heavy metals. These contaminants can enter the food chain, accumulate in living tissues through bioaccumulation, and negatively affect human health. When studying plant bio-indicators, it was noted that they exhibit high sensitivity to elevated levels of atmospheric pollution. The decrease in Chl 'a', Chl 'b', overall chlorophyll content, and total carotenoids in chosen species like *Azadirachta indica* (L.), *Polyalthia longifolia* (L.), and *Ficus religiosa* (L.) was directly linked to the presence of cement dust pollution (Thambavani & Kumar, 2011). Leaves serve as excellent indicators of air pollution. The majority of particulate matter tends to accumulate on the upper surface of leaves. One of the most critical and detrimental effects of air pollution is the gradual decline of chlorophyll and the yellowing of leaves due to reduction of chlorophyll pigments. This can lead to a reduction in the capacity for photosynthesis (Z. Salih & Aziz, 2019). The Peepal tree demonstrated a consistent

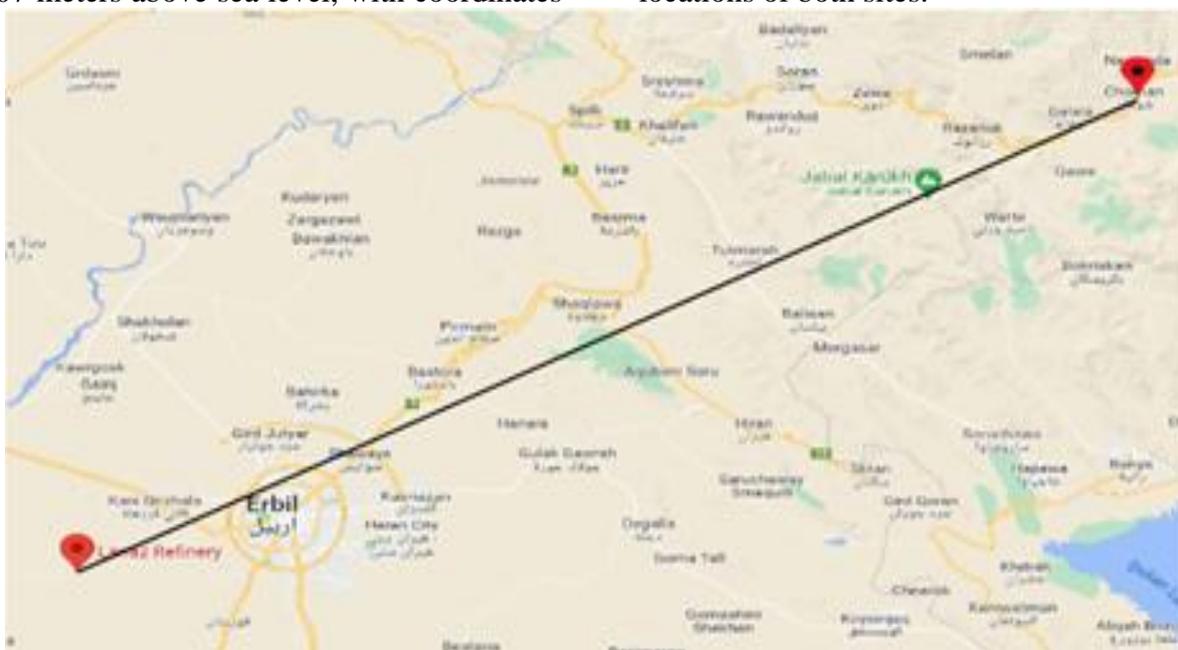
tolerance to pollution levels throughout all seasons, particularly in relation to Particulate Matter. Conversely, the Tamarind tree exhibited sensitivity to pollution levels in every season (Kazi et al., 2021). A regional survey around Kasnazan oil refinery in Erbil, identifying elevated concentrations of Fe, Mn, Ni, Cr, and Zn in surface soils. This study highlights the urgent need for remediation technologies like phyto- and bioremediation in agriculturally impacted areas. Living organisms possess a strong capacity to absorb heavy metals, particularly because these elements can fully dissolve in aquatic environments. Once heavy metals enter the food chain, they can quickly accumulate to harmful levels within the human body. (Almashhadany et al., 2024) *Phragmites australis* in a constructed wetland system removed approximately 98% of total petroleum hydrocarbons (TPH) and 62% of COD from Al-Doura refinery effluent over 42 days. The significant increase in biomass further supports its ecosystem role in remediation efforts. The prefix "phyto," which means "plant," and the Latin root *remedium*, which means "to correct or eliminate a disturbing external factor," are combined to form the phrase "phytoremediation." (Sumiahadi & Acar, 2018). This study aimed to find out how well certain plants can clean up pollution from an oil refinery in Erbil. Researchers looked at six types of plants to see how much heavy metal they absorbed in their leaves when growing near the refinery compared to a clean area. They also studied how pollution affected the plants' health, focusing on things like leaf pigments, Nitrogen, and Protein levels. The goal was to see which plants handled the pollution best and could be useful for cleaning up contaminated environments. By comparing results and looking at patterns, the study also explored how these plants could be used as indicators of environmental pollution. In a research carried out at illegal crude oil refining locations in the South of Nigeria, relatively large differences in heavy metal concentration levels were noted in soil and plants like African stargrass (*Cynodon plectostachyus*)

within the contaminated regions.(Kareem & Abdulla, 2023).

### MATERIALS AND METHODS

**[Study site:** In this study, two different locations were selected for research. The first site is a clean mountainous area in the Choman district, about 171 kilometers from the Lanaz oil refinery. It is located at a high altitude of 2,407 meters above sea level, with coordinates

36.7066° latitude and 44.8458° longitude. The second site is a polluted area inside the Lanaz oil refinery. This refinery is near the villages of Lajan and Tarjan, along the main Gwer road, about 22 kilometers southwest of Erbil city. Its coordinates are 36.0818° latitude and 43.4749° longitude, and it is situated at 347 meters above sea level. (**Figure 1**) shows the locations of both sites.



**Figure 1. The map of two studied sites. Control site (unpolluted site of Choman) and polluted site (Lanaz oil refinery).**

This research involved the examination of five specific plant species: *Melia azedarach*, *Punica granatum*, *Cupressus arizonica*, *Platanus orientalis* and *Platanus orientalis*. These plants were estimated to be between 4 and 6 years old. In July 2022, samples were gathered from both uncontaminated and polluted sites. From each plant, three samples of mature and healthy leaves were carefully cut using clean scissors, taken from different sides of a small lower branch near the apical bud. These samples were then placed in appropriately labeled plastic bags and subsequently transported to the laboratory for the analysis of various biochemical parameters. The spectrophotometric technique suggested by (Metzener, Rava, & Sender, 1965) was used to assess the levels of photosynthetic pigments, including chlorophyll a, chlorophyll b, and carotenoids. The overall chlorophyll concentration was derived from the combined measurements of

chlorophyll a and chlorophyll b. Total Nitrogen content was ascertained using the Kjeldahl method (Jones, 2018). To determine the total Protein content, the total Nitrogen value was multiplied by a factor of 6.25. The data was analyzed using SPSS (Version 17), and the results were presented as means with standard error. To compare pigment and total Protein levels between the unpolluted and contaminated sites for each plant species, an independent t-test was employed. For comparing the studied parameters across the different plant species, an Analysis of Variance (ANOVA) along with a Duncan post-hoc test was conducted. Pearson correlation was utilized to establish relationships between heavy metals, pigments, and total Protein. A significance level of  $P \leq 0.05$  was deemed statistically meaningful. (**Table 1**) shows the vicinity of the oil refineries which lie along the Erbil-Gwer road, this study suggests that there are marked

differences in the concentration of heavy metals in the in plant leaves of the area during specific seasons. The concentration of lead (Pb), zinc (Zn), copper (Cu), and cadmium

(Cd) in plant tissues during the wet season was shown to be much greater compared to that in the dry season.

**Table 1. Means ± SE of Fe, Cu, Mn, Ni , and Hg concentration in leaves of plants grown in the control and oil refinery sites in the**

Plants	Fe (mg/Kg)		Cu (mg/Kg)		Mn (mg/Kg)		Ni (mg/Kg)		Hg (mg/Kg)	
	Control	Polluted	Control	Polluted	Control	Polluted	Control	Polluted	Control	Polluted
<i>Melia azedaracc</i>	1464	1629**	8.04	77.49***	8.05	200.88***	7.56	18.94 *	0.015	0.015
<i>Punica granatum</i>	1220	1788**	3.92	20.89**	5.50	21.20**	1.70	17.10**	0.023	0.040*
<i>Cupressus arizonica</i>	2686	4067***	11.27	31.71**	60.96	83.66 *	7.23	18.9 *	0.044	0.046
<i>Platanus orientalis</i>	1800	5131***	12.71	41.72**	5.55	215.31**	1.66	17.6 **	0.015	0.017
<i>Morus alba</i>	2447	3136 *	5.18	21.95**	51.69	91.45**	4.48	17.05**	0.015	0.041*
<i>Callistemon viminalis</i>	1432	2775 **	2.03	47.03***	25.35	49.96 *	5.25	18.58**	0.015	0.044*
Mean	1841.5	3087.66	7.19	40.13	26.18	110.41	4.64	18.02	0.021	0.291
WHO, permissible limits in plants	Less than 300		1-20		Less than 70		1-5			

Means of three replicates ± standard error  
t-test significant at \*\* P ≤ 0.01, \*\*\* P ≤ 0.001

Manganese (Mn) and chromium (Cr) concentrations also fluctuated seasonally, though to a lesser extent. Its noted that results from both investigations revealed higher concentrations of heavy metals in were around the industrial sites, but the difference was in the order or concentration of certain metals. Such changes may be the result of local conditions, refinery activities, or the type of plant species that were used in the study. For example, the concentration of Lead (Pb) in leaves of plants was reported as 6.26 mg/kg during the dry season and 16.15 mg/kg for the wet one, alongside Erbil refineries, which is above the limit set by WHO which is 2mg/kg. As for the zinc (Zn) concentration in that study, it averaged 73.21 mg/kg and 32.69 mg/kg for the dry and wet seasons respectively. Both values are above WHO standards of 0.6 mg/kg. These findings corroborate our results as the increased concentration of metals in the leaves of the plants indicates Significant industrial emission-induced environmental pollution. The variation of seasons in the uptake of

the heavy metals, as stated in both studies, is affected by rainfall, atmospheric deposition, and runoff which alter the availability of the metals in soil in addition to the mobility(Kareem & Abdulla, 2023). This study discovered the presence of high concentrations of lead (Pb), nickel (Ni), copper (Cu), cadmium (Cd), and iron (Fe) in the leaves of the plants. Concentrations of Pb in stargrass leaves ranged between 6.57 and 6.62 mg/kg and Ni possessed values between 13.95 and 14.32 mg/kg. The relatively high accumulation of Ni suggests that the stargrass possesses significant potential for phytoabsorption and, in comparison to other metals, was least effective for phyto-stabilization (Alharthy et al., 2025). (Table 2) provides information about the mean concentrations (mg/Kg) of five different elements (Zn, As, Pb, Co, and Se) in the leaves of various plant species grown in both a controlled environment ( unpolluted site ) and oil refinery (polluted site), during the dry season. The table shows that, for most elements (Zn, As, Pb, Co, Se), the

concentrations in leaves of plants grown in polluted oil refinery site are significantly higher compared to those in the control site. This suggests a substantial impact of the oil refinery on the accumulation of these elements in plant leaves. The presence of asterisks (\*) suggests that the differences in mean concentrations are statistically significant. The WHO's permissible limits for these elements in plants are given for reference. These

limits help assess whether the concentrations are within safe levels. Indicating potential environmental contamination. These findings align with the results of a prior study, which observed a higher accumulation of heavy metals in leaves of Nerium and Phragmites plants at the polluted site in contrast to the non-polluted site. (Z. Salih & Aziz, 2019)

**Table 2. Means ± SE of Zn, As, Pb, Co, and Se concentration in leaves of plants grown in the control, and refinery sites in the dry season**

Plants	Zn (mg/Kg)		As (mg/Kg)		Pb (mg/Kg)		Co (mg/Kg)		Se (mg/Kg)	
	Control	Polluted	Control	Polluted	Control	Polluted	Control	Polluted	Control	Polluted
<i>Melia azedarach</i>	140.40	2520.27 ***	2.89	42.38 **	42.63	152.13 ***	1.57	5.72 *	0.12	0.22 *
<i>Punica granatum</i>	200.78	350.75 *	2.43	3.60 *	47.84	63.03 **	1.54	3.73 *	0.12	0.24 *
<i>Cupressus arizonica</i>	275.17	519.18 **	2.91	6.33 *	48.63	82.51 **	1.90	4.61 *	0.12	0.22 *
<i>Platanus orientalis</i>	211.82	605.46 **	2.31	6.04 *	49.63	71.57 **	1.72	4.87 *	0.12	0.22 *
<i>Morus alba</i>	308.89	435.88 **	2.90	4.55 *	43.19	70.14 **	1.99	4.26 **	0.12	0.29 *
<i>Callistemon viminalis</i>	169.89	559.25 **	2.25	4.44 *	42.75	75.88 **	1.38	3.95 *	0.12	0.29 *
Mean	217.82	8331.7	2.615	11.22	45.73	85.87	1.68	4.52	0.12	0.246
WHO, permissible limits in plants	Less than 300		3-10		5-10		Less than 10			

Means of three replicates ± standard error  
Significant at \*P ≤ 0.05, \*\* P ≤ 0.01, \*\*\* P ≤ 0.001

Table 2 provides information about the mean concentrations (mg/Kg) of five different elements (Zn, As, Pb, Co, and Se) in the leaves of various plant species grown in both a controlled environment (unpolluted site) and oil refinery (polluted site), during the dry season. The table shows that, for most elements (Zn, As, Pb, Co, Se), the concentrations in leaves of plants grown in polluted oil refinery site are significantly higher compared to those in the control site. This suggests a substantial impact of the oil refinery on the accumulation of these elements in plant leaves.

The presence of asterisks (\*) suggests that the differences in mean concentrations are statistically significant. The WHO's permissible limits for these elements in plants are given for reference. These limits help assess whether the concentrations are within safe levels. Indicating potential environmental contamination. These findings align with the results of a prior study, which observed a higher accumulation of heavy metals in leaves of Nerium and Phragmites plants at the polluted site in contrast to the non-polluted site. Salih and Aziz (24).

Table 3 reveals substantial variation in heavy metal retention among different plants species, as demonstrated with different alphabets to right of matrix (p <0.05). Iron (Fe) was highest in *Platanus orientalis* (5131mg/kg, a) mg/kg, a) and the lowest in *Punica granatum* (1622 mg/kg, e) most pronounced by Budovich (2021) which reported elevated Fe bioaccumulation in broadleaf species. Copper (Cu) was significantly higher in *Melia azedaracch* (77.49 mg/kg, a) as compared to *Morus alba* (11.95 mg/kg, e). This finding corroborated with Asiminicesei et al. (2024) where it was noted that Cu accumulation is associated with the soil composition and the region's cover vegetation. *Platanus orientalis* had the highest manganese (Mn) content (215.31 while the lowest was recorded on *Punica granatum* (21.2 mg/kg, d). These results

corroborate that of Aslam et al. (2024) who asserted that root exudates affect Mn bioavailability. Nickel (Ni) did not exhibit distinct results among the different species, akin to Al-Heety et al. (2021), that reported Ni had indiscriminate uptake by tree species from polluted sites. Aslam et al. (2024) classified *Melia Azedarach* as a Nach Zink hyperaccumulator and these results well supported that findings where zinc (Zn) accumulation was highest in *Melia Azedarach* (2520.27 mg/kg, a) and lowest in *Punica granatum* (350.75 mg/kg, e). *Melia Azedarach* exhibited similar pattern of arsenic (As), as high as 42.38 mg/kg77 far exceeding the levels exhibited by *Punica granatum*, which is 3.60 mg/kg. Aslam, Umar (5), AL-Heety, Hasan (2) Govindaraju, Ganeshkumar (9).

**Table 3. Comparison of heavy metals concentration (mg/kg) dry matter in leaves between different plants grown in lanaz refinery in dry season**

Plants	Fe	Cu	Mn	Ni	Zn	As	Pb	Co	Hg	Se
<i>Melia azedarach</i>	1629 e	77.49 a	200.88 a	18.94 a	2520.27 a	42.38 a	152.13 a	5.72 a	0.015 a	0.22 c
<i>Punica granatum</i>	1788 e	20.89 d	21.2 d	17.1 a	350.75 e	3.60 d	63.03 d	3.73 c	0.040 a	0.24 bc
<i>Cupressus arizonica</i>	4067 b	31.71 c	83.66 b	18.9 a	519.18 c	6.33 b	82.51 b	4.61 b	0.046 a	0.22 c
<i>Platanus orientalis</i>	5131 a	41.72 b	215.31 a	17.6 a	605.46 b	6.04 b	71.57 c	4.87 b	0.017 a	0.22 c
<i>Morus alba</i>	3136 c	11.95 e	91.45 b	17.05 a	435.88 d	4.55 c	70.14 c	4.26 b	0.041 a	0.29 a
<i>Callistemon viminalis</i>	2775 d	47.03 b	49.96 c	18.58 a	559.25 c	4.44 c	75.88 c	3.95 bc	0.044 a	0.29 a
<i>p-value</i>	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.05	0.001	0.001

Post-Hoc Duncan- test: no differences between groups with the same letter.  
Significant differences between groups with different letters

This study seems to have produced comparative results with the previously discussed study on *Tetraena qataranse* as it

showed increased levels of nickel (Ni) and copper (Cu) in the leaves of plants that were growing in contaminated soils.

**Table 4. Photosynthetic pigments, and carotenoids in leaves of plants grown in control area and oil refinery in dry season**

Plants	Chlorophyll a (mg/g)			Chlorophyll b (mg/g)			Total chlorophyll (mg/g)			Carotenoids (mg/g)		
	Control	Polluted	R%	Control	Polluted	R%	Control	Polluted	R%	Control	Polluted	R%
<i>Melia azedarach</i>	1.89	1.52*	19.6%	2.48	0.18**	92.7%	4.37	1.7***	61.1%	2.17	0.96***	55.8%
<i>Punica granatum</i>	1.36	0.95**	30.2%	1.52	0.80**	47.4%	2.88	1.75***	39.3%	1.47	0.71**	51.8%
<i>Cupressus arizonica</i>	0.75	0.69*	8%	0.83	0.67*	19.3%	1.58	1.36*	11.4%	0.73	0.58*	20.6%
<i>Platanus orientalis</i>	1.74	0.97*	44.3%	2.26	0.85***	62.4%	4.01	1.82***	54.7%	1.92	0.78*	59.4%
<i>Morus alba</i>	1.40	1.02*	27.2%	1.63	1.61*	1.30%	3.03	2.63**	13.3%	1.56	1.17*	25%
<i>Callistemon viminalis</i>	1.13	0.90*	20.4%	1.10	0.73***	33.7%	2.24	1.63***	27.2%	1.07	0.84*	21.5%
<b>Total</b>	<b>8.27</b>	<b>6.05</b>	<b>26.72%</b>	<b>9.82</b>	<b>4.84</b>	<b>50.71%</b>	<b>18.11</b>	<b>10.89</b>	<b>39.65%</b>	<b>8.92</b>	<b>5.04</b>	<b>43.49%</b>

Means of three replicates ± standard error      R% = reduction percentage  
Significant at \*P ≤ 0.05, \*\* P ≤ 0.01, \*\*\* P ≤ 0.001

The bioaccumulation of these metals reflects a plant's ability to endure and detoxify heavy metals and helps in mitigating contamination within the ecosystem. In particular, Ni concentrations in *T. qataranse* were found to be 9.6 times greater in the leaves than in the surrounding soil, which shows that the plants can concentrate some metals to a greater extent than their environment. The results of this study strengthen evidence that suggests that *Melia azedarach*, *Punica granatum*, *Cupressus arizonica*, *Platanus orientalis* and *Platanus orientalis* has developed the ability to endure high levels of a toxin by isolating the metal within their tissues. These finding strongly coincide with other research conducted and highlight the role of these plants in combating pollution, especially in industrialized regions. (Usman,

Al-Ghouti, & Abu-Dieyeh, 2019) (Table 4) presents the effects of pollution on chlorophyll a, chlorophyll b, total chlorophyll, and carotenoid content in six plant species, showing significant reductions across all pigments ( $p \leq 0.05$ ,  $p \leq 0.01$ ,  $p \leq 0.001$ ). *Melia azedarach* and *Platanus orientalis* exhibited the highest declines in chlorophyll b (92.7% and 62.4%) and total chlorophyll (61.1% and 54.7%), suggesting severe damage to chloroplast structures and photosynthetic efficiency. *Punica granatum* also showed substantial reductions, particularly in chlorophyll a and total chlorophyll indicating moderate photosynthetic inhibition. In contrast, *Cupressus arizonica* exhibited the least impact, with chlorophyll reductions between 8-11.4%, suggesting a higher ability to maintain pigment stability under pollution

stress. Carotenoids, essential for protecting photosynthetic systems from oxidative stress, were most affected in *Platanus orientalis* (59.4%) and *Melia azedarach* (55.8%), implying increased oxidative stress and potential damage to light-harvesting complexes. These results align with (Jorjani & Karakaş, 2024) who reported that pollution-induced stress significantly disrupts chlorophyll biosynthesis and accelerates pigment degradation, explaining the sharp chlorophyll declines in *Melia azedarach* and *Platanus orientalis* (Jorjani & Karakaş, 2024). Similarly, (Gao et al., 2022) found that pollution stress conditions lead to chlorophyll degradation and reduced photosynthesis, which supports the observed pigment losses in

*Punica granatum* and *Platanus orientalis* (Gao et al., 2022). Conversely, (Kareem & Abdulla, 2023) highlighted that *Cupressus arizonica* maintains relatively stable pigment levels under stress conditions, which matches the low chlorophyll loss (8-11.4%) observed in this study (Kareem & Abdulla, 2023). The findings suggest that species with greater carotenoid and chlorophyll retention, like *Cupressus arizonica*, are more tolerant to environmental stress, making them suitable for urban and industrial planting, while species with high pigment reductions, such as *Melia azedarach* and *Platanus orientalis*, may require additional protective strategies to sustain their photosynthetic capacity in polluted environments (Gao et al., 2022) (Panda, 2003).

**Table 5. Total Nitrogen and total Protein in leaves of plants grown in the control area, and polluted site in the oil refinery in the dry season**

Plants	Total Nitrogen %			Total Protein %		
	Control	Polluted	R%	Control	Polluted	R%
<i>Melia azedarach</i>	4.43	2.82**	36.19%	27.7	17.68**	36%
<i>Punica granatum</i>	1.84	1.38*	24.78%	11.5	8.65*	25%
<i>Cupressus arizonica</i>	2.01	1.34**	33.71%	12.59	8.34**	33.7%
<i>Platanus orientalis</i>	2.02	1.97*	22.5%	12.65	12.3*	41.8%
<i>Morus alba</i>	4.37	3.38**	22.65%	27.31	21.13**	23%
<i>Callistemon viminalis</i>	1.63	1.31*	19.6%	10.18	8.54*	16.2%
<b>Total</b>	<b>16.3</b>	<b>12.2</b>	<b>25.15%</b>	<b>101.93</b>	<b>76.64</b>	<b>24.81%</b>

Means of three replicates ± standard error    R% = reduction percentage  
Significant at \*P ≤ 0.05, \*\* P ≤ 0.01, \*\*\* P ≤ 0.001

Table 5 illustrates the percentage of total Nitrogen and total Protein in leaves of plants grown in both control area and polluted site in oil refinery during dry season. The R% values represent the reduction percentage of these components in polluted site compared to control area. For *Melia azedarach*, total Nitrogen content showed a significant reduction of approximately 36.19% in polluted site, while total Protein content decreased by about 36%. Similarly, *Punica granatum* exhibited reductions of approximately 24.78% in total Nitrogen and 25% in total Protein. *Cupressus arizonica* displayed reductions of approximately 33.71% in total Nitrogen and 33.7% in total Protein. *Platanus orientalis* showed a decrease of approximately 22.5% in total Nitrogen content and 41.8% in total Protein content in the polluted site. *Morus alba* exhibited reductions of approximately 22.65% in total Nitrogen and 23% in total Protein.

*Callistemon viminalis* demonstrated reductions of approximately 19.6% in total Nitrogen and 16.2% in total Protein. In total, the combined data across all plant species indicated a reduction of approximately 25.15% in total Nitrogen and 24.81% in total Protein content in the polluted site compared to the control area. These results highlight the significant impact of pollution from oil refinery on Nitrogen and Protein content in leaves of various plant species during dry season. The reductions observed indicate potential stress on plants due to the presence of pollutants. The statistical significance levels are denoted by asterisks: \* (P ≤ 0.05), \*\* (P ≤ 0.01), and \*\*\* (P ≤ 0.001), indicating the level of statistical significance.

Table 6 provides a comparison of total Nitrogen percentage and total Protein percentage in the leaves of plants grown in oil refinery. The table presents data for six

different plant species: *Melia azedaracch*, *Punica granatum*, *Cupressus arizonica*, *Platanus orientalis*, *Morus alba*, and

and total Protein content among the different plant species (p < 0.001). The Duncan post-hoc test was conducted to further analyze these

	Chlorophyll a	Chlorophyll b	Total chlorophyll	Carotenoids
Fe	-0.6**	0.5**	-0.6**	0.5**
Cu	-0.7 **	-0.7 **	-0.7 **	-0.65 **
Mn	-0.63 **	-0.62 **	-0.65**	-0.63 **
Ni	-0.52 **	-0.68 **	-0.6 **	-0.65 **
Zn	-0.86 **	0.78 **	-0.85**	0.7 **
As	-0.6 **	-0.6 **	-0.63 **	-0.58 *
Pb	-0.815 **	-0.76 **	-0.8 **	-0.69 **
Co	-0.6 **	-0.62 **	-0.63 **	-0.58 **
Correlation is significant at 0.05 levels			– negative correlation found	
			**Correlation is significant at 0.01 levels	

*Callistemon viminalis*. The results indicate significant differences in both total Nitrogen

differences.

**Table 6. Comparison of leaves total Nitrogen, and total Protein between plants grown in the oil refinery**

Plants that share the same letter (a, b, c, or d) do not have significant differences in either total Nitrogen or total Protein content. However, plants with different letters exhibit significant variations in these parameters. For example, *Morus alba* (3.38% total Nitrogen and 21.13% total Protein) shows the highest values and is labeled with the letter "a". On the other hand, *Punica granatum* (1.38% total Nitrogen and 8.65% total Protein) exhibits the lowest values and is labeled with the letter "d". These findings align with Asiminicesei, 2024 (51), who found that plants with higher Nitrogen retention, like *Morus alba*, exhibit greater resilience under environmental stress due to enhanced Nitrogen metabolism and

Protein synthesis mechanisms (Asiminicesei, Fertu, & Gavrilescu, 2024). Similarly, Aslam et al. (2024) emphasized that pollution disrupts Protein synthesis pathways, leading to lower Nitrogen and Protein levels in vulnerable species, which supports the observed reductions in *Punica granatum* and *Cupressus arizonica* (Aslam et al., 2024). Furthermore, Budovich (2021) highlighted that Nitrogen metabolism plays a crucial role in plant adaptation to pollution, reinforcing the idea that species with lower Nitrogen and Protein reductions, like *Morus alba*, possess adaptive advantages in stressed environments (Budovich, 2021)

**Table 7. presents a comparison of photosynthetic pigments (Chlorophyll a, Chlorophyll b, Total Chlorophyll) and carotenoid contents (measured in mg/g) in the leaves of different plant species in the oil refinery site during the dry season. The table shows significant differences in the concentrations of these pigments and carotenoids among the various plant species (p < 0.001). The Duncan post-hoc test was conducted to further analyze these differences**

Plants	Total Nitrogen %	Total Protein %
<i>Melia azedaracch</i>	2.82 b	17.68 b
<i>Punica granatum</i>	1.38 d	8.65 d
<i>Cupressus arizonica</i>	1.34 d	8.34 d
<i>Platanus orientalis</i>	1.97 c	12.3 c
<i>Morus alba</i>	3.38 a	21.13 a
<i>Callistemon viminalis</i>	1.31 d	8.54 d
<i>p-value</i>	0.001	0.001
Post-Hoc Duncan- test: no differences between groups with the same letter. Significant differences between groups with different letters		

Table 7 Comparison of photosynthetic pigments, and carotenoids contents in leaves between ant species in the oil refinery site in the dry season For example, *Morus alba* shows the highest concentrations of Chlorophyll a (1.02 mg/g), Chlorophyll b (1.61 mg/g), Total Chlorophyll (2.63 mg/g), and carotenoids (1.17 mg/g), and is labeled with the letter "a". On the other hand, *Cupressus arizonica* exhibits the lowest concentrations of

Chlorophyll a (0.69 mg/g) and Chlorophyll b (0.67 mg/g), resulting in the lowest Total Chlorophyll content (1.40 mg/g), and is labeled with the letter "f". these results are in agreement with the finding of the previous study , Exposure to heavy metal stress in the plant species *J. maritima* can result in reduced pigmentation and decreased photosynthetic efficiency, ultimately impacting the growth and lifespan of the plant (W. Kamal, 2017).

**Table 8. Pearson's correlation (r) between photosynthetic pigments, carotenoids, and heavy metals in leaves of studied plants in the dry season**

Plants	Chlorophyll a	Chlorophyll b	Total chlorophyll	Carotenoids
Fe	-0.6**	0.5**	-0.6**	0.5**
Cu	-0.7 **	-0.7 **	-0.7 **	-0.65 **
Mn	-0.63 **	-0.62 **	-0.65**	-0.63 **
Ni	-0.52 **	-0.68 **	-0.6 **	-0.65 **
Zn	-0.86 **	0.78 **	-0.85**	0.7 **
As	-0.6 **	-0.6 **	-0.63 **	-0.58 *
Pb	-0.815 **	-0.76 **	-0.8 **	-0.69 **
Co	-0.6 **	-0.62 **	-0.63 **	-0.58 **

Post-Hoc Duncan- test: no differences between groups with the same letter.  
Significant differences between groups with different letters

Table 8 displays Pearson's correlation coefficients (r) between photosynthetic pigments (Chlorophyll a, Chlorophyll b, Total Chlorophyll, Carotenoids) and heavy metals (Fe, Cu, Mn, N Zn, As, Pb, Co) in leaves of studied plants during dry season. These

correlations provide valuable insights into the relationships between photosynthetic pigments and heavy metal concentrations in leaves of the studied plants. They indicate potential impact of heavy metals exposure on photosynthetic processes of the plants

**Table 9. Correlation between plant leaves photosynthetic pigments, total Nitrogen, and total Protein in dry season**

	Total Nitrogen	Total Protein
Chlorophyll a	0.625	0.630
Chlorophyll b	0.365	0.363
Total Chlorophyll	0.793	0.795
Carotenoid	0.893	0.903

\*Correlation is significant at 0.05 levels  
\*\*Correlation is significant at 0.01 level

Table 9 presents correlation coefficients between plant leaves' photosynthetic pigments (Chlorophyll a, Chlorophyll b, Total Chlorophyll, Carotenoids) and their total Nitrogen and total Protein contents during the dry season. Chlorophyll a shows a significant positive correlation with total Nitrogen (0.625) and total Protein (0.630). Chlorophyll b exhibits a positive correlation with total Nitrogen (0.365) and total Protein (0.363), though it is at a lower level compared to Chlorophyll a. Total Chlorophyll demonstrates a higher positive correlation with total Nitrogen (0.793) and total Protein (0.795). Carotenoids display a strong positive correlation with both total Nitrogen (0.893)

and total Protein (0.903). These correlations indicate the interplay between photosynthetic pigments, total Nitrogen, and total Protein in the leaves of the studied plants during the dry season. They highlight the potential influence of Nitrogen and Protein content on the photosynthetic processes of these plants. The highest increase in total amino acids was observed in Mustard residues, reaching approximately 190 mg/L, with a notable concentration in essential amino acids such as Valine and Tryptophan. Additionally, Barley residues exhibited the highest overall increase, reaching around 180 mg/L, particularly in amino acids like Lysine and Phenylalanine, known for their elevated Protein content

(Jorjani & Karakaş, 2024; S. W. J. Kamal & Xavier, 2023).

### CONCLUSION

This research underscores substantial influence of oil refinery emissions on the physiological and biochemical characteristics of plant species. The heightened presence of heavy metals in plant tissues suggests these plants function as accumulators of environmental pollutants. The results highlight the potential of specific plant species for phytoremediation, as they absorb and amass heavy metals from the polluted surroundings. Understanding diverse plant species' distinct responses is critical for formulating effective phytoremediation strategies. Variability in reactions among different plant species underscores the necessity of considering species-specific traits when evaluating pollution impacts. Certain species might serve as superior bioindicators or phytoremediators based on their unique responses. Study doesn't delve into the prolonged effects of pollution on plant health and ecosystem dynamics. Subsequent research could explore plants' resilience and adaptation mechanisms following prolonged exposure to heavy metal pollution. In conclusion, the study provides valuable insights into the intricate interplay between industrial pollution and plant biology, emphasizing the need for sustainable practices to alleviate industrial activities' environmental impact.

### CONFLICT OF INTEREST

The authors declare that they have no conflicts of interest.

### DECLARATION OF FUND

The authors declare that they have not received a fund.

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## دراسة بعض أنواع النباتات كعلاجات نباتية لمعالجة انبعاثات العناصر الثقيلة من مصفاة نفطية

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### المستخلص

أجريت هذه الدراسة للتحقيق في القدرة النباتية لستة أنواع مختلفة من النباتات *Punica* ، *Melia azedaracch* ، *Platanus orientalis* ، *Cupressus arizonica* ، *granatum* و *Platanus orientalis* في مدينة أربيل على التخفيف من انبعاثات العناصر الثقيلة الناتجة عن مصفاة نפט. يتناول البحث قياس الصبغات الضوئية، وتركيزات العناصر الثقيلة (الحديد، النحاس، المنغنيز، النيكل، الزنك، الزرنيخ، الرصاص، الكوبالت، الزئبق والسيلينيوم) في أوراق النباتات، مع تسليط الضوء على استجابتها للتلوث. توضح الفروقات في مستويات العناصر بين المواقع الملوثة والمواقع المرجعية تأثير المصفاة، بينما تشير الانخفاضات في الصبغات الضوئية إلى آثار محتملة على حيوية النباتات. يتم استكشاف العلاقة المعقدة بين مستويات التلوث وفسولوجيا النبات، ما يوفر رؤى مهمة لاستراتيجيات الإدارة البيئية الفعالة. تُعدّ عناصر مثل الزرنيخ والكادميوم والرصاص والزئبق، الشائعة في الغذاء، من المخاطر الصحية الناجمة عن الأنشطة البشرية. وتؤكد الدراسة على أهمية النباتات كمؤشرات ومخفضات للملوثات، مشددة على إمكانيات المعالجة النباتية في التصدي للتحديات البيئية. وتساهم النتائج في تقديم معلومات قيمة لتطوير أساليب مستدامة لمكافحة التلوث، خصوصاً في البيئات الصناعية.

الكلمات المفتاحية: امتصاص الملوثات، النباتات المنقية، جودة الهواء، سمية المعادن، مؤشرات حيوية نباتية، تراكم حيوي.