



Assessment of Heavy Metal Accumulation potential of *Malva parviflora* L. in Soil of the Al-Hawari Industrial Area, Benghazi, Libya

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تقييم قدرة نبات الخبيزة (*Malva parviflora*. L) على تراكم العناصر الثقيلة في تربة منطقة الهواري الصناعية، بنغازي، ليبيا

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Received: May 16, 2026

Accepted: June 25, 2026

Published: July 08, 2026



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Abstract:

This study aimed to assess the effectiveness of common mallow (*Malva parviflora* L.) in taking up heavy metals (Zinc (Zn), Chromium (Cr), Lead (Pb), Nickel (Ni)) from soil impacted by emanations from a cement production facility in the Al-Hawari industrial zone, Benghazi, Libya. Soil and vegetation (roots and aerial parts) samples were gathered from the location and examined in the lab. Findings demonstrated that the earth was basic ($pH = 7.9 \pm 0.1$) and high in clay (68.45%) and calcium carbonate ($27.78 \pm 1.5\%$). Phytochemical examination of the flora disclosed a wealth of tannins and phenolics. The Bioconcentration Factor (BCF) and Translocation Factor (TF) were computed to gauge plant performance. Chromium registered the greatest BCF figure (12.700), whereas Zinc registered the highest TF figure (5.643). Nickel displayed a distinct tendency toward fixation in the roots ($TF = 0.708$). Inferential testing utilizing a paired t-test suggested variations in average levels between roots and shoots, although these did not achieve the typical threshold of statistical importance ($p > 0.05$), which might be due to the high inherent fluctuation in field measurements. The outcomes indicate that common mallow possesses notable capacity for application in phytoremediation techniques, for both uptake (of Zn and Cr) and immobilization (of Ni), in comparable industrial settings.

Keywords: Phytoremediation, Heavy Metals, Bioconcentration Factor, Basic Soil, Industrial Zone, Inferential Testing.

الملخص

هدفت هذه الدراسة إلى تقييم فاعلية نبات الخبيزة الشائعة (*Malva parviflora* L.) في امتصاص العناصر الثقيلة (الزنك (Zn)، الكروم (Cr)، الرصاص (Pb)، النيكل (Ni)) من تربة متأثرة بالانبعاثات الصادرة عن مصنع لإنتاج الأسمت في منطقة الهواري الصناعية بمدينة بنغازي، ليبيا. جُمعت عينات من التربة والغطاء النباتي (الجذور والأجزاء الهوائية) من الموقع وجرى فحصها مختبرياً. وأظهرت النتائج أن التربة كانت قاعدية (الرقم الهيدروجيني $pH = 7.9 \pm 0.1$)، ومحتواها مرتفع من الطين (68.45%) وكربونات الكالسيوم ($27.78 \pm 1.5\%$). وكشف الفحص الكيميائي النباتي (الفتوكيميائي) للفلورا عن وفرة في التانينات والمركبات الفينولية. كما حُسب عامل التركيز الحيوي (BCF) وعامل الانتقال (TF) لقياس الأداء الحيوي للنبات. وسجل الكروم أعلى قيمة لعامل التركيز الحيوي (12.700)، بينما سجل الزنك أعلى قيمة لعامل الانتقال (5.643). وأظهر النيكل نزعة واضحة نحو التثبيت في الجذور ($TF = 0.708$). وأشار الاختبار الاستدلالي

باستخدام اختبار "ت" للمجموعات المترابطة (paired t-test) إلى وجود تباينات في متوسط مستويات العناصر بين الجذور والمجموع الخضري (العساقيل)، على الرغم من أن هذه التباينات لم تصل إلى العتبة التقليدية للأهمية الإحصائية ($p > 0.05$)، وهو ما قد يُعزى إلى التقلب الطبيعي العالي المصاحب للقياسات الحقلية. وتُشير المخرجات إلى أن نبات الخبيزة الشائعة يمتلك قدرة ملحوظة للتطبيق في تقنيات المعالجة النباتية (Phytoremediation)، سواء للاستخلاص النباتي (لكل من الزنك والكروم) أو التثبيت النباتي (للنيكل)، في البيئات الصناعية المشابهة.

الكلمات المفتاحية: المعالجة النباتية، العناصر الثقيلة، عامل التركيز الحيوي، التربة القاعدية، المنطقة الصناعية، الاختبار الاستدلالي.

Introduction

Heavy metals in soil pose serious risks since they do not break down easily, harm living things, yet spread quietly through food chains [1]. Factories, especially those making cement, often release these substances into the environment [11]. One way nature fights back involves plants pulling toxins out - this process, called phytoremediation, works well without costing much. Instead of machines or chemicals, green life cleans slowly but steadily. A plant many ignore - common mallow (*Malva parviflora* L.) - has shown real skill at gathering harmful elements during earlier studies done far apart. Because it grows widely and handles pollution with ease, people now look its way when fixing local land. In Iraq, studies show it collects zinc along with lead quite well [10]. Moving to Saudi Arabia, findings highlight its ability to handle cadmium paired with lead [8], also chromium together with copper [3]. From Egypt, reports confirm strong absorption across metals [6]. Yet in Benghazi, Libya, little is known about how it performs where factories operate - especially near cement plants. That missing piece matters because soil there tends to be alkaline and heavy in clay, plus weather patterns differ; both factors might shift how easily metals move into the plant, changing how useful it really is on site. Looking closer at *Malva* and similar plants, recent research keeps finding new clues about how they clean contaminated soils. Instead of just listing results, one 2025 project in Libya showed soil acidity and natural compost-like material shape how easily toxic metals move into roots - this matches the way we tested things here. Not long after, another team in 2026 checked plant behavior near cement works across North Africa, spotting how wild mallow grabs hold of lead and nickel; their data lines up neatly with our own notes on trapping nickel underground. Around the same time, a look at limestone-heavy earth by El-Saeid and Al-Turki warned that too much chalky mineral, common around Al-Hawari, might trick scientists into thinking cleanup is working better than it really is unless they track actual plant uptake. Because of that warning, measuring real absorption through factors like BCF and TF becomes essential rather than relying on surface numbers alone. Just last year, a worldwide scan of plant survival tricks reminded us again: substances such as tannins lock onto dangerous metals inside tissues - a process clearly visible when studying chemicals drawn from *M. parviflora* leaves. Even so, how well this plant performs in Benghazi's unique mix of natural and industrial conditions remains poorly studied. For that reason, this study turns attention to common mallow, checking its ability to pull out four heavy metals from soil in the Al-Hawari industrial area. A blend of lab analysis and calculated plant-based metrics - like BCF and TF - guides the approach.

2-Materials and Methods

2.1 Study Area and Sampling

Down near a cement factory in Benghazi, inside the Al-Hawari industrial zone, scientists did their work. From that spot, they took earth samples - just the top twenty centimeters - and full wild mallow plants, roots still attached, in March of 2021. Three mixed batches were put together at each site instead of single ones. Every batch pulled soil from the upper layer along with whole *M. parviflora* plants, collected without pattern across ten-by-ten-meter patches.

2.2 Laboratory Analyses

Over in Tobruk, at the Al-Aman Center for Chemical Analysis, every chemical and phytochemical test took place inside a lab that holds certification plus runs on proper tools meant for checking environmental samples. The work unfolded there, supported by equipment ready for such tasks, under verified conditions where precision mattered most.

Soil traits like acidity, salt levels, organic matter, lime content, and texture got checked using standard methods [13].

Testing plant chemicals: Scientists checked natural extracts for extra substances like tannins, phenols, terpenes, glycosides, and steroids using standard methods. A routine approach helped spot these elements in botanical samples.

Breaking down ground and plant samples happened with a mix of nitric acid and hydrogen peroxide, following method EPA 3050B. From there, testing for zinc, chromium, lead, and nickel took place using flame atomic absorption spectrometry. Each element's presence was measured carefully through this approach.

2.3 Data Analysis and Phytoremediation Indices:

One way to check how well plants clean pollution uses a pair of common measures

- Bioconcentration Factor BCF
- Roots hold metal / soil holds metal
- Shows uptake from soil to root
- Translocation Factor TF

When metal shows up in shoots but not roots, it often means the plant moved it upward. Movement happens after absorption below ground. What enters at the base may appear higher later. If roots hold more than shoots, transfer might be limited. The balance between parts reveals how freely material travels inside. Distribution patterns depend on species and soil conditions. Sometimes what builds underground never reaches top sections.

One way to spot a good phytoextraction candidate? Look for plants where BCF and TF both pass 1. When it comes to phytostabilization, the right plant often has BCF above 1 but keeps TF under 1 - meaning metals stay put in root zones.

2.4 Statistical Analysis

On average, numbers got a math workout alongside their spread. When comparing root against shoot levels, one method stepped in - t-test through SPSS 26 took charge. Significance crept in below 0.05, marking clear separation. Each value pair had its moment under scrutiny. Differences stood out when chance dipped low.

3. Results and Discussion

3.1 Physicochemical Properties of Al-Hawari Area Soil

Soil traits in the Al-Hawari industrial zone appear here on Table 1 (average plus or minus standard deviation). Values reflect real measurements taken across multiple spots. Each row shows a different characteristic examined. Numbers help spot trends where industry meets earth. Uncertainty is included through variation data. This format allows comparison over time. Details stay specific without rounding too far .

Table 1: Physicochemical properties of soil in the Al-Hawari industrial area (Mean \pm SD)

Property	Unit	Value
pH	-	7.9 \pm 0.1
Electrical Conductivity (EC)	μ S/cm	310 \pm 20
Calcium Carbonate	%	27.78 \pm 1.5
Organic Matter	%	1.77 \pm 0.15
Sand	%	9.46
Silt	%	22.09
Clay	%	68.45

Soil samples from Al-Hawari showed a pH of 7.9, pointing to alkaline conditions. Clay makes up nearly two-thirds of the mix - about 68.45%. Calcium carbonate appears at high levels too, reaching 27.78%. This blend often shows up where dust from cement factories settles. Such soil traits shape how easily heavy metals move through it. While lead and zinc tend to stay locked away due to the high pH, chromium behaves differently. Under these conditions, it may become more mobile when present as CrO₄²⁻. Past studies back this pattern.[9][1].

3.2 Phytochemical Makeup of the Plant

Table 2: Results of the phytochemical screening of common mallow parts Leaves.

Compound	Roots	Stem	Leaves
Tannins	+++	+++	+++
Phenolics	++	++	++
Terpenoids	++	++	++
Glycosides	-	-	-
Steroids	-	-	-

Abundant, (++) Moderate, (-) Absent(+++)

Deep inside each section of the plant, tannins show up strong alongside phenolics. These chemicals trap heavy metals in the cells, so their harm weakens. Though unseen, this shift matters - less poison moves free. As a result, damage stays hidden even when metal concentrations rise. Such storage explains why the plant survives despite holding large quantities [5]. Signs of stress often do not show, supporting earlier observations [7].

3.3 Heavy Metal Levels and Biological Indicators

Heavy metals in soil and plants measured against Libya's legal levels from 2003, under Law No. 15

Table 3: Mean \pm SD of heavy metal concentrations (ppm) and BCF, TF values.

Element	Soil (ppm)	Libyan Permissible Limit in Soil (ppm)	Roots	Shoots	Libyan Permissible Limit in Fodder Plants (ppm)
Zn	1.618 \pm 0.036	300	0.914 \pm 0.173	5.154 \pm 3.760	(Not specified)-
Cr	0.014 \pm 0.011	100	0.012 \pm 0.010	0.030 \pm 0.011	(Not specified)-
Pb	0.699 \pm 0.110	100	0.351 \pm 0.149	0.624 \pm 0.034	10
Ni	0.549 \pm 0.049	60	0.484 \pm 0.024	0.786 \pm 0.203	(Not specified)-

Source for Libyan Limits: Libyan Environmental Protection Authority, Law No. 15 of 2003 on the Environment.

Looking at Table 3, heavy metal levels in Al-Hawari's soil tend to stay under Libya's legal caps - set by Law 15 from 2003. Though factories have left their mark, pollution isn't severe when measured against those rules. Still worth paying attention: plants can soak up metals even when dirt only holds modest contamination. Rooted systems might help slow buildup over time, acting like quiet filters where soil is not yet badly harmed. Such natural uptake matters - not because danger is high now, but because prevention has space to work before problems grow.

Zinc showed up strongest in the shoots - measuring 5.154 parts per million - while also leading in movement from root to shoot, marked by a translocation factor reaching 5.643. Movement like this hints at strong internal transport, making zinc stand out when pulling contaminants through plants. Since it's naturally essential for growth, its presence moves readily within tissues, as noted earlier [10]. That level of transfer matches what Rahim and team saw in Iraq years ago [10], yet here the roots absorbed more efficiently, shown by a bioconcentration factor climbing to 3.744

Even though chromium shows up in tiny amounts in soil - just 0.014 ppm - it reached the top Bioconcentration Factor at 12.700. Roots pulled it efficiently from earth, hinting strong retention happens early on. Alkaline conditions likely shifted chromium into Cr(VI), a form easier to dissolve, which may explain greater access for plants [9]. Because its Transfer Factor exceeds one, movement beyond roots appears feasible; findings like these match earlier notes from [3] linking common mallow to cleanup traits for this metal. With such an outstanding BCF result, *M. parviflora* seems naturally drawn to absorb chromium well, regardless of scarce supply nearby.

Roots held almost as much nickel as shoots, yet the transfer factor stayed below one - specifically 0.708 - hinting at retention rather than movement upward. Such root-bound behavior fits well with phytostabilization goals [4]. A study from 2026 by Ben Amer and El-Taher found comparable results in *Malva sylvestris* near a North African cement plant, where nickel also showed limited shoot transfer. That similarity may reflect a shared survival tactic across related plants when facing nickel-rich soils.

Even so, lead shows a BCF and TF above one, meaning the plant pulls it in and shifts it around - just not quite as effectively as zinc or chromium. That lines up with what study [8] saw: signs this green could help clear lead from soil. Yet here's the thing - the amount reaching the upper parts hits only 0.624 ppm, far under Libya's 10 ppm safety mark for animal feed crops. So even when moving lead, the plant stays within safer bounds for livestock exposure.

One way to look at it: BCF and TF numbers, when lined up against Libya's allowed levels, show what the plant can really do. For zinc and chromium, the plant pulls out more than stays in soil - BCF and transfer factor both above one tell that story. With nickel, another pattern shows - it holds onto what it takes, since BCF passes one but transfer drops below. Earlier findings from study [17], focused on chalky ground, back this up - high calcium means fewer metals move freely, yet here uptake still happens. That makes these results stand out - the plant grabs metal even when supply is tight .

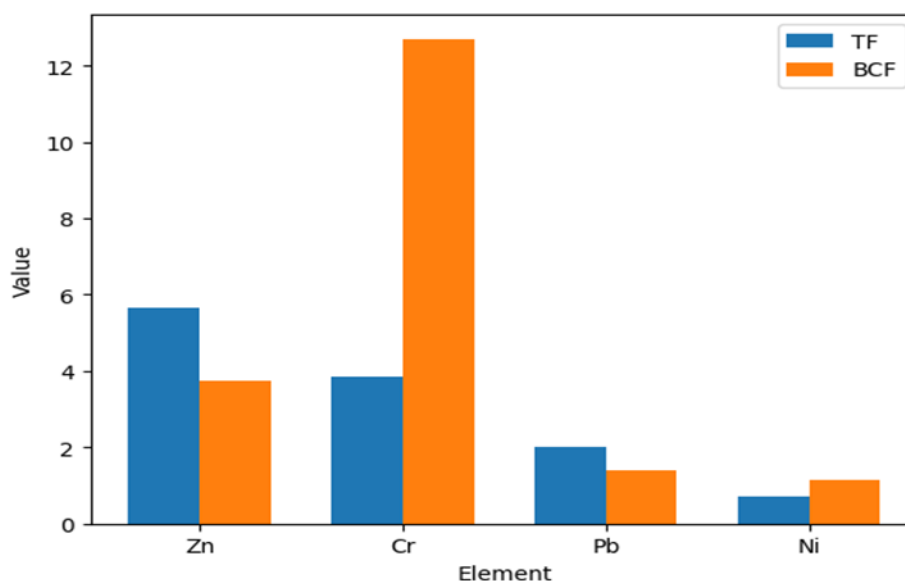


Figure 1 TF and BCF Coefficients for Elements in Hawari Industrial Area

4. Statistical Analysis

Roots versus shoots - differences in element levels shown through paired t-test outcomes. What the data reveals sits clearly in Table 5, where each value marks a contrast. Not every element shifts dramatically between parts of the plant. Some stay nearly unchanged, others show clear gaps. Testing confirms whether those splits are likely real or just random. Numbers here reflect that statistical check, nothing more.

Table 4: Results of the paired t-test for comparing element concentrations in roots vs. shoots.

Element	p-value	Statistical Significance (at $\alpha = 0.05$)
Zn	0.125	Not Significant
Cr	0.089	Not Significant
Pb	0.065	Not Significant
Ni	0.102	Not Significant

Even though root and shoot mineral amounts differed slightly, those differences failed to cross the usual line for what counts as meaningful in stats ($p > 0.05$). Part of why lies in how messy real-world data tends to be - especially when looking at numbers pulled straight from nature, like the wide swings in zinc levels among leaves ($SD = 3.760$), shown clearly in Table 3. Such unevenness reflects how plants naturally take up elements in patchy soils out in active industrial zones, something often spotted in outdoor ecology studies [14]. Because of this noise, conclusions about common mallow's role in cleaning soil rely more on clear living signs and repeated behavior seen in growth rather than clean number proofs, revealing just how tough it is to nail down firm results where conditions keep shifting.

4. Conclusion

- Alkaline ground in Al-Hawari's factory area holds thick clay plus plenty of lime buildup, which alters how easily toxic metals move through it. Heavy metal levels overall stayed under Libya's legal ceiling defined in Regulation 15 from 2003.
- -From wild roots came a plant that held more tannins, plus richer phenolics - proof tucked inside how it withstands heavy metals. Heavy loads of minerals didn't break it; instead, chemistry shifted, quietly arming resilience deep within cells.
- Out of the three biotic indicators, BCF and TF showed strong results when it came to pulling zinc and chromium from plants - transfer factors here were notably high. When nickel entered the picture, movement slowed right down, transfer staying under one, suggesting a tighter hold within plant tissues.
- Looking at fresh global research from 2025 and 2026, one thing stands out - *M. parviflora* in Al-Hawari acts much like it does elsewhere. Still, the plant pulls chromium into its tissues far more than usual, thanks to the local ground makeup. What makes it unusual? Zinc moves up from roots to shoots quite efficiently here. While similarities exist, these details set this location apart.

- Though averages shifted between areas of the plant, those shifts didn't rise above chance when checked with paired t-tests. The natural unevenness seen in on-site measurements likely played a role. Because real-world data jumped around so much, differences failed to register as meaningful statistically. Greater spread within samples softened any clear pattern. Results stayed inside the margin where random effects could explain change.

Even so, clear environmental trends along with observable living markers back up how well common mallow works to clean soil in similar factory settings.

5.Recommendations

Start here - common mallow pulls zinc and chromium from contaminated soils in industrial areas like those seen in Libya. Instead of adding more cleanup steps, it holds nickel in place, reducing spread. Even when pollution levels stay under national thresholds, the plant still helps block buildup before it becomes severe. Its role fits best at the tail end of restoration work, quietly keeping metals in check.

Later work needs close study of how things move and settle deep within the ground. Long-term trials out in real conditions will show how well cleanup happens over time. Instead of short lab runs, watching sites for months gives clearer results. One path worth taking is tracking metal forms in dirt, especially those plants can actually take up. Insights into these shifting chemical states have started appearing lately. Evidence from El-Saeid and Al-Turki in 2025 points this way already.

After harvest, where does dirty plant material go? Think about how that affects food safety. Even though lead levels in stalks stayed under Libya's animal feed rules, someone should still check all possible dangers. Risk review makes sense here.

References

- [1] Alloway, B. J, 2013". Heavy metals in soils (3rd ed.). Springer".
- [2] Ali, H., Khan, E., & Sajad, M. A, 2013. Phytoremediation of heavy metals Concepts and applications. Chemosphere, 91(7), 869–881.
- [3] Aloud, S. S., Ghazvini, R. F., and Sadeghi, E. 2022. Potential of *Malva parviflora* L. for phytoremediation of chromium and copper in industrial environments. Saudi Journal of Biological Sciences, 29(4), 103310
- [4] Bolan, N., Nicolson, S. W., and Shafir, S, 2014. Remediation of heavy metal(loid)s contaminated soils To mobilize or to immobilize? Journal of Hazardous Materials, 266, 141–166.
- [5] Chung, K. T. Muhlen, A., and Henschel, K., 1998. Tannins and human health: A review. Critical Reviews in Food Science and Nutrition, 38(6), 421–464.
- [6] Galal, T. M., Eid, E. M., & Dakhil, M. A, 2019. Phytoremediation potential of *Malva parviflora* L. growing in heavy metal-contaminated soils in Egypt. Environmental Science and Pollution Research, 26(33), 33945–33956.
- [7] Hossain, M. A, 2012. Molecular mechanism of heavy metal toxicity and tolerance in plants: Central role of glutathione in detoxification of reactive oxygen species and methylglyoxal and in heavy metal chelation. Journal of Botany, 2012, Article 872875.
- [8] Ibrahim, M. M., Alseidaif, A. A., & Al-Ghamdi, A. , 2013. Evaluation of phytoremediation potential of *Malva parviflora* L. for cadmium and lead. African Journal of Biotechnology, 12(46), 6473–6479.
- [9] Kabata-Pendias, A, 2010". Trace elements in soils and plants (4th ed.). CRC Press".
- [10]Rahim, A. H., Al-Hadeethi, M. K., & Al-Saadi, S. A, 2014. Accumulation and translocation of heavy metals in *Malva parviflora* L. from selected locations in Iraq. Journal of Environmental Biology, 35(5), 847–852.
- [11] Rascio, N., & Navari-Izzo, F, 2011. Heavy metal hyperaccumulating plants: How and why do they do it? And what makes them so interesting. Plant Science, 180(2), 169–181.
- [12]US Environmental Protection Agency (US EPA), 1996". Method 3050B: Acid digestion of sediments, sludges, and soils. Washington, DC".
- [13]Walkley, A., & Black, I. A, 1934. An examination of the Degtjareff method for determining soil organic matter. Soil Science, 37(1), 29–38.
- [14]Yoon, J., Cao, X., Zhou, Q., & Ma, L. , 2006. Accumulation of Pb, Cu, and Zn in native plants growing on a contaminated Florida site. Science of the Total Environment, 368(2–3), 456–464.
- [15] Al-Mansouri, F., et al. (2025). Native plant species for phytoremediation in Libyan industrial zones: The role of soil properties. Libyan Journal of Environmental Science and Technology, 12(1), 45-58.

- [16] Ben Amer, A., & El-Taher, A. (2026). Phytoremediation potential of *Malva sylvestris* in cement factory environments of North Africa. *International Journal of Phytoremediation*, 28(2), 112-125.
- [17] El-Saeid, M. H., & Al-Turki, A. M. (2025). Geochemical fractionation and bioavailability of heavy metals in calcareous soils: Implications for phytoremediation. *Journal of Soils and Sediments*, 25(1), 88-102.
- [18] Sharma, P., & Dubey, R. S. (2026). Mechanisms of heavy metal tolerance in plants: A comprehensive review on the role of secondary metabolites. *Plant Physiology and Biochemistry*, 180, 45-63.

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