The Libyan Conference on Chemistry and Its Applications (LCCA 2021)
(15 – 16 December, 2021)

Phytoremediation potential of *Malva parviflora* for some heavy metals in roadside soil in Benghazi, Libya

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ARTICLE INFO

Article history:
Received 15 April 2021
Accepted 30 April 2021
Available online 26 June 2022

Keywords:
phytoremediation, Malva parviflora, heavy metal, plant uptake, phytostabilization

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ABSTRACT

The extraction of Pb, Zn, and Ni from soil using *Malva parviflora* plant has been tested. The amount of heavy metals in soil, the part of the plant has been determined using atomic absorption spectroscopy. Biological absorption coefficient (BAC), bioconcentration factor (BCF), and translocation factor (TF) have been calculated for each element in order to understand the mechanism of extraction in the studied plant. *Malva parviflora* has the potential for phytoremediation of soils contaminated by heavy metal.

Introduction

There are many resources for heavy metals in the soil, but most of them are not harmful at a certain level , and exceeding this level they may be toxic and find their way to the human food chain leading to health effects. The main target of soil phytoremediation is to make the soil clean using plants to absorb the contaminants and bring their concentration to a less harmful level.

Phytoremediation includes several mechanisms depending on the plant-soil interaction. For heavy metal contaminated soils, the most common are phytoextraction and phytostabilization. The absorption of pollutants from the soil by the plant is called phytoextraction. After accumulation of metal ions in the roots, stems, leaves, and then plants can be removed or burnt, and the metals can be stored or recovered.(Bader , Alsharif, Nassib, Alshelmani, & Alalem, 2019)

Phytoremediation has gained increasing attention as a clean, cheap, and effective method. Many plant species can accumulate heavy metals from the soil for phytoremediation purpose. (Bader et al, 2019; Bobtana, Elabbar, Bader, 2019; Bouhadi et al., 2021)

All the phytoremediation types require many plant characteristics to get optimum performance. The selection of the plant depends on pollutant nature and concentration, plant-pollutant interaction, root depth, soil structure, and climate. The selected plant should be able to grow fast and accumulate the pollutant without being affected (Babu et al. 2021).

Many studies have been performed on local plants growing in different places in Libya. The obtained results were promised in order to use those plants in soil phytoremediation and therefore to reduce the risk caused by heavy metals.(Bader et al, 2019 ; Bader et al , 2020; Bobtana et al., 2019 ; Saadawi, Algadi, Ammar, Mohamed, & Alennabi, 2015)

Experimental

All chemicals used in the study were in analytical grade. The soil and plant sampling were performed during winter (December 2016) because the region herbs often complete their life cycle during winter.

Plant collection

The *Malva parviflora* were selected and collected from the roadside area near Al-Hawari cement factory during the winter season. The selection was based on its availability, plant condition, and avoiding the hard environmental and soil conditions such as shortage of water and high temperature. The heavy elements during the industrial activities accumulate in the air and clouds and when rain falls, the soil becomes contaminated. Soil samples were also collected from the roots surrounding each plant (0-20 cm depth). After sieving through 2 mm mesh, soil samples were air-dried at room temperature for three weeks and sieved through 2 mm mesh.

The *Malva parviflora* plants were sampled and transported immediately to the laboratory. Washed and cleaned shoot and root parts were separated and dried at room temperature for three weeks, subsequently, the dried matters were grounded and sieved to get the plant ready for the extraction step.

Three replicates were used to estimate the concentration of metals in soil and plant samples. Each tissue was digested in nitric acid according to EPA method 3050. The metals concentrations have been determined by an

8600 series flame atomic absorption spectrometer, from Shimadzu in the Ras Lanuf Company.

Results and discussion

The obtained results of the amount of metals in the soil and the plant are illustrated in figure 1. The concentration of Zn was higher than Pb and Ni.

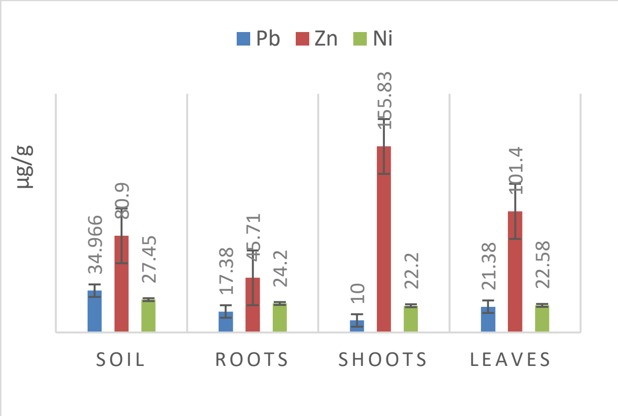

Fig 1 The amount of metals in soil and different parts of *Malva parviflora* (µg/g) with standard error bars.

In the studied heavy metal ions, Zn is more mobile and available for plant uptake. The mobility of metal ions in soil mainly depends on the pH of soil and the presence of chelating agents. Many other factors such as root size, external metal concentrations, temperature, metal interaction, the addition of nutrients, and salinity also seem to play a minor role to influence the metal ion's mobility in soil. In some cases, the solubility of metal ions in water is very low, and they have a strong affinity toward soil particles and many other organic contaminants present in the soil (Bader et al, 2019 ; Bader et al , 2020 ;Bobtana et al , 2019 ; Saadawi et al, 2015**;** Sveta, Lakhveer, Zularisam , Muhammad, Samson, Mohd , 2016)
The accumulation of heavy metals in the plants correlates with the total concentration of metals in soil, soil properties, soil content, and soil acidity. There are certain levels of metal accumulation before the metal concentration affects the plant and it's bioaccumulation capacity (Hamadouche, Aoumeur, Djediai, Slimani, Aoues , 2012). Hyperaccumulators are characterized by a translocation factor (TF) (Shoot/root metal concentration ratio) higher than 1. TF>1 means that the heavy metals are actively transported into the green parts of the plant (Tangahu et al , 2011). Although it can be useful for the early detection of plants that can be potentially useful as a phytoremediation tool, it is not the single measure of hyperaccumulation (Van der Ent, Baker, Reeves, Pollard, Schat,2013 ; Padmavathiamma ,& Li,2007).

Biological absorption coefficient (BAC), bioconcentration factor (BCF), and translocation factor (TF)
BAC has been calculated on the basis of the ratio of heavy metals content in the plant and soils using the following formula: $BAC = C_{Plant} / C_{Soil}$
where C = Metal concentration (Cui , Zhou , & Chao ,2007).

According to the biological absorption coefficient (BAC) range, the plants can be classified into four levels, 1.0–10 is high accumulator plant, 0.1–1.0 is moderate accumulator plant, between 0.01–0.1 known as low accumulator plant, and BAC<0.01 is not accumulator plant (Aziz et al ,2015). According to this classification and the obtained results, *Malva parviflora* can be classified as a high accumulator for Zn and a moderate accumulator for the metals in the following order Ni>Pb (Bader et al ,2019).

The translocation factor is the ratio of metal concentration in the shoot to the root. If the translocation factors are ≥ 1 it means that the plant is hyperacumulator plant and can perform phytoextraction (Yang et al , 2015) and this is the case of Zn. In the case of Ni and Pb, the values are slightly lower than 1.
The calculated values of bioaccumulation factor, bioconcentration factor, and translocation factor for the studied metals are listed in Table 1.

Table 1: BAC, BCF, and TF for the metals in *Malva parviflora*

Metal	*BAC*	*BCF*	*TF*
Pb	0.46	0.50	0.90
Zn	1.25	0.57	2.81
Ni	0.84	0.88	0.92

The bioconcentration factor is the metal concentration ratio of plant roots to soil. Plants with a high BAC value (BAC>1) are suitable for phytoextraction, while plants with a high bioconcentration factor, BCF (BCF>1), and low translocation factor, (TF<1) are more suitable for phytostabilisation (Bader et al ,2019; Cheraghi , Lorestani , Khorasani , Yousefi , & Karami ,2011; Mwegoha & Renman ,2012).

The relatively high values of TF>1 in the case of Zn, means that *Malva parviflora* can take up metal ions in the roots and be accumulated in the shoots. It can be used in phytoextraction (Rodriguez et al , 2012). From the obtained results *Malva parviflora* is more suitable for phytoextraction than phytostabilisation. Although the value of TF is less than 1 in the case of Pb and Ni it was very close to 1.

Conclusions

It can be concluded that *Malva parviflora* might be a promising phytoremediation (phytoextraction or phytostabilization) species because of its characteristics in terms of survival, growth, reproduction and easy handling. It has a good capacity to stabilize and accumulate metals in its tissues. *Malva parviflora* is a good extractor that tend to phytoextraction process.

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