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Evaluation of *Piptatherum miliaceum* Plant Performance for Contaminated Soil Phytoremediation

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ABSTRACT

Piptatherum miliaceum is a popular local plant growing in a wide area of Libya. Absorption of Piptatherum miliaceum for lead and chromium ion has been studied. The amount of lead and chromium has been determined in soil, roots and the green part of Piptatherummiliaceum using flame atomic absorption spectroscopy (FAAS) in order to detect the path of the metals through the plant parts. Piptatherum miliaceum accumulate chromium in the root according to phytostabilization mechanism.

Introduction

Environmental pollution in soil and groundwater caused by Chromium especially Cr(VI) has become a matter of concern. Soil contamination by Cr is of great concern because from soil it can find the way to animal and human food China.[Ramana et al., 2012].

Chromium (Cr) is a metal widely distributed in the environment and it is essential to plants. It exists in nature under various oxidation states, with valences from 2−up to 6+.

The most common in the environment are the morestable and less toxic 3+ andthe unstable and more toxic 6+ valence. [Pilon-Smits, 2005].
Beside the natural resources of Cr there is a huge amounts are coming from the industrial activities [Castilhos et al., 2001].High levels of oxygen in soil can convert Cr^{3+} to Cr^{6+}.

Chromium has a great effect on plant growth by reducing the biochemical processes efficiency including uptake and transport of mineral nutrients [Barbosa et al., 2007; Santana, et al., 2012).

Lead has a cumulative toxicity and harmful influences on animals and human health. Presence of traces of Pb (II) in environmental samples can lead to environmental pollution and many fatal diseases including dysfunction of renal blood and neurological systems. [Bader, et al., 2018].

Phytoremediation can be classified in many categories but the most common are phtoextraction and phytostabilization. Phytoextraction is a technique that concentrates contaminants in the harvestable parts of plants and, phytostabilization is a complexation technique that diminish contaminant mobility and bioavailability in soils and thereby limiting their movement [Nwaichi and Dhankher, 2016]

In the present study, we have tested the performance of Smilograss in phytoremediation of soils contaminated with Cr and Pb

Experimental

***Piptatherum miliaceum samples*:**
Piptatherum miliaceum samples have been collected with the soil surrounding the roots from an open area in the campus of University of Benghazi in Benghazi city. Three samples of the plants have been collected in a radius of about five meters. The location was close to the vehicles road.

The soil samples have been collected in plastic bags and then, dried at room temperature, ground, and sieved using a 1mm mesh sieve.

The plant samples were washed by distilled water, and then dried at room temperature to a constant weight. Dried plant samples were ground using a grinder and sieved through 1mm mesh sieve.

Determination of heavy metals concentration:

After extraction, the total concentration of heavy metals in soil and plant samples has been determined by flame atomic absorption spectroscopy (FAAS) to evaluate Cr and Pb in soil, roots, and shoots. A 1.00 – 2.00 gram homogenous representative sample was obtained and placed in conical beakers and extracted by concentrated nitric acid and 30% hydrogen peroxide as described by The EPA protocol for the acid digestion of the soil and plant samples [Bader et al., 2019]. The samples were then filtered to remove any particulates which might interfere with FAAS analysis. The filtrates were collected in 100 ml volumetric flask and were diluted with deionized water to the final volume. Three replicate for each sample have been prepared. Three replicates of each sample of soil, roots, and leaves for each plant have been prepared and stored in cool place until the time of measurements. All calculations, statistics, and figures have been performed using excel spread sheets.

The metals concentration have determined using Shimadzu (Japan) AA-6800 flame atomic absorption spectrometer in Ras Lanuf Oil Company. The flame conditions were adjusted according the recommendation of the manufacturer. R^2 for Pb was 0.9988 at 283.3nm and 0.9999 for Cr at 357.9nm.

Safety measures were taken during the extraction and no harmful wastes have been delivered to the environment. Transportation protocols have been followed during the transportation of the prepared samples to Ras Lanuf Oil Company in Ras Lanuf city.

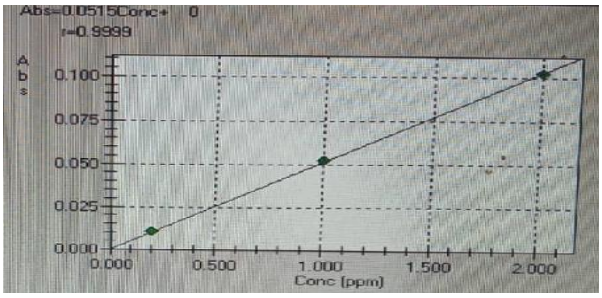

Figure 1: Calibration curve for chromium using Shmadzu AA-6800 FAAS.

Results and discussion

As shown in figure 2, the highest metal content is in soil followed by root and finally no Cr has been detected in the leaves of Piptatherum miliaceum. The obtained results are in agreement with many previous studies.

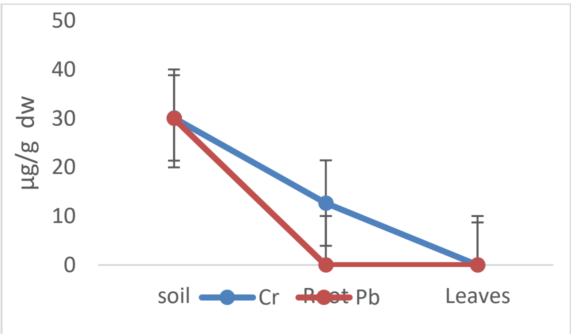

Figure 2. Concentration of the metals in soil and the parts of *Piptatherum miliaceum* (µg/g dry weight) with standard error bars.

The roots are the first part of the plant to utilize nutrient uptake therefore they will accumulate more metals than other parts at least before the translocation process.

The nutrient absorption system of the plant is depending on the soil's element capacity and its solubility in the soil solution. After their movement in soil, elements are held by the roots. The elements first attach to the cell wall, then they reach to the cell through the plasma membrane and being transported to the parts. Ions are taken by the canal proteins and/or carrier proteins [Dokmeci & Adiloglu, 2020].

Figure 2 illustrates the concentration of the elements in a spiked soil. In this case, 2 grams of lead acetate dissolved in a liter of distilled water was added to the soil, and the plant was picked after a month. The figure shows a clear increase of lead in the soil, but it seems that a month is not enough for lead to transfer to the roots of the plant and thus to the green part, or perhaps the presence of lead in the form of acetate prevented its absorption.

The amount of chromium that was absorbed by the plant was, on average of about 40% of the amount of chromium in the soil.

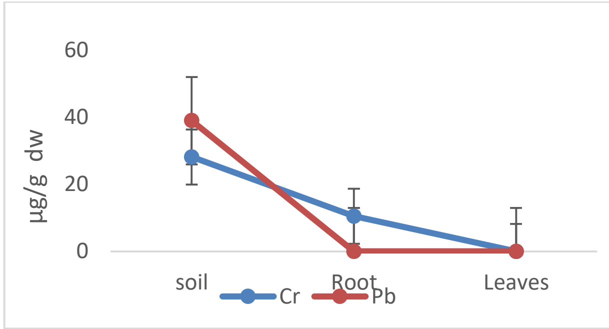

Figure 3. Concentration of the metals in soil spiked by lead acetate and the parts of *Piptatherum miliaceum* (µg/g dry weight) with standard error bars.

Lead was not detected in the plant in both cases even when the concentration in soil was higher this is may be due to the short growth time before the plant was collected or may be the concentration is below the detection limit of instrument. The available form of the metal in soil is also responsible on the metal absorption by the plant.

It has also been reported that soil pH has a significant effect on bioavailability of metals and plant uptake increases as soil pH decreases [Elabbar et al. 2019].

Bioconcentration Factor (BCF):

Bioconcentration factor is the metal concentration ratio of plant roots to soil. Plants with a high biological absorption coefficient value (BAC = the ratio of heavy metals content in the plant and soils) (BAC>1) are suitable for phytoextraction, while plants with a high Bioconcentration Factor, BCF (BCF>1) and low Translocation Factor, Translocation factor is the ratio of metal concentration in the shoot to the root, (TF<1) are more suitable for phytostabilisation [Bader et al., 2019].

The calculated values of BCF for Pb and Cr were 0.00 and 0.42 respectively. The zero value for Pb because no Pb has been absorbed yet in the roots. In both case there was metal found in the leaves which means zero value for translocation factor. According to these findings we can consider the *Piptatherum miliaceum* as phytostabilzer for chromium. Even in case of the soil spiked with Pb the concentration was higher in soil and no Pb has been detected in the plant, this could be attributed to the presence of acetate which act as a buffer or a strong ligand prevent the absorption of the metals.

When Cr^{3+} is present in solution, OH-containing complexes tend to be formed, leading to a change in pH and formation of hydroxides and oxides of insoluble Cr, and then inhibition of ions transport will occur. The toxicity of Cr^{3+} appears as a consequence of its indirect effects on plant metabolism.Cr^{6+} is a stronger oxidant, causing severe damage to all types of cellular membranes [Mei et al., 2002; Santana et al. 2012]

Translocation of toxic chromium ions from the roots to the shoots is usually prevented by the plant in order to protect the green part from the effect of Cr on the photosynthesis and other metabolic activities [Malaviya and Singh, 2011].

In their studies (Paiva et al., 2009). Found that higher concentrations of Cr are found in the roots of most plants than in the aerial parts because of the roots are able to reduce Cr(VI) to Cr(III) which accumulates in the roots and is poorly translocated to the above-ground plant parts

There are many factors affecting the availability of C such as solution pH, redox potential, organic content, and structure of microbial community. In an environment with low oxidation-reduction potential, the most stable form of Cr is Cr(III). Cr(VI) is readily reduced to Cr(III) under acidic conditions and a high proportion of organic matter (Sinha et al., 2018), but the reduction of Cr(VI) to Cr(III) is incomplete therefore further translocation of many Cr(VI) ions to the aerial parts will be occurred [Malaviya and Singh, 2011].

At lower concentrations, the absorption of Cr(VI) can be limited by the available carriers and also hindered by the presence of essential ions such as sulfate [Cervantes et al., 2001].

Faraj et al. (2021) reported that the translocation of Cr increase if the concentration of Cr if the root is increased. This indicates that the translocation of Cr from roots to shoots is effective at concentrations at higher concentrations.

The translocation rate of metal to the shoots may depend on the concentration of the metal in the roots.

For Chromium ion removing from soil *Piptatherum miliaceum* plant should be harvested from the roots.

Conclusions

Piptatherum miliaceum is a good phytostabilizer for chromium in soil. The period life of *Piptatherum miliaceum* therefore it recommended to wait for a period of time in order to give chance for more absorption. *Piptatherum miliaceum* should be used for phytoremediation of low level Cr toxicity in the soils.

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