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Phytoremediation performance of *Piptatherummiliaceum (smilograss)*for Ni and Pb ions in roadside soil in Benghazi, Libya

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ABSTRACT

There is an increased concentrations of heavy metals in the roadside soils due the human activities. Soil and plant samples from the roadside areas in Benghazi city were collected and analysed using Flame atomic absorption spectrophotometry for their heavy metal contents. The total metal content of Ni and Pb has been determined in soil surrounded the plant roots, plant roots, and Leaves. In order to evaluate the performance of *Piptatherummiliaceum* to extract the metals from soil, different factors such as Biological Absorption Coefficient (BAC), Bioconcentration Factor (BCF), and Translocation factor (TF) have been calculated. The results showed that *Piptatherummiliaceum*is more suitable for phytostabilisation than phytoextraction. Phytoremediation as a green technology has many advantages over the other methods of heavy metals removal from soils.

1. Introduction

There is an increased release of anthropogenic inorganic and organic pollutants into the surroundings in the last decades. The heavy metal contaminants can find their way to the food chain of human and livestock [1]. The roadside soils normally contain high amounts of non-degradable and accumulated heavy metals coming from vehicle exhaust and wear of vehicle parts

Essential metals can be toxic to the living organisms if present in high concentration levels. According to many studies they can be harmful to the roadside vegetation, wildlife, and the human [2-5].

Soil phytoremediation technique is well known for cleaning contaminated soil. It has an increasing attention as a cheaper, clean, and effective technology. It based on the ability of many plant species to accumulate heavy metals from soil [6].
It has the advantage over many other physical and chemical methods of being inexpensive and not affecting the physical, chemical and biological structure of soils [7].

There are several possible mechanisms of phytoremediation, such as phytofiltration, phytoextraction, phytodegradation, phytostabilization, and phytovolatization [8,9].
The accumulation of pollutants from soil by the plant is calledphytoextraction. After absorption of metal ions in the roots, stems, leaves, and then plants can be removed and the metals can be recovered by many ways.
The accumulated amount of heavy metals in the plants correlates with the total levels of metals in soil, soil properties, soil content, and soil physical properties.

There are certain levels for accumulated metal ion before the metal concentration affect the plant and it is bioaccumulation capacity [10].

Hyperaccumulators are characterized by a translocation factor (TF) (shoot/root metal concentration ratio) higher than 1, which means that the heavy metals are actively transported into green the parts of the plant [11]. TF can be useful to know if the plant can be useful as phytoremediation tool [12,13].

Halophytes are plants that can tolerate high levels of salts, they can tolerate also high levels of heavy metals, and therefore, they can be used for protection and remediation of areas affected by high levels of chemical content by very effective methods.

Piptatherummiliaceum(L.) Coss, common name smilo grass, is a perennial native winter-active growing species. It produces palatable forage and it is grazed by livestock in natural environments and not considered a harmful pest for farmland and produces sturdy, erect stems that can reach 1.5 m tall. Its attractiveness relies on its ability to face summer drought and to grow on marginal soils, as slopes, roadsides, rocky soils; it is also resistant to soils containing heavy metals [14].

Smilo grass can be cultivated very easily and quickly in disturbed areas such as quarries, burnt areas, dry or very wet areas near roads and in ditches. Moreover, the species had showed a potential to be used as multipurpose species such as biomass energy production, environmental restoration [15,16] due to its capacity to survive the severe conditions for long time[17-19].

The use of halophytes as phytoremdiation tool in Libya is still under investigation [20-22].

The aim of this study was to assess the metal accumulation ability of *Piptatherummiliaceum* (smilograss) growing in roadside soils at the coastal area of Benghazi city in Libya and to know its ability to accumulate metals in its parts against the soil metal concentration at the sampling point

2. Experimental

2.1. *Piptatherummiliaceum*samples

*Piptatherummiliaceum*samples have been collected from roadside places with the soil surrounding the roots at high traffic area in Benghazi city.

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 transferred to the laboratory, 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.

2.2. Soil Analyses

pH is measured in 1:1 (soil: water) suspension was estimated by Mckeague procedure described in by Wayne et al [12] using 3150 Jenway pH meter. The electrical conductivity and total dissolved solids in 1:1 (soil: water) suspension were measured as described in USDA Handbook 60 by InLap73 conductivity meter[20].

Potassium and sodium have been measured in 1: 1 (soil: water) extract using PFP7- JENWAY flamephotometer[20].

2.3. 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 Pb, and Ni in soil, roots, and shoots. All chemicals used in the study were in analytical grade.

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 [23]. 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. The metals concentration have determined using A Novaa350 atomic absorption spectrometer.

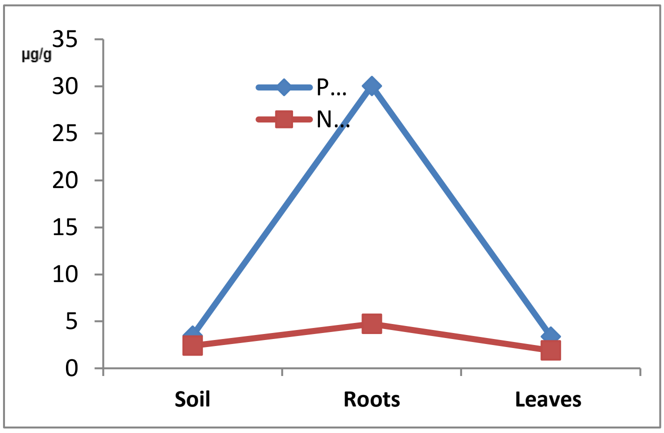
3. Results and discussion

Table 1 shows the analysis results for some soil quality parameters

Table 1. Soil analyses parameters

pH	6.36
EC mS/cm	326
TDS, ppm	165
Na, ppm	27.50
K, ppm	24.12

The results obtained from FAAS analysis for Pb and Ni in soil, roots, and shoots are shown in figure 1. The metal content was in the following order Pb> Ni.



(Figure 1). Concentration of the metals in soil and the parts of *Piptatherummiliaceum*(µg/g).

As shown in figure 1, the highest metal content is at the roots followed by soil and finally the leaves of *Piptatherummiliaceum*. This is in agreement with many previous studies where the metal content was accumulate more in the root than the shoots and leaves because the roots were the first part of the plant to utilize nutrient uptake and the available metal content. [24].

The metals in soil were at the same level, but the accumulation of Pd in the roots was much higher than Ni and then at the same level in leaves.
Although the variation in the reported values of the phytotoxic limits of the elements in soil and plants due to many factors like type of soil, type plant and the chemical composition, the concentrations of Pb and Ni were less the phytotoxic limits (Pb>100 mg kg^{-1} and Ni >12 mg kg^{-1}) [25,26]

There are many factors affecting the mobility of metal ion from soil to the plant such as pH, presence of chelating agents root size, external metal concentrations, temperature, metal interaction, addition of nutrients, and soil salinity.

Some metals have very low solubility in water and they tend interact with soil particles and many other organic contaminants present in soil [27,28].

Ni is a plant essential element, but excessive accumulation of this nutrient in plant may cause toxicity and can modify many physiological and biochemical processes also may interfere the uptake of other essential elements [25,26]

Roots are the first part of the plant come into contact with the metal ions. The permanent contact between root surfaces and nutrient solution in soil can results in an increase in metal contents in the roots.

Table 2. The calculated values of BAC, BCF, and TF

Metal	***BAC***	***BCF***	***TF***
Ni	0.79	1.96	0.40
Pb	0.97	8.59	0.11

This high Pb concentration in roots may be due to the precipitation of the metal on the roots surface.
It also binds to ion exchangeable sites on the cell wall, with further extracellular precipitation as Pb carbonates in addition to the strong ability to bind with carboxyl groups of galacturonic and glucuronic acids in the cell wall, which limits the further transport of Pb. Therefore there was no significant shoot accumulation observed until Pb reaches saturation levels in the roots and the translocation from root to shoot greatly limited [28]

The rate of metal translocation to the shoot expected through diffusion, mass flow and metal concentration in the root [29].

3.1 Performance evaluation

Accumulation of the bioavailable fraction of metals into plant roots is depend on the nature of the roots, soil composition, and soil pH. Plants are able to change the solubility and speciation of metals in the rhizosphere using different strategies including, chelators releasing and changing the pH of the rhizosphere [29].

The performance of *Piptatherummiliaceum*can be evaluated from calculated Biological Absorption Coefficient (BAC), Translocation Factor (TF), and Bioconcentration Factor (BCF).

Biological Absorption Coefficient (BAC)

BAC is the ratio of heavy metals content in the plant and soils [20,21] using the following formula:

$$BAC = C_{Plant} / C_{Soil}$$

C = Metal concentration

According to biological absorption coefficient (BAC) range the plants can be classified to 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 non accumulator plant [30]. According to this classification *Piptatherummiliaceum*is moderate accumulator plant for the metals in following order Pb> Ni.

Translocation Factor (TF):

Translocation factor is the ratio of metal concentration in the shoot to the root. If the value of translocation factors is ≥ 1 it means that the plant is hyperacumulator plants and is able to perform phytoextraction [31].

Bioconcentration Factor (BCF)

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 [32-34].

All the calculated values for the studied metals are listed in table 2.

From the obtained results*Piptatherummiliaceum* is more suitable for phytostabilisation than phytoextraction.

Translocation factor less than 1.0, means that, translocation Piptatherummiliaceum will run more slowly and the metal not yet reached in stems or in leaves if it has more lifetime.[35]
In highly polluted areas, phytostabilization is more suitable for soil remediation, which give possibility to cultivate crops suitable for livestock feeding due to the stabilization of the metal in roots which is the case of Piptatherummiliaceum [36]

4. Conclusions

It has been concluded that Piptatherummiliaceum is moderate accumulator plant for the metals in following order Pb> Ni. Piptatherummiliaceum is more suitable for phytostabilisation than phytoextraction. It can be effectively used as bioindicator for soil contamination monitoring.

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