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Evaluation of *Halocnemum Strobilaceum* and *Hammada Scoparia* Plants Performance for Contaminated Soil Phytoremediation

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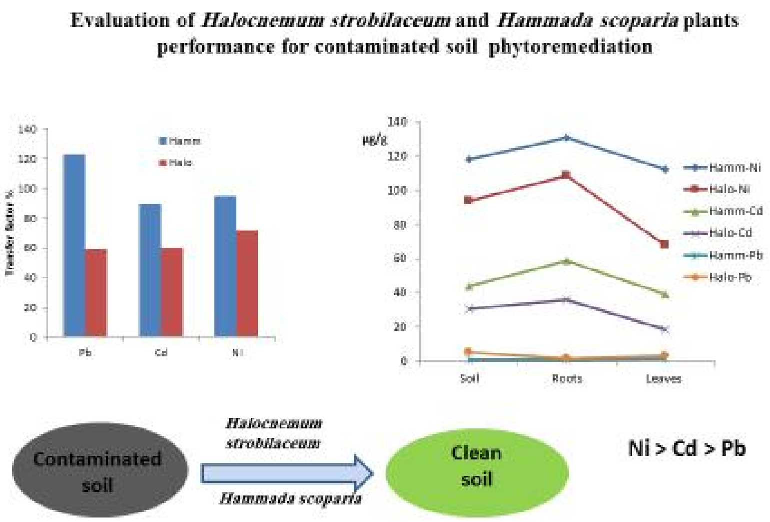
ABSTRACT

The potential of *Hammada scoparia* (*Hamm.*) and *Halocnemum Strobilaceum* (*Halo.*) growing in Benghazi-Libya for soil phytoremediation purpose has been evaluated.
Hammada scoparia (*Hamm.*), *Halocnemum Strobilaceum* (*Halo.*) and their roots' soil samples were collected and analyzed for Cd, Ni and Pb concentrations in a salty area in the north coastal region of Benghazi, near Benghazi asphalt factory, Benghazi steel factory, Brega oil company sorage tanks, and north Benghazi power station.
The biological absorption coefficient (BAC), bioconcentration factor (BCF), and translocation factor (TF) of *Hammada scoparia* and *Halocnemum Strobilaceum* have been calculated. Both plants are moderate extractors which incline to phytoextraction process except Halo which tends strongly to phytostabiliztion process in case of Cu and Fe.

GRAPHICAL ABSTRACT



1. Introduction

Environmental contamination by heavy metals has become a worldwide concern because of its health impacts. Studies have shown that heavy metals are toxic to crops and animals and find their way to the humans when the crops are produced in a contaminated soils.[1, 2]

Metals like Cd, Pb and Ni are toxic and may pose a great danger to plants, animals, and humans through the food chain. Heavy metals can enter the ecosystem through natural geological process or through anthropogenic processes like industrial and municipal wastes.[3]

The use of plant species for cleaning contaminated soils is known as phytoremediation. It has gained increasing attention as a cheaper, clean, and effective technology. Numerous plants species have been studied and tested to know their ability to accumulate heavy metals from soil for phytoremediation purpose, also the metal uptake mechanisms and practical applications have been suggested.[4]

There are approximately 500 plant species which have been considered as hyperaccumulators of trace metals, they can accumulate high concentrations of heavy metals in their tissues.[5]

Halocnemum strobilaceum and *Hammada scoparia* and their ability to remediate heavy metal which contaminates soils in different places in the world have been studied.[6-8]

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2. Results and Discussion

In the following are the results of the physical tests of the collected soil samples surrounded to the roots of the studied plants (**Table 1**).

Table 1. Parameters of plants soil

Soil Parameter / Plant	*Hamm.*	*Halo.*
pH	9.15	8.51
Conductivity (ms/ cm)	0.74	1.63
TDS (g/l)	3.60	7.27

The results obtained from FAAS analysis for Pd, Cd, and Ni in soil, roots, and shoots are shown in figure 1. The metal concentration in all samples was in following order Ni > Cd > Pb. The concentration of all metals in *Halo.* was higher than in *Hamm*

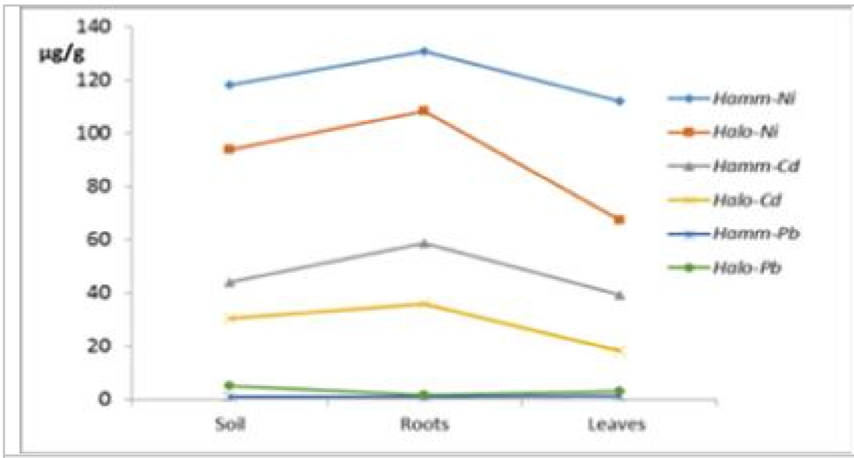

Fig. 1. Metal concentration (µg/g) in soil, roots, and leaves

There are many forms of the metal existing in the soil, from the available to unavailable. All these metal forms of metal in the soil are known as total metal concentration. The metal concentrations in the plants are depended on the available total metal forms and its concentrations in the soils and soil conditions.[9] Only small number of plants that grow on metal contaminated soil can accumulate large amounts of heavy metals in their roots and shoots.[4]

The ability of *Halo.* and *Hamm.* to accumulate Pb, Cd, and Ni in shoots and roots was compared.The activity of oil industries located in the studied area may led to produce and release various metals dust such as Ni, Pb and Cd and many other metals in the environment. In the following discussion, many calculations have been made in order to have a complete picture about the general mechanism of the rule of the plants to remediate the soil. The higher metal concentration in *Hamm.* can be related to the higher TDS in the soil compared with *Halo.* case. The Biological Absorption Coefficient (BAC), Bioconcentration Factor (BCF) and Translocation Factor (TF) values help to evaluate the metal accumulation efficiency in plants and to identify the suitability of plants for phytoextraction and phytostabilization.[4]

The process of phytoextraction generally requires the translocation of heavy metals to the easily usable parts, such as leaves. By comparing BAC and TF, we can estimate the ability of different species for the metals, from soil and their translocation to the aerial parts.[10,11]

BAC has been calculated on the base of the ratio of heavy metals content (*C*) in the plant and soils[12,13]

$$BAC = \frac{C_{plant}}{C_{soil}}$$

There are four categories for biological absorption coefficient (BAC) which are; BAC range of 1.0-10 known as high accumulator plant, 0.1-1.0 as the moderate accumulator plant, between 0.01-0.1 known as low accumulator plant and BAC < 0.01 as non accumulator plant.[14]

In case of the green part of the plants, the BAC value in all cases was in the range of 0.1-1.0 which is the moderate accumulator except the case of Pb accumulation in *Hamm.* which was in the low level of high accumulator.

BCF of Pb in roots was in the range of low and moderate accumulation, but for Ni and Cd was high. Enrichment factor of Pb was minimum, because the activity of Pb is low, which means that Pb is not easy to transfer from soil to the roots. Soil electrolytes concentration or conductivity plays an important role in the process of heavy metal transfer.[1, 15]

Translocation factor (TF) can be used as one of the description aspects of a hyperaccumulator plant that reveal metal concentrating and translocation capacity in the shoot parts. TF was calculated as the ratio of metal concentration in the shoot to the root.[16]

Previous researchers[17, 18] mentioned that heavy metals present in polluted agricultural soils will be directly taken up by plants and eventually accumulate in the green plant parts and tissues.[3]

Table 2 shows the translocation factor for the studied metals in both plants in addition to BAC, and BCF values. The higher translocation factor was in case of Pb and the lowest was for Cd with *Halo.*plant.

TF > 1, means that these plants have the capability to take up Pb in their roots and to be accumulated in their shoots. They can be used in phytoextraction.[19, 8]

Table 2. BAC, BCF, and TF for the metals in the plants

	BAC		BCF		TF	
Metal \ Plant	*Hamm.*	*Halo.*	*Hamm.*	*Halo.*	*Hamm.*	*Halo.*
Pb	1.23	0.59	0.91	0.34	1.35	1.71
Cd	0.89	0.60	1.34	1.17	0.67	0.51
Ni	0.95	0.72	1.11	1.15	0.86	0.62

The soil factors such as total metal concentration and pH are able to change soil heavy metal concentrations and indirectly effect metals concentrations in the plant [20]. It has been reported that soil pH has a significant effect on bioavailability of metals and plant uptake increases as soil pH decreases .[21]

In addition to soil factors, plant factors and components are thought to influence on the bioavailability of metals for uptaking and accumulation in the plants.[22]

The soil to plant transfer percent order was Pb>Ni> Cd for *Hamm*. and Ni> Cd > Pb for *Halo.*. In general the percent in case of *Hamm* was higher than *Halo.*, this is may be due the lower soil pH in case of *Hamm* although the higher TDS value in case of *Halo*. (**Fig. 2**).

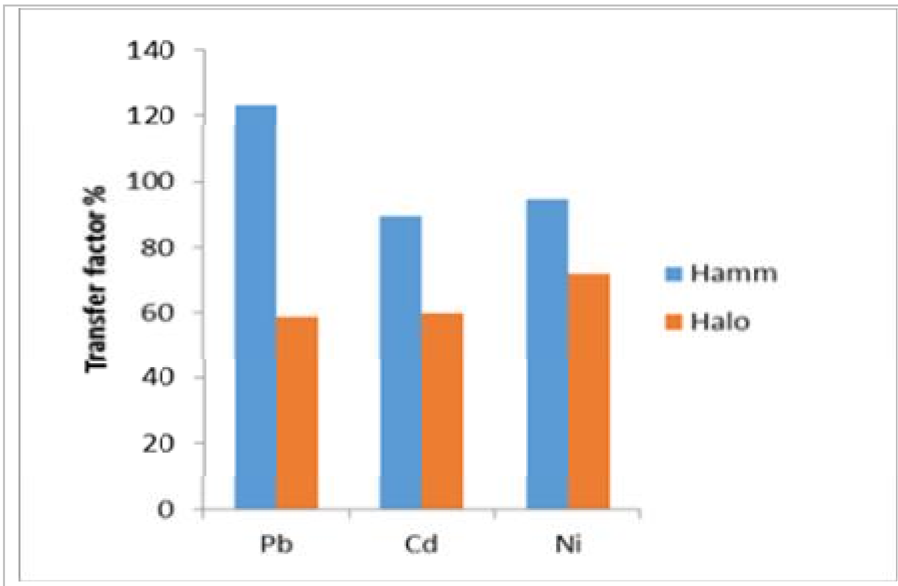

Fig. 2. Transfer factor percent

3. Conclusions

In sum, it can be concluded that *Halo.* and *Hamm.* might be promising phytoremediation (phytoextraction or phytostabilization) species because they are superior in terms of survival, growth and reproduction and, also, their capacity to stabilize and accumulate metals in their tissues. *Hammada scoparia* (*Hamm.*) and *Halocnemum Strobilaceum* (*Halo.*) are moderate extractors which tend to phytoextraction process except *Halo* which tends strongly to phytostabiliztion process in case of Cu and Fe.

4. Experimental or Martials and Methods

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 and 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 air-dried in room temperature for three weeks. Soil pH has been measured using JENWAY 3150 pH meter, and the conductivity using Seven Go CONDUCTIVITY Conductivity meter.

The herbaceous plants, *Halocnemum strobilaceum* (*Halo.*) and *Hammada scoparia* (*Hamm.*) 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 to get plant extraction ready.
Three replicates were used to estimate metals concentration of soil and plant samples of each tissue were acid digestion according to EPA method 3050. The metals concentrations have been determined using M Series flame atomic absorption spectrometer, from THERMO Electron Corporation in the central laboratory of Omar El-Mokhtar University.

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