Halophytes for Phytoremediation: A Promising Approach for Re-Vegetating Saline and Polluted Areas

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ABSTRACT

Halophytes could be explicitly used for cleaning metal contaminated soils provided that suitable species are selected. Members belonging to families Amaranthaceae, Aizoaceae, Euphorbiaceae, Fabaceae and Portulacaceae are known metal hyperaccumulators. However, plant species with shoot metal content higher than the standard permissible limits may also help in depollution process. Plants naturally located on the coasts of Karachi (*Aeluropus lagopoides, Halopyrum mucronatum* and *Heliotropium bacciferum*) not only help in desalination but also supplement removal of multiple elements from contaminated saline soils. Screening on halophytes suggest that metal uptake among halophytes is both habitat and species related. Salt secretors and includers accumulate higher concentration of shoot metals (such as Fe, Mn, Zn, Pb and Cr) which may be harvested from time to time for soil cleaning. Phytoremediation via halophytes is an eco-friendly approach for re-vegetating polluted and saline wastelands. Moreover, some species could be grown as food and fodder for animals besides being used as bio-fuel crops. Hence, growing halophytes on marginal lands would serve dual purpose i.e., suitable alternative crops and cost-effective tool for improving soil that may play a large role in contributing green economy.

Keywords: *Aeluropus lagopoides*, Crops, Halophytes, *Halopyrum mucronatum*, Metal pollution.

INTRODUCTION

Halophytes naturally grow on saline-sodic soils and have known potential of removing salts for their ability to sequester toxic ions from the soil (e.g., Na^+ and Cl^-). These plants of the wild are found on a variety of habitats such as dunes, marshes, salt flats etc. Recent advances suggest that some of the halophytes can also be used for phytoremediation of soils polluted with trace metals (Manousaki and Kalogerakis, 2011). When grown on saline wastelands using saline resources (brackish water and saline soils) halophytes can absorb trace metals via root system. They are well known hyperaccumulators of NaCl and other salts though the term 'hyperaccumulation' for trace metals may not deem fit for them as used for metallophytes (plants naturally growing on metallic soils) as obligate hyperaccumulators have metal concentrations between 300 – 10,000 mg kg^{-1} (Table **1**; Van der Ent *et al*., 2013). Nevertheless, shoot metal concentrations above permissible limits (Ashraf *et al*., 2019) may render 'phytoremediation' ability of halophytes for trace metals. These plants may be used for recovering contaminated soils besides ensuring food security hence do not pose threat for competition with existing food crops on arable lands. Therefore, they are rendered as ethical and sustainable species for both phytoremediation and production of fodder and fuel. In a broader context, they could be used for remediation of abandoned lands which are declared unsuitable for agricultural purposes. Many halophytes such as *Halopyrum mucronatum*, *Panicum antidotale*, *Phragmites karka* and mangroves are known to be potential resources for fodder, biofuel and as sand binder species along with metal phytoextraction. Since studies on local flora are scant, current research was done on screening of halophytes for soil remediation that would increase our knowledge for their sustainable utilization.

OBJECTIVES

The main objectives of the study were: 1) to check shoot metal concentrations (mg kg^{-1} or ppm) among local halophytes for phytoremediation potential 2) compare with other halophytes to find 'hyperaccumulation' ability.

METHODOLOGY

Different species of halophytes along with soil samples from rooting zones were collected from permanent plots framed near polluted coasts of Karachi (Sandspit, Korangi and Clifton/Do-Dariya). After cleaning, fresh samples were weighed and oven dried, powdered in a grinding mill and finally acid digested according to Otte *et al*. (1993). Soil organic matter (ash weight subtracted from dry weight) and pH were measured. Analysis of metals (Fe, Mn, Zn, Pb, Cu and Cr) was done by flame Atomic Absorption Spectrometry. Results for shoot metal accumulation were compared with standard permissible limits (Table **1**) for phytoremediation potential and hyperaccumulation (if any).

Metal Type	Adequate levels in dried shoot/ leaves	Permissible limit (toxic level) for phytoremediation	Hyperaccumulator level
Iron (Fe)	60 – 600[A]	600 [A]	2500 [C]
Manganese (Mn)	50 [A]	50 [B]	2000 – 10,000 [C]
Zinc (Zn)	20 [A]	60 [B]	10,000 [C]
Copper (Cu)	5 – 25 [A]	40 [B]	300 [C]
Chromium (Cr)	0.2 – 5 [A]	> 5 [B]	300 [C]
Lead (Pb)	Up to 0.3 [A]	> 0.3 [B]	100 [C]

[A] Reeves and Baker (2000); [B] Ashraf *et al*., (2019) [C] Van der Ent *et al*., (2013)

CONCLUSION AND RESULTS

Detailed soil analysis of coastal marshes and dunes suggest that Korangi creek was most polluted site with higher organic matter and metal concentrations. Under field conditions, *Aeluropus lagopoides* from marshy areas showed best potential for phytoremediation of five metals (Fe, Mn, Zn, Pb and Cr) and *Halopyrum mucronatum* for four metals (Fe, Zn, Pb and Cr) from sand dunes. *Cressa cretica* showed bio-indication of Fe, Pb and Zn and *Heliotropium bacciferum* for Fe, Pb and Mn though they were not 'hyperaccumulators'. None of the species accumulated Cu above permissible ranges (as mentioned in Table **1**) while most of the halophytes (*Atriplex stocksii, Arthrocnemum macrostachyum, Avicennia marina, Ipomea pes-caprae, Suaeda fruticosa and Salsola imbricata*) showed phytoremediation potential for one or two metals only. However, in some lab grown (ex-situ) plants hyperaccumulation of trace metals has been observed e.g., ~ 1500 Cr in *Suaeda fruticosa*, > 3400 Pb in *Sesuvium portulacastrum*, and > 800 mg kg-1 Cd in *Atriplex halimus* and S*alsola* kali (Bareen and Tahira, 2011; Sharma and Agarwal, 2005) which may be regarded as 'facultative hyperaccumulators'. These findings warrant further experimental studies on halophytes for finding true potential of salt and metal hyperaccumulation.

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