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Environmental Impact of Ghaf Tree (*Prosopis cineraria*) on Heavy Metals Concentration in Atmosphere

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Abstract

The Ghaf is a hardy tree, drought-resistant, and can grow up to ten meters in height, it tree produces small, yellow flowers which attractive to many habitats, like bees, insects, and birds. The leaves and pods of the Ghaf tree have significant antioxidant and anti-inflammatory properties and can be used in new drug development. Ghaf trees can adapt to changing environmental conditions and planting Ghaf trees could be an effective strategy for mitigating climate change in arid regions. The planting and restoration of the Ghaf tree is mostly found in the northern part of the UAE with a unique appearance. In this study, leaf samples were collected from different regions of Sharjah city (UAE), at different distances from traffic roads. The concentration of heavy metals such as; Iron (Fe), Manganese (Mn), Cobalt (Co), Nickel (Ni), Copper (Cu), Zinc (Zn), Chromium (Cr), Cadmium (Cd), Lead (Pb), and Boron (B), in leaves of Ghaf (Prosopis cineraria) tree leaves was measured using Inductively coupled plasma with mass spectroscopy (ICP-MS) various location of Sharjah. The average metal concentrations found in open area locations and far from highways and populated cities in ppm were Fe (381.91), Mn (12.60), Co (0.23), Ni (3.14), Cu (5.45), Zn (8.84), Cr (1.07), Cd (0), Pb (0.94) and B (253.68), and when these metals concentration was measured and compared in crowded locations close to industrial areas the average metals concentration in tree leaves samples was found to be in higher concentrations as follows; Fe (686.30), Mn (27.84), Co (0.53), Ni (5.84), Cu (6.57), Zn (18.89), Cr (3.14), Cd (0.007), Pb (2.06) and B (93.19). This variation in metal concentration in Ghaf tree (Prosopis cineraria) leaves indicates the ability of this tree to intake the pollutants from the atmosphere and thus can work as a pollutant marker besides being an ecological and cultural heritage.

Keywords: Al-Ghaf (*Prosopis cineraria*) tree, *Prosopis cineraria*, Concentration of heavy metals. Air pollution markers, United Arab Emirates.

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INTRODUCTION

Al-Ghaf (*Prosopis cineraria*) tree is originally found in northwest India and East Pakistan, it is used throughout arid environments due to its extreme drought tolerance and a multitude of uses. It is named the national tree in the United Arab Emirates (UAE) as it is part of the country's heritage, With more growth and concern this tree and the desert village of Nazwa in the country is considered the home of the Al-Ghaf Conservation Reserve. It is indigenous to desert regions of Western Asia and the Indian Subcontinent, including Afghanistan, Bahrain, Iran, India, Oman, Pakistan, Saudi Arabia, the United Arab Emirates, and Yemen. This tree species is a flowering tree of the pea family Fabaceae. Al-Ghaf (*Prosopis*

cineraria) trees are well-established imported species in regions of Southeast Asia, particularly Indonesia. The leaves of these trees are fractured and stripy along their branches, and they can withstand severe drought.

Air pollution is one of the serious environmental problems originating from overpopulation, urbanization, industrialization, and heavy metals which are considered industrial contaminants that do not degrade over time. Thus, they accumulate in water, soil, deep sediment, and living organisms like plants.

Within the Fabaceae family of flowering plants is the genus *Prosopis cineraria*, often known as Ghaf. This group of plants includes about 45 species of prickly trees and shrubs that grow in tropical and subtropical climates in the Americas, Africa, Western Asia, and South Asia. They are drought-resistant and frequently grow in desert soil. sometimes growing incredibly deep root systems. Typically, their timber is robust, solid, and strong. Their fruits, which are pods and may contain significant amounts of sugar, are complex leaves [1] (Figure 1 a, b).

The United Arab Emirates government has encouraged its inhabitants to plant Ghaf trees in their gardens as a means of preventing desertification and conserving their nation's cultural legacy. Ghaf is the national tree of the United Arab Emirates [2].

It is known culturally in the UAE that this tree is associated with Landscapes and Bedouin Traditional Lifestyle [3, 4], and it was considered a symbol of tolerance in the UAE for 2019.

Airborne pollutants originate from natural and man-made (anthropogenic) sources. The annual amounts might be in the hundreds of thousands or even millions of tons. A variety of biotic and abiotic factors, including industrial facilities, radioactive decay, forest fires, volcanoes, and other geothermal sources, as well as emissions from land and water, can cause natural air pollution. These lead to a naturally occurring background concentration that fluctuates based on regional sources or particular meteorological circumstances [5, 6]. Toxic material emissions into the environment are widespread in industrialized nations.

Many industrial plants and factories along with heavy traffic play a major role in producing heavy metals contaminants in the atmosphere. Moreover, traffic pollutants include potentially toxic metals that have adverse health impacts (e.g. lead (Pb), cadmium (Cd), and Chromium (Cr)) [7, 8]. However, with the implementation of antipollution rules on automotive, there were signs of decreased levels of several heavy metals, such as (Pb) concentration levels decreasing by 82%.

The lifestyle changes increase the levels at which trace metals are added to the soil, water, and air from anthropogenic sources [9, 10]. In an expanding order, heavy metal pollution has the potential to be a persistent issue worldwide [11].

In this paper, we aim to report on the detection of the levels of different heavy metal concentrations that could be absorbed by the Ghaf trees.

MATERIALS AND METHODS

Study Area

This study was carried out at Emarat of Sharjah which is in the central region of the United Arab Emirates, it is geographically located on the west coast of the United Arab Emirates (Figure 2a). The Sharjah Emirate is the third largest emirate in the United Arab Emirates; yet it is the only emirate to be located on both coastlines, with the Arabian Gulf to the west and the Gulf of Oman (Indian Ocean) to the east (Figure 2b). More than 1.8 million individuals live there. (as of the year 2023), in summer, the temperature reaches more than 40°C with 50% humidity.

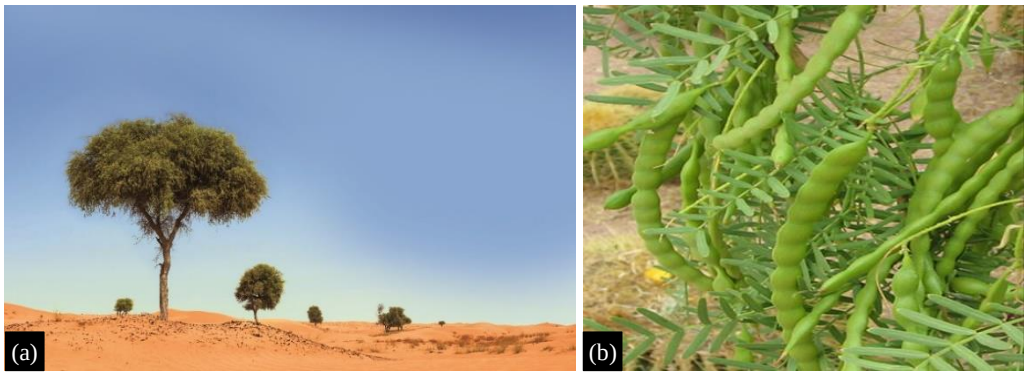

Figure 1. (a) (Al-Ghaf) is a genus of flowering plants belonging to the Fabaceae. (b) The leaves are compound, and their fruits are pods.

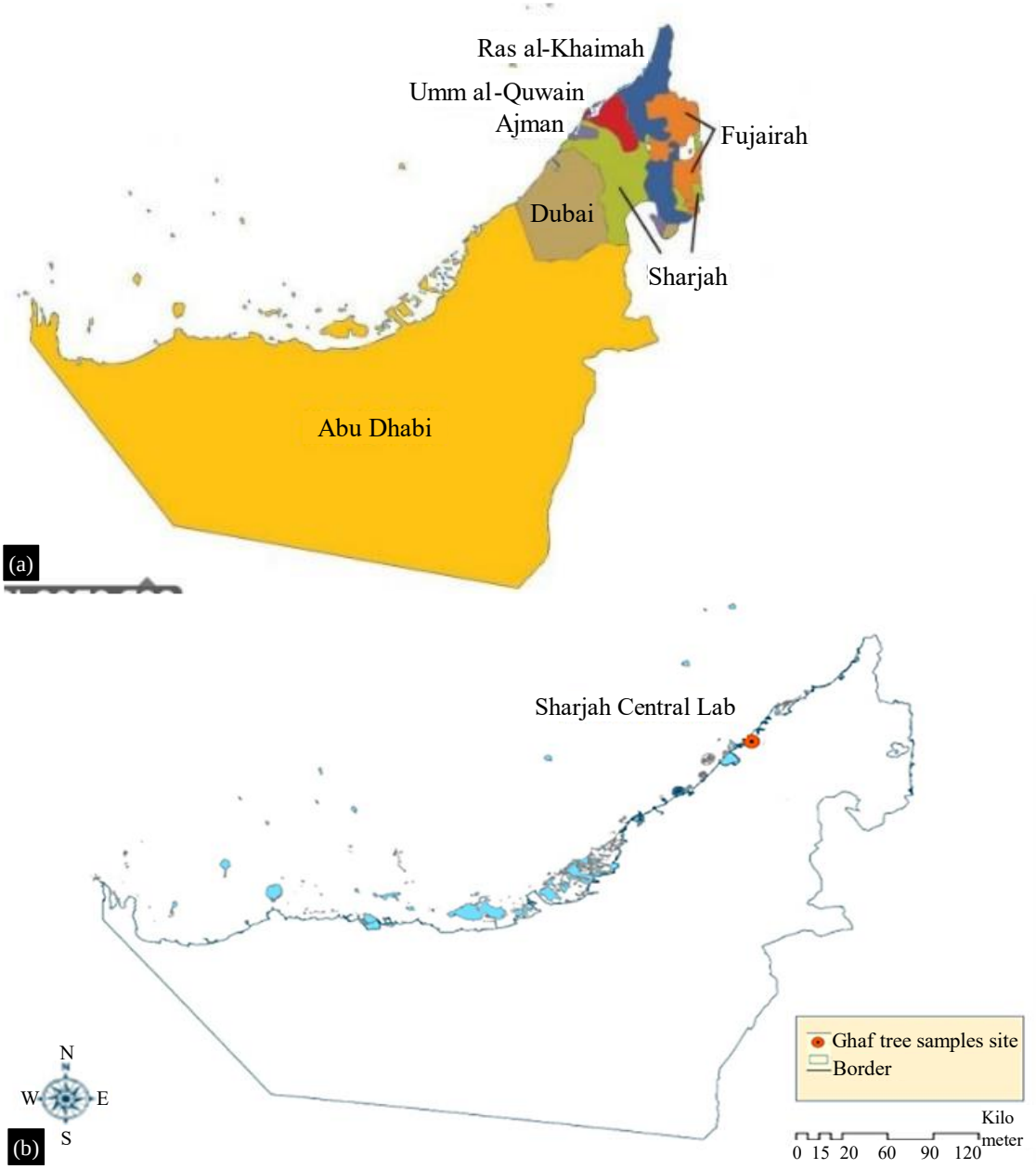

Figure 2. (a) Ghaf trees samples sites, (b) Sharjah location on the UAE map.

Sample Collection

Samples of Ghaf leaves (*Prosopis cineraria*) were collected to cover different locations at the Emirates of Sharjah (Figure 2), 90 samples were collected for this study, using a stainless-steel knife, then samples were stored in polyethylene bags and labeled according to Radojevic and Bashkin [10]. Standards prepared for the determination of Fe, Mn, Co, Ni, Cu, Zn, Cr, Cd, Pb, and B using the ICP-MS method.

Preparation of Standard and Samples

In deionized water (DI), solutions were made with a minimum specific resistance of 18 MΩ-cm (Millipore, Billerica, MA, USA). For reagents and chemicals, we used ultrapure grades. Samples were dried in an Oven at a temperature 70 ^{o}C ± 5 ^{o}C, then the sample was ground in a mortar with a pestle. The method used quantitatively to determine the concentration of Fe, Mn, Co, Ni, Cu, Zn, Cr, Cd, Pb, and B in botanical materials utilizing Microwave digestion with hydrochloric acid (HCl) and nitric acid (HNO_3) in ratio of 3:1.

A spectrophotometric analysis was performed on the element boron (B).

The procedure is not quantitative for other elements that are easily volatilized (i.e. Se, As, Hg). The method detection limit is approximately 4.0 mg Kg^{-1} for B, Zn, Mn, Fe, and Cu. The method is generally reproducible within ± 10%.

Elemental analysis of plant digests was made using inductively coupled plasma mass spectrometry (ICP-MS) PerkinElmer NexION 300X to determine specific matrix modifications, calibration standard range, and the need for instrument-specific sample preparations and dilutions. Determination of trace elements by ICP-MS (Co, Cd, Ni, Mo, Pb) was carried out by using an ultrasonic nebulizer.

Instruments were calibrated following the manufacturer's instructions and accredited companies that follow ISO 17025. Calibrate the instrument using standard calibration solutions. Determine the analyzed concentrations of a method blank, unknown samples, and record analyzed concentrations in mg L^{-1} [12].

Instrumentation

The following instruments were used in this study; A Perkin Elmer ™ ICP-MS NexION 300X (Perkin Elmer, USA); to analyze the elements. A Perkin Elmer ™ Microwave sample preparation system Titan MPS (Perkin Elmer, USA); to digest the samples.

Reagents and Chemicals

Deionized water, ASTM Type I grade. Hydrochloric acid, 37%, Ultratrace®, ppb-trace analysis grade, Scharlue brand. Nitric Acid HNO_3 69% Ultratrace, ppb-trace analysis grade, Scharlue brand. Custom ICP Standard contains all elements used, Accu Standard brand.

RESULTS AND DISCUSSIONS

The concentration of heavy metals in Ghaf tree leaves is presented in Table 1 metal contents of Fe, Mn, Co, Ni, Cu, Zn, Cr, Cd, Pb, and B were analyzed using an ICP-MS instrument. In this study 90 samples were collected from different locations, some of them adjacent to the street while the others were collected from far points around 100 – 150 meters from the road.

The Ghaf tree leaves samples obtained from points adjacent to the street showed a higher concentration of Fe, Mn, Co, Ni, Cu, Zn, Cr, Cd, Pb, and B compared to the other sets of samples taken off the street. The results thus obtained showed a highly significant difference in the content of all tested elements between the two locations of samples, it is clear that the samples that were taken from locations close to the industrial zone accumulated more minerals than those taken from far points from the industrial zone.

Table 2 shows the variation of Ghaf leaves ability to absorb heavy metals for the locations of the study. It is clear Cr concentration is about three folds, while Cd was not detected.

Table 3 shows a comparison between the concentration of selected heavy metals in Ghaf and neem trees which are known for it is environmental impact and ecological properties. The AlGhaf leaves are very effective in metal absorption compared to Neem tree leaves. The Ghaf have double compound leaves and striated trunks and they do have some thorns when they are young.

Different routes of metal/nutrient entrance to the plant via foliar transfer were postulated by the translocation mechanism of metal throughout the plant, which occurs following foliar absorption of heavy metals by plant leaves. The term "foliar uptake" often refers to increased metal levels in foliar tissues; nevertheless, it can be challenging to distinguish between these internal plant processes of foliar metal intake and transmission. According to Säumel [14,15], there are two main processes in foliar metal uptake: (i) metal adsorption and internalization through the cuticle; and (ii) metal penetration through stomatal pores.

Three mechanisms are thought to be involved in the deposition of heavy metals onto plant leaves: chemical, physical, and biological [16].

The mechanical capture of PM-containing heavy metals is associated with the physical adsorption of metals. the chemical and biological aspects of heavy metal adsorption consider the first retention/deposition of metals by plant cuticle, while also accounting for the physical properties of vegetation by the foliage. Furthermore, heavy metal adsorption on plant leaves is also influenced by the permeability of the cuticle and the chemistry of the heavy meals. [17,18]

Table 1. Levels of different elements in Ghaf leaves from two locations.

	Sample									
Sample	***Element ± SE***									
	Fe	*Mn*	*Co*	*Ni*	*Cu*	*Zn*	*Cr*	*Cd*	*Pb*	*B*
Close 0-5 meters	686.3 ± 25	27.84 ± 1.9	0.53±0.02	5.84± 0.27	6.57±0.40	18.89±1.4	3.14±0.35	ND	2.06 ± 0.14	93.19±1.2
Far 100-150 meters	381 ± 3.4	12.6 ± 0.17	0.23 ±0.01	3.14 ±0.05	5.45±0.12	8.84±0.22	1.07±0.02	ND	0.94±0.014	253.7±6.1
P-value	0.000	0.000	0.000	0.000	0.023	0.000	0.000		0.000	0.000

Elements	***Fe (ppm)***	***Mn (ppm)***	***Co (ppm)***	***Ni (ppm)***	***Cu (ppm)***	***Zn (ppm)***	***Cr (ppm)***	***B (ppm)***
Industrial Area	686.3	27.84	0.53	5.84	6.57	18.89	3.14	93.19
Neighborhood	381	12.6	0.23	3.14	5.45	8.84	1.07	253.7

Table 2. A comparison of the efficiency of Ghaf and Neem tree leaves in extracting Fe, Mn, Zn, Cr, Co, Pb, Ni, and Cu from the environment in the UAE [13].

Sample ID	**Fe (PPM)**	**Mn (ppM)**		**Co (ppM)**	**Ni (ppM)**	**Cu (ppM)**	**Zn (ppM)**	**Cr (ppM)**	**Pb (ppM)**
Neem	155.48 8	8.63		0.12	1.42	7.11	5.91	0.63	0.30
Ghaf	621.03	28.73		0.59	6.2	7.87	23.90	2.99	2.45

Table 3. Comparison of the metal content of Neem and Ghaf tree.

Sample	**Fe (ppm)**	**Mn (ppm)**	**Co (ppm)**	**Ni (ppm)**	**Cu (ppm)**	**Zn (ppm)**	**Cr (ppm)**	**Pb (ppm)**
Neem	155.48	8.63	0.12	1.42	7.11	5.91	0.63	0.30
Al-Ghaf	621.03	28.73	0.59	6.2	7.87	23.90	2.99	2.45

According to the current study, Ghaf leaves contain a higher concentration of heavy metals (B and Fe) than other plant leaves do. This suggests that Ghaf leaves can absorb elements, particularly those found along or next to streets. When industrial pollutants find their way into the food chain, they can have detrimental effects on human health. Thus, the purpose of this study was to determine whether the leaves of Ghaf (*Prosopis cineraria*) may serve as bio-indicators of the pollution that the city emits into the environment [19].

CONCLUSION

Increasing the cultivation of green areas, especially trees that can absorb heavy elements from the air will play a role in reducing environmental pollution that has explicit adverse consequences for humans and animals and has a cumulative impact on climate change control. Thus; it is highly recommended to use the Ghaf tree as a landscape tree in streets and around industrial zones.

This study focused on selected heavy metals accumulated in Ghaf Leaves trees in the Sharjah city area in the UAE. *Prosopis cineraria*"Ghaf" trees are good for the reduction of air pollutants. The government and MOCCAE yearly monitor and plant a large number of Al-Ghaf trees in all parts, to monitor climate change.

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