

Research Article

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Study of Heavy Metal Distribution in Medicinal Plant Basil

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Abstract

Medicinal plants and their extracts deserve special attention because of the important influence they have to human health. There are easily contaminated with metals during growth, development and processing. The aim of this study was to achieve the quantitative determination of metallic elements (Cu, Cr, Cd, Mn, Zn, Pb) in medicinal plants basil using ICP-AES. Metal content in the powdered medicinal plants was in descending order: Zn > Mn > Cu > Cr; Pb and Cd were present in minor amounts. Analysis of plant infusions showed transfer of heavy metals during extraction procedure. Monitoring the content of mineral elements in medicinal plants and their boiling water extracts is of high importance because some heavy metals in large quantities in the body may have a toxic effect.

Keywords: Basil; Heavy metals; Translocation factor; Bioaccumulation factor

Introduction

Basil has been planted as a popular culinary and medicinal herb from ancient time until now and the leaves and flowers have been used for the treatment of headaches, coughs, diarrhea, worms and kidney malfunctions, as well as for its carminative, galactagogue, stomachic and antispasmodic properties [1-4]. The use of herbal medicines has been on the rise in recent years due to their low prices and lack of awareness of people about their side effects. There is a common concept among people that herbal medicines have no side effects and that "being natural in origin, herbs are safe". These medicines are popular because of long-term effectiveness against many chronic disorders [5].

The metals i.e. As, Se, Cd, Hg, Pb, etc. are very toxic to humans and environment and plants are suggested as potential biosorbents for trace metals removal from the soil. In plants, several groups (i.e. hydroxyl, carboxyl, carbonyl, sulfhydryl, thioether, sulfonate, amine, amide, imine, imidazole, phosphonate, phosphodiester groups, etc.) are suggested the complexation of metal ions. The World Health Organization (WHO 1998) recommends that medicinal plants which form the raw materials for the finished products may be checked for the presence of heavy metals, pesticides, bacterial or fungal contamination. Herbal plants have been used to remove heavy metals. However, there is an inherent health risk associated with many of these plants due to presence of contaminating HMs. The medicinal herbs are a potential source of toxic metal exposure for man and animals [6-13].

In the present work, the biosorption pattern of HMs in the various plant parts (i.e. flower, leaf, stem and root) of different basil species: namely sweet basil (*Ocimum basilicum*) black basil (*Ocimum sanctum*) and dwarf basil (*Ocimum minimum*) are discussed.

Materials and Methods

Collection of sample

Different parts of basil (i.e. leave, stem, root and seed) and rhizospheric soil were collected from Bhilai (latitude: 21°12'36"N, longitude: 81°22'47"E) near Raipur, capital of Chhattisgarh state, central India). The plants sample was washed thoroughly with distilled water, dried in a shed, compressed into a powder with the help of a manual grinder and the particles <1 mm sieved out.

Sequential extraction process for preparation of sample

The HMs present in different geochemical fractions of the soil was determined by the sequential extraction scheme. The theory behind SEP is that the most mobile metals are removed in the first fraction and continue in order of decreasing of mobility. All SEPs facilitate fractionation. Tessier et al. named these fractions exchangeable, carbonate bound, Fe and Mn oxide bound, organic matter bound, and residual. These are also often referred to in the literature as exchangeable, weakly absorbed, hydrous-oxide bound, organic bound, and lattice material components, respectively. 1 g of soil sample is placed in a 50 mL tube. The sample is exposed to reagents and shaken. Each fraction is separated from the supernatant by centrifugation at 10,000 rpm, (12,000 gravity) for 30 min. The supernatant is collected for lab analysis. The sediment is rinsed with 8 mL of deionized water (DIW) and centrifuged again. For the fourth fraction, a 1 g (dry weight) sample is exposed to 12 mL of 5:1 HF-HClO₄ acid mixture and evaporated to near dryness. A 10:1 HF-HClO₄ acid mixture is added to the sample and again evaporated to near dryness followed by 1 mL of HClO₄, evaporated until white fumes are visible. The final digestion is performed with 12 N HCl and diluted to 25 mL [10].

Chemical and reagents

The AR grade (E. Merck, Germany) chemicals were used for digestion of the soil and plant samples. The ICP multi-element (23 elements) standard (E. Merck, Germany) was used for preparation of the calibration curve.

Chemical analysis

An instrument: inductively coupled plasma-atomic emission spectrometry (ICP-AES) Ultima-2 from Jobin Yvon, France equipped with parallel flow nebulizer and cyclonic spray chamber was used for the monitoring of the heavy metals (i.e. Cr, Mn, Fe, Ni, Cu, Zn,

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and Pb). Atomic Absorption Spectrophotometer (AAS) GBC 932 Australia equipped with Hydride Generator (HG-3000) was used for the determination of the total arsenic and mercury using sodium borohydride for reduction. The standard addition method was used for the quality control and data validation of the method.

Metal contents in coarse particulates

The distribution of coarse particulate matter (PM_{10}) in the ambient air of the study area in Nov. 2004 was obtained by using high volume air sampler over the quartz filter paper. The mass concentration ($n=3$) of PM_{10} in the ambient air was found to be $310 \mu g m^{-3}$. The sample was digested with acids ($HCl+HClO_4+HF$) and analyzed with flame atomic absorption spectrophotometer (AAS).

Results and Discussion

Metal contents in soil

The sequential extraction procedures were employed to investigate the distribution and chemical fraction of heavy metals retained in tested soils. Four extractants i.e. hot water, $NaHCO_3$, $NaOH$ and HCl were used to determine soluble, exchangeable, bound to hydroxide of Fe and Al and carbonate fraction, respectively. Acid mixture i.e. HNO_3 , $HClO_4$ and HF was used to determine the total metal contents. The total contents ($mg kg^{-1}$) of the metal i.e. Cr (828), Mn (1480), Ni (110), Cu (1240), Zn (61), As (13), Hg (4.3), Pb (545) in the rhizosphere soil is ranged from 4.3-27165 $mg kg^{-1}$. Their sum of total extractable fraction in the hot water, $NaHCO_3$, $NaOH$ and HCl are found in increasing order: Cr (4.6) \approx Mn (4.9) \approx Ni (5.0) $<$ As (9.4) $<$ Pb (25.1) \approx Hg (25.2) $<$ Cu (36.5) $<$ Zn (55.0%). Relatively higher fractions ($>1.0\%$) of metals i.e. Cr, Hg was found to be present in the soluble forms. A significant fraction of metals i.e. As, Hg, Pb was found to exist in the exchangeable (co-ordinated to organic acid and other anions) forms. A higher fraction of metals i.e. As, Cu, Hg, and Pb were found in the bound form with oxide and sulfide of Fe and Al. A major fraction of all metals were found to be present in the carbonate forms in increasing order: As \approx Cr $<$ Ni \approx Mn $<$ Hg $<$ Pb $<$ Fe $<$ Cu $<$ Zn in the soil. The $NaOH$ and HCl leachable contents of the HMs and the total contents in the soil solution have fair correction ($R^2 \geq +0.71$). The particle contents of Mn, Fe, Cu, Zn and Pb in the PM_{10} were 0.05, 2.21, 0.94, 0.05 and 0.01%, respectively.

Metal contents in different varieties of Basil

The total mean concentration of the HMs in flower and leaf of three varieties of basil: sweet, black and dwarf are summarized tables 1 and 2. The distribution order for the most of the HMs in three species have similar trend, and found to be in increasing order: Hg \approx As $<$ Ni $<$ Cr $<$ Cu $<$ Zn $<$ Mn $<$ Fe with higher mean values for leaf. Among them, generally, the sweet basil showed the highest HMs contents. However, flower, leaf and stem portions of the plant contained higher concentrations of the trace metals than root due to the fallout of atmospheric pollutants through dry as well as wet deposition. Their contents are found in decreasing order: leaf $>$ flower $>$ stem $>$ root. The highest HMs contents in sweet basil are observed may be due to the highest biomass production as well as the highest growth rate [14-17]. Two coefficients, biological absorption coefficient (BAC) i.e. plant to soil metal ratio and concentration factor (CF) i.e. plant to water soluble metal ratio are used in the present work [18]. The value BAC and CF depend on the physical and chemical composition of the soil, type of basil species and their morphology. The CF and BAC trends observed are Cr $<$ As \leq Hg $<$ Cu \approx Pb $<$ Ni $<$ Zn $<$ Fe $<$ Mn; and Cr $<$ Cu \approx Pb $<$ Mn $<$ Fe \approx Ni $<$ As $<$ Hg $<$ Zn, respectively. The translocation factor (TLF) is a content of metal in root to leaf, and the TLF values of many metals (i.e.

Metal	Sweet Basil (<i>Ocimum basilicum</i>)		Black Basil (<i>Ocimum sanctum</i>)		Dwarf Basil (<i>Ocimum minimum</i>)	
	Flower	Leaf	Flower	Leaf	Flower	Leaf
As	0.17	2.1	0.15	1.8	0.12	1.2
Cr	20.3	21.4	10.7	24.4	9.4	7.8
Mn	100	192	21.4	267	30.8	124
Ni	11.9	18.6	2.7	13.2	2.4	5.7
Cu	23.7	29.2	18.7	21.4	7.4	15.1
Zn	28.8	34.2	18.7	28.2	7.6	11.8
Hg	0.17	2.1	0.20	2.0	0.21	1.2
Pb	15.3	18.5	7.5	9.4	5.3	8.0

Table 1: Metal contents in various parts of basil $mg kg^{-1}$ dry weight.

Metal	Sweet Basil (<i>Ocimum basilicum</i>)		Black Basil (<i>Ocimum sanctum</i>)		Dwarf Basil (<i>Ocimum minimum</i>)	
	Flower	Leaf	Flower	Leaf	Flower	Leaf
As	2.1	1.8	1.2			
Cr	21.4	24.4	7.8			
Mn	192	267	124			
Fe	10814	9043	2465			
Ni	18.6	13.2	5.7			
Cu	29.2	21.4	15.1			
Zn	34.2	28.2	11.8			
Hg	2.1	2.0	1.2			
Pb	18.5	9.4	8.0			

Table 2: Metal contents in leaf $mg kg^{-1}$ dry weight.

As, Cr, Mn, Fe, Ni, Pb) in leaf are found to be significantly high. The levels of Hg and Pb determined in the investigated plant sample were found to exceed the maximum allowable levels of Hg ($0.05 mg kg^{-1}$) and Pb ($1.2 mg kg^{-1}$) by Zentrale Erfassungs- und Bewertungsstelle für Umweltchemikalien (ZEBS) [19-24].

Conclusion

The concentration of the some HMs in various parts of the basil exceeded the permissible levels. The contaminated soil, ground water and dust are expected to be major significant sources for their sorption in the basil. They can accumulate in the basil through the foliage and root system. The use of medicinal plants grown in the polluted site may be one of the dangerous potential entry pathways in humans and other animals.

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