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SOIL–PLANT TRANSFER FACTORS OF CHEMICAL ELEMENTS IN *Artemisia campestris* L. (ASTERACEAE) USING INAA TECHNIQUE

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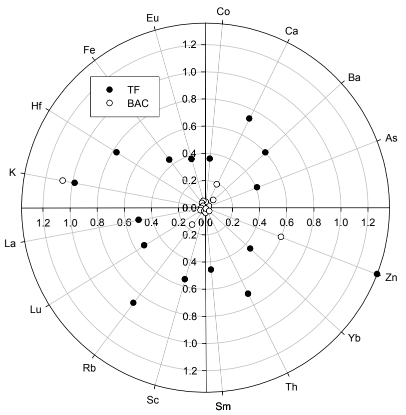
Artemisia campestris L. (Asteraceae) a perennial medicinal herb growing in arid steppe of Algeria has been studied to determine the uptake and translocation of some major, minor and trace elements from soil to plant. Instrumental neutron activation analysis has been employed to determine the chemical elements in different parts of the plant and in the soil in which the plant was grown. As, Co, Cs, Eu, Hf , La, Lu, Sc, Sm, Th, Yb were found to be present at trace levels. Br, Ba, Fe, Zn have been detected at minor levels, however shoots of this plant contain Ca, K and Na as major elements. The study showed that toxic heavy metals such as Cd, Pb, Hg were detected in the samples except As which is below the limit value. The elemental transfer from soil to plant showed enrichment of Na. The accuracy of the data was measured by analyzing the CRMs Eastern sediment (NIST-164a) and Lichen (IAEA 336).



INTRODUCTION

In the flora of Algeria the genus *Artemisia* (Asteraceae family) was presented with 11 spontaneous *Artemisia* species.[1] *Artemisia campestris* L. commonly known as “dgouft” is a perennial scarcely aromatic herb growing in North Africa used to cure several digestive troubles.[2] The leaves of this shrub collected in summer (August) were widely used in traditional medicine as decoction for their antivenom, anti-inflammatory, anti-rheumatic and anti-microbial properties.[3]

Several studies were focused on the composition of the essential oil,[3-5] and its antibacterial and antioxidant activities of *A. campestris*,[6,7] however less attention was given to their inorganic constituents. It is now well established that many trace elements play a vital role in the formation of active constituents in medicinal plants.[8] In this context this work was conducted to determine the elemental composition of *A. campestris* using instrumental neutron activation analysis (INAA), and to determine the elemental transfer from soil to plant.

EXPERIMENTAL

Plant of *A. campestris* and the surrounding soil samples were collected in August 2013 from *Bad Messaoud* region (Djelfa) in arid steppe of Algeria (2°47' E longitude, 34°37' N latitude and 1198 m elevation). The plant samples (shoots and

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roots) were thoroughly washed with double distilled water, and oven-dried at 60 °C.[9] The dried samples were ground and homogenized using pestle and mortar (particle size fraction of < 200 µm).

Plant and soil samples (about 100 mg for each sample) were irradiated at the Es-Salem research reactor (15 MW heavy water reactor type) for 6 h at a thermal neutron flux of 4.5×10^{13} $cm^{-2}s^{-1}$. The γ-ray measurements are carried out with a Canberra (HPGe p-type) high purity germanium detector with 1.9 keV resolution for 1332 keV ^{60}Co and 35% relative efficiency. The software Genie-2000 version 2 was used for spectra processing and peak area element determinations.

One certified reference soil and one reference plant material were prepared with a similar manner to the soil and plant samples, and irradiated simultaneously with them for quality control. The reference materials used in this work were NIST-164a (Eastern sediment) and IAEA 336 (Lichen).

RESULTS AND DISCUSSION

Tables 1 and 2 show the results obtained in the analyses of certified reference materials NIST-164a and IAEA 336, respectively. The obtained results indicated good accuracy and precision of the method applied in this work (Figs. 1 and 2).

Table 1

Comparison of measured values of chemical element mass fraction (µg/g) with certified values in standard reference material NIST-164a (Eastern sediment). Values represent mean ± standard error of mean (n = 3)

Elements	Certified values	Measured values
As	6.23 ± 0.21	6.53 ± 0.23
Ba	210 ± 31.50	202.91 ± 18.50
Ca	5190 ± 200	5281.52 ± 1266.12
Ce	34 ± 5.10	33.90 ± 1.18
Co	5 ± 0.75	4.90 ± 0.18
Cr	40.90 ± 1.90	38.50 ± 1.66
Fe	20080 ± 390	19889.58 ± 192.37
K	8640 ±160	8616.13 ± 888.55
La	17 ± 2.55	18.14 ± 0.46
Mo	1.80 ± 0.27	1.60 ± 0.15
Na	7410 ± 170	7780.35 ± 179.93
Rb	38.00 ± 5.7	36.90 ± 2.52
Sb	0.30 ± 0.05	0.29 ± 0.07
Sc	5 ± 0.75	4.52 ± 0.18
Th	5.80 ± 0.87	5.72 ± 0.36
U	2 ± 0.30	1.81 ± 0.12
Zn	48.90 ± 1.60	47.95 ± 3.42

Table 2

Comparison of measured values of chemical element mass fraction (µg/g) with certified values in standard reference material IAEA 336 (Lichen). Values represent mean ± standard error of mean (n = 3)

Element	Certified Values	Measured Values
As	0.639 ± 0.077	0.639 ± 0.08
Ba	6.40 ± 1.10	5.71 ± 1.78
Br	12.9 ± 1.70	11.41 ± 1.37
Ca	2600 ± 450	2638.5 ± 493.5
Ce	1.27 ± 0.175	1.0 ± 0.16
Co	0.287 ± 0.04	0.288 ± 0.04
Cr	1.03 ± 0.19	1.15 ± 0.04
Cs	0.11 ± 0.01	0.114 ± 0.01
Eu	0.023 ± 0.004	0.026 ± 0.004
Fe	426 ± 46	444.1 ± 21.9
K	1840 ± 200	1683.9 ± 79.4
La	0.66 ± 0.105	0.548 ± 0.03
Na	320 ± 40	221.3 ± 20.3
Rb	1.72 ± 0.20	1.72 ± 0.19
Sb	0.073 ± 0.01	0.067 ± 0.01
Sc	0.17 ± 0.02	0.15 ± 0.02
Se	0.216 ± 0.03	0.215 ± 0.03
Sm	0.106 ± 0.01	0.104 ± 0.02
Sr	9.2 ± 1.10	7.6 ± 1.80
Th	0.142 ± 0.02	0.13 ± 0.01
Zn	31.2 ± 3.50	32.2 ± 1.30

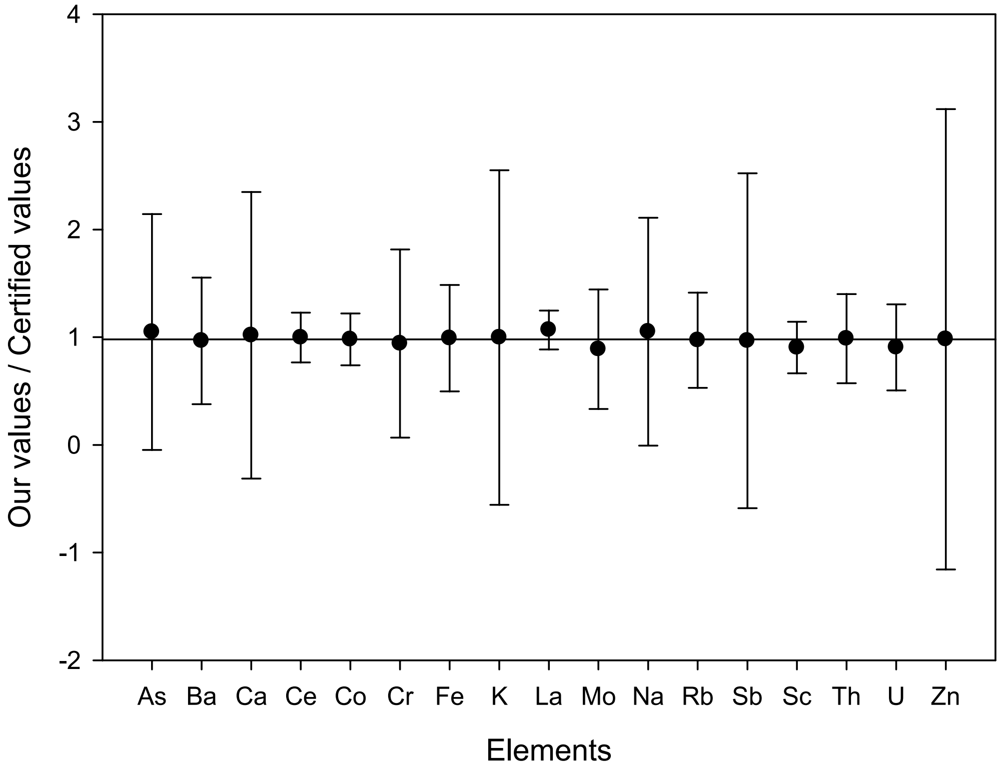

Fig. 1 – Ratios between the obtained results in this work for the NIST-164a (Eastern sediment) reference material and its certified values.

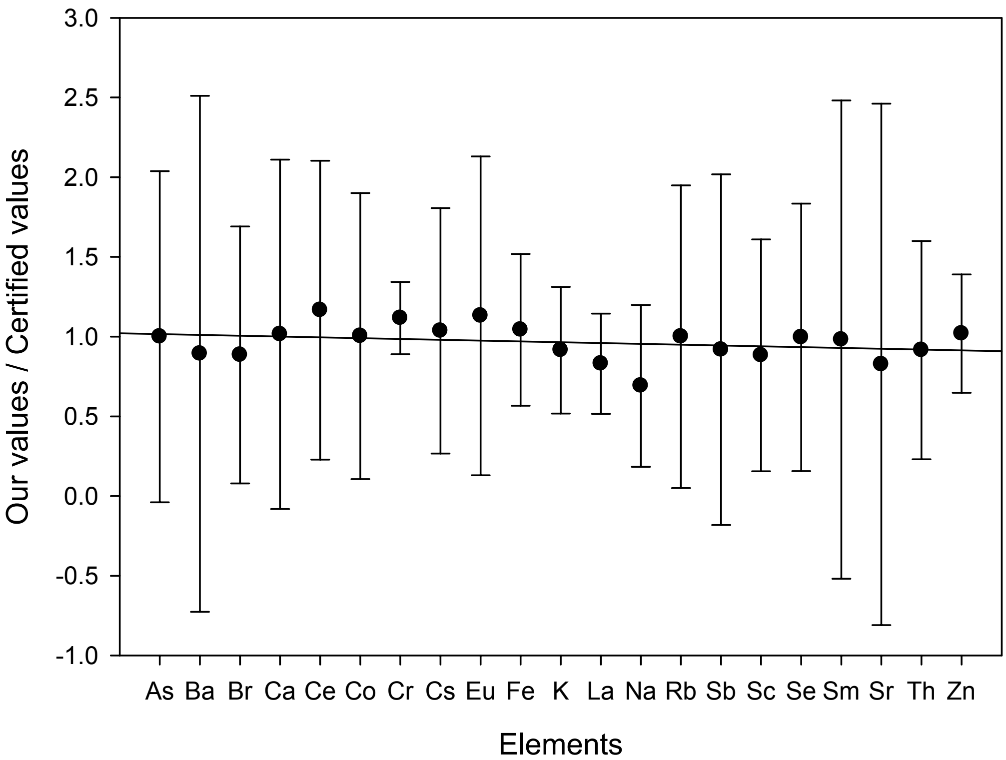

Fig. 2 – Ratios between the obtained results in this work for the IAEA 336 (Lichen) reference material and its certified values.

The element mass fractions determined in plant and associated soil were given in Table 3. Ca, K and Na were the most abundant elements present in this plant, and were found in order Ca > K > Na. These results were in agreement with those founded in other steppic species.[10,11] Calcium is the main constituent of the skeleton and is important for regulating many vital cellular activities such as nerve and muscle function.[12] However K contributes to maintain the blood pressure and cardiovascular system.[13]

Others elements such as Br, Ba, Fe, Rb, Zn were found to be present at minor levels, and Eu, Hf , La, Lu, Sc, Sm, Th, Yb at trace levels. Certain toxic elements such as Pb, Hg, Cd, were not found in this plant, meaning that this medicinal herb could be considered safe to consume except for As which had a mass fraction below the tolerable limits (<2 µg/g).[14]

Except for the Br, most of elements analyzed in root and shoot were lower than those found in associated soil (Table 3).

In order to evaluate the soil-plant transfer elements, we have determined the Bioaccumulation Coefficient (BAC) and the Translocation Factor (TF) (Table 4). The Bioaccumulation Coefficient (BAC) which reflects the plant's ability to absorb elements from the soil was calculated according to the formula:

BAC = [Element] shoot/ [Element] soil.[15]

Table 3

Mean values of chemical element mass fractions (µg/g) determined in shoot, root and soil of *Artemisia campestris*. Values represent mean ± standard error of mean (n = 3)

Elements	Shoot	Root	Soil
As	0.197 ± 0.03	0.48 ± 0.06	6.2 ± 0.2
Ba	20.2 ± 2.90	33.8 ± 3.70	240 ± 21
Br	76.5 ± 9	37.6 ± 4.4	18.8 ± 2.4
Ca *	0.96 ± 0.08	1.3 ± 0.1	5.1 ± 0.9
Co	0.312 ± 0.04	0.86 ± 0.11	7 ± 0.3
Eu	0.034 ± 0.006	0.09 ± 0.02	0.66 ± 0.03
Fe	721 ± 38	1620 ± 80.00	1.61 ± 0.02
Hf	0.101 ± 0.014	0.13 ± 0.02	5.5 ± 0.4
K *	1.341 ± 0.049	1.37 ± 0.05	1.25 ± 0.05
La	0.715 ± 0.039	1.43 ± 0.07	25.3 ± 0.7
Lu	0.009 ± 0.001	0.017 ± 0.003	0.21 ± 0.03
Na	95 338 ± 8684	1599.5 ± 145.5	0.505 ± 0.012
Rb	7.320 ± 0.498	8.3 ± 0.6	46.5 ± 2.5
Sc	0.177 ± 0.019	0.32 ± 0.03	5.9 ± 0.2
Sm	0.134 ± 0.027	0.29 ± 0.06	3.5 ± 0.1
Th	0.027 ± 0.003	0.038 ± 0.004	4.4 ± 0.2
Yb	0.063 ± 0.013	0.14 ± 0.02	1.5 ± 0.1
Zn	14.6 ± 0.7	10.7 ±0.6	24.10 ± 0.9

*: in %

Table 4

Translocation Factor (TF) and Bioaccumulation Coefficient (BAC) from soil to shoot of *Artemisia campstris*

Elements	TF	BAC
As	0.41	0.03
Ba	0.60	0.08
Br	2.03	4.07
Ca	0.73	0.19
Co	0.36	0.04
Eu	0.37	0.05
Fe	0.44	0.04
Hf	0.77	0.02
K	0.98	1.07
La	0.50	0.03
Lu	0.53	0.04
Na	59.60	18.88
Rb	0.88	0.16
Sc	0.55	0.03
Sm	0.46	0.04
Th	0.71	0.01
Yb	0.45	0.04
Zn	1.36	0.60

The Translocation Factor (TF), which indicates the ability of plants to translocate elements from the roots to the shoots, was calculated as the ration between element content in shoots and element content in roots as follow:

TF= [Element] shoot / [Element] root.[16]

As indicated in Table 4, TF was found to vary ranging from 0.36 to 59.6. The high value was observed for Na which shows that this plant is efficient to take up and translocation the sodium from roots to shoots. However BAC varied between 0.01 and 18.88. The highest accumulation was found also for Na indicating the good potential for transfer of this element from the soil to plant tissues. The levels of chemical elements in plants depend on many factors such as the geochemical characteristics of the soil and by the ability of plant species to select and accumulate some of these elements.[17]

CONCLUSION

This paper sheds light on the chemical composition of the *A. campestris* medicinal plant. The results showed the presence of essential elements such as K, Zn and Ca, that could be useful for human health. For toxic elements, As contents were within the safety limits suggested by WHO. Bioaccumulation Coefficient (BAC) which reflects the plant's ability to translocate elements from the soil to plant indicates a good potential for transfer of Na and Br in this species probably due to the nature of the soil (*e.g.*, pH, texture, Organic Matter and cation exchange capacity) or chemical soil disinfection.[18]

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