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Mineral composition of Calligonum aphyllum (Pall.) Guerke.

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***Abstract*—first established mineral composition *Calligonum aphyllum (Pall.) Guerke.* in the ash residue of a plant, represented by 43 elements in aboveground and root parts by application of spectrometry method with inductevly coupled plasma. Content of heavy metals is within allowable limits.**

***Keywords — Calligonum aphyllum (Pall.) Guerke., mineral composition, MAC (maximum allowable concentration),* heavy metals, metnod of spectrometry with inductively-coupled plasma.**

I. Introduction

Plants of genus *Calligonum L.* relate to dumetosous of *Polygonaceae Juss.* family. There are about 80 species of this plant in deserts and plains of Asia and in Middle Asia and about 30 species in Kazakhstan. *Calligonum L.* – bushes from 0,5 to 4 m high, many-branched with open head. *Calligonum L.* identify the landscape of many regions in desert zone, they can stand extreme conditions in most of habit areas. *Calligonum L.* grows on sandy and clayed soils, black alkali soils and some types of saltwort. It has long horizontal roots that can reach 12 meters long. They can grow new side (secondary) roots in the base of their stipitates after covering with sand. It makes it a valuable plant for fixing shifting sands (Fig.1). Cleanness of environment is a topical issue of the humanity. Based on the mineral composition of the plant it is possible to identify environmental condition of the region where it grows. In our case it is Aktobe region, which is considered to be industrial zone of the Republic of Kazakhstan.

II. Materials and methodology

A. *Plant material and reagents*

The plant materials were collected from Aktobe region during flowering stage. The sample was collected in 2013 year. Reference substances: roots, stems, leaves of *Calligonum L.* Physiacl-chemical investigations were carried out using the following equipment: mass spectrometer *with* inductively-coupled plasma «Termo Nicolet Avatar-360» (USA), analytical lab mill , analytic balance «Ohaus» (USA), nest of sieves КП – 109/1 (Ukraine), ash muffle SNOL 8.2/1100 (Lithuania).

B. *Method of determination of mineral composition*

Method of determination of mineral composition includes:

- preparation of plant material;
- ignition of vegetable stock;
- ash burning;
- examination of ashes residue for mineral composition.

1) Preparation of vegetable stock

Electrical laboratory mill is used for milling the vegetable stock. Milling is executed in batches right before ignition. The degree of fineness of the stock is defined with the help of screen analysis. Analysis stock sample is milled and screened through the sieve with mesh diameter of 2 mm. Stock loss at this stage of process is 5% of total amount.

2) Ignition of vegetable stock

A test portion with a weight of 1-3 g is taken to porcelain crucible pre-heated to fixed mass in order to identify total ash by evenly distributing the substance on the bottom of the crucible. After that the crucible is gradually heated allowing the substance to burn down or volatilize at lower temperature. After the coal is burnt down flame is increased.

3) Ash burning

Burning in muffle furnace is carried out with low read heat (about 500 ^{0}C) until constant weight, avoiding melting of ash and its baking with crucible walls. Upon completion of burning the crucible is cooled down in desiccators and weighted. Percent composition of total ash x in absolutely dry stock is defined by the Equation (1):

$$x = \frac{m_{ash} * 100 * 100}{m_{p.c.} * (100 - \omega)} \quad (1)$$

m_{ash} - ash mass, g
$m_{p.c.}$ – mass of stock test weight, g
ω – loss in stock mass during drying, %.

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TABLE I. CONTENT OF MINERAL COMPOUNDS IN CALLIGONUM APHYLLUM

№	Element		Stems мg/кg	Leaves мg/кg	Roots мg/кg	№	Element		Stems мg/кg	Leaves мg/кg	Roots мg/кg
1	Hafnium	Hf	0,2118	0,6669	0,271	23	Niobium	Nb	3,12	10,6	8,832
2	Indium	In	<0,1	<0,1	<0,1	24	Molybdenum	Mo	0,17	0,515	0,2124
3	Uranus	U	<0,05	<0,05	<0,05	25	Tin	Sn	<0,1	<0,1	<0,1
4	Tantalum	Ta	<0,1	<0,1	<0,1	26	Cerium	Ce	1,59	3,63	5,51
5	Gallium	Ga	<10	<10	<10	27	Lithium	Li	0,26	4	0,46
6	Scandium	Sc	<0,1	<0,1	<0,1	28	Lanthanum	La	0,21	0,297	0,291
7	Phosphorus	P	872,7	1444	924	29	Ytterbium	Yb	0,019	0,022	0,024
8	Antimony	Sb	<0,1	<0,1	<0,1	30	Yttrium	Y	0,55	1,07	0,84
9	Manganese	Mn	16,97	10,57	57,37	31	Silver	Ag	<0,1	<0,1	<0,1
10	Titan	Ti	25,79	21,62	26,33	32	Strontium	Sr	99,82	220,9	336,4
11	Zirconium	Zr	1,93	2,33	2,53	33	Gold	Au	<100	<100	<100
12	Tungsten	W	<0,1	<0,1	<0,1	34	Thallium	Tl	<0,1	<0,1	<0,1
13	Chrome	Cr	4,33	3,35	5,75	35	Iron	Fe	81,73	98,05	121,5
14	Nickel	Ni	3,24	3,01	3,39	36	Platinum	Pt	<10	<10	<10
15	Germanium	Ge	<0,1	<0,1	<0,1	37	Thorium	Th	<0,05	<0,05	<0,05
16	Bismuth	Bi	<0,1	<0,1	<0,1	38	Tellurium	Te	<0,1	<0,1	<0,1
17	Barium	Ba	10,13	14,02	29,38	39	Boron	B	12,52	58,96	16,78
18	Beryllium	Be	0,22	0,37	0,32	40	Aluminum	Al	152,07	281,34	268,08
19	Lead	Pb	<0,1	<0,1	3,39	41	Cobalt	Co	0,561	0,519	0,5455
20	Arsenic	As	<0,1	<0,1	<0,1	42	Copper	Cu	5,19	5,99	8,29
21	Vanadium	V	0,99	1,73	1,49	43	Zinc	Zn	8,75	9,48	10
22	Cadmium	Cd	0,61	0,83	1,03						

4) Examination of ashes residue for mineral composition

The evaluation was performed with calibration curves, generated based on the artificial mixtures with preset concentration of microelements. Artificial mixtures were made of spectroscopically pure salts of sodium chloride, calcium carbonate in ratios similar to examined biological objects taking into account coefficients of concentration from oxides of defined elements. There were 43 elements identified in the analyzed samples (Table I).

III. Results and discussion

The purpose of the work is to identify mineral composition in different organs of the plant *Calligonum aphyllum (Pall.) Guerke.*

Species of *Calligonum L.* – are valuable and useful plants, and all the parts of the plant can be used in complex - cortex,

Figure 1. *Calligonum aphyllum (Pall.) Guerke.*

timber, herbage, blossoms and fruits. Under conditions of natural growth and in culture of different types of *Calligonum L.* sand-fixing properties were studied, as well as productivity of herbage and feeding properties. Economic character of these bushes is significant. Their young branches and fruits that have pleasurable, slightly acid flavor are eaten by sheep and camels. Green branches contain tanning materials. Man-made plantings and natural bushes of *Calligonum L.* collect snow and as a result of its melting potting soil is desalinated. Plant is used as fuel that provides smokeless fire. *Calligonum L.* is used in traditional medicine for treating abdominal diseases, tooth ache as anti-diabetic agent [1]. It was proven that *Calligonum L.* possesses anti-inflammatory, anti-ulcerative and cytoprotective properties [2].

Calligonum L. grows on the territory of Kazakhstan in: Caspian, Emba, Turgay, Zaisan, Kyzylorda, Aral sea regions; Betpakdala Kizilkum deserts [3].

Object of research is *Calligonum aphyllum (Pall.) Guerke.*, harvested in the neighborhood of Aktobe region in 2013 in the period of blossoming (Fig.2).

Study of mineral composition of plants is an important problem, because due to continuous interdependence of environment and humanity all the components in the plant are eventually contained in human organism. Elements are received by organism from geochemical environment, parent rock materials, soils, natural waters, atmospheric air due to primary organization of biogenic cycles.

TABLE II. DETERMINATION OF IGNITION OF *CALLIGONUM APHYLLUM*

№	Stems	Leaves	Blossoms	Roots
1	5,42	9,96	5,43	4,45
2	5,18	9,97	5,17	4,43
3	5,39	9,05	5,37	4,5
4	5,78	9,82	4,07	4,46
5	5,77	9,57	5,77	4,45
Mean value	5,51	9,68	5,16	4,458

Figure 2. Natural area of *Calligonum aphyllum (Pall.) Guerke in* Republic of Kazakhstan.

Most of micro and macro-elements have a major impact on life of organisms by connecting with organic matters, synthesized in live cells and often provide their chemical and biologic activity (Table II). They influence fertilization, development, growth, health of an organism, its immunobiological properties, respiratory function of hemoglobin, photosynthesizing function of chlorophyll, fixation of atmospheric nitrogen by microorganisms and other important functions [4].

Mineral components that are important for life in negligibly small quantities become toxic in higher concentrations [5].

There was an interrelation established between soil content of certain chemical elements and production of certain groups of biologically-active substances (BAS) by plants. Plants that produce cardiac glycosides, selectively absorb manganese, molybdenum, chrome; plants producing alkaloids – copper, manganese, cumarins, flavonoids and anthracite-producing – copper, vitamins – manganese and copper, polysaccharides – manganese, crome [6].

Heavy metals are one of the most widespread contaminants of environment. That is why study of mineral composition of plants has scientific and practical interest. Maximum allowable concentration of heavy metals related to dry stock shall be the following: content of lead shall not exceed 0,5 mg/kg, copper – 10 mg/kg, zinc – 50 mg/kg.

Quantitative evaluation of contamination of plants with heavy metals not only helps in evaluation of environmental contamination but also their suitability to use as stock for preparation of medical products (Table III).

Based on mineral composition of *Calligonum aphyllum (Pall.) Guerke.*, it is possible to evaluate both content of useful microelements and plant contamination with heavy metals. Elemental composition was identified by application of inductively coupled plasma mass-spectrometry method.

In order to identify mineral composition the stock was preliminary milled and after that burning took place. Method of ash content definition is based on identification of noncombustible residue of non-organic substances that remain after incineration and calcinations of the stock.

TABLE III. CONTENT OF HEAVY METALS IN CALLIGONUM APHYLLUM

№	Element	Content			MAC
		stems	leaves	roots	мг/кг
1	Lead	<0,1	<0,1	3,39	10
2	Arsenic	<0,1	<0,1	<0,1	2
3	Vanadium	0,99	1,73	1,49	15
4	Cadmium	0,61	0,83	1,03	8
5	Cobalt	0,561	0,519	0,5455	23
6	Copper	5,19	5,99	8,29	35
7	Zinc	8,75	9,48	10	10

IV. Conclusion

Based on the research conducted following conclusions were made:

1) mineral composition of *Calligonum aphyllum (Pall.) Guerke*. is represented by 43 elements and 16 of them are in negligible quantities;

2) content of heavy elements from 0,1 mg/kg to 10 stays within maximum allowable concentrations;

3) the plant accumulates heavy metals in required concentrations for growth and thus protects environment.

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