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Mineral Elements in a Succulent Plant Species, *Orostachys spinosa* L. (Crassulaceae)

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Abstract

Nine mineral elements (in oxide form) were revealed in the ash of leaves and stems of *Orostachys spinosa*. The content of Ca was the highest (62.63%), while the contents of other elements, such as K, Mg, P, Si (varied between 4.63 and 11.96% of absolute dry weight), S, Fe, Mn, Zn (varied between 0.05 and 2.89%) were relatively lower. After estimation of the content of mineral elements (in absolute dry weight) of *O. spinosa*, we revealed that the Ca, Fe, and Mn were relatively higher in *O. spinosa* than those in the other plants.

Key words: ash, element content, medicine, *Orostachys spinosa*

Introduction

A succulent plant species, *Orostachys spinosa* L. is growing in the steppe zone of Mongolia and other regions of Central Asia. Despite of its use in traditional medicine for many years, there are very few studies on medicinal values of this plant. Therefore, it is important to conduct a specific research on this species. The objective of our research is the determination of the macro- and microelements in the ash of *O. spinosa*, in order to define the chemical elements with medicinal values.

Before this work, we discovered Crassulacean Acid Metabolism (CAM) in a native Asian genus, Orostachys (Oyungerel *et al*., 2004). The species studied here, *O. spinosa* also shows the CAM plant characters. The main characteristics are the higher night- and lower daytime acidity values, the leaf stomata open during the night and the higher transpiration intensity at night time than daytime. Due to ecological factors of the environment and duration of growing season, sometimes, CAM species easily switch to other types of photosynthetic pathway. However, *O. spinosa* keeps its CAM characteristics throughout the growing period and regardless of changes in the environmental conditions (Oyungerel *et al*., 2004).

The CAM plants have ability to keep water in their cells, can endure dry and hot conditions, and grow in desert areas. These plants are poorly studied in Mongolia.

A host of plants with CAM photosynthesis live in the shadows of humanity without most people recognizing their unique daily activities. Worldwide, CAM plants such as cacti and bromeliads can be found in countless homes and workplaces. CAM plants also occur naturally with high abundance, where they demonstrate powerful survival abilities, e.g., desert cacti in southwest of North America, the euphorbs of North Africa, bromeliads in rainforest canopies, the Aloe trees of the Kalahari Desert, or the spiny forests in Madagascar. Also they are important crops, e.g., the plantations of pineapple in Hawaii and South America or Agave in Central America (Black & Osmond, 2003).

In the steppe zone of Mongolia, *O. spinosa* is grazed by sheep and goats, and is used by humans as a cold drink, in soups, and for the medical treatments of scabs, hemorrhoids and inflammation (Khaidav *et al*., 1985; Ulziikhutag, 1985; Chastukhina, 1995; http://biodiversity.uno.edu/delta).

Material and Methods

For our study we selected a leaf succulent plant species, *Orostachys spinosa* L. belonging to the

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Figure 1 . *Orostachys spinosa* L. Flowering stage. 31 August 2005. In saira of Chigestei River, Uliastai sum, Zavkhan aimag.

family Crassulaceae (Fig. 1). Plant samples were collected in summer (between July and September) of 2005 from the following places: Khonin Nuga, Doloogiin Am area, District Mandal, Province Selenge (N49^{0}02'53" E107^{0}16'01" elevation 1422m above sea level, temperate taiga forest); Segst Am area, District Yaruu, Province Zavkhan (N48^{0}15'73" E96^{0}43'70" 2302m a.s.l., mountain steppe); Chigestei River, District Uliastai, Province Zavkhan (N47^{0}44'25" E96^{0}49'40" 1742m a.s.l., river valley); Shar Khad area and around Fourth Electric Power Station in Ulaanbaatar city (N47^{0}54'03" E106^{0}49'12" 1262m a.s.l., mountain steppe).

The determination of the macro- and microelements in ash of O. spinosa is conducted in the laboratory of the University of Science and Technology of Mongolia using of Analyzer of X-ray fluorescence (HORIBA, MESA-500W) in November, 2005.

The ash of plant leaves and stems were fried at 700^{0}C in the Mupeli oven. The calcium content of the soil was measured by De Bardi's method, the soil potassium content was measured by Kramer-Tisdal's method, the soil magnesium content was measured by weight method and the soil iron content was measured by using rodanid.

Results

Macro- and microelements in the ash of *O. spinosa*. Nine mineral elements (in oxide form) were revealed in leaves and stems of *O. spinosa* (Table 1). The content of Ca was highest (62.63%) followed by K, Mg, P, Si (varied between 4.63 and 11.96%), and the contents of S, Fe, Mn, Zn were much lower (varied between 0.05and 2.89%) than the previous elements (Fig. 2A-F).

Also we calculated the contents of nine elements of *O. spinosa* in their absolute dry weight, and compared them with those of the other plant species (Table 2). Contents of Ca, Fe, and Mn were relatively higher than those in the other plants. While contents of Mg, Si, and S in *O. spinosa* and other plants were same, but contents of K, Zn, and P were lower in *O. spinosa* than those

Table 1. Content of mineral elements in the ash of *O. spinosa* (%)

Sample	Shar Khad area in Ulaanbaatar city		Fourth electric station in Ulaanbaatar city	Khonin Nuga area, in Selenge aimag	Uliastai, Zavkhan aimag	Yaruu, Zavkhan aimag	Average
	Leaf	Root		Leaf and stem			Leaf and
Date	August		September	August	August	August	stem
Calcium	76.86±2.73	34.09±0.26	64.95±0.43	72.34±0.36	52.04±0.52	61.21±0.15	62.63±8.44
Potassium	8.38±0.13	30.55±0.36	15.33±0.06	10.57±0.59	12.78±0.19	9.17±0.02	11.96±2.69
Magnesium	9.01±2.70	5.15±0.18	6.69±0.44	7.09±1.01	10.13±0.02	15.75±0.56	9.91±4.18
Phosphorus	1.92±0.004	14.11±0.06	4.89±0.036	2.60±0.09	6.05±0.015	4.99±0.07	4.63±1.45
Silicon	1.46±0.11	7.19±0.02	3.57±0.019	2.69±0.42	9.69±0.35	4.45±0.39	5.1±3.14
Sulfur	1.31±0.03	6.71±0.1	3.58±0.022	2.15±0.54	3.26±0.052	2.57±0.04	2.89±0.65
Iron	0.37±0.01	1.84±0.06	0.73±0.037	0.74±0.06	2.65±0.064	1.55±0.019	1.42±0.91
Manganese	0.69±0.02	0.11±0.03	0.194±0	0.58±0.08	0.50±0.002	0.26±0.01	0.38±0.19
Zinc	-	0.26±0.005	0.06±0.001	0.057±0.01	0.06±0.01	0.04±0.001	0.05±0.01

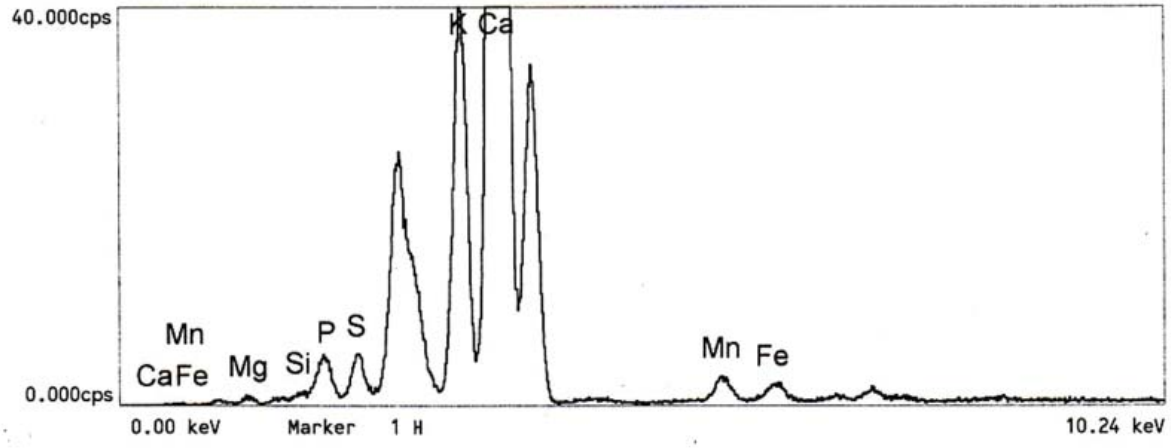

Figure 2. Mineral elements in the leaf of *O. spinosa* from Shar Khad area in Ulaanbaatar city.

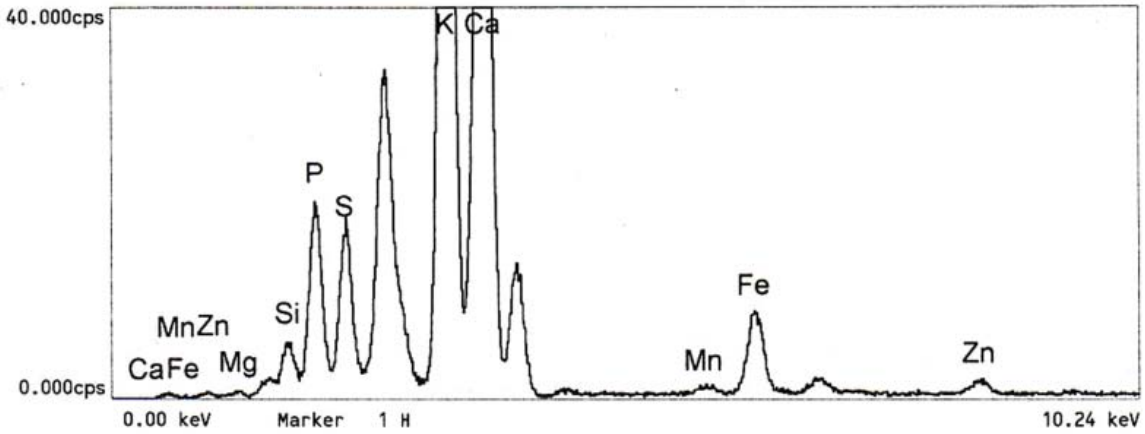

Figure 3. Mineral elements in the root of *O. spinosa* from Shar Khad area in Ulaanbaatar city.

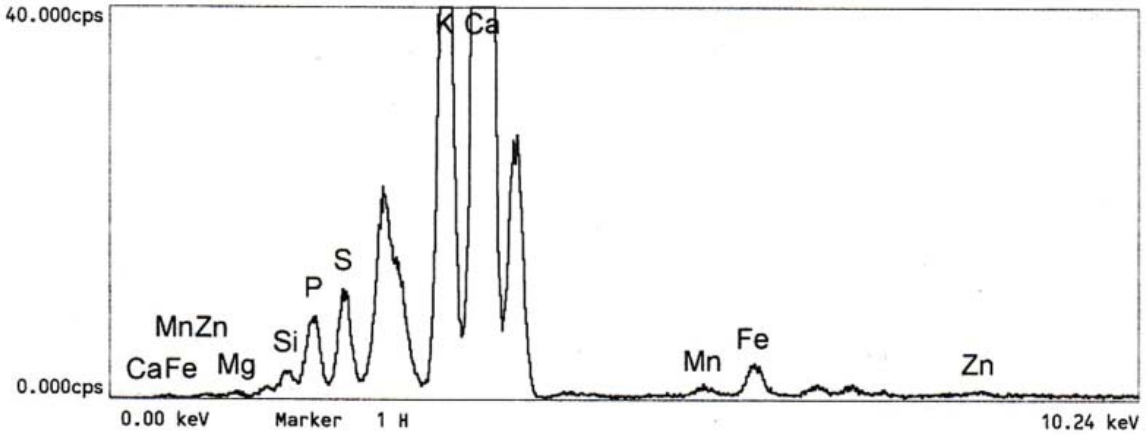

Figure 4. Mineral elements in the leaf and stem of *O. spinosa* from Fourth Electric Power station area in Ulaanbaatar city

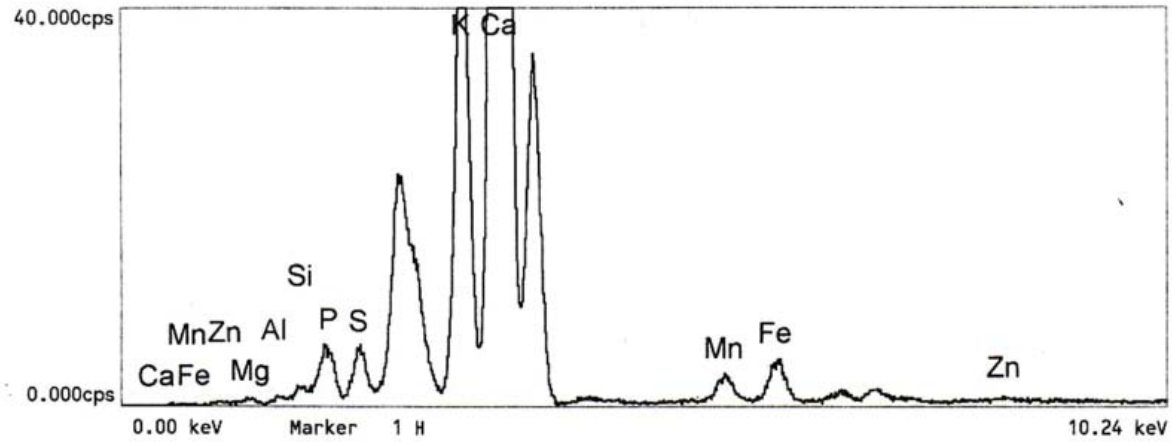

Figure 5. Mineral elements in leaf and stem of *O. spinosa* L. from Doloogiin Am area, Khonin Nuga, of Selenge, Mandal.

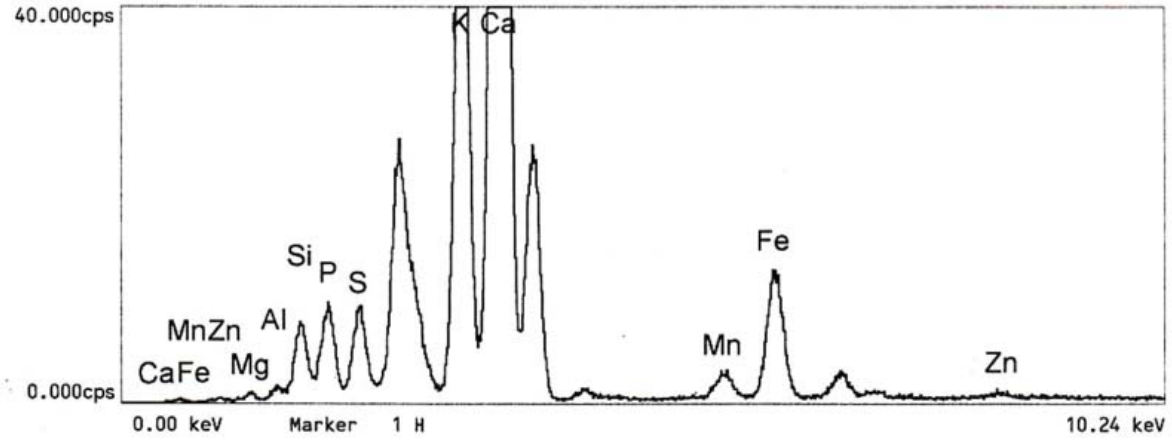

Figure 6. Mineral elements in leaf and stem of *O. spinosa* L. from Nogoon Khashaa area of Zavkhan, Uliastai.

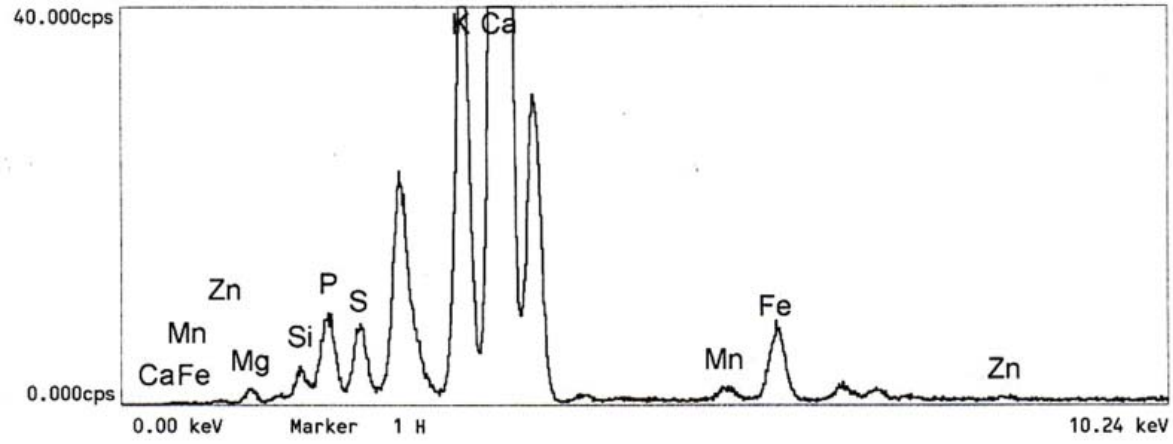

Figure 7. Mineral elements in leaf and stem of *O. spinosa* L. from Nariin goliin Adag area of Zavkhan, Yaruu.

in other plant species.

The revealed elements in *O. spinosa* are very important for the human organism. For example, Ca participates in clotting of the blood; Fe participates in hemopoiesis; Mn cures diabetes, hypertension and arteriosclerosis (Purev & Tsevegsuren, 2002). So, there are some possibilities to use this plant species for medical purposes.

Leaf and root. We defined 8-9 elements in leaves and roots of *O. spinosa* growing in Shar Khad area in Ulaanbaatar city. Content of Mn was more in the leaf than in the root, but other elements were more in the root than that in the leaf (Table 2, Figs. 2-7). Among these elements, Zn was found only in the root.

Plant and soil. Also we defined four macroelements (Ca, K, Mg, Fe) in the soils, in which O. spinosa grows, and these elements dissolved in water (Table 3). It was revealed that in most cases, the content of macroelements in *O. spinosa* depends greatly on the content of mineral elements in the soil. However, in some cases, there are negative correlation between the contents of mineral elements in plant tissues and soils, and we suppose that there are some macroelements with initialization form in the soils.

Thus, in the tissues of *O. spinosa* six macroelements (Ca, K, Mg, P, Si, S) and three microelements (Fe, Zn, Mn) are found. The relative content of all these elements, their physiological function and role for mammals are given below in a comparative way using some data by other researchers (Tsendeekhuu, 1990; Outlaw *et al*., 2002; Purev & Tsevegsuren, 2002).

1. Content of Ca varied between 1.29 and 1.95% in dry weight, and its maximum value

Table 2. Comparison of mineral elements in *O. spinosa* and other plants (in absolute dry weight, %)

	Shar Khad area in Ulaanbaatar city		Fourth electric station in Ulaanbaatar city	Khonin Nuga area, in Selenge aimag	Uliastai, Zavkhan aimag	Yaruu, Zavkhan aimag	Average (in leaf and stem)	Contents in other plants
	Leaf	Root	Leaf and stem					
Calcium	1.38	1.71	1.95	1.64	1.46	1.29	1.59	0.5
Potassium	0.15	1.73	0.46	0.24	0.36	0.19	0.31	1.0
Magnesium	0.16	0.26	0.2	0.16	0.28	0.33	0.24	0.2
Phosphorus	0.03	0.71	0.15	0.06	0.17	0.1	0.12	0.2
Silicon	0.03	0.36	0.11	0.06	0.27	0.09	0.13	0.1
Sulfur	0.02	0.33	0.11	0.05	0.09	0.05	0.08	0.1
Iron	0.006	0.09	0.02	0.02	0.07	0.03	0.04	0.01
Manganese	0.012	0.005	0.006	0.02	0.01	0.005	0.01	0.005
Zinc	-	0.01	0.001	0.002	0.001	0.001	0.001	0.002

Table 3. Comparison of mineral elements (%) in *O. spinosa* and soil

Samples	Ca		Mg		P		Fe	
	Plant	Soil	Plant	Soil	Plant	Soil	Plant	Soil
Zavkhan, Uliastai	1.29	0.31	0.28	1.62	0.17	0.02	0.07	0.017
Zavkhan, Yaruu	1.46	1.03	0.33	1.85	0.1	0.018	0.003	0.019
Shar khad area in UB	1.38	0.6	0.16	1.59	0.03	0.024	0.006	0.012
Khonin nuga, Selenge	1.64	0.78	0.16	1.97	0.06	0.003	0.02	0.007
4th E.P. Station in UB.	1.95	0.46	0.2	1.59	0.15	0.006	0.02	0.002

is found in the samples from mountain steppe (Fourth Electric Power Station in Ulaanbaatar city). Average content of Ca, determined in the plant tissue samples from four different habitats was equal to 1.59%, which is three times greater than that in the other plants. In animals: it is known that the Ca decreases the shock of nervous system, increases the heart beat rate, participates in clotting of the blood and regulates enzyme activity. In plants: used in the synthesis of new cell walls, particularly in the middle lamellae that separate newly divided cells and in the meiotic spindle during cell division. Ca frequently precipitates as soluble crystals of oxalate.

2. Content of K varied between 0.19 and 0.46%, and its maximum value was found also in the samples from the mountain steppe (Fourth Electric Power Station in Ulaanbaatar city). Average content of K in the plant tissue samples from four different habitats was equal to 0.31%, which is three times as lower as than that in the other plants. In animals: K influences on the activity of nervous system, heart blood vessel, muscle, liver, and kidney. In plants: functions in ionic regulations such as the osmotic potential of plant tissues. It also activates some proteins and starch

synthesis.

3. Content of P varied between 0.06 and 0.17%, and its maximum value was found in the samples from the river valley (Uliastai, Zavkhan). Average content of P in the plant tissue samples from four different habitats was equal to 0.12%, which is 1.6 times as lower as that in the other plants. In animals: deficiency of P in young organisms changes the bone function. In plants: P is an integral component of important membrane compounds and active turnover component of intermediary metabolism, respiration and photosynthesis. It has an essential role in energy metabolism. P is also a component of different vitamins and the activities of numerous enzymes are regulated by phosphorylation and dephosphorylation processes.

4. Content of Mg varied between 0.16 and 0.33%, and its maximum value was found in the samples from mountain steppe (Yaruu, Zavkhan). Average content of Mg in the plant tissue samples from four different conditions was equal to 0.24%, which is the same as in other plants. In animals: in case of Mg deficiency, symptoms such as failure of the nervous system, dizziness, trembling of hands and legs appear. In plants: Mg activates many enzymes in respiration, photosynthesis, plus DNA and RNA synthesis. Mg is also an important compound of chlorophyll.

5. Content of S varied between 0.05 and 0.11%, and its maximum value was found in the samples from mountain steppe (Fourth Electric Power Station in Ulaanbaatar city). Average content of S in the plant tissues from four different conditions was equal to 0.08%, and it is same content size as in the other plants. In animal organisms: S is essential for the detoxifying process in the liver. In plants: most sulfur occurs in proteins, especially in the amino acids, cysteine ant methionine and is a constituent of thiamine, biotin and coenzyme S is also essential element for respiration processes such as photosynthesis and the breakdown of fatty acids.

6. Content of Si varied between 0.06-0.27%, and its maximum value was found in the samples from the river valley (Uliastai, Zavkhan). Average content of Si in the plant tissue samples from four different habitats was equal to 0.13%, which is same as in the other plants. In animals: Si has an essential role for the protection of organism as it eliminates toxic substances with the urine. In plants: Si is deposited primarily in the endoplasmic reticulum, cell walls, and intercellular spaces as a hydrated amorphous form and thus may serve an alternate to lignin for the reinforcement of plant cell walls.

7. Content of Fe varies between 0.02 and 0.07%, and its maximum value was found in the samples from river valley (Uliastai, Zavkhan). Average content of Fe in the plant tissue samples from four different habitats was equal to 0.04%, which is four times as greater as in the other plants. In animals: the deficiency of Fe causes anemia. In plants: Fe plays the central bioenergetic role in the transfer of electrons (redox reactions). Fe can be stored as an iron-protein complex, phytoferritin.

8. Content of Mn varies between 0.005 and 0.02%, and its maximum value was found in the samples from temperate taiga forest (Mandal, Selenge). Average content of Mn in the plant tissue samples from four different habitats was equal to 0.01%, which is two times as greater as in the other plants. In organism: Mn intensifies distinction of the insulin, so it used in case of diabetes. Also it cures hypertension and arteriosclerosis. In plants: best defined function of Mn is in the photosynthetic process in which oxygen is produced from water.

9. Content of Zn varies between 0.001 and 0.002%, and its maximum value was found in the samples from temperate taiga forest (Mandal, Selenge). Average content of Zn in the plant tissue samples from four different habitats was equal to 0.001%, which is about two times as lower as in the other plants. In animals: in case of Zn deficiency, the ability of tasting and smelling, and the appetite are decreases. In plants: Zn participates in the chlorophyll formation process and prevents chlorophyll destruction. Zn is required to synthesize the growth hormone, such as auxin.

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References

Black, C.C. & Osmond, C.B. 2003. Crassulacean acid metabolism photosynthesis: Working the

night shift. *Photosynthesis Research*, 76: 329-341.

Chastukhina, S.A. 1995. Medical and Food Plants. Kolimi, *Magadan, AO "MAOBTI"*, p. 76 (in Russian)

Khaidav, Ts., Altanchimeg, B. & Varlamova, T.S. 1985. *Medicinal Plants in Mongolian Medicine*. Ulaanbaatar, p. 188-363. (in Russian)

Oyungerel, Sh., Tsendeekhuu Ts. & Tserenkhand, G. 2004. A study to detect CAM plant in Mongolia. *Mongolian Journal of Biological Sciences*, 2(1): 29-37.

Outlaw, W., Tsendeekhuu, Ts., Sukhdolgor, J. & Enkhmunkh, B. 2002. Plant Physiology. UB. p. 115-315. (in Mongolian, English languages)

Purev, D. & Tsevegsuren, N. 2002. Biochemistry. Ulaanbaatar, p. 307-318. (in Mongolian)

Tsendeekhuu, Ts. 1990. Plant physiology. Ulaanbaatar, p. 178-186. (in Mongolian)

Ulziikhutag, N. 1985. Key to the Forage Plants in the Pasture and Hay-making Areas of the Mongolian People's Republic. Ulaanbaatar, p. 248-249. (in Mongolian)

http://biodiversity.uno.edu/delta

http://www.legendtour.ru/eng/mongolia/info10.shtml

Хураангуй

Хатгуур үлд өвс (*Orostachys spinosa*)-д есөн төрлийн эрдэс элемент газрын дээрх эрхтний үнсэнд исэл байдлаар илэрсэн бөгөөд тэдгээрийн хэмжээг харьцуулахад Ca-ийн агууламж хамгийн их (62.63%), түүний дараа K, Mg, P, Si (4.63-11.96%) орох бөгөөд S, Fe, Mn Zn зэрэг нь бусад элемент харьцангуй бага (0.05-2.89%) агууламжтай байв. Хатгуур үлд өвсний хуурай жинд агуулагдах эдгээр элементийн хэмжээг бусад ургамалынхтай харьцуулахад Ca, Fe, Mn харьцангуй их хэмжээтэй илэрсэн бөгөөд Ca цус бүлэгнүүлэх, Fe цус төлжүүлэх, Mn чихрийн шижин, даралт бууруулах болон судасны хатуурлын эсрэг үйлчлэлтэй зэрэг хүний бие организмд чухал ач холбогдолтой учир түүнийг эмчилгээний зорилгоор ардын төдийгүй анагаах ухааны эмчилгээнд хэрэглэх үндэслэлтэй болохыг тогтоов.

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