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Biomonitoring properties of mosses in Semey town area of the Irtysh River

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ABSTRACT

The property of plants to store high concentrations of heavy metals in their organs isnow the object of world research in order to identify the level of environment pollution. For the first time, the evaluation of biomonitoring properties of two species of mosses *Brachythecium campestre (Muel.Hal.)* and *Bryum caespiticum (Hedw., Sp. Musc. Frond.),* which are most common on the territory of Semey town area of the Irtysh River, was carried out. The concentration of Cd, Cu, Co, Pb, Ni, Zn, Fe, Mn was analyzed using the method of atomic absorption spectrometry. The level of pollution of the studied territory and accumulative properties of mosses were discovered.

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INTRODUCTION

The Irtysh River is the longest River in the Republic of Kazakhstan. Irtysh rises in the mountains of Altai, flows on the territory of East Kazakhstan for about 1700 kilometers, and joins the Ob River [1].

Semey town is situated in the western part of East-Kazakhstan oblast, and lies on both banks of the Irtysh River. There are several big manufacturing enterprises in the town which inject hundreds of ton of harmful substances into the atmosphere [2]. Cement works, construction materials works, machinery works, hardware plant are the biggest manufacturing enterprises of the town. In general, the environmental situation is worsened by many years of nuclear weapon tests on Semipalatinsk nuclear test site [3].

Heavy metals are considered as most common and dangerous environmental pollutants for biota. Soils are able to deposit and accumulate them. Furthermore, the particular danger of heavy metals is that,having been accumulated by soil, they transfer into plants and in future they can transfer to animals and humans on food chains, and this can cause a number of pathologies and diseases [4-10].

Due to the existing ecologic situation on the studied territory, there is a pressing problem of identifying species of plants which are able to help to carry out biological monitoring of environment and, in future, to take steps to improve its condition. This problem is topical not only on the territory of East Kazakhstan or the Republic of Kazakhstan as a whole, but the whole world. Recent researches taken in different countries support this fact and point at possibility to use mosses as biomonitors of environment [11, 12]. However, such species of mosses as *Fontinalis antipyretica* [13], *Hylocomium splendens*, *Sphagnum russowii* [14], *Pleurozium Schreberi*, *Scleropodium purum*, *Thuidium tamariscinum* [15] and some other ones, which foreign researchers usually mentionin their works, are not suitable for dry weather conditions of steppe in East Kazakhstan.

In East Kazakhstan the detailed study of species diversity of mosses and possibility to use them as biomonitors has not carried out before. Such researches are conducted on this territory for the first time.

Methods:

Floodplain of the Irtysh River in the area of Semey town was chosen as the territory of the research. The territory equal to 120 square kilometers including natural zones of steppes and pine forest situated in the floodplain of the Irtysh River was examined. In all, 360 data collection units situated at a different distance from Semey town were chosen and then examined. The objects of the research were soil and two species of moss: *Brachythecium campestre (Muel.Hal.)* and *Bryum caespiticum (Hedw., Sp. Musc. Frond.)*.

Plant classification was carried out according to standard comparative anatomic morphological method using different guides [16, 17].

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The identification of concentration of heavy metals was carried out in "Physicochemical methods of research in Biology" laboratory of al-Farabi Kazakh National University, using method of atomic absorption spectrometry [18, 19] with atomic absorption spectrometer MGA-915 MD. As a research material, top soils and mosses from the data collection units were used. Samples of soil and specimens of moss were taken according to the “envelop method”. For that purpose, sample areas in the form of a square equal to $1m^2$ were made in the three equally spaced data collection units. Specimens were gathered in angles of the selected square and in the center of it.

In order to identify the level of pollution of the environment, nine chemical elements which are common in the sources of anthropogenic pollution of the studied territory were chosen. They are Cd, Cu, Co, Pb, Ni, Zn, Fe, Mn. The process of identification of the concentration of heavy metals was carried out three times in a row.

The main part:

For the purpose of the research, two species of moss, which are widely spread on the studied territory and differ in biologic and ecologic features, were chosen. They are *Brachythecium campestre* and *Bryum caespiticum.*

*Brachythecium campestre (Muel.Hal.)*is rather robust plant in loose, somewhat pale green or yellow-greenmats. Stems are creeping, 12 cm. long, irregularly or quite regularly to subpinnately branched; stem leaves crowded. Branches are erect, acuminate, 15 mm. long; branch leaves are crowded as well. Stem and branch leaves are similar, erect when wet, about 2-2.4 mm. long and 0.7-0.8 mm. wide [16].

Specimens of *Brachythecium campestre* were gathered in July andAugust 2012-2013 on the territory of the pine forest. The first specimens were found as a part of vegetation at a distance of about 20 kilometers away from Semey town in a north-easterly direction, and 30-35 km. in the northerly and easterly directions (pic.1). Moss grows on the surface of forest floor consisting mainly of partly decomposed pine needles and rare remains of herbaceous vegetation, rarely on putrefying branches and stubs. The highest percentage of foliage cover of *Brachythecium campestre* (60-70%) was registered on open territories between pine trees (*Pinus sylvestris ssp. kulundensis*) where there are fewer pine needles and at the same time there is a shade during the most part of the day provided by near-growing trees.

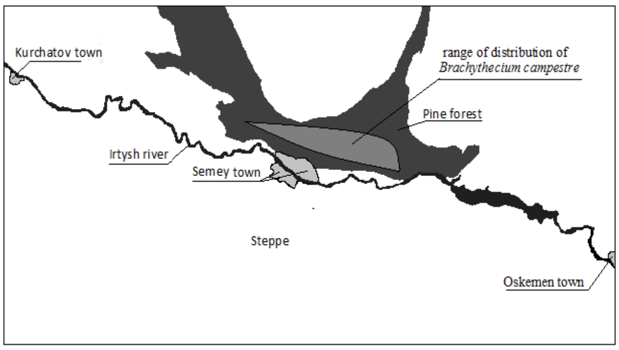
The analysis of the concentration of heavy metals in soils of the pine forest showed the tendency of lowering of the level of pollution of the territory with heavy metals concerning all analyzed elements and distance from Semey town to the north and the north-east (Table 1). In the Eastern part of the studied territory, lowering of concentration of Cu, Co, Pb, Ni, Zn, Mn and increase in concentrations of Cd and Fe were registered.

Bryum caespiticum Hedw., Sp. Musc. Frond. grows in dense, green or green-yellow tufts. Tufts are densely tomentose. Stem of female shoot is short, ca. 1 cm. long, comose; subterminal shoots 1-4, 0.5-1.0 cm. long, rather evenly imbricate to comose. Rhizoids are ferruginous-brown or red. Upper leaves are erect-spreading when wet, loosely appressed when dry; to 2.7 mm. long, 0.8-1.2 mm. wide[17].

*Bryum caespiticum*is widely spread species on the territory of dry steppe. The species was also registered in the pine forest, especially often on slashing sites (picture 2).

As a part of steppe plant community, the species is often found in tangle of *Spiraea hypericifolia L.*, and also among absinthial and gramineous vegetation on open places between plants.

In the westerly direction, 40 km. away from the town, increase of concentrations of Cd, Cu, Co, Ni, Zn, Fe, Mn was registered. Further from the town, 60 km. away, lowering of the concentration of all elements was registered, especially sharply lowering ones are the concentrations of Pb and Zn. In the south-westerly direction, 20 km. away from the town, the highest concentrations of Co and Ni were registered. The increase in concentrations of Zn and Mn were identified with 40 km. away from the town. Lowering of concentration of Co, Ni, Zn and Mn was registered in 60 km. and 10 km. distance. The tendency of increase of concentrations of Cd, Cu, Pb and Fe with the distance from the town was identified (Table 1).



Picture 1: Area of distribution of *Brachythecium campestre*.

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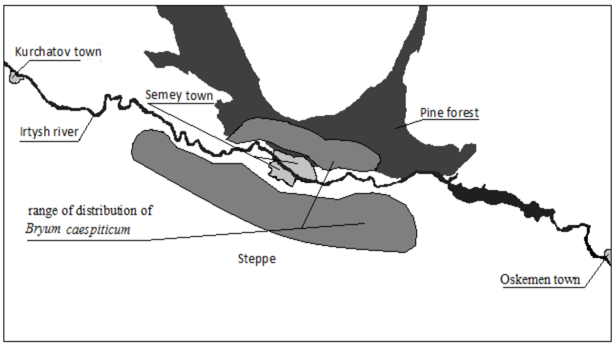
Table 1: Average concentration of heavy metals in soil samples.

Cardi-naldirec-tions	The distance from Semey town, km.	The concentration of elements (mg/kg)							
		Cd	Cu	Co	Pb	Ni	Zn	Fe	Mn
West	10	0,03±0,001	6,36± 0,08	3,6± 0,076	37,35 ± 0,71	13,17 ± 0,5	145,6 ± 2,43	23894 ±378,42	1575 ±27,3
	20	0,08±0,003	6,36 ±0,17	5,54 ±0,15	32,37 ±0,73	17,14 ±0,28	172,9 ±3,7	40436 ±505,2	2430 ±36,5
	40	0,44±0,008	8,64 ±0,14	10,53 ±0,27	33,2 ±1,1	26,82 ±1,04	263,9 ±8,25	29408 ±346,15	3150 ±58,02
	60	0,18 ± 0,007	7,32 ±0,16	8,03 ±0,22	16,6 ±0,47	19,84 ±0,51	93,16 ±3,007	33084 ±475,61	2250 ±31,08
South-west	10	0,24 ±0,008	6,48 ±0,17	8,03 ±0,210	39,01 ±1,2	22,69 ±0,63	200,2 ±5,601	40436 ±622,3	2340 ±32,4
	20	0,12 ±0,002	6,72 ±0,21	11,36 ±0,2	34,03 ±0,77	25,07 ±0,6	145,6 ±3,5	9190 ±173,24	1530 ±27,8
	40	0,4 ±0,006	5,52 ±0,13	4,99 ±0,16	32,37 ±0,802	15,87 ±0,541	282,1 ±4,8	47788 ±728,5	5265 ± 63,25
	60	0,41 ± 0,06	7,12 ± 0,11	5,96 ±0,076	45,37 ±1,05	16,12 ±0,32	237,23 ±3,86	49483 ±647,15	4434 ±121,3
South-east	10	0,78 ±0,012	5,32 ±0,08	8,547 ±0,141	24,12 ±0,55	15,132 ±0,21	92,78 ±1,69	28681 ±623,07	1648,23 ±67,41
	20	0,66 ±0,009	4,65 ±0,18	7,98 ± 0,11	22,36 ±0,672	12,132 ±0,301	88,344 ±3,46	19387 ±288,65	1256,5 ±34,41
	40	0,44 ±0,007	3,18 ±0,04	3,405 ±0,08	12,45 ±0,25	9,9 ±0,272	87,8 ±0,909	13650 ±521,008	1530 ±14,2
	60	0,61 ±0,008	3,45 ±0,06	3,547 ±0,05	12,63 ±0,201	8,76 ±0,089	85,3 ±1,33	10788 ±255,1	1833,11 ±20,07
North	10	0,44 ±0,01	8,11 ±0,14	4,86 ±0,06	26,12 ±0,3	19,12 ±0,27	101,2 ±1,3	52778 ±657,5	702 ±6,85
	20	0,5 ±0,006	6,92 ±0,16	5,268 ±0,05	13,44 ±0,288	13,66 ± 0,26	65 ±0,83	57649 ±755,2	688,2 ±21,01
	40	0,133 ±0,002	6,33 ±0,06	3,77 ±0,062	13,2 ±0,12	15,2 ±0,25	44,5 ±0,86	48626 ±524,1	645 ±7,86
	60	0,06 ±0,001	3,074 ±0,08	3,632 ±0,05	11,62 ±0,328	10,44 ±0,2	44,16 ±0,723	33150 ±445,6	680 ±9,2
North-east	20	0,22 ±0,001	2,4 ±0,06	0,83 ±0,02	14,11 ±0,52	9,52 ±0,156	27,3 ±0,3	7352 ±67,2	180 ±0,42
	40	0,22 ±0,006	2,5 ±0,05	0,84 ±0,011	7,5 ±0,087	5,48 ±0,101	26,8 ±0,35	7121 ±62,8	180 ±2,5
	60	0,18 ±0,004	2,1 ±0,02	0,621 ±0,0072	6,55 ±0,086	5,5 ±0,041	25,78 ±0,37	7111 ±49,3	167 ±1,7
East	40	0,04 ±0,001	1,166 ±0,02	1,362 ±0,035	13,28 ±0,46	4,5 ±0,072	30,36 ±0,37	10335 ±126,4	986 ±35,1
	60	0,13 ±0,004	1,665 ±0,03	1,45 ±0,0612	12,7 ±0,31	4,22 ±0,062	31,75 ±0,68	11375 ±175,6	1140,11 ±52,41



Picture 2: Area of distribution of *Bryum caespiticum*

In the processoftheresearch, accumulativepropertiesofmossesweremeasured (Table 2, 3).

Table 2: Average concentration of heavy metals in specimens of *Brachythecium campestre.*

Cardinal directions	The distance from Semey town, km.	The concentration of elements (mg/kg)							
		Cd	Cu	Co	Pb	Ni	Zn	Fe	Mn
North	40	0,21 ±0,001	8,26 ±0,2	5,066 ±0,8	32,88 ±1,1	68,015 ±0,4	176,22 ±3,6	13203,1 ±154,1	102,3 ±1,9
	60	0,02 ±0,001	8,13 ±0,085	5,3 ±0,05	39,58 ±1,1	53,17 ±1,8	180,04 ±2,6	11004,1 ±111,54	142,02 ±3,2
North-east	20	0,36 ±0,006	5,64 ±0,14	1,5 ±0,02	47,3 ±1,8	25,31 ±1,1	115,2 ±2	4420 ±68,2	266,6 ±7,74
	40	0,25 ±0,008	4,81 ±0,044	1,33 ±0,067	22,13 ±0,75	24,74 ±0,33	75,06 ±2,2	4405 ±83,7	224,03 ±4,3
	60	0,31 ±0,007	3,05 ±0,033	1,01 ±0,01	26,37 ±0,32	18,71 ±0,28	62,11 ±1,8	4230 ±65,5	26,14 ±0,58
East	40	0,12 ±0,005	3,56 ±0,12	4,02 ±0,19	42,08 ±2,1	21,01 ±0,32	117,06 ±3,45	7015 ±89,6	111,03 ±4,1
	60	0,22 ±0,008	3,02 ±0,041	4,11 ±0,15	48,04 ±2,1	21,3 ±0,62	117,2 ±2,5	7142,8 ±85,3	425,41 ±18,11

Table 3: Average concentration of heavy metals in specimens of *Bryum caespiticum.*

Cardinal directions	The distance from Semey town, km.	The concentration of elements (mg/kg)							
		Cd	Cu	Co	Pb	Ni	Zn	Fe	Mn
West	10	0,336 ±0,005	7,794 ±0,16	5,246 ±0,056	25,941 ±0,81	51,68 ±1,005	164,37 ±5,2	23760,5 ±296,3	708,33 ±21,3
	20	0,136 ±0,002	6,163 ±0,08	4,633 ±0,16	28 ±0,92	29,05 ±0,45	211,02 ±7,12	1103,26 ±13,65	3959,18 ±65,2
	40	0,478 ±0,01	12,208 ±0,433	11,576 ±0,23	12,25 ±0,03	33,89 ±0,58	311,25 ±7,82	5586,25 ±57,63	2708,33 ±35,8
	60	0,425 ±0,02	7,947 ±0,12	4,83 ±0,11	21,894 ±0,37	116,81 ±1,12	118,19 ±1,11	1199,09 ±46,15	7633 ±96,47
South-west	10	3,2 ±0,063	8,5 ±0,34	8,01 ±0,18	36,56 ±0,92	37,2 ±0,84	287,35 ±7,36	11032,4 ±354,5	896,7 ±10,65
	20	3,3 ±0,055	25,2 ±1,12	15,3 ±0,253	33,8 ±1,36	28,86 ±0,95	225,45 ±6,41	7658 ±85,3	889,35 ±34,12
	40	1,5 ±0,02	11,8 ±0,34	15,11 ±0,53	11,35 ±0,09	56,77 ±1,58	523,21 ±12,1	46255 ±568,02	3896,44 ±68,5
	60	0,575 ±0,008	3,048 ±0,077	2,176 ±0,063	25,029 ±0,941	20,7 ±0,43	625,65 ±25,31	19837,1 ±358,15	3476 ±56,23
South-east	10	1,8 ±0,005	12,06 ±0,56	7,35 ±0,4	44,16 ±1,24	22,151 ±0,46	328,02 ±11,5	12468 ±563,23	1067,11 ±65,2
	20	1,82 ±0,017	9,34 ±0,246	7,78 ±0,0933	18,08 ±0,31	24,35 ±1,102	230,06 ±8,471	26477,1 ±655,125	1105,41 ±24,56
	40	1,6 ±0,04	9,1 ±0,351	6,41 ±0,2	15,04 ±0,6	26,45 ±0,43	199,15 ±2,03	18634 ±636,2	1618,05 ±65,1
	60	1,41 ±0,02	8,51 ±0,34	6,01 ±0,13	7,056 ±0,17	24,02 ±0,87	176,06 ±4,86	9082,4 ±218,3	2055,03 ±82,5
North	10	1,47 ±0,06	14,2 ±0,55	5,17 ±0,1	28,49 ±0,9	35,7 ±1,1	176,52 ±6,1	12556 ±448,2	1215,3 ±54,06
	20	1,48 ±0,03	24,62 ±0,6	2 ±0,07	14,3 ±0,36	36,76 ±1,2	230,4 ±8,42	14420 ±356,4	412,8 ±11,6
	40	3,54 ±0,071	32,7 ±0,86	8,22 ±0,303	12,6 ±0,31	52,62 ±0,98	92,11 ±3,0	18564 ±378,56	689,2 ±17,5
	60	1,1 ±0,02	6,32 ±0,1	6,05 ±0,085	7,8 ±0,11	38,62 ±1,01	89,02 ±1,64	8568,44 ±178,34	456,5 ±9,17

Conclusion:

It was identified that accumulation properties of *Brachythecium campestre* and *Bryum caespiticum* differ on a number of points (Table 2, 3).

The comparison of quantitative content of heavy metals in the specimens of *Brachythecium campestre* and soil samples showed the property of moss to accumulate Cd, Cu, Co, Pb, Ni, Zn and, occasionally, Mn. In soil the average concentration of Cd is 1.5-2 times as high, CuandCo is almost twice as high, Pb and Zn is more than 3 times as high, Ni is more than 4 times as high. In *Brachythecium campestre* the concentration of Fe is, in average, half as lowas in soil.

Tests for Mn showed - in two cases the concentration of the element in moss was higher than in soil, and both cases relate to the north-eastern part of the territory. In other cases, the concentration of Mn in moss was higher than in soil. On the whole, accumulation properties of *Brachythecium campestre*can be shown by the line of chemical elements arranged in a decreasing way: Ni>Zn>Pb>Cu>Co>Cd>Mn>Fe.

For *Bryum caespiticum* was registered that in moss the concentration of Cd is 4-7 times as high as in soil, the concentration of Cu is 2.5 times as high, the concentration of Ni is 2.6 times as high, the concentration of Zn is twice as high. In soil the concentration of Fe is about twice as much as in *Bryum caespiticum*.

In some cases the concentrations of Co and Mn were rather higher in soil samples, and in some cases - in moss specimens. On the whole, calculation of proportions of the measurements allowed considering the concentration of these elements in soil and moss as an equal one.

The thorough calculations allowed identifying that in most cases *Bryum caespiticum*a llocates Pb rather more than soil does. Thus, accumulation properties of *Bryum caespiticum* can be shown by the line of chemical elements arranged in a decreasing way: Cd>Ni>Cu>Zn>Pb>Co, Mn>Fe.

The comparison of allocation properties of specimens of *Brachythecium campestre* and *Bryum caespiticum* gathered in the northern part of the studied area showed the difference of their biomonitoring properties. As a result, it was registered that *Brachythecium campestre* allocates Pb (twice as much), Ni (1.5 times as much) and Zn (0.6 times as much) more than *Bryum caespiticum* does. In turn, *Bryum caespiticum*a llocates more Cd (almost 17 times as much), Cu (2.5 times as much) and Mn (3 times as much). Allocation of Co may be considered as an equal one. The concentration of Fe in both species of moss is almost twice as low as in soil. Thus, these species of moss are not active allocators of Fe.

Results:

The results of the research performed showed thaton the territory near Semey town in dry weather conditions of steppe for biomonitoring it is more reasonable to use *Bryum caespiticum*. This is also supported by the fact that it is widely spread on the studied territory and it has quite strong accumulation properties for heavy metals.

REFERENCES

[1] Rivers of Kazakhstan. Date Views 14.12.2013 www.myhomekz.com/zentralni-kazakhstan/reki-kazahstana/.

[2] Panin, M.S., 2000. Ecological and biochemical evaluation of the technogenic landscapes of the Eastern Kazakhstan. Almaty: “Avery” publishing house, pp: 338.

[3] Semey. Date Views 14.12.2013www.ru.wikipedia.org/wiki/Semey/.

[4] Health risks of heavy metals from long-range transboundary air pollution, 2007. WHO Regional Office for Europe. Data Views 14.12.2013 www.euro.who.int/__data/assets/pdf_file/0007/78649/E91044.pdf.

[5] Mudgal, V., N. Madaan, A. Mudgal, R.B. Singh and S. Mishra, 2010. Effect of Toxic Metals on Human Health.Data Views 14.12.2013. www.benthamscience.com/open/tonutraj/articles/V003/ 94TONUTRAJ.pdf.

[6] Morais, S., F. Garcia e Costa and Maria de Lourdes Pereira, 2012. Heavy Metals and Human Health.Environmental Health – Emerging Issues and Practice, pp: 227-246. Data Views 14.12.2013 www.intechopen.com/books/environmental-health-emerging-issues-and-practice/heavy-metals-and-human-health/.

[7] Martin, S., W. Griswold, 2009. Human Health Effects of Heavy Metals.Environmental Science and Technology Briefs for Citizens.Date Views 14.12.2013 www.intechopen.com/books/environmental-health-emerging-issuesand-practice/heavy-metals-and-human-health.pdf.

[8] Lu, Y., W. Yin, L.B. Huang, G.L. Zhang, Y.G. Zhao, 2011. Assessment of bioaccessibility and exposure risk of arsenic and lead in urban soils of Guangzhou City, China. Environment Geochem. Health, 33: 93-102.

[9] Komárek, M., V. Chrastný, M. Mihaljevič, 2008. Lead isotopes in environmental sciences: Dataa review. Environment, 34: 562-77.

[10] Al-Saleh, I., N. Shinwari, I. El-Doush, G. Biuedo, M. Al-Amodi, F. Khogali, 2004. Comparison ofmercury levels in various tissues of albino and pigmented mice treated with two different brands of mercury skin-lightening creams. Biometals, 2: 167-75.

[11] Chakrabortty Sh., Paratkar Govind Tryambakro, V.G. Ket's, 2006. Biomonitoring of Trace Element Air Pollution Using Mosses.Aerosol and Air Quality Research, 6(3): 247-258. Date Views 14.12.2013www.aaqr.org/VOL6_No3_September2006/2_AAQR-06-09-OA-0002_247-258.pdf
[12] Zeichmeister, H.G., K. Grodzinska and G. Szarek-Lukaszewska, 2003. Bryophytes, Markert, BA., Breure, AM, and Zeichmeister, HG. (Eds.), Elsevier, Oxford, pp: 329-375.
[13] Ramiro, J.E., Martins, R. Pardo, A.R. Rui Boaventura, 2002. Cadmium(II) and zinc(II) adsorption by the aquatic moss Fontinalis antipyretica: effect of temperature, pH and water hardness. Views 14.12.2013www.sciencedirect.com/science/article/pii/S0043135403005803/.
[14] Ket's, V.G., 2006. Biomonitoring of Trace Element Air Pollution Using Mosses. Chakrabortty et al., Aerosol and Air Quality Research, 6(3).Views 14.12.2013www.aaqr.org/VOL6_No3_September2006/2_AAQR-06-09-OA-0002_247-258.pdf.
[15] Florence, K.L. Adoli, Joseph O. Lalah, Alexander O. Okoth, 2010. Analysis of Moss and Topsoil to Monitor Metal Emissions from a Pulp and Paper Mill in Western Kenya. Bull Environ Contam Toxicol. Springer Science and Business Media, LLC. Date Views 14.12.2013 www.springer.com/.
[16] Ignatov, M.S., E.A. Ignatova, 2003. Flora of mosses Central part of European Russia (1). Moscow, pp: 1-608.
[17] Ignatov, M.S., E.A. Ignatova, 2004. Flora of mosses Central part of European Russia (2). Moscow, pp: 609-944.
[18] Lurie Ju., Nikolaeva, Z.V., 1957. Determination of small concentrations of lead.Head. lab., 6: 228.
[19] Methods for determination of trace elements in soils, plants and water, 1974. "Kolos", Moscow, pp: 446.