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Mosses-Bioindicators in the Environmental Monitoring of Air Pollution by Metal Ions and Radionuclides

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Abstract

The purpose of our research was to identify the degree of air pollution with ions of mettals and radionuclides using moss bioindicators. For the studied samples of moss and soil near Mingechaur, Baku to identify the bioindicator properties of moss and for bioindication of air and soil. Concentrations of heavy metals were determined on an Agilent Technologies 7500 Series ICP-MS (7500cx) instrument using inductively coupled plasma mass spectrometry (ICP-MS, USA). The activity of radionuclides were determined on Gamma spectrometer "Canberra" (USA)γ-spectrometer with high a purity germanium detector (HP Ge). The content of metal ions in the studied samples collected from the least polluted territory of the city of near Mingechaur, which amounted for moss samples: Cd (0.19689), (Cu (59.19030), Ni (18.746), Pb (62.40856), Zn (50.11554) and Hg (0.060154); for soil samples - Cd (1.07352), (Cu (23.24958), Ni (20.33940), Pb (27.45685), Zn (12.11554) and Hg (0.059426) mg / kg, respectively. The content of heavy metals in the studied samples collected from the most polluted area nearthe city of Sumgait was experimentally determined, and for samples of mosses, they were Cd (0.61976), (Cu (64.28251), Ni (22.75801), Pb (65.70956), Zn (167.50293) and Hg (0.091319); for soil samples, Cd (0.29681), (Cu (27.61957), Ni (25.669), Pb (28.596), Zn (87.10275) and Hg (0.090798) mg / kg, respectively. It was determined the activity of radionuclides (7Be, 40K, 60Co, 208Tl, 134Cs, 137Cs, 210Bi, 212Bi, 212Pb) in the samples of of moss, soil and water samples taken from the Mingechaur region and in Baku region of the Azerbaijan Republic. As a result of the research it was revealede the activity of 40K was more than other isotopes (648,1 Bq/kg). It was found out 7Be of activity 79.08 Bq/kg, 214Pb of activity 62.62Bq/kg, 214Bi of activity 28.74 Bq/kg, 137Cs of activity 14.01 Bq/kg, 134Cs of activity 12.15 Bq/kg, 60Co of activity 11.34 Bq/kg and oters, which were more in Mingechaur region than in Baku.

Keywords: Moss; Pollution; Heavy metals; Radionuclides; Mass spectrometry; Bioindicators.

1. Introduction

Mosses are effective accumulators of pollutants contained in the atmosphere. Biomonitoring of atmospheric pollution with of heavy metals, radionuclides and other chemical elements using moss is one of the simplest, most promising and effective methods for monitoring, detecting and evaluating changes in air quality.

Rapid industrialization in cities and the contributory relationships with the original pollution sources can cause serious environmental problems within cities [1-4].

Mosses are living organisms of the plantae kingdom and classified in the phylum bryophyta. They grow in forests, on rocks, on trees, bare soil, cracks of concrete side walls, on burnt bricks on abandoned automobiles, and uncompleted buildings [5].

Previous research works have shown that mosses have proven to be better bioindicators of pollution because they are more sensitive to atmospheric pollution [6].

Meanwhile, atmospheric metals pollution in Nigerian cities has been reported [7] reported that the atmosphere of Owode - onirin in Lagos - state, Southwestern, Nigeria is highly polluted with the heavy metals: Zinc Zn (66.01%), Lead Pb (15.99%), Copper Cu (12.79%), Chromium Cr (2.89%), Nickel and Ni (2.25%) [7].

Mosses are comparatively more effective at accumulating elements and heavy metals than other plant species. Therefore, moss biomonitoring was used as a complementary technique alongside classic instrumental methods in air pollution detection and control. Also, mosses have been used as bioindicators for terrestrial long-lived

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radionuclides (40K, 238U, and 232Th) and artificial radionuclides (137Cs, 90Sr, and 239+240Pu) in the environment [8-12].

The purpose of this work was a qualitative and quantitative assessment of atmospheric air pollution by metal ions and with radionuclides to study regional and local pollution of both atmospheric air and the soils of the studied area by environmental pollutants during biomonitoring of biospheric pollution.

In experimental studies as a bioindicator for air bioindication and determining the degree of contamination of the biosphere with environmental pollutants, we used moss collected in the vicinity of Mingechauri and Baku.

2. Materials and Methods

We have carried out experimental studies and collecting samples of moss, soil from the vicinity of Mingechaur and Baku.

For the determination of metal ions it has been noted that the process has been carried out for the preparation of the microwave oven EN-45, soil and Crudeoil procedure, at a temperature of 35 - 40 ° C, followed by grinding and homogenizing the samples. According to the Soiland Crudeoil DG-EN-45, samples were taken 0.2 0.25 g and the reagents were added; 10 ml of 65% HNO_3, 1 ml of 1% HCl, 1 ml of 30% H_2O_2.

The activity of radionuclides   in the tests of soil, plant and water, was carried out at "Canberra" (USA)γ-spectrometer with high a purity germanium detector (HP Ge).

3. Results and Discussion

The data of quantitative determination of metal ions in moss and soil samples collected from the most polluted territory near Mingechaur using inductively coupled plasma mass spectrometry are presented in Tables 1 and 2.

Table-1. The results of the **analysis of moss samples** collected from the most polluted areas near the city of Mingechaur

Metals	ppm (mg/kg)
Cd	0.53978
Cu	63.19252
Ni	20.55710
Pb	63.40856
Zn	161.20163
Hg	0.061379

Table-2. The results of the analysis of soil samples collected from the most polluted area near the city of Mingechaur

Metals	ppm (mg/kg)
Cd	0.27662
Cu	25.51854
Ni	23.46601
Pb	27.45603
Zn	85.00345
Hg	0.060578

The content of heavy metals in moss and soil samples collected from the most polluted areas near the city of Mingechaur, which amounted to samples for mosses: Cd (0.53978), (Cu (63.19252), Ni (20.557), Pb (63.40856), Zn (161.20163) and Hg (0.061379); for soil samples, Cd (0.27662), (Cu (25.51854), Ni (23.466), Pb (27.456), Zn (85.00345) and Hg (0.060578) mg / kg, respectively (Fig. 1, 2).

Fig-1. Data on the content of metal ions in the studied soil samples collected from the most polluted area near the city of Mingechaur
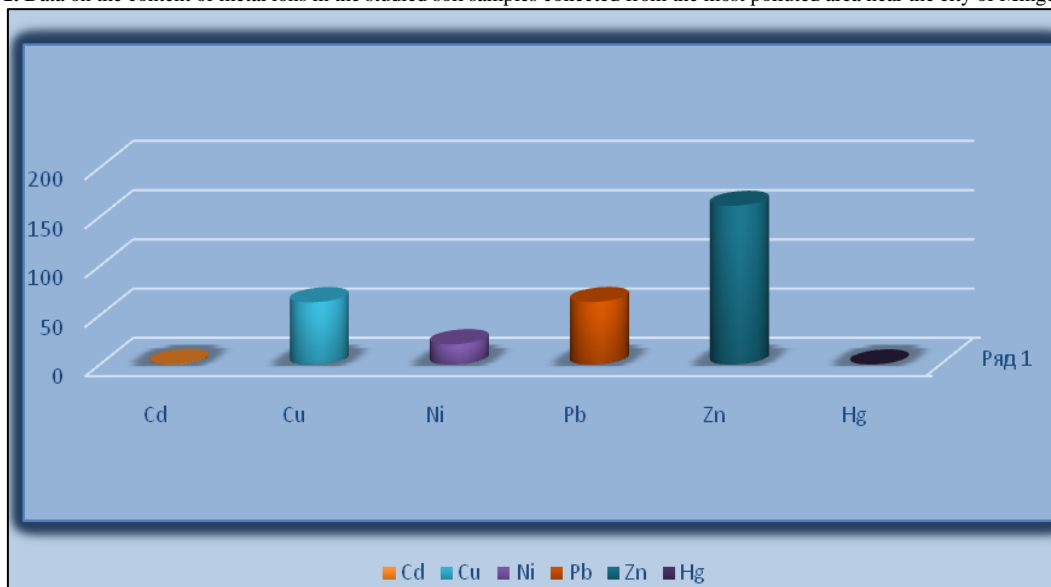
The data of quantitative determination of metal ions in moss and soil samples collected from the least polluted territory of Baku by mass spectrometry with inductively coupled plasma are presented in Tables3 and 4.

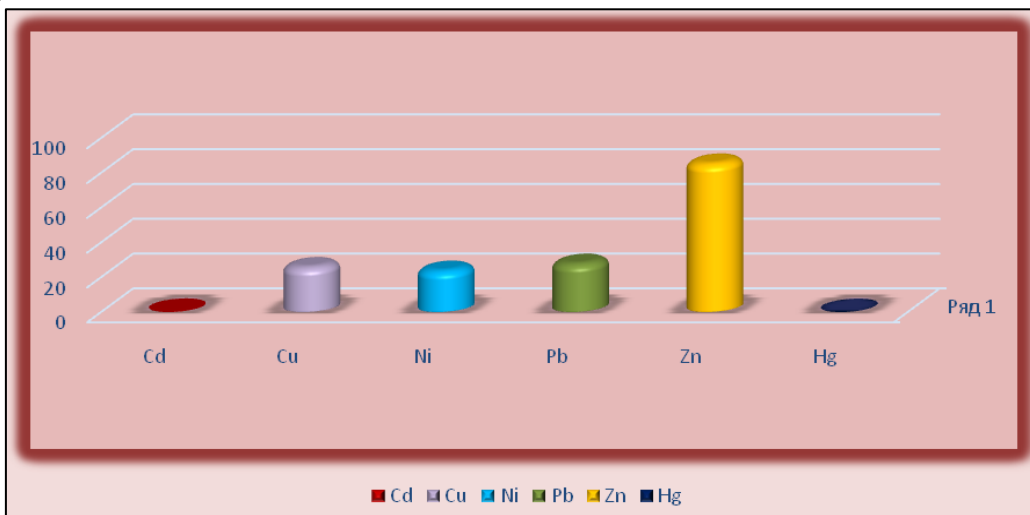**Table-3.** Data of quantitative determination of metal ions in moss samples by mass spectrometry with inductively coupled plasma collected from the least polluted territory of Sumgait

Metals	ppm (mg/kg)
Cd	0.61976
Cu	64.28251
Ni	22.75801
Pb	65.70956
Zn	167.50293
Hg	0.091319

Fig-2. Comparative data on the content of metal ions in the studied samples of moss collected from the most polluted area near the city of Mingechaur

Table-4. Data of quantitative determination of metal ions in soil samples by the method of mass spectrometry with inductively coupled plasma, collected from the least polluted territory of Sumgait

Metals	ppm (mg/kg)
Cd	0.29681
Cu	27.61957
Ni	25.66903
Pb	28.59614
Zn	87.10275
Hg	0.090798

As a result of the analyzes, the content of metal ions in moss and soil samples collected from the least polluted territory of Baku was found, which amounted for samples of moss: Cd (0.61976), (Cu (64.28251), Ni (22.75801), Pb (65.70956), Zn (167.50293) and Hg (0.091319); for soil samples, Cd (0.29681), (Cu (27.61957), Ni (25.669), Pb (28.596), Zn (87.10275) and Hg (0.090798) mg / kg, respectively (Fig.3, 4).

Fig-3. Data on the content of metal ions in the **studied soil samples** collected from the least polluted territory of Sumgait
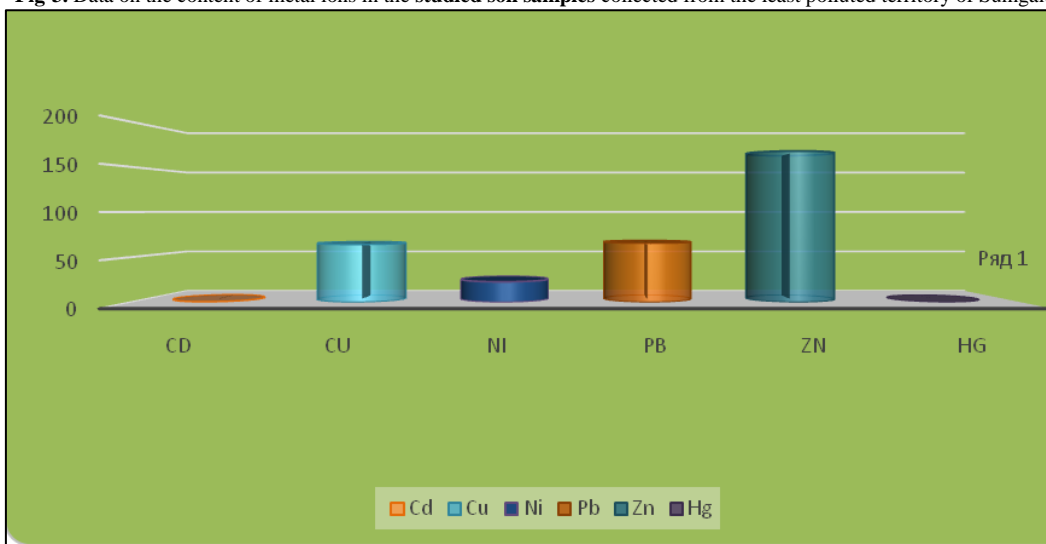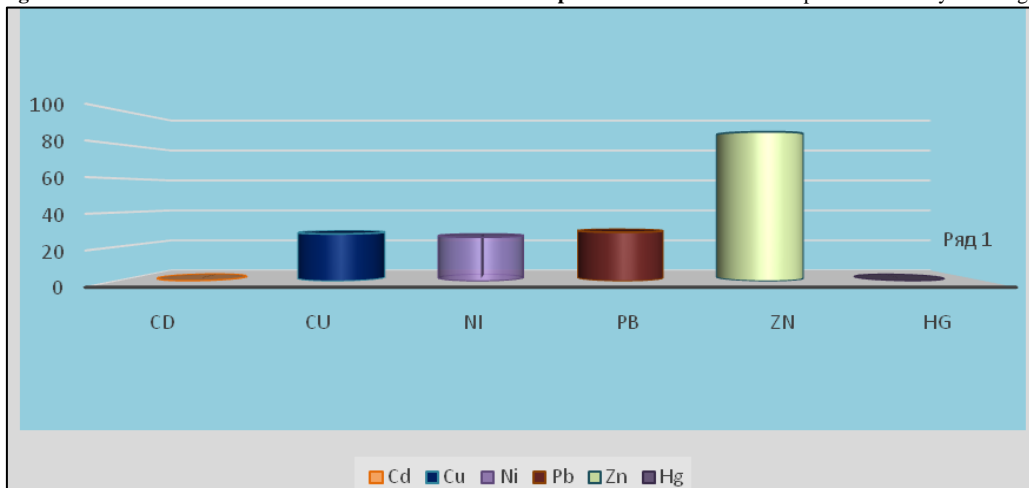
Fig-4. Data on the content of metal ions in the **studied moss samples** collected from the least polluted territory of Sumgait

Thus, when comparing the concentration of metal ions in the samples under study, we can assume that mosses are subject to anthropogenic impact, these data provide the basis for the use of mosses as bioindicators to identify the degree of contamination of the biosphere by pollutants.

Based on the experimental data obtained, it can be stated that the method of mass spectrometry with inductively coupled plasma provides the necessary data on the degree of contamination of the atmosphere with toxic substances, which is reflected in the elemental composition of mosses. Analysis of these data showed that mosses are informative plant species indicating the ecological state of the environment.

It was determined the activity of radionuclides (^{7}Be, ^{40}K, ^{60}Co, ^{208}Tl, ^{134}Cs, ^{137}Cs, ^{210}Bi, ^{212}Bi, ^{212}Pb) in the samples of of moss, soil and water samples taken from the Mingechaur region and in Baku region of the Azerbaijan Republic.

The weight of the of moss, soil and water samples were measured at an electron microscope.

Only natural radioactive elements were revealed in the investigated samples. These radionuclides are - ^{7}Be, ^{40}K, ^{60}Co, ^{208}Tl, ^{134}Cs, ^{137}Cs, ^{210}Bi, ^{212}Bi and ^{212}Pb isotopes.

The activity of radionuclides in samples of moss, soil and water samples are given in fig 5, 6.

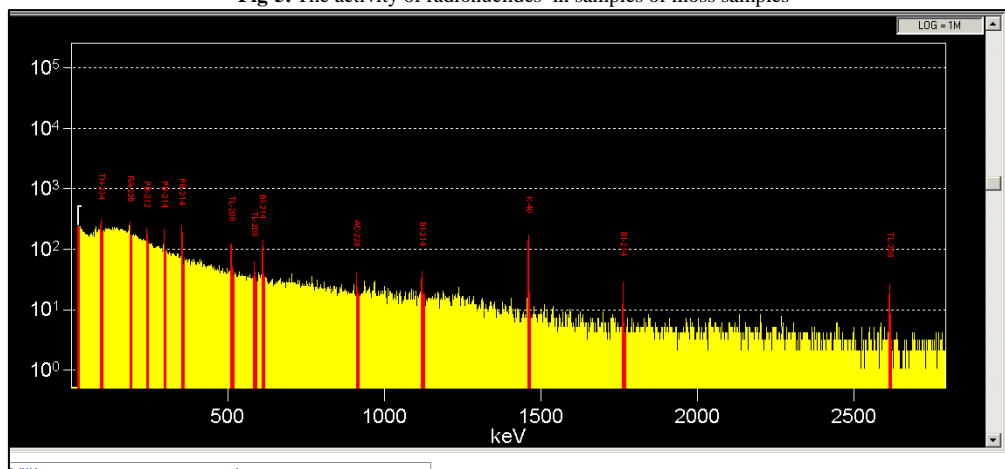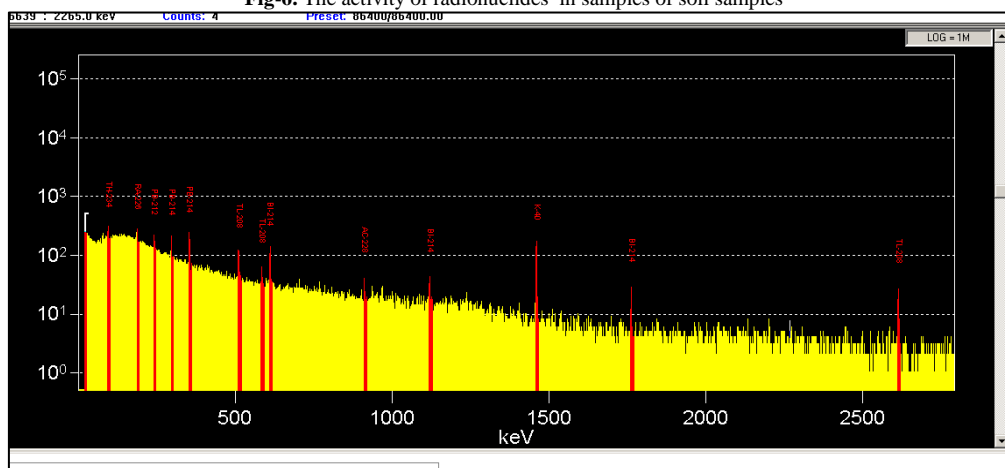**Fig-5.** The activity of radionuclides in samples of moss samples

Fig-6. The activity of radionuclides in samples of soil samples

In this way the magnitude of the activity of radionuclides in moss samples was revealed. soils and water.

The activity of ^{40}K was more than other isotopes (648,1 Bq/kg). It was found out ^{7}Be of activity 79.08 Bq/kg, ^{214}Pb of activity 62.62Bq/kg, ^{214}Bi of activity 28.74 Bq/kg, ^{137}Cs of activity 14.01 Bq/kg, ^{134}Cs of activity 12.15 Bq/kg, ^{60}Co of activity 11.34 Bq/kg and oters, which were more in Mingechaur region than in Baku

Acknowledgements

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