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ECOLOGICAL AND GENETIC MONITORING OF THE AGRO- AND BIODIVERSITY OF THE COASTAL ZONE OF WESTERN GEORGIA

David Baratashvili

Batumi Shota Rustaveli State University,
35/32 Ninoshvili Rustaveli Str., Batumi, 6010, Georgia
baratashvili5@mail.ru

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Abstract. The intensity of heavy metals, natural and anthropogenic radionuclides are studied in the cultivated plants and soil in the vicinity of the western coast of Georgia. It is shown that the intensity of their accumulation depends on the type of plant, the place of sampling and the ecological zone. The highest rate of natural radionuclides is ^{40}K, and the lowest – ^{226}Ra, from the technogenic radionuclides the high-quality activeness is characterized to ^{137}Cs, and its accumulation is the highest in the soil. From the hard metals, the plants most actively absorb lead and cadmium.

Key words: biodiversity, radionuclides, heavy metals, highway, monitoring

1. Introduction

Georgia is one of the most outstanding countries in the world with its agro- and biodiversity. It always surprised the foreign travelers visiting Georgia centuries ago, including the well-known scientists of flora and fauna.

Scientific technological progress and increased anthropogenic factors have significantly aggravated the variation of the biocenoses of the Black Sea coast of western Georgia, which was contributed by the chemical and radioactive contamination of the environment. Marine and automobile transport make a significant contribution to chemical contamination, and radioactive contamination is mainly strengthened by the radionuclides caused by Chernobyl catastrophe [1].

Georgia is a transit country where thousands of lightweight and high-load vehicles are transported from Turkey, Russia, Armenia, Azerbaijan and other areas that pollute the environment with toxic pollution and harmful gases. Perhaps that's why the lead content in the blood of Georgian population has increased.

2. Research place, object and methodology

5 ecological zones, 1–60 km away from the sea coast, were selected for study: Chakvi, Laituri, Tsetskhlauri, Legva, Anaseuli. The intensity of the accumulation of raidonuclides was studied in tea leaves and soil, and the content of heavy metals – only in plant leaves. The research objects were: silver Eucalyptus (Eucalyptus cinerea L.), tangerine Unshiu (Citrus reticulate), Kezhera Pkhali (Brassica oleraceae L.), ordinary tomatoes – Lycopersicon esculentum (Pink Choportula), cucumber – Cucumis sativus, ordinary beans – Phaseolus vulgaris (Batumura species). The – (Thea sinensis L.)

The samples were taken in the immediate vicinity of the motorway – 10 meters and 200 meters away.

Cytogenetic studies were carried out on the Carl Zeiss type microscope. Universally recognized methods modified by us have been widely used in the research [2, 3].

Heavy metals were determined on Atomic Absorption Spectrometer at the Laboratory Gamma Consulting in Tbilisi (Perkin-Elmer 300).

The spectrometric analysis of radionuclides was conducted on the gamma spectrometer at the small radioactivity laboratory of Ivane Javakhishvili State University.

3. Research Results

Studies conducted by us showed that the intensity of accumulating heavy metals (Cu, Zn, Pb, Cd) in the plant leaves on the territories adjacent to the central highways varies according to the plant species, variety and the dependence of sampling place from the motorway (Table 1).

Table 1

The content of heavy metals in certain agricultural and medicinal plant leaves (mg/kg)

N	Name of plant	Sampling distance from the highway, m	Cu	Zn	Pb	Cd
1	Eucalyptus cinerea	10	8.5	40.0	2.3	0.22
		200	7.8	17.5	1.7	0.17
2	Citrus reticulate	10	6.0	30.0	3.2	0.17
		200	7.5	20.0	3.2	0.17
3	Brassica oleraceae	10	7.3	115.0	5.0	0.19
		200	4.8	50.0	4.2	0.34
4	Lycopersicon esculentum	10	25.0	33.0	6.1	0.66
		200	25.8	25.0	5.0	0.66
5	Cucumis sativus	10	17.0	60.0	5.8	0.19
		200	16.6	55.0	5.0	0.12
6	Phaseolus vulgaris	10	14.5	145.0	5.0	0.25
		200	9.7	24.5	3.2	0.25
7	Maximum permissible concentrations for fruit and vegetables		5.0	10.0	0.5	0.03

A high level of heavy metal absorption (1.7–6.1 mg/kg) was observed in the tomato varieties of Vardisferi Choportula (Solanum lycopersicum) leaves (this indicator is 3 to 12 times higher than the permissible concentrations). The following place in this regard belongs to Kezhera Pkhali (a variety of Kohlrabi), cucumber and ordinary beans (a variety of Batumura).

Comparative analysis of heavy metal accumulation showed that the plants quite intensively absorb cadmium (Cd) as well. In this case, the amount of cadmium absorbed by them 4 to 22 times exceeds the permitted concentration. Unlike vegetable crops, woody plantsless intensely absorb heavy metals. They include the tangerine variety broadleaved Unshiu (Citrus reticulata), Japanese Cryptomeria (Cryptomeria japonica), Silver Eucalyptus (Eucalyptus cinerea).

The research methodology of heavy metal accumulation in plants included the sampling at different distances (10–200 m) away from the highway. As the results of the research show, there is no substantial difference towards copper, lead and cadmium according to this criterion. As for the Zinc (Zn), its maximum volume was observed in samples taken by the immediate vicinity of the highway (10 m).

Our studies have shown that in Kobuleti municipality tea plantations, which are quite far away from the motorway, the intensity of accumulation of heavy metals is significantly lower than the permissible norms (Table 2).

According to researchers, the metallization of biosphere principally changes the exchange balance of chemical elements established during thousands and millions of years in biota. Particularly dangerous is the disbalance of elements of high mutagenic activity, such as silver, lead, copper, cadmium, and others [4, 5].

There are different sources of hard metal penetration that can be both natural and anthropogenic [6].

The main anthropogenic way to penetrate Cd in the tea plantations of western Georgia is phosphate fertilizers, vehicle exhaust, burning oil products and so on.

The main way to get Cu into tea plant is the copper-containing fertilizers (Cuo, Cu_2O, $CuSO_4$, 3Cu $(OH)_2$, etc.). The use of copper-containing fungicides and bactericides may also cause copper accumulation to the phytotoxic level.

The main way to penetrate lead into the vegetation of western Georgia is the vehicle exhaust, since the petrol imported in Georgia from different countries contains a sufficient amount of lead. In many countries, including the USA, the use of lead as an additive to petrol fuel is prohibited since 1970s [6].

The main source of Zn in the environment is Zinc fertilizers (ZnO, $ZnCO_3$, $ZnCl_2$ and other), mining and processing of minerals, fecal waste, but in fact, they are not actually used under tea plantations. There are other sources that can play an insignificant role in contamination of plants with Zn (worn tires, vehicle exhaust, etc.).

Table 2

Some Heavy Metal Content in the Leaves of the Tea Plantations of Kobuleti Municipality (Mg/kg Calculation of dry air weight)

Sampling place	Cu	Zn	Pb	Cd
Anaseuli	10.3	23.4	2.1	0.1
Laituri	13.4	40.0	3.0	0.08
Tsetskhlauri	12.5	37.4	3.2	0.14
Legva	17.8	30.4	3.3	0.09
Chakvi	19.4	33.2	3.7	0.18
Maximum permissible concentrations of ready-made production of tea plant	100	50.9	10	1.0

Over the years, we have learned the general frequency and range of natural mutations in citrus and tea plant at the level of cell and chromosomes. Studies have shown that in 1980 the level of natural mutations of tea plant chromosomes varied from varieties and ecological zones within the limits of 1.5–2.5 %. The results we obtained in 1990 were more interesting. For this period the level of natural mutations of chromosomes was 2.5 times higher (4.7±0.5 %) than in 1980. The trend of decreasing the level of mutations of chromosomes was observed in 2000 and 2010 (Table 3) [7].

For scientific analysis and reasoning of the results obtained, we conducted radiation monitoring of the research regions to identify the technogenic and natural radionuclides. The results of the monitoring showed that the number of radionuclide ^{40}K and ^{137}Cs found in the coastal zone of the western Georgia was quite high. In particular, its content in plants in 1997–2003 did not exceed 5–100 Bq/kg, and in the soil – from 100 to 700 Bq/kg. As for the period prior to 1990s, the data is completely different. According to the results of the research in May-June 1986, the content of ^{137}Cs of various origin samples varied from 20 to 20 000 Bq/kg [1]. In our opinion, for the indicated period the increase of frequency of the natural mutation of chromosomes is associated with Chernobyl disaster.

Table 3

Distribution of the chromosomal aberrations in tea plant from the Western Georgia

N	Tea Plantations	Frequency of chromosomal aberrations, %			
		1980	1990	2000	2010
1	Anaseuli	1.9 ± 0.3	4.7 ± 0.5	3.8 ± 0.3	2.3 ± 0.4
2	Laituri	1.4 ± 0.2	4.1 ± 0.4	3.0 ± 0.4	2.0 ± 0.3
3	Tsetskhlauri	1.2 ± 0.2	4.9 ± 0.5	3.2 ± 0.2	2.8 ± 0.4
4	Legva	1.8 ± 0.3	5.0 ± 0.4	3.3 ± 0.3	2.5 ± 0.3
5	Chakvi	1.7 ± 0.3	5.4 ± 0.5	3.6 ± 0.4	2.7 ± 0.3

In the tea leaf and soil the specific activity is different according to the dependence of radionuclide type and ecological zone. As shown in table 4, the specific activity of ^{40}K is high in tea leaves, relatively low in soil. The specific activity of ^{137}Cs is relatively high in the soil. In case of lead and Radium, the advantage is given to the soil. Their amount in leaves is minimal.

Table 4

Natural and Anthropogenic radionuclides in soils and tea plant in the Western Georgia

N	Sampling place	Sample Type	Activity (BQ/KG) Dry Mass			
			^{40}K	^{137}Cs	^{210}Pb	^{226}Ra
1	Anaseuli	Soil	205 ± 17	549 ± 11	154 ± 30	101 20
		Tea Leaves	299 ± 23	23 ± 2	< MDA	<MDA
2	Laituri	Soil	255 ± 15	278 ± 6	116 ± 29	70 ± 16
		Tea Leaves	468 ± 37	20 ± 2	<MDA	<MDA
3	Tsetskhlauri	Soil	180 ± 13	201 ± 5	115 ± 29	50 ± 16
		Tea Leaves	307 ± 38	15 ± 2	<MDA	<MDA
4	Legva	Soil	246 ± 17	334 ± 7	167 ± 31	126 ± 19
		Tea Leaves	414 ± 25	8 ± 2	<MDA	<MDA
5	Chakvi	Soil	201 ± 17	538 ± 11	187 ± 34	101 ± 16
		Tea Leaves	312 ± 32	12 ± 2	53 ± 21	<MDA

In parallel to the radiological surveys of the sea coastline and vegetation cover of Western Georgia we have studied the soils of Adjara mountainous regions (Khulo, Shuakhevi, Keda and Khelvachauri municipalities). In total, 13 radionuclides have been studied, among them ^{40}K, ^{90}Sr, ^{137}Cs, ^{212}Pb are widely spread. (Table 5).

As data comparison analysis shows, ^{40}K content in mountainous soils is much higher than in the surrounding areas of the sea coast (see table 4 and 5). Depending on the depth of the soil, its specific activity varies slightly. The relatively high activeness ^{137}Cs and ^{90}Sr was reported in the villages of Khelvachauri municipality, which range from sea level to 10–100 meters (158–197 and 213–241 (Bq / kg) respectively).

Table 5

Specific Activity of Radionuclides in the Mountainous Regions of the Autonomous Republic of Adjara (Bq / Kg)

Sampling place	Soil depth, cm	Activeness (Bq / кg) calculated on dry weight			
		^{40}K	^{90}Sr	^{137}Cs	^{212}pb
Keda Municipality	0–20	715.0	58.3	22.2	41.5
	0–40	653.0	11.0	10.0	38.0
Shuakhevi Municipality	0–20	605.0	33.25	17.3	38.9
	0–40	683.0	19.3	9.0	41.5
Khulo Municipality	0–20	647.0	28.3	40.3	24.2
	0–40	688.0	20.0	34.8	23.3
Khelvachauri Municipality	0–20	409.0	197.7	213.8	28.7
	0–40	404.0	158.7	241.7	27.3

Conclusions

In the vegetation and soil of the coastal regions of Western Georgia, the radionuclides of natural and technogenic origin will are considered. Their specific activity is different depending on the types of ecological zone and sampling. The high specific activity of technogenic radionuclides is indicated in samples taken from the surrounding territories of the seaside and the natural ones - in the samples taken from 900–1100 meters above sea level.

Agricultural products of cultivated vegetative origin in the region are contaminated with heavy metals whose concentrations are significantly higher in the immediate vicinity of the motorway and in the plant samples of 10 km away the latter concentrations do not exceed the limits.

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