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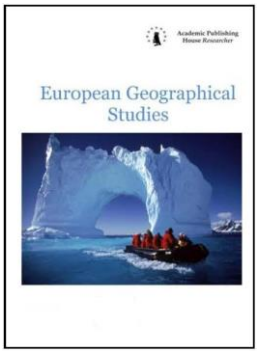

Contamination of Soils by Arsenic in Ambrolauri Municipality and Its Impact on the Health of the Population

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Abstract

In 2019, in Ambrolauri municipality, the level of soil contamination with arsenic as a result of exposure to hazardous industrial waste containing arsenic of the Racha Mining Chemical Plant was studied. In particular, a study was conducted on arsenic contamination of the soils of the villages Uravi, Abari, Utseri, Likheti and Sori Valleys.

Revealed that:

According to the results of the study, of Uravi soils are the most polluted in arsenic;

There is less arsenic pollution in the village of Utsera, Sori Valley and the village of Likheti (average level of pollution);

The village of Abara is relatively clean, a small area where arsenic contamination was observed.

It should be noted that in all cases the arsenic content is higher in the soil top (0-5 cm depth) than in the lower layer (5-20 cm depth). The health condition of the population of Ambrolauri municipality has been revealed.

Based on the 2016 statistical data of the National Center for Disease Control and Public Health, the population of Racha-Lechkhumi and Kvemo Svaneti among the regions of Georgia has the first place in terms of malignant tumours and diabetes.

Keywords: environmental pollution, soil, arsenic, Ambrolauri municipality, public health.

1. Introduction

The aim of the paper is to determine in some regions of Georgia (Racha-Lechkhumi and Kvemo Svaneti) the regularity of the spread of arsenic concentrations, which is by classification from hazard class 1. Soil norms standards -Maximum Permissible Concentration (MPC), Permissible Orientation Concentration (POC) and Clarks were used to visualize and evaluate the results (Methodological guidelines...; Supatashvili, 2009).

The toxicity of arsenic and its compounds has a long history. In the seventies of the last century, their carcinogenic properties were determined. Although, arsenic compounds are widely used in technology, agriculture, medicine, etc. Arsenic is a natural component of the Earth's crust and is common in any environment, air, water and soil. In a number of countries, arsenic is naturally found in groundwater. It is present in nature in organic and inorganic form, the latter being very toxic. Therefore, controlling the content of arsenic in natural waters, soil and food products and studying the regularities of distribution is one of the important and topical issues in the world.

Arsenic and arsenic compounds are included in the list of 10 toxic elements (Hg, Pb, Cd, As, Ni, etc.) that pose significant problems for human health (WHO) (Skalnaya et al., 2001).

Arsenic and arsenic compounds belong to the category of carcinogens proven to be a hazard (IARC) for human (Skalnaya et al., 2001; Arsenic and arsenic compounds...).

Although the ways in which arsenic gets into the body can be through the skin, the airways, it still gets into the human body mainly from food and drinking water. Organic arsenic species are most commonly found in seafood, while in terrestrial products are mainly found 3-5 valent arsenic forms and the unit is organic species. Therefore, arsenic is involved in the food chain mainly from contaminated soil and water (Laferashvili, 2008; European population...).

Arsenic is found in all types of soil. Its oxidation degree varies from -3, 0, +3, +5; the most common are As_2O_3 and As_2O_5. In terms of toxicity, arsenic chloride and salts: lead and copper ars/2mpounds can be represented as follows:

$$AsH_3 > As^{+3} > As^{+5} > R\ As^{x}$$

The main industrial mineral of arsenic in the soil is arsenopyrite (FeAsS).

According to the Basel Convention, arsenic belongs to the category of controlled waste (The Basel Convention..., 1989). All the above mentioned suggests that arsenic is included in the list of normalized substances.

2. Materials and methods

Research zone and methods

Arsenic ores have been established in Georgia (Racha-Lechkhumi and Kvemo Svaneti). They were used to produce arsenic-containing preparations. In the village of Uravi, at the Racha Mining Chemical Plant, 27 km from the mine, Lukhuni arsenic-containing ore was being recycled and white arsenic (As_2O_3) was received.

There were two mining and chemical plants in Lentekhi district – Tsani and Koruldashi.

Waste is generated by the extraction or the recycling of arsenic in arsenic ores, in the form of arsenic anhydride (As_2O_3) and other compounds, which causes them to accumulate in environmental objects (water, soil, plants).

Since 1993, both factories have ceased its functioning. To date, both deposits have been preserved and no arsenic has been produced. Problems include arsenic-containing waste and surrounding areas, including arable land. To date, a large amount of toxic waste left over from the Soviet era (more than 120,000 tons of residue containing 4-9 % white arsenic) has been stored near the villages of Uravi and Tsana. Waste was not safely disposed and there is a high risk of environmental (rivers, groundwater and soil) hazards (Gigauri et al., 2015; Bagrationi et al., 2014; Shavliashvili et al., 2017; Alexidze, Lolishvili, 2016).

It should be noted that in 2014–2016 a joint project of the Ministry of Environment and Natural Resources Protection of Georgia and the Ministry of Economic Affairs of the Netherlands "Management of arsenic-containing mining waste in Georgia" was carried out with mutual co-financing. In the municipalities of Ambrolauri and Lentekhi within the framework of this project, the first-line emergency works of the hazardous industrial waste containing arsenic were carried out.

Despite the work carried out, the content of arsenic in the soil is significantly high. Due to the high arsenic pollution of the soil (the pastures of the region and other agricultural lands) and food products, the health and lives of thousands of people are endangered.

In 2019, the National Environmental Agency (NEA) of the Ministry of Environmental Protection and Agriculture (MEPA) of Georgia carried out fieldworks in various villages of Ambrolauri Municipality. Soil samples were taken at a depths of 0-5 and 5-20 cm and the rolling form of arsenic was determined (Fomin, Fomin, 2001). In the studied municipality mainly Rau Humus Calcareous (rendzic leptosols) soils are common, their total area in Georgia is 4.5 % (317,200 ha), which are clay or loam mechanical characterized by neutral or weakly alkaline reaction (pH – 7.0-7.7) and in composition, with an abundance of silicate forms of iron. Humus content is moderate or small. The soils are deeply humusized, the humus type is humid. The carbonate content varies greatly (20-51 %). Montmorillonites and hydrocarbons predominate in the clay minerals. This soil is characterized by high fertility (Urushadze, 1997).

Soil sampling, labelling, storage and transportation were carried out using the standard methodology of the International Standard Organization (ISO). Laboratory works were performed using ISO and US EPA standard methods. The analyzes were carried out in the Laboratory of

Atmospheric Air, Soil and Water Analysis of the NEA of the MEPA of Georgia with the following technical and instrumental support:

1. Plasma-emission spectrometer ICP-OES;
2. Soil Digestion-Milestone – S tart D Microwave system;
3. pH meter – Milwaukee-Mi 150.

3. Results and discussion

In 2019, we studied the chemical study of the soils of the area contaminated with industrial waste from Arsenic, in particular, for the villages of Uravi, Abari, Utseri, Likheti and Sori Valleys. The results are given in Table 1, where the values of MPC, POC and Clark are given.

Measures to assess the degree of contamination of soils with heavy metals, which are currently used by environmental organizations, are based on the use of the MPC and the POC of the main standards (Methodological guidelines...). These standards were introduced into the legislation from the practice of working in a more homogeneous (water, air) environment. Using this approach is problematic for soils because they are heterogeneous and combine living and non-living, soil-dense, liquid and gaseous phases. It is therefore necessary to take a scientifically based approach to soil assessment, given its heterogeneity, as an important complex multi-component and multi-phase object.

According to the results of the survey, the maximum concentration of arsenic (moving form) according to the data of November 2019 is observed at a depth of 0-5 and 5-20 cm in the area of Uravi, respectively 81.35 (40.7 MPC) - 45.33 (22.7 MPC) mg/kg (Figure 1).

In the village of Utsera, the concentration of arsenic is 25.65 (12.8 MPC) – 9.00 (4.5 MPC) mg/kg at a depth of 0-5 and 5-20 cm (Figure 2).

Table 1. Arsenic in the soils of Ambrolauri Municipality Contents, November, 2019

	Sampling location (cm)		coordinates	As mg/kg
1	Uravi	0-5	X-0359699 Y-4723094	81.35
2	Uravi	5-20		45.33
3	utsera	0-5	X-0380753 Y-4722000	25.65
4	utsera	5-20		9.00
5	Soris Kheoba	0-5	X-0360029 Y-4717768	20.38
6	Soris Kheoba	5-20		2.51
7	Soris Kheoba	0-5	X-0359545 Y-4716415	10.82
8	Soris Kheoba	5-20		5.01
9	Sori Valley, near		X-0359193	15.19

	the Church	0-5	Y-4714541	
10	Sori Valley, near the church	5-20		6.07
11	Likheti	0-5	X-0355715	20.00
12	Likheti	5-20	Y-4717963	10.55
13	Abari	0-5	X-0359629	16.37
14	Abari	5-20	Y-4723832	10.92
15	Abari	0-5	X-0357634	11.25
16	Abari	5-20	Y-4719633	10.53
MPC				2
POC				10
Klark				1,7

According to the results of the survey, the maximum concentration of arsenic (moving form) according to the data of November 2019 is observed at a depth of 0-5 and 5-20 cm in the area of Uravi, respectively 81.35 (40.7 MPC) – 45.33 (22.7 MPC) mg/kg (Figure 1).

In the village of Utsera, the concentration of arsenic is 25.65 (12.8 MPC) – 9.00 (4.5 MPC) mg/kg at a depth of 0-5 and 5-20 cm (Figure 2).

The concentration of arsenic is relatively low in Sori Valley, which is defined as 3 points and is 20.38 (10.2 MPC); 15.19 (7.6 MPC) and 10.82 (5.4 MPC) mg/kg at a depth of 0-5 cm. The concentration of arsenic is much lower at a depth of 5-20 cm and therefore amounts to 2.51 (1.3 MPC); 6.07 (3.0 MPC) and 5.01 (2.5 MPC) mg/kg (Figure 3).

Approximately similar results are obtained in the village Likheti (20.00 (10.0 MPC) and 10.55 (5.3 MPC) (Figure 4).

The village Abari is clean compared to other facilities. Abari, where the concentration of arsenic was determined at two points and the maximum concentration of arsenic was observed at 16.37 (8.2 MPC) mg/kg, and at the second point – even lower – 11.25 (5.6 MPC) mg/kg 0-5 cm at depth. In depth, the concentration of arsenic decreases even more (Figure 5).

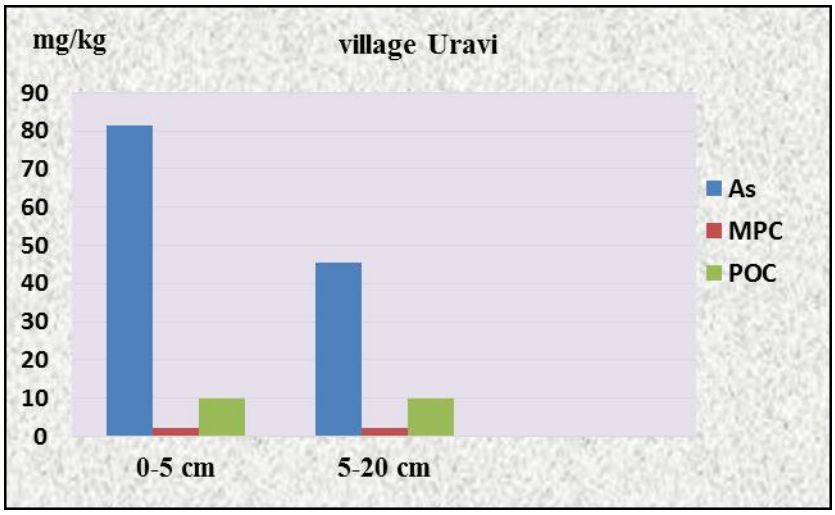

Fig. 1. Arsenic concentration in the village Uravi soils X-0359699 Y-4723094 at depths of 0-5 and 5-20 cm

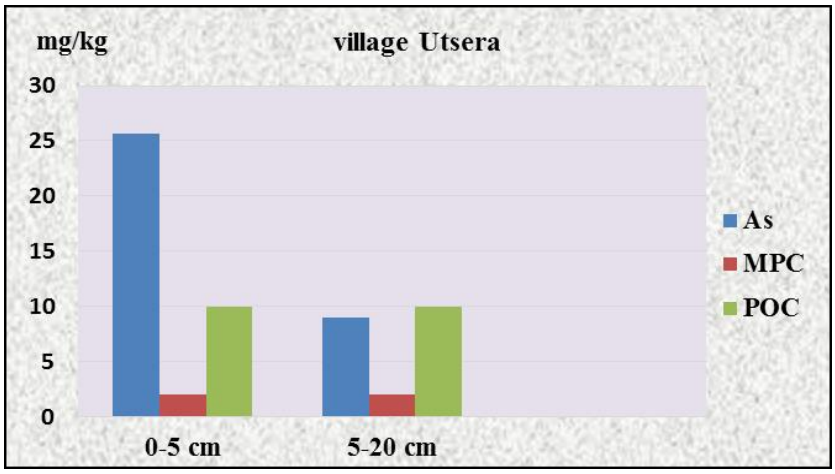

Fig. 2. Arsenic concentration in the village Utsrea soils at depths of 0-5 and 5-20 cm

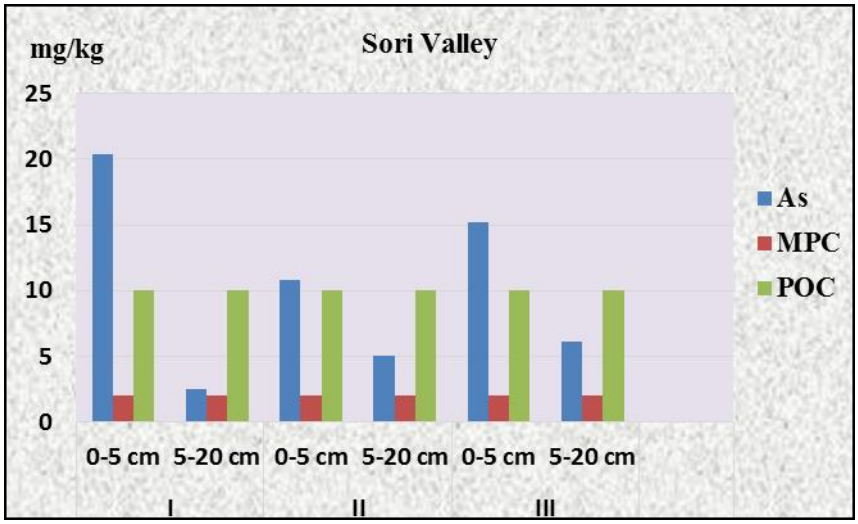

Fig. 3. Arsenic concentration in soils of Sori Valley at depths of 0-5 and 5-20 cm I – X-0360029 Y-4717768; II – X-0359545 Y-4716415 III – X-0359193 Y-4714541 (near the church)

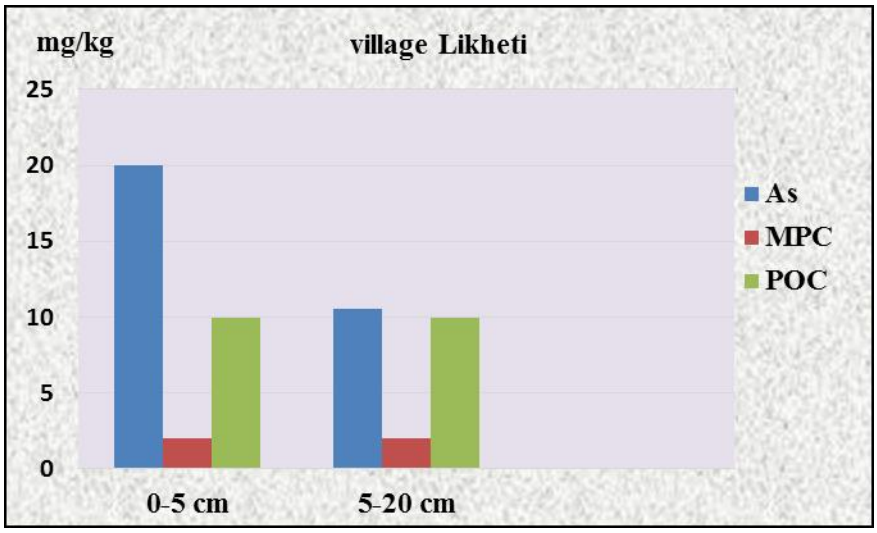

Fig. 4. Arsenic concentration in the village Likheti soils X-0355715 Y-4717963 at depths of 0-5 and 5-20 cm

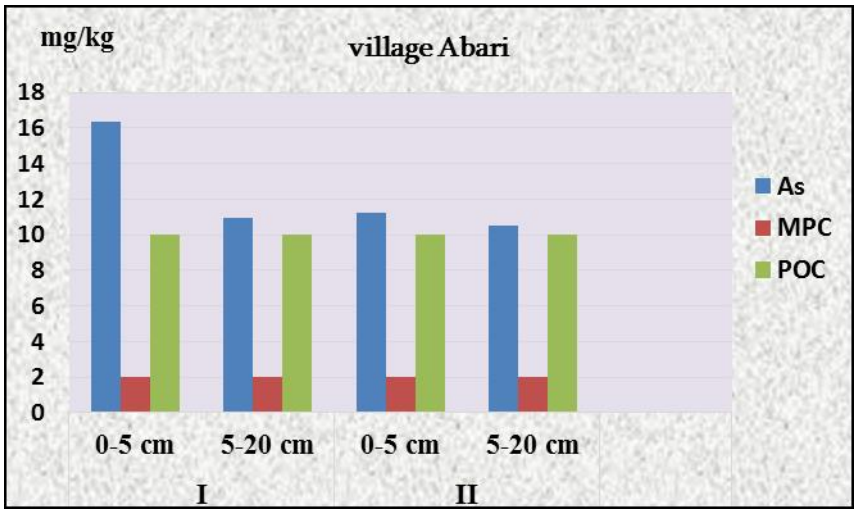

Fig. 5. Arsenic concentration in the village Abari soils at depths of 0-5 and 5-20 cm
I – X-0359629 Y-4723832; II – X-0357634 Y-4719633

It should be noted that according to the results of the study, the maximum content of arsenic in 2014 was in Uravi, in the vicinity of the white arsenic processing plant, where the maximum concentration of arsenic was 61814.9 mg/kg, and in the vicinity of sedimentation place – 36373.7 mg/kg (Shavliashvili et al., 2017).

Based on the 2016 statistical data of the National Center for Disease Control and Public Health, it is clear that the population of Racha-Lechkhumi and Kvemo Svaneti is the first among the regions of Georgia in terms of malignant tumours and diabetes, which in our opinion is associated with arsenic contamination (National Center for Disease..., 2016).

Table 2. Distribution of malignant tumors by regions Georgia, 2016

	According to the place of residence		According to the services received	
	Number of cases	Rate per 100,000 population	Number of cases	Rate per 100,000 population
Abkhazia	127	-	0	-
Adjara	870	257.4	683	202.1
Tbilisi	3789	340.2	7239	649.9
Kakheti	711	223.7	128	40.3
Imereti	1324	249.2	1401	263.7
Samegrelo - Zemo Svaneti	886	269.3	99	30.1
Shida Kartli	590	223.7	152	57.6
Kvemo Kartli	831	194.7	171	40.1
Guria	322	285.5	44	39.0
Samtskhe - Javakheti	313	195.0	54	33.6
Mtskheta –Mtianeti	215	228.7	88	93.6
Racha – Lechkhumi and Kvemo Svaneti	110	351.4	38	121.4
Former South Ossetia	9	-	-	-
Georgia	**1 0097**	**271.5**	**10097**	**271.5**

Table 3. Distribution of diabetes by regions Georgia, 2016

	Number of cases at the end of the year (Contingent)			Number of new cases				
	Total		Including children	Total			Including children	
	Number of cases	Prevalence per 100,000 population	Number of cases	Prevalence per 100,000 population	Number of cases	Prevalence per 100,000 population	Number of cases	Prevalence per 100,000 population
Abkhazia	1334	--	4	--	169	--	1	--
Adjara	11002	3255.0	47	72.1	1944	575.1	23	35.3
Tbilisi	18091	1624.3	65	30.3	7147	641.7	49	22.8
Kakheti	9606	3021.7	23	37.5	984	309.5	3	4.9
Imereti	19353	3642.6	43	42.0	3518	662.1	6	5.9
Samegrelo – Zemo Svaneti	6606	2007.9	77	121.3	1965	597.3	25	39.4
Shida Kartli	7703	2920.0	16	31.4	943	357.5	0	0.0
Kvemo Kartli	9083	2127.7	56	68.0	2747	643.5	15	18.2
Guria	2694	2388.3	18	82.6	338	299.6	0	0.0

Samtskhe – Javakheti	2121	1321.5	17	54.8	449	279.8	9	29.0
Mtskheta – Mtianeti	2061	2192.6	3	16.6	164	174.5	0	0.0
Racha – Lechkhumi and Kvemo Svaneti	1215	3881.8	3	50.0	109	348.2	0	0.0
Another agency	450	-	5	-	263	-	7	-
Georgia	**91319**	**2455.3**	**377**	**52.6**	**20740**	**557.6**	**138**	**19.2**

4. Conclusion

In Racha-Lechkhumi and Kvemo Svaneti regions, the level of pollution of municipal lands with arsenic as a result of exposure to hazardous industrial waste containing arsenic of Racha Mining Chemical Plant was revealed. Research has shown that a special effort must be made to establish strong control over anthropogenic load that is needed to maintain the clean conditions of natural waters, soils and food products and to improve their pollution status.

The following conclusions can be drawn:

1. According to the results of the research, soils village of Uravi are the most polluted in arsenic (moving form). The maximum concentration of arsenic according to the data of November 2019 is 81.35 (40.7 MPC) – 45.33 (22.7 MPC) mg/kg at a depth of 0-5 and and 5-20 cm in the area of Uravi, respectively.
2. The concentration of arsenic in the village of Utsera is 25.65 (12.8 MPC) – 9.00 (4.5 MPC) at the same depths.
3. The concentration of arsenic is relatively low in Sori Valley, which is defined as 3 points and is 20.38 (10.2 MPC); 15.19 (7.6 MPC) and 10.82 (5.4 MPC) mg/kg at a depth of 0-5 cm. The concentration of arsenic is much lower at a depth of 5-20 cm and therefore amounts to 2.51 (1.3 MPC); 6.07 (3.0 MPC) and 5.01 (2.5 MPC) mg/kg.
4. There are similar results in the village Likheti – 20,00 (10,0 MPC) and 10,55 (5,3 MPC) mg/kg.
5. The village Abari is clean compared to other facilities, where the concentration of arsenic was determined at two points and was 16.37 (8.2 MPC) mg/kg, and at the second point – even lower – 11.25 (5.6 MPC) mg/kg at a depth of 0-5 cm. In depth, the concentration of arsenic decreases even more here.
6. Based on the 2016 statistical data of the National Center for Disease Control and Public Health, the population of Racha-Lechkhumi and Kvemo Svaneti among the regions of Georgia has the first place in terms of malignant tumours and diabetes.

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