

In the structure of the analyzed locations, 95.0% of the soils are poorly supplied with phosphorus, in second place are soils with medium phosphorus supply with 3.5%, while soils with a good phosphorus supply are represented by 1.5%. The results of the analysis of the average value of accessible potassium (K₂O) content in the soil of the tested samples are shown in Table 78.

Table 78 Results of analysis of potassium content in the soil in the territory of FBiH

Security mark	Values (average) K ₂ O u mg/100 g	Number of locations	Representation in %
poorly secured soil medium	4,95-9,83	14	5,4
secured soil well secured soil	10,03-19,78	96	36,9
	20,53-68,00	150	57,7
IN TOTAL		260	100,0

In the structure of the analyzed locations, soils that are well supplied with potassium prevail with 57.7%, in second place are soils moderately supplied with potassium with 36.9%, while soils that are poorly supplied with potassium with 5.4%.

The content of inorganic pollutants - heavy metals in the soil

Contamination of soil with heavy metals represents a serious threat to the environment and is one of the most priority environmental problems in the world. Contamination with heavy metals occurs mainly as a result of anthropogenic activities such as mining and processing of metal ores, burning of fossil fuels, use of fertilizers including sewage sludge and pesticides, transportation and many other industrial processes. Although heavy metals are necessary for the functioning of plants and humans, they become toxic when their concentration exceeds the prescribed level. Heavy metals in concentrations above the maximum permitted concentrations represent pollution that can threaten the balance of the ecosystem and ultimately human health. The following is an overview of the results of the research of heavy metals in the soil in the territory of the FBiH. 211

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Table 79 Results of the analysis of the content of heavy metals in the soil in the territory of FBiH

Element	Marking of limit value	Values (average) in mg/kg	Number of locations (No)	Representation %
Bake (With)	Below the limit value of 80.0 mg/kg	6,17 – 79,57	252	96,9
	Above the threshold value of 80.0 mg/kg	82,37 – 179,53	8	3,1
Lead (Pb)	Below the threshold value of 100.0 mg/kg	12,08 – 95,57	258	99,2
	Above the threshold value of 100.0 mg/kg	143,38 – 158,47	2	0,8
Cadmium (Cd)	Below the threshold value of 1.50 mg/kg	0,60 – 1,17	138	53,1
	Above the threshold value of 1.50 mg/kg	1,5 – 5,2	122	46,9
Zinc (Zn)	Below the limit value of 200.0 mg/kg	29,70 – 191,87	258	99,2
	Above the limit value of 200.0 mg/kg	200.70 – 454.20	2	0,8
Nikal (In)	Below the threshold value of 50.0 mg/kg	15,13 – 49,80	111	42,7

²¹¹ Rulebook on determination of permitted quantities of harmful and dangerous substances in the soil and methods of their examination ("Official Gazette of the Federation of Bosnia and Herzegovina", number: 72/09)

Element	Marking of limit value	Values (average) in mg/kg	Number of locations (No)	Representation %
	Above the limit value of 50.0 mg/kg	50,13 – 1.953,53	149	57,3
Besides (Cr)	Below the threshold value of 100.0 mg/kg	6,20 – 99,57	234	90,0
	Above the threshold value of 100.0 mg/kg	108.27 – 1,241.70	26	10,0
Cobalt (Co)	Below the threshold value of 60.0 mg/kg	3,92 – 58,40	254	97,7
	Above the threshold value of 60.0 mg/kg	61,62 – 103,03	6	2,3
Mercury* (Hg)	Below the threshold value of 1.5 mg/kg	0,00–0,817	256	98,5
	Above the threshold value of 1.5 mg/kg	1,54–3,548	4	1,5
Arsenic* (As)	Below the threshold value of 20.00 mg/kg	0,00–19,84	231	88,8
	Above the threshold value of 20.00 mg/kg	20,45–145,9	29	11,2

*average results obtained on the basis of analyzes carried out on samples taken in 2010

The results of the analyzed locations gave the following conclusions:

- **Copper** – the level of soil contamination with copper (Cu) at the investigated locations in FBiH is within the permitted limits, copper contamination is most pronounced in the central area of the Central Bosnian Canton, where the level of contamination is 1.5-2 times higher than the limit values;
- **Lead** – the level of soil contamination with lead (Pb) at the investigated locations in FBiH is within limits allowed, except in two locations where it is slightly above the limit value;
- **Cadmium** - the level of soil pollution with cadmium (Cd) at the investigated locations in FBiH is significant, where in some locations it is 3-3.5 times higher than the limit value, cadmium pollution is most pronounced in the Mediterranean area (HNK, ZHK and Canton 10);
- **Zinc** – the level of soil contamination with zinc (Zn) at the investigated locations in FBiH is within the permitted limits, an exceedance was recorded at two locations where the readings were slightly above the limit values;
- **Nickel** – the level of soil pollution with nickel (Ni) at the investigated locations in FBiH is significant, in some locations even 10-40 times higher than the limit value, the north-eastern area (ZDK and TK) and the southern part of the Mediterranean area are most polluted with this element. (HNK, ZHK);
- **Chromium** - the level of soil contamination with chromium (Cr) at the investigated locations in FBiH is within the permitted limits, except for a certain number of locations where the level of pollution is 5-12.5 times higher than the limit value; in FBiH, the north-eastern area (ZDK and TK) is most polluted by this element;
- **Cobalt** – the level of soil pollution with cobalt (Co) at the investigated locations in FBiH is within the permissible limits, where the level of pollution at certain locations is about 1.5-2 times higher than the limit value, cobalt pollution is most pronounced in the north-eastern area of FBiH (ZDK and TK);
- **Mercury** – the level of soil pollution with mercury (Hg) at the investigated locations in FBiH is within the permissible limits, that is, the level of pollution at four isolated locations is slightly above the limit value;
- **Arsenic** – the level of soil contamination with arsenic (As) at the investigated locations in FBiH is significant, where the level of pollution at certain locations is 3-7 times higher than the limit value; in terms of pollution, the area of central Bosnia stands out.

The cartographic presentation of the research results is shown in Figure 104.

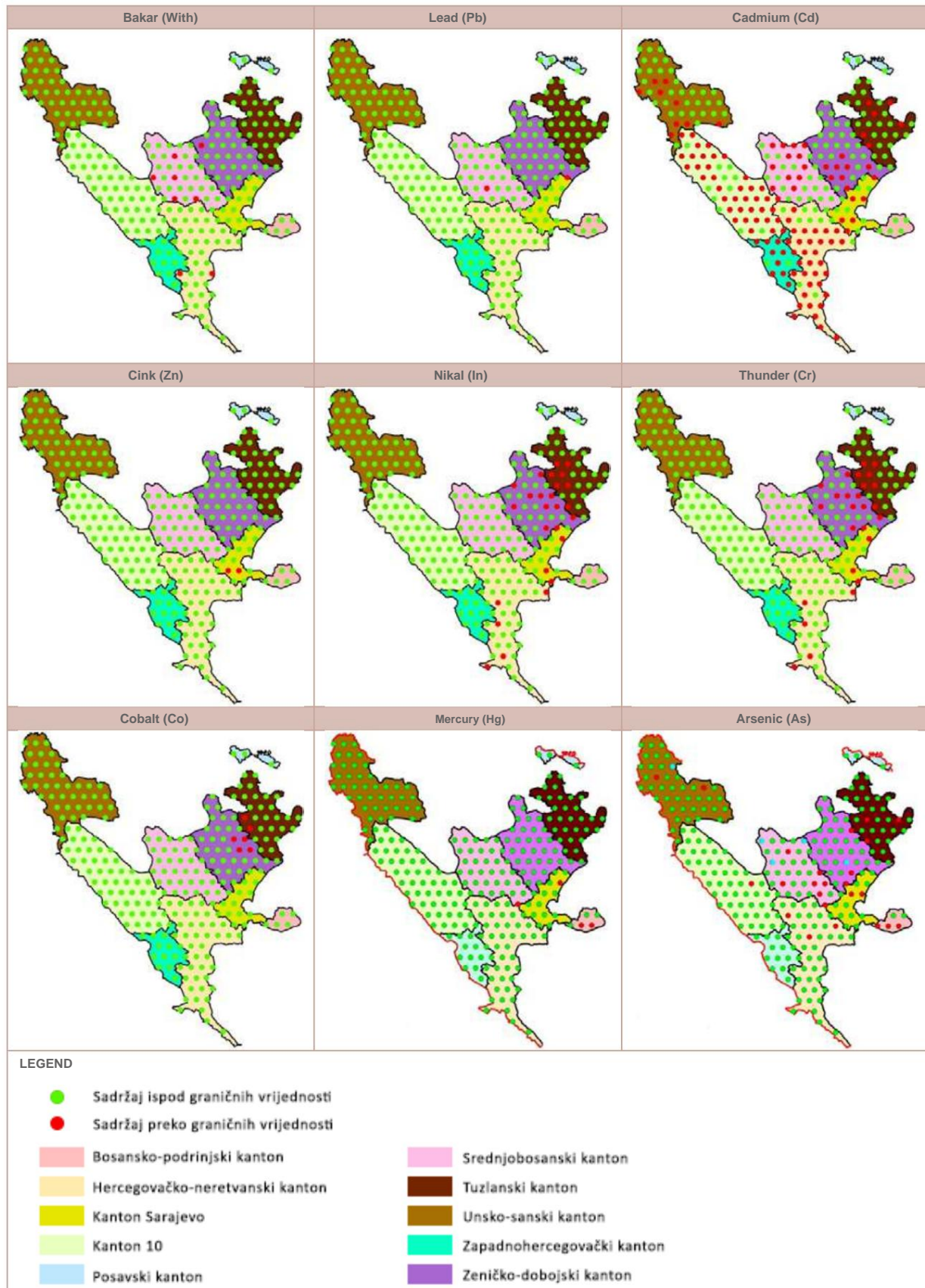


Figure 104 Graphic representation of the results of the analysis of the content of heavy metals in the soil in the territory of FBiH

(Source: Federal Institute for Agropedology)

The FZAP concluded that out of a total of 260 locations, 26 or 10% of the examined areas have a high content of heavy metals whose values exceed the limit values multiple times and which can be characterized as polluted areas. Of the total area of the FBiH, 20% can be considered an absolutely clean area, and if we add to that a part of the area of about 40% in which the level of pollution is small, i.e. low, then organic food and biomass production can be organized on about 60% of the area in the FBiH, as well as the exploitation of drinking water.

After the identified contamination, in 2012 FZAP conducted additional research at 26 contaminated locations with the aim of determining the causes of increased land contamination and their origin (lithological, anthropological or a combination of lithological and anthropological origin). Pedological profiles were opened at contaminated locations and the parent substrate was analyzed (ground and analyzed in the laboratory). Analyzes of parent substrate samples are used to show the connection between the increased values of heavy metals in the soil and their presence in the rocks and to prove their origin.




In locations where the presence of heavy metals in the parent substrate (above the permitted limit values) was not recorded, it was established that the presence of the element is a consequence of anthropological activity.

The following table shows the results of the research at all 26 locations, where different cell colors show different origins, while element content values that exceed the permitted limit values are marked with colored numbers.

Table 80 Results of the investigation of the origin of heavy metals in the soil in the territory of FBiH

Location	No.	With	Pb	Cd	Zn	In	Cr	Co	Mn
Municipality of Srebrenik Fecal KO	1	46,07	33,40	2,77	76,03	390,23	221,77	37,33	2.616,0
	2	46,62	44,80	2,73	44,73	161,48	59,15	32,72	810,3
Municipality of Lukavac KO Brijesnica Donja	1	25,97	30,40	1,13	49,57	473,13	368,7	87,40	1.633,4
	2	30,79	34,11	2,49	54,92	4.494,6	1.116,5	207,4	1.788,0
Municipality of Banovići KO Treštica	1	17,40	50,77	1,80	131,3	1.417,5	692,3	103,0	1.405,0
	2	21,18	55,23	3,33	35,97	285,9	188,2	52,40	711,0
Municipality of Zenica KO Topčij Polje	1	103,4	35,37	0,90	77,27	78,07	36,23	20,73	1.062,4
	2	46,39	445,8	2,60	243,1	271,1	90,46	36,74	1.430,9
Municipality of Zavidovići KO Kamenica	1	40,87	39,03	1,37	52,77	922,27	214,7	91,78	943,4
	2	29,70	163,5	2,74	69,00	1.516,9	186,7	77,52	1.453,4
Municipality of Zavidovići KO Vozujica	1	33,93	49,37	1,33	34,20	926,9	623,5	74,43	1.847,4
	2	34,20	49,19	1,76	47,70	167,8	44,39	21,37	1.789,3
Municipality of Travnik KO Ćelilovac	1	85,43	65,00	1,70	58,83	84,28	93,57	18,13	896,4
	2	17,45	128,8	4,70	72,02	31,44	26,13	14,79	277,4
Municipality of Olovo KO Careva Ćuprija II	1	36,80	32,80	1,07	55,47	1.953,5	1.241,7	61,62	1.064,0
	2	45,22	59,86	2,40	62,20	976,2	577,8	85,76	1.077,6
Municipality of Olovo KO of Careva Ćuprija I	1	42,13	25,33	1,43	49,97	1.391,6	341,8	94,00	1.069,9
	2	46,18	54,22	2,38	52,75	98,59	53,94	29,76	1.084,6
Municipality of Olovo KO of Careva Ćuprija I	1	28,03	47,97	4,37	191,03	47,53	53,87	16,80	3.895,0
	2	28,18	221,3	2,86	466,8	49,11	26,74	15,62	664,7
Municipality of Donji Vakuf KO Prusac I	1	82,37	49,88	1,43	80,45	45,23	37,77	24,57	832,5
	2	40,60	259,8	3,36	383,1	53,87	34,55	19,76	514,6
Municipality of Bugojno	1	179,5	56,17	1,60	84,53	63,13	44,70	26,43	483,0

location	No.	With	Pb	Cd	Zn	In	Cr	Co	Mn
KO Potočani	2	22,54	72,44	3,13	74,33	163,5	69,27	18,67	282,6
Municipality of Bugojno KO Potočani	1	20,88	143,4	4,17	162,6	39,47	57,77	28,20	1.171,0
	2	24,91	32,69	1,04	30,87	17,51	15,42	12,93	591,2
Municipality of Gornji Vakuf/Uskoplje KO Bistrica	1	47,43	158,5	2,13	88,25	29,67	24,60	12,27	612,3
	2	54,22	299,2	2,52	404,6	50,26	26,49	14,97	563,0
Municipality of Gornji Vakuf/Uskoplje KO Uzričje	1	96,87	51,67	1,30	64,53	60,48	58,13	21,37	1.320,4
	2	13,67	157,7	4,08	39,44	50,03	20,00	21,58	478,8
Municipality of Gornji Vakuf/Uskoplje KO Privor I	1	94,63	61,48	1,03	83,00	47,03	37,63	20,93	976,0
	2	38,33	190,8	2,48	202,2	105,7	44,04	24,70	792,5
Municipality of Hadžiji KO Dub	1	30,73	34,48	3,37	200,7	58,67	63,47	18,67	1.291,5
	2	29,79	168,7	2,87	50,27	31,23	17,37	18,14	1.711,4
Municipality of Trnovo KO Presjenica	1	42,77	44,93	5,17	454,2	58,32	132,1	29,47	1.635,0
	2	28,56	139,8	3,96	72,81	111,5	61,69	20,46	275,4
Municipality of Mostar I'm Bogodol	1	51,50	63,43	4,17	124,2	79,53	84,60	34,97	2.192,0
	2	14,26	165,3	3,77	33,14	30,50	19,07	19,34	612,0
Municipality of Mostar OR Goranci	1	47,10	65,63	4,13	95,70	95,20	122,27	33,67	2.255,0
	2	20,95	83,41	3,62	70,13	1.107,1	445,18	56,36	303,5
Municipality of žitluk KO žalići	1	109,7	44,28	1,87	57,20	107,7	55,00	22,07	992,0
	2	26,36	48,67	3,24	42,41	105,6	38,63	30,62	2.226,8
Municipality of Mostar KO Selište	1	44,63	65,53	3,37	73,03	67,20	162,3	22,53	1.091,7
	2	21,23	57,58	3,32	33,40	42,86	29,11	22,97	1.079,9
Municipality of Mostar Kokorina	1	165,6	56,27	2,73	78,40	113,5	64,97	23,80	1.141,7
	2	32,07	92,48	3,69	66,06	45,21	29,13	22,97	1.080,0
Municipality of Neum KO Donje Hrasno II	1	29,93	59,10	4,70	77,10	70,33	156,7	23,07	1.177,5
	2	19,21	80,73	3,80	62,57	108,6	61,36	19,68	274,4
Municipality of Neum KO Neum	1	37,47	65,80	5,20	79,97	97,70	138,8	28,60	1.012,6
	2	29,46	64,26	3,36	46,71	98,57	61,85	30,35	794,2

1 – Average research value from 2008-2010. years		- lithological origin
2 – Value in parent substrate		- anthropological origin
		- anthropological and lithological origin

In the Report on the State of the Environment of the FBiH in 2010, data obtained through sporadic research were presented and served as an indication of the level of soil pollution with heavy metals. The data are presented in percentage as the share of land with medium and high levels of heavy metal content, while the second percentage within the category represents the percentage of land with a high level of pollution.

Due to the different presentation of the data it is difficult to make a comparison between the results, the table below gives an overview of the identified soil contaminants (lead, copper and zinc) for the two reports.

Table 81 Comparative presentation of identified soil pollution with heavy metals through two reports

Canton	Element	2010	2020
Canton Sarajevo	Lead (Pb)	<ul style="list-style-type: none"> • 37% of land with medium and high level of pollution • 13% of land with a high level of pollution 	<ul style="list-style-type: none"> • 1 location with pollution slightly above the limit values
	Bakar (With)	<ul style="list-style-type: none"> • 88% of land with medium and high level of pollution • 12% of land with a high level of pollution 	<ul style="list-style-type: none"> • no location with pollution above limit values has been identified
	Zinc (Zn)	<ul style="list-style-type: none"> • 90% of land with medium and high level of pollution • 0% of land with a high level of pollution 	<ul style="list-style-type: none"> • 2 locations with pollution above limit values
Una-Sana canton	Lead (Pb)	<ul style="list-style-type: none"> • 22% of land with medium and high by the level of pollution • 2% of land with a high level of pollution 	<ul style="list-style-type: none"> • no location with pollution above limit values has been identified
	Bakar (With)	<ul style="list-style-type: none"> • 62% of land with medium and high level of pollution • 0% of land with a high level of pollution 	<ul style="list-style-type: none"> • no location with pollution above limit values has been identified
	Zinc (Zn)	<ul style="list-style-type: none"> • 68% of land with medium and high level of pollution • 0% of land with a high level of pollution 	<ul style="list-style-type: none"> • no location with pollution above limit values has been identified
Tuzla Canton	Lead (Pb)	<ul style="list-style-type: none"> • 11% of land with medium and high level of pollution • 0% of land with a high level of pollution 	<ul style="list-style-type: none"> • no location with pollution above limit values has been identified
	Bakar (With)	<ul style="list-style-type: none"> • 60% of land with medium and high level of pollution • 1% of land with a high level of pollution 	<ul style="list-style-type: none"> • no location with pollution above limit values has been identified
	Zinc (Zn)	<ul style="list-style-type: none"> • 54% of land with medium and high level of pollution • 0% of land with a high level of pollution 	<ul style="list-style-type: none"> • no location with pollution above limit values has been identified
Central Bosnia Canton	Lead (Pb)	<ul style="list-style-type: none"> • 0% of land with medium and high level of pollution • 0% of land with a high level of pollution 	<ul style="list-style-type: none"> • 1 location with pollution slightly above the limit values
	Bakar (With)	<ul style="list-style-type: none"> • 88% of land with medium and high level of pollution • 2% of land with a high level of pollution 	<ul style="list-style-type: none"> • 5 locations with pollution above limit values
	Zinc (Zn)	<ul style="list-style-type: none"> • 78% of land with medium and high level of pollution • 0% of land with a high level of pollution 	<ul style="list-style-type: none"> • no location with pollution above limit values has been identified

It is necessary to mention the results of the monitoring that FZAP together with the Federal Institute for Agriculture (FZZP) conducted in certain areas according to special conclusions of the FBiH Government.

Land monitoring in the territory of the municipality of Zenica (2011-2015)

The main goal of the five-year research was to determine the degree of contamination of agricultural land and leachate with heavy metals, sulfur and organic pollutants in order to assess the possibility of agricultural production in certain areas of Zenica.

Research was conducted at 12 locations. The results of the research showed that the values of nickel (Ni), manganese (Mn) and iron (Fe) from heavy metals, and sulfur (S) from non-metals in the soil are increased in almost the entire research area. Subsequent research determined that the heavy metals nickel (Ni) and manganese (Mn) are of lithological origin and that their accessibility to plants is relatively low.

The presence of transboundary values of lead (Pb), cadmium (Cd) and zinc (Zn) was determined mostly in a small area of the municipality of Zenica in the immediate vicinity of the Arcelor Mittal Zenica ironworks, which indicated the possibility of anthropogenic pollution with these elements.

Taking into account the results of the research, 2 zones of soil pollution were distinguished, namely zone I (risk zone) and zone II (less risk zone), according to which recommendations for agricultural production were given.

Monitoring of the lower course of the Spreja River (2014–2018)

The main goal of these studies was to determine the degree of contamination of agricultural land and plant material with heavy metals and organic pollutants in order to assess the possibility of agricultural production in certain areas of Sprejanski polje and to propose urgent measures for prevention and rehabilitation of the polluted area. The research covered three municipalities, namely Lukavac, Građanica and Dobroj Istok. The chronology of the research is shown in the table below.

Table 82 Chronological presentation of activities on the monitoring of the lower course of the river Spreja

Year	Activities
2014	<ul style="list-style-type: none"> • certain soil types • certain physical and chemical properties of soil at 43 locations • 8 pedological profiles were opened and analyzed in detail • analyzed several agricultural crops
2015	<ul style="list-style-type: none"> • certain physical and chemical properties of soil in 67 locations • analyzed several agricultural crops
2016	<ul style="list-style-type: none"> • agricultural land was sampled at 71 microlocations • analyzed eight samples of plant material
2017	<ul style="list-style-type: none"> • agricultural land was sampled at 17 microlocations
2018	<ul style="list-style-type: none"> • agricultural land was sampled at 8 permanent points

The results of the research showed that the content of total forms of heavy metals in the soil, as well as the content of PAHs, was elevated in all investigated locations. It was pointed out that mercury (Hg) content above the permitted limit values was detected at one investigation location.

The monitoring results in the lower reaches of the Spreja River showed that the heavy metals and PAHs found in the soil were deposited by the flood waves of the Spreja River, with the explanation that when it comes to nickel (Ni) and chromium (Cr) they are bound to the geological substrate in the upper reaches of the river Spreja, while other heavy metals and PAHs can be linked to the industry of the Tuzla basin.