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OBSERVATION AND STUDY OF POLLUTION IN THE REGION OF THE "LEAD-ZINC FACTORY" - KARDZALI

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SUMMARY

A detailed geological and hydrogeological characterization of the area of the examined stage in the region of the " Lead-zinc factory " - Kardzali is done.
The study which is performed shows that in accordance with the utmost allowable concentration the ground layers with thickness up to 1 m are high polluted with Pb, Cu,Zn,Cd,Fe,Mn and As ions.
In depth approximately up to 2,5 m the concentration of these substances decreases several times. Below this depth, where is the level of ground waters, pollution above the values of the utmost allowable concentration with water soluble ions of Pb, Cu, Zn, Cd is established.
The underground waters are from the quaternary horizon of the tertiary depositions and they are semi-pressure, fissure and with shallow circulation. They are distinguished for predominating of sulphate and chloride ions, with high content of Na, K ions and ions of metals which are a result of the main activity of the " Lead-zinc factory", with several times exceeding of the average concentrations compared to the regional background.
The reasons for the established pollutants are shown and a programme for their limitation and elimination is proposed.

INTRODUCTION

The high industrialization of the economy inevitably leads to global pollution of the environment all around the world as well as in the Republic of Bulgaria.The action of toxic and poisonous substances appears especially clear in the regions with developed chemical or metallurgic productions.

The purpose of the task is to be gathered additional information about damages on the environment as a result of the influence of the lead-zinc production of the " Lead-zinc factory"-Joint-stock company, Kardzali, to be given an assessment for the soil and hydrogeological conditions in order to be determined the presence and quantity of the toxic components and their spreading in vertical and horizontal direction, to be planned measures for limitation and non-admission of additional pollution. In order to realize this purpose, on the area of the project additional works for gathering information about the ecological situation of the ground foundation, hydrogeological studies and content of elements which can be controlled in the soil and waters are performed.

GEOLOGICAL AND HYDROGEOLOGICAL CONDITIONS IN THE REGION OF THE "LEAD-ZINC FACTORY" - KARDZALI

The geological and hydrogeological research works of the examined stage are performed with autodrill URB 2A-2 by the rotary method, in dry conditions, in short raids (0,5 m), core drilling, with diameter ϕ=146 mm. Nineteen motor test holes with total footage of 169,7 m are made.

In order to fix the migration of the main pollutants in depth, nineteen piezometers (fig. 1) with total footage of 169,7 m are constructed. After the designed depth is reached, the trunk of the drillhole is widened to 190,5 mm and this is followed by assembling of PVC pipes and filters with ϕ=110 mm.

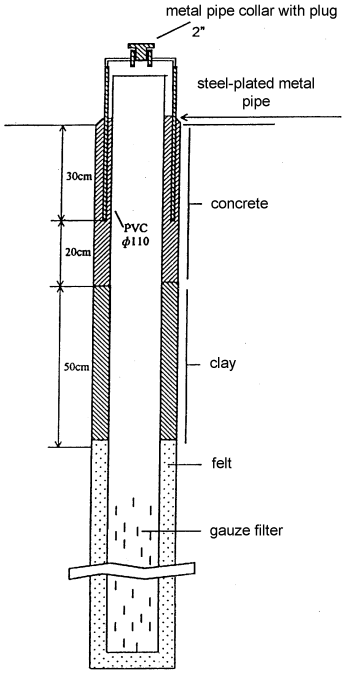

Figure 1. Construction of piezometer

The region is plain terrain with slight slant from south to northeast and in geological respect it is characterized with development of tertiary and quaternary depositions. The tertiary depositions are presented by paleogenic limestones - white to beige-pink in colour, very dense. They are, in fact, the pad on which sandy-marly depositions occur. They are presented mainly by greenish-blue zeolites with thickness of 0,2-0,3 m which are covered with bentonite clay on the south side of the factory. The yellow bentonite clay with solid-plastic to solid consistence is with thickness of the layer up to 1,5 m. In some spots, the total thickness of the depositions, which cover the limestones, reaches 20 m. The quaternary depositions occur over the paleogenic marly depositions and are presented by gravel wash and deluvial wash. The alluvial layer, which is defined by medium to pebble stones with sandy-clayey to clayey-sandy filler, is with thickness of 1,5-5,0 m.

The deluvial depositions are presented mainly by alternation of silty and sandy clays with limy inclusions and medium to coarse sands, in some spots with rubbles. The thickness of this layer reaches 2,8-6,0 m. The total thickness of alluvial and deluvial depositions reaches up to 10 m.

According to the hydrogeological dividing of Bulgaria into districts, the examined stage is situated in subdistrict East Rhodope Mountains, region Perperek-Efrem and from geological point of view it is situated in inner structural trough with sedimental and tuffed materials with limited occurrence of volcanites and with limited plenty of water. Here the underground waters are mainly fissure, with shallow circulation and in some sections they are pressure. They are fresh, with qualities in accordance with the Bulgarian State Standard - Drinkable water. In the region of Kardzali as well as in the examined district they are protected against penetrating of surface pollutants by a thick layer of bentonite clays as well as by natural filters of zeolite tuffs situated under them.

The fluvial terrace in the lower course of the Arda river is formed by alluvial and deluvial depositions, presented by clays, rubbles with different size with clayey filler and sands, which reach thickness up to 10 m. Here a non-pressured water bearing horizon is formed which receives surface waters which are in direct contact with the area of the factory.

DYNAMICS OF THE UNDERGROUND WATERS IN THE EXAMINED REGION

Since the pollution of the underground waters in the tertiary depositions is limited by the bentonite clays and zeolites in them, only the quaternary water bearing horizon is examined. The underground waters in this horizon are semi-pressure because of the geological structure of the ground foundation. In a diagram it may be shown as diploblasic - first layer in the bottom, strongly permeable (gravels and sands) and second one, above it, with low water permeability (sandy clays). It is clear from the drillholes that the water level is in the second layer. The quaternary water bearing horizon, isolated from the occured zones with plenty of water under it, with the help of water tight bentonite clays, reaches thickness up to 10 m.

By the constructed hydrogeological profiles of the examined stage, the conductivity of the layer is determined in the interval 14,8-31,5 m^2 /d. Its average value for the region is approximately 22 m^2 /d which characterizes it as a region without plenty of water in accordance with the gradation in drawing up the hydrogeological maps M 1: 25 000.

The single filtration cost of the underground waters is q=0,126 - 0,214 m^3 /d and the total filtration cost of the underflow, which crossed the area of the factory (with average length of 1150 m) is approximately 190 m^3 /d.

ESTABLISHED POLLUTION IN THE REGION OF THE EXAMINED STAGE

On the basis of the performed investigations is given an assessment of the pollution of the ground foundation (with the different lithological varieties) of the examined region from the area of the " Lead-zinc factory" - Kardzali and the areas which border on it. It is found that the soils in the region of Kardzali are polluted and are called " very high polluted" (in accordance with the content of the toxic elements, the assessment is with 5 degrees - unsoiled, light polluted, medium polluted, high polluted and very high polluted soils) in accordance with the content of Pb, Cu, Zn, Cd, Fe, Mn, As.

Our investigations aim to be found to which depth these toxic substances are in the ground layers. That's why 42 ground samples of the different lithological varieties of the quaternary are taken and investigated. The results of the laboratory analyses are presented in table 1 and table 2.

The obtained results permit to be said that the surface layers to depth of 1 m from the area of the factory are polluted with Pb, Cu, Zn, Cd. Their content is many times above the allowable content. In depth between 1m and 2,5 m the concentration of the ions of heavy metals decreases several times because of the sorption properties of the soil. Below 2,5 m, in the zone where is the fixed level of the ground waters, there is active movement of the water soluble ions of heavy metals and in this zone is found pollution with Pb, Cu, Zn, Cd above the allowable rate. The reason is the depots for waste and warehouses for raw materials on this area.

In the additional performed investigations of the underground waters and migration of the pollutants are presented other 50 components and indicators too. The established anions and cations as well as organic substances are presented in table 3 and table 4.

In the region of feeding the underground waters there isn't ore and non-metalliferous mineralization which could change the geochemical background. That's why the natural factors for the formation of these waters in the examined region are the reason for predominating of hydrocarbonaceous and calcium ions, neutral and light alkaline environment, low content of biogenic components and ions of heavy metals as

well as nitric-oxygenous composition. All examined waters from the main stage (including those from the region of the purifying station) are distinguished for predominating of sulphate and chloride ions, high concentrations of Na and K, ions of heavy metals as a result of the main activity of the " Lead-zinc factory" or from the harmfull admixtures in the raw materials and waste as well as phenols, petroleum products and nitric compounds. The degree of exceeding of the average concentrations in relation to the regional background is several times higher - table 5. Only about few situations it may be said that the reason of this predominating is due to technogenic pollution and pollution of life.

Table 3. Content of ions, petroleum products and volatile phenol in waters, mg/dm^3.

No of test sample	pH	NO_2^-	NO_3^-	NH_4^+	HPO_4^{2+}	volatile phenol	Con-tent
C1	7,2	0,99	7	0,120	0,6		
C2	7,0						
C2-A	6,7						
C3	6,7						
C4	5,7					0,955	1,3
C5	6,8					0,299	0,9
C6	7,4						
C7	7,3					0,287	1,1
C8	7,2						
C9	7,1	0,12	0	0,140	4,4		
C10	7,5	0,07	2	0,004	0,8		
C11	7,3						
C12	7,4						
C13	7,2	5,50	52	0,540	1,4	0,259	1,2
C14	7,1						
C1A	7,4						
C1B	7,1	0,07	2	0,270	1,2	1,142	2,6
C2B	7,2						
C3B	7,3	0,29	16	0,180	2,2		

Table 5. Degree of exceeding of the average contents of ions in underground waters in the region of the " Lead-zinc factory" - Kardzali towards the regional background

component	degree of exceeding (times)
SO_4^{2-}	6,6
Cl^-	8,1
Mg^{2+}	2,3
Ca^{2+}	6,6
Na^+	6,4
K^+	7,5
Cu^{2+}	283,0
Mn^{2+}	146,0
Pb^{2+}	81,0
As^{3+}	4,3
Ni^{2+}	105,0
Al^{3+}	51,0
Fe^{2+}	144,0
Zn^{2+}	370,0

On the basis of this assessment for the damages on the environment from the activity of the " Lead-zinc factory" - Kardzali in the past and nowadays, measures are planned for their liquidation and limitation for the future which are presented in a special programme in another project.

CONCLUSION

On the basis of performed investigations in the region of the " Lead-zinc factory" - Kardzali is found that the ground foundation and underground waters are polluted above the utmost allowable concentrations in relation to heavy metals and other components.

The main reason for the pollution in the past is the outdated production process and the unprotected depots with waste and warehouses with raw materials.

In order to eliminate the damages from the pollution on the environment in the region of the " Lead-zinc factory" - Kardzali is recommended to be realized the measures and taken decisions which are pointed out in the " Programme for elimination the dangerous influence over the underground waters and ground foundation from the production activity of the " Lead-zinc factory" - Kardzali".

It is proposed the results of performed measurements to be bounded with the data for the technological processes and actualized ruler's decisions. That's how the monitoring of the underground waters will achieve its purpose.

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Table 1. Content of heavy metals and metalloids in soil test samples from the “Lead-zinc factory” - Kardzali, mg/kg

Drillhole test sample No	depth (m)	PH	As	Cd	Cu	Pb	Zn
1	2	3	4	5	6	7	8
1-1	0,2-0,4	7,27	13	25,600	142	298	1596
1-2	1,8-2,0	7,25	2	0,200	11	51	216
2-5	0,5-0,7	7,16	102	117,400	1996	11858	28196
2-6	3,1-3,2	6,80	1	3,373	108	1408	1162
3-9	0,8-1,0	6,40	352	1275,250	7604	15144	470
3-10	2,2-2,4	6,98	10	10,119	50	90	10076
4-13	0,4-0,6	6,13	427	1468,056	24800	45828	125194
4-14	2,0-2,2	6,75	3	51,992	66	112	9896
5-17	0,5-0,7	5,76	8	14,712	187	908	2024
5-18	2,4-2,6	7,22	5	< 0,200	26	260	107
7-23	0,6-0,8	6,08	5	3,168	104	2055	2036
7-24	1,4-1,6	7,48	27	3,792	206	900	433
7-26	7,0-7,2	7,46	2	0,000	11	258	18
2-27	0,6-0,8	6,61	3	< 0,200	31	1363	218
8-28	4,8-4,9	7,56	5	0,598	22	220	104
1A-30	0,8-1,0	7,07	88	222,244	1316	4977	17141
1A-31	3,3-3,4	7,74	3	9,543	24	153	421
2A-34	0,6-0,8	3,56	114	54,800	290	386	7136
2A-35	1,4-1,6	8,10	0,8	3,386	40	264	337
2A-36	3,8-4,1	5,95	107	80,312	814	4441	6544
9-37	0,6-0,8	7,67	13	0,998	59	265	339
9-38	2,0-2,1	7,55	12	1,786	49	210	264
9-40	6,5-6,6	6,89	58	13,944	421	1400	1849
10-41	0,6-0,8	7,63	0,2	< 0,200	8	63	76
10-42	3,8-4,0	7,15	4	< 0,200	28	85	186
1B-44	0,3-0,5	6,89	154	18,327	1025	5833	1627
1B-45	2,0-2,2	8,22	8	2,376	92	408	245
13-47	0,4-0,6	5,50	38	49,008	502	2141	5234
13-48	2,5-2,6	6,26	5	< 0,200	21	82	212
6-50	0,6-0,8	6,91	1	< 0,200	23	119	84
6-51	1,3-1,5	6,46	0,4	< 0,200	13	47	64
12-53	0,6-0,8	7,77	29	0,599	23	230	138
12-54	2,2-2,4	7,42	8	4,854	118	592	611
3B-56	0,4-0,6	6,95	5	0,200	14	66	168
3B-57	2,3-2,5	7,82	0,4	< 0,200	8	35	102
2B-60	2,4-2,6	5,98	0,6	< 0,200	6	44	20
11-62	0,4-0,6	7,44	0,2	1,590	121	1968	335
11-63	2,4-2,6	7,63	1	< 0,200	9	95	54
14-65	0,3-1	6,53	11	31,412	176	1477	3590
14-66	1-2,5	7,39	3	3,769	32	105	266

Table 2. Content of metals in soil test samples from the area of the "Lead-zinc factory" - Kardzali, mg/kg

Drillhole test sample No	depth (m)	Fe	Mn	Cr	Ni	Co	Ba	Mo	Bi	Sn
1	2	3	4	5	6	7	8	9	10	11
1-1	0,2-0,4	11160	458	20,8	13,0	32,2	34,2	1,0	<0,2	<10
1-2	1,8-2,0	16620	624	39,2	28,2	18,4	52,4	1,0	<0,2	<10
2-5	0,5-0,7	68800	1825	36,4	32,2	78,0	116	18,6	21,8	<10
2-6	3,1-3,2	12120	592	19,6	12,6	27,2	28,0	0,2	1,6	<10
3-9	0,8-1,0	59800	7480	79,6	71,2	1200	31,0	8,0	<0,2	10,4
3-10	2,2-2,4	16400	1426	59,4	59,0	1004	136	0,4	0,8	10,1
4-13	0,4-0,6	186200	14680	152	75,0	148,4	31,4	15,0	<0,2	<10
4-14	2,0-2,2	19380	1738	35,0	22,2	12,8	23,4	0,8	0,4	<10
5-17	0,5-0,7	20540	1318	57,2	42,6	37,2	45,2	2,8	0,8	<10
5-18	2,4-2,6	3360	564	5,00	12,0	7,40	31,8	0,4	<0,2	<10
7-23	0,6-0,8	23800	1158	77,8	69,6	32,4	131	1,6	<0,2	10,6
7-24	1,4-1,6	3640	642	42,0	11,6	8,40	33,2	1,4	<0,2	<10
7-26	7,0-7,2	1770	93,8	3,60	2,60	5,00	20,4	0,4	<0,2	<10
8-27	0,6-0,8	23200	958	80,6	67,8	15,8	92,0	2,4	<0,2	<10
8-28	4,8-4,9	3000	326	3,20	7,60	15,2	26,4	1,4	<0,2	<10
1A-30	0,8-1,0	26200	2080	31,6	30,2	57,2	35,8	<0,2	40,6	<10
1A-31	3,3-3,4	17740	634	28,4	28,0	9,00	50,6	0,4	1,8	<10
2A-34	0,6-0,8	32600	524	30,8	21,0	7,6	68,8	2,6	<0,2	<10
2A-35	1,4-1,6	14240	630	19,2	20,4	9,0	36,4	<0,2	<0,2	<10
2A-36	3,8-4,0	26720	972	39,0	23,6	18,0	34,0	1,0	<0,2	<10
9-37	0,6-0,8	22000	890	45,0	37,4	14,2	92,0	1,4	<0,2	<10
9-38	2,0-2,1	2660	384	7,60	9,00	4,60	18,4	0,8	<0,2	<10
9-40	6,5-6,6	18900	778	35,8	29,6	17,8	37,0	2,6	1,2	
10-41	0,6-0,8	13700	706	21,4	26,2	10,4	45,6	<0,2	5,0	<10
10-42	3,8-4,0	20380	648	25,8	19,8	10,2	46,2	0,2	<0,2	<10
1B-44	0,3-0,5	18540	756	38,4	37,0	14,2	61,2	0,2	20,6	<10
1B-45	2,0-2,2	14900	958	21,4	16,8	12,4	67,0	1,0	1,2	<10
13-47	0,4-0,6	18320	934	25,8	17,8	42,2	44,2	0,6	0,2	<10
13-48	2,5-2,6	18220	598	23,6	18,8	7,40	37,4	1,6	5,6	<10
6-50	0,6-0,8	17580	728	35,4	28,6	9,00	57,0	0,6	0,8	<10
6-51	1,3-1,5	19520	722	26,8	29,0	11,2	61,0	<0,2	0,4	<10
12-53	0,6-0,8	16700	698	29,8	28,8	11,0	40,6	0,6	<0,2	<10
12-54	2,2-2,4	20360	582	49,2	50,2	11,0	78,8	0,6	6,4	<10
3B-56	0,4-0,6	14340	654	23,0	24,0	8,20	43,0	0,4	1,4	<10
3B-57	2,3-2,5	13900	546	20,6	22,6	6,80	28,2	1,2	<0,2	10,8
2B-59	0,4-0,6	16200	728	35,0	35,8	12,4	70,6	0,2	<0,2	<10
2B-60	2,4-2,6	16520	642	27,6	25,6	9,60	70,8	13,2	2,6	<10
11-62	0,4-0,6	20020	756	47,0	39,6	12,4	71,2	0,4	0,4	<10
11-63	2,4-2,6	15200	610	24,0	21,8	9,60	35,0	<0,2	0,6	<10
14-65		16700	726	26,6	24,8	14,8	49,2	<0,2	1,8	<10
14-66		18610	680	31,5	29,3	10,2	45,1	0,4	0,3	<10

Table 4. Element analysis of waters

Indicators	Dimension	C 7	C 8	C 9	C 10	C 11	C 12	C 13	C 14	LZF I	LZF II	LZF III	Studen Kladenets Dam
Chlorides (Cl^-)	mg/dm^3	38,99	38,90	88,62	14,18	60,26	28,36	177,25	14,18	46,08	38,99	12,40	14,18
Magnesium (Mg^{2+})	mg/dm^3	38,99	29,54	62,8	11,64	4,85	21,45	27,32	10,21	40,4	54,9	38,92	6,94
Calcium (Ca^{2+})	mg/dm^3	231,2	178,4	282,5	76,1	242,6	130,7	246,0	108,8	351,4	523,2	294,7	64,3
Sodium (Na^+)	mg/dm^3	100,9	81,0	283,3	53,7	113,4	79,0	119,7	36,56	193,5	105,6	55,1	28,92
Potassium (K^+)	mg/dm^3	8,75	10,03	9,72	3,75	9,44	9,60	16,86	14,03	22,76	20,1	11,84	3,69
Copper (Cu^{2+})	mg/dm^3	0,009	0,01	0,083	0,011	0,229	0,119	0,035	0,71	2,98	3,93	0,16	0,01
Manganese (Mn^{2+})	mg/dm^3	0,52	0,14	0,249	0,166	1,97	0,91	1,66	5,65	10,79	8,73	0,83	0,47
Lead (Pb^{2+})	mg/dm^3	0,257	0,669	<0,02	0,577	3,64	1,05	0,093	3,34	0,28	9,40	2,61	0,226
Arsenic (As^{3+} и As^{5+})	mg/dm^3	<0,01	<0,01	<0,01	<0,01	<0,01	<0,01	<0,01	0,023	0,011	0,082	<0,01	<0,01
Selenium (Se^{2+})	mg/dm^3	<0,02	<0,02	<0,02	<0,02	<0,02	<0,02	<0,02	<0,02	<0,02	<0,02	<0,02	<0,02
Cadmium (Cd^{2+})	mg/dm^3	<0,004	<0,004	0,062	0,006	0,013	0,009	0,025	0,67	0,008	0,185	0,011	0,033
Nickel (Ni^{2+})	mg/dm^3	<0,004	<0,004	<0,004	<0,004	0,015	0,007	<0,004	0,029	0,063	0,107	<0,004	<0,004
Aluminium ($A1^{3+}$)	mg/dm^3	1,82	2,26	1,35	1,01	9,50	6,05	3,21	9,70	0,11	19,5	4,58	0,134
Iron (Fe^{2+} и Fe^{3+})	mg/dm^3	2,67	2,13	1,21	1,19	10,67	4,12	2,28	5,34	1,28	4,18	5,12	0,186
Zinc (Zn^{2+})	mg/dm^3	0,21	0,146	0,53	0,407	0,73	0,77	0,43	40,80	8,84	63,3	1,69	0,91
Phosphorus (P^{5+})	mg/dm^3	0,167	0,212	0,218	0,215	1,80	1,81	0,329	1,87	0,119	1,41	0,588	0,31
Sulphur (S^{6+})	mg/dm^3	230,8	160,0	379,9	38,07	147,1	66,0	141,1	34,94	403,7	366,1	257,1	40,86
Antimony (Sb^{3+} и Sb^{5+})	mg/dm^3	0,020	<0,02	<0,02	<0,02	<0,02	0,039	<0,02	<0,02	0,037	<0,02	<0,02	0,022
Cobalt (Co^{3+})	mg/dm^3	<0,004	<0,004	<0,004	<0,004	0,023	0,014	0,006	0,054	0,093	0,099	<0,004	40,86
Bismuth (Bi^{3+})	mg/dm^3	<0,02	0,123	<0,02	<0,02	<0,02	<0,02	<0,02	<0,02	0,044	<0,02	<0,02	<0,02
Tin (Sn^{2+} и Sn^{4+})	mg/dm^3	<0,02	<0,02	<0,02	<0,02	0,021	<0,02	<0,02	<0,02	<0,02	<0,02	<0,02	<0,02
Tungsten (W^{5+} и W^{6+})	mg/dm^3	<0,02	<0,02	<0,02	<0,02	<0,02	<0,02	<0,02	<0,02	<0,02	<0,02	<0,02	<0,02

Indicators	Dimension	C1 A	C2 A	C1 B	C2 B	C3 B	C 1	C 2	C 3	C 4	C 5	C 6
Chlorides (Cl^-)	mg/dm^3	60,26	957,15	38,9	42,5	46,08	177,25	1098,9	602,6	77,99	15,95	46,08
Magnesium (Mg^{2+})	mg/dm^3	36,33	53,2	30,07	16,46	18,88	59,3	104,19	65,6	85,3	25,89	17,33
Calcium (Ca^{2+})	mg/dm^3	225,4	439,5	268,9	121,6	238,2	566	685	606	593,2	203,3	198,5
Sodium (Na^+)	mg/dm^3	151,8	346,5	83,5	21,28	20,35	191,9	338,5	350,1	123,8	27,4	31,58
Potassium (K^+)	mg/dm^3	16,1	22,65	22,05	12,57	14,73	21,82	21,96	22,96	30,3	11,39	8,61
Copper (Cu^{2+})	mg/dm^3	0,885	0,052	0,71	0,113	0,039	0,013	0,333	0,44	185,0	0,025	0,11
Manganese (Mn^{2+})	mg/dm^3	2,42	3,82	3,91	4,53	0,337	1,54	4,699	5,16	39,56	1,44	1,24
Lead (Pb^{2+})	mg/dm^3	1,55	0,038	4,20	0,37	0,054	<0,02	2,05	0,346	0,74	0,21	5,54
Arsenic (As^{3+} и As^{5+})	mg/dm^3	0,115	<0,01	0,04	<0,01	<0,01	0,012	0,01	<0,01	<0,01	<0,01	<0,01
Selenium (Se^{2+})	mg/dm^3	<0,02	<0,02	<0,02	<0,02	<0,02	<0,02	<0,02	<0,02	<0,02	0,056	<0,02
Cadmium (Cd^{2+})	mg/dm^3	0,073	0,009	0,068	0,013	<0,004	0,004	0,019	0,647	144,6	0,043	0,033
Nickel (Ni^{2+})	mg/dm^3	<0,004	<0,004	0,036	21,28	0,065	<0,004	0,015	0,009	2,49	<0,004	<0,004
Aluminium ($A1^{3+}$)	mg/dm^3	5,88	2,41	14,63	6,98	3,60	8,90	1,23	4,42	1,83	4,34	4,57
Iron (Fe^{2+} и Fe^{3+})	mg/dm^3	5,54	3,78	12,74	5,03	3,92	6,29	2,40	4,66	13,68	4,94	3,88
Zinc (Zn^{2+})	mg/dm^3	8,07	1,46	4,17	1,48	0,71	0,32	3,16	40,6	1096	2,77	0,92
Phosphorus (P^{5+})	mg/dm^3	0,682	0,377	1,83	1,24	0,33	0,287	0,206	0,406	0,145	0,22	1,12
Sulphur (S^{6+})	mg/dm^3	220,0	274	70,2	41,61	134,5	587	400	497,5	1400	165,2	96,4
Antimony (Sb^{2+} и Sb^{5+})	mg/dm^3	0,053	<0,02	0,044	<0,02	0,026	<0,02	0,148	<0,02	0,032	0,056	0,048
Cobalt (Co^{3+})	mg/dm^3	0,045	<0,004	0,02	0,013	0,006	<0,004	<0,004	0,476	0,67	0,008	0,009
Bismuth (Bi^{3+})	mg/dm^3	<0,02	<0,02	<0,02	<0,02	0,075	<0,02	0,062	<0,02	<0,02	<0,02	<0,02
Tin (Sn^{2+} и Sn^{4+})	mg/dm^3	<0,02	<0,02	<0,02	<0,02	<0,02	<0,02	<0,02	<0,02	<0,02	<0,02	<0,02
Tungsten (W^{5+} и W^{6+})	mg/dm^3	<0,02	<0,02	<0,02	<0,02	<0,02	<0,02	<0,02	<0,02	<0,02	<0,02	<0,02
Permanganate oxidizability	mg/dm^3			16,48	12,80	24,16						