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CHEMOMETRIC ANALYSIS OF THE WATER OF SITNICA RIVER

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Abstract: *The purpose of this study is to determine the water quality of the Sitnica river through the research and determination of some physico-chemical parameters of this water and the degree of pollution with heavy metals and various effluents along the entire flow of the river, within the borders of Republic of Kosovo. The geographical positions of sampling spots were determined by GPS, make GARMIN GEKO, 12 channel. The number of sampling spots is 9, and samples in every sampling spot were taken to determine the chemical parameters.The tracking of heavy materials is done through the ICP-MS and ICP-OES method. Following the results of our analyses it found that the temperature is almost unchanged and it is between 11.5 and 12 degrees. Electrical conductivity, starting from the spring, is increasing and it reaches the maximum rate (840 μS/cm) at point S_5 (Palaj) as a consequence of industrial water spill and other anthropogenic polluters and again after that it starts to drop down along the flow of the river. The pH of water is between 7.83 in S_1(Jezerc) and 8.6 in S_3 (Lipjan). The turbidity is also increasing in S_5. Total hardness reaches the maximum rate in S_4 (Lismir), but it drops again, while the alkalinity reaches the maximum rate in S_5. At sampling spot S_4, metals Ni, Co, Si, Zn are noted for the maximum concentration comparing to other points, except in sampling spot S_9(Mitrovica), where the rate is over 250 μg/dm^3. At the sampling point S_9, the maximum content of cadmium is observed, at the point S_2(Rubovich) - iron, at the point S_1 – chromium. According to the performed chemical analysis, it can be concluded that the pollution of the Sitnitsa River is caused by anthropogenic sources, especially at sampling points S_4, S_5, S_6 (Plemetin) and S_9. Namely, where the river Drenica flows into Sitnica, which carries the industrial waters of the ferronickel plant (S_4), then S_5 and S_6, where industrial waters come from thermal plants, and S_9, where industrial waters come from the ore smelter in Mitrovica.*
Keywords: *pollution, heavy metal, industrial water, ICP-MS and ICP-OES method*
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Introduction

The quality of the rivers' water in developed countries, USA and in particular in the European Union is evaluated in keeping with a classification system, based on which the quality of the rivers water is considered satisfactory from the first to the third category. This classification includes: the number of parameters that are measured and compared, the method of calculation, the physical chemical and biological properties of waters [1-2]. Table 1 shows the classification of rivers waters according to the Economic Commission of the United Nations for Europe (UNECE), based on some chemical parameters such as; total phosphorus, nitrates, dissolved oxygen, Biochemical oxygen demand (BOD), Chemical oxygen demand (COD), and ammonia [3].

The Sitncë River lies in the territory of the Republic of Kosovo and is the main branch of the Ibër River, with a basin size of 2,861 km² and an annual flow of 16.6 m^3 per second.

Table 1. Classification of rivers water quality according to ECUNE (mg/dm^3)

Category	P_{total}	NO_3^-	dissolved oxygen	BOD	COD	NH_4^+
Quality I	<10	<5	>7	<3	<3	<0.1
Quality II	10-25	5-25	7-6	3-5	3-10	0.1-0.5
Quality III	25-50	25-50	6-4	5-9	10-20	0.5-2
Quality IV	50-125	50-80	4-3	9-15	20-30	2-8
Quality V	>125	>80	<3	>15	>30	>8

According to the reports of the Hydro Meteorological Institute of Kosovo for the State of River Waters, the Sitnica River - starting from Ferizaj to Mitrovica, is the most polluted river in Kosovo [4]. In terms of physical parameters, suspended matter is present and exceeds the maximum allowed values. This comes from the discharge of water polluted with physical materials from the Nerodime river, then from the Shtime, Graqanka, Prishtina, Drenica, Llapi, Trepça rivers into the Sitnica river. BOD and COD measurements show high levels of water pollution in this river [5].

Research Methods

ICP-MS (Induction Coupled Plasma-Mass Spectroscopy) and ICP-OES (Induction Coupled Plasma-Optical Emission Spectroscopy), are the most important analytical methods of elemental analysis, due to advantages such as; low detection limits for many elements, very good selectivity and well as high precision [6].

It should be noted that the plasma torch serves as an atomizer and ionizer of the analyte. For solution analyses, the sample is introduced into the aerosol state. Positive metal ions are obtained from the plasma torch, which are introduced into the quadrupole MS through a special device. The spectra obtained are very simple, similar to optical spectra. They consist of a series of spots of isotopes of each element present in the sample. ICP-MS spectra are used for both qualitative and quantitative analysis [7].

The layout of the components of an ICP-MS system is shown in Fig. 1. The most critical part of the apparatus is the connection that couples the ICP torch to the mass spectrometer. ICP-MS is one of the most trusted techniques for routine daily measurements and in sophisticated geoscience applications, especially as these devices are suitable for rapid chemical analysis of geological materials, soils, alloys, glass, etc.

The basic working principle of the ICP-MS instrument is the high temperature of the argon plasma. The fundamental principle of emission spectroscopy is in the excitation of the outer electrons of atoms in the ground state, and in the imitation of photons of the specific wavelengths.

In the plasma, there is enough energy to remove the electron from the orbital to generate ions. The detection of positive ions adds the ICP-MS the characteristics to determine the elements in trace.

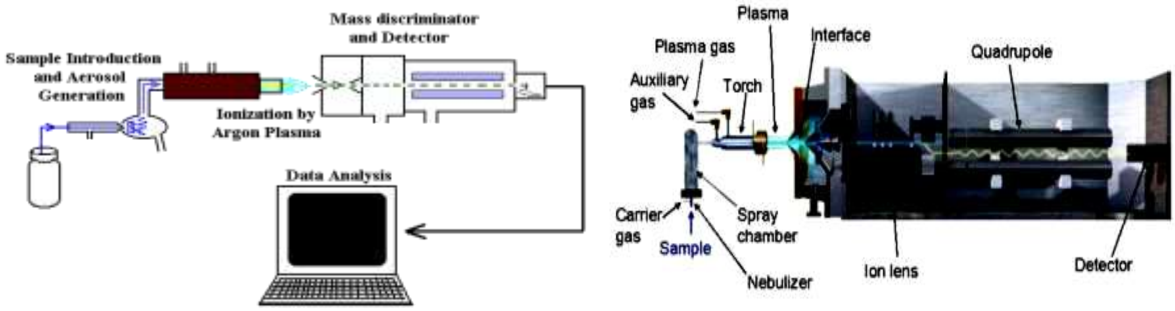

Fig. 1. Schematic of an ICP-MS system

Research Area

The water sampling in the Sitnica River was carried out at the beginning of spring, so the water level was very high due to atmospheric precipitation [8]. The sampling sites were chosen in places where we expected pollution from various factors (traffic, agricultural land, sewage, Electricity Corporation of Kosovo, Ferronickel Factory, etc.) [9]. The parameters that have been determined in the field are as follows: water temperature, air temperature, pH, electrical conductivity, geographical position, relief description, etc.

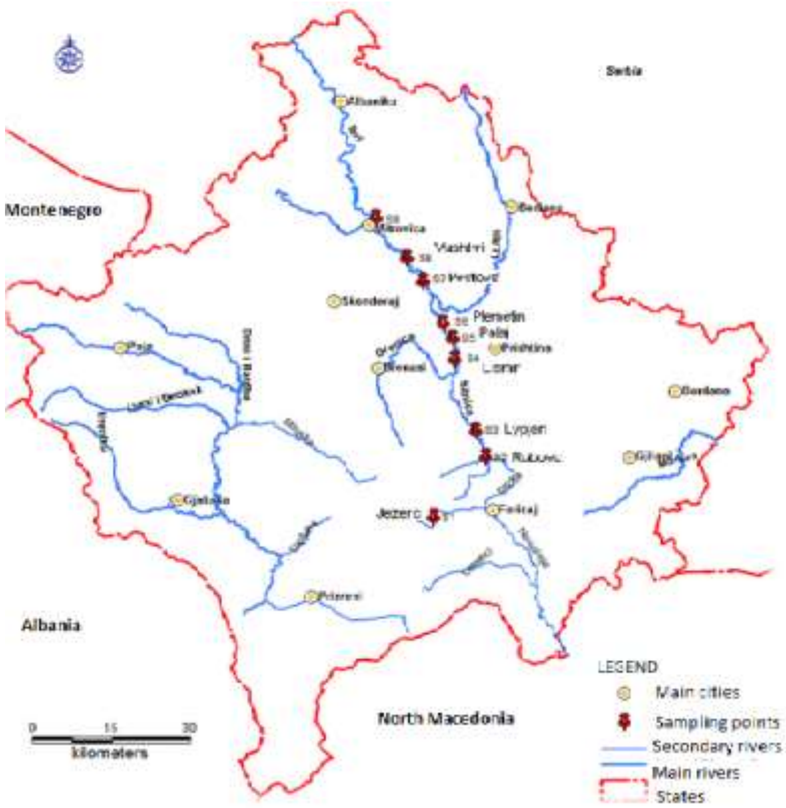

Fig. 2. Hydrological map of Kosovo with main rivers and sampling points

The number of sampling sites is 9 and in the each sampling site was taken one liter of water for analysis. The samples are marked with the symbols S_1, S_2, S_3, S_4, S_5, S_6, S_7, S_8, S_9 (Tab.2). Note that S_1 represents the sample taken in Jezerca and the last sample in Mitrovica is S_9. Also, the results have been processed with the help of the Geographical Information System (GIS). The hydrographic map with sampling sites and main cities of the

Republic of Kosovo was obtained from the data obtained from the field (fig.1)

Table 2. Sitnica river water sampling sites with detailed descriptions

Samples	Location	**The coordinates**	**Altitude (m)**	**Type of soil/relief**	**Water level**	**Possible pollutants**
S_1	Jezerc	34T05011374 UTH468490	753	Mountain/woods	High	little reliability
S_2	Rubovc	34T0511162 UTH4701535	555	Field/agriculture	High	sewage, agricultural pollutants
S_3	Lipjan	34T0509209 UTH4706850	552	Field/agriculture	High	trafic, sewage, agricultural pollutants
S_4	Lismir	34T 0505446 UTH4721046	536	Field/agriculture	High	sewage, agricultural pollutants
S_5	Palaj	34T 0504962 UTH4725257	529	Field/agriculture	High	scrap metal and T.C. Kosova A
S_6	Plemetin	34T 0503151 UTH4728261	489	Field/agriculture	high	Sewage, T.C.Kosova B
S_7	Pestova	34T 0499286 UTH4736647	524	Field/agriculture	high	sewage, agricultural pollutants
S_8	Vushtrri Bridge	34T 0496283 UTH4741292	516	Field/agriculture	high	sewage, agricultural pollutants
S_9	Mitrovica (exit)	34T 0490406 UTH4749405	507	Fushor	high	ore processing smelter, Trafic, sewage

Results

Some of the results obtained due to the determination of some physio-chemical parameters of the Sitnica river water are presented in tabular form (tables 3-6).

Table 3. Temperature, conductivity, pH and turbidity evaluated in the sample

Samples	**Temp. of water / °C**	**Temp. of air/°C**	**Conductivity, µs /cm**	**pH**	**turbidity (NTU)**
S_1	11.9	11.9	400	7.83	0.29
S_2	11.9	11.8	516	7.5	10.3
S_3	11.9	11.8	613	8.61	8.8

S_4	11.9	11.8	792	8.14	14.71
S_5	12	11.5	840	8.20	30.6
S_6	12	11.5	728	8.24	25.3
S_7	11.7	11	630	8.05	30.23
S_8	11.8	11	624	8.04	29.7
S_9	11.8	13	665	8.05	21.3

Table 4. Alkalinity in the presence of methyl orange mA and of phenolphthalein pA, total hardness, transient hardness, carbonate concentration and bicarbonate in mg/dm^3 in the samples.

Samp-ling points	Alkali-nity, mA	Alkali-nity, pA	Total hardness/° D	Trensient hardness/° D	γ(CO_3^{-2}) mg/ dm^3	γ (HCO_3^-) mg/ dm^3
S_1	20	n.d	11.501	0.56	n.d.	122
S_2	20.5	n.d.	12.283	0.574	n.d.	125.05
S_3	23	n.d.	13.958	o.644	n.d.	140.30
S_4	22	n.d.	17,978	0.616	n.d.	134.2
S_5	25	n.d.	17.866	0.7	n.d.	152.5
S_6	21	n.d.	16.024	0.588	n.d.	128.1
S_7	20	n.d.	14.181	0.56	n.d.	122
S_8	20.5	n.d.	13.399	0.574	n.d.	125.05
S_9	21	n.d.	15.577	0.588	n.d.	128.1

Table 5. Consumption of potassium permanganate, amount of magnesium oxide, calcium and chloride concentration in the samples taken for analysis

Sampling points	γ(CaO)/mg dm^{-3}	γ(MgO)/mg dm^{-3}	$KMnO_4$ /mg dm^{-3}	γ (Cl^-)/mg dm^{-3}
S1	8.33	3.17	26.0	17.72
S2	10.96	1.32	25.2	15.9525
S3	11.68	2.27	26.5	17.725
S4	10.73	7.25	26.3	24.815
S5	8.945	8.92	26.3	35.45
S6	11,52	4.51	26.0	21.27
S_7	3.8	10.38	26.2	17.725
S_8	10.62	2.78	26.3	15.95
S_9	7.94	7.64	23.7	14.18

Table 6. Presentation of the concentration of elements determined in river water by ICP-MS and ICP-OES techniques

Element	Sampling points and results								
µg/dm^3	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**
Na	954	11800	16400	25000	30800	23500	18500	16900	17100
Li	< 1	2	4	13	13	12	9	9	11
Be	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Mg	4890	11800	15200	>20000	>20000	>20000	>20000	>20000	>20000
Al	14	46	59	52	30	30	34	24	43
Si	4000	4300	4100	4700	4300	3400	4300	4300	4300
K	700	3440	4970	6120	6390	5100	4470	4200	5370
Ca	> 20000	>20000	>20000	>20000	>20000	>20000	>20000	>20000	>20000
Sc	1	1	< 1	1	1	< 1	1	1	1
Cr	4.5	2.4	2.1	3.1	3.5	4.3	3.1	3.1	3.4
Mn	0.5	93.2	107	265	209	195	94.1	72	172
Fe	40	170	150	120	100	100	80	70	100
Co	0.021	0.265	0.355	0.64	0.611	0.461	0.343	0.288	0.569
Ni	1.4	2.7	3.9	19.5	15.2	13.2	9.9	9.1	9.5
Cu	2.3	3.8	4.7	4.1	7.4	5.7	5.8	5.2	5.9
Zn	4.6	11	11.1	50.1	45.4	31.9	15.5	12.3	> 250
As	0.5	1.53	2.24	3.14	3.25	2.91	2.7	2.56	2.7
Se	< 0.2	0.3	0.4	0.4	0.4	0.5	0.3	0.4	0.4
Sr	60.5	> 200	> 200	> 200	> 200	> 200	> 200	> 200	> 200
Zr	< 0.01	0.07	0.11	0.09	0.05	0.06	0.05	0.03	0.03
Nb	0.01	0.013	0.019	0.018	0.012	0.012	0.01	0.011	0.012
Mo	0.1	0.4	0.4	1	1.3	1.6	0.8	0.8	0.8
Pd	< 0.01	< 0.01	< 0.01	0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Ag	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Cd	0.02	0.03	0.04	0.05	0.06	0.04	0.04	0.03	1.72
In	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Te	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
I	< 1	< 1	< 1	2	1	2	< 1	< 1	< 1
Cs	0.004	0.009	0.014	0.044	0.116	0.1	0.091	0.074	0.13
Ba	10.4	43.9	35.6	52.5	43.2	46.8	37.7	38.8	43.1

La	0.005	0.07	0.083	0.054	0.04	0.034	0.041	0.032	0.043
Ce	0.007	0.109	0.132	0.307	0.061	0.055	0.072	0.055	0.072
Pr	0.001	0.016	0.016	0.013	0.014	0.009	0.009	0.008	0.14
Nd	0.003	0.06	0.063	0.04	0.032	0.028	0.034	0.034	0.038
Sm	< 0.001	0.013	0.017	0.014	0.007	0.008	0.007	0.007	0.009
Eu	< 0.001	0.004	0.003	0.006	0.002	0.004	0.002	0.004	0.003
Gd	0.002	0.015	0.016	0.014	0.01	0.012	0.009	0.009	0.03
Tb	< 0.001	0.003	0.002	0.002	0.001	0.001	0.002	0.001	0.002
Dy	0.002	0.011	0.01	0.01	0.008	0.006	0.008	0.007	0.011
Ho	< 0.001	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Er	< 0.001	0.006	0.006	0.006	0.005	0.005	0.005	0.005	0.005
Tm	< 0.001	<0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Yb	0.001	0.006	0.007	0.007	0.006	0.004	0.004	0.003	0.006
Lu	< 0.001	0.001	0.001	0.001	0.001	< 0.001	< 0.001	< 0.001	< 0.001
Hf	< 0.001	0.002	0.003	0.005	< 0.001	0.001	0.002	< 0.001	< 0.001
Ta	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
W	0.08	0.28	0.13	0.07	0.09	0.09	0.07	0.08	0.33
Re	0.002	0.001	0.003	0.004	0.008	0.01	0.005	0.006	0.006
Os	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
Pt	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3
Au	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
Hg	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Tl	< 0.001	0.005	0.005	0.007	0.009	0.007	0.005	0.005	0.009
Pb	0.55	4.93	1.84	5.8	4.89	11.2	4.89	3.25	6.9
Bi	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3
Th	< 0.001	0.01	0.008	0.007	0.003	0.004	0.005	0.002	0.003
U	0.166	0.797	0.974	1.13	1.1	1.02	0.898	0.95	1.23
Hg, (ng/L)	< 6	14	20	22	20	25	24	10	42

Results and discussion

In the Sitnica river water analysis, the water temperature ranges from 11.7 to 12ºC. The water temperature in nearly every sampling site was the same with a small difference of ± 0.30C. The lowest temperature was recorded in sampling site S_7, namely in Pestova 11.7ºC, while the highest temperature was 12ºC in S_6 and S_5.

The pH ranges from 7.83 at sampling site S_1 and 8.61 at sampling site S_3. Electrical conductivity ranges from 400 to 840 µS/cm. The highest conductivity is recorded in sampling site S_5 (Palaj), while the lowest is in sampling site S_1 (the source). Turbidity ranges between 0.29 NTU at the source and 30.6 NTU at sampling site S_5. Site S_5 is the point within the territory of KEK. Coal mines and large ash wastes are some of the parameters that determined the highest values of turbidity and electrical conductivity [10].

The overall hardness ranges between 11.501ºdH in the source and 17.99ºdH in the sampling site S_4 (Lismir). Transient hardness varies between values 0.56 and 0.7ºdH. The relative increase of these parameters towards the river flow is the result of the addition of salts and other elements in the water [11].

The alkalinity of the water in the presence of the methyl orange indicator ranges between the values of 20 and 25, which proves the presence of bicarbonates in the values of 122 to 152.5µg/dm³. We did not have the alkalinity values recorded in the presence of the phenolphthalein indicator, which proves the absence of carbonates. The consumption of potassium permanganate varies between the values of 23.7 to 26.5 mg/dm^3, which proves the pollution of the Sitnica river water with different organic materials from industrial waters, sewage and other possible natural pollutants, such as rotting plants and animal waste, etc [12-13].

Diagrams 1-8 show the concentrations of some metals at sampling points S_1-S_9.

The diagram 1 shows iron concentration in each sample. From the diagram we can see a jump/very high concentration of iron in sample S_2, the sampling site is the village of Rubovc in the municipality of Lipjan. This increase in concentration came as a result of flooding of a scrap yard located near the river bed [14]. The concentration of iron from sample S_2 to sample S_3 and so on, goes down continuously until sample S_9, where we have an increase in concentration because of the ore processing smelter in Mitrovica.

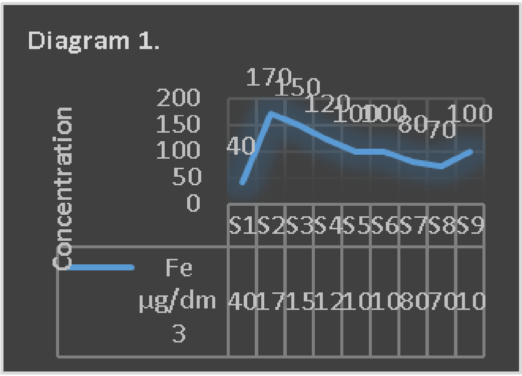

Diagram 1. Iron concentration at sampling points

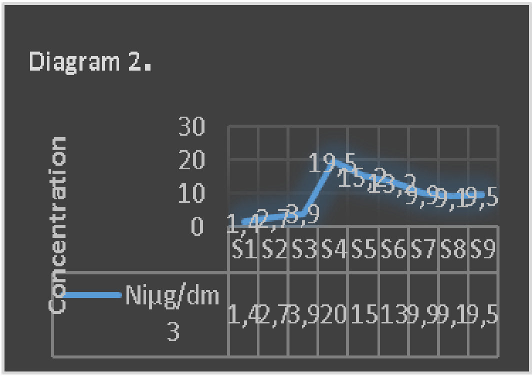

Diagram 2. Nickel concentration at sampling points

Diagram 2 show the Ni concentration diagram in each sample separately. The diagram indicates a jump in nickel concentration in sample S_4 which was taken from the sampling site in Lismir. To our thinking, the increase in the concentration of Ni at this point comes from the industrial waters of Ferro-Nickel [15], which together with the waters of the Drenica River, flow into the Sitnica River in the Lismir village. Then in all the other samples we have a decrease in the concentration of Ni, until sample S_9 where there is also an increase which comes from industrial waters as well.

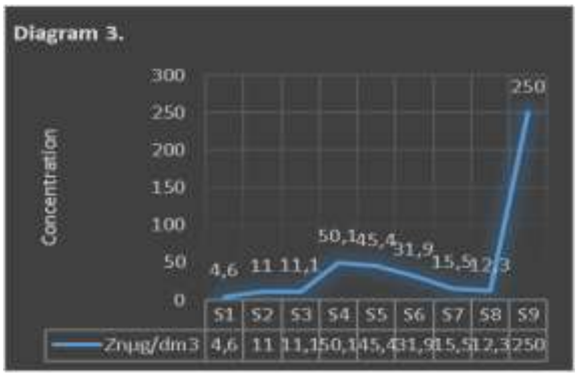

Diagram 3. Zinc concentration at sampling points

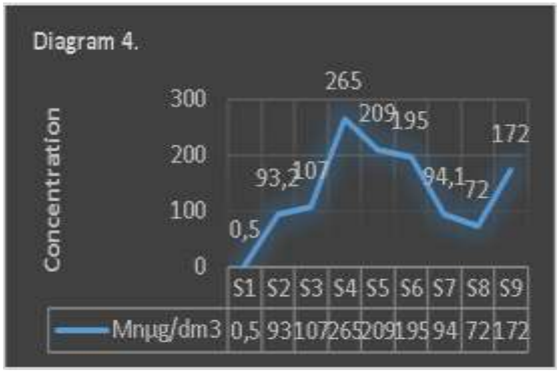

Diagram 4. Manganese concentration at sampling points

Diagram 3 shows the concentration of zinc with an increase in the concentration of the sample S_4 (Lismir), which, in our view comes from the industrial waters of Ferro-Nickel [16]. Characteristic in this diagram is the very high concentration of zinc in sample S_9 above 250µg/dm³, the sampling site of which is outside the city of Mitrovica where is the ore processing smelter.

Diagram 4 shows the concentration of Mn with an increase in the concentration of the samble S_4 then S_5, S_6 and S_9, respectively in Lismir, Palaj, Plemetin and Mitrovica. The high level of manganese comes as a result of industrial water pollution from Ferro-Nickel (S_4), Thermal Power Plants and scrap metal (S_5, S_6) and ore processing smelter in Mitrovica (S_9).

Diagram 5 shows the concentration of cadmium in the waters of the river Sitnica, where we observed that the concentration is the highest in the sampling site S_9, near the ore processing smelter in Mitrovica.

Diagram 6 shows the concentration of chromium with a high value in sampling site S_1 (4.5µg/dm³), respectively in the source and in S_6 (4.3µg/dm³), respektively in Plemetin (Thermal Power Plants). In source (S_1) the high level of chromium may be from the soil composition because the reliability of unnatural contaminants is very small [17].

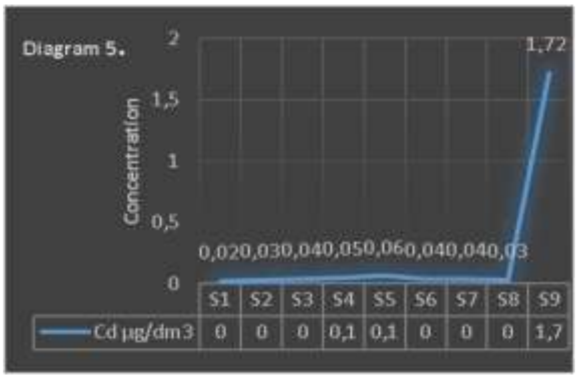

Diagram 5. Cadmium concentration at sampling points

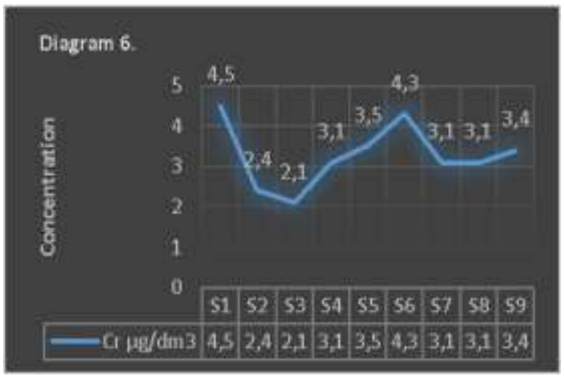

Diagram 6. Chromium concentration at sampling points

Diagram 7 show the highest concentration of Pb is recorded in sample S_6 (Plemetin), respectively 11.2µg/dm³ and in sample S_9 (Mitrovica) 5.8µg/dm³. Sample site S_6 is the point after KEK's (Thermal Power Plants) industrial water discharge, while sample site S_9 is close to the ore smelter in Mitrovica. Therefore, this concentration of Pb in these two points, we believe that comes from the industrial waters of KEK (Thermal Power Plants) and from the smelter.

Diagram 8 shows the highest concentration of Cu is recorded in sample S_5 (Palaj), wher is the Thermal Power Plant (T.C. Kosova A) and scrap metal.

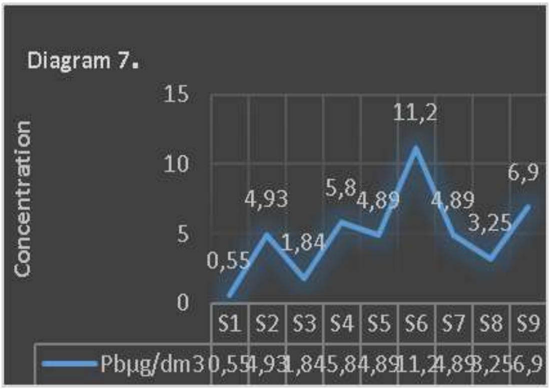

Diagram 7. Lead concentration at sampling points

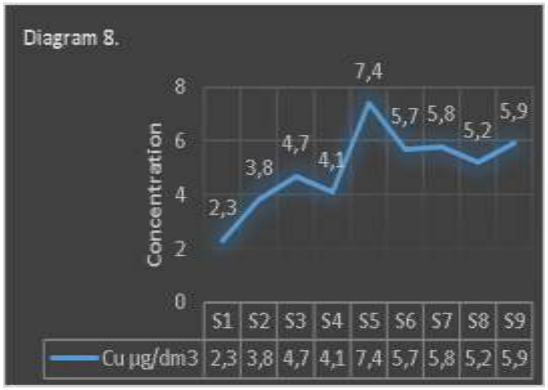

Diagram 8. Copper concentration at sampling points

Conclusions

The determination of the physical-chemical parameters and their evaluation in the water of the river Sitnica was done along the entire flow of the river within the territory of the Republic of Kosovo. Electrical conductivity, hardness and turbidity have increased, depending on the degree of pollution of the river by the human factor; as a result of the addition of various salts and other primes which in one way or another have affected the increase of these parameters. The results of our analyzes show that the water of the Sitnica river has a low alkalinity, while in terms of hardness it is classified as moderately hard water (Tables 3 and 4).

From the results of the analyzes it is also obvious that the high concentrations of metals are mainly marked by industrial water discharges. The pollution of the water of the Sitnica river by heavy metals is the result of the discharge of untreated industrial waters (Ferro-Nickel, KEK - Thermal Power Plants, etc.) into the water flow of the Sitnica river. Besides, the pollution comes as a result of the presence of scrap metal and illegal waste dumps near the bed of river.

Based on the reports of the Hydro Meteorological Institute of Kosovo, on the state of river waters for 2018, 2019, 2021, the Sitnica river is the most polluted river in Kosovo.

Finally, based on our results, we can conclude that the increase in the concentration of the most of the microelements that were determined by the ICP-MS and ICP-OES method mainly occurred in points S4, S5 and S9 (with some exceptions). The question is about the points where there is discharge of the waters of the Drenica river, respectively the industrial waters of Ferro-Nicely (S4), the industrial waters of KEK (S5) and S9 after the ore smelter.

All these come as a result of the lack of legal infrastructure and insufficient control over some industries, especially of their industrial waters before they flow into the rivers in Kosovo.

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SITNICA ÇAYININ SUYUNUN KİMYƏVİ ANALİZİ

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Xülasə: Bu tədqiqatın məqsədi Kosovo Respublikasının sərhədləri daxilində Sitnica çayının suyunun bəzi fiziki-kimyəvi parametrlərinin müəyyən edilməsi yolu ilə keyfiyyətini və çayın bütün axını boyunca ağır metallarla və müxtəlif çirkab sularla çirklənmə dərəcəsinin öyrənilməsidir. Nümunə götürmə nöqtələrinin (S) sayı 9 olmuşdur. Ağır metalların izlənməsi ICP-MS və ICP-OES metodu ilə aparılıb. S_4 nümunə alma nöqtəsində nikel, kobalt və silisium metallarının maksimum konsentrasiyası müşahidə olunub. S_9 nümunə alma nöqtəsində kadmiumun, S_2-də dəmirin və S_1-də xromun miqdarı maksimal olmuşdur.
Aparılan kimyəvi analizlərə əsasən, belə nəticəyə gəlinir ki, bu çayda çirklənməsinin səbəbi insan fəaliyyəti ilə bağlıdır. Məhz, dəmir-nikel zavodunun, İES-larının və Mitrovitsadakı metal əritmə zavodunun sənaye sularının Sitnica çayına tökülməsi nəticəsində çirklənmə baş verir.
Açar sözlər; Sitnica çayı, çirklənmə, ağır metal, sənaye suyu, ICP-MS və ICP-OES metodu.

ХИМИЧЕСКИЙ АНАЛИЗ ВОДЫ РЕКИ СИТНИЦА

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Аннотация: Целью данного исследования является определение качества воды реки Ситница путем исследования некоторых физико-химических параметров этой воды и степени загрязнения тяжелыми металлами и различными стоками по всему течению реки в пределах Республики Косово. Географическое положение точек отбора проб определяли с помощью 12-и канального навигатора GPS, марки GARMIN GEKO. Количество точек отбора проб составляет 9, и в каждой точке отбора проб были взяты пробы для определения химических параметров. Отслеживание тяжелых материалов осуществляли с помощью методов ICP-MS и ICP-OES. По нашим анализам было замечено, что температура практически не меняется и находится в интервале 11.5-12^{0}C. Электропроводность, начиная с родника, увеличивается и достигает максимального значения в точке S_5 (840 мкСм/см), как следствие промышленных разливов воды и других техногенных загрязнителей, после чего снова начинает падать по течению реки. pH воды увеличивается от 7.83 в точке отбора S_1 до 8.6 в точке отбора S_3. Мутность также увеличивается в точке отбора S_5. Общая жесткость достигает максимального показателя в S_4, а щелочность достигает максимального показателя в S_5. В точке отбора проб S_4 никель, кобальт, кремний, а также цинк имеют значительную концентрацию по сравнению с другими точками, за исключением точки отбора проб S_9, где показатель превышает 250 мкг/дм^3. В точке отбора S_9 наблюдается максимальное содержание кадмия, в точке S_2 – железа, в точке S_1- хрома. Замечена аномалия в точке отбора проб S_7, расчетная общая жесткость имеет значительное падение по сравнению с точкой до и после. По проведенному химическому анализу можно сделать вывод, что загрязнение реки Ситница обусловлено антропогенными источниками, особенно в точках отбора проб S_4, S_5, S_6 (Племетин) и S_9. А именно там, где в Ситницу впадает река Дреница, несущая промышленные воды ферроникелевого завода (S_4), затем S5 и S_6, куда поступают промышленные воды от тепловых электростанций, и S_9, куда поступают промышленные воды от рудоплавильного завода в Митровице.

Ключевые слова: загрязнение, тяжелые металлы, техническая вода, метод ИСП-МС и ИСП-ОЭС