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Issue Article

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HYDROCHEMICAL INVESTIGATION OF BIOLOGICALLY ACTIVE IONS IN THE SPRING WATERS OF LOWER TKIBULI, TKIBULI MUNICIPALITY, IMERETI REGION, GEORGIA

Abstract: *The present study aimed to investigate the hydrochemical composition of spring waters located in Lower Tkibuli, Tkibuli Municipality, Imereti Region, Georgia. The concentrations of biologically active and*

environmentally significant parameters, including pH, total hardness, Mg^{2+}, Ca^{2+}, HCO_3^-, Br^-, total arsenic, SO_4^{2-}, total iron, Cu^{2+}, Cl^- ions, permanganate oxidizability, dissolved oxygen (DO), biochemical oxygen demand (BOD_5), and free carbon dioxide (CO_2), were determined using standardized hydrochemical and photometric analytical methods. The novelty of the research lies in the fact that the above-mentioned parameters were determined for the first time in these spring waters using highly sensitive analytical techniques. All laboratory analyses were carried out at the Iason Moseshvili Hydrochemical Laboratory of the Department of Chemistry, Faculty of Exact and Natural Sciences, Akaki Tsereteli State University. The obtained results provide valuable information regarding the hydrochemical characteristics and suitability of the investigated spring waters for drinking and domestic purposes.

***Key words**: spring water, hydrochemical analysis, biologically active ions, Tkibuli Municipality, groundwater quality, drinking water, environmental monitoring.*

***Language**: English*

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Introduction

Water is one of the most important natural resources and plays a fundamental role in sustaining life and maintaining ecological balance. Natural waters are complex systems containing dissolved minerals, gases, and organic compounds originating from geological formations and environmental processes. The chemical composition of spring water is largely determined by local geological conditions, hydrological characteristics, and anthropogenic influences.

The hydrochemical investigation of spring waters is essential for evaluating water quality, determining its suitability for drinking and domestic use, and assessing potential environmental risks. Particular attention is paid to biologically active ions and trace elements because their concentrations directly affect human health and ecosystem stability.

Tkibuli Municipality is located in the Imereti Region of western Georgia and is characterized by diverse geological formations and abundant groundwater resources. Despite the widespread use of local spring waters by the population, comprehensive hydrochemical data for many springs remain limited. Therefore, the determination of major ions, trace metals, and selected physicochemical parameters is important for understanding the quality and environmental status of these water resources.

The objective of the present study was to determine the concentrations of pH, total hardness, Mg^{2+}, Ca^{2+}, HCO_3^-, Br^-, total arsenic, SO_4^{2-}, total iron, Cu^{2+}, Cl^- ions, permanganate oxidizability, dissolved oxygen, biochemical oxygen demand (BOD_5), and free carbon dioxide in the spring waters of Lower Tkibuli. The obtained results contribute to the hydrochemical characterization of local groundwater resources and provide a scientific basis for assessing their suitability for human consumption and household use.

Picture 1.

Tkibuli Municipality

Tkibuli Municipality is located in the Imereti Region of western Georgia, within the Okriba Depression, at an elevation of approximately 600–800 m above sea level. The administrative center of the municipality is the town of Tkibuli. The municipality borders Ambrolauri to the north, Chiatura to the southeast, Terjola to the south, Kutaisi to the southwest, and Tskaltubo to the west.

The territory is characterized by a mountainous landscape covered with forests and is traversed by several rivers, including the Tkibula, Lekhidari, Dzusa, Maghara-Chishura, Tskaltsitela, and Kvekhuna rivers. The region belongs to the humid subtropical climatic zone and is characterized by relatively cold winters and long, warm summers. The average annual air temperature ranges from +9°C to +14°C.

Tkibuli Municipality possesses significant natural resources, including groundwater reserves, and has long been known for coal mining activities. In addition, the area has considerable environmental and tourism potential due to its rich biodiversity, numerous natural landmarks, and favorable climatic conditions. Despite the importance of local spring waters for the population, comprehensive hydrochemical investigations of many springs within the municipality remain limited. Therefore, detailed studies of their physicochemical characteristics are necessary for evaluating water quality and potential suitability for drinking and domestic use.

Results and Discussion

For the first time, a comprehensive hydrochemical investigation was conducted on the spring waters of Lower Tkibuli, Tkibuli Municipality. The following physicochemical parameters were determined using chemical and photometric analytical methods: pH, total hardness, Mg^{2+}, Ca^{2+}, HCO_3^-, Br^-, total arsenic, SO_4^{2-}, total iron, Cu^{2+}, Cl^- ions, permanganate oxidizability, dissolved oxygen (DO), biochemical oxygen demand (BOD_5), and free carbon dioxide (CO_2).

The analytical results obtained for the investigated spring waters are presented in Table 1. The data provide important information regarding the hydrochemical composition of the springs and allow an assessment of their quality in relation to drinking water standards and environmental requirements.

The investigated waters exhibited slight variations in pH and mineral composition, reflecting differences in local geological and hydrogeochemical conditions. Concentrations of major ions, trace elements, and physicochemical indicators were evaluated to determine the suitability of the spring waters for drinking and domestic purposes. Particular attention was paid to biologically active ions and environmentally significant elements, including bromide, sulfate, iron, copper, and arsenic, due to their importance for human health and water quality assessment.

A comparative analysis of the obtained results revealed differences among the investigated springs with respect to hardness, dissolved mineral content, oxygen regime, and trace element concentrations. These variations are likely associated with differences in water-rock interaction processes and local hydrogeological conditions within the study area.

Table 1. Hydrochemical analysis results.

N	Local Names of the Spring Waters	pH	mg-eq/L	Mg/L												
			Water Hardness (mg-eq/L)	Mg^{2+}	Ca^{2+}	Total Fe	Cu^{2+}	Cl^-	Br^-	HCO_3^-	Free CO_2	dissolved oxygen	BOD_5	SO_4^{2-}	Permanganate Oxidizability	Total As
1	Ordjonikidze	6,8	3,96	16.58	49,60	ND	0,001	17,81	0,107	3,68	0,64	1,82	26,24	0,078	0,56	0,012
2	Station	7,5	4,68	28,22	43,20	0,006	ND	7,38	0,097	4,96	0,42	1,57	25,86	0,074	0,24	0,011
3	Gogni road	7,6	2,52	17,92	34,40	ND	ND	9,23	0,246	2,70	0,14	1,89	16,00	0,028	1,04	0,013

Results and Discussion

The pH values of the investigated spring waters ranged from 6.8 to 7.6.

Water hardness was relatively high in the Station Spring, reaching 4.68 mg/L, whereas the lowest hardness value was observed in the Gogni Road Spring (2.52 mg/L).

The highest concentration of Mg^{2+} ions was detected in the Station Spring (28.22 mg/L), while the lowest concentration was recorded in the Ordzhonikidze Spring (16.53 mg/L).

The concentration of Ca^{2+} ions also exhibited variability. The highest concentration was found in the Ordzhonikidze Spring (49.60 mg/L), whereas the lowest concentration was detected in the Gogni Road Spring (34.40 mg/L).

Total iron was not detected in the Ordzhonikidze and Gogni Road springs, as its concentration was below the analytical detection limit. In the Station Spring, the total iron concentration was 0.006 mg/L.

Cu^{2+} ions were not detected in the Station and Gogni Road springs. In the Ordzhonikidze Spring, the copper concentration was 0.001 mg/L.

The highest concentration of chloride ions (Cl^-) was observed in the Ordzhonikidze Spring (17.81 mg/L), while the lowest concentration was found in the Station Spring (7.38 mg/L).

Bromide ions (Br^-) were most abundant in the Gogni Road Spring (0.296 mg/L), whereas their minimum concentration was detected in the Station Spring (0.097 mg/L).

The highest concentration of bicarbonate ions (HCO_3^-) was found in the Station Spring (4.96 mg/L), while the lowest concentration was observed in the Gogni Road Spring (1.70 mg/L).

The concentration of free carbon dioxide was highest in the Ordzhonikidze Spring (0.64 mg/L), whereas the Gogni Road Spring contained the lowest amount (0.14 mg/L).

The dissolved oxygen concentration was highest in the Gogni Road Spring (1.89 mg/L) and lowest in the Station Spring (1.57 mg/L).

The highest BOD_5 value was recorded in the Ordzhonikidze Spring (26.24 mg/L), while the lowest value was observed in the Gogni Road Spring (16.00 mg/L).

Sulfate ions (SO_4^{2-}) were present in relatively higher concentrations in the Ordzhonikidze Spring (0.078 mg/L), whereas the lowest concentration was measured in the Gogni Road Spring (0.028 mg/L).

Permanganate oxidizability was comparatively high in the Gogni Road Spring (1.04 mg/L), while its minimum value was observed in the Station Spring (0.24 mg/L).

The highest concentration of total arsenic was detected in the Gogni Road Spring (0.013 mg/L), whereas the Station Spring contained the lowest concentration (0.011 mg/L).

Experimental Section. Methodology for the Determination of Chemical Elements in Water

The analyses were carried out at the Analytical Chemistry Laboratory of Akaki Tsereteli State University, Kutaisi. Analytical procedures widely accepted in hydrochemical practice were employed [7–19].

The pH values were measured potentiometrically using a potentiometer.

The concentrations of Ca^{2+} and Mg^{2+} ions, as well as total water hardness, were determined by the complexometric method using 0.01 N Complexon III as the titrant. Eriochrome Black T was used as the indicator for magnesium determination in an ammoniacal buffer medium, whereas murexide served as the indicator for calcium determination in an alkaline medium adjusted with 2 N sodium hydroxide.

Total iron was determined spectrophotometrically after preliminary oxidation in an alkaline medium using sulfosalicylic acid as the photometric reagent (UN-5100B UV/VIS Spectrophotometer).

Copper ions (Cu^{2+}) were also determined spectrophotometrically in an ammoniacal medium using sodium N,N-diethyldithiocarbamate as the photometric reagent (UN-5100B UV/VIS Spectrophotometer).

Bicarbonate ions (HCO_3^-) were determined by the acidimetric method using 0.1–0.01 N titrant and methyl orange as the indicator.

Chloride ions (Cl^-) were determined by the mercurimetric method using 0.01 N titrant and diphenylcarbazone as the indicator.

Sulfate ions (SO_4^{2-}) were determined by the classical gravimetric method.

Total arsenic was determined iodometrically using a 0.05 N iodine solution with starch as the indicator.

Free carbon dioxide was determined by the alkalimetric method using a 0.1–0.01 N titrant. A small amount of Rochelle salt and phenolphthalein indicator was added to the sample before titration.

Oxidizability was determined by the permanganatometric method in an acidic medium using a 0.01 N oxidizing agent.

Dissolved oxygen and BOD_5 were determined iodometrically according to the Winkler principle [5].

Bromide ions (Br^-) were determined by the iodometric method. Sodium hydrogen phosphate, sodium hypochlorite, and sodium formate were added to the sample. The mixture was heated, cooled, and subsequently treated with potassium iodide, sulfuric acid, and ammonium molybdate. Titration was carried out with a 0.01 N solution using starch as the indicator. Bromide ions were oxidized by sodium hypochlorite to bromate ions.

Conclusion

In the investigated spring waters of Daba Tkibuli, Tkibuli Municipality, the concentrations of pH, total hardness, Ca^{2+}, Mg^{2+}, total iron, Cl^-, Br^-, HCO_3^-, SO_4^{2-}, Cu^{2+}, permanganate oxidizability, total arsenic, dissolved oxygen, BOD_5, and free CO_2 generally comply with the Georgian Technical Regulation for Drinking Water, with certain exceptions.

The concentration of bromide ions in the Gogni Road Spring (0.296 mg/L) exceeds the permissible limit established by the Georgian drinking water standard (0.2 mg/L).

Overall, the spring waters of Daba Tkibuli, Tkibuli Municipality, can be considered suitable for drinking and domestic purposes.

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