

Hydrochemical Characterization of Spring Waters in Zanati and Sujuna Villages, Abasha Municipality, Georgia

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Abstract

Spring waters are important sources of drinking and domestic water in rural communities; however, their chemical composition may vary considerably in response to local geology, groundwater–rock interactions, land use, and potential anthropogenic pressures. This study presents a hydrochemical characterization of selected spring waters in Zanati and Sujuna villages, Abasha Municipality, within the Samegrelo–Zemo Svaneti Region of Georgia. Water samples were examined using established

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hydrochemical, titrimetric, and spectrophotometric procedures. The analytical programme included pH, total hardness, dissolved oxygen, five-day biochemical oxygen demand (BOD₅), free carbon dioxide, and permanganate oxidizability. Major and trace constituents were assessed through measurements of calcium (Ca²⁺), magnesium (Mg²⁺), copper (Cu²⁺), total iron, bicarbonate (HCO₃⁻), chloride (Cl⁻), bromide (Br⁻), sulfate (SO₄²⁻), and total arsenic. The combined assessment of physicochemical characteristics, major ions, trace elements, and oxygen-related indicators provides a systematic basis for describing the chemical properties of the investigated springs and identifying parameters relevant to local groundwater-quality evaluation. The study establishes baseline hydrochemical information for spring-water resources in the selected settlements and supports subsequent monitoring, comparative assessment, and evidence-based management of rural water supplies in Abasha Municipality. Further seasonal sampling and microbiological assessment are recommended to determine temporal variability and provide a more comprehensive evaluation of the suitability of these waters for human consumption.

Keywords: Abasha Municipality; groundwater quality; hydrochemical assessment; major ions; Samegrelo–Zemo Svaneti; spring water; trace elements; water hardness.

Introduction

Natural waters acquire their chemical composition through interaction with geological formations and soils during their movement through the Earth's crust. As a result, various dissolved minerals and gases enter water, determining its hydrochemical characteristics. The concentration and distribution of dissolved substances vary considerably depending on geological, hydrological, and environmental conditions.



Fresh waters commonly contain calcium, magnesium, sodium, potassium, bicarbonate, chloride, and sulfate ions. The concentration of these components plays an important role in determining water quality and suitability for drinking and domestic use. Some elements and compounds, when present in elevated concentrations, may adversely affect human health or impair the organoleptic properties of water.

The determination of hydrochemical parameters is therefore essential for evaluating water quality and ensuring compliance with drinking water standards. Parameters such as pH, hardness, dissolved oxygen, biochemical oxygen demand, and the concentrations of major ions provide important information regarding the origin, quality, and potential use of groundwater resources.

Abasha Municipality is located in the southern part of the Samegrelo–Zemo Svaneti Region of western Georgia and is characterized by a well-developed hydrographic network. Numerous springs occur within the municipality and are widely used by the local population as sources of drinking water. Despite their practical importance, detailed hydrochemical information on many of these springs remains limited.

The aim of the present study was to determine the hydrochemical composition of selected spring waters in Zanati village and adjacent settlements and to evaluate their suitability for drinking and domestic use.

Results and discussion

The hydrochemical analyses revealed variations in the physicochemical characteristics of the investigated spring waters.

The pH values ranged from 7.0 to 7.7, indicating neutral and slightly alkaline conditions. Water hardness varied from 3.64 to 4.20 mg-eq/L. The highest hardness was recorded in the Gaghma Zanata II spring, while the lowest value was observed in the Uchaneishvilebi II spring.

Magnesium concentrations ranged from 14.15 to 24.40 mg/L, with the highest concentration detected in the Gaghma Zanata II spring and the lowest in the Saguno spring. Calcium concentrations varied between 42.40 and 52.80 mg/L, reaching the highest value in the Saguno spring.

Total iron concentrations showed considerable variation, ranging from 0.009 to 0.166 mg/L. The highest concentration was detected in the Uchaneishvilebi II spring, whereas the lowest concentration was found in the Uchaneishvilebi I spring. Copper concentrations were generally low and, in several samples, remained below the analytical detection limit.

Among the investigated anions, chloride concentrations ranged from 8.52 to 13.49 mg/L, while bromide concentrations varied between 0.053 and 0.256 mg/L. The highest bromide concentration was recorded in the Farm spring. Bicarbonate concentrations ranged from 2.26 to 5.84 mg/L, and sulfate concentrations varied between 0.0010 and 0.0053 mg/L.

The concentration of free carbon dioxide ranged from 0.26 to 0.70 mg/L. Dissolved oxygen concentrations varied from 1.57 to 1.95 mg/L. Biochemical oxygen demand (BOD₅) values ranged from 19.46 to 27.46 mg/L, indicating differences in the organic matter content among the investigated springs.

Permanganate oxidizability values ranged from 0.34 to 1.30 mg/L. Total arsenic concentrations varied from 0.010 to 0.014 mg/L and remained within acceptable limits for drinking water.

Overall, the investigated spring waters were characterized by relatively low mineralization and moderate hardness. The obtained results indicate generally good hydrochemical quality and confirm the suitability of most springs for drinking and domestic use.

Conclusion

The hydrochemical composition of spring waters in Zanati village and adjacent areas of Abasha Municipality was investigated using standard analytical methods.

The results demonstrated that the investigated waters are characterized by neutral to slightly alkaline pH values, moderate hardness, and relatively low concentrations of the analyzed ions. Most physicochemical parameters complied with the requirements of the Georgian Technical Regulation for Drinking Water.

Among the investigated springs, the Farm spring exhibited a bromide concentration slightly exceeding the permissible limit. Nevertheless, the overall hydrochemical quality of the studied waters can be considered satisfactory.

The obtained results provide baseline information on the hydrochemical characteristics of spring waters in the study area and may serve as a basis for future monitoring and environmental assessments.

Introduction

While moving through the Earth's crust, water dissolves numerous substances, including salts, which leads to the formation of waters with specific chemical compositions. The amount of salts in water varies within wide limits. Their total concentration, i.e., mineralization, is relatively low in surface waters and significantly higher in groundwater [1].

Natural waters contain almost all chemical elements, though in different concentrations. Fresh waters commonly contain cations such as calcium, magnesium, sodium, potassium, and iron. Among anions, chloride, sulfate, and hydrocarbonate ions are predominant. In highly mineralized waters, chloride and sodium ions are the major components, while magnesium and calcium are found in smaller amounts.

Natural waters generally exhibit a nearly neutral reaction, which is determined by the balance of opposite charges. The total concentration of cations equals the total concentration of anions in water [2].

One of the main objectives in studying water composition is the determination of ion concentrations. The analysis is based on the specific properties of each ion and determines their concentration in water.

Ions differ significantly in their properties. Some ions are highly toxic, making water unsuitable for drinking purposes. For example, strontium, beryllium, nitrate ions, lead, and selenium are toxic substances, and their permissible concentrations in water are extremely low. Some ions may not be poisonous but can deteriorate the chemical and organoleptic properties of water. Iron, for instance, is not toxic, but its presence in water is undesirable. If its concentration exceeds 0.3 mg/dm³, such water becomes unsuitable for drinking and household use. Water containing excess iron has a brown-yellow color and a metallic taste. The permissible concentration of chlorides is 350 mg/dm³, sulfates up to 500 mg/dm³, while the total salt content should not exceed 1000 mg/dm³ [3,4,5].

Natural waters always contain dissolved gases such as oxygen, nitrogen, and carbon dioxide. In some cases, methane, hydrogen sulfide, hydrogen, and inert gases may also occur.

Surface waters mainly contain oxygen, nitrogen, inert gases, and carbon dioxide. Nitrogen and oxygen have low solubility in water; therefore, their concentration in surface waters is relatively low (7–9 mg/dm³). Carbon dioxide, however, is highly soluble, resulting in its elevated concentration in some mineral waters. Oxygen is dissolved in comparatively small quantities because it is consumed during the chemical transformation of organic substances [6,7].

Abasha Municipality is an administrative-territorial unit in western Georgia, located in the southern part of the Samegrelo–Zemo Svaneti region. It borders Martvili Municipality to the north, Samtredia and Khoni municipalities to the east, Samtredia and Lanchkhuti municipalities to the south, and Senaki Municipality to the west. The territory is mainly a plain-lowland area situated 20–50 meters above sea level and composed of Quaternary sediments such as gravel, sand, and clay. The area slopes from northeast to southwest. The highest point of the municipality is located near the village of Sepieti, characterized by gently undulating elevations.

The municipality possesses a rich hydrographic network. The lower reaches of rivers are mainly represented here. In the southern part, the River Rioni flows gently from east to west over a distance of 42.4 km. Along the border with Samtredia Municipality flows the right tributary of the Rioni, the Tskhenistskali River. In the northwestern part of the municipality lies the Abasha River, which

joins the Tekhuri River. Smaller rivers include Noghela, Kovza, and Zana. A branch called Great Noghela separates from the Tskhenistskali River. The rivers have mixed feeding regimes, with floods characteristic in spring and low-water periods during winter. Among the most notable rivers are the Rioni, Tskhenistskali, and Abasha Rivers. In the southwestern part of Abasha Municipality lies the “Siriachkoni” swamp, which is a continuation of the interregional Guria-Samegrelo marshland, where drainage canals have been constructed.

Discussion of Experimental Results

For the first time, the following parameters were determined in the spring waters of Zanati village, Abasha Municipality: pH, water hardness, Mg^{2+} , Ca^{2+} , Cu^{2+} , total iron, HCO_3^- , Br^- , total arsenic, SO_4^{2-} and Cl^- ions, permanganate oxidizability, dissolved oxygen, BOD_5 , and free carbon dioxide using chemical and photochemical methods. The analytical results are presented in Table 1.

Table 1. Hydrochemical Characteristics of Spring Waters in Zanati Village, Abasha Municipality

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	Saguno Spring	7,0	3,80	14,15	52,80	ND	ND	12,78	0,114	4,50	0,62	1,86	25,92	0,0038	0,47	0,010
2	Gaghma Zanata I Spring	7,7	3,84	16,10	50,40	0,022	0,002	10,65	0,080	4,46	0,26	1,95	19,46	0,0023	0,34	0,012
3	Gaghma Zanata II Spring	7,3	4,20	24,40	44,00	0,070	ND	13,49	0,093	4,92	0,70	1,82	24,90	0,0010	0,40	0,011
4	Uchaneish vilebi I Spring	7,4	4,00	20,01	47,20	0,009	ND	9,80	0,063	4,80	0,36	1,57	25,22	0,0022	0,96	0,014
5	Uchaneish vilebi II Spring	7,5	3,64	18,54	42,41	0,166	0,002	11,22	0,062	2,26	0,42	1,86	27,46	0,0045	1,28	0,013

6	Farm Spring	7,0	3,88	21,47	42,40	0,142	ND	8,52	0,256	5,84	0,54	1,63	24,64	0,0053	1,30	0,011
7	Akhobadzeebi Spring	7,4	4,08	20,69	48,00	0,035	0,002	10,51	0,053	4,90	0,58	1,89	23,62	0,0037	0,88	0,013

The pH values of the investigated spring waters ranged from 7.0 to 7.7.

Water hardness was relatively higher in the Gaghma Zanata II spring (4.20 mg/L), while the lowest hardness was recorded in the Uchaneishvilebi II spring (3.64 mg/L).

The highest concentration of Mg^{2+} ions was found in the Gaghma Zanata II spring (24.40 mg/L), whereas the lowest concentration was detected in the Saguno spring (14.15 mg/L).

The concentration of Ca^{2+} ions also varied among the studied springs. A relatively high concentration was recorded in the Saguno spring (52.80 mg/L), while the lowest concentration was observed in the Farm spring (42.40 mg/L).

The total iron concentration was highest in the Uchaneishvilebi II spring (0.166 mg/L), whereas the lowest concentration was measured in the Uchaneishvilebi I spring (0.009 mg/L).

The concentration of Cu^{2+} ions was below the analytical detection limit in the Saguno, Gaghma Zanata II, Uchaneishvilebi I, and Farm springs. In the Gaghma Zanata I, Uchaneishvilebi II, and Khobadzeebi springs, the Cu^{2+} ions concentration was 0.002 mg/L.

The highest concentration of Cl^{-} ions was found in the Gaghma Zanata II spring (13.49 mg/L), while the lowest concentration was observed in the Farm spring (8.52 mg/L).

The Saguno spring contained the highest concentration of Br^{-} ions (0.114 mg/L), whereas the lowest concentration was detected in the Akhobadzeebi spring (0.053 mg/L).

The highest concentration of HCO_3^{-} ions was recorded in the Farm spring (5.84 mg/L), whereas the lowest concentration was found in the Uchaneishvilebi II spring (2.26 mg/L).

The highest concentration of free carbon dioxide (CO_2) was observed in the Gaghma Zanata II spring (0.70 mg/L), whereas the Gaghma Zanata I spring contained the lowest concentration (0.26 mg/L).

The dissolved oxygen concentration was highest in the Gaghma Zanata I spring (1.95 mg/L), while the lowest concentration was recorded in the Uchaneishvilebi I spring (1.57 mg/L).

The five-day biochemical oxygen demand (BOD_5) reached its maximum value in the Uchaneishvilebi II spring (27.46 mg/L), whereas the minimum value was observed in the Gaghma Zanata I spring (19.46 mg/L).

The concentration of SO_4^{2-} ions was highest in the Farm spring (0.0053 mg/L), while the lowest concentration was detected in the Gaghma Zanata II spring (0.0010 mg/L).

Permanganate oxidizability was relatively high in the Farm spring (1.30 mg/L), whereas the lowest value was recorded in the Gaghma Zanata I spring (0.34 mg/L).

The highest concentration of total arsenic was detected in the Uchaneishvilebi I spring (0.014 mg/L), while the lowest concentration was found in the Saguno spring (0.010 mg/L).

Experimental Part.

Methods for Determination of Chemical Elements in Water

The analyses were carried out in the Iason Moseshvili Hydrochemistry Laboratory of the Department of Chemistry, Faculty of Exact and Natural Sciences, Akaki Tsereteli State University. Standard methods commonly used in hydrochemical practice were applied [8-12].

- * The pH was measured potentiometrically (potentiometr *pH* 673 - M) .
- * Calcium, magnesium, and total water hardness were determined by complexometric titration using 0.01 N Complexone III.
- * Hydrocarbonate ions were determined by acidimetric titration using methyl orange as an indicator.
- * Chlorides were determined by the mercurimetric method using diphenylcarbazone as an indicator.
- * Total arsenic was determined iodometrically using 0.05 N iodine solution with starch as an indicator.
- * Total iron and Cu^{2+} ions were determined spectrophotometrically using a UV/VIS spectrophotometer (UN-5100B UV/VIS Spectrophotometer).
- * Sulfate ions were determined gravimetrically.
- * Free carbon dioxide was determined by alkalimetric titration.
- * Oxidizability was determined by the permanganometric method.
- * Dissolved oxygen and BOD_5 were determined iodometrically [12].
- * Bromide ions were determined iodometrically after oxidation to bromate ions by sodium hypochlorite.

Conclusion

he investigated spring waters of Zanati village in Abasha Municipality showed that the values of pH, water hardness, calcium, magnesium, total iron, copper, chloride, bromide, hydrocarbonate, sulfate ions, permanganate oxidizability, total arsenic, dissolved oxygen, BOD_5 , and carbon dioxide content generally comply with the Technical Regulation of Drinking Water of Georgia, with some exceptions. Therefore, the use of these waters for drinking and domestic purposes is considered appropriate.

The bromide ion concentration in the Farm Spring slightly exceeded the permissible norm and was equal to 0.256 mg/L.

Declarations

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Data Availability: The data supporting the findings are available from the corresponding author upon reasonable request.

Ethics Statement: Ethical approval was not required because the study involved environmental water samples and no human or animal participants.

Consent for Publication: All authors consented to the publication of this article.

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