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# QUANTITATIVE DETERMINATION OF BIOLOGICALLY ACTIVE IONS IN THE SPRING WATERS OF THE LAGVILAVA NEIGHBORHOOD, INCHKHURI VILLAGE, MARTVILI MUNICIPALITY, SAMEGRELO-ZEMO SVANETI (GEORGIA).


***Abstract***: *The objective of this study was to examine the chemical composition of spring waters in the Lagvilava neighborhood of Inchkhuri village, located in the Martvili Municipality of Samegrelo-Zemo Svaneti, Georgia. To achieve this, the studied springs were evaluated for pH, total water hardness, concentrations of $Mg^{2+}$, $Ca^{2+}$, $Cu^{2+}$, $HCO_3^-$, $Br^-$, $Cl^-$, and $SO_4^{2-}$ ions, total iron (Fe), total arsenic (As), permanganate oxidizability, dissolved oxygen ($O_2$), 5-day biochemical oxygen demand ($BOD_5$), and free carbon dioxide ($CO_2$).*

*The novelty and relevance of this work lie in the fact that the quantitative analysis of these biologically active ions in the specified spring sources was conducted for the first time.*

***Key words**: Water, component, factor, significance, renewal, natural resource, life, spring, determination.*

***Language**: English*

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**Introduction**

Georgia is a country rich in natural water resources, a quality attributed to its complex topography, diverse geological structure, and varied climatic conditions. Numerous springs of various types are formed throughout the country as atmospheric precipitation infiltrates subsurface layers, filters through rocks, and subsequently emerges at the surface. Spring waters are often characterized by high purity, natural balance, and pleasant taste characteristics.

The chemical and physical properties of Georgian spring waters depend significantly on the geological environment in which they are formed. Water composition varies according to the mineral makeup of the surrounding rocks, the depth of underground movement, and the residence time within subsurface reservoirs. Consequently, springs across different regions vary in their mineralization levels, temperature, acidity, and concentration of dissolved substances.

Georgia's territory features fresh as well as mineral and thermal springs. Fresh springs are primarily utilized as drinking water, whereas mineral and thermal waters are extensively used for therapeutic and preventative medical purposes.

Spring waters frequently contain elements essential for the human body, including calcium, magnesium, sodium, potassium, and various trace elements. These substances actively participate in metabolism, neurological functions, bone tissue formation, and the maintenance of overall systemic homeostasis. For these reasons, the quality and chemical composition of spring waters hold exceptional importance from the perspective of both daily consumption and therapeutic practice.

Water is the foundation of life—living organisms cannot survive without it. It plays a fundamental role in global biogeochemical cycles, where the hydrological cycle ensures the continuous renewal of water resources. It creates habitats for numerous plant and animal species, and plants absorb essential nutrients dissolved within it. Water is equally critical for human activity, serving imperative roles in drinking supply, industry, agriculture, hygiene, and energy production. Covering a vast portion of Earth's surface, water is ubiquitous—present around us and within our organisms. Like carbon, water is an indispensable chemical compound for living systems, making its importance to life impossible to overestimate.

Water is unevenly distributed across the globe. Beyond Earth's surface, it is present underground and in the atmosphere as water vapor. Soil also retains water alongside other compounds. Possessing unique physical and chemical properties, water is vital for vegetation, fauna, and human existence, representing a paramount natural resource. Under natural conditions, salts, gases, and organic substances are always dissolved in water in varying concentrations. Were it not so crucial for survival, human activity might have depleted this extraordinary substance long ago. Water constitutes an essential component of the diet, participating in metabolic processes, digestion, the excretion of metabolic waste products via urine, and thermoregulation. The biological demand for water varies based on climate, physical workload, health status, dietary composition, and other environmental factors.

Elements essential for living organisms that play a major role in their vital functions are termed **biogenic elements**. Many of these elements are present in organisms in minute quantities and are classified as **trace elements** (microelements). Trace elements enhance enzymatic activity and facilitate the synthesis of sugars, starches, proteins, nucleic acids, and vitamins. As a core component of nature, water sustains life, maintains ecosystem stability, and preserves ecological balance.

**Geographical Context: Martvili Municipality**

Martvili Municipality is situated in the north-eastern part of Western Georgia, spanning the Odishi Plain (southern part) and the foothills (central part) and southern slopes (northern part) of the Egrisi Range. It borders Lentekhi to the north, Khoni and Tsageri to the east, Senaki and Abasha to the south, and Chkhorotsku to the west.

The southern region of Martvili is occupied by a lowland that rises from the south-west to the north-east, with elevations ranging between 60 and 170 meters above sea level. The highest point—the source of the Tskhenistsqali/Tekhuri river system—reaches an altitude of 3,003 meters. The massifs of Mount Askhi border the south-west, featuring abundant karst caves, waterfalls, mineral deposits, and construction-

grade limestone. Furthermore, the mountain regions of Lebarde, Chegola, and Dviri are rich in therapeutic mineral waters.

Martvili Municipality is an administrative unit within the Samegrelo-Zemo Svaneti region of Georgia. Established in 1930, it was named Gegetchkori District from September 3, 1936, until 1990. Between 1963 and 1966, the Abasha District was temporarily merged into it. The administrative center is the town of Martvili.

River valleys form distinctive landforms along their banks, creating small alluvial plains and plateaus where orchards are cultivated on alluvial soils. The mountain massifs house unique flora and fauna species. The climate is humid subtropical. The primary water arteries are the Abasha, Inchkhia, and Tekhouri rivers. The municipality covers an area of 880.6 km², of which 300 km² is dedicated to agricultural land. Its major mineral wealth includes construction limestone as well as mineral waters (Lebarde, Chegola, among others).



**Pic. 1**

**Results and Discussion:**

The spring waters from the Lagvilava neighborhood of Inchkhuri village were analyzed for pH, water hardness, concentrations of $Mg^{2+}$, $Ca^{2+}$, $Cu^{2+}$, $HCO_3^-$, $Br^-$, $Cl^-$, and $SO_4^{2-}$ ions, total Fe, total As, permanganate oxidizability, dissolved $O_2$, $BOD_5$, and free $CO_2$ using chemical and photocolorimetric analytical methods. Highly sensitive analytical procedures were selected. All testing was carried out at the Iason Moseshvili Hydrochemistry Laboratory, Department of Chemistry, Akaki Tsereteli State University. The analytical results are summarized in Table 1.

**Table 1. Results of the Quantitative Determination of Biologically Active Ions in Spring Waters of the Lagvilava Neighborhood, Inchkhuri Village, Martvili Municipality**

| N | Angular name of spring waters | pH | mg-eq./L | Mg/L | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Water hardness | $Mg^{2+}$ | $Ca^{2+}$ | total Fe | $Cu^{2+}$ | $Cl^-$ | $Br^-$ | $HCO_3^-$ | Free $CO_2$ | Dissolved oxygen | total As | $BOD_5$ | $SO_4^{2-}$ | Permanganate oxidation |
| 1 | Tobashi | 7,4 | 3,00 | 2,44 | 56,00 | 0,146 | 0.004 | 9,23 | 0,141 | 2,98 | 0,32 | 2,02 | 0,008 | 24,26 | 0,0011 | 0,96 |
| 2 | Sakire | 7,7 | 2,48 | 1,66 | 47,20 | 0,066 | - | 11,22 | 0,160 | 4,34 | 0,26 | 2,14 | 0,007 | 22,98 | 0,0048 | 0,56 |
| 3 | Enveri | 7,7 | 3,32 | 9,76 | 50,40 | - | 0,001 | 9,94 | 0,153 | 3,78 | 0,27 | 2,89 | 0.008 | 23,94 | 0,0105 | 0,66 |
| 4 | Makhuzia | 7,8 | 3,64 | 22,45 | 36,00 | 0,008 | - | 7,67 | 0,122 | 5.62 | 0,50 | 1,90 | 0,009 | 24,64 | 0,0170 | 0,80 |
| 5 | Iosebi | 7,5 | 3,08 | 11,22 | 43,20 | 0,100 | - | 8,38 | 0,213 | 4,46 | 0,58 | 1,25 | 0,006 | 22,72 | 0,0059 | 1,66 |
| 6 | Jimsheri | 7,4 | 2,20 | 0,97 | 42,40 | 0,333 | 0,001 | 9,37 | 0,081 | 4,56 | 0,51 | 1.70 | 0,010 | 19,20 | 0,0063 | 0,72 |
| 7 | Lagvilava | 7,8 | 4,20 | 20,98 | 49,60 | 0,144 | 0,002 | 10,08 | 0,210 | 3,38 | 0,38 | 2,27 | 0,009 | 24,70 | 0,0024 | 1,92 |

- **pH Values:** Ranged between 7.4 and 7.8 across all analyzed samples.
- **Water Hardness:** Highest in the Makhuzia spring (3.64 mEq/L) and lowest in the Jimsheri spring (2.20 mEq/L).
- **$Mg^{2+}$ Content:** Reached its maximum in the Makhuzia spring (22.45 mg/L) and minimum in the Jimsheri spring (0.97 mg/L).
- **$Ca^{2+}$ Content:** Highest in Tobashi (56.00 mg/L) and lowest in Makhuzia (36.00mg/L).
- **Total Fe:** Total Fe is higher in Tobashi spring (0.146 mg/L) and lowest in Makhuzia spring (0.008 mg/L); in Enveri spring, total iron was below the analytical detection limit.
- **$Cu^{2+}$ Ions:** $Cu^{2+}$ ions were highest in Tobashi spring (0.004 mg/L) and lower in Enveri and Jimsheri springs; $Cu^{2+}$ was not detected in Sakire, Makhuzia, and Iosebi springs (below analytical sensitivity).
- **$Cl^-$ Ions:** Measured highest in Sakire (11.22mg/L) and lowest in Iosebi (8.38 mg/L).
- **$Br^-$ Ions:** Peak concentration observed in Lagvilava (0.210 mg/L) and minimum in Iosebi (0.081 mg/L).
- **$HCO_3^-$ Ions:** Reached maximum levels in Makhuzia (5.62 mg/L) and minimum in Tobashi (2.98 mg/L).
- **Free $CO_2$:** Highest concentration found in Iosebi (0.58 mg/L) and lowest in Sakire (0.26 mg/L).
- **Total As:** Measured highest in Jimsheri (0.010 mg/L) and lowest in Iosebi (0.006 mg/L).
- **Dissolved $O_2$:** Highest in Lagvilava (2.27 mg/L) and lowest in Iosebi (1.25 mg/L).
- **$BOD_5$:** Maximum in Lagvilava (24.70 mg/L) and minimum in Jimsheri (19.20 mg/L).
- **Permanganate Oxidizability:** Peak value recorded in Lagvilava (1.92 mg/L), with the minimum in Sakire (0.5 mg/L).
- **$SO_4^{2-}$ Ions:** Highest in Makhuzia (0.0170 mg/L) and lowest in Tobashi (0.0011 mg/L).

**Experimental Part. Methodology for the Determination of Chemical Elements in Water**. The analyses were carried out at the Iason Moseshvili Hydrochemistry Laboratory, Department of Chemistry, Faculty of Exact and Natural Sciences, Akaki Tsereteli State University. The analyses were performed using methods validated and widely applied in hydrochemical practice [4, 5, 6, 7].

1. **pH Determination:** Measured potentiometrically using a calibrated pH meter. (Potentiometer PH 673 – M)
2. **$Ca^{2+}$, $Mg^{2+}$, and Total Hardness:** The concentrations of $Ca^{2+}$ and $Mg^{2+}$, as well as the total water hardness, were determined by complexometric titration using 0.01 N Complexone III. For the simultaneous determination of $Ca^{2+}$ and $Mg^{2+}$, Eriochrome Black T was used as the indicator in the presence of an ammonia buffer. $Ca^{2+}$ was determined using Murexide as the indicator in the presence of 2 N NaOH.
3. **$HCO_3^-$ Ions:** Quantified acidimetrically using 0.1- 0.01 N HCl titrant with methyl orange as an indicator.
4. **$Cl^-$ Ions:** Analyzed by mercurimetric titration using 0.01 N $Hg(NO_3)_2$_ with diphenylcarbazone indicator.
5. **Total Arsenic As:** Determined iodometrically using 0.05 N iodine solution as titrant and starch indicator.
6. **Total Iron Fe:** Spectrophotometrically analyzed after preliminary oxidation in alkaline media using sulfosalicylic acid (UN-5100B UV/VIS SPECTROPHOTOMETER).
7. **$Cu^{2+}$ Ions:** $Cu^{2+}$ ions were determined by spectrophotometry in an alkaline medium (ammonia) using sodium N,N-diethyldithiocarbamate as the complexing reagent with a (UN-5100B UV/VIS SPECTROPHOTOMETER**).**
8. **$SO_4^{2-}$ Ions:** Determined gravimetrically via precipitation as barium sulfate ($BaSO_4$).
9. **$NH_4^+$ Ions:** Analyzed alkalimetrically using 0.1N NaOH} with phenolphthalein. Hydrogen ions liberated from the reaction between ammonium ions and formaldehyde were titrated with alkali.
10. **Free $CO_2$:** Quantified by alkalimetric titration (0.1 - 0.01 N NaOH) with phenolphthalein indicator in the presence of Rochelle salt.
11. **Permanganate Oxidizability:** Determined permanganometrically using 0.01 N $KMnO_4$, in acidic media, titrated back with 0.01 N $H_2C_2O_4$ oxalic acid.
12. **Dissolved $O_2$ and $BOD_5$:** The dissolved oxygen (DO) content and five-day biochemical oxygen demand (BOD5) were determined using the iodometric method (titrant: 0.01 N sodium thiosulfate). In an alkaline medium, manganese(II) ions are oxidized by dissolved oxygen present in the water, converting into a tetravalent manganese compound. Upon acidification of the solution in the presence of excess potassium iodide, free iodine is liberated, which is subsequently titrated.
13. **$Br^-$ Ions**: $Br^-$ ions were determined using the iodometric method. Sodium hydrogen phosphate, sodium hypochlorite, and sodium formate were added to the water sample, and the resulting mixture was heated and subsequently cooled. Potassium iodide, sulfuric acid, and ammonium molybdate were then added. The solution was titrated with 0.01 N sodium thiosulfate using starch as an indicator. Bromide ions were oxidized to bromate $BrO_3^-$ ions by sodium hypochlorite.

**Conclusion:**

The physical and chemical parameters of the examined spring waters in the Lagvilava neighborhood of Inchkhuri village (Martvili Municipality)—including pH, hardness, major cations $Mg^{2+}$, $Ca^{2+}$, anions $HCO_3^-$, Cl-, $SO_4^{2-}$, microelements $Cu^{2+}$, total Fe, total As, $Br^-$, dissolved $O_2$, and oxygen demand parameters—generally comply with the Technical Regulations for Drinking Water of Georgia, with minor exceptions. Notably, bromide ion concentrations slightly exceed the national threshold limit (0.2 mg/L) in the osebi (0.213 mg/L) and Lagvilava (0.210 mg/L) springs. Overall, the investigated spring waters are deemed suitable for domestic and drinking purposes.

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