ISSN: 2573-9565

Research Article

Journal of Clinical Review & Case Reports

Assessment of the Importance of Water Quality and Other Exogenous Factors for Urolithiasis in Georgia

Kvernadze Vasil, Darsania Tamar* and Kurashvili Bela

Department of Environmental and Occupational Health, National Food Agency, Tbilisi State Medical University, Nutritional, Age Medicine, Tbilisi (0159), Georgia

***Corresponding Author**
Darsania Tamar, Department of Environmental and Occupational Health, National Food Agency, Tbilisi State Medical University, Nutritional, Age Medicine, Tbilisi (0159), Georgia.

Submitted: 09 Oct 2025; **Accepted**: 17 Oct 2025; **Published**: 25 Nov 2025

Citation: Vasil, K., Tamar, D., & Bela, K. (2025). Assessment of the Importance of Water Quality and Other Exogenous Factors for Urolithiasis in Georgia. *J Clin Rev Case Rep, 10*(11), 01-07.

Abstract

Background: *No studies have yet been conducted to assess the characteristics of kidney stone disease and the contributing risk factors in Georgia. The goal of our study is to investigate and assess the impact of drinking water quality and other contributing factors on the incidence of urolithiasis in Georgia.*

Materials and Methods: *As part of a descriptive study, the incidence of kidney stone disease across different regions of Georgia was examined, along with its possible association with the mineral composition of drinking water. Additionally, a sociological survey was conducted within the framework of the study among 318 patients who were diagnosed with urolithiasis.*

Results: *Western Georgia has soft water, in contrast, Eastern Georgia has medium or high hardness water. Nationwide, Pearson correlation analysis revealed a statistically significant positive association between the Ca:Mg ratio in centralized water and the incidence of urolithiasis. In non-centralized or small-scale water supplies, this correlation appeared to be generally strong and highly reliable.*

Conclusion: *Based on the above, statistical material shows that the calcium/magnesium ratio has the strongest influence on the incidence of urolithiasis, compared to water hardness and other indicators, and the presence of other exogenous risk factors in patients is also evident. At this stage, preventive measures could include the development of early-stage screening programs in high-risk regions to facilitate early detection of the disease, along with initiatives aimed at improving water quality.*

Keywords: Water hardness, Urolithiasis, Ca/Mg ratio, Water quality, Salt consumption

1.Introduction

Urolithiasis is one of the most prevalent diseases both in industrialized and developing countries [1]. Urolithiasis typically develops in patients during the productive age (20–50 years), often leading to disability [2]. Global annual morbidity due to urolithiasis ranges between 0.5 and 5.5%, while in some countries and endemic regions this rate reaches 13–20% [3, 4].

It is worth noting that in recent decades, the primary focus has been on the development and widespread implementation of Extracorporeal Shock Wave Lithotripsy (ESWL) and contact lithotripsy, as well as other modern high-tech treatment methods [5, 6]. However, neither minimally invasive nor traditional surgical treatments can fully resolve the issue; they have not given us the expected result - the number of people suffering from urolithiasis and the difficulties associated with their treatment have not decreased at all, as the removal of stones does not restore the patient to full health [7]. After this procedure, the patients still have a predisposition to stone formation. At the same time, exogenous factors (the composition of drinking water, pollution of atmospheric air and water, climate, unhealthy dietary habits) contribute to the rapid recurrence of the disease [2, 8-10].

Thus, the primary emphasis should be shifted toward prevention, as it is more cost-effective than treatment and reduces both healthcare expenses and the burden of sick days for state and private structures. Effective prevention depends on understanding the etiological and contributory factors involved. Both endogenous and exogenous elements contribute to urolithiasis, and this study focuses on the exogenous factors.

According to the literature, exogenous factors influencing urolithiasis include soil and plant mineral content, water mineralization, climate, dietary habits, water intake volume, and physical activity [11, 12].

Numerous studies have focused on exploring the connection between water quality and the development of urolithiasis. However, the findings have been contradictory. Several studies have found a relationship between water hardness and the development of urolithiasis [8].

According to ***Anmar M Nassir,*** 70% of the participants consumed bottled mineral water, but this did not affect the formation of stones [13]. This factor is also confirmed by other studies, where water hardness does not affect the regional incidence of urolithiasis. According to ***S.K. Sulaiman et al.,*** low levels of calcium and magnesium in drinking water promote lithogenesis [14].

In the United Kingdom, the quality of centralized drinking water was compared across different regions of the country [15]. According to the authors, depending on where one lives, drinking 2−3 L of tap water can contribute over one-third of the recommended daily calcium and magnesium requirements, with possible implications for KSD incidence and recurrence [15]. In another study, the authors concluded that high sodium content in drinking water is a stronger risk factor for urolithiasis than calcium, magnesium, and sulfates, particularly in the formation of calcium stones [16].

A study conducted in North America found no significant difference was observed in the incidence of urolithiasis between people living in regions with hard and soft water [17]. A study conducted in Iran found a weak correlation between centralized magnesium-rich drinking water and the incidence of urolithiasis [18].

In a study conducted in Guam by ***R.L. Haddock et al***., the consumption of hard water was directly linked to the development of urolithiasis [19].

In Australia, a descriptive study was conducted to investigate the mineral composition of centralized and bottled water [20]. The study revealed differences in the composition of centralized water across Australian cities. ***K. Kohri et al.*** studied the effect of the magnesium and calcium content of centralized tap water and geological features on the formation of stones in Japan [21]. They found that the magnesium-to-calcium ratio in drinking water was negatively correlated with the incidence of urolithiasis, i.e., they couldn't find any correlation between the concentration of calcium and magnesium in drinking water and the incidence of the disease. Regarding Japan's geological characteristics, the incidence of urolithiasis was lower in regions with basalt and sedimentary rocks and higher in granite regions. The highest incidence was observed in limestone regions. The authors concluded that stone formation may depend both on the calcium-to-magnesium ratio in drinking water and the geological region [21]. Thus, most researchers suggest that kidney stone disease has a multifactorial nature.

It should be noted that shortcomings in the statistical recording of kidney stone disease in Georgia hinder the development of effective treatment and prevention methods. Most patients do not undergo full diagnostics due to financial constraints, which means treatment often proceeds without identifying the type of stones. As a result, it is impossible to provide detailed clinical assessments. This is further complicated by the insufficient digitization of the medical-statistical data collection system, especially at the level of primary healthcare.

As of 2022, the incidence of kidney stone disease varies across regions of Georgia [22]. In Western Georgia, the incidence is 219.6 cases per 100,000 people, while in Eastern Georgia, it is 117 cases per 100,000 people [22].

It is noteworthy that despite Georgia's relatively small territory, it features almost all types of climate. This climatic diversity is due to two main factors: Georgia's location at the northern edge of the subtropical zone between the Black and Caspian Seas, and its highly complex terrain.

Georgia is divided by the Likhi Range, which creates two sharply contrasting climatic zones. Due to its proximity to the Black Sea, Western Georgia is characterized by a humid and forested environment, whereas Eastern Georgia is known for its drier climate and relatively sparse forest cover.

Although Georgia is one of the world's richest countries in terms of water resources, providing the population with high-quality drinking water still requires improvement. Key issues include the sanitary protection of water supply sources in populated areas from household, industrial, and agricultural waste, as well as wastewater contamination and some other problems. The urgency to solve water-related problems is dictated by the country's underdeveloped water and utility infrastructure, which forces a significant portion of the population to use surface and underground water sources (such as wells and boreholes) for domestic and household use.

Monitoring results from the National Food Agency of Georgia show higher water hardness and microbiological contamination in centralized drinking water in some regions of Georgia [23]. Despite urolithiasis ranking first among urological diseases and being the leading cause of death from urological conditions in Georgia as of 2015, no studies have yet been conducted to assess the characteristics of kidney stone disease and the contributing risk factors in the country.

Based on the above, the goal of our study is to investigate and assess the impact of drinking water quality and other contributing factors on the incidence of urolithiasis in Georgia and to develop preventive measures based on the results obtained.

2. Materials and Methods

As part of a descriptive study, the incidence of kidney stone disease across different regions of Georgia was examined, along with its possible association with the mineral composition of drinking water. Incidence rates for 2022–2023 were obtained from the National Center for Disease Control and Public Health of

Georgia [22]. The data reflected urolithiasis-related medical visits, categorized by place of residence. Incidence rates were calculated per 100,000 inhabitants for different regions of Georgia, including Western and Eastern Georgia, as well as at the level of individual municipalities.

Drinking water quality data were provided by the National Food Agency, which annually carries out laboratory and instrumental examinations of both centralized and local (non-centralized or small-scale water supply systems) water sources. The analysis of parameters in drinking water samples was carried out using internationally recognized methods following ISO standards (ISO 6059:1984; ISO 7980:1984; ISO 10304-1:2007) [23].

Additional data on local waters were obtained from accredited laboratories operating under ISO/IEC 17025:2017/2018. In each case, the calcium and magnesium content was determined, and their ratio was calculated.

For the primary data analysis, only the levels of calcium and magnesium, along with their ratio, were used as the main focus of the study. Other chemical indicators—such as sulfates, chlorides, mineralization, and hydrocarbonates—were included as supplementary data and are intended for consideration in future research.

Additionally, a sociological survey was conducted within the framework of the study among 318 patients who were diagnosed with urolithiasis and treated at the Urology Center in Tbilisi between 2022 and 2024. The patients were selected through random sampling, and the diagnoses were made using modern radiological and laboratory methods. informed consent was obtained from all the individuals participating in the study. The survey was approved by the relevant ethics committee.

The questionnaire covered socio-demographic, dietary, and environmental factors, including age, gender, education level, place of residence, body mass index, type of drinking water, amount of water consumed, frequency of salty food intake, and family history of the disease.

Statistical analysis: Descriptive statistics (mean parameters, standard deviations) were used to analyze the data, both for quantitative and categorical variables. To determine differences between regions (e.g., between eastern and western Georgia, between individual municipalities), independent samples t-tests were used for quantitative variables.

To assess the association between the Ca:Mg ratio and the incidence of urolithiasis in tap water and local water, nonparametric correlation analysis, specifically Spearman's rho (ρ) and Kendall's tau_b (τb), was used due to the small regional sample size ($N < 10$). For the nationwide data ($N = 18$), we used Pearson's correlation method, as it is suitable for normally distributed data.

To assess the differences between regional groups (Eastern and Western Georgia) in categorical variables obtained from the sociological survey (e.g., demographic characteristics, source of drinking water, frequency of salty food consumption, presence of family history, etc.), the chi-square test (χ^2) was used. Statistical significance was evaluated at the $p < 0.05$ and $p < 0.01$ levels. Data analysis was performed using SPSS version 23.00.

3. Results

Table 1 presents the incidence rates of kidney stone disease across Georgian regions for the years 2022–2023. The data showed that the number of new cases in Western Georgia generally exceeds the rates in Eastern Georgia. Particularly high incidence rates were observed in the Samegrelo, Adjara, and Imereti regions. Within Eastern Georgia, relatively higher rates were observed in Kvemo Kartli, Mtskheta-Tianeti, and Kakheti. High incidence rates are also observed in the capital of Georgia, Tbilisi.

Table 1: Incidence of Urolithiasis per 100 000 in the regions

N	**Region**	**incidence per 100 000 population 2022**	**incidence per 100 000 population 2023**
1	western Georgia	197.3	211.8
2	Samegrelo	334.9	316.8
3	Imereti	151.7	172.2
4	Racha-Lechkhumi	68.7	95.4
5	**Eastern Georgia**	110.9	132.1
6	Kakheti	117.7	129
7	Shida Kartli	81.1	109.3
8	Kvemo Kartli	138.9	166.2
9	Samstkhe-Javakheti	59.8	68.2
10	Mstkheta-Tianeti	114.1	140.2
11	Tbilisi	143	193.5

12	incidence in Georgia	151.1	180.6
13	western Georgia	197.3	211.8

Centralized drinking water hardness data (Table 2) show that Western Georgia has soft water (0–225.1 ppm $CaCO_3$), especially in the coastal zone. In contrast, Eastern Georgia has medium or high hardness water. For example, in some areas of Marneuli, water hardness reaches 850.7 ppm. Although the mean value is higher in the East (M = 513.4, SD = 56.28) than in the West (M = 118.6, SD = 1.26), the t-test showed that this difference is not statistically significant (t(122.09) = 1.55, p = .123, Mean Difference = 394.84, 95% CI [-225.1, 850.7]). When comparing water mineralization, the mean was significantly higher in the Eastern regions (M = 308.99, SD = 274.43) than in the West (M = 108.76, SD = 75.37). The difference is statistically significant (t(174.38) = 8.66, $p < 0.001$, 95% CI [154.62, 245.85]).

Table 2: Water quality in tap water within regions

Residence	**N**	**Hardness (ppm)**			**mineralization (mg/l)**			**Chlorides (mg/l)**			**Sulphates (mg\l)**		
		Mean	**Std. deviation**	**Std. Error Mean**	**Mean**	**Std. deviation**	**Std. Error Mean**	**Mean**	**Std. deviation**	**Std. Error Mean**	**Mean**	**Std. deviation**	**Std. Error Mean**
Eastern Georgia	123	513.4	56.27	5.074	309	274.43	22.25	25.36	8.647.391	1.072.57	105.44	173.01	21.459
Western Georgia	160	118.6	1.260	.0996	109	75.36	6.216	4.287	345.844	.32250	12.2	12.333	1.150

The levels of chlorides and sulfates in water are on average higher in the East, although in the case of chlorides the difference does not reach statistical significance (p = 0.054; 95% CI [-0.35, 42.52]), while the level of sulfates is significantly higher and statistically significant (t(64.37) = 4.34, $p < 0.001$, Mean Difference = 93.25, 95% CI [50.32, 136.17]).

Table 3 presents the results of the analysis of local waters (wells, boreholes). In waters from non-centralized or small-scale water supplies, a significant difference in the Ca:Mg ratio in the West is 5:1, and in the East is 6:1 ($p < 0.001$).

Table 3: Water quality of local water supplies in the regions

No	**Municipality/ local water supplies**	**Hardness, ppm**	**mineralization, mg/l**	**Ca (mg/l)**	**Mg (mg/l)**	**chlorides, mg/l**	**sulphates, mg/l**
1	Western Georgia	83.57	229.6	43.9	7.1	7.5	12.5
2	Eastern Georgia	375.32	456.6	130.8	20.3	41.8	116.9

In Table 4, Spearman and Kendall tests revealed that the Ca:Mg ratio in non-centralized or small-scale water supplies in Western Georgia is statistically significantly associated with the incidence of urolithiasis (rho = .781, p = .022; tau_b = .617, p = .041). A strong correlation was also confirmed between the Ca:Mg ratios in centralized and decentralized or small-scale water supply sources (rho = .800, p = .017). However, the relationship between the Ca:Mg ratio in centralized water and incidence is weak and not statistically significant (rho = .390, p = .339).

Table 4: Ca/Mg corellation in tap and local water supplies in Eastern and western Georgia

Region/water supplies	**Tap water**			**Local water**		
	Mean	**St.dev**	**N**	**Mean**	**St.dev**	**N**
Eastern Georgia	3.94	1.331	10	3.88	1.24	10
Western Georgia	6.6	2.63	10	6,5	2.27	10

In eastern Georgia, the Ca:Mg ratio in tap and local waters is almost identical on average (3.94 and 3.88), although no statistically significant relationship was found between these ratios and the incidence (all $p > 0.36$).

Nationwide, Pearson correlation analysis revealed a statistically significant positive association between the Ca:Mg ratio in centralized water and the incidence of urolithiasis ($r = .595$, $p = .009$). In non-centralized or small-scale water supplies, this correlation appeared to be generally strong and highly reliable ($r = .780$, $p < .001$).

Additionally, χ^2 tests conducted on data obtained from a sociological survey showed that age ($p = 0.000$) and education level ($p < 0.03$) differed significantly between regions, whereas gender and BMI did not show any statistically significant differences ($p > 0.05$). Similarly, no credible differences were found regarding the frequency of physical activity and consumption of salty foods (Table 5).

The average daily water intake of respondents was 1.447 liters, which is statistically significantly different from zero ($p < 0.001$, 95% CI [1.38, 1.56]) (table5), however, this indicator did not differ between regions ($p = 0.094$). A family history of urolithiasis was present in 44.6% of participants.

N	Region	Water consumption	I prefer salted	I do not like salted	*Physical activity level*			
					Sedentary	Light physical activity	Moderate physical activity	Heavy physical activity
1	Eastern Georgia	1.43	85.8	14.2	43.3	15.0	30.8	10.8
2	Western Georgia	1.60	90.0	10.0	37.5	22.5	30.0	10.0
3	Total	1.447	86.9	13.1	41.9	16.9	30.6	10.6

4. Discussion

Studying the dynamics of urolithiasis in Georgia is complicated by inadequate case registration. Nonetheless, the disease is widespread. In 2022–2023, the number of new cases in Western Georgia was higher compared to Eastern Georgia, although certain regions in the east, such as Kvemo Kartli, Kakheti, and the capital city Tbilisi, also showed high incidence rates.

Since it was known from the annual reports of the National Food Agency about high water hardness levels in the eastern regions of Georgia, we decided to study whether the high incidence of urolithiasis coincides with regions with high water hardness. However, considering that urolithiasis is a multifactorial disease, we also examined the prevalence of contributing risk factors among those affected with urolithiasis, such as daily water intake, body mass index (BMI), frequency of salty food intake, and physical activity.

Centralized and decentralized water hardness varies widely in Georgia, from very soft to very hard. The calcium-to-magnesium (Ca:Mg) ratio is also unsatisfactory, primarily due to high calcium and low magnesium concentrations in drinking water. In some regions, such as Adjara, low calcium (12.2 mg/l) and magnesium (1.2 mg/l) contents in water are observed, which, according to the literature [14,16,21], have an unfavorable impact on human health. It is also worth noting that in Tbilisi, where the quality of drinking water is constantly monitored, the calcium-to-magnesium (Ca:Mg) ratio is unsatisfactory (9/1). Within the region itself, water quality varies between individual municipalities, including water hardness, calcium, and magnesium content etc. For example, in the Eastern Georgia region, the Marneuli municipality of Kvemo Kartli has the highest incidence of urolithiasis compared to other municipalities.

The same municipality also has the most unsatisfactory water quality, according to the annual data of the National Food Agency. However, in the region as a whole, i.e., Kvemo Kartli, the incidence lags behind Samegrelo, Adjara, and Imereti in terms of the number of new cases or incidence per 100,000 population. In Samegrelo itself, the largest share of new cases falls on the Khobi municipality. In Adjara and Imereti, the highest shares of new cases are reported in Batumi and Kutaisi, respectively.

At the same time, in certain regions of Western Georgia—particularly in Adjara's coastal municipalities—very soft water with a very high calcium-to-magnesium (Ca:Mg) ratio is observed. In Samegrelo, where the number of new cases is highest, water hardness ranges from soft to moderately hard, yet still displays a high Ca:Mg ratio.

As for the prevalence of other risk factors in patients with urolithiasis, in both regions, overweight and obesity are observed, along with a sedentary lifestyle, and high consumption of salty foods. Additionally, daily water intake is below recommended levels, which is especially concerning in Georgia, as it is characterized by hot summers.

Based on the above, statistical material shows that the calcium/magnesium ratio has the strongest influence on the incidence of urolithiasis, compared to water hardness and other indicators, and the presence of other exogenous risk factors in patients is also evident.

5. Conclusion

The calcium-to-magnesium (Ca:Mg) ratio showed the strongest association with urolithiasis. In this context, a high Ca:Mg ratio primarily reflects low magnesium content in drinking water. Unsatisfactory quality of supplied drinking water, characterized by deviations from the recommended calcium and magnesium levels, along with other risk factors, such as overweight, physical inactivity, excessive intake of salty foods, and insufficient daily water intake, appears to be a contributing factor to urolithiasis in Georgia.

In addition, it is worth noting the relatively small proportion of patients with a family history. However, the uneven distribution of the disease among individual municipalities requires further research at the municipal level, as well as a study of dietary habits would further contribute to our understanding of this issue.

At this stage, preventive measures could include the development of early-stage screening programs in high-risk regions to facilitate early detection of the disease, along with initiatives aimed at improving water quality.

6. Study Limitations

One of the key limitations of our study lies in the emergence of new, previously unrecognized issues during the research process—issues that could not be fully addressed within the scope of a single study. For instance, water hardness and other quality indicators varied not only at the municipal level but even within a single city. This was due to cities often being supplied from multiple water sources. Consequently, water quality indicators showed substantial intra-regional and intra-urban variability.

It was impossible to analyze the significance of all water quality indicators within one study due to the high variability of these indicators. Therefore, further studies should be carried out and specific cases analyzed. It is necessary to study water quality indicators and the incidence of urolithiasis in municipalities and cities by district in order to identify factors contributing to urolithiasis. The latter is needed to develop specific and targeted preventive measures.

Autor Contributions

Conceptualization, K.B., K.V.; Methodology, K.B., D.T.; Investigation, K.V., B.K., D..T.; Data curation, K.V., K.B.; Writing—original draft preparation, K.V., D.T.; Writing—review and editing, K.B.; Supervision, K.B., All authors have read and agreed to the published version of the manuscript.

Use of AI tools declaration

The authors declare they have not used Artificial Intelligence (AI) tools in the creation of this article.

Conflict of Interest

The authors declare no conflict of interest.

Funds

No funds

References

1. Dirie, N.I., Hassan, J., Hussein, A.O. et al. (2024). Burden of urolithiasis: a systematic review of epidemiological and clinical trends in Somalia. Afr J Urol 30, 64 (2024).
2. Alelign, T., & Petros, B. (2018). Kidney stone disease: an update on current concepts. Advances in urology, 2018(1), 3068365.
3. Awedew, A. F., Han, H., Berice, B. N., Dodge, M., Schneider, R. D., Abbasi-Kangevari, M., ... & Dirac, M. A. (2024). The global, regional, and national burden of urolithiasis in 204 countries and territories, 2000–2021: a systematic analysis for the Global Burden of Disease Study 2021. EClinicalMedicine, 78.
4. Moftakhar, L., Jafari, F., Ghoddusi Johari, M., Rezaeianzadeh, R., Hosseini, S. V., & Rezaianzadeh, A. (2022). Prevalence and risk factors of kidney stone disease in population aged 40–70 years old in Kharameh cohort study: a cross-sectional population-based study in southern Iran. BMC urology, 22(1), 205.
5. Shafi, H., Moazzami, B., Pourghasem, M., & Kasaeian, A. (2016). An overview of treatment options for urinary stones. Caspian journal of internal medicine, 7(1), 1.
6. Monga, M., Murphy, M., Paranjpe, R., Cutone, B., & Eisner, B. (2023). Prevalence of stone disease and procedure trends in the United States. Urology, 176, 63-68.
7. Thakore P, Liang TH. Urolithiasis. [Updated 2023 Jun 5]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2025 Jan
8. Mitra, P., Pal, D. K., & Das, M. (2018). Does quality of drinking water matter in kidney stone disease: A study in West Bengal, India. Investigative and clinical urology, 59(3), 158-165.
9. Noh, T. I., Hong, J., Kang, S. H., & Jung, J. (2021). Association of meteorological factors and ambient air pollution on medical care utilization for urolithiasis: a population-based time-series study. BMC nephrology, 22(1), 402.
10. Turney, B. W., Appleby, P. N., Reynard, J. M., Noble, J. G., Key, T. J., & Allen, N. E. (2014). Diet and risk of kidney stones in the Oxford cohort of the European Prospective Investigation into Cancer and Nutrition (EPIC). European journal of epidemiology, 29(5), 363-369.
11. Littlejohns, T. J., Neal, N. L., Bradbury, K. E., Heers, H., Allen, N. E., & Turney, B. W. (2020). Fluid intake and dietary factors and the risk of incident kidney stones in UK Biobank: a population-based prospective cohort study. European urology focus, 6(4), 752-761.
12. Basiri, A., Kashi, A. H., Zahir, M., Omran, H. S., Borumandnia, N., Taheri, M., ... & Hajebrahimi, S. (2024). Exploring the impact of family history, demographics and ecological factors

on Urolithiasis Prevalence: insights from a nationwide study. Urology Research and Practice, 50(2), 115.
13. Nassir, A. M. (2019). Prevalence and characterization of urolithiasis in the Western region of Saudi Arabia. Urology Annals, 11(4), 347-352.
14. Sulaiman, S. K., Enakshee, J., Traxer, O., & Somani, B. K. (2020). Which type of water is recommended for patients with stone disease (hard or soft water, tap or bottled water): evidence from a systematic review over the last 3 decades. Current urology reports, 21(3), 6.
15. Michael, K. G., & Somani, B. K. (2022). Variation in Tap Water Mineral Content in the United Kingdom: Is It Relevant for Kidney Stone Disease?. Journal of Clinical Medicine, 11(17), 5118.
16. Michael, K. G., Michael, S., Abusada, E., Srirangam, S. J., Bourdoumis, A., & Surange, R. (2022). Does the mineral content of tap water correlate with urinary calculus composition?. Urolithiasis, 50(6), 691-699.
17. Schwartz, B. F., Schenkman, N. S., Bruce, J. E., Leslie, S. W., & Stoller, M. L. (2002). Calcium nephrolithiasis: effect of water hardness on urinary electrolytes. Urology, 60(1), 23-27.
18. BASIRI, A., SHAKH, S. N., Khoushdel, A. R., Pakmanesh, H., & Radfar, M. H. (2011). Drinking water composition and incidence of urinary calculus introducing a new index.
19. Haddock, R. L., Olson, D. R., Backer, L., & Malilay, J. (2016). Urolithiasis, urinary Cancer, and home drinking water source in the united states territory of Guam, 2006–2010. International Journal of Environmental Research and Public Health, 13(6), 523.
20. Kwok, M., McGeorge, S., Roberts, M., Somani, B., & Rukin, N. (2022). Mineral content variations between Australian tap and bottled water in the context of urolithiasis. BJUI compass, 3(5), 377-382.
21. Kohri, K., Kodama, M., Ishikawa, Y., Katayama, Y., Takada, M., Katoh, Y., ... & Kurita, T. (1989). Magnesium-to-calcium ratio in tap water, and its relationship to geological features and the incidence of calcium-containing urinary stones. The Journal of urology, 142(5), 1272-1275.
22. National Center for Disease Control and Public Health. Statistics reference-Book (2018-2021).
23. Food National Agency. Drinking water monitoring results 2024.