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RELATIONSHIP BETWEEN THE PREVALENCE OF UROLITHIASIS AND WATER QUALITY

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Abstract

Background: Quality of drinking water affects the general metabolism, and especially in the occurrence of urological diseases. Kidney stones mainly contain minerals, which usually depend on the water state.

Aim: to study the relationship between the epidemiology of urolithiasis and the state of drinking water in the Turkestan oblast.

Methods: For the evaluation of the water quality physical, chemical and microbiological tests of water were performed in two regions of Turkestan oblast: Saryagash region and Turkestan city. Secondary educational and higher educational institutions, residential buildings, municipal public spheres, medical institutions and water supply sources were among the objects of research. Protocols for the study of drinking water samples from centralized and non-centralized water supply No. 2020/00/00 were used. Statistical analyses were conducted using R Studio software (Integrated Development Environment, Boston, USA).

Results: The main comparative differences were noted in pH, oxidizability and total hardness of the water, as well as in the content of such minerals as residual, free and combined chlorine, ammonia nitrogen, nitrite and nitrate, chloride and copper. In all these parameters, the content of indicators is higher in the drinking water of Turkestan city, which may indicate a potential threat to the growth of urolithiasis in the regional centre. Microbiological data of both the city of Turkestan and the Saryagash region comply with state standards.

Conclusion: The study results confirm the combined effect of differences in water physical and chemical parameters on the prevalence of urolithiasis in the regions of the Turkestan oblast.

Key words: *water quality, urolithiasis, epidemiology, Turkestan region.*

Резюме

ВЗАИМОСВЯЗЬ МЕЖДУ РАСПРОСТРАНЕННОСТЬЮ МОЧЕКАМЕННОЙ БОЛЕЗНИ И КАЧЕСТВОМ ВОДЫ

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Актуальность: Качество питьевой воды влияет на общий обмен веществ, особенно при возникновении урологических заболеваний. Камни в почках в основном содержат минералы, количество которых обычно зависит от состояния воды.

Цель: изучить взаимосвязь эпидемиологии мочекаменной болезни и состояния питьевой воды в Туркестанской области.

Материалы и методы исследования: Для оценки качества воды были проведены физико-химические и микробиологические исследования воды в двух регионах Туркестанской области: Сарыагашском районе и городе Туркестан. Объектами исследования были средние и высшие учебные заведения, жилые дома, муниципальные и медицинские учреждения, а также источники водоснабжения. Использованы протоколы исследования проб питьевой воды централизованного и нецентрализованного водоснабжения № 2020/00/00. Статистический анализ проводился с использованием программного обеспечения R Studio (Integrated Development Environment, Бостон, США).

Результаты: Основные сравнительные различия были отмечены в pH, окисляемости и общей жесткости воды, а также в содержании таких минералов, как остаточный, свободный и связанный хлор, аммиачный азот, нитрит и нитрат, хлорид и медь. По всем этим параметрам содержание показателей выше в питьевой воде города Туркестан, что может свидетельствовать о потенциальной угрозе роста мочекаменной болезни в областном центре. Микробиологические данные города Туркестан и Сарыагашского района соответствуют государственным стандартам.

Заключение: Результаты исследования подтверждают совокупное влияние различий физико-химических показателей воды на распространенность мочекаменной болезни в регионах Туркестанской области.

Ключевые слова: качество воды, мочекаменная болезнь, эпидемиология, Туркестанская область.

Түйіндеме

НЕСЕП-ТАС АУРУЫНЫҢ ТАРАЛУЫМЕН СУДЫҢ САПАСЫНЫҢ БАЙЛАНЫСЫ

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Өзектілігі: Бүйректердегі тастардың көбісі минералдардан тұратын болғандықтан ауыз су сапасы ағзаның жалпы зат алмасуына, сонымен қатар урологиялық аурулардың пайда болуына әсер етеді.

Мақсаты: Несеп-тас ауруының эпидемиологиясына ауыз судың сапасының байлынысын Түркістан облысы бойынша зерттеу.

Зерттеу әдістері: Түркістан облысындағы екі елді-мекендердің (Сарыағаш ауданы және Түркістан қаласы) су сапасын тексеру үшін физико-химиялық және микробиологиялық зерттеулер жүргізілді. Тексеру объектілері қатарына орта және жоғарғы оқу мекемелері, тұрғын үйлер, муниципалды және медициналық мекемелері, сонымен қатар сумен жабдықтау көздері кіргізілді. № 2020/00/00 орталықтандырылған және орталықтандырылмаған сумен жабдықтаудың ауыз су сынамаларын зерттеу хаттамалары пайдаланылды. Статистикалық талдау R Studio (Integrated Development Environment, Бостон, АҚШ) бағдарламалық жасақтамасының көмегімен жүргізілді.

Нәтижелер: Негізгі салыстырмалы айырмашылықтар pH, тотығу және судың жалпы қаттылығында, қалдық, бос және байланысқан хлор, аммиак азоты, нитрит және нитрат, хлорид және мыс сияқты минералдардың құрамында байқалды. Барлық осы параметрлер бойынша көрсеткіштердің құрамы Түркістан қаласының ауыз суында жоғары, бұл облыс орталығында несеп-тас ауруының өсуінің ықтимал қаупін көрсетуі мүмкін. Түркістан қаласы мен Сарыағаш ауданының микробиологиялық деректері мемлекеттік стандарттарға сәйкес келеді.

Қорытынды: Зерттеу нәтижелері судың физико-химиялық көрсеткіштері айырмашылықтарының Түркістан облысының аймақтарында несеп-тас ауруының таралуына жиынтық әсерін растайды.

Негізгі сөздер: *судың сапасы, несеп-тас ауруы, эпидемиология, Түркістан облысы.*

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Introduction

There are many different endogenous and exogenous factors affecting the occurrence of urolithiasis [1, 9, 12]. Among exogenous agents, special attention is paid to those related to the consumption of water and nutrients [5, 7, 8, 11]. Drinking a lot of fluids is the basis for the prevention of urolithiasis as it increases volume and decreases urine oversaturation (Figure 1) [6]. The latter affects the occurrence of almost all types of stones.

Moreover, increased fluid intake leads to an increase in the frequency of urination, which is also desirable to prevent the retention of precipitated solutes. Increased urine output is also helpful in preventing urinary tract infections [2]. In this respect, water is the most important of all liquids as it is economical and affordable.

In addition to the quantity and quality of water, the degree of pollution of water sources plays an important role in the development of urolithiasis. So, in a large study with the participation of more than 38 thousand people, of which 30% were from the city and the rest from the countryside, 118 water samples were taken from three sources: a water supply system, a hand pump and a well. The researchers analysed the hardness, Ca, Mg, Na, K, iP, SiO_3, SO_4, Cl, F, Cu, Zn and Mn in liquids and concluded that tap water was the softest [13].

As well as the amount of water consumed, the composition and pH of the liquid are the subjects of constant controversy among researchers. The role of water pH was also shown in an Iranian study among the adult male population in 2017-2018. (120 adult men with kidney stones and 240 healthy controls). The average pH value of daily water consumption was 7.1 ± 250.3 and 7.4 ± 250.3 in the experimental and control groups, respectively. Multivariate logistic regression analysis, after adjusting the covariate, found a significant relationship between the pH of drinking water (not with other fluids) and nephrolithiasis. Study findings support the potential protective effects of drinking higher pH drinking water for preventing kidney stones [4].

The main factors of water that contribute to stone formation are mineral and electrolyte content, pH, microbiological state and the ability of water to induce or inhibit the formation of calculi.

The purpose of this article is to establish a link between the epidemiology of urolithiasis and the state of drinking water in the Turkestan region (Figure 1). For this, the indicators of physicochemical and microbiological studies of water in two regions of this region were used: the city of Turkestan and the Saryagash region.

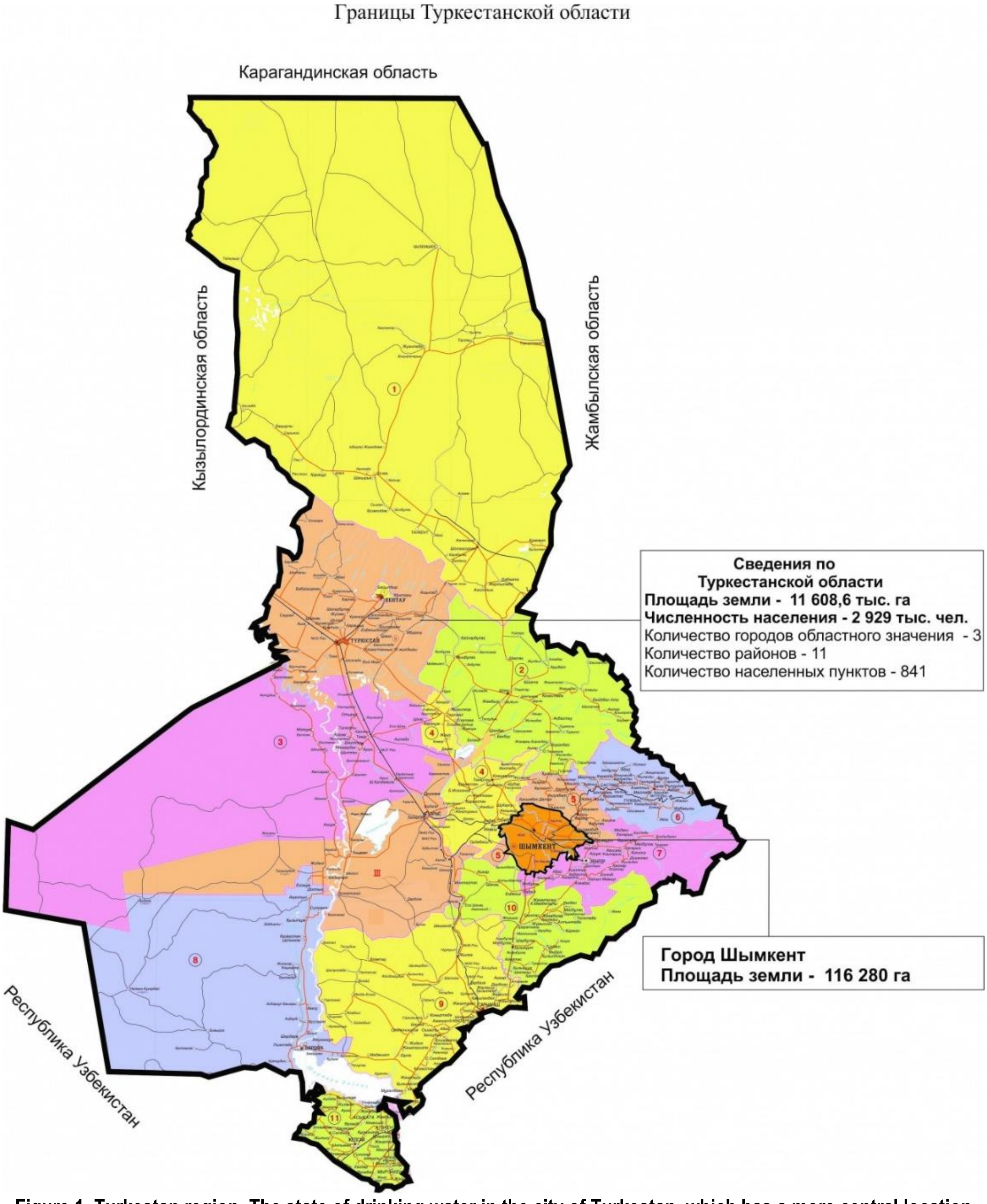

Figure 1. Turkestan region. The state of drinking water in the city of Turkestan, which has a more central location relative to the territory of the region (highlighted in orange), and the Saryagash region, located in a more southern direction and bordering the Republic of Uzbekistan (number 9, highlighted in yellow), were investigated.

Materials and methods

The dataset for this population-based study were collected from various institutions in both regions: secondary educational institutions (secondary school named after S. Seifullin, secondary schools No. 23 and No. 17, No. 21 of the city of Turkestan, secondary schools and gymnasiums No. 10, No. 24, No. 28, No. 29, No. 32, No. 45, No. 51 and No. 74 of the Saryagash region), higher educational institutions (educational building, male and female dormitories of the International Kazakh-Turkish University), medical institutions (Regional Perinatal Center No. 3 of the city of Turkestan), residential buildings (microdistrict No. 1, the city of Turkestan, the hotel "Eurasia"), municipal public spheres (Employment Center of the Turkestan region, Railway station in Turkestan, the Ministry of Emergency Situations of the city of Turkestan), as well as water supply sources (“Telman” water supplier). In the structure of the Saryagash region, waters were taken from the city of Saryagash, Zhibek Zholy, Kaplanbek, Akzhar, Zhartytobe, Kurkeles, Zhylga, Dastan, Kanagat and Atameken districts.

Places of sampling in the above objects were centralized water supply pipes, table drinking water. To extract the data in Table 1, Protocols for the study of drinking water samples from centralized and non-centralized water supply No. 2020/00/00 were used. The volume of water taken was 1.5 litres. Statistical analyses were conducted using R Programming Package and R Studio software (Integrated Development Environment, Boston, USA) using the RCran library resources.

Results. The choice of these regions was justified by the fact that, according to common and proven facts, the quality of drinking water was significantly different from each other. In particular, the city of Saryagash, which is popular in the country, and its medical sanatorium-resort institutions, first of all, has a reputation for the usefulness of water for the rehabilitation of patients with various pathologies, including urological and gastro-enteric diseases. Table 1 shows indicators of physical and chemical analysis of water in both regions of the Turkestan region.

Table 1.

Average indicators of physical and chemical observation of water in the regions of the Turkestan oblast.

Indicators	Detected concentration		Normative indicators	The name of the current RLA*
	Turkestan city	Saryagash region		
odour at 20°C	0.0	0.0	2.0	STATE STANDARD 3351-74
odour at 60°C	0.0	0.0	2.0	STATE STANDARD 3351-74
taste at 20°C	0.0	0.0	2.0	STATE STANDARD 3351-74
colour at 35°C	0.0	0.0	20	STATE STANDARD 31868-2012
turbidity, mg/dm^3	0.0	0.0	1.5	STATE STANDARD 3351-74
pH	7.5	7.4	6-9	STATE STANDARD 26449.1-85
residual chlorine, mg/dm^3	0.5	0.3	0.3-0.5	STATE STANDARD 18190-72
free chlorine, mg/dm^3	0.1	0.0	0.3-0.5	STATE STANDARD 18190-72
combined chlorine, mg/dm^3	0.1	0.0	0.8-1.2	STATE STANDARD 18190-72
residual ozone, mg/dm^3	0.0	0.0	0.3	STATE STANDARD 18301-72
oxidizability, mgO_2/dm^3	1.3	1.1	5.0	STATE STANDARD 55684-2013
ammonia nitrogen, mg/dm^3	0.1	0.0	2.0	STATE STANDARD 33045-2014
nitrogen nitrite, mg/dm^3	0.1	0.0	3.0	STATE STANDARD 33045-2014
nitrogen nitrates, mg/dm^3	28.4	28.0	45.0	STATE STANDARD 33045-2014
overall hardness, mol/dm	5.5	4.9	7.0	STATE STANDARD 31954-2012
dry residue, mg/dm^3	540	410	1000	STATE STANDARD 18164-72
chlorides, mg/dm^3	36.0	31.0	350.0	STATE STANDARD 4245-72
sulphates, mg/dm^3	182.0	182.0	500.0	СТРК 1015-2000
iron, mg/dm^3	0.0	0.0	0.3	STATE STANDARD 4011-72
copper, mg/dm^3	0.3	0.0	1.0	STATE STANDARD 31866-2012
beryllium (Be^{2+}), mg/dm^3	0.0	0.0	0.0002	STATE STANDARD 18294-89
boron (B), mg/dm^3	0.0	0.0	0.5	M 01-09-2010
cobalt, mg/dm^3	0.0	0.0	0.1	STATE STANDARD 31870-2012
selenium (Se), mg/dm^3	0.0	0.0	0.01	STATE STANDARD 31866-2012
chromium (Cr^{6+}), mg/dm^3	0.0	0.0	0.05	STATE STANDARD 31866-2012
nickel (Ni), mg/dm^3	0.0	0.0	0.1	STATE STANDARD 31870-2012
camdium, mg/dm^3	0.0	0.0	0.001	STATE STANDARD 31866-2012
petroleum products, mg/dm^3	0.0	0.0	0.1	M 01-05-2012
zinc, mg/dm^3	0.0	0.0	5.0	STATE STANDARD 31866-2012
molybdenum, mg/dm^3	0.0	0.0	0.25	STATE STANDARD 18308-72
arsenic, mg/dm^3	0.0	0.0	0.05	STATE STANDARD 31866-2012
lead, mg/dm^3	0.0	0.0	0.03	STATE STANDARD P 31866-2012
fluorine, mg/dm^3	0.0	0.0	1.2-1.5	STATE STANDARD 4386-89
residual aluminium, mg/dm^3	0.0	0.0	0.5	STATE STANDARD 18165-2014
anionic surfactants, mg/l	0.0	0.0	0.5	STATE STANDARD P 51211-2003
polyphosphates, mg/dm^3	0.0	0.0	3.5	STATE STANDARD 18309-72
manganese, mg/dm^3	0.0	0.0	0.1	STATE STANDARD 31866-2012
mercury, mg/dm^3	0.0	0.0	0.0005	STATE STANDARD 31866-2012
calcium, mg/dm^3	-	-	-	STATE STANDARD 23268.5-78
magnesium, mg/dm^3	-	-	-	STATE STANDARD 23268.5-78
hydrocarbonates, mg/dm^3	-	-	-	STATE STANDARD 31957-2012

*RLA – regulatory legal acts.

As can be seen from the table, the physicochemical indicators of water in the Saryagash region have more acceptable and closer to the normative indicators data established by the regulatory legal acts indicated in the fifth column of the table. Compared to the indicators of the Saryagash region and generally recognized norms, the water in Turkestan lags in quality indicators (Table 1). This can contribute in the long term to an increase in stone formation, subsequently to an increase in the occurrence of urolithiasis and other calculi-forming diseases.

In particular, the odour, taste, colour and turbidity of water at different temperatures were normal in both regions. Also, approximately the same indicators corresponding to the standards were noted in the level of residual ozone, sulphates, iron, beryllium, boron, cobalt, selenium, chromium, nickel, cadmium, petroleum products, zinc, molybdenum, arsenic, lead, fluorine, residual aluminium, anionic surfactants (surfactants), polyphosphates, manganese, and mercury.

The main comparative differences were noted in pH, oxidizability and total hardness of the water, as well as in the content of such minerals as residual, free and combined chlorine, ammonia nitrogen, nitrite and nitrate, chloride and copper (Figure 2). In all these parameters, the content of indicators is higher in the drinking water of the city of Turkestan, which may indicate a potential threat to the growth of urolithiasis in the regional centre.

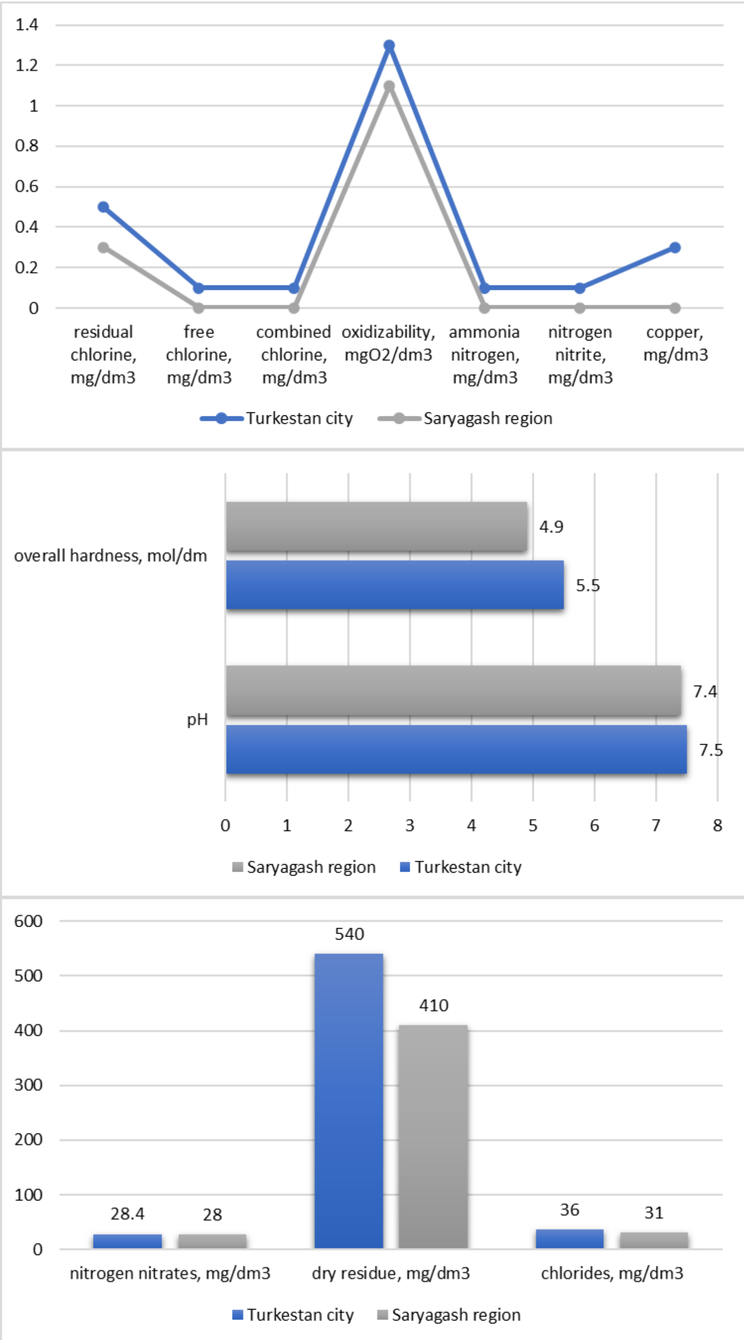

Figure 2. Distinctive parameters of the physical state and chemical composition of the waters of the city of Turkestan and the Saryagash region

In repeated studies, the pH of the water was equal to 7.4 and 7.6 in most cases (Table 2). However, a relatively high pH level in the water of the Turkestan Railway Station (pH = 7.8) was repeatedly noted, although it meets the standards.

In addition to studying the physical and chemical state of water, an analysis of the microbiological composition of water sources in both regions of the Turkestan region was carried out. The results of the study are shown in Table 3. Places of sampling were table drinking water from the centralized water supply pipelines. The volume of water for this study was 0.5 litres. According to the Medical Documentation Form No. 123 / y and the Protocol of microbiological examination of water, the total microbial count, total coliform bacteria and thermotolerant coliform bacteria were studied.

Table 2. **Indicators of water pH in various objects of the city of Turkestan, at normal pH values = 6-9.**

Object name	pH of water
"Employment Centre of the Turkestan Region"	7.6
"Secondary school named after S. Seifullin city of Turkestan"	7.4
"Regional Perinatal Center No. 3 of the city of Turkestan"	7.6
"Turkestan city, 1 micro district, 30-12"	7.6
"IKTU, men's dormitory"	7.4
"IKTU, women's dormitory"	7.4
"IKTU, academic building"	7.4
"Turkestan Railway Station"	7.8
"Telman water supplier"	7.4
"Secondary school number 23"	7.4
"Secondary school number 17"	7.4
"Ministry of Emergency Situations of Turkestan"	7.4
"Secondary school number 21"	7.6
"Hotel Eurasia"	7.6

Table 3.

Average indicators of microbiological observation of water in the regions of the Turkestan region.

Indicators	Unit of measurement	Normal values	Test results		Test method
			Turkestan city	Saryagash region	
Total microbial count	1 ml	no more than 50	27	11	STATE STANDARD 18963-73
Total coliform bacteria	100 ml	absence	not found	not found	STATE STANDARD 18963-73
Thermotolerant coliform bacteria	100 ml	absence	not found	not found	STATE STANDARD 18963-73

Microbiological data of both the city of Turkestan and the Saryagash region comply with state standards STATE STANDARD 18963-73 and correspond to population epidemiological studies of the spread of urolithiasis by struvite stones, which are often caused by infectious agents.

Figure 3 shows data on the incidence of urolithiasis in the regional centre and the Saryagash region. The data was taken for the period 2017-2019. According to the data, in the city of Turkestan, the prevalence of stones of the kidneys and urinary system is 2 times higher than in the compared region.

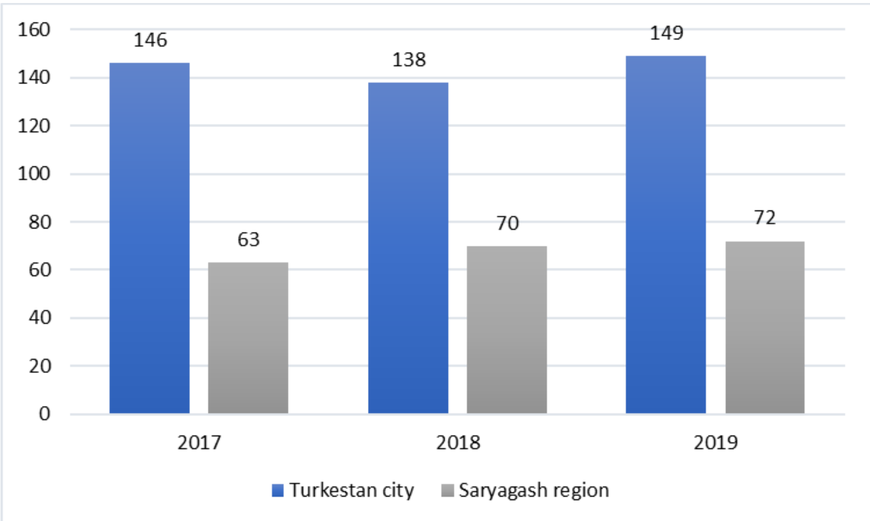

Figure 3. Prevalence of urolithiasis in the city of Turkestan and Saryagash region for the period 2017-2019.

Combining the data on the composition of water and epidemiologic studies, we obtain the graph shown in Figure 4. This correlation analysis was performed using the R Studio software (Integrated Development Environment, Boston, USA) using the correlation matrix from the RCran library. The results of the obtained statistical analyses confirm the combined effect of differences in water physical and chemical parameters on the prevalence of urolithiasis in the regions of the Turkestan oblast.

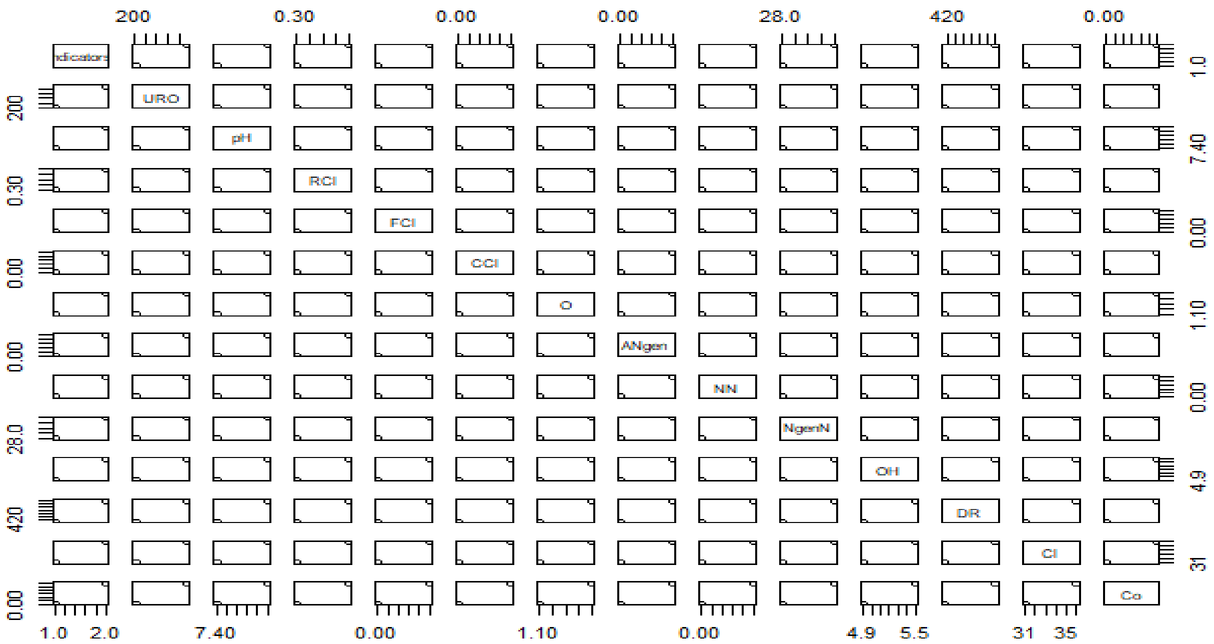

Figure 4. Influence of distinctive indicators of water composition on the prevalence of urolithiasis.
URO - Urolithiasis; RCl - residual chlorine; FCl - free chlorine; CCl - combined chlorine;
O - oxidizability; ANgen - ammonia nitrogen; NN - nitrogen nitrite; NgenN - nitrogen nitrates;
OH - overall hardness; DR - dry residue; Cl - chlorides (chlorides); Co – copper.

Discussion

Various studies analyze not only drinking water but also the pH of urine. Thus, the alkaline pH of urine promotes the crystallization of calcium and phosphate-containing stones, while acidic urine promotes the formation of uric acid or cystine stones. The activity of many calcium, citrate and phosphate transporters is sensitive to changes in systemic or local pH, as shown for the NaDC1 and TRPV5 transporters [14]. Violations of urine acidification (active release of alkali) contribute to the development of kidney stones. Also, the low excretion of ammonium in patients with metabolic syndrome leads to acidification of the urine and a higher incidence of uric acid stones. In this condition, insulin resistance can reduce the proximal tubular excretion of ammonium. On the other hand, defence mechanisms may prevent kidney stones from forming in conditions such as hypercalciuria, where high lumenal calcium concentrations stimulate urine acidification and decrease urinary concentrations through the calcium-sensitive receptor, resulting in acidic and dilute urine excretion.

There is conflicting evidence from clinical and epidemiological studies on the effects of different beverages on the risk of urinary stones. When evaluating the results of a prospective mail survey of 21 specific beverage types, the risk of stone formation was found to be reduced by daily consumption of caffeinated and decaffeinated coffee by 10%, tea (14%), beer (21%) and wine (39%) [3]. While beer consumption can reduce the risk of stone formation [10], then drinking apple and grapefruit juice can increase the risk of stones by 35% and 37%, respectively [3].

Conclusion

The results of studies of the relationship between drinking-water hardness and urolithiasis are highly controversial. Despite the data obtained, one should also take into account the influence of other factors of lithogenesis, population migration and the composition of food consumed. These studies are the subject of future studies of the prevalence of urolithiasis and its risk factors. But despite this, there is a strong and significant relationship between the composition of water and the epidemiology of urolithiasis.

A small example in the Turkestan region clearly demonstrates the statistically significant differences between the two neighbouring regions. A similar study on a national scale is required to study in detail both the prevalence of kidney and urinary tract stones and its risk factors, in particular, the mineral and microbiologic content of water. This will help not only to precisely prevent urolithiasis in the republic but also reduce healthcare costs.

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Contribution of the authors to the study:

Sh.M. Seidinov was responsible for conceptualization, methodology, investigation, data curation, formal analysis and project administration.

R.A. Fatkhi was responsible for visualization, writing, reviewing, and editing.

All authors attest that they meet the current ICMJE requirements to qualify as authors.

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