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Spring water in Vilnius City: chemical composition and quality

Vytautas Juodkazis,

Linas Papievis

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The marginal moraine areas of continental glaciation are lithologically notable for great variations in surface deposits. If such Quaternary deposits are deeply cut by river valleys and ravines, their slopes and terraces make favourable conditions for groundwater to be exposed and to form springs. Most often such springs are of a falling type, i. e. water streams under the influence of gravitation.

In the ancient times people used spring water for drinking and preparation of food, since it was clean and tasty. Such an image of spring water has remained up to the present days, although due to increased pollution of the environment, the water of such springs can be both good and bad. Regardless of this, people bring it to their homes thinking that spring water is of a better quality than that provided by the municipal water supply. Such practice is also widely exercised in Vilnius, where the geomorphological conditions are favourable for springs to be formed. Therefore, Hydrology and Engineering Geology Department of Vilnius University have analysed the chemical composition of the city spring waters and assessed their quality in respect of the quality of water suitable for drinking.

Key words: spring, groundwater, chemical composition, pollution

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Vytautas Juodkazis, Linas Papievis. Department of Hydrogeology and Engineering Geology, Vilnius University, Čiurlionio 21, LT-03001 Vilnius, Lithuania. E-mail: vytautas.juodkazis@gf.vu.lt

INTRODUCTION

The protection of shallow groundwater in towns and settlements is in the focus of attention since it is used for individual supplies in many urbanized areas, and hence, the investigations cover the chemistry and quality of drilled and dug wells. In 1997 the International Association of Hydrogeologists organised its 17th Congress on the Groundwater in Urban Environment (Groundwater..., Vol. 1, 2). Hydrogeochemical investigations intended for the assessment of the chemistry of shallow unprotected groundwater and its hygienic state in the Lithuanian towns have begun approximately 40 years ago (Kondratas, 2001). From 1966–1967 a good deal of work has been done in Lithuania to solve the problems of the groundwater protection in urban areas (Kondratas, 2001; Klimas, 1995; 1996; 1997; Diliūnas et al., 2004; etc.). However, spring water investigations to define the peculiarities of its formation in urban areas have not met sufficient attention.

Lithuania's area is within the zone of the continental glaciation, where marginal moraine belts characterise surface deposits that greatly vary lithologically. Such Quaternary deposit formations are in some places deeply cut by river valleys, ravines or gullies, where conditions favourable for the groundwater to flow to the surface and form springs are observed on their slopes and terraces. Most often such springs are of a falling type, i. e. water streams under the influence of gravitation. Usually water runs from sandy alluvial, glaciofluvial or other deposits covering the surface slopes of the river valleys or their terraces.

In the ancient times people used spring water for drinking and cooking, since it was clean and pure. Such an image of spring water has remained up to the present days, although due to the increased pollution of the environment, the water of the springs can be both good and bad, depending on the area the water flows from. Although today there are centralised water supplies in the cities and towns, people often bring spring water to their homes thinking that it is of a better quality. Such situation is also observable in Vilnius, the capital city of Lithuania, where geomorphological conditions are favourable for the formation of springs.

In order to solidify the knowledge of the students, Hydrology and Engineering Geology Department of Vilnius University performed a chemical analysis of city springs and assessed the quality of its water used for drinking. The first 12 springs were studied in 1999–2001 with the sampling performed in each season. Later, after five most typical springs had been selected, an additional year-long study was performed (from the beginning of April in 2002 to the end of April in 2003) with the sampling made once per month. It should be noted that the dwellers of Vilnius used

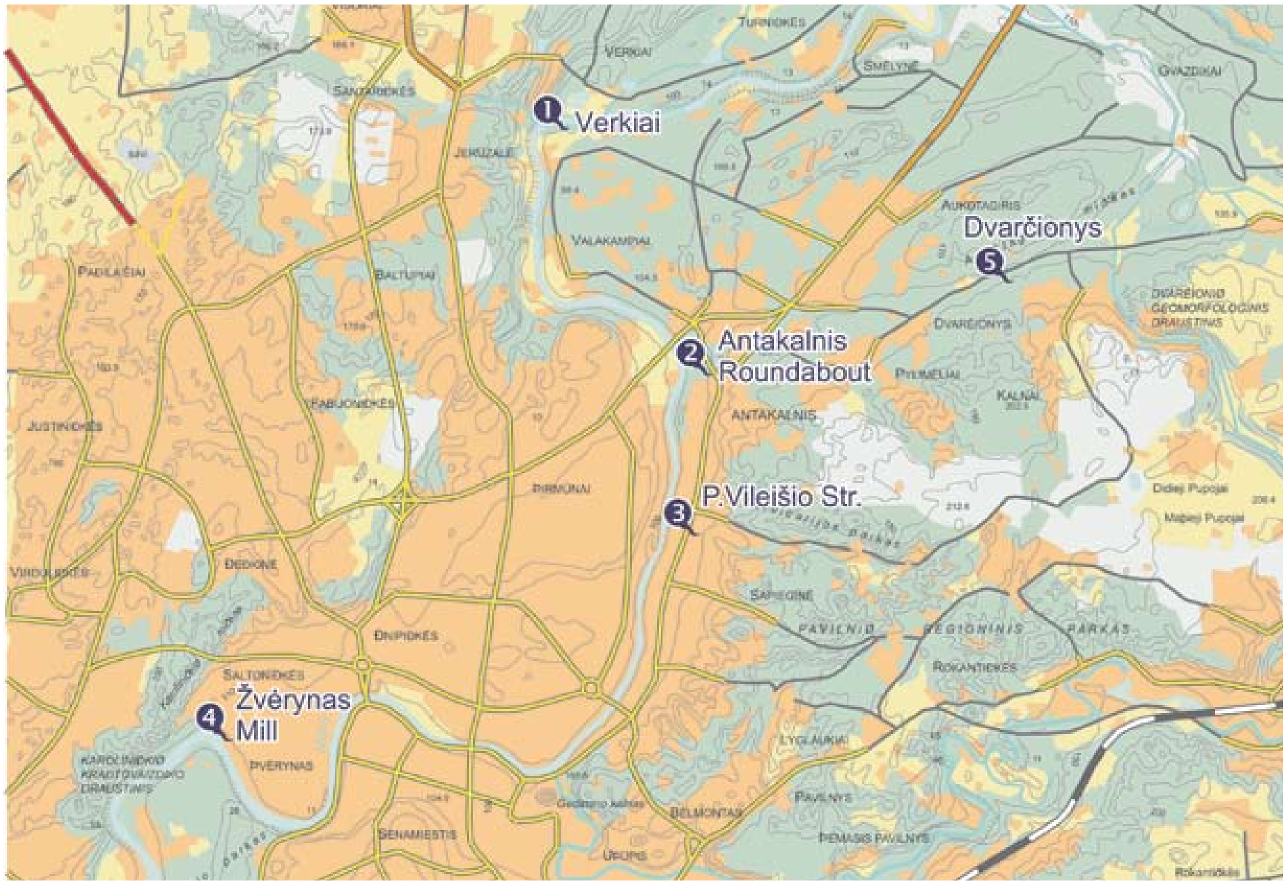

Fig. 1. Disposition of the studied springs of Vilnius city
1 pav. Tirtų Vilniaus miesto šaltinių išsidėstymo schema

the water of these five springs most often (Fig. 1). In 2006 one more sample was taken from a spring located in Žvėrynas district and analysed to specify the stability of the data at the maximum and minimum intervals determined previously. The systematised data are given in the present article.

HYDROGEOLOGICAL CONDITIONS OF THE SPRING ENVIRONMENT

The springs in Vilnius are located mainly in the Neris River and related to its first above-floodplain terraces. These locations are inconvenient for the economic development or are used for recreation. Other former springs, which had been located at the higher terraces of the Neris were drained since they hindered the city from development.

The majority of the springs in the Neris valley flow from shallow groundwater – the unconfined aquifer extending form the surface and having no impermeable cover. Therefore, the city pollution affects its chemistry. It should be noted that the pollution conditions differ depending on the place. For a long time there has been a waste dump close to the Verkiai Spring. Having realized the threatening impact of waste, people closed the dump, but, unfortunately, the soil remained polluted. The spring at the Antakalnis Roundabout is in a small forest without any pollution typical of the city. On the contrary, the spring in P. Vileišio Street is in the urban area covered by asphalt, but under it, there is the network of municipal faecal and rain sewerage with pipes leaking in some places, thus, as the experience shows, the pollutants reach the groundwater. The spring of Žvėrynas Mill squirts water formed in the district of individual homes, where asphalt areas are rare and the soil is open, nearly under natural conditions, is apparently polluted. The Dvarčionys Spring unlike the above-mentioned springs is located in an area of nearly natural conditions – at a twenty-meter forest elevation, the lower part of which is girdled by the isoline of 140 m a. s. l. A part of precipitation seeps deeper into this area and is discharged in a ravine on the slope of this elevation.

BRIEF CHARACTERISTICS OF THE SPRINGS STUDIED

The Verkiai Spring is located in the northern part of the downtown on the left bank of the Neris River in the wall formed by an unnamed tributary and suffosion cirque landslide. The water flows from sand deposits. It is a shallow groundwater that can be polluted by nearby wastes from the houses and fertilisers from the gardens. The average annual discharge of the pollutants is 0.29 l/s or 25 m^3/d. The water is used by the local population. The residents are apparently not disinterested in it, since they have closed the long-lived dumping site near the spring and arranged the steps on the steep slope for climbing down to the spring.

The Antakalnis Roundabout Spring is located closer to the downtown on the left bank of the Neris River close to the channel. It is a springy ravine, where the water flows as a wide belt in a scattered way from above-floodplain terrace deposits. This unconfined aquifer extends far away in the City's area. The location of the sources is rather inconvenient for investigations – it is difficult to determine its discharge.

The Spring of P. Vileišio Street flows from a site on the left bank of the Neris River below the springy Antakalnis' ravine from the alluvium of the above-floodplain terrace also expanding towards the downtown. The captation is well-arranged. The discharge of the spring varies, depending on the season, from 0.43 to 0.9 l/s with the average of 0.72 l/s or 62.2 m^3/d. Vileišio Street is close to the downtown and has many multi-storey blocks of flats. The residents of this place bring to their homes 10–12 l of the spring water every day.

The Žvėrynas Mill Spring flows from the right bank of the Neris River under conditions similar to those described above. It collects water from several above-floodplain terraces related to the area of individual houses. As in P. Vileišio Street, the captation is well arranged – a curb with a pipe is set here. The discharge of the spring ranges from 0.44 to 0.87 l/s, with the annual average being 0.68 l/s or 59 m^3/d. On the average local residents take 5–6 l of water per one visit.

The Dvarčionys Spring, unlike the above-described springs, is in a site far away from the river channel on the slope of the 7th terrace, above which there is a twenty-meter hill, most probably composed of sand accumulated by the wind. Trees grow in the site that is not polluted. This is the most popular spring among the residents of Vilnius, where from a well-arranged captation they can handily fill their bottles with water. People bring water from this outlying place in bottles of 3 l or larger. On the average, one person takes 40–50 l of water per one visit.

DATA ABOUT CHEMICAL COMPOSITION OF THE SPRING WATER

There is a saying that water is something more than food, since it maintains the necessary temperature in living organisms, takes part in metabolism, removes waste substances and performs many functions in a human body. Unlike the foodstuffs that we can select according to our taste, we are "forced" to drink water everyday. It is desirable that the water should be good from the point of view of hygiene and its quality should correspond to the long experience of the mankind and should be confirmed by analyses (Table 1). Fresh groundwater suits the best the demand for drinking and cooking. However, there is no absolute guarantee. Thus, it is necessary to know the formation of the groundwater chemistry and physical features, and whether it contains harmful microbes or not. The sampling from all the five mentioned springs in Vilnius was performed once per month with the total of 14 samples for each spring, and then the general chemical analysis was carried out (Table 1).

Table 1. **Data of general chemical analysis performed for Vilnius city spring water (average and max. / min. values)**
1 lentelė. **Vilniaus miesto šaltinių vandens bendrosios cheminės analizės duomenys (vidurkis ir max / min rodiklių vertės)**

Indicator	Spring							
	Verkiai	Dvarčionys	Antakalnis Roundabout	Antakalnis Vileišio Str.	Žvėrynas Mill	2006	HN 24 : 2003	HG Background
Solids, mg/l	492 564/440.7	246.66 258.9/234.9	411.46 434.8/386.9	440 485/418	384.9 417.9/354	594	< 1000	479 546/431
HCO_3, mg/l	281.62 305/274.5	224.18 237.9/213.5	317.68 329.4/305	345.95 359.9/335.5	309.8 329.4/292.8	329	n. n.	293 364/250
SO_4^-	48.4 63.5/36.6	43.96 55.5/27.3	48.46 60/29.7	51.3 62.7/41.2	52.3 63.5/30.5	49.6	< 250	38.8 47.1/32.7
Cl^-, mg/l	72.38 115.2/54.9	6.8 7.1/5.3	44 53.18/37.22	37.49 51.4/31.9	28.36 30.1/26.6	48.7	< 250	19.1 241/13.9
Ca^{++}	96.88 107.2/86.2	62.7 65.1/60.12	90.77 94.2/78.2	99.4 107.3/96.2	81.13 94.2/84.12	100	n. n.	29.5 38/21
Mg^{++}	22.6 30.4/19.45	16.2 17/14.6	23.58 25.5/21.9	25 26.8/23.7	23.97 26.8/20.06	24	n. n.	29.5 38/21
NO_3^-, mg/l	62.78 69.5/52	0.94 1.4/0.6	19.33 20.5/18.1	27.28 37.6/23.6	17.49 24.8/4.5	15.7	< 50	2.04 3.66/1.21
COD_{Mn}, mg/lO_2	0.83 1.2/0	0.3 1/0	0.6 1.8/0	0.46 1/0	0.57 1/0	2.33	< 5	3.42 4/2.8
COD_{Cr}, mg/lO_2	4.05 6.4/2.35	2.93 9.38/0.71	3.6 6.7/0.71	4.4 9.66/1.9	3.55 7.2/0.71	6	n. n.	n. d.
O_2, mg/l	10.36 12.78/7.9	11.2 14.4/8.74	9.91 13.31/7.93	6.16 8.31/4.51	6.41 10.98/3.4	n. d.	n. n.	n. d.
pH	7.21 7.62/6.25	7.7 7.83/7.41	7.52 7.73/7.3	7.26 7.55/6.82	7.05 7.46/5.78	7.25	6.5–9.5	7.58 8.1/7.0
Eh, mV	190.25 260/107	170.9 216/127	167.5 217/127	158 243/120	158.9 235/92	598	n. n.	211 303/162

* HN 24: 2003 – Lithuanian Hygiene Standard; HG background – hydrogeochemical background (after Diliūnas et al., **2004); n.** d. – no data; n. n. – non-standard component for drinking water.

The quality of drinking water in our country is regulated by the Lithuanian Hygiene Standard (HN 24: 2003). Therefore, to be sure that the water is chemically suitable for drinking, the investigation data should be compared to the requirements of this standard. While studying the chemical composition of the shallow groundwater formed in the urban environment, it is also interesting to compare it to that of the background – water of the same type formed under conditions less affected by the human activity. One more criterion can be used to assess the spring water quality – hygiene quality indices applied to the public water supply system.

ESTIMATION OF HYDROCHEMICAL DATA

The content of solids is one of key indicators of water quality, since drinking water must be fresh and the content of dissolved solids should not exceed 1000 mg/l. Indeed, the solids in HN 24 : 2003 are given as specific electrical conductivity (SEC) with its permissible limit being 2500 μS/cm. Recalculated into the solids, it corresponds to approx. 1250 mg/l, i. e. a little higher than attributing to the traditional fresh groundwater type. From this viewpoint, the water from all the springs studied is perfect, since the solids there make up 400–500 mg/l on the average. Only the water from the Dvarčionys Spring shows lower values of solids reaching only 250 mg/l, since the conditions for its enrichment with salts are less favourable because of the small distance between the precipitation input zone and the spring site. By the way, the water of Dvarčionys is also notable for a lower content of the organic matter, as well as nitrates and chlorides, since the water is composed in a clean area. It should be noted that solids and key chemical components varied in a very small interval, except for the Verkiai Spring water, where chlorides were observed to increase. So, the lowest content of solids was in the water of the Dvarčionys Spring located mainly in a natural environment, and the highest content of solids was in the Verkiai Spring that is affected by the most unfavourable environmental conditions (Fig. 2 A).

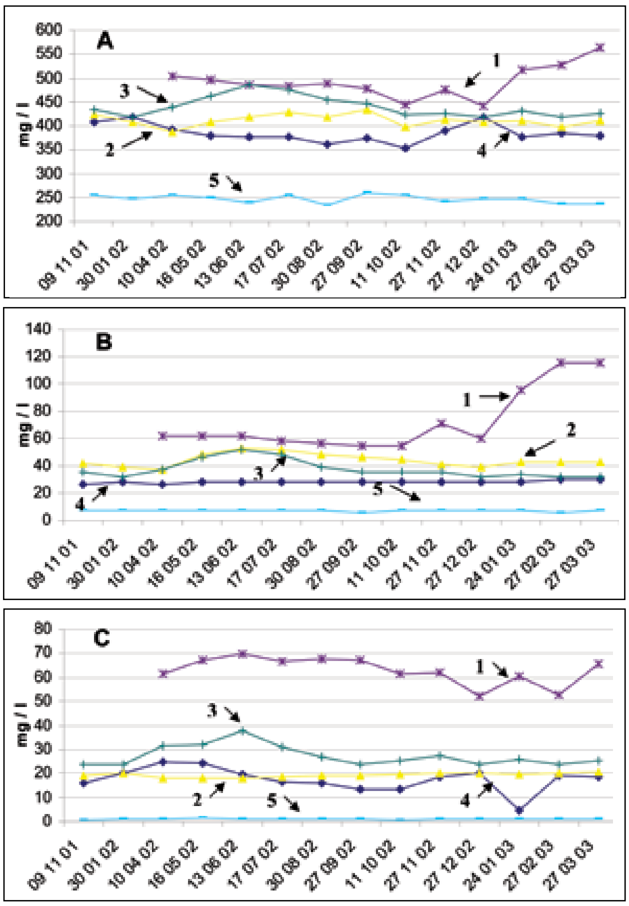

Fig. 2. Variations in the content of water chemical indicators for Vilnius springs in time: *A* – solids, *B* – chlorides (Cl) and *C* – nitrates (NO_3^-), curves of chemical indicator values: *1* – Verkiai, *2* – Antakalnis Roundabout, *3* – P. Vileišis Street, *4* – Žvėrynas Mill, and *5* – Dvarčionys

2 pav. Vilniaus šaltinių vandens būdingų cheminės sudėties rodiklių koncentracijos kaitos per tam tikrą laiką grafikai: *A* – bendrosios mineralizacijos, *B* – chlorido (Cl), *C* – nitrato (NO_3^-); cheminio rodiklio koncentracijos kaitos šaltinio vandenyje kreivės ženklas: *1* – Verkių, *2* – Antakalnio žiedo, *3* – P. Vileišio gatvės, *4* – Žvėryno žiedo, *5* – Dvarčionių

Chlorides is a very good indicator of groundwater pollution from the household areas. As it has been mentioned before, there was a waste dumping near the Verkiai Spring that was later closed by local people. The soil, however, remained polluted, and after the refuse was removed, water began to seep more actively and transport pollutants into the subsurface. The picture of chloride content changes clearly show that from the autumn of 2002, the chloride content has increased abruptly, while the chloride content in other springs remained approximately stable (Fig. 2 B).

Speaking about the content of solids, it should be noted that if the salt content in water is low, concentrations of macrocomponents – HCO_3^-, SO_4^{2-}, Cl^-, Ca^{2+} and Mg^{2+} – determining water hardness, as well as Na^+ and K^+, are not high and, as a rule, under natural conditions do not exceed permissible limits. The contents of chlorides and sulphates in Vilnius spring water are significantly lower than the permissible level indicated in the standard (Table 1).

The content of iron that used to be abundant in the Soviet-time water supply system is not high in the spring water. This seems to be the reason why people consider the spring water to be better. Iron in the spring water studied did not exceed 0.1 mg/l (the permissible limit is 0.2 mg/l), and most often only traces of iron were observed. It is natural, since shallow groundwater is rich in oxygen that is capable to turn all iron into trivalent iron hydroxide $Fe(OH)_3$ that is an insoluble compound settling on sand particles in the aquifer and causing their brown colour that is observed in all spring sites.

When the environment is being polluted, nitrogen compounds are present in significant amounts and enters groundwater as ammonium (NH_4^+), nitrite (NO_2^-) and nitrate (NO_3^-) ions. If groundwater is rich in free oxygen, it contains no ammonium and nitrites, since they are intensively oxidised, and the final result of the chemical reaction is the nitrate ion: $NH_4^+ \Rightarrow NO_2^- \Rightarrow NO_3^-$ that prevails in spring water.

As it has been mentioned, the content of oxygen (O_2) is high in spring water and ranges from 6 to 14 mg/l. Deeper aquifers usually contain significantly less oxygen. Therefore, if ammonium and nitrate ions were detected in spring water, their content did not exceed 0.01–0.05 mg/l, and there were only several cases within the range of 0.14–0.24 mg/l (the permissible limit is 0.50 mg/l). On the contrary, nitrate contents are rather high and range on the average from 20 to 27 mg/l (the permissible limit is 50 mg/l). This is 10 times higher than the average background values resulted from obvious human polluting impact (Table 1). According to the nitrate content as a toxicological indicator that is used for the quality assessment of drinking water, water of three springs of the studied ones is significantly worse than that provided by the public supply company "Vilniaus Vandenys". According to the nitrate indicator, the Dvarčionys Spring water is the best among the studied samples, since it is formed in the environment that is not polluted. It should be noted that the nitrate content in the spring water varied insignificantly in time, hence, no accumulation of the organic matter in large amounts occurs in the environment of the springs (Fig. 2 C).

Organic matter (OM) is an important component of drinking water, since its higher contents deteriorates the quality of water, and even micro-amounts of some organic compounds are harmful to a human organism and are limited by HN 24 : 2003 standard. A determination of individual OM compounds requires high labour expenditures and funding. Therefore, general investigations employ, as a rule, a summarised indicator of the organic matter, i. e. Chemical Oxygen Demand (COD) using potassium permanganate that is a weak oxidiser and, hence, it reacts with substances, which can be easily oxidised (OM_{LO}) – fulvic and humic acids, mainly. This indicator is referred to as the permanganate index and expressed as COD_{Mn}. In order to obtain a summarised content of all the organic matter OM_{SUM} (up to 75–95%), a stronger oxidiser – potassium dichromate – is used, and this indicator is referred to as the dichromate index and expressed as COD_{Cr}.

The analysis of COD data given in Table 1 shows that $COD_{Mn} << COD_{Cr}$, hence, the water contains considerably more organic matter that is difficult to be oxidised ($OM_{SO} = COD_{Cr} – COD_{Mn}$) than the easily oxidised matter (OM_{LO}). Toxic compounds of the human activity, such as pesticides, PAHs, etc. regulated by HN 24 : 2003 standard are attributed to OM_{SO} (Appelo, Postma, 1993; Juodkazis et al., 2003; etc.). Their studies are complicated, therefore, an attempt was made to determine their potential occurrence only in one water sample taken from the Žvėrynas Mill Spring. Analyses showed the presence of halogenated hydrocarbons, such as trichloroethene (0.25 μg/l) and tetrachlorethene (1.06 μg/l); their summarised permissible limit for drinking water is 10 μg/l (HN 24: 2002 standard). Aromatic hydrocarbons of petrol and Diesel fuel were not detected in spring water. Pesticides were not analysed. The results force to consider the situation seriously, since the detection of organic compounds attributable to toxic ingredients in the Žvėrynas Mill Spring water can take place in other springs.

Additional chemical analysis done in 2006 for Žvėrynas water samples showed that the values of main macro- and micro-components remained within the range of minimum and maximum values determined previously and close to their average (Table 1, 2006 column). COD_{Mn} is, however, distinguished by 2.33 mg/l O_2 value that is higher than the previous results that were ranging from 0 to 1 (average 0.57) mg/l O_2. Moreover, COD_{Cr} was found to be 6 mg/l O_2 – the value that was close to the former maximum 7.2 mg/l O_2 (Table 1). This encouraged the authors to arrange an additional discussion of OM formation in the water of all the studied springs of Vilnius.

ORGANIC MATTER IN THE SPRING WATER

The major part of organic matter (OM) detected in Vilnius spring water is of land surface origin, since the spring water flows from a shallow aquifer that is not protected from surface pollutants. The OM content characterised by maximum values of COD_{Cr} in the spring water, however, differed notably during the period of the study among different sites. So, COD_{Cr} maximum values varied as follows: 6.4 mg/l O_2 in the Verkiai Spring situated near the former refuse dumping, 9.38 and 6.7 mg/l O_2 in two remote wooded sites, Dvarčionys and Antakalnis Roundabout spring respectively, 9.66 mg/l O_2 in P. Vileišio Street in Antakalnis district with the spring environs covered by asphalt under which rain and faecal sewerage system is laid, and 7.2 mg/l O_2 in Žvėrynas, where individual houses with gardens and recreation zone ponds and meadows prevail.

The data of COD_{Cr} and COD_{Mn} averages show considerably higher contents of stable organic matter that is more difficult to oxidise (OM_{SO}) than the easily oxidised matter (OM_{LO}). This is clearly expressed by the COD_{Cr} and COD_{Mn} ratio, the value of which grows with the growing OM_{SO} in water (Table 2). When COD_{Cr} / COD_{Mn} is less than 1.3, the water forms under natural conditions, and COD_{LO} make up 75% of the total OM; if this ratio exceeds 4, the water is formed under conditions of intensive pollution, and COD_{LO} make up only 25% of the total OM (Juodkazis et al., 2003).

The data given in Table 2 indicate that, according to the average values, easily oxidised organic matter (OM_{LO}) in all the springs studied make up about 20%. There were only rare cases when it reached 30–40% of the total OM (Fig. 3). The rest part seems to belong to the OM more resistant to oxidation (OM_{SO}), microbes are unable to decompose it into simpler compounds. Therefore, OM_{SO} in spring water, as a rule, exceed 80% and often make up all 100%. Moreover, additional studies are necessary to be carried out on toxic organic matter limited by

Table 2. **Chemical oxygen demand values for Vilnius spring water and their average COD_{Cr} / COD_{Mn} ratio**
2 lentelė. **Vilniaus šaltinių vandens deguonies sunaudojimo vertės ir $ChDS_{Cr} / ChDS_{Mn}$ santykio vidurkinės reikšmės**

Indicator	Springs and COD_{Cr} / COD_{Mn} values				
	Verkiai	Dvarčionys	Antakalnis Roundabout	Antakalnis Vileišio St.	Žvėrynas
COD_{Cr}	4.05	2.93	3.60	4.40	3.55
COD_{Mn}	0.83	0.30	0.60	0.46	0.57
COD_{Cr}/COD_{Mn}	4.88	9.76	6.00	9. 56	6.22
OM_{LO} %	20.50	10.24	16.66	10.45	16.06
OM_{SO} %	79.50	89.76	83.34	89.55	83.94

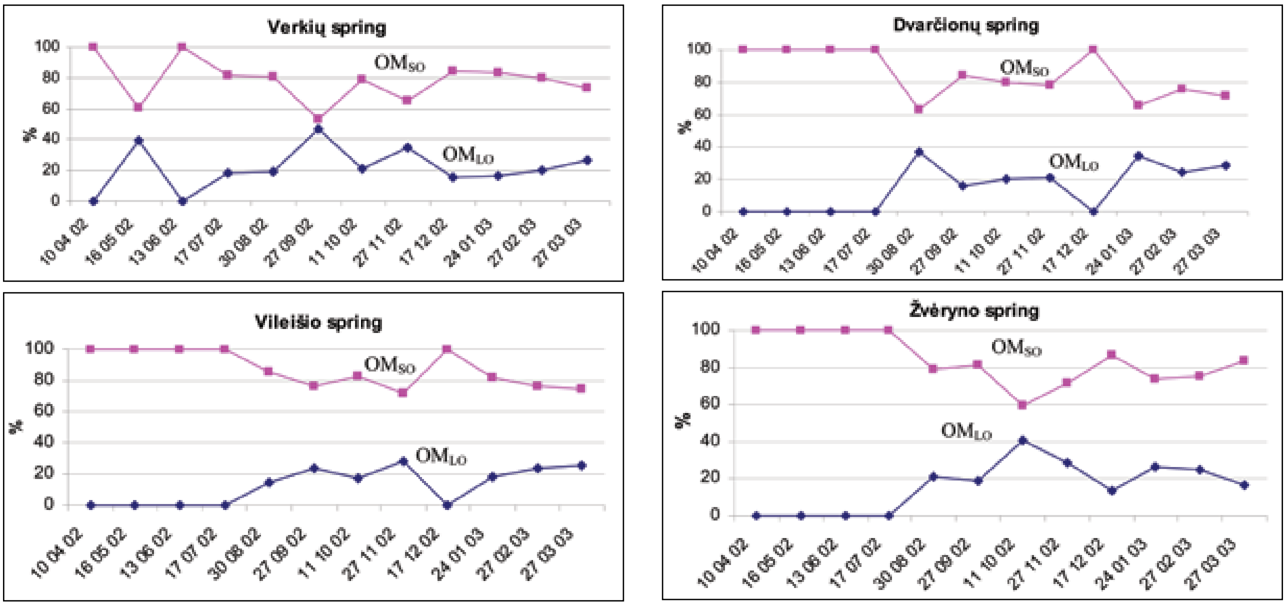

Fig. 3. Percentages of organic matter types (easily oxidised OM$_{LO}$ and more oxidation resistant OM$_{SO}$) from the summarised content (OM$_{SUM}$) determined in spring water of Vilnius City, where OM$_{LO}$ = COD$_{Mn}$; OM$_{SO}$ = COD$_{Cr}$ – COD$_{Mn}$

3 pav. Lengvai (OM$_{LO}$) ir sunkiai (OM$_{SO}$) oksiduojamos organinės medžiagos transformacijos grafikai: % – (OM$_{LO}$) ir (OM$_{SO}$) dalis nuo bendro (OM$_{SUM}$) organinės medžiagos kiekio, nustatyto Vilniaus šaltinių vandenyje; OM$_{LO}$ = ChDS$_{Mn}$; OM$_{SO}$ = ChDS$_{Cr}$ – ChDS$_{Mn}$.

drinking water standards. Therefore, the curves in Fig. 3 show that the variations of both COD indicators in time are identical, since they are the same for both easily degradable OM$_{LO}$ and more resistant OM$_{SO}$. It is natural, since the formation of the chemical composition of spring water takes place under similar geological / hydrogeological conditions just slightly differing in time.

The microbiological state of the spring water was not investigated during the present study, but other sources had noticed that it deteriorates in the springtime. So, in 2005 faecal bacteria were found in the water of P. Vileišio Str. and old springs of the Missionaries; such situation can recur in other places as well.

DISCUSSION

The graphical analysis of easily oxidised (OM$_{LO}$) and more resistant (OM$_{SO}$) organic matter leads to a serious contemplation of OM origin and the significance of indicators in assessing the quality of groundwater, as well as the role of microbes in the formation of non-stationary regime of OM content variations in the spring water. The curves expressing transformation of OM (Fig. 3) obviously show that the process is of a non-stationary type. From the April of 2002 to the beginning of July, three springs contained extremely low amounts of OM$_{LO}$ – at the trace limits. Later, closer to the midsummer time, OM$_{LO}$ content in the spring water increased, which can be related to the activation of microbes due to higher temperature of soil and water. At the end of the year, OM$_{LO}$ decreased again, even to the minimum in some springs. There was an exception – the Verkiai Spring located close to the former refuse dump that had been closed, refuse removed, but soil remained highly polluted and forming better conditions for microbes to act. In spite of this, the curves show the cyclic character of OM transformation related to the microbe activity.

It is obvious that technogenous pollution plays a significant role in spring formation in the geological environment. But it is interesting, whether it forms OM that is more resistant to oxidation. So, the springs of Dvarčionys and Žvėrynas are located in recreational areas of the City with thrifty vegetation and soil rich in organics. Perhaps the intensive activity of microbes contributes to the production of this resistant part of OM.

The material presented in the paper shows that comprehensive hydrochemical and microbiological investigations should be carried out in order to reveal the processes related to the OM formation and its transformation into the easily degradable form, as well as its decline and the appearance of new portions.

CONCLUSIONS

The investigations presented in the article were performed in order to confirm or deny the opinion of the residents of Vilnius using the water of springs located in the city area and considering the quality of the spring water better than that of the water supplied by the public supply system. The investigations were performed as a constituent part of the study programme implemented at the Hydrogeology and Engineering Geology Department of Vilnius University for the final theses to obtain Bachelor and Master degrees. There were no detailed studies of the spring water of Vilnius before, therefore at the initial phase of the investigations it was decided to assess the quality of the spring water only based on the data of general chemical and summarised organic matter analyses.

The investigation of five typical springs, the waters of which are mostly used by the residents of Vilnius, showed that the water quality was the best in the Dvarčionys Spring and the worst in the Verkiai Spring that contained high amounts of organic matter and, moreover, the nitrates exceeded the permissible hygienic limits. The Verkiai Spring water is used by a few families living nearby.

The content of nitrates in the rest three springs did not exceed the standard limits but was 4–5 times higher than that in the water provided by the municipal supply company. The water of these springs contained much organic matter that is resistant to oxidation, and this might be related to the toxic organics dissolved in water. This presumption was confirmed by special analyses of one water sample taken from the Žvėrynas Mill Spring. High content of organic matter is a source of microbial pollution. Therefore, the spring water brought home should be boiled before use.

The springs of Vilnius also play an important role as a landscape element. Unfortunately, their environs are not maintained properly; their view does not make an aesthetic image for a Vilnius resident or a guest. People who use spring water do not know what they drink, nevertheless, they often say that it is better than the water from the municipal supply. City's neighbourhoods should place information stands there in order that people were informed about the quality of the water – it is good for drinking or not.

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References

1. Appelo C. A. J., Postma D. 1993. Geochemistry, groundwater and pollution. Rotterdam, Brookfield: A. A. Balkema. 5–23.
2. Diliūnas J., Bajorinas V., Čyžius G. ir kt. 2004. Požeminio nuotėkio ir vandens cheminės sudėties formavimasis technogenezės sąlygomis. *Lietuvos žemės gelmių raida ir ištekliai*. Vilnius. 486–514.
3. Groundwater in the urban environment. Vol. 1. Problems, processes and management. Ed. John Chilton et al. 1997. *Proceedings of the XXVII IAH Congress on groundwater in the urban environment. Nottingham. UK. 21–27 September 1997*. Rotterdam, Brookfield: A. A. Balkema. 682 p.
4. Groundwater in the urban environment. Vol. 2. Selected city profiles. Ed. John Chilton et al. 1997. *Proceedings of the XXVII IAH Congress on groundwater in the urban environment. Nottingham. UK. 21–27 September 1997*. Rotterdam, Brookfield: A. A. Balkema. 342 p.
5. Juodkazis V., Arustienė J., Klimas A., Marcinonis A. 2003. Organic matter in fresh groundwater of Lithuania. Vilnius: Vilnius University Publishing House. 232 p.
6. Klimas A. 1995. Impacts of urbanisation and protection of water resources in the Vilnius district, Lithuania. *Hydrogeology Journal*. ***3***(*1*). 24–35.
7. Klimas A. 1996. Methodology for mapping shallow groundwater quality in urbanized areas: A case of study from Lithuania. *Environmental geology*. ***27***(*4*). 320–328.
8. Klimas A. 1997. Impact of urbanization on shallow groundwater in Lithuania. *Proceedings of the XXVII IAH Congress on groundwater in the urban environment. Nottingham. UK. 21–27 September 1997*. Rotterdam, Brookfield: A. A. Balkema. 463–468.
9. Kondratas A. 2001. Antropogeninis poveikis Lietuvos gėlo požeminio vandens kokybei (1960–1995). Vilnius, Geologijos institutas. 192 p.

Vytautas Juodkazis, Linas Papievis

ŠALTINIŲ VANDENS CHEMINĖ SUDĖTIS IR KOKYBĖ VILNIAUS MIESTE

Santrauka

Žemyninio apledėjimo kraštinių morenų ruožuose yra susidariusi labai kaiti litologiniu požiūriu paviršinių nuogulų danga. Jeigu į tokius kvarterinių nuogulų darinius yra giliai įsirėžusių upių slėnių ar griovų, tai tokiais atvejais jų šlaituose ir terasose atsiranda palankios sąlygos į žemės paviršių ištekėti požeminio vandens šaltiniams. Dažniausiai tai krintantieji šaltiniai, kurie teka gravitacinių jėgų veikiami.

Nuo seno miestų gyventojai gerdavo šaltinių vandenį, naudodavo jį maistui gaminti, nes jis buvo švarus ir skanus. Šis gero šaltinio vandens įvaizdis yra išlikęs iki šių dienų, nors padidėjus aplinkos taršai mūsų aptariamų šaltinių vanduo gali būti ir geras, ir blogas. Nepaisydami to gyventojai nešasi ar vežasi jį į namus tikėdami, kad jo kokybė yra geresnė nei viešai mieste tiekiamo vandens. Vilniaus mieste yra palankios geomorfologinės sąlygos šaltiniams susidaryti. Todėl Vilniaus universiteto Hidrogeologijos ir inžinerinės geologijos katedra ištyrė Vilniaus miesto šaltinių vandens cheminę sudėtį, įvertino geriamojo vandens kokybę. Svarbiausieji rezultatai pateikti lentelėje ir grafikuose. Tyrimai rodo, kad šaltinių vanduo yra prastesnis už viešojo vandentiekio vandenį – jame yra daug antropogeninės kilmės sunkiai oksiduojamos organinės medžiagos.

Витаутас Юодказис, Линас Папиевис

ХИМИЧЕСКИЙ СОСТАВ И КАЧЕСТВО РОДНИКОВЫХ ВОД В ВИЛЬНЮСЕ

Резюме

На территориях, покрытых краевыми ледниковыми образованиями, толща четвертичных отложений состоит из слоев весьма изменчивого литологического состава. Если в пределах таких краевых образований имеются глубоко врезанные речные долины со многими эрозионными оврагами, то создаются благоприятные условия для образования источников подземных вод. Как правило, они являются нисходящими, движимыми с помощью гравитационных сил.

В Вильнюсе водою источников жители города пользовались с давних времен, ибо родниковая вода была отличного качества – чистая и вкусная. Существует мнение, что качество родниковой воды и сейчас лучше, чем вода из сети централизованного водоснабжения. Поэтому до сих пор некоторые жители города для питья используют воду источников. В связи с этим сотрудники Кафедры инженерной гидрогеологии Вильнюсского университета исследовали воду наиболее популярных источников города и оценили ее качество. Основные результаты исследований систематизированы в виде таблицы и графиков. Оказалось, что вода источников по качеству хуже воды городского водопровода: в ней, прежде всего, много трудно окисляемых органических веществ антропогенного происхождения.