QUALITY OF THE GROUNDWATER IN ŠIAULIAI CITY

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Annotation
In Lithuania, only underwater is used for drinking; its resources are large and the quality of this water is higher than that of the surface-water. Moreover, it is better protected from pollution. Implementation of water monitoring is a major state regulated control means to prevent from pollution. The article deals with the analysis of problems of the groundwater quality in Šiauliai city, the assessment of the monitoring results for the underwater in Šiauliai city referring to the investigation of the groundwater.
Key words: underwater, groundwater, monitoring, quality of water.

Introduction

Underwater means all the waters in the Earth's crust which are found in its pores, cracks, underground lakes and rivers. Their importance to the humankind is immense. Underwater is used for various human and industrial purposes. It is the largest treasure of the humankind. Both underwater and surface-water is used to supply the drinking water. The priority is given to the underwater because it is of a higher quality and is better protected from chemical and bacteriological contamination. Only in Lithuania, Denmark, Slovenia, Italy, Hungary identified among European counties, almost solely underwater is used for drinking and domestic needs (>90 %). In other European countries, a part of the underwater in the total balance of the consumed water is lower (50–75 %); whereas in Ireland, Sweden, Norway a part of the consumed water consists of surface-water (even up to 85 %). Thus, Lithuania is one of few countries whose demands of residents and larger part of industrial companies are met by the underground water resources [10].

According to its characteristics and usage, the underwater is of several types. The Law on the Underground Resources of the Republic of Lithuania establishes the following division of the underwater [4]:

Fresh underwater is the water which contains less than 1 gram per litre of the total concentration of dissolved substances or which can be used as the drinking water.

Mineral underwater is the water that contains 1 gram per litre or more of the total concentration of dissolved substances or which is characteristic of specific chemical and (or) physical, and (or) biological features. According to the total concentration of dissolved substances (in grams per litre), the mineral underwater is divided into very low (up to 2 grams per litre), low (from 2 to 5 grams per litre), moderate (from 5 to 15 grams per litre), high (from 15 to 35 grams litre) mineralisation water and brine (35 and more grams per litre).

A slightly too high amount of iron is perhaps the largest problem of the underground drinking water in Lithuania. This chemical feature does not harm health but causes unwanted effects because, when the water is brought to surface, iron hydroxides precipitate as brown sediment. Therefore, the water is being deironed in large water extraction plants, i.e. iron compounds are removed [8].

Increased concentration of nitrate in the underground water is another frequently manifesting problem in relation to the quality of water, which directly impacts health of people consuming groundwater. Nitrate is a toxic chemical compound found in the drinking water, too. The maximum permissible concentration (MPC) of nitrate in the drinking water should not exceed 50 mg/l [2].

The horizon of the groundwater has formed on top of the first impermeable layer of soil. The depth of the groundwater in different periods of the year is quite different and depends on the rainfall. The quality of the drinking water depends not only of domestic activities maintained by people but also on the chemical composition of rainfall. The underwater is relatively protected from surface pollution; however, sometimes small concentration of nitrates and traces of some toxic substances, such as heavy metals and pesticides, are found [3].

The groundwater stratifies closest to the surface and reacts to the anthropogenic load fastest. Therefore, it is a sensitive indicator of the environmental condition, and its impact on the underground hydrosphere is highly important. The quality of the groundwater is usually negatively affected by high amounts of iron, carbonates and nitrates [2].

The level of the groundwater, its chemical composition and temperature vary under the impact of external factors: climate, surface-water deposits, plants and human activity [1].

The underwater is the most important source of the drinking water in Lithuania; therefore, it is necessary to protect it from pollution and save it. The threat of over-exhaustion occurs when exploitation of the underwater exceeds the resources. A threat of contamination of the underwater is much higher that of over-exhaustion [12].

In Lithuania, not only larger cities and centres of districts have centralised systems of public water supply to residents but also majority of smaller towns and village-type settlements do. A part of residents extract the drinking water from individually equipped boring wells and dug wells [1].

The monitoring of the underwater is being carried out according to the State Programme for Environmental Monitoring. A major task of this programme is to assess the resources for renewing the underwater resources, chemical condition of the underwater, tendencies of the quality change and determining factors. The Underwater Monitoring Activity Programme comprises continuous measurements of the level of the underwater as well as the taking of underground water samples and laboratory examinations [6].

Relevance of the research. In Lithuania, the underwater is used by every resident; nevertheless, not many think of how this water occurs. It is very important to find out more about the resources of the underwater, their quality, to understand the causes which may reduce the resources of the underwater and its quality.

Research object: the groundwater in Šiauliai city.

Aim of the research: to analyse the problems of the groundwater quality in Šiauliai city.

Objectives of the research:

1. To analyse the resources of the fresh underwater and its extraction in Lithuania.
2. To assess the monitoring results for Šiauliai city underwater by examining the groundwater.
3. To find out the problems of pollution of the groundwater in Šiauliai city.

Research methods. Analysis of scientific literature, data of the monitoring of Šiauliai city underwater and soil for 2019.

Samples of the water from wells were taken using the water-drawing devices equipped near the wells or by using a specific ladle. Samples of water from boring wells were drawn by using a specific electric pump plunged into properly cleaned boring wells.

Resources and extraction of the underwater.

The underwater is a dynamic, renewable natural mineral resource which collects in pores and cracks of solids. The sites which are favourable for collection of larger amounts of the underwater are called underwater deposits. The freshwater, mineralised, industrial and thermal water is extracted from the underground. A part of the deposit where underwater catchment, raising and supply are installed is called the water extraction plant [9].

The resources of the underwater intended for exploitation are the amount of water which may be extracted from the aquifer by technically and economically rational means, i.e. not causing a negative effect on environment. The European Union directives consider resources intended for exploitation as available resources of the underwater [9].

When implementing the measures set in the programme of assessment of the underwater resources and their usage for supplying the drinking water for a period 2007–2025, it was found that the resources of the fresh underwater available in Lithuania comprised 3.72 mln. m3/ day. The part specified for resources of the Register of Underground Resources of Lithuanian Geological Survey registers 1,928 water extraction plants on the entire territory of Lithuania, including 32 plants of the mineral underwater. Currently, all resources of the fresh (drinking and production) underwater have been examined, approved and registered to the Register of Underground Resources [7].

Grounding on the data of Lithuanian Geological Survey for 2019, over 141,033.44 thousand cubic metres of the fresh underwater have been extracted from the underground in comparison to the data for the period 2015-2019; this is the most intensive water extraction over the period (see Table 1).

Table 1

Extraction of the fresh underwater in the Republic of Lithuania [5]

Amount / Year	2015	2016	2017	2018	2019
thousand m^3	132,054.40	130,002.71	121,000.00	104,052.20	141,033.44

Network for the underwater monitoring. Currently, Šiauliai city municipality network for

the underwater monitoring comprises 27 examination points. 16 examination points, including 9 specialised monitoring boring wells and 7 shaft wells belonging to residents, have been installed in the groundwater stratum.

In 2019, the monitoring was conducted in 23 points of the monitoring network. The groundwater, intertill and Permian aquifer deposits were surveyed. The monitoring of the underwater was carried out by M. Čegys' enterprise.

Physical and chemical indicators of the underwater. Before drawing samples of the underwater in field conditions, volatile physical and chemical parameters, such as water temperature, concentration of hydrogen ions pH, potential of oxidation-reduction Eh, electrical conductivity of water (SEL), have been measured in the boring wells and wells of the monitoring network.

Investigation of chemical composition of the underwater. Šiauliai city monitoring of the effect on the underwater includes the monitoring of the ground (in boring wells and wells), intertill and surface Permian (in boring wells) aquifer. In the reported year of 2019, chemical composition of all these aquifer strata was examined.

Quality of the groundwater. The quality of the groundwater is being surveyed in the water of the specifically for the monitoring equipped boring wells and wells belonging to residents. The results of the examination of the groundwater for 2019 are presented in Šiauliai City Municipality Report on Underwater and Soil Monitoring in 2019 [11].

Quality of the groundwater of boring wells. The quality of the water was examined in seven boring wells (no. 1701, no. 1702, no. 2364, no. 35849, no. 35854, no. 60138 and no. 60139). Boring wells no. 60138 and no. 60139 were installed on the territory of the former factory "Elnias", other boring wells are situated around the city. All samples of the water were collected in November 2019.

The total concentration of dissolved mineral substances (TCDMS) in the groundwater in the wells situated in Šiauliai city varied in the interval 353–988 mg/l (723 mg/l on the average). The least TCDMS of the water was found in the boring well no. 2364 situated on Spindulio street; the largest was found in the boring well no. 35849 on Pročiūnų street. Mineralisation of the water of these boring wells did not exceed the maximum mineralisation of the freshwater (1 g/l). Chemical composition of the water in the boring wells remained stable, changes of mineralisation were low.

The index values for amounts of organic substances dissolved in the water of the boring wells were quite different. The permanganate index (PI) varied in the interval 1.48–5.54 mg O/l, and in the water in the boring well no. 35854 it reached 23.8 mg O/l. Chemical oxygen demand according to bichromate (COD) index in the water of this boring well was also higher, i.e. 325 mg O/l. In the water of other boring wells, it varied in the interval <4.64–25.6 mg O/l.

Sulphates in the groundwater were found up to 29.1 mg/l. This concentration is not significant. The amount of chlorides varied in the interval 3.15–392 mg/l; increased concentrations were found in the boring wells no. 1701 (392 mg/l) and no. 1702 (166 mg/l).

Features of low pollution with nitric compounds were found in the monitoring boring wells, and ammonium dominated on this site. Ammonium was found in the water of all boring wells. Its larger concentration remained in the boring well no. 2364 (5.39 mg/l) and found in the boring wells no. 35854 (4.27 mg/l) and no. 1701 (3.03 mg/l). However, such amount exceeded only the MPC applied in the case when the underwater is used for domestic purposes. Concentration of ammonium in other boring wells did not reach 1 mg/l. Traces of nitrates (up to 1.32 mg/l) were found in the water of the boring well no. 35849 only.

In the boring wells no. 60138 and no. 60139 situated on the territory of the former factory "Elnias", features of the groundwater pollution remained. Mineralisation of the water of the boring wells was higher; the TCDMS reached 1726–2832 mg/l. Higher mineralisation of the water was found in the well no. 60138. An especially high amount of dissolved organic substances remained in the water of these boring wells. The COD index varied in the interval 716–912 mg O/l. The PI index varied 369–375 mg O/l. Last year, this index was twice higher and reached 580–748 mg O/l. Causes of changes in the mineralisation are not clear; they may be determined by natural (changes of the seasons, hydrodynamic mode) reasons as well as by domestic activity on the territory.

There is an increased amount of sulphates (319–757 mg/l) and chlorides (99.4–190 mg/l) in the water of the boring wells.

The amount of main cations, calcium, in the water reached 232–313 mg/l. The amount of sodium and potassium was higher; it varied in the interval 168–356 mg/l and 21.8–32.1 mg/l,

accordingly. The amount of these cations in the groundwater is not restricted; nevertheless, the found concentrations are not typical to the water originating in clean natural environment. In the water of the boring well no. 60138, sodium was the prevailing cation. In the water of the boring wells no. 60138 and no. 60139, higher concentrations of ammonium exceeding the MPC remained (5.48–26.1 mg/l). In the water of the boring well no. 61038, the concentration of ammonium increased from 12.1 to 26.1 mg/l. No other compounds containing mineral nitrogen (nitrites and nitrates) were found in the water.

In the groundwater on the territory of the former factory "Elnias", an especially high amount of chromium, 1000–1100 μg/l, was found. Such concentration exceeded the limit value (LM) 10–11 times. A higher amount of nickel, 75 μg/l, in the water of the boring well no. 60139 was found.

In the autumn of 2019, the quality of the groundwater on the territory of the former factory "Elnias" was poor, features of pollution remained.

Quality of the groundwater of wells. The quality of the water was examined in seven shaft wells belonging to residents [11]. The water samples were collected in November 2019.

The water of the wells was characteristic of moderate and slightly higher mineralisation: the TCDMS varied in the interval 529–1086 mg/l.

In the groundwater of the wells, cations of calcium dominated. The amount of calcium in the water of the wells varied in the interval 101–200 mg/l (146 mg/l on the average). Its largest concentration was found in the well no. 16s. The amount of magnesium in the water of the wells varied in the interval 7.35–52.6 mg/l; the largest concentration of it was found in the water of the well no. 44s. The amount of sodium on the territory continued varying as well (12.5–85.3 mg/l, 36.2 mg/l on the average). A slightly higher concentration of sodium remained in the water of the well no. 1š (85.3 mg/l). In this well, the concentration of chlorides exceeded the background concentration, too. Usually, higher concentrations of sodium chloride in the groundwater occur due to rock-salt being spread on the roads. This year, average concentrations of main cations were found to be higher.

The amount of organic substances dissolved in the groundwater of the wells varied. The PI displaying the amount of easily oxidising organic substance varied in the interval <0.6–40.9 mgO/l. The COD index displaying the total amount of organic substances in the water varied in the interval <4.64–73.9 mgO/l. The highest pollution with organic substances was found in the wells no. 16s and no. 30s.

Pollution with mineral nitrogen compounds found in the groundwater of the wells belonging to residents is observed; nitrate is the main compound. Nitrates were found in the water of all examined wells. Their amount varied in the interval 3.59–130 mg/l (42.9 mg/l on the average). A higher concentration of nitrates was found in the water of the wells no. 44s and no. Pb6s; there, their amount varied in the interval 65.9–130 mg/l. The amount of nitrates in the water of the well no. 44s exceeded the LM (1.3 times). In other wells, the quality of the water was better, found nitrates were 3.59–49.7 mg/l. No nitrites, which are the most easily oxidised compounds of mineral nitrogen, were found in any sample. Traces of ammonium were found in the water of practically all wells (up to 0.029 mg/l). Its concentration did not reach the assessment criteria. Pollution of the groundwater with nitrogen compounds is usually associated with mal-managed local system for wastewater collection, attempts of residents to engage with domestic farming activities.

Conclusions

1. Resources of the fresh underwater in Lithuania are quite large and they continuously renew. In the Register of Underground Resources, the part dealing with the resources, 1,928 water extraction plants situated on the territory of Lithuania are registered. All resources of the fresh underwater have been examined, approved and registered in the Register of Natural Resources.

2. Aiming to find out the problems of the quality of the groundwater in Šiauliai city, the analysis of Šiauliai city municipality underwater and soil monitoring for 2019 was carried out, methods for surveying the groundwater as well as examination points and surveyed indexes of the groundwater were explored.

3. When analysing the information on the indexes of the groundwater and the results of their survey, it was found that major problems of the groundwater pollution were related to the surface pollution, maintained domestic activities, caused by natural reasons and technogenic effect. The boring wells and wells for extracting water should be arranged further from potential spots of pollution present on the territory, following the installation requirements.

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