Magnuss VIRCAVS

CHEMICAL COMPOSITION AND ASSESSMENT OF DRINKING WATER QUALITY: LATVIA CASE STUDY

Abstract: Assessment of drinking water quality in seven largest Latvia drinking water supply systems (Riga, Daugavpils, Liepaja, Ventspils, Jelgava, Jurmala, and Rezekne) in 2008 using mathematical statistical processing of chemical composition data and calculation of drinking water quality indexes are carried out. Daugavpils, Liepaja, Ventspils, and Rezekne drinking water supply systems are assessed as excellent, Riga and Jurmala - good, but Jelgava - fair quality of drinking water. In Jelgava drinking water sulphate concentration exceed the accepted maximum permissible value (MPV) for 97 mg/dm$^3$ and in Jurmala - for 26 mg/dm$^3$. Besides, high values of total iron (1.15 ±0.54 mg/dm$^3$) and turbidity (14.2 ±7.2 nephelometric turbidity units) were obtained also in Jelgava drinking water. Relative high concentration of aluminum in Liepaja drinking water (0.2 mg/dm$^3$) takes place that achieves the MPV (0.2 mg/dm$^3$). In all analyzed drinking water the concentrations of Hg, Cd, Pb, Cu, Ni, Cr (total), BrO$_3^-$ and trihalomethanes (total) were observed in the level of their determination or less than it or concentration changes were observed only in some cases that are significantly less than their MPV. In general drinking water quality of the largest Latvia drinking water supply systems is assessed as agreeable to the existed legal norms.

Keywords: drinking water quality, chemical composition, mathematical statistics, and drinking water quality indexes, Latvia

Introduction

Provision of a qualitative drinking water is an important precondition for improvement of the life quality. Drinking water quality directly affects human health. The impacts reflect the level of contamination of whole drinking water supply system (raw water, treatment facilities and distribution network to consumers). The primary goals of environmental especially drinking water management are to provide safe drinking water supply in international and national scale. The international organizations, eg World Health Organization (WHO) have major functions to propose regulations, guidelines, and recommendations in order to realize human right to have access to an
adequate of safe drinking water independently of their stage of development and their social and economic conditions [1].


Management of drinking water quality is a matter of great importance in Latvia. Implementation of the State Investment Program 800+, drinking water regular and audit monitoring as well as other environmental projects are integral part of public health and environmental protection.

The present study is devoted to assessment of drinking water quality in seven largest Latvia drinking water supply systems in 2008 using mathematical statistical processing of chemical composition data.

**Materials and methods**

Quality assessment of Latvia drinking water is carried out using chemical composition data of drinking water obtained from the Public Health Agency of the Ministry of Health. Drinking water was analyzed in 2008 in seven largest Latvia drinking water systems - Riga, Daugavpils, Liepaja, Ventspils, Jelgava, Jurmala, and Rezekne (Fig. 1).

Drinking water was sampled from the site of consumers and analyses were carried out considering the requirements (testing methods, sampling frequency, the necessary
Chemical composition and assessment of drinking water quality: Latvia case study

precision and accuracy, maximum permissible values (MPV) of the variables) in Republic of Latvia Cabinet Regulations No. 235 “Mandatory harmlessness and quality requirements for drinking water, and the procedures for monitoring and control thereof” (adopted 29 April 2003) and in Cabinet Regulations No. 118 adopted on March 12, 2002 “Regulations regarding the Quality of Surface Waters and Groundwaters” (with amendments). Drinking water quality was evaluated by the following variables: color, turbidity, pH, conductivity, aluminum, iron (total), fluorides, sulphates, ammonium, nitrates(V), nitrates(III), mercury, cadmium, lead, copper, nickel, chromium, bromates, trihalomethanes (total).

Data processing of drinking water chemical composition includes mathematical statistical calculations. The Q-test was applied for suitability estimation of drinking water data set. The mean and the confidence interval of chemical composition variables of drinking water was expressed using Chebyshev’s inequality (confidence level $\alpha = 0.06$):

$$\bar{x} - 4s/\sqrt{n} \leq \mu \leq \bar{x} + 4s/\sqrt{n},$$

where $\mu$ - mathematical expectation, $\bar{x}$ - mean, and $s$ - standard deviation, and $4s/\sqrt{n}$ - standard error of mean [3]. Rezekne drinking water supply system was characterized only by two measurements of the variables. Availability of the data for further processing was evaluated using also Chebyshev’s inequality: $|x_1 - x_2| < 4s$ (where $x_1$ and $x_2$ - results of measurements). It was used for estimation of Al, Fe, F$, pH$, turbidity, and conductivity values. Assessment of differences between sample means was carried out using Bartlett’s test criterion.

Drinking water quality index (DWQI) was calculated using formulas set in Water Quality Index 1.0 User Manual [4].

WHO, EU and Latvia drinking water standards

Drinking water quality assessment is based on the determination of legal selected and accepted set of water quality variables of concern and their comparison with regulatory standards. Drinking water quality characterizes the chemical, physical-chemical and microbiological variables.

WHO produces international norms on water quality and human health in the form of guidelines that are used as the basis for regulation and standard setting in developing and developed countries worldwide. The Guidelines provide a range of supporting information, including microbial, chemical, radiological aspects and acceptability aspects. In 2006 WHO published Guidelines for drinking water quality [1] that replace the previous Guidelines for drinking water quality of 1993. Comparison of WHO drinking water standards of 1993 and of 2006 shows that many standards are less strict now, e.g. for antimony, boron, carbon tetrachloride. In return some other standards of the variables are much stricter in the recent WHO drinking water standards, like uranium and DDT. Besides, there are no guidelines any more for some variables such as chloride, sodium, sulphate, zinc and some others.

The requirements of the directives have incorporated in national water policy of the EU member states.

The Drinking Water Directive 98/83/EC ensures that water intended for human consumption is safe. The Directive 98/83/EC aims both protection of human health and also the environment. Precautionary principle is reflected in the Directive 98/83/EC setting contaminant levels. In general the EU standards are in line with WHO guidelines for drinking water quality of 2006. However there are differences between WHO and EU standards. For example, cadmium health based guideline by the WHO is 0.003 mg/dm$^3$ but EU standards qualify cadmium concentration 0.005 mg/dm$^3$. The WHO guidelines of 2006 do not set health based guideline for iron. However the WHO guidelines of 1993 defined desirable iron concentration 0.3 mg/dm$^3$ that is higher than EU standard for Fe (0.2 mg/dm$^3$).

Latvia drinking water standards are set in Republic of Latvia Cabinet Regulations No 235 “Mandatory harmlessness and quality requirements for drinking water, and the procedures for monitoring and control thereof” that contain legal norms arising from the Directive 98/83/EC. Latvia has transitional arrangements for providing of safe drinking water quality up to December 2015 in order to introduce the goals of the Directive 98/83/EC.

**Drinking water quality indexes**

A major objective of drinking water quality assessment is to determine whether or not the drinking water quality meets previously defined objectives for designated uses, to describe drinking water quality at regional, national or international scales, and also to investigate trends in time as well as to provide environmental including drinking water managers, technological staff of drinking water supply, scientists and public with a multitude of data and detail information on drinking water quality.

Water quality data is usually summarized in technical reports that are very valuable to individuals who understand the technical content, however, this information is not always useful to non-technical individuals. Therefore a water as well as drinking water indexes are processed. The objective of the DWQI is to turn drinking water quality data (chemical, physical-chemical and microbiological) into understandable, easily accessible, and useable by the public information [5]. The development of DWQI gives a tool for simplifying the reporting of water quality data [4, 5]. The index essentially is a mathematical instrument used to transform large quantities of water quality data into a single number that represents water quality level. A number of indices have been developed and their differences include the mathematical way describing water including drinking water quality data, eg exponential function, the Pearson type 3-distribution function and others [6]. Since 1965 a great deal of consideration has been given to the development of water quality index methods [6, 7].

The DWQI is to consumers enlightened information on drinking water quality. The DWQI is a unit less number ranging from 1 to 100. A value of 100 means the best possible index (excellent quality) and a value of 0 - the worst possible index (poor quality). The DWQI expresses overall water quality. Besides, the developed mathematical models of the DWQI characterize an attendance and concentration of individual as well as selected chemical substances in drinking water. The DWQI
developed by the Canadian Council of Environment Ministers [4] is widely used. The DWQI includes three measures of variance from the selected drinking water quality objectives - scope (F₁), frequency (F₂), and amplitude (F₃) [4]. The scope represents the extent of water quality legal norm non-compliance over the time period of interest. The scope is expressed:

\[
F_1 = \frac{\text{[Number of failed variables]}}{\text{[Total number of variables]}} \times 100 \% \quad (1)
\]

The frequency characterizes percentage of individual tests that do not meet objectives:

\[
F_2 = \frac{\text{[Number of failed tests]}}{\text{[Total number of tests]}} \times 100 \% \quad (2)
\]

The amplitude represents the amount by which failed tests do not meet their objectives:

\[
F_3 = \text{nse}/ (0.01 \times \text{nse} + 0.01) \quad (3)
\]

where nse indicates the normalized sum of excursions that is the collective amount by which individual tests are out of compliance.

The DWQI is calculated as:

\[
\text{DWQI} = 100 - \left(\sqrt{F_1^2 + F_2^2 + F_3^2}/1,732\right) \quad (4)
\]

**Characteristic of Latvia drinking water supply and quality control**

Latvia has rich water resources, especially freshwater, which well exceeds current and planned consumption. Water resources allow providing high quality drinking water for all population - 70% is composed from artesian and 30% from surface water sources (rivers and lakes). Total amount of surface waters comprises 13,300 m³ per capita but in EU it comprises at an average 7,250 m³ per capita [8]. In most water supply systems hydrogen-carbonate calcium water with mineralization 0.3÷0.4 g/dm³ is used. Chemical structure of rock and infiltration water is caused by calcium hydrogencarbonate water.

Mostly artesian waters are used for the centralized water supply in Latvia drinking water supply systems. They are better protected than ground water table. Drinking water sources for the capital of Latvia Riga comprise a mixture of surface, natural groundwater, and artificially recharged groundwater from Lake Mazais Baltezers that is the main source for artificial recharge plant supplying up to 25% of Riga drinking water [9]. Reservoir of Riga hydro-power plant on the Daugava River is used as a surface water source. The Daugava Waterworks is the largest surface water treatment plant in Latvia that purifies more than 100000 m³ per day using alum as a coagulant [10]. However, quality of water taken from the reservoir of Riga hydro-power plant depends on transboundary pollution that enters into the Daugava River from Russia and Belarus. In the period from 1990 to 1997 three large accidents happened in the river Daugava basin. In November 1990 during filling a railroad tank in a chemical plant “Polimir”, Novopolock (Belarus) spill of acetone cyanohydrin (ACH - operates on respiratory centers) occurred. Significant amount of ACH leaked into the Daugava River. Due to the pollution mass fish deaths were observed in the river. Therefore during one week water supply from the Daugava River was interrupted in Riga. The second accident involved sanitation leakage from Belarus in the middle of 1990s. The last accident, disruption of oil pipe line Unecha - Ventspils (enterprise „Zapad-Transnefteprodukt”, Russia), caused...
the Daugava River ecosystem contamination with diesel fuel that happened 23 March 2007. Diesel fuel of 4,171 Mg entered into the territory of Latvia, but ~90% was collected from the Daugava River waters. The noted accidents can originate and affect Riga as Republic of Latvia capital drinking water quality [11].

Drinking water quality control and assessment is developed in two stages. The first includes drinking water analysis in accordance with the requirements of the Regulations No. 235. The second stage comprises comparison of the obtained data with the MPV of physical-chemical, chemical, and microbiological variables, determination of the scope ($F_1$) and frequency ($F_2$).

The Public Health Agency is liable for monitoring of drinking water quality against the standards set in the Regulations No. 235. The Public Health Agency develops a drinking water monitoring program that includes regular and audit monitoring as well as the Agency carries out monitoring data assessment. In the period from 2000 to 2008 Latvia drinking water quality assessment is summarized in Figure 2. The data show the tendency to decrease of percentage of chemical variable unconformity of audit monitoring but regular monitoring data testify fluctuations around 36÷40%. Unconformity of microbiological variables during the tested period fluctuates in the range 3÷10% and likely it will decrease. The high concentrations of iron, manganese, ammonium, sulphates, and values of color, turbidity and some others comprise unconformity of drinking water quality in respect to chemical composition [12].

![Fig. 2. Unconformity of chemical and microbiological variables of Latvia drinking water quality: 1 and 2 - chemical and microbiological variables of audit monitoring; 3 and 4 - chemical and microbiological variables of regular monitoring](image)

Harmlessness and quality requirements of the Directive 98/83/EC and the Regulations No. 235 are not applied to drinking water obtained from separate places (individual households) of production or supply which are utilized by less than 50 persons and the amount of the supply of which does not exceed 10 m$^3$ per 24 h. Thereby
in rural areas about 10% or 200,000 inhabitants of Latvia are using drinking water from wells that is not comply with the control of state health and sanitary institutions. The centralized drinking water supply, for example in the studied seven largest Latvia drinking water supply systems is provided for 1,011,350 residents (in 2008 total Latvia population comprise 2,270,894).

Results and discussion

Statistical description of drinking water chemical composition

The analyzed drinking water data of seven largest Latvia drinking water supply systems are conditionally divided into two groups. The first group involves the variables whose values do not change. They are the concentrations of Hg, Cd, Pb, Cu, Ni, Cr (total), BrO$_3^-$ and trihalomethanes (total). These variables were observed in the level of their determination or less than it or concentration changes were observed only in some cases. The lowest observed concentrations are the following (in µg/dm$^3$): Hg - 0.1, Cd - 0.5, Pb - 1.0, Cu - 0.2, Ni - 2.0, Cr (total) - 1.0, BrO$_3^-$ - 1.0, and trihalomethanes (total) - 10.0. Besides, the exceptions comprised total Cr concentration in Daugavpils drinking water - 20.0 µg/dm$^3$ and Ni concentration in Jelgava drinking water - 5.4 µg/dm$^3$ (1 measurement). Total concentrations of trihalomethanes of Riga drinking water varied in the wide range of 0.1÷50.1 µg/dm$^3$ (mean and standard error of mean 23.8 ±0.35 µg/dm$^3$). The same statistics for total concentrations of trihalomethanes of Liepaja drinking water are the following: range of 0.10÷1.14 µg/dm$^3$, mean and standard error of mean - 0.54 ±0.21 µg/dm$^3$. All noted concentrations are less than their MPV.

Drinking water color modified in the range of 5÷10 units of Pt/Co scale with the exception of 20 units of Pt/Co scale in Daugavpils and Jurmala drinking water (1 measurement). The second group includes the variables whose value changes were observed - turbidity, pH, and conductivity, concentrations of Al, Fe (total), F$^-$, SO$_4^{2-}$, NH$_4^+$, NO$_3^-$, and NO$_2^-$. The obtained data of processing are summarized in Table 1. Data set distribution character was estimated only for Riga drinking water variables (sample size n = 18) and its inadequacy to normal distribution was obtained. Therefore Chebyshev’s inequality was applied to calculate confidence intervals of variable means because Chebyshev’s theorem could be used to random variables of any distribution.

Comparison of variable mean and median shows that these statistics are not equal for all variables. Median is a statistic that is sensitive to data set symmetric or asymmetric distribution. Data symmetric distribution is observed if the mean and median are equal but in the opposite case - asymmetric distribution. Considering the diversity of sample sizes from n = 2 to n = 18 evaluation of data distribution character was not carried out. Comparison of differences between sample means at confidence level а = 0.05 using Bartlett’s test criterion testifies on the following assurance.

In all analyzed drinking water systems nitrate(III) and fluoride concentrations do not significantly differ. Mean concentration of aluminum in Liepaja drinking water system (0.2 mg/dm$^3$) significantly differs from its concentration in other drinking water systems that have statistically equal value 0.02 mg/dm$^3$. Concentration of aluminum in Liepaja drinking water is equal with MPV (0.2 mg/dm$^3$).
### Table 1
Characteristics of chemical composition in the largest Latvia drinking water supply systems (2008)

<table>
<thead>
<tr>
<th>Statistic</th>
<th>Riga</th>
<th>Daugavpils</th>
<th>Liepaja</th>
<th>Ventspils</th>
<th>Jelgava</th>
<th>Jurmala</th>
<th>Rezekne</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>678,000</td>
<td>82,467</td>
<td>79,300</td>
<td>39,363</td>
<td>59,670</td>
<td>42,550</td>
<td>30,000</td>
</tr>
<tr>
<td>Al, MPV (^2) - 0.2 mg/dm(^3)</td>
<td>0.08 ±0.04</td>
<td>0.08</td>
<td>0.02</td>
<td>0.2(^6)</td>
<td>0.02(^6)</td>
<td>0.02(^6)</td>
<td>0.04 ±0.02</td>
</tr>
<tr>
<td>Me(^3)</td>
<td>0.02+0.2</td>
<td>\textendash</td>
<td>\textendash</td>
<td>\textendash</td>
<td>\textendash</td>
<td>\textendash</td>
<td>\textendash</td>
</tr>
<tr>
<td>Range</td>
<td>\textendash</td>
<td>\textendash</td>
<td>\textendash</td>
<td>\textendash</td>
<td>\textendash</td>
<td>\textendash</td>
<td>\textendash</td>
</tr>
<tr>
<td>NH(_4^+), MPV - 0.5 mg/dm(^3)</td>
<td>0.04 ±0.02</td>
<td>0.04</td>
<td>0.04(^6)</td>
<td>0.04 ±0.04</td>
<td>0.01 ±0.01</td>
<td>0.03 ±0.01</td>
<td>0.03(^6)</td>
</tr>
<tr>
<td>Me</td>
<td>\textendash</td>
<td>\textendash</td>
<td>\textendash</td>
<td>\textendash</td>
<td>\textendash</td>
<td>\textendash</td>
<td>\textendash</td>
</tr>
<tr>
<td>Range</td>
<td>\textendash</td>
<td>\textendash</td>
<td>\textendash</td>
<td>\textendash</td>
<td>\textendash</td>
<td>\textendash</td>
<td>\textendash</td>
</tr>
<tr>
<td>Fe (total), MPV - 0.2 mg/dm(^7)</td>
<td>0.12 ±0.07</td>
<td>0.13</td>
<td>0.04 ±0.02</td>
<td>0.08 ±0.08</td>
<td>1.15 ±0.54</td>
<td>0.06 ±0.04</td>
<td>0.05 ±0.03</td>
</tr>
<tr>
<td>Me</td>
<td>\textendash</td>
<td>\textendash</td>
<td>\textendash</td>
<td>\textendash</td>
<td>\textendash</td>
<td>\textendash</td>
<td>\textendash</td>
</tr>
<tr>
<td>Range</td>
<td>\textendash</td>
<td>\textendash</td>
<td>\textendash</td>
<td>\textendash</td>
<td>\textendash</td>
<td>\textendash</td>
<td>\textendash</td>
</tr>
<tr>
<td>NO(_3^-), MPV - 1.5 mg/dm(^3)</td>
<td>0.13 ±0.08</td>
<td>0.11 ±0.02</td>
<td>0.45 ±0.11</td>
<td>0.9 ±0.9</td>
<td>0.24 ±0.12</td>
<td>0.21 ±0.26</td>
<td>0.31 ±0.15</td>
</tr>
<tr>
<td>Me</td>
<td>\textendash</td>
<td>\textendash</td>
<td>\textendash</td>
<td>\textendash</td>
<td>\textendash</td>
<td>\textendash</td>
<td>\textendash</td>
</tr>
<tr>
<td>Range</td>
<td>\textendash</td>
<td>\textendash</td>
<td>\textendash</td>
<td>\textendash</td>
<td>\textendash</td>
<td>\textendash</td>
<td>\textendash</td>
</tr>
<tr>
<td>NO(_2^-), MPV - 50 mg/dm(^3)</td>
<td>1.9 ±1.6</td>
<td>0.86 ±0.48</td>
<td>0.013(^6)</td>
<td>0.9 ±0.9</td>
<td>0.24 ±0.12</td>
<td>0.20 ±0.32</td>
<td>0.5(^6)</td>
</tr>
<tr>
<td>Me</td>
<td>1.00</td>
<td>0.80</td>
<td>0.013(^6)</td>
<td>0.7</td>
<td>0.24 ±0.12</td>
<td>0.20 ±0.32</td>
<td>0.5(^6)</td>
</tr>
<tr>
<td>Range</td>
<td>0.24±5.12</td>
<td>0.41±1.20</td>
<td>0.35±0.51</td>
<td>0.003±0.01</td>
<td>0.20±0.32</td>
<td>0.5±0.10</td>
<td>0.5±0.50</td>
</tr>
<tr>
<td>SO(_4^{2-}), MPV - 250 mg/dm(^3)</td>
<td>0.008 ±0.008</td>
<td>0.05 ±0.04</td>
<td>0.003(^6)</td>
<td>0.3(^6)</td>
<td>0.01(^6)</td>
<td>0.008(^6)</td>
<td>0.04(^6)</td>
</tr>
<tr>
<td>Me</td>
<td>0.002</td>
<td>0.04</td>
<td>0.003±0.016</td>
<td>0.3</td>
<td>0.01±0.016</td>
<td>0.008±0.016</td>
<td>0.03±0.016</td>
</tr>
<tr>
<td>Range</td>
<td>0.003±0.016</td>
<td>0.04±0.016</td>
<td>0.04±0.008</td>
<td>0.3</td>
<td>0.01±0.016</td>
<td>0.008±0.016</td>
<td>0.03±0.016</td>
</tr>
<tr>
<td>pH, maximum permissible interval 6.5±9.5</td>
<td>43.0±14.0</td>
<td>10(^6)</td>
<td>210±28</td>
<td>215</td>
<td>2.1(^6)</td>
<td>347±164</td>
<td>276±129</td>
</tr>
<tr>
<td>Me</td>
<td>27.4</td>
<td>10(^6)</td>
<td>185±227</td>
<td>215</td>
<td>2.1(^6)</td>
<td>347±164</td>
<td>276±129</td>
</tr>
<tr>
<td>Range</td>
<td>11±81.1</td>
<td>10(^6)</td>
<td>185±227</td>
<td>215</td>
<td>2.1(^6)</td>
<td>347±164</td>
<td>276±129</td>
</tr>
<tr>
<td>Turbidity</td>
<td>7.58±0.40</td>
<td>7.88±0.16</td>
<td>7.74±0.01</td>
<td>7.62±0.32</td>
<td>7.16±1.00</td>
<td>7.22±0.03</td>
<td>7.22±0.03</td>
</tr>
<tr>
<td>Me</td>
<td>7.83</td>
<td>7.90</td>
<td>7.72</td>
<td>7.59</td>
<td>7.38</td>
<td>6.00±7.45</td>
<td>\textendash</td>
</tr>
<tr>
<td>Range</td>
<td>6.91±8.01</td>
<td>7.77±8.00</td>
<td>7.73±7.76</td>
<td>7.48±7.82</td>
<td>7.16±1.00</td>
<td>7.22±0.03</td>
<td>\textendash</td>
</tr>
<tr>
<td>Conductivity, MPV - 2500 (\mu S/cm)</td>
<td>0.38±0.04</td>
<td>0.31±0.11</td>
<td>0.58(^6)</td>
<td>1(^6)</td>
<td>14.2±7.4</td>
<td>2.9±0.4</td>
<td>0.6±0.1</td>
</tr>
<tr>
<td>Me</td>
<td>0.34</td>
<td>0.20</td>
<td>0.58(^6)</td>
<td>1(^6)</td>
<td>14.2±7.4</td>
<td>2.9±0.4</td>
<td>0.6±0.1</td>
</tr>
<tr>
<td>Range</td>
<td>0.11±0.65</td>
<td>0.11±0.90</td>
<td>\textendash</td>
<td>\textendash</td>
<td>14.2±7.4</td>
<td>2.9±0.4</td>
<td>0.6±0.1</td>
</tr>
</tbody>
</table>

1 Drinking water supply system
2 Number of residents that use drinking water
3 Maximum permissible values (Republic of Latvia Cabinet Regulations No 235 “Mandatory harmlessness and quality requirements for drinking water, and the procedures for monitoring and control thereof” (adopted 29 April 2003))
4 \(\bar{x} \pm SE\): mean and standard error of mean \(\bar{x} \pm 4s/\sqrt{n}\), where \(\bar{x}\) - mean, \(s\) - standard deviation and \(n\) - sample size
5 Me - median
6 All results in the series are equal
Total iron concentration (1.15 ±0.54 mg/dm$^3$) in Jelgava drinking water system significantly differs from total iron concentration of other systems but it does not exceed the MPV. High iron concentration is an important problem of drinking water quality in Latvia that is caused by high content of iron in ground water tables. Therefore drinking water de-ironing is included in Latvia drinking water processing.

In Riga drinking water nitrate(V) concentration has a wide dispersion that is specified by high standard deviation (±1.6 mg/dm$^3$). Mean concentration of nitrate(V) (1.9 mg/dm$^3$) is significantly higher than in other drinking water systems that are in the range from 0.013 to 1.1 mg/dm$^3$.

Sulphate concentrations in Jelgava (347 ±41 mg/dm$^3$) and Jurmala (276 ±32 mg/dm$^3$) drinking water systems are significantly higher than in drinking water of Riga, Daugavpils, Liepaja, Ventspils, and Rezekne. High concentrations of sulphate in drinking water have natural origin owing leakage from gypsum formations. Comparison of sulphate concentrations with the MPV shows that in Jelgava drinking water average linear deviation is 97 mg/dm$^3$ and in Jurmala - 26 mg/dm$^3$.

In all drinking water systems conductivity mean values have a great dispersion with significantly high values of 1189 ±315 and 944 ±172 µS/cm in drinking water of Jelgava and Jurmala. It could be explained by high concentrations of sulphates.

Significantly high value of turbidity (14.2 ±7.4) was observed in Jelgava drinking water. The Regulations No. 235 testifies turbidity values as acceptable to consumers and no substantial changes. In the case of surface water treatment, it should be striven to reach that turbidity caused by treatment plants does not exceed 1.0 nephelometric turbidity units.

Mean of drinking water pH falls in the range from 7.16 (Jurmala) to 7.88 (Daugavpils). pH of Riga and Jurmala drinking water significantly differs from pH of Daugavpils, Ventspils, Rezekne, and Jelgava drinking water owing their data great dispersion. Mean values pH stand in the pH range 6.5÷9.5 satisfied in the Regulations No. 235.

**Drinking water quality index**

The calculated DWQI of seven largest drinking water supply systems summarized in Table 2 show satisfied drinking water quality in the range from fair to excellent quality. The DWQI have additional information that was obtained using mathematical statistical assessment. The exceeded concentrations of iron and sulphate and values of turbidity deteriorate drinking water quality.

The removal of iron and together with it some other substances is the most important step in artesian water treatment facilities in order to meet MPV of drinking water chemical composition. In regard to consumers 82,467 residents in Daugavpils, 79,300 in Liepaja, 39,563 in Ventspils, and 30,000 in Rezekne use drinking water of excellent quality, 678,000 in Riga and 42,500 in Jurmala - of good, and 59,670 in Jelgava - of fair quality drinking water.
Table 2
Drinking water quality indexes and their characteristics of the largest Latvia drinking water supply systems

<table>
<thead>
<tr>
<th>Drinking water supply system</th>
<th>DWQI¹</th>
<th>Water quality categories [4]</th>
<th>Failed tested variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>Daugavpils</td>
<td>97</td>
<td>Excellent: water quality is protected with a virtual absence of threat or impairment; conditions very close to natural or pristine levels.</td>
<td>1 test - Fe (total)</td>
</tr>
<tr>
<td>Ventspils</td>
<td>97</td>
<td></td>
<td>1 test - NO₂</td>
</tr>
<tr>
<td>Liepaja</td>
<td>95-100</td>
<td>All tests are below the MPV²</td>
<td></td>
</tr>
<tr>
<td>Rezekne</td>
<td>95-100</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Riga</td>
<td>91</td>
<td>Good: water quality is protected with only a minor degree of threat or impairment; conditions rarely depart from natural or desirable levels.</td>
<td>3 tests - Fe (total), 1 test - turbidity and pH, respectively</td>
</tr>
<tr>
<td>Jurmala</td>
<td>81</td>
<td></td>
<td>3 tests - sulphates, 1 test turbidity and pH, respectively</td>
</tr>
<tr>
<td>Jelgava</td>
<td>69</td>
<td>Fair: water quality is usually protected but occasionally threatened or impaired; conditions sometimes depart from natural or desirable levels.</td>
<td>4 tests - sulphates, Fe (total), and turbidity, respectively</td>
</tr>
</tbody>
</table>

¹ DWQI - drinking water quality index
² MPV - maximum permissible value

Conclusions
The carried out quality assessment of seven largest Latvia drinking water supply systems (Riga, Daugavpils, Liepaja, Ventspils, Jelgava, Jurmala, and Rezekne) in general shows high drinking water quality. Chemical variable data analyses were carried out using mathematical statistics and calculating drinking water quality indexes. Among the studied drinking water supply systems Daugavpils, Liepaja, Ventspils, Rezekne drinking water supply systems are assessed as excellent, Riga and Jurmala - good but Jelgava - fair quality of drinking water. Jelgava drinking water quality is significantly deteriorated by high concentrations of sulphates and total iron, and values of turbidity. The concentration of aluminum in drinking water (0.2 mg/dm³) is achieved the maximum permissible value in spite of excellent drinking water quality in Liepaja. The concentrations of Hg, Cd, Pb, Cu, Ni, Cr (total), BrO₃⁻ and trihalomethanes (total) are in the level of their determination or less than it or concentration changes were observed only in some cases that are significantly less than their MPV in all analyzed drinking water systems.

Acknowledgements
The author thanks the concerned authorities the Public Health Agency of the Ministry of Health for providing facilities to carry out this study.

References
SKŁAD CHEMICZNY I OCENA JAKOŚCI WODY PITNEJ.
ŁOTWA - STUDIUM PRZYPADKU

Abstrakt: W 2008 r. za pomocą metody matematyczno-statystycznej przetwarzania danych, dotyczących składu chemicznego i obliczenia wskaźników jakości wody pitnej, przeprowadzono ocenę jakości wody pitnej w siedmiu największych systemach wody pitnej Łotwy. Systemy wody pitnej Daugavpils, Liepaja, Ventspils i Rezeknie zostały ocenione jako bardzo dobre, Ryga i Jurmala - jako dobre, natomiast Jelgava - jako o dość dobrej jakości wody pitnej. W wodzie pitnej Jelgavy stężenie siarczanów przekraczało maksymalne wartości dopuszczalne (MPV) - 97 mg/dm$^3$ a w Jurmala - 26 mg/dm$^3$. W wodzie pitnej Jelgavy stwierdzono też duże stężenie żelaza (1,15 ±0,54 mg/dm$^3$) i równie poziom mętności (14,2 ±7,2 (NTU)). Oznaczono stosunkowo duże stężenie glinu (0,2 mg/dm$^3$) w wodzie pitnej Liepaji, bliskie wartości MPV. We wszystkich analizowanych wodach pitnych stężenie Hg, Cd, Pb, Cu, Ni, Cr (stężenie całkowite), BrO$^-3$ i trihalometanów (stężenie całkowite) było na granicy oznaczalności albo poniżej lub obserwowano jedynie zmiany w niektórych przypadkach (stężenie było znacznie poniżej dopuszczalnej wartości maksymalnej - MPV).

Ogólnie jakość wody pitnej z największych systemów wody pitnej Łotwy oceniono jako zgodną z obecnymi normami prawnymi.

Słowa kluczowe: jakość wody pitnej, skład chemiczny, statystyki matematyczne, indeksy jakości wody pitnej, Łotwa