

UDC: 556.3:628.1

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MULTIVARIATE ANALYSIS OF WATER QUALITY DATA FOR WATER SECURITY

Water issues are the most relevant in most countries of the world, including Ukraine. It is known that Ukraine is one of the European countries least endowed with freshwater resources. It is just 1200 m³ of freshwater annually per capita in Ukraine, which is significantly less than the average value in Europe of 8600 m³.

At the same time, only 75.6% of the population of Ukraine is provided with access to drinking water from centralized water sources. In Ukraine, centralized treatment is done to both water from surface sources (86.4% of total centralized water supply), and from artesian wells (13.6%). Decentralized sources of drinking water include artesian wells and wells.

Quality of drinking water in Ukraine is regulated by DSanPiN 2.2.4-171-10 "Hygienic requirements for drinking water intended for human consumption", which includes total of 86 parameters of water quality, of which 75 are physico-chemical and 11 are microbiological. Drinking water must comply with all quality requirements set forth in this document.

Information on drinking water quality is presented annually in the "National Report On the Quality of Drinking Water And the State of Drinking Water Supply in Ukraine" as the fractions of non-standard samples according to physico-chemical and microbiological parameters of water quality. (Non-standard samples are considered those in which one or more parameters of water quality do not meet established requirements). Information provided in the national report does not contain details of specific parameters or pollutants, which makes it difficult to assess the degree of danger of drinking water usage in Ukraine.

Regarding this, UWS WaterNet developed and introduced software product "Map of Water Quality in Ukraine" — the only up-to-date database of quality of drinking water in various regions of Ukraine, which is available to public usage. To make it possible, UWS WaterNet since 2010, as part of Ukraine Water Quality Map project, has been conducting regular monitoring and systematization of water quality analyses from different sources located in settlements of all regions of Ukraine. As of the end of the 1st quarter of 2020, database includes more than 46800 drinking water analysis results, including 8200 samples of tap water, 32100 thousand samples of water from artesian wells and 6500 thousand samples of water from wells.

According to the collected data, the fraction of non-standard samples for each type of water source was calculated for various water quality parameters. Analysis of data on composition of drinking water in Ukraine shows that deviations are most often recorded for physico-chemical quality parameters including turbidity, total dissolved solids (TDS), color, chemical oxygen demand, total hardness, total iron, manganese and nitrates.

Fractions of non-standard samples for the most common water parameters and pollutants from various sources of water consumption in Ukraine for 2010–2019 are shown in table 1. Similar analysis can be carried out not only for the country, but also for each individual region or specific settlement (figure 1-3), and can be used to analyze seasonal changes (figure 4).

Table 1 Fractions of non-standard samples for the most common water quality parameters from various sources of water supply in Ukraine for 2010–2019.

Fraction of non-standard samples, % / Parameter	Source of Water Supply		
	Centralized Water Supply	Artesian Well	Well
TDS	1,4	4,8	20,2
Total Hardness	9,6	26,0	67,9
Turbidity	38,9	69,6	45,8
Color	46,4	17,8	17,1
Chemical Oxygen Demand	25,3	6,2	8,9
Total Iron	20,2	59,7	16,0
Manganese	36,4	64,7	38,6
Nitrates	1,6	9,5	52,4

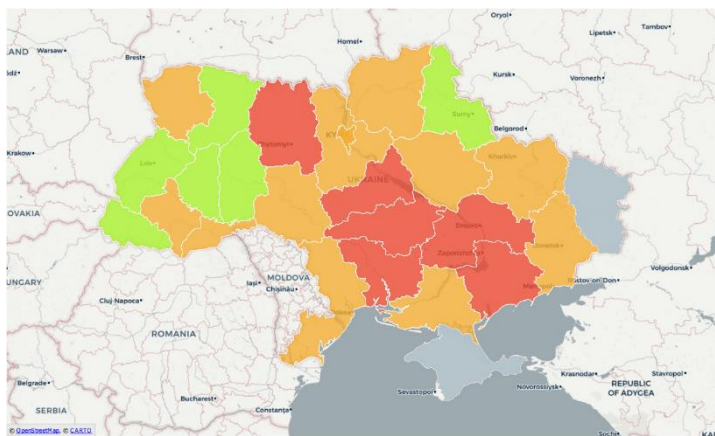


Figure 1 The average value of colour of tap water in different regions of Ukraine:
 ■ — 0-10 PCU; ■ — 10-20 PCU; ■ — 20-30 PCU; ■ — not enough data.

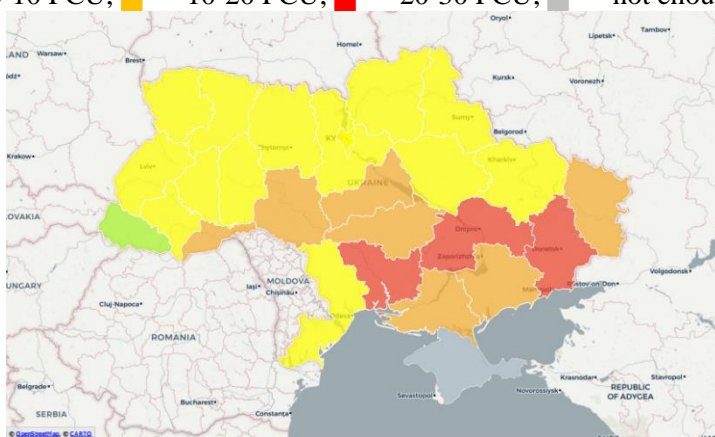


Figure 2 The average value of hardness of artesian water in different regions of Ukraine:
 ■ — 0-5 mmol/L; ■ — 5-10 mmol/L; ■ — 10-15 mmol/L; ■ — 15-20 mmol/L; ■ — not enough data.

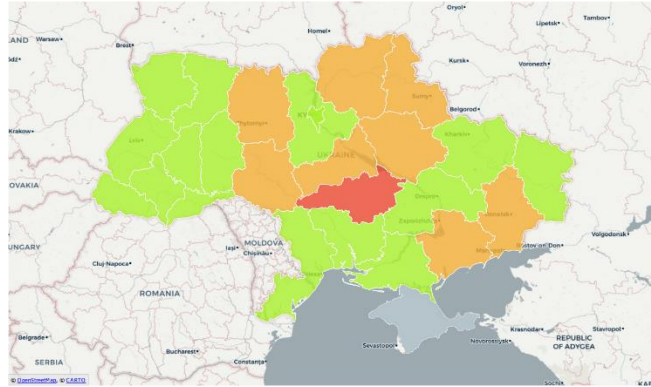


Figure 3 The average value of nitrate of artesian water and groundwater in different regions of Ukraine:

■ — 0-10 PCU; ■ — 10-20 PCU; ■ — 20-30 PCU; ■ — not enough data.

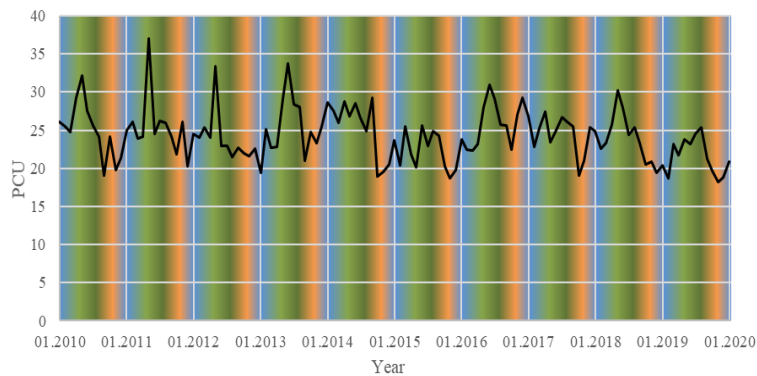


Figure 4 Change in the mean value of color of tap water in the city of Kiev for the period from 2010 to 2019:

■ — winter; ■ — spring; ■ — summer; ■ — autumn.

Analysis of the data shows constant presence of non-standard water samples in various sources of drinking water consumption according to the following quality parameters:

- for centralized water supply — color, chemical oxygen demand, turbidity and manganese;
- for artesian well water — turbidity, total iron, manganese and total hardness;
- for well water — turbidity, TDS, nitrates and total hardness.

Multivariate analysis of water quality off-line data can be a useful tool for decision support both in centralised and decentralised water supply:

- it can be used for spatial evaluation of water-health risks related with potential formation of DBPs and nitrate contamination (figure 3).
- it can be used for planning of decentralised water treatment solutions (figure 2).
- it can be used for treatment process control and optimisation of mixed water supply during seasonal outbreaks (figure 4).

REFERENCES

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