

ASSESSMENT OF THE ECOLOGICAL STATE OF RURAL SETTLEMENTS
BY INDICATORS OF DRINKING WATER QUALITY IN THE CONTEXT
OF SUSTAINABLE DEVELOPMENT

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Abstract. The purpose of the study was to assess the state of ecological development of rural areas of the amalgamated territorial communities of Zhytomyr district based on drinking water quality indicators of non-centralised water supply sources to ensure their sustainable development. It was found that the average pH value was within the current standard, which indicates an excellent environmental condition for this indicator. The average content of nitrates in drinking water, which in all the studied communities exceeded the standard by 1.4 to 3.5 times, was assessed at only one point. The average concentration of total iron exceeded the current standard by 1.9 times only in the rural settlements of the Liubar community. Satisfactory water quality, in terms of total iron content, was recorded in 50 per cent of the surveyed communities. In 70 per cent of the studied communities, the average value of total hardness was recorded at a level higher than 7.0 mmol/dm³, which indicates, according to European legislation, a poor condition of drinking water. Thus, having assessed the ecological state of rural areas in terms of drinking water quality, it was found that most of the studied communities have a satisfactory state of the territories, as the total number of points varied between 2.25–3.3 points. And the greatest contribution to the decline in the level of environmental development of rural settlements is made by the indicators of nitrate content in drinking water and its hardness.

Keywords: rural urban areas, drinking water, pH, nitrates, total iron, hardness.

1. Introduction

According to the main provisions of the Sustainable Development Strategy of Ukraine for the

period up to 2030, ensuring the environmental safety of rural areas through the development of a balanced system of nature management and timely prevention of the negative impact of anthropogenic processes on the environment is a prerequisite for their sustainable development (Sustainable Development Strategy, 2023). One of the main tasks for ensuring the sustainable development of rural settlements is to achieve Global Goal 6 “Clean water and adequate sanitation”. The danger of this situation can be seen from different angles. Firstly, drinking water from private shaft and tube wells, private capitals and even natural springs often does not meet regulatory requirements for the content of substances harmful to health, and secondly, the lack of sewage can lead to contamination of drinking water. Therefore, assessing the environmental status of rural areas in terms of drinking water quality should become a priority task for municipal authorities in amalgamated communities to achieve sustainable development goals.

2. Experimental part

The state of drinking water supply in rural areas is of concern to many scientists around the world. Assessments of the quality of drinking water from non-centralised sources and its pollution within rural settlements have been carried out in Ukraine (Huschuk et al., 2018; Zufiaurre et al., 2020), European

countries (Moldovan et al., 2020; Zufiaurre et al., 2020), the USA (Wheeler et al., 2015) and China (Yu et al., 2020). A significant number of studies have focused on the impact of poor-quality drinking water on public health (Moldovan et al., 2020; Pustovit, 2013; Stehney, 2015). However, research on assessing sustainable rural development is mainly focused on comprehensive assessments (Tymoshenko, 2018), with little attention paid to environmental factors (Stehney, 2015). Therefore, we believe that the assessment of the environmental development of rural settlements in terms of drinking water quality is insufficiently studied (Herasymchuk et al., 2022).

Therefore, the purpose of this study is to assess the state of environmental development of rural settlements by drinking water quality indicators to ensure sustainable development of rural settlements in Zhytomyr Oblast.

The study was carried out within the framework of the topic on the territory of amalgamated territorial communities of the expanded Zhytomyr region. Drinking water samples were collected from nonconcentrated water sources (public and private wells, boreholes and natural springs) in the following cities, towns and rural settlements amalgamated into a rural ATC: Zhytomyr, Liubar, Novohuyvynske, Pulyny, Cherniakhiv, Berezivka,

Vilshanka, Volytsia, Hlybochytsia, Oliyivka, Stanyshivka and Teterivka. Drinking water quality was analysed according to generally accepted methods, including pH, nitrates, total iron and total hardness. The results show that the standards in force in Ukraine, namely DSanPiN 2.2.4-171-10 “Hygienic requirements for the quality of water intended for human consumption” (DSanPiN 2.2.4-171-10, 2010) are mandatory and DSTU 7525:2014 “Drinking water. requirements and methods of quality control” reflects the requirements of Council Directive 98/83/EC on the quality of water intended for human consumption and is mainly advisory in nature (DSTU 17525: 2014).

To calculate the ecological state of rural settlements, the methodology presented in the work of Pustovit I. M. was chosen, according to which the traditional five-point scale and the standards presented in Table 2 were used (Lototska et al., 2018).

Since the criteria in Table 2 are in line with DSTU 7525:2014, the ranking by total hardness is also based on this document. This document defines the recommended values of total hardness as an indicator of the physiological adequacy of drinking water, which range from 1.5 to 7.0 mmol/dm³.

The graphical representation of the study results was prepared using ArcGIS Pro software.

Table 1

Drinking water quality standards for non-centralised water supply sources

Number	Indicator	Unit of measurement	Standard according to Sanitary and Epidemiological Norms 2.2.4-171-10 (Zufiaurre et al., 2020).	Standard according to DSTU 7525:2014 (Kotsiuba et al., 2022).
1.	Hydrogen index (pH)	units pH	6.5–8.5	6.5–8.5
2.	Nitrates	mg/dm ³	50.0	5.0
3.	Total iron	mg/dm ³	1.0	none
4.	Total hardness	mmol/dm ³	10.0	1.5–7.0

Table 2

Reference table for determining the ecological status of rural areas by drinking water quality indicators (Pustovit et al., 2013)

Indicator	Environmental condition of a rural settlement				
	1 Very poor	2 Not good free	3 Advanced	4 Good	5 Excellent good
pH	>8.5 <6.0	6.0–8.5	6.0–8.0	6.5–8.5	6.5–7.0
Nitrate content, mg/dm ³	>50.0	10.0–50.0	7.1–10.0	5.0–7.0	<5.0
Total iron content, mg/dm ³	>2.0	1.0–2.0	0.3–1.0	0.2–0.3	<0.2
Total hardness*, mmol/dm ³	>7.0	5.1–7.0	3.1–5.0	1.5–3.0	<1.5

* The introduction of this indicator was proposed by the authors of the study.

3. Results and Discussion

The results of the analytical survey showed that, on average, none of the surveyed districts had any inconsistencies with the pH standard. However, in almost all settlements, with the exception of Liubarska, Vilshanska and Volytska, there are isolated cases of pH decreasing to 5.45, and in the Oliyivska community, a pH increase to 12.5 units was recorded (Fig. 1).

The average content of nitrates in drinking water in all study areas exceeded the reference value (50 mg/dm^3), ranging from 1.4 times in Novohuyvynske community to 3.5 times in Volytsia community (Fig. 2).

The average content of total iron in drinking water in rural settlements exceeded the standard (1 mg/dm^3) set by the Sanitary and Epidemiological Norms by 1.9 times only in the village of Lyubar. Compared to European legislation, which sets a safe level of iron at 0.2 mg/dm^3 , the average iron content in drinking water in all settlements, except for Vilshanka and Volytsia, exceeded the standard by 1.15-2.7 times (Fig. 3).

Depending on the region, the average values of total hardness ranged from 4.2 to 11.3 mmol/dm^3 . Only the drinking water of the Vilshanka community exceeds the standards set by the Sanitary and

Epidemiological Norms, and taking into account the recommendations of DSTU 7525:2014, the water of good quality is provided by the Berezivka, Hlybochytisia and Teterivka communities (Fig. 4).

As for the pH of well water, 75 % of the surveyed communities received a score of 5, with almost all communities having excellent environmental conditions. The average nitrate content in drinking water in all cases exceeds the norm, so each community received only one point, which indicates a very poor environmental condition. Only in Vilshanka and Volytsia communities the average content of total iron was less than 0.2 mg/dm^3 , which corresponds to five points. The communities of Zhytomyr, Chernyakhiv and Stanyshivka, where the average iron content ranged from 0.2 to 0.3 mg/dm^3 , received 4 points; 50 % of the communities received 3 points for satisfactory drinking water quality in terms of iron content, and only in the community of Rybar the average iron content was higher than 1.0 mg/dm^3 , which corresponds to a score of 2. The average water hardness value was above 7.0 mmol/dm^3 in 70 % of the surveyed communities, which corresponds to a score of 1; only Hlybochytisia community received a score of 2, while Berezivka and Teterivka communities received a score of 3 (Table 3).

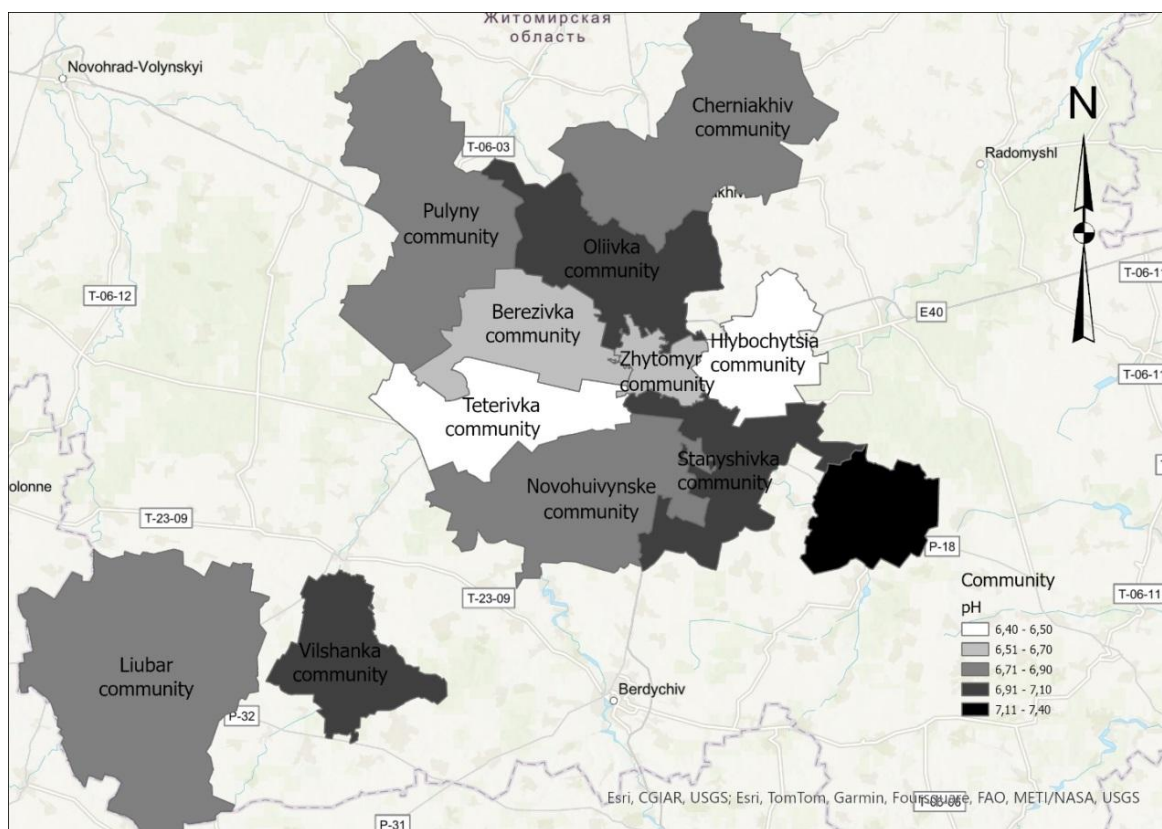


Fig. 1. Average pH values of drinking water in ATCs

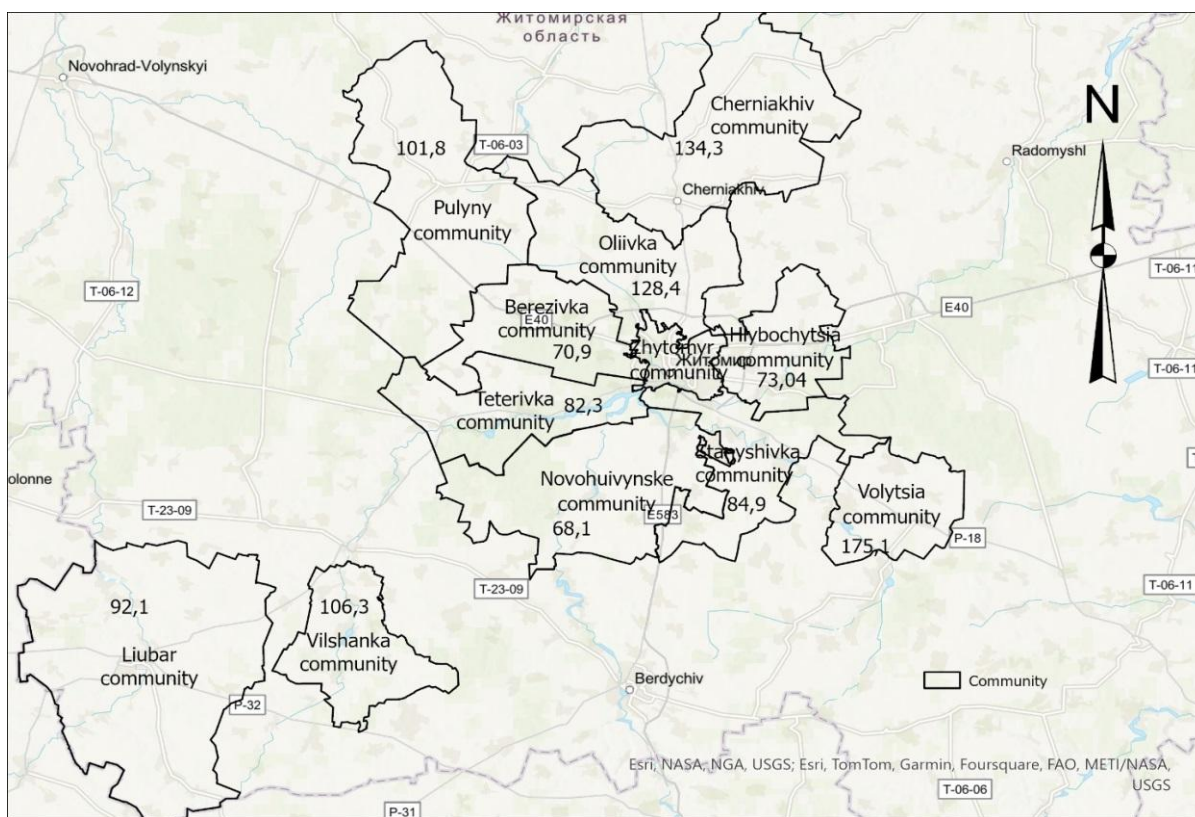


Fig. 2. Nitrate content in drinking water in ATCs

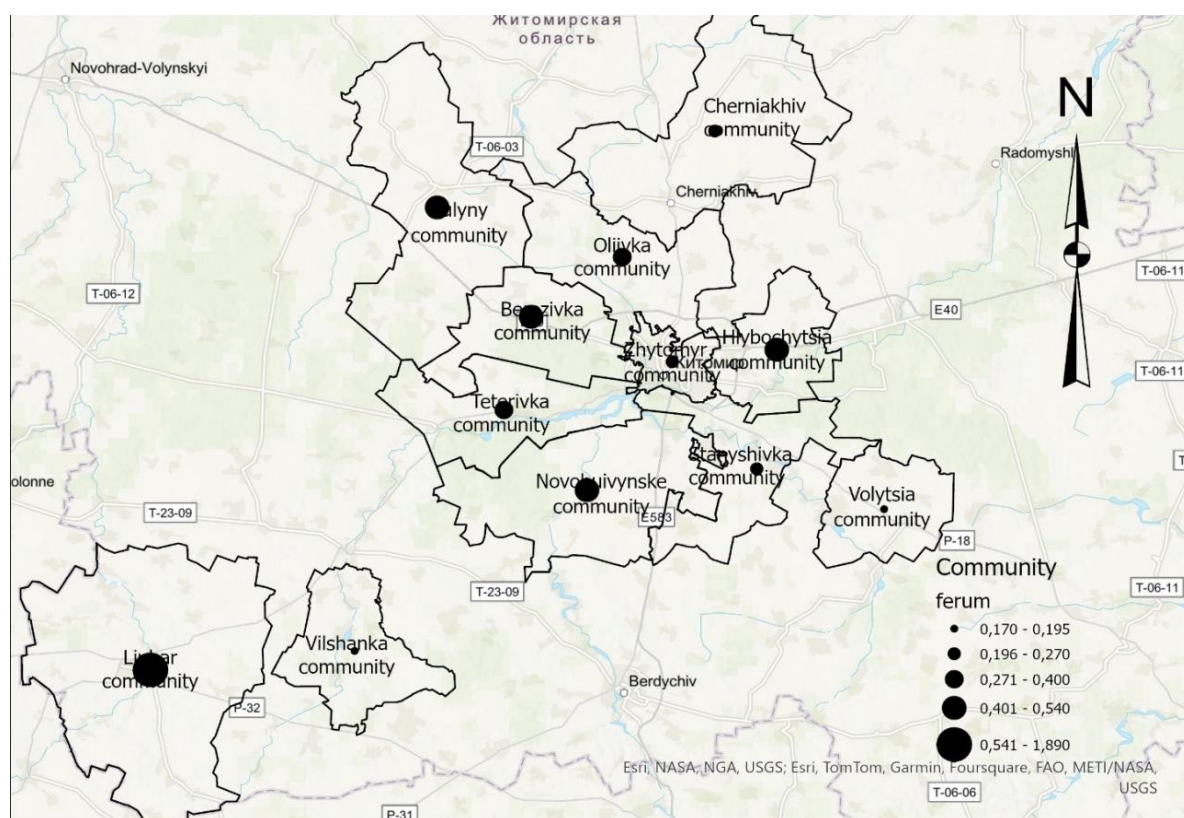


Fig. 3. Total iron content in drinking water in amalgamated territorial communities, mg/dm³

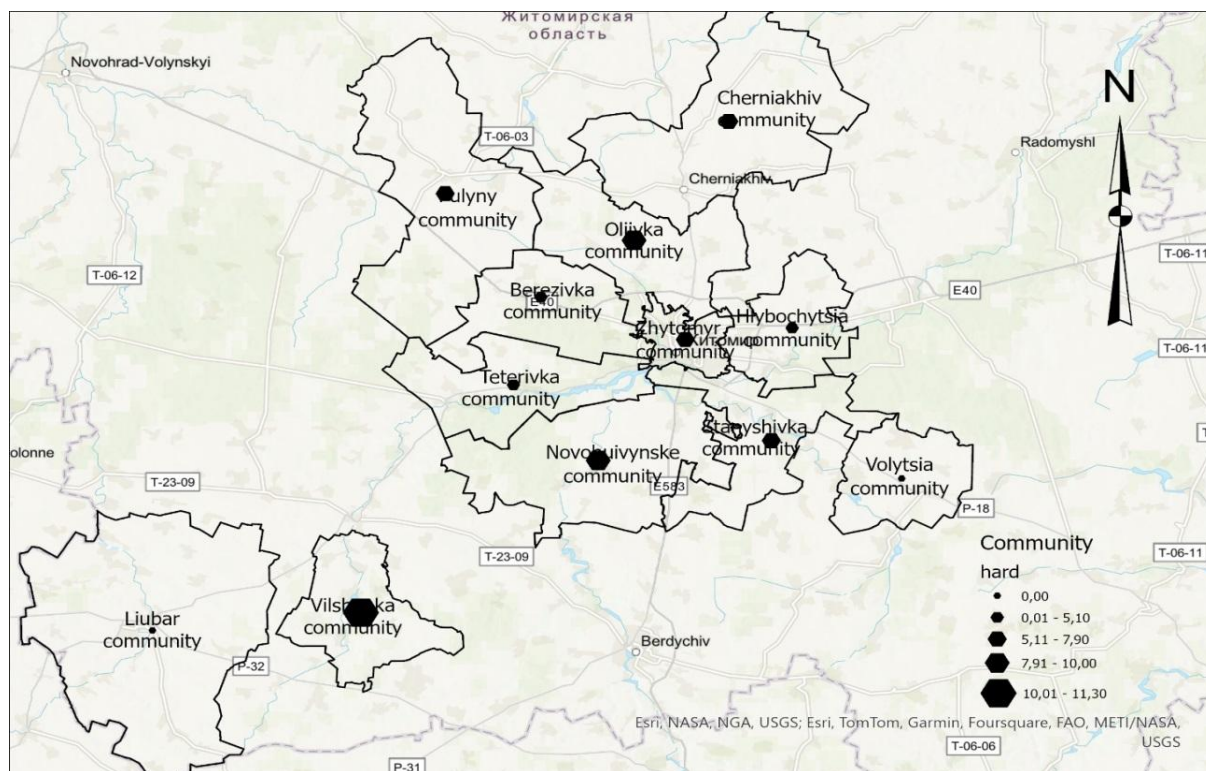


Fig. 4. Total hardness of drinking water in ATCs (mmol/dm^3)

Table 3

Number of points assigned to communities for drinking water quality indicators

Community	Number of points for the relevant indicators				
	pH	nitrates	iron	hardness total	number of points
Zhytomyr	5	1	4	1	2.75
Lyubar	5	1	2	-	2.7
Novohuyvynske	5	1	3	1	2.5
Pulyny	5	1	3	1	2.5
Chernyakhiv	5	1	4	1	2.75
Berezivka	5	1	3	3	3
Vilshanka	5	1	5	1	3
Volytsia	4	1	5	-	3.3
Hlybochytsia	5	1	3	2	2.75
Oliyivka	4	1	3	1	2.25
Stanyshivka	5	1	4	1	2.75
Teterivka	3	1	3	3	2.5

Thus, having assessed the ecological state of rural areas in terms of drinking water quality, it was found that the total number of points varied between 2.25 and 3.3 points. Most of the communities studied have a satisfactory state of the territories and require attention, and Volytsia has a good state that needs to be improved (Fig. 5)

Thus, it has been established that it is the content of nitrates in drinking water and its hardness that most contribute to the reduction of the level of environmental development of rural settlements.

4. Conclusions

The results of the study indicate that the hardness indicator has a significant impact on water quality and should therefore be included in the list of drinking water quality indicators for calculating the environmental status of rural areas, and the ranking of hardness indicators was carried out on the basis of DSTU 7525:2014 "Drinking Water. Requirements and methods of quality management", which reflects the requirements of the European Directive. The

ecological condition of all the surveyed areas was assessed as satisfactory, and the good ecological condition of rural settlements was found in Volytsia village. The worst environmental condition of rural settlements in terms of the quality of drinking water from non-centralised sources was found in Oliivka village.

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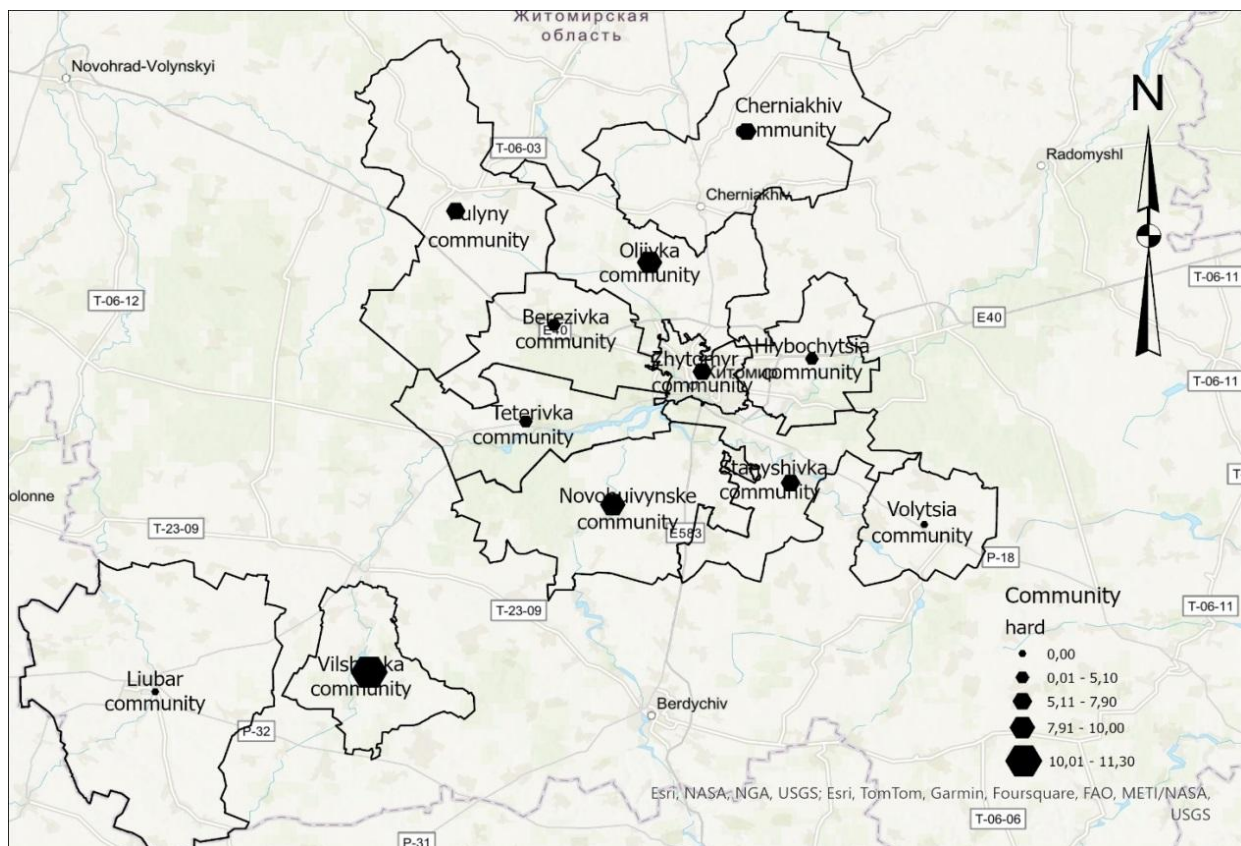


Fig. 5. Environmental status of the community by drinking water quality indicators, points

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