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## DETERMINATION OF DRINKING WATER QUALITY USING NEW INFORMATION TECHNOLOGY

***The paper analyzes the indicators of drinking water quality using modern information technology. The results of laboratory tests for the Volyn region are presented. Newest information technologies are described which can be used for reporting in the existing system of water management.***
***Keywords:*** *drinking water; water supply; quality indicators; information technology; water management.*

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## ВИЗНАЧЕННЯ ПОКАЗНИКІВ ЯКОСТІ ПИТНОЇ ВОДИ ЗА ДОПОМОГОЮ СУЧАСНИХ ІНФОРМАЦІЙНИХ ТЕХНОЛОГІЙ

***У статті проаналізовано показники якості питної води за допомогою сучасних інформаційних технологій. Викладено результати лабораторних досліджень, проведених у Волинській області. Запропоновано сучасні інформаційні технології для ведення звітності в існуючій системі водного господарства.***
***Ключові слова:*** *питна вода; водопостачання; показники якості; інформаційні технології; водне господарство.*
***Рис. 6. Табл. 2. Літ. 10.***

**Виктор Д. Рудь, Наталия М. Гулиева**

## ОПРЕДЕЛЕНИЕ ПОКАЗАТЕЛЕЙ КАЧЕСТВА ПИТЬЕВОЙ ВОДЫ С ПОМОЩЬЮ СОВРЕМЕННЫХ ИНФОРМАЦИОННЫХ ТЕХНОЛОГИЙ

***В статье проанализированы показатели качества питьевой воды с помощью современных информационных технологий. Изложены результаты лабораторных исследований, проведенных в Волынской области. Предложены современные информационные технологии для ведения отчетности в существующей системе водного хозяйства.***
***Ключевые слова:*** *питьевая вода; водоснабжение; показатели качества; информационные технологии; водное хозяйство.*

**Introduction.** Water supply and sewerage in the Volyn region are exercised by 6 utility companies and 21 production units, owned by local communities of cities, villages and townships. Water regional settlements are provided with underground springs and 227 public water wells. The length of the municipal water supply and water supply in the settlements of the region is 1116 km on wastewater sewage – 753 km (except rural areas). In an emergency situation there are 387,7 km water and nearly 75 km of sewer networks, that is respectively 34 and 10% of the total network. Water losses range from 5 to 30%.

A developed industry and agriculture have anthropogenic impact on the landscape and the result is the contamination of surface waters, so only underground waters can be a reliable source of drinking water. At the same time during the last decades of often uncontrolled anthropogenic activities leading to contamination of underground water at existing intakes (rivers Stir, Pripyat, Turia, Stohid, Zahidniy Bug, Luga and others). The main pollutants of underground water are Manevitskiy

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penal colony VK-42 and area around the old air technology base of Defense of Ukraine (a/h A-1416) near the city of Lutsk.

Engineering methods and technologies using hydrochemical data in practice design and operations of water and wastewater treatment facilities are underdeveloped and don't give a clear guidance on the processing, analysis and calculations of baseline data on water sources. To reduce the costs of design and construction of water supply systems we need to have science-based information about the actual chemical composition of water for each water source. This problem can be effectively solved with the use of newest computer technologies.

**Recent research and publications analysis.** Analysis of recent research shows that the problem of water supply and safe drinking water is interdisciplinary. Water management in the basin of the Zahidniy Bug river in Volyn was investigated by M. Boyarin and A. Nekos (2009). Ecological and economic problems were studied by Z. Gerasymchuk, Y. Molchak and M. Hvesyk (2009). Technology ozonation of natural and waste waters was researched by V. Orlov (1999). Water resource technologies were investigated by P. Horuzhyi, T. Homutets and V. Horuzhyi (2008).

**Unresolved issues.** Water and waste waters of Volyn in contrast to other regions of Ukraine have several advantages, primarily, due to geographical location. Aquifers are within the Volyn-Podolsk artesian basin in which fresh and mineralized underground water are spread. Their formation and territorial extension is determined by geology and geochemical structure of subsoils. Aquifer sediments are paleozoic, mesozoic and cenozoic, which, in turn, are divided into several distinct horizons. To fully realize the potential of water infrastructure it is necessary to take measures for the development of environmental and regulatory logistics, technical and technological solutions of water and information and analytical coverage of this issue.

In our opinion, above all, the technical and technological inventory need to be held, as many items of domestic water complex is obsolete and physically worn out. Equally important is government support and promotion of water companies, increased funding, attracting investments and so on. This approach of improving water complex will provide new opportunities for the development of water management, improving the environment, enhancing water quality, rising living standards etc.

**The research objective** is to develop a computerized information database designed on the analysis of surface and underground waters of Volyn region.

*To achieve this goal it is necessary to solve the following tasks:*

- to classify and define the role of organizations conducting water monitoring;
- to analyze the quality of natural waters;
- to justify the selection of an effective way to clean water depending on its actual condition;
- to propose a mechanism for interaction of regulatory organizations on the basis of information technologies.

**Key research findings.** Water monitoring, overseeing and improving the sanitary and epidemiological welfare of the population in the Volyn region engage a number of organizations schematically shown in Figure 1: the Volyn regional center for hydrometeorology, sanepidem service area, the state ecological inspectorate in Volyn region, Volyn regional department of water resources and water management, "Oblderzhrodyuchist".

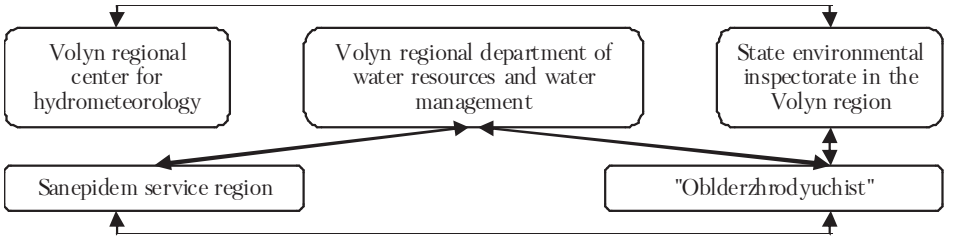


*Figure 1.* **Actors of water monitoring in the Volyn region,** *on the basis of ecological passport*

These organizations carry out monitoring of surface water, sources of wastewater discharges into surface water, groundwater, surface water for agricultural purposes (Table 1).

*Table 1.* **Water Observing System in the Volyn region, units (2012)**

| # | Entities of water monitoring | Number of observations | | | | |
|---|---|---|---|---|---|---|
| | | surface water | sources of wastewater discharges into surface | water groundwater | surface water / destination | drinking water |
| 1. | Volyn regional center for hydrometeorology | 12 | - | - | - | - |
| 2. | Sanepidem service region | 50 | 32 | 92848 | - | 474 |
| 3. | State environmental inspectorate in the Volyn region | 93 | 26 | - | - | - |
| 4. | Volyn regional department of water resources and water management | 14 | - | - | - | - |
| 5. | "Oblderzhrodyuchist" | - | - | - | - | - |

Source: on the basis of ecological passport.

Most attention is paid to the state of surface water. In particular, in 2012 Volyn regional center for hydrometeorology made 12 observations of it, sanitary epidemiological service area – 50, state environmental inspectorate in Volyn – 93, Volyn region department of water resources and water management – 14 (Figure 2).

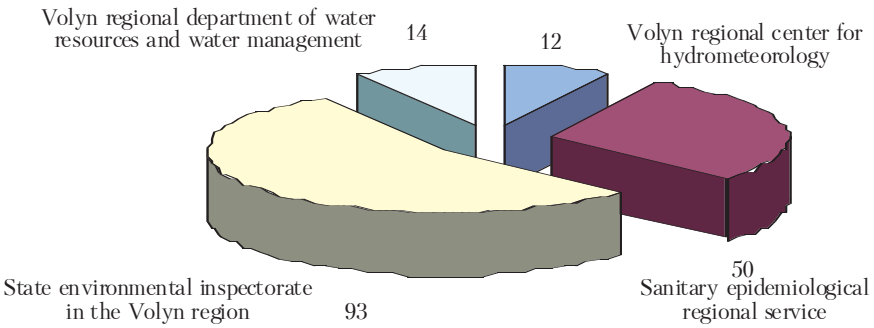


*Figure 2.* **The number of points observations of surface waters in the Volyn region (2012),** *on the basis of ecological passport*

Research analysis of surface water quality in Volyn was performed by Ecology laboratory of Lutsk National Technical University according to standard procedures

with the following parameters: biochemical oxygen demand (BOD), sulfates, chlorides, nitrates, nitrites (Figures 3–5).

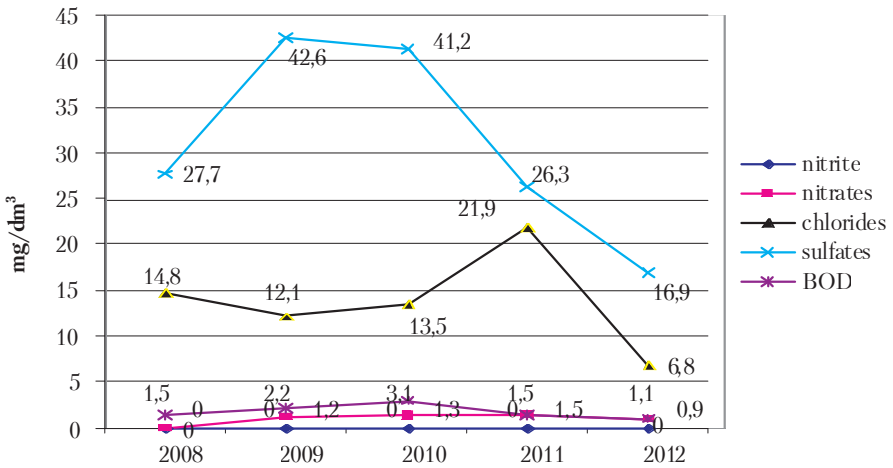


*Figure 3.* **Organoleptic characteristics of water, the Pripyat,** *elaborated by the authors*

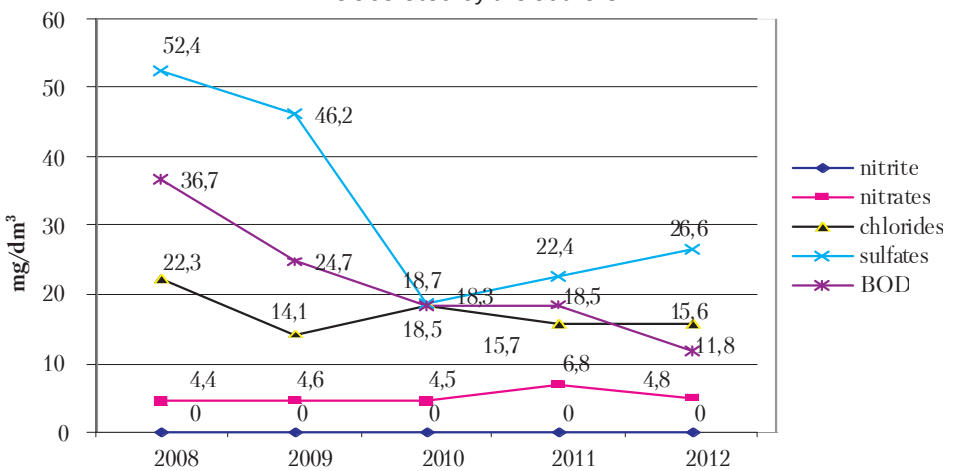


*Figure 4.* **Organoleptic characteristics of the water, the Steer,** *elaborated by the authors*

One of the causes of poor water treatment in Volyn region is insufficient oxidation and degradation of pollutants and inefficient processes of filtration. Based on theoretical generalizations and own 5-year experience in the study of regional features of cleaning surface and underground water by physico-chemical methods we have developed a method of cleaning and disinfection, which involves oxidation-cavitation effect, nonchemical coagulation, filtration. Water treatment plant is developed,which is characterized by the presence of porous filter material based on natural minerals (saponite), a new constructive solution filter combined ozonation and cavitation in the circulation circuit, automatic aeration processes.

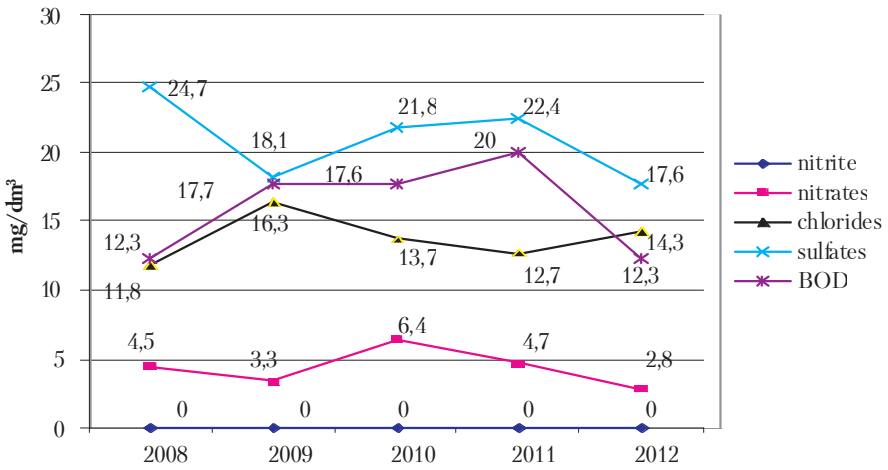


*Figure 5.* **Organoleptic characteristics of the water the Turiya,** *elaborated by the authors*

Depending on the quality and the quantity of water pollutants in the initial water the content of ozone, required for the oxidation of pollutants is set through the ejector. Multiple water treatments, dispersion of ozone-water mixture obtained in ejector, cavitation occur in the cell oxidation, oxidative processes are actively occurring. It further provides high efficiency of removal of those pollutants which are oxidized and coagulated. Water ozonation (single or multiple, depending on the quantity and quality of pollutants and existing water treatment systems) provides long-acting and effective dispersion of ozone to optimize all the stages of water treatment (Figure 6). Cavitation is the formation of a fracturing fluid drip as a result of lowering local pressure. Acoustic cavitation is used for disinfection. The combination of ozonation and cavitation reinforce each other and create conditions for air-water mixture with the ozone concentration of 1–2% or more. Thus, destabilization of pollutants is so great that the rate of oxidation by atmospheric oxygen and coagulation of metal and other impurities simultaneously increases, and more than 90% of microorganisms are killed.

As for the analysis and quality evaluation of drinking water, we have examined the sources of water supply in Novovolynsk and Lutsk and more than 30 individual water sources in villages and residential areas of cottage type. Regardless the method of water supply and water consumption, we proposed to obtain clean drinking water using individual devices. Hardware support for such mini plants depends on the state of water. Table 2 shows the results of water purification for one of the companies using the proposed technology.

To process the results of experimental and theoretical studies, we used the software "Geologist" 3.3. With its help we carry out statistical processing of the results of chemical analysis. This program can perform statistical processing of the results of chemical analysis of soil and water and helps to analyze according to State sanitary norms and rules 2.2.4-171-10. In the sample window we add a group of columns to display the results of chemical analyses. The values were loaded from the program Lab 3.0 importing data from LTG-files. Anions and cations of water samples are displayed in 3 units: $dm^3$, mg/eq, eq%.

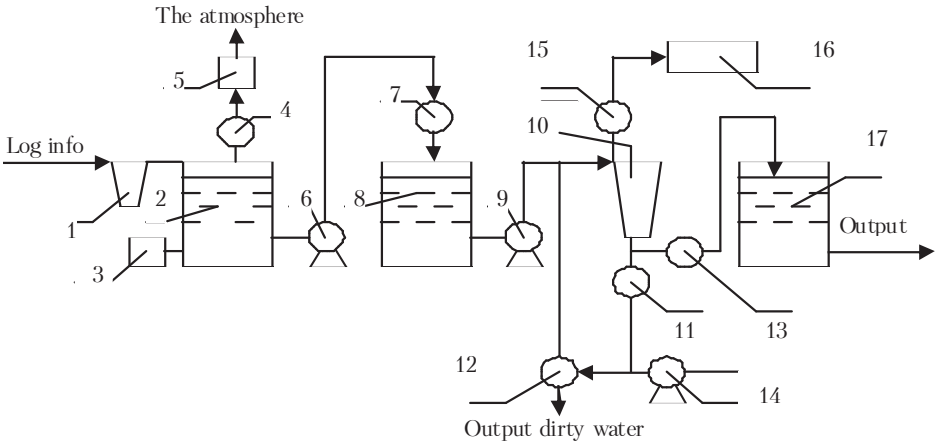


*Figure 6.* **Installations for water treatment:** 1 – mechanical filter; 2 – cell oxidation; 3 – ozone; 4 – gauge; 5 – block for residual ozone decomposition; 6 – pump to drain water to further purification; 7 – electrocautery; 8 – block nonchemical coagulation; 9 – pump; 10 – grainy filter loading; 11 – wash valve; 12, 13 – pipelines to cart wash water; 14 – wash pump; 15 – gauge electrical connections; 16 – control unit; 17 – drive clean water, *developed by the authors*

*Table 2.* **Organoleptic and physical and chemical parameters of drinking water after filtration,** *elaborated by the authors*

| # | Indicator | Units | Test results $N_0$ | Test results $N_1$ | Test results $N_2$ | Test results $N_3$ | Test results $N_4$ | Require-ments |
|---|---|---|---|---|---|---|---|---|
| 1. | Odor at 20°C and at 60°C | points | 0/0 | 0/0 | 0/0 | 0/0 | 0/0 | No more than 2 |
| 2. | Taste and flavor at 20°C | points | 0 | 0 | 0 | 0 | 0 | No more than 2 |
| 3. | Coloration | degrees | 15 | 5 | 5 | 4 | 3 | No more than 20 |
| 4. | Turbidity | mg/dm$^3$ | 1.77 | 0.40 | 0.39 | 0.38 | 0.37 | No more than 1.5 |
| 5. | Oxidation | mg/dm$^3$ | 1.4 | 1.2 | 1.2 | 1.1 | 2.8 | - |
| 6. | Ammonia and ammonium salts | mg/dm$^3$ | 0.06 | 0.05 | 0.05 | 0.05 | 0.04 | No more than 2 |
| 7. | Nitrite | mg/dm$^3$ | <0.003 | 0 | 0 | 0 | 0 | No more than 3.3 |
| 8. | Nitrates | mg/dm$^3$ | 2.73 | 3.15 | 3.56 | 3.94 | 3.46 | No more than 45 |
| 9. | Sulphates | mg/dm$^3$ | 33.18 | 31.02 | 28.45 | 25.83 | 25.82 | No more than 500 |
| 10. | Chlorides | mg/dm$^3$ | 25.0 | 24 | 22 | 22 | 21 | No more than 350 |
| 11. | Iron general | mg/dm$^3$ | 0.33 | <0.1 | <0.1 | <0.1 | <0.1 | No more than 0.2 |
| 12. | Solidity general | mg-ekv./dm$^3$ | 6.7 | 6.4 | 6.1 | 5.8 | 5.7 | No more than 7.0 |
| 13. | Calcium | mg-ekv./dm$^3$ | 5.2 | 4.3 | 4.2 | 4.2 | 4.3 | - |
| 14. | Magnesium | mg-ekv./dm$^3$ | 1.5 | 1.5 | 1.6 | 1.6 | 1.6 | - |
| 15. | Alkalinity | mg-ekv./dm$^3$ | 6.5 | 6.5 | 6.5 | 6.5 | 6.5 | - |
| 16. | pH | - | 6.84 | 6.76 | 6.76 | 6.75 | 6.75 | 6–9 |

With the help of this program the following transactions were carried out: editing of chemical parameters, calculating data, summary report. The report consists of 3 tabs, according to the acceptable drinking water quality. The report is compiled according to statistical processing requirements.

**Conclusion and further research prospects.** Surface and underground water of the Volyn region are unfit for human consumption, there is a tendency that the farther is the distance from a treatment plant the greater the content of organic and nonorganic impurities is. The cause for this is outdated equipment and cyclic water supply.

The use of powder filter materials based on saponite will provide the necessary purification of drinking water, retain their basic natural characteristics: the balance of chemical composition, organoleptic properties, safety, physiological usefulness and biological stability, as saponite has a high ion-exchange adsorption, catalytic and filtration properties.

The difference in quality of the groundwater in Volyn region necessitates the use of different equipment and technologies for purification before serving to consumers.

Ways of water resources improvement:

- financial support for the activities for state and local budgets in order to improve the quality of water supply and sanitation;
- implementation of state policy in the field of drinking water and drinking water supply according to the regional program "Drinking Water of Ukraine" in the Volyn region in 2006–2020;
- rationalization of water use rates and improving the collection by bringing it to a certain economic level;
- introduction of newest energy-saving technologies, materials and equipment to water and wastewater facilities;
- creation of favorable conditions for attracting private domestic and foreign investments;
- modernization of sewage pumping stations and rehabilitation of sewage treatment plants;
- application of specialized software: Geologist 3.3, Laboratory 3.3, Excel 2010, Statistica 2010, Delcam CAD CAM, MathCAD 14 and others for analusis.

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