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# Investigations of Mineralization of Water Bodies on the Example of River Waters of Ukraine

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**Abstract:** International and national requirements concerning regulation of water quality, particularly mineralization (TDS), have been considered in this article. Analysis of series of natural resources of water of Kharkiv region (Ukraine) has been performed. It has been demonstrated that waters of *Borivsky district* are not physiologically full and do not conform to the international and national standards on discussed parameters. Effects of usage of such water by human population have been analyzed.

**Key words:** Natural resources of water, mineralization, water quality.

## Introduction

Naturally occurring waterbody like pond, river, lake, ground water etc. is a base of human existence and a source of necessary component of human life and activities. Necessary condition for this is acceptable qualitative and quantitative composition of discussed water. Particularly, pH, mineralization, concentration of the certain cations and anions, turbidity, colour, smell and the others are the main water characteristics.

Quality of water intended to be used for human consumption is subjected to the series of regulatory documents of different levels as well as international standards (WHO, Council Directive 98/83/EC, Health Canada) and national standards (State SanPin 2.2.4-171-10, DSTU 878:2006, DSTU GOST 27384:2005).

Water is one of the sources of micro- and macro-elements intake but their total content influences on the person's health. Lack of mineral components, particularly calcium, results in diseases of the genitourinary system, urolithiasis, diseases of the nervous, endocrine systems, and reproductive system in women. Excess of iron content promotes progression of blood diseases allergic reactions, high concentration of chlorine and sodium results in progression of idiopathic hypertensia. It may be noted that significant content of sulphates and mineralization up to 4 g/l induces inhibition of acid—zymoplastic functions of stomach and progression of gastroduodenal diseases. Whereas, lack of calcium and magnesium provides development of coronary heart disease, hypertension, peptic ulcer, gastritis, cholecystitis, growth inhibition and microplasia in children but low mineralization results in gastrointestinal tract disorders, fluid-and-electrolyte balance disorders (Prokopov, 2012).

Mineralization is one of the most important quality attributes which characterizes total content of cations and anions. If insoluble salts are absent in water, then

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parameter 'mineralization' (total dissolved soils 'TDS') can be identified with parameter 'dry residue'.

Dry residue (or mineralization) is a normalized value. Normative documents regulate different values of this parameter. Thus, according to State SanPin 2.2.4-171-10 (2010), (DSTU 878:2006, DSTU GOST 27384:2005) it should not exceed 1000 mg/l, or, in some cases, and for wells and catchments not exceed 1500 mg/l. The standard of WHO (WHO, 2011) also states this value as the limit, noting that at 1200 mg/l is already changing the taste of water. While in Canada (Health Canada, 2017) limit of TDS is regulated as 500 mg/l. The European Directive on drinking water quality in general offers to determine the conductivity and regulates acceptable level 2500 μSm/cm at 20°C (Council Directive 98/83/EC). There are microbiological, chemical, physical, radiological parameters of water quality in the international standards (WHO, 2011; Council Directive 98/83/EC; Health Canada, 2017).

According to Ukrainian standards, water quality is estimated by physiological full-value (State SanPin 2.2.4-171-10). In particular, total hardness (1.5 -7.0 mmol/dm$^3$), total basicity (0.5 - 6.5 mmol/dm$^3$), dry residue (200-500 mg/dm$^3$), iodine content (20-30 μg/dm$^3$), potassium content (2-20 mg/dm$^3$), calcium content (25-75 mg/dm$^3$), magnesium content (10-50 mg/dm$^3$), sodium content (2-20 mg/dm$^3$) and fluorides (0.7-12 mg/dm$^3$) are regulated by this standard. Consumption of drinking water, where the total content of mineral salts is within the indicated range, is a condition for ensuring productive life.

To predict availability of water for human consumption determination of total content of mineral salts in water can be performed with different ways (Eksperiandova et al., 2006), as well as using conductometry as prescribed by instruction. The goal of this work is to investigate quality of natural resources of Kharkiv region (Ukraine) in terms of mineralization and to estimate their availability for human consumption according to the international and national standards.

## Experimental

Experimental investigations have been performed using laboratory conductometer – salinometer MP 513 in the mode of 'TDS'. Instrumental error does not exceed 1.5% of the full-scale range. Sampling of natural waters was performed according to (ISO, 2014). Data processing has been performed using standard statistical analysis (Dvorkin, 2001) for probability $P$ = 95%.

Measurements of mineralization was performed as follows: electrode with contacts covered with platinum was rinsed by the test solutions several times and then was immersed in test solution. Readings were taken in 30-40 seconds. Measuring of water mineralization for each sample was performed five times ($n$ = 5). All results registered automatically at the temperature 25°C.

## Results and Discussion

Investigations of natural water bodies of Kharkiv region have been performed on first stage (Figure 1). Measurement results are given in Table 1.

According to the classification of mineral waters (Directive, 2009) Kharkiv region is characterized by the presence of mineral waters (they are between 'low mineral content' and 'rich in mineral salts') (Table 2). But water of Borivsky district has mineralization value

**Table 1: Mineralization of natural water samples of Kharkiv region (Ukraine), g/l**

| *Parameter* | *Borova river (Borivsky district)* | *Merefa river (Kharkiv region)* | *Natural source (Dergachi district)* | *Well (Gubarivka village, Bogoduhiv district)* | *Distilled water* |
|---|---|---|---|---|---|
| $X_{mean}$, | 2.38±0.01 | 0.804±0.001 | 0.826±0.001 | 0.566±0.001 | 0.0030±0.0003 |
| $S_r$, % | 0.24 | 0.07 | 0.07 | 0.10 | 9.14 |

**Table 2: Classification of water on mineralization (g/l)**

| *Indications* | *Criteria* |
|---|---|
| Low mineral content | Mineral salt content, calculated as a fixed residue. Not greater than 500 mg/l |
| Vary low mineral content | Mineral salt content, calculated as a fixed residue. Not greater than 50 mg/l |
| Rich in mineral salts | Mineral salt content, calculated as a fixed residue. Greater than 1500 mg/l |

3-4 times higher than for other areas ('rich in mineral salts'). It was equal to 2.4 g/l (Table 1). Further work was connected with more detail investigation of the mineralization of Borivsky district's water objects (Figure 2).

The Oscil river was taken as subject of research as one of the biggest river of region and adjacent water objects. Water from Oscil river and Borova river is used for irrigation; human consumption is acceptable only after additional treatment. Water from resources 1 and 2 and from Pidlyman village is used by residential population for drinking. Measurement results are given in Table 3.

As Table 3 shows high value of mineralization is typical for natural water of Borivsky district. Such value is characteristic both for surface and for underground resources, their waters are rich in mineral salts (according to Table 2). In our opinion it can be connected with structural peculiarities of grounds and geological structure of Borivsky district.

Water from Borova river, resources 1 and 2, from Pidlyman village is not physiologically full on the parameter 'mineralization' ('dry residue') according to State SanPin 2.2.4-171-10 (2010) and it does not correspond the requirements for drinking water quality standards regulated by WHO (2011) and Canadian (Health Canada, 2017) standards. By applying the conductivity conversion factors in mineralization (TDS) (0.55–0.75) (Hem, 1970) to the European standard, we get the normative standard (1375-1875 mg/l). Abovementioned water does not comply with the requirements (Council Directive 98/83/EC, 1998). Moreover it is not recommended for everyday consumption.

Another situation for Oscil river: its water is physiologically full on the parameter 'mineralization' (State SanPin, 2010) and meets the requirements (WHO, 2011; Council Directive, 1998; Health Canada, 2017) because its mineralization value is low. But everyday consumption of this water is limited by biological component of water.

In our opinion above mentioned contradiction concerning different mineralization of water of natural resources from Borivsky district is connected with the location of resources' heads. Natural resources of Borivsky district have high mineralization because their heads are in the same district, while Oscil river goes back from another district (Timskiy district, Kursk region, Russia) and it only passes Borivsky region. Waters that supply Oscil river in Borivsky district don't change its mineralization significantly.

Permanent consumption of mineralized water like waters from Borivsky district can cause accumulation of salts in the organism of human population of Borivsky district and can increase level of progression of musculoskeletal system disorders and formation of the stones in kidneys and liver. To prevent such disorders preliminary mineralization of such water in the range of 0.5 to 1.0 g/l is needed (WHO, 2011; Health Canada, 2017; State SanPin, 2010).

## Conclusions

So, it may be concluded that:

1. As scientific result it can be noted that mineralization value from 2.4 to 0.5 g/l is typical for waters of Kharkiv region. So such waters are not physiologically full, although they partially meet the requirements of international and national standards for drinking water quality.
2. In comparison with other districts of Kharkiv region high mineralization value (2.4-1.6 g/l) of natural water from Borivsky district is explained with the peculiarities of grounds and geological structure of Borivsky district.
3. Usage of water from Borivsky district for drinking and agriculture should be limited. Constant usage of such water increases level of progression of musculoskeletal system disorders and formation of the stones in kidneys and liver. It is recommended to perform demineralization up to 0.5-1.0 g/l.
4. Resources of Borivsky district effect on the mineralization of river Oscil slightly. Water from

**Table 3: Mineralization of natural water samples of Borivsky district of Kharkiv region (Ukraine), g/l**

| *Parameter* | *Borova river* | *Oscil river (slough)* | *Oscil river (recreation camp 'Zarya')* | *Resource 1 (near Horokhovatka village)* | *Resource 2 (near Horokhovatka village)* | *Well (Pidlyman village)* |
|---|---|---|---|---|---|---|
| $X_{mean}$, | 2.38± ±0.01 | 0.555± ±0.004 | 0.581± ±0.001 | 1.67± ±0.01 | 1.82± ±0.01 | 1.64± ±0.01 |
| $S_r$, % | 0.24 | 0.65 | 0.20 | 0.35 | 0.32 | 0.61 |

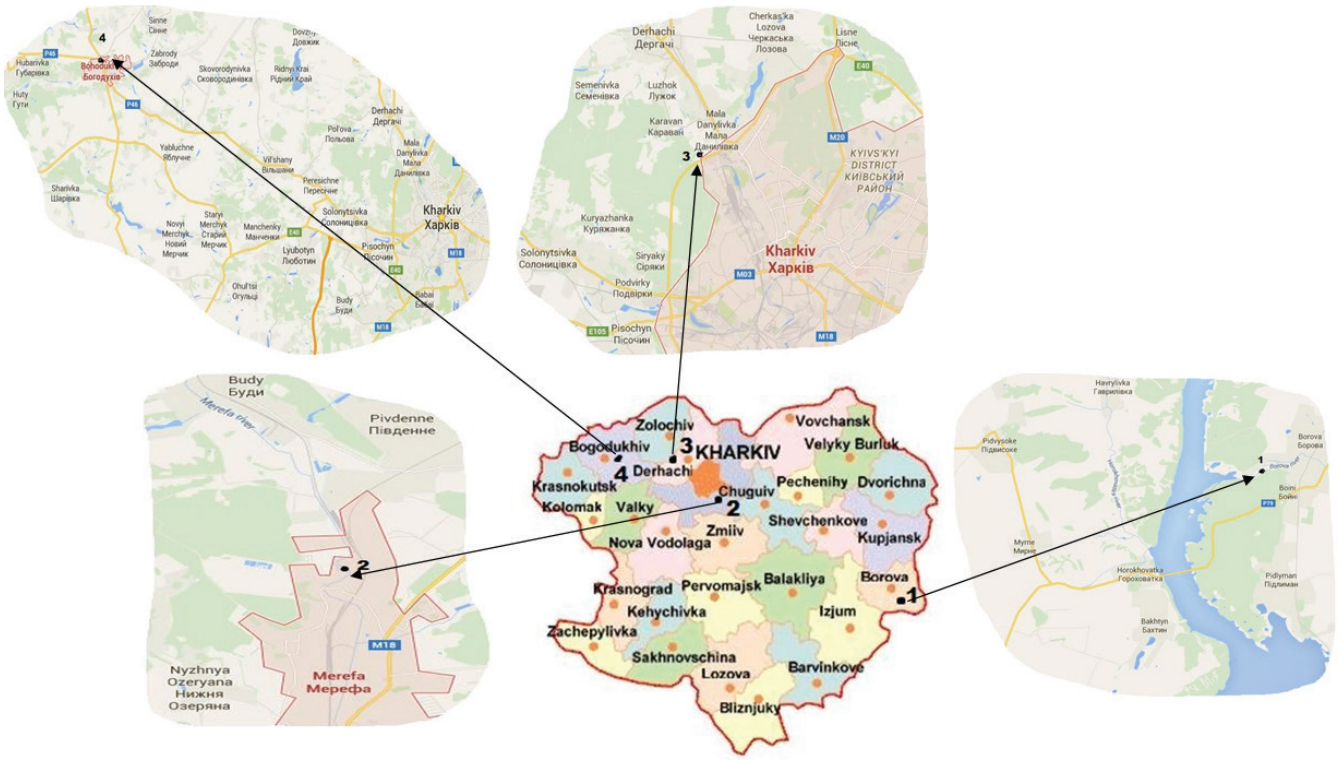


**Figure 1: Resources of Kharkiv region: 1 – Borova river, 2 – Merefa river, 3 – natural source near Kharkiv city; 4 – well of Gubarivka village.**


**Figure 2: Water sampling locations in Borivsky district. T1 –Borova river, T2 – Oscil river (slough), T3 – Oscil river (recreation camp 'Zarya'), T4 – resource 1 (near Horokhovatka village), T5 – resource 2 (near Horokhovatka village), T6 – well (Pidlyman village).**

river Oscil can be used for human consumption without additional demineralization, but after removing of biological components.

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