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Application of direct coulometry for rapid assessment of water quality in Krasno-Oskol Reservoir (Kharkiv Region, Ukraine)

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ABSTRACT

Regulatory regional and international requirements concerning water quality, particularly mineralization (TDS), have been considered in this article. Analysis of water Krasno-Oskol Reservoir *(Kharkiv oblast, Ukraine) has been performed by applying conductometric method. It has been demonstrated that water of* Krasno-Oskol Reservoir *is physiologically full and conform to the international and national standards in respect to mineralization.*

Key words: mineralization, natural resources of water, water quality.

INTRODUCTION

Naturally occurring waterbody like pond, lake, river, ground water etc. is a base of human existence. Their presence is necessary for a full human life and activities and for all living organisms. Necessary condition for this is acceptable qualitative and quantitative composition of discussed water.

Particularly, mineralization, concentration of the certain cations and anions, turbidity, pH, color, odour and the others are the main water characteristics. Cationic and anionic content of water is an individual characteristic stipulating its properties and suitability for use.

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 [1, 2, 3] and national standards [4, 5, 6].

General content of cations and anions, existing in water as micro- and macroelements, affects the human 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. High concentration of chlorine and sodium results in progression of idiopathic hypertensia. Excess of iron content promotes progression of blood diseases and allergic reactions. To 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 magnesium and calcium provides development of coronary heat disease, hypertension, gastritis, peptic ulcer, cholecystitis, growth inhibition and microplasia in children but low mineralization results in gastrointestinal tract disorders, fluid-and-electrolyte balance disorders [7]. Water quality is also important for living organisms. Particularly, in Ukraine for reservoirs having commercial fishing importance, water quality is regulated by [8] but for surface water it is subjected to the regulations specified in [9]. Moreover in some cases these regulations are more rigorous in comparison to normative requirements to drinking water.

Mineralization is one of the most important quality attributes which characterizes total content of cations and anions. «Mineralization» (total dissolved soils «TDS») can be identified with parameter «dry residue», if insoluble salts are absent in analysed water.

Dry residue (or mineralization) is a normalized value. It is normalized by normative documents of national and international level.

Dry residue (or mineralization) is a normalized value. Normative documents regulate different values of this parameter. Thus, according to [4, 5, 6, 8] it should not exceed 1000 mg/l, or, in some cases, and for wells and catchments not exceed 1500 mg/l [4]. The standard of the WHO [1] also states this value as the limit, noting that at 1200 mg/l is already changing the taste of water. While in Canada [3] 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 20^0C [2]. There are microbiological, chemical, physical, radiological parameters of water quality in the international standards [1, 2, 3].

Drinking water quality is estimated by physiological full-value according to Ukrainian standard [4]. In particular, total hardness (1.5 -7.0 mmol/dm^3), dry residue (200-500 mg/dm^3) iodine content (20-30 μg/dm^3), calcium content (25-75 mg/dm^3), magnesium content (10-50 mg/dm^3), total basicity (0.5 - 6.5 mmol/dm^3), sodium content (2-20 mg/dm^3), fluorides (0.7 -1 2 mg/dm^3), potassium content (2-20 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.

On the other hand, quality of surface waters, used for drinking, is not always satisfactory due to the exposure of natural and antropogenic factors [10 –14].

Figure1 – Krasno-Oskol Reservoir in Kharkiv oblast

To predict availability of water for human consumption determination of total content of mineral salts in water can be performed with different ways [15, 16], as well as using conductometry as prescribed by instruction.

Krasno-Oskol Reservoir is one of the largest artificial lake on Oskol River in Borovskoy district of Kharkiv oblast, Ukraine (рис. 1). Krasno-Oskol Reservoir has volume 435.1 million cub. m, surface about 122.6 sq. km. It's length 84.6 km, average width 1.6 , maximal width 4.0 km. Reservoir is located in Borovskoy, Izumskiy and Kupyansk districts of Kharkiv oblast. The purpose of the reservoir is to regulate flooding, serve as source for electricity and to help fishing industry, as well as place of resort for the men and women of neighboring oblasts (Kharkiv, Doneck and Lugansk).

The goal of this work is to investigate quality of natural resource of Kharkiv region (Ukraine) - Krasno-Oskol Reservoir in terms of mineralization and estimate its availability for human consumption according to the international and national standards, and from the perspective of water use for fishery.

MATERIALS AND METHODS

Experimental investigations have been performed using conductometer EC -1385. Instrumental error does not exceed 2 % of the full-scale range. Sampling of natural waters was performed according to [17, 18] for the period October 2015 until May 2016 .

Determination of mineralization was performed as follows: electrode was rinsed by the test solutions several times and then was immersed in test solution. Readings was taken in 30 - 40 seconds. Measuring of conductivity for each sample was performed five times (n = 5). All results registered automatically at the temperature 25 ^{0}C. Mineralization was calculated according to [19] using correction factor 0.7.

Data processing has been performed using standard statistical analysis [20] for probability P = 95 %.

RESULTS AND DISCUSSION

In this paper water quality in Krasno-Oskol Reservoir was studied on the area, presented on the Fig.2 and placed between urban settlement Borova and village Pidlyman.

Investigations of natural water of Krasno-Oskol Reservoir has been performed in two stages:

In the first stage (October 2015) water quality research in Krasno-Oskol Reservoir on the area from the middle to riverside was carried out (Fig. 3).

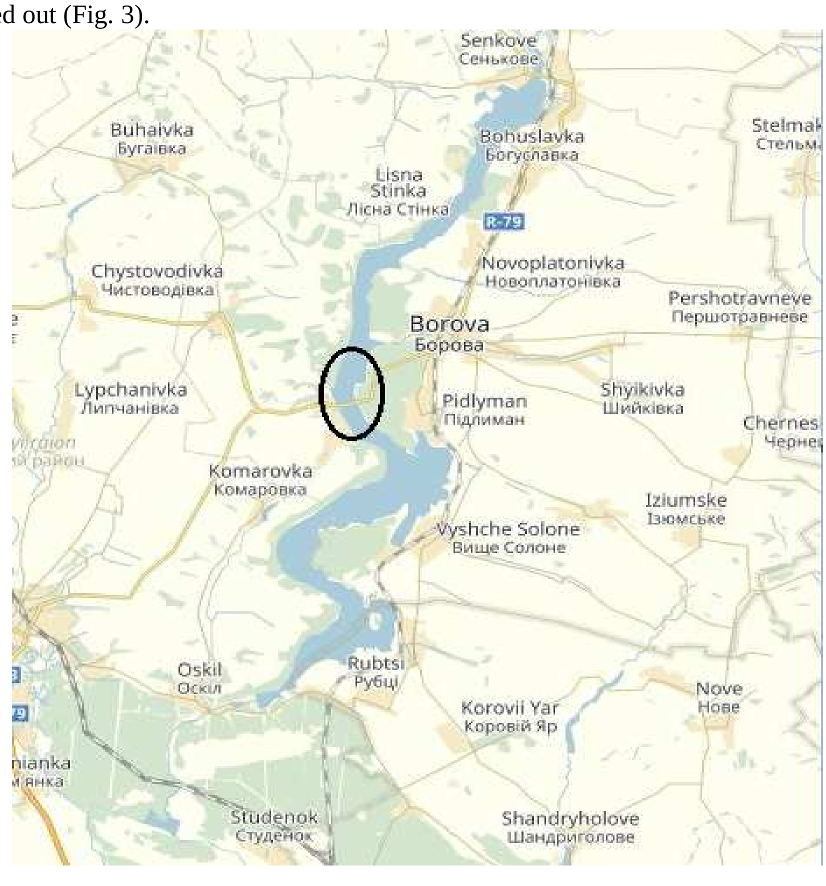

Figure 2 – Map of Krasno-Oskol Reservoir with marked research area

Figure 3 – Location of water sampling on the selected area in Krasno-Oskol Reservoir, points 1', 2', 3', 4', 5' are located from 100 m from one another

As seen from the results (Fig. 4), significant changes in mineralization of Krasno-Oskol Reservoir depending on the distance from investigated points to the riverside are not observed.

Further stage involves water quality research in Krasno-Oskol Reservoir (along selected area) in terms of mineralization during the period from January 2016 until May 2016. Sampling points are given on the Fig. 5. Samples were taken at 1 - 2 m distance from shore.

Investigation was performed taking into account anthropogenic influence. In particular, effect of fish inspection activity, tourist camps activity, located on the shore of Krasno-Oskol Reservoir – within a 150 m from fish inspection , close in lighter berth, across 300 m after fish inspection (bridge), in 500 m after fish inspection (slough) and in 1000 m after slough (tourist camp "Goluba volna". Water from underground source of village Pidlyman (water well) was reference.

Increase in mineralization value is observed in January (table 3.1) then it is flatten out but after area of tourist camps it increases a bit.

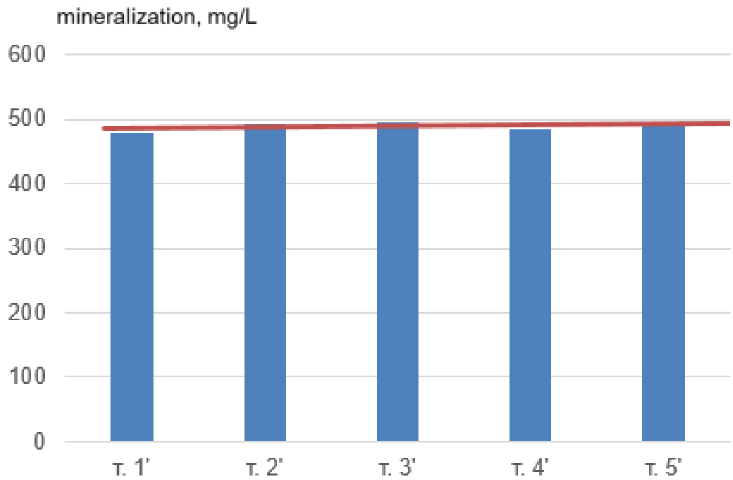

Figure 4 – Results of investigation of mineralization of Krasno-Oskol Reservoir in selected points in October 2015

Figure 5 – Places of water sampling on the selected area along Krasno-Oskol Reservoir. 1 – in front of fish inspection, 2 – fish inspection, 3 – bridge, 4 – slough, 5 – tourist camp "Goluba laguna", 6 – underground source of village Pidlyman

Influence of activity of fish inspection and tourist camps is not significant in April (Table 3), even if a slight increase in mineralization is observed on the area from point 1 to point 5.

Table 1 – Results of measurement of mineralization of investigated water samples from Krasno-Oskol Reservoir in January 2016, mg/L

Parameter	Sampling points				
	1	2	3	4	5
$x_{av,}$ mg/L	494.2	497.1	618.8	484.4	550.2
S_r, %	1.9	0.1	0.6	1.6	0.7

In February (Table 2) mineralization increases in slough and after passing tourist camps. Fish inspection does not influence significantly.

In April ifluence of fish inspection and tourist camps is almost negligeable (Table 3) although there is slight ncrease in mineralization on the area from point 1 to point 5.
In May mineralization values in points 2 and 3 increased (Table 4). This can be caused by intensive work of fish inspection.

Table 2 - Results of investigation of mineralization in water samples of Krasno-Oskol Reservoir in February 2016, mg/L

Parameter	Sampling points				
	1	2	3	4	5
$x_{av,}$ mg/L	459.2	460.6	462.0	491.4	543.2
S_r, %	0.8	0.7	0.7	0.6	0.7

Table 3 – Results of investigation of mineralization in water samples of Krasno-Oskol Reservoir in April 2016, mg/L

Parameter	Sampling points				
	1	2	3	4	5
$x_{av,}$ mg/L	445.2	446.6	453.6	455.1	462.1
S_r, %	0.9	0.7	0.7	0.1	0.1

Considered all it may safely be said that work of tourist camps influences on mineralization very slight during the period from January until February (Fig. 6). But tourist camps' work does not influence on this parameter during the period from April until May, besides in April activity of fish inspection is noticeable a bit.

Table 4 – Results of investigation of mineralization in water samples of Krasno-Oskol Reservoir in May 2016, mg/L

Parameter	Sampling points				
	1	2	3	4	5
$x_{av,}$ mg/L	464.8	473.2	483.1	462.1	463.4
S_r, %	0.8	0.8	0.1	0.1	0.7

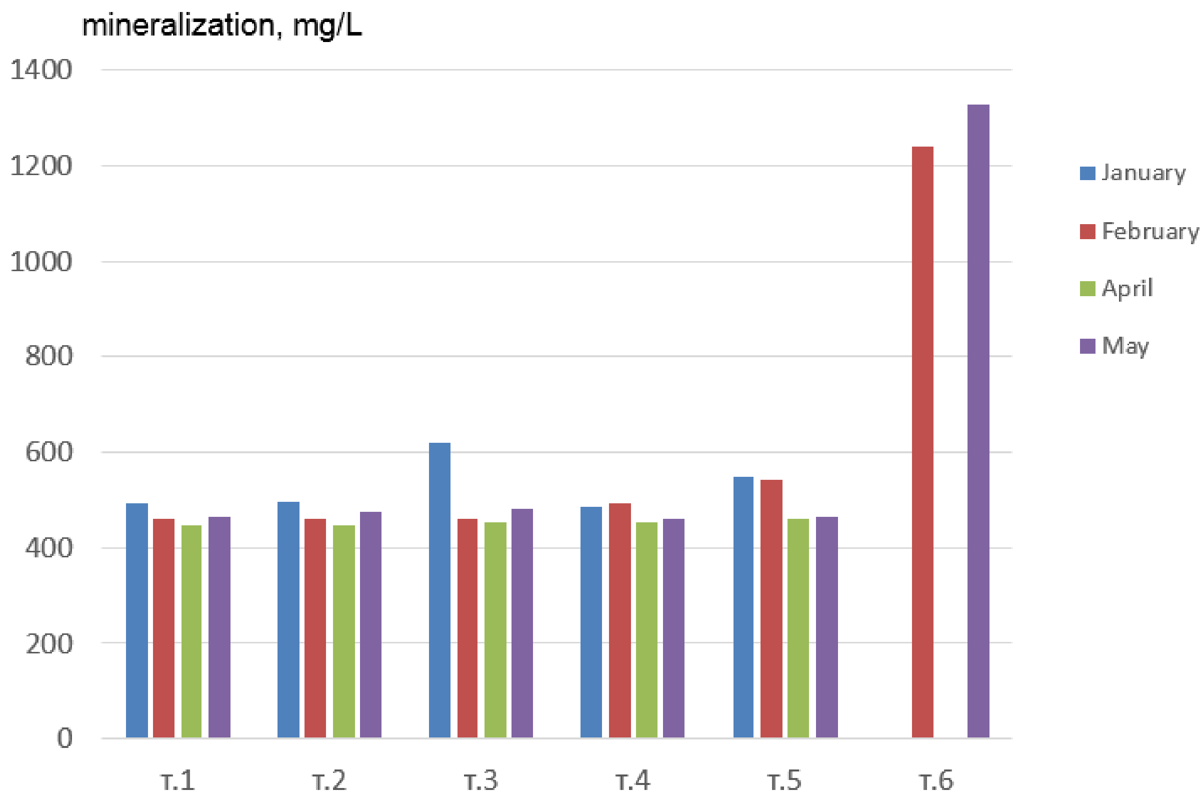

Figure 6. Results of investigation quality of water samples of Krasno-Oskol Reservoir in selected points in January, February, April and May of 2016. Point 1 – in front of fish inspection, point 2 – fish inspection, point 3 – bridge, point 4 – slough, point 5 – tourist camp "Goluba laguna", point 6 – underground source of village Pidlyman

As can be seen from Figure 6, mineralization for underground water of village Pidlyman of Borovskoy district (Kharkiv oblast) (point 6) I 2 – 2.5 times greater tnah for Krasno-Oskol Reservoir.
According to the classification of mineral waters [21] water of Krasno-Oskol Reservoir is characterized by the presence of mineral waters, which belong to the water of «low mineral content» (Table. 5)

As you can see water from Krasno-Oskol Reservoir is physiologically full on the parameter «mineralization» («dry residue») according to [4] and it correspond the requirements for drinking water quality standards regulated by WHO [1] and Canadian [3] standard. It also meet the requirements specified to the surface waters in Ukraine [8] in terms of «mineralization» («dry residue».

Table 5. Classification of water on mineralization (g/l) [21]

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 1 500 mg/l

By applying the conductivity conversion factors in mineralization (TDS) (0.55 – 0.75) [19] to the European standard, we get the normative standard (1375-1875 mg/l). Abovementioned water comply with the requirements and [2]. But everyday consumption for drinking this water is limited by biological component of water.

Water from underground source, located on the territory in Borovskoy district of Kharkiv oblast (Ukraine), has a higher values of mineralization. As reported by [21] this water is between «Low mineral content» and «Rich in mineral salts». It does not comply WHO requirements [1] and requirements of national standards for drinking and surface water while according to the European [2] and Canadian [3] standard it is suitable as drinking water.

In our opinion above mentioned contradiction concerning different mineralization of water of natural resources of Krasno-Oskol Reservoir and underground source of village Pidlyman of Borovskoy district (Kharkiv oblast) is connected with the location of resources' heads. Natural resources of Borovskoy district have high mineralization because their heads are in the same district, while Krasno-Oskol Reservoir is formed by Oscol river. Oscol river goes back from another district (Timsky district, Kursk region, Russia) and it only passes Borovskoy region. Waters, that supply Oscol river in Borovskoy district and form Krasno-Oskol Reservoir, don't change its mineralization significantly.

Permanent consumption of mineralized water like waters from Borovskoy district can cause accumulation of salts in the organism of human population of Borovskoy 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 [1, 3, 4].

CONCLUSION

So, it may be concluded that:
1) Value of water mineralization differs in standards of different countries and can range for drinking water from 1000 to 1500 mg/l.
2) Significant changes of mineralization in the water samples, taken in the area from the middle to the shore of Krasno-Oskol Reservoir, are not observed. It was shown, that activity of fish inspection influences a bit on May. Water from Krasno-Oskol Reservoir has mineralization twice greater than the same parameter in underground water of Borovskoy district.
3) In general, water quality of Krasno-Oskol Reservoir comply the requirements of international, foreign and national standards on drinking water and surface water and it does not exceed 500 mg/l. Everyday consumption of this water for drinking is limited by biological component of water.

Usage of water from underground water of village Pidlyman of Borovskoy 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 of this water.

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