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THE WAY OF SOFTENING OF UNDERGROUND WATERS UNDER IONIC EXCHANGE USE

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Висвітлено один з найважливіших показників води — її твердість. Підвищений уміст солей у воді зумовлює низку негативних наслідків, а інколи і небезпек. Встановлено, що частково допомогти у розв'язанні цієї проблеми можуть сучасні методи пом'якшення води, серед яких — іонообмінний метод, оснований на використанні катіонітів природного та штучного походження, що мають здатність обмінювати іони Na^+ та H^+на іони Ca^{2+} і Mg^{2+}, які містяться у воді. За результатами досліджень наведено дані щодо очищення питної води від солей кальцію і магнію за допомогою іонообмінного методу.

Ключові слова: *підземна вода, твердість, пом'якшення, катіоніт.*

Currently, the percentage of substances and microparticles of drinking water is totally different from that we had 10 years ago. According to assessments of ecologists, only 1% of the Earth water resources do not require purification before use. And this is extremely insufficient, taking into consideration global population.

After numerous biological and anthropogenic disasters, 19% of fresh water became absolutely unsuitable for use. When we speak about drinking water, we immediately think about its quality.

Due to deterioration of ecological situation, the problem of water treatment from natural and anthropogenic additions becomes relevant. One of the methods to improve water treatment is softening [1].

The most accepted methods are chemical processing. The non-reagent methods, which are recently developed, include magnetic, ultrasonic water softening and the newest Softnor sorbent water processing.

Despite wide use of water conditioning modern methods, such as nanofiltration, reverse osmosis, electrodialysis, ion exchange, the reagent methods are still essential. The main advantage of reagent softening is deposition of hardness ions as the low-soluble mixtures (hydroxides and carbons) and separation of deposits using water precipitation method [2–5].

Reagent methods are widely used in the power engineering and other branches of industry, as the first stage of water softening (mechanical filters). These methods allow partial water softening, elimination of water hardness and partial elimination of organic substances. The method group mentioned above also includes the ion-exchange method. It is based on cation exchanger use and allows sufficient decreasing of water hardness to any required value. The ion-exchange method uses strong-acid and weak-acid cation exchangers in both Na^+- and H^+-forms.

The most important properties of ion-exchangers are:

- purity;
- full static exchange capacity;
- osmotic stability;
- granulometric composition.

Variation of chemical composition and physical properties does not impact on sorption properties (full static exchange capacity), whose values allow comparing the efficiency of cation exchangers. Therefore, the aim of this research was selection of optimal water softening absorbent [6, 7].

MATERIALS AND METHODS

The following components were used while studying the water reagent softening process:

– strong-acid helium cation exchangers, synthesized based on styroledivinylbenzene with different divinylbenzene content:

Table 1

Physicochemical and operational parameters of tested cation exchangers

Parameter	Brand			
	KU-2–8 (Extra quality)	KU-2–8 (First quality)	Marathon C	S 100
Chemical composition, %	6	7	7.5	8
Grain-size composition: a) Grains effective size, mm	0.55	0.55	0.55	0.55
б) Uniformity index	1.40	1.46	1.09	1.83
Mass fraction of moisture in the H^+-form, %	57.3	55.3	53.8	53.0
Specific volume in the H^+-form, cm^3/g	2.83	2.66	2.53	2.49
Full static exchange capacity in the H^+-form, $mmol/cm^3$	1.86	1.93	2.10	2.00
Osmotic stability, %	98.0	98.5	99.8	99.2

- KU-2–8 (Extra quality);
- KU-2–8 (First quality);
- Marathon C;
- Marathon S 100.

The standard test solution (tap water) parameters:

- pH = 7.32;
- hardness — 4–10 $mmol/dm^3$;
- turbidity factor — 5.05 mg/dm^3;
- dry particles — 381 mg/dm^3;
- water oxidizability — 1.1 $mg{\cdot}O_2/dm^3$;
- water alkalinity — 6.66 $mmol/dm^3$;
- total iron — 0.3 mg/dm^3;
- manganese — 0.15 mg/dm;
- nitrates — 2.47 mg/dm^3.

The required calcium and magnesium salt content was acquired by introduction calcium and magnesium chlorides. Water softening parameters were measured using complex metrical method, in accordance with State standard 4151-72 [8].

RESULTS AND DISCUSSION

As the result of experiments, the physicochemical data was measured for test samples. As we see from comparison of the main physicochemical parameters with the results of dynamic tests (Table 1), the resulting data shall not be used for conclusion regarding the effectiveness of the specific sample during water softening process. Chemical composition of samples affects the osmotic stability. The osmotic stability factor increases with chemical composition. The moisture and specific volume factors decrease.

The water softening degree depends on composition of linking agent and grain-size composition. Besides cation exchangers' properties, there are specific factors affecting the degree of water softening such as regeneration mode, salt consumption and fluid flow rate.

Fig. 1 and 2 below illustrates the KU-2–8 (sample 1), KU-2–8 (sample 2), Marathon C (sample 3) and S 100 (sample 4) cation exchangers affect on water softening factor.

Analysis of the results (Fig. 1) indicated that at equal consumption of salt for regeneration:

- the most efficient removing of hardness ions was achieved using the Marathon C cation exchanger (sample 3);
- least effective was the KU-2–8 (Extra quality) (sample 1).

Therefore, these two samples were used for further experiments. Based on the results (Fig. 2), subject regularity is referred to all the values of salt consumption during regeneration. The increase of water flow speed from 30 to 50 m/h results in water softening depth decrease by 10–12% for both samples.

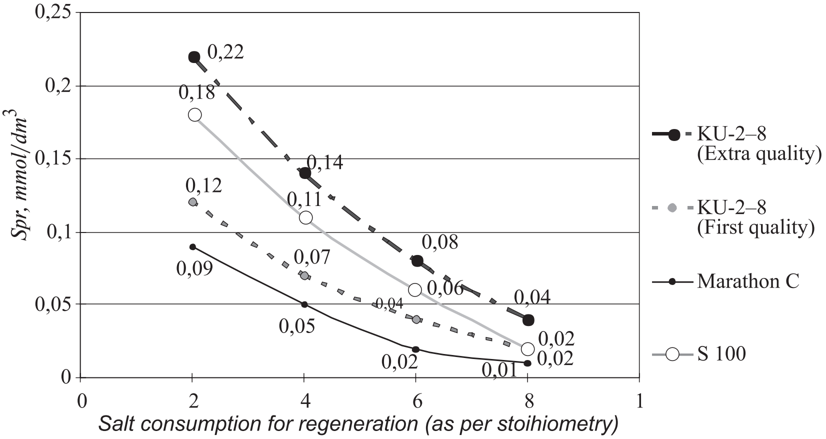

Fig. 1. Correlation between Ca^{2+} density (Spr, mmol/dm^3) in treated water and salt consumption for regeneration (as per stoichiometry)

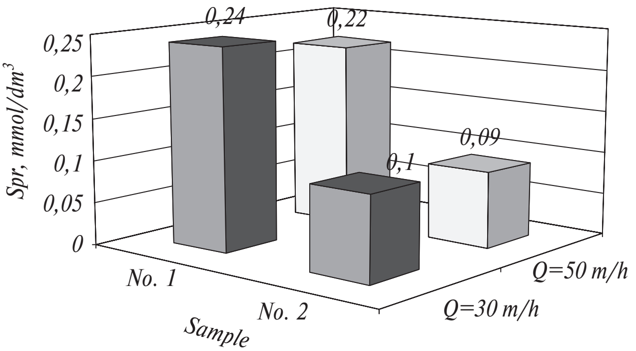

Fig. 2. Relationship between Ca^{2+} density (Spr, mmol/dm^3) in the treated water and water flow speed(Q, m/h)

CONCLUSION

Bazed on the results of calculations and experimental researches, the problem of water softening with 4–10 mmol/dm^3 hardness can be successfully resolved using the ion-exchange method. The result of research determined the effectiveness of different types of cation exchangers, used for water softening. It is noted that utilization of KU-2–8 (First quality) and S 100 cation exchangers did not result in sufficient increase of water softening.

Taking into account the results attained, the hardness of water can be decreased as follows:

- 0.04 mmol/dm^3 with using the KU-2–8 (Extra quality);
- 0.01 mmol/dm^3 with using the Marathon C.

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