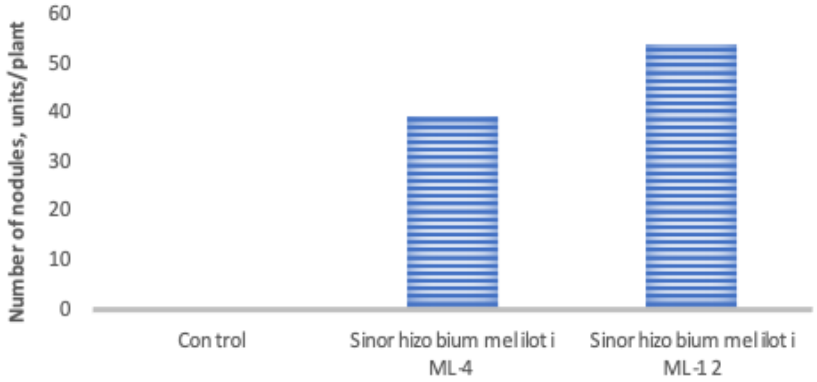

Fig. 1. **Nodulation activity of new strains of *Sinorhizobium meliloti* on roots of alfalfa variety Plateau**

Fixation of atmospheric nitrogen in symbiosis with legumes is an energy-intensive process that occurs due to solar energy accumulated during photosynthesis. The intensity of photosynthesis and symbiotic nitrogen fixation are two interrelated processes: as the supply of nitrogen to plants improves, the intensity of photosynthesis increases, and as photosynthesis intensifies, the volume of nitrogen fixation increases. A better supply of biologically bound nitrogen and better use of solar energy increases the yield of legumes.

Consequently, thanks to the research, the alfalfa nodule bacteria strains *Sinorhizobium meliloti* ML-4 and ML-12 can be used as bioagents in modern biological products.

References

1. Carelli, M., Gnocchi, S., Fancelli, S., Mengoni, A., Paffetti, D., Scotti, C., Bazzicalupo, M. (2000). Genetic diversity and dynamics of *Sinorhizobium meliloti* populations nodulating different alfalfa cultivars in Italian soils. Appl Environ Microbiol, 66. 4785-4789.
2. Štrbanović, R., Stanisavljević, R., Đukanović L., Dobrivoj P., Marković, J., Gavrilović V., Dolovac N. (2017). Variability and correlation of yield and forage quality in alfalfa varieties of different origin. Tarim Bilimleri Dergisi. 23. 128-137.
3. Brenner, Don J., Krieg, Noel R. and Staley James T. (2005). The Proteobacteria. Bergey's Manual of Systematic Bacteriology 2nd ed. New York: Springer.

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INVESTIGATION CHANGES IN PARAMETERS OF TECHNOLOGICAL MODES OF WATER TREATMENT FOR THE RECIRCULATING COOLING SYSTEM

Abstract. The recirculating cooling system (RCS) of power plants requires a significant amount of high-quality water, which is achieved by using water treatment methods. The study shows changes in water quality indicators during water treatment by lime softening and anti-scale treatment for RCS Rivne NPP.

Key words: particle size distribution, lime softening, HEDP, sulfuric acid.

Mineral scale, caused by hardness cations on the surface of any material in contact with water, often causes serious technical and economic consequences in domestic, municipal and industrial water supply systems [1]. The quality of water treatment in the power industry affects the reliability, economy, and

safety of operation, due to which high demands are placed on the water quality of power industry facilities [2]. To prevent the formation of scale [3], the following methods are used: RCS blowing, reducing the hardness of the cooling water (in particular lime softening), carrying out stabilization anti-scale treatment (in particular phosphonate and sulfuric acid). The wide application of lime softening is limited, because this process creates an excessive amount of sediment, introduces additional components to the water being treated [4]. The authors previously studied the processes of changing the components of the carbonate system during water treatment [5], in the literature there are very few systematic studies on changes in water quality indicators and particle size distribution (PSD) of particles formed in the process of water treatment [6].

The purpose of our research is the analysis and systematization of changes in quality indicators and particle size distribution of purified water particles in the process of water treatment by softening with lime and stabilization treatment with 1-hydroxy ethylidene-1,1-diphosphonic (HEDP) and sulfuric acids. Chemical control data were used [7]. Measurements of the concentration of control indicators were carried out using standardized measurement methods, PSD measurements were carried out by the laser diffraction method using a laser particle counter HIAC/ROYCO 8000A.

Water treatment of cooling water of RCS Rivne NPP is carried out by liming in clarifiers and anti-scale treatment, water treatment methods there are in tab. 1. Water intake and water discharge of the RCS Rivne NPP is carried out from/into the Styr River, a reservoir for fishing purposes.

Table 1

Characteristics methods of water treatment RCS Rivne NPP

Method of water treatment	Reagent	Dose, mg/dm^3	Parameter
Lime softening	lime	116.7 - 161.4	pH: 8.8 - 9.8
Anti-scale corrective	sulfuric acid H_2SO_4	11.5 - 24.5	pH: 7.0 - 7.6
	HEDP	0.2 - 0.5	[8]

During lime softening, the following processes occur in water: carbon dioxide (1) dissolved in water binds and calcium ions and bicarbonate ions are removed (2):

$$2CO_2 + Ca(OH)_2 \rightarrow Ca(HCO_3)_2 \quad (1)$$

$$Ca(HCO_3)_2 + Ca(OH)_2 \rightarrow 2CaCO_3 \downarrow + 2H_2O \quad (2)$$

As a result of removing Ca^{2+} and HCO_3^- during lime softening, the ratio of Ca^{2+} to cations (Mg^{2+}, Na^+, K^+) and anions (Cl^-, SO_4^{2-}) changes. During anti-scale treatment (HEDP+H_2SO_4), part of CO_3^{2-} is converted into HCO_3^-, which also shifts the general ratio of cations and anions (Fig. 1). For all investigated waters, their type is characterized as calcium-bicarbonate.

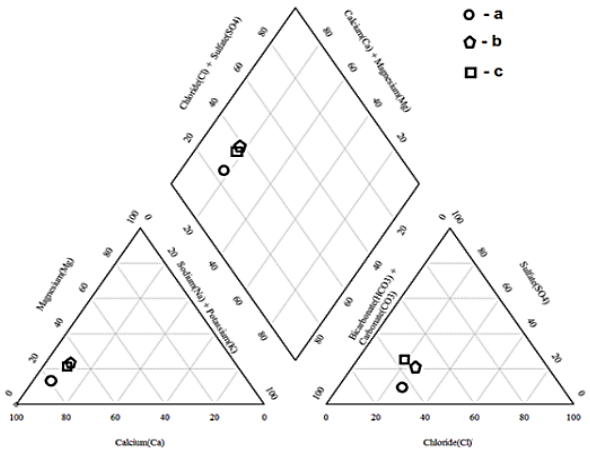

Fig. 1. **Piper diagram characterizing the main indicators of the composition of Styr River water (a), water treatment by liming (b), water treatment by liming and corrective treatment with H_2SO_4+HEDP (c) for 2022**

In the process of water treatment of RCS Rivne NPP, a decrease in the concentration of HCO_3^- and CO_3^{2-}, Ca^{2+} and an increase in the content of total suspended solids (TSS) are observed (Fig. 2). During

lime softening, there is a 35% decrease in the concentration of HCO_3^- and CO_3^{2-}, anti-scale treatment with acids neutralizes alkalinity and reduces the content of HCO_3^- and CO_3^{2-}, the total decrease in the concentration of HCO_3^- and CO_3^{2-} is up to 70%.

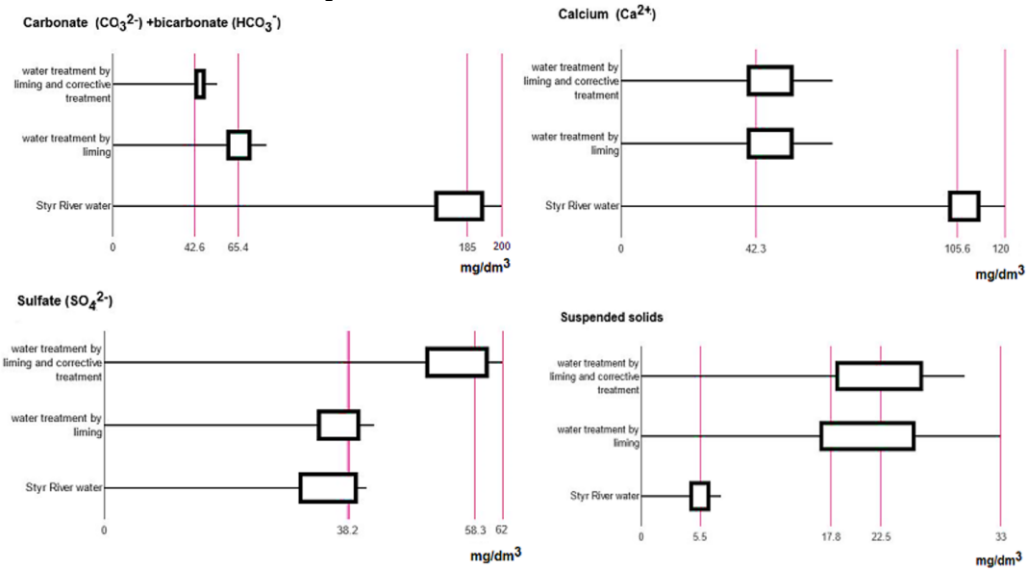

Fig. 2. **Change in water parameters during water treatment by liming, water treatment by liming and corrective treatment with H_2SO_4+HEDP for 2022**

Up to 60% reduction of Ca^{2+} and SO_4^{2-} is observed during liming. The content of TSS in the liming process increases three times compared to the incoming water of the Styr River, further corrective treatment with H_2SO_4+HEDP does not affect their concentration.

Integral curves of PSD for TSS in the water treatment process of RCS Rivne NPP are shown in Fig. 3. In the process of water treatment, there are changes in PSD, the maximum TSS fraction for Styr river water is 2-15 μm, for water that has undergone water treatment by lime softening and with corrective H_2SO_4+HEDP is 5-30 μm.

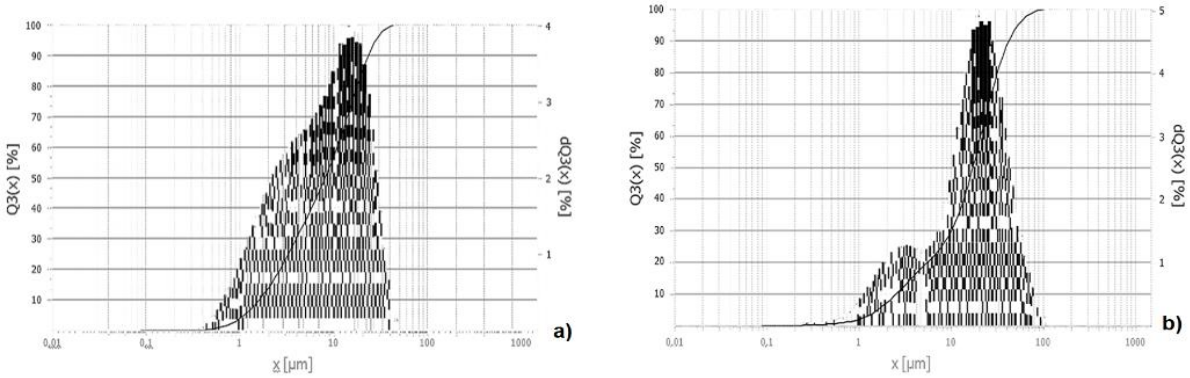

Fig. 3. **Integral curves of PSD for water Styr river (a), treatment by liming and with corrective H_2SO_4+HEDP (b) at water treatment RCS Rivne NPP**

The RCS Rivne NPP water treatment process ensures effective removal of calcium ions and stabilization of the anti-scale properties of the cooling water. Further research can be focused on identifying possible methods for optimizing technological modes, assessing the impact of corrective components and TSS of return water RCS Rivne NPP discharged into the water body of the Styr River.

References

1. Zhang L., Mishra D., Zhang K., Perdicakis B., Pernitsky D., Lu Q. Impact of influent deviations on polymer coagulant dose in warm lime softening of synthetic SAGD produced water. *Water Research*. 2021. Vol. 200. P. 117202. URL: https://doi.org/10.1016/j.watres.2021.117202 (date of access: 08.04.2023).
2. Kuznietsov P., Biedunkova O. Experimental Tests of Biocidal Treatment for Cooling Water of Safety Systems at Rivne NPP Units. *Nuclear and Radiation Safety*. 2023. Vol. 1(97). P. 30–40. URL: https://doi.org/10.32918/nrs.2023.1(97).04 (date of access: 05.05.2023).

3. Meier D. A., Chen B., Myers C. Cooling water systems: An overview. *Water-Formed Deposits*. 2022. P. 239–267. URL: https://doi.org/10.1016/b978-0-12-822896-8.00020-0 (date of access: 13.05.2023).
4. Li J., How Z. T., Benally C., Sun Y., Zeng H., et al. Removal of colloidal impurities by thermal softening-coagulation-flocculation-sedimentation in steam assisted gravity drainage (SAGD) produced water: Performance, interaction effects and mechanism studies. *Separation and Purification Technology*. 2023. Vol. 313. P. 123484. URL: https://doi.org/10.1016/j.seppur.2023.123484 (date of access: 05.05.2023).
5. Kuznietsov P. M., Biedunkova O. O., Yaroshchuk O. V. Experimental study of transformation of carbonate system components cooling water of Rivne Nuclear Power Plant during water treatment by liming. *Problems of Atomic Science and Technology*. 2023. Vol. 2(144), P. 69–73. URL: https://doi.org/10.46813/2023-144-069 (date of access: 30.04.2023).
6. Coto B., Martos C., Peña J. L., Rodríguez R., Pastor G. Effects in the solubility of CaCO3: Experimental study and model description. *Fluid Phase Equilibria*. 2012. Vol. 324. P. 1–7. URL: https://doi.org/10.1016/j.fluid.2012.03.020 (date of access: 13.05.2023).
7. Reports on the assessment of the impact of non-radiation factors on the environment of the Rivne NPP SE "NAEK Energoatom" for the years 2016-2022.
Kuznietsov P. M., Yaroschuk O. V., Bedunkova O. O. Application of variability of phosphonate stabilization treatment to minimize discharges into water bodies. Ecology. Environment Energy saving. 2023: Collective monograph. Poltava: NUPP named after Yuriy Kondratyuk. 2023. p. 92-104. https://nupp.edu.ua/uploads/files/0/events/conf/2022/3mnpk/monogr.pdf

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ENVIRONMENTAL RISKS OF CONTAMINATION OF LIVESTOCK BY-PRODUCTS WITH MICROORGANISMS AND ANTIBIOTICS

Abstract. Intensive livestock farming poses significant risks of contamination of by-products with dangerous biological agents, including pathogenic and opportunistic microorganisms. Today, the number of antibiotic-resistant strains of microorganisms in livestock production is growing, which is another environmental risk. This problem is medical, economic, veterinary, environmental, and social. Unfortunately, the monitoring of antibiotic resistance formation is not currently effective enough. In the future, the introduction of omnibus monitoring would reduce negative environmental impacts.

Key words: animal husbandry, by-products, environment, pollution, microorganisms, antibiotics

The growth rate of the livestock sector in the world is the highest among other sectors of agriculture. Researchers have confirmed that livestock facilities are a source of many chemicals that can be a source of odors, cause negative effects on the environment by disturbing the comfortable living conditions of people, animals, vegetation, and create a greenhouse effect. In addition, emit other exgalates, such as dust, endotoxins. Ecological inconsistency of intensive technologies in agriculture, including livestock, causes a number of environmental problems: degradation of agrobioresources, ecological imbalance of functional connections in agroecosystems, energy crisis and deterioration of agricultural products.