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## Technological and Environmental Problems in the Stabilization Treatment of the Main Condenser Cooling Circuit by Sulfuric Acid

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**Abstract.** The method of anti-scale stabilization treatment of cooling water of the circulating cooling system (CCS) with sulphuric acid to reduce the content of bicarbonate and carbonate ions allows to effectively reduce scale formation processes in power plant’s cooling systems. The results of the research and analysis of the sulphuric acid dosage to ensure the water-chemical regime of the reversible cooling system are presented in the example of the Rivne NPP. The analysis of the results of the control of the technology of stabilization treatment of cooling water with sulphuric acid was carried out, as the influence of the technological changes on the content of sulfate ions in the discharge water and the influence of the water discharge into a water body were evaluated. The sulphuric acid stabilization treatment makes it possible to neutralize the alkalinity caused by the content of bicarbonate and carbonate ions and to convert the proportion of calcium ions bound to bicarbonate and carbonate ions into a permanent hardness that is not prone to scale formation under the influence of temperature and has a lower tendency to scale formation. The use of sulphuric acid may be suitable for the optimal choice of water chemistry regime for scale reduction in CCS, according to the criteria of acidification of additional cooling water, which is the dosing criterion. The technological regimes for CCS stabilization treatment with sulphuric acid introduced at the Rivne Nuclear Power Plant (NPP) ensured a decrease in the use of sulphuric acid and a decrease in discharges into the water body by an average of 220 t/year, a decrease in the increase in the content of sulfate ions before the water intake and after the water discharge of the Rivne NPP, which correlates with a decrease in the amount of sulphuric acid used for CCS water treatment and a decrease in the environmental impact on the water bodies of the Styr River.

**Keywords:** circulating cooling systems, cooling water, nuclear power plant, sulfuric acid, sulfate ions, stabilization treatment.

## 1 Introduction

Water is used extensively in many technological processes in power plants: the steam-water cycle, cooling plants, or cooling systems that interact with condensers. Each nuclear power plant (NPP) is located near water resources (e.g., seacoasts, rivers, lakes) to ensure the necessary water supply during operation. NPP operation requires a large amount of water for cooling and has high-quality requirements, so NPP construction significantly impacts the regional distribution of water resources, which requires constant monitoring [1].

NPP can operate in a closed-loop or in an open-loop cooling, where cooling water is collected from the

reservoir and returned to the reservoir. For both open-loop and closed-loop systems, there are problems of environmental impact associated with the location of the NPP, and their effective solution requires regular monitoring is necessary to assess the impact of pollutants on the ecosystem and the environment [2]. In general, the number of studies related to the assessment of ecosystems in the vicinity of NPP is limited, especially for long-term monitoring, which allows for a comprehensive study of the dynamics of the impact of NPP on aquatic ecosystems [3].

The circulating cooling system (CCS) is the most widely used to implement cooling systems. The use of circulating water supply in the energy sector is due to the

conservation of water resources because, based on water treatment technologies, it is possible to minimize water consumption [4]. Water treatment technologies used in CCS should significantly reduce the scale deposition rate on the surface of heat exchange equipment and protect metals from corrosion [5, 6]. The formation of scale in the technical water supply system can reduce the system's productivity with a decrease in cooling efficiency, clogging of internal surfaces, corrosion of heat exchangers, and loss of heat transfer performance.

Therefore, providing an effective stabilization treatment that slows down scale formation is essential. When maintaining the water chemical regime in order to reduce scale formation with the neutralization of free alkalinity and the transfer of part of the carbonate hardness, it becomes constant according to the reaction - equation (1) uses stabilization treatment of CCS cooling water with sulfuric acid  $H_2SO_4$  [7]:



Despite the significant reductions in anthropogenic emission of atmospheric sulfur in recent decades, current levels of concentration of sulfate ions in surface and groundwater remain above natural background levels and have been increasing since the middle of the 20th century [8].

The pollution of surface waters by sulfate ions can have toxic effects on aquatic plants and animals, including fish, invertebrates, and amphibians, and can also adversely affect human health [9]. An increase in the sulfate supply is considered a problem in managing freshwater aquatic ecosystems [10].

## 2 Literature Review

Sulfuric acid is perhaps the most significant chemical used in power plants. The sharp increase in the price of concentrated  $H_2SO_4$  in recent years has made it the optimum choice for many power plants. As a result, power plant operating organizations are responding by implementing programs to minimize or eliminate the use of  $H_2SO_4$  for CCS water stabilization treatment [11]. Sulfate ions are formed during the dissociation of sulfuric acid, and the concentration of sulfate ions in the cooling and effluent water increases with the dosing of sulfuric acid [4].

Natural sources of sulfate ions in freshwater ecosystems include weathering of minerals containing sulfides or free sulfur, decomposition and combustion of organic matter, and oxidation of sulfides during geochemical processes [8]. Natural concentrations of sulfate ions in aquatic systems show considerable variability depending on the prevailing geology and hydrology of the catchment. The concentration of sulfate ions in freshwater typically ranges from 0 to 630  $mg/dm^3$  in rivers, from 0 to 250  $mg/dm^3$  in lakes, and from 0 to 230  $mg/dm^3$  in groundwater [12].

A distinction is made between the direct environmental impact of sulfate ions on the environment, as a result of the action of sulfate ions themselves, and the indirect environmental impact through its metabolites, in particular sulfide. The reduction of sulfate ions to

sulfide occurs due to the oxidation of organic carbon by bacteria. Sulfide has a strong negative impact on freshwater organisms and ecosystems [13]. Reduction of sulfate to sulfide accounts for 12–81 % of organic matter mineralization in freshwater sediments and affects iron cycling and eutrophication of freshwater ecosystems [9].

The dose of reagents for the implementation of stabilization treatment is determined at the stage of designing the power plant. It is usually carried out at constant concentrations that do not consider further changes in technological regimes and indicators of the quality of cooling water during operation [14]. The use of chemical reagents for water treatment and maintenance of the water-chemical regime of the technological environment of power plants affects the economy of operation of the power plant as a whole [15].

To increase the efficiency of work, measures should be taken to exclude the possibility of unjustified overdosing of reagents with the introduction of effective mechanisms for rational their use, minimizing the use of chemical reagents for power plants with the discharge of return water into water bodies is also due to the need to minimize the discharge of pollutants and the impact on the environment [16].

Focusing on the optimal choice of the water chemistry mode of sulfuric acid consumption for the stabilization treatment of power plant cooling water, the authors present an original method for rational the use of sulfuric acid, which allows for minimizing the environmental impact of power plant effluents.

The research aims to determine the technological features of using sulfuric acid to stabilize Rivne NPP cooling water, which determine the content of sulfate ions in the effluent water.

## 3 Research Methodology

The study was carried out for the CCS Rivne NPP's technological waters and the Styr River's surface water. Rivne NPP has four power units of the VVER type located in Eastern Europe, in Ukraine. Rivne NPP – CCS cooling system of an open type with water cooling in tower cooling towers is presented in Figure 1.

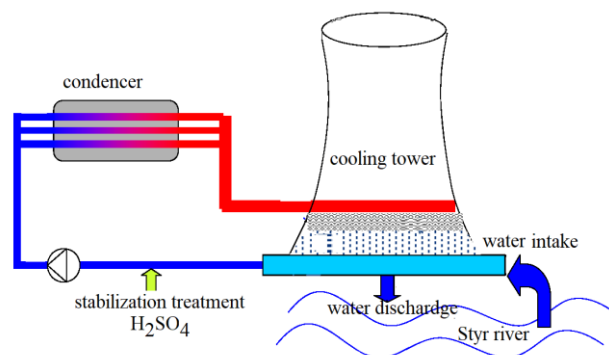


Figure1– Schematic diagram of the CCS at Rivne NPP cooling system

Cooling water consumption of power units No. 1, 2 (VVER-440) is 91 thousand  $m^3/h$  for each power unit, and power units No. 3, 4 (VVER-1000) –  $188.9 \cdot 10^3 m^3/h$  for each power unit. Water intake and discharge of CCS

Rivne NPP cooling water is carried out in the Styr River. The water of the Styr River belongs to the carbonate-calcium type. The water treatment of the CCS Rivne NPP is carried out by liming. The hydrocarbon mode is used. Therefore, upon cooling, water contains up to 70 % of permanent temporary (carbonate) hardness, which can be precipitated by temperature.

According to the design decision of Rivne NPP, the dosing of sulfuric acid should be added to make up the cooling water of the CCS should be carried out until the value of the hydrogen index of the additional cooling water decreases to pH 7.5–7.8, while maintaining its concentration, which does not exceed 24 mg/dm<sup>3</sup>. The actual dose is sulfuric acid  $g(H_2SO_4)$ , and water required for processing is determined according to the formula based on the values of total alkalinity made up of water  $TA^{mw}$  and cooling water  $TA^{cw}$  according to equation (2):

$$g(H_2SO_4) = 49 \cdot (TA^{mw} - TA^{cw}) \cdot 10^{-3}, \quad (2)$$

where 49 is the equivalent mass of sulfuric acid.

The amount of sulfuric acid consumption  $G(H_2SO_4)$  is determined based on the consumption of make up water and  $Q$  dose of sulfuric acid  $g(H_2SO_4)$  according to the formula:

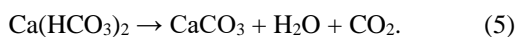
$$G(H_2SO_4) = g(H_2SO_4) \cdot Q. \quad (3)$$

Control over the intensity of scale formation in the cooling water CCS Rivne NPP is made according to the ratio of the difference in evaporation coefficients  $\varphi$  and  $\psi$ , mmol/dm<sup>3</sup>:

$$\varphi = \frac{Cl^{cw}}{Cl^{mw}}; \quad \psi = \frac{TH^{cw}}{TH^{mw}}, \quad (4)$$

where  $Cl^{cw}$ ,  $Cl^{mw}$  – contents of chloride ions, mmol/dm<sup>3</sup> in cooling and make up cooling waters of CCS, respectively;  $TH^{cw}$ ,  $TH^{mw}$  – total hardness of chloride ions.

The difference  $(\varphi - \psi)$  should not exceed 0.2 mmol/dm<sup>3</sup>. Otherwise, the scale formation processes occur due to the loss of carbonic acid of calcium hydrogen carbonate during heating with the formation of calcium carbonate according to the following equation:



According to the mode of rationale, the use of sulfuric acid was introduced in 2017. Dosing is not carried out when a low-scale formation value is ensured with the ratio of  $\varphi$  and  $\psi$  not exceeding 0.2 mmol/dm<sup>3</sup>.

The optimization of sulfuric acid content is influenced by the total hardness value, which depends on the evaporation coefficient  $\varphi$ .

Maximum permissible concentrations of sulfate ions in the fishery water and domestic use of Ukraine are specified per standard are 100 and 500 mg/dm<sup>3</sup>, respectively. The approved permissible concentration of sulfate ions in Rivne NPP discharge waters, under the terms of the permit for special water use [15], is 250 mg/dm<sup>3</sup>. For the Isar 2 NPP (Germany), which has a similar CCS system, sulfate ion discharge limits of 900 mg/dm<sup>3</sup> have been set. The sulfate ion discharge limit for each NPP depends on the amount of sulphuric acid used for stabilization treatment, the amount of feed and purge,

and the chemical composition of the feed used to replenish losses in the CCS.

Sampling and sample control were carried out by a certified measuring laboratory of Rivne NPP (certificate of recognition of measuring capabilities No. R-8/11-57-5 dated 22.12.2017), using measuring devices that have passed verification in the field of state metrological supervision of Ukraine, the measurement of the concentration of sulfate ions was carried out according to the methodology performance of measurements. The analysis of chemical control data of Rivne NPP was carried out according to the reports on the assessment of factors of non-radiation impact on the environment of Rivne NPP, the permission of Rivne NPP for the publication of control data in open sources was obtained (Rivne NPP's Act No. 036-08-A, dated 02.03.2023).

## 4 Results

The consumption of sulfuric acid for the processing of CCS Rivne NPP is determined by the consumption of additional water (3). Since 2017, there has been a downward trend toward the use of sulfuric acid (Figure 2).

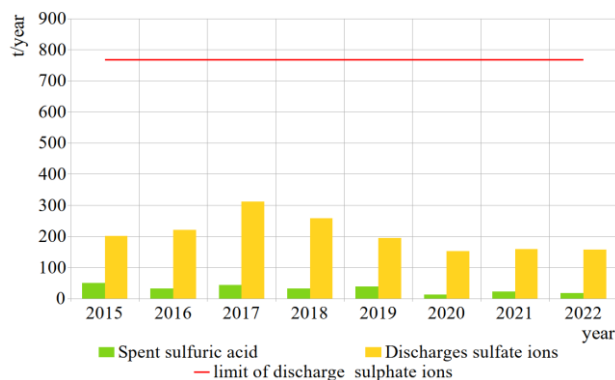


Figure 2 – Average annual quantities of sulfuric acid spent for CCS stabilization treatment and discharge of sulfate ions at Rivne NPP

The average annual amount of sulfuric acid consumption for 2017–2022 was 228 t/year. For the period of constant dosing of sulfuric acid in 2015–2016, with the maintenance of concentration up to 24.5 mg/dm<sup>3</sup>, it was 410.5 t/year, reduced dosing of sulfuric acid reduces the content of sulfate ions in discharge waters and, accordingly, reduces the supply of sulfate ions with return waters of CCS Rivne NPP and the amount of sulfate ion discharges. Discharge of sulfate ions with CCS Rivne NPP return waters does not exceed the limit of the discharge of 780 t/year by permit conditions for special water use (Figure 2).

With the implementation of the mode of the rationale for the use of sulfuric acid for CCS Rivne NPP, a decrease in the dose of sulfuric acid for dosing into additional cooling water is observed (Figure 3).

The concentration of sulfate ions in the additional cooling water of the CCS Rivne NPP increases with the amount of the increase in sulfate ions determined by the mode of stabilization treatment with sulfuric acid.

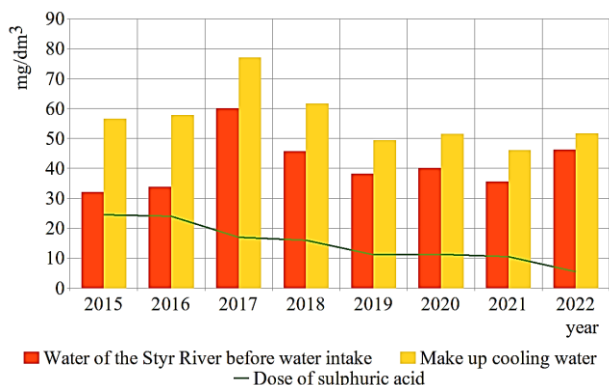


Figure 3 –Average annual changes in the concentration of sulfate ions in the water of the Styry River and make up cooling water CCS Rivne NPP and the dose of sulphuric acid

Table 1 – Average annual values of the concentration of sulfate ions in process waters CCS Rivne NPP and water of the Styry River before/after the water intake and discharge of the RAPP

Year	Statistical parameter	Mass concentration of sulfate ions, mg/dm <sup>3</sup>			
		Styry River, before water intake of Rivne NPP	Make up cleaning water of Rivne NPP	Return cooling water of Rivne NPP	Styry River after water intake of Rivne NPP
Constant dose H <sub>2</sub> SO <sub>4</sub> according to the criteria of equations (2), (3)					
2015 (n = 48)	M ± SE	32.17 ± 7.23	56.67 ± 14.90	155.84 ± 34.6	35.90 ± 7.40
	Min-Max	25.65–62.30	42.52–95.61	125.0–202.1	23.31–68.05
	CV	33.19	27.29	45.83	34.41
2016 (n = 48)	M ± SE	33.80 ± 6.66	57.80 ± 12.74	173.4 ± 32.75	36.07 ± 5.18
	Min-Max	21.70–65.30	44.92–99.60	121.0–235.0	34.55–57.02
	CV	33.69	27.74	41.83	44.83
Fractional dose H <sub>2</sub> SO <sub>4</sub> according to criteria (4)					
2017 (n = 48)	M ± SE	60.12 ± 7.16	77.10 ± 22.46	228.4 ± 48.98	61.28 ± 8.40
	Min-Max	26.90–88.00	45.60–98.00	175.6–268.0	32.40–82.08
	CV	33.16	32.46	48.20	38.44
2018 (n = 48)	M ± SE	45.73 ± 4.16	61.70 ± 32.46	160.5 ± 37.12	46.03 ± 5.40
	Min-Max	36.64–92.60	35.60–120.3	110.6–231.3	38.20–97.70
	CV	32.32	32.52	47.12	43.44
2019 (n = 48)	M ± SE	38.27 ± 12.24	49.40 ± 20.53	138.5 ± 49.98	39.2 ± 12.31
	Min-Max	25.60–62.30	36.21–70.62	88.61–226.30	26.50–63.55
	CV	39.56	29.98	48.37	39.42
2020 (n = 48)	M ± SE	40.23 ± 6.23	51.50 ± 19.29	149.4 ± 39.37	41.36 ± 6.40
	Min-Max	30.22–55.20	32.30–69.68	96.02–223.5	31.32–56.30
	CV	32.22	27.26	47.12	32.44
2021 (n = 48)	M ± SE	35.70 ± 7.54	46.20 ± 16.46	130.6 ± 32.15	36.00 ± 8.02
	Min-Max	20.30–42.6	35.30–55.60	96.00–203.12	27.90–45.80
	CV	33.08	39.20	49.11	33.25
2022 (n = 48)	M ± SE	46.34 ± 5.64	51.80 ± 11.82	140.0 ± 48.70	45.80 ± 6.52
	Min-Max	35.90–48.30	30.60–70.62	80.3–229.0	34.60–46.52.30
	CV	32.64	41.39	49.63	42.44

In 2017, there was an increase in the concentration of sulfate ions in the cooling water of the CCS Rivne NPP to the average and maximum values of 228.4 and 268 mg/dm<sup>3</sup>, respectively, which is due to an increase in their content in the incoming water of the Styry River (Figure 3).

Compared with additional cooling water, the content of sulfate ions in CCS cooling water increases proportionally with the evaporation coefficient  $\varphi$  (Figure 4).

The average values of the difference  $\varphi$  and  $\psi$  in the CCS Rivne NPP cooling water, which characterize the scale formation intensity (6), for the period 2012-2022,

The concentration of sulfate ions in the additional cooling water of the CCS Rivne NPP was in the range from 30.6 to 120.3 mg/dm<sup>3</sup>, and the increase in comparison with the content of sulfate ions in the Styry River was determined by the mode of partial or full dosing of sulfuric acid during stabilization treatment (Table 1).

The concentration of sulfate ions in the cooling water of CCS Rivne NPP was from 88.61 to 268.0 mg/dm<sup>3</sup> and was determined by the evaporation coefficient  $\varphi$  according to Eq. (4) (Figure 4).

do not exceed the normalized value of 0.2 mmol/dm<sup>3</sup> and characterize the cooling water as not prone to scale formation (Figure 5) and accordingly determine the periods for which the dosage of sulfuric acid in make up cooling water was applied CCS Rivne NPP.

The difference between  $\varphi$  and  $\psi$  for periods of constant and partial sulfuric acid dosing are quite comparable. Periods of no dosing of sulfuric acid (when  $\varphi - \psi \leq 0.2$  mmol/dm<sup>3</sup>) into the cooling water of CCS Rivne NPP did not lead to the intensification of scale formation processes.

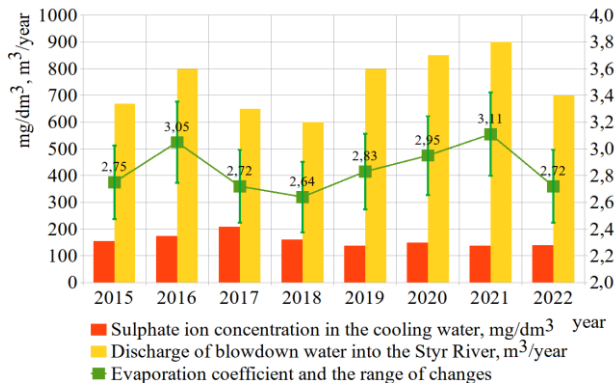


Figure 4 –The value of the concentration of sulfate ions in the cooling water of the CCS Rivne NPP, and the amount of discharged water in the Styry River and the corresponding values of the evaporation coefficients  $\phi$

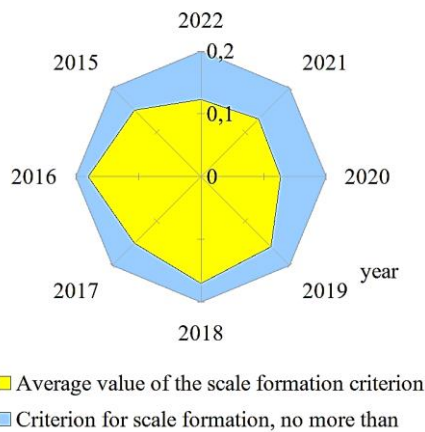


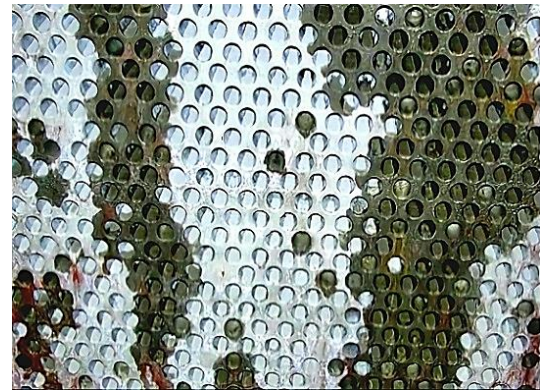
Figure 5 – Values of the different  $\phi$  and  $\psi$  coefficients characterizing the scale formation intensity in the CCS Rivne NPP cooling water

The results of the low intensity of scale formation in CCS Rivne NPP, obtained from the results of control of scale formation criteria  $\phi$  and  $\psi$ , are confirmed by the actual satisfactory condition of the internal surfaces of consumers (Figure 6) in compliance with the normative values of the temperature pressure of CCS Rivne NPP consumers.

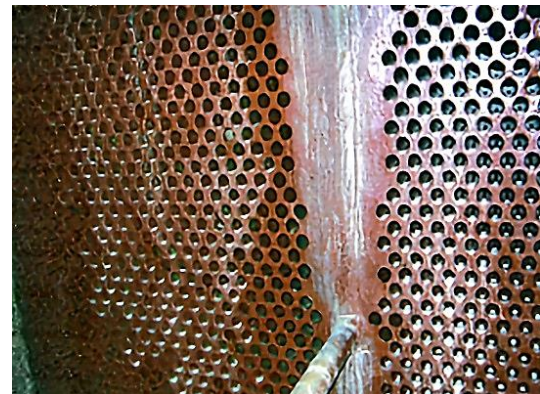
The concentration of sulfate ions in the discharge water of the CCS Rivne NPP did not exceed the limit of the concentration of sulfate ions in the discharge water under the conditions of special water use – 250 mg/dm<sup>3</sup> (Figure 7).

According to the results of water control of the Styry River before the water intake and after the return water discharge of the CCS Rivne NPP, a slight, up to 2 %, increase in the concentration of sulfate ions was recorded, which does not exceed the maximum permissible concentration in water bodies for fish farming – 100 mg/dm<sup>3</sup> (Figure 7).

There is a decrease in the difference in the growth of sulfate ions in the Styry River before water intake and after discharge in 2017–2022, which correlates with a decrease in the amount of sulfuric acid used to stabilize CCS (Figures 2, 7).



a



b

Figure 6 – Visual state of internal surfaces of main condenser CCS Rivne NPP in 2015 (a) and 2022 (b)

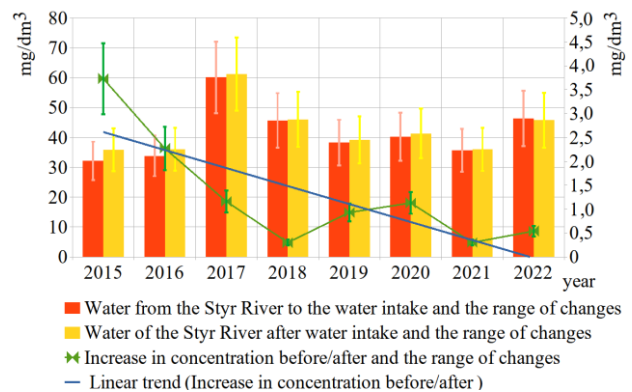


Figure 7 – Dynamics of changes in the concentration of sulfate ions in the water of the Styry River before/after the Rivne NPP water

The sulfate ions concentration in the Styry River before the Rivne NPP is determined by natural and anthropogenic influences on the natural water composition [8, 12]. The mode of stabilization treatment with sulfuric acid of the CCS Rivne NPP is determined by the neutralization reaction (1) and the dose and costs (2), (3). Then, during concentration processes due to evaporation in the CCS, sulfate ions are concentrated (Figure 8) in proportion to the evaporation coefficient  $\phi$  (4).

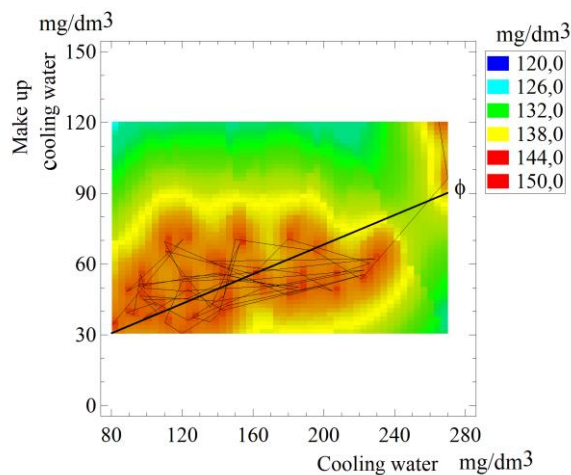


Figure 8 – Dynamics of change in the concentration of sulfate ions in the water of the Styry River before/after the Rivne NPP water intake

The correlation of values for the content of sulfate ions in make up cooling water, cooling water Rivne NPP and Styry River water is shown in Figure 9.

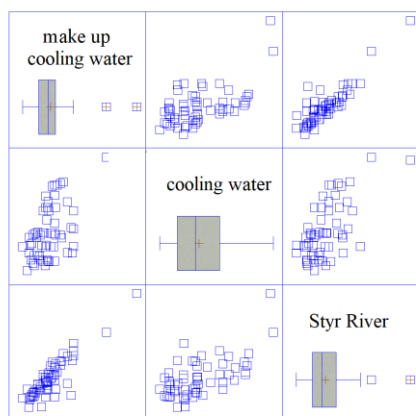


Figure 9 – Correlation of sulfate ion concentration values in make up cooling water, cooling water at Rivne NPP and Styry River (2019–2022)

The correlation between the values is positive, with a high correlation (Figure 10) with values of the *r*-Pearson correlation moment *r* from 0.58 to 0.88.

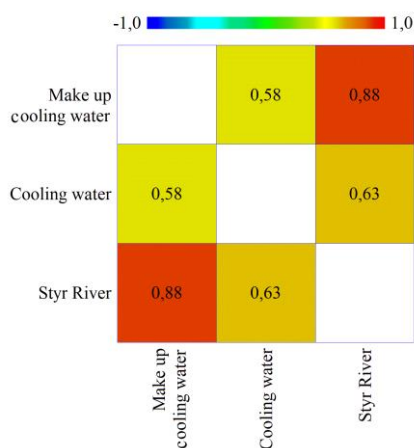


Figure 10 – The Pearson correlation value of the concentration of sulfate ions in make up cooling water, cooling water at Rivne NPP and Styry River (2019–2022)

The content of water-soluble components in make up cooling water, cooling water CCS is related by the evaporation coefficient  $\phi$  according to equation (2) and Figure 8. Therefore, a high degree of correlation ( $r = 0.88$ ) is observed for make up cooling water with cooling water CCS Rivne NPP.

The determining factor in the formation of discharges of sulfate ions with CCS return water is the sulfuric acid content in make up cooling water and cooling water. The calculated dependence equation that determines the content of sulfate ions in the waters of the Styry River after the discharge of Rivne NPP return water can be determined based on the content in make up cooling water using the evaporation coefficient  $\phi$  (Figure 11).

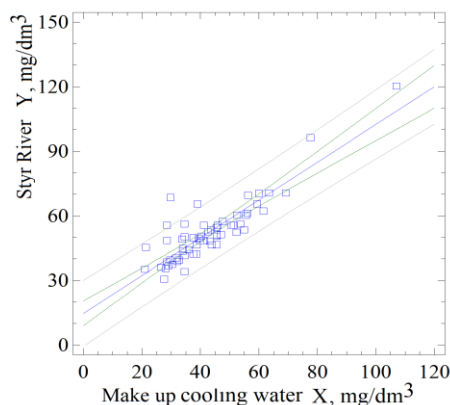


Figure 11 – Correlation of changes in the concentration of sulfate ions in the Styry River water (Y) after discharge and the content in make up cooling water (X) at Rivne NPP

Minimizing the dosage of sulfuric acid in make up cooling water of CCS Rivne NPP will allow reducing discharges of sulfate ions according to the correlation of Figure 11 and reducing the increase in the concentration of sulfate ions before/after the Rivne NPP water intake (Figure 7).

## 5 Discussion

To date, no analysis of the effect of changes in sulfuric acid dosage on the sulfate ion content of the effluent has been carried out for Rivne NPP. At the same time, the environmental consequences of sulfur compounds leaching into natural waters are a pressing issue on a global scale, especially as the climate continues to change [17]. The presented results of our studies indicate that the mode of anti-type stabilization treatment of cooling water CCS Rivne NPP with sulfuric acid to reduce the content of bicarbonate and carbonate ions can effectively reduce the processes of scale formation in the cooling system of power plants while maintaining optimal quality indicators of the water-chemical mode for CCS. Similar effects are described in scientific works related to the practical experience of circulating water systems [18, 19].

The method of stabilization treatment with sulfuric acid makes it possible to neutralize the alkalinity caused by the content of bicarbonate and carbonate ions and to convert the part of calcium ions bound to bicarbonate and carbonate ions into permanent hardness, which is not prone to scale formation under the influence of

temperature and has a lower tendency to scale formation [20].

However, the inhibitory effect of any agent on the formation of  $\text{CaCO}_3$  will be justified only at its optimal concentrations in the cooling system's water, which requires a search in each case [21].

We analyzed the effects of optimizing the use of sulfuric acid for CCS cooling water stabilization treatment by partial dosing criterion. As a criterion for the optimization of reagents for the anti-type of correction treatment of CCS cooling water, we used the scale intensity index, which was calculated from the difference between the  $\varphi$  coefficient, determined by the content of chloride ions, and the  $\psi$  coefficient, determined by the total hardness. Such criteria (together with the supersaturation and activity coefficients of particles that inhibit calcium hydrogen carbonate crystals) are indicative indicators [22].

Our analysis showed that the introduced mode for the optimal choice of the use of sulfuric acid for the stabilization treatment of CCS Rivne NPP provided an average reduction in the use of sulfuric acid and discharge into the water of Styr River by an average of 220 t/year. Considering the current approaches to protecting water resources from sulfur compounds [23] and cost savings in the technological cycles of power plants [24], we consider this a significant positive effect. Periods of no stabilization treatment of additional water with sulfuric acid did not affect the processes of scale formation in CCS, as assessed by the ratio of the difference of coefficients  $\varphi$  and  $\psi$  and the visual condition of the equipment. It also allowed to minimize the number of reagents used for treatment and to reduce the discharge of pollutants into water bodies during the operation of CCS at the Rivne NPP.

The above fact is an additional measure to strengthen the safety of a nuclear power plant for the environment [25] since the existing concentrations of sulfates in the wastewater do not require sorption or other additional measures to reduce them [26].

The correlation of sulfate content in water Styr River, make up cooling water, cooling water with a bond tightness from 0.58 to 0.88 proves the importance of

controlling the sulfate content at all stages of water circulation in the cooling system, which is also confirmed by other observations of the presence of corrosion inhibitors in the process water of nuclear power plants [27].

In our opinion, this will also predict changes in the content of sulfates in the return waters and p. Steer after CCS Rivne NPP backwaters discharge and calculate sulfate ion concentration in Styr River, depending on their content in make up cooling water and cooling water CCS Rivne NPP, the importance of which is proved by world-famous studies [28, 29].

We believe that the results of our research can be used further to optimize the technology of stabilization treatment with sulfuric acid to minimize the discharge of sulfate ions with return water into the Styr River.

## 6 Conclusions

The analysis of the technological characteristics and environmental impact of the water stabilization treatment in the main cooling circuit of the Rivne NPP condenser revealed the positive effect of the adjustment of the sulfuric acid dosage.

According to the results of the control of Styr River before the water intake and after the discharge of CCS Rivne NPP backwaters in the period before the partial dosing, the increase of the content of sulfate ions was recorded within 2 %, but it did not exceed the environmental standards.

For the period of partial dosing of sulfuric acid (2017–2022) according to the criterion of the ratio of the difference between the  $\varphi$  and  $\psi$  evaporation coefficients, there was a decrease in the concentration of sulfate ions in wastewaters, a decrease in the increase in the content of sulfate ions to the water intake and after the discharge of water by CCS Rivne NPP.

The decrease in the content of sulfates in the surface water of the Styr River correlated with a decrease in the amount of sulfuric acid used for water treatment at CCS, which proves the feasibility of controlling the dosage of corrosion inhibitors to reduce the environmental impact on water bodies.

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