Data in Brief 54 (2024) 110347

Contents lists available at ScienceDirect

Data in Brief

journal homepage: www.elsevier.com/locate/dib

Data Article

Evaluation of the scaling and corrosive potential of the cooling water supply system of a nuclear power plant based on the physicochemical control dataset

Pavlo Kuznietsov

National University of Water and Environmental Engineering, Rivne 33028, Ukraine

A R T I C L E   I N F O

Article history:
Received 28 February 2024
Revised 14 March 2024
Accepted 14 March 2024
Available online 19 March 2024

Dataset link: Evaluation of the scaling and corrosive potential of the cooling water supply system of a nuclear power plant based on the physicochemical control dataset (Original data)

Keywords:
Statistical analysis
Scaling and corrosiveness potential
Physicochemical characteristics of water
Langelier saturation index
Ryznar stability index

A B S T R A C T

The data of physicochemical control for the cooling water supply system of the Rivne Nuclear Power Plant (Ukraine), where water samples were monitored three times a day during 2022–2023. The pH, temperature, total dissolved salts, total hardness and total alkalinity were measured using standard methods. The differences in ϕ and ψ, Langelier saturation index (LSI) and Ryznar stability index (RSI), which characterise scaling and corrosive potential, were calculated The calculated values are ϕ - ψ: 0.29 ($\pm$ 0.62), LSI: 1.51 ($\pm$ 0.39), and RSI 5.74 ($\pm$ 0.69). According to the scaling and corrosive classification, the water is characterised as susceptible to scale formation. Moreover, to the Pearson correlation coefficient (ρ), there is a very strong relationship $\rho = -0.9635$ between LSI and RSI, a weak relationship $\rho = -0.2370$ between ϕ - ψ and RSI, and $\rho = -0.2997$ between ϕ - ψ and LSI.

E-mail address: p.m.kuznietsov@nuwm.edu.ua

https://doi.org/10.1016/j.dib.2024.110347

Specifications Table

Subject	Energy Engineering and Power Technology
Specific subject area	Evaluation of corrosion and scale processes in the cooling water supply system of a nuclear power plant based on results of physicochemical control
Data format	Raw and processed
Type of data	Tables and Figures
Data collection	Samples of water were taken for physicochemical analysis using standard methods. An electrochemical methods was used at the site to measure the pH (ionomer "I-160"), temperature (thermocouple ТХК-2588), and TDS (conductometer КВЧ5М). The concentrations of chloride, was determined in the laboratory using AgNO3 titration method. The standard EDTA method was used to determine total hardness (TH) and acid titration for total alkalinity (TA) determination. Scaling and corrosive potential were determined by the differences in φ and ψ, Langelier saturation index (LSI), and Ryznar stability index (RSI). Statistical treatment of the research results involved determining the range of data series (min–max), arithmetic mean (M), standard deviation (SD) of the corresponding sample and statistical analysis of data using the BioEstar software package (Version 5.3, MLM). Dataset analysis was performed using the Pearson correlation analysis using the Pearson correlation coefficient (ρ) in order to evaluate the relationship.
Data source location	Samples were collected at the Rivne Nuclear Power Plant (RNPP), Ukraine; analyses were performed at the Measurement Laboratory, RNPP, Varash, Rivne Region, Ukraine. Monitoring data processing was performed by the National University of Water and Environmental Engineering, Rivne, Ukraine.
Data accessibility	Data are reported here and accessible in Mendeley data to keep it updated and provide larger details (https://doi.org/10.17632/3pd3×2wcmx.1).

1. Value of the Data

- The data repository contains the physicochemical control data set related to the scale and corrosion formation of the cooling water supply system in the nuclear power plant (NPP).
- Chemical monitoring with physicochemical dataset determination is mandatory in the operation of a cooling water supply system NPP, as this data assessment enables predictive modelling of scale and corrosion risks under varying operating conditions or the development of more efficient water treatment strategies.
- The data are related to the operational RNPP that is located in the Rivne Region, Ukraine and spread over several years of samplings (three times a day) and may be useful for managers of water and wastewater companies, operators of water resource facilities and treatment plants, and NPP operations managers.
- Scale and corrosion cause problems in the operation of nuclear power plants, and this data is valuable because it allows us to assess these processes, which is necessary to avoid economic losses and ensure the reliability and safety of nuclear power plants.
- Scaling and corrosion processes were calculated by different methods using the differences in the φ and ψ, LSI, and RSI, and this methodology may be useful for other NPP and basic statistic elaboration is applied to comparison the scale and corrosion indicators and their relationships during the series.

2. Background

The assessment of corrosion and scale processes in NPP is very important as these processes affect the reliability, safety and economic operation. The cooling water supply system (CWS) of NPP requires the use of large water flows. Assessment of corrosion and scale processes in the CWS NPP requires continuous monitoring of the physicochemical control of the water and application of effective methods for assessment of these processes. Different methods are used to assess corrosion and scale processes, using different physicochemical data, so the motivation is to determine the actual values of corrosion and scale assessment indicators and their relationships. The context of the compilation is to calculate and compare the indicators of corrosion and scaling processes in NPP cooling water in order to determine the appropriate method of controlling these processes.

3. Data Description

The data presented here relates to the monitoring of the CWS of NPP water physicochemical parameters, which allows to assess the potential for corrosion and scale processes. A sketch of the CWS of NPP is shown in Fig. 1. Evaporation and concentration occur in CWS due to heat removal, which increases the concentration of salts that can cause corrosion and scale formation. In the course of the study, the following physicochemical parameters were determined: pH, temperature, total dissolved salts (TDS), chloride (Cl^-), total hardness (TH), and total alkalinity (TA) concentrations using standard methods listed in Table 1.

Data presented here deal with monitoring of physicochemical parameters of water CWS RNPP including pH, TDS, TA, TH, temperate, and Cl^- which have shown in Table 2. The composition of the physico-chemical parameters (Table 2) of a NPP CWS water is determined by the quality of the incoming water from a natural reservoir, the water treatment processes used and the CWS operating parameters (feed and blowdown mode, power units, etc.). The main purpose of a NPP CWS is heat removal, so the average annual temperature (25.90 ± 6.45 °C) does not depend on the season, but is determined by the capacity of a NPP power units. Due to the heating of the water in the CWS by the CWS cooling tower (Fig. 1), evaporation and concentration processes occur, and as a result, an increase in the physicochemical parameters of the CWS RNPP water (pH, TDS, TA, TN and Cl-) is observed in comparison with makeup water.

The results of the calculations for φ - ψ, Langelier saturation index (LSI), and Ryznar stability index (RSI) for water CWS RNPP were presented in Fig. 2. The data showed that φ - ψ ranged

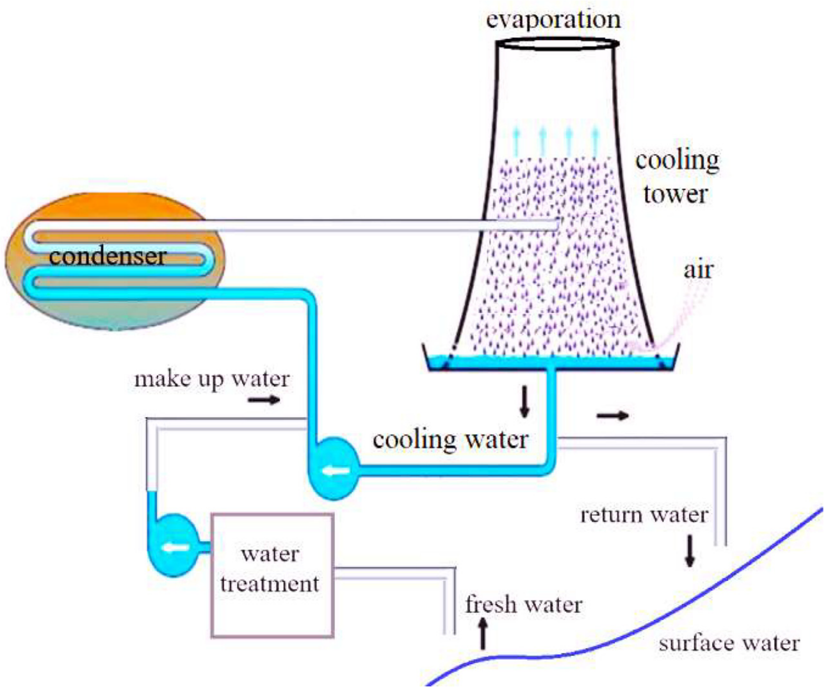

Fig. 1. Schematic diagram of the CWS RNPP.

Table 1
Characterization of methods for measuring the concentration physicochemical parameters of water CWS RNPP (CI - is the measurement range, δ - is the relative measurement error, Δ - is the absolute measurement error).

Indicator	CI	δ (Δ)	Method of measurement (Standard in Ukraine)
pH_{25}	1–12	(±0.2)	DSTU 4077-2001 Water quality. Determination of pH
TDS, mg/dm^3	50–10,000	±5 %	MWB 081/12-0109-03 Surface, groundwater and return water. Methodology for measuring the mass concentration of dry residue (dissolved solids) by the gravimetric method
TA, mM	–	–	DSTU ISO 9963-1:2007 Water quality - Determination of alkalinity - Part 1: Determination of total and composite alkalinity
TH, mM	–	±0.04 %	DSTU ISO 6059:2003 Water quality — Determination of the sum of
calcium and magnesium — EDTA titrimetric method			
Temperate, °C	1.5–70	(0,1 °C)	MWV 081/12-0311-06 Surface, groundwater and return water. Methods of temperature measurements
Cl$^-$, mg/dm^3	7 –1500	±20 %	MWV 081/12-0653-09 Surface, groundwater and return water. Method for measuring the mass concentration of chlorides by the titrimetric method

Note: Conversion to $CaCO_3$ for LSI and RSI calculation was performed according to Annex A of DSTU ISO 9963-1:2007.

Table 2
Mean and standard deviation values of physicochemical parameters of water CWS RNPP for 2022–2023.

Physicochemical parameters	Min	Max	M	SD
pH	8.00	9.44	8.69	0.13
TDS, mg/dm^3	305	1048	592	120
TA, mM	1.40	6.55	3.49	0.68
TH, mM	1.7	10.20	5.63	1.23
Temperate, °C	2.00	42.80	25.90	6.45
Cl$^-$, mg/dm^3	16.7	113.8	42.85	14.40

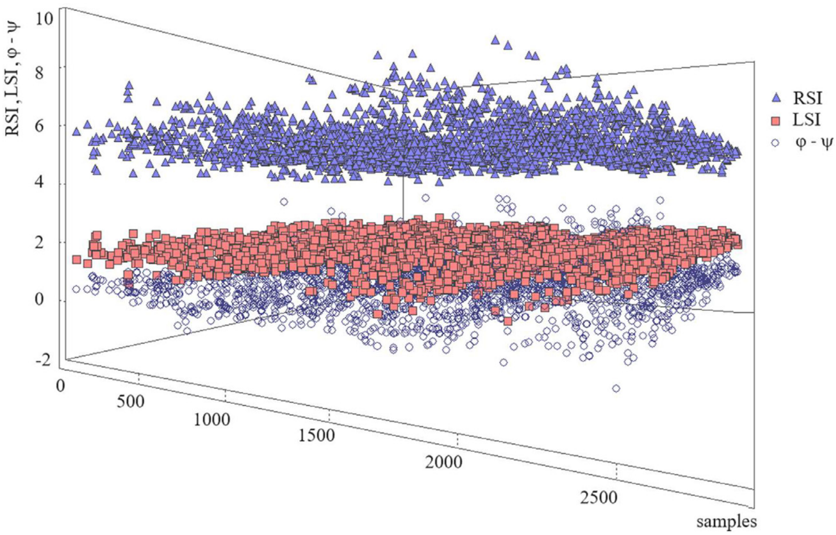

Fig. 2. Values of the φ - ψ, LSI, and RSI for water CWS RNPP.

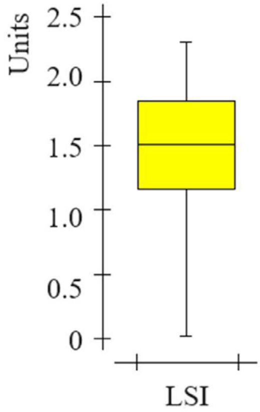

Fig. 3. Values of the LSI for water CWS RNPP.

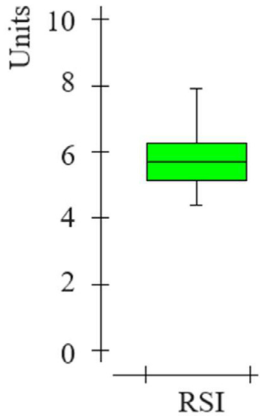

Fig. 4. Values of the RSI for water CWS RNPP.

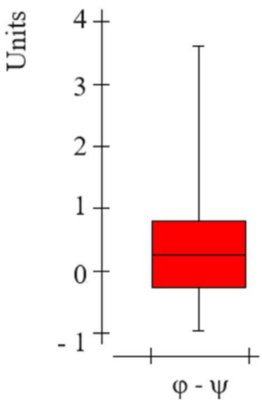

Fig. 5. Values of the φ - ψ for water CWS RNPP.

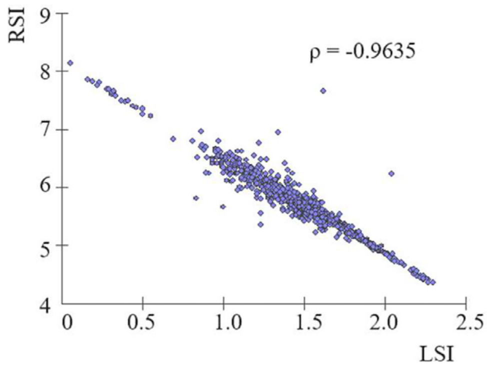

Fig. 6. The relationship between LSI and RSI for water CWS RNPP.

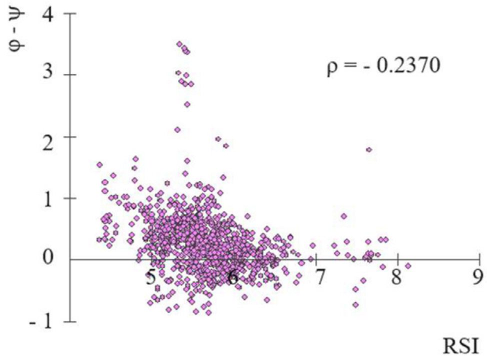

Fig. 7. The relationship between ϕ - ψ and RSI for water CWS RNPP.

between − 0.97 and − 3.63, LSI ranged between 0.10 and 2.31, RSI between 4.25 and 7.95 (Figs. 3-5).

There is a negative correlation at the level of a very strong relationship $\rho = -0.9635$ between LSI and RSI (Fig. 6). There is a negative correlation at the level of weak association $\rho = -0.2370$ between φ - ψ and RSI (Fig. 7). There is a negative correlation at the level of weak association $\rho = -0.2997$ between φ - ψ and LSI (Fig. 8).

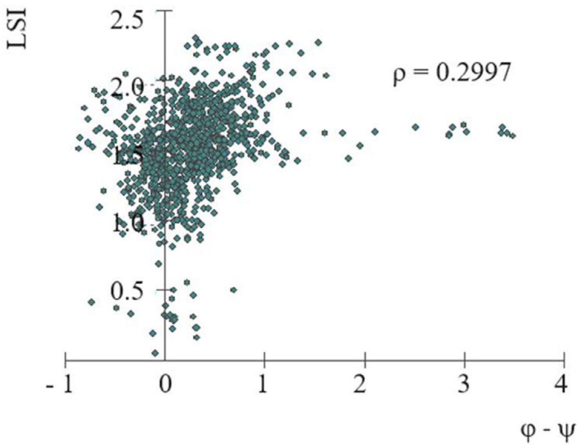

Fig. 8. The relationship between LSI and ϕ - ψ for water CWS RNPP.

4. Experimental Design, Materials and Methods

The systems and components used in NPPs require a CWS for normal operation [1]. Failure of a CWS is critical and necessary to remove heat from safety-related components [2]. The safety of NPP operation is significantly improved after the establishment of physicochemical control of water quality indicators [3]. The raw data for physicochemical control are collected from the reports provided by the RNPP and loaded and publicly available in Mendeley Data [4] (https://doi.org/10.17632/d5mczptz5z.1). Fig. 1 describes a simplified scheme of the CWS RNPP. RNPP performs regular monitoring (3 times per day) of physicochemical parameters [5]. The analysis of physicochemical parameters is performed in accordance with international and approved national standards (Table 2). The sampling protocol is in accordance with the RNPP operating documentation. The water sample was collected from the open channel of the cooling system to the condenser (Fig. 1) using a submersible bathometer and transported to the laboratory in a 1 dm3 polyethylene container. The determination of physicochemical parameters was performed immediately after sampling. The monitoring period covered different operating conditions of the NPP, including full and reduced power operation and unit shutdown. This methodological approach ensures the robustness and validation of the data and allows the calculation of corrosion and scaling indicators. Scaling and corrosive potential were determined by the differences in φ - ψ [3], LSI [6], and RSI [7]. If the φ - ψ are less than 0.2, this indicates no scaling tendency and more than 0.2 indicates a scaling tendency. If LSI $<$ 0, this characterises water as having a corrosive tendency, LSI $=$ 0 - a neutral tendency, LSI $>$ 0 - a scaling tendency. If RSI $<$ 5.5, there is a high scaling tendency in water, 5.5 $<$ RSI $<$ 6.2 - scaling tendency, 6.2 $<$ RSI $<$ 6.8 - neutral tendency, 6.8 $<$ RSI $<$ 8.5 - low corrosive tendency, and RSI $>$ 8.5 - high corrosive tendency. All the collected data was statistically analysed to characterize the distribution and the errors connected to the database built with a definition min-max, M, SD and using the Pearson correlation analysis [8] to evaluate the relationship between the differences in φ and ψ, LSI, RSI, ρ of $<$0.1 indicates a negligible, 0.1 - 0.39 represents a "weak" association, whereas 0.40 – 0.65 is a "moderate" association, 0.65 – 0,9 is a "good" association and $>$0.9 a very strong relationship [9]. There is no associated primary research article for this dataset. Further work by the author in compiling a research article and analysing the data for modelling and relating to operational parameters and actual scale formation and corrosion state of the equipment, including bench-scale tests.

Limitations

The dataset has certain constraints. Determination errors and mistakes of physicochemical indices control determine the errors and mistakes of index determination. The use of more accurate control methods will allow more accurate determination of the scale and corrosion potential of water.

Ethics Statement

The proposed data does not involve any human subjects, animal experiments, or data collected from social media platforms.

Data Availability

Evaluation of the scaling and corrosive potential of the cooling water supply system of a nuclear power plant based on the physicochemical control dataset (Original data) (Mendeley Data).

Acknowledgments

The author would like to thank Rivne NPP for the use of their laboratory equipment. Information about the influence of substances that were studied in the article is partially presented and is publicly available in «Reports on the assessment of the impact of non-radiation factors on the environment of the Rivne NPP SE "NAEK Energoatom" for the years 2022–2023».

Declaration of Competing Interest

The author declares that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

[1] P. Suganya, G. Swaminathan, B. Anoop, Assessing the factors affecting the water chemistry parameters in the auxiliary water system of a nuclear power plant, SN Appl. Sci. 2 (2020) 1889 p., doi:10.1007/s42452-020-03693-z.
[2] P. Kuznietsov, O. Biedunkova, Evaluating the impact of dispersed particles in the water of a power plant recirculating cooling system on the discharge of suspended solids into a natural water body, East. Eur. J. Enterp. Technol. 20236 (2023) 6–16 10, 126p., doi:10.15587/1729-4061.2023.292879.
[3] P.M. Kuznietsov, O.O. Biedunkova, Technological and environmental problems in the stabilization treatment of the main condenser cooling circuit by sulfuric acid, J. Eng. Sci. 10 (2023) H1–H8 (Ukraine)2p., doi:10.21272/jes.2023.10(2).h1.
[4] P. Kuznietsov, Evaluation of the scaling and corrosive potential of the cooling water supply system of a nuclear power plant based on the physicochemical control dataset, Mendeley Data (2024) V1, doi:10.17632/3pd3x2wcmx.1.
[5] P.M. Kuznietsov, O.O. Biedunkova, The formation of the carbonate system of circulating cooling water of the Rivne NPP and its influence on changes in the surface waters pH levels of the Styr river, IOP Conf. Ser. Earth Environ. Sci. 1254 (2023) 012102 p., doi:10.1088/1755- 1315/1254/1/012102.
[6] A. Alam, A. Singh, Groundwater quality evaluation using statistical approach and water quality index in Aurangabad Bihar, Rasayan J. Chem. 188 (2022) 180–188 p..
[7] A. Alam, S. Kumar, Groundwater quality assessment and evaluation of scaling and corrosiveness potential of drinking water samples, Environ. Sci. Proc. 25 (1) (2023) 64 p..
[8] P. Schober, C. Boer, L.A. Schwarte, Correlation coefficients: appropriate use and interpretation, Anesth. Analg. (2018) 1763–1768, doi:10.1213/ANE.0000000000002864.