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Evaluation of water quality influence on water discharge of a nuclear power plant (non-radiation impact factor)

Pavlo Kuznietsov, Olha Biedunkova, Olesya Yaroshchuk, Alla Pryshchepa

National University of Water and Environmental Engineering

INTRODUCTION & AIM

In nuclear power plants (NPP), water is used extensively in many technological processes. Power generation requires constant access to fresh water sources with suitable physical and chemical properties. The main function of a NPP cooling circuit system (CCS) is to remove heat from the power plant equipment. The quality of cooling water can affect the operation of a power plant [1]. At the same time, the quality of make-up water during water treatment and cooling water during cooling system operation changes [2], all of which contribute to the quantitative and qualitative indicators of water discharge. The basis for assessing the suitability of water for cooling is the analysis of the main parameters affecting the functioning of the circuits [3]. In a NPP, a large amount of water is withdrawn and used by the CCS to remove residual heat from the steam turbines. Water consumption is defined as the amount of water that evaporates or is lost in production processes after extraction [4]. The Water Code of Ukraine (WCU) and the Water Framework Directive (WFD) are the relevant documents regulating the environmental impact of water discharge. The WCU establishes an analogue to of the environmental quality standard - the Maximum Permissible Concentration (MPC) of a substance in water, which determines the suitability of water for "specific water use purposes".The discharge of substances, taking into account their composition and properties, is limited by the establishment of the Maximum Permissible Discharge (MPD) of pollutants with wastewater, which is the maximum amount that can be discharged into a water body from an environmental point of view.

The purpose of the study is to analyse the quality of the make-up, cooling and return water of the NPP CCS and the surface water of the water body into which the plant discharge water.

METHODS

CCS of the Rivne NPP cooling water was chosen as the research object. The Rivne NPP - a nuclear power plant located in the west of Ukraine, has four power units of the VVER type with a total power of 2835 MW (Figure 1). The water intake and discharge of the cooling water CCS of the Rivne NPP is carried out in the Styr River, a reservoir for fishing purposes. MPD for polluting chemicals (PC) were calculated by the direct calculation standard method.

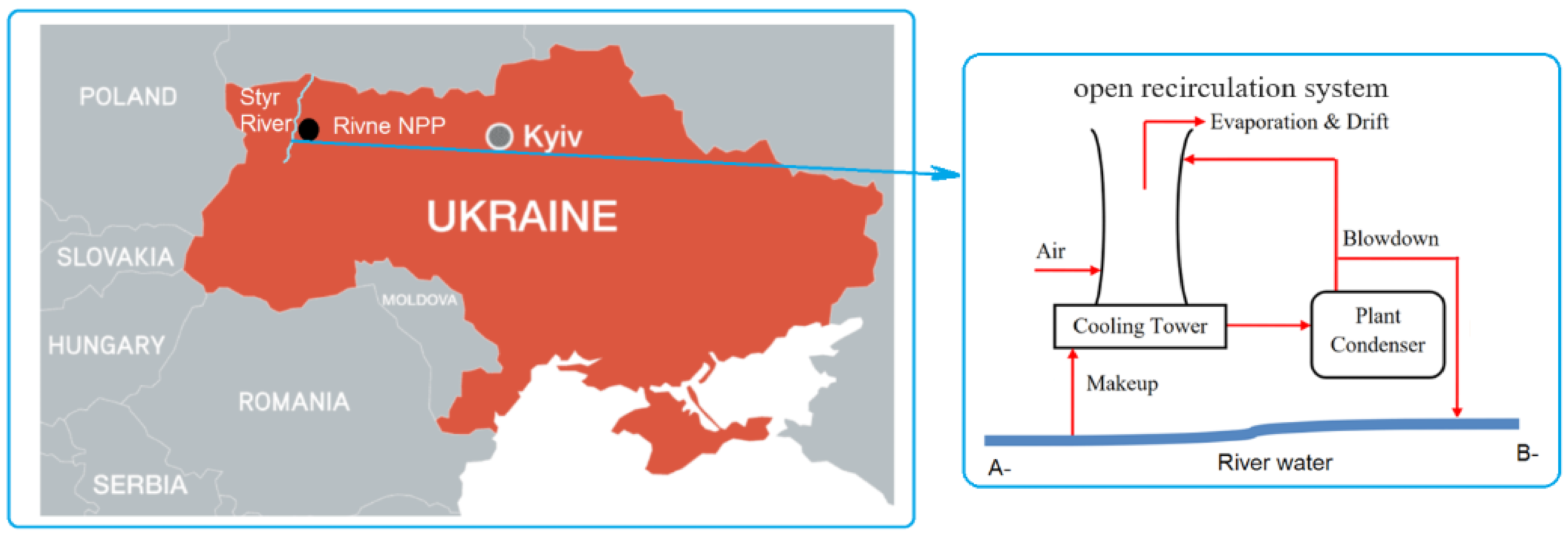

Figure 1. *Scheme of CCS Rivne NPP*

RESULTS & DISCUSSION

Changes in the quality of the make-up and cooling water CCS of the Rivne NPP and the Styr River water are shown in Figures 2-4. Make-up water is added to the CCS in a volume that depends on evaporation, blowdown and other losses. The requirements for make-up water quality parameters are more restrictive than for cooling water.

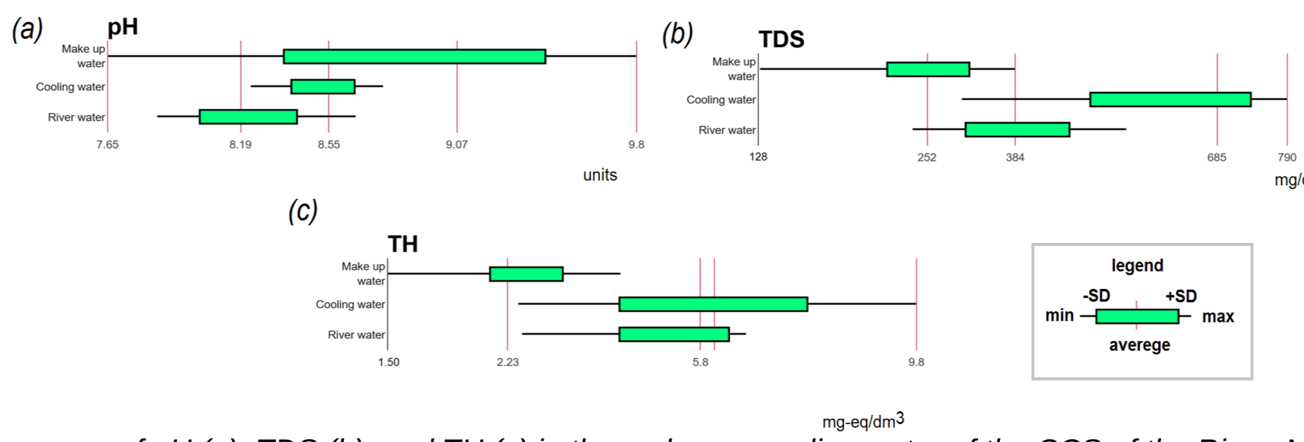

Figure 2. *Values range of pH (a), TDS (b), and TH (c) in the make up, cooling water of the CCS of the Rivne NPP and the Styr river water.*

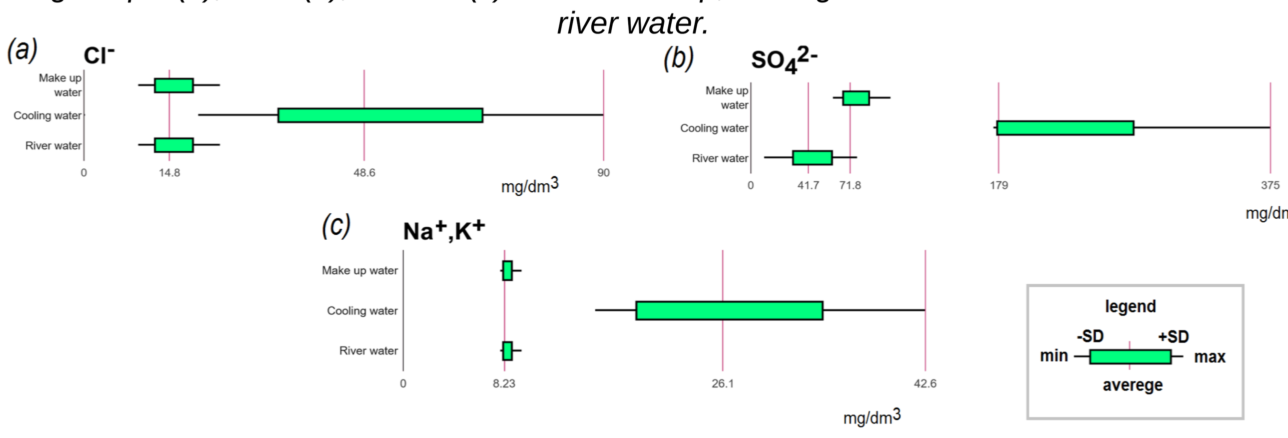

Figure 3. *Concentration range of Cl- (a), SO_4^{2-} (b), Na+ and K+ (c) in the make up, cooling water of the CCS of the Rivne NPP and the Styr river water.*

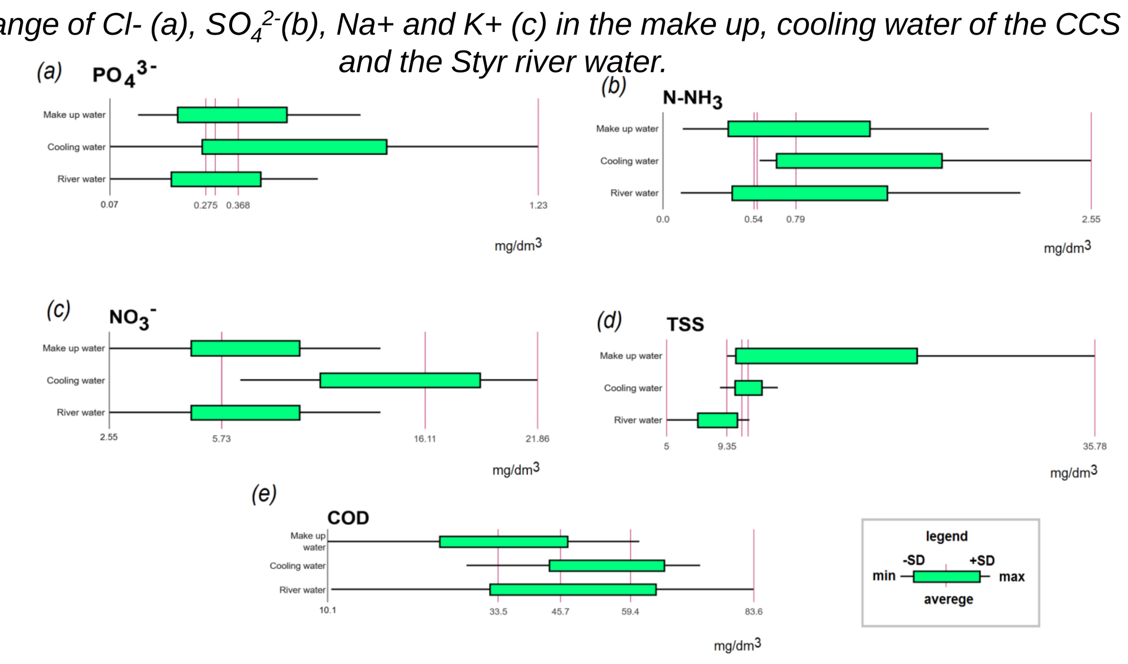

Figure 4. *Concentration range of PO_4^{3-} (a), N-NH3 (b), NO_3^- (c), TSS (d), COD (e) in the make up, cooling water of the CCS of the Rivne NPP and the Styr river water.*

Significant correlations between the Styr River indicators were found for temperature and TSD, pH, DO, PO_4^{3-}; TSD and Cl-, SO_4^{2-}, TH, TA, Na+, K+; pH and TA; COD with DO, BOD5; NO_3^- with NO_2^-, BOD5 (Fig. 5a). The correlation of make-up values repeats the correlation trends identified for the Styr River, except for the inverse relationship between pH and TH, which is due to the treatment of the make-up water (Fig. 5b). The correlation of cooling water values also follows the trends found, but there is a greater degree of correlation between temperature and physical and chemical parameters due to the concentration dependence of CCS (Fig. 5c). Dendrogram data the components parameters for water sampled in the sampling locations and generates cluster graph data the components parameters of group water samples are shown in Figure 6.

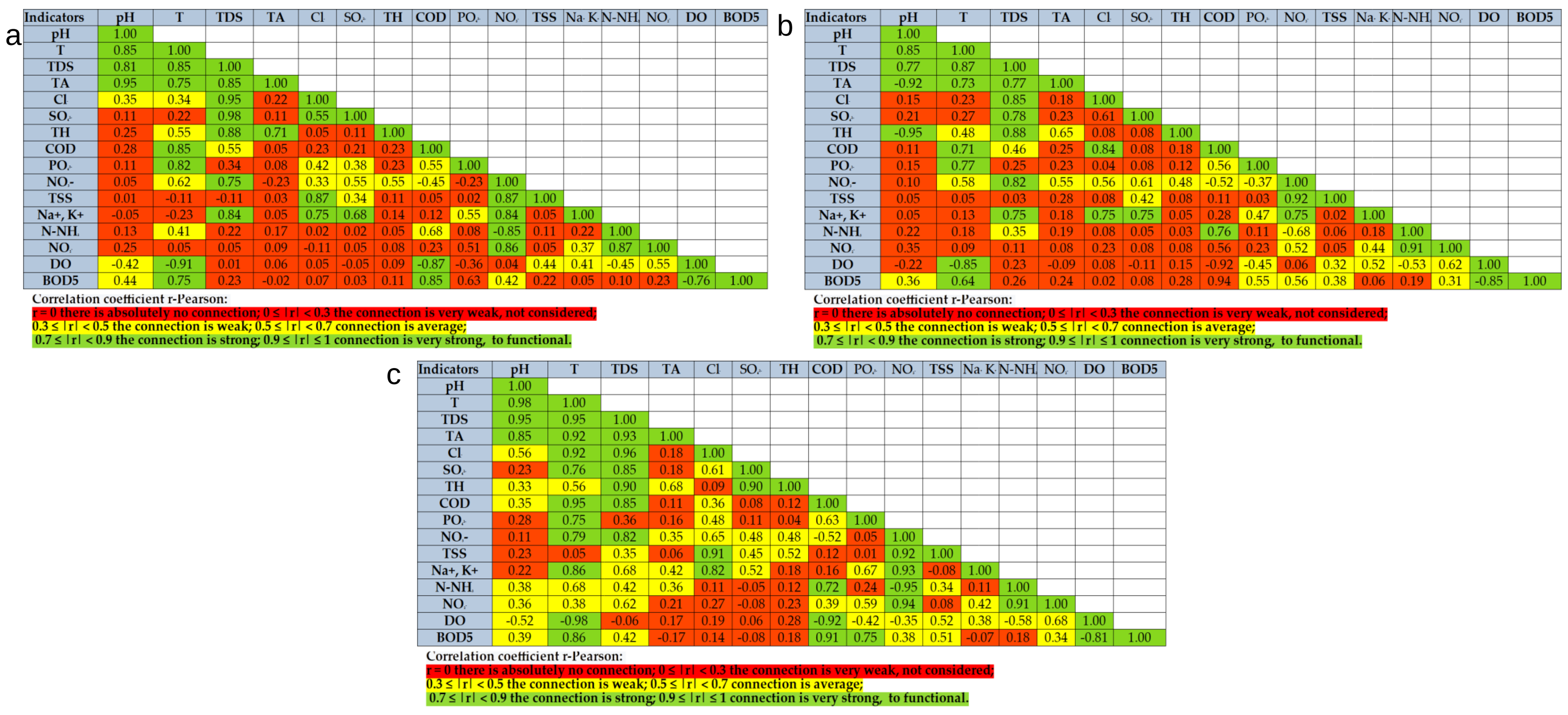

Figure 5. *Persons correlation coefficient for physic and chemical parameters for a - water Styr River, b -make up water CCS of Rivne NPP, c - cooling water CCS of Rivne NPP.*

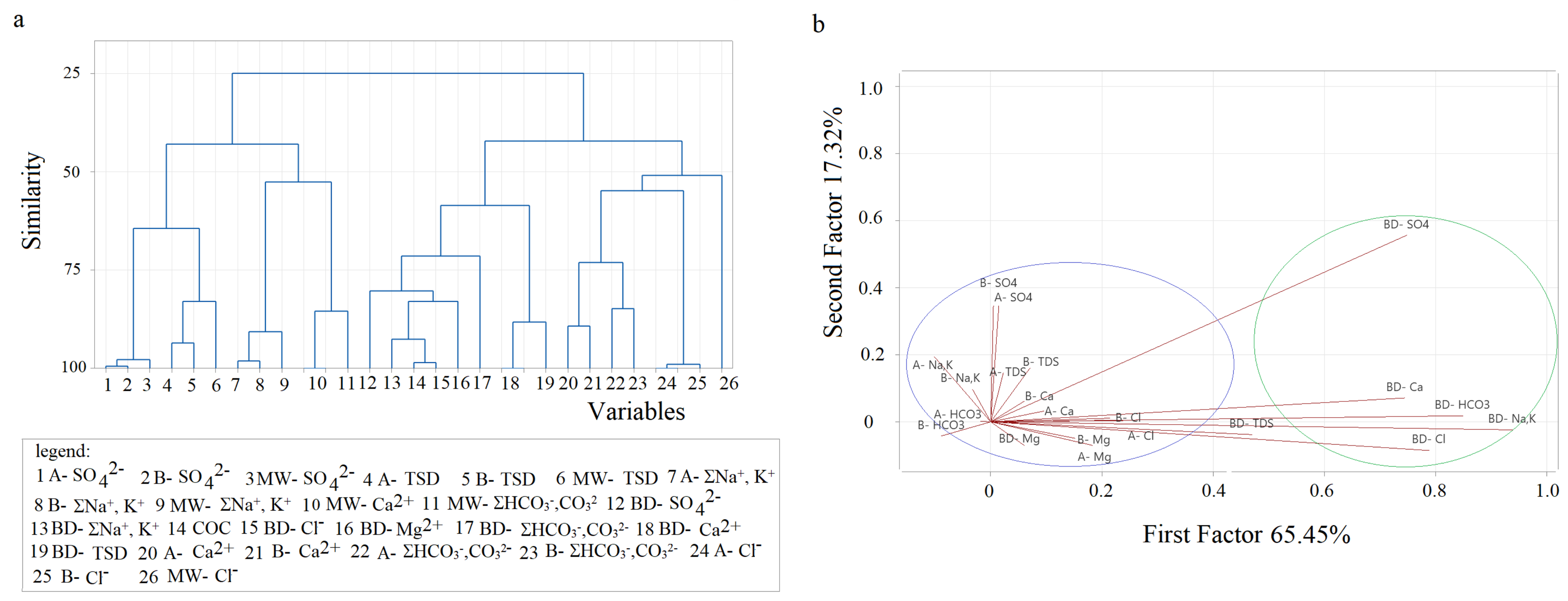

Figure 6. *Dendrogram data the components parameters for water sampled in the sampling locations (a) and generates cluster graph data the components parameters of group water samples (b).*

The value of the actual discharge ADmax of a single PC, which corresponds to the maximum concentration in the return water. The actual annual discharge of the constituents, based on the average (ADav) and maximum (ADmax) values of the water discharge, is significantly lower than the standardised MPD values, indicating a limitation of the uptake of PC with wastewater (Figure 7). The content of the monitored indicators did not exceed the MPC. The discharge of cooling water with low values does not affect the quality indicators of the Styr River, as it ensures that the corresponding MPC value is not exceeded.

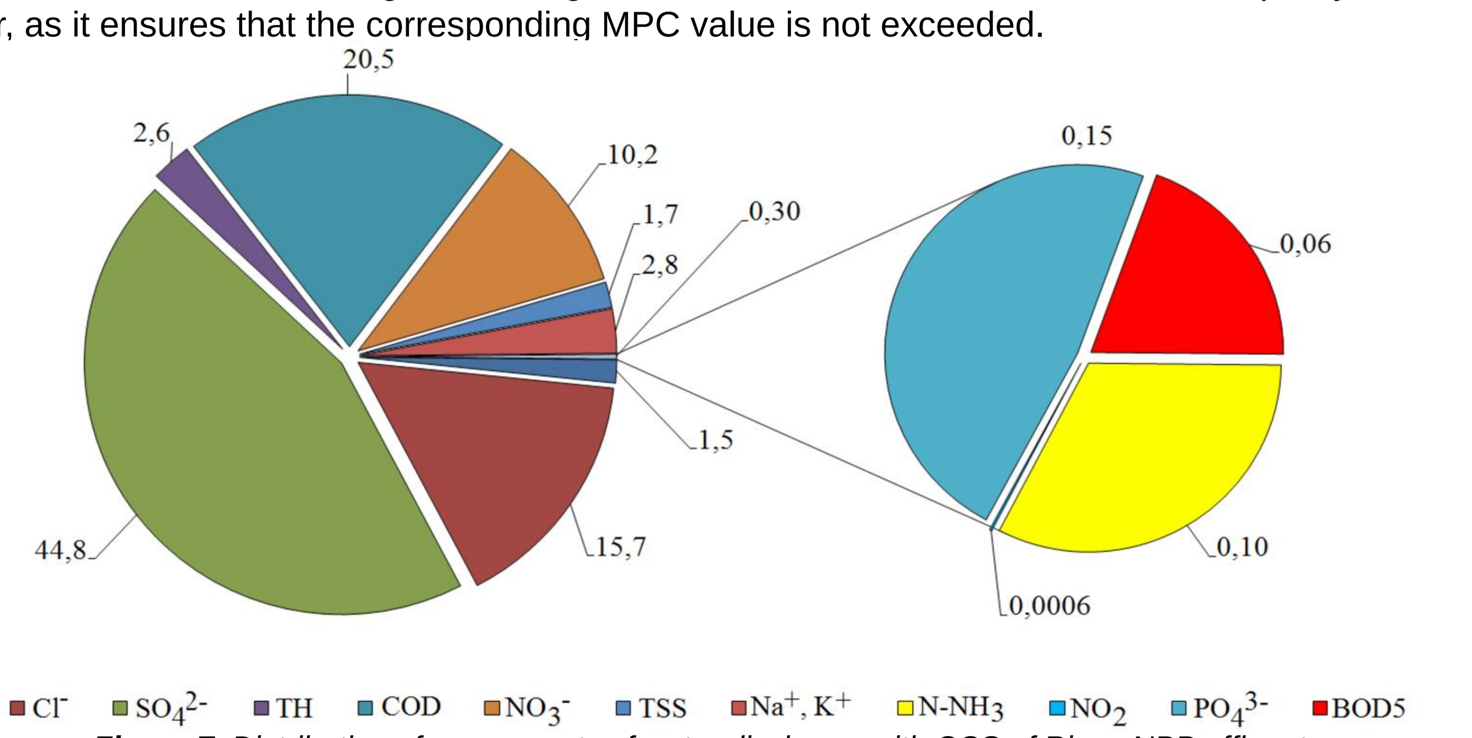

Figure 7. *Distribution of components of water discharge with CCS of Rivne NPP effluent.*

The paper shows the correlation between physical and chemical indicators of the quality of process (make-up and cooling) and discharge CCS wastewater of the Rivne NPP, assesses compliance with the operational standards of the water-chemical regime and the ecological status of the Styr River, a reservoir of the wastewater recipient. Make-up water is added to the CCS in a volume that depends on evaporation, blowdown and other losses. Requirements for make-up water quality parameters are more restrictive than for cooling water. Analysing the chemical composition of CCS make-up and cooling water allows us to determine the limiting parameters and increase the efficiency of CCS. It is advisable to continuously monitor the parameters and assess the quality of the CCS of Rivne NPP return water and Styr River water in the area of water discharge influence to prevent undesirable phenomena.

CONCLUSION

The efficiency and reliability of a NPP is directly dependent on the quality of the water in the cooling system, and the environmental condition in the area of influence of a NPP on compliance with environmental standards. The changes in quality indicators during water treatment in the cooling water treatment plant and discharge of return water CCS are determined. Compliance with the operational standards of the water chemical regime and the ecological status of the Styr River, a reservoir of the return water receiver, were assessed. In general, the studies indicate that there is no negative (non-radiation impact of the PC water discharge with the CCS Rivne NPP effluent on the surface water of the Styr River.

FUTURE WORK / REFERENCES

The prospects for further research will be to identify correlations between the content of constituents and the content of make-up, cooling and return water from RNPP and the Styr River.

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