THE FUTURE PERSPECTIVES OF RECEIVING RIVERS UNDER THE REVISED URBAN WASTEWATER TREATMENT DIRECTIVE

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Abstract

The updated Urban Wastewater Treatment Directive (UWWTD) represents a significant change in the European Union's strategy for better surface water quality management. Addressing the increasing pressures from urbanization, climate change, and industrial activities, the directive introduces stricter regulations and innovative approaches to enhance the treatment and achieve integrated wastewater management. The major goal is to pursue synergies with other EU legislation and to meet the requirements of the Water Framework Directive (WFD), Drinking Water Directive. Key measures include enhanced nutrient removal processes, stricter monitoring of micropollutants, and promoting circular economy principles in water management. The main objective of this research is to examine the impact of the urban wastewater treatment plant on the receiving rivers, in the light of the above-mentioned new regulations. Therefore, the effect of seasonality at different water levels in Veszprem city area (Hungary) was investigated for one year. The monitored water quality indicators were nitrogen and phosphorus nutrients, some specific pollutants containing heavy metal ions (such as Cd(II), Zn(II), Cu(II), and Pb(II)), and residual traces of pharmaceuticals, which were detected mainly in the spring and autumn seasons respectively, in the form of analgesics (e.g. painkillers).

Keywords: *water quality, receiving waterbody, discharged treated wastewater, nitrogen and phosphorus-based nutrients, micropollutants*

1. INTRODUCTION

The updated Urban Wastewater Treatment Directive (UWWTD) represents a significant step forward in the European Union's efforts to protect water bodies from pollution [1]. This directive, which revises the original legislation [2], introduces stricter requirements for the treatment of urban wastewater before it is discharged into the environment, determining the Global Environmental Issues [3]. The primary objective is to reduce the adverse impacts of pollutants such as nutrients, pathogens, and hazardous substances on receiving water bodies, including rivers, lakes, and coastal waters [4,5]. By enhancing the efficiency and effectiveness of wastewater treatment processes [6], the updated directive aims to improve water quality, safeguard aquatic ecosystems, and support the EU in achieving broader environmental and public health goals. Some of the current requirements of the ***EU Urban Wastewater Treatment Directive*** are mentioned as follows**:**

- Wastewater should be collected and treated according to EU minimum standards in all urban areas with population equivalents (p.e.) higher than 2000;
- Secondary treatment of all urban area discharge with >2000 p.e., and advanced treatment in areas with >10 000 p.e. and areas designated as sensitive;
- Discharge from urban wastewater, the food-processing industry, and industry discharging into urban wastewater collection systems must be pre-authorized;

- ***Wastewater treatment plant performance and receiving waters must be monitored***;
- Controls of sewage sludge disposal and reuse of treated wastewater, following a previous revision, complying with maximum allowable concentrations of total phosphorus and nitrogen in wastewater plant discharges into areas sensitive to eutrophication.

In this paper, some of the above-mentioned aspects were pointed out in the frame of a case study of the Veszprémi-Séd Stream, which is the main surface watercourse of the oldest urban areas in Hungary, namely Veszprém.

2. MATERIALS AND METHODS

2.1 Description of sampling sites

Veszprém area lies around 15 km north of the Balaton Lake, which is an important ecological system, being confirmed by its presence on the list of "Wetlands of International Importance as Waterfowl Habitat" established by the Ramsar Convention [7]. In the same time, Veszprém area is famous because include a city with the same name, which is one of the most important administrative, economic, and cultural centres of Hungary. Fig.1. shows the location of Veszprém city in the European and local context, pointing out some characteristics of the Municipal Waste Water Treatment Plant (WWTP), designed to treat wastewater generated by a population of over 100,000 inhabitants. The treated wastewater is discharged in the natural effluent, namely Veszprémi-Séd Stream (marked with blue colour on the associated map from Fig. 1).

Fig. 1. Wastewater treatment plant of Veszprém city, Hungary

Veszprémi-Séd Stream is generally characterized as clean surface water, providing drinking water supply for the 60,000 inhabitants of Veszprém city and residents of the surrounding settlements and for the local industry, but is vulnerable and sensitive to anthropogenic pollution. The middle section of Veszprémi-Séd Stream is located in Veszprém city and according to the River Basin Management Plan, it belongs to the typology category 3M [8]. The stream is high-altitude calcareous with coarse bedrock. The length of the middle section is 25.56 km and the catchment area is 416 km^2. It flows through the city where are different diffuse pollution sources [9], such as wastewater treatment plants, on which this study was focused.

Fig. 2. shows the location of the three monitoring sites along the Stream Veszprémi-Séd (marked with 1 and 2) before and after the discharge of treated wastewater (marked with red color).

Fig. 2 Sampling points in the Veszprémi-Séd stream located in the upstream and downstream positions of the water discharge point from the wastewater treatment plant of the Veszprém city;
1-sampling point above the discharge point (located 50 m in upstream)
2-sampling point below the discharge point (located 100 m in downstream)

2.2 Description of the research methodology

The water quality indicators analyzed are the common nutrients based on nitrogen and phosphorous, the heavy metals ions Cd(II), Zn(II), Cu(II), and Pb(II) [10] and pharmaceutical residues in terms of Diclofenac and Carbamazepine.

The effect of seasonality on the surface water quality was investigated for one year, based on the proposed monitoring program and the obtained database. This monitoring program is implemented in each designated sampling site (Fig.2), involving 2.5 L water samples collected monthly in glass bottles and analysed [10-13], according to the standard methods. Monthly mean sampling results were processed seasonally.

The selected water quality indicators can be used for pollution alerts [14]. Some of the advantages of this program are the reliable measurement methods and low measuring costs. Categorization of the surface water was performed, according to consideration that the treated wastewaters reach the receiving river by direct discharge [15].

3. THE OBTAINED RESULTS

According to WFD [2], the investigated waterbody is of typological type (3M). The pH value corresponding to the geological conditions is 7.7. The conductivity of Veszprém-Séd stream had an average value of 848 µS/cm before the discharge point and 921 µS/cm after the discharge point (Fig.3). The average electrical conductivity measured in the treated wastewater was 986 µS/cm.

Chemical Oxygen Demand (COD) and Total Organic Carbon (TOC) are two important indicators for water quality assessment which are presented in (Fig.4). Both indicators measure the content of organic matter present in water, but they use different analytical methods and refer to various aspects. Generally, the COD/TOC ratio in a given water sample can be constant, but this ratio depends on the type of organic matter and its oxidability.

A seasonal average COD value of 5.4 mg/L was found in the stream, which increased to 44 mg /L after the discharge of treated wastewater from the wastewater treatment plant.

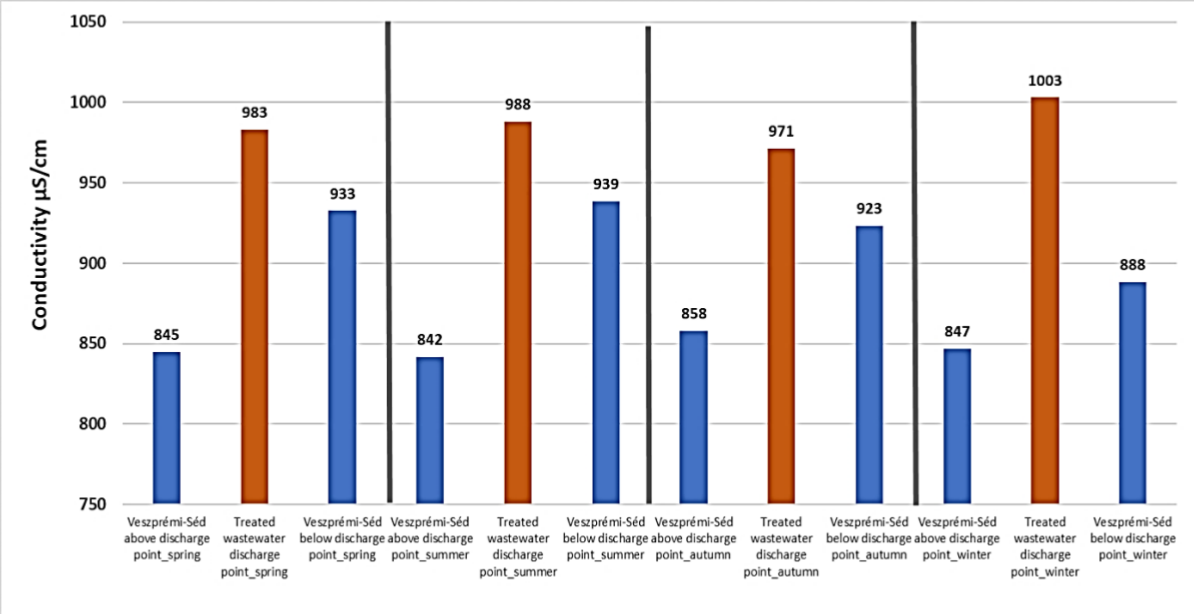

Fig. 3. Electrical conductivity measured in each of the sampling points (before, after, and at the treated water discharge point) during the seasonal monitoring program.

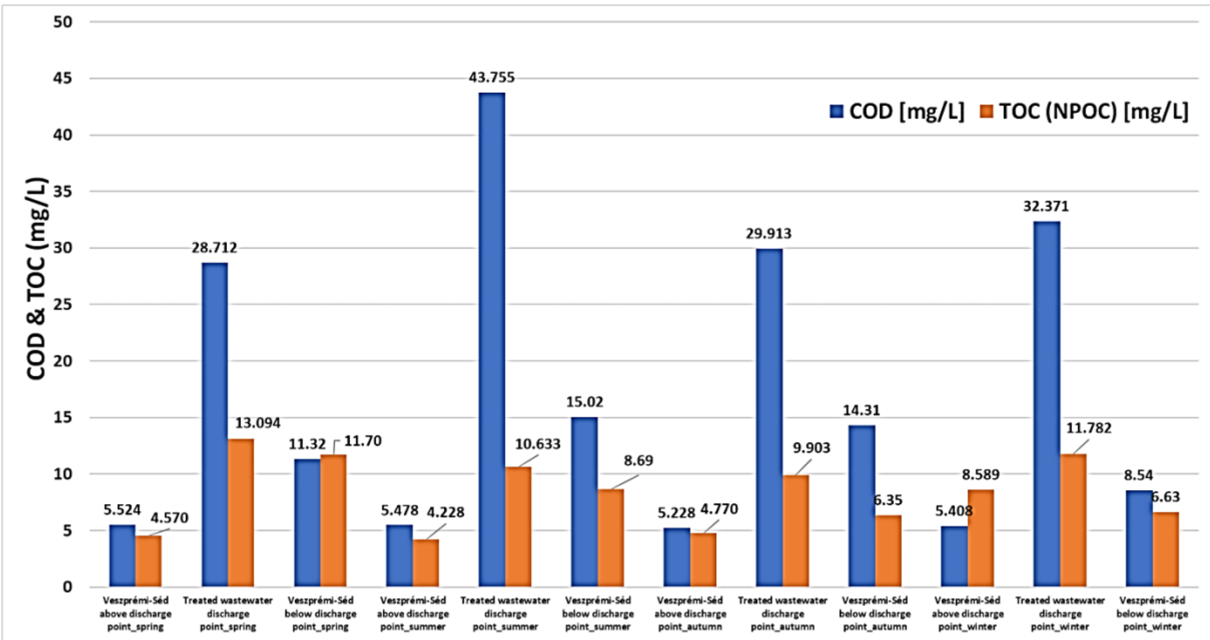

Fig. 4. COD & TOC values measured at the 3 sampling points during the seasonal monitoring program.

It can be seen that the COD/TOC ratio in a watercourse is constant. In the treated effluent, COD is higher than TOC, indicating that not only organic matter, but also other oxidizable substances were present in the water sample (such as: hydrosulphides or sulfides), which contributed to the value of the chemical oxygen demand.

Seasonal changes in the concentration of nitrogen forms (ammonium-N, nitrite-N, nitrate-N, and total nitrogen-TN) in the receiving stream during the seasonal monitoring program are presented in (Fig.5) and respectively in (Fig.6) in the discharge point of treated wastewater from the wastewater treatment plant.

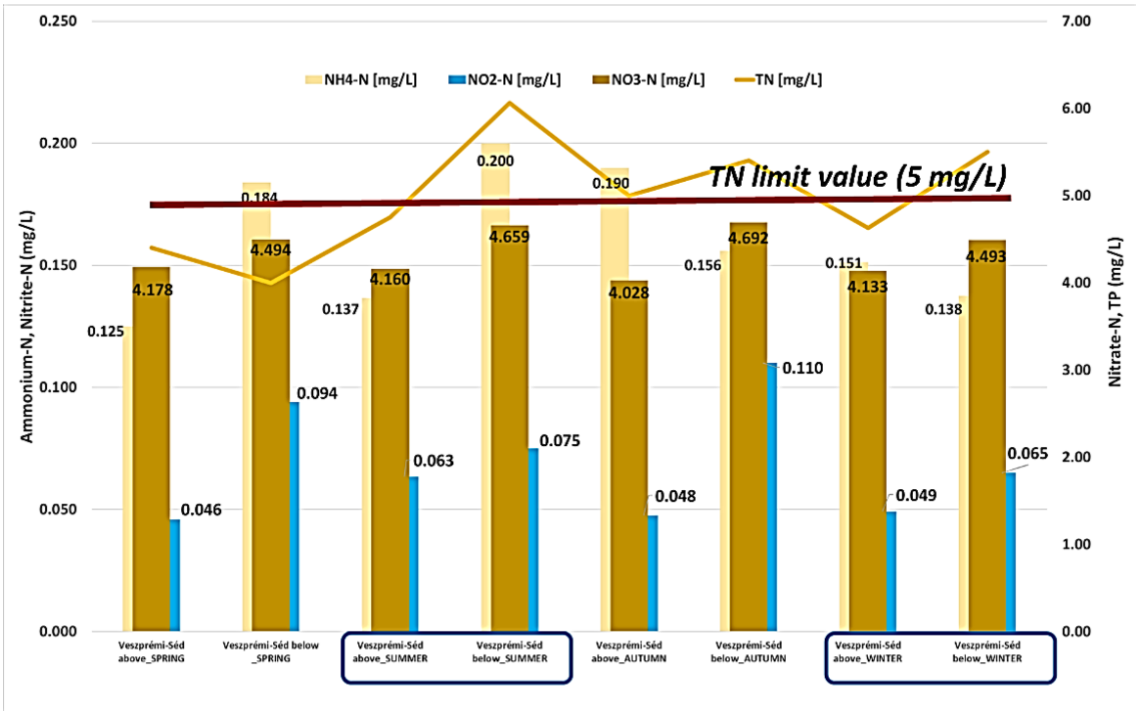

Fig. 5. Seasonal changes in the concentration of nitrogen forms (ammonium-N, nitrite-N, nitrate-N, and TN) in the receiving stream during the seasonal monitoring program.

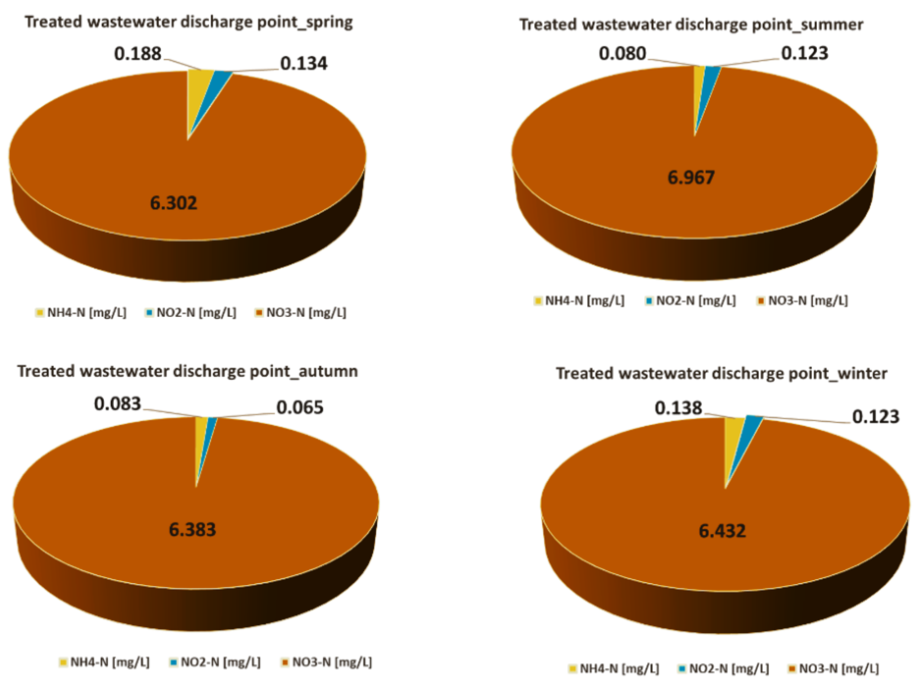

Fig. 6. Ammonium-N, nitrite-N, and nitrate-N concentrations measured in the discharge point of treated wastewater during the seasonal monitoring program.

Seasonal changes in the concentration of Phosforus forms (in term of Orthphsphate-P) in the receiving stream (upstream and downstream) and respectively in the discharge point of treated wastewater from the wastewater treatment plant, during the seasonal monitoring program are presented in (Fig.7).

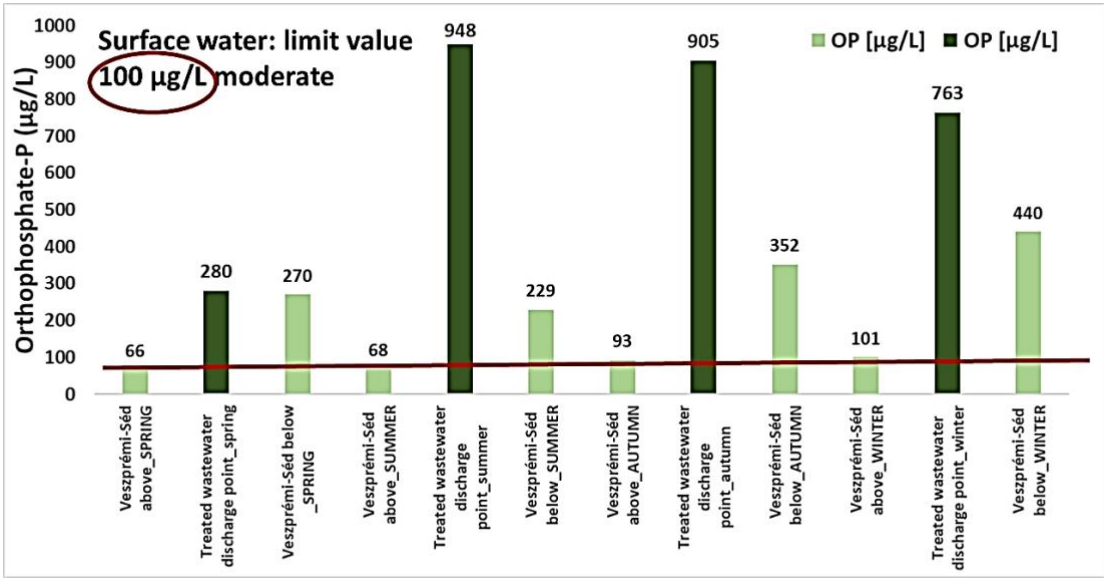

Fig. 7. Change of Orthophosphate-P concentration in the receiving stream and in the discharge point of treated wastewater during the seasonal monitoring program.

The specific pollutants are related to the concentration of the heavy metal ions, such as: Zn(II), Cu(II), Pb(II) and Cd(II)) presented in (Fig.8), and respectively residual traces of pharmaceuticals, in the form of analgesics (e.g. painkillers: Diclofenac and Carbamazepine) are presented in (Fig.9).

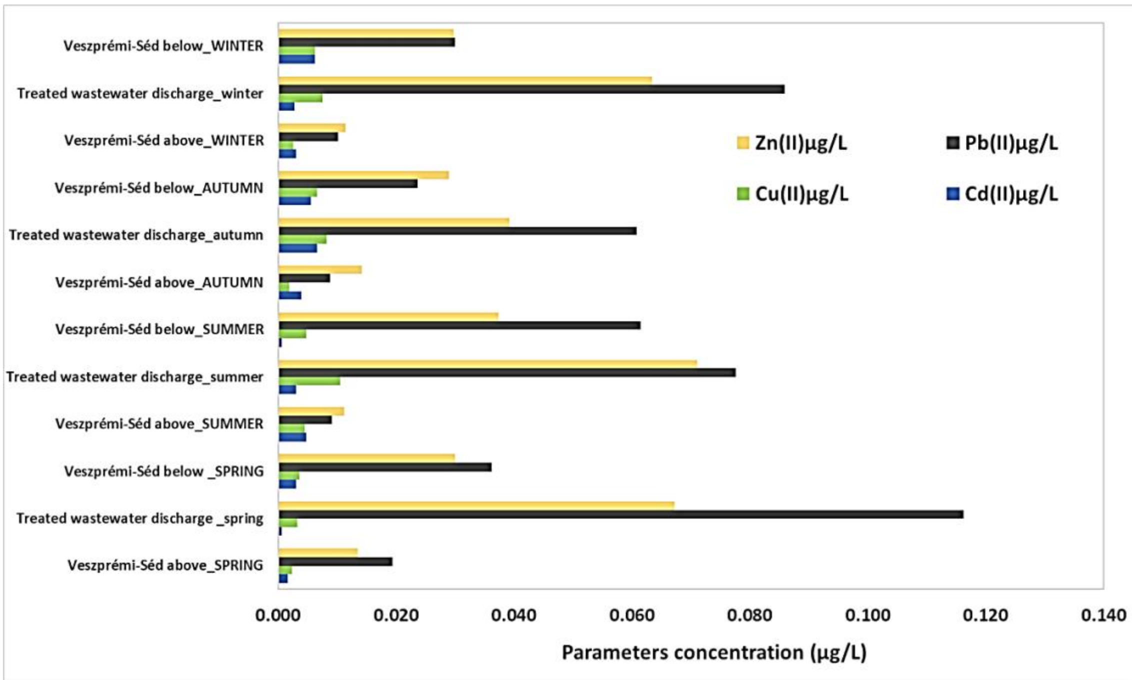

Fig. 8. Changes in heavy metals concentrations in the receiving stream and in the discharge point of treated wastewater during the seasonal monitoring program.

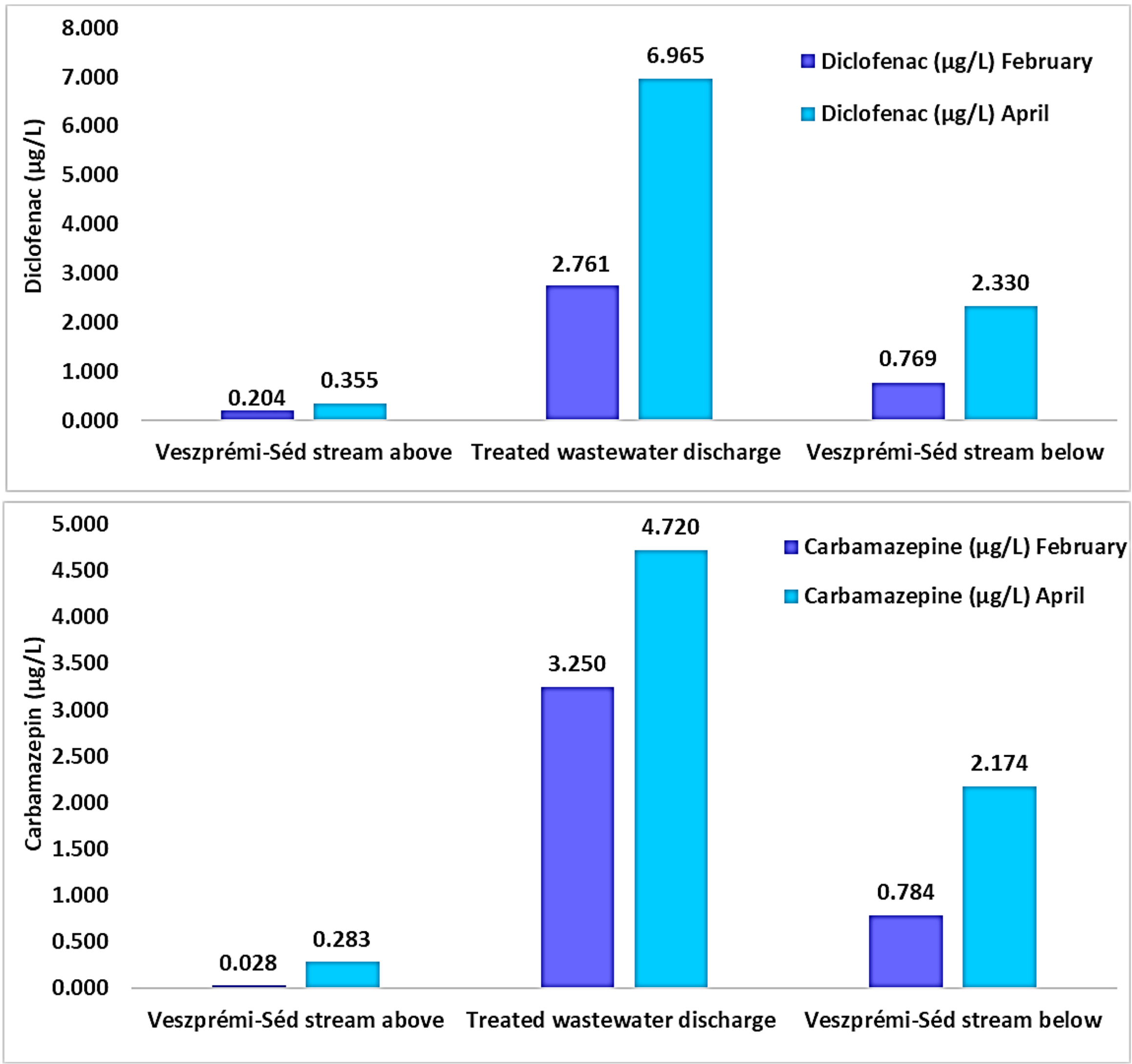

Fig. 9. Changes in Diclofenac and Carbamazepine concentrations in the receiving stream and in the discharge point of treated wastewater during the seasonal monitoring program.

4. DISCUSSIONS

The treated wastewater from the Wastewater Treatment Plant of Veszprém city has an average concentration of nitrate-N (6.9 mg/L) higher than the permitted limit (5.7 mg/L) in all seasons, except during the winter time.

The forms of nitrogen measured in the treated wastewater were below the emission limit values specified for the WWTP (limit values [16]: TN=20 mg/L, Ammonium-N=10 mg/L, and Nitrate-N=5.7 mg/L). The Fig.3 show that the average value of the ammonium-N concentration is higher after the discharge point in the Stream of Veszprémi-Séd during the spring, summer and autumn periods.

In the case of the Veszprém-Séd stream, after the discharge point and mixing zone, the average TN value exceeded the maximum allowable concentration of 5 mg/L during the summer, autumn, and winter, resulting in inadequate water quality.

In the case of orthophosphate-P, the average concentration values measured after the Veszprém-Séd discharge point exceeded the permitted limit in every season. In the case of orthophosphate-P, based on the measured values, the Veszprém-Séd stream has a moderate water quality.

The measured concentrations of the heavy metals are below than the permitted limit value for each metalic ion, including the Veszprém-Séd stream is the category of waterbody with good water quality.

As it is expected, the pharmaceutical residues, due to their high toxicity have a significant impact on the receiving waters, but fortunately their concentration (in terms of painkillers: Diclofenac and Carbamazepine) were detected in Veszprém-Séd stream as traces after discharge of treated wastewater from WWTP, except in the spring season.

5. CONCLUSIONS

The water quality along the Veszprémi-Séd Stream fluctuates because it receives very different pollution loads from various types of pollution sources across its different sections while flowing through agricultural and urban areas. Therefore, significant differences were found in the values of water quality indicators [17], not only along the water course but in the same sampling points during each yearly season. The water quality of the middle section of Veszprémi-Séd ranges between moderate and poor [8, 16], which is caused by nutrient pollution (ammonium-N, nitrite-N, nitrate-N, and orthophosphate-P). The good water quality status of the stream is expected to be achieved by 2027. As a result, a careful investigation and monitoring of the water quality should be performed. In this context, three sampling sites located before and after the discharge of the Municipal Waste Water Treatment Plant of Veszprém city were monitored, from which, one monitoring point was set up directly at the effluent of the WWTP, where the results pointed out that the forms of nitrogen were below the emission values limit specified for the WWTP.

Based on these measurements, the water quality is classified as moderate in spring and summer, and poor in autumn and winter.

Using such a water quality database and time series regression models could forecast the water quality indicators for the Veszprém area, which is an important ecological area. Additionally, the use of seasonal ARIMA or ARIMAX models [7] (when online data measurement becomes available) will include both seasonal trends and external hydrological variables (precipitation, water flux, etc.) into the models for more accurate forecasting potential.

The primary aims of the revised Directive highlight the improvement of water quality by addressing remaining urban wastewater pollution, focusing on more stringent limits on nitrogen and phosphorous and establishing limits values for micropollutants such as pharmaceutical residues (13 components identified).

ACKNOWLEDGMENTS

The presented research was carried out within the framework of the Széchenyi Plan Plus program with the support of the RRF-2.3.1 21-2022-00008 project.

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