Report nº 3 (2020)

of the postdoctoral project

"Streamwater quality real-time data analysis"

Acronym: SQRTDA

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SUCEAVA, 2020

CONTENT

1. Introduction

“Streamwater quality real-time data analysis” is a scientific project of postdoctoral research funded by UEFISCDI, which aims to implement a Suceava River monitoring network upstream and downstream of the homonymous city for the collection of data on the physical and chemical properties of river water. The data obtained serves scientific analyzes and the results of the measurements can be viewed by the public in real time.

In order to achieve the project objectives, the following water quality parameters were chosen (minimum parameters required): electrical conductivity, dissolved oxygen, pH and ORP (Oxidation Reduction Potential). Additional parameters are added to these parameters: water level, water temperature.

The monitoring is performed upstream and downstream of the city of Suceava to capture the characteristics of the water immediately before entering the city and, respectively, the impact of the city on the flowing water downstream, where it can be optimally measured after the waters from the city's sewage treatment plant are well mixed with the waters of the river.

In accordance with the provisions of the work plan of the project from the Funding Application and those of the Implementation Plan of the project from the Financing Contract, the following progress has been made in 2020 in the implementation of the project:

- real-time monitoring of water quality and recording of measurement data;

- verification in the field of the operation and security of the equipment and the representativeness of the monitoring sites;

- analysis of measurement data through scientific methods;

- writing scientific materials;

- writing open access scientific articles with ISI indexing; 1 scientific article was published that use the data obtained in the project, thank the project and can be found in the scientific journal Water (ISSN 2073-4441; CODEN: WATEGH), with impact factor 2,524 (Clarivate Analytics), being in Q2 (yellow area)) according to the Impact Factor criterion:

Briciu, A.-E., Mihăilă, D., Graur, A., Oprea, D.I., Prisăcariu, A., Bistricean, P.I. Changes in the Water Temperature of Rivers Impacted by the Urban Heat Island: Case Study of Suceava City. Water 2020, 12, 1343, DOI: 10.3390/w12051343 - https://www.mdpi.com/2073-4441/12/5/1343; a second article is under review;

- organizing a scientific workshop at the end of the project (conducted online due to the epidemiological context);

- writing the final scientific report of the project.

The presentation of the scientific results of the project at international scientific conferences in 2020 could not be realized due to traffic restrictions caused by the coronavirus pandemic, the establishment of a state of emergency at national level and the quarantine of the city of Suceava.

The project was extended by 31 days by invoking force majeure as a result of the COVID-19 pandemic and to complete the project in good conditions.

In the annual reports and previous studies, emphasis was placed on the selection of monitoring sites, on the identification of appropriate analysis methods for the selected parameters, on the analysis of time series with a length of one year (from own measurements) and on the analysis of the daily fluctuations of the monitored parameters.

In 2020, in this report and in the published or under review articles, the quality index of Suceava River water, the thermal pollution of river water, the impact of urban heat island on the river and the bidirectional relationship of the caloric exchange between river and urban atmosphere are presented both at the annual scale and at the diurnal scale and some analyzes are offered that can serve to estimate the future evolution of some studied parameters.

According to the initial expectations, the monitoring system is functional even after the end of the project and continues to offer online the real-time evolution of the monitored parameters. It will also provide scientific information for future studies.

2. Study area

The Suceava River runs through the middle of the city of Suceava (fig. 1) and is affected by the city through the wastewater it receives from the city's wastewater treatment plant, through uncontrolled wastewater discharged in some parts of the city and through the urban heat island. Suceava city has a population of approximately 100,000 inhabitants (including commuters), while the metropolitan area of the city reaches 150,000 inhabitants. The population affects through the uncontrolled discharges the water quality of some local, small, tributary rivers of the Suceava River, such as: Dragomirna, Șcheia, Pârâul Cetăţii, Podu Vatafului.

The water quality monitoring points within the project in 2020 have the same location as in 2019: upstream of Suceava, the monitoring site is behind the Mihoveni mobile dam (47.681°N, 26.2°E - fig. 2); the monitoring point downstream of the city of Suceava is near the locality of Tișăuți (47.618°N, 26.323°E - fig. 3), downstream of the former landfill of the city and the effluent of the urban water treatment plant.

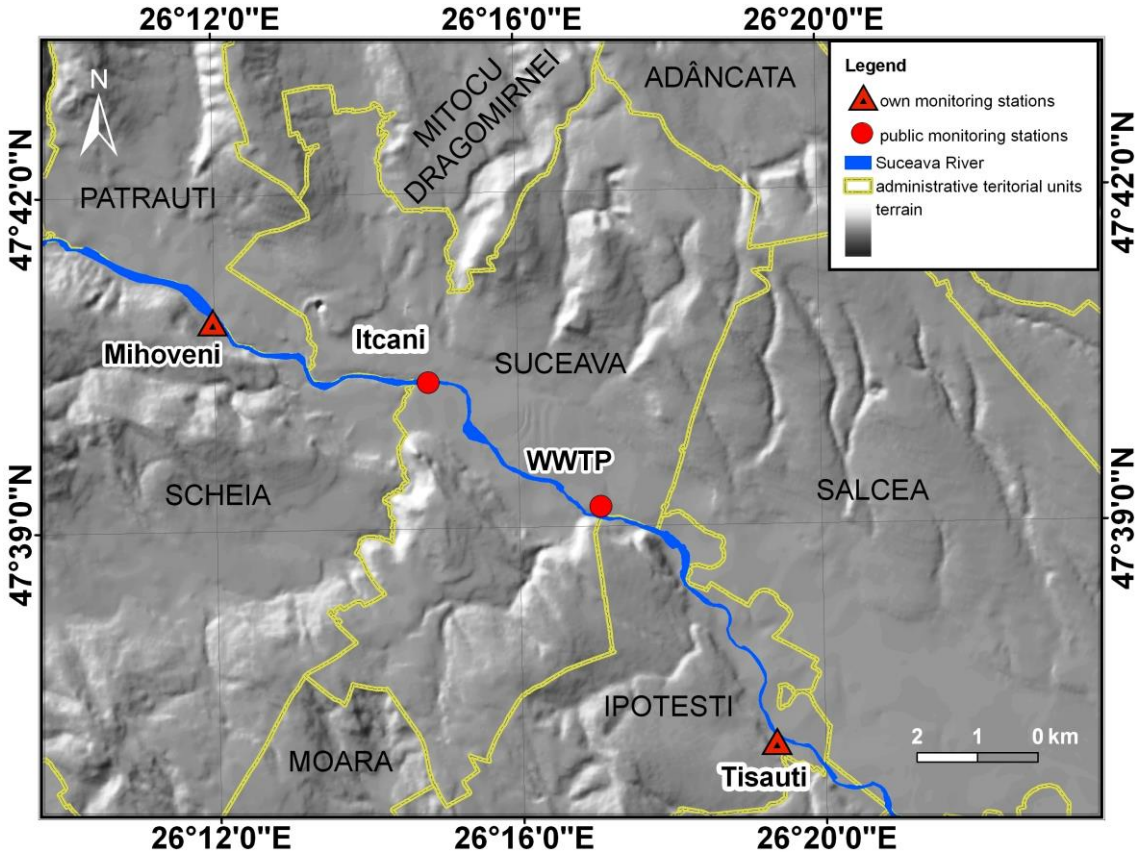


Fig. 1. Location of monitoring sites in relation to Suceava city.

Fig. 2. Permanent monitoring site upstream of Suceava city (Mihoveni).

Fig. 3. Site of permanent monitoring of Suceava River downstream of Suceava city.

This report presents analyzes of some data obtained in the monitoring sites shown in fig. 1: the 2 sites with the maintenance ensured within the project (Mihoveni and Tişăuţi), the Iţcani hydrometric station (Suceava River) and the treatment plant of the city of Suceava (treated waters discharged).

More details about the study area (such as data on flows and urban tributaries) can be found in the scientific articles that analyze the data obtained within the Suceava River water monitoring system, published in 2019 and 2020, listed at: http://water.usv.ro/publications.php

The 2020 study on the impact of the heat island of Suceava on the river of the same name ("Changes in the Water Temperature of Rivers Impacted by the Urban Heat Island: Case Study of Suceava City") analyzes a larger area of land, which includes the metropolitan area of the city. This study, conducted in collaboration by 2 research teams, included several sites for monitoring atmospheric parameters. More details can be found in the mentioned open access article.

3. Data and methods

Each of the 2 monitoring sites within the project has a pair of instruments - for measuring water and air parameters and for transmitting data to a server. The data collected by the sensors are transmitted by Tube 300R to the server, from where they can be viewed through the HydroVu application, incorporated in the research project website on the DATA page, accessible through the menu (http://water.usv.ro/data.php).

Each site of permanent monitoring of the water of the Suceava River has a set of instruments consisting of In-Situ equipment, as follows:

- AquaTROLL 500 multiparameter sonde, having sensors for measuring the following streamwater parameters: pressure/level (accuracy: ± 0.1% full scale (9 m), resolution: 0.01% full scale), temperature (accuracy: ± 0.1°C, resolution: 0.01°C), electric conductivity (accuracy: ± 0.5% of reading +1 µS/cm, rezoluție: 0.1 µS/cm), dissolved oxygen (accuracy: ± 0.1 mg/L, resolution: 0.01 mg/L), pH (accuracy: ± 0.1 unități pH , resolution: 0.01 pH) and ORP (accuracy: ± 5 mV, resolution: 0.1 mV) – the sensors meet the precision criteria mentioned in the Funding Application;
- Tube 300R telemetry unit - instrument with the ability to temporarily store and transmit data from measurements, being also equipped with a barometer (to compensate the air pressure measured by the AquaTROLL 500, so to obtain the water level).

The data analyzed in this scientific report and in the scientific articles of 2020 correspond in particular to the monitoring period 1 January 2019 - 31 December 2019. During the one-year period (365 days) mentioned, the data were collected on an hourly basis.

In the scientific analyzes carried out in 2020, new methods were used. The methods are described in detail in the articles and, in part, in this report (especially if a method is used only here, not in the articles). Thus, the maps regarding the urban heat island used the IDW (inverse distance weighted) method for the optimal interpolation of the air parameter values (IDW was applied within ArcGIS). For the three-dimensional detailing of the temporal evolution of the water temperature of Suceava River, surface plots were used (these plots are obtained through the “surf” function in MATLAB). ANCOVA (analysis of covariance) was used to show, from a statistical point of view, the degree of dependence of a variable (parameter) on a number of variables (parameters) that could explain the variation of the first variable. In this analysis, the degree of matching of the values obtained by a linear regression model with the real values

was calculated and Type III SS tables (analysis of the sum of squares) were realized - these tables estimate the contribution of each explanatory variable to the mentioned model by eliminating one variable per turn and calculatinf the effect of this elimination on the quality of the model. ANCOVA was done with XLSTAT.

In the analysis of the relations between the monitored parameters of Suceava River water, the Principal Component Analysis (PCA) was also used, which is suitable for finding similarities in the evolution of time series with multivariate data. PCA was performed in XLSTAT.

Additional wavelet analyzes were performed compared to 2019. Thus, classical/simple, but also multiple (MWC) wavelet coherence analyzes (WTC) were performed - in the latter case, 2 parameters are used to find an evolution consistent with that of the chosen main parameter. These analyzes were performed in MATLAB.

In order to make evolution predictions of some monitored parameters, the "fittestWavelet" function was used within the R program. This function is part of the TSPred function group. The function uses the wavelet transformation to decompose time series into mathematically analyzable components in order to make predictions. Details of the scripts used, options, inputs (arguments, values) and outputs (examples) can be found at: https://rdrr.io/cran/TSPred/man/fittestWavelet.html

For the synthetic analysis of the water quality of Suceava River, a water quality index (WQI) was calculated through a special formula, adapted to the parameters available for calculating such an index, widely used internationally, but with extremely variable/flexible calculation methods.

4. Analyses

NOTE: Some analyses and observations have been removed from this report under the embargo policy in order to ensure the research team's priority in publishing results in peer-reviewed journals. The full report is deposited at UEFISCDI.

The monitoring of Suceava River waters in the period 2018-2020 showed that there are several periodicities that modulate the evolution of the measured parameters. The most important such cyclicities, detectable in the time series obtained so far, are the annual periodicity and the daily periodicity. The mentioned periodicities are caused by the direct and indirect environmental consequences of the variation of the air temperature.

To exemplify the variations specific to an entire calendar year, we will analyze the year 2019. The hourly measurements made were summarized in tables 1-3, where the monthly and annual averages, the annual standard deviations are calculated and the monthly and annual minimum and maximum values are highlighted.

The monthly averages of dissolved oxygen (OD) were higher at Mihoveni than at Tişăuţi. The lower values downstream of the city are caused by the chemical consumption of oxygen, which is higher downstream, by various water contaminations and by the increase in water temperature. The pollutants come from various illicit discharges of wastewater and from the treatment plant. The average annual difference between Mihoveni and Tişăuţi is 2 mg/L. The lowest minimum hourly values were registered in Tişăuţi, where values below 5 mg/L appear sporadically, especially during low waters. Suceava River water at Tişăuţi is frequently loaded with decomposing organic matter (e.g. faeces discharged from the spill upstream of the treatment plant) and sludge from the treatment plant, which leads, on the one hand, to increased biochemical oxygen consumption and, on the other hand, to the clogging of the monitoring site from Tişăuţi with various colloids that cause the local reduction of the oxygen concentration in the water. This deficiency of the site was partially solved by increasing the frequency of visits to the monitoring site for manual cleaning of the probe and by reducing the time interval between 2 successive automatic cleaning of the sensors, performed by the wiper attached to AT500 (once at 12h).

The water temperature of Suceava River is higher downstream of the city, mainly due to the waters discharged by the treatment plant and secondarily due to the urban tributaries, very affected by the island of urban heat. The average annual difference between the 2 sites was ~ 0.5 ° C.

Table 1. Mean, minimum and maximum monthly values of the water parameters of the Suceava river studied at the monitoring point upstream of the city of Suceava (at Mihoveni) in 2019.

	DO (mg/L)	SC (µS/cm)	ORP (mV)	pH (unit)	level (m)	temperature (°C)
monthly averages						
J	13.1	587.1	427.5	8.4	0.7	0.2
F	12.7	498.5	432.6	8.5	0.8	1.8
M	11.6	424.9	422.2	8.5	0.8	5.9
A	10.7	410.9	405.9	8.5	0.8	10.0
M	9.7	369.0	394.7	8.4	1.0	14.4
J	8.6	414.1	372.7	8.4	0.9	20.6
J	8.6	493.2	424.3	8.5	0.8	21.6
A	7.8	471.1	423.4	8.5	0.8	22.5
S	8.4	514.5	455.7	8.5	0.7	17.9
O	9.8	523.8	459.5	8.6	0.7	12.7
N	11.0	575.1	462.3	8.7	0.7	8.0
D	12.8	619.5	468.0	8.8	0.6	2.5
monthly minima						
J	11.9	554.9	378.2	8.3	0.7	-0.1
F	11.6	386.8	399.1	8.3	0.7	-0.2
M	10.4	331.0	374.5	8.3	0.8	2.1
A	8.8	275.9	376.4	8.2	0.7	5.4
M	7.3	224.6	318.8	7.9	0.5	6.8
J	7.3	251.4	293.1	7.9	0.7	13.5
J	5.9	309.8	373.0	8.2	0.7	15.1
A	5.2	400.2	374.9	8.3	0.7	17.2
S	5.3	482.0	430.0	8.3	0.6	11.9
O	8.0	486.7	449.1	8.4	0.7	8.3
N	8.8	531.1	454.2	8.6	0.6	1.6
D	10.9	570.2	461.3	8.6	0.6	-0.1
monthly maxima						
J	14.7	659.2	447.6	8.6	0.8	3.3
F	13.9	573.1	449.2	8.5	1.0	4.2
M	13.8	517.8	443.1	8.6	1.0	10.4
A	12.2	489.3	435.8	8.6	1.4	16.4
M	11.6	444.7	431.2	8.6	1.4	20.7
J	10.0	537.8	444.0	8.6	1.5	25.5
J	10.9	543.2	459.0	8.6	1.1	25.1
A	9.9	550.9	457.8	8.7	0.9	28.6
S	10.7	548.0	469.5	8.6	0.7	25.0
O	12.3	583.7	470.3	8.7	0.7	16.9
N	12.9	610.7	471.2	8.8	0.7	11.4
D	15.2	687.0	474.9	8.9	0.7	5.6

Table 2. Mean, minimum and maximum monthly values of the water parameters of the Suceava river studied at the monitoring point downstream of the city of Suceava (at Tișăuți) in 2019.

	DO (mg/L)	SC (µS/cm)	ORP (mV)	pH (unit)	level (m)	temperature (°C)
monthly averages						
J	12.4	699.2	409.7	8.3	0.8	0.6
F	12.2	568.9	371.4	8.4	1.0	2.0
M	10.4	477.2	370.7	8.1	1.0	6.2
A	8.5	459.8	333.4	8.5	1.0	10.3
M	8.4	403.3	328.0	8.3	1.4	14.8
J	7.5	444.3	288.5	8.3	1.3	21.0
J	6.1	536.7	297.9	8.1	0.8	22.0
A	6.1	529.1	256.9	8.1	0.7	22.6
S	6.0	590.2	305.7	7.8	0.5	18.3
O	7.2	605.9	314.2	7.8	0.5	13.1
N	7.8	669.4	346.6	7.9	0.4	8.6
D	8.3	734.1	411.6	7.9	0.4	3.5
monthly minima						
J	9.3	626.8	337.2	7.6	0.7	-0.1
F	10.3	440.4	323.9	7.8	0.8	-0.1
M	8.3	371.7	287.4	7.9	0.9	2.5
A	5.4	301.1	286.4	8.0	0.9	6.3
M	4.8	250.5	289.9	7.6	1.1	7.0
J	3.7	283.3	220.8	7.9	0.9	14.3
J	2.5	361.3	219.7	7.7	0.7	16.7
A	2.9	445.7	197.0	7.6	0.5	17.7
S	2.1	549.0	202.3	7.5	0.4	12.4
O	3.6	516.0	265.9	7.6	0.4	9.0
N	4.5	629.1	282.4	7.7	0.4	3.7
D	1.3	666.3	347.1	7.7	0.3	0.4
monthly maxima						
J	15.8	778.2	460.4	8.6	0.9	3.7
F	13.9	708.3	442.8	8.6	1.2	4.8
M	13.7	576.8	412.2	8.6	1.4	11.5
A	11.0	526.9	391.6	9.1	2.1	18.1
M	11.1	471.3	378.2	8.8	2.2	21.6
J	9.8	606.3	364.0	8.8	2.6	26.9
J	9.1	589.0	345.8	8.9	1.4	26.5
A	10.6	593.4	312.7	8.6	1.0	28.7
S	10.0	625.6	425.1	8.3	0.6	25.5
O	11.1	657.9	359.1	8.4	0.6	17.9
N	11.3	725.2	441.8	8.2	0.5	12.1
D	15.4	870.4	445.6	8.3	0.5	6.0

Table 3. Annual (2019) statistical indicators of the water parameters of the Suceava River studied in the two monitoring points.

	DO (mg/L)	SC (µS/cm)	ORP (mV)	pH (unit)	Level (m)	temperature (°C)
Mihoveni						
average	10.39	491.89	429.09	8.52	0.78	11.54
minimum	5.21	224.61	293.09	7.89	0.51	-0.20
maximum	15.16	687.02	474.87	8.92	1.47	28.58
standard dev.	1.94	81.94	32.21	0.13	0.13	7.99
Tișăuți						
average	8.38	559.97	336.12	8.13	0.82	11.97
minimum	1.29	250.51	196.97	7.47	0.33	-0.14
maximum	15.81	870.40	460.42	9.11	2.56	28.65
standard dev.	2.50	108.36	53.76	0.29	0.37	7.90

The water of Suceava River is, on an average day, warmer than the urban air during the night and colder than this during the day. In 2019, the river water was warmer than the air in the first half of the year and colder in the rest of the year. During March-June, the river water was colder than the urban air and the heat transfer was predominantly from the city into the river. During the summer rains, there is sometimes a significant increase in the water temperature of Suceava River downstream of the city due to the fact that the rains wash the warmer (than the surroundings) surfaces of the city. The specific conductivity (SC, at 25°C) indirectly shows the increase of the chemical load of the river waters downstream of the city. The smallest differences between downstream and upstream are in the warm semester, more precisely in the rainiest months; the higher river flow better dilutes the various pollutants in the water. In December and January, the average monthly difference is greater than 100 µS/cm. The water level had very low values in the autumn-winter period due to the little atmospheric precipitations. The end of spring-beginning of summer period was within normal parameters, and the average annual flow in 2019 in the city of Suceava was 19.5 m^3/s at Iţcani hydrometric station. ORP (redox potential) is a measure of the capacity of an electron transfer solution. Oxidation (loss of electrons) and reduction (gain of electrons) are complementary processes. The stronger the solution, the stronger the negative ORP; oxidizing solutions have positive ORP values. The effluent of the treatment plant has a negative ORP and its impact on the Suceava River is observed in the reduction of the ORP value of Suceava River downstream of the city. The average monthly difference between the 2 monitoring points was 92.97 mV during 2019. The pH values were lower at Tişăuţi also due to the pollution. The values oscillate downstream of the city around 8 units, while, upstream of

the city, the average value is 8.5 units. The measured pH values are automatically compensated for temperature changes by the AT500 instrument. An annual cyclicity of the temporal evolution of the monitored parameters can be observed at the measurement points upstream and downstream of the city (except for the pH), as observed in figures 4 and 5.

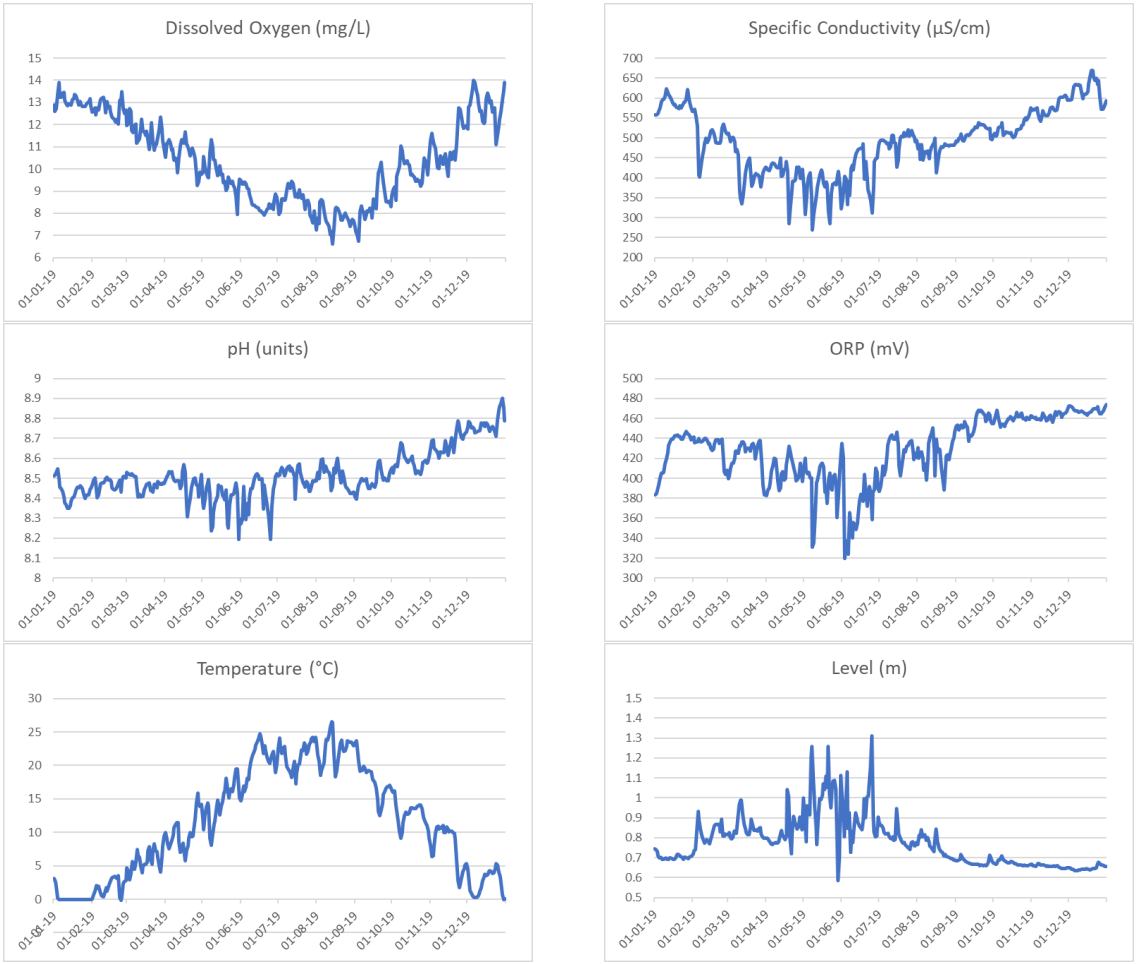


Fig. 4. The evolution of the hourly values of the monitored parameters of Suceava River at Mihoveni monitoring point in 2019.

It is possible to observe, on an annual scale, the complementary evolution of some parameters. There is an almost antiphase relationship between dissolved oxygen and water temperature (Pearson correlation coefficient: -0.95 upstream and -0.74 downstream), on the one hand, and a similar link between specific conductivity and water level also exists (-0.77 upstream and -0.81 downstream correlation coefficient), on the other hand. The consistent gap between the dissolved oxygen-temperature correlation coefficients is caused by the anthropogenic contribution to the change of the dissolved oxygen concentration downstream of the city. During the rainy period from late spring to early summer, the specific conductivity values reach similar minima (below 300 µS / cm) in both permanent monitoring points, indicating that this is a good time to identify intense episodes of self-purification of Suceava River.

In the case of the ORP, values lower than the annual average were found during the warm semester of the year. The ORP is not compensated for changes in water temperature due to the multitude of factors that determine its values.

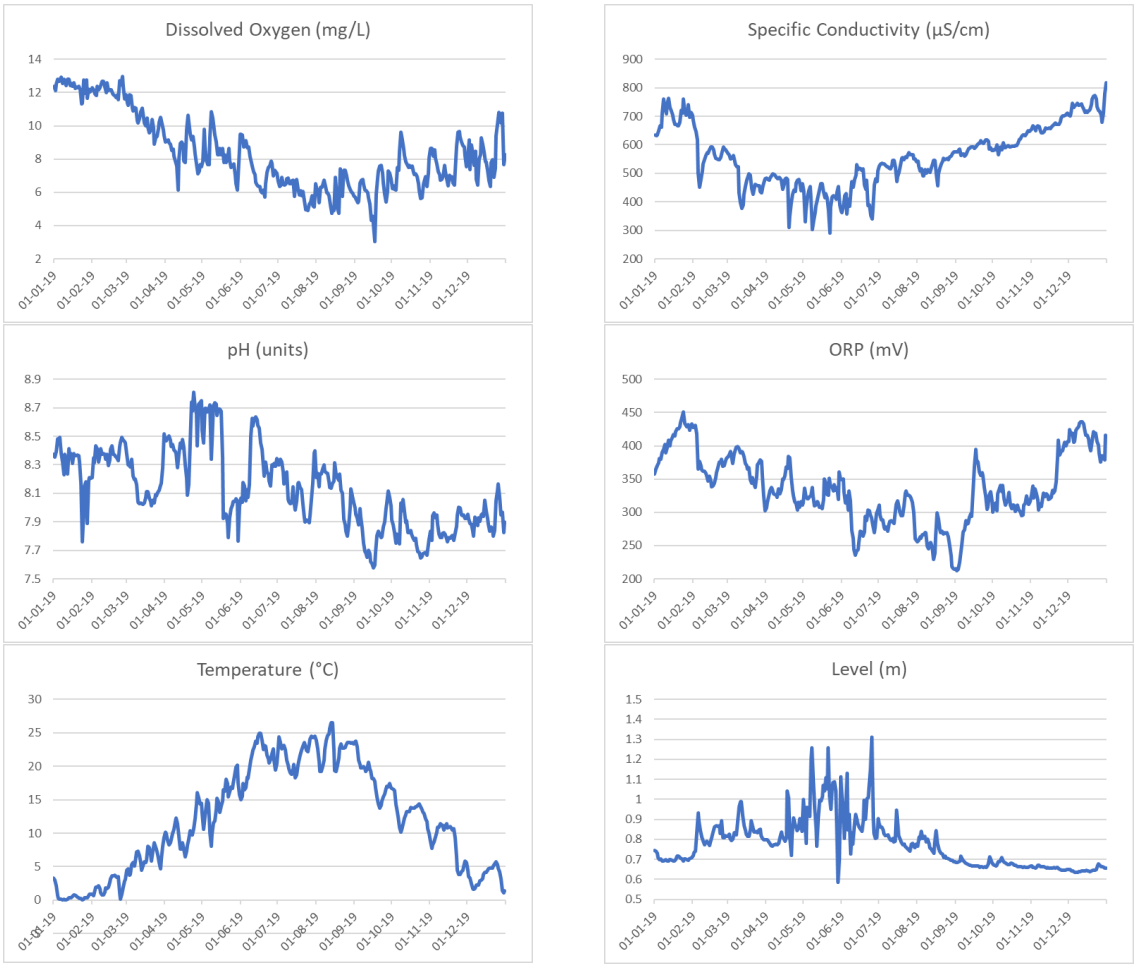


Fig. 5. The evolution of the hourly values of the monitored parameters of Suceava River at Tişăuţi in 2019.

The water quality of the Suceava River downstream of the city of Suceava is degrading mainly due to the effluent of the wastewater treatment plant of Suceava city. As can be seen in Figure 6, the treated wastewater has specific oxygen consumption and concentrations of some chemical elements above the average values of the Suceava River (as shown by environmental reports). The temperature of the discharged wastewater (16.3°C annual average) is higher than that of the river, except in the summer months, when tap water - which later becomes wastewater - is colder than river water. The latter aspect has a slight positive influence on the river's ability to retain more dissolved oxygen. Normalizing the values of all water quality parameters monitored at the treatment plant in 2019 and summing them up in a water pollution index would show an increase in the daily values of this index towards the end of the year, which explains, along with the sharp decline in river levels, during the 2nd half of the year, the relatively constant increase of the differences between DO and pH

values at the Mihoveni and Tişăuţi monitoring points from mid-2019 to the end of the year.

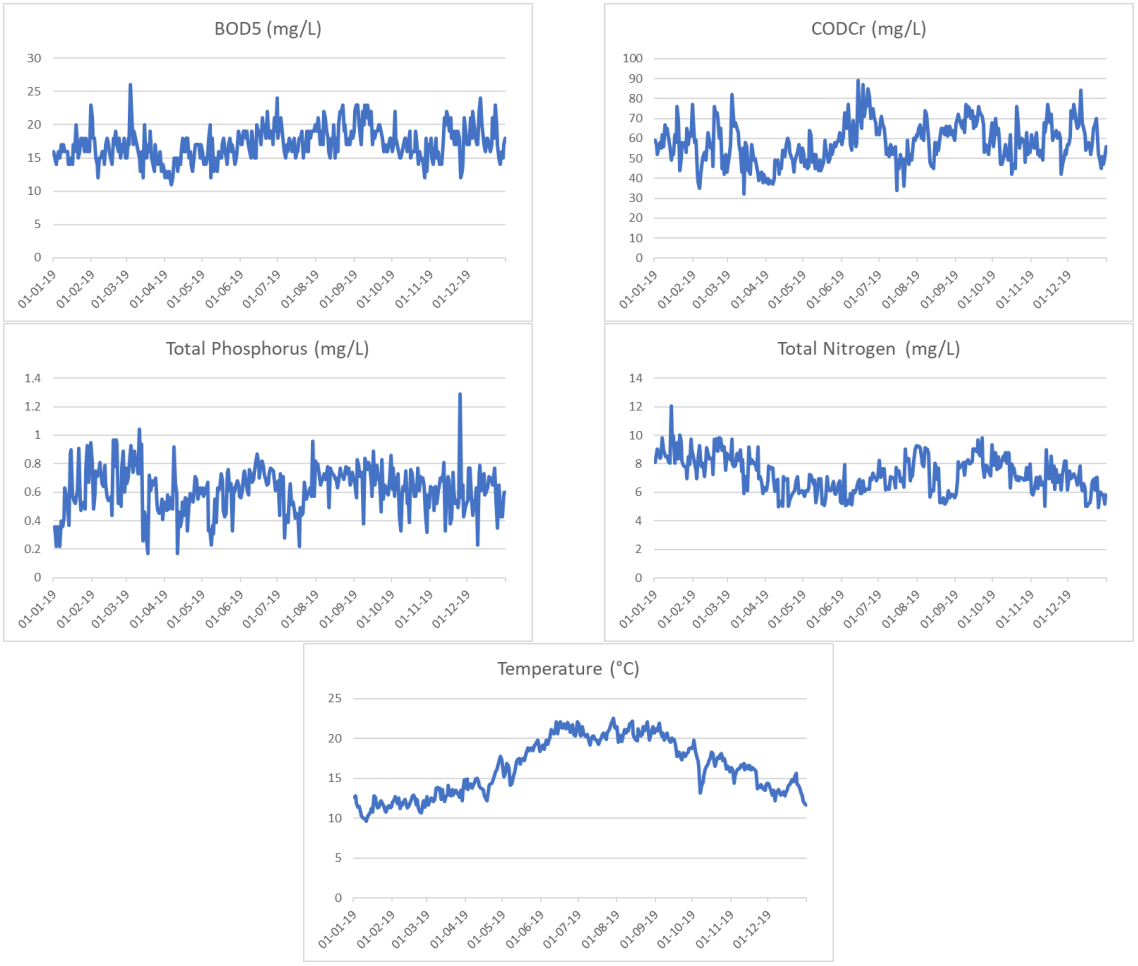


Fig. 6. The evolution of the daily values of some parameters of the effluent of the treatment plant of Suceava city in 2019 (source of data used to make these graphs: ACET Suceava, 2020).

The scatter plots (figure 7) drawn for the values of the same parameter at the 2 permanent monitoring sites show that there is a good (DO) or very good (SC, temperature) correlation between some parameters, while other parameters have no correlated evolutions (pH, ORP), most likely due to the treated and/or untreated wastewaters discharged by Suceava city. Regarding the water level, 2 groups of points are observed. This split is caused by the fact that the water retention level behind the Mihoveni mobile dam is variable, oscillating between the state with high dam and the one with low dam.

There is a weaker correlation between dissolved oxygen and water temperature in Tişăuţi compared to Mihoveni (figure 8) due to the water from the wastewater treatment plant, which alters both the temperature and the dissolved oxygen concentration of the river downstream.

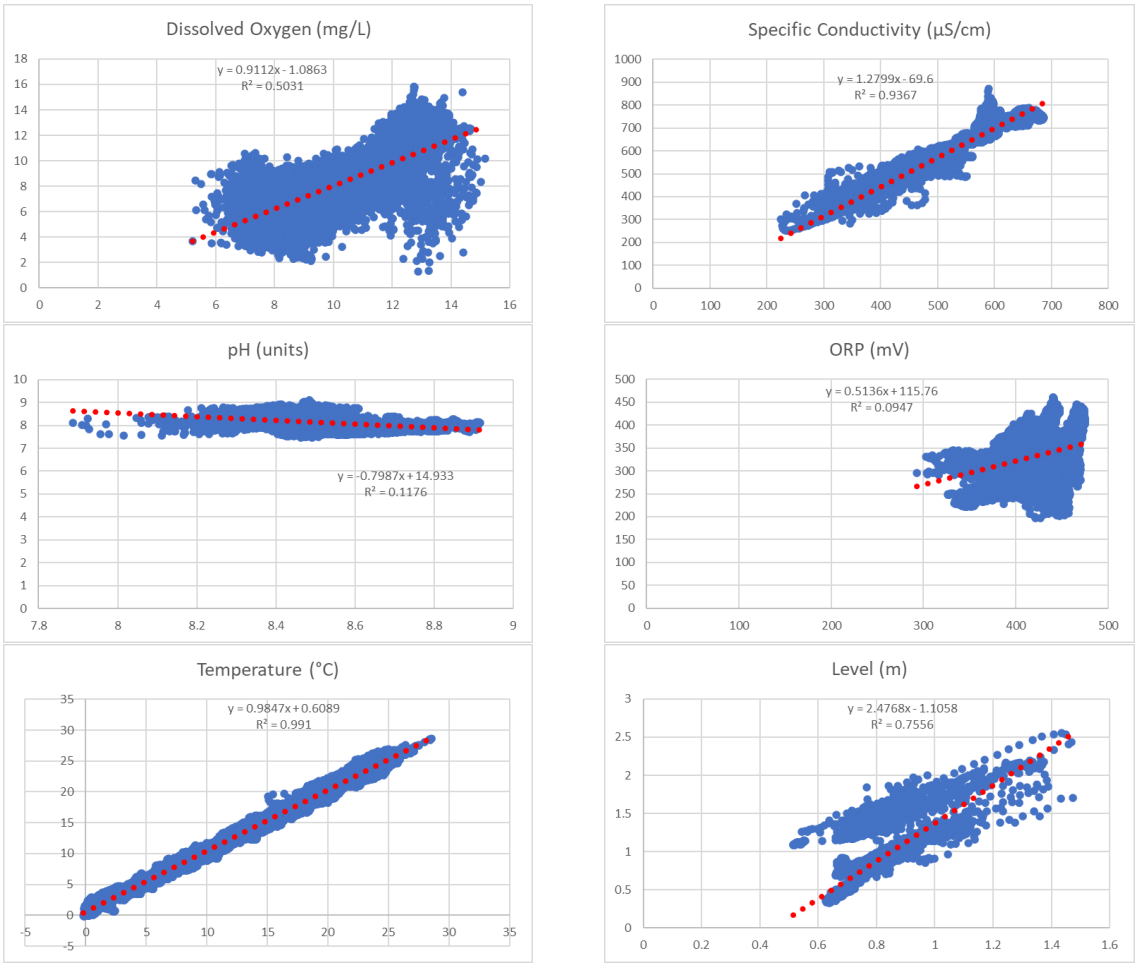
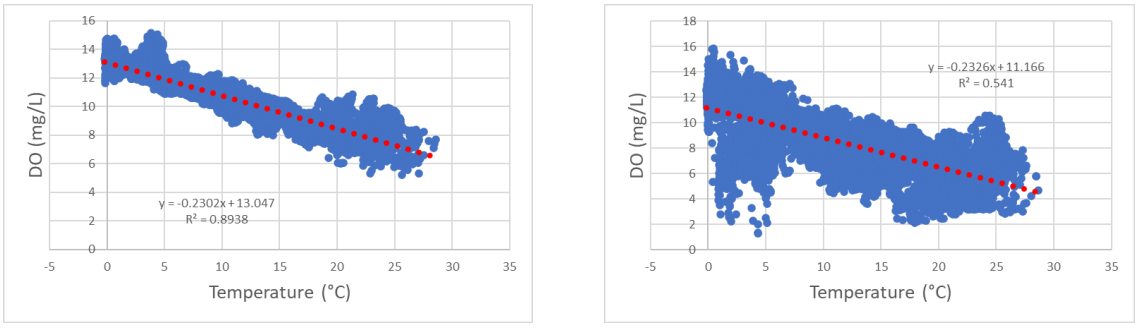


Fig. 7. Relationships between the hourly values of a parameter at Mihoveni and Tişăuţi monitoring sites in 2019.

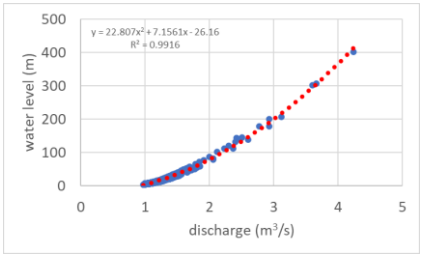


a b

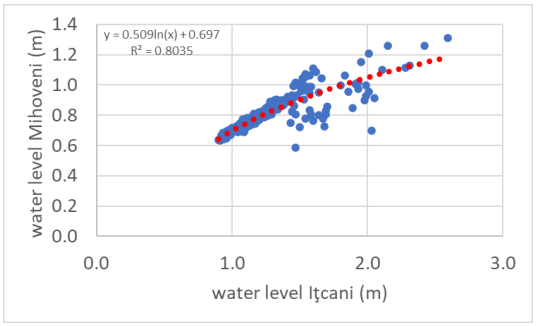
Fig. 8. The relationship between the dissolved oxygen and the temperature of Suceava River at Mihoveni (a) and Tişăuţi (b) - the dotted red line represents the linear trend.

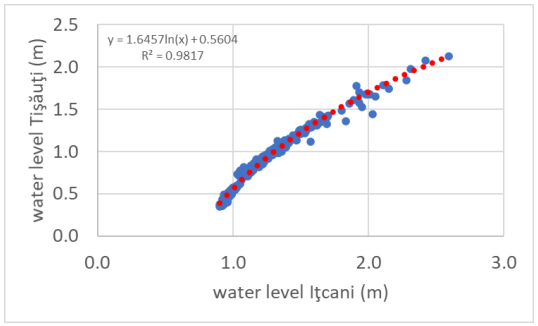
Some water parameters can be estimated, in the absence of specific measurements, based on the linear correlation that is established between the estimated parameter and another parameter, which is measured at the time of estimation. Acceptable estimates can be made for SC at the Iţcani hydrometric station if the flow of Suceava River is known (this is constantly measured at this

station). Thus, if we take into account the water level that is measured at Iţcani hydrometric station, a correlation curve can be made between the water level and the flow at this station (figure 9.a). The level from Iţcani can be correlated with the one from Mihoveni and Tişăuţi (figure 9.b, c - for a better correlation with the level from Mihoveni, corrections must be introduced in order to eliminate the effects of hydrotechnical maneuvers). Then, the relationship between level and SC in Mihoveni and Tişăuţi is analyzed (figure 10). The relationship between level and other monitored parameters is much weaker (figure 11) and cannot be used. The water level at Iţcani is taken into account because it is the only parameter constantly monitored at high frequency at this station.



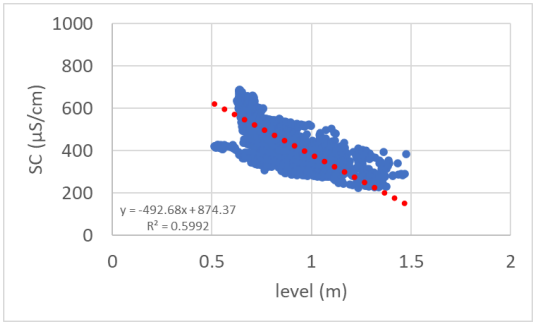
a

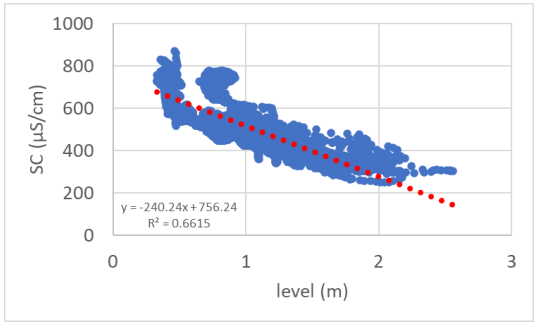




b c

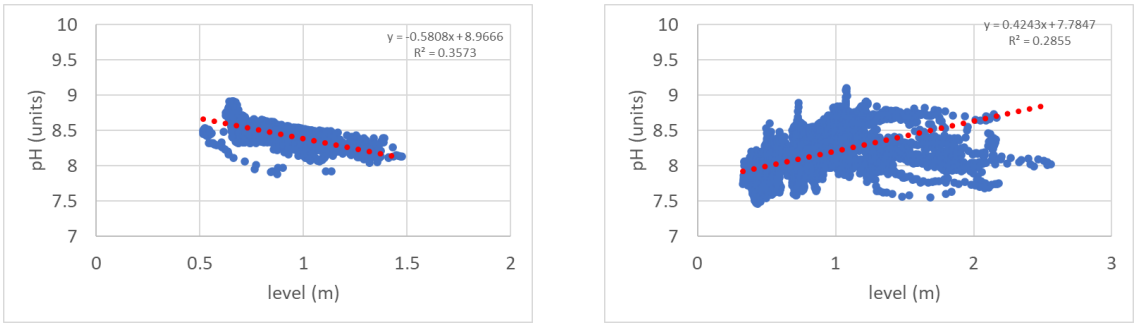
Fig. 9. Relationships between parameters of Suceava River, synthesized by trend lines: of polynomial type of order 2 between water level and flow at Iţcani in 2018; of logarithmic type between water level at Iţcani and at Mihoveni (b) or Tişăuţi (c) in 2019 (source of Iţcani level and flow data: ANAR - Siret Water Basin Administration).





a b

Fig. 10. The relationship between water level and SC in 2019 at Mihoveni (a) and Tişăuţi (b), synthesized by linear trend lines (dotted red lines).



a b

Fig. 11. The relationship between water level and pH in 2019 at Mihoveni (a) and Tişăuţi (b), synthesized by linear trend lines (dotted red lines).

To predict the evolution of the values of some water quality parameters of Suceava River, we used the wavelet transformation, which took into account the average daily values from 2019 to estimate values in the next 6 months (fig. 12).

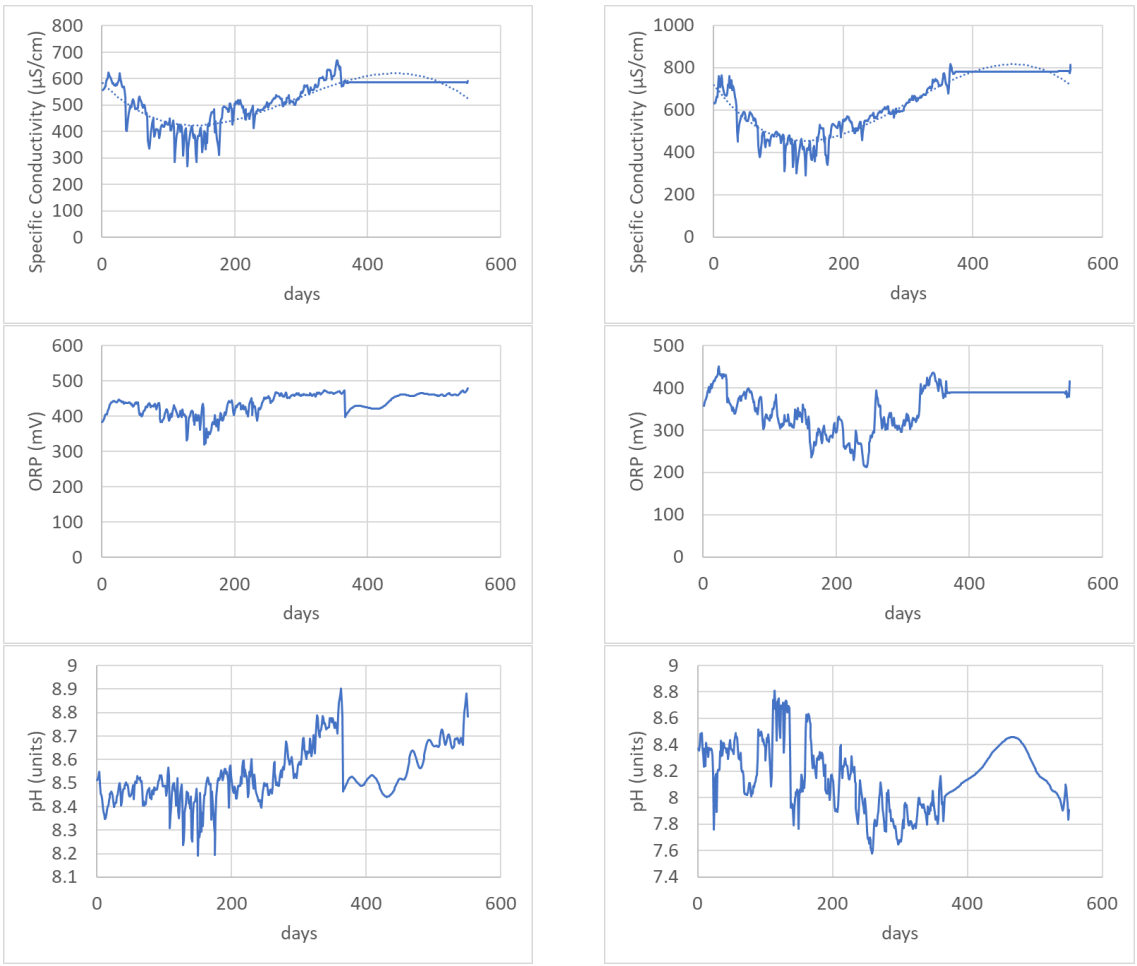


Fig. 12. Forecasts of the evolution of SC, ORP and pH values in the first 6 months of 2020 (days 366-551) at Mihoveni (first column) and Tişăuţi (second column) - the dotted line from the SC graphs represents a polynomial trend line of order 3.

The wavelet transformation used for the forecast (from the “fittestWavelet” function, within the R program) took into account the mother wavelets such as Haar, Daubechies, Least Asymmetric, Best Localized and Coiflet for the decomposition of the initial time series into components to be used as basis for prediction (the wavelet type is automatically selected according to the best match with the oscillations of the time series to be analyzed). In calculating the prediction, the ARIMA model is subsequently applied to achieve future evolution models with a confidence level of 0.95. In this report, only the values of the average evolution model are taken into account. DO forecasts do not generate realistic values because they do not take into account the annual oscillation. For the more accurate forecasting of the evolution of SC, a polynomial trend derived from the time series 2019 + 6 months generates more adequate results. The forecasted values were compared with those measured at the beginning of 2020 and can be taken as average values for several days combined. For the forecast on a daily scale and for several months, a database (with measurements of the analyzed parameters) much larger than the one obtained within the project is necessary (the measurements must be performed for a period longer than 2 years).

5. Conclusions

The postdoctoral project "Streamwater quality real-time data analysis" managed to successfully implement a real-time monitoring system of water quality parameters of Suceava River, with measurement points upstream and downstream of Suceava city. This system is also operational after the end of the project. The project has achieved its proposed objectives.

Among the progresses brought by the project in the knowledge of the characteristics of Suceava River in the homonymous urban area, we mention: detailing the annual regime of the level, temperature, specific conductivity, dissolved oxygen, pH and ORP; discovering the local specifics of the causal relationships between some of the mentioned parameters; identification of periodic signals using wavelet analysis; detailing the temporal and spatial variation of the diurnal profile of the studied parameters; highlighting thermal pollution and its causes; calculating a water quality index and describing its variability.

The good development of the project was, in part, possible due to the support provided by the National Administration "Romanian Waters" (Siret Water Basin Administration) and Acet S.A. Suceava, which facilitated the access to Mihoveni Dam, to the flow rate and water quality data of Suceava River and its tributary, Şcheia, and to data on the physical and chemical characteristics of the waters discharged from the wastewater treatment plant of Suceava city.

It is desirable that, in the future, as concluded at the end of the project workshop, an even denser river monitoring network be created within the city, for more parameters, to extract even more valuable information from Suceava River flow.

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