Report nº 1/2018

of the postdoctoral project

"Streamwater quality real-time data analysis"

Acronym: SQRTDA

Project leader:

Andrei-Emil Briciu (Ștefan cel Mare University of Suceava)

Mentor:

Adrian Graur (Ștefan cel Mare University of Suceava Ștefan cel Mare University of Suceava)

SUCEAVA, 2018

CONTENT

1. Introduction 3

2. Measuring instruments 5

3. Monitoring sites 7

4. Methods and data 13

5. Analyses 14

6. Conclusions 17

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.

To achieve the project objectives, the following water quality parameters were proposed: electrical conductivity, dissolved oxygen, pH and ORP (Oxidation Reduction Potential).

Monitoring should be carried out within 5 km upstream and downstream of Suceava's administrative boundary to capture the characteristics of water just before entering the city and the impact of the city on downstream water where it can be measured optimally after the waters of the sewage treatment plant of the city is well mixed with the river's waters.

From a scientific point of view, the results that can be obtained through this monitoring can be useful for detecting the temporal and spatial evolution of the parameters analyzed, for detecting the city's environmental footprint, for detecting the intensity of self-purification (if applicable), for obtaining average diurnal profiles of the monitored parameters and, last but not least, for wavelet analysis with the available time series.

According to the provisions of the project working plan of the Grant Application and the project implementation plan of the Financing Contract, the following major progresses were made in the implementation of the project in 2018:

-the identification of the sites for the installation of pre-existing (pre-project) equipment in the field for the necessary preliminary analyzes until the purchase and placement of the new equipment

- acquisition and installation of water quality monitoring system equipment consisting of two pairs of instruments with water quality sensors, recorder and data transmitter (with associated telemetry service) and data receiving / storage server

-testing the implemented system to identify possible weaknesses and remedy them (changing the depth of water for the sensors, reorienting the transmission antenna)

- real-time monitoring of water quality and recording of measurement data on the server

Also, a convention was signed by Ștefan cel Mare University - MANSiD Research Center for the exchange of scientific data with the Romanian Waters Administration - Siret Basin Water Administration. The data that can be provided by ANAR can help to understand the data obtained in the research project.

2. Measuring instruments

The instruments that have been used to measure the environmental parameters needed to understand the monitoring sites are of two types: the pre-existing ones, from pre-project endowment, and those acquired from the postdoctoral project.

The pre-existing instruments refer to instruments like the Eutech CyberScan pH 11 water / air temperature probe, the Garmin GPSmap 62s GPS tracking device, the Hach DR 2800 spectrophotometer, but the most productive tools for providing useful data were the water sensors with dataloggers. The instruments in this last category were iButton and TruBlue and were used for continuous measurements until the new equipment was installed.

The iButton DS1922L-F5 # was used for air temperature measuremens, while TruBlue 585 CTD and TruBlue 275 Baro were used to measure conductivity, temperature and water pressure and, respectively, air temperature and pressure respectively. Measurement of some air parameters is not only necessary for a better understanding of environmental conditions that have caused water variations, but also for corrections of measurements (see the telemetry unit described below).

The measurement instruments purchased from the project are represented by a portable Hach HQ40d portable multiparameter and two remote water monitoring systems. The 2 pairs of monitoring systems can be viewed as part of a larger monitoring system as data from monitoring sites located upstream and downstream of the city are centralized on a storage server and can be seen via the HydroVu service.

Each monitoring site has a set of In-Situ instruments as follows:

- AquaTROLL 500 multiparameter probe equipped with sensors to measure the following water parameters: pressure / level, temperature, electrical conductivity (accuracy: ± 0.5% of reading +1 µS / cm, resolution: 0.1 µS / cm), dissolved oxygen (accuracy: ± 0.1 mg / L, resolution: 0.01 mg / L), pH (accuracy: ± 0.1 pH units, resolution: 0.01 pH) and ORP (accuracy: ± 5 mV, resolution: 0.1 mV);

- Tube 300R telemetry unit – a tool with temporary storage capacity and remote transmission of measurement data, also equipped with barometer (to compensate the water and air pressure measured by AquaTROLL 500 -needed to calculate water level).

The Hach HQ40d portable multiparameter allows for the measurement of water temperature, electrical conductivity, dissolved oxygen, pH and ORP in

areas between the permanent monitoring points in order to detect potential causes of fluctuations observed by the continuous measurement equipment.

3. Monitoring sites

Preliminary measurements (those prior to the installation of the monitoring system) were made to identify the most suitable sections of the riverbed for the installation of the equipment that will perform long-term measurements, both in terms of the representativeness of the measured values and of the safety of the instruments (protection against flood and vandalism)

These preliminary measurements of the characteristics of the Suceava River water are those made with iButton and TruBlue sensors in 2 sites. A site is located immediately upstream of the city of Suceava and the other is located downstream of Tișăuţi, in a place where the upstream meandering of the Suceava River allowed the complete mixing of the waste water from the Suceava wastewater treatment plant with the river waters Fig. 1).

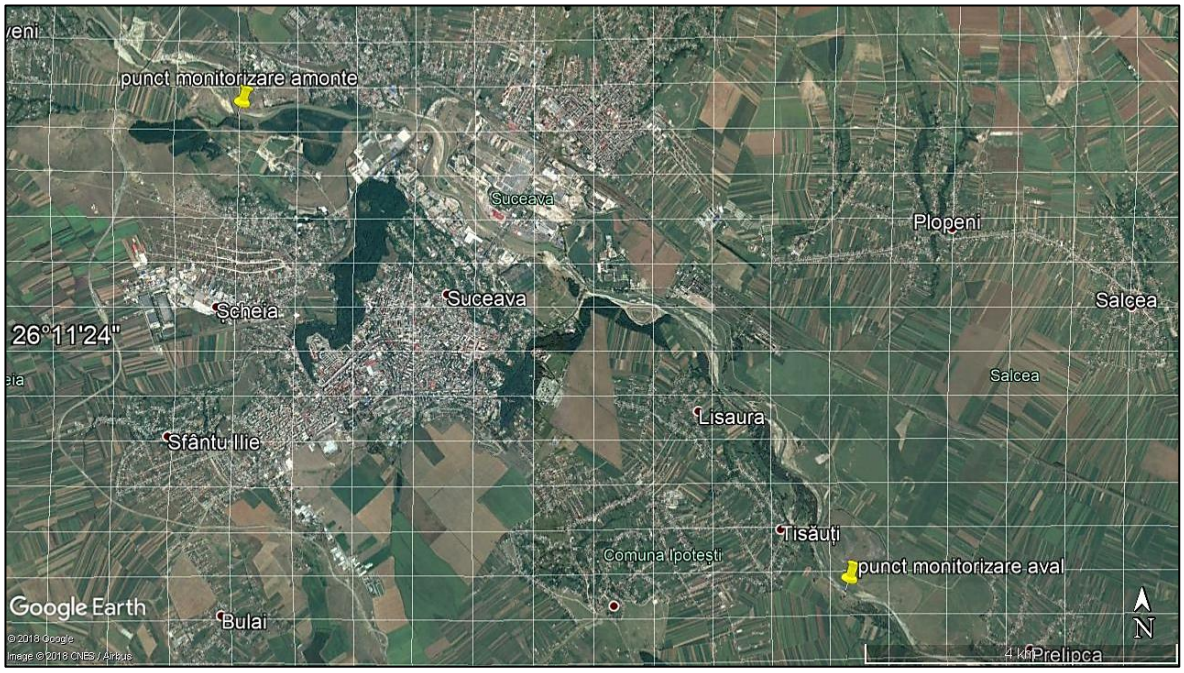


Fig. 1. Preliminary monitoring points of the Suceava River water.

Apart from some special locations, the waters of the Suceava River are well mixed due to the small water depths of approx. 1 m at the baseflow in the study area. In the longitudinal profile of the riverbed there can be observed a series of ruptures corresponding to weirs built to protect some targets upstream of them (such as the pillars of a bridge). The upstream monitoring point was chosen on a river branch (Figure 2a) downstream of an area with good water mixing, visible through rapids imposed by sandstone layers. However, this monitoring site has not been retained for the implementation of the long-term monitoring system due

to the lack of flood protection. Other sites have been checked for the latter purpose, as is the site shown in Fig. 2b.

a

b

The Suceava River in various sections: a. The right branch used for preliminary measurements upstream of the city of Suceava; b. Site located 200 m upstream of the site described at a.

The site which is visible at 2b has another deficiency: the water depth is about 5.5 m (May 2018) and the banks are steep. Water can be stratified into such sectors, which we have avoided.

The preliminary monitoring point downstream of the city of Suceava was located on the right bank of the river, 400 m upstream of the pillars that support the passage of methane gas across the river (Fig.3). The pillars in the middle of the river have subsequently become support for the permanent river monitoring system in the downstream sector of the city of Suceava (Figure 4).

Fig. 3. The Suceava River Monitoring site, downstream of the city of Suceava.

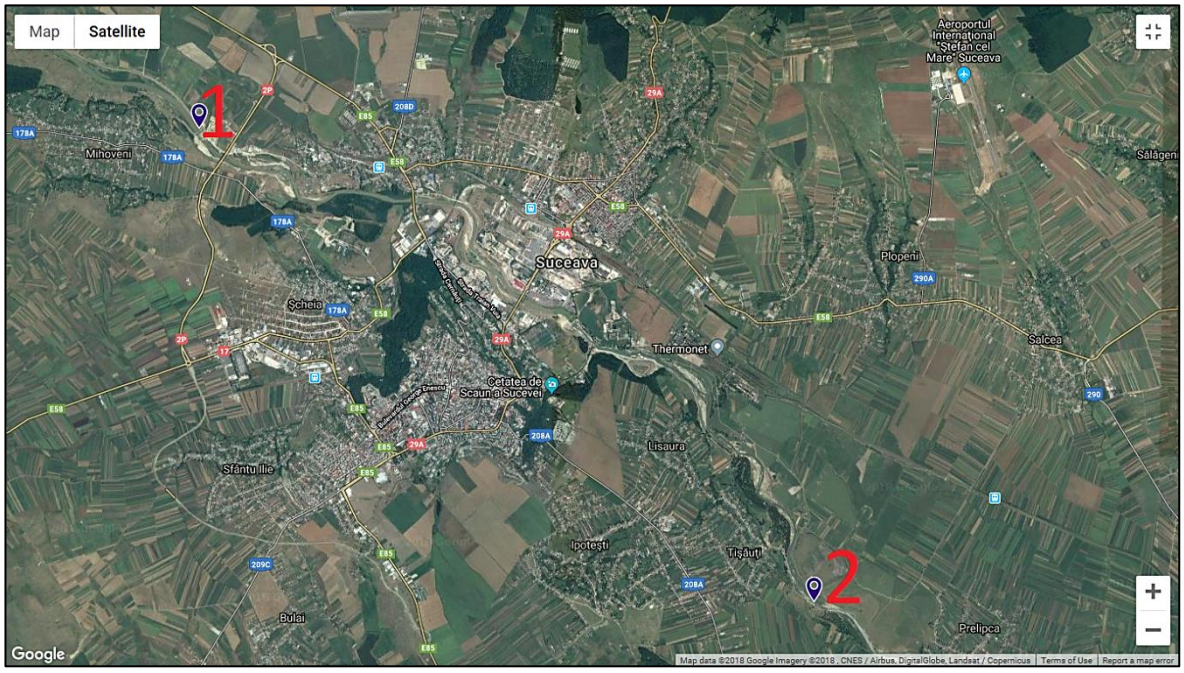
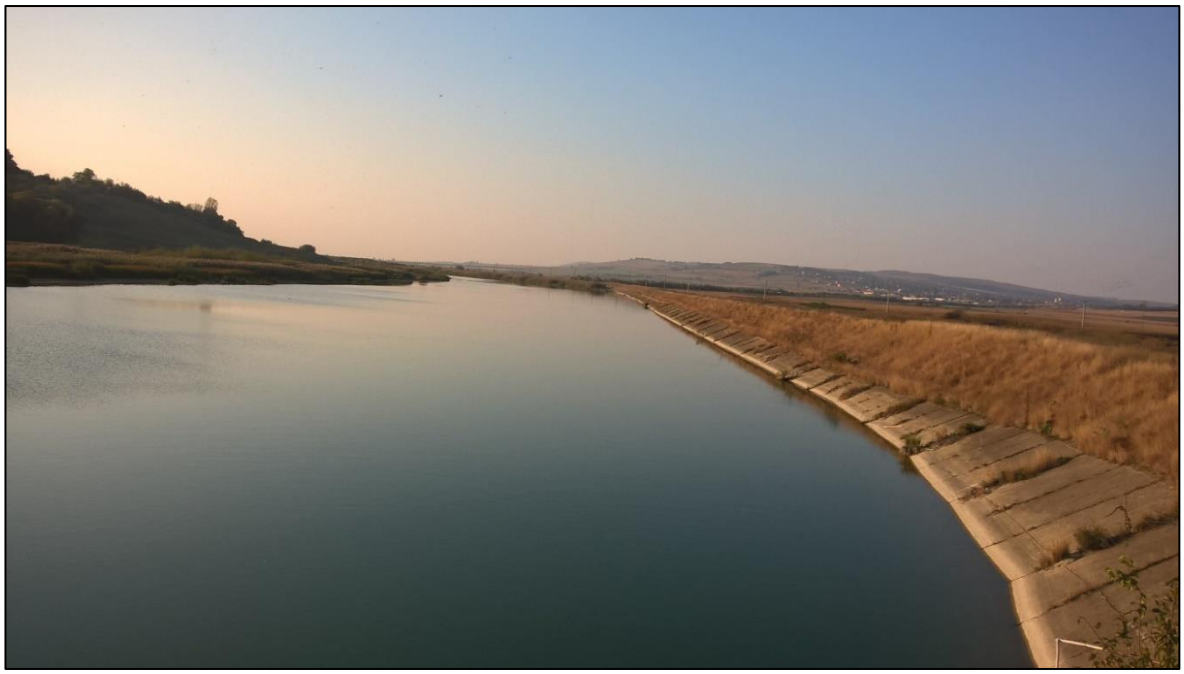


Fig. 4. Permanent monitoring sites. in HydroVu: 1. Upstream, 2. Downstream.

The permanent monitoring point of Suceava River upstream of the city was chosen to be the Mihoveni Dam (Figure 5a). It is built on the streambed, has a symbolic retention capacity and ensures a secure placement of the apparatus and a relatively constant level of water at the baseflow (this advantage does not apply to the downstream point at Tișăuți). Moreover, in the storage lake (Fig.5b) there is a water flow that has not suffered excessive aeration / oxygenation induced by the hydraulic jumps related to the water discharge from the dam.

a



b

Fig. 5. The permanent monitoring site located upstream of the city of Suceava, at Mihoveni Dam: a. the dam body, b. the reservoir.

Several weirs exist between the new and the old upstream monitoring points, which contributed to the decision to place the monitoring point in the lake (Figure 6). A possible disadvantage of the site would be the dam's operations during the high water, operations consisting in raising and lowering the gate, with the inherent modification of the water flow and the partial artificial rise of the water level.

a

b

Fig. 6. Weirs on Suceava streambed: a. immediately downstream of the Mihoveni Dam; b. downstream of Suceava's ring road bridge (Mihoveni Dam in background / upstream).

The permanent monitoring points have the advantage of a stable flow section of the riverbed. The water flow pattern is restricted into the body of the Mihoveni Dam, while, at Tișăuți, the right bank of the river is concreted.

The 2 points chosen for the long-term monitoring of the Suceava River also correspond to the Mihoveni and Tișăuţi monitoring points, where SGA Suceava regularly performs physical, chemical and biological water quality measurements. Thanks to the data exchange agreement with the Romanian Waters, the information from the project can be efficiently correlated with those provided by ANAR. The data that will be provided from inside the city, from Itcani hydrometric station (on the Suceava River), will also serve as helpful information.

4. Methods and data

Water monitoring sensors are currently under a 70-80 cm water column. Initially, upstream equipment was placed under a larger water column (120 cm above the sensors), but the very irregular variations in DO, pH and ORP required a reduction in depth. Higher depths most likely involved the random measurement of well-mixed surface water or of the relatively stagnant water from the greater depths (issue caused by the dam). After changing the depth at which the apparatus is located in the water, the upstream and downstream monitoring points have comparable depths that help to interpret the upstream and downstream evolution of river water features.

Preliminary measurements have seen a slight tendency to deposit fine alluviums in sensors carcasses, which may lead to a diminution of measured amplitude, for example diurnal, over time. To prevent this occurring, the probes were equipped with a wiper / cleaner that was set to clean the sensors once a day.

The data collected by the sensors is transmitted by Tube 300R to the server, from where they can be viewed through the HydroVu application, incorporated into the research project website on the DATA page, accessible through the menu (http://water.usv.ro/data.php).

Preliminary measurement data was obtained during the monitoring period from June 27 to October 1, 2018. Measurements in the current monitoring campaign in new sites with automatic data collection on a server began experimentally on September 29, 2018, after which standard data stream (visible in Hydrovu) was initialized on October 9, 2018.

Preliminary measurements were performed at semi-hourly frequency. Preliminary measurement data required corrections for re-positioning of sensors in the site, driven by variations in water level. Measurements made with the new apparatus have an hourly frequency that is sufficient to capture the daily variations of the monitored parameters.

5. 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.

In-depth analyzes are planned to be carried out starting with January 2019, according to the approved schedule. Specific analyzes are also planned to be carried out when one year of field measurements is carried out.

The data of the measurements made at the new monitoring points (currently active) were analyzed for the period 29 September - 23 November 2018. Figure 7 shows the sudden decrease of the measured level due to the repositioning of the probe to obtain more relevant DO, pH and ORP measurements. In the same figure, the micro-operations of the Mihoveni Dam are observed as small variations of the water level, which correspond, with some delay, to inverse water level evolution at the downstream monitoring point, at Tișăuți. The gap between the moment of the change in the two points is variable depending on the water level.

Water temperature has relatively similar daily minimum values in the two permanent monitoring points, but a higher maximum is recorded downstream (Figure 8). The specific water conductivity has very high values downstream of the city in the second half of November, which does not correlate with the upstream evolution of the same parameter (Figure 9). Values higher than 700 μS / cm downstream of Suceava are due to salt applied on streets to eliminate road traffic problems caused by snowfall in the city since November 17. Figures 10-12 show the stabilization of fluctuations of dissolved oxygen, pH and ORP in diurnal cycles at the upstream monitoring point due to the reduction of the water column above the probe. November has a malfunction of the downstream water monitoring equipment, which needs corrections.

The pH values were higher upstream (average 8,306) than downstream of the city (average 7,716) between September 29 and November 23, 2018. The mean ORP, as well as that of dissolved oxygen, was higher downstream (416.5 mV) than upstream (356 mV). All three parameters indicate an increase in river pollution downstream. The river was heated by about 0.35 °C as a result of city transit during this period (upstream: 10.09 °C; downstream: 10.44 °C). As observed in preliminary measurements, specific conductivity is greater downstream, approximately 70 μS / cm, between September 29 and November 23, 2018 (upstream: 515.4 μS / cm; downstream: 585.36 μS / cm).

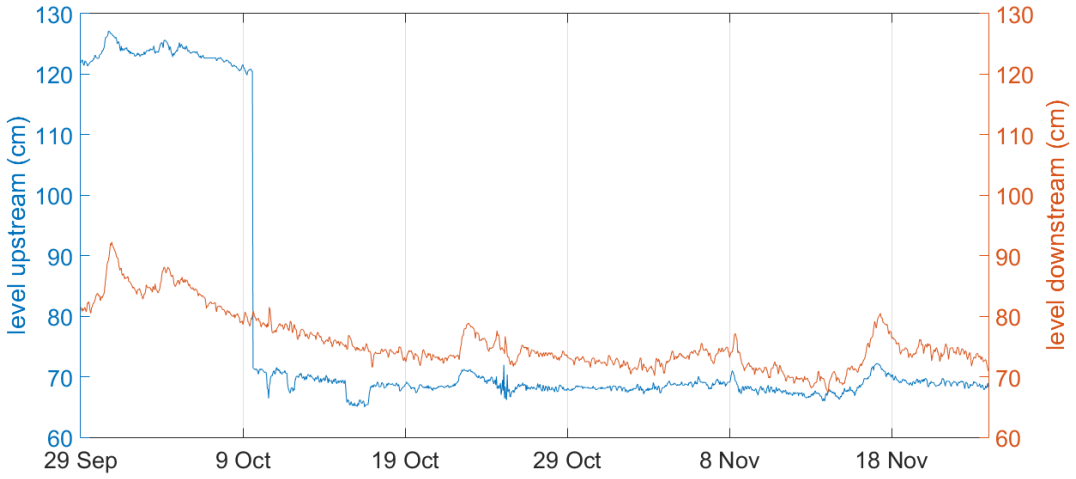


Fig. 7. Changes in water level at the permanent monitoring points.

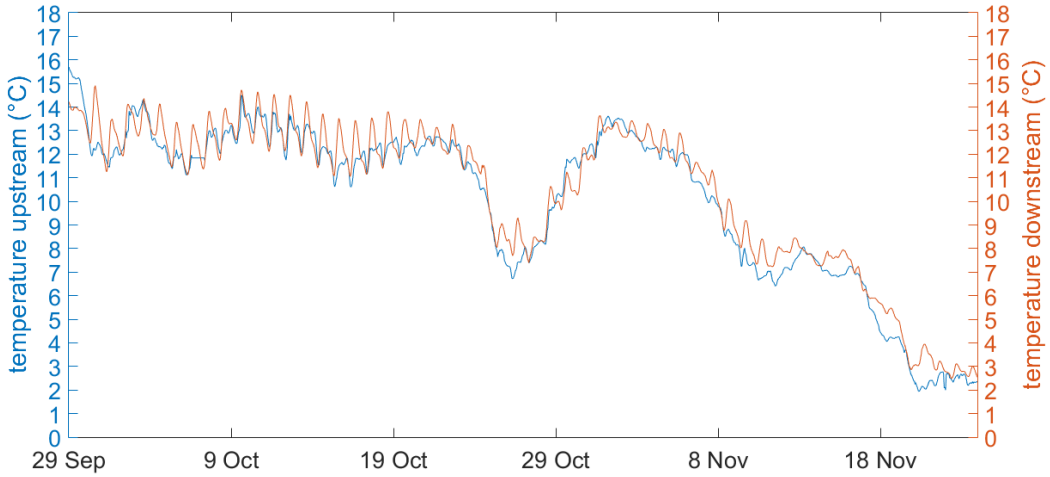


Fig. 8. Changes in water temperature at the permanent monitoring points.

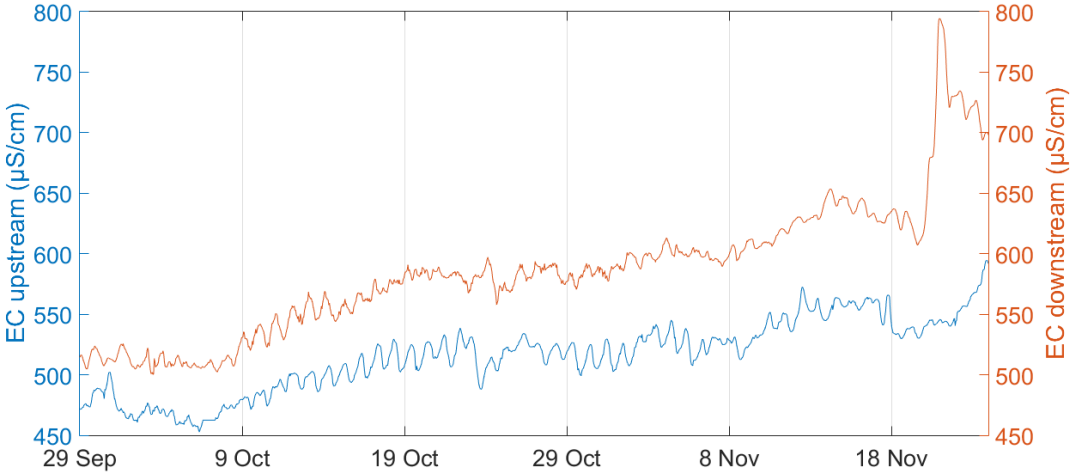


Fig. 9. Changes in water EC at the permanent monitoring points.

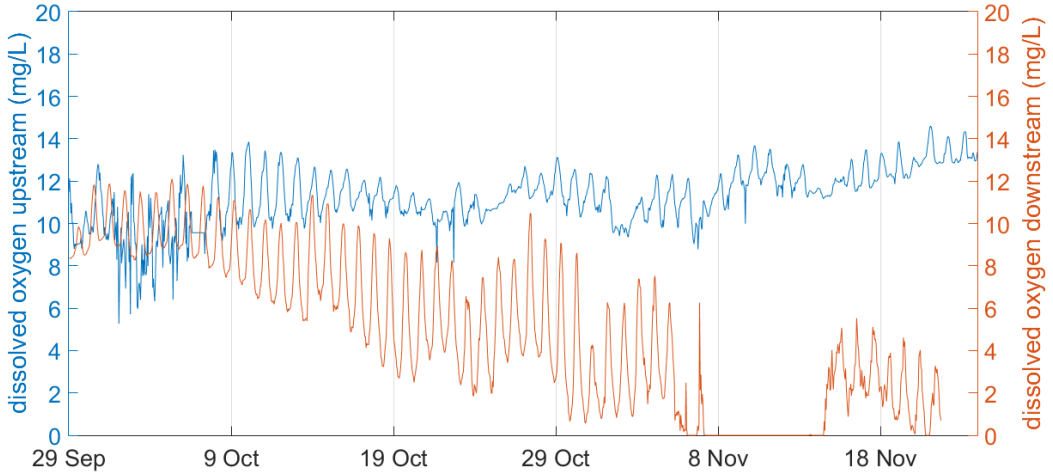


Fig. 10. Changes in water DO at the permanent monitoring points.

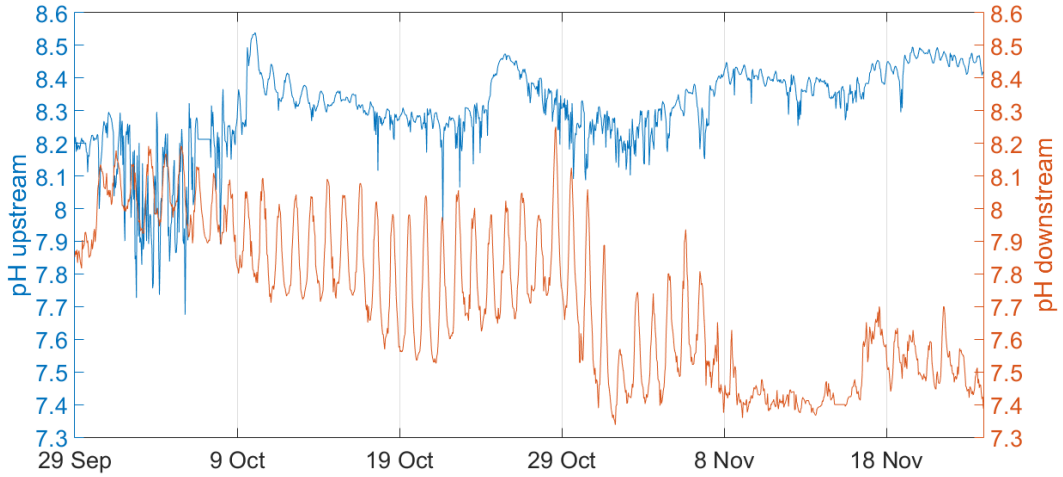


Fig. 11. Changes in water pH at the permanent monitoring points.

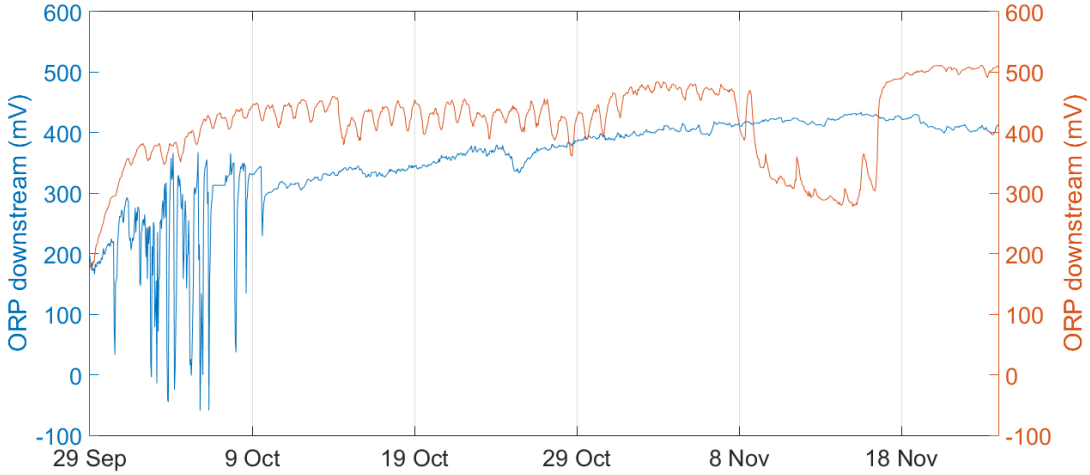


Fig. 12. Changes in water ORP at the permanent monitoring points.

6. Conclusions

At the beginning of the research project, field observations were made to identify sites for preliminary measurements as well as sites suitable for the long-term installation of the monitoring equipment purchased under this project. Preliminary measurements were carried out in expeditionary or continuous mode to identify the characteristics of the Suceava River, useful for the installation and maintenance of new equipment.

The equipment for continuous and remote monitoring of the water quality parameters of the Suceava River was installed in the field. Upstream and downstream of the city of Suceava, pairs of instruments consisting of probes with sensors connected to transmitters were placed (sensors for measuring the water level, temperature, electrical conductivity, dissolved oxygen, pH and ORP). The data is collected and stored on a server, the time series can be viewed online from the start of the measurements to the present.

The analyses indicate an increase in the pollution of the Suceava River downstream of the city, as indicated by: the increase of the water temperature from the values measured upstream; the diminishing of pH and dissolved oxygen concentration downstream; the increasing of ORP and electrical conductivity after the river passes through the city.

The observed phenomena will be analyzed in detail after collecting a larger data volume, after correlating the information gathered within the project with those available from the Romanian Waters National Administration and after applying new data analysis techniques.

Acknowledgement: *This work was supported by a grant of Ministery of Research and Innovation, CNCS - UEFISCDI, project number PN-III-P1-1.1-PD-2016-2106, within PNCDI III.*