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Floating platform for continuous monitoring of surface water quality

Rumen Popov[1*], Dimitar Tokmakov[1], Slaveya Petrova[2,3], Bogdan Nikolov[2]

[1]Department of Electronics, Telecommunications and Information Technologies, Faculty of Physics and Technology, University of Plovdiv "Paisii Hilendarski", 24 Tzar Asen Str., Plovdiv, 4000, BULGARIA

[2]Department of Ecology and Environmental Conservation, Faculty of Biology, University of Plovdiv "Paisii Hilendarski", 24 Tzar Asen Str., Plovdiv, 4000, BULGARIA

[3]Department of Microbiology and Ecological Biotechnologies, Faculty of Plant Protection and Agroecology, Agricultural University, 12 Mendeleev Blvd., Plovdiv, 4000, BULGARIA

*Corresponding author: rumen.popov@uni-plovdiv.bg

Abstract. Monitoring the quality of river water in real time is critical for protecting aquatic life, public health, and the sustainability of our freshwater resources. A Floating Online Monitoring System enables continuous, remote measurement of key water parameters—like pH, dissolved oxygen (DO), turbidity, and contaminants—right at the water's surface. For this purpose, an automatic, remote measuring station was developed, intended for installation on the floating platform. It is designed for not only collecting and archiving information about the ecological situation along the river, but also periodically forwards the data to a communication server.

Key words: water, air quality, monitoring station.

Introduction

Surface water monitoring includes: assessing the quantity and quality of water in rivers, lakes and streams, using physical, chemical and biological methods to track changes; detecting pollution; detecting flood threats; protecting ecosystems and managing irrigation resources; assessing the health of biological species (Popov et al., 2024).

While traditional laboratory tests are widespread, modern approaches increasingly use real-time sensors, the Internet of Things (IoT) and remote sensing technologies to process and analyze continuous data streams on parameters such as pH, dissolved oxygen (DO), turbidity, temperature and flow, allowing for faster responses to problems such as algal blooms or pollution (Pasika & Gandla, 2020; Trevathan et al., 2021).

Through its directives and other instruments, including financial instruments, the EU aims to ensure that all surface water bodies achieve good ecological and good chemical status. To ensure the former, surface waters must comply with certain minimum levels of so-called quality elements, including biological, hydro-morphological, physico-chemical (including nutrients) and general quality elements. For good chemical status, surface waters must meet minimum quality standards for selected pollutants and the reduction or gradual elimination of emissions of these substances into water must be ensured.

There are 100,000 surface water bodies in the EU, including streams, rivers, lakes, wetlands and reservoirs (EU- Energy, Climate change, Environment, https://environment.ec.europa.eu/). Only 40% of surface waters are in good status which implies on their systematic monitoring. Over 1/3 of river basin districts are transboundary (EC, 2025).

The provisions set out in the Water Framework Directive 2000/60/EC (https://eur-lex.europa.eu/) are of fundamental importance.

Annex V to Directive 2000/60/EC describes in detail the quality elements to be taken into account in the assessment of ecological status. These elements include pollutants of national or local importance for which Member States must set and comply with environmental quality standards.

Within the framework of the project: "Technological solutions and social models for sustainable development of protected ecosystems" a team from the Plovdiv University "Paisii Hilendarski" is conducting periodic observations on the impact of anthropogenic activity along the Veleka River (Petrova et al., 2024). Thus, a design of an automatic monitoring station for surface water quality was created, intended for stationary installation on the river bank (Popov et al., 2024).

The next step of this research is to supplement the capabilities of the monitoring system in terms of observation in places that are not equipped with fixed cabins on the shore. The aim of the present study is to develop a floating platform, which can be used for integrated monitoring of surface water properties.

Materials and methods

Study area

The Veleka River is the largest and the longest river in Strandzha Mountain (147 km). It rises from Demirkapu Peak in Turkey and crosses the Bulgarian border through beautiful gorges. A short section of Veleka River (about 8 km) is navigable – starting from its mouth up to Tsarskoto kladenche Area (the Tsar's Well Area). This section of the river is very attractive to the fans of water tourism.

Several control points with higher anthropogenic pressure have been identified where periodic measurements of water and ambient air quality have been performed (Petrova et al., 2024). They are located near the settlements of Sinemorets, Brodilovo, Kosti, Gramatikovo and Zvezdets (Fig. 1).

Fig. 1. The location of the monitoring zone along the Veleka River, Bulgaria. (Source: https://mapy.com/)

Requirements to the monitoring station

From a technical point of view, there are a few options for mounting the probe equipment for monitoring surface water parameters, namely:

- crab discovered on shore;
- waterfront cabin;
- cabin in the water, on a foundation;
- floating platform (PT, 2024).

Sudriani et al. (2023) and Lima et al. (2021) reported some additional mounting possibilities for using of:

- unmanned surface vehicles;
- drones;
- satellite remote sensing.

Restrictions in the Strandzha Nature Park does not allow construction activities along the

river bank. Our choice, presented in this publication, is to use floating platform, due to a number of significant advantages over other options:

- high mobility;
- lack of impact on the river bank;
- lightweight design;
- self-compensation of river level changes;
- lower cost.

Results and Discussion

The developed floating monitoring system allows simultaneous measurements on both water and air quality, including various sensors as described below. All data is stored at a memory card, as well as transmitted via internet to the server, when an internet connection is available. Autonomous work of the system is guaranteed by a solar panel and rechargeable battery, allowing for up to 48 hours work, even at a lack of sunlight.

The structural diagram of the automatic floating monitoring station is shown in Fig. 2. It consists of four sections: water quality monitoring section, air quality monitoring section, data collection and communication section and power supply section.

Water quality measurement section

The specifications of the sensors for water quality monitoring are presented in Table 1. The set of sensors (produced by Desun Uniwill electronic technology company) can be seen on Fig. 3.

The water sensor module (7 different sensors) is mounted into housing box, equipped with an automatic self-cleaning brush from impurities.

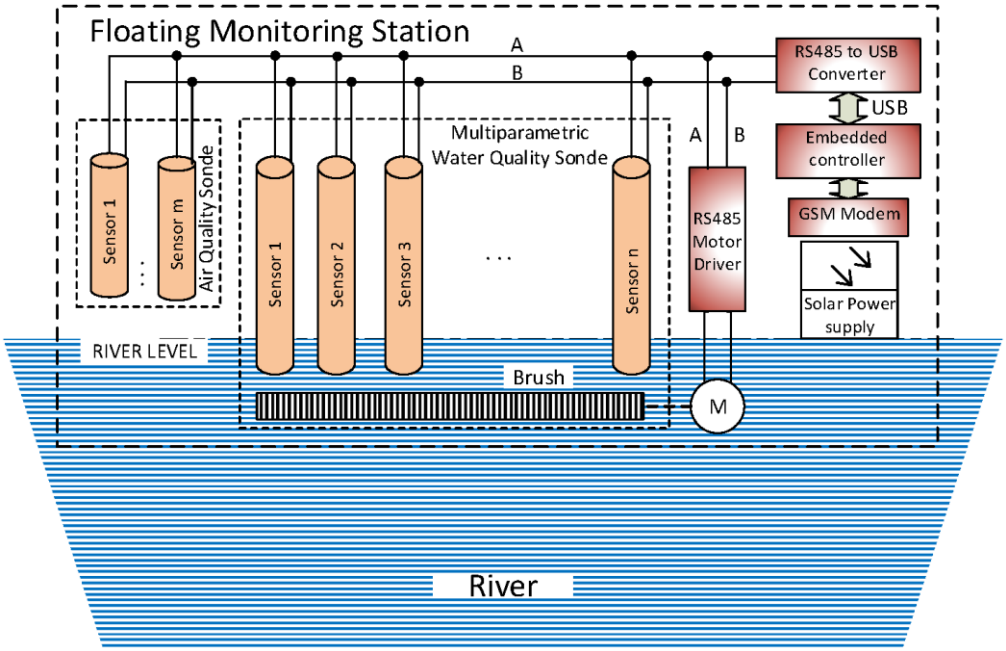

Fig. 2. Schematic diagram of the automatic floating monitoring station.

Table 1. The water quality monitoring sensors.

Sensor	Range	Accuracy
Online optical dissolved oxygen probe	0-20mg/L or 0-200%	±0.3mg/L
A four-electrode conductivity sensor	1uS/cm-200mS/cm 1uS/cm-100mS/cm	1% FS
Online chlorophyll sensor	0~400 ug/L or 0~100RFU	-
Online digital pH sensor	0-14pH	±0.1pH
Ammonia nitrogen sensor	0~1000mg/L	±10%
Online oil in water sensor	0-20ppm or 0-50ppm	0.01
Nitrate sensor	0~1000mg/L	±5%

Fig. 3. Water quality monitoring sensors.

Air quality monitoring section

The air quality monitoring section is presented in Fig. 2 as a separated box, situated above the surface water level. It has the same interface connection RS485 as a water quality section.

There is additional variant of the sensor box, connected to microcontroller module trough USB or WiFi, as shown in Fig. 4. The air quality sensors have various measure-ment options, presented in Table 2.

Fig. 4. Air quality monitoring sensor box.

Table 2. The specifications of the air quality measurement sensors options.

Parameter	Minimum value	Maximum value
Temperature	-40 °C	+85 °C
Humidity	0% RH	100% RH
PM1.0	0 µg/m³	1000 µg/m³
PM2.5	0 µg/m³	1000 µg/m³
PM10	0 µg/m³	1000 µg/m³
Carbon Dioxide	400 ppm	5000 ppm
VOC	10 ppm	1000 ppm
Formaldehyde	0 ppm	5 ppm
Ozone	0 ppm	10 ppm
Noise level	30dB	130dB

Data collection and communication section

The station collects measurement data for an extended period of time in a local SIM card and, when a connection to the communication server is available, transmits them via a GSM modem. This approach ensures trouble-free operation of the station for extended periods of time in the absence of network coverage in the measurement site.

The communication section of the remote monitoring station consists of three levels:

- Local Modbus RS485 or WiFi/USB network segment (between the sensors and the microcontroller);
- GSM network. transfers data between the remote station and the fixed Ethernet connection;

Power supply section

A portable 12 V solar power station equipped with LiFePO rechargeable battery allows the station to work up to 2 days, even in the absence of sunlight.

The developed floating station for monitoring of the surface waters and air quality is still in the process of testing. These tests are currently being carried out in manual mode and in laboratory conditions. The high degree of mobility and operability of the station will allow us to increase the intensity of data collection from a number of points with no stationary equipment along the Veleka River during the next year.

Conclusions

Mobile automatic systems for monitoring the quality of surface water and air are a very useful and reliable tool for monitoring the dynamics of changes in the environmental conditions. The design in the form of floating buoys, increase the possibility of their use in various protected areas, where strong restrictions for stationary installation of sensors on the shore are present. The data obtained through long-term measurements will provide an opportunity for mathematical modeling of the risk of natural disasters and will help in proactive prevention of these areas of conservation importance.

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