REAL TIME IT-MONITORING OF WASTEWATER QUALITY IN THE PREVENTION OF THE COVID-19 PANDEMIC

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Abstract: New measures are being taken in the EU member states for flexible and scalable solutions in monitoring wastewater quality. The latest scientific studies have further confirmed the presence of SARS-CoV2 virus in wastewater. This virus was also detected in stool samples of patients with COVID-19 symptoms, but also in asymptomatic cases of the disease, which confirms the possibility of faecal-oral transmission. The aim of this paper is to introduce automated real-time online monitoring in the wastewater treatment plant ”Ekogramont” with the possibility of using this monitoring in the prevention of the COVID-19 pandemic. The plant is located at 1080 m above sea level and was built in the period from 1998 to 1999 for the needs of the company for bottling spring water "Vlasinska ROSA", which is now owned by the company "Coca Cola” HBC. The proposed SCADA system collects the data from the sensors located in the sewage water and delivers the obtained results to the computers in the central station. The suitability of such automated monitoring comes to the fore in extreme weather conditions which prevail in this high mountain area, when for the purposes of standard analysis, wastewater sampling is disabled. The system also contains the so-called “contamination” alarm which is activated by every parameter which exceeds the set critical limit. The standard RT-PCR protocols WHO and FDA are used to detect SARS-CoV2.

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The detection of the viral genome in sewage, prior to the exponential phase of the epidemic, is a valuable indicator of the imminent danger of an outbreak.

In this field, modification of legal regulations in Serbia would enable the formation of a network for automated real-time monitoring of water quality control, with continuous measurement systems that would deliver the measurement results via SCADA systems to the competent institutions.

**Key words**: real-time monitoring, SCADA, wastewater, COVID-19

**INTRODUCTION**

New measures are being taken in the EU member states for flexible and scalable solutions in monitoring wastewater quality. Automated real-time water quality monitoring has proven to be a very reliable solution that allows simultaneous delivery of analysis results to the institutions responsible for water quality as well as for dealing with accidents. Thus, for example, the ISA - UV/Vis Spectrometer System is already used to measure water quality on the Elbe River [1].

The latest scientific studies have further confirmed the presence of SARS-CoV2 virus in wastewater [2]. This virus was also detected in stool samples of patients with COVID-19 symptoms, but also in asymptomatic cases of the disease, which confirms the possibility of faecal-oral transmission [3]. Detection of SARS-CoV2 in a company’s wastewater by rapid PCR tests would be a tool for early warning and monitoring of COVID-19 status in the employee population. Efficient delivery of rapid PCR test results to the competent institutions is possible via the SCADA system.

The proposed SCADA system collects the data from the sensors located in the sewage water and delivers the obtained results to the computers in the central station. The SCADA system consists of software and hardware that are designed to provide a flexible set of functions for collecting all parameters of measuring wastewater quality, the treatment thereof, monitoring and response in an adequate manner. The sensors are a part of the proposed automated real-time water quality monitoring system which can control up to seventeen parameters [4]. The system also contains the so-called “contamination” alarm which is activated by every parameter which exceeds the set critical limit. The proposed system is modular and scalable, and there is an application for both smartphones and personal computers. In the hierarchy of supervision, man represents the last link.

The aim of this paper is to introduce automated real-time online monitoring in the wastewater treatment plant "Ekogramont" (Fig. 1) with the possibility of using this monitoring in the prevention of the COVID-19 pandemic. The plant is located at 1080 m above sea level and was built in the period from 1998 to 1999 for the needs of the company for bottling spring water “Vlasinska ROSA”, which is now owned by the company “Coca Cola” HBC. So far, wastewater monitoring has included periodic monitoring of common physicochemical and biological markers through standard analytical methods. Owing to IT technology, it is possible to continuously monitor these parameters by using modern sensors, smart modules, intelligent transducers, immersion UV/Vis spectrophotometer (ISA), control systems, online analysers and software.
The suitability of such automated monitoring comes to the fore in extreme weather conditions which prevail in this high mountain area, when for the purposes of standard analysis, wastewater sampling is disabled.

Due to the outbreak of the COVID-19 pandemic, automated monitoring can also be used to send the results obtained by analysing the presence of the viral genome in wastewater through rapid PCR tests.

MATERIAL AND METHODS

The biological wastewater treatment plant "Ekogramont" processes water which is a mixture of faecal, technological, technical and atmospheric water. Technological, technical and faecal water are gravitationally brought to the plant through sewage pipes. Through a network of gravity pipelines which are connected to the sewage system, the atmospheric water is collected from roof, green and asphalt surfaces. The processed water is discharged from the plant into the left headstream of the Vrla River, which belongs to the South Morava basin.

Fig. 1. "Ekogramont" - biological wastewater treatment plant

The plant contains an oil and grease interceptor, primary and secondary tube settler, recirculation unit, bio filter dripper, sludge digester, basin for sanitary hydrophytocultures, waste stabilisation pond and slow sand filter [5]. Biological wastewater treatment is a combination of aerobic, facultative anaerobic and anaerobic processes. This plant is based on a simple, energy-efficient and economically acceptable technological solution for wastewater treatment, which uses both microbiological and macrobiological methods [6]. Since the water from the plant is discharged into a watercourse classified as Category 1, wastewater treatment level and discharge schedule must ensure the category 1 water quality. This is an additional reason for the introduction of automated monitoring of the water discharge regime from the plant in order to prevent any possible accident.

The proposed automated monitoring of wastewater quality is based on the SCADA system (Supervisory Control and Data Acquisition) which collects data from sensors at the plant and delivers them to the central station. The primary purpose of the system is alert to changes in water quality.
The SCADA system consists of hardware and software which are designed to provide a flexible set of functions for collecting wastewater quality measurement parameters, processing thereof, monitoring and adequate response.

The SCADA system consists of functionally connected units, namely: software subsystem, hardware subsystem, communication subsystem and system of measuring sensors at the plant. The SCADA system can use a combination of radio and telephone lines for communication as well as satellite systems. This system consists of one or more MTUs (Master Terminal Units) or workstations where the appropriate software is installed. In many applications, the MTU is required to communicate with other computers in the system [7].

Rapid PCR tests are used to detect the presence of RNA from SARS-CoV2 in wastewater. The standard RT-PCR protocols WHO [8] and FDA [9] are used to detect SARS-CoV2. The samples should be taken before and after the processing in the treatment plant. The samples should be taken early in the morning (it is recommended to do so at 7 o'clock), at least once a week, by pouring 1000 mL of wastewater into sterile HDPE plastic containers. The collected samples should be transported to the laboratory in a refrigerator with ice and a temperature of 4 °C. The samples should be taken only when there is no rain, because mixing water from atmospheric precipitation with sewage water gives false results about the presence and the amount of RNA from SARS-CoV2. In the laboratory, 800 mL of each wastewater sample is first concentrated by precipitation with 20% polyethylene glycol 6000. It is then resuspended in 3 mL of PBS (sodium dihydrogen phosphate), pH 7.4 [10]. Viral RNA extraction is performed from 1mL concentrate and is eluted in 50 µL, according to the commercial instructions of the given manufacturer.

RESULTS AND DISCUSSION

SARS-CoV2 (severe acute respiratory syndrome coronavirus-2) is an infectious virus that causes a disease called COVID-19. SARS-CoV2 is a positive, single-stranded RNA coronavirus containing 29,903 nucleotides and ranging in size from 200 nm. Coronavirus are pathogenic to humans and animals.

It has been proven that SARS-CoV2, in addition to the respiratory system, can also infect the cells of the gastrointestinal tract, in which case the gastric, duodenal and rectal epithelium releases a huge amount of virus. The amount of RNA copies of the virus then ranges from $10^2$ to $10^8$ per gram [11]. SARS-CoV2 was detected in stool samples of patients with symptoms of COVID-19, but also in asymptomatic cases of the disease, which confirms the possibility of faecal - oral route of transmission. Prior to the outbreak of the COVID-19 pandemic, wastewater monitoring, in addition to monitoring common physicochemical and biological markers (e.g. enteroviruses), also included monitoring those markers that indicate specific human activities such as use of narcotics, drug use/abuse, the emergence of genes for antimicrobial activity, etc.

In this way, the presence of RNA SARS-CoV2 in the wastewater of Spain had been proven before the local authorities reported the first cases of COVID-19 (the first case was reported in Barcelona on February 25, 2020). This study showed that after primary wastewater treatment, SARS-CoV2 RNA was present in 11% of samples and that after tertiary water treatment, RNA of this virus was not detected in any of the samples [12].
The latest scientific papers have additionally confirmed the presence of SARS-2 in wastewater, so in some European cities, this type of its detection has already begun. In the Republic of Serbia 3,164,313 persons were tested by the middle of March 2021, out of which the presence of SARS-CoV2 was confirmed in 520,911 cases. Mortality rate was 0.91% [13].

The first attempt to introduce the detection of the presence of SARS-CoV2 from wastewater in Serbia began in Vranje, in mid-August 2020, from the wastewater of the city river. This water flows into the South Morava River without any prior treatment [14], [15], [16].

Early detection of SARS-CoV2 RNA in wastewater is a tool for early warning and monitoring of COVID-19 status in a given human population. Due to the large number of asymptomatic cases, monitoring of SARS-CoV2 RNA, originating from sewage water, gives a reliable picture of the current epidemiological situation. Detection of SARS-CoV2 from wastewater allows early detection of this virus. The detection of the viral genome in sewage, prior to the exponential phase of the epidemic, is a valuable indicator of the imminent danger of an outbreak. In this way, it is possible to monitor the status and trend of COVID-19 infection. This monitoring strategy is a much cheaper alternative to mass population testing (which is the primary choice in the fight against this epidemic). Thus, SARS-CoV2 can be detected several weeks before the confirmation of the first case in each subsequent wave, which gives epidemiologists enough time to implement all measures to slow down the spread of the disease. The presence of RNA SARS-CoV2 had been proven in the wastewater of some cities in Spain before the local authorities reported the first cases of COVID-19. Thus, for example, the examination of archived wastewater samples from 2018 and 2019 confirmed the presence of RNA from SARS-CoV2 in the sample from March 12, 2019, i.e. one year before the pandemic was declared [17].

The suggested system is the system for automated real-time water quality monitoring “GO systemelektronik” GmbH, which in practice has proven to be an efficient and long-term solution for online water quality monitoring. The system consists of multiple sensors, smart modules, smart transducers, immersion UV/VIs spectrophotometers (ISA), control systems, online analysers and software (Fig. 2).
The system contains an immersion UV/Vis spectrophotometer (ISA) and sensors to control eleven parameters in wastewater, as follows: ammonium, biochemical oxygen demand (BOD), colour, conductivity, chemical oxygen demand (COD), nitrate, pH, dissolved oxygen, temperature, turbidity (FNU), and total suspended solids (TSS).

The software includes a computer operating system, SCADA software, a PLC operating system (Programmable Logic Controller), programs for local management using PLCs, communication programs, and network control software. The hardware subsystem consists of computer equipment, PLC, communication hardware, indicators, encoders, modems, cables and other equipment. The communication subsystem consists of hardware and software elements that stand out as a separate subsystem of the SCADA system. The system is modular and scalable, thus there is an application for smartphone, PC and tablet. For example, using the so-called "BlueGate cloud" data service (Fig. 3) one can automatically back up all data and remote access is possible via any web browser [18]. This service also offers real-time data display, visualization and the ability to export all measurement data. All communication over the network is encrypted.

![Fig. 3. Cloud data service “BlueGate” (GO Systemelektronik GmbH)](image)

SCADA software performs functions of data management, monitoring and acquisition, but also additional functions (communication, report generation and printing of results). SCADA manages the hardware via a PLC that executes a program written in accordance with the IEC 61131-3 standard. The communication protocol is RS-232, and the PLC and PC exchange messages representing strings of ASCII characters. The functions of the SCADA system are implemented using the Delphi programming language and the components library that are part of the Borland Delphi 6.0 package [19]. The system also allows the setting of alarms, such as notifications of exceeding the limit values (MAC - maximum allowable concentrations), the so-called "Contamination alarm" which is activated when any of the specified parameters reaches and / or exceeds the critical limit. This is especially important because in this way any deviation that would probably go unnoticed by classical periodic laboratory analyses is identified and alarmed [20].

CONCLUSION

The proposed SCADA system collects the data from the sensors located in the sewage water and delivers the obtained results to the computers in the central station. SCADA software performs functions of data management, monitoring and acquisition, but also additional functions (communication, report generation and printing of results). SCADA manages the hardware via a PLC that executes a program written in accordance with the IEC 61131-3 standard.
The functions of the SCADA system are implemented using the Delphi programming language and the components library that are part of the Borland Delphi 6.0 package. Using the so-called "BlueGate cloud" data service one can automatically back up all data and remote access is possible via any web browser.

The suggested system is the system for automated real-time water quality monitoring “GO systemelektronik” GmbH, which in practice has proven to be an efficient and long-term solution for online water quality monitoring. Owing to IT technology, it is possible to continuously monitor these parameters by using modern sensors, smart modules, intelligent transducers, immersion UV/Vis spectrophotometer (ISA), control systems, online analysers and software. In addition to monitoring the quality of physicochemical parameters, the system can also be used to distribute the results of rapid PCR tests in order to detect the presence of SARS CoV2 in wastewater. The standard RT-PCR protocols WHO and FDA are used to detect SARS-CoV2. The system also allows the setting of alarms, such as notifications of exceeding the limit values (MAC - maximum allowable concentrations), the so-called "Contamination alarm" which is activated when any of the specified parameters reaches and / or exceeds the critical limit.

The suitability of such automated monitoring comes to the fore in extreme weather conditions which prevail in this high mountain area, when for the purposes of standard analysis, wastewater sampling is disabled.

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IT-MONITORING KVALITETA OTPADNE VODE U REALNOM VREMENU U PREVENCIJI PANDEMIJE COVID-19

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Sažetak: U državama članicama EU preuzimaju se nove mere za fleksibilna i skalabilna rešenja u praćenju kvaliteta otpadnih voda. Najnoviji naučni radovi potvrdili su prisustvo SARS-CoV2 virusa u otpadnim vodama. Ovaj virus je otkriven i u uzorcima stolice kod pacijenata sa simptomima COVID-19 ali i kod asimptomatskih slučajeva oboljevanja što potvrđuje i mogućnost fekalno-oralnog prenošenja. Cilj rada je uvođenje automatizovanog on-line monitoringa u realnom vremenu u postrojenju za prečišćavanje otpadne vode „Ekogramont“ sa mogućnošću korišćenja ovog monitoringa i u prevenciji pandemije COVID-19. Postrojenje se nalazi na 1080 m nadmorske visine i izgrađeno je 1999. godine za potrebe rada preduzeća za flaširanja izvorske vode „Vlasinska ROSA“-Coca cola HBC. Predložen je SCADA sistem koji sakuplja podatke sa senzora smeštenih u kanalizacionoj vodi i dobijene rezultate dostavlja računarima u centralnoj stanici. Pogodnost ovakvog automatizovanog monitoringa dolazi posebno do izražaja u ekstremnim vremenskim uslovima, kada se premaši kritična granica. Za detekciju SARS-CoV2 koristi se standardni RT-PCR protokoli WHO i FDA. Otkrivanje virusnog genoma u kanalizacionoj vodi, pre eksponencijalne faze epidemije, predstavlja dragocen indikator o neposrednoj opasnosti od izbijanja epidemije. Izmene zakonske regulative u Republici Srbiji, u ovoj oblasti, omogućile bi formiranje mreže automatizovanog monitoringa kontrole kvaliteta vode u realnom vremenu sa kontinualnim mernim sistemima koji bi rezultate merenja preko SCADA sistema dostavljali nadležnim institucijama.

Ključne reči: real-time monitoring, SCADA, otpadne vode, COVID-19.

Prijavljen: Submitted: 22.03.2021.
Ispravljen: Revised: 12.04.2021.
Prihvaćen: Accepted: 16.04.2021.