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APPLICATION OF NEW TECHNOLOGIES IN THE WATER SUPPLY SYSTEM

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ABSTRACT

Freshwater water resources are not inexhaustible [1]. In recent decades, more and more facts point to this statement from the European Charter for Water. Uncontrolled drinking water interventions, losses in water supply and climate change indicate the problem of sufficient quantities of drinking water [2]. Looking at this problem, it is hard to believe that new quantities of drinking water can be produced. The model of integrated water management has been increasingly used in recent years. The application of new technologies in water supply creates conditions for the controlled management of water intakes and losses in water supply. Each water sapply system needs to develop its own model for integrated water management.

Keywords: *water supply, new technologies, integrated management*

INTRODUCTION

Groundwater level measurement is the basis for proving one of the statements of the European Water Charter that freshwater resources are not inexhaustible [1]. From the aspect of groundwater level measurement in PE Water and Sewerage "Srebrenik" j-s.c., it can be stated that groundwater levels in wells that are in operation have certain oscillations, that is, static levels in the same periods of one hydrological year are not at the initial levels that correspond to the measurements from the design and technical documentation of the well condition.

Each water supply system is based on the capacity of the well (water intake) [3]. For many years, there have been evident indicators of a reduction in the amount of groundwater used for water supply, with data provided by representatives of water utilities at every gathering in BiH, where these topics are present. The history of the emergence of a water supply system in its simplest form can be presented as a regular connection of various structural objects: water intake, (gravity or pumping station), supply or push the pipeline, reservoir, distribution network and consumers [3,4].

Water utilities in BiH, which have remained at this classical level of water supply organization, have problems in ensuring the conditions of continuous supply of water for drinking to consumers. The reason is the maintenance of the water supply system, which cannot be reduced to repairs of visible malfunction [5].

This method had to evolve into a model of water supply that must follow the elements of disturbances in the hydrological cycle and integrate new technologies into the system of integral management of the water supply system [6].

MONITORING AND CONTROL PARAMETERS

New technologies in the field of process control and management enable continuous monitoring and management of parameters that are essential for the functioning of the water supply system [6]. The analysis of parameters for monitoring and control was done within the PE Water and Sewerage "Srebrenik" j-s.c.

The SCADA system (Supervisory Control And Data Acquisition), made it possible to monitor and control analog and digital signals from the water supply process.
Analog signals in the SCADA system: current strength pump electricity, pipeline pressure, well flow, well level, battery voltage [7].

Digital signals in the SCADA system as shown in the following figure (Figure 1): open door of the object, presence of overvoltage / undervoltage on the mains, operation mode, faults or activation of the pump motor thermal protection, operating signals (automatic / manual), compressor fault, minimum-lower-upper-maximum expansion vessel levels, signals from the measuring set, impulse output, lower and higher electricity tariff, signal from the flow meter [7].

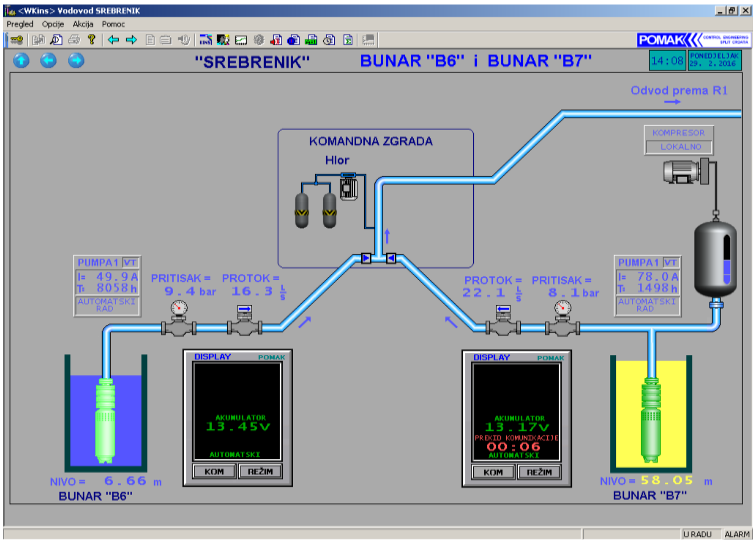


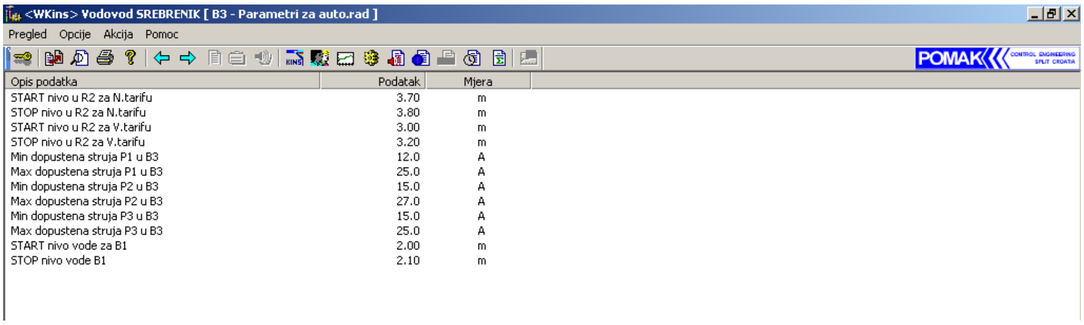
Figure 1. Monitoring and control parameters

MODEL OF THE WATER SUPLLY SYSTEM MANAGEMENT

In 2001, the PE Water and Sewerage "Srebrenik" j-s.c., Srebrenik established a model of water supply system management using the SCADA system. The management model is called the SDNU system (Remote Monitoring and Control System). It is application software that is adapted to the functional characteristics of the Srebrenik water supply system. Figure 1 shows a visualization of one part of the SDNU system where two wells and two pumping stations are monitored and operated [8]. Elements with monitoring function: water level in the well (m), pump status (in operation, at standstill), electricity tariff (HT/LT), current of pump in operation (A), voltage (V), pump operating hours (h) , pressure in the pipeline (bar), flow on the pipeline (l/s), alarm system protection, battery voltage (V), water level in the tank (m), water turbidity (NTU), water flow at the outlet reservoir (l/s), the concentration of residual chlorine in drinking water (mg/l).

Elements having a control function: pump mode (automatic/manual; there is a possibility to remotely change the pump mode via the actuators in the SCADA system), automatic dosing of water disinfectant, control of the compressor plant for protection of the pipeline against hydraulic shock, mode operation of the electric motor valve (open/closed status).

To build a model that precedes any application software of the SDNU system, it is necessary to know very well all the functional elements of the water supply system. The following figure (Figure 2) shows the parameters for automatic operation of a single object, which can also be called control parameters for all functional entities contained in the application part of the SDNU system.


<WKins> Vodovod SREBRENIK [B3 - Parametri za auto.rad]

Pregled Opcije Akcija Pomoc

Opis podatka	Podatak	Mjera
START nivo u R2 za N.tarifu	3.70	m
STOP nivo u R2 za N.tarifu	3.80	m
START nivo u R2 za V.tarifu	3.00	m
STOP nivo u R2 za V.tarifu	3.20	m
Min dopustena struja P1 u B3	12.0	A
Max dopustena struja P1 u B3	25.0	A
Min dopustena struja P2 u B3	15.0	A
Max dopustena struja P2 u B3	27.0	A
Min dopustena struja P3 u B3	15.0	A
Max dopustena struja P3 u B3	25.0	A
START nivo vode za B1	2.00	m
STOP nivo vode B1	2.10	m

Figure 2. Parameters for automatic operation

Visualization of the monitoring and control parameters shown in the previous figures (Figures 1 and 2) must be supported for each functional part of the water supply system, which creates the basic conditions for the integral management of the water supply system. Water supply systems that have remote monitoring and control systems for functional parameters can be called modern water supply systems. The new era of this type of water supply system management may provide elements that indicate that such a system will be able to plan for the long term to perform the function for which it was designed and built.

The presented model of water supply system management in the structure of control parameters enables monitoring of water level in the well and continuous measurement of water flow to consumers. Due to the occurrence of oscillations and decreases in groundwater levels, the SDNU system creates opportunities to manage losses in the water supply system. Water loss management can be presented in the context of finding new available quantities of water within the existing water supply system. When looking at the history of monitoring and analysis of water losses in water supply systems, the simplest way is to relate the total amount of Q_{zah} water abstracted and the total invoiced amount of Q_{fak} water. In order to obtain this information, there must be measurements on the well, distribution pipeline and consumers. This ratio is expressed as a percentage, at the end of the accounting period, which used to be three months, and today it is on a monthly basis in most water supply systems.

Here, the question of the response time is justified, that is, what time period elapses before the water loss in the system is detected, the total water losses, whether apparent or physical, are discussed.
Analyzing the data from the introduction of the SDNU system into the Srebrenik water supply system in 2001 to 2002, the first results of simply calculated water losses of Q_{gub}, according to the mentioned ratio, were 42%, or Q_{gub} = 17.6 l/s. This amount includes data that has been measured with measuring devices at the well, main distribution lines and with consumers. (There was no lump sum calculation of water consumption or illegal consumers). The total impact on the three wells analyzed was Q_{zah} = 42 l/s. In the Water Loss Management Program of the PE Water and Sewerage "Srebrenik" j-s.c. Srebrenik for 2019, which contains and the percentage of water losses calculated according to the presented simple calculation is 27% [9]. Looking at the percentage difference of water losses from 2002 and 2019, it can be concluded that the losses have been reduced by 64% or that a new available amount of Q_{ras} = 6.3 l/s has been provided, compared to the reduced percentage of water losses. By applying one segment of new technologies in the water supply system in the process of measuring the amount of water abstracted and distributed, great effects were achieved. This model is the basis for monitoring and managing the amount of water used in the water supply system. Based on this model, the relation can be established:

$$Q_{gub} \rightarrow Q_{gubmin} \leftrightarrow Q_{zah} \rightarrow Q_{fak.}. \qquad (1)$$

A functional dependency can be established on the basis of this relation:

$$Q_{zah} = f\,(Q_{klpr} + Q_{fak} + Q_{gub}) \tag{2}$$

Therefore, in the water supply system, the amount of water in the process directly related to the hydrological cycle, apropos climate change, cannot be affected. Also, the invoiced amount of Q_{fal} water that is tied to consumers needs cannot be affected. Reducing the percentage of water losses or the amount of water associated with Q_{gub} water losses is a resource that can provide new available quantities of Q_{ras} water to offset the unevenness of Q_{zah} water at the well caused by climate change Q_{klpr}.

APPLICATION OF NEW TECHNOLOGIES

By applying the SDNU system in the water supply system, it can be said that the conditions for reducing water losses have been created. If we look at the International Water Association (IWA) methodology [10], the status of apparent and physical water losses can be seen in the water balance for the amount of uncharged water. In the previously conducted analyzes in PE Water and Sewerage "Srebrenik" j-s.c. Srebrenik, it was found that transparent water losses have a negligible part, the conditions of comprehensive measurement are respected, there are no illegal consumers and regular water meters are replaced in order to reduce the percentage of incorrect measurement to minimal error. Physical water losses are the testing ground for providing the available quantities of Q_{ras} water [11]. In order to generally approach the management of physical losses, water metering requirements using the SDNU system must be met.

Each night flow during the period from midnight to 5 p.m. each day represents a potential loss in the water supply system, provided that no consumption of any of the consumers is determined after that measurement point. If the continuous night consumption of one of the consumers is known, the flow value for that consumer must be determined. So, the response time T_{odz} from quarterly or monthly has already been reduced to 24 hours. Efficiency calculation is not necessary here because the effects are visually visible from the text. The determined night flow at the outlet of the reservoir, or at the main of the distribution pipeline, is an alarm or a signal for potential physical water loss. The next step is finding a water loss in the distribution system that takes some time. The time of finding a loss can take an indefinite period of time if the appropriate model of loss investigation is not applied, that is, it goes into the notion of fault investigation on a distribution network with a specific investigation time T_{istkv}. In order to T_{istkv} be as short or as small as possible, appropriate available technologies should be used.

The next module used, as a new technology, is software for creating a geographical information system (GIS). In short, GIS is a visualization of an element of a water supply system in a spatial environment with clearly defined spatial coordinates xyz [12]. The following figure (Figure 3) shows the application of GIS for the water supply system of the PE Water and Sewerage "Srebrenik" j-s.c.,Srebrenik.

Figure 3. GIS system of the PE Water and Sewerage "Srebrenik" j-s.c., Srebrenik

The application of the GIS system creates the basis for the formation of District Measurement Area (DMA) zones, that is, isolated measurement zones to reduce the time of fault investigation. Each DMA zone formed at the entrance must have a measuring instrument and a device for collecting, processing and sending data (Data logger) [13]. The function of the Data Logger is to continuously measure the flow and pressure of water at the entrance to the DMA zone, and to send data to software for data processing and analysis (Figure 4).

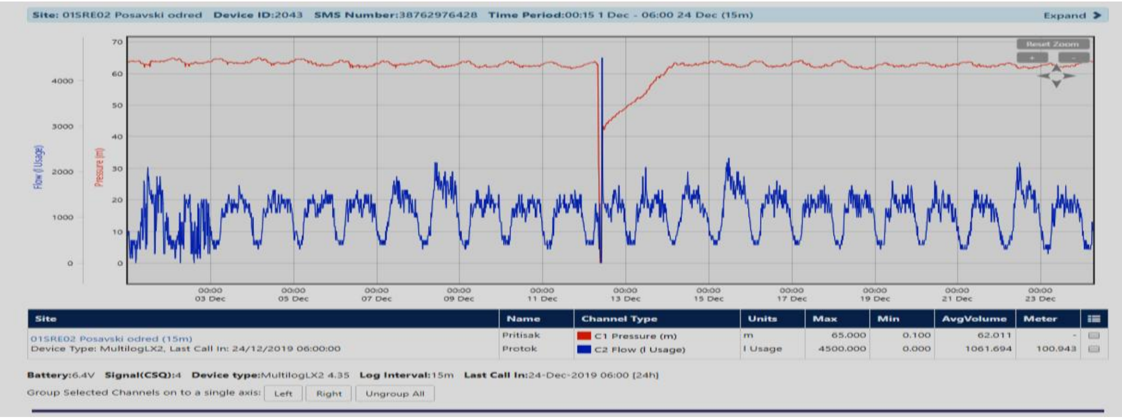


Figure 4. Flow and pressure measurement i the DMA zone

The software used to measure flow and pressure in the DMA zone is application software (MeterIng). The diagram (Figure 4) clearly shows the deviations of normal night consumption compared to normal experientially determined consumption. Data are read remotely at user-specified intervals. If the reading of the minimum night flow was made on the main distribution pipeline, and the consumption that is not in accordance with the usual conditions for that period of consumption is counted, then there is a potential physical waterloss in the water supply system. The next step is to read the minimum night-time water flow on the Data loggers on the formed DMA zones after the readout on the main distribution pipeline. The increase in the minimum night flow on the main distribution pipeline must be recorded at the same or approximate size (depends on the error of the measuring instrument) on one or more measuring devices in the DMA zones. This way, the DMA zone where the water loss is located can be determined. Determination of the microlocation of the place of occurrence of a waterloss or occurrence of a failure can be done by a physical tour of the pipeline route (data from the GIS system is used), or by further measurement and investigation processes. If these are hidden faults that are not visible on the earth's surface, which is the biggest problem in the waterloss management model, then the next stage of the fault investigation is approached.

An ultrasonic flowmeter (Figure 5) used to determine the approximate location of the resulting water loss. An ultrasonic flow meter (Figure 5) is used as a portable device for continuously measuring the flow of water through a pipeline.

Figure 5. Ultrasonic flowmeter

Using an ultrasonic flowmeter (Figure 5) using sectional valves and spatial data of the distribution network layout, the potential location can be reduced to an optimal space where water loss is possible. After this method, if it is not possible to determine the location of the loss of water, and a microlocation is established (microlocation means a distribution pipeline where it is possible to perform complete isolation of consumers and search this space within a reasonable time, which indicates that the space can be thoroughly investigated for max. 2 hours), the following method of fault investigation is used using a noise detection device (Figure 6). A noise detection device (Figure 6) used as a final stage in the investigation of physical water losses that are not visible on the surface. The investigation procedure consists in a physical tour of a particular microlocation on a distribution pipeline whereby a ground noise detection sensor is used to determine the potential location of a fault.

The accuracy of the determined noise in relation to the actual location of the fault occurs depends on the operator's ability. It can be experienced that the location of forests in relation to the actual location of failure does not extend beyond 0.5 meters, which is quite satisfactory for water supply systems where the minimum excavation depth of the trench for laying the smallest pipeline profile is 0.8 meters.

Figure 6. Noice detection device – Geophon

In the following figure (Figure 7) presents the result of finding water loss on the distribution pipeline (material-PEHD pipes, profile-DN 63 mm, built in 1989., data from the GIS system). On the main flow meter in the Eastern Water Supply Zone (material-PVC pipe, profile-DN 200 mm, built in 1994., data from the GIS system), an increase in night flow of 2.5 l / s was found. The water supply zone is further subdivided into four DMA zones where night flow readings were also performed, and an increase in night flow at the "Hazima Vikala" DMA zone was detected. Hazima Vikala DMA zone has eight secondary supply sub-zones. Using an ultrasonic flowmeter, the potential loss of water in the subzone at Bajazeta Kešetović Street was determined. Using a noise detection device, an investigation of the 123-meter-long pipeline in Bajazet Kesetovic Street was made, and the microlocation of potential water loss in the pipeline was determined. Remediation of water loss is done, which is shown in Figure 7. The time from detection of increased night flow in the period from midhight to 5 o'clock in the morning (flow increase was detected in the diagram in 01^{20} after midnight), and repair of the failure at 11^{45} a.m. the next day, took 10 hours and 25 minutes.

This detection and remediation time is unmatched by the initial method of detecting physical water loss for three months.

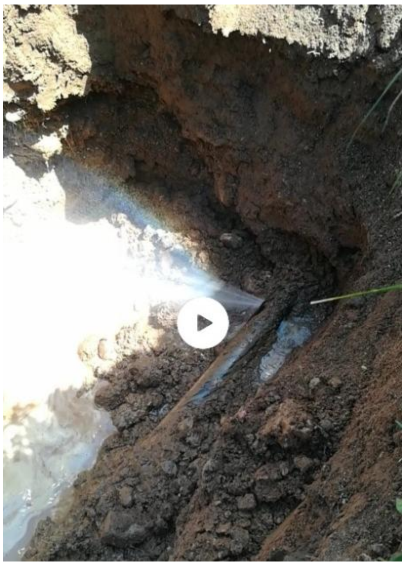


Figure 7. Water loss detection

In the integrated water supply management model, water loss management is an important segment in order to manage the availability quantities of drinking water. A model that was presented as a testing ground for the application of new technologies in the PE Water and Sewerage "Srebrenik" j-s.c., Srebrenik has produced visible results. The model that is being developed in the PE Water and Sewerage "Srebrenik" j-s.c., Srebrenik with integrated elements of the entire water supply system is shown in the following figure (Figure 8).

An integrated model of water supply system management (Figure 8) in the application sense should contain the basic functional elements of each water supply system. Functional elements include diagnostic parameters, remote monitoring and control system, geographic information system, accounting system and reliability element of water supply system as a measure of customer satisfaction. Given the increasing presence of artificial intelligence in management systems, water supply systems will in the future evolve as "learning systems"

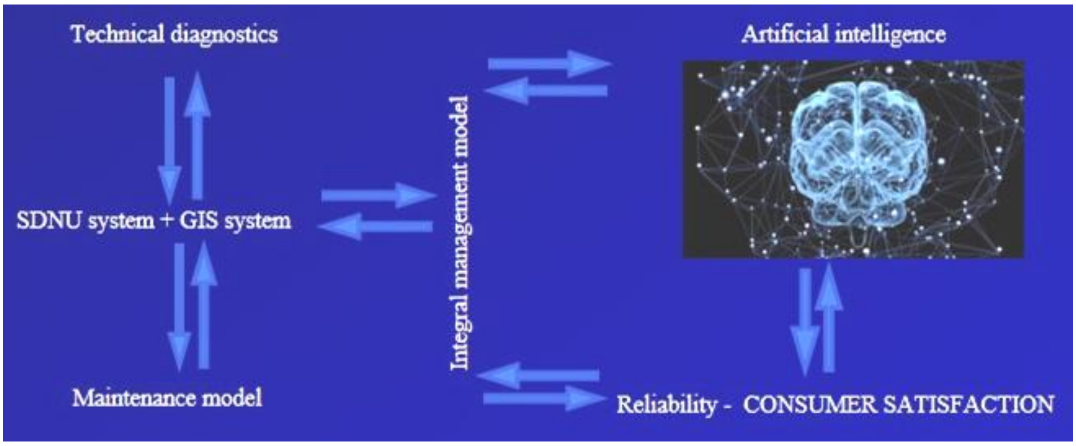


Figure 8. Model of integral management of water supply system

This model of development of the water supply system in the future is enabled by data that is continuously collected in an integrated management model (Figure 8), on the basis of which it is possible to develop a neural network that will aim to optimize any element of the water supply system, that is, to create conditions for increasing the reliability of the water supply system. A water supply system that has the shortest time to suspend drinking water for consumers, the least maintenance costs and the lowest incidence of drinking water can be said to be a successful water supply system.

CONCLUSION

"Water must be measured". A water supply company that does not meet this requirement cannot say for itself that it manages its water supply system. This condition in the PE Water and Sewerage "Srebrenik" j-s.c. Srebrenik was fulfilled in 2001., and the data analyzed can be considered as a real reflection of the situation.

The effects can be seen in different time periods. Reducing the consumption readout time from three to one month reduced the response time to determine potential water loss to 30 days. The construction of the SDNU system (Figures 1 and 2) enabled the reading of night flow at the main distribution pipeline over a period of 24 hours from the previous 30 days.

The construction of DMA zones with GIS system and the Data Logger (Figures 3 and 4) created the conditions for shortening the time of the fault investigation on the distribution network in such a way that the increase of the night flow on the main flow meter correlates with the flow meters on the DMA zones.

By identifying a supply zone that has experienced an increase in night flow, the failure time is reduced by the use of a ultrasonic flowmeter (Figure 5) that allows the measurement of instantaneous flow at each distribution pipeline, which shortens the time to detect the mirlocation of potential water loss on the pipeline. The next step is to use a noise detection device (Figure 6) to determine the microlocation of potential water loss on the pipeline (Figure 7).

This model of water loss management using new technologies can be applied in any water supply system (Figure 8).

The time of detection of potential water loss until repair cannot be predicted, but conditions have been created to manage the water loss and ensure that any water loss can be detected, found and repaired. Based on the above, the functional dependence of $Q_{zah} = f\ (Q_{klpr} + Q_{fak} + Q_{gub})$ can be confirmed.

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