DEVELOPMENT OF WATER QUALITY MONITORING STATION

Vörös Csaba

research scientist, head of department

University of Miskolc Research Institute of Applied Earth Science

H-3515 Miskolc, Egyetemváros

ABSTRACT

The staff of the University of Miskolc supported by a Hungarian GOP project has been developed a easy-to-mobilize multi-parameter water quality investigation station. During the station construction we performed instrumental, mechanical, electronics and information technology tasks. At the begining of the current project we selected a Hungarian river-section where we wish the whole, multi-point measuring-network will be realize. We had been walked around the whole selected area and mapped the suitable sub-areas where the system could be realise. After that we reviewed the similar implemented projects and based on the experiences and prepared the primary plans of our station. We reviewed the available water quality sensor offers and compared with the most important water quality parameters. With the selected sensors we had make calibration measurements and for that developed some unique level-interface electronics. In addition developed a suitable sensor-carrier-body and formed the conditions the immersion in water. For the physical design we had developed and realised the whole measuring station which operate by a stand-alone solar-cell solution. Two microcontroller which are on different levels and communicate with each other process the signals from the sensors. The measured parameters are transmitted to the server station via wireless GPRS communication. With the help of server station the measured data can be view on the internet as well as adjustable the system. Finally installed the whole system on the selected area.

INTRODUCTION

The staff of the University of Miskolc developed a container-based, be accredited water quality investigating station in a two-year project which launched in 2010. Number of conventional water quality measuring device and a newly developed robot analyser has been installed into the container. The water supply system carried out by a water-pump which is inside the container. The measured data could be transmitted to the central server station help with wireless GPRS communication. The finished container played an important role into the red-sludge disaster occurred on October 4, 2010, when the container station help the consequence of the shooting. The container which installed in Devecser for months and 24 hours per a day, transmitted water quality data from the Torna creek to the National Directorate of Water Management as well as Disaster Recovery.

DOI: 10.26649/musci.2015.051

Despite of the smallest container - offers on market - has been selected the transportation was difficult and needed significant costs. At the end of the successful operation formed a claim to develop - moving along a different newly-way - a easy-to-transport and easy-to-install measuring station. The development started in the summer of 2013 with the aim of build a complex water quality measuring, analysing and forecasting system which have the primary reporting agent tools are remote control sensor-base, grid-type mobile measuring stations.
The overall aim of the project is the with continuous monitoring the main properties of the surface waters (creeks, streams, rivers, lakes, reservoirs) and with as necessary to carry out control measurements, and the help the service of online information provide high level and efficient protection for the wildlife, the environment and the technology installed near to the water areas.
The results of the project the staff of University of Miskolc developed a stand-alone type water pollution measuring field station with an independent power source, and a laboratory equipment which models the flowing and mixing conditions in rivers.
The results of the whole project a complex service package to be created which integrated, scalable, mobile and the functionality is adjusted to the expanded user profile. The significant elements of the complex service package are:

- Objective and model-base investigation method: determines the water quality, the selection of the necessary predictive measurements.
- Reference laboratory environment for the reproducibility between the effect on water quality and parameters as well as suitable process modelling the flow investigation.
- Sensors-based test equipment and a grid-based measuring network which built from this.
- Modelling software with environmental condition assessment functions.

FIELD WORKS

In the first stage of the implementation was assigned a specific pilot area. Firstly will be done the reference measurements which are determines the status of water quality on the pilot-area. The results of the measurements will be compared with both of data from the Water Board of Directors, and values set out in the Water Framework Directive.
The second stage will be installed the prototype measuring station on the pilot area, which can work with an independent power supply, and could continuously collect given parameters.
In the third stage will be established the full measurement network, which included the prototype-based measuring-columns, and the measuring containers on the reference measuring venues.
The pilot-area was selected on the north-Hungarian region, on the Sajó-river. During the field work we had appointed 20 different areas on the river-sections and the surrounding watercourses (Table 1), which suitable for install measuring column or measuring containers in the future.

Table 1
Possible places for installing measuring columns or measuring containers

Sajó river – Sajópüspök authoritative gauge	Sajó river - Sajóecseg
Sajó river - Bánréve waterwork, railway station	Bábony creek – Sajóecseg
Hangony creek - Sajónémet road bridge	Sajó river - Szirmabesenyő
Hangony creek, authoritative gauge - Ózd-center	Sajó river - Miskolc
Sajó river - Putnok	Szinva creek – Miskolc
Bán creek – Vadna	Sajó river - Sajópetri
Sajó river - Kazincbarcika	Hernád river - Bőcs
Sajó river, authoritative gauge - Sajószentpéter	Sajó river - Kesznyéten
Bódva creek - Boldva	Takta creek - Kesznyéten
Bódva creek – Boldva, water abstraction points, barrage	Sajó canal – Tiszapalkonya (Tiszaújbánya)

The coordinates of the venues – which had selected during the field works - are fitted to the Google Maps surface, in this way become visible the exact location of the selected measuring points at the river section. The map available on the following site:
http://www.afki.hu/vizmin/sajo.html

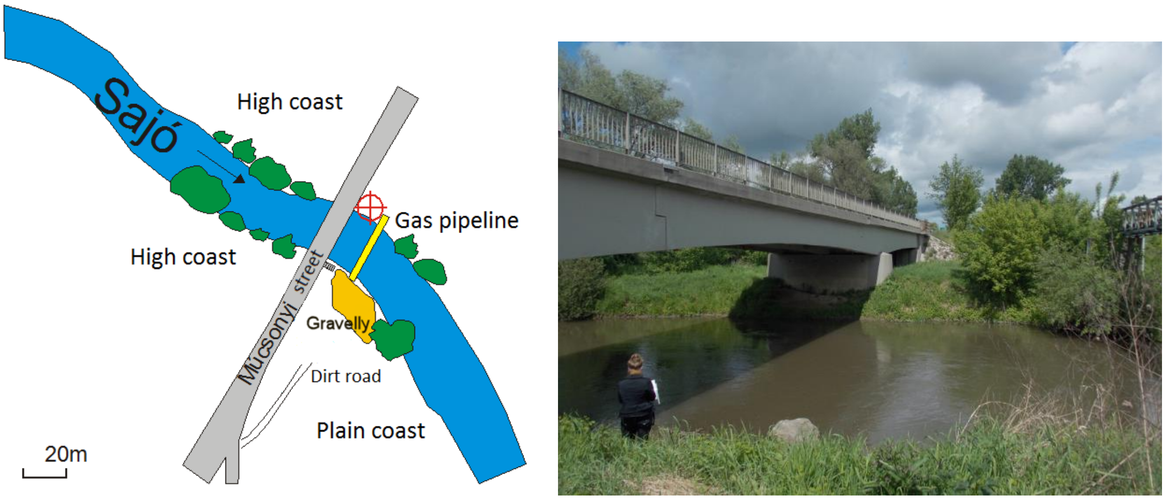

Figure 1
Example for the layout and photo documentations which prepared during the field works

Several data was recorded during field works:

- on-field signal strength of the three domestic mobil provider (Telekom, Telenor, Vodafone)
- a description of the accessibility of the area and layout drawing (Figure 1),
- base on the field experience proposal for primary design of the measuring station
- water conservancy data, such as water level and river width,
- list of the possibility or potential pollution source in the surrounded area,
- available electrical network,
- photo documentations.

Based on the experience of the field works we marked the exact place where we wished to install the prototype measuring system. The selected location stands inner area of Miskolc, under the No. 3 road Sajó-bridge which is easily accessible from the University of Miskolc, it clearly visible from the road, and the installation - expected - can easily be performed.

MEASURED PARAMETERS

On the next stage in the realisation we had collected the parameters which mostly affected the water quality. The compiled the list is based on parameters and values which stands in Water Framework Directive and we take into consideration which are the general investigated water quality parameters. (pH, conductivity, dissolved oxygen, turbidity, chlorophyll A, COD, BOD, chloride, sulphate, ammonium, nitrate, nitrite, heavy metals, etc.).

In a second stage we had reviewed the sensors, which:

- corresponding sensitivity - for the given water parameter limits,
- robust, field construction, remains operational in extreme weather conditions, less fragile,
- low-maintenance needs - potentially (all the material and time respects),
- possible to have a longer life (for example in case of pH measuring sensor more than 2 years),
- low power needs - potentially - both in sleep and measuring mode,
- digital output preferred instead of to the analogue,
- commercially available instruments, sensors,
- and finally considering the all listed aspects it has a good price/value ratio.

Compared the parameters listed above and the available instruments we could determine the list of the values or parameters which we will measure with the station:

- Temperature
- Water level
- pH
- Redox
- Conductivity
- Dissolved oxygen
- Ammonium
- Chloride

MEASURING, CONTROL AND COMMUNICATION SOLUTIONS

By the station carried out tasks

Parameter measurement: Querying the values of individual sensors - in given periodic. In the implementation the repeat of measuring number and the cycle time are adjustable.
Signal conversion: The electrical output signals of the measured water quality parameters must be converted to a signal which, the built-in digital data logger able to receive and processed.
Communication: the measuring station transmit towards the collected signals or values to the server station. In the implementation the communication cycle times (scheduled communications) are adjustable - according to the actual demand. The system has been adapted to start an individual communication (non-scheduled communication) in the case of a value goes over the alarm limits.
Calibration: The calibration process of the built-in sensors can be performed in the field conditions. For the implementation of this task we used electronics, communications and IT solutions.

Levels of station

The station is realized on two different levels (Figure 2).

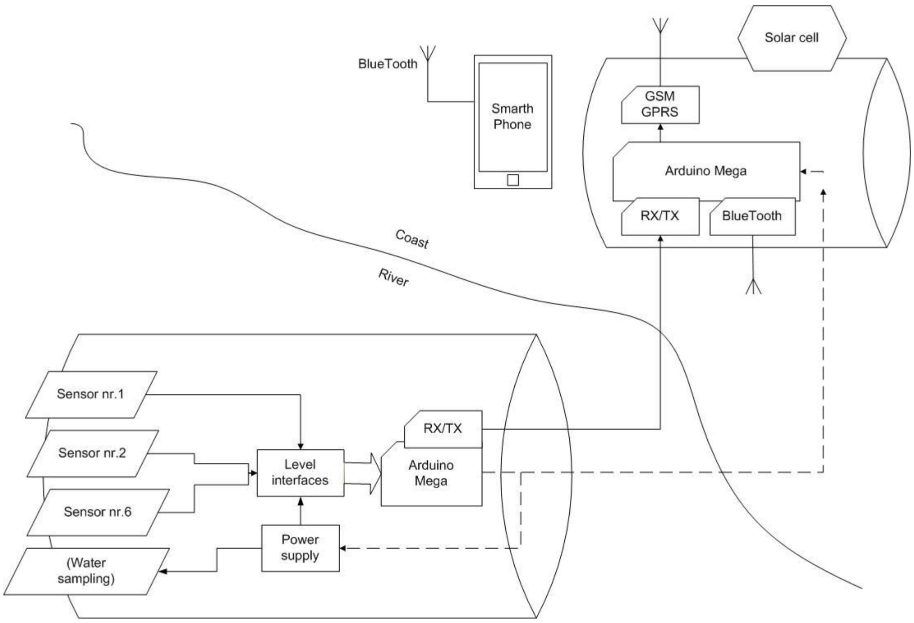

Figure 2
Data-connection structure in the implemented system

Microcontroller in the sensor-carrier-body (in water): The microcontroller in the sensor-carrier-body is a passive (slave) unit, so it does neither initiate communication, nor measuring or sampling. This controller carry out the digitalisation of the signals

which come from sensors - via the level interface -, and realise a connection towards to another microcontroller.
Microcontroller in the instrument-cabin (rack) on the measuring-column - The (master) controller on the column is the centre unit of the whole measuring station and measuring system. This device - in itself - is an active unit, so it could start communication or measuring, and also could processed the command came from the server-station (eg. asset protection, and battery voltage monitoring). In addition it could completely unplug the whole sensor electronics part in case in sleep-operation-mode - energy efficiency reasons -, because this part have a real function only in case of measuring time (this feature enables the energy consumption reduced significantly).

ELECTRICAL MEASURING SYSTEM

After selection the sensors and microcontrollers it is possible to determine the signal or level conversion needs. We developed several unique electronic circuits between the microcontroller and the sensors (Figure 3). We solved the signal conversion of the conventional and high output resistance sensor electrodes with several two- or four-stage amplifier which built from easy and cheap operational amplifier.

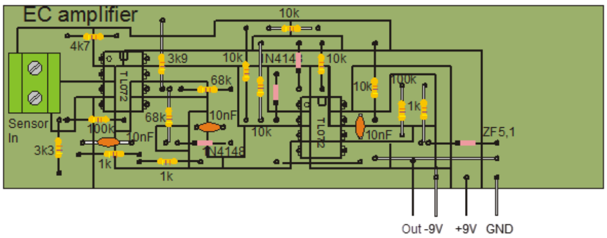

Figure 3
Level-interface electronics for EC sensor

For the feeding the whole electronics system we should take into account several sensors needs both positive and negative output voltage. Due to the foregoing, to strengthen the negative input voltage needs a double power supply and plus/minus voltage, which is made from the available battery-voltage.

STRUCTURE OF THE MEASURING SYSTEM

A modular structured and easy-to-install system we wished to create for monitoring the water quality (Figure 4). The water quality examining field system consists of the following major components:
- communication column,
- connecting and immersion piping,
- submersible carrier-body with sensors.

The tasks of the communication-column are transfers the data which comes from the sensors towards to the server station, as well as executes the commands which comes from the server station.

The main task of the connection pipe is protects the electrical cables between the communication column and sensors-carrier-body.
The submersible sensor-carrier-body with the sensors inside performs the parameter measuring tasks and transfers the measured values towards the controller on the column.
The main part of the communication column is a steel pipe which is 4,5 m length and have 100 mm diameter. The customized steel-pipe contains the electrical cabinet, the solar cell, the base structure, the necessary clamp units for awning plate and the holes which necessary for wiring. There is an electrical cabinet fixed on the column at 2,5 height, which contains the whole central electrical control system. The column is connects into a specially designed base-plate. The base-plate could receive - mounting way - the column, and it have four connector thread to receive the concrete-weights. Stands at the top of the construction the solar cell which ensure the electricity supply. The generated energy is storage into a battery which placed under the column in the ground and protected by a barrel.

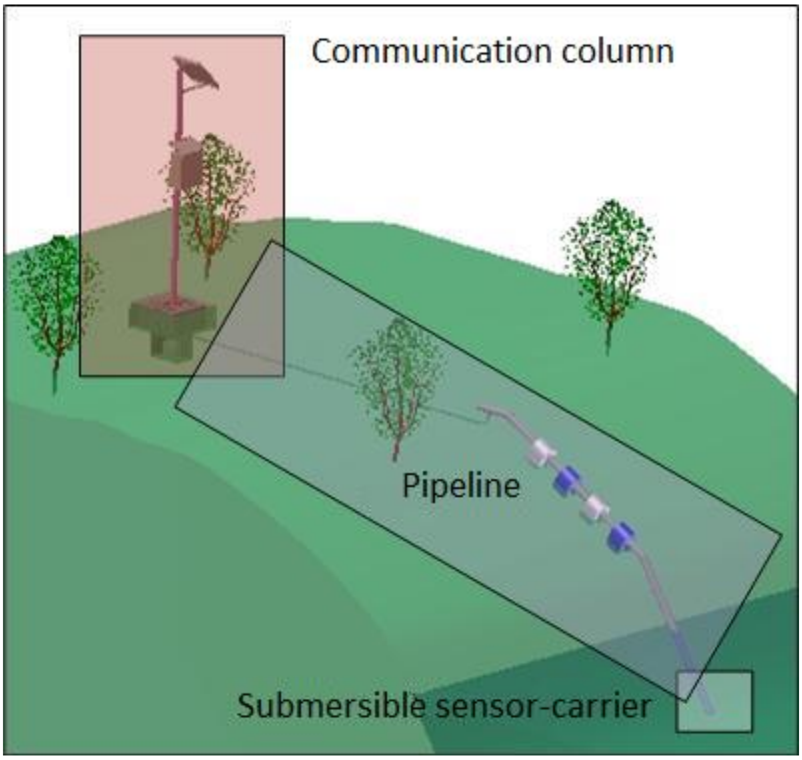

Figure 4
Layout of the implemented measuring station

The selected sensors placed into a pressure resistant plastic carrier body (Figure 5). The main tasks of the realised sensor-carrier-body:
- mounts the sensors,
- protects the sensors,
- protects the electronic (control- communication- and signal processing) modules,
- contains the dive-enabling pins.

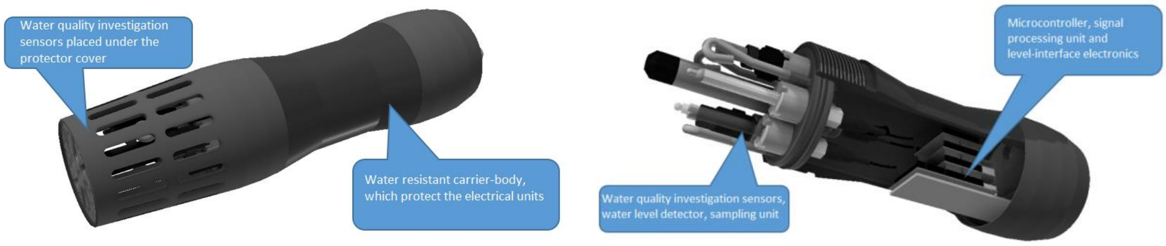

Figure 5
Layout of the multisensor carrier-body

In the head of the carrier-body overall six different water quality examining sensors and a submersible water level detector possible to placed. The head is a modular type structure, it means any number of used from the available universal sensors-places. The non-used sensor-places could closed by dummy plugs. The electronically implementation also follow the modular structure, that means corresponding number sensor connectable to the microcontroller's level-interface mainboard.

WEB PUBLICATION

Created a server script which receives the GPRS messages come from the field measuring station, in addition also created a web page which could shows the incoming data in both of graphs and tables form (Figure 6). The operation mode of the measuring system is also adjustable (setting the schedule time and parameters) from this website.

Figure 6
Parameters and data on the website