Online Water Flow, Level and Water Quality Monitoring Concept for Mines

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Abstract Modern technological solutions make it possible to carry out environmental monitoring in real time. By doing so, environmental impact information is available immediately. Early alarm options through automation system ensure minimising environmental hazards and enhance the occupational safety.
Many water-quality parameters, for example: pH, conductivity, turbidity, COD, BOD and up to 5 different metals can be analysed online. Also, online weather and water balance monitoring, which are important to the mine industry, are available.
Online monitoring is also more accurate than traditional manual sampling and in conjunction with laboratory analysis makes the environmental load calculations more reliable.

Background

Water quality can change frequently over time, necessitating frequent, repeated measurements to adequately characterise variations in quality. Modern technologies make it possible to implement environmental monitoring mainly by sensors. Operation of a water-quality monitoring station provides a nearly continuous record of water quality that can be processed and published or distributed directly to the Internet. The water-quality record provides a nearly complete record of changes in water quality that also can serve as the basis for computation of constituent loads at a site. Data from the sensors also can be used to estimate other constituents if a significant correlation can be established, often by regression analyses. The early alarm options as well are important parts of the concept to be presented. The traditional environmental monitoring practices are too slow and not accurate enough for today's industries' needs and for the people and organisations that are connected to them.

The new concept: Environmental Monitoring and Safety Concept, EnMonCon

The environmental monitoring concept where most of the measurements are automated was developed by EHP with its international partners. Mines, as well as other industries; are the core users of the solution. The concept includes online weather (rain, wind, air pressure, temperature and so on), water level, for example in basins or lagoons, and water quality monitoring options, flowing in rivers, ditches and/or in pipelines.

EnMonCon is an answer to a new Environmental Protection law and regulations that require actors and industrial companies to focus on proactive actions to preserve the environment. Implementation of EnMonCon is also the BAT solution for environmental safety monitoring and environmental risk management.

The concept emphasises online measurements instead of manual sampling and laboratory analysis. Almost all the most important parameters can be automated. Through the auto-

mation system, the alarm option minimises the environmental hazards and ensures environmental and occupational safety. The concept also includes laboratory analysis of water samples and field measurements data saved in digital format.

Real-time data from measurements makes load calculations more accurate thus making optimisation of processes easier, ensuring increased productivity and cost savings. Environmental impact reporting can easily be implemented to the authorities through the cloud server, which may speed up the application process for an environment permit. In addition, everyday environmental measurement information can be read from the server by computer or handheld / mobile device. The user-interface for the accessing the data is through an internet browser.

The Environmental Monitoring Concept, EnMonCon, (the full concept is shown in Fig. 1) including all needed environmental monitoring and reporting options and functions is ready to be offered and delivered to industrial clients. This is an optimal solution for mines and industries that have a number of water and weather related measurement requirements to make their operation safe and efficient.

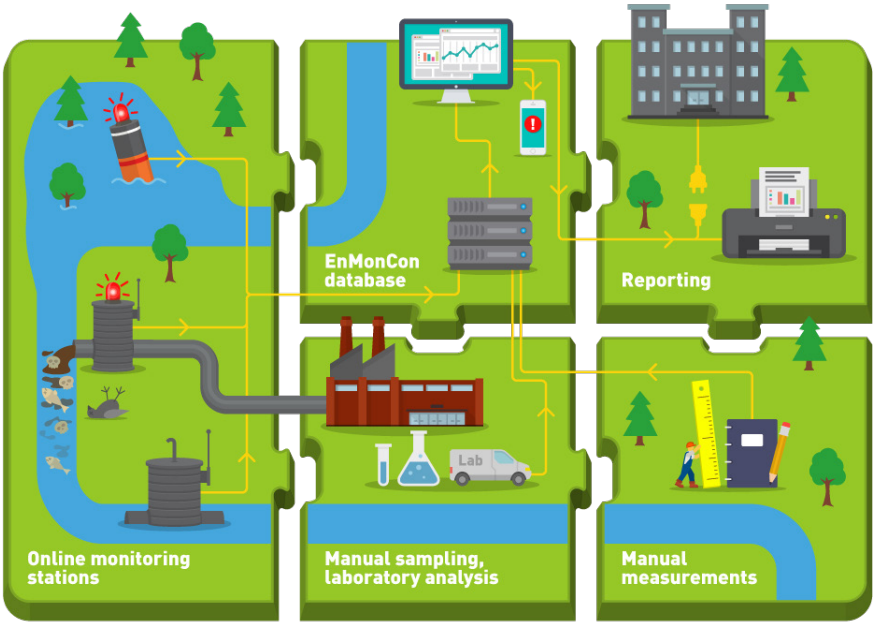

Figure 1. *The Environmental Monitoring and Safety Concept, EnMonCon*

What parameters can be measured online?

Majority of the water quality parameters can be analysed online as well as the water flow and level in different locations at the mine/industry area and at its environment. Several water quality parameters, for example pH, conductivity, turbidity, COD, BOD and oil-in-

water can be included to the system. Additionally, up to 5 different metals can be continuously monitored by the system. Copper, zinc, nickel and lead are familiar to EHP to be measured online at mine environments, for example. The metal monitoring solution technology is based on a voltammetry principle. Electrochemistry presents good specificity, excellent stability, high sensitivity and low limit of detection for trace metal analysis. The detection limit may be as low as 1 µg/L with typical measuring accuracy of ± 10 % at level 10 µg/L, depending on a parameter.

Automated trace metal monitoring systems were tested in-field in an industrial site cooperation with University of Oulu (Mahosenaho et al.) Electrochemical measurement was performed by differential pulse anodic stripping voltammetry (DPASV) for Zn determination. Comparison of online measurement data and reference laboratory analysis results (total trace metal analysis by ICP-MS) for Zn is shown in Fig. 2. According to the results elevated concentrations can be detected using online measurement system. Sudden peaks would have been missed when monitored by laboratory samples. It must though be taken into account that comparing those results is challenging due to the fact that online system detects only electrolabile fraction, not the total concentration of the metal to be measured. Ratio between electrolabile and total concentration of the metal depends on the content of complex-forming compounds present in the sample. Also relatively large measurement uncertainty value (± 20%) of ICP technique makes it difficult to compare the results. Despite the mentioned facts, the online metal monitoring system can ideally be used as an early warning system.

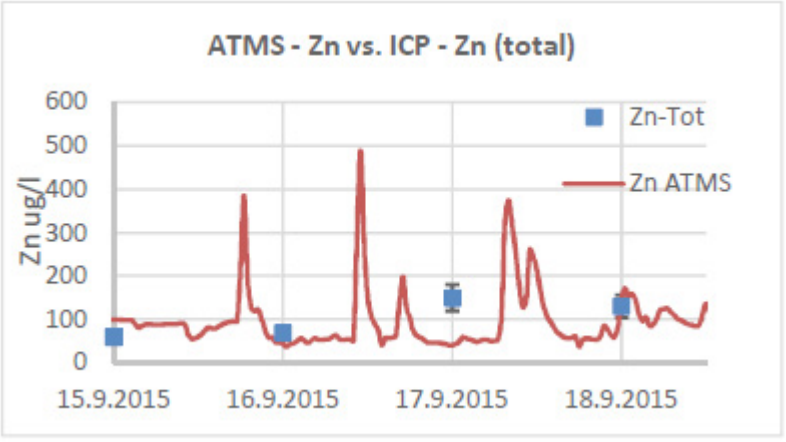

Figure 2. *Comparison of online measurement data for Zn with online analyser and reference analysis results for total Zn concentration.*

Total measurement uncertainty

Uncertainty of measurement is the most important single parameter that describes the quality of measurements. This is because uncertainty fundamentally affects the decisions

that are based upon the measurement result. Uncertainty that originates in the analytical portion of the measurement is usually known. It has become increasingly apparent that sampling is often the most important contribution to uncertainty and requires equally careful management and control. The uncertainty arising from the sampling process must therefore be evaluated. The total measurement uncertainty of online measurements, manual sampling and laboratory analyses have been studied by VTT Technical Research Centre of Finland Ltd (Ojanen-Saloranta 2016). The measured parameters were pH, turbidity, suspended solids and COD. Simultaneously to online measurements, sampling was carried out by two certified sampling persons representing different organisations. The laboratory analysis were carried out by two accredited laboratories. The results of both monitoring systems are quite equal (even if measurement uncertainties are not taken into account) as can be seen from Figure 3, where pH results of online monitoring and laboratory results are plotted as an example.

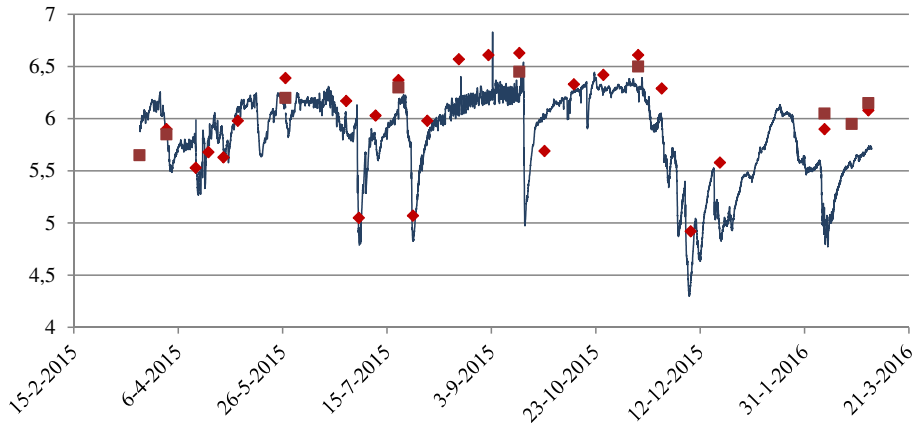

***Figure 3**. pH results of online measurement (solid line) and laboratory analysis of manual water samples (marked as rhombus and square representing different laboratories)*

The main findings of that research were that the manual sampling plays an important role in total measurement uncertainty and online measurements, when properly maintained and calibrated, are more accurate than manual sampling and laboratory analysis.

It can be seen in Figure 4a and Figure 4b that in this study the sampling is more significant uncertainty contribution for the suspended solids measurement than the laboratory analysis. For turbidity and COD measurements, the uncertainties due to sampling and laboratory analyses are of the same order of magnitude. For pH measurement, sampling contributes to the combined uncertainty, but the analysis is the most important contribution.

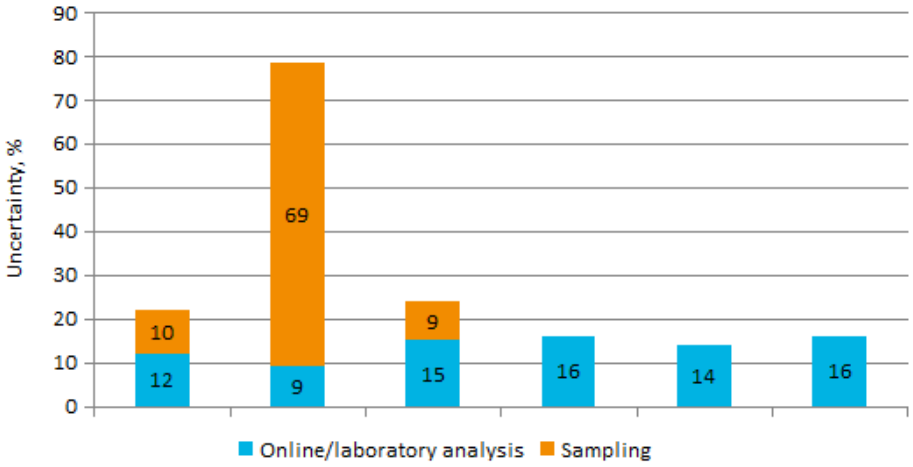

Figure 4a. *Uncertainties for turbidity, suspended solids and COD.*

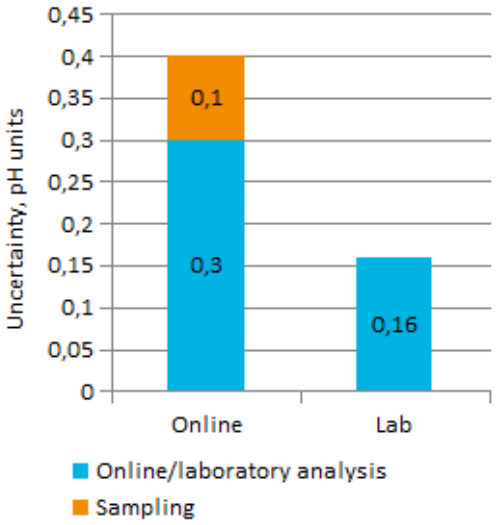

Figure 4b*. Uncertainties for pH.*

Online Water Balance Management solution for the mine

The online water balance management-function is one essential part of the system. The seepage through dams, that is quantity and quality (e.g. pH, conductivity, turbidity/suspended solids) of the seepage water, can be monitored continuously by the system. Additionally, piezometers for bore water pressure online monitoring and inclinometers for monitoring the earth movements can be included to be part of the system to bring the safety monitoring of the dams in modern online level.

By connecting all essential monitoring devices to the EnMonCon data system, it is possible to automate the water balance monitoring as well as the other monitoring needs, including environmental monitoring data collection and reporting to the authorities.

For predicting and modelling the future situation of the water balance, EHP operates with a partner to provides this information, which is also available online. Water Balance Management at mines has been under careful investigation in Finland during the last years. Online monitoring technology and solutions offers many benefits to follow, report and manage the Water Balance. It also ensures the environmental safety of the mine and prevents environmental hazards.

Conclusions

Online monitoring is an excellent way to know an environmental load in real time. It also significantly reduces costs compared to manual sampling and laboratory analysis, especially when monitoring is required on weekly or even a daily basis. Early warning systems and water balance monitoring enhances environmental and occupational safety. Almost all of the critical parameters can be monitored continuously. By combining all the environmental data to a cloud server, the handling of data is made easier. It also makes the environmental performance more transparent to the stakeholders and authorities and the data is available for key persons globally all the time, where-ever they are located.

References:

Mahosenaho MJ, Räty JP, Virtanen V Automated trace metal monitoring systems implemented in field test study in an industrial site, submitted to J Environ Monit

Ojanen-Saloranta M (2016) Uncertainty estimation of online measurement and manual sampling in water quality measurements, VTT Technology Report 263/2016