IMPLEMENTATION OF DAAS FOR INNOVATIVE REAL TIME WATER QUALITY MONITORING

FOLLOWING CASE STUDY DEALS WITH DATA AS A SERVICE (DAAS), CURRENTLY BEING IMPLEMENTED IN MEXICO TO PROVIDE INFORMATION ABOUT THE WATER QUALITY OF THE ATOYAC RIVER (PUEBLA STATE).

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Figure 1.s: can water quality monitoring schema
Problem
This river is currently suffering from an excess of uncontrolled urban discharges (more than 50 towns in Tlaxcala and Puebla states) and industrial pollutant discharges (over 10,000 industries ranging from textile, food, chemical, petrochemical, mechanic, automotive and paper industries) which surpass its natural self-purification capacity representing nowadays a serious hazard for the environment and health, requiring extreme measures.

A consistent monitoring strategy becomes then crucial and the only solution to increase the knowledge of the water quality in the targeted area that would allow taking the corrective actions to achieve the current environmental objectives. With this purpose, 12 s::can monitoring stations have been installed to monitor the quality of the water in the Atoyac River and tributaries under a Data as a Service innovative concept. All data is collected in a data central platform and is made available now to academic partners and later to the local government authority. The online monitoring of the water quality in the Atoyac River through the implemented solution represents a unique and breaking project in Mexico and Latin America, making the collected information transparent and accessible to the customer and opening huge opportunities for preservation of water bodies.

Facts
The poor quality of water bodies is a general problem in developing countries, reporting high concentrations of dissolved organic carbon, E.coli and dissolved metals. With respect to this, the Atoyac River is reported as the third most polluted river in Mexico, representing a serious health hazard for more than 2 million people living near the watercourse. The Atoyac River, located in the Alto Atoyac watershed, with a contribution area of 4,135.52 km² (including part of the state of Puebla and Tlaxcala) has been identified as having pollution levels eight times higher than the norm.

Factors Contributing To Poor Water Quality:
Contamination in the Atoyac River has a long history, being enforced by the industrial and urban growth, and the lack of fulfillment of already weak environmental laws for allowed discharges. All industries, ranging from food, textile, chemical, petrochemical, automotive, beverages, iron and steel and pharmaceutical among others, are discharging their waste to the river. This situation requires extreme measures to be taken in order to increase the knowledge about the sources of pollution and apply the corrective actions to bring back the river to acceptable environmental conditions.

Solution: With Advanced Approach
Being able to efficiently monitor the water quality of the river is the first step to investigate the origin of the pollution. Unfortunately, during the last ten years attempts to monitor the Atoyac River basin based on traditional water quality system have resulted unsatisfactory. Inspired by the previous s::can successful case study for monitoring of the Ganges River in India, a different approach to continuously monitor the water quality of the river has been implemented since December 2017 with the operation of a whole monitoring network that includes several advanced features.

Financed by the government of the state of Puebla in Mexico (SDRSOT) and under a “Data as a Service” (DaaS) project for IPN CIEMAD (National Polytechnic Institute), s::can has installed and successfully operated a set of innovative water quality monitoring systems along the Atoyac River as a whole monitoring network with the aim of:

- Getting crucial insights about the river...
behavior

- Measure trends
- And identify sources of pollution.

**Operational Result**

Each water quality monitoring system continuously transmits real-time water quality data at high frequency to a central cloud-based platform for transparent and real-time visualization. The long-term operation of the implemented monitoring network has allowed to gather crucial information about the environmental conditions of the Atoyac River and the real-time detection of pollution events 24 hours a day, exceptional information to be used within the design of public policies, sanitation and control actions for preservation of the Atoyac River catchment.

**Data as a Service (DaaS) s::can Solution**

With 20 years of expertise in the water industry, being a leader in online water quality monitoring, s::can is implementing worldwide its new business model, DaaS to deliver data with high quality to customers that are only interested in the data itself. In this case, s::can takes care of the whole data chain, taking into account not only the technical requirements, but also the constraints and local conditions of the measuring sites and specific applications. The success of such a service encompasses crucial aspects, ranging from proper design and installation of the monitoring systems, to proper implementation and operation to finally data collection and exploitation. The
complete implemented monitoring schema has been included as illustrated in the Figure 1 the following elements:

- Technological specifications and design of the monitoring network: In line with the continuous effort to improve the quality of natural water, to reduce the health risks for water consumers, to optimise the efficiency of drinking and (industrial) wastewater treatment and for environmental protection, s::can offers a full range of innovative, simple, easy to use, digital sensors for online water quality measurement, ranging from spectrometer probes to ion selective probes and physical probes, covering an extensive list of measurable parameters of interest. The technological offer is completed with compact and versatile IoT terminals for data acquisition, data communication and station control.

- Installation and commissioning: Adaptation to local conditions has been crucial for a successful monitoring with the proper installation of the involved equipment, including sensors, controllers, fixation structures and communication network. In comparison with the traditional unsatisfactory setup, important challenges associated to hard hydraulic conditions, efficient energy supply, protection against vandalism, robust sensors mounting, data collection and communication have been faced and effective solutions has been implemented. As an example, Figure 3 shows the two different setups for the sensors installation tested and evaluated within the project.

- Standard operational procedures: Continuous quality assurance and quality control program (QA/QC) based on reference measurements and ad-hoc standard operating procedures to achieve good data quality of the on-line measurements, detect systematic errors and needs for maintenance activities.

- A data management platform: Which integrates the information from the different measurement locations through the DaaS approach. The huge amount of data generated by the sensors (water quality parameters plus alarms information) is automatically collected, validated and made available to stakeholders for remote access and real–time visualization in a transparent way.

The success of the monitoring network depends on the right implementation of the above elements to answer to local needs under the basis of adapted and mature standard products and procedures.

**Measuring Site and Water Quality Monitoring Installation**

The implemented monitoring network combines the joint use of in-situ monitoring stations and advanced on-line water quality sensors for the collection of high frequency data. A set of 12 s::can monitoring stations installed along the river and tributaries (as shown in Figure 2) provide continuous information about the status of the Atoyac River basin. The main focus in this case study is on organic pollution (expressed as COD and BOD) and industrial spills detection. Each monitoring station encompasses the following elements:

- Up to 6 sensors to measure 14 to 20 water quality parameters. Innovative online sensors based on UV–VIS spectrometry provide online measurements of crucial water quality parameters including: Total and filtered Chemical Oxygen Demand (CODt, CODf), Biological Oxygen Demand (BOD), Nitrates (NO3), Total Suspended
Solids (TSS), Absorbance at 254 nm (UV254), Color and Turbidity. Ion-selective probes and physical probes complete the set of parameters providing the following parameters: Electrical Conductivity, pH, Dissolved Oxygen (DO), Redox Potential (ORP), Ammonia (NH4), Potassium (K), temperature and level.

Additional to the sensors above, and in order to detect specific pollution events, customized and trained alarms are also continuously monitored and used furthermore to automatically trigger auto-samplers for subsequent lab analysis for correlation and identification of pollution sources.

s::can station terminal with PostgreSQL database interfaces for almost any number of digital and analogue sensor inputs, SDI–12, Modbus, USB, TCP/IP–Ethernet, 4–20 mA, and other interfaces. Up to 64 parameters can be managed.

Operating software moni::tool on the s::can terminal for station and sensor management (on site or remote), data validation and event detection.

Self-automatic cleaning setup, using pressurized air or mechanical brushes, which reduce dramatically maintenance tasks and field visits and improving the quality of the data being collected.

Data transfer via GPRS network and secure SSH protocol through the s::can Cloud Server.

Setup for sensors installation. Two different structures were used as shown in Figure 3. Due to local constraints, a directly submerged installation of the sensors in the river was not possible, therefore a bypass installation was implemented.

Due to requirements from the customer, each monitoring system was installed within an already existent civil infrastructure as shown in Figure 4, which includes vandalism protection, energy supply and hydraulic installation for water intake from the river.

Data Management Platform
For the monitoring of the Atoyac River, the 12 s::can monitoring stations are continuously providing information about the water quality in the river and tributaries with a sampling time of three minutes each. Each monitoring station is then generating more than 160 measurements each sampling period, creating more than 2 Million data points per year for the whole monitoring network. The data is sent in real time to the central cloud-based data system, where the data is received, stored and visualized by the customer remotely.

s::can implemented a cloud based monitoring platform with a time series optimized relational database for central data storage. The platform collects measurement and metadata from s::can data loggers for easy visualization, alarming, download access and information processing. A GIS-system is also implemented for geographical display and analysis. Each monitoring system is equipped with the telemetry needed for data transmission to the s::can cloud, where the thousands of files are processed into the database. Besides enabling the efficient operation of large measurement networks, the platform provides a common and transparent place for data and asset management for customers or engineers. In case of large water quality monitoring projects, the use of a platform as the implemented one is indispensable to guarantee an efficient data handling and reliable data supply.

Benefits Of The Installed Monitoring Network
The implementation and long term operation of the monitoring network since December 2017 has resulted in important improvements compared to previous attempts carried out with a similar objective the last 10 years, success that will have an important impact in the design, implementation and operation of future monitoring water quality programs in Latin America and worldwide.

The main interest in this case study was focused on organic pollution and industrial spills detection by means of the continuous monitoring of key parameters. Additional to the technological challenge, local intrinsic constraints associated to the measuring site were successfully faced. Examples of such challenges were associated to...
the complex matrix of the medium being measured, as shown in Figure 7, with strong dynamic conditions and pollution events from more than 10,000 industrial enterprises in the catchment area, from what is reflected in COD values higher than 1200 mg/L and zero oxygen concentrations, indication of a dead river. Hydraulic issues have been another major challenge (Example Figure 8) concerning the existing civil infrastructure and intake design, highly depending on the hydraulic conditions of the river, water level, course of the river changing due to seasonal conditions and human intervention and level of sediments.

**Noted Improvements**

Major improvements were achieved compared to the first project attempt of others:

- Improved mechanical and hydraulic design, to adapt in a much better way, catering to the local needs and challenges in extreme environmental conditions
- Online measurement of water quality parameters (that so far were not efficiently measured) by using innovative sensors reagent-free and operated almost without maintenance
- As result of the above mentioned, the old equipment that combined huge individual analyzers for individual parameters estimation, was replaced with a compact solution reducing dramatically the space needs
- Cloud-based solution that allowed a transparent and high quality data supply 24/7, including additionally data evaluation, alarming and visualization.
- Reliable reference measurements for quality assurance and quality control (QA/QC) of the online measurements

**Major Conclusion**

As a major conclusion, in this case study reliable and mature s::can products have been combined with a DaaS model that has brought many advantages to the customer, who gets constant and real-time information about the water quality of the Atoyac River. The implemented s::can solution guarantees the proper operation of the system to ensure reliable data to the customer for further analysis and decision making. Under this innovative business model in water quality monitoring the customer has no investment risk, paying only for the data received. Because s::can takes the responsibility of installation, maintenance and operation of the whole system, the effort and knowhow needed from the customer is also dramatically reduced. The customer receives useful, trustable, reliable data accessible in real time for its own goals amongst others to describe pollution dynamics, real time identification of illicit discharge and pollution episodes, identification of pollution sources and cause–effect relationships and in general for a better understanding of the overall evolution of the water quality in the water body for its effective management.