A DISTRIBUTED SENSOR NETWORK FOR WASTE WATER MANAGEMENT PLANT PROTECTION

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Background

Discharges of toxic substances that reach the waste water management plants, may adversely affect the plants themselves, causing the release into the environment of pollutants at illegal and harmful concentrations.

Anomalous load due to dairy products processing.

Effects on sea water of overflow discharge of waste waters

SIMONA Project implements:

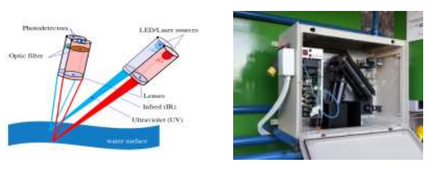
- ✓Remote monitoring of water quality along the sewage infrastructure.
- ✓Identification of anomalous or malicious immissions along the infrastructure.
- ✓Water quality forecasting in significant nodes including waste water management plant.

Prototype Wireless Sensor Nodes

Water Presence: One of the project requirements is to monitor the presence of water in overflow nodes that have to carry water only in very peculiar events (heavy rainfalls) highlighting mainteinance issues. A harsh environment water presence sensor has been deployed integrating a Gavazzi Optical water sensor with an ST ultra low power L series Nucleo Board and GSM Aurduino compatible Board.

Multisensor Device: A multisensor device have been developed for long term (6 Months) unattended non-contact operation. The system is devised to observe multiple variables and spot anomalous behaviours that can represent a proxy of significant variations in the quality of the sewage water. Sensor array included Microphones, H2S sensor, remote T sensor, ultrasound water level sensor.

Multisensor Device sensor array and MCU



LoadMon system principle of work and on site installation in Massa Centro waste water management plant

LoadMon: An optical multisensor, originally developed by the WRC, is being furtherly developed within the framework of project SIMONA. Using two powerful LED (IR and UV) and respective detectors, the device capture and analyze the sewage water reflectance aiming at the estimation of suspended solids (T**SS**) concentration and **COD** (Chemical oxygen demand).

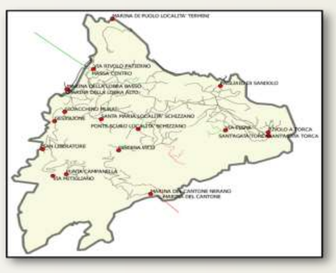
Multisensing network deployed at Massa Lubrense (NA)

The network includes five contact sensing commercial systems (*s::can™*), integrating different electrochemical and spectrometric transducers, operating at focal nodes of the collecting networks [1], together with custom non-contact multisensors .

All the sensing systems relies on the 3G infrastructure for data transmission.

Focal sensor nodes transmit near real time information (**T_s=1min**) on:

- ➢COD (Chemical Oxygen Demand)
- ➢Ammonia
- ➢TSS (Total Suspended Solids)
- ➢Water level
- ➢pH
- ➢Temperature

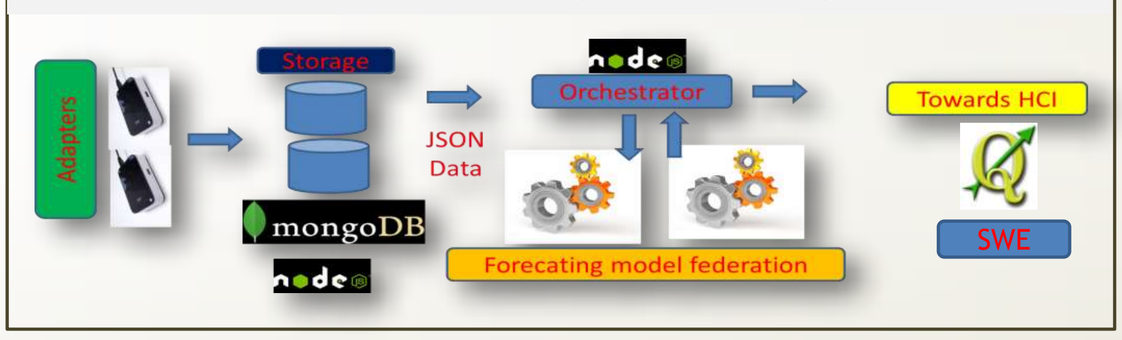


The open part of the optical path of the multiparameter spectrometer commercial device. Biofilm and algae growth are evident while the optical path appear clean due to compressed air cleaning.

Multisensing device installation site Marina della Lobra. Each contact transducer is protected by physical shocks by tubings.

Prototype multi-sensing systems rely on anomaly detection algorithm to transmit only relevant data together with a beacon summary reporting sensing variables hourly averages on a daily basis [2].

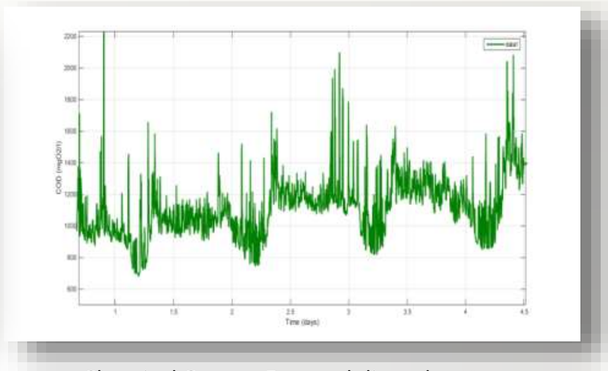
Data Processing Engine Technologies



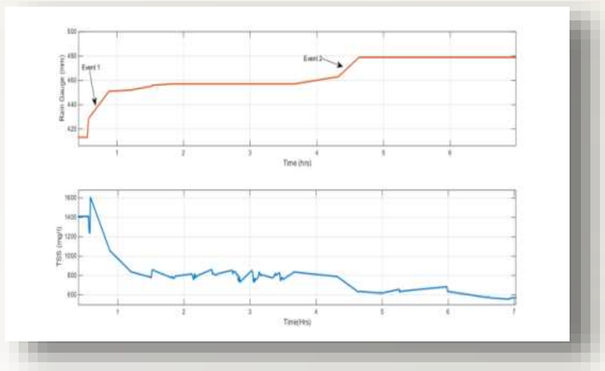
Preliminary Results of Monitoring Campaign

The sensor network was deployed starting on July 2015 and will be active until end of March 2016 for testing and validation purposes. In this contribution we report the preliminary results obtained during the campaign. The sewage has confirmed to be a harsh deployment scenario with several issues requiring maintenance and tuning respectively for contact sensors and prototype sensors. First results obtained by contact sensors, indicate a relatively stable behavior of the water quality in the network with repeatable diurnal patterns. Instead, fall of water level due to seasonal changes (population, low rainfall levels) was unexpectedly large at one of the sites and caused the sensors to run dry multiple times. Sensor nodes have required multiple maintenance actions due to EC sensors instabilities. Data transmission coverage was also instable. As a result the average date availability among the commercial nodes was found to be less than 25%. Notwithstanding this, interesting features of the wastewater chemistry at ML have been recorded and further analysis are in progress for optimizing hydraulic and chemical ML network model parameters by the data recorded during the Stress test (see right box under).

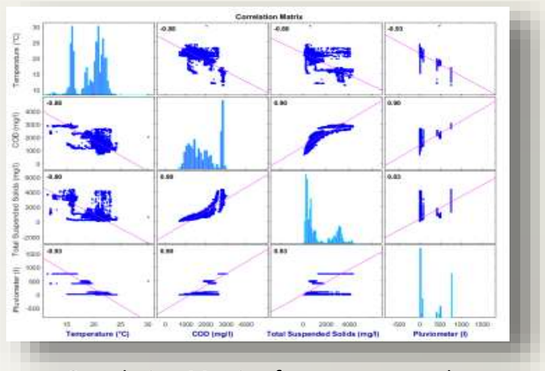
Schematic representation of Massa Lubrense sewer network with highlights sensor nodes positions. CM1.3 corresponds to wastewater management plant.



Chemical Oxygen Demand diurnal pattern as recorded at wastewater management plant (Massa Centro site).

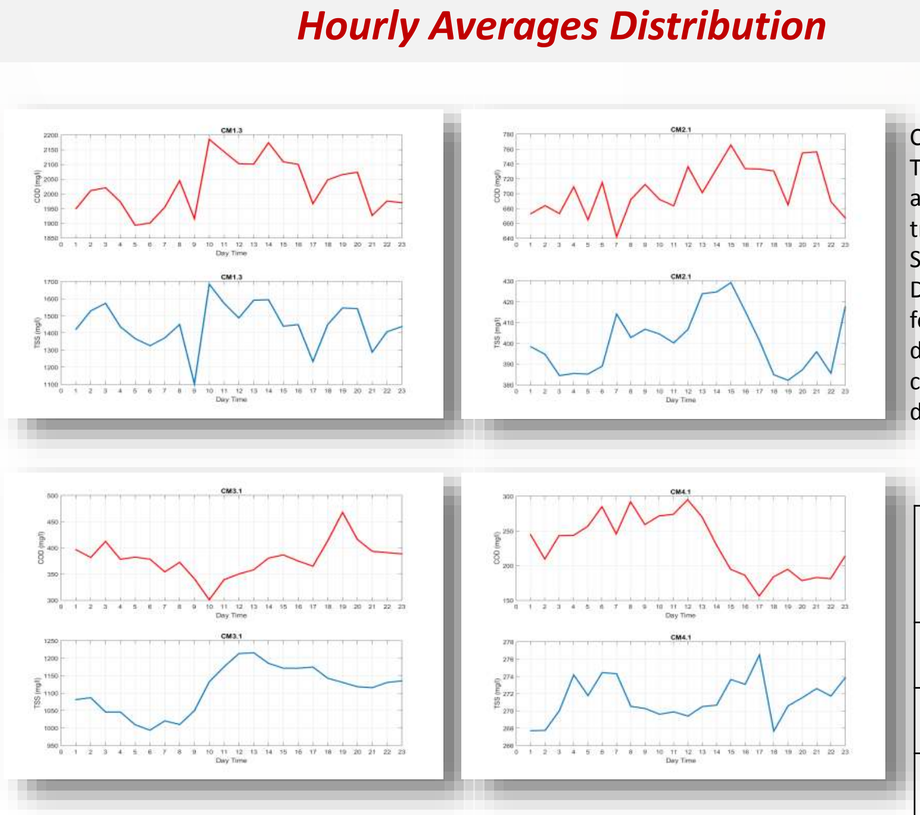


Rain Gauge and Total Suspended Solid during two rainfall events in November. It is possible to note the dilution process in TSS (blue) concentration fall due to the rain (red, Massa Centro site).



Correlation Matrix of some measured parameters. As expected from wastewater chemistry, the best correlation factor is measured for COD and TSS .

Hourly Averages Distribution



COD (red) and TSS (blue) average hourly trend, from September to December 2015 for the 4 deployed commercial devices.

Data Availability rate	
CM1.3	20%
CM2.1	27%
CM3.1	33%
CM4.1	15%

Stress Test Preliminary Results

On February 2nd, a stress test has been planned allowing the evaluation of the operating network.

300+300 liters of Nutrient™ have been injected in the network at two different sites:

- •Punta Campanella (22x25lt in 5mins)
- •Patierno (12x25lt in 3 mins)

with at 40 mins interval.

Nutrient discharge was expected to increase both the COD and the TSS value.

Deployed sensors have recorded and transmitted the simulated event propagation throughout the waste water network (see figure).

It can be observed that the first detection of contaminant was read at 12:17 and the second at 13:00 by CM1.3. For CM3.1, the plumes transition was detected at 11.39.

References

[1] S::CAN website : , accessed January 2016.

[2] Salvato M. et al., An adaptive immune based anomaly detection algorithm for smart WSN deployments, Proceedings of XVIII AISEM Conference, 2015, IEEE, pp 1-5, .

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In loving memory of Dr. F. Scognamiglio