A water quality monitoring network for environmental management of port areas
An example from the Port of Venice

Nicola Torricella (nicola.torricella@port.venice.it), Marta Citron (marta.citron@port.venice.it)
Stefano Biondi (s.biondi@stormwateritalia.com), Francesca Sambo (f.sambo@
stormwateritalia.com)

Abstract

One of the pollution source in port areas can arise from harmful substances spills, coming from vehicles or containers. To prevent these unpredictable impacts an emergency management system is required.

The Port of Venice has to interact with a really unique ecosystem, since it is located in the Venice Lagoon: VPA aims to preserve Lagoon quality by avoiding spills or losses, as well as possible contamination due to stormwater runoff from port wharves and yards.

To reach this goal, VPA designed a monitoring net, with stations installed in the stormwater drainage system. The aim of these activities is to give a dynamic instrument to continuously measure the quality of the water discharged into the lagoon. Each station monitors some “key” parameters (pH, conductivity and turbidity), useful to assess the overall quality of the stormwater discharged.

The system can also detect unusual events, such as accidental spills or significant water quality alterations. In a subsequent step, the project contemplates the installation of a pneumatic system for the automatic closure of discharge pipes in less than 1 second.

1. Introduction

The Port of Venice is located in the Venice Lagoon. The Venice lagoon ecosystem is of great importance for the inhabitants of a wide area in its surroundings and it represents a unique asset for the Veneto Region. It is the largest wetland in Italy and one of the most important coastal ecosystems in the whole Mediterranean basin, with a total area of 550 km^2. It is densely populated (about 1 million inhabitants in a watershed of 2,000 km^2) with urban settlements, extensive infrastructure (airport, rail road bridge and the lagoon sea port) and the large industrial area of Porto Marghera.

As shown in the following figure, the Port is divided in two different operative areas, the commercial terminals area which is located in Porto Marghera zone (the area underlined with a circle on the left), in the hinterland, and the cruise/ferry terminals area (Marittima), located in the historical center (underlined with a smaller circle on the right).

Picture 1: Port of Venice Location within the Venice Lagoon

The Venice Port Authority (VPA) is a public body. Its task is to guide, plan, co-ordinate, promote and monitor port operations. It is also in charge of maintaining common areas and the seabed, overseeing the supply of services of general interest, managing the State Maritime Property and planning the development of the port.
In order to be successful, the Port of Venice aims to be a sustainable port, by promoting the imperative of environment protection.
To achieve these goals, Venice Port Authority (herewith VPA) is carrying out “green” activities foreseen both by the planning document “Three Annual Operative Plan – P.O.T.” 2008-2011 and by the P.O.T. 2013-2015). The green port concept revolutionizes the way the port is traditionally conceived and translates into a range of concrete actions to protect the environment in which the port develops its activities. Between green initiatives, some notable project have been developed in the last few years to treat rainwater in port area, both in Passenger terminal and in the commercial area.

2. Rainwater discharge in the Venice Lagoon.

The pollution resulting from rainwater runoff of port areas is an important theme in Venice Area, since for the Venice Lagoon safeguarding a special legislation has been developed: with a Ministerial Decree, the so called “Ronchi-Costa”, since 1999, water discharges in the lagoon have to respect very low emission limit.
In the following table, some emission limits are reported: for example, allowed concentration for Arsenic discharge in the lagoon is of 1 µg/l. This should be seen in comparison to allowed groundwater concentration, established by national low (10 µg/l), or to potable water allowed limit (10 µg/l as well).

Parameters	Limit
Total chrome	100 µg/l
Iron	500 µg/l
Manganese	500 µg/l
Zinc	250 µg/l
BOD	25 mg/l
Total nitrogen	10 mg/l
Total phosphorus	1 mg/l
COD	120 mg/l (O_2)
Ammonia Nitrogen	2 mg/l (N)
Nitrogen nitrous	0,3 mg/l (N)
Phosphates	0,5 mg/l (P)
Fluorides	6 mg/l
Hexavalent chrome	0,1 mg/l
IPA	1 µg/l
Dioxins	0,5 pg/l (TE)
Arsenic	1 µg/l
Lead	10 µg/l
Cadmium	1 µg/l
Mercury	0,5 µg/l
polychlorinated biphenyls	absence (5)
Pesticides Organochlorine	absence (5)

Tab.1: parameters and emission limit in surface water (MD Ronchi-Costa 07/30/1999 [sections 1, 2, 4])

In order to be in compliance with national and local regulations and to prevent and mitigate environmental pollution, VPA is constantly working on:

- Obtaining a better knowledge of drainage systems in port areas and maintain the system;
- Improving a correct management of yards, from an environmental point of view;
- Improving tools for the management and the treatment of waters, finding out best practices and technologies.

To create a dynamic instrument to continuously measure and monitor the quality of the water discharged into the lagoon, in the last few years, VPA, together with Stormwater Italia, have planned the installation, in the drainage system, of a network of stations able to acquire wastewater data in continuous and monitor key parameters (pH, conductivity and turbidity).
This system have been implemented thanks to SAFEPORT European project "The Port and industrial and environmental risk management", (Italy-Slovenia 2007-2013 program), that promoted the development of strategies and/or joint plans for the prevention and reduction of environmental and industrial hazards in the port areas Homepage Url: http://safeport-project.com/ .

3. The monitoring system

Environmental management implemented tools consists of a network of water quality measuring stations, able to define the "characteristic curve" of discharged water on the base of single parameters such as pH, Conductivity and Turbidity. The project development area is the commercial port sector located in Porto Marghera.

The three installation points were chosen in order to analyze different port areas (container terminal, rinfuse terminal and street areas), characterized by activities that could differently influence rainwater characteristic. What was expected, in fact, was a correlation between rainwater characteristics and the activities performed in the areas.

Three units have been installed in two different terminals (container and rinfuse terminal) of commercial port and the third unit have been installed at the end of a sewer leaching, an area characterized by heavy traffic. Each monitoring station is equipped with a control unit for collecting and processing data and can communicate remotely with the GSM network operator.

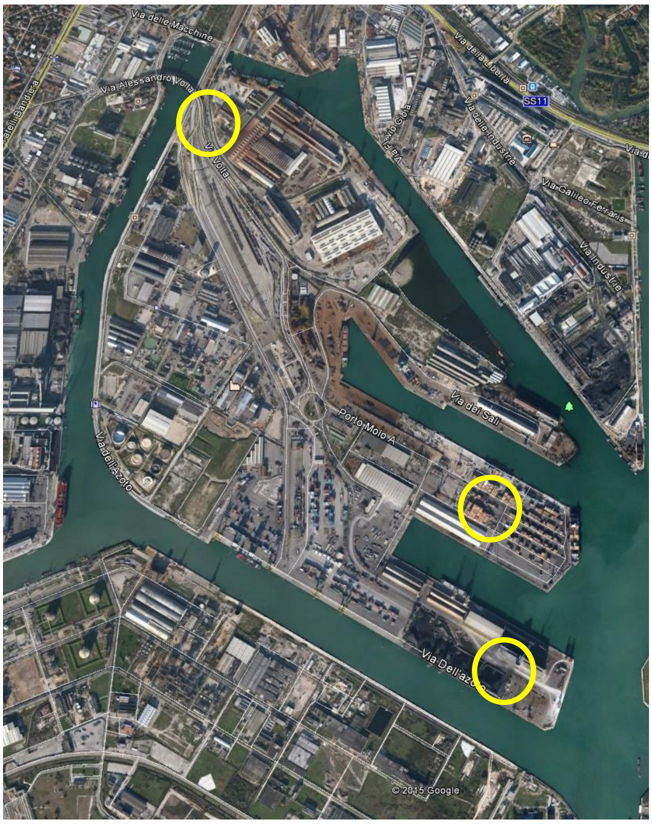
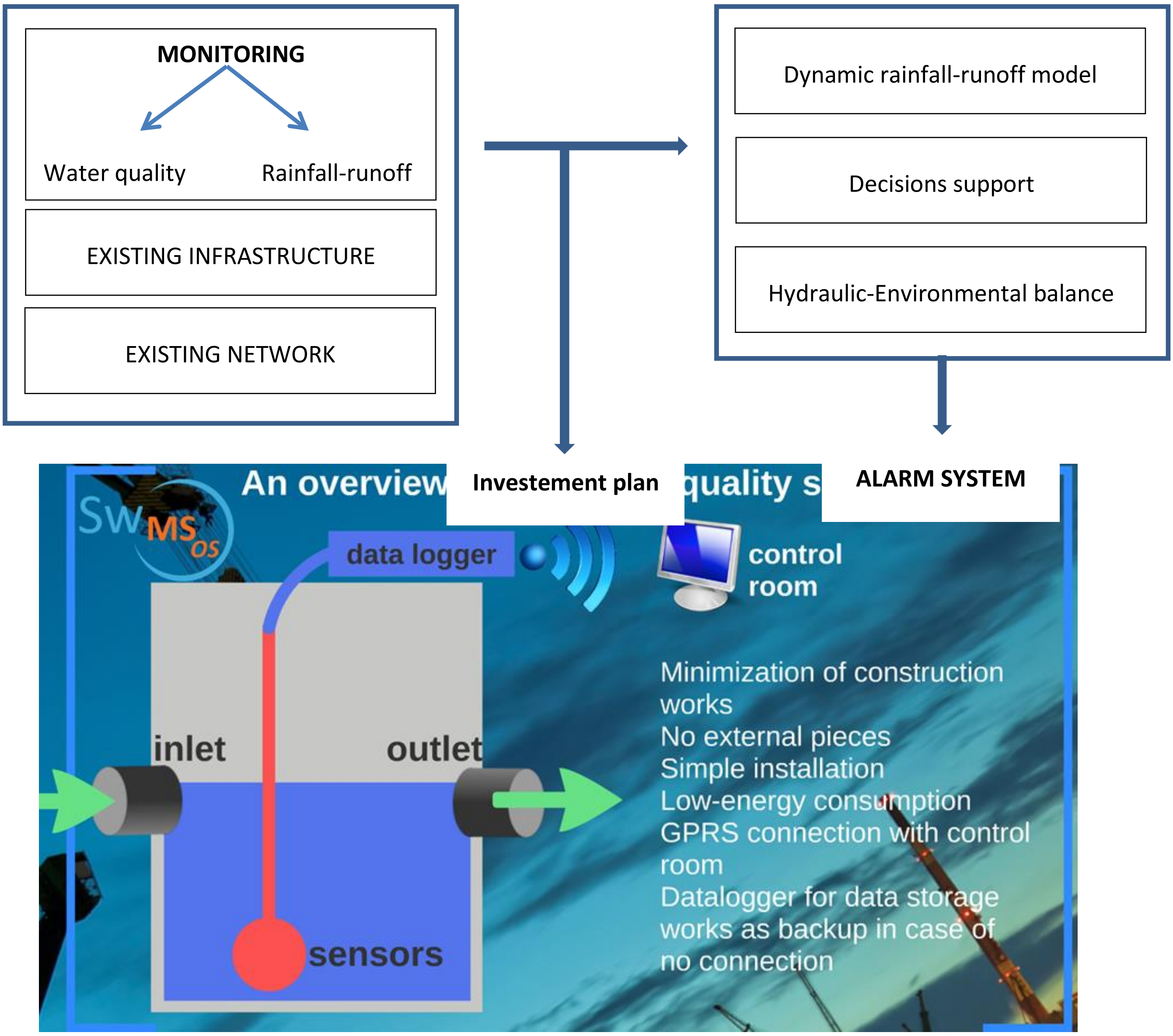


Fig. 2 Installed monitoring point map

Fig. 3 Installed tool

Integrating all available data a useful decision support system can be developed.



4. Data Collection

Probes installed are guarded in a waterproof housing provided with a collision protection system and the monitoring station as a whole is waterproof (IP 68). As a the turbidity meter is installed, a pneumatic cleaning system is also added, to avoid biofilm formation and dirt deposit on the sensor (this would affect data soundness).

pH, turbidity and conductivity have been chosen as "synthetic" parameters, useful for the detection of liquid spills. In fact a change in their value can be brought back to the presence of a number of pollutants (acids, basis, salts, ect.) that can be the result of a spill. The choice of these parameters was also made to balance cost, maintenance requirements and energy consumption.

The probes continuously communicate with the plc, where data are stored, processed and remotely forwarded.

Each monitoring station infact is equipped with an “intelligent” data collection module able to record data measured by the probes, log them in a csv file, send alarms and alert messages; daily, data recorded are sent by email, to be analyzed and critically read.

The PLC is provided with a GSM module that sends all the data stored to an operation center, via GSM. Beyond probes data, that are sent once a day, the PLC communicates alarms real-time, so that the situation can be monitored and kept under control.

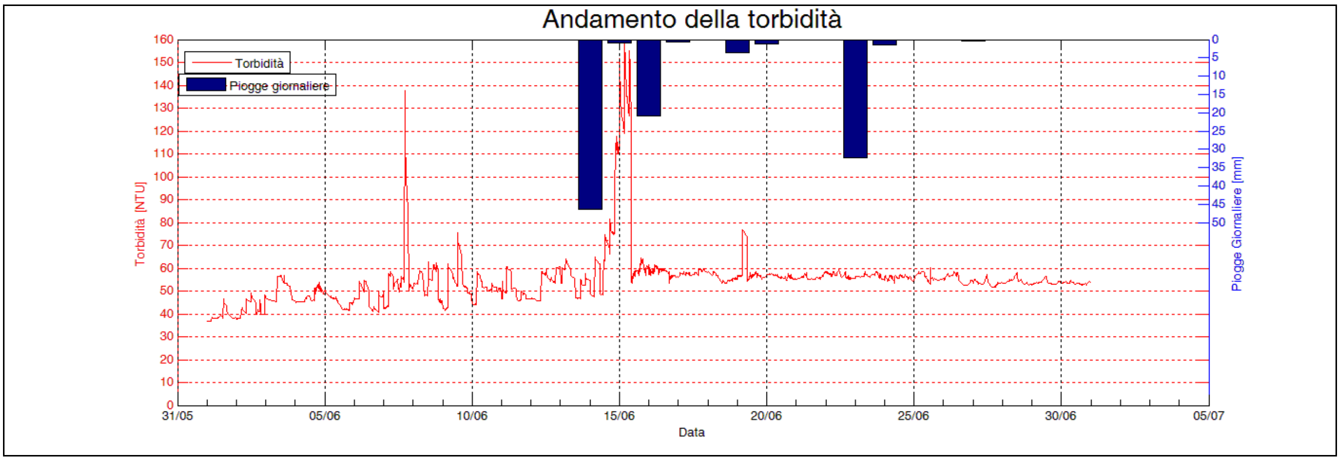
Different devices can be networked (it will be the second phase of this project) to a unique operation center, from where each single plant is monitored and eventually operated. In this way, alarms coming from the whole plant network and maintenance activities can be managed with a better cost/benefit balance.

The data collected and received by email are recorded and graphically read, in order to find correlation between measures, parameters behavior in different condition, and in order to define a range on “normality” or “alert” situation.

5. Results

A. Clear correlation between parameters and rainfall

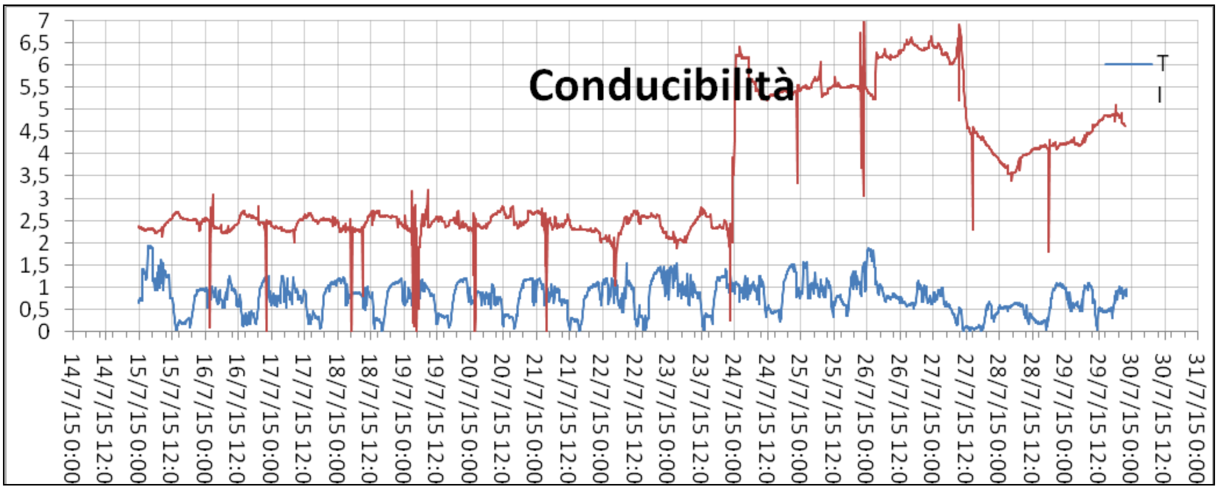
As shown in the following graph, **turbidity** is directly related with rainfall, and washout influence determine a peak in turbidity, immediately after the rain event. This peak is much more evident as the intensity of the rain itself. For what is concerning **conductivity**, correlation is linked with rain intensity, and determinates a direct or inverse influence depending by the kind of the storm.
Also, conductivity is influenced by the length of dry period antecedent the rain event, as it decreases with increase of dry periods.



Graph 1.

B. Correlation between parameters and activity held on the areas

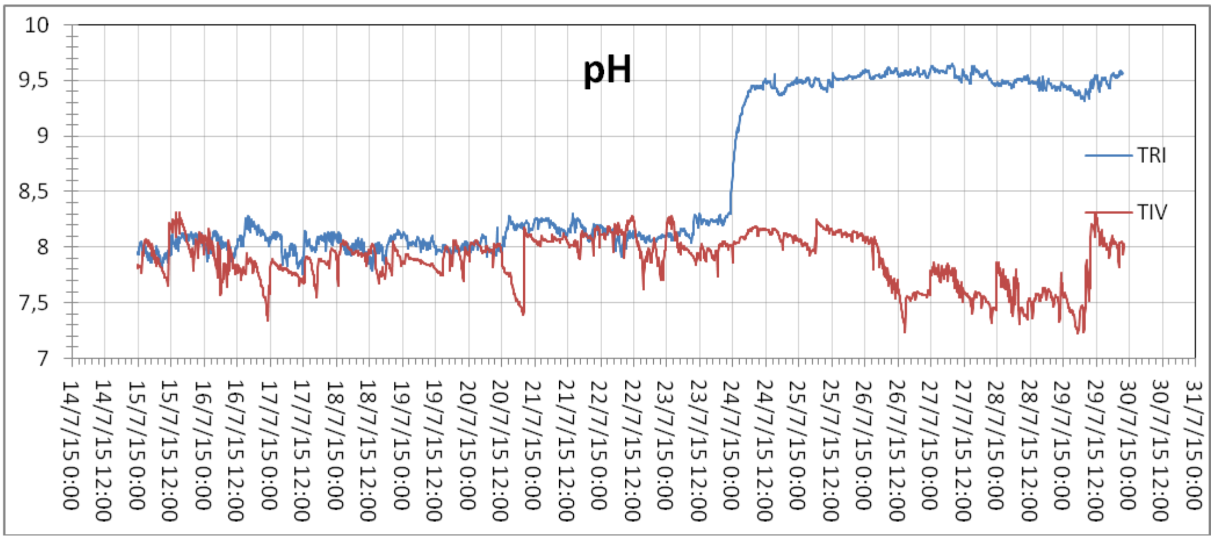
Data analyses has shown how parameters are deeply influenced by the activity held on different areas: the table below shows how during the same period monitored, in two near stations (so in the same weather condition), the same parameter (such as pH, for instance) has the same behavior, but shifted in the values: much higher in a “*rinfuse” terminal,* than in a “*container”* one. The two graphs could be overlapped, but shifted.



Graph 2.

C. Spill event individuation

The graph below is quite interesting as it shows the potentiality of the system and its strong solidity in the determination of spills or particular event. In the same table it is shown behavior of pH in two different stations; until a certain event, pH is more or less constant in the two stations, then, in one of the terminal "something" has happened and the value measured by the probes increases significatively . Analyzing data from ships and activity of the terminal, this event happens together with arrival in the terminal of a big amount of sodium carbonate, so that the two events can be clearly related.



Graph 3.

6. Conclusions

The implementation of a monitoring net to detect possible pollution in the rainwater drainage system and receiving bodies allows proper management of the port areas, with their different activities.

Data can be collected in a unique central control room and analyzed in relation to rain and statistic events. This water quality measuring stations network could become a decision support system for the management of the areas and environmental emergencies.
The choice to analyze “only” key paramenters instead of a complete water sample chemical analysis allows to have a huge amount of data, immediatley available to manage accidental spills.