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ASDECO

Hydrolink

ASDECO a Real Time Monitoring and Decision Support System for Impacts Minimization of Desalination Plant Brine Discharge into the Marine Ecosystem

During the last decades desalination has experienced a great growth as an alternative for solving water scarcity problems, for decreasing pressure on surface and groundwater water resources, or for improving water quality intended for human consumption or irrigation. This development has been especially notable in the Gulf, Red Sea, Oriental Mediterranean (Israel) and Occidental Mediterranean (Algeria, Spain). These areas hold more than 75% of the worldwide desalination capacity. This fact leads us to think about the possibility of transferring pressures from continental waters to the coastal ones. In that case it is necessary to evaluate the effect of these pressures on the marine ecosystem. In this sense, important research I sunderway, such as that co-ordinated by Tecnoma in Spain. The aim of this research is to improve monitoring and forecasting in real time of the impact of the hypersaline plumes in the marine environment.

The development of Seawater Desalination Plants (SWDP) for urban supply and agricultural purposes in different world areas has increased greatly in recent years as a way of lessening water scarcity [1].
From an environmental point of view, waste discharge management, where brine is the main component, is the most important problem [2]. When the raw water is taken from the sea, the effluent salinity can increase between 10% and 70%, depending on the technology used [1]. In the case of effluent discharge into the sea, and especially in the presence of communities of particular biological interest (such as marine phanerogam grass-lands that have a poor tolerance to increases in salinity [3]), outfall management should be carried out based on the principles of caution and sustainability. In order to achieve appropriate discharge management, we must increase our knowledge and provide the authorities and the entities that are developing and managing the installations with appropriate tools to improve discharge efficiency and to increase the effectiveness of brine dilution into the sea. The implementation of many of the above-mentioned desalination projects in Spain requires meeting the requirements of the Environmental Impact Declaration (EID), which involve strict monitoring programs that activate protocols for the periodic stoppage of the plant mainly by the activation of alarms when the salinity values are exceeded in the protection perimeters of the most vulnerable biological elements.

The pioneer project, named ASDECO [4] (Automated System for Desalination Dilution control) is lead by Tecnoma with the SIDMAR partnership collaborating with instrument integration. Likewise, the project has the expert advice from the Polytechnic University of Madrid's Port & Coast Laboratory and the Polytechnic University of Valencia's Hydraulics and Environment Engineering Institute.

This applied research project aims to create a prototype that adapts and improves the control of desalination plant discharges in the marine environment. The goal is to combine the capacity of a Decision Support System (DSS) and latest instrument innovation to predict the behavior of the hypersaline plume, which will allow an Adaptive Management to be implemented in the desalination plant. As a pilot case for the development of the system, we are currently implementing the prototype at the Alicante Channel Desalination Plant (Alicante, Spain), thanks to the collaboration of the "Canales del Taibilla" water company.

The prototype developed is a powerful prediction, alarm and information tool for the promoting authorities, the companies operating the Plant and the controlling environmental authorities.

ASDECO has been developed in the following phases:

a. Design and integration of the instrumentation. A prototype of the ocean-meteorological data acquisition station was designed. The basic objective was to design a compact and reliable solution that allows the integration of a large number of sensors: CTD, current, wind, and wave height profilers and water quality (dissolved oxygen, temperature, turbidity, redox, chlorophyll a, green algae, etc).

b. Development of an Alarm and Information System. The information system allows the compilation and validation of time series acquired in real time by multiple instrument systems. This information system generates automated reports in an easy-to-use web environment, providing development authorities with the necessary tools for control and vigilance of the desalination plant discharges. This tool can be shared with environmental agencies or be made available to the public. The alarm system is especially useful when certain salinity threshold values [3] are exceeded over certain periods of time (exceeded percentile). These thresholds can define several action levels (alarm level, emergency level, etc.) in accordance with the criteria defined in the EID or in the discharge authorization.

c. Development of a Decision Support System (DSS). This phase is mainly dedicated to the production of a decision tool that analyzes the instant and seasonal operation of the brine discharge. This tool provides management measures to maximize the brine dilution and thus reduce its impact on the receiving medium. The core of the tool is based on a forecast module that uses a combination of fuzzy logic and neural networks [5] to forecast the distribution of the plume and predict salinity levels in the protection perimeters. The use of neural networks associated to oceanographic forecasts has been extensively used [6] [7] [8]; however, their combination with fuzzy logic techniques are very recent, for example those associated with predicting the ecological state of continental surface water bodies [8] or the analysis of reservoir water quality [7].

This forecast system makes use of the implemented sensors to train and validate the neural network in such a way that, at a monitoring point, the salinity will depend on the ocean-meteorological conditions of the marine environment and the flow and salinity of the desalination plant discharge (Figure 1). This facilitates an Adaptive Management by providing feed back data to the predictive system. The system will create predictive alarms similar to the ones provided by the real time control that allow the desalination plant managers to advance the discharge impact and adapt the management to reduce it.

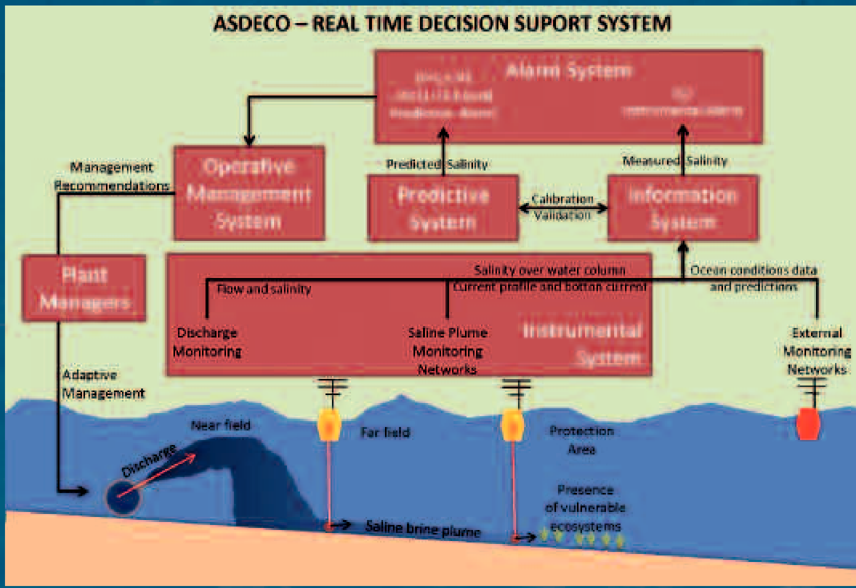

Figure 1.- Decision Support System Outline. Systems integrations and their interaction.

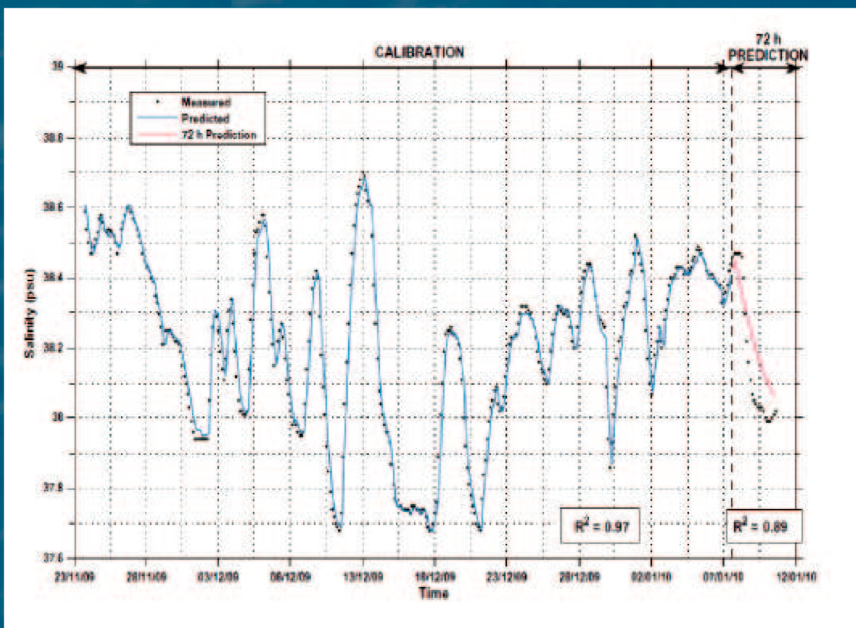

Figure 2.- Measured, calibrated and predicted (72 h) time series comparison in a far field monitoring point.

Project Validation and Results

The prototype system has been implemented into the Alicante Channel desalination plant discharge. The desalination plant is a Reverse Osmosis (RO) Plant with a treatment capacity of 130.000 m^3/day. The brine is diluted and discharged on the surface of the coastline. The Plant generally operates with a dilution rage of 1:2/1:4, using seawater and generates 7 m^3/s discharge flow with a salinity of 50 psu. This discharge is currently the object of an intensive monitoring program due to the existence of Posidonia oceanica grasslands that are located approximately 1.6 km in front of the discharge point.

The integration of this pilot system consists of the installation of an Acquisition System for Oceanographic Data in near-field and far-field, and has been adapted to the specific conditions of the brine discharge. The buoys and data acquisition instrumentation are complemented with a CTD field due to the characteristics of the seabed during the calibration phase. These data provide knowledge about the plume behavior and they also provide a large number of records for the training and validation of the forecast system. The pilot installation and integration of the system has been underway since November 2008.

During the pilot implementation several tests have been performed in order to reduce the number of monitoring variables and for the identification of the variables with most influence in saline plume mixing and persistence. The results indicate the cumulative mixing energy great influence in the brine plume dispersion [11]. This energy has been expressed as the 3 days cumulative maximum daily wave height (WH). The evolution of bottom salinity is also sensible to the previous salinity persistence. Of course the experiences shows also the important dependency due to the increase in salt load ([Flow]*[Salt concentration]) discharged.

The prediction is based on multiple neurodifuse networks calibrated at the monitoring points. The network is based in a two rules neuron with 0.8 of cluster radio.
With regard to the calibration of the forecast system, some favorable adjustments have been obtained with R2 greater than 0.90 (Figure 2). Actually the system works based on an on-line retraining that will be extended waiting for wide representativeness of monitored ocean-climatic scenarios.

The pilot application has been also useful to validate the ability to anticipate alarms for the forecast system. Figure 2 shows the calibration obtained and the 72 hours prediction values. These predictions will be useful to anticipate the potential impact of changes on discharge conditions and also to evaluate the effect of environmental conditions (WH) on plume dispersion. The predictions in Figure 2 show that the prototype is able to predict the plume trend with a high correlation with measured data with minor errors for the feasibility of predictive alarm implementation.

It is worth mentioning that only three variables explain the average dispersion condition of the plume in the sea or the occasional peaks of salinity. This prediction fit has been reached for extended periods of calm where the salinity increase with respect to the salinity base values is high, and also periods with relevant wave height, where the plume undergoes more dispersion.

The pilot implementation shows that the use of neural diffusion can be a very useful option for the follow-up and control of waste brine into the sea. At least, until the deterministic models finally adjust correctly to the turbulent dispersion processes in the problem of transport and dispersion of brine plumes and the computational requirements are feasible for real-time applications. The data compiled through the project will be useful information to help in these model developments.

Project Diffusion

An International Symposium related to brine discharge took place in Valencia (Spain) last 5th and 6th of October. It was organized by Tecnoma as a meeting point for the different professionals, technicians, scientists, and other who were involved in the issue of desalination in order to create an environment where the transmission of knowledge plays a decisive role.
The symposium had a participatory format with a primarily scientific and technical approach. Experts from different institutions (Figure 3) discussed the different tools that are available for carrying out Environmental Impact Studies for desalination plants (instrumentation, data capture, physical models and vulnerability of marine ecosystems against brine effluent).

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The goal for ASDECO is to facilitate the preventive and adaptive management of desalination plant outfalls, by making possible the prediction of impacts over the time.

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