Methods in Oceanography 17 (2016) 221–231

Contents lists available at ScienceDirect

Methods in Oceanography

journal homepage: www.elsevier.com/locate/mio

Full length article

Sensorized buoy for oil spill early detection

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HIGHLIGHTS

- The Sea is a fragile environment to be protected against pollutants.
- A sensorized buoy for the detection of oil spills is proposed.
- The buoy includes meteorological and marine sensors and an E-nose.
- Pollution data are classified through two artificial neural networks.
- Real time data visualization and long-term assessment of water quality is allowed.

ARTICLE INFO

Article history:
Received 21 April 2016
Received in revised form
13 October 2016
Accepted 13 October 2016
Available online 5 November 2016

Keywords:
Sensorized buoy
Marine pollution
Oil spills
Electronic noses
Hydrocarbons classification

ABSTRACT

The Sea is often a fragile environment to be protected against possible pollutants. In this context, the present work contributes to its safeguard by proposing a new buoy equipped with advanced sensors for the detection of oil spills. In particular, the buoy is provided with various sensors for the evaluation of both meteorological and marine parameters (e.g. waves, wind, temperature), and chemical/physical data acquired by an electronic nose system specifically designed for the detection of hydrocarbons. The electronic nose is composed of a flow chamber, a chamber equipped with photo ionization sensors, pumps and valves for air inlet and outlet, and a low-cost electronic board. The designed system samples the air above the water and produces data that are processed through two artificial neural networks allowing for a classification of detected hydrocarbons and overall pollution level. Suitable network interfaces and a connector toward a Marine Information System (MIS) allow

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http://dx.doi.org/10.1016/j.mio.2016.10.002

both for real-time data visualization and for long-term assessment of water quality.

1. Introduction

The Mediterranean Sea represents a very fragile ecosystem, with the presence of highly polluted areas, heavy commercial and touristic traffic, as well as a particular position and shape, making its waters slowly renewable. In fact, the fast urban settlements expansions, along shorelines, as well as the high and increasing human pressure, made the Mediterranean Sea sensitive to pollutants, especially hydrocarbons, often produced by oil spills and ship transits (Er-Raioui et al., 1999; Ferraro et al., 2009). Therefore, massive global changes could affect this basin more rapidly and intensively than oceans, because of the persistent bio-accumulative chemical compounds that cause problems for the entire ecosystem (Zaghden et al., 2014).

Thus, in the Mediterranean as well as in other areas of Europe and worldwide, a number of safeguard methods have been adopted in last years in order to reduce the negative impact of pollution on the marine ecosystem. In particular, in the northern Tyrrhenian Sea and, specifically, in the area delimited by Corsica, Elba Island, Ligurian coast and Provence, which is considered one of the most important feeding and reproductive places for a number of cetaceans in the Mediterranean, the "*Pelagos Sanctuary*" was constituted. This measure was undertaken in order to preserve such animal species from the disruptive impact of environmental pollution (Azzellino et al., 2012).

Hence, the adoption of innovative strategies for environmental monitoring applied to marine areas has experienced a growing interest in last decades, thus involving state-of-the-art methods to accomplish successfully this aim.

Among the strategies adopted throughout the last years, the employment of electrochemical sensors, sometimes included in systems based on the Electronic Nose (E-Nose) – for air analysis – or Electronic Tongue (E-Tongue) (Czolkos et al., 2016) – for liquid analysis – technology, could represent a useful add-on to current methods, in order to increase their sensitivity and accuracy.

Thus, the aim of this work is to present a system, based on the technologies of E-Nose (Sobanski et al., 2006), integrated into moored buoys (Moroni et al., 2015) and capable of monitoring the presence of hydrocarbons, seen to be the highest-impact pollutants for the marine ecosystem (Clark, 1992), on the sea surface in a given area. This system, which samples the air above the water, could be complemented by similar approaches, for example, integrated into floating vehicles (e.g. AUV, ROV etc.), as already described in literature (Tonacci et al., 2015a,b), for a complete monitoring – both from static and dynamic point of view – of an area of interest. The proposed system, based on a sensor-equipped moored buoy, is used as a node in a monitoring network – of different complexity depending on the size and traffic of the area to be monitored – to control areas of interest; to this end, the buoy is equipped with network interfaces allowing for external communication. A connector with a Marine Information System (MIS), offering storage functionalities as well as suitable interfaces for data fruition and processing (see e.g. Cortes et al., 2000; Jordi et al., 2006; Tampucci et al., 2013) is presented. Through the connector, the real-time access to the data acquired by the buoy and transmitted wirelessly to the MIS is possible, together with the request of particular procedures to be performed.

The paper is organized as follows. In Materials and Methods: the basic facts dealing with the buoy and its sensor payload are introduced; the E-Nose from a hardware perspective is presented, the onboard data processing functionalities are described and, finally, communication interfaces and connection to the MIS are reported. Results displays and discusses experimental results while final remarks are presented in the Conclusions section.