Marine Pollution Bulletin xxx (xxxx) xxx–xxx

Contents lists available at ScienceDirect

Marine Pollution Bulletin

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

Temporal evolution of the environmental quality of the Vallona Lagoon (Northern Mediterranean, Adriatic Sea)

Chiara Maggi, Maria Teresa Berducci*, Bianca Di Lorenzo, Manuela Dattolo, Antonella Cozzolino, Silvia Mariotti, Valerio Fabrizi, Roberta Spaziani, Claudia Virno Lamberti

Italian National Institute for Environmental Protection and Research, Rome, Italy

ARTICLE INFO

Keywords:
Metals
Sediment
Biota
Environmental Quality Standard
Vallona lagoon

ABSTRACT

Guidance Document 25/2010, suggests sediment and biota are the most suitable matrices for the trend monitoring purpose, because they integrate the pollution over time and space. So, from 2005 to 2014, the sediment and biota concentrations of heavy metals (As, Cd, Cr, Hg, Ni, Pb) were analysed in the Vallona Lagoon (northern Adriatic Sea, Italy), widely used for intensive and extensive bivalve farming. The contamination levels in sediment and biota were compared with Environmental Quality Standard (EQS) and threshold levels (TL) for human health.

The results identified critical issues related to Cd in sediment samples as well as to Hg and Pb in biota which were not only ascribable to the physiological and seasonal variability of organisms. The Cr and Ni levels in sediment were higher than the EQS. However, the concentration increases at biota stations close to sites where EQS excesses were observed in sediment were not verified.

1. Introduction

Wetland areas can be greatly affected by chemical contamination due to the long hydrologic residence time and consequent long-term retention of pollutants. This is especially acute for contamination by heavy metals, which are often present in industrial and municipal effluents and are major pollutants in the industrial world causing long-term effects on marine ecosystems (Jarup, 2003; Chapman et al., 2013; Wong et al., 2015; Antizar-Ladislao et al., 2015). The European Parliament and Council decision No. 245572001/EC identified hazardous priority substances that have to be progressively reduced or phased out from discharges; these metals include Cd, Hg, Ni and Pb (Maggi et al., 2008). According to Directive 2008/105/EC (EQS Directive), the Italian Parliament issued Legislative Decree 210 in 2010, which established the Environmental Quality Standard (EQS) for Cd, Hg, Ni, Pb (priority and hazardous substances), Cr and As in sediment from marine coastal areas, lagoons and coastal ponds (Maggi et al., 2012). For the purpose of trend monitoring, sediment and biota are the most suitable matrices, recommended by the EQS Directive because they integrate, over time and space, the pollution in a specific water body. Indeed, the changes of pollution in these compartments are not as fast as in the water column, and long-term comparisons can be made (Guidance Document n. 25, 2010; Carere et al., 2012; Maggi et al., 2012).

Generally, marine pollution monitoring approaches combine examinations of chemical and biological parameters. Chemical analysis of sediments is commonly used since it reflects the spatial and temporal variation of contaminant concentrations, while analysis of tissues of filter-feeding organisms provides data on the accumulation of bioavailable fractions of pollutants. Heavy metals introduced into the marine environment accumulate in sediment, and thus several studies aimed at evaluating this contamination have focused on the sediment compartment that constitutes an important food source for many deposit- and suspension- feeding animals (mussels and clams) (Guerzoni et al., 1984; Guerzoni, 1989; Fabbri et al., 2001; Liang et al., 2004; Romano et al., 2013; Diop et al., 2015).

Likewise the bioaccumulation of metals in tissues of marine organisms has been extensively studied in the Mediterranean Sea (Squadrone et al., 2016) and other parts of the world (Siddig et al., 2016), and bivalves are recognized as suitable organisms for biomonitoring in marine environments (Goldberg et al., 1983; Claisse, 1989; Langston and Spence, 1995; CIESM, 2002; Carro et al., 2004; Burger, 2006; Vassiliki and Florou, 2006). These organisms also represent one of the important seafood products for human consumption, so they are studied from the environmental point of view as well as food safety (Cardellicchio et al., 2007; Cardellicchio et al., 2010; Spada et al., 2013). In particular Cd, Hg and Pb content in organisms' tissues are regulated by European legislation (EC Regulation 1881/2006) that sets maximum levels in foodstuff.

* Corresponding author.
E-mail address: mariateresa.berducci@isprambiente.it (M.T. Berducci).

http://dx.doi.org/10.1016/j.marpolbul.2017.07.046
Received 17 March 2017; Received in revised form 18 July 2017; Accepted 19 July 2017

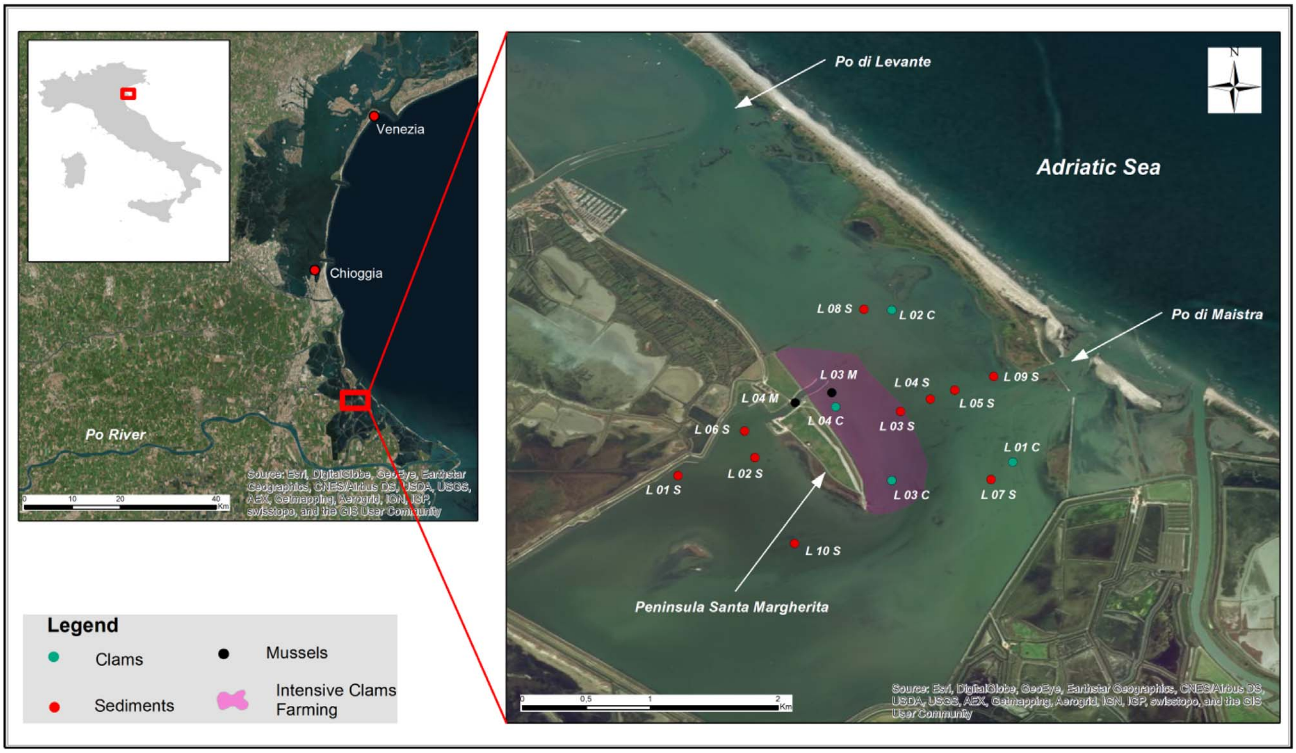

Fig. 1. Location of the study area and distribution of sampling stations in the Vallona Lagoon. (For interpretation of the references to colour in this figure, the reader is referred to the web version of this article.)

The aim of this work was to evaluate the temporal trend of data coming from ten-years monitoring (summer 2005–2014) and to verify that metals concentrations do not significantly increase in sediment and biota of the Vallona Lagoon, a transitional water basin located in the north Adriatic Sea.

To describe the general contamination status of this wetland area, including the protection of human health, the sediment contamination and the bioavailability of contaminants were assessed through the monitoring of hazardous metals, recommended by Legislative Decree 219/2010, and the comparison with Environmental Quality Standards (EQS) and threshold levels (TL) for human health (Reg. 1881/2006) was performed.

2. Materials and methods

2.1. Study area

The Vallona Lagoon is a complex ecosystem that overlooks the Adriatic Sea, a shallow basin that receives fresh water input from a series of sources; the most important one is the Po River which drains large, intensely cultivated and highly industrialized inland areas and delivers to the sea huge amounts of dissolved and particulate materials, including anthropogenic contaminants (Romano et al., 2013). A channel flows directly the Po di Levante (at the north) in the lagoon through the mouth of the homonymous port, while at sea, there is the mouth of the Po di Maistra (at the south).

Both, but especially the former, have considerable influence as regards the lagoon's hydraulic system and the contribution of sediments; these mouths influence wetland water and sediment quality. The Vallona Lagoon is characterized by low average water depths (< 2.2 m), and the main hydrodynamic influence is tides with a maximum tidal range of 1 m. The salinity of the lagoon (14–22‰) is mainly controlled by water exchange with the Adriatic Sea. South of the Po delta the belt of fine sediment is wider and better defined than north of it (Correggiari et al., 2001).

The lagoon was created in the 1970s when previously drained farmland was re-flooded by seawater due to severe land subsidence. Like the rest of the coast, Vallona Lagoon experiences a semi-diurnal micro-tidal regime (Le lagune del delta del Po, 2013). It is used privately for shellfish aquaculture and seasonal hunting. It has sluice gates that are actively managed to maximize water exchange and maintain good water quality (Quaderni Ca' Vendramin, 2010; Wong et al., 2015).

Like all lagoons, Vallona is characterized by poor biodiversity and high productivity. Human influences impose stress from physical changes in the lagoon and hinterland (run-off) and from chemical contamination. Recently, near the Peninsula Santa Margherita, the bed was affected by handling due to the laying of gas pipelines coming from an offshore regasification plant. Intensive and extensive clam farming is the most important activity in this area. The onshore area (so-called Bagliona Valley) is delimited by fish farms, which draw from the lagoon most of the water necessary for their activities (Virno Lamberti et al., 2013).

2.2. Sampling

Biota and sediment samples were collected during monitoring surveys from 2005 to 2014 from 10 sites for sediment (red colour and letter “S”) and 6 sites for biota: 4 for clams (green colour and letter “C”) and 2 for mussels (black colour and letter “M”) (Fig. 1).

The 6 sediment stations were arranged along the gas pipeline, two other stations were in the north, where intensive farming is present, and two stations were at the south of the pipeline where extensive farming has been cultivated. The biota stations were in the north (intensive clams farming) and the south (extensive clams farming) with respect to the pipeline. Sediment samples were always collected during summer season for 8 surveys in total, while biota samples were collected seasonally (4 times a years) from 2005 to 2011 and twice a year (summer and winter) during 2012–2014. Clams were harvested by a manual rake from sediments, while mussels where gathered by a wooden stick from hard substrates. Each biota sample was prepared pooling about 150