Marine Environmental Research 121 (2016) 49–63

Contents lists available at ScienceDirect

Marine Environmental Research

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

Relationships between lines of evidence of pollution in estuarine areas: Linking contaminant levels with biomarker responses in mussels and with structure of macroinvertebrate benthic communities

A. De los Ríos [a, d], B. Echavarri-Erasun [a], S. Lacorte [b], J. Sánchez-Ávila [b, f], M. De Jonge [c], R. Blust [c], A. Orbea [d, e], J.A. Juanes [a], M.P. Cajaraville [d, e, *]

[a] Environmental Hydraulics Institute "IH Cantabria", University of Cantabria, c/ Isabel Torres nº 15, 39011 Santander, Spain
[b] Department of Environmental Chemistry, IDAEA-CSIC, Jordi Girona 18-26, 08034 Barcelona, Catalonia, Spain
[c] Department of Biology, Ecophysiology, Biochemistry and Toxicology Group, University of Antwerp, Groenenborgerlaan 171, B-2020 Antwerp, Belgium
[d] Laboratory of Cell Biology and Histology, Department of Zoology and Animal Cell Biology, Faculty of Science and Technology, University of the Basque Country (UPV/EHU), Sarriena z/g, E-48940 Leioa, Basque Country, Spain
[e] Research Centre for Experimental Marine Biology and Biotechnology PIE, University of the Basque Country (UPV/EHU), Areatza z/g, E-48620 Plentzia, Basque Country, Spain
[f] Mexican Center of Innovation in Geothermal Energy (CeMIE-Geo), Earth Sciences Division, CICESE, Av. Rinconada del Pedregal 95, Pedregal Playitas, 22860 Ensenada, B.C., Mexico

ARTICLE INFO

Article history:
Received 31 October 2015
Received in revised form
18 February 2016
Accepted 26 February 2016
Available online 2 March 2016

Keywords:
Biomarkers
Macroinvertebrate benthic communities
Environmental pollutants
Caged bivalves
Lines of evidence
Multivariate analysis

ABSTRACT

Data obtained in a pollution survey performed in estuarine areas were integrated using multivariate statistics. The sites selected for the study were areas affected by treated and untreated urban discharges, harbours or industrial activities as well as reference sites. Mussels were transplanted to each site and after different times of exposure, samples of water, sediments and mussels were collected. Biomarkers were analysed on mussels after 3 and 21 days of transplant whereas concentrations of contaminants were measured in water, sediments and mussels after 21 days of transplant. The structure of macroinvertebrate benthic communities was studied in sediment samples. Studied variables were organised into 5 datasets, each one constituting a line of evidence (LOE): contaminants in water, contaminants in sediments, contaminants accumulated by transplanted mussels, biomarkers in transplanted mussels and changes in the structure of macroinvertebrate benthic communities of each sampling site. Principal Component Analysis (PCA) identified the variables of each LOE best explaining variability among sites. In order to know how LOEs relate to each other, Pearson's correlations were performed. Contaminants in sediments were not correlated with the rest of LOEs. Contaminants in water were significantly correlated with contaminants and biomarkers in mussels and with structure of macroinvertebrate benthic communities. Similarly, significant correlations were found between contaminants and biomarkers in mussels and between biomarkers in mussels and structure of macroinvertebrate benthic communities. In conclusion, biomarker responses give relevant information on pollution in estuarine areas and provide a link between chemical and ecological statuses of water bodies in the context of the Water Framework Directive.

1. Introduction

The EU Water Framework Directive (WFD) (CEC, 2000) defines a strategy to deal with water contamination, with the final goal of reaching a "good status" of European water bodies by 2015 and, when not achieved, extended until 2021. In order to achieve it, both

* Corresponding author. Laboratory of Cell Biology and Histology, Department of Zoology and Animal Cell Biology, Faculty of Science and Technology, University of the Basque Country (UPV/EHU), Sarriena z/g, E-48940 Leioa, Basque Country, Spain.
E-mail address: mirenp.cajaraville@ehu.es (M.P. Cajaraville).

http://dx.doi.org/10.1016/j.marenvres.2016.02.012
0141-1136/

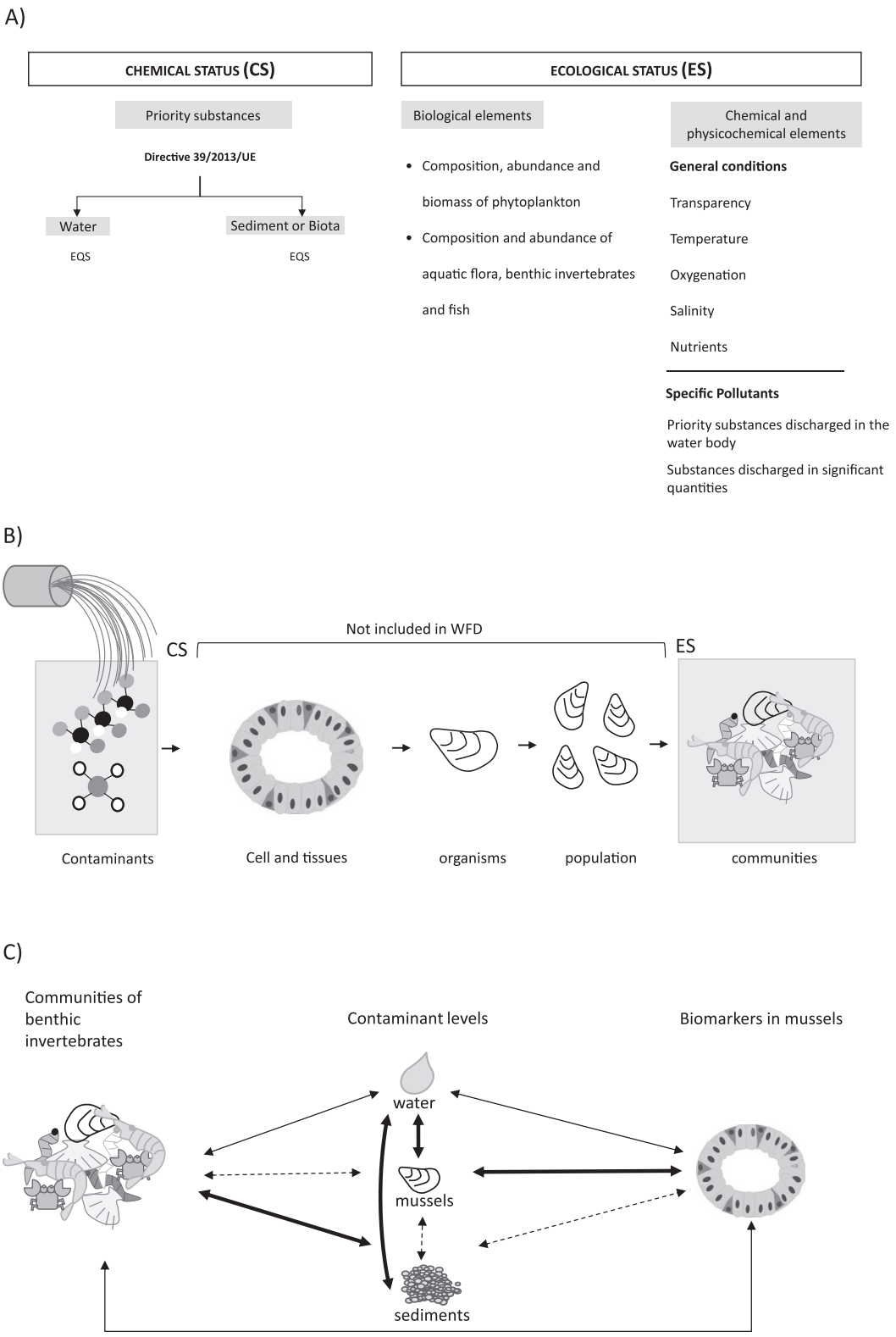

Fig. 1. A) Quality elements for the classification of chemical and ecological status of water bodies under the WFD 2000/60/EC (EQS: Environmental Quality Standards). B) Conceptual model of interaction of contaminants with biological systems at different levels of biological organisation (CS: chemical status; ES: ecological status; WFD: Water Framework Directive). C) Hypothetical conceptual model of relationships among different lines of evidence of environmental contamination studied in the present work. The expected strength of the relationships is indicated by lines width (dashed line: weak; thin line: moderate; thick line: strong).

chemical and ecological good status must be accomplished (Fig. 1A). Obtaining "good chemical status" (GCS) implies compliance with the Environmental Quality Standards (EQS) for a group of priority substances indexed in Directive 2013/39/EU. On the other hand, assessment of ecological status is based upon measures at community level of phytoplankton, phytobenthos, benthic invertebrates, aquatic flora and fish, as key quality elements.

Both chemical and ecological status assessments have