Environ Sci Pollut Res (2016) 23:12491–12494
DOI 10.1007/s11356-016-6836-5

EDITORIAL

Integrated environmental characterization of the contaminated marine coastal area of Taranto, Ionian Sea (southern Italy)

Nicola Cardellicchio[1] · Stefano Covelli[2] · Tamara Cibic[3]

Received: 29 April 2016 / Accepted: 4 May 2016 / Published online: 18 May 2016

The Project RITMARE (la Ricerca ITaliana per il MARE—Italian Research for the sea) is one of the national research programs funded by the Italian Ministry of University and Research. RITMARE (2012–2016), coordinated by the National Research Council (CNR), and has involved an integrated effort of most of the scientific community working on marine and maritime issues. Within the project, different marine study areas of strategic importance for the Mediterranean were identified: among these, the coastal area of Taranto (Ionian Sea, southern Italy) was chosen for the presence of large industrial settlements and their impact on the marine environment. In particular, the research has been focused on the Mar Piccolo of Taranto, a complex marine ecosystem model important both from an ecological and social–economic points of view. In fact, water, sediments, and biota in the Mar Piccolo have been affected by a wide spectrum of anthropogenic pressures (among others, the most important iron and steel plant in Europe, the largest Italian Navy shipyard, an oil refinery, and shipbuilding activities) for decades. These stress factors have been responsible for a severe environmental contamination, mainly due to heavy metals, polycyclic aromatic hydrocarbons (PAHs), organic solvents, polychlorinated biphenyls (PCBs), and dioxin, with their consequent possible transfer to the aquatic trophic chain also considering the widespread fishing and mussel farming activities in this area.

Within the project RITMARE, a task force of researchers composed of hydrogeologists, modellists, sedimentologists, geochemists, chemists, microbiologists, and biologists has contributed to elaborate a working conceptual model with a multidisciplinary approach useful to identify sources of anthropogenic stress, their impacts, and possible solutions of environmental remediation. Several topics have been addressed, among them: identification of sources of contaminants and anthropogenic pressures, distribution of contaminants, water mass circulation and sedimentary fluxes, biogeochemical cycling, bioaccumulation and biomagnification of contaminants, and risk analysis. All of them have been included in the conceptual model of the Mar Piccolo in order to provide the necessary input to a decision support system which should help in evaluating the correct mitigation strategies to be adopted. Therefore, this could be considered a comprehensive pilot study that may be applied to other shallow coastal environments with similar contamination issues.

This special issue contains a collection of 22 publications. The review by Cardellicchio et al. (2015) introduces the state of knowledge on the Mar Piccolo, before the beginning of the RITMARE project, the ecological importance of this basin and its environmental issues.

Two articles present the output of numerical modeling: the first by Zuffianò et al. (2015) defines the contribution of subaerial and submarine coastal springs to the hydrological dynamic equilibrium of the basin while De Pascalis et al. (2015) examine the main

Responsible editor: Philippe Garrigues

✉ Tamara Cibic
tcibic@ogs.trieste.it

[1] CNR - Institute for Marine Coastal Environment, Unit of Taranto, Taranto, Italy

[2] Department of Mathematics and Geosciences, Trieste University, Trieste, Italy

[3] OGS (Istituto Nazionale di Oceanografia e di Geofisica Sperimentale), Trieste, Italy

hydrodynamical processes and transport scales of the system by means of a 3D finite element numerical model application.

Eight publications cover the geological, chemical, biological, and ecological aspects of contaminated sediments. The article by Vitone et al. (2016) describes the mineralogy, composition, and physical properties of the sediments along three 20-m-long sediment cores, collected in the most contaminated area of the Mar Piccolo, to gain geotechnical information necessary to plan in situ mitigation solutions. The paper by Bellucci et al. (2016) focuses on major and trace elements, PAHs, and PCBs determined in surface sediments and sediment traps collected in two periods with the aim to evaluate the contamination degree, sediment transport, and particle redistribution dynamics within the area. Other three papers relate to the remobilization of contaminants at the sediment–water interface. De Vittor et al. (2015) assess nutrient fluxes at the sediment–water interface through in situ benthic chamber experiments, whereas in the same experiments, Emili et al. (2015) investigate the mobility of heavy metals and discuss its implication for the widespread fishing and mussel farming activities in the area. In a simulated resuspension experiment using a short-term small reactor, Di Leo et al. (2015) calculate PCBs and heavy metal partitioning between the solid and water phases and, in the latter, between the dissolved and particulate phases, and examine their toxicity for the pelagic trophic web. Three articles further focus on the benthic communities inhabiting the sediments of the Mar Piccolo. Matturro et al. (2015) report the results from a PCBs biodegradation experiment performed for 1 year in microcosms containing marine sediments collected from Mar Piccolo with or without the addition of *Dehalococcoides mccartyi*, the main microorganism known to degrade PCBs through the anaerobic reductive dechlorination process. Moreover, photoautotrophic and heterotrophic benthic functional pathways are addressed separately in two papers. Rubino et al. (2015) assess the benthic ecosystem trophic status and the response of the active and resting components of the microbenthic community to multiple and diffuse anthropogenic impacts. Finally, the heterotrophic pathways of the benthic ecosystem functioning are addressed by Franzo et al. (2015), by considering both its structural (prokaryotes, meiofauna, and macrofauna) and functional (microbial processes of C reworking) levels.

Two publications report on the physical–chemical features of the area. De Serio and Mossa (2015) examine meteorological and biochemical marine data collected in the nearby Mar Grande over a period of 11 months to highlight the correlation between wind and waves and the principal behavior of the currents. Furthermore, Kralj et al. (2015) evaluate the physical–chemical features of the Mar Piccolo through four surveys and compare the obtained results with a 20-year dataset to assess the effectiveness of relocation of the sewage discharges for the reduction of eutrophication of the area.

Other two contributions describe the plankton dynamics in the Mar Piccolo. The effect of the relocation of the sewage outfalls on the phytoplankton assemblages and the blooming of potentially toxic microalgae is assessed by Caroppo et al. (2015). All levels of the planktonic trophic web (virioplankton, the heterotrophic and phototrophic fractions of pico-, nano- and microplankton, as well as mesozooplankton) are examined in the paper by Karuza et al. (2015), and their implications for the intensive mussel farming in the Mar Piccolo are discussed.

The following two papers integrate the data in the water column with those in the sediments. Bongiorni et al. (2015) apply the stable isotope analysis to examine the main organic matter sources and benthic and pelagic consumers in this basin. In the article by Cibic et al. (2015), planktonic primary production and heterotrophic prokaryotic production are used as proxies of functioning and combined with the benthic rates to have an overall view of the ecosystem functioning.

The ecotoxicological aspects are discussed in the articles by Costa et al. (2015) and Moschino and Da Ros (2015). In particular, Costa et al. (2015) apply a multiorganisms and multiend-points approach, exposing organisms from different trophic levels to elutriate and whole sediment, combining an ecotoxicological investigation with chemical analysis. In contrast, Moschino and Da Ros (2015) use a battery of biomarkers at low level of biological organization (biochemical and cellular) in the native mussel *Mytilus galloprovincialis*, a sentinel organism to assess contamination effects.

In the paper by Giandomenico et al. (2015), concentrations of some heavy metals and PCBs are evaluated in edible marine organisms from different trophic levels and with different feeding behaviors, i.e., bivalve molluscs, gastropod molluscs, and some commercial species of fish. In the last two papers, a different type of threat to this particular ecosystem is considered, i.e., the biological contamination caused by the presence of non-indigenous species in the Taranto Seas that have been introduced by shipping and shellfish importation. The article by Lorenti et al. (2015) is devoted to a non-indigenous isopod species, *Paranthura japonica*, collected also from the Mar Piccolo in 2013, whereas in the review by Cecere et al. (2015), the main activities and vectors responsible for the introduction of non-indigenous species are identified through the analysis of 135 questionnaires compiled by different categories of local stakeholders.

References

Bellucci LG, Cassin D, Giuliani S, Botter M, Zonta R (2016) Sediment pollution and dynamic in the Mar Piccolo of Taranto (southern Italy): insights from bottom sediment traps and surficial sediments. Environ Sci Pollut Res. doi:10.1007/s11356-016-6738-6

Bongiorni L, Fiorentino F, Auriemma R, Bernardi Aubry F, Camatti E, Camin F, Nasi F, Pansera M, Ziller L, Grall J (2015) Food web of a confined and anthropogenically affected coastal basin (the Mar Piccolo of Taranto) revealed by carbon and nitrogen stable isotopes analyses. Environ Sci Pollut Res. doi:10.1007/s11356-015-5380-z

Cardellicchio N, Annicchiarico C, Di Leo A, Giandomenico S, Spada L (2015) The Mar Piccolo of Taranto: an interesting marine ecosystem for the environmental problems studies. Environ Sci Pollut Res. doi:10.1007/s11356-015-4924-6

Caroppo C, Cerino F, Auriemma R, Cibic T (2015) Phytoplankton dynamics with a special emphasis on harmful algal blooms in the Mar Piccolo of Taranto (Ionian Sea, Italy). Environ Sci Pollut Res. doi:10.1007/s11356-015-5000-y

Cecere E, Petrocelli A, Belmonte M, Portacci G, Rubino F (2015) Activities and vectors responsible for the biological pollution in the Taranto Seas (Mediterranean Sea, southern Italy): a review. Environ Sci Pollut Res. doi:10.1007/s11356-015-5056-8

Cibic T, Bongiorni L, Borfecchia F, Di Leo A, Franzo A, Giandomenico S, Karuza A, Micheli C, Rogelja M, Spada L, Del Negro P (2015) Ecosystem functioning approach applied to a large contaminated coastal site: the study case of the Mar Piccolo of Taranto (Ionian Sea). Environ Sci Pollut Res. doi:10.1007/s11356-015-4997-2

Costa E, Piazza V, Gambardella C, Moresco R, Prato E, Biandolino F, Cassin D, Botter M, Maurizio D, D'Adamo R, Fabbrocini A, Faimali M, Garaventa F (2015) Ecotoxicological effects of sediments from Mar Piccolo, South Italy: toxicity testing with organisms from different trophic levels. Environ Sci Pollut Res. doi:10.1007/s11356-015-5471-x

De Pascalis F, Petrizzo A, Grezzo M, Lorenzetti G, Manfè G, Alabiso G, Zaggia L (2015) Estuarine circulation in the Taranto Seas. Environ Sci Pollut Res. doi:10.1007/s11356-015-5389-3

De Serio F, Mossa M (2015) Environmental monitoring in the Mar Grande basin (Ionian Sea, Southern Italy). Environ Sci Pollut Res. doi:10.1007/s11356-015-4814-y

De Vittor C, Relitti F, Kralj M, Covelli S, Emili A (2015) Oxygen, carbon, and nutrient exchanges at the sediment–water interface in the Mar Piccolo of Taranto (Ionian Sea, southern Italy). Environ Sci Pollut Res. doi:10.1007/s11356-015-4999-0

Di Leo A, Annicchiarico C, Cardellicchio N, Cibic T, Comici C, Giandomenico S, Spada L (2015) Mobilization of trace metals and PCBs from contaminated marine sediments of the Mar Piccolo in Taranto during simulated resuspension experiment. Environ Sci Pollut Res. doi:10.1007/s11356-015-5472-9

Emili A, Acquavita A, Covelli S, Spada L, Di Leo A, Giandomenico S, Cardellicchio N (2015) Mobility of heavy metals from polluted sediments of a semi-enclosed basin: in situ benthic chamber experiments in Taranto's Mar Piccolo (Ionian Sea, Southern Italy). Environ Sci Pollut Res. doi:10.1007/s11356-015-5281-1

Franzo A, Auriemma R, Nasi F, Vojvoda J, Pallavicini A, Cibic T, Del Negro P (2015) Benthic ecosystem functioning in the severely contaminated Mar Piccolo of Taranto (Ionian Sea, Italy): focus on heterotrophic pathways. Environ Sci Pollut Res. doi:10.1007/s11356-015-5339-0

Giandomenico S, Cardellicchio C, Spada L, Annicchiarico C, Di Leo A (2015) Metals and PCB levels in some edible marine organisms from the Ionian Sea: dietary intake evaluation and risk for consumers. Environ Sci Pollut Res. doi:10.1007/s11356-015-5280-2

Karuza A, Caroppo C, Camatti E, Di Poi E, Monti M, Stabili L, Auriemma R, Pansera M, Cibic T, Del Negro P (2015) 'End to end' planktonic trophic web and its implications for the mussel farms in the Mar Piccolo of Taranto (Ionian Sea, Italy). Environ Sci Pollut Res. doi:10.1007/s11356-015-5621-1

Kralj M, De Vittor C, Comici C, Relitti F, Auriemma R, Alabiso G, Del Negro P (2015) Recent evolution of the physicalchemical characteristics of a Site of National Interest - the Mar Piccolo of Taranto (Ionian Sea) - and changes over the last 20 years. Environ Sci Pollut Res. doi:10.1007/s11356-015-5198-8

Lorenti M, Keppel E, Petrocelli A, Sigovini M, Tagliapietra D (2015) The non-indigenous Paranthura japonica Richardson, 1909 (Isopoda: Anthuroidea: Paranthuridae) from the Mar Piccolo lagoon, Taranto (Italy, Mediterranean Sea). Environ Sci Pollut Res. doi:10.1007/s11356-015-4994-5

Matturro B, Ubaldi C, Grenni P, Barra Caracciolo A, Rossetti S (2015) Polychlorinated biphenyl (PCB) anaerobic degradation in marine sediments: microcosm study and role of autochthonous microbial communities. Environ Sci Pollut Res. doi:10.1007/s11356-015-4960-2

Moschino V, Da Ros L (2015) Biochemical and lysosomal biomarkers in the mussel Mytilus galloprovincialis from the Mar Piccolo of Taranto (Ionian Sea, Southern Italy). Environ Sci Pollut Res. doi:10.1007/s11356-015-4929-1

Rubino F, Cibic T, Belmonte M, Rogelja M (2015) Microbenthic community structure and trophic status of sediments in the Mar Piccolo of Taranto (Mediterranean, Ionian Sea). Environ Sci Pollut Res. doi:10.1007/s11356-015-5526-z

Vitone C, Federico A, Puzrin AM, Ploetze M, Carrassi E, Todaro F (2016) On the geotechnical characterisation of the polluted submarine sediments from Taranto. Environ Sci Pollut Res. doi:10.1007/s11356-016-6317-x

Zuffianò LE, Basso A, Castrano D, Dragone V, Limoni PP, Romanizzi A, Santaloia F, Polemio M (2015) Coastal hydrogeological system of Mar Piccolo (Taranto, Italy). Environ Sci Pollut Res. doi:10.1007/s11356-015-4932-6

Nicola Cardellicchio graduated as a chemist at the University of Bari. Since 1983, he is research scientist at the National Research Council (CNR). Presently, he is director of research and responsible at the Institute for Coastal Marine Environment—UOS of Taranto. He has been coordinator of several national and international research projects. He was professor at Universities of Bari, Lecce, and Potenza and winner of the Chair of Environmental Chemistry and Cultural Heritage at the University of Salento (Lecce). Since 1981, he is member of the Italian Chemical Society, founding member of the Division of

Environmental Chemistry and Cultural Heritage of which he has been the president for a 3-year period. Nicola Cardellicchio is the author of over 200 publications and editor of five books in the field of environmental chemistry. He has organized more than 30 congresses and schools. His interest areas are analytical chemistry, marine chemistry, pollution and degradation of the environment, biogeochemistry, ecotoxicology, and remediation technologies. The Italian Chemical Society awarded him the medal of the Environmental Chemistry and Cultural Heritage Division.

Stefano Covelli is Associate Professor in Geochemistry at the Department of Mathematics and Geosciences of Trieste University (Italy) where he is also coordinator of the MercuRILab working group. He earned his Ph.D. in Environmental Sciences (Marine Sciences) from the same University in 1998. His main research interest is on the biogeochemical cycle of mercury in the aquatic environment. He is especially involved in measuring fluxes at the air–water–sediment interfaces both in situ and through laboratory experiments. His research activity also includes the fate, behavior, and impact of contaminants, mainly trace metals, in coastal environments (estuaries and lagoons). During the RITMARE project, Stefano Covelli has investigated the mobility and speciation of mercury and other trace metals at the sediment–water interface in order to explore the possibility of reusing dredged sediments for the restoration of saltmarshes.

Tamara Cibic is a research scientist at the Oceanography Section of OGS (Istituto Nazionale di Oceanografia e di Geofisica Sperimentale) in the "Marine Ecology and Biodiversity" research group that she also coordinates. She has obtained her Ph.D. degree in Biomonitoring from the University of Trieste in 2006. Her research activity focuses on microphytobenthic biodiversity, primary production in water column and sediments, respiration in soft sediments, and benthic ecology. She has been involved in studies aimed to assess the effects of increased CO_2 on diversity and functioning of marine benthic communities. Lately, her main field of research is the assessment of the ecosystem functioning in contaminated costal sites subjected to different types of anthropogenic pressure. Within the project RITMARE, she was the scientific responsible for the research unit "Functioning of coastal ecosystems in polluted areas" and member of the scientific committee for the restoration of the Mar Piccolo of Taranto (Italy).