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Dottorato di Ricerca in RESEARCH METHODS IN SCIENCE AND TECHNOLOGY

Tematica vincolata 4: Enhancing protection and preservation of nature, biodiversity, and mitigating various forms of pollution: analysis of the emerging pollutants, eutrophication and microbial load in vulnerable sites and risk for the biodiversity

CANDIDATE: Angela Freddi

TITLE: Climate change impacts and anthropogenic pressures: integrated research and approaches to protect and preserve the biodiversity in coastal environments (Ecologia BIO07)

RESEARCH PROPOSAL

Introduction of the problem and state of the art

Climate change and anthropogenic pressures pose significant threats to the marine ecosystem. In particular, these systems are affected by various sources of pollution. The integrity of coastal area is highly influenced by flow regimes [1]; this holds particularly true in the Adriatic Sea, where large volumes of water flow from rivers. Indeed, severe river discharge may introduce high loads of chemical and microbiological contaminants into the coastal sea. When contaminated water is discharged into the sea, it can alter the trophic chain and biodiversity of the coastal ecosystem [2]. The presence of chemical and microbiological contaminants poses risks both to marine organisms and human health. Therefore, it is crucial to study the water quality and quantity of the contaminants that can reach seawaters, in order to ensure the health and sustainability of coastal ecosystems. In fact, the urgent need to preserve coastal ecosystems led to the development of such projects under the PNRR regulations. The project is coherent with Mission 2 C4 of the PNRR (Protection of the territory and water resources; C4-1;2;3;4). It focuses on the development of strategies for the conservation of the coastal marine ecosystem and biodiversity.

Research Objectives

Through the application of an integrated use of both consolidated and cutting-edge methodologies, this project aims at defining an innovative approach to allow for a more efficient, reliable, and integrated based approach study of the coastal environment in response to the discharge of chemical and microbiological pollutants into the sea, as a consequence of both anthropogenic activities and climate change-related events. The final objective of this study is to enhance the protection and preservation of the coastal ecosystem and biodiversity in order to mitigate the effects of such impacts through this research project

that will be performed in both river and coastal marine environments and to guide towards an improved management of pollution in coastal environments.

Methodology

This project intends to address the abovementioned aspects through the integrated use of the following methodological approaches during and after raining extreme events.

- Use of hydro-meteorological in situ stations, capable of performing real-time monitoring of river flow and rainfall levels with an immediate visualization of the data (including CTD, a network of sensors for various chemical, physical parameters, and a web portal).

- Multiple Parameters Analysis: this project will employ advanced techniques that can simultaneously measure various fecal and chemical parameters in both river water and seawater. In addition to the analysis associated with trophic and fecal bacterial status, innovative system will be utilized to assess microbial pollution. In more detail:

- For the study of trophic status of coastal waters, nutrient concentration of nitrogen and phosphorus, as well as dissolved oxygen and chlorophyll *a*, will be determined in seawater. Nutrient loads will be also measured based on the freshwater input. The nutrient concentrations will be considered as the primary driving forces for eutrophication processes, which are transported through river discharges in estuarine and coastal areas, as referred to Directives 91/676/EEC, 91/271 /EEC, 2000/60/EC, 2008/56/EC. These environmental and biological parameters will be measured at the target area, which is near riverine discharge. This area is affected by eutrophication events, which is influenced by variability of freshwater discharge. Chlorophyll *a* will be also measured on marine sediments.
- Microbial contamination will be assessed through the analysis of faecal contamination in river and seawater, and sediment samples. Faecal contamination will be analysed by means of culture-based methods for Fecal Indicator Bacteria (e.g. *Escherichia coli* and intestinal enterococci) and through innovative molecular (qPCR) methods [3] which allow to evaluate the potential sources of faecal contamination (e.g., animal, human) in environmental samples, thus providing a further means to assess the associated public health risks. In addition,
- a novel microbial approach will be developed utilizing fluorescent and impedance biosensors. This innovative technique will enable remote and real time monitoring to assess the abundance of the microbial load, offering a cutting-edge solution for microbial study.
- Emerging Contaminants (ECs) will be analysed on marine sediments. Within this class of contaminants, the distribution of pesticides will be determined to support playmakers in promoting the safety and quality of water-bodies.
- The biodiversity status of the area will be evaluated through the study of meiofauna, using indicator species found in the sediment to assess the quality and ecological condition of the area.

The study area will be located at the mouth of the Arzilla River in front of Fano town in the Marche Region, which represents a source of riverine discharge into the coastal environment. This area has been selected as a pilot site because it exhibits the typical characteristics of a highly urbanized city in the summer season. In addition, heavy rainfall frequently causes the local sewage network, responsible for collecting sewage from Fano town, to overflow. As a result, the excess sewage is discharged into the river and reaches the coastal area [4].

Expected results

The project aims to achieve the expected results, within the context of EU's common strategic priorities, by enhancing the environmental quality of the sea, safeguarding marine biodiversity, and contrasting human pollution in accordance with the PNRR and it includes:

1. Identification of major source origin of chemical and microbiological pollution in the coastal areas and overall assessment of water quality.
2. Evaluation of the biodiversity status of the area through the analysis of the trophic status and the study of indicator organisms (e.g., meiofauna) in sediment samples. This evaluation will provide insights into the ecological condition and overall quality of the coastal ecosystem.
3. Enhanced understanding of the impacts of climate change on the health of coastal environments: The study aims to contribute to a better understanding of the interactions between pollution and climate change in the coastal environment. This knowledge can help inform future research and policies addressing the combined effects of these factors.

Bibliography

1. Cozzi et al., 2018 <https://doi.org/10.3390/w11010001>
2. Lathrop & Carpenter, 2014 <https://doi.org/10.5268/IW-4.1.680>
3. Ahmed et al., 2019 <https://doi.org/10.1016/j.scitotenv.2018.11.439>
4. Ferrarin et al., 2021 <https://doi.org/10.3390/w13111525>

ABSTRACT

This project aims to study the effects of anthropogenic and climatic impact on the coastal marine ecosystem in response to river discharge into the sea. The study will be multidisciplinary, involving chemical, physical and microbiological analyses as well as an evaluation of the biodiversity status. Innovative techniques, such as qPCR and biosensors will be also employed to investigate the abundance of fecal bacteria. Overall, through the proposed activities and approaches, the project expects to provide improved knowledge and tools for the monitoring and preservation of the coastal ecosystem in response to both anthropogenic pressures and climate change-related events and to provide further indications towards an improved management of human pollution in coastal environments.