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This deliverable has been submitted to the European Commission and is currently under review. The final version after the approval may differ.

MOBILES

D5.2 – Policy Brief on Biotic and Abiotic Pollutants

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Project coordinator:	**prof. Evangelos Hristoforou** **dr. Angelo Ferraro** National Technical University of Athens (NTUA)
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D5.2 – Policy Brief on Biotic and Abiotic Pollutants

Short summary: This document has been prepared by MOBILES consortium with the support of Marine Shield Cluster members.[1] It is based on the operational experience of MOBILES researchers. The intended audience includes EU funding authorities and implementing bodies such as: Directorate-General for Research and Innovation (DG RTD), European Research Executive Agency (REA), European Innovation Council (EIC), European Research Council (ERC) and other similar agencies.

Biotic and abiotic pollutants are profoundly connected with ecosystems and human health. Biotic pollutants are living organisms, whereas abiotic pollutants are organic and inorganic chemicals. An excessive presence of either or both factors can damage aquatic and terrestrial environments and provoke serious human health issues.

Given the enormous number of organisms and chemicals that require monitoring, MOBILES project recognizes the challenges faced by environmental stakeholders and recommends conducting pollutant association studies/research with the goal to identify pollution markers/indicators. The objective is to identify specific pollution markers that, once detected, can serve as indicators for the potential presence of additional contaminants. Thus, analysing a limited number of markers enables the detection of a wide range of biotic and abiotic pollutants.

Furthermore, such markers/indicators represent an opportunity to reduce the detrimental effects biotic and abiotic pollutants have on the environment and safeguard human health. Multi-contaminant indicators reduce the need for multiple targeted analyses, lowering operational costs and enabling more frequent or spatially extensive monitoring without increasing budgets.

Most of the benefits from developing these targeted pollution markers will accrue to national authorities responsible for implementing national, regional, and European water and marine legislation, including, e.g., the Marine Strategy Framework Directive.

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[1] https://marineshield.eu/

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Policy brief title

Biotic and Abiotic Pollutants in Water and Soil: Monitoring Challenges and Policy Pathways for Europe

1. What are biotic pollutants?

Biotic pollutants are living organisms, often resulting from human activities, that may alter the quality of aquatic and terrestrial environments, posing serious biosafety issues. Besides their physical presence, some biotic pollutants such as pathogen bacteria, may produce toxins or dangerous metabolites which can cause food poisoning, infection issues, reproductive failure, developmental defects, as well as contribute to the decline of wildlife populations. Another serious consequence associated with biotic pollutants is the release of genetic traits (e.g., genes) that can significantly compromise the biological integrity of wildlife populations. This is particularly relevant for microbes carrying *antimicrobial resistance (AMR) genes*, which can transfer these traits to other microorganisms, leading to pathogens that are highly resistant to conventional treatments.
Human activities that contribute to the release of biotic pollutants include the introduction of non-indigenous and invasive species (plants, animals, microbes), collectively referred as *Invasive Alien Species* (IAS), into aquatic or terrestrial habitats, as well as the release of *genetically modified organisms* (GMO). Biotic pollution can also arise indirectly. For example, the excessive release of nutrients in water bodies can, together with warm climate, trigger the overgrowth of phytoplankton which leads to the formation of marine mucilage.

2. What are abiotic pollutants?

Abiotic pollutants are non-living, physical and chemical components introduced to the environment by human activities, or natural phenomena (e.g., volcano eruptions or geochemical release of arsenic and other toxic chemicals). Their impacts include chemical toxicity, bioaccumulation, habitat degradation, as well as soil sterility and changes in key environmental conditions such as temperature, pH and salinity. Common abiotic pollutants are heavy metals, synthetic organic chemicals (antibiotics, pesticides, PFAS), nutrients (excess nitrogen/phosphorus), plastics, oil, hydrocarbons and others.
Many abiotic pollutants have remarkable chemical stability and resist natural degradation processes. Such chemicals are grouped under the definition of *persistent organic pollutants*; this category includes insecticides, PFAS, heavy metals and others. Although not organic, heavy metals also persist indefinitely in the environment and pose long-term risks.
Another class of abiotic pollutants is defined as *degrading pollutants,* which encompass plastics, hydrocarbons, pesticides, herbicides, polychlorinated biphenyls and other synthetic polymers used mainly in electronic devices. Degrading pollutants tend to break down into increasingly small

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fragments, sometimes at micro- and nanoscales, and accumulate both in the environment and in living organisms. Their accumulation in living organisms may lead to biological magnification, increasing contaminant levels up the food chain and threatening end-chain consumers, including humans.
Others abiotic pollutants that are increasingly detected in the environment belong to the so-called class of *chemicals/contaminants of emerging concern (CEC)*. This class includes substances originating from pharmaceuticals, cosmetics, detergents, personal care products, and household chemicals. Like other abiotic pollutants, their persistence, potential for bioaccumulation, and potential toxicity as well as their long-term ecological and human health impacts, are a growing policy concern.

3. MOBILES recommendations

To reduce the detrimental effects of biotic and abiotic pollutants it is important to constantly monitor their occurrence and concentration in the environment as well as in the water and food intended for human consumption, livestock feed, and wild life.
As briefly mentioned in the previous two sections, **the number of organisms, genes and chemicals that compose the families of biotic and abiotic pollutants is huge**. This diversity makes their detection and monitoring a major challenge for environmental authorities and agencies.
The MOBILES project is currently developing biosensors capable to detect a limited number of both biotic and abiotic pollutants in water and in soil. Furthermore, a work package is dedicated to study the microbiota found in polluted areas.
Therefore, MOBILES research teams engaged in the project quite often handle real samples of contaminated waters and soils. Given that **water bodies and soils are more often affected by complex mixtures of chemical substances and biological contaminants rather than single pollutants**, it is clear that monitoring and detecting such contaminates one-by-one represent a challenge both for experimental laboratories and for environmental agencies/authorities.
The timely detection is further complicated by the fact that most contaminants remain in water or soil for short periods due to evaporation, carried off by rain or river flow and when persist, their concentration might be very low.
To address these challenges, MOBILES recommends:

> Support studies and research initiatives that deepen the understanding of interactions among biotic and abiotic pollutants. One of the objectives of such initiatives should be the **identification of pollution markers/indicators that might be used to reveal the presence of multiple contaminants.** To identify such indicators a systematic physio-chemical characterization of contaminated waters and soils across multiple European sites is necessary. Subsequently association study based on machine learning can be applied together with the analysis of complex database comprising chemical, molecular and biological structures.

The main characteristics of effective pollution markers should include:

- Presence in water and soil at sufficiently high concertation to allow reliable detection
- Easy to be detected on site without complex procedures
- Persistence in environmental matrices even after heavy rainfalls or other extreme weather events

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Once identified, detection limits for pollution markers can be part of the EU environmental legislation. By acting as early-warning signals, pollution markers could help authorities identify hotspots, prioritise interventions, and strengthen enforcement. Strategic pillars where a dedicated "call for proposals" could be included are: *Marine Strategy Framework Directive (MSFD); Water Resilience Strategy; 8th Environment Action Programme (EAP); EU Soil Strategy for 2030.*

As the revised MSFD framework moves toward adoption in late 2026, support the adoption of integrated monitoring tools will be allow to meet new expectations for efficiency, coherence, and environmental effectiveness. The development and deployment of pollution markers capable of signalling the presence of multiple contaminants represent a strategic opportunity. These markers can streamline monitoring workflows, reduce sampling redundancy, and enhance the comparability of assessments across marine regions.

The revision of MSFD aims to achieve two main objectives:

- Increase the protection of the marine environment and support progress toward achieving **good environmental status**;
- Simplify implementation and reduce the administrative burden in line with the overall simplification objective.

Multi-contaminant indicators can contribute to both of these MSFD objectives. Integrating such pollution markers into national and regional monitoring programmes represents a meaningful step toward improved protection of water bodies as well as soil health. Furthermore, it directly supports the EU's goals of cleaner, healthier, and more resilient marine ecosystems while reducing administrative and financial burdens.

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Abbreviation	Abbreviation for
AMR	Antimicrobial Resistance
CEC	Chemicals/Contaminants of Emerging Eoncern
DG RTD	Directorate-General for Research and Innovation
EIC	European Innovation Council
ERC	European Research Council
GMO	Genetically Modified Organisms
IAS	Invasive Alien Species
MFF	Multiannual Financial Framework
PFAS	Per- and Polyfluoroalkyl Substances
REA	European Research Executive Agency

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4. Project Consortium

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