

MARS fact sheet #04

Multiple stresses on Europe's freshwaters: emerging challenges for science, policy and management

The interactions and impacts of multiple stressors on aquatic ecosystems is one of the key challenges for freshwater science, policy and conservation. Whilst there are many success stories of pollution being reduced on rivers and lakes across the continent, Europe's freshwaters are still subject to multiple stresses, many of which are complex and poorly understood. In order to safeguard the health and diversity of Europe's freshwaters, and the ecosystem services that they provide to humans, we need to better understand and manage the challenge of multiple stressors.

Multiple stressor combinations in European freshwaters

A 2012 report by the European Environment Agency 'European Waters - Assessment of Status and Pressures' outlines how multiple stressors such as water pollution, water scarcity, flooding, water abstraction and flow modifications increasingly affect Europe's surface waters (i.e. rivers, lakes, transitional and coastal waters). From data collected as part of the Water Framework Directive monitoring, it is evident that more than 40% of European water bodies are negatively impacted by multiple stressors.

In European lakes and rivers, the most common two-stressor combination is diffuse water pollution combined with hydromorphological pressures. For example, this might describe a river fragmented by weirs and dams and subject to nutrient pollution from agricultural fertilisers. In transitional and coastal environments, the most common stressor combination is diffuse pollution with a group of 'other' stressors including overfishing, the impact of alien species and waste disposal.

Similarly, a 2015 literature review by MARS scientist Peeter Nõges and colleagues dealing with multistressor effects found that most scientific studies also address the combined impact of nutrient pollution and hydrological alteration.

Interactions and impacts of multiple stressors: synergism and antagonism

New scientific research suggests that such stressors can interact in complex and dynamic 'cocktails' to potentially intensify or neutralize their individual and additive effects on the environment. However, these interactions are not yet fully understood: a knowledge deficit which poses challenges for the management of aquatic environments and the ecosystem services they provide, particularly in the context of on-going climatic change. The cumulative impact of multiple stressors on the environment does not always equal the sum of the individual parts. Instead, synergistic and antagonistic interactions between multiple stressors are increasingly being observed.

Synergistic interactions between multiple stressors create effects that are greater than the sum of the individual stressor effects. Synergistic interactions can be expressed in a formula as $1+1=3$. *Antagonistic interactions*, on the other hand, occur when certain stressors cancel out the impacts of others. Antagonistic interactions can be expressed in a formula as $1+1=1$.

The interactions and impacts of multiple stressors: challenges for aquatic science, policy and management

Both interactions pose challenges for the management of aquatic systems. Synergistic interactions mean that ecosystem change and decline might

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be underestimated if assessed on the cumulative sum of individual stressors. Similarly, new stressors in an ecosystem may have unpredictable effects as a result of such synergistic interactions. Antagonistic interactions mean that environmental management of a single stressor may have the unintended effect of worsening detrimental ecosystem effects, because the antagonistic, nullifying between-stressor effects are removed.

There are additional uncertainties about the variable impacts of multiple stressors in different types of aquatic ecosystems. Peeter Nõges and colleagues found that in lakes, the impacts of multiple stressors had more significant impacts on ecological change than single stressors. However, in transitional and coastal waters, single stressors were more damaging than multiple combinations.

Further reading

European Environment Agency (2012) European waters – assessment of status and pressures. EEA Report n°8. EEA, Copenhagen.

Nõges P., Argillier C., Borja Á., Garmendia J. M., Hanganu J., Kodeš V., Pletterbauer F., Sagouis A., Birk, S. (2015) Quantified biotic and abiotic responses to multiple stress in freshwater, marine and ground waters. *Science of The Total Environment*. doi:10.1016/j.scitotenv.2015.06.045

The MARS project: addressing the challenge of multiple stressors

Multiple stressor conditions in aquatic environments are no longer the exception, but the norm. However, scientific knowledge on their interactions and impacts is still incomplete and inconclusive. The European Union FP7 MARS project is designed to address the shortfall in knowledge, and to provide policy-relevant information on multiple stressors at a range of scales necessary to inform the Water Framework Directive and River Basin Management Planning.

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Figures

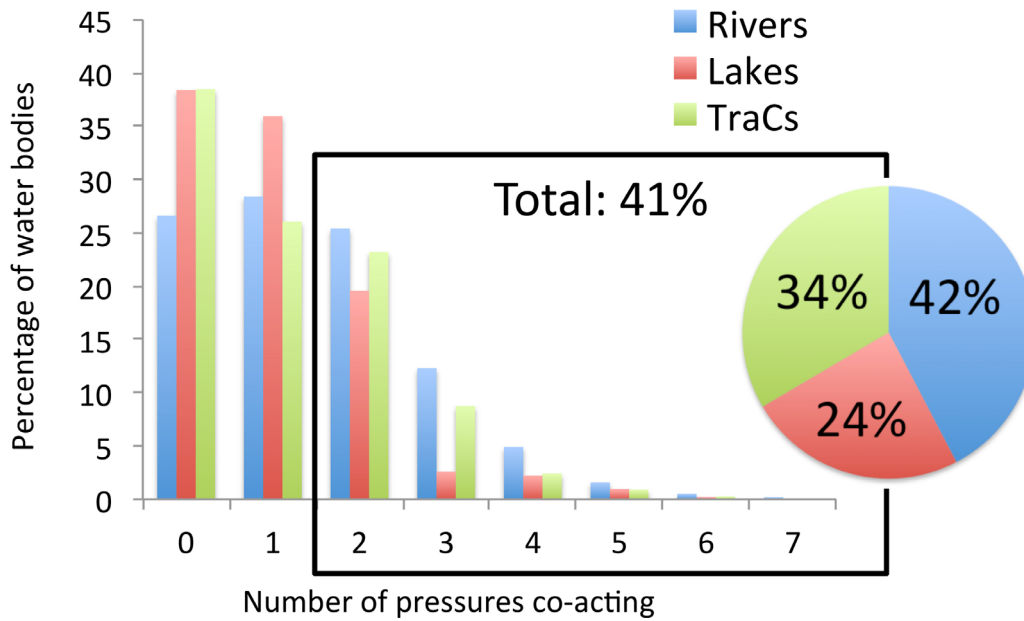


Figure 1: Multiple pressures acting on EU surface waters
Data source: WISE WFD database (EEA 2015; n = 108,130 water bodies of 26 EU Member States)
TraCs: Transitional and Coastal waters

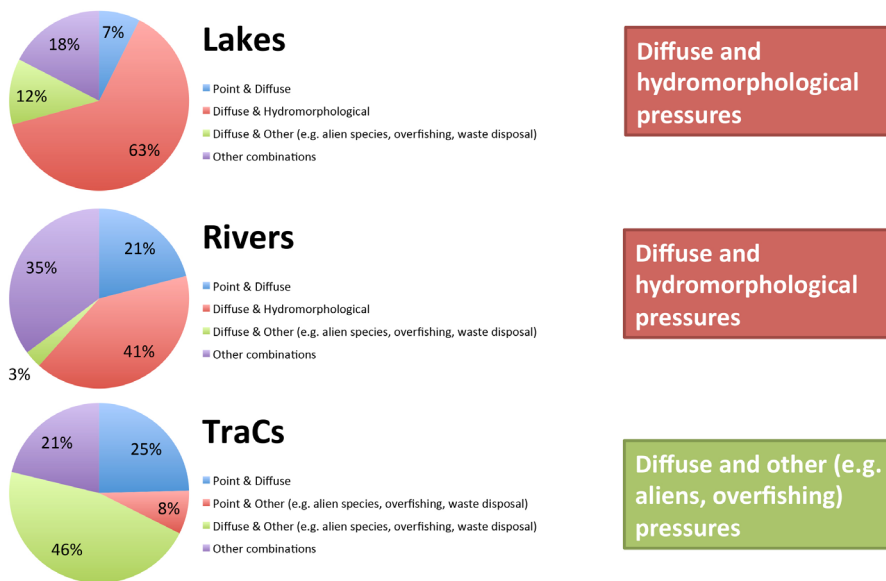


Figure 2: Two-pressure combinations acting most frequently
Data source: WISE WFD database (EEA 2015; n = 26,345 water bodies of 26 EU Member States)
TraCs: Transitional and Coastal waters