River sediment contamination & the remobilization of persistent organic pollutions in a plastic continuum context: from litter to microplastic & finally to nanoplastic

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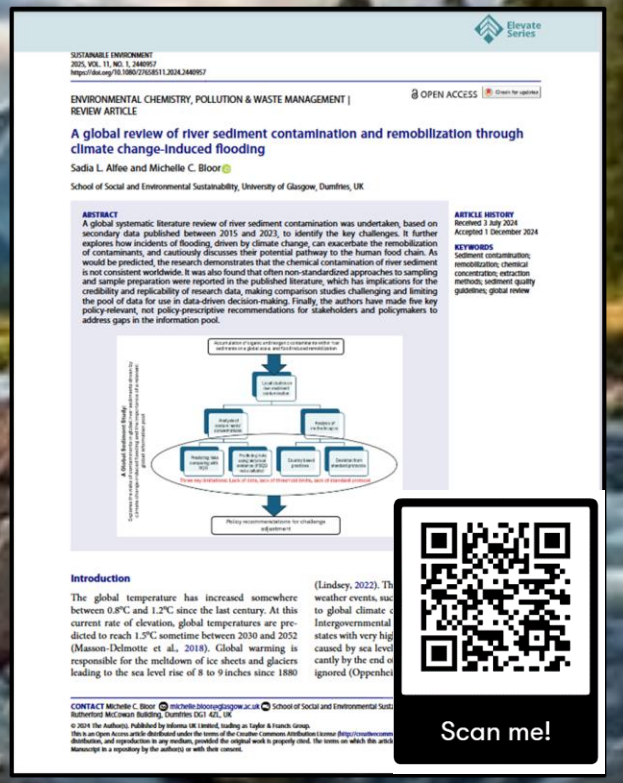
BUILDING SCOTLAND'S RESILIENCE TO NATURAL HAZARDS

A global review of river sediment contamination and remobilization through climate change-induced flooding



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ENVIRONMENTAL CHEMISTRY, POLLUTION & WASTE MANAGEMENT | REVIEW ARTICLE

OPEN ACCESS

A global review of river sediment contamination and remobilization through climate change-induced flooding

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School of Social and Environmental Sustainability, University of Glasgow, Dumfries, UK

ABSTRACT

A global systematic literature review of river sediment contamination was undertaken, based on secondary data published between 2015 and 2023, to identify the key challenges. It further explores how incidents of flooding, driven by climate change, can exacerbate the remobilization of contaminants, and cautiously discusses their potential pathway to the human food chain. As would be predicted, the research demonstrates that the chemical contamination of river sediment is not consistent worldwide. It was also found that often non-standardized approaches to sampling and sample preparation were reported in the published literature, which has implications for the credibility and replicability of research data, making comparison studies challenging and limiting the pool of data for use in data-driven decision-making. Finally, the authors have made five key policy-relevant, not policy-prescriptive recommendations for stakeholders and policymakers to address gaps in the information pool.

ARTICLE HISTORY
Received 3 July 2024
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KEYWORDS
Sediment contamination; remobilization; chemical concentration; extraction methods; sediment quality guidelines; global review

Introduction

The global temperature has increased somewhere between 0.8°C and 1.2°C since the last century. At this current rate of elevation, global temperatures are predicted to reach 1.5°C sometime between 2030 and 2052 (Masson-Delmotte et al., 2018). Global warming is responsible for the meltdown of ice sheets and glaciers leading to the sea level rise of 8 to 9 inches since 1880 (Lindsey, 2022). Th weather events, suc to global climate c Intergovernmental states with very hig caused by sea level cantly by the end o ignored (Oppenhei

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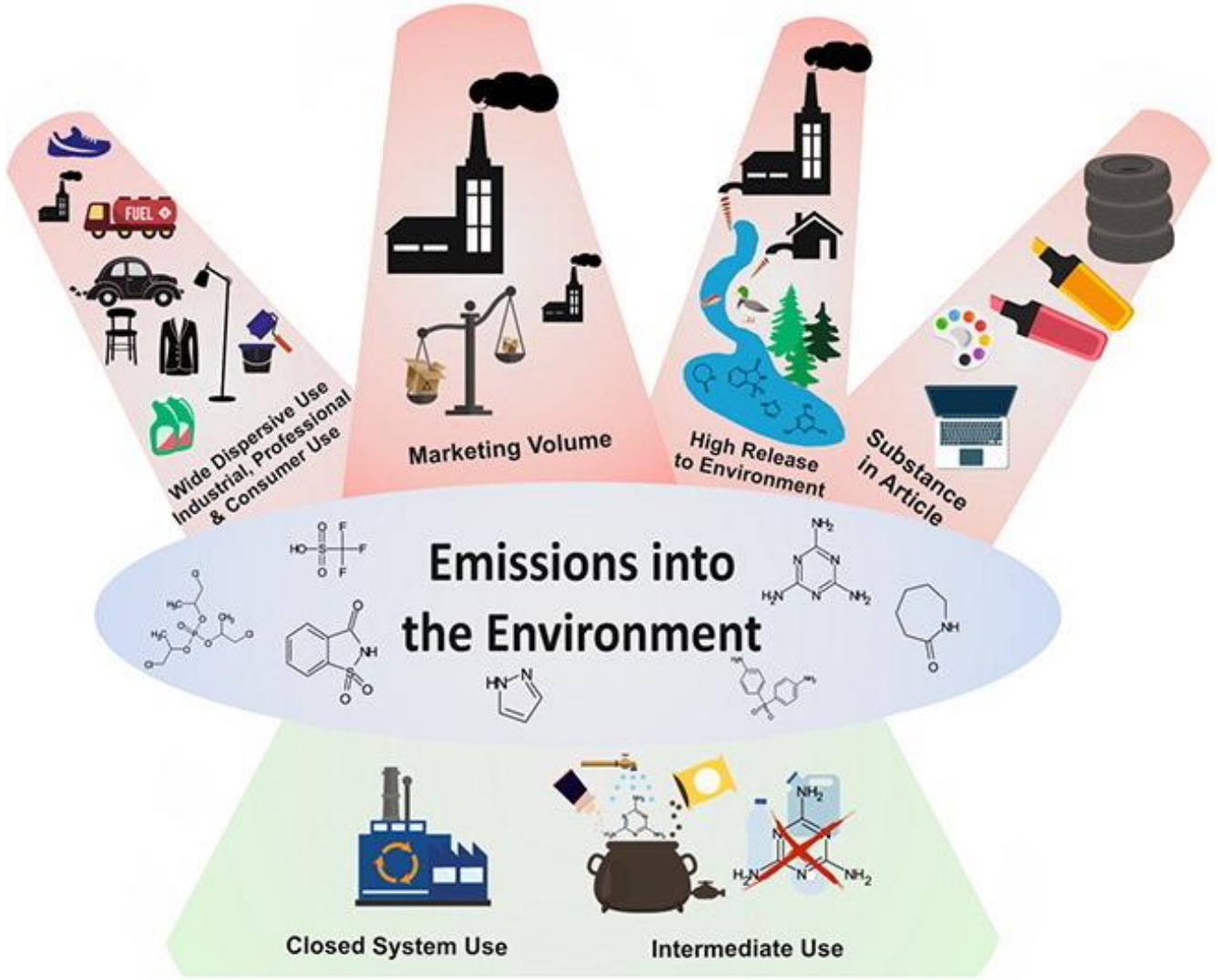

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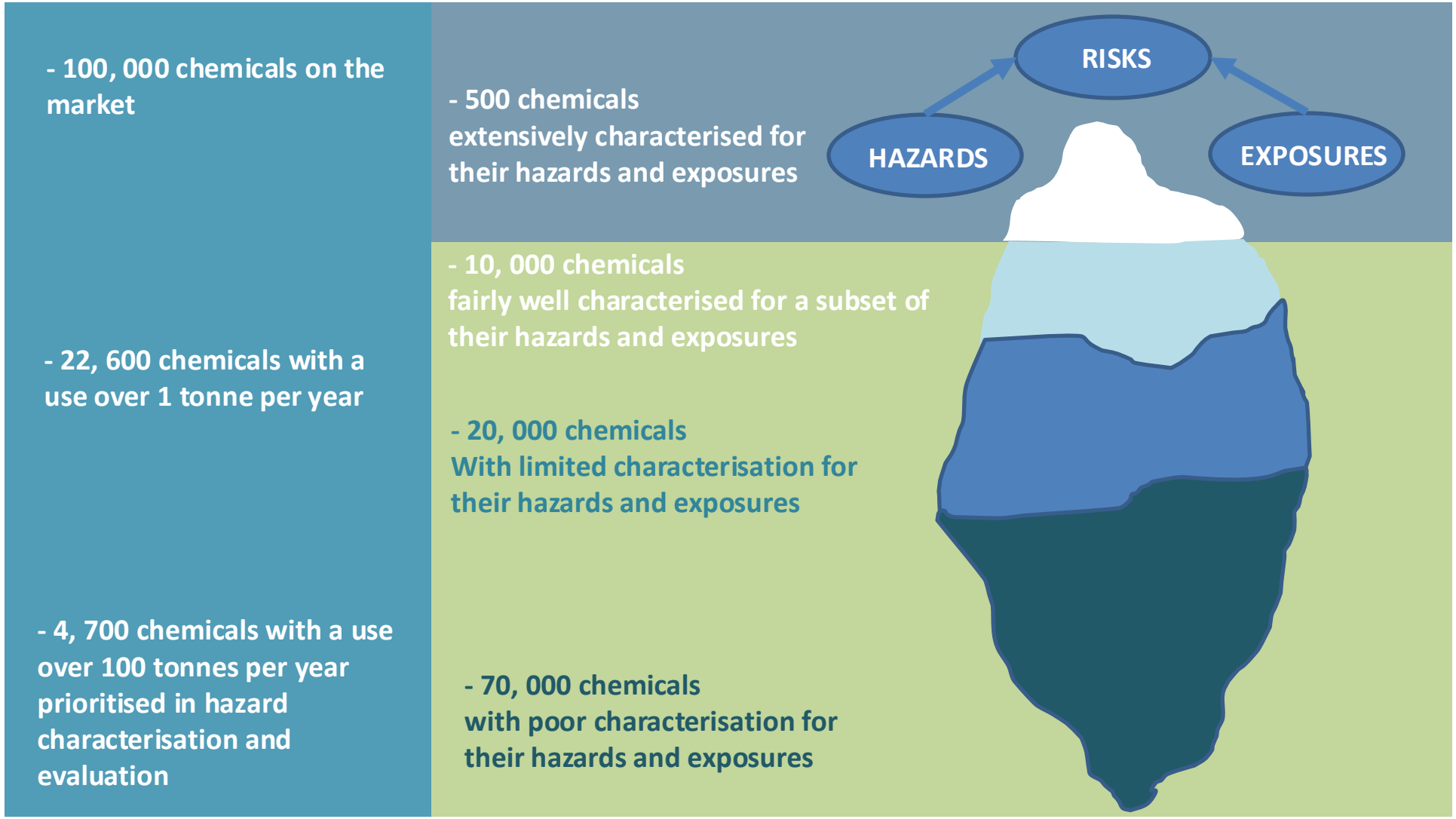
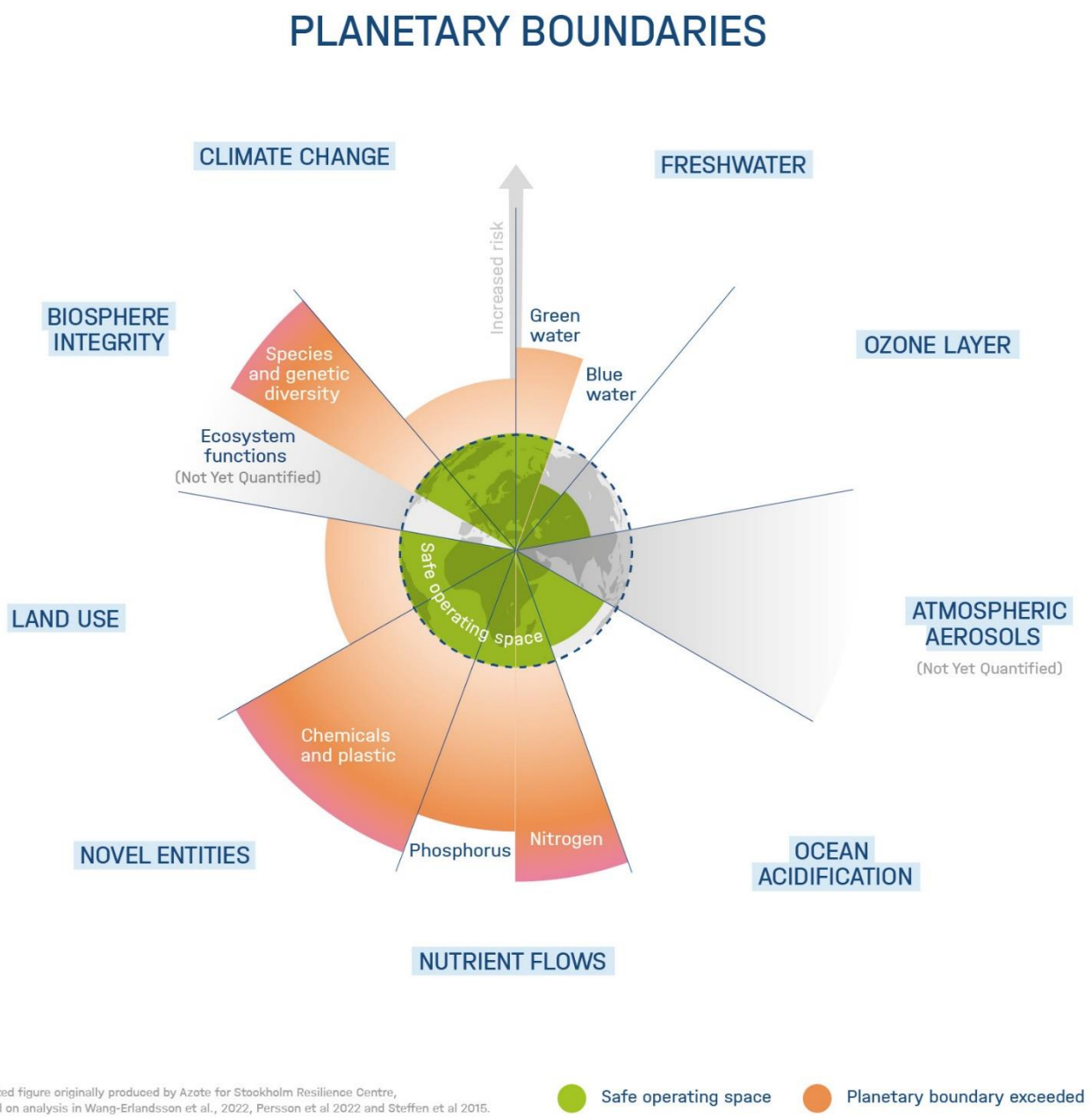
The Chemical Iceberg - the unknown territory of chemicals risks Iceberg



EEA, The European Environment – State and outlook report, 2020

Globally, there are 350, 000 chemicals on the market



IPCC (1988) **The Intergovernmental Panel on Climate Change** assesses the science related to climate change.

IPBES (2012) **The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services** to strengthen the science-policy interface for biodiversity and ecosystem services for the conservation and sustainable use of biodiversity, long-term human well-being and sustainable development.

ISP-CWP (2025)
The Intergovernmental Science-Policy Panel on Chemicals, Waste and Pollution established to provide scientific advice on chemicals, waste, and pollution to support policy decisions and protect human health and the environment.

ecetoc

6-7 May 2026 | Hotel The Standard, Brussels

PLANETARY BOUNDARY FOR NOVEL ENTITIES

DEFINING A SAFE OPERATING SPACE FOR CHEMICALS WITH ACTIONABLE TARGETS TO PROGRESS A TRANSITION TO A SUSTAINABLE FUTURE

This workshop is part of ECETOC's 2026 NEXUS WEEK

Open Workshop on ECETOC's Nexus Week **May 6-7**, 2026, Hotel The Standard Brussels, Belgium. Planetary Boundary for novel entities: Defining a safe operating space for chemicals with actionable targets to progress a transition to a sustainable future

Objectives

The primary goal of this workshop is to discuss the challenges and opportunities in defining the Planetary Boundary for novel entities and elaborate on the need to further develop this framework into well-defined, practical "Safe and Just" ESBs with appropriate control variables. The aim is to lay out a coherent framework based on the DPSIR framework that builds upon current chemical management practices and the wealth of chemical knowledge and data available. A workable ESB definition should be linked to targets and pathways, linking Planetary Boundary science with 'Zero Pollution' ambitions and include KPIs to operationalize sustainability and safety targets.

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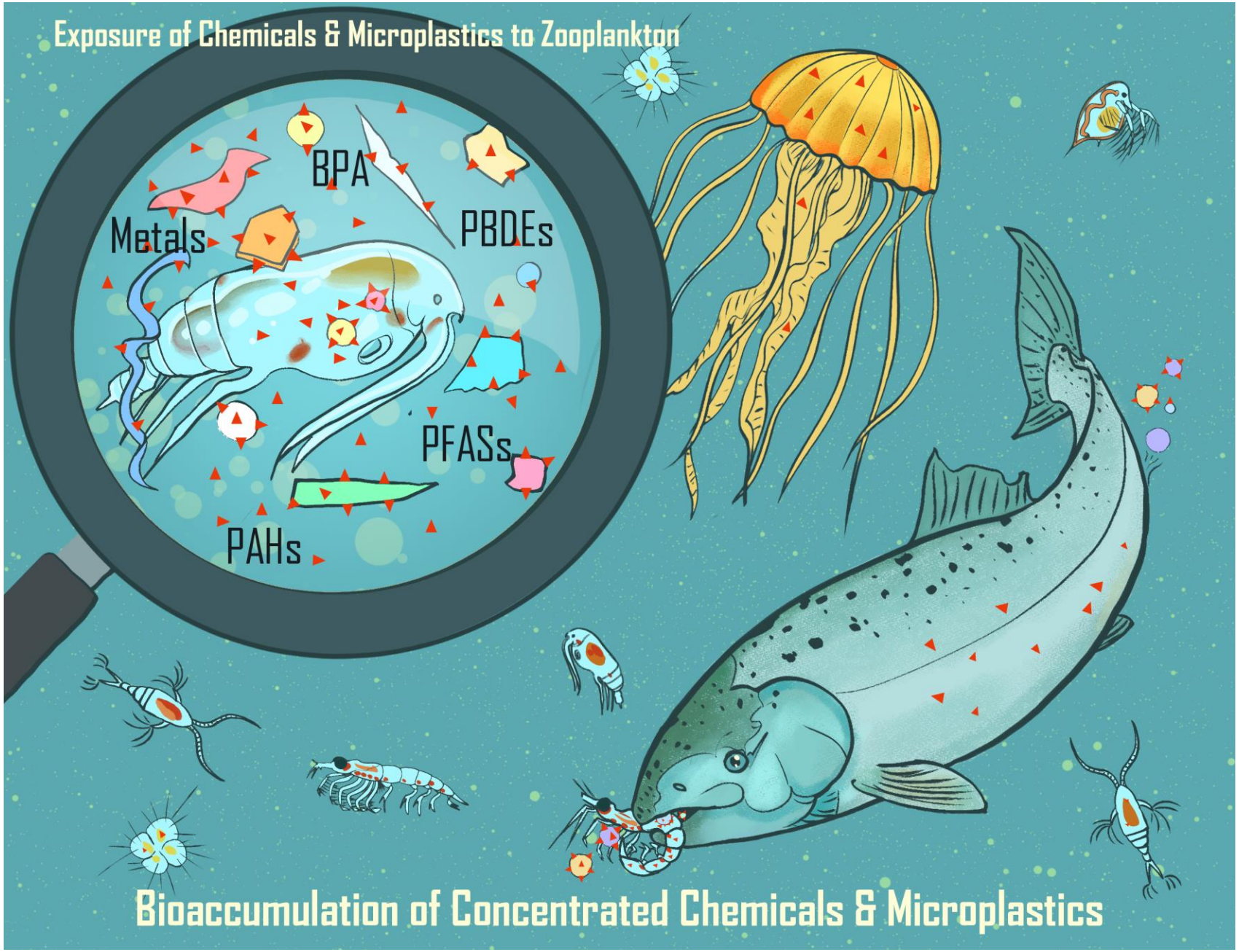
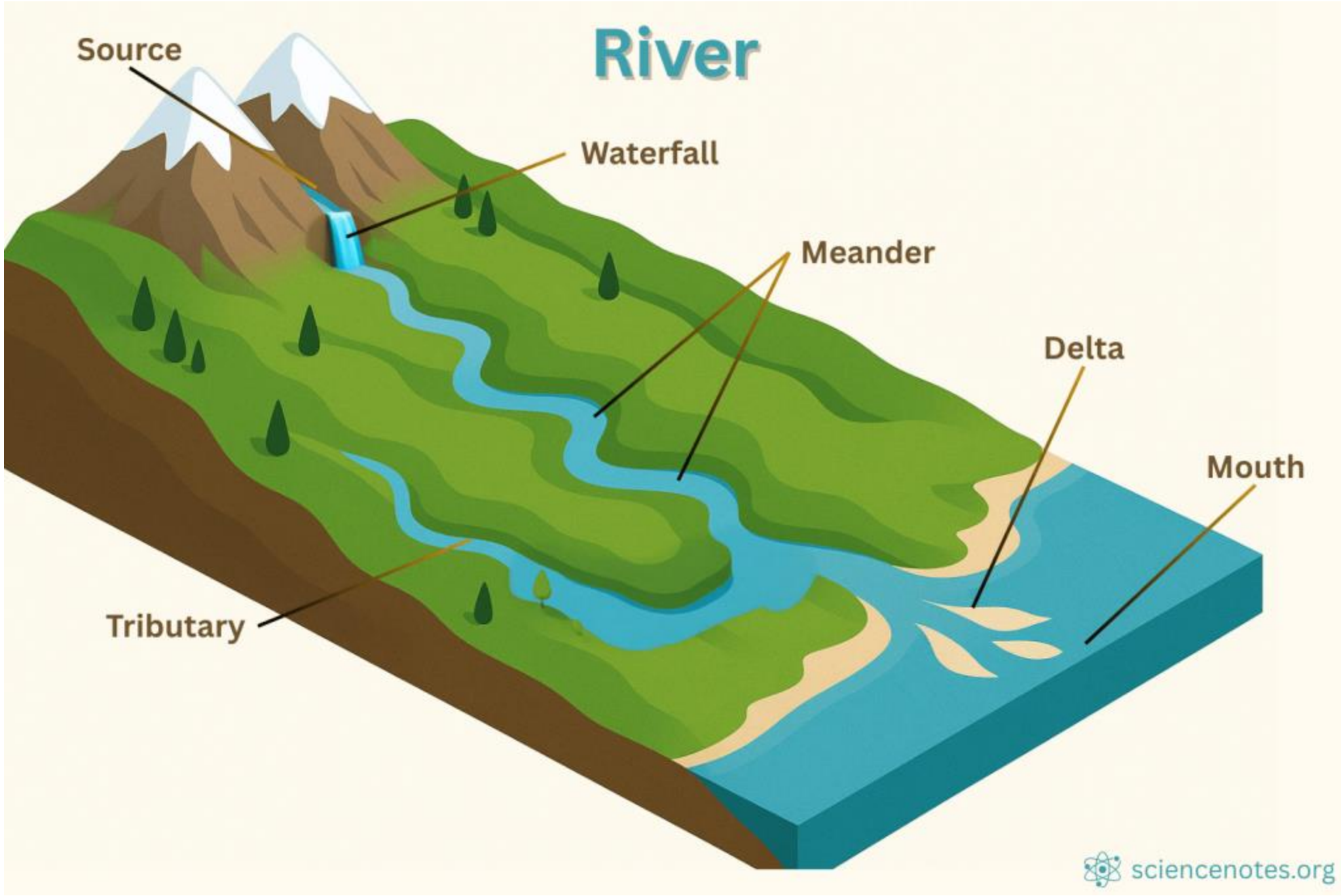


Weis, J. S., & Alava, J. J. (2023). (Micro)Plastics Are Toxic Pollutants. Toxics, 11(11), 935. https://doi.org/10.3390/toxics11110935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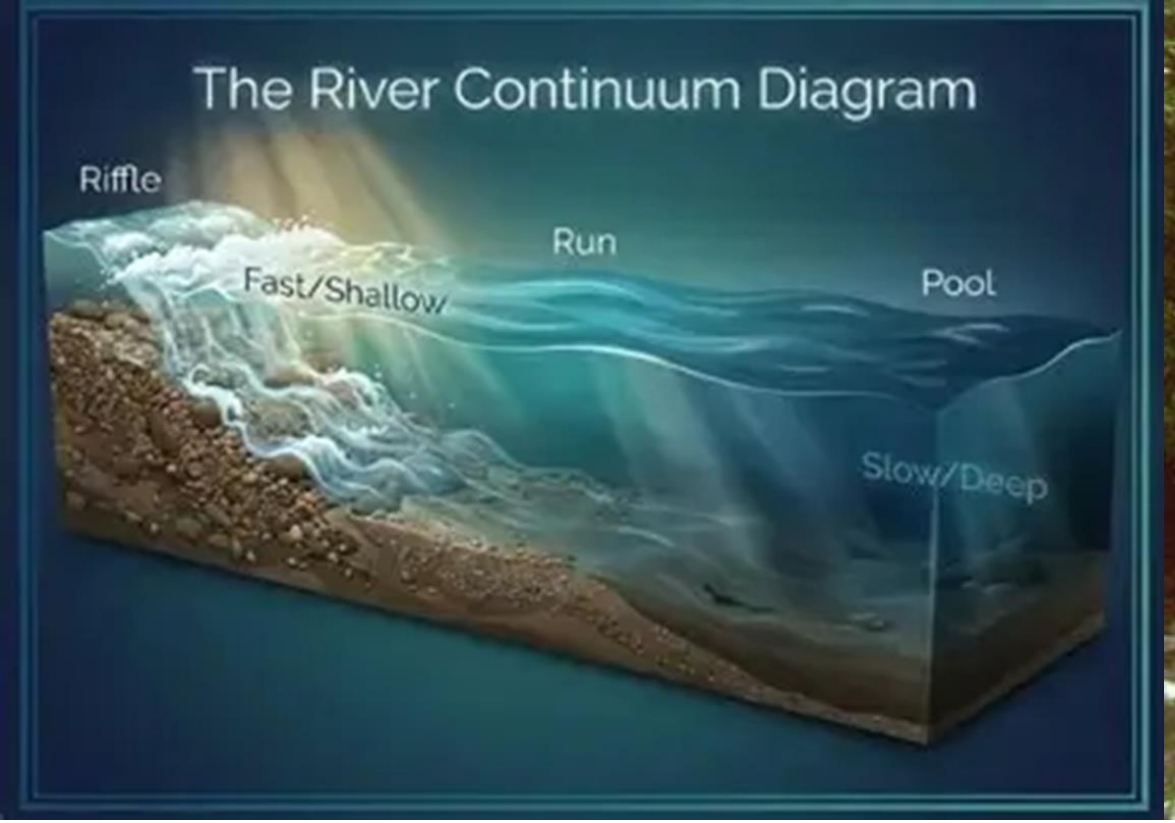

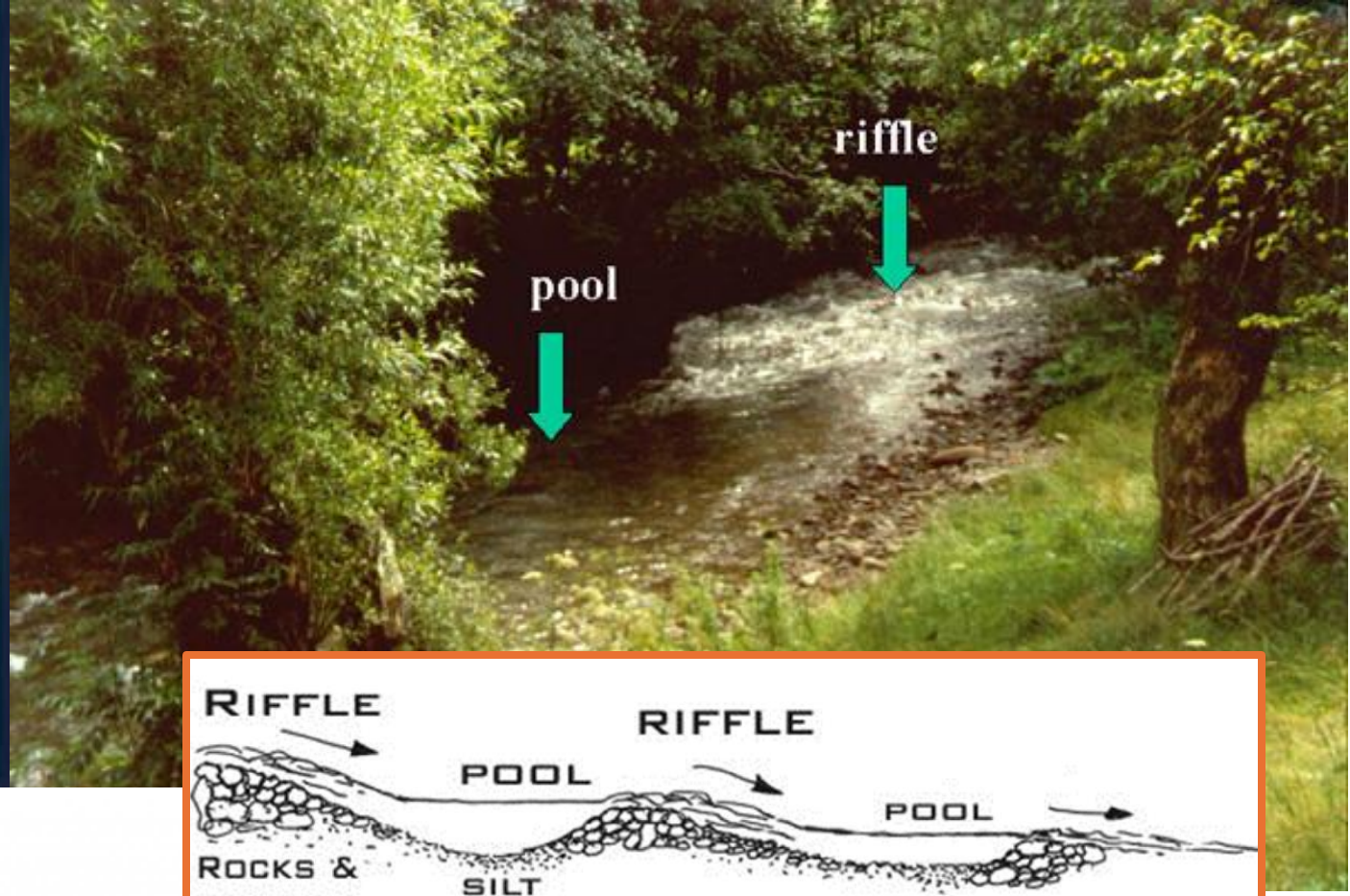

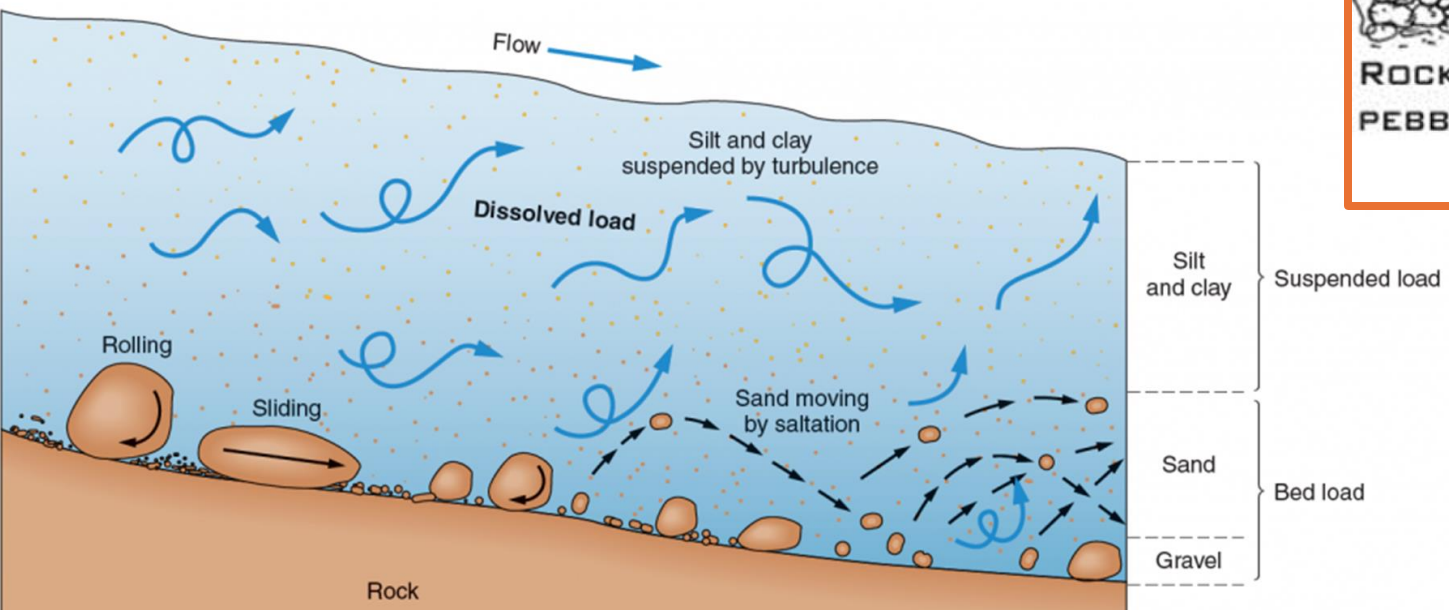

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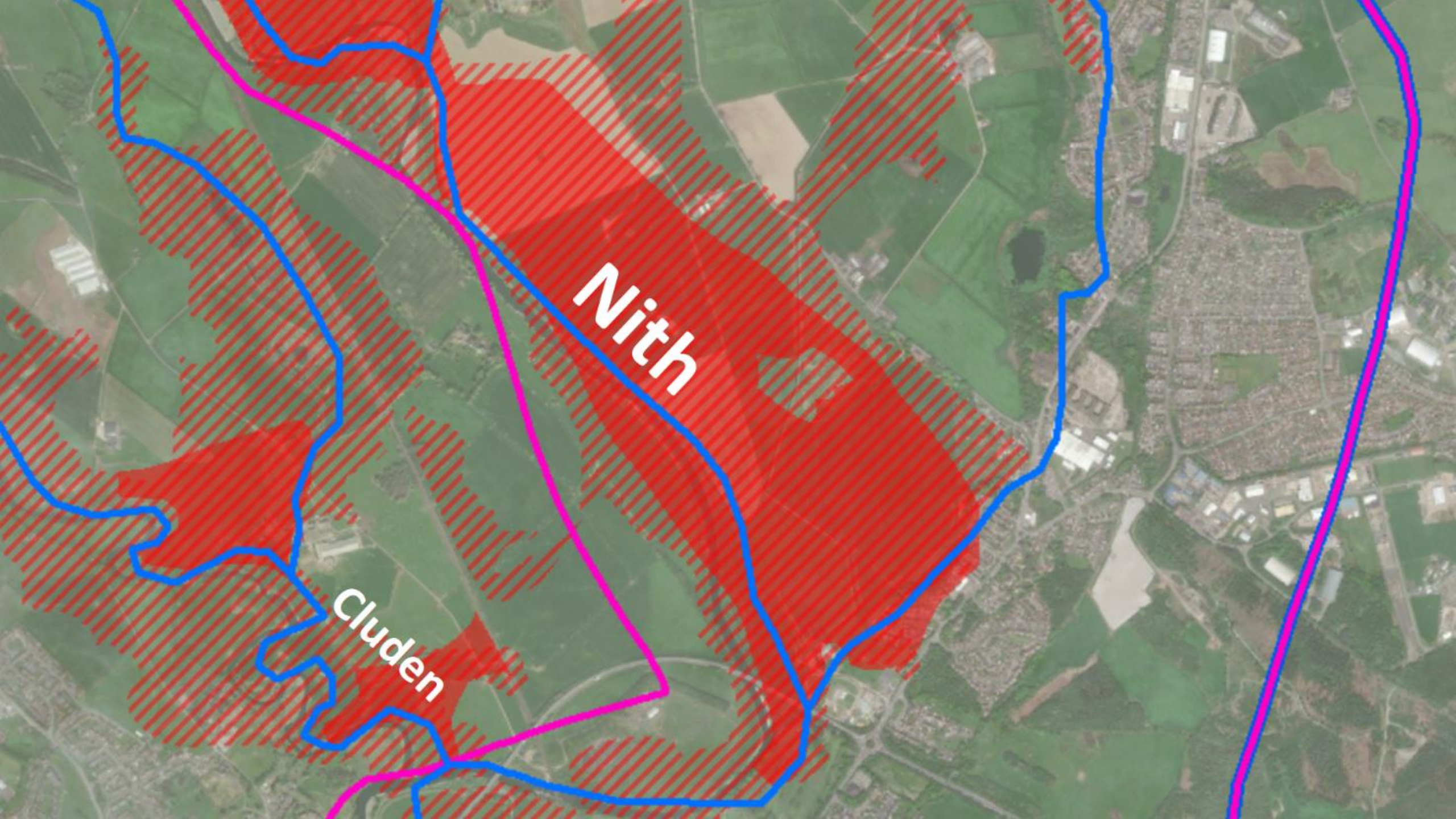
River Nith, Dumfries, Scotland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Wider evidence

Suspended particulate matter includes organic and inorganic constituents, such as clay minerals and humic substances, which bind with contaminants e.g. POPs, such as PCB and PAH, OCP and other potential toxic elements.

A recent study found that microplastics smaller than 2 mm in size was abundant under deep river sediments due to the redox potential of the humic substances (Tian et al., 2022).

Other studies have supported the theory that microplastic abundance in deep sediment is related to bacterial communities using plastic as electron donors in anoxic environments and causing the breakdown into smaller pieces (Rogers et al., 2020).

While at a shallow depth, plastics degrade with time, exposure to sunlight (ultraviolet radiation), pH, temperature, physical weathering caused by friction, oxidative weathering, and biodegradation by microorganisms, however this may be a very long process (Huang et al., 2020, 2021; Li et al., 2019).

Wider evidence

Microplastics can also be transported from the sediments by flooding and bank erosion (Horton & Dixon, 2017; Tramoy et al., 2020).

The dynamic water current during flooding disrupts the vertical sediment layer, which contains the deposited microplastics and results in remobilization (Ockelford et al., 2020).

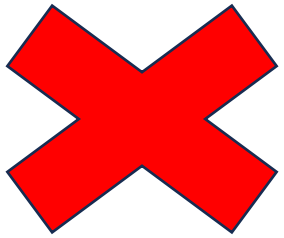
Depending on the situation, the remobilization-storage cycle can last for centuries. The distance travelled by the MP, the duration of their movement, and how long they will be stored will depend on the number of flooding incidents and their intensity (Tramoy et al., 2020).

Some contaminants, such as POPs can reside in the environment for a few months to decades because of their lipophilic nature and biotransformation rates, which is an environmental risk (Crawford et al., 2022).

Legacy pollution implications.

Sediment Sampling, analytical extract for analysis

Standardised testing



Recommendation 1: Evidence to address data gaps

Routine sediment sampling and analytical analysis should be considered, in rivers that tend to flood within agricultural areas, for example, to protect food security.

Moreover, in addition to sediment testing, flood extent mapping could be undertaken to identify the maximum predicted flooding range for a specific river (Figure 1), which would also enable testing of the soils and crops within that zone.

Through this testing, a pathway of sediment-soil-crop contamination could be understood, and this approach could also be extended to include livestock if desired so that appropriate mitigation measures could be applied.

Figure 1. River nith, Dumfries (in UK) flood extent from 1962 (red hatching) and 1997 (red block). Background Image: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community. Flood maps are based upon Ordnance Survey material with the permission of Ordnance Survey on behalf of the Controller of Her Majesty's Stationery Office © Crown Copyright. Any unauthorised reproduction infringes Crown copyright and may lead to prosecution or civil proceedings. SEPA Licence number 100,016,991 (2019). Some information was digitised from a copy of the County Architect plan.

Recommendation 2: Adoption of standard methodology protocols

If data are to be used for regulatory purposes, the authorities should provide clear guidance on the acceptable methodology (Brock et al., 2021).

In this study, a specific focus was given to sample extraction from organic and inorganic sediment.

Globally, many researchers have applied modifications to standardized method guidelines or have failed to present a clear and detailed account of their methodology. Both, of course, have serious limitations for the development of a transparent and robust evidence base.

It is recommended that authorities provide guidance and instruction to stakeholders who wish to provide scientific evidence for the consideration of data-driven decision-making. For example, this could include but is not limited to, standard method for sample collection and storage, standardized toxicity testing, water analysis, and other tools, such as SQG, transparency in reporting, FAIR data etc.

Recommendation 3: Threshold limits and other tools

Standard Quality Guidance (SQG) has been published by the USEPA, CCME, ANZECC and ARMCANZ but currently, they do not cover all potential contaminants, which is partly due to financial constraints.

Although, SQG has some limitations, they are a robust primary tool for the exploration of mapping spatial patterns and measuring temporal trends, in addition to their application as a secondary tool for environmental risk assessment and a tiered assessment scheme. Consequently, increasing the range of available Threshold Limits would be beneficial.

The development of other tools would also be advantageous for the exploration of sediments including, but not limited to, sediment quality modelling, especially for areas with multiple dischargers and affected sediments.

Sediment toxicity identification tools to confirm the cause of sediment toxicity and bioaccumulation studies to use as tools to address the bioavailability of contaminants (already *in-situ*) to benthic organisms. All these tools would complement recommendation one from this study.

Recommendation 4: Evidence platform

Stubbington et al. (2021) and Weitere et al. (2021) highlight that chemicals are not always ‘to blame’, and other factors might be responsible for the identified impacts.

Data are crucial to unravelling the truth, and the accessibility of robust data is important to understand these complex wicked problems.

Considering this, the authors encourage the development of toxicological databases (including sediment species) for standard toxicity endpoints, or water-only toxicity test databases coupled with equilibrium partitioning (EqP) to calculate probable sediment effect concentrations for benthic species. Ideally, these databases would involve a national, a regional, and a global framing to maximize their usefulness.

Recommendation 5: Capacity building

For the framing of this study, capacity building refers to investment, education, and knowledge exchange. The investment would include, but is not limited to, policy, tools, sampling programmes, further research, mitigation and remediation etc. but also the development and adaptation to safer chemicals alternatives etc.

Education to enable companies and citizens to minimize upstream and downstream waste and utilize safer alternatives etc. is required. But also ensuring future graduates are equipped with knowledge, skills, and training to develop the new tools and safer chemicals alternatives etc.

Concerning knowledge exchange, the authors also include collaboration under this purview. Multidisciplinary collaborations are often quoted as the way to tackle wicked problems, but research demonstrates that communication is often the weakest link in these relationships, which is often attributed to discipline-specific language (van Dijk et al., 2021). Perhaps, therefore, the breakdown of these word silos might also be an area to explore under the banner of education.

Many value chains are global and, therefore, it is not enough to tackle the wicked problems associated with them locally. There needs to be an ethos to practice, to create, to store, transfer, and to apply knowledge globally.

The EU Green Deal's ambition for a toxic-free environment: Filling the gap for science-based policymaking

Integrated Environmental Assessment and Management — Volume 17, Number 6—pp. 1105–1113

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Brief Communication

The EU Green Deal's ambition for a toxic-free environment: Filling the gap for science-based policymaking

Joanke van Dijk,[1,2] Annegaaike Leopold,[3,4] Hannah Flerlage,[2] Annemarie van Wezel,[2] Thomas-Benjamin Seiler,[5] Marie-Hélene Enrici,[6] and Michelle C. Bloor[7]

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Abstract

Around the world, many ambitious environmental conventions and regulations have been implemented over recent decades. Despite this, the environment is still deteriorating. An increase in the volume and dive main drivers of this deterioration, of which biodiversity loss is a telling indicator. In response to t a chemicals strategy for sustainability (CSS) was published in the EU. The CSS is the first address chemical pollution in a holistic manner. The CSS covers the complete lifecycle of a che better substances and remediation options, to remove chemicals from the environment. The st a "toxic-free environment," for which no clear definition exists, potentially hampering the impl paper, a definition for a "toxic-free environment" is proposed on the basis of a survey and SETAC Europe Annual Meeting. In addition, key issues that are absent from the CSS but are realization of a toxic-free environment are identified. To achieve the policy goals, it is recomme risk across the different chemical legislations, to establish a platform for open data and data utility and use of novel scientific findings in policymaking, through the development of a feedback mechanism and vice versa. The paper concludes that environmental scientists have challenges presented in the CSS. However, an extra step is needed by both policymakers and s processes and tools, to increase the robustness and transparency of deliberation processes, ar

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KEYWORDS: Environmental pollution, Green Deal, Regulatory risk assessments,

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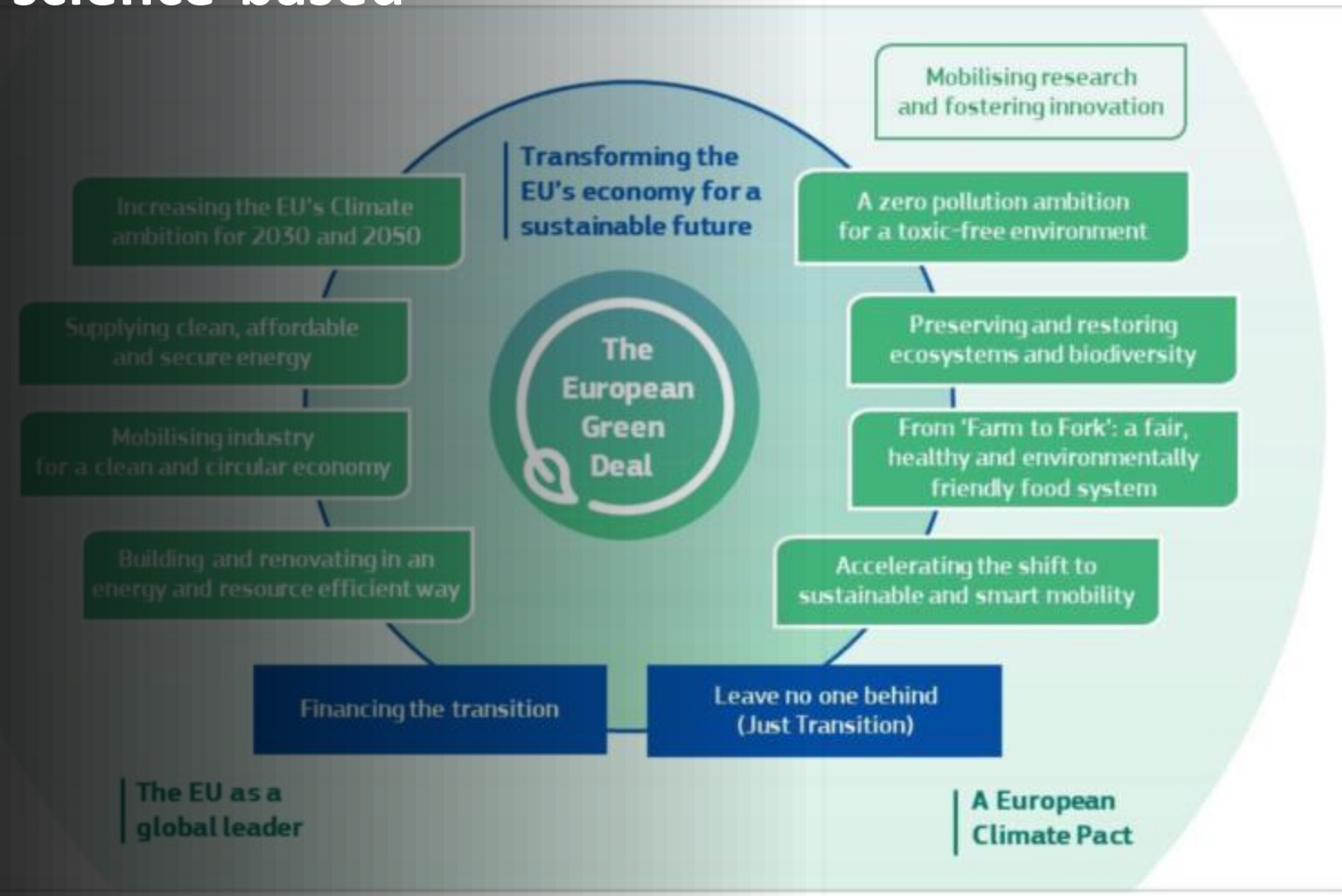

Green Swans countering chemical pollution

Integrated Environmental Assessment and Management — Volume 20, Number 3—pp. 888–893

888

Debates, Dilemmas, and Discoveries

Debates, Dilemmas, and Discoveries (3D) offers rapid publication on compelling and timely issues. Contributions should answer the "so what?" question and should encourage readers to think, challenge them to do better science, and motivate them to excel in the ways in which they apply science to environmental assessment and management.

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In a Nutshell. . .

COUNTERING CHEMICAL POLLUTION

Green Swans countering chemical pollution by Posthuma et al.

It is hoped that Green Swan solutions can offset the adverse impacts of chemical pollution by inverting identified risks to opportunities in a sustainable economy.

EXPOSOMICS AND EMERGING PUBLIC HEALTH ISSUES

Exposomics in Practice: Multidisciplinary Perspectives on Environmental Health and Risk Assessment by Wood et al.

Areas that can benefit from exposome research and refinement include One Health, factors linking exposure and effects, informing intervention and treatment regarding adverse health outcomes, and environmental regulation.

DOI: 10.1002/ieam.4936

Green Swans countering chemical pollution

Leo Posthuma,[1,2] Michelle Bloor,[1] Bruno Campos,[3] Ksenia Groh,[3] Annegaaike Leopold,[4] Hans Sanderson,[5] Hanna Schreiber,[6] Christoph Schür,[3,7] and Paul Thomas[8]

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DOI: 10.1002/ieam.4915

If a problem has exponential features, its solution asks for counter-exponential approaches. Chemical pollution appears to be such a problem. Analyses of chemical hazards to human health, biodiversity, and ecosystem services and estimates of the cost of inaction suggest the potential for adverse impacts, and analyses of trends in the chemical economy appear exponential in kind. Here, we argue that we need and can develop an exponential and application-focused mindset in thinking about solutions.

Today, the people of the Nations [UN]) of a triple plane effects of climate change, bi pollution (UN, 2022). The UN has its own causes and effect resolved if we are to have a Observations such as the >75 insects in European nature (pr 2017) make one think of both c

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Research gaps and recommendations to improve the Safe and Sustainable by Design framework

Integrated Environmental Assessment and Management, 2025, **21(4)**, 735–738
https://doi.org/10.1093/inteam/vjaf059
Advance access publication: May 21, 2025
Letter to the Editor

Research gaps and recommendations to improve the Safe and Sustainable by Design framework

Annegaaike Leopold[1], Michelle Bloor[2,*], Ksenia Groh[3], Leo Posthuma[4], Hans Sanderson[5], Hanna Schreiber[6], Christoph Schür[7], and Paul Thomas[8]

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Introduction

The "Safe and Sustainable by Design" (SSbD) vision, highlighted in the European Commission's (EC) Chemicals Strategy for Sustainability (CSS), part of the European Green Deal, is central to ensuring the long-term sustainability of the chemical sector and its products in Europe (Caldeira et al., 2022; EC, 2020). The framework marks a paradigm shift in the regulatory management of chemical manufacturing and use, in that it promotes a proactive assessment of both safety and sustainability throughout the innovation process, including its early stages. To enable effective implementation of the SSbD framework, the key concepts and approaches used to perform safety and sustainability assessments need to be aligned and improved further, both scientifically and practically. The multifaceted nature of SSbD calls for joint co-development and testing of novel approaches and methodologies, where a multipartite involvement is key: for example, what can be offered by science (academia and beyond)

the EC's SSbD guidance (Abbate et al.
framework originated in the European
of broader relevance for the global pr
ment and management.

Consultation process

The organization of stakeholder cons
wise approach. In the first step, an
ideas was compiled. These were sorte
ond step and used to inform the discus
where the main conceptual opportu
were identified and reflected on. Furt
tion process and the original expert
each step are compiled in three res
through SETAC resource links (se
material S1, S2, and S3; see also Leopol

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Priority setting for chemicals, waste and pollution: a risk-based strategy for environmental and human health protection

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https://doi.org/10.1093/etojnl/vgaf215
Advance access publication: August 22, 2025
Original Article

Hazard/Risk Assessment

Priority setting for chemicals, waste, and pollution prevention: a risk-based strategy for environmental and human health protection

Michelle C. Bloor[1,*], Stijn Baken[2], Adriana C. Bejarano[3], Tarryn L. Botha[3], Michelle Embry[4], Todd Gouin[5], Darren Koppel[6], Lorraine Maltby[7], Amanda Reichelt-Brushett[8], and Helena Silva de Assis[9]

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Abstract

Chemicals provide numerous benefits that support and improve the health and welfare of humans
range of applications. The environmental release of chemicals, however, can result in risks to
Minimizing and eliminating chemical pollution should thus represent an important goal for all
Recognizing the global concerns associated with chemical pollution, in 2022, the United Nations E
proved the adoption of resolution 5/8, declaring that a science-policy panel should be established to
management of chemicals and waste and to prevent pollution. Three years later, the Intergoverna
Chemicals, Waste and Pollution (ISPCWP) was established on June 20, 2025 at an Intergovernme
Uruguay. A globally harmonized approach and collective international effort can maximize the va
overcome regional disadvantages related to socioeconomic and geopolitical factors, and fast-track in
ing and legacy chemicals and waste issues. The mission of the ISPCWP will only be achieved wit
owner engagement, a robust scientific foundation, and the sound implementation of policies. A con
that supports a risk-based prioritization of issues and actions for environmental and human healt
the conceptual framework provides a tool that can be adopted to support science-based prioritizatio
parency with respect to the decision-making process of the ISPCWP's work program.

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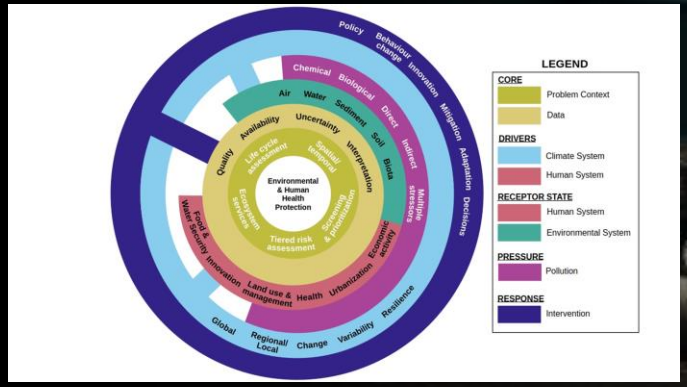

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