GESAMP WORKING GROUP 38

THE ATMOSPHERIC INPUT OF CHEMICALS TO THE OCEANS

Annual Report to SCOR by the Co-Chairs of GESAMP Working Group 38

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During the past year GESAMP WG 38 has focused its attention on the four areas outlined below. We also indicate our plans for WG 38 activities for 2024-20245 at the end of this report.

WG 38 Activities during 2023-2024

1) **Completed a GESAMP Reports and Studies document entitled "The Atmospheric Transport of Microplastics to and from the Ocean: Proceedings of a GESAMP International Workshop" as well as a "Summary for Policymakers" from the same workshop**.

Microplastics within the marine environment have become an issue of widespread public and scientific interest over the last decade. However, it is only very recently that the potential of the atmosphere as a vector of microplastics transport has been considered, leading GESAMP to develop this activity. This Reports and Studies (R&S) document building on a peer reviewed scientific paper published by the group in 2022[1] describes the outcome of a joint workshop between GESAMP Working Groups 38 and 40 to consider the relative importance, to the marine environment, of the atmospheric transport of microplastics.

The Workshop had two main objectives:

- To identify our current understanding, and provide a quantitative estimation, of the major sources and types of atmospheric microplastics, their atmospheric transport paths, and their inputs to and emissions from the global ocean; and,

- To develop guidelines on appropriate future sampling and measurement and modelling methods and strategies for atmospheric microplastics.

The workshop concluded that atmospheric transport is likely to be an important transport route for microplastics to the ocean, for the recycling of microplastics within the ocean, and for the return transport to land. Microplastics are very long-lived contaminants with few well identified mechanisms of complete degradation. It is likely that, during the environmental lifetime of plastics, they are subject to repeated cycles of emission to the atmosphere and re-deposition to the land or ocean. During these cycles the plastic particles may become smaller and change their environmental behavior, with consequent changes to exposure pathways and changes to the risk of potential negative impacts. but will not necessarily become less harmful. This means that addressing the issue of microplastic pollution in the ocean will require not only management of emissions, but also consideration of the legacy of plastic material already released into the environment.

Recommendations are made for further research priorities and for a strategy to monitor the atmospheric cycling of microplastics. The report considers the different approaches that can

[1] Allen et al 2022 Nature Reviews Earth & Environment 13, 393-405

be adopted for atmospheric sampling in the marine atmosphere including island station sampling, ship of opportunity and research ship sampling, and some newer sampling approaches such as buoys and aircraft. The report uses this information to suggest appropriate ways to develop a scientifically robust and cost-effective monitoring strategy for the atmospheric transport of microplastics to the ocean, building on the existing WMO/GAW network.

The following conclusions were developed and also included in a separate Summary for Policymakers:

1. The evidence to date suggests that atmospheric transport may indeed be an important route by which microplastics reach the ocean, alongside emissions from other sources such as rivers and sewage discharges, although the current data available to substantiate this case are limited.
2. The ocean may be an important source of microplastics to the atmosphere and land via resuspension of microplastics previously released into the ocean.
3. Atmospheric transport and recycling allow the effective and rapid transport of microplastics to even the most remote areas of the Earth, far from the primary sources of plastic emissions to the environment.
4. Emissions to the atmosphere, and resuspension of previously released plastic material from both land and the ocean, probably forms an important part of the global cycle of microplastic particles.
5. The original sources of such plastic material are widespread and disparate, including manufactured plastic material, precursors of such material, textiles, paints and plastic coatings and vehicle tire and brake wear.
6. In such a global environmental microplastics cycle, plastic material released into the environment can be both resuspended and also degraded into successively smaller particles over a microplastic item's environmental lifetime of many years.
7. The societal goal of reducing the environmental burden of microplastics will require not only control of primary emissions of such material into the environment, but also consideration of the existing legacy of plastic material previously released into the environment, over many decades.

The available data base with which to quantify and model the atmospheric transport of microplastics and its role within the entire environmental cycle of microplastics is very limited. This data base needs to be improved to allow effective environmental management strategies for this pollution problem to be developed. Given the evidence that this process is a quantitatively substantial component of the global cycle of microplastics, the workshop report also recommended:

(a) research to improve and standardize sampling and analytical methods for atmospheric microplastics;

(b) further research to improve an understanding of the processes involved in atmospheric transport of this material; and

(c) a systematic global long-term program of monitoring of atmospheric microplastics be developed over remote areas of the ocean. The report identifies what is believed to be a cost-effective approach to develop such a monitoring program by expanding the sampling program at existing well established sampling sites run by GAW and others.

2) Began development of a paper from a workshop in South Africa on the ocean management and policy implications of the air/sea exchange of nutrients in the southwest Indian Ocean.

The report from this workshop has been delayed but the causes of the delays have hopefully now been overcome and we hope to deliver both a scientific paper and a GESAMP Reports and Studies document in the coming months.

3) Organized a session on air/sea chemical exchange at the 2024 European Geosciences Union General Assembly in Vienna, Austria in April 2024.

For the eleventh year in a row WG 38 organized a session on the atmospheric input of chemicals to the ocean for the 2024 European Geosciences Union meeting, held in Vienna, Austria in April – "Air-Sea Exchanges: Impacts on Biogeochemistry and Climate". Oral and poster papers at this session were presented by a combination of WG 38 members and other scientists.

4) Developed plans for a new initiative entitled "Research priorities for improving global flux estimates of atmospheric deposition to the ocean".

This initiative is a joint effort between GESAMP Working Group 38, WMO's Global Atmospheric Watch (GAW), and Future Earth's Surface Ocean - Lower Atmosphere Study (SOLAS). Both mathematical/computer models of the transport and deposition of chemicals from the atmosphere to the ocean, and the techniques for the actual physical and chemical measurement of these fluxes have significant weaknesses and flaws. For example, we cannot accurately measure the dry deposition of atmospheric particles to the ocean surface. With few exceptions, we cannot measure the flux of trace gases between the atmosphere and the ocean with any great accuracy. Our mathematical models that attempt to calculate the relevant fluxes also have significant weaknesses – for example, the great difficulty in accurately modelling the exchange of particles of different composition in the high relative humidity gradient right near the air/sea interface. To date there has been no holistic effort to address the current weaknesses of, and how to improve, the measurement and modelling of the fluxes of different gaseous and particles between the atmosphere and the ocean. We expect that this effort should lead to some significant improvements to the estimation/measurement of these fluxes from the atmosphere to the ocean, thereby allowing better informed management of the marine environment. Representatives from GESAMP WG 38, GAW, and SOLAS recently met virtually at the University of East Anglia to develop plans for a workshop to address this issue. Following that initial planning meeting it was decided to hold the in-person workshop at the University of Crete in Heraklion, Greece in April 2025.

Plans for WG 38 for 2024-2025.

Working Group 38 has the following plans for the period 2024-2025:

- Final publication by WMO of the GESAMP Reports and Studies document "The Atmospheric Transport of Microplastics to and from the Ocean: Proceedings of a GESAMP International Workshop".

- Completion of the peer-reviewed paper presenting the results of the 2022 workshop in South Africa on the ocean management and policy implications of the air/sea exchange of nutrients in the southwest Indian Ocean and developing a report for GESAMP on that workshop.

- Carrying out the new workshop “Research priorities for improving global flux estimates of atmospheric deposition to the ocean” in Heraklion, Crete, Greece in April, 2025 and begin developing relevant papers and reports from that workshop.

- Development of a session on air/sea exchange of chemicals at the 2025 European Geosciences Union General Assembly in Vienna in April 2025.