EIM0027

Written evidence submitted by the Grantham Institute, Imperial College London

Executive Summary:

- While microbeads make a very small contribution to the amount of microplastics in the ocean, in our view a microbead ban would be an important and enabling first step to address plastic pollution.
- Stopping any plastic from getting into the ocean in the first place is the most effective and prudent way to deal with the ocean plastic pollution problem
- Since the impact of plastic pollution depends critically on its concentration and spatial distribution, much more understanding of the global inventory of ocean plastic is desperately needed.
- Further research on ocean plastic pollution could be addressed by a joint strategic research progamme funded by a combination of UK research councils.

Brief Introduction:

About Imperial College London and the Grantham Institute:
Consistently rated amongst the world's best universities, Imperial College London is a science-based institution with a reputation for excellence in teaching and research that attracts 13,000 students and 6,000 staff of the highest international quality.
Within the College, the Grantham Institute is committed to driving research in climate change and the environment, and translating it into real world impact. Established in February 2007 with a £12.7 million donation over ten years from the Grantham Foundation for the Protection of the Environment, the Institute's researchers are developing both the fundamental scientific understanding of climate and environmental change, and the mitigation and adaptation responses to it. The research, policy and outreach work that the Institute carries out is based on, and backed up by, the world leading research by academic staff at Imperial.

About the author:
Dr Erik van Sebille is an oceanographer and lecturer within Imperial College's Grantham Institute and Department of Physics. He studies how ocean currents move heat, plankton and plastic around. He has published over 50 peer-reviewed articles, including in top-tier journals like *Science*, *Nature Communications* and the *Proceedings of the National Academies of Science*. He has won the 2016 Outstanding Young Scientist Award from European Geosciences Union's Ocean Science Division. He is a member of the UK Future Earth Committee, on behalf of the Royal Society.

Response to the ToRs:

ToR4: Other countries, including the USA, have taken action against microbeads in personal care products. What kind of impact would a similar ban in the UK have on the environmental situation around microplastics?

1) A microbead ban is about taking action to tackle ocean plastic pollution at source and, in our view, this is the right way to address the problem, making it a good choice of policy. It is clear that a range of policy actions need to be taken to reduce the plastic pollution problem, and a microbead ban would send a very important signal to producers and consumers of plastics, encouraging the use of alternative materials. Banning plastics for this use will also demonstrate that the government and other stakeholders in the UK are willing to use policy levers to tackle pollution at source.

2) Microbeads make up a very low proportion of plastics in use, and it is therefore expected they make a very small contribution to the amount of microplastics in the ocean, many of which are the result of the degradation of larger pieces of plastics. There is limited scientific literature available that assesses the relative role of primary microplastic to overall microplastics in the ocean. Therefore, a microbead ban would only have a relatively low impact on the much larger challenge of plastic pollution.

3) However, in our view a microbead ban would be an important and enabling first step to address plastic pollution, even though in isolation it would not have a high impact to the larger problem of ocean plastic pollution.

ToR5: To what extent do larger pieces of plastic in the ocean contribute to microplastic pollution, and how can this be dealt with?

4) Once large plastics enter the environment they begin to fragment, eventually becoming secondary microplastic or even nanoplastic particles. Researchers estimate that this happens on timescales of months to years. Solar UV radiation and the oxidising conditions in the marine environment are the main causes of this fragmentation [1,2].

5) This process of fast fragmentation is occuring in paralel to biotic degradation, so-called 'mineralisation', which converts the carbon atoms into CO_2 and inorganic chemicals [3,4]. The biotic degradation, however, occurs over much longer time scales (hundreds of years) in the ocean. Moderate temperatures on the ocean surfaces and the high salt concentration means that degradation in the ocean happens much slower than in the air or commercial composting facilities [5,6]. This is true for both 'normal' and biodegradable plastics.

6) Microorganisms, plants, algae and marine life, such as barnacles, colonise floating plastic debris, a process known as biofouling. Biofouling hinders photo-absorption, reducing the rate of degradation. As microorganisms gather, the density of the plastic increases and it sinks to the aphotic (dark) and cold sediment zones of oceans, where no or extremely slow fragmentation and degradation is expected.

7) While there may be chemical engineering solutions to stop large floating plastic pieces to fragment into small micropellets, stopping any plastic from getting into the ocean in the first place is a more effective and prudent way to deal with the ocean plastic pollution problem.

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2. Yakimets, I., Lai, D. W. & Guigon, M. (2004). Effect of photo-oxidation cracks on behaviour of thick polypropylene samples. Polymer Degradation and Stability, 86 (1): 59-67.
3. Gewert, M. M., Plassmann, B. & MacLeod, M. (2015) Pathways for degradation of plastic polymers floating in the marine environment. Environmental Science: Processes & Impacts, 17, 1513.
4. Cooper, D. A. & Corcoran, P. L. (2010) Effects of mechanical and chemical processes on the degradation of plastic beach debris on the island of Kauai, Hawaii. Marine Pollution Bulletin, 60(5), 650-654.
5. Andrady, A.L. & Pegram, J.E. (1990) Weathering of polyethylene (LDPE) and enhanced photodegradable polyethylene in the marine environment. Journal of Applied Polymer Science, 39, 363–370.
6. Pegram, J.E. & Andrady, A.L. (1989) Outdoor weathering of selected polymeric materials under marine exposure conditions. Polymer Degradation and Stability, 26, 333-345.

ToR6: How comprehensive and certain is our knowledge about the scale of microplastics and their effects on the natural environment? What should research priorities be, and who should fund this research?

8) The total amount of plastic floating on the ocean surface is between 7,000 and 236,000 metric tonnes [7,8,9]. The amount of plastic entering the ocean in the year 2010 alone, however, is 4.8 to 12.7 million tonnes [10], or roughly two orders of magnitude larger than the amount of plastic floating on the surface of the ocean. The large gap between the amount of plastic entering the ocean and the amount floating is because more than 99% of all ocean plastic is in reservoirs other than the surface (Figure 1): the water column and ocean floor, beaches, and within biota.

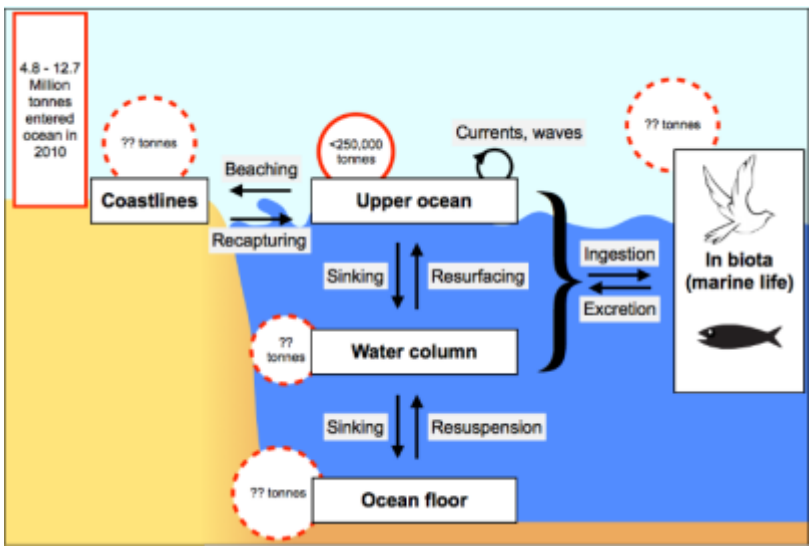

Figure 1: The five main reservoirs of plastic in the ocean (white boxes with bold print), and the fluxes between these boxes. The red rectangle in the top left is the mismanages plastic waste available to the ocean number from Jambeck et al [10] and the red circle on the Upper ocean box is the estimate of floating small plastic from a set of three recent studies [7-9]. More than 99% of the plastic that has gone into the ocean is not at the surface anymore, but in one of the other four reservoirs. [Figure by Erik van Sebille]

9) There is very little information on how all this plastic in the deep ocean, on coastlines and in biota is geographically distributed. Just like with the plastic on the surface of the ocean, there is likely a large heterogeneity of plastic densities on scales from meters to hundreds of kilometres, leading to hotspots of plastic. Since the impact of plastic pollution depends critically on its concentration and spatial distribution, much more understanding of the global inventory of ocean plastic is desperately needed.

10) Further research on ocean plastic pollution could be addressed by a joint strategic research progamme funded by a combination of UK research councils. Such a research programme could cover a range of scientific disciplines: physics, life sciences as well as engineering solutions and social science elements related to behaviour change and economic levers. There is also a role for the international research community, which could happen through programmes such as the Future Earth platform.

7. A. Cózar, F. Echevarría, J.I. González-Gordillo, X. Irigoien, B. Ubeda, S. Hernández-León, et al., Plastic debris in the open ocean, Proc Natl Acad Sci. 111 (2014) 10239–10244.
8. M. Eriksen, L.C.M. Lebreton, H.S. Carson, M. Thiel, C.J. Moore, J.C. Borerro, et al., Plastic Pollution in the World's Oceans: More than 5 Trillion Plastic Pieces Weighing over 250,000 Tons Afloat at Sea, PLOS One. 9 (2014).
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10. Jambeck, J.R., Geyer, R., Wilcox, C., Siegler, T.R., Perryman, M., Andrady, A.L. et al. (2015) Plastic waste inputs from land into the ocean, Science, 347.

ToR7: How effective is international cooperation around these issues, and what more can be done?

11) There are a range of international activites taking place in relation to plastic pollution. It is important that international activity takes place, as ocean currents move plastics through the oceans across jurisdictions, although it remains essential that local legislation and action is also taken.

12) The international research community convenes to produce a report on ocean plastics that spans the entirety of the sciene associated with plastic pollution – including production, transport of plactics in the ocean and environmental harm. This group is convened through the United Nations' Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection (UN GESAMP) Working Group 40 on 'Sources, fate and effects of micro-plastics in the marine environment', with support of UNEP, IMO, WMO and UNESCO. The new Future Earth research platform is also bringing together researchers to improve the scientific understanding of the plastic pollution challenge.

13) There is also some international activity in relation to cleaning up oceans, but much of the attention is currently focussed on the end point of the plastic pollution journey, while cleaning the oceans would be more effectively focussed on the sources of plastic pollution [11].

14) The NGO community is very well-developed on this topic, and there are both international and more local NGOs that focus on specific parts of the plastic pollution challenge, but also coordinate to some degree.

15) There is potential for further coordination amongst policy makers, and industry groups. The G7 has shown an interest in addressing this challening problem, which helps galvanise some high-level policy makers. In addition, some industry players, both in the plastics industry, but also in the recycling and waste management community, are beginning to come together to address this issue.

11. P. Sherman, E. van Sebille, Modeling marine surface microplastic transport to assess optimal removal locations, Environ Res Lett. 11 (2016) 014006.

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