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Physical processes behind interactions of microplastic particles with ice

Irina Chubarenko
Shirshov Institute of Oceanology, Atlantic Branch, Kaliningrad, Russian Federation (irina_chubarenko@mail.ru)

Microplastic particles (MPs) are found in marine ice in larger quantities than in seawater, indicating that the ice is an important link in the chain of spreading of this contaminant. Some studies indicate larger MPs abundance near the ice surface, while others did not find any consistent pattern in the vertical distribution of MPs within sea ice cores. We discuss physical mechanisms of incorporation of MPs in the ice and present the results of laboratory tests, underpinning our conclusions.

First, plastic hydrophobicity is shown to cause the effect of pushing the floating MPs further up of the newly-forming ice. This leads to a concentration of MPs at the ice surface in the laboratory, while in the field the particles at the surface may by covered by snow and become a part of the upper ice layer. Under open-air test conditions, the bubbles of foamed polystyrene (density 0.04 g/cm^3), initially floating at the water surface, were gone by weak wind when the firm ice was formed.

Second, the difference between freshwater and marine ice is considered. Since fresh water has its temperature of the density maximum (Tmd=3.98 C) well above the freezing point (Tfr=0 C), the freshwater ice is formed when the water column is stably stratified for a relatively long period of cooling from the Tmd down to the Tfr. Under such steady conditions, even just slightly positively/negatively buoyant MPs have enough time to rise to the surface / to settle to the bottom. In contrast, the ice in the ocean freezes when thermal convection is at work, further enhanced by the brine release. Thus, strong convection beneath the forming marine ice keeps slightly positively/negatively buoyant MPs in suspension and maintains the contact between the MPs and the forming ice. Laboratory tests show both the difference between the solid-and-transparent freshwater ice and the layered, filled with brine marine ice, and the difference in the level of their contamination.

Lastly, it is demonstrated that MPs tend to be incorporated in the ice together with air bubbles and in-between the ice plates (in brine channels). This is most probably due t plastics' hydrophobicity.

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