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Baseline

Anthropogenic microlitter in the Baltic Sea water column

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ABSTRACT

Microlitter (0.5–5 mm) concentrations in water column (depth range from 0 to 217.5 m) of the main Baltic Proper basins are reported. In total, 95 water samples collected in 6 research cruises in 2015–2016 in the Bornholm, Gdansk, and Gotland basins were analysed. Water from 10- and 30-litre Niskin bathometers was filtered through the 174 μm filters, and the filtrate was examined under optical microscope (40 ×). The bulk mean concentration was 0.40 ± 0.58 items per litre, with fibres making 77% of them. Other types of particles are the paint flakes (19%) and fragments (4%); no microbeads or pellets. The highest concentrations are found in the near-bottom samples from the coastal zone (2.2–2.7 items per litre max) and from near-surface waters (0.5 m) in the Bornholm basin (5 samples, 1.6–2.5 items per litre). Distribution of particles over depths, types, and geographical regions is presented.

Microparticles of anthropogenic litter (denoted here as MPs), the major part of which is made of plastics (UNEP, 2016; UNEP and GRID-Arendal, 2016), are an emerging pollutant in the present-day marine environment. The most investigated type - the floating plastics - in the open ocean makes up only less than 1% of the total plastics that has reached the oceans since mid 20th century, when it began to be produced (UNEP and GRID-Arendal, 2016). As for the sinking litter, much less observations are available. Since the overwhelming majority of the litter sources is located along the coasts, larger pieces of sinking litter should settle on underwater coastal slopes, while microparticles are transported much farther (Chubarenko and Stepanova, 2017). Woodall et al. (2014) have demonstrated that deep-water sediments are the final destination of anthropogenic microparticles. Moreover, the initially floating MPs get biofouled soon and sink as well (Chubarenko et al., 2016). As the result, analyses of bottom sediments reveal presence of particles initially made of various materials, both heavier and lighter than marine waters (e.g., Claessens et al., 2011; Van Cauwenberghe et al., 2015). However, neither mechanisms of transfer from the surface to the bottom are known, nor observations of their sinking behaviour are available, and reports on concentrations of anthropogenic microparticles in water column are still very few (e.g., Lassen et al., 2015; Norén et al., 2009).

Semi-enclosed basins, such as the Baltic Sea, are especially vulnerable, since they retain pollutants for a longer time, accumulating potentially hazardous substances in larger concentration. The Baltic Sea has a very limited exchange with the ocean via shallow and narrow Danish Straits, so the bulk water residence time is estimated to be about 25–30 years (Wulff et al., 1998; Döös et al., 2004). At the same time, the ages of water masses within the Baltic Sea differ significantly because of rather strong vertical stratification, varying between 10 and 40 years (Meier, 2007; Leppäranta and Myrberg, 2009). These time scales are much larger than the settling times estimated for different kinds of microplastics (e.g., Chubarenko et al., 2016; Khatmullina and Isachenko, 2017), implying that the entire “life cycle” of the Baltic MPs – from its source somewhere at the sea surface to the final destination in bottom sediments (Woodall et al., 2014; Chubarenko and Stepanova, 2017) takes place in the very sea water column. Thus, attending the distribution of anthropogenic MPs in the water column is very important for understanding of both current ecological situation and physical processes behind it.

In order to attend background levels of MPs pollution in the water body of the Baltic Sea, 95 water samples were collected during six cruises in 2015–2016. Sampled area spans across several regions of the Baltic Sea Proper: the Bornholm basin, the Gdansk basin, and the Eastern Gotland basin (Table 1, Fig. 1, and Table A1 in Supplementary materials). Water samples were collected from different horizons from 0 to 217.5 m, both in the coastal zone (cruises by r/v NORD: the sea depth 6–21 m) and in open-sea areas of the Bornholm, Gdansk and Gotland basins. About a half of the samples was taken from the near-bottom layers (deeper than 0.9 of the local sea depth; 50 samples, or 52%), with 34% (32 samples) from the near-surface layer (within upper 0.1 of the local sea depth), and 14% (13 samples) from intermediate depths (of the Eastern Gotland basin). Water samples were collected using Niskin bottles with volume of 10 or 30 L.

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Table 1
Cruises and number of collected samples, used for the analysis.

UID	r/v, cruise No	Dates	Area	Number of samples	Layers[a]
1	NORD, 1	30 October 2015	Coastal waters off Yantarny	8	Near-bottom
2	NORD, 2	3 November 2015	Coastal waters off Yantarny	4	Near-bottom
3	Professor Shtockman, 131	30 March–2 April 2016	Gdansk basin	26	Near-surface, water body, near-bottom
4	Professor Shtockman, 132	12–14 June 2016	Gdansk basin	24	Near-surface, near-bottom
5	Akademic Nikolay Strakhov, 32-1	1–19 August 2016	Bornholm and Gdansk basins	15	Near-surface, near-bottom
6	Akademic Nikolay Strakhov, 32-3	1–16 September 2016	Eastern Gotland basin	18	Near-surface, near-bottom

[a] "Near-bottom" and "Near-surface" indicate that the distance to the boundary is less than 0.15 of the local sea depth. For particular distances to the boundary and depths of samplings see Table A1 (in Supplementary materials).

In the cruises of r/v "NORD" (in Tables 1 and A1 denoted as NORD-1 and NORD-2), and r/v "Akademic Nikolay Strakhov" (ANS cruises in Tables 1 and A1) water samples were taken by individual lowering of the 10-litre Niskin sampling bottles. The sampling bottle was mounted on the cable with an anchor on its free end and then lowered vertically with the winch, distance between the anchor and the lower part of the bottle was measured (0.7–2 m). The depth of the instrument submersion was defined by the mechanical winch gauge. Water from the surface was collected with the black plastic (polyethylene) bucket. During the cruises of r/v "Professor Shtockman" (PSh-131 and PSh-132, see Tables 1 and A1) water samples were collected using Multi Water Sampler SlimLine 12 at different depths and filtered onboard. Depth of the instrument was recorded online from the pressure data received from the Multi Water Sampler. On some stations additional water samples were taken from the near-bottom layer by individual lowering of the 30-litre Niskin bottle.

Water samples were filtered through the 174 μm filters either onboard or in the land-based laboratory after transportation in the pre-washed 5-litre bottles. Each filter was folded twice, thoroughly packed into individual polyethylene bags with a string lock, and preserved at room temperature until further examination.

In order to minimize contamination, prior to sampling the filters and all other equipment were rinsed thoroughly with tap water. The colour of the ship deck, colours and material of the staff clothes, etc., were recorded in protocols, and later in laboratory the filters were examined regarding possible listed types of contamination. As the result, no contamination cases were detected for fibres and films; as for the paint flakes, however, about 50% of them were green, the same colour as the ship deck and shipboards.

In laboratory, all the filters were visually examined under a microscope with 40 × magnification. In comparison with bottom or beach sediment samples, processed in our laboratory (e.g., Esiukova, 2017;

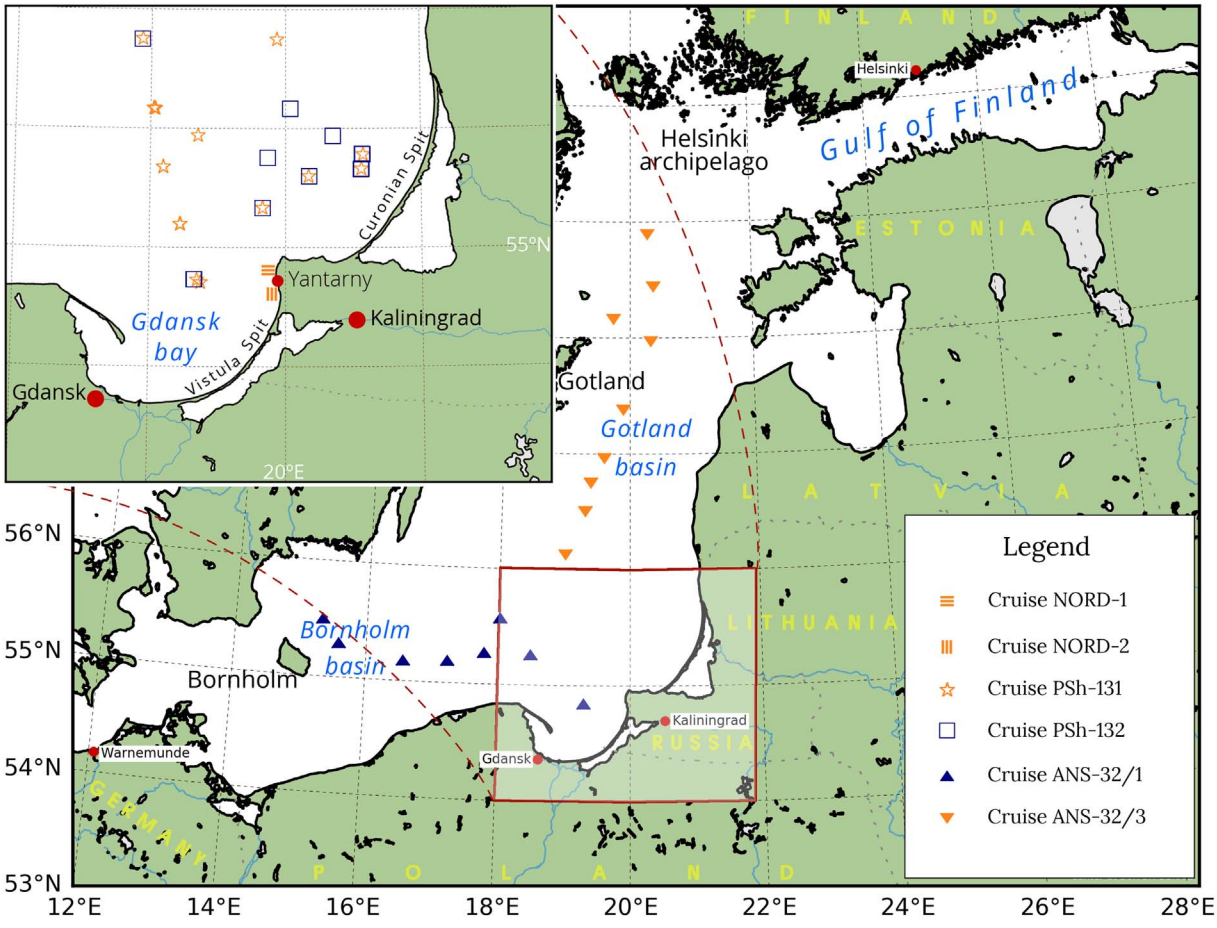

Fig. 1. Map of the Baltic Sea Proper with sampling locations. In insert: enlarged map for the south-eastern part of the Gotland basin. Cruises are indicated in the figure legend. See Supplementary materials for further details.