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Plastic pollution on the Baltic beaches of Kaliningrad region, Russia

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ABSTRACT

Contamination of sandy beaches of the Baltic Sea in Kaliningrad region is evaluated on the base of surveys carried out from June 2015 to January 2016. Quantity of macro/meso/microplastic objects in the upper 2 cm of the sandy sediments of the wrack zone at 13 sampling sites all along the Russian coast is reported. Occurrence of paraffin and amber pieces at the same sites is pointed out. Special attention is paid to microplastics (range 0.5–5 mm): its content ranges between 1.3 and 36.3 items per kg dry sediment. The prevailing found type is foamed plastic. No sound differences in contamination are discovered between beaches with high and low anthropogenic load. Mean level of contamination is of the same order of magnitude as has been reported by other authors for the Baltic Sea beaches.

Coastal and ocean waters have accumulated nowadays hundreds of thousands of tons of polymer litter of primary and secondary origin (Wright et al., 2013; Koelmans et al., 2014; Eriksen et al., 2014; Jambeck et al., 2015; Rilling, 2012; Browne et al., 2011; Wang et al., 2016). Plastic debris circulates in the environment and breaks into smaller pieces of various sizes. There is no universally agreed terminology concerning micro/meso/macro/mega plastic size (Arthur et al., 2009; Galgani et al., 2014; Kershaw, 2015; Hidalgo-Ruz et al., 2012; Thompson, 2015; Duis and Coors, 2016; Chubarenko et al., 2016). We use these terms to denote particles <5 mm (micro-), larger than 5 mm (meso-), larger than 25 cm (macro-), and 1 m (mega-), correspondingly.

The most dangerous kind of polymer pollution found in the ocean is thought to be microplastics (Arthur et al., 2009; Bergmann et al., 2015; Rocha-Santos and Duarte, 2015; Cole et al., 2011). It is considered so harmful due to its ability to effectively accumulate toxins on its surface, being at the same time very attractive to marine wildlife Having been mistaken for food, microplastics is ingested by fish, birds, etc., and the toxins find the way to human bodies (Sundt et al., 2014; Bergmann et al., 2015; Kershaw, 2015; Ivar do Sul and Costa, 2014; Morét-Ferguson et al., 2010; Cole et al., 2014). Moreover, the fragments of plastic are hazardous per se, causing harm or death to marine fauna and seabirds (Derraik, 2002; Farrell and Nelson, 2013; Bergmann et al., 2015). Microplastics in environment can be of primary or secondary origin: destruction of larger objects generates the so-called secondary microplastics, while primary microplastics are, e.g., lost industrial pellets or ingredients of personal healthcare and beauty products (Kershaw, 2015; UNEP, 2015; Napper et al., 2015). Like other plastic litter, marine microplastics can float on the surface, sink to the sea bed or accumulate on the beaches. Microplastics have been detected on the beaches worldwide (Claessens et al., 2013; Hidalgo-Ruz et al., 2012; Van Cauwenberghe et al., 2015; Corcoran et al., 2009; Endo et al., 2005; Derraik, 2002), but less data is available about the contamination of the Baltic Sea beaches (Stolte et al., 2015; Stolte, 2015).

During our surveys it was found out that plastic litter on the beach wrack line is often accompanied by paraffin pieces and amber crumbs. This is why further on paraffin and amber are regarded together with abundance of plastics. Paraffins float on the water surface, are capable of sticking to various objects and accumulate all kinds of debris on their surface. They can solidify (at around 20 °C) and form clumps (UEG, 2014). Due to their different composition, paraffins can vary between soft and hard, with their melting points from about 40 °C up to 70 °C, correspondingly (UEG, 2014; Lassen et al., 2014). For the Baltic Sea coasts and beaches, paraffins are pointed out as a quite typical contaminant (UEG, 2014). Baltic amber has its material density from 1.05 to 1.09 g cm^{-3}, which is close to densities of many plastics (Poinar, 1992; Chubarenko et al., 2016), so their transport, beaching, and accumulation are supposed to be similar (Chubarenko et al., 2016).

The aim of this study is to provide an initial assessment of the presence and distribution of various plastic objects on the beaches of the south-eastern part of the Baltic Sea (Kaliningrad region, Russia). Special attention will be given to the main types and quantitative composition of the microplastic particles.

The coasts in Kaliningrad region are 147 km long and comprise of sandy beaches (e.g., at the Curonian and the Vistula Spits) and high, unstable moraine coastal cliffs of the northern shore of the Sambian Peninsula (Łabuz, 2015; Harff et al., 2011), see Fig. 1. They are exposed to northerly and westerly winds, especially strong during fall/winter season

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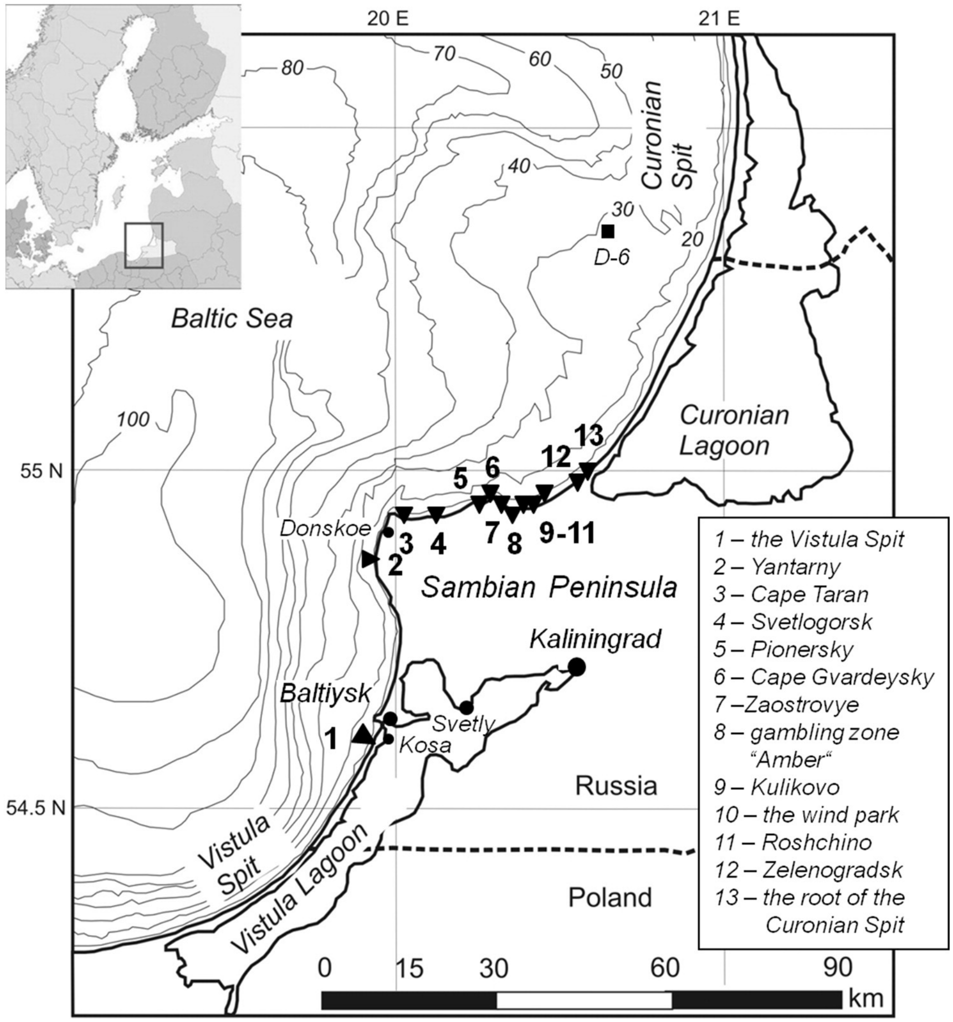

Fig. 1. Sampling locations along the shoreline of the Baltic Sea (Kaliningrad region, Russia).

(Harff et al., 2011; Bobykina and Stont, 2015; Gilbert, 2008; Babakov, 2010; Krek et al., 2016). The reported surveys, which took place from June 2015 to January 2016, covered the situations after several such storms. Anthropogenic contamination in the area under investigation comes mainly from recreation, fishing, and navigation (Cieślak et al., 2009; Gilbert, 2008; Lillebo et al., 2015). Among the sources of the observed plastic pollution there are outlets of the Curonian and the Vistula Lagoons, the harbor of Pionersky, shipping routes to Baltiysk, Pionersky, and Klaipeda (Lillebo et al., 2015), waste water outputs from coastal cities of Baltiysk, Yantarny, Svetlogorsk, and Zelenogradsk (Granit et al., 2011), as well as house-building and recreation activities along the entire coast.

Thirteen field surveys were undertaken from June 2015 to January 2016 aiming at collecting surface sediment on the wrack line of beaches along the shores of Kaliningrad region. The major part of the expeditions was carried out after storm events. Altogether, 60 sediment samples were collected from 13 beaches. The cumulative length of the shoreline where the samples were collected is about 20 km (Fig. 1). Preference was given to those beaches that are exposed to high anthropogenic load: areas around the town of Baltiysk, the northern part of the Vistula Spit (near the settlement of Kosa (location 1 at Fig. 1)), and recreation areas along the Sambian Peninsula (settlements of Yantarny (2), Kulikovo (9), towns of Svetlogorsk (4), Pionersky (5), Zelenogradsk (12)). For comparison, five less populated areas (hereinafter referred to as "untouched beaches") were sampled as well – the locations numbers (3), (6), (7), (11), and (13) at Fig. 1 – with the idea to monitor the areas where the pollution by only stranded litter is expected, whilst littering from land by tourism is minimum.

At the sampling place, the samples were collected from several points along the beach, visually selected by the highest accumulation of litter – those located at wrack lines after episodes of strong winds (Ruiz-Delgado et al., 2015; Hammann and Zimmer, 2014; Orr et al., 2005; Filipkowska et al., 2009). The action of sea weaves and winds is the main explanation for the greater density of macro-, meso-, and microplastics along wrack lines on the sandy beaches (Hammann and Zimmer, 2014; Suursaar et al., 2014; Filipkowska et al., 2009). Wrack lines on the sandy beaches of the non-tidal Baltic Sea look like linear piles of marine and coastal debris. Storm tide leaves the debris at the highest and most landward edge of the swash zone, far out of reach of ordinary waves. Typical debris contains algae, wood chips and branches, charcoal, feathers, shells, amber, paraffin, fish bones – and also diverse anthropogenic debris (mostly plastics, fishing gears, cigarette butts, etc.) (Fig. 5).

Beach samples were collected at the locations shown in Fig. 1. At each location, 2–7 positions were randomly selected along the wrack lines (sometimes formed by several previous storms). Top 2 cm of sand were collected from 0.15 m^2 area using a wooden sampling frame and a clean stainless steel spatula. Sediment samples were packed into new polyethylene packages with a string lock. Sampling locations, dates, surrounding conditions, and other details were recorded.

In the laboratory, samples were dried at room conditions. The dried sample was weighed with an accuracy of 0.1 g. Dry sediments were