Marine Pollution Bulletin 73 (2013) 161–169

Contents lists available at SciVerse ScienceDirect

Marine Pollution Bulletin

journal homepage: www.elsevier.com/locate/marpolbul

Assessment of marine debris on the Belgian Continental Shelf

Lisbeth Van Cauwenberghe[a,*], Michiel Claessens[a,1], Michiel B. Vandegehuchte[a], Jan Mees[b,c], Colin R. Janssen[a]

[a] Ghent University, Laboratory of Environmental Toxicology and Aquatic Ecology, Jozef Plateaustraat 22, 9000 Ghent, Belgium
[b] Flanders Marine Institute (VLIZ), Wandelaarkaai 7, 8400 Oostende, Belgium
[c] Biology Department, Marine Biology Research Group, Ghent University, Krijgslaan 281/S8, 9000 Ghent, Belgium

ARTICLE INFO

Keywords:
Marine debris
Southern North Sea
Abundance
Composition
Plastics
Microplastics

ABSTRACT

A comprehensive assessment of marine litter in three environmental compartments of Belgian coastal waters was performed. Abundance, weight and composition of marine debris, including microplastics, was assessed by performing beach, sea surface and seafloor monitoring campaigns during two consecutive years. Plastic items were the dominant type of macrodebris recorded: over 95% of debris present in the three sampled marine compartments were plastic. In general, concentrations of macrodebris were quite high. Especially the number of beached debris reached very high levels: on average 6429 ± 6767 items per 100 m were recorded. Microplastic concentrations were determined to assess overall abundance in the different marine compartments of the Belgian Continental Shelf. In terms of weight, macrodebris still dominates the pollution of beaches, but in the water column and in the seafloor microplastics appear to be of higher importance: here, microplastic weight is approximately 100 times and 400 times higher, respectively, than macrodebris weight.

1. Introduction

Our seas and oceans are subjected to different kinds of threats of which the accumulation of anthropogenic debris is a major and worldwide problem. Although the origin of these polluting materials is both land- and waterway-related, land-based sources are considered to be more significant since they account for over half of the world's marine debris (GESAMP, 1991; Sheavly, 2007). Despite widespread recognition of the problem, evidence suggests that debris pollution is still increasing (Barnes et al., 2009; Moore, 2008; Ryan et al., 2009).

As marine debris is quite variable in type so are its environmental and economic implications. It is aesthetically displeasing, making shorelines unattractive and forcing coastal communities to invest in beach maintenance. It can also be a nuisance to boaters and the shipping industry, and result in damage to vessels and equipment (McIlgorm et al., 2011). The deleterious effects most widely reported are those imposed on marine biota (Derraik, 2002; Laist, 1997). Marine organisms can be entangled in nets, fishing line, ropes and other debris, which can inflict cuts and wounds or cause suffocation or drowning. Ingestion of marine litter may cause obstructions in throats or digestive tracts. Finally, marine litter can also pose a threat to human health and safety, as beach visitors can be harmed by broken glass, medical waste and syringes (Sheavly and Register, 2007).

Decades ago, most of our waste was composed of organic, degradable materials. Now, our solid wastes often contain synthetic elements, plastics in particular. Plastics have a range of unique properties, making them popular for use in everyday life: they can be used at a very wide range of temperatures, provide an excellent oxygen/moisture barrier, are bio-inert, strong and though but lightweight at the same time, durable, and above all, they are cheap (Andrady, 2011; Andrady and Neal, 2009; Laist, 1987). However, some of these characteristics (durability, strength, light weight, etc.) are properties that make plastics a serious environmental contaminant (Pruter, 1987). Approximately 58 million tons of plastic are produced annually in Europe; globally annual production increases to 280 million tons per year (PlasticsEurope, 2012). Despite the magnitude of this potential problem, little quantitative information is available on the quantity of plastics that eventually ends up in the marine environment, although it is estimated that up to 10% of all newly produced plastics will eventually find their way to our seas and oceans (Thompson, 2006). This would mean that presently approximately 28 million tons of plastics per year end up in the marine environment. Plastics account for the major part of marine litter and it has been estimated that plastics contribute from 60% to 80% of the total marine debris (Gregory and Ryan, 1997). Other types of debris found in considerable quantities in the marine environment are glass and

* Corresponding author. Tel.: +32 9 264 37 07; fax: +32 9 264 37 66.
E-mail address: lisbeth.vancauwenberghe@UGent.be (L. Van Cauwenberghe).
[1] Present address: DuPont Coordination Center, Antoon Spinoystraat 6, 2800 Mechelen, Belgium.

0025-326X/$ - see front matter © 2013 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.marpolbul.2013.05.026

metal objects (Galgani et al., 2000). The continuous input of large amounts of these materials has led to their gradual accumulation in the marine and coastal environment. The dominant types and sources of debris come from what we consume (i.e. domestic items) and use in transport (Sheavly and Register, 2007), and will eventually end up in the environment via inappropriate disposal or accidental spillage.

In the last decade, it has been discovered that the large, visible pieces of plastic debris degrade into smaller fragments with dimensions as little as a few μm, i.e. so-called microplastics. UV-B radiation in sunlight initiates the degradation process. While floating in seawater, the UV-B induced degradation process of plastic is, however, slowed down (Andrady, 2011). On the other hand, fragmentation of plastics increases by physical abrasion through wave action (Barnes et al., 2009). Another source of microplastics, apart from the degradation of larger plastic items, is the plastic manufactured to be of a microscopic size, and used as scrubbers in cosmetics and air blasting materials (Cole et al., 2011; Fendall and Sewell, 2009). Many authors have defined microplastics as particles smaller than 5 mm (e.g. Arthur et al., 2009) while others have set the upper size limit at 1 mm (e.g. Costa et al., 2010). While the value of 5 mm is more commonly used, 1 mm is a more intuitive value (i.e. 'micro' refers to the micrometer range) and hence the size limit used in this research.

Microplastics have already been reported in the water column and marine sediments at sites worldwide (Browne et al., 2011; Claessens et al., 2011; Martins and Sobral, 2011; Ng and Obbard, 2006; Reddy et al., 2006; Thompson et al., 2004). Laboratory experiments have shown that these particles can be ingested by polychaete worms, barnacles, amphipods and sea-cucumbers (Graham and Thompson, 2009; Thompson et al., 2004), and that even translocation to the circulatory system can occur (Browne et al., 2008). Additionally, there is the potential for plastics to adsorb, transport and release chemicals, but it remains to be shown whether toxic substances can pass from plastics to these organisms and eventually to the food chain (Teuten et al., 2009).

Despite many research and monitoring actions, the (quantitative) distribution of marine litter remains unclear. There are three main reasons for this: (i) there is a lack of standard methods and units used to quantify the debris, (ii) studies focus almost always on litter in one marine compartment only (e.g. beach litter or floating litter or benthic litter), and (iii) to date, only a few studies have examined concurrently the occurrence of both macro- and microplastics in these compartments (Browne et al., 2010). The objective of this study was to study simultaneously the presence of marine debris, as well as its degradation products (i.e. microplastics), in the different marine habitat compartments. This was accomplished through dedicated quantitative monitoring surveys of the seafloor, the sea surface and beaches of a single marine region, i.e. the Belgian Continental Shelf and its adjacent beaches. By doing this, we wanted to quantitatively assess the distribution of marine litter in the different environmental compartments and provide a baseline of marine debris data for future comparison.

2. Materials and methods

Here, a detailed description is given of the different techniques used to extract both macro- and microdebris from the three marine compartments studied. Table 1 summarises the different sieve, filter and mesh sizes used to isolate both macro- and microdebris.

Table 1
Table summarising the different sieve, filter and mesh sizes used to isolate both macro- and microdebris.

	Macro (mm)	Micro (μm)
Beached debris	Sieve 1	Sieve 35
Floating debris	Mesh 1	Filter 5
Seafloor debris	Mesh 10	Sieve 38

2.1. Macrodebris

2.1.1. Beached debris

Along the 67 km Belgian coastline, 4 beaches were selected based on features such as tourism pressure (high vs. low) and sedimentation regime (erosion vs. accretion) (Fig. 1 and Table 2).

Every beach was sampled in the summer of 2010 (August), and in the spring of 2011 (April). A transect of 100 m, parallel to the water line, was established extending from the low-water mark to the dune line. Along this transect, all non-natural anthropogenic debris was collected by recorders who walked along the width of the surveyed transect. The macrodebris was labelled and upon arrival in the lab, further processed. This involved the cleaning, weighing and identification of the collected debris according to a procedure prescribed by OSPAR (OSPAR, 2010) and UNEP (UNEP, 2009) classification lists.

2.1.2. Floating debris

Floating debris in Belgian coastal waters (up to 20 km offshore) was sampled in February and July 2011. A total of 24 samples were collected from 12 sampling stations, distributed over the coastal waters to uniformly cover an area of approximately $50 \times 24\ km^2$ (Fig. 1). Samples were collected using a neuston net with a 2×1 m opening and 1 mm mesh size. The net was towed over a distance of 1 km, with vessel speed restricted to 1–2 knots (0.5–1 m s^{-1}). Any debris present in the net was labelled and, upon arrival in the laboratory, classified according to the same classification system as for the beached debris.

2.1.3. Seafloor debris

A single campaign for sampling seafloor debris on the Belgian Continental Shelf (BCS) was conducted in September 2010 and performed according to UNEP guidelines (UNEP, 2009). Five sampling grids of 5×5 km were established, and per sampling grid a 800 m bottom trawl was conducted in three randomly selected sub-blocks of 1 km^2. For the sampling grids AM1 and AM2 only two sub-blocks were sampled, due to logistic problems (Fig. 1). In two of the three sampling blocks (AM1 and AM3), representing 5 trawls in total, towing was performed with an otter trawl (4 m width, 10 mm mesh size). All other trawls (8 in total) were performed using a beam trawl (10 mm mesh size, 3 m width).

Each trawl sample was manually sorted and all litter was then classified according to the UNEP classification list (UNEP, 2009).

2.2. Microplastics

To assess the presence of microplastic debris (<1 mm) on the beaches, 2 L sediment samples were collected from the upper 5 cm of the sediment at the low- and high-water mark. Microplastic extraction was performed using elutriation and sodium iodide (NaI) extraction (Claessens et al., 2013b). In summary: the sample was sieved through a 1 mm sieve into an elutriation column. The water flow and aeration of the elutriation column were adjusted to ensure an efficient separation of the lighter particles from the heavier sand particles. The effluent containing the lighter particles, including microplastics, was retained on a 35 μm mesh sieve. NaI (approximate density of 1.6 g cm^{-3}) was then added to the material collected on the sieve. After shaking thoroughly and subsequent centrifugation (5 min at 3500 g) the supernatant was collected. This NaI-extraction was repeated three times. The collected supernatant was finally filtered over a 5 μm membrane filter (Whatman AE98).