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USING THE COASTAL CLEAN INDEX TO ASSESS THE IMPACT OF ANTHROPOGENIC PRESSURE ON SANDY BEACHES IN USTKA, POLAND

Katarzyna Bigus*, Anna Jarosiewicz

Pomeranian University in Słupsk, Institute of Biology and Earth Science, Arciszewskiego 22a, 76-200 Słupsk, Poland; e-mails: katarzyna.bigus@apsl.edu.pl, anna.jarosiewicz@apsl.edu.pl

** corresponding author*

Abstract:
The article summarizes results of the studies of the Coastal Clean Index (CCI) on selected Polish beaches. In 2022, an attempt was made to estimate the amount of litter on the beach in Ustka. Debris on the beach was collected during a peak season in July and August. An attempt was also made to estimate the daily increase in garbage on the beach. The main part of the research was based on the quality and quantity of litter in beach sediments to the east and west of Ustka. Litter was divided according to a type of material, use, size and origin. The collected material was dominated by a plastic waste. The largest amount of marine litter was collected on the beach, on the eastern side of the Słupia River.

Key words: marine litter, plastics, sandy beaches, Coastal Clean Index, Baltic Sea.

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INTRODUCTION

Sandy beaches are important and widespread marine coastal ecosystems characterized by dynamic nature, structure of which is determined by wind, sand and water in a state of constant motion (Schoeman *et al*., 2000; Mudryk and Podgórska, 2006; Bigus *et al*., 2017). They are contact zones between the land and the sea. This natural landscape is one of the main assets for a seaside tourism. The negative impact of tourism on the environment keeps increasing, since a coastal tourism is becoming the main source of income for the inhabitants of the coastal towns and the main source of income, then protection of the landscape should be a priority for coastal communes. However, with the tourism development, a conflict between the needs for tourism development and environment protection increases (Kołodziejski, 1989; Łabuz, 2002). A growth of marine litter in this environment is among the main problems of the coastal areas (Anfuso *et al*., 2015; Bergmann *et al*., 2015; Jambeck *et al*., 2015; Arcangeli *et al*., 2017; Łabuz, 2021). A marine litter is a global problem, recognized as the major factor in the marine and coastal environment. An impact of plastic pollution on biodiversity is severe in particular marine systems, and it was identified as one of the top threats on biota (Gray, 1997; Thushari and Senevirathna, 2020). Plastic pollution exerts varied socio-economic impact in different aspects, such as commercial fishery, tourism, shipping and human health, and negatively acts on the national economies by allocating an extra budget for a waste removal (Thushari and Senevirathna, 2020). Marine litter is defined as any solid waste produced or processed that enters the marine environment from any source (Łabuz, 2021). Often referred to as a marine debris, it is defined as any persistent, manufactured or processed solid material made or used by humans, and either deliberately or accidentally discarded, disposed or abandoned in the marine and coastal environment (Łabuz, 2021). It includes items or fragments that have been directly discarded on the beaches (e.g., coastal and beach tourism, recreational activities) that have been somehow transported from a land to a sea (e.g., households, farming, illegal dumping, input by rivers, wind and land runoff) and those coming from ocean-based sources (e.g., storm water overflows, off-shore industries, commercial shipping, fisheries, port activities and boating) (Cesarano *et al*., 2023). However, the problem of marine litter is not limited to open water. Recently, the problem of litter pollution in the coastal zone, including coastal beaches, has been observed more and more often. Numerous reports highlight the increasing common sight of litter on beaches and in coastal water (Cheshire *et al*., 2009; Łabuz, 2021).

Currently, plastics are indispensable materials used in every sector of the everyday life. Plastic products have many advantages over former materials (glass, wood, leather, metals), they are versatile, lightweight, flexible,

Table 1. Summary of coast Cleanup Reports for the years 2015–2021 (http://cleanseascoalition.org/).

	Year						
	2021	2020	2019	2018	2017	2016	2015
People	318 928	221 589	943 195	1 080 358	789 138	504 583	791 336
Pounds	5 595 330	5 229 065	20 772 394	2 333 816	20 471 242	18 399 900	18 062 911
Kilograms	2 537 996	2 371 864	9 422 199	10 584 041	9 285 600	8 346,055	8 193 200
Miles	16 766	49 635	24 456	22 301	18 935	14 997	25 188 6
Kilometers	27 195	79 880	39 358	35 890	30 472	24 136	40 538 8
Total Items	9 760 227	8 066 072	32 485 488	97 457 984	20 824 689	13 840 398	13 806 887

moisture resistant, strong and relatively inexpensive. A popular use of plastic is due to its versatility, relatively low cost and durability, because of their high chemical stability and low degradability.

Marine debris is distributed worldwide and constitutes an increasing threat to the environment. An exponential increase of plastic debris raises numerous concerns and has led to intensification in plastic monitoring and research. However, global spatial and temporal patterns and knowledge gaps in debris distribution, both on land and at sea, are relatively poorly understood, mainly due to a lack of comprehensive datasets. An extraordinary global expansion of plastics is observed. In 1950, the worldwide production of plastic reached 2 million tons per year. The current global annual production of plastic represents ~40 kg for each of the 7 billion humans on the planet (Valavanidis, 2016). The global production in 2014 of polymer materials and plastics reached 311 million metric tons, an increase of 3.9% from 299 in 2013. The annual production increased nearly 200-fold, reaching 381 million tons in 2015 (Rakesh *et al.*, 2021). China is the largest producer of plastics in the world, with around 25% of the global production. In the last decades the European Union produced 25.2 million tons of post-consumer plastics waste. Today, an average person in developed countries consumes 100 kg of plastic each year, mostly as flexible packaging materials and household items. In the last decades, the massive globalization of a single use of the food plastic packaging and thrown away mentality, increased dramatically the volume of plastic waste in cities, beaches, transportion by sea and industries. Studies showed that 40% of plastic waste goes to landfills, 14% is recycled but 32% ends in the marine environment as a litter. It can be seen in their dramatic rise of waste in every corner of land and water (Valavanidis, 2016).

Marine debris can reach sea coast in two ways. They can originate from the sea, as an effect of a sea transport, and with wastewater and impact of the tourist activity (Gheskiere *et al.*, 2005; Santhiya *et al.*, 2011). It is estimated that the pollutants derived from the land as a consequence of direct human activity, constitute 90% of pollutants reaching this environment (Andrulewicz, 1994). Plastic debris with counts of five trillion, weighing more than 260,000 tones, is floating over the world's ocean surface as a result of improper waste disposal (Eriksen *et al.*, 2014).

Plastic pollution causes different socio-economic impacts (Thushari and Senevirathna, 2020). These environmental and social costs are difficult to quantify. The marine plastics pollution problem cannot be solved just by cleaning up the ocean. Most marine plastics are not discarded directly into the sea but derive from land-based sources. They end up in the sea due to a multitude of reasons, such as inadequate filtering of wastewater, improper or illegal disposal, and unexpected natural disasters. A lack of effective waste management and mitigation strategies, particularly in low- and lower-middle-incom countries, has resulted in accumulation of large amounts of plastic debris in the environment.

Monitoring of aquatic environments suggests the overall level of plastic (typically accounting for 61–87% of debris) is increasing, with plastic production and consumption rates showing no sign to slow down. It is currently difficult to assess the impact of marine litter on beaches due to limited spatial availability of data and information, and also because of lack incomparability between data due to the differing methodologies used. Also, little is known on the accumulation and loading rates and correspondingly stranding fluxes and rates are difficult to assess (Velander and Mocogni, 1999).

The real amount of debris in the coastal environment is shown in annual reports presented by the International Coastal Cleanup (ICC). ICC is a movement guided by the Ocean Conservancy that joins volunteers around the world, to clean up aquatic and marine environments and to provide recommendation for the State Ocean Protection Council (Clean Seas Coalition, Clean Seas Coalition, https://oceanconservancy.org/trash-free-seas/international-coastal-cleanup/annual-data-release/). They show an amount of marine litter collected, a length of a shoreline cleaned, a number of volunteers and the costs incurred when collecting the marine litter (Table 1).

According to the reports, the amount of marine litter on the coast has been steadily increasing, reaching 97,457,984 pieces in 2018. This amount of plastic waste was collected on 35,890 km of the coastline in 25 different countries around the world. The covid-19 pandemic has limited the annual cleaning of the coast. However, even in 2021, despite three times fewer volunteers, 27,195 km of the world's coast were cleaned and over 8 million pieces of waste were collected (https://oceanconservancy.org/trash-free-seas/international-coastal-cleanup/annual-data-release/).

A Clean-Coast Index (CCI) was developed and suggested as a new tool to determine coast cleanliness (Gallaghet *et al*., 2015; Lusher *et al.*, 2015). Globally many researchers apply CCI for assessing the cleanliness of coastal regions (Ribic *et al*., 1992; Anon, 2008; Cole *et al*., 2011; Eriksen, *et al*., 2014; Eerkesmedrano *et al.*, 2015; Galgani *et al*.,

Fig. 1. Examples of garbage found on the beach in Ustka (authors' photographs).

2015; Zhang *et al*., 2017; Bhuyan *et al*., 2021; Liu *et al*., 2022). In the past, studies focused on distribution of heavy metals, organic matter and pollution status of coastal sediments of the Polish beaches (Mudryk and Podgórska, 2006; Bigus *et al*., 2016, 2017; Perliński *et al*., 2023).

The Polish beaches have also a littering problem (Fig. 1).

The photos show various types of marine litter found on the beach in Ustka during fieldworks. This is due to a large influx of tourists, especially in summer, as well as the habit of littering and illegal dumping of waste into rivers and seas. Bad littering habits are observed in many other countries too (Alkalay *et al*., 2007; Ondara and Dhiauddin, 2020).

The aim of this study is:
– to identify types of marine litter on beaches and their source;
– to compare the CCI index on selected sections of the beach in Ustka;
– to discuss the methodological problems of research.

MATERIAL AND METHODS

Study area

The study was carried out on a non-tidal sandy marine beach in Ustka (54°35′N, 16°51′E), southern Baltic Sea. It represents a dissipative beach type with longshore bars and troughs. According to the classification of McLachlan and Brown (2006), it is classified as exposed and with an approximate slope of 7–9° while the width of the beach is about 45–85 m (Trojanowski *et al*., 2014; Bigus *et al*., 2016). This means that it is a subject to strong waves, is usually flat and eroded. The studied beach, particularly in autumn and winter, is exposed to strong winds that generate high waves, which cause strong erosion onshore. As a result, the seashore along the studied beach is heavily destroyed and the coastline retreats 0.10 m each year on average (Zawadzka-Kahlau, 1999). In general, quartz sand of exposed beaches is fine and medium-grained (~90% of the grain size is 0.125–0.250 mm).

Ustka is the largest seaside resort on the Słowińskie Coast between Kołobrzeg and Sopot. It is located at the mouth of the Słupia River and has served as a port for Słupsk since the 14th century. Since the end of the 19th century, Ustka has evolved to a popular touristic destination and nowadays it is a health resort (Orłowska, 2001). Because of its good climate and sandy beach, it is frequently visited by tourists throughout the year. The Ustka beach with its surf zone is among the most picturesque, very popular bathing beaches and recreational areas in Poland. Polish and foreign tourists as well as local inhabitants intensively visit (to 500 thousand annually) this beach, and it is usually very crowded during the summer months (Perliński *et al*., 2023). Many hotels and spas raised along the beach of Ustka, which is divided into a western and eastern part. The eastern part of the beach, close to the city centre, is the most popular beach of Ustka (Trojanowski and Bigus, 2013; Bigus *et al*., 2016).

Sampling procedure

Beach litter was collected in summer 2022 during warm and sunny days, twice in July (12 and 21) and once in August (18). Waste was collected in the early morning (around 7 a.m.). During the day, it could not be possible due to the large number of tourists and beach screens, making a research transect impossible. In August, the daily garbage growth was checked on the western beach. For this purpose, on the transect designated in the morning, a garbage was also collected late in the evening (around 8 p.m.). Research was not possible on the eastern beach due to a large number of tourists at the pre-determined transect.

The creator of the Coastal Clean Index is Alkalay, who applied it for the first time for Israeli beaches (Alkalay *et al*., 2007). During the research, the methodology used by him and the method of calculating the cleanliness of the beaches were used. CCI is measured in transects. Beach litter was collected on the beach on the eastern and western sides of the mouth of the Słupia River. The beaches differ in a number of tourist visitors. The eastern beach, thanks to the availability of rich catering facilities and numerous hotels, was more often visited by tourists and holiday makers. A transect was marked on each beach (Fig. 2). Transects are performed from the coastline at the measuring moment, to the border of the coast, represented by any obstacle – sand dune, cliff, vegetation, road or fence (Alkalay *et al*., 2007). In accordance with this procedure, 10 m lenght transects were marked out. The wide of the beach was measured each time in order to determine the surface area of the examined transect. The beach on the western side of the mouth of the Słupia River was more than twice as wide as the beach on the eastern side. On July 12, the beach on the eastern side of Słupia had an average width of 31.9 m, and on the western side 82.5 m. On July 21, the beaches were 30.3 m and 82.4 m wide, respectively and on August 18 – 32.2 m and 80.5 m. All visible beach debris was collected.

All types of garbage were collected: plastics material , glass, metals, wood, textiles and others. All visible waste was included in the study. An abundance of beach macro-litter greater than 2.5 cm (macro-litter) in the longest dimension of each type of debris was collected. However, smaller particles of meso-litter (0.5–2.5 cm), e.g. cigarette butts and plastic fragments, are also partially included. After the debris was classified, the contents of each transect were stored in separate garbage bags. The remains were then returned to the laboratory, air-dried, and individually identified. The litter was then brushed to remove any soil or sand that might have caused inaccuracies during the weighing process (Alkalay *et al*., 2007). Only plastic marine litter was included in the Coastal Clean Index analysis. The term ‘plastic’ refers to any artificial waste of plastic material, made or partly made. Mixed materials are also included, e.g. conduits made of rubber and metal. The calculation of the CCI is presented in the following equation

$$Plastic\ parts/m^2 = \frac{Total\ plastic\ parts\ counted\ in\ Z\ lines}{Z \times 2\ [\mathrm{m}] \times beach\ width\ [\mathrm{m}]}$$

In order to make the picture clearer for the public, the

Fig. 2. Location of research site (authors' photographs).

results were graded. For statistical reasons, as well as for convenience, the coefficient K (20 involved in the equation), was inserted into the equation. The beach classification of the applied methodology is shown in Table 2.

Additionally, to quantified beach litter abundance, the density (D) of items will be calculated as the number of items m2 (D = N/A), where N = total number of items per transect, and A = area (length of transect [m] × 10 [m]) (Alkalay *et al*., 2007).

RESULTS

Throughout this research, the beach litter items varied widely in composition. Totally, 656 pieces of beach macrolitter were found in all surveyed beaches (Table 3).

A composition of the beach litter during sampling periods shows that polymers/plastics (459 items, 70.2%) constitute the highest number of particles at all beaches. Next, paper (75 items, 9.7%) and others (64 pieces, 5.2%) stand

Table 2. Classification of beaches based on CCI (Alkalay *et al*. 2007).

Density (items/m^2)	CCI results	Beach classification	Description of the beach
0–0.1 parts/m^2	0–2	very clean	no litter is seen
0.1–0.25 parts/m^2	2–5	clean	no litter is seen over a large area
0.25–0.5 parts/m^2	5–10	moderate	a few pieces of litter can be detected
0.5–1 parts/m^2	10–20	dirty	a lot of waste on the shore
more than 1 part/m^2	20 +	extremely dirty	most of the shore is covered with plastic debris

Table 3. Sum of particular litter types (own data).

Types of garbage	July 12	July 12	July 21	July 21	August 18	August 18	August 18
	east beach	west beach	east beach	west beach	east beach	west beach in the morning	west beach in the evening
plastic materials	50	39	73	50	120	70	56
glass	0	2	3	4	5	1	0
wood	0	0	1	1	0	0	0
metal	3	3	10	2	22	0	2
other	1	39	6	4	7	4	3
paper	13	10	10	3	9	11	19
sum of litter	**67**	**93**	**103**	**64**	**163**	**86**	**80**

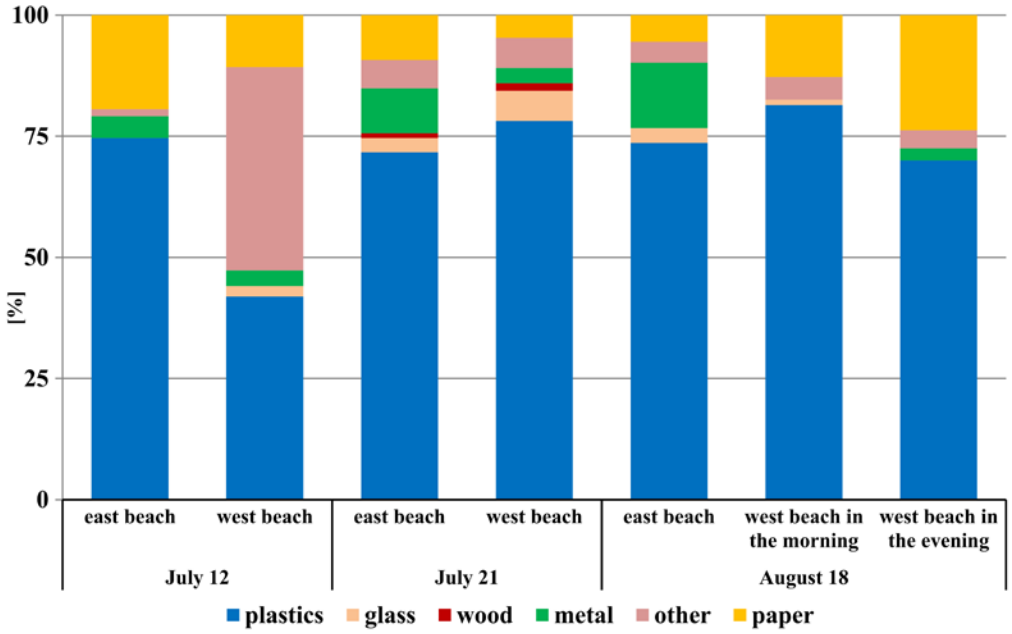

Fig. 3. Percentage share of particular types of marine litter on the beach in Ustka (own data).

in second and third positions. Receipts, bar and restaurant leaflets and business cards dominated among the paper litter on the beach. Whereas, the least amount of macro litter is glass (15 pieces, 2.2%) and metal (2 items, 0.4%) (Fig. 3). A plastic litter was a very diverse group on both beaches. It consisted both food packaging, lollipop sticks, rubber, polystyrene foam, strings, plastic bags and cigarette butts. The cigarette butts dominated among the plastic waste and they were a big problem regardless of the type of beach and timing of the marine litter collection. Food waste was also a large group. They constitute a large group of waste. This includes food packaging (candy wrappers and crisps, lollipop sticks and takeaway food related products). In addition, based on the results obtained, it was observed that the amount of waste on the eastern beach increases with each collection of waste. On July 12, a similar amount of plastic waste is observed on both beaches (50 on the eastern beach and 39 on the western beach). In August, the eastern beach, which is the main tourist attraction of Ustka, is twice as polluted. 120 pieces of plastic waste were found on the eastern beach in the morning and 70 on the western beach. The density (items/m^2) of macrolitter on all beaches is strongly associated with the composition and distribution of beach litter. Density range from 0.05 items/m^2 to 0.16 items/m^2 in 12 July 2022 was found. Meanwhile, on July 21, 2022, the abundance was 0.06 to 0.24 items/m^2. In August, the density starts from 0.07 to 0.38 items/m^2.

The results of the CCI calculations showed that the western beach was always very clean. CCI values increase during peak season on the eastern beach. Initially, the beach in July is clean, while in August it is classified as moderate. An attempt was also made to estimate the daily increase in marine litter on the beach. Early in the morning, 86 marine litter was collected in the transect on the western beach, 81.4% (70 pieces) of which were plastics. Late in the evening, 80 pieces of marine litter were found in the same tract, with 70% (56 pieces) of plastics. A similar attempt was made on the eastern beach. In the morning, 163 pieces of marine litter were collected in the studied transect. Unfortunately, it was not possible to repeat the measurements later, due to taking into account a number of tourists and beach screens on the basis of the transect. By 8 p.m., the beach was full of holiday makers and garbage collection later in the day was impossible due to limited brightness after a dusk.

Determining the transect on the beach and estimating the CCI index is difficult on the Polish beaches in the summer season. The beach in Ustka (especially the eastern one) has been systematically subjected to tourist development since June. There are bars, sportfields and music stages. Determining a permanent transect is therefore difficult, because tourist development appears in its place. Another problem is the ubiquitous beach screens. They make selection of the transect and collection of the marine litter difficult, especially at the peak of the tourist season. Earlier studies of the CCI on the Polish coast were carried out in early spring and autumn, that is beyound the tourist season. These are methodological problems, not only on the beach in Ustka, but also other Polish beaches.

DISCUSSION

The human activity generates vast quantities of waste material. Plastic waste dominates among them. Fragments of plastic debris represent a substantial contamination problem (Carpenter *et al*., 1972; Gregory, 1978; Corcoran *et al*., 2009; Ivar do Sul *et al*., 2009; Browne *et al*., 2010; Wright *et al*., 2013; Tencati *et al*., 2016; Diggle and Walker, 2022). Sandy sea beaches are extremely important elements for the contemporary man from the business and economic points of view. They are also an important tourist element of the landscape. They are selected as leisure destinations by most people around the world. So, they should be characterized by clean coastal water and beach sediments (Bigus *et al*., 2016, 2017; Astel *et al*., 2020). For many years, research on beach sediments focused on their physico-chemical parameters. Recently, attention has also been drawn to the growing problem of waste in the marine environment (Anfuso *et al*., 2015; Bergmann *et al*., 2015; Jambeck *et al*., 2015; Arcangeli *et al*., 2017; Łabuz, 2021). Marine litter has become a global problem and is recognized as an important factor affecting the aesthetics of sandy beaches. Marine debris, including beach litter, had become attractive to scientists due to its persistence in the environment. It is becoming a global issue after giving the impact on marine organisms, ecological processes, marine economic and human health (Trojanowski *et al*., 2014; Bigus *et al*., 2016; Anfuso *et al*., 2015; Bergmann *et al*., 2015; Jambeck *et al*., 2015). For this reason, many attempts have been made to estimate the cleanliness of the beaches. Already in the 1990s, attempts were made to systematize the methods of collecting marine litter and its classification (Ryan and Moloney, 1993; Velander and Mocogni, 1999; Corcoran *et al*., 2009). The main two methodological problems concern: a size of the study area and a size of the marine litter. The choice of different methods does not allow for unambiguous determination of the amount of marine litter on the beach and does not give comparable results. The solution to this problem may be the Coastal Clean Index. CCI is used by scientists from Israel, Brazil, Malaysia and the Mediterranean coast to assess the cleanliness of beaches. The beaches are a tourist attraction all year round, and these countries face a big problem of their littering. In the collected material, marine litter constitutes a diverse group. Most often, plastic waste has the largest share. On the analyzed 39 beaches in Israel they account for 90.4%, 85% at 24 sites in Brazil and 98% on the Zaglav beach in Croatia. Only on the surveyed beaches in Malaysia in 2017, plastic waste did not dominate and accounted for 48%. Plastic marine litter is a diverse group. The largest group of them are cigarette butts. Plastic bags, bottles, bottle caps, nylon cords and pieces of polystyrene are also common (Alkalay *et al*., 2007; Kaur *et al*., 2009; Fernandino *et al*., 2016).

The assessment of litter composition is among the great strengths of coastal monitoring. A detailed assessment can provide information on potential harm to the environment and potentially, on the litter source (Ansari and Farzadkia, 2022). This is particularly important, because only a thorough knowledge of the source of pollution can eliminate it. This problem also affects the Baltic beaches. The Baltic Sea is an intracontinental sea whose water exchange takes place through the Danish Straits. This fact makes it subject to strong anthropogenic pressure, including the problem of marine litter. Litter pollution on the Polish coast has been monitored since 2015. It is a requirement of the Marine Strategy Framework Directive (MSFD) aiming to achieve Good Environmental Status (GES) of the EU marine water by 2020 (available at: https://eur-lex.europa.eu/eli/dir/2008/56/oj). The key objective is a protection of marine resources ensuring the effective growth of marine related economy and social welfare (Bergmann *et al*., 2015). Every year, marine litter is collected and classified on 15 stretches of the coastline. The data obtained show that the amount of marine litter on the coast is constantly increasing. Only during the covid-19 pandemic, their number decreased. Much greater pollution was observed in summer and on the tourist beaches. Recent survey of marine litter on the beach, carried out for the Central Baltic Sea area (MARLIN, 2013; Bergmann *et al*., 2015), has shown that the amount of litter might range from 75.5 items/100 m on rural beaches to 236.6 items/100 m on urban beaches. This is confirmed by the statement that coastal tourism is the main source of marine litter on beaches during summer (https://rdsm.gios.gov.pl/index.php/pl/poprzednie-oceny) (Fig. 4). Plastic litter dominates the collected material. They account for 66% (2020) to 79% (2019) of all collected waste. Among the collected pollutants, apart from plastic waste, the presence of waste wood (13.75%), metal (7%), glass (4.2%) and paper (2.8%) was observed.

On Polish beaches, the CCI analysis was carried out in 2015. On 13 beaches (Świnoujście, Międzyzdroje, Świnoujście-Wolin National Park, Niechorze, Kołobrzeg, Mielno, Dąbki, Jarosławiec, Rowy, Lubiatowo, Kuźnica, Gdynia-Orłowo and Sopot) marine waste was collected in spring and autumn. Scientists from the National Marine Fisheries Research Institute obtained similar results (https://mir.gdynia.pl/dot16noplaze/). In spring, all beaches were classified as very clean. A deterioration of the indicator was observed in autumn, after the end of the tourist season. Among the plastic waste, cigarette butts and food pack-

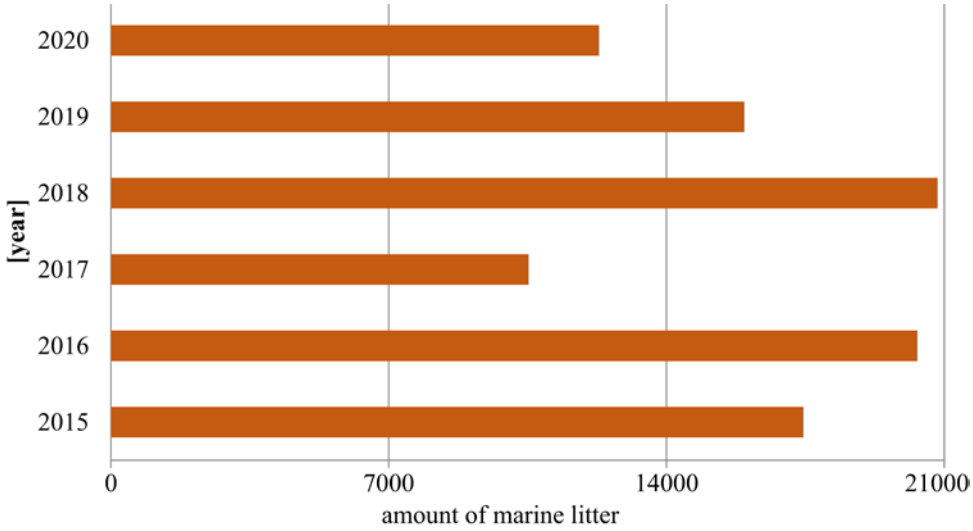

Fig. 4. Amount of marine litter on Polish beaches in 2015 – 2020 (based on https://rdsm.gios.gov.pl/index.php/pl/poprzednie-oceny).

aging dominated. Pollution by cigarette butts is easily attributed to tourism activities (smoking while visiting beach) (Bergmann *et al*., 2015). An increasing amount of marine litter is observed on the Polish coast. Unfortunately, the monitoring program and collecting garbge from the beach does not affect the awareness of the inhabitants and does not improve the aesthetics of the beaches by increasing their cleanliness. In Israel, the CCI was used to increase the public awareness regarding coast cleanliness and motivate the authorities to clean their beaches (Alkalay *et al*., 2007).

The collection of 80 different types of garbage in the transect cleaned up in the morning on the western beach in Ustka, as well as the fact that scientists from the National Marine Fisheries Research Institute collected more litter on the beaches after the summer season confirm the fact that tourism is the main source of beach pollution. The amount of waste left by vacationers on beaches has increased significantly since 2009, exceeding 85% of the identified waste on average. On the Baltic coast, 40 to 80% of litter originates from tourist behaviour and the other 20–40% from land sources (Balčiūnas and Blažauskas, 2014; Strand *et al*., 2016; Hasler *et al*., 2018; Łabuz, 2021; Zalewska *et al*., 2021). Similar behavior is observed on other coasts around the world. The littering habit is a serious problem on many beaches (Rosevelt *et al*., 2013; Laglbauer *et al*., 2014; Jambeck *et al*., 2015; Fernandino *et al*., 2016; Munari *et al*., 2016). Research on the amount of marine litter on the coast show poor local awareness and underline the need for educational programs that can help to reduce the coastal littering (Aydın *et al*., 2016). In addition, a beach litter is seen as a threat to beach tourism values and efforts are made to keep beaches clean. An example of such actions may be placing more litter bins and emptying them more often. The CCI is a simple tool to assess the cleanliness of beaches. However, it was not used to assess the cleanliness of Polish beaches. There are many methodological problems, on the Polish coast, where the peak of the season is associated with mass tourist traffic in summer. The main problem is to designate a research site. The emerging tourist buildings and the ubiquitous beach screens of tourists make it impossible to obtain accurate and repeatable results.

CONCLUSIONS

Over the past 50 years, plastics production has progressed exponentially. Their poor segregation, as well as a low degree of their recycling, result in an increasing pollution of marine ecosystems with waste. A large part of this waste ends up in the coastal zone and on sandy beaches, causing their pollution. Unfortunately, a big problem is the habit of littering the beaches by tourists. Marine beach litter represents a serious issue for marine life, coastal ecosystems, human health and several economical activities. The increasing common sight of littered beaches lowers their aesthetics and affects the tourism of coastal regions. Therefore, a number of initiatives have recently been launched to assess the degree of litter on the sea coasts. An example is the International Coastal Cleanup, where thousands of volunteers take part in cleaning the beaches every year. Recently, methods of assessing cleanliness of beaches have been undertaken. One of them is the Coastal Clean Index, an easy way to estimate a cleanliness of the beaches. Plastic litter on a beach is the largest group of pollutants. In the collected material, they accounted for about 70% of all garbage. Most of them were cigarette butts and food packaging. Glass was the smallest group in the collected waste. A larger amount of waste was collected on the beach on the eastern side of the Słupia River. This is due to a greater number of tourists on this beach. The Coastal Clean Indeks omits other groups of marine litter, which also reduce the aesthetics of sandy beaches. Literature data and our own observations indicate that plastic waste dominates on the Polish beaches, so the CCI index seems to be a good tool to estimate a cleanliness of beaches.

However, CCI analysis, especially in the middle of summer on an attractive tourist beach, poses many methodological difficulties. The first of them was the tourist infrastructure appearing on the beaches (music stage, beach playground and restaurant on the beach). This made it impossible to repeat the research along the same research transect. Another problem was a presence of a large number of vacationers on a beach on a sunny day. For this reason, the best time for garbage collection is at 7–8 a.m., when the beaches are even less crowded. It also stated that the daily beach litter increment should be done the next day, not in the evening. It was also specified that transects for CCI analysis should be located at each beach access in order to compare the results. For this reason, autumn and winter analyzes will be conducted in these places.

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