Vol-07 Issue 05, May-2023 ISSN: 2456-9348
Impact Factor: 6.736

iJETRM
International Journal of Engineering Technology Research & Management

ORIGIN OF MARINE LITTERS AT SANDY BEACHES: OUTDATED AQUACULTURE CAUSING THE POLLUTION

Thi Lim Duong[1]

Thi Lan Huong Nguyen[1]

Thi Hue Nguyen[1]

Tran Quan Dang[1]

Thi Huong Thuy Nguyen[1]

Thu Thuy Tran[1]

Minh Trang Trinh[1]

Thi Dung Pham[1]

Trung Kien Nguyen[2]

Ngoc Nhiem Dao[2,3]

Quang-Bac Nguyen[2,3,*]

[1] Institute of Geography, Vietnam Academy of Science and Technology, 18 Hoang Quoc Viet, Hanoi 100000, Vietnam.

[2] Institute of Materials Science, Vietnam Academy of Science and Technology, 18 Hoang Quoc Viet, Hanoi 100000, Vietnam.

[3] Graduate University of Science and Technology, Vietnam Academy of Science and Technology, 18 Hoang Quoc Viet, Hanoi 100000, Vietnam.

ABSTRACT

This study examined 16 sampling sites and detected a total of 16,122 marine litter items, which were identified and classified into 39 different types. Foam fragments ranging from 0.5 cm to 50 cm in size accounted for the majority of the litter at 68.4%. Plastic waste was found to be the most common type of litters, making up 95.86% of the total while paper, glass, and metal were present in smaller amounts. The sources of marine litter in the study area were attributed to three main sources: aquaculture and fishing activities (73%), municipal waste (13%), and unidentified sources (14%). Through field observations, it was found that the use of small boats with foam sheets as buoyancy materials, foam containers for storing and transporting seafood, and the use of foam materials in aquaculture are the primary contributors to plastic waste found on beaches.

Keywords:

Marine litter, plastic waste, Vietnam, sandy beach.

INTRODUCTION

Marine waste pollution is a major threat to coastal ecosystems, the economy, the environment, as well as human health [1-3]. Marine litter is difficult to decompose and distributed everywhere in nature [4]. Marine litter consists of various materials, including plastics, metals, wood, rubber, glass, and paper, with plastic being one of the leading causes of coastal pollution, according to most surveys [5-7].

An important step in preventing marine waste pollution is identifying the sources and pathways of waste entering the marine environment [8]. Identifying the source of marine litter is a complex task that requires attention to the diversity and multiple pathways of waste [9]. In fact, identifying and evaluating the details of the source of marine litter on beaches in Vietnam is still quite limited. This study identified the sources of marine litter on several beaches along the North-Central and South-

iJETRM
International Journal of Engineering Technology Research & Management

Central Coast of Vietnam. Based on data from previous studies, all beaches had vibrant tourism activities, were close to urban areas, and were river estuaries. This study provides information on the sources of litter to serve local planning and implementation of measures to prevent and reduce marine waste pollution at the local level.

METHODOLOGY

Study area

This study was conducted on beaches in localities with well-developed tourism services along the North-Central and South-Central Coast of Vietnam. The sampling locations of the beaches are shown in Figure 1, with a total of 16 sampling locations and a number of collected items presented in Table 1.

Table 1. Items found in each sampling area.

Sample ID	Area (m^2)	Number of items in the dry season	Number of items in the rainy season
SL1	194	170	283
SL2	100	145	199
SL3	180	168	229
SL4	800	450	441
SL5	810	386	508
SL6	790	335	397
SL7	440	1147	1623
SL8	420	1006	1477
SL9	460	1379	1484
SL10	2756	600	663
SL11	2462	444	567
SL12	2723	443	513
SL13	4636	324	477
SL14	2791	64	46
SL15	2998	35	35
Sl16	3625	46	38

Among them, the North-Central Coast area has 9 locations (SL1-SL9), and the South-Central Coast area has 7 locations (SL10-SL16). Sampling was conducted in December 2021, representing the dry season, and in July 2022, representing the rainy season for the North-Central Coast area. For the South-Central Coast area, sampling was conducted in December 2021, representing the rainy season, and in March 2022, representing the dry season.

iJETRM
International Journal of Engineering Technology Research & Management

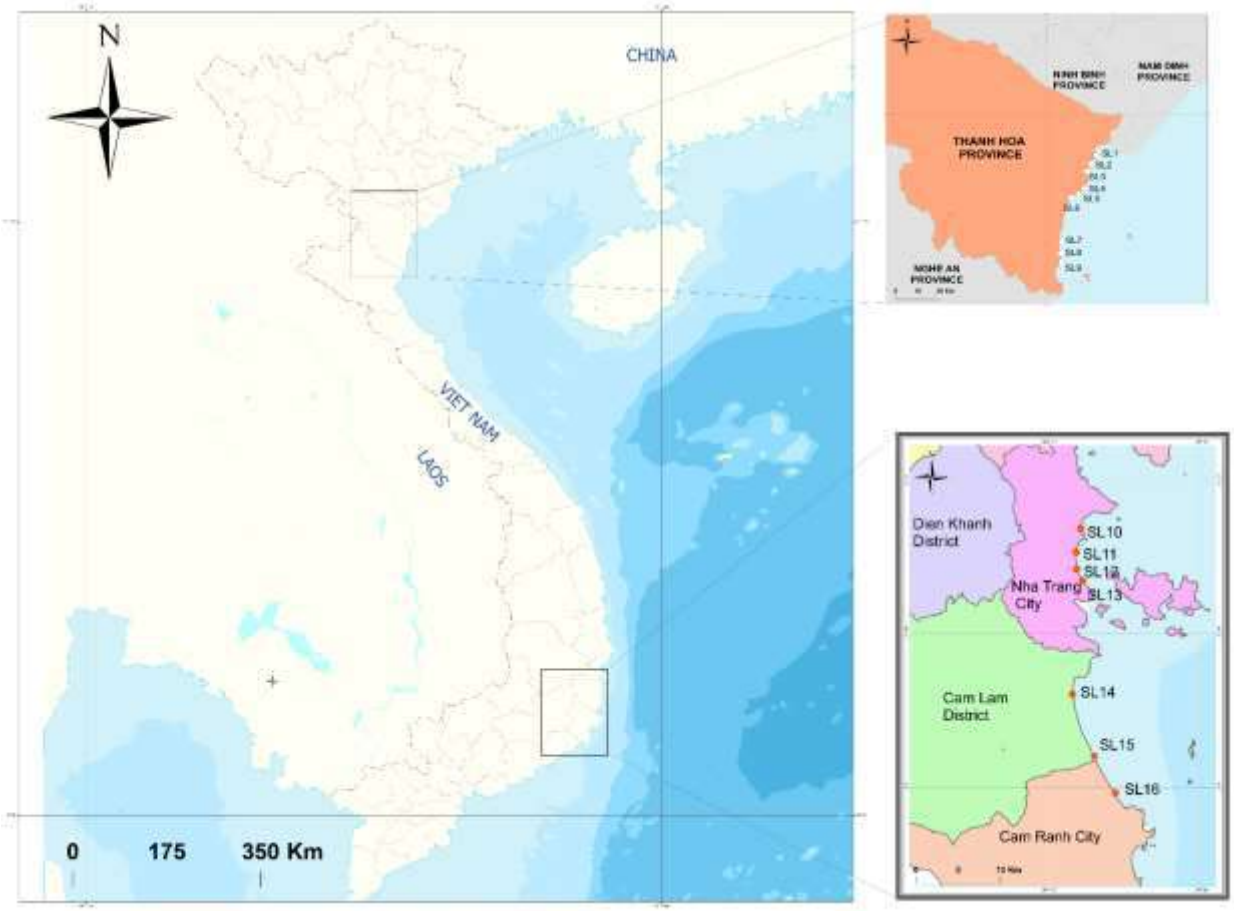

Fig. 1: Sampling areas along the coastal area of Vietnam.

It should be noted that the level of accumulated waste on the beaches in the study area is influenced by factors such as urban areas, tourism, hospitality activities, fishing and aquaculture operations, and the impact of river mouths and ports.

Sampling

The marine litter samples on the beaches were described in studies [10,11] and adjusted for the actual conditions of the study area. The sampling locations ensured the following criteria: the sampled areas had a beach length greater than 100 m; the sampled beaches had slopes ranging from 8o to 20o; the sampling units were not affected by wave barriers or ports; and the research team's sampling units had access to the entire year. In this study, marine litter samples were collected using two methods, specifically as follows:

Method 1: Applied to beaches with high-density marine litter in the North-Central Coast, the sampling unit was established with a length of 10 m along the coastline and divided into five intervals, each 2 m wide. The limit of the sampling unit was the water's edge at low tide and the foot of the vegetation zone or the upper bank of the beach.

Method 2: Applied to beaches with low-density marine litter in the South-Central Coast, the sampling unit was established with a length of 100 m along the coastline. The limit of the sampling unit was the water's edge at low tide and the foot of the vegetation zone or the upper bank of the beach.

The boundary of each sampling unit was determined by GPS devices to ensure that all sampling units were consistent for all repeated surveys. All marine litter with a size (≥5 mm) were collected and identified by name on-site, and unidentified items were appropriately noted.

iJETRM
International Journal of Engineering Technology Research & Management

Classification of marine litter

The collected marine litter items were classified according to the Guideline for Monitoring Marine Litter on the Beaches in the OSPAR Maritime Area [12], adjusted appropriately for the study area. The quantity and names of the items generating the litter were determined at the site, with unidentified items being noted with complete information. The marine litter was classified into: plastic, rubber, textiles, paper, processed wood, metal, glass, ceramics, and other categories.

Determination of marine litter origin

To identify specific sources, we used the method of determining the origin of waste found on beaches through sources that can be detailed in the study [13]. Six potential sources have been identified based on characteristics of waste found on beaches:

1. Public litter: Objects dropped or left behind by the public on beaches or inland that are carried by wind and rivers.

2. Aquaculture waste, including gear, floats, fishing lines, and weights.

3. Shipping: Items lost or discarded from ships.

4. Fly-tipped waste: Illegally dumped waste, including furniture, ceramics, and construction materials.

5. Medical waste: Includes medical-related items such as inhalers, adhesive plasters, and syringes.

6. Non-sourced waste: Items too small or damaged to identify a specific source.

Beach waste is classified under non-sourced waste. To further clarify the origin of these waste items, they are classified into two groups: Waste with origins at sea and waste with origins from land, specifically:

Sea-based waste: Waste related to activities such as shipping, fishing, offshore construction, or dumping at sea.

Land-based waste: Waste related to activities such as coastal tourism may also come from farther areas such as towns and industrial zones, carried by wind or washed into the sea. Waste entering marine environments through wastewater outfalls is considered land-based waste, even though most outfalls are located in rivers or directly discharging into the sea. Similarly, litter along riverbanks is considered land-based waste, even though some littering may be caused by vessels moving along the river.

Evaluation of non-sourced marine litter

The researchers utilized the Matrix Scoring Technique to evaluate and rank various marine litter sources based on their contribution to unidentified waste items [14]. The technique involved several steps, including identifying the important sources that could generate marine litter items by considering the quantity and type of waste produced and the location of the litter source. The next step was to assign weights to each marine litter source, then create a matrix consisting of different marine litter sources along one axis and criteria along the other. Points were then awarded for each marine litter source based on how well they met each criterion, and the point score for each marine litter item was multiplied by its corresponding quantity. The total points for each source were then summed up, and the marine litter sources were ranked based on their total score. This ranking was then used to prioritize interventions aimed at reducing marine litter. In this specific study, the evaluation criteria were categorized into five groups: very likely (LL), likely (L), possible (P), unlikely (U), and very unlikely (UU). A scoring system ranging from 0-4 was assigned to each specific likelihood category, with LL = 4, L = 3, P = 2, U = 1, and UU = 0. This approach allowed the researchers to effectively evaluate and prioritize the sources of marine litter based on their relative contribution to the problem.

iJETRM
International Journal of Engineering Technology Research & Management

RESULT AND DISCUSSION

Marine litter classification

The total number of marine litters identified in surveys was 16122 and classified into 39 categories of items, with the top 20 item categories found most frequently on beaches presented in Table 2.

Table 2. List of the first twenty categories of marine litter.

	Category	ID in OSPAR	Items	Amount (%)
1	Foam fragments (0.5-50 cm)	48	11300	68.40
2	Plastic pieces (2.5-50 cm)	46	1004	6.08
3	Small plastic bags	3	676	4.09
4	Cigarette butts	64	587	3.55
5	Cartons	118	557	3.37
6	String and cord	32	438	2.65
7	Straws	22	433	2.62
8	Plastics cups	21	250	1.51
9	Plastic strings	23	241	1.46
10	Food containers	6	223	1.35
11	Caps/lids	15	185	1.12
12	Candy packets	19	110	0.67
13	String and cord	32	83	0.50
14	Noodle packets	19	78	0.47
15	Medical items	105	65	0.39
16	Bottles	4	61	0.37
17	Other plastic items	48	50	0.30
18	Toys	20	37	0.22
19	Rubber pieces	53	31	0.19
20	Cups	65	23	0.14

In this study, the predominant component of the collected marine litter is the foam fragments, ranging in size from 0.5 cm to 50 cm, accounting for 68.4% of the total litter. Following this are plastic pieces measuring from 2.5 cm to 50 cm, small nylon bags, cigarette filters, milk carton lids, and other miscellaneous items, which make up a smaller percentage.

The collected marine litter was categorized into material groups, including plastic, rubber, paper, wood, glass, fabric, and metal, as shown in Figure 2, with their respective percentages.

iJETRM
International Journal of Engineering Technology Research & Management

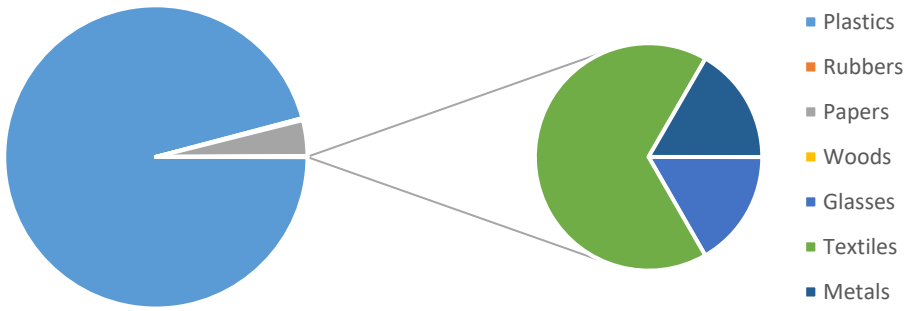

Fig. 2: Marine litter composition.

Plastic litter constitutes the majority, accounting for 95.86% of the total waste collected, followed by paper, which comprises 3.84%. The remaining components, including rubber, wood, glass, fabric, and metal, make up a small percentage of the overall.

Marine litter sources

Marine litter can originate from various sources, and there are different opinions on how to classify the sources of them. The total amount of marine litter collected during survey expeditions is determined to have originated from fishing and aquaculture activities, public waste, and unknown sources. The percentage distribution of the sources of marine litter is presented in Figure 3.

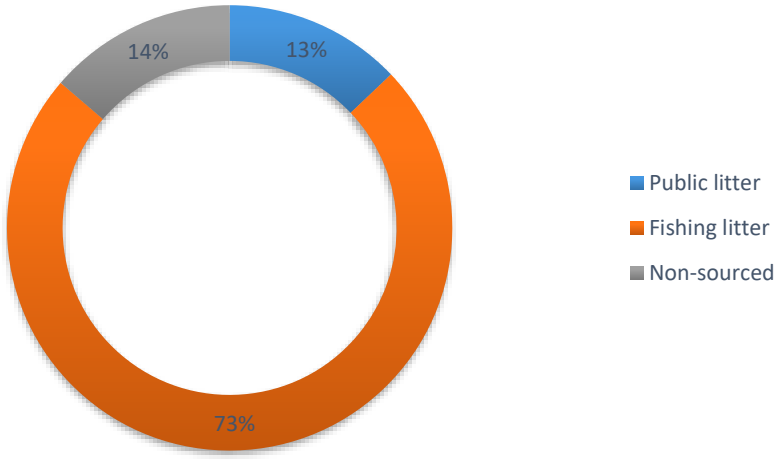

Fig. 3: The percentage of marine litter sources

In Vietnam, waste on beaches originates mainly from aquaculture and fishing activities, accounting for the largest proportion at 73% of the total marine litter. The causes of this issue will be discussed further in a later section. The remaining marine litter includes non-sources and public activities, accounting for 14% and 13% of the total marine debris, respectively. Public activity waste is primarily comprised of single-use products associated with fast food services and packaged food items. The presence of public waste on beaches in Vietnam can be attributed to several factors, such as inadequate waste collection and treatment management by local authorities, lack of financial penalties for littering cases, and low awareness among coastal residents and tourists regarding proper waste disposal practices. A significant amount of waste with unknown origins has been

attributed to two specific sources (on land and at sea), with 70% of the total waste originating from land associated with tourism and entertainment activities, seafood trading on beaches, and residential areas; while the remaining 30% originates from the sea related to fishing and transportation of seafood, and recreational activities on the water.

Outdated aquaculture is the main reason for the pollution

The origin of waste on the beaches in the North-Central Coast region is mainly from the following activities: Fishing vessels of local residents in the coastal area typically use foam sheets as buoyant materials, foam nets, and foam boxes for preserving and transporting seafood (Figure 4a, 4b). Under the influence of sunlight, seawater environment, waves, wind, and collisions, the foam material will be broken down into small pieces. The low density of the foam materials makes them float and disperse widely. The floating foam debris drifts into estuaries, onto beaches, and gets trapped in mangrove forests (Figure 4c, 4d). Under favorable weather and oceanographic conditions, the debris will eventually wash up on sandy beaches.

a. Fishing boat at the beach

b. Styrofoam boxes to preserve seafood

c. Litters in the Ma River estuary area

d. Styrofoam litter in the mangroves

Fig. 4: Sources of beach litter in the North-Central Coast region

Unlike the North Central Coastal region, the origin of marine waste in the South-Central Coast is mainly attributed to aquaculture activities at the river mouth area, as shown in Figure 5a. In addition, plastic waste at fishing ports (Figure 5b) that is not collected and disposed of properly also contributes significantly to the amount of waste on the beaches in this area. This highlights the need for proper waste management practices to mitigate the negative impact of human activities on the marine environment.

iJETRM
International Journal of Engineering Technology Research & Management

a. Styrofoam plates for raising *Perna viridis* in the Cai estuary area

d. Litters in Hon Ro port, Nha Trang

Fig. 5: Sources of beach litter in the South-Central Coast region

The proportion of marine waste distribution in different locations is presented in Figure 6. In the North-Central Coastal region, the majority of the waste originated from aquaculture activities (86%), followed by waste of unknown origin (10%) and public waste (4%) as the least source of marine waste. In contrast, the composition of waste sources is relatively evenly distributed in the South-Central Coast, with public waste being the largest proportion (38%), followed by aquaculture waste (35%), and lastly, waste of unknown origin (27%). These findings indicate the need for location-specific waste management strategies to effectively address the root causes of marine waste pollution.

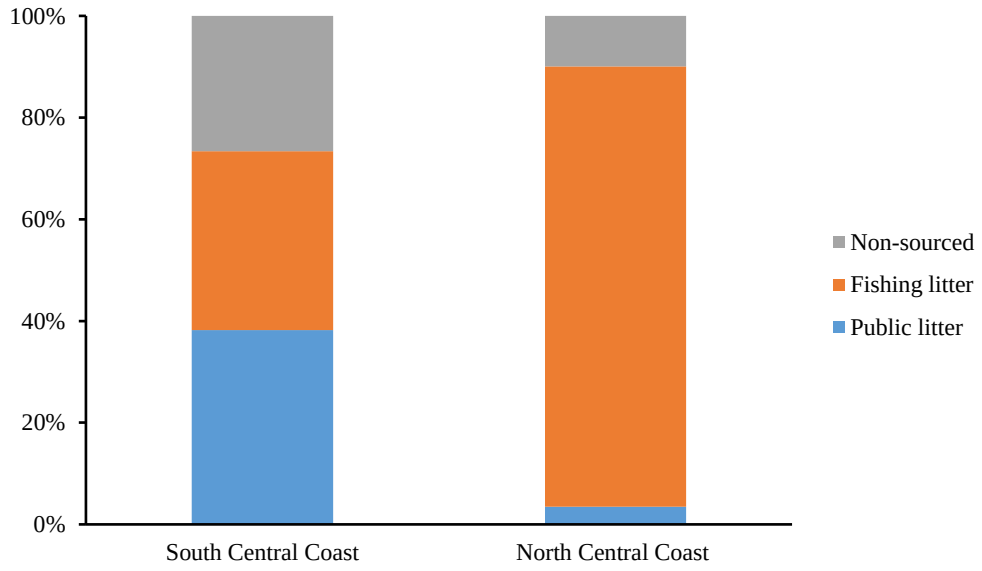

Fig. 6: Distribution of marine litter origin in different localities.

In order to minimize marine debris pollution caused by aquaculture and fishing activities, localities must have specific strategic plans that are appropriate for the characteristics of the origins of marine debris in their area. Specifically, for the North-Central Coast region, local authorities need to disseminate, mobilize and have policies to support coastal residents to convert their fishing boats to use buoyant materials made of more environmentally-friendly and durable materials than PS plastic. In the South-Central Coast area, measures to prohibit the use of foam floatation materials in aquaculture in estuaries and waste collection in fishing port areas should be taken. Enhancing communication efforts to raise local people's awareness about marine environmental protection and minimizing marine debris pollution is also necessary.

iJETRM
International Journal of Engineering Technology Research & Management

CONCLUSION

This study provides ample evidence of the sources of waste on beaches in the North-Central Coast and South-Central Coast regions, serving as a basis for these localities to develop prevention plans that reduce marine debris pollution on beaches, thereby contributing to the promotion of sustainable economic and social development in the region. The proportion of plastic particles with sizes ranging from 0.5 cm to 50 cm originating from fishing gear and materials used in aquaculture constitutes a significant amount, indicating that the backwardness of aquaculture and fishing are the main causes of the presence of waste on beaches. It is necessary to have stricter management measures for using fishing gear and materials in aquaculture and fishing local government authorities to ensure livelihoods for local people while reducing the marine environmental pollution. Raising awareness among local people about the harmful effects of marine debris and providing financial and technical support policies for them to replace outdated fishing gear gradually is also essential.

ACKNOWLEDGMENTS

This study was financially supported by the Vietnam Academy of Science and Technology supported grant number: UQSNMT.02/21-22. Quang-Bac Nguyen was funded by Vingroup JSC and supported by the Master, PhD Scholarship Programme of Vingroup Innovation Foundation (VINIF), Institute of Big Data, code VINIF.2022.TS010.

REFERENCES

[1] La Daana, K.K., Asmath, H. and Gobin, J.F. *The status of marine debris/litter and plastic pollution in the Caribbean Large Marine Ecosystem (CLME): 1980–2020*. Environ. Pollut., 118919, 2022.
[2] Sciutteri, V., Pedà, C., Longo, F., Calogero, R., Cangemi, G., Pagano, L., Battaglia, P., Nannini, M., Romeo, T. and Consoli, P. *Integrated approach for marine litter pollution assessment in the southern Tyrrhenian Sea: Information from bottom-trawl fishing and plastic ingestion in deep-sea fish*. Mar. Pollut. Bull., 188, 114661, 2023.
[3] McIlgorm, A., Raubenheimer, K., McIlgorm, D.E. and Nichols, R. *The cost of marine litter damage to the global marine economy: Insights from the Asia-Pacific into prevention and the cost of inaction*. Mar. Pollut. Bull., 174, 113167, 2022.
[4] Mugilarasan, M., Karthik, R., Robin, R.S., Subbareddy, B., Hariharan, G., Anandavelu, I., Jinoj, T.P.S., Purvaja, R. and Ramesh, R. *Anthropogenic marine litter: An approach to environmental quality for India's southeastern Arabian Sea coast.* Sci. Total Environ., 866, 161363, 2023.
[5] Büyükdeveci, F. and Gündoğdu, S. *Composition and abundance of benthic marine litter in the fishing grounds of Iskenderun Bay, northeastern Levantine coast of Turkey*. Mar. Pollut. Bull., 172, 112840, 2021.
[6] Terzi, Y., Erüz, C. and Özşeker, K. *Marine litter composition and sources on coasts of south-eastern Black Sea: A long-term case study*. Waste Management, 105, 139-147, 2020.
[7] Vlachogianni, T., Fortibuoni, T., Ronchi, F., Zeri, C., Mazziotti, C., Tutman, P., Varezić, D.B., Palatinus, A., Trdan, Š., Peterlin, M. and Mandić, M. *Marine litter on the beaches of the Adriatic and Ionian Seas: An assessment of their abundance, composition and sources.* Mar. Pollut. Bull., 131, 745-756, 2018.
[8] Chuturkova, R. and Simeonova, A. *Sources of marine litter along the Bulgarian Black Sea coast: identification, scoring and contribution*. Mar. Pollut. Bull., 173, 113119, 2021.
[9] Strand, K.O., Huserbråten, M., Dagestad, K.F., Mauritzen, C., Grøsvik, B.E., Nogueira, L.A., Melsom, A. and Röhrs, J. *Potential sources of marine plastic from survey beaches in the Arctic and Northeast Atlantic*. Sci. Total Environ., 790, 148009, 2021.
[10] Alkalay, R., Pasternak, G. and Zask, A., *Clean-coast index—a new approach for beach cleanliness assessment.* Ocean & Coastal Management, 50(5-6), 352-362, 2007.
[11] Hanke, G., Galgani, F., Werner, S., Oosterbaan, L., Nilsson, P., Fleet, D., Kinsey, S., Thompson, R., Van Franeker, J.A., Vlachogianni, T. and Palatinus, A. *Guidance on monitoring of marine litter in European seas*, 2013.
[12] Wenneker, B. and Oosterbaan, L., *Guideline for Monitoring Marine Litter on the Beaches in the OSPAR Maritime Area*. Edition 1.0, 2010.
[13] Veiga, J.M., Fleet, D., Kinsey, S., Nilsson, P., Vlachogianni, T., Werner, S., Galgani, F., Thompson, R.C., Dagevos, J., Gago, J. and Sobral, P. *Identifying Sources of Marine Litter*. MSFD GES TG Marine Litter Thematic Report; JRC Technical Report; EUR 28309, 2016.
[14] Tudor, D.T. and Williams, A.T. *Development of a 'Matrix Scoring Technique'to determine litter sources at a Bristol Channel beach.* J. Coast. Conserv., 10(1), 119-127, 2004.