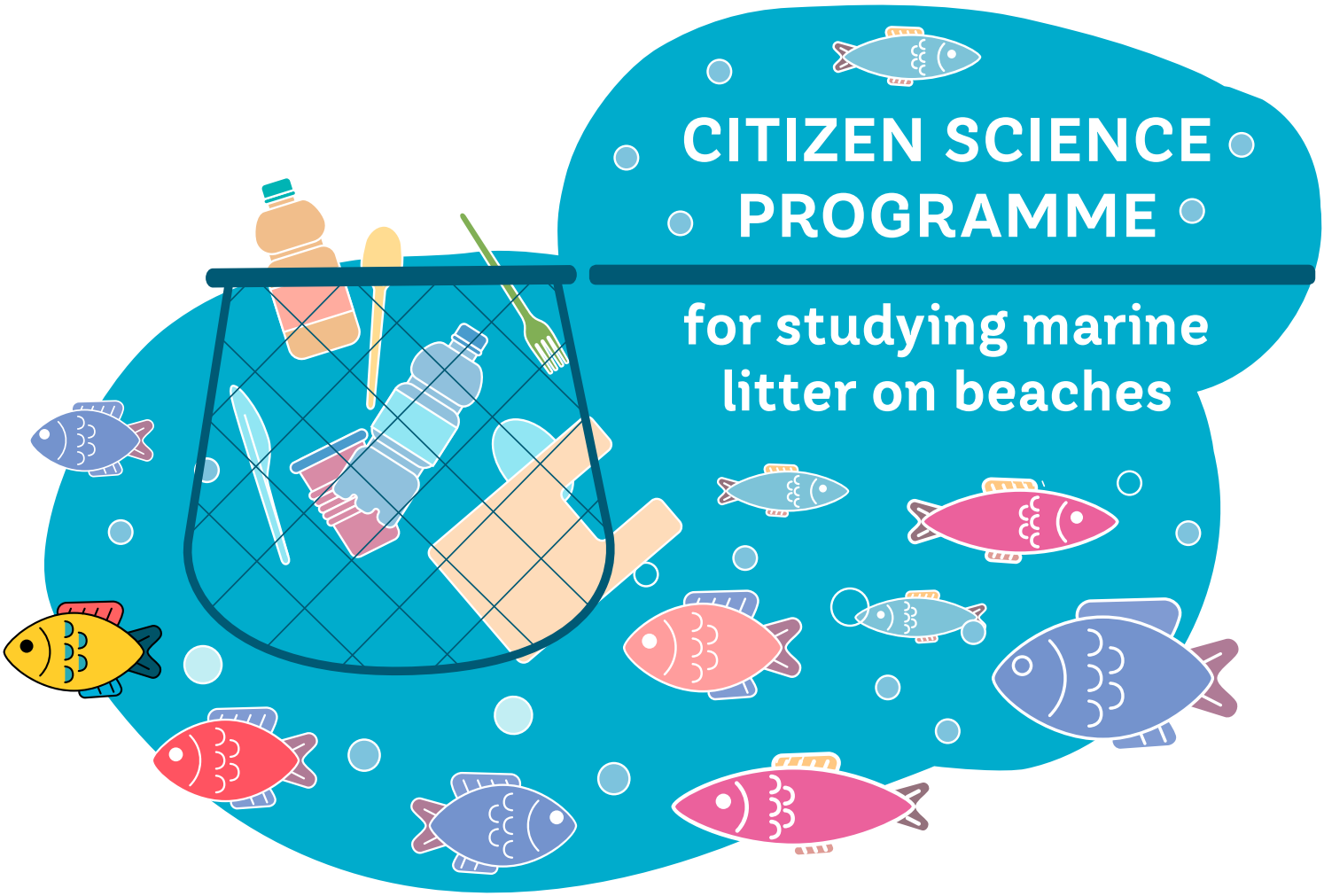
NATURE AND ORIGIN of Marine Litter



CITIZEN SCIENCE PROGRAMME

for studying marine litter on beaches

SEI
URBAN ECO ISLANDS
European Union
European Regional Development Fund
Interreg Central Baltic

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1. INTRODUCTION TO THE PROGRAMME

Marine litter as a global and Baltic Sea environmental problem is introduced. Litter can enter the sea as a result of human activities on both land and the sea. Group work is taking place, in which the beaches are being studied in order to identify the litter found there. Participants are familiarising themselves with the materials comprising sea litter, learning to identify the most common types and sources of sea litter. The results will be presented to fellow students and the links between the characteristics of the beach, marine litter composition and distribution will be discussed together. The research programme, which has been tested on Aegna Island together with the Aegna Nature House, is suitable for use on both island and mainland beaches.

Target group: Upper Secondary School Students

The programme consists of three parts:

- Activities at school prior to the day of study: learning about the topic of marine litter through web-based materials and selecting the beach areas to be studied (Chapter 3)
- One day of study at the seaside (Chapter 4)
- Analysis of the marine litter collected, a presentation and discussion of the results, which can be done at the seaside or at school (Chapter 5)

Programme materials include:

- worksheets for students (Excel file);
- marine litter image bank, with examples of litter types (pages 10 and 11).

The students participating in the citizen science programme conduct research, which began in June 2020 as part of the European Union's Central Baltic programme **Urban Eco-Islands: Urban and Smart Island Tourism Destinations.**

The results of the analysis of marine litter collected during the day of study are entered by the students in the database of results for the marine litter study programme[1]. With the addition to the database of the results of repeated surveys, it will be possible to analyse the changes in marine litter data over time.

The programme has been prepared by Harri Moora, Piret Kuldna and Evelin Piirsalu, from the Stockholm Environment Institute Tallinn Centre.

1.1. Means necessary for collecting litter

Each participant will bring along the following to the day of study:

- Work gloves

Equipment to be brought by the group:

- One smaller and one larger garbage bag (5–30 l), possibly a basket or bucket for heavier litter (e.g., reusable plastic bucket)
- Two boxes: for small litter particles and for collecting micro-litter sediment samples
- A writing pad and a pen
- A phone that can set coordinates and take pictures of the litter

1 https://bit.ly/2YNA9Rx

2. THE PURPOSE OF THE PROGRAMME AND ITS CONNECTION WITH THE CURRICULUM

PURPOSE: To determine the spatial distribution, composition and possible origin of marine litter on selected beaches.

RELATION TO THE CURRICULUM: Subjects: Geography, Social Studies. Central theme: environment and sustainable development – analysis of anthropogenic marine litter, which affects the state of the marine environment and coasts as well as human health and the economy.

LEARNING OUTCOMES: The student acquires knowledge about the nature, route and sources of marine litter. Awareness of litter reaching the Baltic Sea is increasing.

3. PRELIMINARY ACTIVITIES AT SCHOOL PRIOR TO THE DAY OF STUDY

3.1. Getting acquainted with the topic of marine litter

At school, prior to the day of field study, get acquainted with marine litter as a global and Baltic Sea environmental problem, for which the following materials can be used:

- Project BLASTIC information material Plastic Waste Pathways into the Baltic Sea[2]
- Project BLASTIC Marine Waste Knowledge Bank[3]
- Video on the global movement of marine litter:
  Filming rubber ducks in the Big Blue[4]
  3 Times Scientists Did Weird Experiments With Rubber Ducks[5]

2 www.sei.org/projects-and-tools/projects/blastic-plastic-waste-pathways-into-the-baltic-sea/

3 www.blastic.eu/knowledge-bank

4 www.bbc.co.uk/programmes/articles/5r4gpxYrCv2KknmvP1Zcrn3/filming-rubber-ducks-in-the-big-blue

5 www.youtube.com/watch?v=eLMSMs6AYYc

Marine litter is any persistent, manufactured or processed solid material discarded, disposed of, or abandoned in the marine and coastal environment.

Marine litter consists of items and the parts thereof which people have deliberately discarded into the sea or left on the beach. The litter may indirectly reach the marine environment via rivers, effluent and storm water outlets or via the wind. Marine litter includes fishing gear and ship's cargo that have been lost at sea.[6]

During the day of field study, litter found on the beach – litter that has been washed ashore by the sea and left by people on the beach – is studied. Litter left on the beach can also be considered **marine litter**, since it is likely to end up in the sea if it is not removed from the beach.

The results of Estonian beach litter monitoring shows that plastic litter **(plastic + foam) accounts for an average of 63% of coastal litter.**[7]

Results of research conducted in the BLASTIC project:
About **80% of** the litter in the Baltic Sea comes from **land and 20% from the sea**.

Cigarette butts and filters account for a large part of the litter that reaches the sea with rainwater from the territory of the City of Tallinn – **quantitatively up to half of the litter**.

Micro-litter is mainly released into the environment directly from industry or through the decomposition of larger-scale plastic pollution. People's daily activities, such as turning corks and peeling film are also a source of microplastics.[8]

Smart applications, such as Litterati[9], have also been developed to determine the coordinates and photograph the location of litter with the aim of collecting data on litter in a global database.

6 UNEP Regional Seas Programme (2005). Marine Litter – An analytical overview

7 Keep the Estonian Sea Tidy 2019. Monitoring of Marine Litter in Estonian Coastal Areas 2017–2018

8 ERR 30.03.2020, novaator.err.ee/1070446/keskkonda-paiskub-mikroplasti-juba-pudeli-avamisel

9 litterati.org

3.2 The formation of groups and selection of beach sections to be studied

Groups of **four to six students** are formed to perform the research.

Under the teacher's guidance, each group selects a section of the beach to be surveyed, from the area's map in the Land Board's map application. The length of the section is **at least 500 metres**. The coordinates of the start and end points of the section are marked in Table 1.

3.3. Safety rules

At the beginning of the day of study, the teacher introduces the safety rules related to field learning. Among other things, the following guidelines for litter collection must be clarified:

- **If you find unknown and dangerous objects** (objects that are potentially explosive or resemble explosive objects, packaging and containers containing chemicals or unknown liquids, sharp objects, etc.), they must not be touched or picked up.
- If such items are found, the **teacher or the adult instructor accompanying the group** must be **notified.**

4. DAY OF STUDY AT THE SEASIDE

The next two chapters introduce the method for collecting and documenting marine litter, and the structure of the presentation and discussion of the results. Two hours can be set aside for collecting marine litter on the beach, with another two hours reserved for analysing, presenting, and discussing the litter.

4.1. Marine litter collection methodology

Marine litter is collected in two sections: Along a 500 m long section of beach and a 5–10 m wide section within this area, where sediments (sand, gravel) also allow sampling to detect the presence of micro-litter (see Figure 1).

- First, the members of the group move along a **500-meter section of beach across the width of the beach** and collect **litter larger than 5 cm (macro-litter)** in a **garbage** bag.
- **Large and heavy** litter that cannot be removed is only photographed at its location.

The width of the beach is the area from the waterline to the maximum impact limit of the waves (see photos 1 and 2).

If this area is wider than 50 m, litter is collected from a **strip of beach that is up to 50 m wide.**

- Along the same section of beach, the group selects a **5–10-meter-wide section** for more thorough litter collection, also picking up **litter smaller than 5 cm (meso-litter)**.

  In this section, the members of the group move side by side slowly across the shore, from the water's edge towards the mainland, and try to find all of the litter within the beach sediment of the section, including small pieces of litter (glass fragments, cigarette butts, pieces of plastic, etc.). The small litter found is collected in a separate box
- From the same **5–10 m section a sediment sample** is collected in a box to test for the presence of **micro-litter** (less than 5 mm) – a handful of sediment from sediment washed away by a wave.
- The location coordinates for the sediment sample are entered in Table 1.

  NB! Bio-waste is not collected among marine litter.

Students are advised to **take pictures of** macro and meso-litter where it is discovered, which will help to better characterise it later. From the photos, students can create a picture bank of marine litter, which can be used as supporting material for the presentation of the results of the day of study.

Macro-litter – diameter >5 cm

Meso-litter – diameter >5 mm... <5 cm

Micro-litter – diameter <5 mm

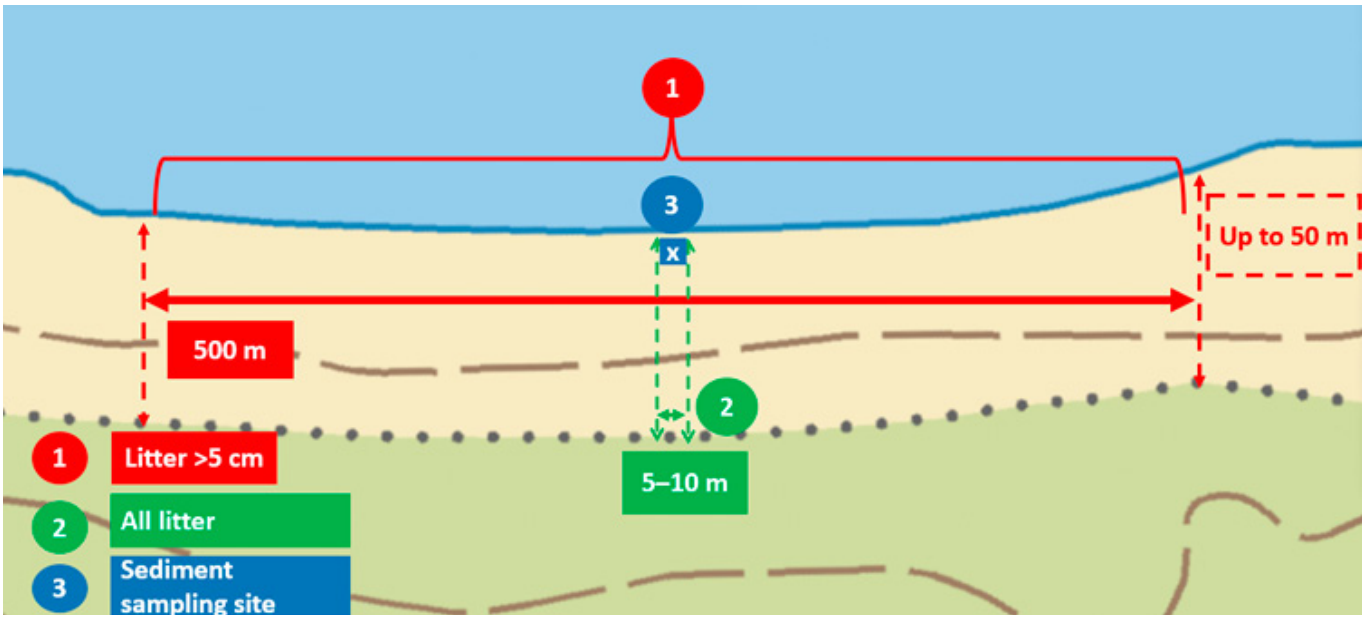


Figure 1. Marine litter collection sections and sediment sampling location on the beach

Photo 1. Wave exposure boundary on the North Beach of Aegna Island

Photo 2. Wave exposure boundary along Mustamäe Beach on Aegna Island

4.2. Description of the investigated section of beach

Each group describes the selected beach and section of beach according to the indicators in Table 1.

Table 1. Description of the beach, in order to identify sources and routes of marine litter (Excel spreadsheet)

№	INDICATORS CHARACTERISING THE BEACH	ANSWERS
1.	**Beach name** (if marked on the map):	
2.	**Location of the surveyed stretch of beach**	
	Coordinates of the starting point of the 500 m section:	
	Coordinates of the end point of the 500 m section:	
	Coordinates of the sediment sampling location (located in a section 5–10 m wide):	
3.	**Average width of the section of coastal beach** (from the rline to the point of maximum wave exposure, m):	
4.	**Types of beach found in the section of coastal beach** (*mark X*):	
	Coastal escarpment	
	Sandy beach	
	Gravel-pebble beach	
	Rocky beach	
	Silt shore	
	Artificial shore	
5.	**Coastal process characteristic of the section of beach** (*mark X*):	
	Erosion process	
	Deposition process	
6.	**Beach location** (*mark X*):	
	Open towards the mainland	
	Open towards the open sea	
7.	**Is the beach open to waves?** (*mark X*):	
	Yes	
	There are objects in the sea (such as a quay), which can affect currents and waves	
	The sea area is hidden by a peninsula	
	Sediments are damping waves	
8.	**Are the beach and/or adjacent sea area being used by (during the observation or in general)** (*mark X*):	
	Swimmers, sunbathers, beachgoers	
	Fishermen	
	Recreational craft	
	Other small craft (yachts, personal watercraft, canoes, windsurfers, kayaks, etc.)	
	Passenger ships travelling on the fairway	
	Cargo ships travelling on the fairway	
	Other (what or who?)	
9.	**Other observations about the beach:**	

5. ANALYSIS OF MARINE LITTER, PRESENTATION OF RESULTS AND DISCUSSION

5.1. Composition of marine litter

First, the members of the group sort the collected litter (items and pieces) based on the material and the type of litter, in accordance with Table 2.

- If the litter consists of more than one material, it should be classified under **the material of the highest content.**
- **Example 1:** Candy and ice cream wrappers, packaging for curds and other snacks are made only of plastic (polymer material) or mixed material (aluminium + polymer). In general, the predominant material is (by weight) plastic; therefore, it is plastic packaging in accordance with marine litter methodology, which should be classified using code **PL07**.
- **Example 2:** A plastic yoghurt **cup** with a tear-off lid made of aluminium foil is a plastic package with the code **PL06**, as plastic comprises the majority of the package.
- **Example 3:** Pure aluminium foil is also widely used in food packaging (e.g., inner foil wrappers for chocolates) for which code **ME06** should be used.
- To determine if the packaging consists of pure aluminium, students can try to rub the packaging into balls between their fingers – if they are successful in doing so, the material is aluminium.
- **Example 4:** Cardboard beverage packaging with an inner foil layer (Tetra Pak type) is classified as cardboard/cardboard packaging (**PP03**).
- **Example 5:** Synthetic fibres (i.e. plastics, code **PL22**) are nowadays the predominant means used in making cords (especially thinner cords). To determine which material is contained in the greatest quantity in a rope or cord, a small test with fire can be performed under controlled conditions – in the flame, the synthetic material melts and burns with a large flame, while natural fibres do not melt. NB! Students are not allowed to do this experiment on the beach on their own.

- If it is not possible to determine the type of litter, enter the quantity of it in **the last cell based on the litter's material, where there are other items of the corresponding material**.
- Litter, the material and type of which cannot be identified should be entered **in the last cell of the table with code OT06**.
- If the object has broken down into several pieces, **count each piece of litter separately for the numerical quantity**.
- As an aid in determining litter types, an image bank of e**xamples of marine litter types with codes can be used (on pages 10 and 11)**.
- When entering the results in an Excel table, the amounts and weights are calculated automatically and a pie chart of the composition of the marine litter by material is displayed below the table.

PP03 A cardboard cup

PE03 A wooden pallet crate

PL08 A plastic bag

PL22 Plastic cord, which is a mixture of synthetic and textile fibres

PL25 Other plastic items and pieces (a shell of bird hunting ammunition)

PL07 A thin plastic packaging of curd (plastic coated with a thin layer of aluminum)

PL21 Monofilament line

PL09 A plastic film piece

PL22 Plastic cord

ME03 An aluminium can

PL25 Other plastic items and pieces (a goods fastening device)

OT02 Pieces of solid oil (bitumen)

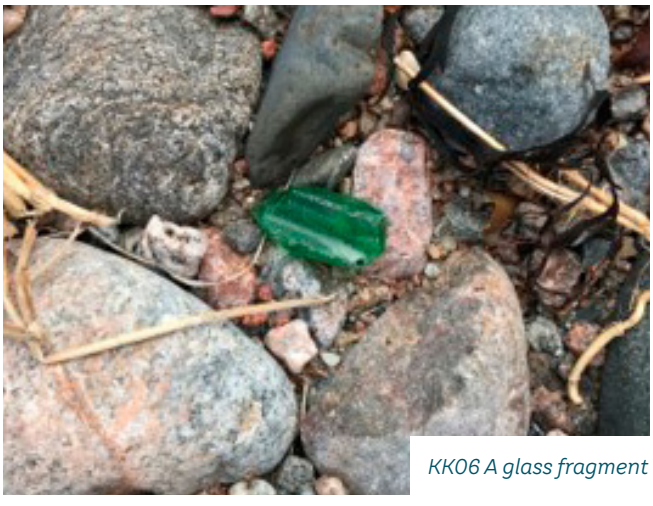
VP03 A piece of foam insulation

KE02 A flip-flop

TE03 Textile cord

PL25 Other plastic items and pieces (a shell of bird hunting ammunition)

KE03 A rubber glove



KK06 A glass fragment

Table 2. Material, type and quantity of marine litter collected (Excel spreadsheet)

CODE	TYPE OF MARINE LITTER	QUANTITY	%
PLASTIC ITEMS			
PL01	Bottle caps & lids		
PL02	Bottles <2 L		
PL03	Bottles, drums, jerrycans & buckets >2 L		
PL04	Knives, forks, spoons, straws, stirrers (cutlery)		
PL05	Drink package rings, six-pack rings, ring carriers		
PL06	Food containers (fast food, cups, lunch boxes & similar)		
PL07	Thin plastic packaging (e.g., wrappers of candies, ice cream, snacks)		
PL08	Plastic bags (opaque & transparent)		
PL09	Other plastic film pieces		
PL10	Sheeting and mesh bags (tarpaulin or other woven plastic bags, palette wrap, vegetable bags)		
PL11	Strapping		
PL12	Toys & party poppers		
PL13	Plastic gloves		
PL14	Cigarette lighters		
PL15	Cigarettes, butts & filters		
PL16	Syringes		
PL17	Baskets, crates & trays		
PL18	Resin pellets		
PL19	Plastic buoys		
PL20	Fishing gear (lures, traps & pots)		
PL21	Monofilament line		
PL22	Plastic or plastic fibre cord		
PL23	Fishing net		
PL24	Fibreglass fragments (e.g., boat fragments)		
PL25	Other plastic items and pieces		
FOAM ITEMS			
VP01	Cups & food packs		
VP02	Foam packaging, except food packaging		
VP03	Foam insulation		
VP04	Foam buoys		
VP05	Other foam items and pieces		
	TOTAL PLASTIC ITEMS		100%
	SHARE OF TOTAL MARINE LITTER	**PLASTIC**	
TEXTILE ITEMS			
TE01	Clothing, shoes, hats & towels		
TE02	Backpacks & bags		
TE03	Rope & string (except from plastic fibre)		
TE04	Carpet & furnishing		
TE05	Other cloth (including rags)		
	TOTAL TEXTILE ITEMS		100%
	SHARE OF TOTAL MARINE LITTER	**TEXTILE**	

GLASS, CERAMICS, AND OTHER MINERAL ITEMS			
KK01	Bottles & jars		
KK02	Tableware (plates & cups)		
KK03	Light globes/bulbs		
KK04	Fluorescent light tubes		
KK05	Glass buoys		
KK06	Glass or ceramic fragments		
KK07	Bricks and other mineral construction material		
KK08	Other		
	TOTAL GLASS, CERAMICS, AND OTHER MINERAL ITEMS		100%
	SHARE OF TOTAL MARINE LITTER	**GLASS AND OTHER MINERAL MATERIAL**	
METALLIC ITEMS			
ME01	Tableware (plates, cups & cutlery)		
ME02	Bottle caps, lids & pull tabs		
ME03	Aluminium drink cans		
ME04	Other cans (<4 L)		
ME05	Gas bottles, drums & buckets (>4 L)		
ME06	Foil wrappers		
ME07	Fishing gear (sinkers, lures, hooks, traps & pots)		
ME08	Wire, wire mesh & barbed wire		
ME09	Other metallic items, appliances, and pieces		
	TOTAL METALLIC ITEMS		100%
	SHARE OF TOTAL MARINE LITTER	**METAL**	
PAPER AND CARDBOARD ITEMS			
PP01	Paper (incl. writing paper, newspapers, magazines)		
PP02	Cardboard boxes & fragments		
PP03	Cups, food trays, food wrappers, drink containers, cigarette packs		
PP04	Tubes for fireworks		
PP05	Other paper and cardboard items and pieces		
	TOTAL PAPER AND CARDBOARD ITEMS		100%
	SHARE OF TOTAL MARINE LITTER	**PAPER AND CARDBOARD**	
RUBBER ITEMS			
KE01	Balloons, balls & toys		
KE02	Footwear (flip-flops)		
KE03	Rubber gloves		
KE04	Tyres		
KE05	Inner-tubes and rubber sheet		
KE06	Rubber bands		
KE07	Condoms		
KE08	Other rubber items and pieces		
	TOTAL RUBBER ITEMS		100%
	SHARE OF TOTAL MARINE LITTER	**RUBBER**	

WOODEN ITEMS			
PE01	Corks		
PE02	Ice-cream sticks, chip forks, chopsticks & toothpicks		
PE03	Processed timber and pallet crates		
PE04	Matches & fireworks		
PE05	Fishing traps and pots		
PE06	Other wooden items and pieces		
	TOTAL WOODEN ITEMS		100%
	SHARE OF TOTAL MARINE LITTER	**WOOD**	
ITEMS OF OTHER MATERIAL AND UNIDENTIFIED PIECES			
OT01	Paraffin or wax		
OT02	Pieces of pitch and solid oil		
OT03	Asbestos cement		
OT04	Sanitary (nappies, cotton buds, tampon applicators, toothbrushes)		
OT05	Batteries		
OT06	Other material		
	TOTAL ITEMS OF OTHER MATERIAL AND UNIDENTIFIED PIECES		100%
	SHARE OF TOTAL MARINE LITTER	**OTHER**	
	ALL MARINE LITTER TOGETHER		**100%**

5.2. Origin of marine litter

To analyse the origin of the litter on the basis of its sources, fill in Table 3 using the data from Table 2.

- Discuss which litter may have originated from local sources and which may have originated from elsewhere.
- When entering the results in an Excel table, the amounts and weights are calculated automatically and a pie chart of the origin of the marine litter is displayed below the table.

Table 3. Possible origin of marine litter (Excel spreadsheet)

SOURCE	TYPE OF MARINE LITTER	AMOUNT	%
Terrestrial origin			
Littering on the beach (tourism and leisure)			
Littering elsewhere on land (other human activities)			
Construction and demolition activities			
Ports			
Other			
	TOTAL FROM LAND		**100%**
	SHARE OF TOTAL MARINE LITTER	**FROM LAND**	

Marine origin			
Ship traffic, water tourism			
Fisheries			
Other			
	TOTAL MARINE		**100%**
	SHARE OF TOTAL MARINE LITTER	**FROM THE SEA**	
ALL LITTER TOGETHER			**100%**

5.3. Micro-litter analysis

In order to identify pieces of micro- and meso-litter, the sediment collected from the beach is examined under a microscope (if possible on-site or later at school) and Table 4 is filled in based on the results.

- In what shape are the particles (fibres, granules or other pieces) found?
- Discuss the possible origin of the particles of litter found.

Table 4. Content and shape of micro- and meso-litter particles in the analysed sediment sample (Excel spreadsheet)

INDICATORS	ANSWERS
Sediment material studied:	
Shape of pieces of micro- or meso-litter (mark X):	
Fibres	
Granules	
Other pieces	

The fibres come from textiles.

Blue-tinted plastic fibre ropes are widely used in shipping and fishing.

Granules and other pieces are formed as a result of the decomposition of other materials, especially plastic litter.

5.4. Presentation and discussion of results

1. Each group will summarise their research:

- Brief description of the studied coastal section (based on Table 1)
- Results of marine litter analysis:

  What was the composition of the litter? (Based on Table 2)

  Where could the litter come from? (Based on Table 3)

  Existence of micro-litter (based on Table 4)
- If possible, the groups present the results in the form of diagrams:

  Distribution of marine litter based on material and the proportions of these materials among total marine litter.

  Distribution of types of marine litter by the most common marine litter materials and the proportions of these types out of the total quantity of material. For example, compile a breakdown of plastic item types as a proportion of the total plastic items.

Distribution of marine litter based on origin, the proportions of terrestrial and marine origin in total quantity of marine litter.

2. Then all groups will jointly discuss the spatial distribution, composition and origin of marine litter found on the examined beaches

- What are the similarities and differences between the results of the studied coastal sections?
- When determining the reasons for the similarities and differences in the results, take into account the type, location and area of use of the beach, the coastal process, currents, etc. (Based on Table 1)
- Which type of beach accumulates the most litter and which type of beach has the least amount of litter?
- What are the similarities and differences between the data of marine litter found on the day of study and the litter collected from the Baltic Sea beaches in the course of previous research?

After the presentation and discussion of the research results, the sorted litter will be taken to the designated litter collection point.

3. Each group will fill in the results database of the marine litter study programme[10]

At the end of the day of field study or at school, students will enter the results of group work into Tables 1–4 of the marine litter database. Students may use the collected data in their research.

10 https://bit.ly/2YNA9Rx